

Home Energy Management Systems

Research and Analysis of a Home Energy Management System in support of Smart Grid Development and the Green Energy and Green Economy Act, 2009

Date August 10, 2010

Confidential

Prepared by 

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Introduction

The report explores the application of Home Energy Management Systems (HEMS) technology to Ontario. It was developed for the Ministry of Energy and Infrastructure and is intended to inform policy makers about the current and future status of HEMS technology, and specific opportunities and issues with its deployment in Ontario.

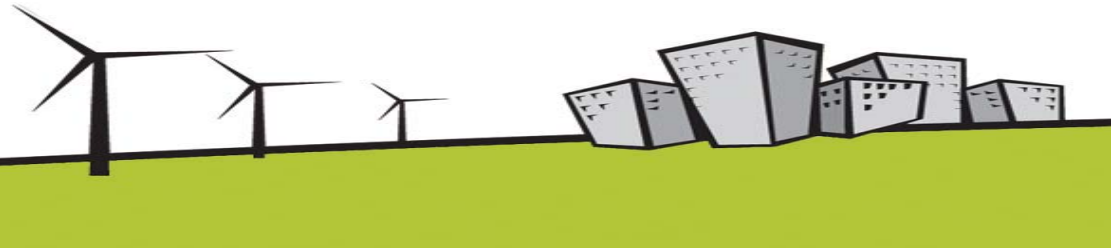
HEMS are an emerging category of products that take advantage of advances in communications, computing and display technologies to help consumers better understand and manage their use of energy. This includes:

- ◆ In-home displays that provide the consumer with information on the current usage and price of energy
- ◆ Load control devices that can allow the customer or the utility to remotely change settings on connected thermostats, pool pumps or other household and commercial appliances.



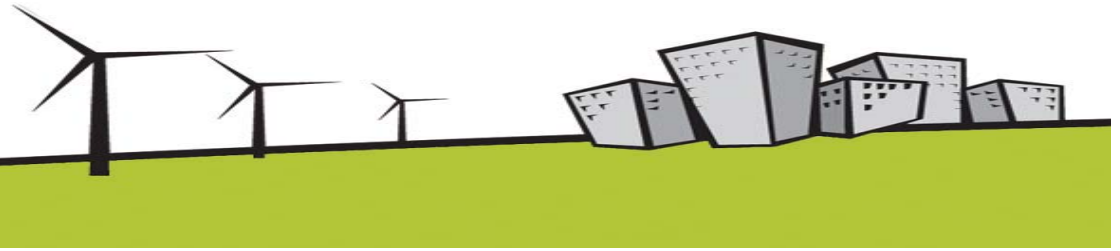
Ontario

Ministry of Energy and Infrastructure



Introductions

- ◆ **Michael Martin**, Senior Managing Consultant, IBM's Global Center of Competency for Energy & Utilities
- ◆ **James Strapp**, Associate Partner and Leader of IBM's Global Center of Competency for Energy & Utilities



Agenda

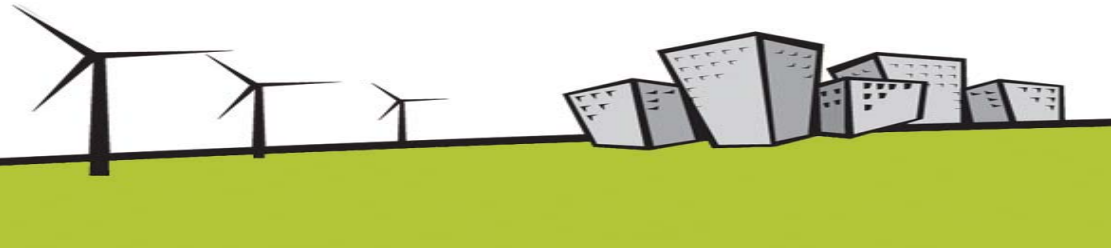
- ◆ Introductions
- ◆ Standards
- ◆ Drivers of Change
- ◆ Benefits
- ◆ Vendor Review
- ◆ Solutions
- ◆ Next Steps
- ◆ Examples of In-home Devices
- ◆ Questions



Standards are driving adoption

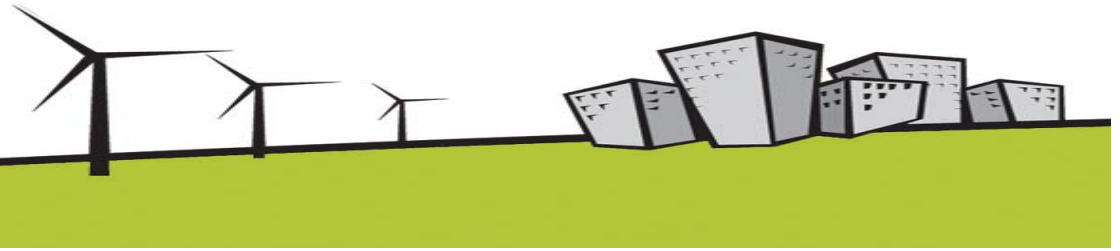
Three open communications standards are most important in enabling two HEMS devices to connect:

- ◆ **Wi-Fi** is the most common wireless network operating in many Ontario homes and is growing in its use for home automation.
- ◆ **ZigBee** is an emerging standard for wireless networks. It is the standard for inclusion in smart meters because it is ideal for situations such as gas metering that requires lower power use and high security.
- ◆ **HomePlug** is a powerline carrier standard that enables communications in homes where wireless connections are difficult without any additional wiring.



Drivers of change

- **Increased device interconnectivity:** The increased ability of home energy management devices to connect with each other around the home will enable several new products. Some of these are already becoming available, such as a USB stick that can be plugged into any computer, connecting the computer to any other ZigBee compliant device in the house, such as a smart meter. Also, a smart electrical outlet that can be turned off or on through a remote device or web portal.
- **Growth in multi-purpose devices:** The concept of a dedicated display to show energy use is giving way to multi-purpose devices where one application relates to energy use. PCs, laptops, Netbooks, tablet computers, smart phones and other computing products will become the dominant devices to monitor and control energy use.



Drivers of change

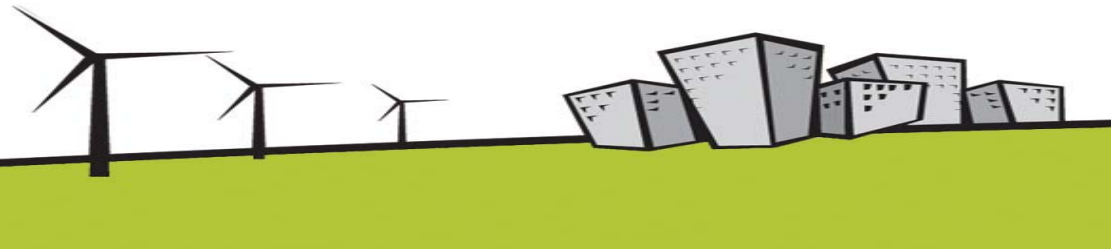
- **Entry of major device manufacturers:** To date, most of the providers of home displays and other communicating home energy management devices have been relatively small start-up companies. Larger companies such as General Electric, Honeywell, Whirlpool have already announced plans to expand their business into communicating home energy management products.
- **Greater non-utility data access:** Customers will increasingly want to make data about their own energy use available to service providers of their choice, not just their local utility. Already models introduced by Google and Microsoft insert themselves between the utility and the customer for home energy management services.



