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CanmetENERGY

Leadership in ecoInnovation

FALL 2009

R&D ENERGY TECHNOLOGY HIGHLIGHTS for RESIDENTIAL HOUSING

GENERAL INFORMATION

LEEP® LOCAL ENERGY EFFICIENCY PARTNERSHIPS

Builders are the key to being able to increase the speed at which early products are adopted in their marketplace. CanmetENERGY's LEEP™ builder-driven methodology brings together local Home Builder Associations to learn about, and decide, which new technologies will be most beneficial in their local markets.

HOUSING ENVELOPE AND WINDOWS

for Low-rise Residential Buildings: An overview of CanmetENERGY's current research activities that are focussed on achieving more than 40% improvement in thermal performance while ensuring durability of all envelope components.

SOFTWARE

HOT3000:

This new energy analysis tool is being released this Fall to help Canada's residential construction industry advance the design of energy efficient and net-zero energy homes.

SPECIFIC TECHNOLOGIES

FORCED AIR ZONE SYSTEMS:

CanmetENERGY's research to assist Canada's HVAC industry in making a reasonable business case for improved distribution approaches, that will help reduce peak residential air-conditioning electrical loads and improve the comfort of homes.

SOLAR PHOTOVOLTAIC THERMAL PV/T:

Analysis of the performance of real systems in a real world demonstration and the review aspects of PV/T characterization of open loop air collectors.

LIGHTING and CONTROL STRATEGIES:

An overview of some of the latest research findings in lighting controls.

INTEGRATED ENERGY SYSTEMS

Brushless (ECM) Motors; Hot Water Usage Field Study; and Micro-cogeneration.

LEEP™

LOCAL ENERGY EFFICIENCY PARTNERSHIP PROJECT

CanmetENERGY was interested in developing a builder-driven model for bringing new energy efficient and renewable technologies to market. This led to the creation of a partnership with the City of London who managed the initial LEEP™ project based upon advice by the London HBA. The facilitated LEEP™ process took place during the winter of 2006/2007. The builders found the materials on the various technologies useful however, it was the process of working together to direct the inquiry into these technologies that proved to be of the greatest benefit to them. The basis of the process was to:

1. Review a wide range of emerging energy related technologies according to the criteria the builders set
2. Determine which ones were of most interest to the group and to their particular company, and
3. Have technology experts make presentations in response to builder raised questions and issues on the technologies of most interest.

Builders are the key to being able to increase the speed at which early products are adopted in the marketplace. They live in a buffer zone between the end customer and the myriad of suppliers that would all like their products to go into the homes that the builders produce. Builders put thousands of components together and while many builders would like to try new products, they add risk of call backs, schedule slowdowns, and warranty problems. To try new products, builders need support from initiatives that put their interests first. They need to know the important facts and potential issues related to a product before making a decision to use it in their homes.

- LEEP enables builders to work together to understand the pros and cons of the different innovative technologies, and use a structured process to find the ones that are most appropriate, to their building sites.
- LEEP is the first phase in an integrated builder engagement model designed to help builders incorporate new and innovative technologies into their building practices. thus
- LEEP is a first step in helping home builders speed the pace of innovation in their industry.

The LEEP™ team is working to streamline and extend the process and recognizes the need to integrate evaluation mechanisms to track technological uptake, resulting from the LEEP™ process. The next stage will be to carry out the LEEP™ process with a few HBAs in Ontario, and pilot chosen technologies among a select group of early adopters. This will assist in constructing the support mechanisms necessary to move candidate technologies toward broader adoption among builders.

Finally, LEEP™ and the technology pilot is intended to integrate with the Building Canada® program, that engages the largest and most influential production builders in Canada, to adopt energy efficient building technologies and practices. The continuum of LEEP, the Technology Adoption Pilot (TAP) and Building Canada® form a technology adoption model for the Canadian housing market to achieve broad based market transformation.

This project is also designed to provide feedback to technology researchers that can inform their thinking on questions such as the following:

- What technologies are builders most interested in and why?
- Where can technology facilitation resources be used most effectively?
- What are the technical barriers preventing a particular renewable or energy efficient technology from being accepted in the marketplace?
- What are the best applications for different classes of new technologies?

