Smart meters, displays and appliances

The electricity system is changing. Many of us have heard the terms 'smart grid', 'smart meter' and 'smart appliance' but may not know what they mean or how they could affect us.

Smart grid is often used to mean closer integration of the supply side and demand side of the electricity system, through better communications and controls. Although there is no single accepted meaning, it covers a range of emerging technologies and systems, as well as new relationships between electricity businesses and their customers.

Electricity cannot be easily stored on a large scale, so supply and demand have to be kept in constant balance. In the past this has meant matching supply to demand, by varying the output of power stations and making sure the network (the poles, wires and transformers) can meet the heaviest demands expected, even if they occur for only a few hours each year. This is proving increasingly expensive, and is one of the main factors driving growth in electricity prices in recent years.

Rising use of variable forms of renewable electricity generation such as wind and photovoltaics has also increased the difficulty of matching supply and demand and controlling voltage in some parts of the network, even though it has helped reduce greenhouse gas emissions.

One way to signal periods of abundance and periods of scarcity in the availability of electricity (as for any other goods or services) is through differential pricing, also called 'time of use' (TOU), 'time-variant' or 'flexible' pricing. You can then either adjust your energy use so that more of it takes place during low price periods or make a conscious decision that it is worthwhile to pay more for power when you really want it. This principle has long been used in off-peak tariffs, where consumers consent to having limits placed on when their water heaters or other devices can operate in return for a cheaper tariff. New technology allows electricity prices to vary not just between fixed peak and off-peak periods but at shorter intervals as well.

Traditional electricity meters

The traditional electricity meter, or accumulation meter, only records the amount of electricity that has passed through it since it was first installed (or last reset by the utility). All you can tell about your electricity use with an accumulation meter is how much energy you have used since you looked at it last. A house with an off-peak water heater usually has two accumulation meters — one for the water heater and one for everything else.

Traditional electricity meter, with spinning metal disc and accumulating registers.

Electricity billing is based on the differences between successive readings. Traditionally, meter readers went from house to house every two or three months, to record the numbers on each meter's registers, originally on paper and more recently on hand-held data recorders. Gas and water meters are still read this way.

More advanced electricity meters, also called interval meters, measure energy electronically rather than electro-mechanically (i.e. with the traditional spinning

disc). They can record energy use at half-hourly intervals, usually have a digital display, and can download the data to the meter reader via an electronic or optical interface. The main difference from the accumulation meter is that they can support TOU tariffs, under which the customer pays different rates for electricity used at different times. However, these meters are not generally considered 'smart'.

How smart a typical electronic interval meter, with digital and optical readouts, is depends on its communications and control capabilities.

Smart meters

Smart meters offer a range of capabilities and services which accumulation meters do not. They can:

- transmit energy use data to the utility, so that meter readers are no longer required
- receive and carry out commands such as disconnecting the supply when customers move out and reconnecting it when the next customer moves in
- monitor the supply for faults and automatically advise the utility in case of problems
- act as a 'gateway' or point of communications to the home for important information such as changes in price or notification of emergencies
- ultimately act as a two-way interface with the customer's own appliances via a 'home energy network'.

> *Smart meters can transmit data, receive commands, monitor supply and communicate with appliances.*

How these capabilities are used by electricity suppliers and their customers varies from place to place, and is likely to change over time. In Australia, different states and electricity utilities have different policies on smart meters. Some are committed to replacing old meters with smart meters over a predetermined timeframe, some are installing smart meters only in new buildings or when old meters need replacement, and some are continuing to install meters, which may have digital displays and record interval data but are not actually smart.

Having a smart meter installed does not mean that you (or your electricity supplier) have to make use of all of its capabilities. There is no technical reason why a customer with a smart meter cannot remain on an old-style single rate tariff. In fact, one state government (www.smartmeters.vic.gov.au) has specified that customers must be offered a choice of staying on a single rate tariff even after a smart meter has been installed.

In-home displays

In-home displays (IHDs) give a visual indication of how much energy the home is using and/or what it is costing at any given time. Most of us never go near our electricity meters, so cannot easily see how quickly the registers or the numbers on the display are changing. Even if you could, it would still be difficult to work out how much electricity you are using, how much it is costing and whether it is more or less than it was an hour, a week or a year ago. On a TOU tariff, it is not always easy to remember when one price period stops and the next one starts.

IHDs can bring all this information inside your home, or onto your computer and mobile phone, in a form that is easy to understand. The simplest IHDs just indicate, with coloured lights or symbols, whether you are in a high, medium or low price period, to help you decide whether to run high-load appliances such as vacuum cleaners. An IHD of this type needs to know only the clock time and TOU tariff schedule, which can be pre-programmed.

Typical in-home display, indicating present rate of electricity use (watts), recent use (kWh) and rate of expenditure at current use.

