EPRI Solutions Custom Report

# Direct Energy Feedback Technology Assessment for Southern California Edison Company

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# Overview

Energy is a common subject these days: costs are up and utilities are exploring the use of more complex rates, such as time-of-use or critical peak pricing. It seems obvious that for energy users to control their use and cost of energy, they need useful, timely information about how and when they are using energy and what it costs them. Yet, such information is rarely available directly for the consumer. No major meter or advanced metering infrastructure/automated meter reading (AMI/AMR) manufacturer provides a real-time in-home display as a standard feature.

Stepping up to the challenge to provide "in-home" energy information are about a dozen, mostly small, young companies that make in-home displays to provide customers direct feedback on their energy use.

A few utilities have demonstration or pilot programs with in-home displays for research purposes. Results just released from the Hydro One pilot suggest a reduction in energy use of 6.5% for residential customers on non-time differentiated rates.

The first part of this report provides the context for energy feedback: what it is, what effects it can have on customer energy use, which utilities have pilot programs, and how the technologies work. The second part of the report gives detailed information on specific real-time direct energy feedback technologies. We concentrate primarily on products that are now available, or soon will be, and that are designed specifically for the energy market. A richer, more creative array of products or product concepts exists in the realm of information display, tangible computing, and informative art. We conclude with a look at some intriguing projects in these areas that could perhaps be adapted to energy applications.

# The Results from Energy Feedback

## Types of Feedback

Feedback is critical to improving performance in any area. Feedback lets us know how we're doing and where we can improve. There are two types of feedback: direct and indirect.

- **Direct feedback** is what a customer can see in real or almost real time. It helps to cement the concept of action and result or consequence. For example, if a customer turns on an electric clothes dryer, a direct feedback device would show that energy use increases dramatically (as does the cost).
- **Indirect feedback** is mediated through another delivery channel. It generally also is time-lagged rather than instantaneous. It may combine several effects. For example, the traditional utility bill does provide usage information, but at such a scale—at least 30 days later and

combining so many end uses (air-conditioning, water heating, cooking, lighting, etc.)—that it is extremely difficult to discern the effects of specific actions or behaviors.

In utility applications, the most common feedback method is the indirect feedback of the service invoice or "energy bill." Often this feedback elicits a dramatic response from the customer—"Oh no, my bill is too high!" or "Look at this bill. What did I do? I hate my utility!"—but it's not really very useful. For example, it doesn't suggest what made the bill so high (left to speculation by the customer) or what the customer can do to change it. In this report, we address technologies that can provide direct feedback at the time the energy is used.

To manage their energy-consumption behavior (and energy costs as well), consumers would ideally have access to two different types of information:

- **Energy prices**. If customers are on rates that change daily or seasonally, it is helpful to have a reminder of energy costs. For time-of-use, critical peak pricing, or real-time pricing programs—in which energy costs may be known only a few hours in advance—some type of price notification system is essential.
- **Energy use and energy cost**. Customers on constant and time-varying rates alike can use information on how much energy they are using and what it is costing. For customers on flat rates, energy use and cost are linearly related, so lowering use automatically lowers cost a corresponding amount. For customers on time-varying rates, the cost information is likely more useful than the use information. With it, a customer can decide, for example, whether it is worth delaying running a dishwasher or clothes dryer until a lower-price time. The most valuable aspect of the information is that it provides customers with feedback on the consequences of their electric "behavior."

## What the literature says

Numerous studies have demonstrated that customers do indeed respond to feedback on their energy use. The "Final Report—California Information Display Pilot Technology Assessment" includes a review of literature from the past three decades and found savings ranging from 1% to 20% when customers were given real-time feedback.[1] Most of the studies, however, found savings in the 4 to 15% range.[2] As noted in the California report, the wide range of results is a consequence of the research, which generally consists of small samples, using various methodologies, and populations that can not readily be compared. Despite the current difficulty in quantifying the precise amount of reduction in energy use, it is clear nonetheless that direct feedback is what makes the link between cause and effect obvious for electric consumers.

Interesting results from the literature review include the following:

- In Europe, where bills are sometimes sent only twice a year, simply providing monthly feedback reduced space heating energy use by 3–9% and electricity consumption by 17–21%.[3]
- The sooner the feedback is delivered, the more effective it is.[4]

- Daily feedback has an impact on heating and cooling. Continuous or real-time feedback affects other energy uses.[5]
- Feedback is most useful in conjunction with a specific goal for the customer, such as reducing energy use by 10%.[6]
- One 1986 study found savings of 4–5% from installing in-home displays in Canadian homes, but no savings from installing the same displays in California homes.[7] The authors note there could be many possible reasons for why Canadians appeared more likely than Californians to respond to conservation programs (Canada had colder winters, higher prices, more and better government conservation programs at the time).
- Northern Ireland Electricity has prepayment meters for about 20% (125,000) of their customers. With training, customers reduced their electricity use by about 11%; without training they still reduced use, but by about 4%.[8]
- Woodstock Hydro in Ontario, Canada has 2,600 customers (25% of their residential customers) on a voluntary pay-as-you-go plan and estimates they use 15–20% less electricity than traditionally metered customers, despite having higher penetration of electric water heating and space heating.[9]
- U.S. prepayment programs seem to achieve 10%–20% energy savings, as documented in an EPRI Solutions Customer Insights 2003 report on prepayment programs.[10] Studies done by the Salt River Project (SRP) in Phoenix, Arizona, which has the largest prepayment program in the U.S. at more than 34,000 participants, have consistently found savings of 10%–15%, with an average of about 12% in its most recent study.[11]
- Customers who purchased in-home displays in New Zealand and Australia are pleased with them. Ninety-two percent (92%) of those surveyed would recommend them to others and 67% reported that they changed their behavior as a result of the device.

The feedback studies, many of them from the 1970s and 1980s, certainly indicate a tendency for customers with real-time energy feedback to reduce their energy consumption. All of these studies involved customers on flat rates, which encouraged people to turn off devices, or to consider whether an amenity was worth the cost.

The largest and most rigorous evaluation on the topic of direct energy feedback was released in March 2006, based on a Hydro One pilot program that began in 2003. Hydro One installed in-home displays in 500 homes and collected data for two and a half years. On average, residential customers reduced energy use by 6.5% with the in-home energy monitor. Reductions were somewhat greater for non-electrically heated homes. These reductions are absent any instructions or incentives for conservation or any pricing signals. The study concludes that if the monitor was combined with other price and/or conservation measures, the impact would be larger.[12] (For additional information, see Hydro One Pilot on p. 5.)

There is little documented experience about providing energy use and cost feedback to customers on dynamic pricing programs. It seems plausible that these customers, who sometimes see rates as high as $1/kWh, would be very motivated to minimize their energy use during these times or shift use to other, lower-price times. At the same time, they might welcome a tool that would help them decide whether the savings are worth the inconvenience.

Keep in mind that expectations about the availability and frequency of information have changed dramatically over the past 30 years. The Internet, cell phones, widespread wireless communications, and paging have become commonplace in recent years. Detailed, up-to-the minute information on bank account balances, baseball scores, stock prices, and myriad other data of interest to consumers is readily available. Thus, customers likely might want and perhaps expect better information about energy use. Likewise, technologies that can automatically reduce or shift energy use are much more common now than they were in the past.

We cannot say definitively how recent technology changes have affected customer desire for and ability to respond to energy-use feedback. But we speculate that customers will become increasingly "information hungry," especially for easy-to-understand data displays that can improve their ability to lower energy costs.

# Why Consider Real-time Energy Feedback Now?

Despite a general consensus that direct energy feedback is an effective tool for changing energy use behavior, it is not widely used. There are only a few companies offering some type of feedback devices, and they are fairly small, young companies providing a niche product. A few utilities, notably in Canada, have deployed them in pilot programs. The technologies and concepts are not new, so considering real-time energy feedback begs the question "why now?"

There are three factors in play currently that prompt consideration of real-time energy feedback now.

- **Dynamic pricing.** An increasing number of utilities are considering dynamic pricing programs. Under these programs, customers face a time-of-use or critical peak pricing rate. On critical peak days, the rate can rise to a super-peak price for a few hours and price notification is essential. Also, being able to see the costs of various energy-using activities can enable customers to reduce their usage during the critical peak and affect peak energy use at the utility level.
- **General conservation.** Utilities are also becoming more interested in general conservation as a component of demand-side planning. Arguably, when customers see that they can achieve savings by turning off lights, adjusting space temperatures, and other actions, they will be more apt to take action to reduce costs and energy usage.
- **AMI/AMR.** Vendors have been promoting AMR for years. Recently, it has been transformed to AMI to reflect the score of services (direct energy feedback, time-varying pricing, remote connect/disconnect, outage notification, load control) enabled by advanced metering. Presenting energy feedback information requires getting the energy use and price data to the customer. Many of the systems currently on the market collect the use from the home wiring

system and have the user enter a fixed energy cost. A more elegant and accurate system collects both use and (changing) price data directly from the meter. Utilities looking at replacing metering and/or meter reading systems would do well to consider direct feedback at the same time. Currently, no major AMI vendor offers an in-home display, though several are talking with AMI vendors about incorporating their products. If a utility were to make an in-home display a requirement for an AMI sale, vendors say they could fairly readily include one.

# In-Home Display Pilots

Although display units have been used in North American prepayment programs for several years, most display units intended to provide feedback for promoting efficiency are new to the market and are installed in only a relative handful of geographic locations. There are probably fewer than 11,000 in-home or small business feedback displays in North America, of which the majority have been purchased and installed by individuals.

Most of the in-home displays on the market work with flat energy rates, though a few can handle time-of-use rates. Moreover, vendors are working with advanced meter manufacturers to develop products that will integrate with metering infrastructure and be able to accurately display energy use and costs for dynamically changing rates such as real-time pricing and critical peak pricing.

In Canada, four utilities and one town are currently conducting pilot programs to establish how having energy information displays affects consumer energy use. **Table 1** summarizes utility pilot programs.

## Hydro One

Pilots are underway at Hydro One, BC Hydro, London Hydro, Newfoundland Power, and the town of Torbay to quantify the effects of in-home displays. The largest is Hydro One, where 500 homes have been equipped with real-time displays. All participants are on a flat-rate, so there is no incentive to shift high energy use activities to another, lower-cost time. Professor Dean Mountain of McMaster University performed sample design and the impact evaluation, which is the most robust study of customer response to direct energy feedback we have seen.

The Hydro One pilot followed 500 participants over two and a half years, from January 2003 through September 2005. Hydro One found an average reduction in energy use of 6.5%.[13] (This sample is large enough to estimate accuracy at a 95% confidence level.) The participants were not given price or conservation incentives, so the 6.5% reduction could be considered as a minimum savings attributable to the feedback device. Also of significance is the fact that the savings persisted over the study period. Participants with electric heat had smaller percentage reductions than customers with non-electric heat. Based on the results of the pilot, Hydro One plans to deploy more in-home display units, on the order of 10,000 to 30,000. Unlike the pilot, customers would choose to have the displays.[14]

### Table 1. Selected in-home display (IHD) pilot projects and programs

| Utility and pilot/project name | IHD device and manufacturer | Dates of trial/program operation | Pilot / program details | Results |
|---|---|---|---|---|
| **Southern California Edison**<br><br>Information Display Pilot | Energy Orb Ambient Devices (adapted by EPRI Solutions, Inc.) | July 2004–Dec 2005 | Part of California statewide Pricing Pilot (SPP)<br><br>Implemented with a subset of customers on CPP variable rate to test whether increased energy info awareness increases response<br><br>Signals sent to Orbs to convey energy pricing status and approach of critical peak to customers<br><br>Information in the form of colors (blue: off-peak, green: peak, red: super peak, flashing red: warning of imminent super peak) | None of the pilot results were statistically significant due to limits of small sample size<br><br>Residential customers showed reduction in energy use during Super Peak and 4-hour warning periods<br><br>Commercial customers, while positive about the program, did not show a consistent impact |
| **Electricité de France**<br><br>Tempo Tariff | Three displays are used:<br><br>Sagem B600 Sagem Communication (SAFRAN Group)<br><br>Two other devices | Ongoing since1995<br><br>Still active, though not open for new enrollment | Days are designated a color via a notification box to express pricing (blue: lowest price, 300 days; white: medium price, 43 days; red: highest price, 22 days)<br><br>Each day has fixed peak and off-peak hours<br><br>Day type determined at end of the day for next day | In pilot program with 800 customers, average daily consumption reduced by 15% on white days and 45% on red days<br><br>Participants shifted 30% more energy use from peak to off-peak times on white days as compared to blue days, and shifted even more on red day |

**Table 1. Selected in-home display (IHD) pilot projects and programs (continued)**

| Utility and pilot/project name | IHD device and manufacturer | Dates of trial/program operation | Pilot / program details | Results |
|---|---|---|---|---|
| **Salt River Project**<br>Prepayment program | Customer Information Unit<br>Ampy<br>Powercom (meter and display solution)<br>Motorola | Ongoing since 1994/1995 | With 40,000 participants (or 5% of those who are eligible), the largest active prepayment program in the U.S.<br>Key components include SRP M-Power meter and in-home display unit | Consistently shows 10-15% in savings, with an average of 12.8% compared to control groups (according to most recent study completed within the last 12 months) |
| **Salt River Project**<br>PowerWise | Customer Information Unit (without prepayment slot for smart card)<br>Ampy | Nov 1, 2005–Oct 31, 2006 | PowerWise pilot run by SRP to prove the hypothesis that people with information reduce their consumption (as opposed to reduction caused by prepay disconnections)<br>900 total participants – 450 on PowerWise (on non-TOU basic plan—seasonally differentiated) and 450 in control group (comprised of customers on regular basic plan)<br>Uses same display as SRP prepay program, but without smart card slot and two-way communication capability<br>Customers can discern usage and cost per minute, hour, day, and month and perform benchmark comparisons (that are automatically programmed into the device)<br>Customer bill calculation doesn't perfectly match paper bill<br>25-50 text messages (preprogrammed into the display) provide efficiency tips | SRP will record quarterly analysis and perhaps release a midpoint review<br>Final results will be released in Nov/Dec 2006 |
| **Tacoma Power**<br>PAYGo prepayment project | Customer Interface Device (CID)<br>Dent Instruments | In beta-testing; roll out slated for spring 2006 | PAYGo to exploit Tacoma's fiber network to homes<br>CID offers customers ability to scroll through list of questions to elicit specific information; for example, see how much power/money remaining on account<br>When button pressed, query sent to utility server via fiber network and a nearly instantaneous response displayed on CID screen<br>About 1,000 CIDs are expected to be installed | N/A |

