Display your power
Smarter metering

Simpler, real-time feedback on energy usage is the best way to drive changes in behaviour: that's the promise of smart-meter connected in-home displays. Richard Keech explains how they work and tests three models.

Back in *ReNew 121* I looked at smart meters and their associated web portals, which can provide useful information to consumers about how and when they use electricity. This article goes the next step and looks at how in-home displays can be used for personal energy monitoring.

On the tail of the rollout of smart meters around Australia (see Table 1 for the status of the rollout in each state), consumers can expect to see more products and services which take advantage of the facilities that smart meters provide.

One of the more interesting aspects of smart meters is their use of a wireless home-area network via a technology called Zigbee. This allows compatible in-home devices to communicate directly with the meter and display information of interest to the consumer. Such devices are known as in-home displays (IHDs).

As the old saying goes, you can't properly manage what you can't measure. The theory goes that if electricity consumers are given more information about how and when they consume their electricity, then they will become more careful and more efficient consumers.

Many studies have looked into this, with varying results ranging from showing no improvement, to showing savings in the order of 20%. Energy-use feedback that is closer to real-time usage tends to be associated with better savings.

The curiously named Zigbee system is a digital wireless home-automation method used to let a smart meter talk to other devices in the home, hence the idea of a 'home-area' network. The meters have a rich set of data (not just instantaneous power) that they can communicate to Zigbee-connected devices.

Furthermore, the connected devices are not limited to displays, and control of devices is possible to provide active demand-response.

Zigbee is a low-power, low-data-rate system which allows it to be incorporated in devices that require very little power to run—after all it would be counter-productive for an energy saving device to actually increase power use.

Testing Zigbee IHDs

By being able to talk directly to the meter, Zigbee IHDs can be authoritative in that they show the meter's actual readings, not an estimate. These types of devices are beginning to be subsidised in Victoria as part of the VEET scheme (and possibly in other states also). So look out for a rush of them on the market in the near future. In writing this article I sourced and trialled three Zigbee IHDs.

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Getting set up to use an in-home display

The Zigbee wireless signal used by smart-meter connected in-home displays doesn't stop at your property boundary, so it's important for privacy that no one can snoop your meter data. To ensure privacy, data is encrypted and Zigbee devices have to establish a trusted relationship with the meter—a process known as 'binding'.

Binding of the Zigbee device only needs to happen once, unless you want to move the device to another meter. Many devices can be bound and communicating to a meter at any given time. The Zigbee device-binding process proceeds like this:

1. **Find the codes.** The device being bound uses two long code numbers—a MAC and an install code. The MAC is a digital address that uniquely and permanently refers to the device. The install code is a unique cryptographic code which can be used like a password. These numbers will either be printed on the device, provided on a card or displayed on the device itself on first use.
2. **Enter the codes.** Using your smart meter web portal, choose the 'add new device' (or equivalent) function. This will prompt for the MAC and install code, which will then pass the codes to the smart meter and make it listen out for the particular new device for a few minutes.
3. **Turn on the device.** While the meter is receptive, turn on the new Zigbee device and it should bind automatically. Successful binding should be obvious on the IHD itself and on the web portal.

eKo from Intercel

The Australian-designed eKo from Intercel has the distinction of being the first IHD registered in Victoria under the VEET scheme. It has a compact circular colour screen surrounded by a ring of lights, plus a traffic-light trio of lights across the top. It uses a USB power source and draws a mere 0.7 W when the screen is on, and 0.6 W when the screen automatically turns off.

The operation of the unit is based around a user-set dollar budget per billing period. Combined with tariff settings, this then gives an energy target per day. The ring of lights advance clockwise and change colour from green to amber to red as your usage approaches and passes the daily target. The traffic lights across the top represent instantaneous power. Green is shown when power corresponds to a rate that would be less than 50% of the daily target, amber for 50% to 99% and red for levels above.

The system attempts to estimate your power bill and the underlying 'standby' power level. Note that standby power is measured as the lowest level of power usage over a period and so includes devices that are on all the time such as refrigerators which wouldn't usually be counted as standby; baseline power may be a more apt name.

Daily energy used shows only the imported energy, so, if you have solar PV, the monitor won't help with tracking your daily exported or net supplied (imported minus exported) energy.* This also skews the standby power estimate as the lowest imported level will often be zero—but you can read the lowest level at night to get a more accurate measure.