Benefits

The benefits of home energy management systems stem from five areas:

- **Energy conservation:** Studies in Ontario and elsewhere indicate that real-time feedback can reduce overall consumptions 4% to 13%. (Importantly for Ontario, these studies provided near real-time feedback to consumers about their energy use within a few seconds.)
- **Peak load shifting:** A Hydro One study showed that providing real-time displays to customers on Regulated Price Plan (RPP) Time-of-Use (TOU) rates increased the load shifting impacts in typical days from 3.7% to 5.5% and on hot days (over 30°C) to 8.5%. Participants on a load control pilot in Newmarket reduced their consumption during critical peak periods by approximately 31%.



Benefits

- **Consumer demand:** Customers have consistently express a desire for these types of devices. A March 2010 survey conducted by the Independent Electricity System Operator (IESO) indicated that more than 57 percent of respondents expressed interest in purchasing a real-time energy monitor that shows electricity use on a visual display in the home or, remotely, on a web page. In a 2008 Hydro One study, 63 percent of participants with a real-time monitor found it useful to help them conserve electricity. No studies, however, have formally tested Ontarian's willingness to pay for these devices, or more precisely, what types of functions they want.
- **Support for the next generation energy industry:** HEMS solutions are expected to become an important part of solutions for the future smart energy model. HEMS devices are important in monitoring and potentially managing distributed generation, energy storage and electric vehicle charging infrastructures.



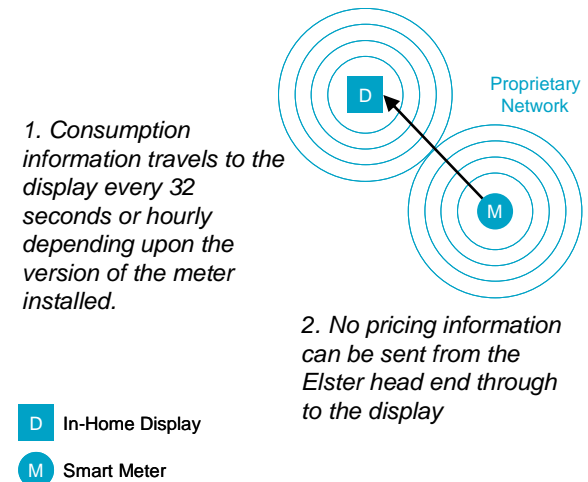
Benefits

- **Economic Development:** Canadian and Ontario companies are well represented in the current HEMS market. Of the 22 vendors that have non-metering products certified under the ZigBee Smart Energy Profile, five are Canadian, and three are based in Ontario. These companies are the first movers in development of hardware. Other companies are poised for investments in related software development, professional, installation and maintenance services.



Approach and capabilities vary by meter vendor

- ◆ **Elster** is the leading smart meter in Ontario in terms of number of meters. It has been selected by at least 33 utilities, representing about 40% of Ontario meters.
- ◆ Elster states that the meters are capable of updating the IHD in less than one minute directly from the meter. Consumption data comes from the meter. TOU windows and TOU rates would come from the Utility via a messaging capability. In some cases, more software development is required to get these features to the most effective levels and avoid manual updates by the consumer.



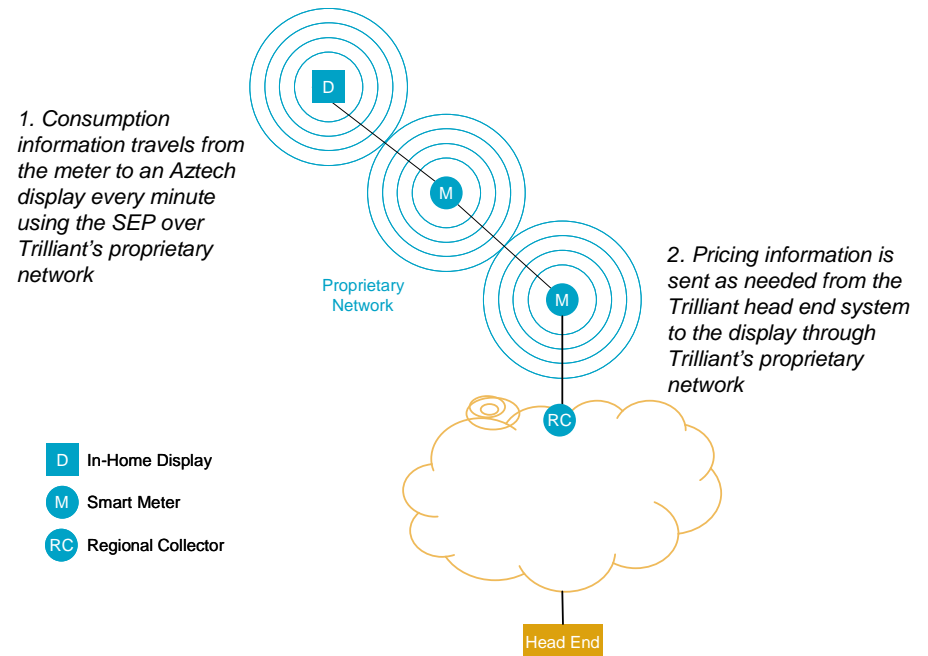
Elster

1,909,000 meters or 40%

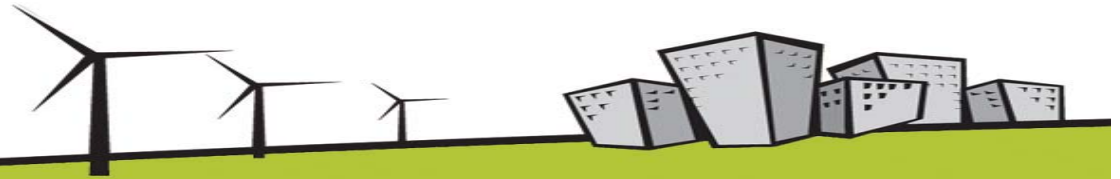


Manner and capabilities vary by meter vendor

- ◆ **Trilliant** meters were selected by Hydro One and Milton Hydro and account for approximately 28% of Ontario's smart meters. Trilliant smart meters communicate to other devices over a proprietary communications network, but following the Smart Energy Profile. They are able to pass consumption information every minute to a display device, and update pricing as required.
- ◆ Because they use a proprietary communications network, vendors must pay for a license from Trilliant to develop products. Trilliant has announced partnerships with several HEMS vendors, including Aztech Associates of Ontario, to enable devices to connect to their meter.