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HOUSING ENVELOPE AND WINDOWS FOR LOW-RISE RESIDENTIAL BUILDINGS

If we are to reach the EnerGuide Rating System, ERS 80 benchmark, currently the R-2000 for low-rise housing, by 2012, we have to reduce the average annual heat losses of 80 to 130 gigajoules(GJ). These averages are climate zone dependant but this means that there needs to be a cost-effective energy strategy in place that will assist each household to reduce their heat losses by 50 to 60%, or 40 to 70 GJ.

A large percentage of the current housing and buildings markets are still only using minimum Code requirements for envelope systems, in spite of demonstrated technical feasibility of highly performing envelopes. It has been well understood that a number of barriers exist to large-scale adoption of high performance envelopes. These include thickness, especially of walls that decrease liveable floor space and the cost premiums that are associated with additional labour and materials.

We know that once we have obtained low heat losses, this will expand the opportunities to effectively introduce renewable energy systems. Technologies that will play a key role to further energy effective strategies will be:

- High-R envelope insulation;
- High-R and high-solar-gain windows; and
- Cost-effective high performance foundation wall systems.

Current research and demonstration activities are targeted to:

1. Advance the development of next generation building envelope systems with 50% better thermal and energy performance; and
2. Conduct field evaluations of innovative technologies in new and existing houses and buildings.

CanmetENERGY partners with the Institute for Research in Construction of National Research Council (NRC-IRC), Canada Mortgage and Housing Corporation (CMHC), Public Works and Government Services Canada (PWGSC) and external industry clients and leading-edge builders.

The projects include the development of specifications for:

- Above and below-grade wall assemblies suitable for net-zero energy new and existing housing;
- Net-zero or positive energy flow windows;
- Innovative insulation materials;
- Design and construction of prototype wall assembles with super insulation products; and
- Life-cycle energy use assessments of insulation products.

Highlights of current CanmetENERGY projects:

- Developing, validating and prototyping energy efficient and durable wall assemblies and windows, for near and net-zero housing and building applications.
- Evaluating the potential for windows that combine high solar gains with lower heat loss factors for enhanced house energy performance.
- Assessing performance of selected, advanced thermal insulation materials and construction of building components. Collection of data for cradle to grave energy analysis will also be done during this period.
- Participating with CMHC and NRC, to develop field test procedures and assessment methods for thermal storage in insulated-concrete form wall assemblies.
- CanmetENERGY serves as the technical authority for OEE's Housing Division's window, envelope systems and 'house-as-a-system applications', for the best-in-class programs such as ecoENERGY Retrofits – Homes, R2000, ENERGY STAR for Homes and EnerGuide Rating System and to the ENERGY STAR program for Windows

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HOT3000 SOFTWARE

CanmetENERGY developed the HOT3000 energy analysis software tool to advance the design of energy efficient and net-zero energy homes in Canada. The latest version is due to be released in October at the ENERGY RETROFITS FOR HOUSES: Affordable Comfort for Canadians, October 28-29 in Toronto.

HOT3000 replaces HOT2000, with new capabilities that will support:

1. the upcoming new energy code (MNECH)
2. the evolving R-2000 standard
3. the evolving ERS (used in the ecoENERGY Retrofit program and several energy codes)

This energy analysis tool provides Canada's residential construction industry with the necessary means to evaluate the energy consumption and energy savings potential at the early design stages of new houses or renovating existing ones. For example, it evaluates hourly energy demands and fuel consumption which are necessary for optimizing energy savings, emission reductions and economic costs associated with advanced passive-solar design, cogeneration, solar-heating and time-of-use rates.

