Top 20 Technologies and Trends of 2015 - ESource

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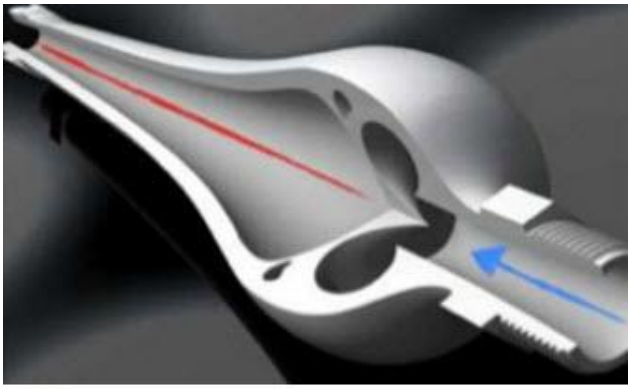
In 2015, potentially disruptive technologies made substantial headway—and headlines—in the energy business. Energy storage hit the market with a bang, led by news of Tesla's new residential batteries. The first plug-and-play thermal storage technology, which makes thermal storage as easy to implement in some facilities as adding a wireless mouse to a computer, added to the growth of the storage industry. Complementing cheap battery storage was the development of potentially ultra-low-cost solar photovoltaics (PV). And supporting ultra-low-cost solar PV was the development of smart PV inverters, which allow utilities to "condition" the power a solar array puts onto the grid. At the same time, electronic devices kept getting smarter: Home energy management, grid-enabled water heating, and smart thermostats have evolved with new features and functionality. On the gas side of the industry, a unique heat-recovery technology is poised to transform the residential furnace market, and ice rink resurfacing just got an efficiency boost from a new water-treatment technology. And last but not least, the growth of the cannabis industry has strained the grid and is one of the factors spurring the development of horticultural-specific LED lighting, which, in turn, is an enabling technology for urban farming. Below, we present 20 of the most exciting, newsworthy, or promising technologies that came to prominence this year.

20. Vortex Water Treatment—Skating to Big Savings
Mary Horsey

Successfully producing a smooth, hard ice surface in ice rinks is not a trivial undertaking. Cold potable water poured on ice will freeze too quickly, trapping air bubbles that cause bumps and cracks on the ice surface. Heating the water before flooding removes the air bubbles, resulting in a smooth, hard surface, but it consumes a lot of energy in the heating and refreezing process.
Thanks to a recent measurement and verification pilot program conducted by FortisBC, we can now report on a new ice-resurfacing technology, vortex water treatment, that reduces the need for hot water, produces a glass-smooth and rock-hard surface, and also reduces the amount of mechanical cooling required to maintain a high-quality ice sheet. The heart of vortex water treatment is a mechanical de-aerating device that uses cavitation to remove air bubbles as water flows through the device (**Figure 1**) and into the resurfacing tank on the Zamboni. De-aerated resurfacing water only requires enough heating to bring it up to 60° Fahrenheit (F) from the city tap water temperature, considerably less than the 140°F required to remove air bubbles. And city water pressure is high enough to push water through the device, so no additional pumping energy is required.

FIGURE 1: Cross section of a vortex water-treatment device

City tap water flows through the device (blue arrow) into the cavitation chamber, where air bubbles are separated out and removed. The de-aerated water flows out of the device (red line) and into the resurfacing water tank.



Source: Realice Canada

The FortisBC pilot reported a natural gas thermal-energy savings of 79 percent when using lower-temperature water for resurfacing. The amount of electric energy required for refrigeration was reduced by 28 percent because the cooler resurfacing water does not raise the temperature of the ice sheet as much as the traditional method. As a result, the ice sheet can be maintained at a temperature that is approximately two to three degrees higher than when hot water is used.

19. Color-Tunable LEDs
Ira Krepchin

One of the distinguishing benefits of LEDs is the ability to tune the color of the light output in a variety of ways:

Dim-to-warm. The color temperature of the light softens to a warmer glow, mimicking what happens when an incandescent lamp is dimmed.
Full-color tuning. Just about any color of light can be produced.
White-tunable color. Color temperature can be varied in a number of ways such as matching daylight spectral variations, correcting circadian rhythms, or influencing mood.

A US Department of Energy (DOE) presentation, Specifying Color Tunable Luminaires: What You Need To Know (link is external) (PDF), provides more details. But the report cautions that standards need to be defined and more research is needed to quantify some of the benefits and risks.
A number of products for both commercial and residential applications are available—for a list of some, see our Tech Roundup – February 2015 web conference presentation. And there's been a recent addition. Toward the end of the year, GE introduced two new bulbs: C-Sleep and C-Life. The first targets bedroom use and varies colors to support natural sleep cycles. The second is a single-color dimmable bulb meant for the rest of the home. Both can communicate with cell phones and tablets via Bluetooth. In another development, tunable LEDs became part of the broadened scope for the Energy Star lamps requirements (link is external) (PDF) scheduled to take effect on January 2, 2017.