The general layout seems well designed and strikes a good balance between simplicity and detail. The operation with the ring lights (for daily energy) and traffic lights (for instantaneous power) allow for a good at-a-glance summary of the energy situation.

*Correct display of daily solar generation is apparently to be included in the next release of the eKo's internal software.

EMU from Rainforest Automation

The EMU (Energy Monitoring Unit), out of Vancouver, Canada, is the simplest of the devices tested. It has a non-backlit LCD screen and is battery operated and designed to stick magnetically to your fridge or sit on a bench. It provides a simple up/down button arrangement to cycle through display modes showing 1) Date and time 2) Current meter readings (import and export) 3) Current power use in both kW and cents/hour 4) Total-to-date energy use, both in kWh and dollars 5) Tariff and 6) Messages.

To save energy the screen powers off until a button is pressed. On the left of the display is a light bar which flashes green or red, depending on real-time tariffs, e.g. if the tariff were to spike due to high power use, then the IHD can let you know. Since we don't have dynamically adjusted tariffs yet in Australia, this feature is redundant and the residual flashing green light is annoying (fixed in the next firmware release apparently).

The EMU doesn't try to be fancy, just simple and easy to use. The main practical limitation for use in households with solar is that there is no facility to enter export tariff or, indeed, to enter peak/off-peak tariff rates. The device is built assuming that the meter will have the proper tariffs as the designers of Zigbee intended (see Tariff Setting). So for me, the estimated energy cost was completely bogus. Let's hope this gets fixed. Another minor concern was that the display was hard to read in low light.

Impressive was its capacity to run for extended periods from four AA batteries. So there's negligible energy used in saving energy.

Intelligy from Millennium Electronics

It's not often in Australia that you find consumer electronics designed and built in your own neighbourhood. I was pleasantly surprised to find that the Melbourne-based Millennium Electronics not only design, but also manufacture from a factory quite near my home. Millennium is not a retailer, but design and manufacture to order, so the Intelligy unit is not generally available as a retail product.

The Intelligy is a high-end IHD and provides a colour LCD touch-screen in a smart white and chrome case. The display would generally be off to preserve energy; touching the screen activates it for two minutes by default. The display is encircled by an illuminated line, which represents the power level in the usual traffic-light scale of goodness.

The Intelligy uses the data in an interesting colour-coded graphical representation of power and energy usage. Tariff arrangements for import and export can be entered on the device without too much trouble.

The main problem I found with the device is the failure to give a suitable representation of power when exporting to the grid—it simply displays zero when power is being exported. Another niggle was that accumulated energy-use history (per day, week, month) all reset when the device is turned off.

A bonus with the Intelligy is its capacity to monitor and control appliances directly through the use of (optional) wireless power-measuring switches. I can see merit in being able to monitor the energy used by things such as refrigerators. However, in testing, the power-measuring switches were poor at sensing low-power appliances. I tested one on a radio drawing 2.9W, which the Intelligy recorded as 0 W.

Common issues

In using three different IHDs I had several concerns in common, all of which relate to smart meters rather than the IHDs.

Real-time data. A claimed feature of IHDs is the real-time nature of the readings. In reality the power readings can be delayed by up to a minute depending on the smart meter and IHD. In my case the meter updates its internal Zigbee module every 45 seconds and the IHD polls the meter every 15 seconds. So on average the data is 30 seconds old, which significantly limits the usefulness in taking instantaneous power readings. I understand that the frequency with which the meter updates the Zigbee information is a function of the embedded meter software and may be improved in the future.

Precision. The meter controls the precision with which the energy readings are interpreted on the IHD. In my case the energy values have a precision of 1 kWh. Some other meters apparently have a 0.1 kWh precision. This might seem like a small detail, but it can affect the usefulness of measurements of energy used. For example, if the real start-of-day consumption value is 6701.900 kWh, then this will be taken as 6701 kWh. If at 8am the real consumption value is 6703.100 kWh, then the actual energy used is 1.200 kWh, but it will be shown as 2.000 kWh. So, for me, the accuracy is +/- 1 kWh, which is a large margin of error. This is another problem with the smart meter's own software, not the IHD itself.