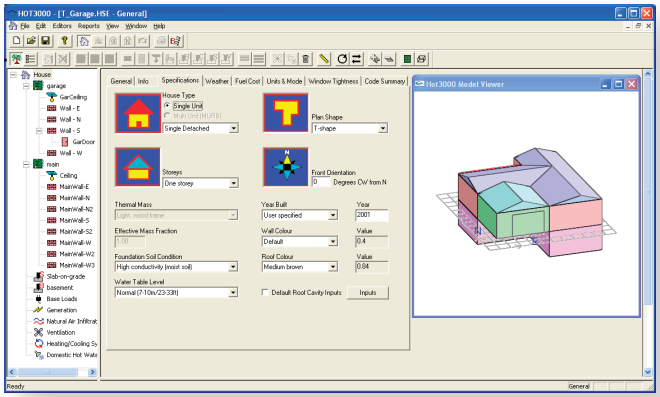
Applications:

- multi-zone house models
- passive and active solar house design analysis
- small time-step analysis

The ESP-r/HOT3000 simulator evolved out of the HOT2000 software in answer to increased simulation engine requirements. Because the engine is based on a small time-step approach, the software is able to model more complex physical house systems and heat transfer processes.

This allows both a broader and finer resolution to the simulation. The software has been developed by Canada's CanmetENERGY in collaboration with the University of Strathclyde and other leading research centres around the world using the state-of-the-art ESP-r energy analysis core.

HOT3000 Version 1.0 features include:



- new house wizard for simple creation of house models
- comprehensive simulation engine
- 3-D graphical view of house model
- ease of HOT2000 inputs with an advanced engine (ESP-r)
- hourly or sub-hourly analysis
- hourly scheduling of heating/cooling
- set-back thermostat simulation
- ground heat losses by frequency-domain model (BASESIMP)
- infiltration modelling
- solar domestic hot water systems
- photovoltaic systems
- thermal mass and passive-solar design
- conventional HVAC systems, including furnace, baseboards, A/C and DHW
- weather data for Canadian and International locations
- customizable HTML reports
- detailed outputs available
- simulation run-time - approximately 1 minute for typical house

For further information, contact
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FORCED AIR ZONE SYSTEMS

Development, Field Trials, Modelling, & Smart Grid Application

Providing comfortable cooling can be challenging. Frigid basements and second floor bedrooms that are too hot for sleeping can both result from leaky ductwork and higher density cooled air dropping through open stairwells. Current trends towards open concept homes that are taller, narrower, and have greater variability in window sizing all make functional cooling design more challenging.

CanmetENERGY wanted to know the impact of using zoning to supply cooled air only to where it is needed. This led to questions such as:

- Could it improve comfort while reducing energy use during summer peaks on the electricity grid?
- How much of the cooling demand is required by the uppermost floor?
- How will homeowners choose to use zoning?
- Can zoning be sold on comfort and still lead to peak shifting? energy savings?
- What approaches reduce the cost premium so that zoning can be installed as a standard feature in tract housing?
- How will homeowners use zoning during the winter time and what will its effect be on the heating bill?
- Can zoning be used to enable utilities to offer customers a new option for peak and off peak energy planning now that SmartMeters are coming?

CanmetENERGY's progress to date includes:

- A standardized 3 zone approach was proposed where the mechanical dampers would be built directly into the air handling product. It was thought that this factory engineered approach had the potential to:
  1. reduce the site cost of installing zoning
  2. enable the heating or cooling source to reduce its output when fewer zones require conditioning. CanmetENERGY carried out a technical risk assessment on this approach.
- A Canadian manufacturer developed the approach into a commerically available zoned air handler and associated small diameter duct system.
- A number of builders have installed these zoned air handling systems in townhomes, singles, and custom homes in Southern and Eastern Ontario. They have also been used in retrofit applications. Units have been installed with various heat generators (condensing and instantaneous water heaters, boilers, and ground source heat pumps).
- A monitored field trial is underway in 22 homes. Analysis of cooling season results will be available in January, and the results from the heating season 6 months thereafter.
- Data from a single previously monitored installation indicated that 80% of the cooling demanded was supplied to 2nd floor bedrooms, 20% of the cooling demanded was supplied to the mainfloor, and no cooling demands were made by the basement zone. The larger field trial sample will provide more definitive results.
- Next summer, a smart grid electric peak shifting pilot will be conducted in the same homes. A similar pilot will occur during the winter to determine natural gas savings.
- A multifloor zoning model is currently being implemented in next generation home energy software (HOT3000) so that peak shifting can be predicted. The model will be calibrated once field results are available.