18. The Beginning of the End for HFC Refrigerants
Jay Stein

When chlorofluorocarbon (CFC) refrigerants and then hydrochlorofluorocarbon refrigerants were phased out by the Montreal Protocol, beginning in 1991, hydrofluorocarbon (HFC) refrigerants emerged as the most popular chemical for air-conditioning (AC) systems. This development came as no surprise because HFCs are nontoxic, are nonflammable, and offer similar or slightly less-efficient performance than the refrigerants they replaced. HFC refrigerants do have one flaw, though, that is leading inexorably to their demise: They exhibit high global-warming potential (GWP), which, in other words, means that they trap much more heat than an equivalent amount of carbon dioxide. For example, R-410A, which is widely used in unitary equipment, exhibits a GWP of 2,088. R-134a, which is used in high-pressure chillers, exhibits a GWP of 1,430. In contrast, carbon dioxide, which is used as a refrigerant in some commercial refrigeration systems as well as heat pump water heaters, exhibits a GWP of 1. For this reason, when the 197 parties to the Montreal Protocol met most recently in Dubai in November, they agreed to develop an amendment that would effectively phase out the global production and consumption of HFC refrigerants (Figure 2). Four groups (from North America, India, the European Union, and Island States) are circulating proposals for the amendment's language, which is expected to be completed in 2016, and they each call for industrialized nations to begin reducing HFC production in years ranging from 2017 to 2019. For AC markets there are low-GWP refrigerants available, but none are ideal: Hydrocarbons, like propane, are flammable. Ammonia is toxic. Carbon dioxide runs at extremely high pressure. Hydrofluoroolefins are expensive. Nearly all the alternatives are less efficient than HFCs. Even though there's a lot of uncertainty, utilities need not panic. Judging from previous phase outs, the AC industry will adapt, and cooling loads will not be disrupted. The efficiency of cooling equipment will likely decline, though, and it will probably drive interest in improving the efficiency of both cooling loads and auxiliary equipment.
FIGURE 2: Say goodbye to HFC refrigerants
The refrigerant in the can, HFC-134a, will likely be phased out soon, along with all other HFC refrigerants.

Source: Wikimedia Commons
Stephanie~commonswiki

17. Smart Inverters Help Solar Systems Work for Utilities
Logan Jacobson

This year, we've heard a lot of clamor (see #1, Tesla Battery Announcement Overloads the Hype Circuits) about solar and battery systems facilitating a stable, more renewably powered grid, but smart inverters will also play a critical role in integrating solar PVs with the distribution system we all share. This technology adds smarts and communication capabilities to PV systems, enabling utilities to disconnect and reconnect the system to the grid and balance voltage instantaneously. Despite the profound benefits this technology would offer to the industry and the grid, complications and disagreements in communication standards and other requirements hinder its adoption. To help address these issues, the University of California, San Diego, recently hosted a project to demonstrate interoperability between various smart inverters and their PV system counterparts. And the Smart Inverter Working Group, formed by the California Public Utilities Commission and the California Energy Commission, aims to define a set of standards to improve smart inverter implementation. We are unaware of any final decisions, but we look forward to following it in the coming year.

16. Accelerated Growth in Small Commercial and Residential Demand-Management Systems
Jay Stein

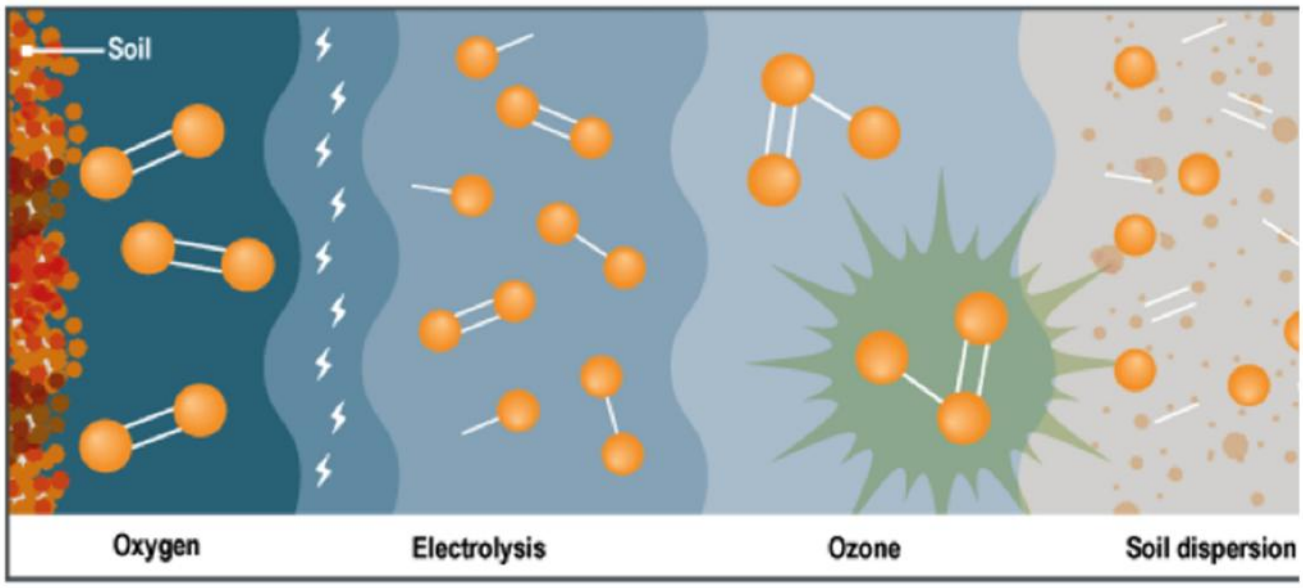
In 2015, ComEd supported legislation in the Illinois legislature that would make it the first major utility to impose demand charges on all customer classes. The legislation is expected to pass in 2016, with new demand charges going into effect in January 2018. As utilities seek new rate structures to balance the costs and benefits of distributed energy resources, other power companies are sure to follow ComEd's lead. As they do, they'll undoubtedly look to new technologies that will enable small commercial and residential customers to manage their demand and soften the blow of the new charges. Research on such systems proceeded apace in 2015 with both Oak Ridge National Laboratory (ORNL) and Purdue University publishing papers on the topic. The systems they developed, which coordinate the operation of AC units and prevent multiple units from operating simultaneously, did well in both field tests and simulations. For example, in the report An Inexpensive Retrofit Technology for Reducing Peak Power Demand in Small and Medium Commercial Buildings (link is external) (PDF), the ORNL researchers estimated their system could be installed for $300 and would pay for itself in less than a year. Field Diagnostics (link is external), a software and services company, incorporated the Purdue algorithm into its Internet thermostat monitoring and control system. Another manufacturer offers a commercialized product that operates in a similar manner: the Toronto, Canada-based Encycle (link is external), formerly known as Regen Energy. In tests conducted by the Sacramento Municipal Utility District in 2012 (Evaluation of Envirogrid: Technology Performance (link is external) [PDF]), the company's controller was found to reduce peak day AC demand by as much as 21 percent in small commercial buildings. We expect to see more products for managing demand in both small commercial buildings and residences come to the fore in 2016.