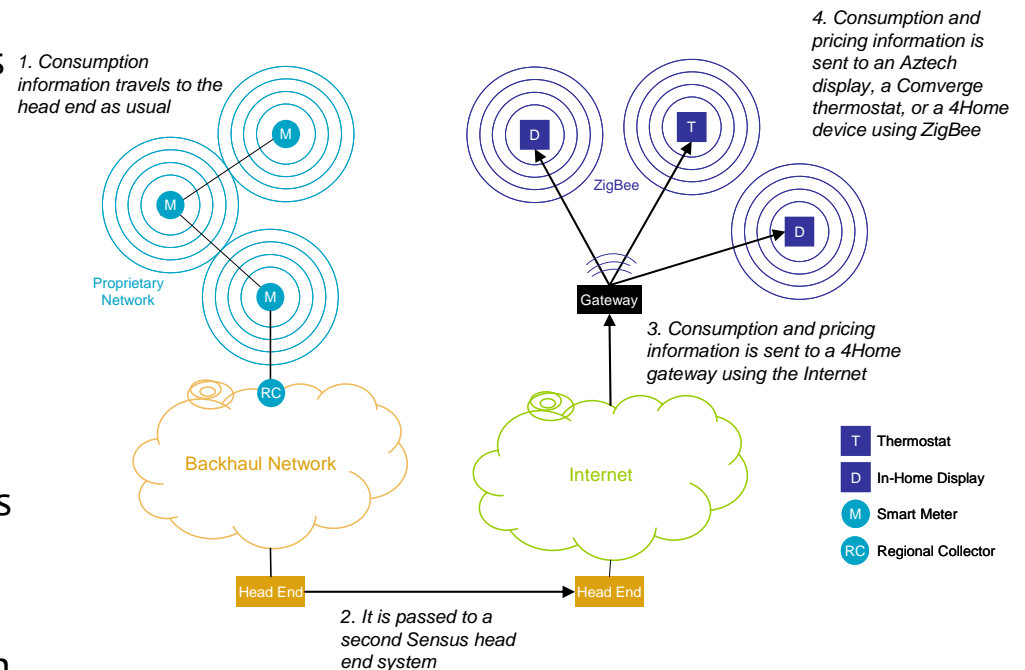


Trilliant
1,345,000 meters or 28%



Manner and capabilities vary by meter vendor

- At least 36 utilities in Ontario, representing 28% of Ontario customers have selected the **Sensus** smart metering solution. If the AMI network is used to communicate to the IHDs, licensed frequencies may need to be used, however, the additional cost for spectrum will need to be paid for by one of the involved parties, the LDC, third-party service provider (PageNet), government, or customers.
- The Sensus approach for HEMS devices in an Ontario pilot at Niagara-on-the-Lake uses a separate gateway that communicates to the home using broadband Internet. This gateway then connects to display and load control devices inside the home. Consumption information can be sent to this gateway as frequently as it is collected by the utility.



Sensus

1,339,000 or 28%



Manner and capabilities vary by meter vendor

- ◆ **Tantalus** meters were selected by Chatham-Kent Hydro (Middlesex Hydro) – 39,120 meters or 0.8%
- ◆ **Silver Springs Networks** meters were selected by Guelph Hydro – 48,000 meters or 1.0%
- ◆ **4,746,709** meters in total in Ontario with approximately 4,675,887 meters accounted for representing an estimated 98.5% of the total



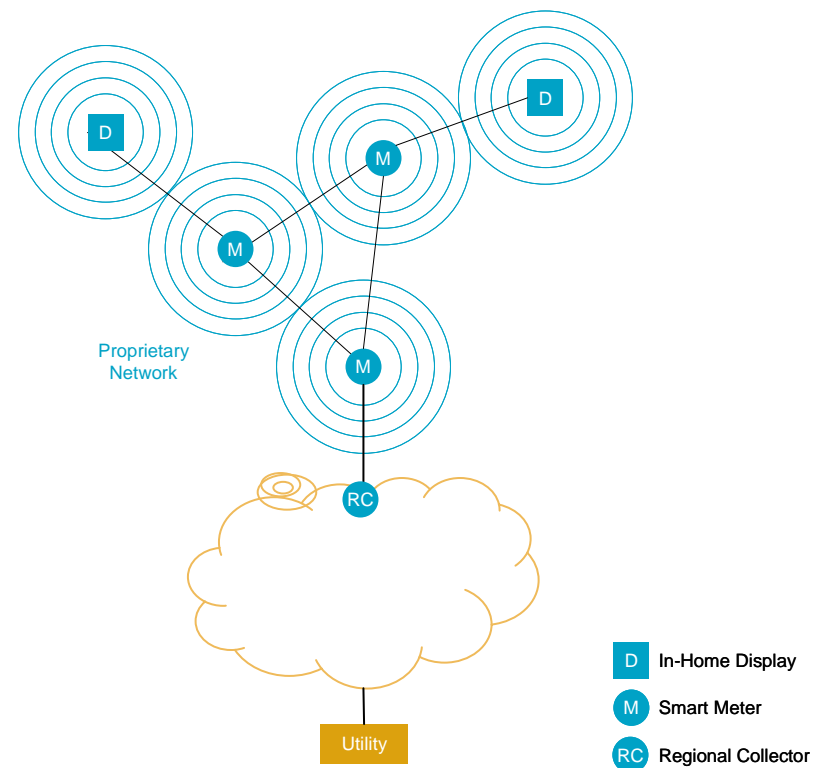
11 potential types of existing HEMS products

Type of Device	Visibility	Control
Broadcast Display	Price Only	No
Outlet Monitors	Consumption Only	No
Clamp-on Display	Consumption Only	No
Smart Meter Connected Display	Consumption Only	No
Outlet Timers and Smarter Plugs	No	Customer (one outlet only)
Programmable Thermostat	No	Customer (heating and cooling only)
Programmable Communicating Thermostat	Consumption, sometimes Price	Customer and Utility (heating and cooling only)
Load Control System	No	Utility
Prepayment Metering System	Price and Consumption	Customer
PC or Smart Phone	Price and sometimes Consumption	Customer (display only with no control, unless connected to a gateway solution)
Home Automation Gateway	Price and Consumption	Customer and optionally Utility



Smart Metering Based Solution

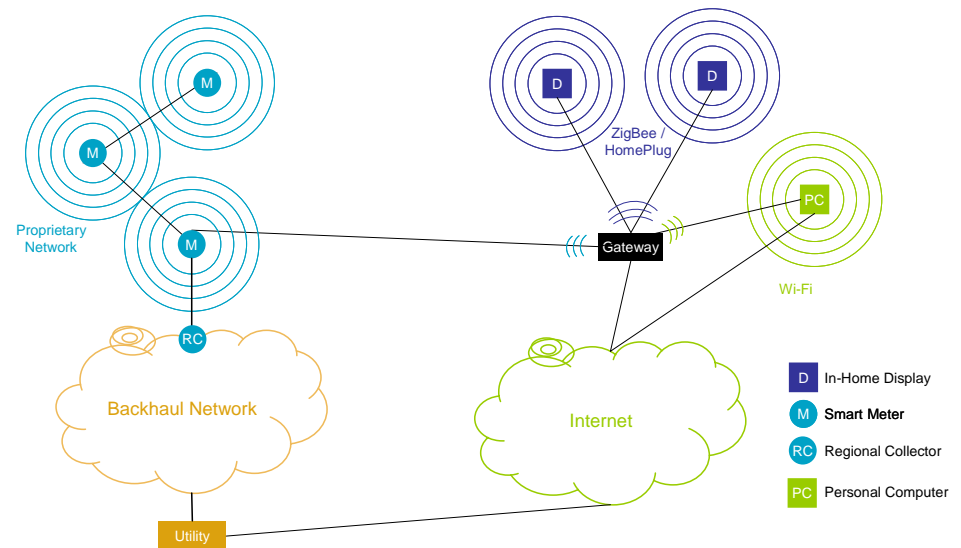
- ◆ **Smart Metering Based** is where displays and other devices rely on the existing or planned smart metering infrastructure as a communications channel.
- ◆ Given that Ontario's smart meters do not include a second tier of ZigBee radios for a HAN, this will require a different approach to the solution. With the current infrastructure, distributors would be required to provide a device that is compatible with their specific and unique smart metering infrastructure.