**Table 1. Selected in-home display (IHD) pilot projects and programs (continued)**

| Utility and pilot/project name | IHD device and manufacturer | Dates of trial/program operation | Pilot / program details | Results |
|---|---|---|---|---|
| **Canadian Utilities** (Hydro One, BC Hydro, Newfoundland Power, London Hydro, and the Town of Torbay) | Energy Power Monitor<br>Blue Line Innovations | 2003–2005 | Each utility plans to evaluate quant results and customer acceptance of in-home displays pre-, during, and post-installation<br>Collective sample of nearly 900 participants<br>Distributed IHDs: Hydro One: 500, BC Hydro: 100, Newfoundland Power: 100, London Hydro: 70, and Town of Torbay: 100 | Results released in early 2006 from BC Hydro found average reduction in energy use of 6.5%<br>Savings persisted over study period<br>Participants with electric heat had smaller percentage reductions than customers with non-electric heat |
| **Country Energy** (located in Australia)<br>Home Energy Efficiency Trial (HEET) | First-generation IHD (precursor to EcoMeter)<br>Ampy | Dec 2004–end-2005 | HEET incorporates four electricity prices (8¢ off peak, 12¢ shoulder, 17¢ peak, and 37-38¢ critical peak) that are communicated to trial participants over powerlines via Ampy's first-generation in-home displays<br>200-customer sample size | 30% reduction in demand during CPP events (though only two 1.5-hour CPP events were called)<br>Positive customer reception<br>Widespread bill savings averaging $20/mo<br>As a result of pilot, Country Energy plans to enhance communication link between it and its customers by perhaps moving to general packet radio service (GPRS) |
| **Woodstock Hydro**<br>Pay-as-you-go (PAYG) voluntary program | Customer Information Unit<br>Ampy | Ongoing since 1989 | About one quarter (3,000) of Woodstock Hydro residential customers on the program | PAYG customer use 15-20% less energy than traditionally metered customers, despite having higher penetration of electric water and space heating<br>Woodstock Hydro hasn't studied customers in detail because PAYG is a payment option, not a pilot program, and thus utility does not want to inconvenience customers |

Table 1. Selected in-home display (IHD) pilot projects and programs (continued)

| Utility and pilot/project name | IHD device and manufacturer | Dates of trial/program operation | Pilot / program details | Results |
|---|---|---|---|---|
| **Northern Ireland Electricity (NIE)**<br>Prepayment time-of-day program | Keypad Powershift<br>Polymeters Response Int'l (PRI) | Oct 2003–Sept 2004 | NIE conducted time-of-day trial with 200 prepayment customers<br>All trial participants had a keypad meter that allowed them to access real-time info on current use, past use, credit remaining, and max demand time and rate<br>A control group was on a flat tariff, while a "price message" group was on a time-of-day (TOD) tariff and received price messages on the display during high-price periods<br>The TOD tariff had 3 parts: low overnight, medium during the day, and high during late afternoon/early evening (4-6 pm)<br>NIE has since officially launched a TOD tariff (as of Dec 1, 2005) and has 110 customers on it (without marketing effort) | Customers who received price messages about the high-cost hours reduced consumption during those hours by an average of 11%<br>Over 1/3 of this group used at least 20% less than control group average peak consumption<br>Nearly 25% of the "price message" group achieved 5-10% in bill savings, 15% saved 3-5%, and about 50% saved some amount less than 3%<br>Based on results of the trial, NIE plans to roll out a TOD tariff as an option for all customers in late 2005 |
| **Denver Water Development (DWD)** | Conservation Station<br>Itron | Feb 10 to Aug 23, 2004 | Trial encompassed 45 self-selected residential participants on the same billing cycle<br>In-home displays programmed with specific rate structures to allow participants to approximately calculate gallons used and projected bill<br>Conservation Station devices did not have two-way communication capability; customers pressed a reset button to determine consumption since last reading | Most participants reported little use of IHD unit once they understood the number of gallons they used for different appliances/activities<br>Participants did save water, but not significantly; some used more water when they realized how cheap it was<br>Some customers complained about device's plug-in requirement because they didn't have an available outlet in their kitchens (the preferred room in the house for keeping the display)<br>According to DWD, commercialized Conservation Station could retail for approximately $50; if DWD pursued deployment, utility estimates could conceivably buy units at cost and offer customers a rebate of upwards of 50% |

## SRP PowerWise

On November 1, 2005, SRP kicked off a 900-home pilot program called PowerWise. Of the 900 randomly selected homes, 450 were assigned to a control group and 450 were assigned to a participant group. Participants were outfitted with a PowerWise User Display Terminal (UDT). The device is similar to the one used in the utility's prepayment program, but without a smart card slot and two-way communication capability. (See Table 1, p. 7 for additional information on SRP's prepayment customer interface device.) The homes were primarily single family (95%), averaged 1,950 square feet, and were split about evenly between all-electric homes and gas-heated homes.

The participant-group homes receive marketing materials explaining how to use the PowerWise equipment and encouraging use of the UDT to conserve energy. Separately, the control group is told of SRP's intention to conduct a test program that tracks household electricity use and how changes in the household affect electric usage. The participants take part in telephone surveys at the time of recruitment and again at the pilot's conclusion, 12 months later. The surveys allow SRP to monitor key variables that change during the 12-month period (e.g., a family could be away on vacation for several weeks, thus affecting usage). The participant group receives $25 and movie tickets for the pre- and post-test survey. The control group receives movie tickets mid-way through and $15 after the final survey.

According to Marty Clyde, Senior Principal Analyst at SRP, the PowerWise pilot is being run to test the hypothesis that people equipped with better information and awareness reduce their overall consumption. While the utility's successful prepayment program (which is voluntary and serves over 40,000 residential customers, or about 5% of those eligible) has shown average energy consumption reductions of 12.8%, some consumer advocates have questioned the validity of the savings, asserting that "self-disconnections," triggered when credits are not renewed on the prepayment meter, are the primary driver of the purported drops in usage. "Our belief is our customers on prepay are reducing their consumption because of information awareness," says Clyde. "The UDT makes electricity tangible, minute-by-minute." SRP hopes that the pilot will help determine whether customer awareness, in fact, impacts usage behavior.

PowerWise participants have access to most of the information that SRP's prepay customers have. They can view their usage and cost by hour, day, and month and make daily and monthly comparisons by pushing buttons on the device that have been programmed to perform specific operations They can also use the device, known to customers as "the box," to isolate specific appliances and determine how much they cost to run (this is done by leaving everything constant and turning an additional appliance on to determine the difference). Customers can use a log if they'd like to benchmark results. Separately, SRP programmed 12 pop-up text messages into the UDT that rotate through the display to provide users with energy efficiency tips. For example, participants see statements such as: "Adjust pool timer seasonally." These messages cannot be turned off unless users unplug their UDT. They can, however, quickly change the display by pressing a button to access other screens. The tips are not seasonal due to the necessary amount of programming time that was needed. SRP did not have time to modify this functionality given its pilot schedule.

Everyone in the PowerWise program is on a basic electricity plan, which is a seasonally differentiated flat rate. For the pilot, SRP is not collecting any information via two-way communication, as it does for its prepayment program, but instead is collecting data via walk-by meter reads. SRP is only collecting monthly usage data (kWh consumption) to compare with the control group's consumption and the previous year's consumption. Its focus is to identify energy savings as a result of real-time information. No peak demand or peak pricing data are being collected. The utility also plans to segment usage by demographics.

The monthly usage shown on the display tracks closely with the monthly paper bill, which is the "official record or amount owed." Minor differences between the two occur for two reasons: 1) the display resets at midnight on the first day of the month while a meter read for billing occurs at a slightly different time, and 2) local tax rates across SRP's service territory vary so an average tax rate was built into the UDT to help customers estimate their bills.

The pilot started on November 1, 2005 and will run for 12 months. SRP will analyze data quarterly and may release a midpoint review. Final results will be released at the end of 2006.

# Real-Time Energy Feedback Displays

Feedback displays typically provide information on either energy price (cents per kWh) or energy use (current kW or daily kWh) and cost ($/hour). Price displays need to be in communication with the utility to accurately show changing prices. Energy use displays must obtain actual energy use, either by direct measurement or through communication with the electric meter.

## Price displays

There are few technologies currently available that display energy prices for consumers. This report investigated displays that would be intuitive and easy for the customer to use. Rather than requiring the customer to go to a website for information, we were looking for a device that would subtly alert the customer to changes in energy prices in their home or business.

The Energy Orb™—a glowing globe that changes color with electricity prices—was used by Southern California Edison and San Diego Gas & Electric for a subset of customers in the Information Display Pilot in 2004 and 2005.[15] The orbs were programmed to be blue during off-peak hours, green during on-peak hours, and red during critical peak hours. The orbs also began to pulse red four hours before critical peak began. Altogether, 66 orbs were deployed in the Information Display Pilot. Since the pilot has started, over 2,000 orbs have been purchased by these California utilities for use in ongoing pricing programs.

The Energy Orb was enabled by customized programming of the off-the-shelf Stock Market Orb, manufactured by Ambient Devices. The off-the-shelf Orb is a stand-alone information device designed to display a user-selected channel of information, such as temperature or stock market performance. Inside the Orb are LEDs and a paging receiver. Information is sent to the orb, telling it what color to display. The Orb is easy to understand, but it can not provide layers of information. (Ambient Devices refers to it as a "one pixel" display and has other displays that can convey more information at once, though the more complex displays are less visually appealing and require a bit more effort on the part of the viewer.) At a retail price of $150, plus $7 /month for access to the wireless network that delivers information to the orb (i.e., what color to turn), the Orb is not an inexpensive device.

A few other utilities have looked into using the Energy Orb. National Grid has given about 10 to commercial customers. These Orbs are programmed to show the New England ISO electricity price and to pulse red when National Grid calls a targeted demand response event. National Grid reports some problems with paging coverage. Their most successful installation is in a college, where it is on public display and generates discussion.

## Energy-use displays

Regardless of how they collect energy-use data, in-home energy-use displays have three basic components:

- **Input sensor collects the energy-use data**. The input may come from the meter itself, or via a device that collects data from the meter or from the home circuit panel. The accuracy of the data varies with the type of sensing.
- **Display screen is the part the customer sees**. It displays parameters such as the current electric demand (kW), daily and monthly use (kWh), current cost ($/hr), and daily and monthly cost ($). Some units have algorithms for predicting daily and monthly costs and can compare these to budgets. Some have alarms when parameters exceed pre-set levels.
- **Communication takes place between the sensor and the display unit**. In most cases, the communication is either wireless or by powerline, so the display unit can be positioned and even moved around the house at the user’s convenience. A few units have the display unit hardwired to the sensor. This limits the location of the display unit to within a few feet of the home circuit panel, usually in the garage or basement, which is not an ideal location for frequent reference.

Display units can have one-way or two-way communication. In a one-way system, the display unit is sent data about energy use from the meter or device that measures energy use. To calculate cost, the unit multiplies use by a fixed price (usually input into the display unit by customer, contractor, or utility). Because the display unit is not in direct communication with the utility, it has no way to receive a time-varying price input. Therefore, it cannot show cost of energy use under time-varying rates, and is not well suited for critical peak pricing or other dynamic rates.

If the display is integrated with a metering system that has two-way communication between the meter and the utility, the utility can send the meter the current cost of electricity. Such systems are capable of displaying energy costs in real time, even for critical peak pricing and other pricing programs where prices change throughout the day.

About half a dozen companies sell in-home displays to provide real-time energy feedback to occupants. We divide these into three categories:

- units that collect data from house wiring
- units that collect data directly from the existing utility meter
- units that are integrated with AMR/AMI systems

### Units that collect data from house wiring (via CT)

One way for stand alone, non-communicating in-home displays to sense or measure energy use data is by installing a current transducer (CT) at the customer's circuit panel. CTs clip on to the main wire and do not require removing wires. The CT measures current (amps) and multiplies by volts—which may be measured or assumed, depending on the device—to get watts.

Clip-on sensing must be installed by an electrician and scheduled with the customer (since it's installed at the circuit panel in basement or garage). Installation costs depend on contracts negotiated with electricians, but on average, installation runs between $75 and $200.

These types of devices currently have the most manufacturers and cost from $50 to $200, plus installation. In addition, they share the following basic traits:

- Installation requires getting into the customer's home. Installation time must allow for scheduling and coordinating with the customer's schedule. It could also potentially open up liability issues for utilities, such as finding improperly wired circuit panels.
- Installation can be done without utility participation (or even knowledge) since CT sensing is independent of the meter.
- While fairly cumbersome for existing homes, installation would be easier and less costly during new construction.
- Depending on the type of CT, units may have problems with power factor and report inaccurate readings for motor and electronic loads.

The in-home displays in this category present energy use in different ways. Some show instantaneous use only; others project a total monthly bill. The displays also have different types of communication between the sensor and the display. Some are hard-wired, requiring the display to be within a few feet of the circuit panel. Some communicate via powerline, so the display can be plugged into any home outlet. Still others use wireless communications, so the battery-operated display can be moved anywhere in the house.

There are four vendors of CT-based sensing displays, and about 21,000 units installed (the majority in Australia and New Zealand). In-home displays that collect data from the home wiring are unlikely to appeal to utilities for large-scale implementation in existing buildings because requiring access into each customer's home to install them will be too cumbersome. Utilities could, however, encourage their installation in new construction at fairly minimal cost. Likewise, builders could choose to put them in their new homes, as a sort of "energy dashboard." Finally, individuals who want to know more about their home's energy use could purchase them through retail home improvement or electronic stores.

## Units that collect data directly from meter

A second way for stand-alone displays to collect data is via meter-based sensor reading devices. Two types of equipment—optical-read devices and "meter collars"—perform this function.

Optical-read devices attach to the meter, count meter revolutions, and translate them into energy use. Such systems have a slight time lag (less than a minute) built in because they need to count revolutions before they can display use. Optical-read sensing is designed to be installed onto the glass of the existing electromechanical meter. Installation doesn't require an electrician or access to customer premises, so is less costly than CT installation, but it does take a bit of care because the reader must line up with the spinning disk.

There is only one manufacturer of optical-read devices, Blue Line Innovations. They have about 500 units installed with four utilities in Canada. The appeal of the optical-read device—that it can easily be installed on an existing meter—also ultimately limits its usefulness. As utilities replace electro-mechanical meters with solid-state meters, there will be no longer be a spinning disk to read. Blue Line reports they are working with meter manufacturers to develop versions that will work with solid-state meters.

