# A summary of NRC Construction housing activities for 2012: a report prepared for the Canadian Home Builders' Association, February 2013

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A Report Prepared for the Canadian Home Builders' Association

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Designers and code authorities use fire testing data to improve the fire safety of dwellings.

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February 2013

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# A Message from the General Manager of NRC Construction

Residential construction in Canada remains a strong indicator of the country's economic strength. NRC Construction continues to respond to the needs of builders who want to adopt and implement new technologies that provide a competitive advantage, while addressing changing societal expectations for safe and cost-effective construction. This year, more than 1,500 industry firms and organizations have been engaged directly in initiatives and projects with NRC Construction.

The release of the 2011 National Energy Code—and more recently the addition of energy efficiency requirements for housing and small buildings to Part 9 of the National Building Code—will assist builders in providing cost-effective, energy-efficient solutions to consumers.

The work of the Part 9 code committee is progressing on the development of proposed changes on specific subject areas including airborne sound transmission, exterior finish and insulation systems, log home construction, solar collectors and water use efficiency.

We are working with industry on projects to evaluate the performance of photovoltaic (PV) panels integrated into roofing membranes.

Collaborating with industry and government partners, we have conducted projects to validate and improve performance of indoor air quality technologies including the mitigation of radon in homes.

We continue to work with industry and fire safety authorities to develop technologies and decision-making tools for improved fire resistance and efficient fire suppression technologies. We have completed projects that characterize fires in multi-suite residential buildings, leading to improved understanding of fire development and severity rates.

NRC is working with the wood industry (including the Canadian Wood Council and FPInnovations, Natural Resources Canada and the governments of Ontario, Quebec and British Columbia) to develop technical data and solutions to facilitate the use of wood-based structural elements in mid-rise buildings. The results will be provided to the Codes Commission for potential code incorporation and to practitioners for use in design standards and guides, and new materials for manufacturers, especially on fire resistance and sound transmission.

As we close yet another successful year, we look forward to continuing our collaboration with industry. We strive to respond to your needs through collaborative projects, and deploy our findings from research and technical services to secure economic growth for our partners and clients.

On behalf of our staff, I wish to thank you for your continued support and sustained engagement to our mission and business.

Morad Atif
*General Manager*

# Building Envelope and Materials

## *Energy-efficiency of VIP-insulated Wall Assemblies*

From January 2011 to September 2012, researchers investigated three energy strategies to retrofit conventional wall assemblies by adding exterior insulation. The objective of the study was to develop recommended construction specifications and guidelines for assembling next-generation building envelope systems, with the ultimate goal of encouraging their use in buildings. The test was performed in the state-of-the-art NRC Construction Field Exposure of Walls Facility (FEWF). (http://archive.nrc-cnrc.gc.ca/eng/facilities/irc/field-exposure.html)

The three wall specimens were installed in side-by-side test bays exposed to weather on the exterior side and to controlled conditions on the interior side. The reference wall involved the installation of a 50 mm XPS insulation board (R10). The other two walls were comprised of vacuum insulated panels (VIPs) (~R40) sandwiched between two layers of rigid insulation XPS (i.e., 25 mm and 15 mm thick insulation boards - R5 and R3). These insulation materials were added to the exterior of typical RSI 3.52 (R20) 38 mm by 140 mm (2x6) walls. The hygrothermal tool hygIRC-C was used to determine the energy savings due to retrofitting the wood-frame wall systems with VIPs. One VIP method used tongue-and-groove panels and the other used panels that were clipped to strapping.

The reference wall added 50 mm to the wall thickness for a gain in R-value of 10. For both VIP walls, the additional insulation increased internal temperatures, thereby reducing the risk of moisture and damage. The addition of 55 mm of wall thickness to the exterior of existing 38 mm x 140 mm (2x6) typical wood-frame wall of RSI 3.52 (R20) added a nominal R-value of about RSI 8.5 (R48), potentially giving a total nominal R-values of about RSI 12 (R68). The attachment methods and cladding used did not imperil the VIPs and the sandwich panel configurations facilitated changing a panel, should one be found to be faulty at the time of installation.

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*Retrofitting conventional wall assemblies by adding exterior insulation.*

*Roof-integrated photovoltaics were installed on the Canadian Centre for Housing Technology InfoCentre roof.*

## *Roof-integrated Photovoltaics*

NRC Construction researchers have been collaborating with NRCan and the Clean Energy Fund to investigate the performance of innovative roof-integrated photovoltaic (RIPV) products. The objective of this project is to quantify the energy production potential of RIPV products and to assess their performance as roofing systems.

For the field trial, an RIPV system was installed and monitored at the Canadian Centre for Housing Technology InfoCentre located on the NRC campus in Ottawa. The panels assessed in this project are multicrystalline silicon. Installation of the system involved removing the existing roof shingles, installing a modified-bituminous roofing membrane, and affixing the panels to the roof using adhesive. This is a novel approach adapted from a roofing system that would typically be found on low-sloped roofs such as commercial supermarkets, industrial warehouses, and school buildings.

Over a 12-month period (September 2011 to September 2012), the RIPV system generated over 2 MWh of electricity, and had a measured system efficiency of 5.3%. Snow cover resulted in a 90% loss of potential energy production in January.

The wind uplift resistance of the roofing system was evaluated by static and dynamic testing at NRC Construction's Dynamic Roof Testing Facility (http://www.nrc-cnrc.gc.ca/eng/solutions/facilities/hygrothermal.html).