Home Energy Gateway Solution

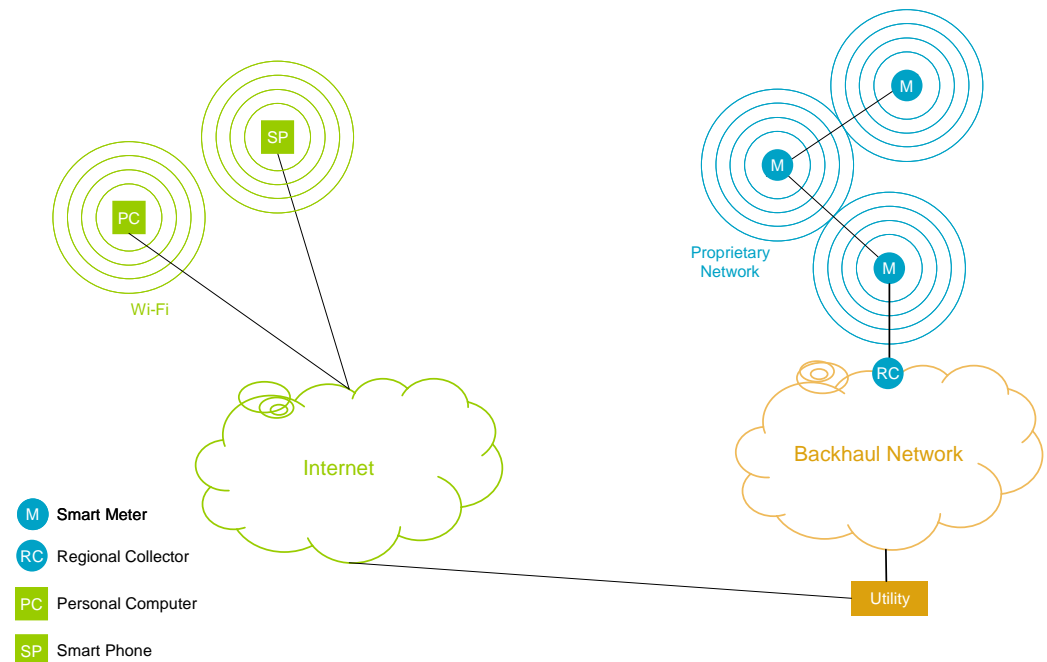
- ◆ **Home Energy Gateway** is where a dedicated gateway device is introduced into homes to communicate, over a variety of protocols with various displays, thermostats, load control modules, and smart meters.
- ◆ In the future, the gateway may be able to control distributed generation, electric vehicles, and energy storage systems.
- ◆ Enables richer load control and display functions to Ontario homes than in the smart meter option.
- ◆ Updates of consumption present some challenges because of the smart metering infrastructure.
- ◆ More amenable to a distributor-led deployment, rather than a retail purchase option.





Smart Device Solution

- ◆ **Smart Device** is where developments outside the energy infrastructure are leveraged and adapted to energy management.
- ◆ This might include websites to display energy use, or smart phone applications to control thermostats over a Wi-Fi network.
- ◆ This approach accepts the home networking constraints of Ontario's smart meters, and focuses on development of a more advanced independent network.
- ◆ It requires the least amount of new infrastructure or changes to existing infrastructure and could be deployed quickly.
- ◆ In practice, this model is only available to those with broadband Internet access.



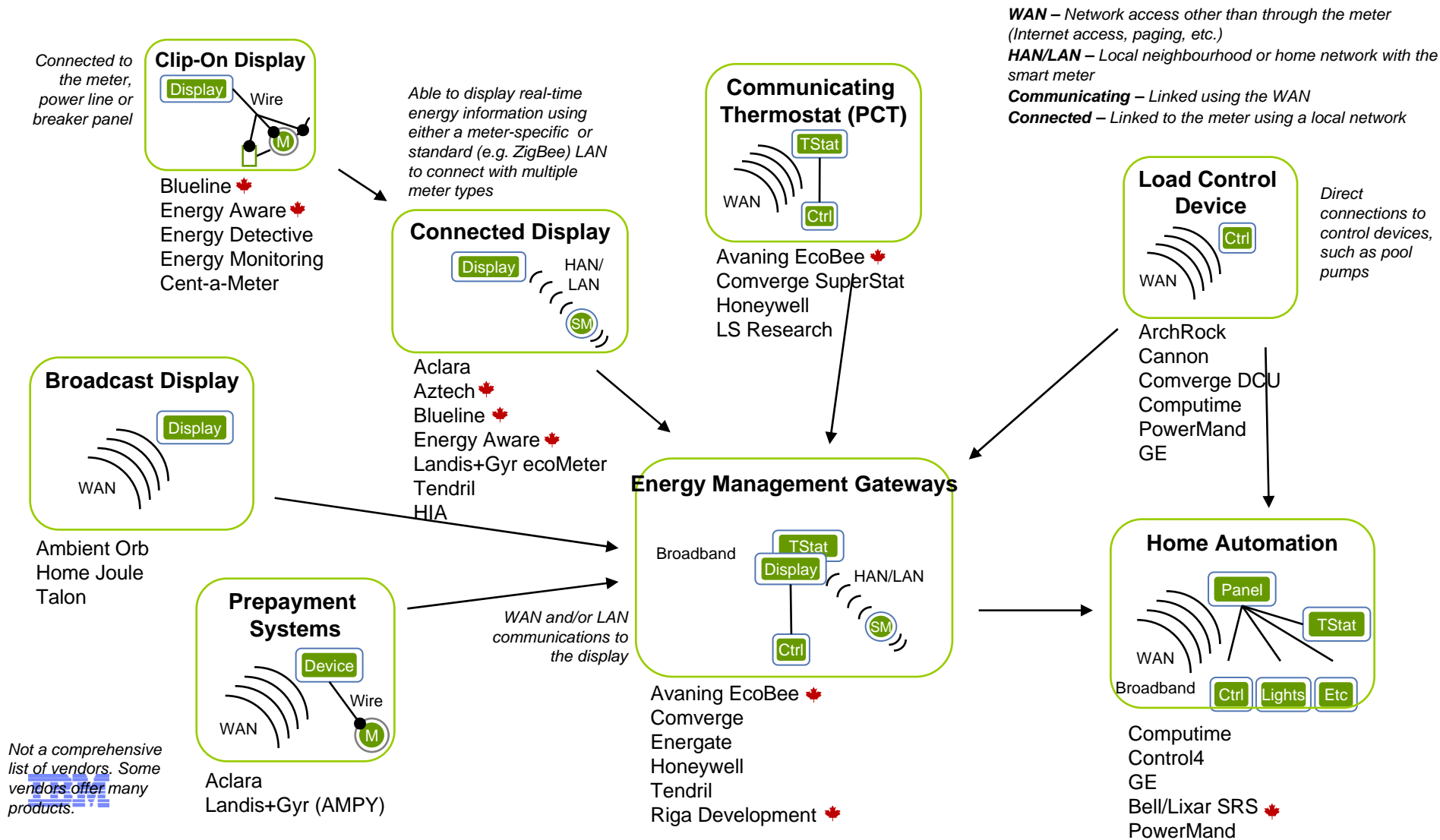


Next Steps

- ◆ Given Ontario's smart metering infrastructure, it is important to understand the impact of delays in feedback to consumers in energy consumption compared to previous pilots. The customer may have near real-time feedback from the meter to the IHD. However, some LDCs are sending the data directly to web portals for customers to access. This aspect may affect the timeliness of the communications. To assess the impact, we suggest a coordinated series of pilots across different distributors that test the conservation and peak shifting implications of different meter read display frequencies. Such a series of pilots would also benefit the Ontario start-up companies currently in discussion with Ontario distributors.
- ◆ We also recommend a short study of the implications of increasing the meter read frequency in Ontario to be shorter than the current 24 hours, including the implications on the MDM/R, distributor systems and communications contracts. This will help determine what display update frequency is possible for smart phones and other smart devices given Ontario's smart metering infrastructure.