Another company, Energy Control Systems, makes a sensor/transmitter meter collar that installs between the socket and the meter. Installation is performed by a utility meter installer who removes the meter and sets the transmitter into the meter socket and the meter into the transmitter. The transmitter sends meter data to the display unit via powerline.

Either of the meter-based sensing devices has the advantage of showing the customer the same consumption as the meter sees. There are no issues with power factor.

## Units integrated with AMR/AMI systems

In theory, integrating an in-home display unit with an AMI makes sense. The meter would read electricity use instantaneously and transmit the information to the display device. There would be no problem with potential discrepancies between what the utility reads and bills for and what the customer sees. Further, smart meters that communicate with utilities can handle time-varying rates, such as critical peak pricing. And, since the energy consumption comes directly from the meter, the display costs always are exactly the same as the billing costs. In fact, with this system, the bill can be calculated at the meter and sent back to the utility, rather than sending the billing determinants back and calculating the bill at the utility end.

We interviewed several meter manufacturers who indicate willingness to incorporate in-home displays, if they felt there was a market for them. By this, they mean large orders, not a few hundred for a pilot program. However, lacking a clear market, and with other priorities, they are not spending R&D monies to develop in-home displays. According to Sharon Allan, Elster Electricity's Chief Knowledge Officer, Elster will open their meter to a vendor who wants to put communications under glass so the in-home display will work with the meter, but Elster is not planning to develop an in-home display. To get Elster to the table, says Allan, they would need real orders and a clear set of specifications.

# Commercially Available In-home Display Devices

This section describes in-home displays that provide direct energy feedback and are currently on the market. The device profiles encompass a range of brands; they include those whose means of data collection is via house wiring, optical-read sensing systems, meter-based systems, and prepayment systems.

## Units that collect data from house wiring (via CT)

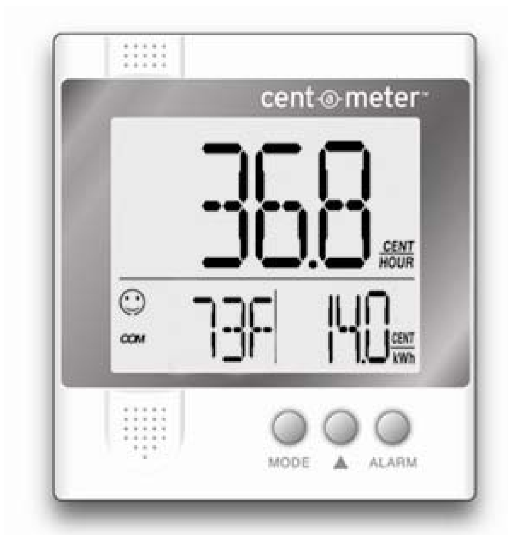
**Table 2** provides an overview of currently available in-home displays that collect data from house wiring via CT.

### Cent-a-Meter (Whitesands Limited and Cenergies)

#### *Description*

The Cent-a-Meter is an in-home display device that looks similar to an indoor-outdoor digital thermometer (see **Figure 1**). It measures electricity use via a clip-on CT. The Cent-a-Meter includes a wireless transmitter and display, which can be moved around the house. The user inputs an average electricity rate and the Cent-a-Meter shows current use (kW) and cost ($). It does not display total usage, so a cost-to-date for the month is not available. This feature was deliberatively omitted, as the utilities that sponsored development of the Cent-a-Meter in Australia felt that having the customer compare Cent-a-Meter readings to utility bills would result in many calls to the utility.

**Figure 1. The Cent-a-Meter**




The Cent-a-Meter is an in-home display device with clip-on CT sensing. It can be moved around the house.

*Source: Whitesands Limited*

**Table 2. Overview of selected in-home display devices, units that collect data from house wiring (via CT)**

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **Cent-A-Meter** | Island Power Pty Ltd. (Cenergies Unlimited, L.P. in U.S.) | Colin Kelly<br>Director/Business Development<br>Island Power Pty Ltd<br>(Whitesands Limited - Distribution Vehicle for U.S. operations)<br>Tel: 61 2 4963 1241<br>colinkelly@smartchat.net.au<br><br>Kent E. Nelson<br>President<br>Cenergies Unlimited<br>9501 Cargo Avenue, Suite 100<br>Austin, Texas 78719<br>Tel: 512.215.4332<br>kentnelson@cenergies.com<br>www.cenergies.com | Clip-on sensor technology<br><br>Movable in-home display w/wireless communications to sensor<br><br>Displays real-time kW, $/hour, temperature, humidity, GHG emissions<br><br>Does not show cumulative readings, e.g., daily or month-to-date use or cost<br><br>Alarm<br><br>Assumes voltage (does not measure)<br><br>Non-communicating, can't handle dynamic pricing | Learn baseline and monitor<br><br>Check unit before leaving house to make sure everything off<br><br>See cost of running appliances | 11,000 sold in Australia and New Zealand<br><br>150-amp version launched in U.S. in spring 2005<br><br>200-amp version (160 amp 2-phase, 240 amp 3-phase) to launch in U.S. in early 2006<br><br>Developing TOU version | ~ $150 | ~ $50-$200<br><br>Requires access to customer's home and electrician or contractor to attach sensor to circuit panel |
| **EUM-2000** | Energy Monitoring Technologies | Juan Gonzales<br>President<br>Energy Monitoring Technologies<br>7516 NW 55 Street<br>Miami, FL 33166<br>Tel: 305-470-9716<br>jgonzalez@energymonitor.com<br>http://www.energymonitor.com | Clip-on sensor technology<br><br>Display hard-wired to circuit panel, so cannot be moved around home<br><br>Displays instantaneous $; kW; daily, month-to-date, and projected monthly $ and kWh<br><br>Calculates projected bill<br><br>Alarm<br><br>Assumes a constant price, suitable for flat rates<br><br>Non-communicating, can't handle dynamic pricing | Learn baseline and monitor<br><br>Monitor projected bill | ~10,000 devices installed in U.S. | $199.50 for whole-house monitor package (2 solid current clips)<br><br>$275 for display packaged w/2 split core current clips<br><br>$175 for apartment version (only one current clip) | ~ $75-200<br><br>Requires access to customer's home and electrician or contractor to attach sensor to circuit panel |

**Table 2. Overview of selected in-home display devices, units that collect data from house wiring (via CT) (continued)**

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **The Energy Detective (TED)** | Energy, Inc. | Dolph Rodenberg<br>President<br>44-G Markfield Drive<br>Charleston, SC 29407<br>Tel: 843-766-9800<br>drodenberg<br>@theenergydetective.com<br>www.theenergydetective.com | Clip-on sensor technology<br>Movable display can be plugged into any electrical outlet (powerline carrier communications)<br>Displays instantaneous $, kW; day, month-to-date and projected monthly $ and kWh<br>Calculates proj. monthly bill<br>Alarms LEDs<br>Programmable for various fixed rate structures (TOU, fixed bill component, taxes, etc.)<br>Non-communicating, can't handle dynamic pricing | Learn baseline and monitor<br>Check voltage<br>Estimate bill<br>Store data and download for additional analysis | Launched spring 2005 | ~ $240 (list price) | ~ $75-200<br>Requires access to customer's home and electrician or contractor to attach sensor to circuit panel |
| **In-Home Energy Assistant (IEA)** | San Vision Energy Technology | Priyan Gunatilake<br>President<br>San Vision Energy Technology Inc.<br>12170 Via Milano<br>San Diego, CA 92128<br>Tel: 858-405-6827<br>priyan@svtinc.com<br>www.svtinc.com | Two-way communications (broadband-enabled) enables demand response functions and relates real-time consumption to cost info<br>LCD instantaneous displays kW, $/hr, $/kWh, day and month-to-date, comparison to previous usage<br>Receives interval-metered data from companion base meter over powerline or broadband-over-powerline network<br>Unique alarm tones sound to convey peak pricing period or load management event<br>Moveable display with wireless capability to meter<br>Plugs into standard 110V wall socket | Learn baseline and monitor use<br>Compare monthly bills<br>Acknowledge critical peak price and load management signaling | In talks with a couple of utilities to deploy pilots of 100+ units during early 2006 | Project cost is dependent on scale:<br>~$350/home for <1,000 units<br>~$300/home for 1,000–10,000 units | Electrician required to install CT coil to base meter in non-AMR environment; typical price runs about $75-$100<br>No installation needed if meter readings read from utility server in an AMR environment<br>Need adapter to directly connect with AMR meter |

Programming the Cent-a-Meter is minimal and fairly straightforward, if one reads the instruction manual. The various displays are viewed by pushing just a few buttons. The Cent-a-Meter displays instantaneous cost ($), use (kW), temperature, humidity, and greenhouse gas emissions (GHG). GHG emissions are calculated using preset pounds of $CO_2$/kWh and do not account for generation source varying over time. There is an alarm if instantaneous use or cost exceeds a pre-set limit.

A next-generation Cent-a-Meter design that integrates features including time-of-use capability (where users could enter several prices to, for example, mimic California's daily peak, off peak, and shoulder rates) is expected to become commercially available in the U.S. during the latter half of 2006.

### *Company and experience*

The Cent-a-Meter is the creation of Wireless Monitors Australia (which owns the patent rights). The device is distributed in New Zealand and Australia by Power Save Marketing Ltd, and in the U.S. by both Whitesands Limited and Cenergies. The product has been actively promoted for just under two years (January 2004 launch in Australia and May 2004 launch in New Zealand) and has garnered a fair amount of local publicity. It has been featured on TV news spots, was a finalist for the Australian Museum Eureka Prize (awarded to companies that, through innovation, seek to "elevate corporate responsibility for scientific endeavor to a level consistent with our national capacity needs"), and is reportedly popular with customers. Many customers use it to make sure everything is turned off. They learn what their regular use is and establish a baseline. Before leaving home, they check to make sure that their use matches with their expectation; if it's more, they go back to see if they've left something on.

A November 2004 telephone survey, conducted by MM Research for Power Save Marketing Ltd, evaluated 207 New Zealanders who had purchased Cent-a-Meters and found that respondents liked the device. In fact, 92% said they had or would recommend the Cent-a-Meter to others. Low-income households were most likely to recommend it, and two-thirds of purchasers reported changing their energy consumption as a result of the in-home display. However, given the sample—people who had bought the Cent-a-Meter as a tool to help control their energy costs—it is not surprising that so many reported changing their behavior.

### *Installation*

Installation in the U.S. requires a licensed electrician because CTs are attached at the circuit panel. The wires go to a transmitter mounted on the wall near the panel. The battery-powered display unit can be placed anywhere in the home and moved as desired.

### *Differentiating features*

The Cent-a-Meter display is fairly large (3" x 4") and easy to read (numbers are 1.5" high). It is wireless and battery-powered, so can be moved around the house. In addition to electricity use and cost, the Cent-a-Meter displays temperature, humidity, and greenhouse gas emissions. Though the latter is not a big selling point for the U.S. market, it is of interest in New Zealand and Australia.

Unlike other in-home displays that use CTs, the Cent-a-Meter does not measure voltage. The CT measures amps and is accurate to +/- 5 percent. The user inputs the voltage. The use, actually calculated by multiplying measured amps by stipulated voltage, accounts for neither voltage fluctuations nor power factor correction. It is therefore less accurate for reactive loads or locations with under-, over-, or variable voltage. This inaccuracy is not likely to be very noticeable to the customer.

In our own trial, we found that the Cent-a-Meter goes through a lot of batteries. The transmitter unit takes three AA batteries which we replaced every three months or so. The display unit used another three AA batteries which lasted about six months. The unit can also be plugged into an outlet.

### *Cost*

The Cent-a-Meter is priced at US$150. Installation costs would vary with location and the contract negotiated between utility and installers, likely in the $75–$200 range.

### *Commercial status and deployment*

As of July 2005, over 7,000 Cent-a-Meters have been installed in Australia and 4,000 in New Zealand through retail outlets, distributors, and utilities. Participating utilities promote the Cent-a-Meter to meet reduction targets for GHG and energy consumption because they find in-home displays to be a relatively low-cost but highly visible way to help achieve these goals. Australian utility AGL offers Cent-a-Meters from its webpage, while others provide links to sales channels. Market penetration is higher in New Zealand than in Australia partly because New Zealand's building code allows homeowners to install the devices themselves, so marketing and sales are handled through retail channels. By contrast, in Australia, installation requires an electrician, so additional marketing and sales must be done via electrical wholesalers and contractors.

Utilities in the two countries take different approaches. Australian utilities don't discount the Cent-a-Meter from retail, so they make a slight margin. As retail electric competition increases, Whitesands expects that the display will be part of an incentive to switch (or stay with) electricity providers. In New Zealand, utilities sell the Cent-a-Meter at a significant discount from retail, so they aren't making a profit on the product. Instead, the driving motivation is to create goodwill.

NPower, a large power provider in the UK, will be offering the Cent-a-meter free to every new customer.

A U.S. launch is planned for 2006. The Cent-a-Meter will be distributed in the U.S. through a newly formed Austin, Texas-based company, Cenergies. The U.S. affiliate is currently working with a Texas utility on a small pilot project and has received inquiries about the Cent-a-Meter from the California Public Utility Commission and the U.S. Department of Energy.

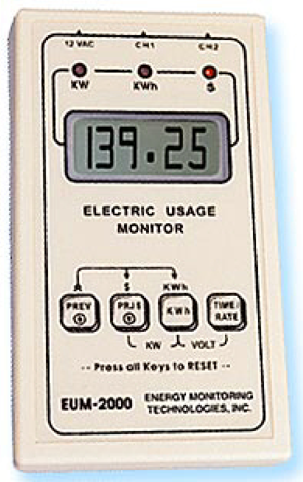
## EUM-2000 (Energy Monitoring Technologies)

### *Description*

Energy Monitoring Technologies' display device, the EUM-2000, displays both instantaneous energy use (kW) and cumulative energy use (kWh) and cost ($). It also calculates a projected energy bill and can show an alarm if projected monthly bill or peak demand exceeds preset levels (see **Figure 2**). Like most other current

CT-based displays, it uses only one electricity rate, and cannot show cost for TOU or CPP rates. The display is hard-wired to the CT and must be located near the circuit panel.

**Figure 2. Energy Monitoring Technologies' EUM-2000**




The EUM-2000 uses clip-on CT sensing. The display must be located near the circuit panel because it is hard-wired to it.