Successful collaboration is key. On this project, CanmetENERGY has collaborated with many others including: a manufacturer, IRAP, two universities, and some Ontario builders. CanmetENERGY has received funding to carry out or administer this work from PERD, eco-ETI, and TEAM.

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SOLAR

Photovoltaic Thermal PV/T Research Overview

There are 2 aspects to the current research in PV/T systems: the analysis of the performance of real systems in a field study or real world demonstration and the PV/T characterization using the following approach:

- Identification of the main issues with the current testing and characterization methods
- Development of a testing procedure to perform on an open-loop air PV/T collector based on actual standards for testing air collectors and PV panels and PV Catapult PV/T liquid testing method
- Testing of collector according to procedure
- Characterization of PV/T collector tested based on empirical results
- Characterization of other existing PV/T systems from available experimental measurements

Starting with System Performance Analysis, CanmetENERGY looked at the electrical performance of the ÉcoTerra House BIPV/T roof which has 21 Unisolar PV laminates, a nominial power of 2.86 kW and a 30 degree slope. It was selected based on structural considerations.

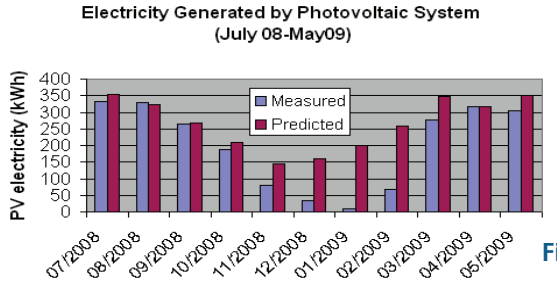


Figure 2

Figure 2 shows the monthly electricity production of the PV/T system, from July 2008 to May 2009 during which the total PV electricity production delivered was 2202 kWh. The team had expected that the production would be approximately 2933 kWh. The difference between the predicted and measured PV electricity is about 25%. The graph shows the amount of electricity produced by the PV in the winter months as considerably lower than that expected due to the snow coverage.

It was determined that 17 of the 25% production losses came from snow coverage due to the 30 degree roof angle and the roughness of the laminates surface. The other 8% losses came from shading in the summer, due to surrounding trees. Nevertheless, the PV system components, including the inverter, had an average efficiency over 95% and appeared to work well. In general, the findings were that the EcoTerra PV system performs well in summer, but will underperform in winter, in regard to roof angle, snow coverage and laminate surface texture.

The system also performed better in the last 12 months compared to the first 6 months. From the whole 2008 year, the system produced 1632kWh and from July 208 to June 2009, so only for 11 months, the system produced approximately 2500kWh. This difference is mainly due to the fact that the system was down for a considerable period of time in 2008. Another aspect of the PV/T research related to characterization, with the objective to:

- Develop simple models to predict the electrical and thermal yield of PV/T systems based on characterization applicable to air collectors and open-loop systems
- Emphasis on testing procedures to estimate the PV cell temperature from measured collector characteristic temperature and thermal resistances

The issue being addressed was the lack of tools to easily get estimates of PV/T yield.

Issues with Current Characterization Method

A characterization method was developed as part of the IEA Task 35 on PV/T systems for closed-loop collectors. The design scheme was based on the modified Hottel-Whillier bliss equation for PV/T collectors. From computer simulations, it was found that by keeping all parameters and inputs constant, except for the incident beam radiation and ambient temperature, the following 3-plot system could be produced.