15. Residential Ozone Laundry
Logan Jacobson

We've been following ozone laundry in commercial applications for some time now—the technology even made an appearance in our Top 22 Technologies and Trends of 2014 list. Since then, we learned about a Nicor Gas pilot for residential customers that will wrap up in 2016. Because the results of this pilot aren't available yet, we are left to reflect on this technology's success in the commercial sector. In this application, two demonstrations found that ozone laundry may save 65 to 91 percent of natural gas consumption and 15 to 70 percent of water consumption.
Ozone is a highly effective biocide that also acts as a cleaning agent by dissolving in water, opening up cloth fibers, and releasing stains (Figure 3). It's typically produced in an ozone generator and introduced into the cold wash water as the clothes washer is being filled. After the wash cycle, the ozone is vented through a carbon tower and absorbed. This technology saves energy and water by operating with less cold water compared to standard machines. Because existing washing machines can be retrofitted with ozone, this technology can also be an effective efficiency measure for machines currently in use.

FIGURE 3: How ozone laundry works

Ozone generated via electrolysis separates soil from fabrics, leaving garments clean and dry.



We're eager to collect the results of the residential pilot; stay tuned to see the evaluation next year. To learn more about ozone laundry and other innovative laundry strategies, see our report Alternative Commercial Laundry Systems: Poised for Big Energy Savings.

14. Horticulture: A Growth Market for LEDs
Ira Krepchin

LEDs offer several features that make them attractive for horticultural applications:
The spectrum of light that they emit can be tailored and, with some products, adjusted over time to provide the optimal wavelengths—properties that can help to improve yield and cut energy use.
LEDs emit little radiant heat, and that feature together with their compact form makes them useable in tight quarters, which is crucial for use in indoor urban farming (**Figure 4**).
Because LEDs emit less heat than conventional lights, the plants will require less water.
If users tailor the light spectrum correctly, fewer chemicals will be required for feeding the plants.
LEDs' long life means less maintenance is required.
With LEDs' desirable properties and the coincidental, increasing interest in feeding humanity via urban or vertical farming and the legalization of cannabis growth in some states, 2015 may be remembered as the year that launched the horticultural application of LEDs. A recent market study by Navigant research, LED Lighting for Horticultural Applications (link is external), predicted that by as early as 2017, LED products would account for more than half of new horticultural luminaire sales. And the application even served as the topic of the keynote address at the DOE's Solid-State Lighting Technology Development Workshop late in the year: Tessa Pocock, of Rensselaer Polytechnic Institute's Smart Lighting Engineering Research Center, noted in the presentation Tuning the Spectrum for Plant Growth (link is external) (PDF) that plants have complex interactions with light. A dozen photoreceptors regulate a range of plant attributes that include flowering, branching, plant height, biomass accumulation, plant immunity and defense, stress tolerance, and phytoceuticals (medicines derived from plants). The fact that the spectral output of an LED system can be controlled gives LEDs the potential to provide big benefits. Pocock envisions that someday LEDs can even be part of a feedback loop in which plants communicate their spectral needs and the lights respond accordingly. For more information on horticultural applications, see the 2015 E Source Forum presentation LEDs in Horticulture: A Growing Application (PDF).

FIGURE 4: LEDs in horticulture
Cool operation and compact size enable LEDs to be used in close quarters; this kind of lighting is becoming more suitable for horticultural operations.

Source: Philips

13. Coming to a Store Near You: Space Heating, Cooling, and Hot Water from a Single Heat Pump
David Podorson

Mini-split heat pumps (MSHPs) have gained popularity due to their high efficiency and easy installation. At the same time, heat pump water heaters (HPWH) have also become more popular because they offer large energy savings compared to electric-resistance water heaters: They're almost 2.5 times as efficient. But HPWHs suffer from much higher initial costs than conventional units because they include the extra expense of a compressor and other elements of the vapor-compression cycle. Because both MSHPs and HPWHs require the same type of expensive components, it's logical to combine them into one unit to save on equipment costs. Enter the multifunction heat pump: one heat pump to provide both space conditioning and hot water to a home. Preliminary tests show high—but not top-of-the-line—efficiency on all fronts. We will have to wait until the product enters the market to see the final retail price, however. To learn more about this new class of product, see our presentation in the Tech Roundup – August 2015 web presentation.

