Adaptive Technology and Benefits in Ontario

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EXECUTIVE SUMMARY

Adaptive technology for the smart home, or simply, the "Smart Thermostat" is an innovative category within the home automation field with tremendous potential for customers, policy makers and governments alike. It not only delivers on its customer promise of seamlessly regulating temperatures while adapting to the needs of each house, but provides real, proven savings in the areas of energy efficiency and energy management, avoiding the need for additional generation. This ultimately translates into significant CO2 emission reductions and real climate change actions a government can take.

The purpose of this memo is provide the government of Ontario and the Independent Electricity System Operator (IESO) with information that can assist with meeting the dual goals of CO2 reductions (through the Climate Change Action Plan) and energy management goals (energy efficiency and demand response). As part of the Climate Change Action Plan and the *peaksaver*Plus review, we recommend that the government provides an incentive for "adaptive technology" to be purchased and installed in homes and businesses. This can result in significant benefits through energy savings (10-12% heating savings, and about 15% cooling savings[1]) and CO2 reductions (0.5 tonnes per thermostat installed[2]) as further highlighted in the memo. More detailed data supporting the results can be provided if needed, as part of the consultation process.

Questions about these comments can be directed to:

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[1] Energy Trust of Oregon; NIPSCO; Vectren; https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf

[2] Ibid.

OVERVIEW OF NEST LABS

Founded in 2010, Nest Labs is dedicated to reinventing home products like the thermostat and smoke alarm to provide customers with simple, beautiful and thoughtful hardware, software and services helping them reduce energy consumption and keeping families comfortable and safe. Today, Nest products are sold in the United States, Canada, United Kingdom, Ireland, France, Belgium, and the Netherlands, and are installed in more than 120 countries. Nest is a wholly-owned subsidiary of Google Inc. and is based in Palo Alto, California.

Nest manufactures the Nest Learning Thermostat, a smart thermostat equipped with sensors, Wi-Fi capability, and processors, to help customers consume less energy: it learns their preferences, adjusts the temperature when the house is empty, and automatically lowers air conditioner runtime when humidity conditions permit, helping people lower their energy use without sacrificing comfort. Nest is designed to enable "Do It Yourself" installation, and to date the vast majority of Nest Learning Thermostat customers have done the installation themselves, most in under 30 minutes.[3]

Independent energy savings studies show Nest Learning Thermostat saves about 10%-12% of heating usage and about 15% of cooling usage in homes with central air conditioning. In Ontario, this equates to 345 m^3 of natural gas heating savings and 293 kWh electric savings, or approximately 0.5 tonnes of CO2 per thermostat per year.

In addition to reaching provincial energy efficiency and CO2 reduction targets, Nest also provides service offerings for utilities to help address load management needs.

RESIDENTIAL THERMOSTAT OPTIONS ARE RAPIDLY EVOLVING

Traditional manual thermostats allow the home occupants to simply turn the heating or cooling up or down. The result is that many residences "set it and forget it", resulting in unnecessary heating and cooling, and correspondingly higher energy bills.

Traditional programmable thermostats (PTs) allow customers to set up a pre-programmed schedule for raising or lowering the temperature in the home. This enables occupants to ensure that the heating or cooling is not on high when they are away at work, for example.

[3] Statistics derived from Nest customer surveys.

While the ability to pre-program thermostats can be a convenience feature and save energy for some households, there are challenges and difficulties with PTs. For many people they are not intuitive and hard to program; therefore, some people never establish a correct schedule. In that case, they may be used like non-programmable manual thermostats with people turning them up or down ad hoc. Even if PTs are programmed initially, they are often overridden or placed on "hold" at some point in the future and then not reprogrammed. This override could happen for any number of reasons; a house full of guests, unusual weather, daylight savings time, change in season, etc., and may erode the energy savings of PTs. The U.S. Environmental Protection Agency originally had an ENERGY STAR specification for PTs but suspended it in 2009 as a result of continuing questions concerning the actual energy savings and environmental benefits achieved by PTs under the specification.[4]

A new category of thermostats, known as "smart thermostats" (STs), have a number of advantages over traditional programmable thermostats when it comes to energy efficiency assurance and persistence, demand response capabilities and ease of use. Smart thermostats can learn a household's habits and preferences and create a customized schedule without programming. Through motion sensors and/or geofencing technology, STs can recognize when occupants have left the home and automatically adjust temperature settings. They can also connect to the Internet, enabling them to receive software updates, be controlled remotely by the user, and receive signals from a utility, energy aggregator or other home energy management system. In Appendix A, you will find a definition of "Adaptive Technology" being proposed for the EPA's new Energy Star thermostat proposal and the Illinois Technical Reference Manual that Ontario may also consider using.