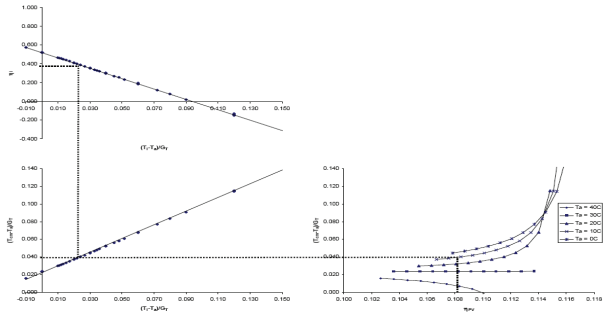
SOLAR

Photovoltaic Thermal PV/T Research Overview

cont'd

One of the method's main drawbacks is that the production of the third plot requires the collector to be tested in a wide range of ambient temperature which is not necessarily easy to do. Another potential problem with that method is the fact that the mean cell temperature is used in the 2nd and 3rd plots. In case of PV/T collectors, neither the PV rear temperature, nor the mean fluid temperature has a one-to-one relation with the true PV cells temperature. Therefore, it would be necessary, in testing conditions, to measure another temperature from which the real PV cell temperature could be calculated. PV Catapult suggested a method where the PV cell temperature is estimated from a characteristic temperature and thermal resistances, but this method needs more experimentation.

Design » scheme: 3 plot system for a closed-loop PV/T collector as suggested by IEA SHC Task 35 group (Collins, M. Recommended Standard for Characterization and Monitoring of PV/Thermal Solar Systems, Report DB2 – IEA SHC Task 35 on PV/Thermal Solar Systems)



***Only Gb and Tamb are varied (only applicable at particular flow rate and Vwind)*

Finally the use of the fluid inlet temperature to represent the thermal efficiency for open-loop collectors does not necessarily make sense since the air is directly drawn from outdoors.

Also, these 3-plots are only applicable for a particular flow rate and wind speed and the thermal efficiency of PV/T collectors is affected by flow rate, and wind has an effect on the thermal yield of unglazed PV/T modules.

So first we identified the main issues with the current testing and characterization methods. Then we developed a testing procedure to perform on an open-loop air PV/T collector based on actual standards for testing air collectors and PV panels and guides developed by PV Catapult on PV/T liquid testing method.

The next steps are to test an open-loop PV/T collector according to this procedure and find out the best way to characterize it based on the empirical results. The method will then be applied to characterize other existing PV/T systems.

The next 6 months of CanmetENERGY's research will contribute towards developing a more appropriate characterization method for open-loop air collectors.

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ENERGY SAVINGS THROUGH OFFICE LIGHTING AND CONTROLS STRATEGIES

Energy performance, application, research, and technology

Recommendations for commissioning of lighting controls to enable components to function at optimal levels and energy savings potential:

1. Each occupancy sensor should be opened, with the timer set to the appropriate time delay. Factory settings are typically at the lowest time; people can sit still for five minutes, but not for 15 or 20 minutes without moving.
2. If there are individual controls over the lighting, it is important to ensure the building control system is programmed to allow the override.
3. Occupancy control should only dim lighting —not turn it off when people are away from their workstations. Continual on/off reduces the efficiency and life of the ballasts and most lamps.
4. While it is fine to integrate controls, there can be danger in integrating too many different types of building level controls systems together. Although they may all be LON or BacNet-compatible, there are numerous issues related to programming, etc (i.e. each control program wants to be the master and overrides the others).
5. The manufacturers and their representatives should be consulted to confirm lamp/ballast compatibility —not all fluorescent ballasts work well with all fluorescent lamps.

Figure 1
Courtesy PWGSC

Lighting makes up approximately 15 per cent of energy costs within a commercial building, but both facility managers and end users continually rate it as one of the most important environmental factors affecting occupant satisfaction. Consequently, the design/construction and real estate industries are striving to ensure lighting balances the variables of energy efficiency, safety, comfort, and well-being. However, the constant change in products, systems, and building designs can complicate things.

This article provides an overview of some of the latest research findings in lighting Control, for commercial buildings. It offers an example of how proper lighting design application alone can save energy and operations and maintenance (O&M) costs, sharing tips on commissioning electrical systems to ensure performance and satisfaction.

Integrated approach to lighting

Lighting standards, regulations, and guidelines for offices have typically been written for optimal illumination and distribution at the workstation desk. As most lighting is developed before interior designers have finalized furniture colours and layouts, lighting professionals and contractors have traditionally used what is known as the uniform grid layout—row on row of luminaires to cover any furniture design (Figure 1).