*Source: Energy Monitoring Technologies*

### *Company and experience*

Two former utility employees founded Energy Monitoring Technologies in 2000. Based in Florida, it currently has 12 employees and about 10,000 devices installed. EMT sells to distributors and directly to end-users. EMT is talking to several utilities, but has not yet sold to them.

### *Installation*

Energy Monitoring Technologies suggests using a licensed electrician to install the CTs. This generally takes about 15 minutes. However, split-core CTs can be installed by a handyman or homeowner. The CTs are attached at the circuit panel.

### *Differentiating features*

The EUM-2000 uses a split-core CT that measures both volts and amps, so it can measure and account for power factor accurately. The split-core CT has 7,500 turns and is accurate to +/- 1%.

The EUM-2000 is most often used in the "monthly-bill projection" mode. It calculates average use/minute for the month-to-date and calculates the projected monthly bill. Use and cost for each of the past 60 days is stored and accessible. Versions of the EUM-2000 are also available for individual appliances and apartments.

### Cost

EMT sells a less expensive whole-house monitor package that retails at $199.50. It comes with two solid-core current clips and requires a wire disconnect for installation. For $275, a EUM-2000 display comes packaged with two split-core current clips that do not require wire disconnect for installation. An apartment version (one current clip instead of two) costs $175.

Installation costs depend on local electrician costs, but are similar to other CT-based devices (about $75–$200).

### Commercial status and deployment

Roughly 10,000 EUM-2000 devices have been installed nationwide: 80-90% in residential applications and 10-20% in small businesses. The EUM-2000 does not support 3-phase so there are no large commercial installations.

The EUM-2000 is undergoing a redesign, estimated for release in 2006. The overhauled appearance will move away from the current calculator look and include a large LCD display, though no additional functionality. Energy Monitoring Technologies' primary aim is to reduce EUM-2000's price and make it easier to use. The display is sold online at the company's website, and by several other distributors, including Energy Buddy, Promo Life, and Fuel Cell Store.

## The Energy Detective (Energy, Inc.)

### Description

The Energy Detective (TED) by Energy, Inc. shows instantaneous kW and month-to-date kWh. It is accurate to within 2%. It also projects what the estimated use will be at the end of the month. It can accommodate some degree of programming for more complex rates (such as time-of use, but not critical peak pricing). TED communicates the data via powerline to the display unit, which can be moved and plugged into any outlet (see **Figure 3**). Data displayed include instantaneous use (kW and $), use today (kWh and $), use month-to-date (kWh and $), projected monthly bill, peak demand (kW and $), voltage (current, highest and lowest today), and current electricity rate. A blinking green light flashes when operation is normal. It turns yellow when there is a rate change and turns red when any alarm parameter has been exceeded. TED also has an alarm that can be programmed in various ways: if cost/hour or kW/hour exceeds the limit; if $ per day, kWh per day, month-to-date, or monthly projection exceeds the limit; and for low or high voltage. The alarm mode has an audible beep and a red flashing light.

### Company and experience

Energy, Inc. was founded in 2002. Oak Ridge National Laboratory provided input during TED's development. They participated in several meetings and offered technical advice to Energy, Inc. on design and functionality. By June 2005, the first units were in production. The company markets TED to utilities and home stores and also sells directly to consumers over the Internet. It is also working with homebuilders to get the devices installed in new construction.

**Figure 3. Energy, Inc.'s The Energy Detective (TED)**


Among the information displayed by TED is electricity usage month-to-date and projected monthly usage. It is somewhat programmable for complex rates, such as time-of-use rates, but does not accommodate critical peak pricing.

*Source: Energy, Inc.*

### *Installation*

Like other clip-on devices, TED requires an electrician to install the CTs. Data are communicated to the display device over powerline. The display can be plugged into any standard electrical outlet.

### *Differentiating features*

TED displays instantaneous and month-to-date energy use and cost in a single and easy-to-read display. It also has an audible alarm and red and yellow LEDs. TED stores two months worth of hourly readings.

TED has more functions and is more programmable than the other CT-based displays. The user can input rate details, including flat fees, time-of-use or demand pricing, and taxes. Based on these data, TED can estimate the electric bill accurately. However, there is some discrepancy because the exact time of the utility read varies.

According to President Dolph Rodenberg, future plans include being able to control loads directly from TED and adding communications capability so TED can display costs for dynamic pricing. TED also has a connection directly from the display to USB so the user can download data to a computer for analysis. Energy, Inc. is working with a utility meter manufacturer to have TED built into an AMR meter so that once a new AMR meter is installed, the TED display device can become a communication tool that allows utilities to initiate real-time pricing, and send load-shed signals and message alerts.

### *Cost*

TED Model 1000, which presents detailed electricity consumption information for residential or small business use, has a retail price of $240. The cost to the electric utility is significantly lower. Installation costs are similar to other CT-based devices, at $75–$200.

### *Commercial status and deployment*

To date, Energy, Inc. has performed a small number of installations and claims to be working with several utilities in Canada and along the East Coast on potential pilot opportunities. It sells its TED Model 1000 over its website.

Energy, Inc. is currently developing two additional models. The Model 5000 will be introduced as an enhanced version of the Model 1000, and will be able to communicate with a PC to allow for more sophisticated analysis and graphing of historical data, downloading rates from the Internet, and receiving signals/data from the electric utility via powerline carrier or RF. The TED3 is a forthcoming commercial model that will accommodate three-phase power (up to 400 amps). Both the TED5000 and TED3 will have backlit LCDs to make reading easier. They will also be able to perform load-shed functions. Energy, Inc. expects to release both models by the end of 2006.

## In-Home Energy Assistant (San Vision Energy Technology)

### *Description*

The In-home Energy Assistant (IEA) displays real-time energy consumption and cost display and analysis. We have not worked with the display, but according to the manufacturer, it also has critical peak pricing and load management demand response functionality. It is an internet protocol (IP), broadband-enabled, two-way communication device that can receive metered data from any electronic meter (with an adapter) or from a utility server. Customers must have broadband (delivered via cable, DSL, or BPL). The IEA calculates consumption cost based on TOU rates and price-signaling events.

Work on the IEA began in 2004, when San Vision Energy Technology (SVET) advised a Toronto-based energy company on the development of an in-home display device capable of displaying real-time energy consumption and cost information. A management change at the Toronto concern ended the project, but SVET pushed ahead on its own. In 2005, SVET expanded the IEA's features, completing a second version of the product in September. The new features enable the IEA to support broadband over powerline (BPL) communication (via the HomePlug 1.0, which is an adapter for broadband within the house), critical peak pricing and load management demand response support, and broadband content support. The device, however, does not require a BPL network—it can also receive a broadband signal via cable or DSL.

In information display mode, the IEA's LCD screen displays real-time consumption (kWh/hour), month-to-date (kWh), and cost-to-date ($) for the current billing period, in addition to current temperature, date, and time of day (see **Figure 4**). The device is configured to reset cost and kWh when the utility meter-reading date occurs (this programming is part of the installation process). The device also contains 32kB of flash memory that allows users to keep track of a reference month, e.g., the same month a year ago or last month. Energy use and cost are displayed and compared to the reference month. This information is displayed graphically; for example, green indicates current usage at 0–60% of the reference month, amber 60–90%, and red 90% or more.

**Figure 4. The In-Home Energy Assistant**


In information display mode, the In-Home Energy Assistant displays real-time consumption (kW) and cost-to-date of the current billing period ($). It is also has critical peak pricing and load management demand response functionality.

*Source: San Vision Energy Technology*

A utility can signal a critical peak pricing event to an IEA over broadband. The IEA notifies the customer with blinking red lights, an audible alarm, and a text message on the LCD screen with details of event time, duration, and price. The customer presses a button to acknowledge the event. The acknowledgement is communicated back to the utility. If the customer does not respond during a predefined window of time, then a “no response” message is sent to the utility. In a similar manner, a utility can also send a forthcoming load management event to the IEA. When this occurs, green bars on the display blink while an alarm tone—distinct from the peak time alert—sounds. If customers press “enter,” they acknowledge the event and communicate to the utility that they are willing to participate and reduce their load by a certain amount for credit. If, however, they press any other key on the display, they acknowledge the transmission but signal their unwillingness to participate in the called event. As with the peak time alert, the alarm will continue to sound if customers do not respond at all. In addition to providing customers with the means to convey their intent to reduce load, the “return” button function provides utilities with useful benchmarking data to better understand acknowledgement and participation rates.

The IEA can be plugged in anywhere in the home and also contains a rechargeable lithium battery for back-up power.

### Company and experience

San Vision Energy Technology (SVET) is a 50-person start-up company headquartered in San Diego, CA. It was spun off from IT outsourcing company San Vision Technology in March 2005. SVET's marketing and sales division is based out of the U.S., while the bulk of its employees handle R&D and manufacturing responsibilities in Tamil Nadu, India. The company has two primary focuses: 1) Development and manufacturing of energy efficiency systems (it is the exclusive manufacturer for a patented chiller efficiency module for a Tier-1 HVAC company) and 2) Metering (in addition to the IEA, it has developed an AMR-capable digital electronic meter).

### Installation

A wall-mounted base meter is used to provide interval meter readings to the IEA in a non-AMR environment. The base meter senses the consumption via a CT that attaches to the incoming powerline to the home. Like other CT installations, this requires installation by an electrician at estimated cost of $75–$200.

In an AMR environment, no installation is necessary if the real-time consumption data can be read from the utility meter data server over broadband. Alternatively, an adapter is required to enable direct communication between the customer's AMR meter and the IEA. This adapter may be fitted at the factory or may require a retrofit. The function of the adapter is to convert the meter data to Home Plug 1.0 that can be received by the IEA. This adapter will not affect the behavior of the utility meter or alter its accuracy.

### Differentiating features

The IEA can display both price and use. It is one of the only units that can verify to the utility that the customer has received the price signal. Both of these attributes make it suitable for demand response or critical peak pricing programs.

### Cost

The IEA is currently in preproduction. SVET estimates that orders of fewer than 1,000 units would retail at $350/unit, while orders of 1,000–10,000 would sell for $300/unit. The IEA package includes the display, base meter, and home plug adapter.

### Commercial status and deployment

SVET has not yet deployed any of its units commercially. It is currently in talks with several utilities and hopes to deploy pilots of over 100 units during 2006. It is also exploring integrated metering and demand response solutions with technology companies.

## Units that collect data directly from the meter

**Table 3** provides an overview of currently available in-home displays that collect data directly from the meter.

### Power Cost Display System (Energy Control Systems)

#### *Description*

The Power Cost Display System (PCDS) by Energy Control Systems has two components: the transmitter and the display monitor. It does not use a clip-on CT, but works with the existing utility meter. The transmitter is a collar that sits behind the existing residential utility meter, sensing electricity consumption and sending the data to the display. The advantage of this approach is the display sees exactly the same data as the meter. The PCDS is totally invisible to any metering devices, such as AMR meters, RF transmitting systems for billing purposes, etc. It works with either electro-mechanical or digital meters.

The transmitter is installed between the existing electric meter and the utility meter socket. Meter data are communicated by using powerline transmission protocol to the display monitor. The monitor is very simple. It looks a bit like a digital clock, with two function keys and a bright red LED display. It plugs into any standard electrical outlet (see **Figure 5**). It displays a conversion of the current energy usage into what the energy cost would be for the whole month. That is, the cost displayed is the instantaneous energy use (kW) times the cost (cents/hour) times 24 hours/day times 30 days/month. So, for example, a 100-watt bulb at an electricity rate of 8¢/kWh would show up as $5.76 (100W/hr * kW/1,000W * 24 hrs/day * 30 days/mo * 8¢/kWh = $5.76/mo). The value displayed is thus not accurate in the sense that use is not constant for all hours of the month. Energy Control Systems chose this representation of cost because it is high enough to grab attention. The PCDS will also display power, current, and voltage. It stores no data so the system is not a threat to meter data security. Customers cannot compare readings to bills, so calls to utilities are minimized.

The PCDS bases cost calculations on a flat rate. The designers state they could provide an internal clock to accommodate peak rate pricing into the conversion upon request. But since it has no external communications interface, the device could not respond to critical peak nor calculate costs for real-time rates.

#### *Company and experience*

Energy Control Systems is a start-up company located in Incline Village, Nevada, with fewer than 10 employees.

#### *Installation*

A utility meter installer must install the PCDS since it requires removing the meter. The display monitor is located in the residence, and can be moved around and plugged into any electrical outlet. It communicates via powerline carrier with the PCDS transmitter at the meter. Installation requires only access to the meter, so does not require scheduling with the customer and should be easier and less costly than installing CTs.

Table 3. Overview of selected in-home display devices, units that collect data directly from meter

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **Power Cost Display System** | Energy Control Systems | Bill Littlehales<br>CTO & Inventor<br>Energy Control Systems<br>P.O. Box 3360<br>Incline Village, NV 89450<br>Tel: 775-831-0727<br>wmlit@aol.com<br>www.energycontrolsysinc.com | Transmitter collar installs behind electric meter, in meter socket<br>Movable display device communicates via powerline, can be plugged into any electrical socket<br>Displays instantaneous voltage, amperage, kW, and cost<br>“Cost” shown is monthly cost if all loads currently on ran for entire month<br>Assumes a constant price, suitable for flat rates<br>Non-communicating, so can't handle dynamic pricing | See cost of running appliances | A few devices installed at utilities and builder | $380 in small quantities | Few minutes of utility electrician’s time to pull meter, set transmitter, replace meter |
| **PowerCost Monitor** | Blue Line Innovations | Kent Sargent<br>VP Sales & Marketing<br>1st floor, ICON Building<br>187 Kenmount Road<br>St. John’s, NL A1B 3P9<br>Canada<br><br>Tel: 709-757-3763<br>ksargent<br>@bluelineinnovations.com<br>www.bluelineinnovations.com/innovation.php | Optical-read sensor attaches to outside of existing electromechanical meter<br>Movable in-home display with wireless communications to sensor<br>New display presents near-instantaneous kW and $/hour<br>Slight lag (15 sec–1 min) in displayed parameters, as data sensed through change in spin rate of meter disc<br>Assumes voltage (does not measure)<br>Non-communicating, can’t handle dynamic pricing | Learn baseline and monitor<br>Monitor projected bill | 870 installed through Canadian utilities<br>Planning pilots with NRECA and U.S. IOU in fall 2005<br>Developing version to work with AMI and solid-state meters | $150 | Can be installed by customers |

**Figure 5. Energy Control Systems' Power Cost Display System with meter collar sensing**


The Power Display System uses a meter collar to measure consumption and transmit it to the display, which can be moved around the house. The display shows what energy cost for month would be if current use were constant for the whole month.

