EXECUTIVE SUMMARY

New time of use electricity rates, rising costs and interest in shifting electricity use to off peak periods are driving the need for better control of electrical base loads in Canadian homes. Several commercial home energy monitors are now available to help reduce these loads by providing information to homeowners on their energy use through two-way communications enabled receptacles, switches or circuits. The dx2 home energy management system takes this technology one step further by providing both user feedback and the ability to actively control electrical loads. This study evaluates the effectiveness of the dx2 system to reduce energy, shift loads to off-peak times, and optimize the operation of base loads for cost savings to the homeowner.

The dx2 system provides energy use feedback and electrical load control functionality through the use of software, a user friendly interface, SMART receptacles (safe plugs) and light switches (Figure 1). Individual electrical loads are configured according to user based preferences for an *at home* setting, an *away* setting and a *sleep* setting. The system can be controlled remotely by computer, via a smart phone, or if desired, by a utility to reduce peak demand.

The dx2 system evaluated in this study was installed in the Archetype Sustainable House owned and operated by the Toronto and Region Conservation Authority. This demonstration home contains several innovative residential green building technologies, a comprehensive energy monitoring and data acquisition system, as well as the dx2 home energy management and control system.

In this study, electrical loads were automated to simulate a typical residential electricity load profile. Three scenarios were monitored to assess the potential benefit of the system both from a cost and energy savings perspective. The first scenario is a worst case, assuming no energy savings control either by the homeowners or via an automated system such as dx2. The second scenario assessed energy savings with automated controls for an *at home* and *away* setting. The final scenario adds *sleep* modes to generate greater energy savings.

Results of this study show energy reductions and cost savings from load shifting, control of phantom loads and, more significantly, from the control of individual plug loads (Figure 2). Phantom loads were reduced by 60% under the test scenarios, with costs falling from $37 to $15. Reducing the operation of select base loads in the form of plug and exterior lighting (135 watts) showed annual savings of approximately $64 between the highest and lowest energy use scenarios tested. If these energy savings are applied on a scale of 500 homes over the course of a year, the net reduction is 406 MWh. Based on an annual, medium home use energy profile reported by Armstrong et al (2009), the net energy savings would be sufficient to power an additional 50 homes.

Significant potential savings were also available to homeowners when the system was used to control hard wired lighting. The annual cost savings between a scenario with most lights on all the time ($985), and the same lights turned off during the day and during sleep times ($324) was $662. While it is unlikely that homeowners would leave lights on when they leave the house or go to bed at night, the lights on all the time scenario offers important insight as a comparative reference point to the application of system modes and their associated cost savings with regards to hard wired lighting.

In addition to cost savings, benefits of this home energy management system also include control of electrical loads from a convenient, centralized and/or remote location, and safety features such as protection from under/over voltage conditions; surge, arc fault, and lightning protection; and home security features. Although the value of these features was not specifically evaluated in this study, these are clearly important selling features of the system as a whole.

This study documents successful energy management control, and reviews potential for load reductions and cost savings associated with the application of various control strategies. Recommendations are provided for product development and future research needs associated with the evaluation and practical application of the technology for controlling electrical loads and home energy scenarios not addressed in this study.