Achieving optimal split ambient/task lighting can best be facilitated through an integrated approach to office design. This involves including lighting specialists throughout the project, from concept to commissioning. To illustrate how such an approach can meet the different requirements of ambient and task lighting, Public Works and Government Services Canada (PWGSC) undertook an integrated design approach when its Architectural & Engineering Service Sector moved into new head office space at Place du Portage in Hull, Quebec.

ENERGY SAVINGS THROUGH OFFICE LIGHTING AND CONTROLS STRATEGIES

Energy performance, application, research, and technology cont'd

In 2005, this author conducted a comparison energy evaluation as part of a lighting project for the Natural Resources Canada's CanmetENERGY under the Program of Energy Research and Development (NRCan PERD).

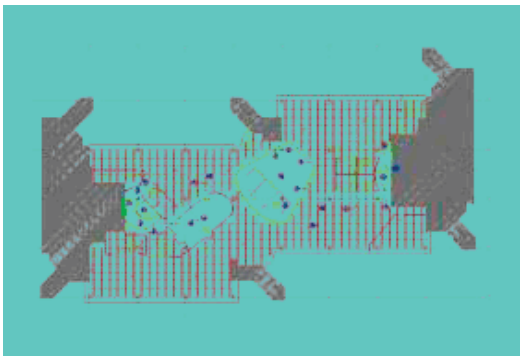

Figure 2

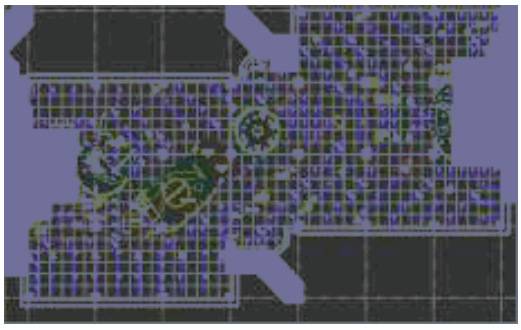

Figure 3

Images courtesy PWGSC

The space had an existing recessed 1x4 two-T8 lamp troffer grid, with a total of 605 recessed luminaires and ballasts and 1210 32-W lamps (Figure 2). With the new furniture layout, the lighting was changed to meet the COSH split task/ambient requirements. The new ambient lighting was a direct/indirect system suspended in the aisles between workstations and in corridors. The same direct/indirect luminaires were installed on 1.5-m (5-ft) partitions separating workstations that faced each other. The new system consists of 1.2 to 2.4-m (4 to 8-ft) luminaires with the same energy-efficient electronic ballasts and two T8 lamps per 1.2-m luminaire.

For this type of workstation-specific design, 158 direct/indirect and recessed troffer luminaires and 316 32-W tri-phosphor lamps were used. Some of the recessed troffers remained to continue acting as the emergency lighting system (Figure 3). The total average for Figure 2 is 38,720 W, while Figure 3 totals an average of 10,112 W. The reduction of 605 to 158 two-lamp luminaires means a 28,608-W savings per luminaire.

This does not include controls, dimming, daylight harvesting, or occupancy sensors. Another issue examined was first costs; typically the bottom line when considering a new lighting system. The original recessed troffers are the standard workhorses of office lighting, with the installed cost approximately $150 per fixture (depending on region). The price of the new direct/indirect system typically averages $100 per linear foot. The cost of the existing troffers was $90,750, while the workstation-specific lighting design was about $59,376; a savings of $31,374.

Annual operating costs were also examined, using this calculation:
Annual Cost = [Total Ballast Watts x Operating hours x $kWh]/1000

Depending on the region and cost of power the standard grid of 605 luminaires would be approximately $22,259 annually. The application-specific design would be about $5,813; an annual savings of $16,446.

Although GHG emissions were not calculated during this project, initial emissions for the lighting was approximately 38 t (42 tons); after the redesign, emissions were approximately 28 t (31 tons), a reduction of 10 t (11 tons) of CO2. These substantial savings do not have to be rare, provided an experienced lighting designer or application specialist is allowed to take a lighting project from concept to commissioning.