The results from the two research activities are being used to develop a computer model to examine heat and moisture performance of these new roofing systems under a variety of climate conditions, and to benchmark an energy simulation model to predict whole house energy performance at selected locations across Canada.

To maximize energy potential of roofing systems, further RIPV research ideas are being developed on shading analysis and evaluation of the next generation of inverters.

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## *Photovoltaic Panels on Residential Roofing*

With the decreasing cost of photovoltaic (PV) modules, growing awareness of solar energy, climate change, and net-zero houses, a significant increase in the use of roof-mounted photovoltaic systems on steep-slope, residential roofing is expected.

Crystalline silicon technology is the most common PV system used on residential roofing. However, there are no design guidelines or installation standards. To address these shortcomings, NRC Construction has initiated a consortium project, SIGDERS – PV on Residential Roofing, with particular emphasis on wind loads and weather resistance. Rather than focusing on individual PV systems, this project deals with the interaction of the roofing system and the PV system. The research will be a combination of full-scale wind tunnel testing (design pressure coefficients), laboratory testing (wind uplift resistance) and field monitoring (weather resistance and pressure coefficient verification).

The project will identify technical barriers to the installation of independent PV systems and develop appropriate design solutions for incorporation into building codes.

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## *Window/Wall Interface Details for Managing Rainwater and Air Leakage*

The objective of this multi-year project was to investigate the ability of various housing window/wall construction details to manage rainwater and air leakage, and to provide guidelines for builders.

In addition, a study was conducted to evaluate the condensation risk at the window frame/glazing interfaces of installations incorporating a sill pan. Specific window/wall installation details were subjected to low temperature extremes and air leakage across the interface. Information on this study can be found under "window/wall" at http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/.

A Construction Technology Update titled Window Installation Details for Effective Sealing Practice is currently being published. When available, it can be viewed at http://archive.nrc-cnrc.gc.ca/eng/ibp/irc/ctus/ctus-index.html. Two more Updates are anticipated in the near future addressing other key issues of window/wall interfaces.

CMHC and a number of private sector partners in Canada and the United States supported this research.

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*Effective sealing practice during window installation was being researched at NRC.*

## Hygrothermal Properties of Cross-laminated Timber (CLT)

Cross-laminated timber (CLT) is a new wood-based material with potential for use in residential and commercial construction. CLT is produced with three to seven layers of lumber or planks attached to one another at right angles to make large floor, wall, and roof modules.

NRC Construction, in partnership with the Mid-rise Wood project partners and funders (see article on page 15), was tasked with determining the moisture management performance of CLTs. This will be done by measuring the hygrothermal properties of CLTs and then performing hygrothermal simulations. The identification of appropriate test methods for the generation of hygrothermal performance data for CLTs will facilitate the design of durable and effective wood construction using this material.

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## Eco-friendly Advanced Thermal Insulation

NRC Construction has been working to develop high-performance thermal insulation products that are eco-friendly (i.e., renewable, energy-efficient, biodegradable and indigenous). Laboratory studies and on-site investigations of the performance of various insulations have been completed, and a life cycle analysis of the insulation materials was completed in 2012. The final results from this study show the positive influence of insulation materials on the life cycle impact of building envelope construction.

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## Field Application of VIPs in the Yukon

NRC Construction researchers, in association with Yukon College, Yukon Housing Corporation, Panasonic Canada and Energy Solutions Centre, have installed VIPs in an institutional building retrofit project in Whitehorse, Yukon. The VIPs were sandwiched between two layers of rigid foam insulation boards to prevent mechanical or physical damage. The performance of the VIPs is being continually monitored and the results available from the first year of monitoring show very high insulating performance. These results will be used to optimize material selection criteria and construction details.

*Installing vacuum insulation panels in the Yukon.*

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# Intelligent Building Operations

## *Pollutant Transfer from Attached Garages*

Pollutants are noticeably higher in homes with attached garages compared to homes where the garage is a separate structure. The reasons for the pollutant transfer from the garage into living spaces might be multi-factorial, for example: poor airtightness design, neglecting quality assurance procedures during building and retrofitting, or occupant behaviour such as disabling self-closing doors or operating gas-powered equipment inside attached garages.

To provide healthier indoor environments, NRC Construction has initiated and completed several activities to understand the situation and provide better solutions for minimizing pollutant transfer to acceptable levels.

A review of the National Model Codes (from the first edition in 1941 through to the 2010 version) was undertaken. The code review identified that the provisions affecting attached garages have not changed significantly since 1995, when the requirement to seal joints in the air barrier system was introduced.

A survey of home builders was completed in 2012. The survey of current building practices revealed that the most common type of attached garage constructed shared a wall with the home (i.e., no room above) and was sized for two cars.

To enable full-scale experiments, a two-car garage was attached to the existing Indoor Air Research Laboratory (IARL), separated by a common wall. The new enhanced structure will be used to assess the efficacy of two selected technological solutions: (i) exhaust ventilation in the garage itself, and (ii) pressure control between the garage and home. The effectiveness of these technical solutions will be verified by the use of tracer gases in 2013.

Finally, NRC will also evaluate in field trials the pre-tested technical solutions developed in NRC's full-scale test facility. The existing concentrations and types of pollutants will be measured in 36 homes with attached garages and the impact of interventions designed to reduce the transfer of pollutants into the living space will be assessed. These interventions include the installation of exhaust fans in the attached garage and improving the airtightness of the common wall between the garage and the dwelling. Occupant behaviour information will also be obtained. Results from this work are expected in fall 2013.