12. The Line Between Home Security and Energy Management Blurs
Essie Snell

As part of the evolution of the smart-home market, residential security and home energy management increasingly seem to be overlapping and even merging. Here are just a few of the developments we followed this year:
Security firm Alarm.com increased its focus on smart home systems that can also encompass energy management, unveiling a new thermostat (see #8, Partnerships and Projects: The Smart Thermostat Market Evolves) and releasing an initial public offering (link is external) to support its expansion beyond its traditional security products.
Nest unveiled its Nest Cam (link is external), a connected security camera (Figure 5), earlier this year to further develop its smart home efforts.
Comcast dramatically ramped up its attempts to forge utility partnerships, getting involved in ComEd's demand-response (DR) initiatives (link is external) in Chicago, Illinois, and even working with Crius Energy (link is external) to sell cobranded packages comprising both energy and television services in deregulated markets.
FIGURE 5: The Nest Cam
The Nest Cam is designed to help improve home security. It can communicate with Nest's thermostats and smoke detectors to record video when users are away from home, and it can alert users to potential sources of smoke.

Source: Nest

These kinds of developments highlight the growing relevance of third-party companies in the energy space. They also show utilities the value in monitoring these organizations and forming mutually beneficial partnerships with them.

11. Plug-and-Play Thermal Storage
David Podorson

What do computer peripherals and thermal-energy storage have in common? Nothing … until now. Introducing the first plug-and-play thermal-energy storage system, created by Axiom Exergy (link is external) for use in supermarkets and other applications with a centralized refrigeration system. Just as a wireless mouse can be connected to a computer and can be detected, configured, and operational with no changes to the system by the user, this method of thermal-energy storage can be easily installed into existing systems. The thermal storage tank appears to the supermarket's refrigeration system as a refrigerated display case, and the load can be charged at night when electricity costs are low. Then, during periods of peak demand, with the storage tanks cooled, the refrigeration system's compressors can be shut off, and the chilled tanks will cool the refrigerant directly, keeping the refrigeration cycle running.

How is this possible? The purpose of the compressors in the refrigeration cycle is to increase the temperature of the refrigerant, so that heat can be dissipated into the surrounding environment. As the refrigerant is brought back to low pressure, the temperature drops and the refrigerant is ready to perform its cooling duties once again. With this new system, when the compressors are shut off, the refrigerant is cooled directly with the thermal-storage tanks, keeping the refrigeration cycle going (albeit with a small amount of energy needed for pumping).

Axiom Exergy claims its system can curtail 100 kilowatts for 6 hours—a load roughly equivalent to that of a small commercial facility. Furthermore, besides reducing supermarkets' high peak-demand charges, the system also offers backup refrigeration in the case of an outage, which could otherwise cost the customer millions of dollars of lost product in a very short amount of time. See our presentation of this technology in the Tech Roundup – August 2015 web conference slides.

10. Is There a Future for Ground-Source Heat Pumps?
Jay Stein

Supporters of ground-source heat pumps (GSHPs) have long argued that the exorbitant cost of in-ground heat exchangers was justified by the improved performance they make possible when compared to air-source heat pumps (ASHPs). Recent improvements in ductless MSHPs, which are a form of ASHPs, are calling that logic into question (**Figure 6**). In the Pacific Northwest, researchers funded by the Northwest Energy Efficiency Alliance monitored 69 homes with ductless heat pumps for a year. The recently published study, Final Summary Report for the Ductless Heat Pump Impact and Process Evaluation (link is external) (PDF), documents their findings that the average heating-season coefficient of performance (COP) estimated for the overall group of heat pumps was 3.0. Even the heat pumps installed in the coldest location, eastern Idaho, exhibited a COP of over 2.8. Meanwhile, Manitoba Hydro conducted an evaluation of its GSHP program, as reported in its report Performance of Ground Source Heat Pumps in Manitoba (link is external) (PDF). After monitoring 10 homes with GSHPs for over a year, the evaluators found that the heat pumps in these homes exhibited an average heating-season COP of 2.8. So considering that GSHPs are much more expensive to install, commission, and maintain, they would have to outperform ductless mini-split units by a fair amount to justify those additional costs. The studies above show that they do not outperform MSHPs, at least not consistently. As a result, when the federal tax credit for GSHPs expires at the end of 2016, we don't see much reason why anyone in a climate with a design temperature higher than about –10°F to –25°F (we're still not yet sure where to draw the line) would choose a GSHP over a ductless mini-split.

FIGURE 6: Outdoor condensing units in cold climates
Now that ductless mini-split heat pumps exhibit heating-season performance that rivals that of much more-expensive ground source heat pumps, we expect to see many more outdoor condensing units in cold climates.

Source: Ildar Sagdejev

9. Transport Membrane Humidifier
Mary Horsey

Recovering low-temperature heat from residential flue gas has long been a dream of energy-efficiency advocates. It is almost painful to see all those BTUs escaping upwards into the sky, but capturing them cost-effectively has been impossible—until recently. The Gas Technology Institute's (GTI's) nanoporous ceramic-tube heat exchanger that we introduced as an emerging technology in our Top 20 Technologies and Trends of 2013 is now being tested and readied for commercialization by Minnesota's Center for Energy and the Environment (CEE). The CEE identified high-efficiency residential heating as one of the biggest energy-savings opportunities in the state, with nearly 800,000 furnace units operating at about 80 percent efficiency. GTI's transport membrane humidifier (TMH) offers the opportunity to transform this market of midrange-efficiency residential furnaces: It can boost furnace efficiency by 15 percent while providing a free source of whole-house humidification. The other efficiency alternative, upgrading to a condensing furnace, would cost much more and wouldn't provide the benefit of humidification.