*Source: Energy Control Systems*

### *Differentiating features*

PCDS was designed for use as a means to provide direct feedback to residents, from high-end luxury homes to low-income housing. Its display is the simplest of all the monitors studied. It shows only the "estimated monthly cost," though, as noted above, the cost displayed is not a cost a customer would actually pay, but rather a cost if the house ran at current state for a month.

### *Cost*

The PCDS costs about $380 in small quantities. The transmitter is installed behind the meter, so it requires a utility meter installer. Energy Control Systems says the entire installation takes less than five minutes. Installation costs are included in the selling price, as Energy Control Systems will pay the utility for the variable cost of removing and replacing the meter.

### *Commercial status and deployment*

A handful of PCDS units are installed at Southern California Edison, and a few other utilities, according to the manufacturer. Southern California Edison has also tested three units in its meter shop and has found them to be accurate within ANSI guidelines. Energy Control Systems is currently speaking to regional power companies about the possibility of offering the PCDS to their customers.

## PowerCost Monitor (Blue Line Innovations)

### *Description*

The PowerCost Monitor (PCM) displays energy use and cost in near real time (see **Figure 6**). The portable in-home display receives a wireless signal from a battery operated optical-read sensor affixed to the outside of an existing household electromechanical meter. A large format display imparts real-time consumption (kW) information in dollars and cents for the homeowner or resident. There is a slight lag (30 seconds) in displayed parameters because data are sensed through the change in the spin rate of the meter disc. Time and temperature are also displayed. A representation of a spinning disk spins faster as electricity consumption increases.

**Figure 6. Blue Line Innovations' PowerCost Monitor with optical-read sensing**


The Power Cost Monitor senses consumption via an optical reader affixed to the meter and transmits it wirelessly to the display. The display can be moved around the home. It show current cost and month-to-date cost, outdoor temperature, and time. The circle approximates a meter, and spins faster as consumption increases.

*Source: Blueline Innovations*

### *Company and experience*

Blue Line Innovations Inc. is a Newfoundland and Labrador-based firm that intends to develop other real-time feedback technologies to meet demand-side management objectives and save consumers money.

Formed in March of 2003, Blue Line has established relationships with electrical utilities and meter manufactures across North America. The PowerCost Monitor, their lead product, is targeted at the North American installed base of 70 million residential electric meters. Blue Line's Power Cost Monitor is the technology used in the Hydro One pilot discussed on p. 5.

### *Installation*

The PowerCost monitor is designed to be installed by the homeowner. The optical sensor attaches to the outside of the meter glass of the existing household electromechanical meter with a ring clamp. The sensor does not interfere with the ability of utility meter readers and technicians to collect information or service the meter.

In usability studies conducted by Maskery Human Interaction Engineering, an Ottawa, Ontario-based firm hired by Blue Line, subjects rated the installation complexity of the PowerCost Monitor to be on par with bicycle speedometers, thermostats, TVs, and stereos. According to one customer, "It's easier than a modem, more difficult than a toaster." In the Canadian pilots, the utilities did the installation to make sure there were no errors.

### *Differentiating features*

The PowerCost Monitor is the only in-home display designed to be installed by the homeowner or resident. In theory, this means individuals could purchase and install the PCM without any utility involvement. In practice, however, utilities do not like attachments to their meters without their approval, so it is likely utilities would be involved. Blue Line will also deliver PCMs to customers specified by the utility.

The benefit of simple installation is initially very appealing because it works inexpensively with existing meters. Over the long term, though, we expect the optical read device, which only works with electromechanical meters, will have limited usefulness since utilities will be switching to solid-state meters. Blue Line is developing a display that is compatible with solid-state meters that the company expects to have ready within the next 4–6 months

When operated in battery mode, the user can move about with the display in hand to determine the electricity consumption cost of household appliances and lighting fixtures located throughout the home.

Since data are coming directly from the meter, the display accurately reflects power factor and voltage fluctuations on energy consumption.

### *Cost*

The PowerCost Monitor sells for $150. If the customer installs the optical reader, there are no installation costs.

### *Commercial status and deployment*

Nearly 900 PowerCost Monitors are deployed for evaluations at four Canadian utilities (Hydro One, BC Hydro, Newfoundland Power, London Hydro) and Town of Torbay. Blue Line is also planning pilots with the

National Rural Electric Cooperative Association (150 units) and a U.S. investor-owned utility. Blue Line anticipates significant deployments, largely in Canada, on the order of tens of thousands of units, in 2006.

In addition, AMI and solid-state compatible displays are under development with product launches planned for 2006.

## Units integrated with AMR / AMI systems

**Table 4** provides an overview of currently available in-home displays that are integrated with AMR/AMI systems.

### EMS-2020 (USCL)

#### *Description*

The EMS-2020 is a portable display monitor that works with a Landis+Gyr Focus meter with a USCL communications chip under glass. The display and meter work together so this display requires meter replacement. The EMS-2020 display monitor looks a bit like a TV remote control, with the addition of a full color screen (see **Figure 7**). The monitor communicates wirelessly with the metering system. In the optimal configuration, according to USCL, the meter and display unit are part of an integrated utility communications infrastructure, or AMR/AMI network.

**Figure 7. USCL's EMS-2020**

USCL's EMS-2020 is part of an advanced metering infrastructure system. The display communicates with the meter, which in turn has a full two-way communication with the utility. The unit will match the utility bill exactly and can handle critical peak or other dynamic pricing. The display is color and can present graphics.

*Source: USCL*

**Table 4. Overview of selected in-home display devices, units integrated with AMR/AMI systems**

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **EMS-2020** | USCL | Tom Tamarkin<br>President<br>2737 Eastern Avenue<br>Sacramento, CA 95821<br><br>Tel: 916-482-2000<br>tdtamarkin@usclcorp.com<br>http://www.usclcorp.com | Part of AMI system, including remote read and connect/disconnect<br><br>Since data are collected from the revenue meter, will match utility bill exactly<br><br>Moveable in-home display with wireless communications to meter<br><br>Displays instantaneous kW, $/hr, $/kWh, day and month-to-date, projected budget<br><br>Alarm when use exceeds preset use or budget<br><br>Two-way communications (RF network), between utility and EMS-2020 can handle complex, dynamic rates<br><br>Since part of AMI system, requires meter replacement and some geographic density (i.e., not well suited for drop-in, geographically dispersed installations) | Learn baseline and monitor use<br><br>See cost (burn rate) of running appliances<br><br>Monthly bill projection<br><br>Alarm if exceed budget or during peak times | 350-unit pilot currently being installed in Los Angeles County | Cost is dependent on scale:<br><br>$250/home (for 400 units) includes meter and EMS-2020<br><br>Projected ~$175/home for 10,000 units<br><br>RF network $10–30/meter | Utility meter technician can replace meter in a few minutes |
| **EcoMeter** | Ampy Email Metering | Vincent D'Agostino<br>50 Cyanamid Street<br>Laverton Nth VIC 3015<br><br>Tel: 61 3 8368 1622<br>Vincent.D'Agostino<br>@ampymetering.com.au | Part of an automated meter reading system<br><br>4” screen shows electricity, gas, and water $ and usage; GHG emissions; and current electricity prices<br><br>Visual TOU tariff indicator lights show off-peak, shoulder, peak, and critical peak events<br><br>Taxes and other fees not included in projected bill<br><br>Moveable in-home display (wireless) | Learn baseline and monitor use<br><br>Monitor projected bill<br><br>View instantaneous use | Australian product launch planned for 2006 | ~ US$55 | Electrician or contractor fee |

**Table 4. Overview of selected in-home display devices, units integrated with AMR/AMI systems (continued)**

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **Customer Interface Display (CID)** | DENT Instruments | Chris Dent<br>President<br>DENT Instruments<br>64 NW Franklin Avenue<br>Bend, OR 97701-2906<br><br>Tel: 541-388-4774<br>CDent@ DENTinstruments.com<br>www.DENTinstruments.com | Part of system that includes always-on communication network and communicating meter<br><br>Movable display can be plugged into any electrical outlet (powerline carrier communications)<br><br>Display unit is "dumb," lists queries (e.g., What's my current use?); customer selects one and pushes button to send; result displayed nearly instantly<br><br>Utility can remotely program additional queries and languages<br><br>Without utility broadband connection, display can still show any desired parameter available from the electronic meter<br><br>Install with meter replacement (DENT's PowerPal, based on Sensus iCon)<br><br>Works with utility fiber optic, Wi-Fi, or other broadband network for full functionality<br><br>Requires meter replacement or communication with the utility | Learn baseline and monitor<br><br>See cost of running appliances | To be used in Tacoma Power prepayment pilot, 12 installed Sept. 2005, 1,000 to be installed in 2006<br><br>In development: PowerPal meter communicates with in-home display, could be used as standalone system for prepayment or for customer feedback<br><br>If broadband connection to customer exists, could be part of AMI system | ~$300 for meter plus ~$250 for CID<br><br>Next generation cost projected at $200 for quantity of 1,000 | Few minutes of utility meter technician's time to replace meter |

**Table 4. Overview of selected in-home display devices, units integrated with AMR/AMI systems (continued)**

| Technology | Company | Contact information | Description | Typical use | Status | Purchase cost | Installation cost |
|---|---|---|---|---|---|---|---|
| **PowerStat IV and TWACS PowerStat In-Home Display"** | DCSI | Mark Day<br>Executive Director of PowerStat Products<br>DCSI<br>945 Hornet Drive<br>Hazelwood, MO 63042<br><br>Tel: 314-895-6510<br>mday@twacs.com<br>http://www.twacs.com/Support/2004%20Spec%20Sheets/PowerStat.Pdf | PowerStat IV consists of a prepayment meter and display unit<br>DCSI's TWACS system includes AMI, load control, prepayment, and display capabilities<br>In-Home Display (in development) will show daily and monthly energy use and cost<br>In-Home Display will be able to receive demand response or other messages (utility can send either single point or broadcast)<br>TWACS PowerStat In-Home Display requires TWACS AMI powerline communications technology<br>Standard TWACS PowerStat In-Home Display will show periodic information; real-time information will be available but will require a modified meter | Learn baseline and monitor usage<br>See cost of running appliances<br>Regular billing<br>Prepayment<br>Demand response notification<br>General messaging | In mid-1990s, field trial of In-Home Display with existing meter<br>PowerStat prepayment system currently installed in ~30,000 endpoints at ~25 utilities<br>TWACS AMI system installed at ~200 utilities<br>TWACS In-Home Display will be available 1Q '06 | PowerStat cost is ~$450<br>In-Home Display unit for use w/existing TWACS system will retail for ~$100 | TWACS In-Home Display designed to work with existing TWACS AMI system without meter changeout<br>User needs only plug unit in; utility will run software at its end to communicate information to display |

The EMS-2020 display gets data directly from the meter and is programmed with all components of the utility tariff. Because the meter has two-way communication with the utility, it can accurately show energy costs on a critical peak pricing tariff. It is the only display that reportedly presents costs that will match the utility bill exactly. The EMS-2020 can project a monthly bill based on use-to-date and current use. Its budget feature allows the customer to set a monthly dollar budget. An alarm sounds when use is predicted to exceed budget.

For geographically dense areas, the AMR/AMI network can be a fixed radio frequency. For less dense areas, USCL uses a powerline carrier technology. In either case, many additional AMI functions such as remote disconnect, tamper/theft detection, outage reporting, and meter reading are also available.

The EMS-2020 and Focus meter combination can be used without the full AMI network, as a stand-alone in-home device. In this configuration, however, the EMS-2020 would not have two-way communications between meter and utility, so would not be able to show costs for dynamic rates.

### Company and experience

USCL is a metering and communications company located in Sacramento, California. President Tom Tamarkin has long been involved in the areas of AMR and information display and in 1990 formed TAMAR Corporation, an early AMR vendor. In 1992, Tamarkin wrote an article in *Public Power* that was one of the first to posit information display to customers as a potential benefit of AMR: “Utilities can enhance customer relations by selling internal display units to customers that provide up-to-the-minute monitoring of power consumption, in dollars and cents. This can be used as an energy management tool and allows customers to verify and reconcile bills.” USCL has a partnership with an AMR company, Arad Technologies of Israel, for collecting data from electric, gas, and water meters. This partnership gives USCL the ability to integrate a wide-area or fixed AMR network into their product offering.

### Installation

The EMS-2020 is part of a system that includes a new meter and RF wireless communications between the meter and the display unit. Once the advanced metering is in place, the EMS-2020 communicates wirelessly and requires no installation. However, the underlying meter with a chip that communicates with the EMS-2020 as well as the AMR/AMI network requires utility purchase and installation.

### Differentiating features

The EMS-2020 is the most complex in-home display device we encountered. Its full color screen shows bar graphs of energy use. The user can choose from dozens of screens. The most unique feature is that the calculation of the energy cost will match the utility bill exactly, since all tariff components are programmed into the EMS-2020. In fact, USCL says the utility could actually implement “subscriber-side billing”—in other words, calculate the bill at the home or business, even for advanced variable rate structures, and send the bill, rather than just billing determinants, back to the head office.

The USCL system has features beyond the in-home display, such as meter reading, outage reporting, and tamper detection in real time. It can support remote disconnect of service with an additional contactor module. It can also collect data from gas and water meters, all of which can be displayed on the EMS-2020.

If the utility chooses not to implement a full AMR deployment, it can still leverage the EMS-2020, but that will require installing a new meter, since the meter is the data collector for the display. As noted above, without a communication path between utility and meter, the meter/display will not be able to accurately reflect energy costs during critical peak times.

### *Cost*

The cost of the EMS-2020 and whole USCL system is dependent on scale. In small quantities (on the order of 400) the cost for the meter and EMS-2020 is about $250 per home. In quantities of 10,000, USCL projects costs at about $175 per home. Costs for an RF network range from $10-30 per meter, depending on geography and density.

Installation costs are the utility electrician’s time for a few minutes to replace the meter.

### *Commercial status and deployment*

USCL reports that Southern California Edison and the County of Los Angeles will be deploying 350 EMS-2020s in five housing developments in 2006. The company is also engaged in exploratory talks with NYSERDA and ConEd.

## EcoMeter (Ampy Email Metering—part of the Bayard Group)

### *Description*

Ampy’s EcoMeter is an in-home display device that is part of an AMI system. The EcoMeter has a 4” square screen that shows current electricity, gas, and water usage and corresponding cost; and greenhouse gas emissions. It also shows current electricity prices. Past week and month data are also available. Different color lights indicate off-peak, shoulder, peak, and critical peak times. The EcoMeter can also be part of a prepayment system. The EcoMeter can receive and display data from gas and water meters, so customers can see all utility use information in one place.