More complex IHDs can tell us much more:

- The total power the house is using is shown at any given time, usually in kilowatts (kW). It varies according to which appliances are on, what their settings are (e.g. high or low) and where they are in their operating cycle (e.g. heating water or washing clothes). You can also learn where the energy is going in the home, by switching appliances off and on one at a time, and understand which appliances to avoid using during high price periods. Some customers may be on a form of contract that limits the maximum load in kW, so it is especially important to stay within a limit.
- The tariff at the present time, usually in cents per kWh, is shown.
- The amount of energy (power x time) used over a given time period (in kWh) can be given, for example, for the past hour, past day or past month, or since the meter was last read.
- The total electricity cost over that period is shown, taking into account how much electricity you may have used at low, medium and high price periods.
- The energy use over a selected period can be compared with a similar period a day, month or year ago.

For this level of information the IHD needs to be connected to the meter or sense the current flowing through the mains supply. The meter or sensor usually transmits this information to the IHD using a low-power wireless link (similar to the wifi that many homes now have). If the IHD is programmed with tariff details, it can calculate and display what you need to know.

Some IHDs can do even more. They can receive real time information from the electricity supplier, including automatic updates of tariff prices and conditions or messages about network issues. For example, some customers may wish to know if there is a high availability of wind generation in the network so they can use energy when the greenhouse gas intensity of the supply is low. Some suppliers are also trying out 'critical peak' pricing in which customers get advance notice of expected peak load events, usually when the weather bureau forecasts very hot or very cold days. Services such as these need real time communication between the electricity supplier (or some other party) and the IHD — through a smart meter or perhaps other channels such as the internet.

These sophisticated IHDs could also act as a point of control for appliances, provided they can communicate with the appliances in some way. For example, users could program their IHD with the electricity price level at which they want certain appliances to start or stop operating, even if nobody is at home.

If you think of IHDs as sets of functions and capabilities rather than separate devices, the distinction between high-end IHDs and home automation systems begins to blur (see *Home automation*). So does the distinction between IHDs and other electronic devices such as computers and mobile phones. This convergence of functions is part of the smartening of the grid — the closer integration of the supply side and the demand side of the electricity system through better communications and controls.

Smart appliances

Because the market is evolving so rapidly, there are no accepted definitions of smart appliances. The description is used fairly loosely by product manufacturers. Some use the term for any appliance with a wider range of settings or options than its competitors, or with touch controls and digital displays instead of switches and knobs.

Others use it for products that combine functions and technologies in new ways. For example, a refrigerator may have a bar code reader to scan items going in and out, and a screen that can display an inventory of

contents. The screen could also function as a television and an internet portal for the kitchen, through which the user (or the refrigerator's own software) could place grocery orders.

None of these functions is new, and most homes have computers, televisions, internet connections and even bar-code scanners that could do the same job, but the combination into one device may save space, increase convenience and create new possibilities for the user.

For other manufacturers, smart appliances take advantage of lower electricity price periods. Many dishwashers and clothes washers have had features for years, such as delayed start, so this capability alone does not make them smart.

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A smart appliance must be able to receive, process and respond to information about the outside world, beyond just responding to the immediate commands and settings of the user. The information could be a signal from an energy supplier or other authorised entity, or the smart appliance might monitor the voltage and frequency of the electricity grid to detect signs of overload and stress, and react accordingly.

The American Council for an Energy-Efficient Economy and Association of Home Appliance Manufacturers (www.aham.org) have proposed the definition:

> The term 'smart appliance' means a product that uses electricity for its main power source which has the capability to receive, interpret and act on a signal received from a utility, third party energy service provider or home energy management device, and automatically adjust its operation depending on both the signal's contents and settings from the consumer.

AS/NZS 4755:2012, Demand response capabilities and supporting technologies for electrical products, includes the definition:

> The automated alteration of an electrical product's normal mode of operation in response to an initiating signal originating from or defined by a remote agent.

A smart appliance must be capable of demand response — responding automatically to the information it receives in a way that is helpful to the user and/or the grid. It could reduce its energy use, turning off entirely for a brief period or perhaps turning on when it would not otherwise be operating in order to access cheaper energy. Smart controllers linked to distributed generation or energy storage devices could respond by switching on the generator or by discharging stored energy to the grid — if the product is an electric vehicle controller, for example, and it senses that there is a vehicle connected to it with adequate charge in its battery.

Although the user is able to predetermine the mode of operation under various conditions, and usually be able to override an event if it occurs at an inconvenient time (though possibly with a significant reduction in cost savings), a smart appliance responds automatically to pre-programmed events unless instructed otherwise.

This is a step beyond just accessing information from IHDs, where you usually need to be physically home, aware of electricity price changes or other circumstances (unless notified on a mobile device), and then need to decide what to turn on and turn off. With smart appliances, decisions can be made ahead of time and you do not even need to be aware of price changes or special events — a form of 'set and forget'.