The final outputs of this project should benefit builders and homeowners, while providing valuable information to committees responsible for National Building Code content.

Supplementary details and published papers are available using the search words "attached garages" at www.nrc-cnrc.gc.ca.

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*Attached garage under construction at the Indoor Air Research Laboratory.*

*A view of nature can help ease the stress of everyday life. (Architect: John Donkin. Used with permission: Peter Fritz)*

## *The Physiological and Psychological Effects of Windows, Daylight, and View at Home*

NRC Construction reviewed current knowledge and developed a research agenda concerning the physiological and psychological effects of windows, daylight, and view in residential buildings.

The NRC review identified three broad processes through which residential windows and skylights affect occupants, for good and ill: visual processes, including seeing tasks and space appearance judgments; non-visual ocular processes, including regulation of sleep/wake cycles and daytime mood and alertness; and processes occurring in the skin. There is an extensive research agenda to guide future research, both at NRC and elsewhere.

Conclusions included these points:

- Although a daily pattern of light and dark is most healthful and most efficiently delivered using daylight, uncontrolled daylight can also cause problems: glare from the sun reduces visibility and causes visual and thermal discomfort.
- The optimal pattern of light and dark exposure, as well as the limit at which daylight control is needed, varies by race, age, individual differences, and possibly culture.
- The desire for daylight as the source of the light exposure also depends on how the openings affect the space appearance, on the function of the space, and on cultural norms about privacy, enclosure, and view.
- A view of the outdoors is also a contributor to well-being, particularly if it is a nature scene or similar pleasing sight. Windowless spaces, separating occupants from the outside world, create monotonous conditions that may be stressful.

Effective daylighting and attractive views are part of the architectural quality of residences, and contribute to higher real estate valuations. As the research agenda is accomplished, the knowledge gained will be useful to those undertaking future revisions of building energy codes around the world by providing specific guidance on optimal window size and placement and on daylighting control.

This work was commissioned by VELUX A/S. The complete review is available at: http://dx.doi.org/10.4224/20375039.

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## *Evaluation of Indoor Air Quality Solutions and Technologies (IAQST)*

While technologies claiming to improve indoor air quality (IAQ) abound, their actual performance is often untested and poorly understood. As part of a project developed under the Canadian Government's Clean Air Regulatory Agenda (CARA), the IAQST team conducted a comprehensive review of these technologies with the objective of identifying those in need of refined protocols by which their IAQ impact could be reliably assessed.

In the first phase of the project, three protocols were developed:

1. Initial IAQ Performance of Portable Air Cleaners (PACs)
2. Effectiveness of Duct Cleaning in Commercial Office Buildings
3. IAQ Impact of Heat and Energy Recovery Ventilators

In the second phase of the project, three additional technologies have been selected for evaluation protocol development:

4. IAQ Impact of Indoor Passive Panel Technologies (IPPT)
5. Long-term Performance of Portable Air Cleaning Devices
6. IAQ Impact of In-duct Air Cleaning Devices

This research will lead to the development of validated test methods to assist manufacturers with product design and development and labeling systems that can be used by consumers to make informed purchasing decisions.

**Portable Air Cleaners:**

http://archive.nrc-cnrc.gc.ca/obj/irc/doc/pubs/rr/rr311.pdf
http://archive.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc54013.pdf

**HRV and ERV:**

http://archive.nrc-cnrc.gc.ca/eng/facilities/irc/indoor-air-lab.html

**More reports and related papers are available at:**

http://archive.nrc-cnrc.gc.ca/eng/projects/irc/air-initiative/iaq-solutions.html

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*An air duct after cleaning.*

## Chemical Emissions from Building Materials

Chemical compounds are emitted from many construction materials. Previous work at NRC Construction identified 90 chemicals, including health-relevant ones such as formaldehyde, which have maximum concentrations specified in Health Canada guidelines for residential buildings. The findings of this work were embodied in the IA-Quest decision support tool (http://archive.nrc-cnrc.gc.ca/eng/projects/irc/simulation.html) which contains a database developed from all NRC-tested products and the ability to predict the emissions over time for different building constructions and ventilation schedules.

The scope of IA-Quest is being expanded. Additional building materials are being tested and new compounds detected. There is a need to address evaporative sources (e.g., stored gasoline) and consumer products (e.g., cleaning products, glues) to better capture the full range of emission sources in Canadian homes. In addition, improved detection techniques are enabling additional health relevant chemicals to be detected (e.g., acrolein, phthalates and flame retardants). NRC Construction also tests specific materials for manufacturers or builders.

IA-Quest has been is being upgraded as new data is developed. It is currently being tested and is due for release in 2013.

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## Resistance of Building Materials to Mould Infestation

*Researchers are evaluating the effectiveness of treating building materials to prevent mould growth.*

Mould growth can occur on materials used in construction of the building envelope (i.e., wall cavities) as well as on interior surfaces within the living space (e.g., bathroom walls/window trim) with potential health consequences for occupants and durability of the building envelope. Environmental conditions in indoor environments change on a daily/seasonal basis. This can lead to mould growth, when temperature and humidity conditions are favourable.