CEE researchers are installing the TMH in five single-family homes currently equipped with standard-efficiency (78 to 83 percent) furnaces that are representative of typical residential furnace installations. Research staff will monitor and evaluate the units over the course of the 2015 and 2016 heating seasons and use the data to model annualized and lifetime energy savings. Results from the five installations will be extrapolated to the Minnesota market and, along with field observations on design, sizing, and installation, will be used to generate realistic estimates for simple payback periods and market adoption. In addition to quantifying energy savings in the field, CEE's Innovation Exchange will conduct periodic interviews to assess owners' perceptions of comfort and system operation. We look forward to the commercialization of this technology and learning more about the impact that whole-house humidification, a non-energy benefit (NEB), can have in driving program participation and bringing about market transformation.

8. Partnerships and Projects: The Smart Thermostat Market Evolves
Essie Snell

Smart thermostats, defined as programmable digital thermostats with wireless communications that have the ability to implement temperature setbacks during unoccupied periods, continue to flourish. According to Parks Associates (link is external), they already account for nearly half of all thermostat models currently being sold—and more and more utilities are developing and refining the DR and energy-efficiency programs that use these devices. Not surprisingly, 2015 saw several noteworthy developments in the smart thermostat landscape. Some of the highlights follow:

Opower quietly discontinued the smart thermostat offering it had been working on with Honeywell, along with the OpenStat application programming interface (API) it had touted as recently as late 2014. However, the company continues to heavily pursue its residential behavioral DR offerings using existing thermostats in homes.

ComEd, North Shore Gas, and Peoples Gas unveiled an ambitious goal to install 1 million smart thermostats in northern Illinois within the next five years, as announced in it's announcement, Nation's Largest Smart Thermostat Initiative Launched in Illinois (link is external). To reach this goal, the utilities are providing rebates of up to $120 to customers who purchase an ecobee3 or Nest smart thermostat.

SolarCity partnered with Nest to install 10,000 smart thermostats in homes that added rooftop solar systems. The goal of the project was to understand how connected homes could optimize the use of variable solar-power output. For more information, see the Utility Dive article SolarCity Partners with Google's Nest to Integrate Smart Thermostats with Rooftop Solar (link is external).

As part of its push into the smart-home space, security company Alarm.com launched a custom-built smart thermostat (Figure 7) that integrates with home security sensors. It can perform several functions, such as setting the temperature back if it notices that a window or door is open. It also uses more-common energy-saving strategies such as geofencing, occupancy sensing, and learning algorithms.

HVAC manufacturer Carrier made a small equity investment in smart thermostat manufacturer ecobee to further solidify the companies' existing strategic partnership. Ecobee is currently collaborating with Carrier to develop the Wi-Fi-enabled Carrier Cor smart thermostat.

Apple stopped selling Nest thermostats online and in its stores due to their incompatibility with HomeKit, Apple's nascent smart-home platform. In its place, Apple will now promote the HomeKit-compatible ecobee3.

FIGURE 7: The Alarm.com Smart Thermostat

Designed to be a lower-cost smart thermostat that still provides a full range of capabilities to help users save energy and maximize comfort, the Alarm.com Smart Thermostat is just one of the new smart thermostats that emerged in 2015.

Source: Alarm.com

We continue to follow the smart thermostat space closely. For more information on smart thermostat products and technologies available in the market, see Smart Thermostats Rising: Current Technologies and Trends; for information on program design and best practices, see Smart Thermostat Programs: Pros, Cons, and Lessons Learned; and for an overview of all the utility smart thermostat pilots and programs we've identified, see Smart Thermostat Pilots and Programs: A Catalog of Current and Recent Utility Initiatives.

7. Valuing Non-Energy Benefits
Ira Krepchin

Energy-efficiency projects can do more than just cut energy bills—they offer an entire other category of benefits as well, including increased comfort, higher productivity, and higher real-estate value. For end users trying to justify a project and for utilities trying to pass cost-effectiveness tests, the challenge is that those NEBs can be hard to quantify: How do you put a number on comfort or productivity? Consequently, many analyses simply ignore those benefits—but even the roughest estimate of the value of NEBs is bound to be more accurate than crediting them with no value at all. The good news in 2015 was that NEBs are getting increased attention. For example, in October, the Bonneville Power Administration (BPA) published Research Strategy for Valuation of Comfort, Health, Noise Reduction, & Safety Non-Energy Benefits (link is external) (PDF). That report came in response to the Northwest Power and Conservation Council's directive to "increase recognition of non-energy benefits," as stated in its 7th Power Plan Action Plan. The BPA report summarizes some of the research that has been conducted and proposes a method for quantifying NEBs. The focus is on benefits, such as improved comfort, health, and safety, that result from weatherizing and upgrading HVAC systems in single-family detached homes. On the commercial side, a different type of NEB is described in How to Calculate and Present Deep Retrofit Value (link is external) from the Rocky Mountain Institute. The report discusses valuing factors such as higher rents and improved tenant retention that can result from a major energy retrofit. For more information on NEBs see our infographic Non-Energy Benefits Can Tip the Scales in Favor of an Energy-Efficiency Project and our article How are non-energy benefits being included in total resource cost calculations?