These are the smart functions of most value to electricity suppliers, because they contribute directly to balancing electricity supply, demand and price. If a utility can be sure that in five years' time, say, there will be 100MW of smart appliance load that can be instantly and reliably reduced during peak load periods, this is equivalent to building 100MW of additional supply capability — and it is likely to be much cheaper.

> *All electricity consumers will pay less for energy with smarter networks because it will reduce the costs of new poles, wires and substations.*

All electricity consumers will pay less for energy with smarter networks because it will reduce the costs of new poles, wires and substations, all major contributors to rising electricity prices. Of course, utilities have to establish communication with their customers' smart appliances but this is not a new idea. Many existing channels could be used: the ripple control system, a common form of load control, can control water heaters, the internet, the mobile phone network or even broadcast radio.

Consumers who permit businesses to manage their loads, if only for a few hours each year, will of course need to see some financial benefit from allowing appliances to respond to signals and grid conditions. On a TOU tariff, the benefit would be realised as automatic cost savings during high price periods. Alternatively, some utilities offer cash incentives for customers to buy and connect smart appliances, irrespective of the tariff they are on. Electricity suppliers in Australia (and elsewhere) have tested many different ways of engaging their customers and sharing the financial benefits of smart appliances with them. While some electricity suppliers use smart meters, TOU tariffs or IHDs as part of their smart appliance strategy, others do not.

Demand responsive smart appliances

It will take some time to achieve agreement between appliance manufacturers, electricity suppliers and governments on what constitutes smart appliances, and how they might interact with each other and with the grid.

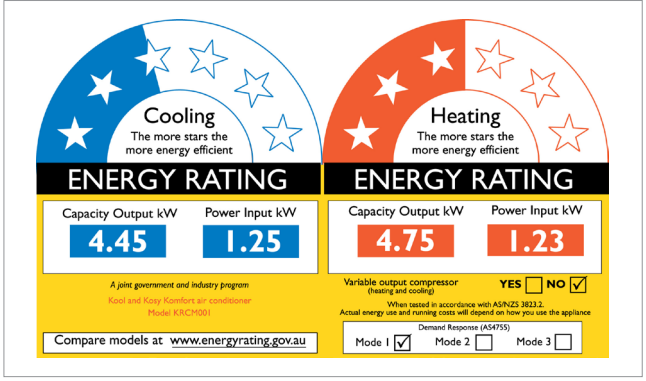
AS/NZS 4755:2012 specifies how smart appliances should respond to external signals. The standard covers the appliances that contribute most to summer and winter peak demand on the electricity system:

- air conditioners, a main cause of summer peaks in most parts of Australia
- swimming pool pumps, which tend to be on during summer peaks
- electric, heat pump and solar-electric water heaters, which have traditionally operated with either day-rate or off-peak tariffs, but often give better service under a demand response arrangement, where their operation is not locked into fixed time periods but can follow changing prices and grid requirements — including storing heat when there is excess renewable generation
- charge/discharge controllers for electric vehicles and other electricity storage devices, a market that is still very small, but could well contribute significantly to peak loads in the future.

You can already buy air conditioners that meet this standard, as indicated on the Energy Rating Label, which has a set of tick boxes marked Demand Response (AS4755).

If there are ticks in one or more of these boxes, the model is capable of demand response.

- Mode 1: the air conditioner can respond by switching the compressor off for a period (but leave the fans running, so air continues to circulate); normally used only in emergencies, when the grid is at risk of blackout.
- Mode 2: the air conditioner continues to cool, but limits its power demand to 50% of its rated capacity; more likely to be used during periods when generation costs are high, and to relieve stress on the grid.
- Mode 3: the air conditioner continues to cool, but limits its power demand to 75% of its rated capacity.



Energy Rating Label for a demand response capable air conditioner.

A 25% or even 50% load reduction may not seem much (and trials have shown that most customers are unaware when it happens, even on the hottest days) but thousands of smart air conditioners with this capability could make the difference between building a new substation or not.

Some electricity utilities are offering customers cash incentives to buy AS/NZS 4755:2012-compliant smart air conditioners and have them connected to the utility's communications system, e.g. Energex (www.energex.com.au) in Queensland in 2012.

Demand responsive smart appliances do not necessarily need smart meters or TOU tariffs, although where smart meters are installed they may be used as the means by which the appliances are controlled.

This is the likely future of smarter grids and smarter appliances. Neither the supply side nor the demand side needs to be completely smart, but with the right technology and mutual agreement of suppliers and consumers, the combination of supply and demand can achieve what neither can do alone. We will all get more value from the electricity system, and maintain a safer and more reliable supply of electricity at less cost.

Energy

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The smart meter situation is changing rapidly, and your electricity tariff options will depend on where you live. Carefully consider whether a particular package of tariff and metering options is right for you. Several comparison websites can help you do this. Whether you benefit from a TOU tariff may depend on adjusting your energy use to take advantage of low price periods and avoiding high price periods.

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Author

George Wilkenfeld, 2013