The EcoMeter also calculates how much a customer will spend in an hour if consumption continues at the current demand level. This allows a customer to see the financial impact, positive or negative, of demand changes (i.e., if air conditioning is turned off). When the meter is read remotely by the utility a message can be sent to the EcoMeter indicating the precise bill amount (and the various components that comprise the total).

The display device receives radio frequency or PLC-based messages, so it can be used anywhere in the house. It also receives price signals, so it can be used with critical peak pricing.

AMPY is also making a stand-alone version of the display (without communications or AMR), which could be sold as a “consumer item” by the utilities as part of an energy-saving initiative. The device would work with AMPY Email meters. A small RF transmitter module would attach magnetically over the meter's optical port and would read the meter’s registers and communicate this information via RF to the in-home display. No complicated commissioning or installation is required.

## Company and experience

The EcoMeter is manufactured, sold, and supported by Ampy Email Metering, a member company within the Bayard Group. The company is dominant in both Australia and the UK metering markets (approximately 70–80% and 40% market share, respectively) and was acquired by private investment firm Bayard Group in 2003 for US$40 million. Bayard also purchased Swiss-based meter manufacturer Landis + Gyr in 2004 and is now the largest electricity metering company in the world. It plans to exploit its market size and global strength to drive advanced/smart metering.

## Installation

With an Ampy email meter in place, EcoMeter installation is as simple as plugging the device in. There are no additional installation costs.

## Differentiating features

The EcoMeter displays information in a straightforward manner. There are separate buttons for energy (electricity and gas), water, greenhouse gas emissions, and comparison graphs (which display cost and energy for today, week, month, and year). Thus, the user has only to push a button, rather than learn a series of buttons and display sequences, to view data. (see **Figure 8**) The EcoMeter is also quite versatile: It can display real-time energy use and cost, as well as current cost via easy-to-understand colors. EcoMeter can be an add-on to an existing AMI system. In Australia, Ampy's high share of the metering market gives it the potential to expedite sales and deployment of the EcoMeter.

**Figure 8. Ampy EcoMeter**

Ampy Email Metering's EcoMeter features separate buttons that display energy (electricity and gas), water, and greenhouse gas emissions. Comparison graphs also convey daily, weekly, monthly, and yearly cost and energy use.

*Source: Ampy*

### *Cost*

Ampy Email expects to retail its EcoMeter at about US$55. Ampy is working with Landis + Gyr North America on a plan to roll out the EcoMeter in the U.S. and Canada by mid-2006.

### *Commercial status and deployment*

Ampy Email initially developed the EcoMeter for the Australian market. Australia faces fairly significant supply and network electricity constraints. Officials expect base load to grow an average of 2.2% annually, and for peak load growth to progress at a 3% yearly clip. Consequently, state governments are in various stages of considering smart metering to ease congestion. To date, a number of geographic regions have either embarked on or announced plans to roll out smart meters (defined as an interval meter only—not necessarily communicating) to customers. Victoria has mandated 100% deployment of smart meters to large businesses by 2008 and all customers by 2013. Energy Australia, a large New South Wales utility, has voluntarily begun smart meter implementation. Other major utilities have undertaken business cases to assess AMI investments.

Country Energy, outside of Canberra, in partnership with Ampy Email and Bayard, is currently running a "Home Energy Efficiency Trial" (HEET) to better understand customers' willingness to change their consumption patterns based on information awareness. Begun in December 2004, HEET incorporates four electricity prices (8¢ off peak, 12¢ shoulder, 17¢ peak, and 37-38¢ critical peak) that are communicated to trial participants over powerlines via 200 of Ampy's first-generation in-home displays. Results have been encouraging, including a 30% reduction in demand during critical peak events—though only two 1.5-hour CPP events have been called, positive customer reception, and bill savings averaging $20 per month.

Ampy Email is participating in a second trial with another utility commencing in December of 2005 that will include 1,300 participants and incorporate TOU and CPP rates. Ampy plans to announce additional details about this second trial.

## Customer Interface Display (DENT Instruments)

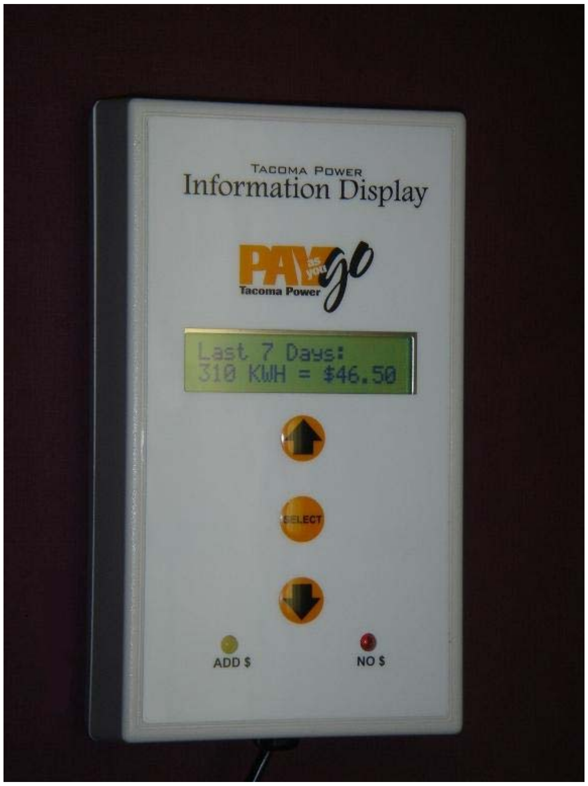
### *Description*

The Customer Interface Display (CI) is a simple unit that communicates with the utility and displays energy feedback and other information. It is being used as part of a prepayment pilot at Tacoma Power, which has a hybrid fiber/coax broadband connection to each house. The meter is connected to this network, so the utility can get data from the meter at any time. The display is connected to the utility via powerline carrier technology that links to the fiber/coax broadband. The user calls up information by scrolling through a list of questions such as "What is my present usage?"; "What was my usage a month ago? (or last year?)"; or "What is my account balance?" The user presses a button at the desired query and the CI sends a signal to the utility server and then displays the response. The CI device itself has little intelligence. It acts as both a web server and web client. The queries themselves reside not on the CI device, but on the utility server. This feature makes it easy for the utility to change or add queries for all customers without having to reprogram individual devices. Typical displays are amount remaining ($ and time remaining), current use (kW and $/hr), yesterday's use (kWh and $), last 7 days' use, and last 30 days' use.

The CI display relies on a broadband network, such as Tacoma's fiber network, to be able to read the meter at any time. DENT Instruments says it could incorporate a wireless receiver into the CI display to replace the powerline communication. However, there would still need to be some kind of always-on network between the utility and the meter to read the meter.

The CI Display also has two LEDs that a utility can turn on or flash to indicate a new message or other account information, for example that the account is running low (see **Figure 9**). For a critical peak pricing tariff, the LEDs could indicate price signals. The utility also has control over the display so that the LEDs could be used to alert the user of a new message, such as a price change, the text of which would then be shown in the display.

**Figure 9. Dent Instruments' Customer Interface Display**




The Customer Interface Display is being used in City of Tacoma's Pre-Pay Metering (PAYGo) program. The device displays amount remaining ($ and time remaining); current use (kW and $/hr); and yesterday's, last 7 days', and last 30 days' use (kWh and $).

*Source: Dent Instruments*

### *Company and experience*

DENT Instruments, formerly Pacific Science & Technology, is a manufacturer of equipment for electronic data acquisition, storage, analysis, and presentation with clients in all 50 U.S. states and over 30 countries. DENT is headquartered in Bend, Oregon.

### *Installation*

The CI Display plugs directly into a standard electrical outlet and requires no special setup. The intelligence resides in the utility server, so the utility simply programs functional queries at the server end. Once the CI Display is plugged in, the user presses the up or down arrow keys to display queries and send to get an answer.

### *Differentiating features*

The CI Display is versatile in that it can display any message from the utility. The device itself communicates, but queries are stored/generated at the utility server. It can easily support multiple languages. When the utility wants to make more information available to the customer, a new query is added to the scroll list. The CI Display requires meters connected to the utility via a two-way, always-on connection.

### *Cost*

The CI Display device costs ~$250. There is no installation cost for the CI Display, since it just plugs in.

### *Commercial status and deployment*

DENT Instruments is working with the City of Tacoma's Pre-Pay Metering (PAYGo) project. Tacoma has a citywide fiber/coax network and is replacing all meters with network-interface meters. Tacoma can remotely read the meters, connect/disconnect power, and perform other functions over the fiber network. For the PAYGo program, Tacoma needed a way to let customers see how much power/money they have left on their accounts. DENT Instruments developed the Customer Interface Display for this purpose.

The technology developed uses TCP/IP protocol over power-line carrier communication. However, it could also be used with a wireless 802.11x "Wi-Fi" network, including one that is city wide—much like those being either considered or run by San Francisco and Philadelphia.

The display technology also has application as part of a stand-alone pre-paid metering system where the CI Display Device communicates over the building wiring to an electronic meter that has no other connection to the utility (e.g., the DENT PowerPal system). In this situation the electronic meter acts as the data server and contains information such as current energy use, historical use, pre-pay account information (if applicable), and so on that the occupant could access.

## PowerStat (DCSI)

### *Description*

The PowerStat IV is a complete standalone prepayment metering system (see **Figure 10**). It consists of a special function meter and disconnect sleeve that communicates with an in-home display device via powerline carrier technology. The display shows the current cost of electricity; the current rate of use; cost of electricity for previous day, week, and month; and amount of credit remaining in the account. These are typical values displayed with prepayment metering systems.

**Figure 10. DCSI's PowerStat IV Display**


The PowerStat IV is standalone prepayment metering system. It consists of a special function meter and disconnect sleeve that communicates with an in-home display device via the powerline.

*Source: DCSI*

CIC Global, which developed the PowerStat, was acquired by DCSI in 2004. In 1995, CIC Global worked on a pilot project with PacifiCorp to provide in-home display of electricity use and cost to about 50 customers. The display device, called the EM-1, was similar to the prepayment display except that it worked with the standard utility meter. It also had LED indicators that would light during peak rate, when the customer was under load control, or when it was projected that the customer would exceed monthly budget. The system used Metricom communications.

According to Ken Anderson, who managed the in-home monitoring program for PacifiCorp, the system worked well. Only 50 were deployed because it was part of a larger AMR project that ultimately did not go forward. The key was to get customers to position the units for easy viewing. To accomplish that meant making them useful to the customer—and useful to the customer meant that they needed to convey more than just electricity use. Had the program continued, Anderson would have had the displays show temperature and time. The displays always had the right time because they were synched with the communications network time. He also found that making the displays fit into the existing décor was important and was working on customized faceplates that included several colors and a clear option that could hold a photo.

DCSI is currently developing an in-home display device—The PowerStat In Home Display—that will communicate using the company's AMR/AMI system, the Two-Way Automatic Communication System, or TWACS. This product will leverage the experience from projects such as the EM-1 and will show daily and monthly energy use and cost, be able to receive demand response or other messages (utility can send either single point or broadcast), and will have the capability to illustrate real-time information (this feature, however, requires a modified meter).

### *Company and experience*

DCSI, a provider of AMR and load control using powerline communication technology, acquired the intellectual property of CIC Global in July 2004. DCSI is currently working on ways to incorporate prepayment and in-home display technology within their AMI system. The PowerStat IV standalone prepayment system continues to be offered and supported by DCSI. The soon-to-be-introduced TWACS PowerStat In Home Display will support prepayment, regular billing, demand response notification, and general customer messaging.

### *Installation*

PowerStat IV installation requires meter replacement.

The TWACS PowerStat In Home Display will plug directly into the wall and communicate via TWACS powerline communications. It will work with existing TWACS AMI systems.

### *Differentiating features*

The TWACS PowerStat works with any existing TWACS-equipped meter. It was designed so utilities with TWACS don't have to replace the meter or make other changes. However, it displays daily data, so cannot provide real-time feedback.

### *Cost*

The PowerStat IV standalone prepayment system, which works only with a replacement meter, costs approximately $450. The TWACS PowerStat In Home Display is expected to debut during Q1 of 2006 and retail for approximately $100.

### *Commercial status and deployment*

The PowerStat standalone prepayment system is currently installed in 30,000 endpoints at over 25 utilities. The TWACS AMI system is installed at 200 utilities. DCSI expects to have the TWACS PowerStat In Home Display available for purchase by mid-2006.

# Other In-Home Displays of Interest

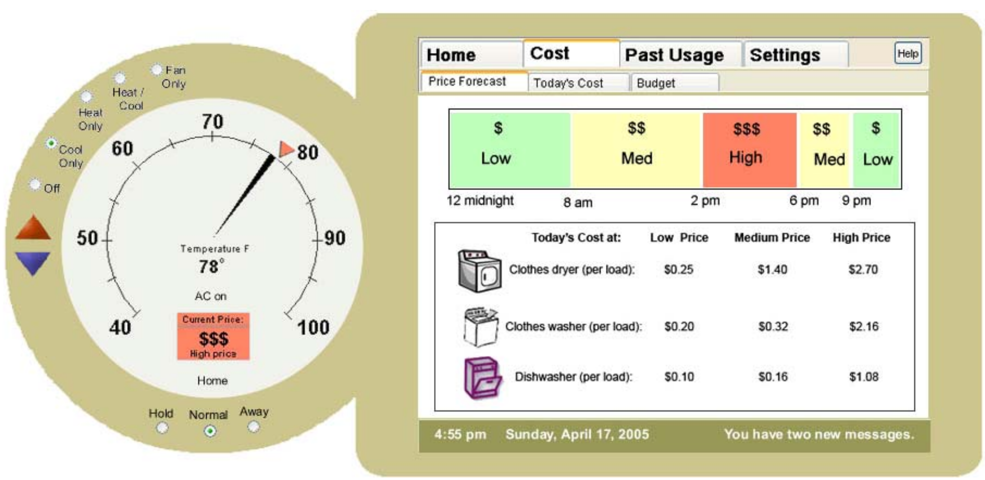
Other in-home displays that could potentially show real-time electricity use and cost are in varying states of development. Some are purely conceptual at this point, while a few have been developed for the water market.