6. LEDs Change the Nature of the Lighting Business
Ira Krepchin

LED products can cost a lot and last a very long time, creating a very different business environment than the one that grew around conventional bulbs and fixtures. This year we saw several different approaches to working in this new environment:
Make less-robust products. If it's hard to make a profit selling products that last forever, sell products that don't last as long. One example is a new Philips 60-watt-equivalent bulb that's sold at a price of two for $5. It's still very efficient but rated for only 10,000 hours of life instead of 25,000 hours; it isn't dimmable, either. This "less robust" logic has led Energy Star to lower the bar on lamp life (from 25,000 hours to 15,000 hours) in the new lamp specification that will take effect in the beginning of 2017. Energy Star research (link is external) (PDF) showed that consumers don't value very long life as much as they value first cost and efficiency.
Offer consumer electronics. Make products that consumers view as consumer electronics items. They won't wait until the bulb burns out; instead, they'll buy add-ons or upgrades during that LED's lifetime, as the technology advances (**Figure 8**). There are several "smart" LED products available that could qualify, including Philips' Hue (link is external), Stack Labs Inc.'s Alba (link is external), and LiFx (link is external); about 200 phone apps are now available for the Hue. The Hue can also be linked to Apple's HomeKit system for home automation. The GE bulbs mentioned in #19, Color-Tunable LEDs, will be sold and supported through C by GE (link is external), a new online presence aimed at helping consumers buy and understand the smart bulbs. This year also saw the introduction of Astro Inc.'s Twist (link is external), a lightbulb that can stream music and serve as a speaker. Now, it's not a given that consumers want smart bulbs, but one survey (link is external) by research firm ON World found that one in five respondents own or expect to purchase smart bulbs within the next two years.
Provide lighting as a service. Sometimes facilities can't justify the expense of a system of LEDs and controls, so lighting companies are selling lighting as a service. In this business model, the supplier maintains ownership of the lights and the user pays for the energy consumed. For example, a leading fixture manufacturer, Zumtobel, offers the Now! (link is external) service, which tells its customers they can "receive the best light to perform your tasks, without having to buy any luminaires or having to take care of their operation." And Philips has announced a lighting-as-a-service deal with an airport in Amsterdam, the Netherlands (see the LEDs Magazine article Philips Lighting Supplies LED Lighting As a Service to Amsterdam Airport (link is external)). In a different approach, GE recently moved its commercial and industrial lighting products into a business called Current (link is external), which will emphasize the data-collection and data-analysis possibilities afforded by the sensor and network connections of LED products.

FIGURE 8: More than just a bulb

Products like the Alba from Stack Lighting do more than just provide light—they feature capabilities like color tuning and occupancy sensing. And they can communicate with cell phones and other home-automation devices, moving them into the category of consumer electronics.

5. New Legislation, Products, and Pilots for Grid-Interactive Water Heating

David Podorson

The future of grid-interactive water heating was uncertain as the year began, but after a long decision-making process at the DOE, large-capacity grid-interactive water hears (GIWHs) were allowed to be manufactured and used in utility load management and DR programs. The legislation took effect on April 30, 2015, as part of the Energy Efficiency Improvement Act of 2015, and overruled the previous ban on large-capacity electric-resistance models. Grid-interactive water heating is the consensus term describing real-time, two-way communication between the water heater and the utility, independent system operator, or aggregation entity. The technology allows the water heater to be used as a thermal-storage medium for shifting loads, balancing renewable energy, frequency regulation, and other ancillary services. For more information on the technology, see our report Battery Killers: How Water Heaters Have Evolved into Grid-Scale Energy-Storage Devices.

The year 2015 also saw the introduction of two new water heater control products and new pilot tests. GIWHs have worked very well in a pilot program in Hawaii and a new pilot has begun in Minnesota. New Wi-Fi-enabled smart controllers for electric water heaters have been introduced to the market by Power Over Time Inc. (link is external) and Sunnovations Inc. (link is external) We expect to see more new products and installations in 2016—stay tuned.

4. Pilots for Inexpensive Plug-and-Play Solar
Logan Jacobson

In the February 2015 Tech Roundup, we introduced a Plug and Play PV System from the Fraunhofer Center for Sustainable Energy Systems (link is external) (CSE). This system was successfully installed and commissioned in less than two hours during a demonstration in 2014. A cost analysis indicates the installed cost of a Plug and Play PV System will be a fraction of that of a conventional PV system. The quick, safe, and relatively inexpensive installation is the result of a collection of innovative technologies and strategies including, most notably, the automation of the permitting, inspection, and interconnection process. The system conducts a self-test after installation but before interconnection, verifying compliance to be sure that system components match the system design and are Underwriters Laboratories–listed. The self-test results—and electronic visual documentation of parts of the system such as cable management—are transmitted to the local jurisdiction and utility through a Plug and Play PV Server, with a request for the recipient to approve interconnection. A variety of components can be incorporated into the system, including a solar connection device and conventional or lightweight modules that adhere directly to the roof, string, or micro-inverter (**Figure 9**).

FIGURE 9: Fast installation of rooftop solar panels
During a demonstration, a group of contractors who were not specifically trained in solar photovoltaic installations successfully installed a PV system on a test home in less than two hours. The clever use of premanufactured cables and panels that adhere directly to the shingles instead of relying on a rack mount contributed to this quick and simple installation.

Courtesy of Fraunhofer Center for Sustainable Energy Systems

Since February 2015, the Fraunhofer CSE has completed another successful demonstration in Boston, Massachusetts, and it's planning another in California in early 2016. Next year, the group will run pilots with systems installed on occupied residences. To learn more about this system, visit the Fraunhofer CSE Plug and Play PV Systems (link is external) page. If your utility is interested in participating in the Plug and Play PV System Alliance or Fraunhofer CSE's system pilots, reach out to Fraunhofer CSE to see how you can be involved in the future. In the meantime, we will all anticipate the results of the 2016 pilot.