[4] See: https://www.energystar.gov/index.cfm?c=archives.thermostats_spec

BENEFITS OF A SMART THERMOSTAT IN ONTARIO

There are many benefits to the creation of a smart thermostat program in Ontario namely:

1. Proven energy savings for consumers. Nest third party studies have found 10-12% heating savings, and about 15% cooling savings[5]
2. Average CO2 reductions of 0.5 tonnes per thermostat installed
3. Positive customer engagement/experience[6]
4. Potential for additional energy efficiency savings (Seasonal Savings) and the ability to offer demand response (Rush Hour Rewards)

1. Proven Energy Savings

There have been four studies of the Nest Learning Thermostat energy savings based on comparisons of utility bills from before and after installation. Three of the studies were independently funded, designed and evaluated by utilities in Oregon, Indiana. The fourth study was performed by Nest using a national sample of Nest customers across 41 states in the U.S. who had also enrolled in Nest's MyEnergy service.

The energy savings results of the studies were similar -- showing Nest Learning Thermostat savings equal to about 10%-12% of heating usage and electric savings equal to about 15% of cooling usage in homes with central air conditioning. Furthermore, the Oregon study noted that the majority of participants reported feeling more comfortable after the Nest Learning Thermostat was installed and all studies found high levels of customer satisfaction.

Although the average savings were similar across the four studies, it's important to note that thermostat savings in any given home can vary from these averages, due to differences in occupancy patterns, housing characteristics, heating and cooling equipment, and climate.

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[5] Energy Trust of Oregon; NIPSCO; Vectren; https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf

[6] Ibid.

Nest is committed to being an industry leader in measuring and sharing energy savings results. We expect to have industry-leading measured energy savings, but we prioritize keeping people comfortable and in control of their homes. Our thermostat is designed to capture as much energy savings as feasible without compromising comfort or convenience.

2. Energy Savings and GHG Reduction Calculations for Ontario

Nest estimated the energy savings from thermostat installations in Ontario based on heating and cooling savings from the US studies applied to the heating and cooling energy use of current Nest customers in Ontario. Savings values of 11% of heating and 15% of cooling are used.

We calculated the heating and cooling system energy-use based on the average actual hours of heating and cooling system run-time during 2015, multiplied by the estimated energy input rates of the heating and cooling systems. In 2015, Nest customers in Ontario used an average of 918 hours of heating and 556 hours of cooling (for the 91% of thermostats that controlled a central air conditioner). Nest employed an HVAC system sizing estimation algorithm based on climate data and other factors to estimate an average 99 kbtu/hr input rate for gas heating systems and 2.66 kW input for central air conditioners. We also estimated the *electricity use* of the gas heating systems (air handler fan plus other fans, pumps, etc.) at 0.77 kW. (Please see Table 1: Energy and CO2 Emissions Reductions per Thermostat for a complete summary.)

Table 1: Energy and CO2 Emission Reductions per Thermostat

		Natural Gas m^3/yr		Electricity kWh/yr	
	% of Homes	Usage	Savings	Usage	Savings
Heating	99%	2831	350	706	84
Cooling	91%	-	-	1,314	232
Total Energy per thermostat		2794	345		293
Total CO2 tonnes avoided			0.52		0.01

The table treats all home heating as natural gas, ignoring the fact that a small fraction use other fuels -- 1.3% fuel oil, 2.9% propane, and 3% heat pumps (primarily dual fuel).

Fuel oil and propane emit more CO2 per unit of energy than natural gas (propane 19% greater and fuel oil is 38% greater), making the values in the table more conservative.