Work at NRC Construction continues in developing laboratory-scale systems capable of simulating the dynamic environmental conditions found in Canadian homes and establishing boundary conditions for mould growth. This effort is supported by advanced computer modelling to understand how properties of common building materials contribute to mould growth. Modelling will reveal how building materials respond to non-steady state temperature and humidity conditions. The modelling results will then be used to develop realistic environmental testing conditions suitable for evaluating the effectiveness of building material treatments aimed at preventing mould growth.

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## *Radon Mitigation*

Radon is present in almost all homes in Canada. Health Canada estimates that 7% of homes are above the national guideline and that radon accounts for approximately 3000 lung cancer deaths each year. Due to peculiarities of ground geology, it is not possible to predict which homes will be above the national guideline prior to construction, and the test takes three months to complete – a task left to homeowners. The 2010 National Building Code requires homes to be 'radon ready' so that active sub-soil mitigation systems can be more easily installed should there be a positive test.

The effectiveness of active sub-soil depressurization (ASD) is well known and is accepted as the best method to reduce radon concentrations in homes. However, there are several issues of concern. Two of these issues are being evaluated at the Indoor Air Research Laboratory (http://www.nrc-cnrc.gc.ca/eng/solutions/facilities/indoor_environment.html) and the Canadian Centre for Housing Technology (CCHT): (http://www.ccht-cctr.gc.ca)

1) In Canada, the exhaust from the ASD system is typically located at ground level and there is a risk of re-entrainment into the home or transfer to a neighbouring home – clearly outcomes that should be avoided. Tests to date have shown that there is a possibility of re-entrainment. Experiments during winter 2012/13 will establish if the existing guidelines should be updated.

2) The cost of running an ASD system is currently being evaluated in the CCHT. This testing will capture both the direct cost of running the system and its effect on the overall building's energy consumption. For example, the ASD system could potentially contribute to a lowering of the ground temperature or increased ventilation in a home due to the removal of air from below the basement slab.

The final outputs of this project are expected to be useful for builders, homeowners, and committees responsible for National Building Code content.

Supplementary details and published papers are available using the search word "Radon" at: www.nrc-cnrc.gc.ca.

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*Active sub-slab depressurization ductwork and radon monitor.*

*A smart meter used at the Canadian Centre for Housing Technology.*

## *Developing and Demonstrating Zero-Peak Houses*

This project, completed in spring 2012, was designed to explore ways to dramatically reduce household electricity use during periods when utility-wide electricity use is at its highest.

A review of recent utility pilot projects showed critical peak pricing (temporary but substantial elevation of electricity prices during a few key hours on a few days), with enabling technology to automatically curtail loads, could reduce peak demand by 30% without occupant hardship.

Analysis of smart meter data from several hundred dwellings in southern Ontario showed that the Peaksaver® program (cycling the air conditioner during a few key hours on a few days) reduced average peak loads by 10-35%. Further, it was shown how whole-house smart meter data could be analyzed to identify houses with particularly high base loads or appliance loads, and particularly high electricity use in the heating or cooling season. Such information could help utilities better target peak demand and energy conservation programs.

Finally, simulation was used to study a range of house design and operation strategies to reduce on-peak electricity use, and then the most promising ones were tested at full-scale at the Canadian Centre for Housing Technology. Results demonstrated that a combination of practical operational modifications (such as air-conditioner cycling and doing laundry later in the evening) and commercially available technology (exterior shading, modest PV array, energy-efficient lighting) dramatically reduced the peak electrical demand from the grid on the hottest days of the year.

For details, see: http://archive.nrc-cnrc.gc.ca/eng/projects/irc/zero-peak.html

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## *Tubular Daylighting Devices*

NRC Construction researchers have completed a project to develop methods to compute the lighting and thermal performance of tubular daylighting devices (TDDs). TDDs are an alternative to conventional skylights, delivering daylight without the unwanted solar heat gain. They admit light to areas not usually covered by windows and skylights. This research was undertaken because manufacturers need reliable and accurate calculation methods and design tools (i) to predict the energy performance of TDD products when installed, (ii) to show compliance with building energy codes, and (iii) to rate existing and/or innovative TDDs.

*Tubular daylighting devices provide daylight without the solar heat gain.*

Project researchers have developed and validated simplified algorithms to compute the performance indicators of residential and commercial TDDs as follows:

- optical (light transmission and radiation absorption);
- lighting (lumen output, light diffusion, and intensity/luminance distribution); and
- thermal (U-factor and solar heat gain coefficient).

The optical and thermal models of TDDs are sufficiently accurate to address the various geometrical and optical complexities of TDD products. Therefore, it is recommended manufacturers use the models to develop TDD product ratings instead of using costly measurement procedures. Implementation of the models in fenestration design tools will help simulators, lighting designers, and practitioners to design site-specific and energy efficient TDD products for installation in given building types.

This project was jointly funded by the American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). Full project reports are available from ASHRAE. Several technical papers are also available from the HVAC&R Journal.

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*Fire testing in a living room set-up.*

# Fire Safety

## *Characteristics of Fires in Multi-suite Residential Dwellings*

Determining the characteristics of residential fires and typical combustible furnishings, then eventually portraying them as design fires (simulation fires increasingly used to solve fire-safety problems), was the goal of a collaborative project with industry and municipal partners. Started in 2006 and completed in 2012, the project focused on fires that can occur in apartments, semi-detached houses, duplexes, row houses, secondary suites, and residential care facilities, as these have a potentially greater impact on adjacent suites.