Taxonomy of Residential In-Home Energy Device — Trends and Sample Vendors





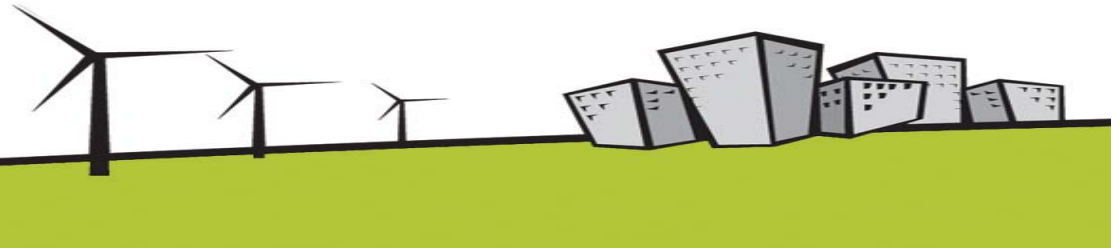
The networking capabilities of established home energy management devices have been limited to communications to the utility or very specific connections to devices in the home.

Type of Device	Connected to a Manual Meter	Connected to a Smart Meter	Connect with Other Home Devices	Connect with the Utility	Connect with the Internet
Broadcast Display	No	No	No	Yes (One way)	No
Outlet Monitors	No	No	No	No	No
Clamp-on Display	Yes	Yes (via Optical Pulse)	No	No	No
Smart Meter Connected Display	No	Yes (on smart meter network)	No	Yes (via smart meter)	No
Outlet Timer or Smarter Plugs	No	No	Yes	Yes	Yes
Programmable Thermostat	No	No	No	No	No
Programmable Communicating Thermostat	No	No	No	Yes	Optionally
Prepayment Metering System	Yes	No	Optionally with a display	No	No
Load Control System	No	No	No	Yes	No
PC or Smart Phone	No	No	Yes	No	Yes
Home Automation Gateway (Proprietary)	No	No	Yes	No	Yes



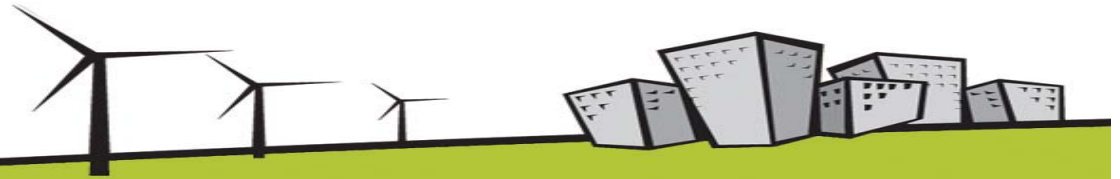
Summary of applicable communications standards

Technology	Mechanism	Governing Bodies	Relative Bandwidth	Relative Cost	Relative Power Consumption	Range (meters)
Bluetooth	Wireless	IEC, IEEE	Medium	Low	Medium	10 to 100
Echelon LonWorks	Wired	Echelon, ISO/IEC, IEEE	Low	High	Medium	50 to 100
HomePlug	Wired	TIA / ANSI, IEEE, ZigBee	High	Medium	High	50 to 100
INSTEON	Wired & Wireless	INSTEON Alliance	High	High	High	50 to 100
Wi-Fi	Wireless	ISO/IEC, IEEE, ANSI	High	Medium	High	50 to 100
ZigBee	Wireless	IEEE, ISO/IEC, IETF, W3C	Medium	Low	Very Low	100+
Z-Wave	Wireless	Z-Wave Alliance	Low	Medium	High	100+



Known existing collaboration arrangements between the major Ontario smart metering vendors and HEMS device providers. * indicates Ontario companies

Smart Meter Vendor	Displays	Programmable Thermostat / Load Control	Home Gateway
Elster	Aztech Associates* Blue Line Innovations Energy Aware LS Research Riga Development Tendril	Comverge Cooper Power Systems	Augusta Digi Tendril Energate*
Trilliant	Aztech Associates* Blue Line Innovations	Cooper Power Systems GridPoint	GridPoint Energate*
Sensus	Aztech Associates*	Comverge Honeywell Radio Thermostat	4Home Home Automation, Inc Microsoft



The Ambient Energy Orb changes colour based on broadcast information about dynamic electricity prices or any other general status information, such as stock markets.





The Kill A Watt device is one example of a outlet monitor that provides detailed consumption information about a single outlet.





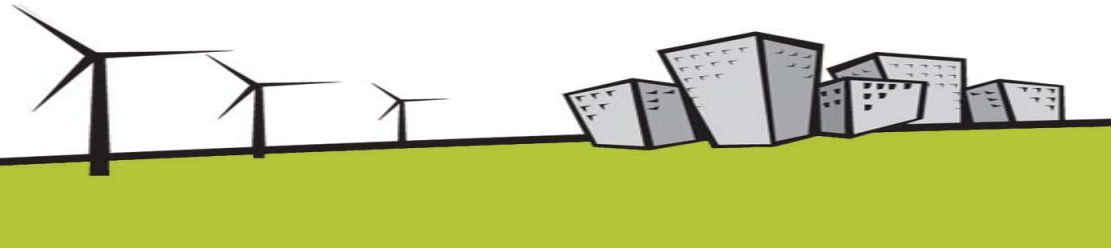
The PowerCost Monitor from Blue Line Innovations of Newfoundland connects to electric meter and displays consumption information.



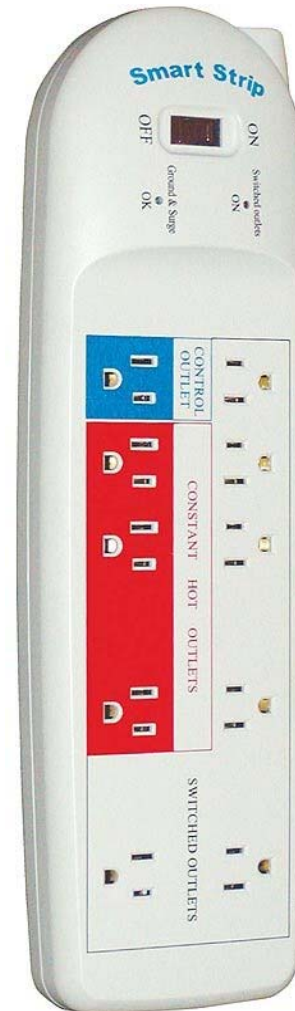


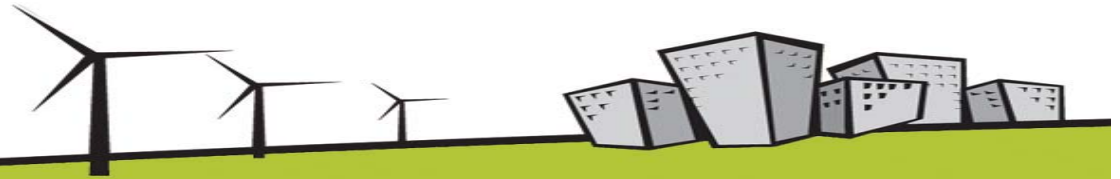
The In-Home Display from Aztech Associates, of Kingston, Ontario, connects to a smart meter to provide pricing and consumption information to the consumer.