CO2 emission reductions were calculated based on standard CO2 emission factors for natural gas and an estimated 0.029 kg/kWh for electricity (based on the low carbon emissions of the Ontario power grid).

3. Positive Customer Engagement and Experience

Nest places customer engagement, satisfaction and data privacy at the centre of its business strategy. It recognizes that a positive consumer engagement and experience is critical to the success of an energy management program. In an effort to ensure maximum positive outcomes for the customer and the utility or government agency, Nest offers several mechanisms to reach the customer. From personalized customer portals to mobile apps, and "quick tips" through e-mail, Nest provides a variety of tools to encourage customer interaction.

Furthermore, when Nest partners with utilities or government agencies, co-branding and integrated marketing strategies can be developed. Utilities and government agencies can leverage Nest's marketing ability through a Nest website, use of Nest creative templates, brand training and so on. Using integrated marketing strategies can raise consumer awareness and improve the success rate of an energy management program.

4. Potential for Additional Energy Efficiency and Demand Management

The savings described above are based on savings from Nests as installed. However, smart thermostats, due to the fact that they can communicate via the internet, have the potential to provide additional ongoing benefits to Ontario. Below is a description of some additional programs offered by Nest when sponsored by a utility or governmental agency.

Seasonal Savings

Nest Seasonal Savings is an energy efficiency "booster" program that can be offered twice a year, at the change of seasons from heating to cooling and cooling to heating without sacrificing comfort or requiring daily behavioral changes. Seasonal Savings is only offered to customers in geographies where a utility or government sponsors the program. Customer participation is always optional. Typically the customer is offered the opportunity to participate without any incentive except the opportunity to reduce their energy usage and therefore their energy bills.

How does Seasonal Savings work?

Twice annually, prior to the cooling or heating season, Nest sends eligible customers information about savings potential and asks if they want to participate. Opting into the program, by simply clicking "Continue", begins a two to three week process of micro-adjustments to their temperature set point. The changes are so small and gradual that most customers do not even notice an impact on their comfort. However, customers always have the ability to override the changes if they want to.

On average, this saves an additional 3~5% of heating and AC load, 0.1 kW peak reduction. And, 89% of customers report being just as comfortable as before the adjustments.

Seasonal Savings is currently implemented by a number of Nest gas and electric utility partners. In addition, the Department of Energy Resources for the Commonwealth of Massachusetts (analogous to the Ministry of Energy in Ontario) purchased Seasonal Savings for all Nest customers beginning in the winter of 2014-2015 as part of an effort to curb natural gas consumption during a time of critical shortage.[7] This program was deemed a success, with an average of ~4% heating load reduction during the very difficult winter of 2015. Massachusetts felt the program was such a success that it repeated it in the Summer of 2015 and has purchased it again for the 2016 Winter. Ontario could do a similar program with the savings primarily coming from reduced natural gas usage for heating. The more thermostats that are installed, the bigger the benefit of such a program.

[7] http://www.datascienceforsustainability.org/past-talks/measuring-energy-savings-and-other-data-analysis-challenges-at-nest-slides, see pages 40-53

Demand Response (Rush Hour Rewards)

Nest wants to change the way people think about demand response. Nest's Rush Hour Rewards is a mass-market demand response offering for customers with air-conditioning that offers utilities and governments a way to reduce peak loads during the summer. Rush Hour Rewards is only offered to customers in geographies where a utility or government sponsors the program. Customer participation is always optional. Typically, the customer is offered the opportunity to participate with a financial incentive such as a $50 per summer.

How does Rush Hour Rewards work?

Nest sends eligible customers invitations to participate in Rush Hour Rewards along with an offer of a financial incentive. Once customers opt-in, the sponsor of the program can call up to 20 events per summer. When the sponsor calls an event, Nest sends a signal to participating customers' thermostats. The thermostats then pre-cool in the hour before the event starts and then allow the standard cooling set point to drift upward several degrees during the event. The net result is that roughly half the air-conditioning usage during that period is avoided. At the end of the event, the thermostat goes back to it regular set point and cools the house down.