The research approach utilized literature reviews, surveys (to determine typical configurations and combustibles), computer simulations, and full-scale fire experiments. In the survey, typical furnishings that constituted a significant portion of the movable fire load were identified, and values of fire load densities were calculated for rooms such as kitchens, dining rooms, living rooms and bedrooms. Although kitchens had the highest fire load density, the actual fire load (heat content) was found to be lower than that for bedrooms, which had higher values due to the presence of mattresses, clothing and carpeting.

The results showed that fire development and severity vary within a residential building due to variation in fuel load characteristics, ventilation, and geometric dimensions of various living spaces within a dwelling. For example, flashover, a phenomenon that results in a fire becoming a conflagration, generally occurred in approximately five minutes. It occurred in as little as 140 seconds in fires started with a strong flame in highly combustible furnishings, such as sofas and beds. Following flashover, the potential for a fire to cause damage and fatalities in adjacent rooms and suites is greatly increased. Temperatures as high as 1200 °C, occurring shortly after flashover and lasting for up to 30 minutes, were recorded.

One of the main conclusions was that regardless of test variables (i.e., ventilation, fuel load, ignition method and room size), the maximum average peak temperatures fall within a narrow range of between 1150 °C to 1200 °C. However, test variables—particularly ventilation, first-ignited item, and composition of the fuel load—have a significant effect on the time of attainment of the peak temperature. The peak temperature and its duration are key measures of fire severity.

Another main conclusion was that primary bedrooms resulted in the most severe fire conditions since they contained the greatest amount of combustible materials.

Researchers completed a detailed analysis of the results and identified features of the fires to form the basis of a computation model. Designers and code authorities can draw on this comprehensive set of data to get a better understanding of the impact of fires on various aspects of a dwelling. The results provide quantitative information on combustible contents in residential dwellings, rates of fire growth, and duration of the intense period of a fire.

Commonly available calculation methods for determining variables such as time to flashover, maximum heat release rate supported by a given window size, peak temperature, and fire duration, were evaluated against the test data, and recommendations were provided where improvements were needed.

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## *Research for Wood Use in Mid-rise Buildings*

NRC is working in collaboration with the Canadian Wood Council and FPInnovations, and in partnership with Natural Resources Canada and the governments of Ontario, Quebec and British Columbia, to develop technical data to facilitate the use of wood-based structural products in mid-rise buildings. The research has focused on developing technical solutions to meet building code objectives in key areas of performance, including structural integrity, fire safety, acoustics, and building envelope performance. The current phase of experimental work is expected to be completed by summer 2013. The results will be passed to the Canadian Commission on Building and Fire Codes for use in the code development process, and to practitioners for use in design standards and design guides.

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## *Canadian Firefighting Research*

Fire services from across Canada are working with NRC to keep communities safe from fire. To improve their safety and effectiveness in facing challenging fires, firefighters constantly need new knowledge and technology. Recent projects have improved tactics for fighting fires in roofs, developed best practices for the use of foam-water firefighting systems, and evaluated technology to track firefighters as they move through burning buildings. NRC will continue to work with fire services to identify key issues, plan research projects to develop innovative solutions, and transfer knowledge and best practices to the Canadian firefighting community.

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*NRC researchers work with fire services across the country to identify key issues in firefighting.*

# Canadian Centre for Housing Technology Activities

*The Canadian Centre for Housing Technology InfoCentre is located on the NRC campus.*

*CCHT features twin research houses to evaluate whole-house performance of new technologies in side-by-side assessment.*

The Canadian Centre for Housing Technology (CCHT) is a partnership between the National Research Council of Canada, Natural Resources Canada (NRCan), and Canada Mortgage and Housing Corporation (CMHC). CCHT (http://www.ccht-cctr.gc.ca) features a twin R-2000 house facility. A third building, the InfoCentre, includes a display area and an office space. It also contains the FlexHouse™ – a townhouse designed to adapt to an occupant's changing needs. Since 1999, CCHT researchers have assessed over 50 housing-related technologies, ranging from compact fluorescent light bulbs and high-performance windows to natural gas-fired engines and combined heat and power systems.

## *Projects Undertaken During 2012*

Highlights of CCHT projects advanced or undertaken during 2012 include:

- **Roof-Integrated Photovoltaics (PV).** In fall 2011, CCHT installed a roof-integrated photovoltaic system on the InfoCentre roof to monitor energy production, heat and moisture performance and other integration issues. The 2 kW PV system, assessed from October 2011 to September 2012, produced over 2 MWh of electricity during that year. Shading and snow cover effects were also monitored and a report is currently being prepared. This effort was part of a larger project funded by the Clean Energy Fund, NRC and NRCan. (See the Building Envelope and Materials section for details.)

- **Air-Source Heat Pump Water Heaters (ASHP-DHW).** ASHP-DHW systems heat water using energy taken from the air surrounding the equipment. This can be beneficial in southern U.S. climates but may not be as beneficial in the more northerly Canadian climate. The purpose of this project was to evaluate the performance of these systems at the CCHT twin house facility and their impact on whole-house energy consumption, including space heating and cooling loads. Evaluation took place in the 2011-2012 heating season, and the 2012 cooling season. A final report is planned for early 2013. This project is being lead by NRCan, with funding from the ecoENERGY Innovation Initiative (ecoEII) and the Office of Energy Efficiency (OEE).

- **FlexHouse™ renovation.** In addition to the upgraded appliances and lighting required for the Smart Power System Project (described in the next paragraph), the FlexHouse™ unit will also undergo interior renovations to update the finishes and improve some accessibility features in early 2013. This renovation is being funded by CMHC.