Tariff setting. When time-of-use pricing applies, setting the tariff in the IHD is non-trivial because of the need to set a schedule on a device with a small display and few buttons. The entire underlying system (Zigbee, meter and upstream communications) is designed to send updated tariff information to the display. Unfortunately this feature is not used in Victoria because of competitive issues between the stakeholders. This leaves IHD designers having to work around the problem or to omit useful features.

Complementary to web portal

I expect in-home displays to become a common and useful feature of energy-aware homes. The information they provide is complementary to that provided on web portals. Table 2, below, compares the features provided by the two approaches.

Given the greater richness of data presentation in a web portal, I think the historical energy-use features of IHDs are somewhat redundant. However for near-at-hand and near-real-time monitoring of energy I see IHDs as having a useful role.

Unfortunately, in Victoria at least, the usefulness of IHDs is compromised by a couple of easily rectified shortcomings in the smart meters themselves. ✱

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Other resources:
'Track your energy use online' in *ReNew 121*
ATA's *Consumer Guide to Smart Meters* available at www.ata.org.au.

In-home display only	Features in common	Smart meter web portal only
Near-real-time power monitoring. Compact, single-purpose device. Extension features such as appliance control. Reading instantaneous values of meter registers.	Short- and medium-term historical power usage. Estimated costs of power use. Estimates of things like standby power and electricity bills.	Longer-term historical usage. Richest graphical representation of usage patterns. Extension features such as tariff comparisons.

↑ Table 2: Some functions can be performed by both a smart meter web portal (see *ReNew 121* for full details of one web portal) and by an in-home display.

State	Status
ACT	A small number of smart meters were installed by Metropolis prior to 2009. No plans for universal rollout.
NSW	Approximately 27,000 smart meters have been rolled out in eight separate trial programs. Market-driven universal rollout of smart meters is under consideration; however no plans as yet.
NT	300 smart meters in use in Alice Springs. No plans for universal rollout.
QLD	4800 smart meters in four separate trials. No plans for universal rollout.
SA	7100 smart meters in three separate trials. No plans for universal rollout.
TAS	Small number of smart meters were installed by Metropolis prior to 2009. No plans for universal rollout.
VIC	State wide rollout underway. With almost 2 million smart meters installed already, they'll be in almost all homes by the end of 2013.
WA	11,000 smart meters rolled out in the smart grid foundation project. Western Power proposing to replace 300,000 meters with smart meters over the next five years (⅓ of meters on the South West Interconnected network).

Table 1: The status of each state in terms of smart meter rollout. Only Victoria has a universal rollout underway.

From *National Smart Meter Infrastructure Report Release 1.3*, Dept of Resources Energy and Tourism, 4 Feb 2013.

What is VEET?

VEET stands for the Victorian Energy Efficiency Target. It is a market that has been created within Victoria to deliver a specific amount of emissions reductions (currently 5.4 million tonnes per annum) through the installation of more efficient technology in Victorian homes and businesses. It is similar in its operation to how the national Renewable Energy Target works. Eligible energy efficiency technologies (for example, LED lighting or in-home displays) are awarded a specific number of VEET certificates for their lifetime energy savings. These certificates have value within the VEET market and provide a discount to the end consumer on the purchase price of those technologies. South Australia and NSW also have state-based energy efficiency markets.

Other energy monitoring options

Rich Haynes from eTool takes us through other options for energy monitoring systems across Australia.

While Victoria is well on the way to completing its universal rollout of smart meters, the rest of Australia could be in for a long wait, as shown in Table 1 on the previous page. But if your utility provider is yet to supply a smart meter to your premises, there's no need to delay as there are plenty of other options available.

In fact, some of the independent energy monitoring solutions on the market actually offer greater functionality than the smart-meter connected displays. For example, you can monitor numerous circuits and compare things such as the energy use of the lights versus the stove, check how well your solar PV system is performing and, in some cases, monitor individual plug loads as well.

Different solutions for different meters

Regardless of the type of meter you have, there is a sensor that will enable you to monitor your energy use. The simplest sensor is a current clamp which clamps around a cable to measure current. However, real power = voltage x current x power factor, and these simple clamps don't measure either the voltage or power factor; they estimate power based on current only. This can lead to inaccuracies due to fluctuation in your supply voltage and the power factor of the loads in your house. That said, they are well and truly suitable for identifying your power use 'hot spots'. They usually rely on battery power to transmit the information back to the in-home display or network gateway.