## d.r.e.a.m. (UC Berkeley)

Researchers at the University of California at Berkeley are developing a set of Demand Response Enabling Technologies (DRET). The research is being sponsored by the California Energy Commission's (CEC) Public Interest Energy Research (PIER) program. The Demand Response Electrical Appliance Manager (d.r.e.a.m.) device is one aspect of this research. Although still largely conceptual in form, project lead Therese Peffer envisions the d.r.e.a.m. console serving as the central control system and user interface for DRET technologies, communicating pricing and usage information while simultaneously allowing a user to adjust thermostat setpoints for comfort.

The primary emphasis of the d.r.e.a.m. device is to develop an effective method to communicate electricity cost and consumption information to aid energy users in decision making. To date, the research has produced a rudimentary prototype with wireless system, indoor sensors (including motion, temperature, relative humidity, and power), and outside weather station all hooked up to a home PC. The design for the display has multiple touch screen tabs that relate daily and monthly projected cost and usage data, graphs of electricity use broken out by appliance and price period, programmable electricity use settings, utility text messages, and a screensaver for improved aesthetics (see **Figure 11**). A built in audio speaker sounds alarms.

**Figure 11. The Demand Response Electrical Appliance Manager (d.r.e.a.m.)**




Still a work in progress at UC Berkeley, a conceptual version of the d.r.e.a.m. device has multiple touch screen tabs that relate daily and monthly projected cost and usage data, graphs of electricity use broken out by appliance and price period, programmable electricity use settings, utility text messages, and a screensaver for improved aesthetics.

*Source: University of California Berkeley*

The team is presently testing an in-house network that has wireless sensors and actuators. The network would be one-way or two-way capable, allowing utilities to send price signals and consumers to provide usage information.

During spring 2006, the interface will be tested and more functionality will be added. Possibilities include modulating setpoints to account for outdoor temperature or wind and broadcasting text messages when opening windows would be a good alternative to running air conditioning. The researchers plan to test the full system in six houses in the summer of 2006.

The overall DRET research is geared towards designing and developing enabling technologies for future, mainstream use. As such, the d.r.e.a.m. device is not expected to be commercialized in the immediate future. Estimated device costs will not be assessed for at least another year or so.

For more information: http://www.sims.berkeley.edu/courses/is213/s05/projects/thermostat/.

## Conservation Station (Itron)

Itron is a major provider of AMR networks, both fixed and mobile. It has developed an in-home display called the Conservation Station. Itron does not currently market the Conservation Station and declined to discuss specifics, citing a competitive market. We gleaned some information from Bob Blaveldt, Customer Service Field Manager at the Denver Water Department (DWD), who oversaw a trial run in 2004.

Itron's Conservation Station device is primarily designed for water applications, but it could be adapted to accommodate electric and gas markets (see **Figure 12**). The small display unit allows customers to view both current and projected water use. The device assumes flat rates. If the rate changes, the device needs to be reprogrammed.

The Conservation Station receives readings from an AMR device by radio frequency. The AMR transmits readings every 3 seconds to the display. An embedded chip in the display stores readings every 15 minutes, making it possible for Itron, and conceivably utilities, to analyze customer consumption patterns and more easily identify the possibility of a leak or excessive usage. The device plugs into a standard outlet. Depending on the distance between the meter and the display, the Conservation Station may need a signal repeater to obtain the radio frequency signal from the water meter. A few field trials have tested the signal repeater. The Denver Water Department (DWD) trial, which ran from February 10 to August 23, 2004, was comprised of 45 volunteer residential customers on the same billing cycle. The in-home displays were programmed with block rate structures to allow the device to calculate gallons used and estimated projected bill. In addition to use, the display showed the water rate block price, which depended on water use. The Conservation Station devices did not have two-way communication capability. The Conservation Station estimated bill did not match the actual bill because it did not include customer charges, taxes, and the like. To get the closest match possible, the customer would need to know exactly when the utility was reading the meter and press "reset" on the Conservation Station.

**Figure 12. Itron's Conservation Station**


Itron's Conservation Station is designed for water applications but could be adapted to serve the gas and electric markets. As constituted, the small display unit allows users to view current and projected water use.

*Source: Itron*

Most participants in the DWD trial reported that once they understood the number of gallons they used for different appliances/activities—this took about two months—that they rarely looked at their Conservation Station unit again. Participants did save water, but not significantly. In fact, some people used more water because they had not realized how inexpensive it was. Separately, some customers complained about the device's plug-in requirement because they didn't have an available outlet in their kitchens, the preferred room in the house for keeping the display.

Bob Blaveldt suggests that, based on customer feedback regarding their willingness to pay, a commercialized Conservation Station device could retail for approximately $50. If the DWD pursued deployment, he estimates the utility could conceivably buy the units at cost and offer customers a rebate of upwards of 50%.

## Energy Monitor (Whirlpool)

Several years ago, Whirlpool built a fairly expensive in-home display prototype called the Energy Monitor (EM). It collects and stores whole-house electricity usage in real time. The Energy Monitor is a standalone device that runs Windows CE on an industrial type monitor. A 12" touch screen allows users to see a variety of information (e.g., a particular bar graph denoting kitchen appliance usage broken out). Data are collected from the circuit breaker panel via hard-wired instrumentation. Rather than use a single, whole-house CT, Whirlpool collects data on individual circuits.

The device was used for a small energy visibility and monitoring research pilot conducted in late 2003/early 2004. Whirlpool input specific electric rates to allow users to see energy use and cost. The six homes that participated in the pilot could sign up for time-of-use rates, and the Energy Monitor could calculate off- and on-peak costs. The EM did not project future use or monthly bills.

The pilot showed that appliances do not use as much electricity as most people think—closer to 20%, as compared to an expected 35%. Another interesting finding was that people didn't want to go to their computers to monitor their houses. They preferred a screen mounted on the wall, like a thermostat, or perhaps anticipating plasma TVs. The monitoring device became an integral part of the house—its control panel.

Whirlpool does not sell the Energy Monitor and does not plan to do so. However, it is working with a third party that is developing a whole house monitor. The device is expected to retail at $200–$300 and to have greater versatility such as bill projection. The new unit will not break down appliance usage like the demos previously constructed by Whirlpool.

A future selling strategy might include packaging energy-efficient Whirlpool appliances—most are EnergySTAR compliant—with the electricity monitor for new home construction.

## ORION Water Meter Monitor (BadgerMeter, Inc.)

The ORION Water Meter Monitor is an adjunct to the ORION water meter and AMR system. It was developed in 2003, in response to requests from the cities of Aurora and Arvada, Colorado. At this time Colorado was in the throes of a multi-year drought and the cities wanted an in-home display device that could put water usage and billing information into the hands of their customers.

The ORION Water Meter Monitor is a remote receiver and display that allows consumers to view their water use. It receives RF signals sent from the ORION transmitter, which is part of the AMR system. It works with any water meter connected to an ORION AMR transmitter. The customer can program two separate time intervals for monitoring data (e.g., one interval could be the current month or billing cycle, the other might be one day in which a lawn is being watered).

The unit includes a receiver, LCD display, push buttons for instantaneous meter reading or use over specified time intervals, and a battery (see **Figure 13**). It also contains an optional leak detection alert that triggers a flashing red light if there is continuous consumption for 24 hours. Leak detection is valuable for water utilities. According to Cliff Deeds, Arvada's transmission and distribution superintendent, 90% of the 300 to 400 high bill complaints he receives each year are due to toilet leaks.

The display presents system information, meter readings, interval readings, and meter serial number. In general, the device only displays water usage in gallons; it does not provide price. BadgerMeter opted to provide limited functionality in order to keep the price of the unit low. To estimate cost, customers refer to water consumption and rate tables provided by the utility and do the math. The battery-powered in-home display can be located anywhere indoors, within several hundred feet of the water meter. It contains a magnet built into the case, so it can be attached to the refrigerator door.

**Figure 13. The BadgerMeter's ORION Water Meter Monitor**


The ORION Water Meter Monitor, which works with the ORION AMR system, displays water use during defined time periods.

*Source: BadgerMeter*

After approximately two years of collaboration between BadgerMeter and the cities of Aurora and Arvada, the device was released nationally to utilities in February 2005. For Aurora's small businesses and residents, the unit costs $50. The city supplies a $30 water conservation rebate. The City of Arvada, meanwhile, whose units include the added internal leak detection feature, pays $65 per unit. It charges its small businesses and residents a $20 deposit fee per display, which it will return to customers whenever they return their units. Only one business has reportedly returned a unit.

Of the 72,000 homes and small businesses within Aurora's service territory, 12,000 are outfitted with water meter reading systems capable of working with the in-home display. About 1,500 of these have the monitor. Over the next five years, Aurora plans to upgrade its entire water meter reading system to the ORION transmitter so that it can work with the monitor. Of Arvada's 34,000 customers, 4,500 are on the ORION AMR system that is compatible with the Water Meter Monitor, but approximately 300 of the monitors have been deployed in the field. Like Aurora, over a six year period, Arvada plans to phase out its older transmitters and refit them with the ORION transmitter.

Anecdotally, both Aurora and Arvada officials claim customers have become more water conscious and efficient as a result of the Water Meter Monitor. It will, however, be another year or two before they can perform a solid evaluation with quantifiable data. Still, officials assert that economics are driving behavioral change. Every customer in Aurora and Arvada is on a variable three-tier monthly water budget based on historical usage per thousands of gallons. If customers exceed their monthly allotment, they automatically jump to a higher price category. Customers revert to the lowest tier rate at the start of each month.

BadgerMeter reports that it has shipped approximately 5,200 units since the device's release in 2005. Beyond the cities of Aurora and Arvada, other utility customers include Fresno Water Department, the city of Lynchburg (VA), and Three Lakes Water District (WA). According to Dennis Webb, VP Sales/Marketing and Engineering at BadgerMeter, the ORION Water Meter Monitor could be adapted to other markets, though this is not a primary focus for the company. Badger currently makes an AMR solution for both water and gas, and provides a meter only for the water sector. It has partnered with powerline carriers DSCI and Hunt who have incorporated ORION receivers into their equipment.

For more information: http://www.badgermeter.com/pdf/orion/tech/ori-t-43.pdf.

## Tempo Program (Electricité de France)

In France, state-owned Electricité de France (EdF) has offered the Tempo tariff, a time-of-use rate with three different day types, since 1995. The year is divided into 300 low-cost "blue days," up to 43 average "white days," and up to 22 expensive "red days." Each day is further divided into peak and off-peak periods. All told, there are six different kWh tariff prices. The prices for 2005, fixed in the Tempo tariff, are shown in **Table 5**.

**Table 5. Electricité de France's Tempo tariff**

| | Blue days (≥300) | White days (≤43) | Red days (≤22) |
|---|---|---|---|
| **Off-peak (euro/kWh)** | 0.0446 | 0.0907 | 0.1682 |
| **Peak (euro/kWh)** | 0.0553 | 0.1075 | 0.4702 |

The Tempo tariff divides the year into three periods, each with a peak and off-peak rate. Prices include taxes.

*Source: Electricité de France*

Selection of blue, white, and red days occurs based on temperature, weather, and wholesale prices, and is made a day ahead of time. Red and white days can be called weekdays between November and March. Weekends and public holidays are always blue days, as are all days April through October. (France is winter peaking.) Customers learn what color day it is by a signal sent to an in-home display unit. The signal is sent the day ahead from a central point down the network via powerline or RF ripple control system to a solid-state meter at the customer's home. The meter is programmed to bill according to the tariff. It is usually connected to a water heater control and output that can be directed to a more sophisticated energy management system. EdF has over 10 million solid-state meters (about a third of the total number of the country's meters). 400,000 of these are Tempo meters, a fraction of which are equipped with optional in-home displays.

EdF's smart meter works with several optional displays that can be used in the Tempo tariff program. They all meet the same functional requirements but offer slightly different designs. All three displays are provided by EdF free of charge and need only be plugged into a wall outlet to commence operation. They provide users with the color of the day, the color of the next day, and a summary of what happened previously.

The Sagem B600 display, one of the three designs, has a series of indicators that convey current and next day's color-coded tariff rate, peak and off-peak status, device status (i.e., whether it is on or disabled from participating in tariff communiqués), and an alarm to alert users of an impending red day (see **Figure 14**).

**Figure 14. Sagem B600 Tempo Home Tariff Indicator**


The Sagem B600 unit is one of three optional in-home displays EdF provides, free of charge, to its Tempo tariff subscribers.

*Source: EdF*

Tempo subscribers are informed either via their in-home display, telephone, or email of the color of the next day. Also, users can register to be alerted by short message service (SMS) text messaging about a forthcoming red day.

EdF officials regard the utility's suite of demand response programs, of which Tempo tariff is a part, as a success. Through these offerings, EdF has been able to flatten its load curve and shave winter peaks in both the mornings and evenings. However, according to Anne-Lise Didierjean, Project Manager at EdF, many customers typically have not taken full advantage of the program. They signed up for the tariff in response to marketing, but do not react to the different days and tariff pricing mechanisms. These customers tend to either not fully understand the program's structure or to stop responding to the Tempo rate after a few months.

EdF is not presently enrolling any new customers in the Tempo tariff; it is only supporting current subscribers. New regulations implemented during the summer now allow the utility to provide greater services in gas, water, and electricity that go beyond the meter. As a result, EdF is revising its business processes, which includes considering the design of an infrastructure capable of supporting AMR and price signaling.

EdF is looking into offering newer, user-friendly devices that include LCD screens that convey energy usage and cost. It intends to run a small technical pilot by 2007.

To view the EdF Tempo Tariff website (in French only): http://particuliers.edf.fr/article482.html. For further information on the Sagem B600: http://www.sagem.com/index.php?id=145&L=0 .

# Experimental/Research Technologies

A number of for-profit companies and university labs have developed both commercialized and conceptual products that offer innovative information display alternatives. These largely experimental units often incorporate calm or ambient technologies to trigger peripheral human awareness in a non-intrusive and non-exclusive manner. Below is a sampling of these products.

## Violet Company Product Line

A French company named Violet bills itself as a smart object company that develops products and services based on calm and emotional technologies. Founded in 2002, the small design shop has manufactured a number of innovative products that could conceivably be adapted to work within the electricity arena. The company's main product line, briefly described below, is flexible, portable, and engagingly playful.

For more information on Violet, see http://www.violet.net/index_us.jsp .

### La Lampe Dal

The Dal Lamp is an intelligent object that is wirelessly connected to the Internet (see **Figure 15**). It can receive messages sent via email or telephone, which are broadcast as customized colored animations. Dal can, for example, communicate the weather, the stock market, traffic conditions, or receipt of an email from a loved one by changing colors that correspond to the user's preprogrammed preferences. The lamp can also be personalized to react to noise in a room or to show ambient animation created by digital artists.