- **Smart Power System with Advanced Energy Storage.** This project, which began in 2011 with funding from the Clean Energy Fund (CEF), explores the integration issues of energy power systems including power generation, storage, and management. In 2012, the project received additional support from Program of Energy Research and Development (PERD) to continue research for the next four years. As part of this effort, modifications to the CCHT FlexHouse™ are well underway. The FlexHouse™ is now currently equipped with a z-wave system capable of simulating a variety of realistic occupant-driven lighting loads, and work has begun to automate the appliances by early 2013. An energy management and battery system has been installed, and there are plans in progress to connect the 2 kW roof-integrated photovoltaic system. Efforts in 2013 will examine the possibility of taking the FlexHouse™ unit completely off-grid, using the energy management system to orchestrate the operation of the various technologies that were installed. Other partners in this project include NRC, NRCan, DRDC, and Electrovaya Inc.

- **Modulating Geo Heat Pump.** One CCHT twin house was retrofit with a modern, variable capacity ground source heat pump that can emulate the performance of a variety of commercially available designs, including full output, two or more output levels, and full variable operation. The heat pumps can make use of up to three existing vertical ground wells at the facility. The energy performance of the heat pump was compared to a high-efficiency condensing gas furnace during the 2011-2012 heating season, and to a mid-range efficiency air conditioner in the 2012 cooling season. This project, funded by NRCan, CMHC and ecoEII, is at the reporting stage.

- **Mini-split Heat Pumps.** NRCan lead a project to verify modelling predictions that a mini-split, zoned-heating system has the potential to produce energy savings—when compared to a central AC (cooling) and condensing-gas furnace (heating) system—without any loss of occupant comfort. A side-by-side comparison was conducted in cooling, shoulder, and heating season conditions. The results to date are promising; report writing is underway. Funding for this project is provided by: the ecoENERGY Innovation Initiative (ecoEII), the Program of Energy Research and Development (PERD) and the Office of Energy Efficiency (OEE).

- **Evaluating Radon Mitigation Strategies.** As part of this multi-year project, designed to develop technical documents for Health Canada on the performance of existing radon remediation strategies, a sub-slab depressurization fan was installed in the CCHT Test House. Researchers are examining its impact on home energy consumption for heating, and the risk of cross contamination between adjacent houses caused by radon discharge at ground level or at roof level. Winter testing is expected to be complete in February 2013. Funding for this project is provided by Health Canada. (See the Intelligent Building Operations Section for more details.)

*Mini-split heat pumps have the potential to produce home energy savings.*

*A cold climate air-source heat pump was tested against a traditional air conditioning system at CCHT.*

- **Cold Climate Air-Source Heat Pump.** Researchers are in the process of evaluating a central air-source heat pump designed specifically for use in cold climate applications. In summer 2012, this heat pump was compared to a traditional central air conditioning system with a rating of SEER 13. (The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is.) This winter, the same heat pump will be compared to a standard condensing gas furnace (94% measured efficiency). Researchers are specifically interested in how the heat pump performs in very cold weather, and how much energy the backup heat source uses in very cold conditions. Funding for this project is provided by NRCan and CMHC.

For more information on CCHT, consult the website at http://www.ccht-cctr.gc.ca.

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# Development of the National Model Construction Codes

In late 2012, the Canadian Commission on Building and Fire Codes (CCBFC) released the first series of revisions and errata to the 2010 National Model Construction Codes, the National Energy Code of Canada for Buildings 2011 and the User's Guide – NBC 2010, Structural Commentaries (Part 4 of Division B). The revisions to the National Building Code of Canada 2010 (NBC) included the addition of energy efficiency requirements for housing and small buildings to Part 9, and an erratum that clarifies the relationship between Part 6 and Part 9 ventilation requirements. Also published in 2012 were intent statements for the NBC, as well as the National Fire Code of Canada 2010 and the National Plumbing Code of Canada 2010.

The fall 2012 public review to the National Model Construction Codes included a few proposed changes with implications for Part 9 – Housing and Small Buildings. The Part 9 committee will review public comments on these changes in spring 2013, and process the changes for publication in the 2015 edition of the NBC. In addition, there remain several specific subject areas for which the Part 9 committee continues to develop proposed changes. The following highlights describe progress on some of this work.

## *Airborne Sound Transmission*

The CCBFC Joint Task Group on Airborne Sound Transmission is considering the use of a new rating to address airborne sound transmission between dwelling units. The proposal is to replace the currently referenced rating, which only addresses sound transmitted through the wall or floor separating adjacent dwelling units, with a rating that reflects the acoustical performance of the complete building system (Apparent Sound Transmission Class or ASTC). The ASTC is a truer measure of the actual sound level perceived by occupants, as it includes noise transmitted through wall, ceiling and floor junctions (i.e., flanking noise). The Task Group also proposes setting the minimum ASTC design requirement at 47 for the complete system, which is roughly equivalent to the current minimum requirements.

*The Flanking Sound Transmission Facility is used for characterizing flanking sound transmission paths using an automated measurement system.*

Compliance with these proposed requirements would be demonstrated using one of two options in Parts 5 and 9 of the NBC: first, either measuring the ASTC directly or looking up acceptable constructions in provided tables, or second, using a new, third calculation option to be added to Part 5. To support the use of this calculation method, the acoustics group at NRC Construction is working with construction industry partners to develop an explanatory design guide and conduct research to obtain the required product data. A draft design guide is expected to be completed by March 2013, with proposed changes likely ready for public review in fall 2013.