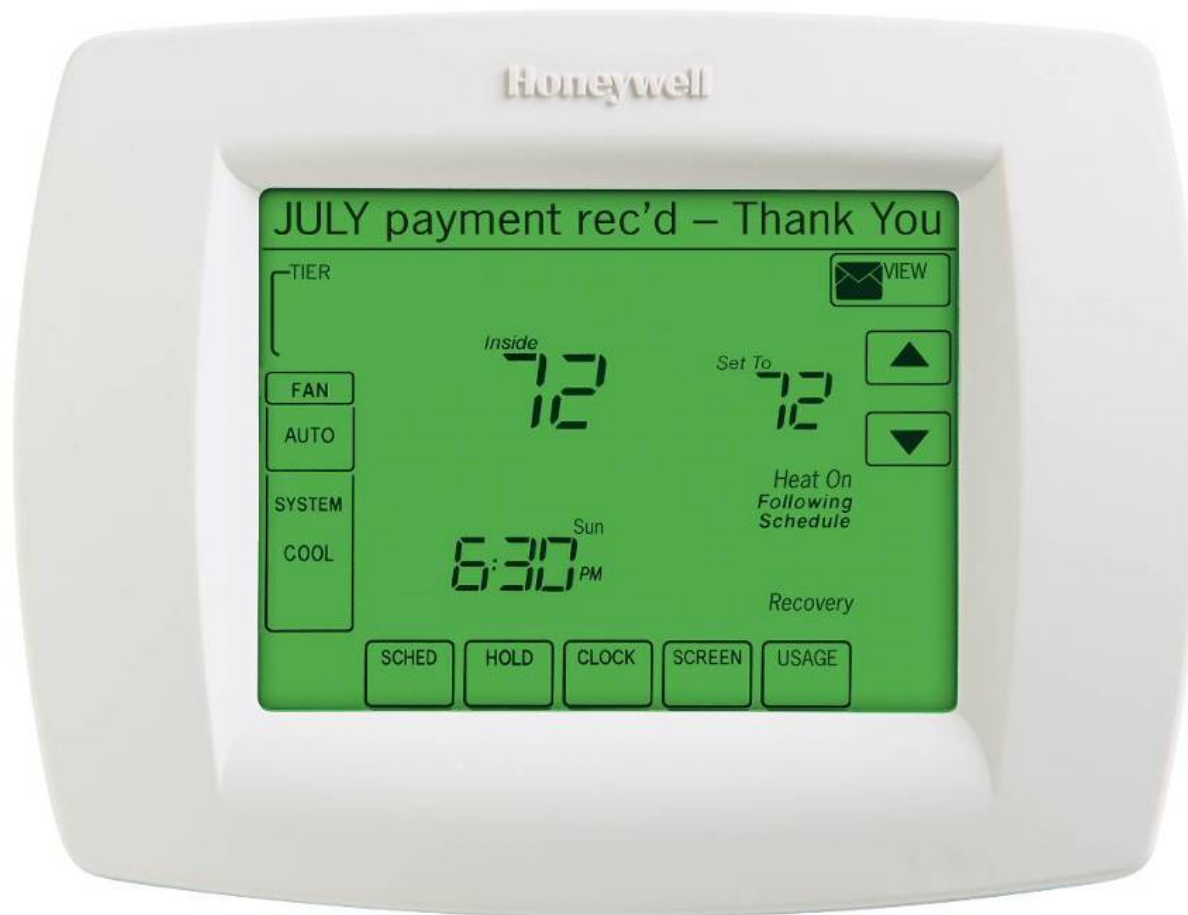


Outlet Timers and Smart Plugs are simple devices that give consumers direct automated control of their energy use.





The Honeywell UtilityPRO thermostat is a typical PCT. It communicates to the utility for load control and messages, but does not link directly to a smart meter for consumption information.





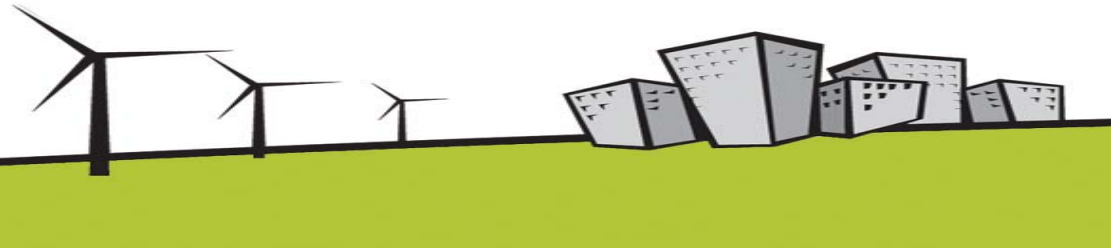
The smart thermostat from ecobee, of Toronto, has a touch screen and more advanced energy management features than a typical PCT.





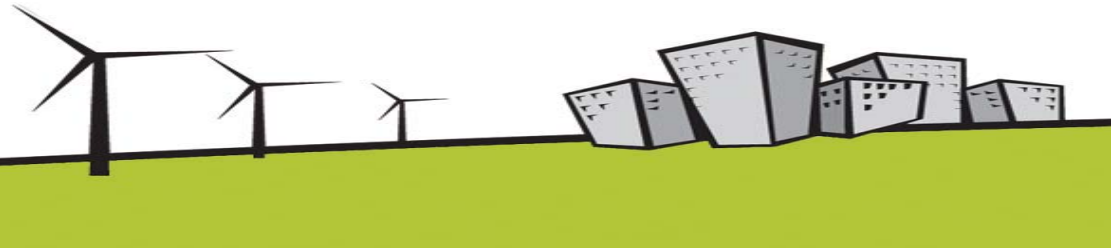
General Electric recently announced its entry into the HEMS market with the GE Home Energy manager.





A typical load control device, this one controlling a clothes dryer, has no display capabilities





Prepayment Metering Systems





PG&E uses the Aclara Energy Analyses to provide their customers with more information about their energy usage on website.

The screenshot shows the PG&E Home Energy Analyzer interface. At the top, there is a navigation bar with links for 'your home', 'your business', 'CUSTOMER SERVICE', 'REBATES', 'SAFETY', and 'FIELD WO'. Below this is the 'Home Energy Analyzer' title and the location 'SANTA FE SPRINGS, CA 90670'. The main content area is divided into several sections:

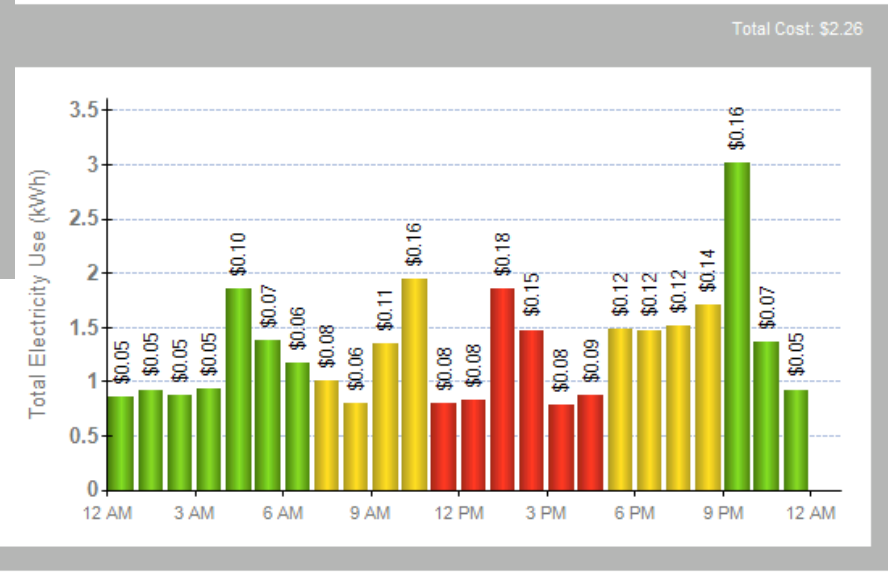
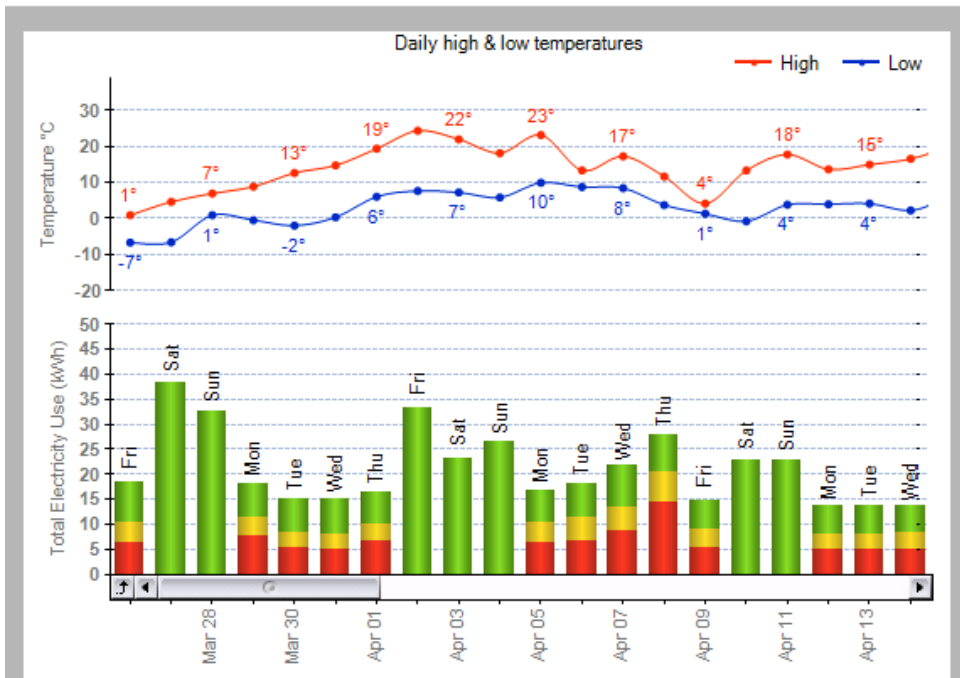
- My Home Energy Center:** A introductory text block encouraging users to explore 'Find ways to save' and 'Energy Calculators'.
- What are my top ways to save?:** A table listing savings opportunities categorized by Water Heating, Lighting, and Heating and Cooling.
- How does my home compare?:** A section showing 'Annual Total Energy Use' of \$1,880, compared to the 'Avg. Home' and a bar chart indicating energy usage levels.
- My Energy Bills:** A section for entering bills to compare energy use.
- How does my home use energy?:** A section with an 'Annual Total Cost' pie chart showing the breakdown of energy expenses.
- My Appliances:** A section for identifying the highest energy expense.
- Seasonal Tips and Tools:** A section with 'Quick Tips' and specific calculators like 'Water Heater Calc' and 'Save on water heating'.

Savings Opportunities	Annual Savings
Water Heating	
Insulate water heater tank	\$2 - \$4
Lighting	
Use compact fluorescent bulbs in recessed fixtures	\$45 - \$56
Use compact fluorescent bulbs in high-use lamps	\$36 - \$44
Heating and Cooling	
Install a programmable thermostat	\$13 - \$21
Seal leaks in ducts	\$17 - \$29

Category	Cost
Pool	\$434
Cooling	\$414
Other	\$350
Hot Water	\$280
Food Storage	\$201
Lighting	\$151
Heating	\$144
Cooking	\$78



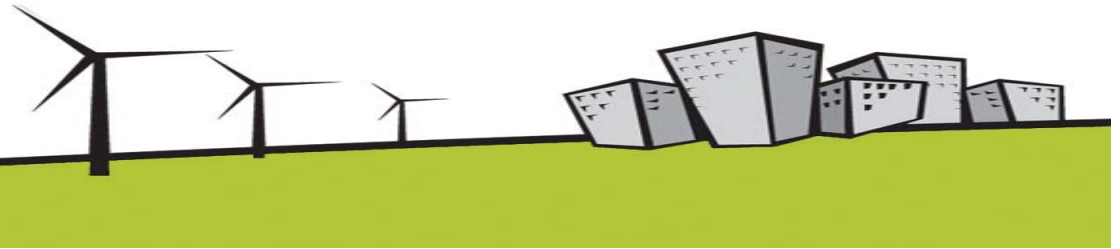
Toronto Hydro provides their customers with graphical displays about their energy usage