Alternatively, a DIN rail sensor relies on mains power to transmit the current readings. Some DIN rail sensors also measure voltage and may even measure power factor (check the specs). Both DIN rail and current clamp sensors can be installed alongside any meter. They are often used for measuring power in individual circuits that aren't independently captured by the utility meter (e.g. solar generation).

From there, the sensors get more sophisticated and generally incorporate a current clamp as well as a parallel connection to enable voltage measurements, power factor calculations and also power the transmitter.

Regulations require that electricians install all the above types of sensor. If relying on a current clamp or DIN Rail sensor and you have three phase power, you'll need three sensors to determine your whole energy use, so this can push the cost up a little.

If you have a meter equipped with a pulse light you can use a pulse sensor to measure your consumption. The pulse light on a meter is usually a small red LED that flashes periodically. A pulse sensor simply sticks on top of the LED and recognises every time the LED flashes. This is the most accurate way of measuring your usage as it simply relays the meter's measurements to your energy monitor. The other advantage of these sensors is they don't require an electrician to install them. Unfortunately you can't use pulse sensors for multiple circuits as they only pick up the total energy usage as read by your meter.

To get the best of both worlds you could use a combination of a pulse sensor to get a very accurate reading of your total energy consumption and current clamps or DIN rail sensors to identify the highest and lowest consumption circuits. The functionality comes at a cost though, and if you're hoping to monitor your energy for economic reasons, a simple, low cost solution could quickly help you identify the big energy users in your home by letting you watch your consumption as you walk around turning appliances on and off.

Review of independent energy monitoring solutions

Table 3 provides a summary of some of the non-smart meter energy monitoring solutions currently available on the Australian market. It is by no means exhaustive, but gives a guide to some of the options available. Readers are encouraged to conduct research themselves and shop around, as things can change very quickly in the energy monitoring market.

For more information about the difference energy monitoring systems can make to your consumption and energy bills, watch Rich's online video www.youtu.be/CPrUHXWcOX8 or visit eTool's blog: www.etool.net.au/eblog/

Brand	Model/system	In Home Display hardware	Web based reporting	Monitoring of additonal circuits	Monitoring of power sockets	Price for single phase setup	Price for 3 phase setup	Number of additional circuits	Additional cost per circuit	Additional cost per socket	Transmitter power source	Receiver power source	Annual cost of web connection	User complexity
Efergy	Efergy Elite Classic 3.0	✔	✗	✗	✗	$80	$110				Battery	AC		Simple
	Engage Hub Kit	✗	✔	✗	✗	$90	$130				Battery	AC	Free	Simple
	EcoTouch (3 Sockets)	✔	✗	✗	✔	$159	$199			$20	Battery	AC		Simple
Current Cost	EnviR	✔	✗	✔	✔	$140	$180	9	$70	$120	Battery	AC		Simple
	EnviR with Bridge (1 Channel)	✔	✔	✗	✗	$190	$230				Battery	AC	Free*	Simple
	EnviR with Bridge (10 Channel)	✔	✔	✔	✔	$200	$240	9	$70	$40	Battery	AC	Free*	Simple
Wattson	Wattson SOLAR Plus	✔	✗	✔	✗	$220	$290	1			Battery	AC		Simple
Watts Clever	EW4500	✔	✗	✗	✗	$80	$120				Battery	AC		Simple
Smart Energy Groups	SegMeter	✗	✔	✔	✗	$700	$760	7	$30		AC	AC		Intermediate
Power Tracker	Power Tracker Gateway	✗	✔	✔	✔	$350	$670	10+	$150	$120	AC	AC	Free	Simple
Open Energy Monitor	Home Energy Monitor Kit	✔	✗	✔	✗	$110	$135				Battery / AC	AC	Free	Complex
	OpenEnergyMonitor	✔	✔	✔	✗	$180	$205	10+	$30		Battery / AC	AC	Free	Complex
Fluksometer	FLM02	✗	✔	✔	✗	$210	$270	4	$30		AC	AC	Free	Intermediate

Table 3. Energy monitors that don't require a smart meter.

* CurrentCost web accounts free for first two years for one circuit monitoring only. Fees apply otherwise.
Note that all systems that use clamp and DIN rail sensors must be installed by an electrician. The Watts Clever EW4500 is exempt as it has a simple stick-on sensor. Prices do not include installation.