3. Cannabis Growth Strains the Grid
David Podorson

With the recent legalization of cannabis in some states, owners of cultivation facilities have rushed to increase production and gain market share, and they have often overlooked energy considerations in the process. This trend has created new, large demands for electricity. Cannabis is currently legal in some form in 23 states and the District of Columbia, and some experts predict that another 11 states will soon follow suit. Indoor cannabis-cultivation facilities are huge year-round energy consumers; each marijuana plant requires more energy than seven refrigerators; and each cultivation facility may contain upward of 400 plants. In Washington State, according to the Northwest Power and Conservation Council (link is external), analysts anticipate a load growth of 80 to 160 average megawatts of power over the next 20 years due to cannabis production—the equivalent of a small city. In Oregon, where cannabis was recently legalized for recreational consumption, indoor growing operations resulted in seven blackouts over the course of the summer.
To make matters worse, because cannabis is still illegal on the federal level, no publicly funded research is being performed on ways to mitigate the energy consumption of this industry. The quick growth of the industry, the lack of publicly funded guidance, the strict environmental conditions required to grow the plants, and the inapplicability of standard commercial HVAC practices to cultivation facilities have left contractors in the dark when it comes to designing energy-efficient facilities. E Source has attempted to fill this knowledge gap with the publicly available report Harvesting Energy Savings in Cannabis Cultivation Facilities.

2. The Elephant in the Room: Home Energy Management
Essie Snell

Smart-home technology is rapidly emerging, bringing with it unprecedented opportunities for utilities to collect data on—and control—residential energy end uses. This year, we witnessed the introduction of a host of innovative smart products; new market developments like California's Assembly Bill 793 (link is external), which will promote the deployment of both residential and commercial energy-management technologies; and promising collaborations around smart home platforms from major companies. The first devices compatible with the Apple HomeKit began to trickle into the market in 2015. Nest formed a long list of partnerships with other manufacturers of connected products, ranging from smart-appliance makers such as LG and Whirlpool, to car companies (Mercedes-Benz), lighting manufacturers (Philips), and more-eclectic businesses like watchmaker Pebble and Big Ass Fans, producer of smart ceiling fans. LG even launched a sleek hockey puck—like sensor (**Figure 10**), which can add wireless capabilities to existing dumb appliances.

FIGURE 10: The LG SmartThinQ Sensor
LG's SmartThinQ Sensor is a thin, round device that can attach to many other devices, including clothes washers and dryers, refrigerators, and air conditioners. By sensing vibration and temperature in the appliance, it can deliver data and notifications to users through the SmartThinQ smartphone app, while also facilitating wireless control of the appliances it's attached to.

Although some may view the residential "Internet of Things" as a passing fad that's unlikely to be widely adopted outside of the wealthy millennial niche, recent market research suggests otherwise. For example:
The Shelton Group's 2015 Energy Pulse study (link is external) found that 35 percent of smartphone/tablet owners already manage some home function with a phone app, and 49 percent of the remaining owners plan to do so within the next year.
Icontrol's 2015 State of the Smart Home (link is external) (PDF) suggests that 50 percent of consumers in North America plan to buy at least one smart-home product in the next year.
Business Insider's 2015 Connected-Home Report (link is external) found that shipments of connected-home device are likely to grow "faster than smartphone or tablet device growth," possibly reaching 1.8 billion units shipped in 2019.
For utilities, smart-home devices can offer a broad range of benefits, including increased availability of detailed energy-use data; improved customer engagement; and sophisticated, new load-management and DR functionalities. As disruptive developments like solar PV and battery storage systems become more prevalent in the market, and as utilities' efficiency and carbon-reduction goals become more stringent, the potential to control nearly all major energy end uses in the home may soon become a key part of utilities' strategies for managing the grid. With that in mind, we think utilities would be well served by reaching out to prominent third parties sooner rather than later to start developing partnerships around the smart home.
Interested in digging into this subject even more? E Source has explored this topic from several perspectives:
Home Energy Management Is Coming: Are You Ready? provides an in-depth overview of the space and the potential opportunities for utilities.
From Smart Devices to Smart Homes describes some of the specific home energy-management systems we think are most promising.
The 2015 E Source Forum sessions Unraveling the Smart Home (PDF) and Positioning Your Utility for the Connected Home (PDF) provide even more insights.