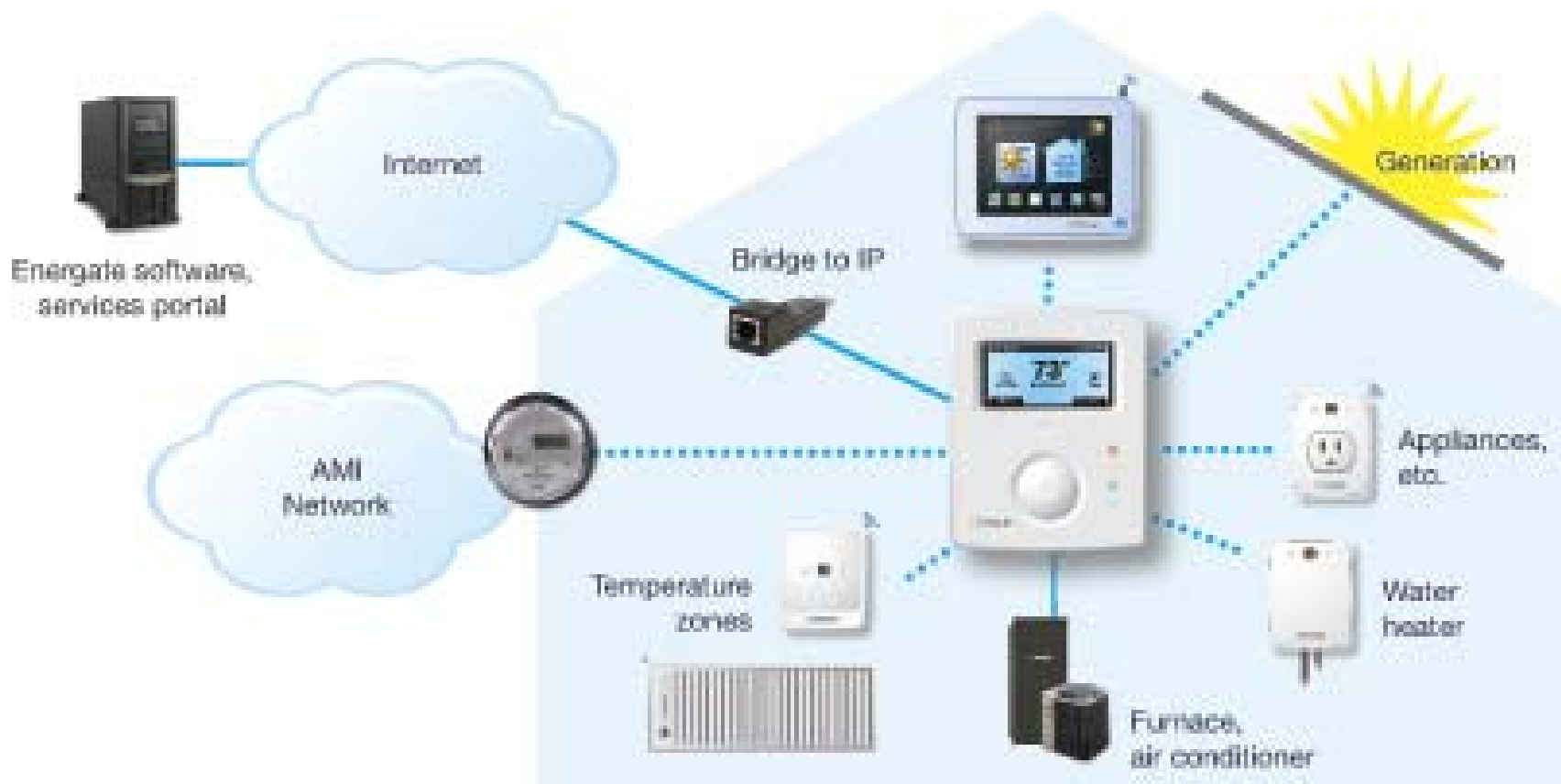


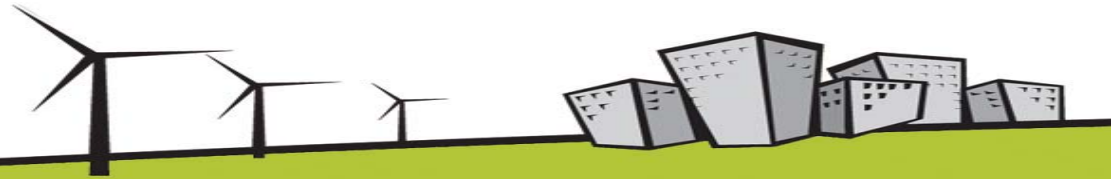
The Crestron home gateway provides central control of entertainment, lighting and other functions around the home with automated with other Crestron and partner products.





Energate Gateway Home Energy Management Systems





Control4 uses an application on the Apple iPad and iPhone to effectively turn them into the control center to manage its home automation suite of products over a Wi-Fi network

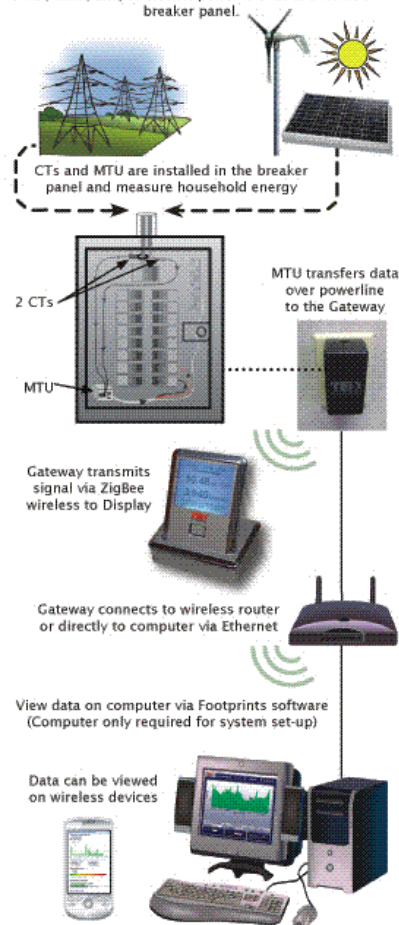


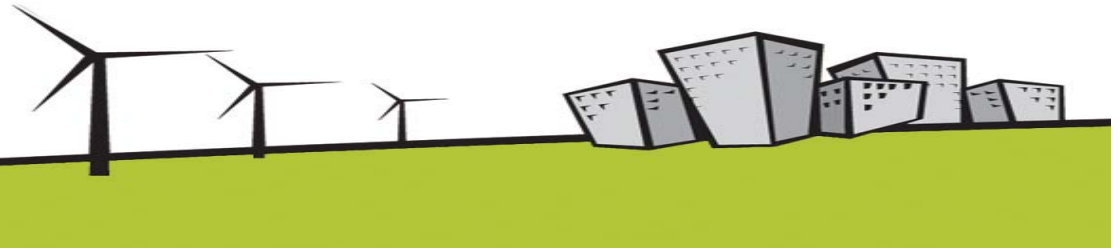


The combination of readings directly from the breaker panel using the TED system and the Google PowerMeter means the consumer has access on their computer to granular and very up-to-date information without any involvement from their electrical utility.

How TED 5000 Works

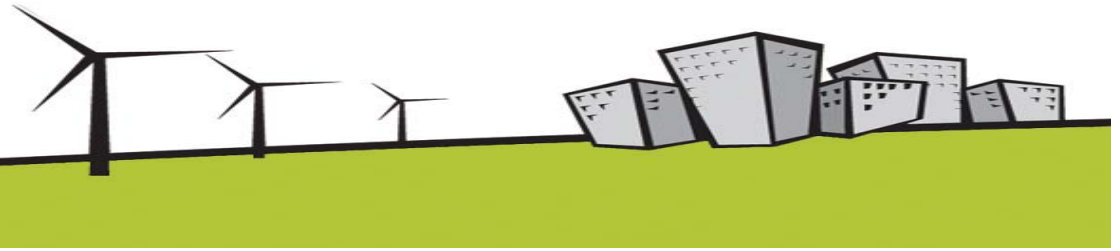
Solar, wind, and/or electric power is sent to a home's breaker panel.





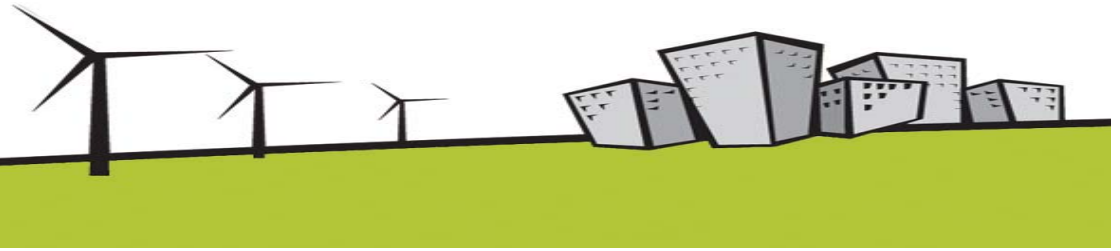
How will the HEMS solutions be Implemented?

Marketing Approach	1. Smart Meter Based	2. Home Energy Gateway	3. Smart Device
Mandatory Program	Very High	Medium	n/a
Incentivized Discretionary Purchase	Medium	Low	Medium
Discretionary Purchase	Low	Low	Low-Medium



Questions?

- ◆ What solution is best?
- ◆ Does one size really fit all?
- ◆ What about the consumer? Who are they? What do they want?
- ◆ What sort of research is still needed? Demographic? Psychographic? Economic? Technological?
- ◆ What pilot projects still need to be done?
- ◆ What issues are still unknown or unclear?
- ◆ Who will pay?



Thank You for your Time and Attention

IBM

Global Center of Competency for Energy & Utilities