An important feature of Rush Hour Rewards is that customers can always override the set point simply by turning down their thermostat during an event. However, most of them don't. Over thousands of event days, on average 85% of customers never override and those that do, do it toward the end of the event thereby providing some peak reduction benefit.

This is relevant to Ontario because demand response can reduce peak demand on the electric system. While this saves a small amount of kWh, what it does do is reduce the need to run the dirtiest gas-fired peaker plants which are used to meet peak demand. Therefore, it will disproportionately reduce CO2 gases compared to carbon content of the average generation mix. Reducing peak demand can also reduce the need for infrastructure upgrades which can save Ontarians money as well.

In addition to CO2 savings and as IESO develops a plan to evolve the existing *peaksaver*Plus program to an IESO administered market, Rush Hour Rewards can facilitate the process. Implementing a Rush Hour Rewards program that enhances *peaksaver*Plus can continue to drive energy savings and load shifting at critical peaks. Since 2012, Nest has partnered with over a dozen utilities in North America to offer customers two unique ways to save energy and participate in easy-to-understand load management programs. On average, Rush Hour Rewards participants reduce peak by about 1 kW per customer.

CONCLUSION AND RECOMMENDATION

Smart Thermostat technology has evolved to a point where it helps utilities and government agencies achieve CO2 emissions reductions and energy management (energy efficiency and demand response). Nest has outlined how the Learning Thermostat, out of the box can help achieve Ontario's dual objectives. In addition, Nest programs, such as Seasonal Savings and Rush Hour Rewards can continue to boost those savings.

Nest recognizes that there are current plans targeting conservation (Demand Side Management for gas utilities and Conservation Demand Management for electric utilities). In addition to these initiatives, the Ministers of Energy and Environment and Climate Change recently announced $100 million through the Green Invest Fund for emissions reduction. Nest applauds this action and looks forward to participating in all the above mentioned programs.

It should be noted, however, that the most effective programs are those with scale and a robust rebate program (a customer incentive) at the provincial level will accelerate the customer savings and societal benefits. Nest recommends that Ontario adopt a province-wide rebate program. It can gain increase momentum by Nest's integrated marketing strategy and ability to engage customers, which in will help achieve the CO2 reduction targets, enhance IESO's existing *peaksaver*Plus program and make the people of Ontario associate the province conservation efforts with a tangible product.

Nest looks forward to being engaged in the consultations showing its commitment, and providing advice, support, and in-depth data as programs are developed and enforced.

Appendix A: Definition of "Adaptive Technology"

Across North America, a variety of regulatory and policy bodies are in the process of defining "Smart Thermostats" as a category. From EPA's Energy Star to state utility commission Technical Reference Manuals, there is great interest in defining this new technology so that it may be included in a variety of efficiency programs. What has been proposed in a variety of proceedings is as follows:

Smart Thermostat: A device that controls heating, ventilation, and air-conditioning (HVAC) equipment to regulate the temperature of the room or space in which it is installed, and has the ability to communicate with sources external to the HVAC system. For connection, the device may rely on a home area network (e.g. Wi-Fi) and an internet connection that is independent of the Smart Thermostat. A smart thermostat has the functionality to make automatic adjustment decisions regarding heating and cooling, using the following functions:

A. Two-way communication between the thermostat and a utility, energy aggregator, or other home energy management service.

B. Automatic variations to that schedule driven by local sensors and software algorithms, and/or through connectivity to an internet software service. Data triggers to automatic schedule changes might include, for example: occupancy/activity detection, expected arrival and departure of conditioned spaces, historical and population energy usage trends, weather data and forecasts.

C. This class of products and services are relatively new, diverse, and rapidly changing. Generally, the savings expected for this measure aren't yet established at the level of individual features, but rather at the system level and how it performs overall. This measure treats heating and cooling savings independently. Note that it is a very active area of ongoing study to better map features to savings value, and establish standards of performance measurement based on field data so that a standard of efficiency can be developed. That work is not yet complete but does inform the treatment of some aspects of this characterization and recommendations. Energy savings are applicable at the household level; all thermostats controlling household heat and cooling should be smart thermostats. Multiple smart thermostats per home do not accrue additional savings beyond that associated with the generally higher baseline HVAC energy consumption often found in such homes.