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## Exterior Insulation and Finish Systems

Currently, there are no specific requirements in the NBC for exterior insulation and finish systems (EIFS). They are, however, addressed in Parts 5 and 9 of the NBC through general requirements related to heat transfer, air leakage, and precipitation protection. A joint task group of the Standing Committees on Environmental Separation (SCES), on Housing and Small Buildings (SCHSB), and on Energy Efficiency in Buildings (SCEEB), was established in 2011 to review these requirements and determine whether it would be appropriate to reference three Underwriters' Laboratories of Canada (ULC) standards dealing with EIFS materials, installation and design.

The Task Group has completed its review of the three ULC standards and is proposing to reference them in Part 9 of the NBC. This proposal was accepted by the SCHSB in November 2012, and a final review and discussion by the committee on referencing the EIFS standards is expected in spring 2013. Discussions at the Task Group and Standing Committee level continue on how best to deal with EIFS in Part 5.

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## National Farm Building Code

*Updating the requirements of the National Farm Building Code of Canada was made a priority in 2012.*

The CCBFC has made it a priority to update the requirements of the National Farm Building Code of Canada (NFBC), last published in 1995. This decision is supported by the Provincial/Territorial Policy Advisory Committee on Codes (PTPACC) and the Canadian Farm Builders' Association.

A joint CCBFC/PTPACC Task Group reviewed the key issues associated with the changing nature and scale of farm building operations and submitted a report of its recommendations to the CCBFC's annual meeting in June 2012. The report recommended splitting requirements between small and large farm buildings, with "small" being defined as having less than 600 square metres of building area and not more than three storeys. It advocated the creation of a separate occupancy classification for farm buildings, with sub-categories based on suggested criteria.

No new objectives were proposed, as the general ones in the Codes remained appropriate and could be linked to updated farm building requirements. As for development of technical requirements, it was recommended that given their multidisciplinary nature, a coordinating committee be established to oversee the work. Members would be selected from the CCBFC's standing committees based on their expertise. Lastly, the Joint Task Group recommended developing a flexible approach for farm building regulation that would enable the provinces and territories to easily opt out of adopting the requirements, should they so choose.

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## Grab Bars

A joint task group of the Standing Committee on Use and Egress and the Standing Committee on Housing and Small Buildings has been established to discuss potential Code solutions for requiring grab bars in tubs and showers in dwelling units to reduce falls and related injuries, especially among seniors. The Task Group will review constructability and cost data related to grab bars as well as fall incident statistics. It will also review and compare the costs and benefits for a number of potential solutions and make a final recommendation to the parent Standing Committees in spring 2013.

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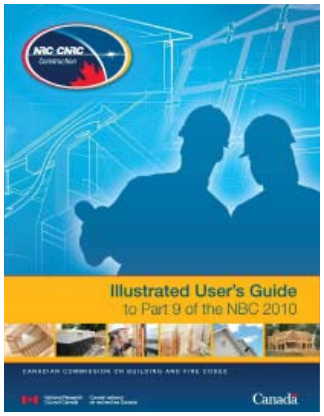
## Illustrated User's Guide to Part 9 of the NBC 2010

A CCBFC Task Group established to oversee production of an Illustrated User's Guide to Part 9 of the NBC 2010 has completed its mandate. The monumental task of producing the guide involved combining two earlier publications, the National Housing Code of Canada 1998 and Illustrated Guide and the User's Guide – NBC 1995 Housing and Small Buildings (Part 9), into one document, then remapping the content to match the format used in Part 9 of the NBC 2010. Duplicate text and illustrations were removed, mistakes corrected, style made more consistent, and information on objective-based codes added. The information was then updated to 2005 and 2010 code levels and supplemented with new material on the recently published energy efficiency requirements for housing and small buildings.




*The Illustrated User's Guide to Part 9 of the NBC 2010 will be published in spring 2013.*

The user guide will be a compendium document to Part 9 that provides guidance for each of the Part 9 articles. It will explain the intentions and reasons behind the requirements, describe various approaches for their application, and illustrate important principles of minimum accepted practice. Relevant code information will be cross-referenced and sources of statistics will be provided. Note, however, that it will not be a how-to guide on home construction nor, with the exception of some appendix information, will it duplicate the information found in Part 9.

Finalization of the guide, which will have the same scope, application and structure as Part 9, is expected to be completed in February 2013, with publication planned for mid-2013. At nearly 600 pages, it will be available for purchase as a soft-cover book as well as via online subscription or downloadable PDF.

In the future, the guide will be updated at the same time as the NBC. Plans for the next edition include improving its internal consistency as well as the technical quality of the drawings and text, adding more illustrations and eliminating the overlap with existing appendix information.

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*Solar collectors and their impact on the rest of the building are being addressed.*

## Solar Collectors

The CCBFC is looking at solar collectors, their impact on the rest of the building, and how best to treat them in the National Model Construction Codes. The intent is not to require such collectors, but to provide for their safe installation when specified by building designers. The task was originally assigned to the Task Group on Climatic Loads to determine their impact on building loads, but the Task Group members quickly determined that there were more far-reaching issues involved as all aspects of the building, and several Parts of the Codes, would be affected. They recommended that a coordinating committee be formed to oversee the work and report back to all those involved. The CCBFC approved the recommendation.