**Figure 15. Violet Company's La Lampe Dal**

La Lampe Dal communicates the weather, the stock market, and traffic conditions and other information by changing colors that correspond to the user's preprogrammed preferences.

*Source: Violet*

## Wi-Fi Plastic Bunny (Nabaztag)

This 10-inch Wi-Fi-enabled plastic Nabaztag bunny (Nabaztag is the phonetic English spelling of the Armenian word for bunny) is a smart object that communicates a variety of messages to its users by wriggling its ears, singing, talking, and lighting up its body with a hundreds of colors (see **Figure 16**). The rabbit can transmit messages, music, MP3 files sent to it via the web, text messages, phone, or email.

For example, the Nabaztag bunny can be programmed to flash colors across its body coded to weather forecast (e.g., yellow is sunny, blue is rain, red is hot, etc.). It can also be programmed to speak the time, temperature, and weather forecast at a specific time of day, much like an alarm clock. Separately, friends can send MP3 digital music files or voice messages and transmit them to a Nabaztag. It is fairly easy to see how all of the above schemes could be adapted to convey electricity prices and usage.

The device is always connected to the Internet. Users must have a Wi-Fi access point and a permanent cable or DSL internet connection. A dedicated website (www.nabaztag.com) allows users to register their devices and select the services they want. The Nabaztag bunny costs 95 € (euros).

EdF has an R&D project looking at using the Nabaztag bunny to convey price signals. Some ideas they are considering are having the bunny turn red for excess electricity use, green if the central heater requires maintenance, blue in the event of a water leak, and yellow if your EdF representative wants to call you.

For more information: http://www.nabaztag.com/vl/FR/qui_est_nabaztag_eng.jsp.

**Figure 16. The Wi-Fi-enabled plastic Nabaztag bunny**

The Nabaztag bunny is a smart object that communicates a variety of messages, such as the weather, to users by wriggling its ears, singing, talking, and lighting up its body with colors. EdF is considering using the bunny for price signals.

*Source: Violet*

### Le P@d Osmooze

The Pad diffuses perfume when it registers that the owner has received messages—either via email, mobile phone, or SMS text message (France-only)—from specific people. The Pad owner configures the device to recognize desired people/sources, and also programs the diffusion force and time depending on the nature of the message received. The device currently includes one diffuser and five perfumed cartridges (citronella, juniper, lavender, ylang ylang, and tangerine). Violet states that forthcoming functionality will allow users to attach scents to stock market change, weather forecasts, traffic congestion, and more. This device could run into trouble in Boulder and California where some public spaces designate "fragrance-free" zones. Someone eating lunch at their desk could mistakenly "send" a nearby co-worker a Stage-2 alert.

## Informative Art Project (Viktoria Institute)

The Informative Art research project is driven by the Future Applications Lab at the Viktoria Institute, in Götenborg, Sweden. It has developed a variety of visual displays that integrate modern art forms to provide users with peripheral information in a simplified manner. The Informative Art project has not, to date, installed any of its creations beyond several experimental pilots run within its own lab and at nearby offices. It was in contact with the Swedish Energy Commission about the possibility of using some of its devices as energy awareness displays. The Commission, however, decided to fund the Interactive Institute's Static! project instead (see below) and talks came to a halt.

Several prototypes could perhaps be adapted to convey useful electricity sector pricing and/or usage information to consumers. For more information: http://www.viktoria.se/fal/projects/infoart/index.html.

### E-Mail Composition

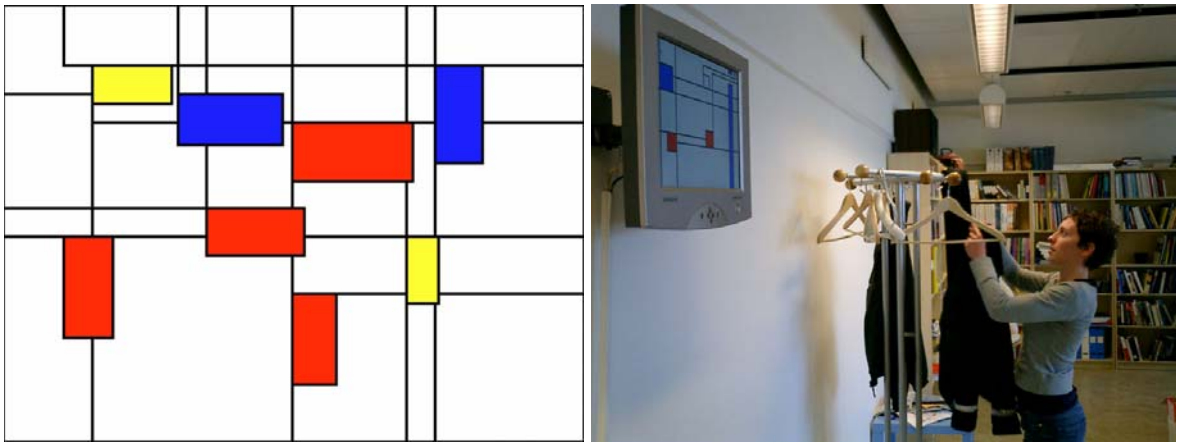
The E-mail Composition prototype incorporates elements of a Mondrian work of art to convey the level of email traffic within an office (see **Figure 17**). The visual display relates colored squares. Each square represents a person in the office. The size of the square grows and shrinks according to the aggregate level of email activity incurred over the last several days. The different colors indicate the level of recent activity (e.g., red mean a person was involved in email activity during the last hour, yellow means some time has passed since the last registered activity, and blue means email unchecked over the last day).

It is conceptually fairly easy to recognize how the email composition prototype could be adapted to portray whole-home electricity appliance use. Instead of representing people, the squares could depict appliances while the colors and sizing could correspond to electricity expenditures and activity. Background color could represent electricity cost. Implementation would obviously be challenging.

### Motion Painting

This visualization presents a recent history of activity level in a room. A web camera continuously records movements within a room which are then translated to an electronic display. The display projects vertical stripes of color to indicate a specific activity level. The color represents a particular activity level, while the width indicates the duration (see **Figure 18**).

**Figure 17. Informative Art Project's E-Mail Composition prototype**



The Mondrian email composition prototype illustrates office email traffic. Each square represents a person in the office. The size of the each square varies depending on email activity, while differing colors indicate latest email use. If applied to electricity use, the prototype's squares could represent appliances while the colors and sizing could correspond to electricity expenditures and activity.

*Source: Informative Art Project*

Adapted to serve the electricity arena, the motion painting could communicate tariff pricing periods. For example, critical peak pricing events, along with their duration, could be expressed.

**Figure 18. Informative Art Project's Motion Painting prototype**

The motion painting display projects vertical stripes of color to indicate a specific activity level. The color represents amount of activity, while the width indicates the duration. The motion painting could convey tariff pricing periods.

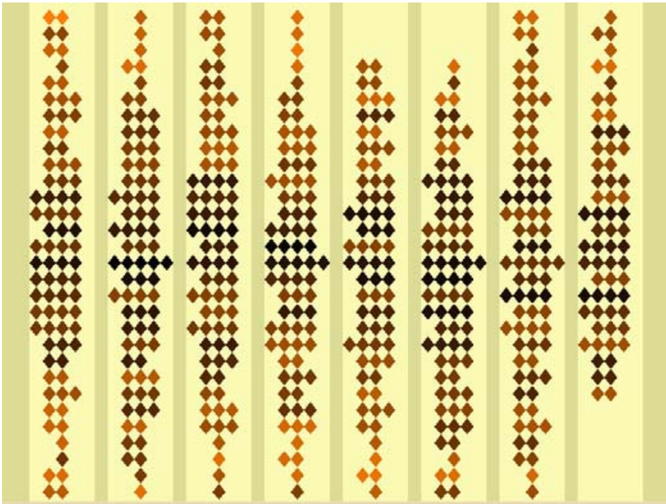
*Source: Informative Art Project*

### Activity Wallpaper

Activity Wallpaper collects activity data using various sensors and displays a visual interpretation. Patterns of columns change shape and color, depending on activity type and level (see **Figure 19**).

Again, this innovation could perhaps be adapted to the electricity sector to convey in-home electricity use, color-coded to specific pricing events.

**Figure 19. Informative Art Project's Activity Wallpaper prototype**



The activity wallpaper uses columns of colored shapes to show activity type and level. The columns could represent the days of the week. The color and patterning could be adapted to convey energy prices, including critical peak periods.

*Source: Informative Art Project*

## Static! Project

Some of the most creative, fun, and visually appealing work we found is being done in Sweden at Static!, a joint project of the Interactive Institute. The Interactive Institute is an experimental IT-research institute that combines art, design, and technology. Static!, a joint project of the POWER and RE:FORM studios, "investigates design as a way of increasing our awareness of how energy is used and how to stimulate changes in energy behaviour." Some of the projects may make it into mainstream production, while others will likely never leave the lab, but stretch our imaginations nonetheless. For more information, see http://www.tii.se/static/.

## Power-Aware Cord

The Power-Aware Cord looks like a regular power strip cord—until you plug something into it and the cord lights up (see **Figure 20**). Initial user feedback was positive. Users easily understood the light to represent electric current. One thought the light was the electricity—that the Power-Aware Cord just showed what is hidden in regular cords. The Power-Aware Cord was awarded a patent in July 2005.

**Figure 20. Power-Aware Cord**

*Source: Static!*

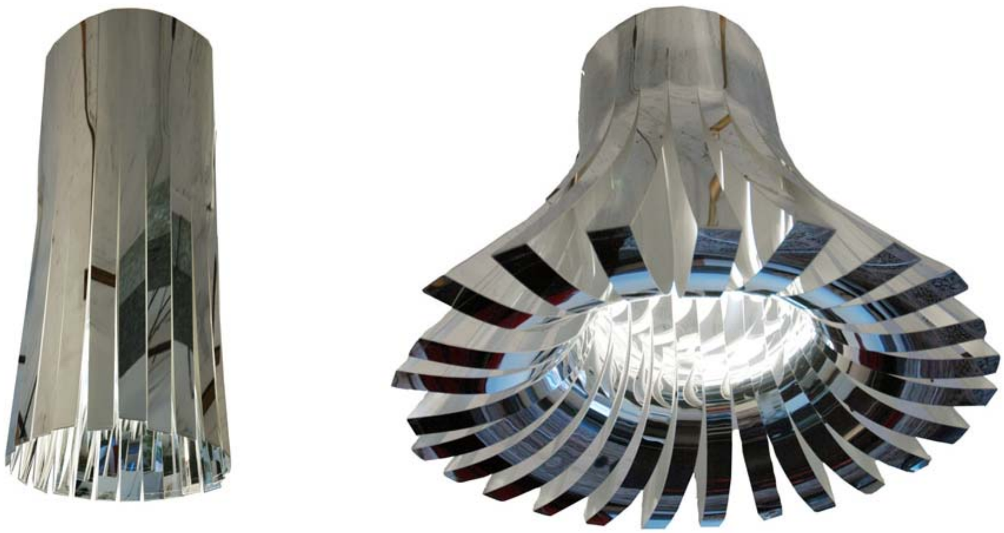
## Flower Lamp

The flower lamp is a hanging lamp that changes shape depending on how much energy is being used in the house. It blooms when energy consumption has been low for some time and contracts when energy use is high (see **Figure 21**).

## Energy Tap

The energy tap is a free-standing outlet that anyone may use. It has a hand crank that generates the electricity. It helps users to understand how much energy it takes to power electronics or other loads (see **Figure 22**). For more information, download Free Energy 1,2,3, or 4 from http://www.tii.se/static/press.htm.

Figure 21. Flower lamp



Source:Static!

Figure 22. Energy Tap

Source:Static!

## Wattbug (Mutlu+Milano Design Studio)

The Wattbug domestic electricity meter won first prize at the first annual Viridian design competition in 2001, sponsored by the Sustainability Institute of USA in cooperation with the International Network of Resource Information Centers. The contest, which encompassed two rounds of judging, challenged entrants to design “a household energy consumption meter that provides accurate, compelling, and artistically fascinating feedback to homeowners about their energy use.” The Wattbug is an anthropomorphic energy display with animal like characteristics. It purrs when energy consumption is low and flashes a red light on its tail when consumption is high. Like a pet, the sound and visual feedback of the display asks the user to pay attention to it. Rather than simply informing the occupants, it becomes an occupant and demands focused attention rather than peripheral awareness (see **Figure 23**).

**Figure 23. Wattbug**

Although Wattbug has received significant public and media interest, it has not yet been produced. Several companies, including Philips, Real Goods, Ecofys, and Siemens have either passed on the opportunity for strategic reasons, balked at the high initial cost of production, and/or lacked the sufficient means necessary for mass production. It’s a shame Wattbug hasn’t reached commercial stature; initial reception was quite warm. Turkish design studio Mutlu + Milano, the conceiver of Wattbug, reported receiving numerous orders from a variety of potential customers who did not realize the device had not evolved from its conceptual form.

For more information: http://www.incimutlu.com/html/awards01.htm.

# Notes

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2 "Final Report – California Information Display Pilot Technology Assessment" [2]

3 Maarit Haakana, Liisa Sillanpää, and Marjatta Talsi, "The Effect of Feedback and Focused Advice on Household Energy Consumption," proceedings, ECEEE Summer Study (1997).

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8 Graeme Hunter, personal communication, October 26, 2004, HomeEnergy Direct Manager, NIE Supply, Woodchester House, 50 Newforge Lane, Belfast, BT9 5HT, tel: 028 9068 5017, Graeme.Hunter@nie.co.uk.

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10 Karen George, "Will Customers Pay in Advance? And Should They?" *Primen Perspective: Customer Insights*, CI-PP-05-02, June 2002.

11 John Willis, personal communication, August 29, 2005, Manager, Project Management and Analysis, Salt River Project, Phoenix, Arizona, tel 602-236-2177, email jwwillis@srpnet.com.

12 Dean C. Mountain, "The Impact of Real-Time Feedback on Residential Energy Consumption: The HydroOne Pilot," March, 2006.

13 Dean C. Mountain [12]

14 Jatin Nathwani, "Hydro One's Real-Time Feedback Pilot Project," presentation to EPRI Solutions Web Seminar, March 6, 2006.

15 For more details, see "Final Report--California Information Display Pilot Technology Assessment" [1], and "Final Report: Information Display Pilot, California Statewide Pricing Pilot," prepared by Nexus, Opinion Dynamics, and Primen, January 2005.