1. Tesla Battery Announcement Overloads the Hype Circuits
Jay Stein

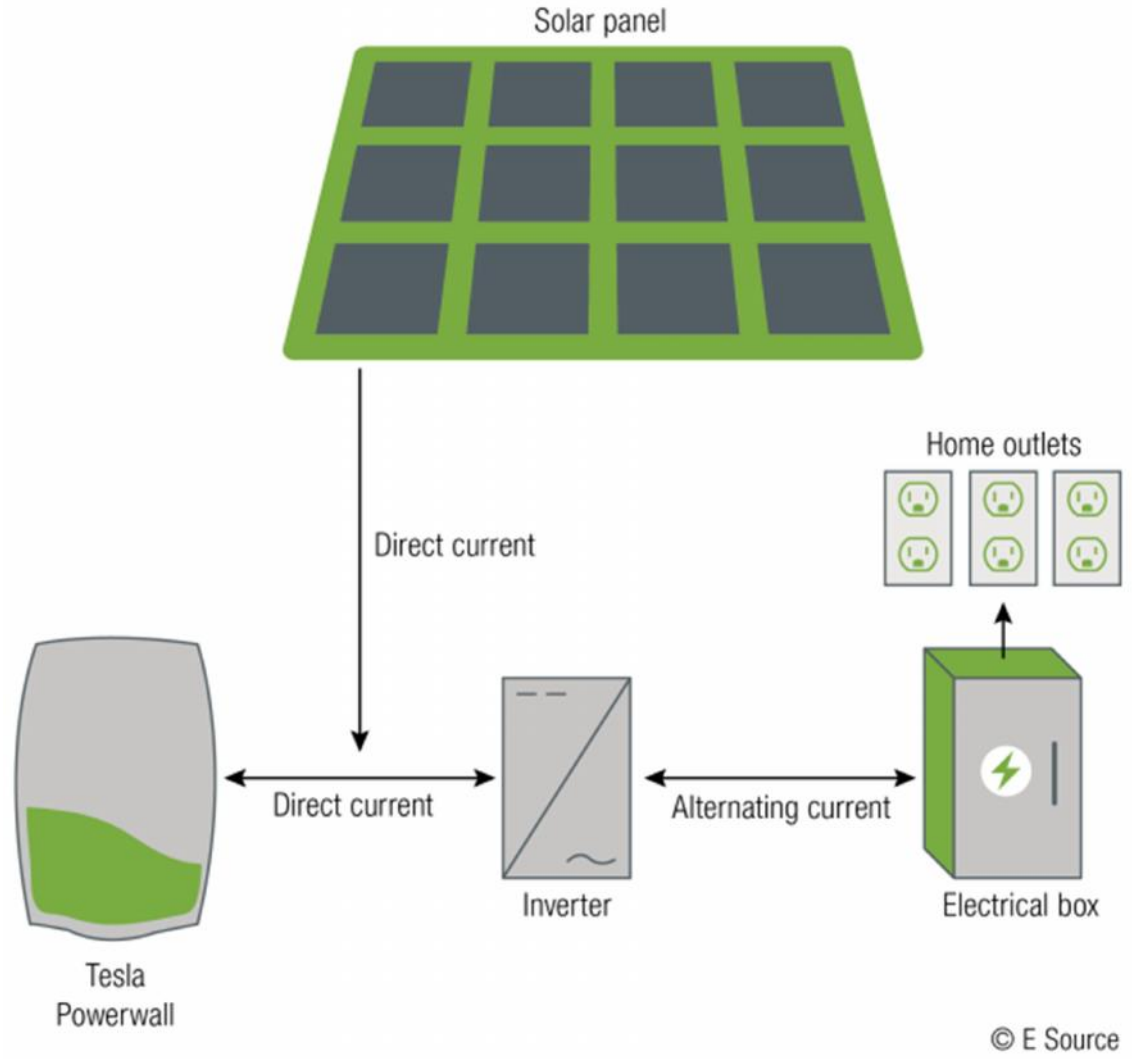
When Tesla Motors' CEO Elon Musk announced the advent of his company's suite of stationary batteries on April 30, he hyped up the product's potential use for solar storage. Musk told the crowd gathered for the announcement, "You could actually go, if you want, completely off the grid. You can take your solar panels, charge the battery packs, and that's all you use." (**Figure 11** illustrates how the battery can be set up at a home.) Numerous news outlets picked up on Musk's enthusiasm and broadcasted predictions that homeowners would combine the new batteries with solar panels, go off the grid, and put electric utilities out of business. In an article titled Why Tesla Won't Disrupt Utilities (link is external), I explained why this nightmarish scenario won't happen, and why only a trivial amount of US homes will become fully autonomous solar generators. However, the lack of a robust domestic solar market doesn't mean that prospects for the Tesla battery line are poor. On the contrary, there are three markets that offer exciting prospects (I explored these points further in a series of blogs, too):

Residential backup. The small natural gas generators that dominate this market have the advantage over the Tesla batteries when it comes to power and energy. Some homeowners, though, will be ready to overlook those benefits to enjoy the simplicity, quietude, and prestige associated with the batteries.

Commercial building demand management. Combined with predictive software, these batteries charge up during times of low demand and discharge during peak times, when monthly demand levels are set. Such systems are popular in California and New York, where state and local utilities collaborate to offer incentives and vendors offer no-money-down financing. As battery prices decline, look for these vendors to expand their operations to other states.

*Grid-scale storage***.** Utilities use large-scale batteries for a variety of applications, such as shifting excess supply to times of higher demand, regulating frequency, supporting voltage, deferring transmission and distribution upgrades, and relieving congestion. Judging from the partnerships that Tesla has forged so far—including agreements with Southern California Edison, AES, and Oncor—it seems the company is well on its way to building the capabilities needed to compete for utility sales. Indeed, on the basis of revenue, it appears that utilities are going to be Tesla's biggest battery customers.

FIGURE 11: Tesla's recommended installation for the Powerwall battery
Tesla recommends the Powerwall be installed on the direct-current side of the inverter, combined with solar panels. If homeowners have the right kind of inverter, then, they won't need separate inverters for both the panels and the battery. Because these installations are more economical, Tesla plans to give such customers priority when the batteries are available to ship.



Even though Tesla generated extensive public interest in its new stationary battery line, it doesn't necessarily follow that those products will be successful. Tesla is investing heavily to get into this business and is in the process of building the world's largest battery factory, which it has dubbed the "Gigafactory." The company's ability to profitably produce batteries at a high volume will heavily depend on how quickly and impeccably it scales up the Gigafactory. It remains to be seen how well Tesla performs at this highwire act and there's good reason to be skeptical. After all, the company has yet to make a profit on its market-leading and beautifully crafted electric vehicles.