In the proposed model, the coordinating committee will be comprised of representatives from standing committees who wish to participate (likely the Standing Committees on Structural Design, Environmental Separation, Building and Plumbing Services, Housing and Small Buildings, Fire Protection, and Energy Efficiency in Buildings). Each of the Standing Committees involved will first work independently on the specific issues relating to their areas of expertise then feed the results to the coordinating committee, which will ensure that all issues are addressed and no adverse consequences are introduced in other areas of the building's performance.

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## Roofing, Dampproofing and Waterproofing Standards

In 2012, a Joint Task Group of the CCBFC Standing Committee on Environmental Separation and the Standing Committee on Housing and Small Buildings (SCHSB) reviewed the NBC 2010's currently referenced Canadian General Standards Board (CGSB) standards related to roofing, dampproofing and waterproofing, as they are outdated and no longer maintained.

Following consultations with provincial and municipal regulators and the construction industry, the Joint Task Group is proposing to delete the installation standards for dampproofing and waterproofing in Part 9 entirely and replace the CGSB material standards with ASTM standards for those materials. No new requirements are proposed. The recommendations were accepted by the SCHSB in November 2012 and are expected to be submitted for public review in fall 2013.

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## Stairs, Ramps, Handrails and Guards

Several new and outstanding issues related to NBC requirements for stairs, ramps, handrails and guards prompted the CCBFC to establish a Joint Task Group under the direction of the Standing Committee on Housing and Small Buildings and the Standing Committee on Use and Egress.

The Joint Task Group on Stairs, Ramps, Handrails and Guards is working on resolving inconsistencies between Parts 3 and 9 of the NBC, as well as terminology use, and on permitting more design choices for stairs while ensuring the safety of occupants who use them. Three sub-task groups have been set up to deal with:

- Issues related to handrail and guard requirements, including a revisit of climbable guard requirements;
- Exit stair width in public buildings and inconsistencies in measuring ramp width in Parts 3 and 9 of the NBC; and
- Stair configurations in dwelling units to determine if the range permitted could be expanded (only straight runs with one winder or curved flights are currently allowed).

Approximately 30 proposed changes were developed, most of which have been accepted by the responsible parent Standing Committee. These changes are expected to be submitted for public review in fall 2013.

The CCBFC has also established a Joint Task Group on Step Dimensions to examine current tread and riser dimensions inside dwelling units in response to a code change request recommending that they be changed to reduce the incidence of falls and injuries. This Joint Task Group is examining data on incidence and cause of falls on stairs related to step geometry as well as design and cost implications of riser and tread dimensional changes. A final report will be prepared, with input from each of the parent Standing Committees, and submitted to the CCBFC Executive Committee in spring 2013 to determine if changing these dimensions is justified.

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## Log Home Construction

The energy efficiency requirements for housing and small buildings in the NBC 2010 revisions include changes that affect log home construction. These provisions are the outcome of discussions with the log home construction industry aimed at ensuring that their products would not be eliminated when the energy efficiency requirements were implemented. One result is that the NBC's lumber material data and calculation methods for log walls are now consistent with those used by the log home industry in Canada and the United States.

The changes include a reference to an International Code Council standard, ICC 400 "Design and Construction of Log Structures", that provides a method (cont. next page)

*Energy efficiency requirements for housing and small buildings include new provisions for log home construction.*

for calculating the thermal resistance of any log shape or wood type. This method is consistent with the one used by Natural Resources Canada's ENERGY STAR® for New Homes Initiative.

The new provisions consider log walls to be an air barrier system, since the air permeance of solid lumber is negligible, but as such they need to comply with prescriptive requirements for airtightness. The low vapour permeance of thick solid lumber also makes them a vapour barrier.

Finally, the CCBFC committees developing the changes made all efforts to ensure that log homes can comply with most requirements in the prescriptive path, with the result that some log types (e.g., large diameter rectangular logs or hybrid (insulated) log walls) meet all of the requirements. Wall constructions using thinner or round logs having a lower thermal resistance, need to make up the difference in required RSI-values for the above-grade assemblies by installing additional attic insulation. Another option for log homes to comply with the energy efficiency requirements would be to use the performance path option, which models the energy use of the entire log building and offers greater flexibility.

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## *Water-Use Efficiency*

*Requirements for water-use retention products, such as low flow toilets, are being developed.*

The CCBFC is making progress on adding water-use efficiency to the NBC and the National Plumbing Code. The Joint CCBFC/PTPACC Task Group on Water-Use Efficiency Objective developed a new objective and is currently preparing functional statements. The CCBFC also expanded the mandate of this Joint Task Group to include recommendations on the proposed scope of the technical requirements, which will be developed by the Standing Committee on Building and Plumbing Services.

The Joint Task Group recommended that the proposed water-use efficiency objective address "excessive use of water" under the umbrella of the environment objective created in 2011, and that technical requirements apply only to water used by the building (all types of buildings – large and small) and its code-required systems. Water used by processes, such as manufacturing, or by appliances not regulated by the codes (e.g., dishwashers and clothes washers) would not be affected. The Joint Task Group also envisioned a gradual development of technical requirements, with mandatory requirements for water-use reduction products (such as low flush toilets), components or systems in all buildings, regardless of the water source, being developed first. The development of enabling provisions will be dealt with later, such as for the use of voluntary products, components or systems using grey water or harvested rainwater.

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