ENERGY SAVINGS THROUGH OFFICE LIGHTING AND CONTROLS STRATEGIES

Energy performance, application, research, and technology

cont'd

Lighting controls

Over the last few years, numerous articles have claimed substantial savings can be provided by lighting controls, including dimming ballasts and occupancy or photocell sensors. Many studies have shown energy savings in the area of 25 to 75 per cent when such products are specified for open office environments. Nevertheless, on/off timers and occupancy sensors for storage rooms and meeting rooms are still the exception rather than the best practice norm.

December 2007 saw the completion of a year-long research study at the Burnaby headquarters of BC Hydro, part of CanmetENERGY's PERD and BC Hydro's research program along with the National Research Council of Canada's Institute for Research in Construction (NRC-IRC), looking at the energy savings and ancillary occupant benefits of lighting controls.

Like the PWGSC project, the lighting layout was reconfigured to be workstation-specific, with individual personal controls added over the ambient lighting. Each luminaire used three 32-W T8 Lamps with dimming ballasts. Photocell sensors were installed in each workstation along the perimeter and at those within 2.5 m (8.2 ft) of windows. Occupancy sensors were installed in all the workstations.

The field study was set up so people could control the direct lighting from the luminaires over their workstations, but not the ambient settings. The indirect lighting was connected to the photocell sensors, but would only dim to approximately 50 per cent to ensure continual (and even) distribution of light over the ceiling. The occupancy sensors would also dim the lighting when they did not detect movement in a workstation.

Sensors were calibrated to read inactivity for 15 to 20 minutes before reacting and dimming the lighting.

The results indicated reduced power density provided 42 per cent savings over the standard recessed grid and the lighting controls data indicated a 70 per cent savings over the same grid. This also showed the peak power demand was reduced from 5.8 to 3 W/m2. When comparing the three control systems together, combined with the workstation -specific lighting design, the average daily peak power demand was reduced by up to 70 per cent. If the system did not have any control or dimming capability, the daily peak power demand savings were up to 50 per cent.

Researchers found the combination of controls saved 42 to 47 per cent, if compared to the same system with no control.

Individual savings were:

- occupancy sensors—35 per cent;
- photocell sensors—20 per cent; and
- individual controls—11 per cent.

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INTEGRATED ENERGY SYSTEMS

Brushless (ECM) Motors; Hot Water Usage Field Study; and Micro-cogeneration.

Retrofitting ECM Fan Motors in Existing Warm Air Furnaces:

CanmetENERGY have characterized the significant energy savings, performance advantages and technical requirements for brushless DC motors (commonly known as ECM's), as compared to conventional PSC motors in warm air furnaces. We now have three suppliers of retrofit kits which would allow the replacement of these motors in existing furnaces. CanmetENERGY, in cooperation with OEE, is developing the potential path forward for a Canadian motor retrofit program.

For more information, contact Martin Thomas at martin.thomas@nrcan.gc.ca

Field Study of Hot Water Usage Patterns in Canadian Homes:

This study has shown that the hot water usage pattern presently used for determination of the efficiency of residential hot water heaters is not representative of Canadian (or even North American use) and results in a significant over-estimation of the efficiency of many present water heating technologies, for many tank-based and some tankless systems. CanmetENERGY, in cooperation with OEE and US partners (including ACEEE, LBL) is developing a new test procedure which will allow more efficient technologies to show their true performance advantages of conventional water heaters.

For more information, contact Martin Thomas at martin.thomas@nrcan.gc.ca or Skip Hayden at skip.hayden@nrcan-rncan.gc.ca

Micro-cogeneration technologies for Canadian homes:

Following CanmetENERGY's laboratory development, there are now a number of field demonstrations of highly efficient micro-cogeneration technologies in Canadian homes, designed to supply all of the space and water heating and most of the electricity requirements of a Canadian home, while operating at overall efficiencies approaching 90%, compared to a central power plant of about 33%.

For more information, contact Evgueniy Entchev at evgueniy.entchev@nrcan-rncan.gc.ca or Mark Douglas at madougla@nrcan-rncan.gc.ca