Advanced Metering for Energy Supply in Australia

Prepared for Total Environment Centre

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TOTAL ENVIRONMENT CENTRE INC.

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EXECUTIVE SUMMARY

Currently, recording the quantities of energy consumed by end-users is mostly carried out by using ***accumulation meters*** which simply record energy consumption progressively over time. However, more advanced meters are increasingly being used. ***Interval meters*** record the quantities of energy consumed over set, frequent time intervals. ***Smart meters*** include, in addition to the interval metering capability, one-way or two-way communications between the energy supplier and the meter.

The Victorian energy regulator has mandated a statewide rollout of interval meters for Victorian electricity customers and the Victorian Government has extended this to incorporate smart meters with several additional functionalities. COAG has committed to the progressive [national] rollout of smart meters to areas where benefits outweigh costs, as indicated by the results of a cost-benefit analysis.

Apart from Victoria, no other jurisdiction currently has any regulation that applies specifically to advanced metering. However, some state regulators have introduced regulatory provisions that provide incentives for demand management. These provisions could encourage electricity businesses to use the functionalities available in advanced meters to implement demand management programs.

Advanced meters enable the implementation of time-varying pricing under which the price per unit of energy varies according to the time of the day. Seasonal variation in prices is also possible. Time-varying tariffs send price signals to customers that reflect the underlying costs of generating, transporting and supplying electricity, enabling resources to be allocated more efficiently. Furthermore, price-based demand response programs can reduce or shape customer demand, particularly to reduce loads at peak times on the electricity system. Trials of advanced metering technology and customer response to time-varying pricing are currently being carried out in most States.

This report also identifies and reviews a number of low cost technology products that enable various load control functions. This review draws the following conclusions:

- **interval metering** is not necessary to carry out load control functions – available technology can remotely switch loads without requiring connection to a meter;
- **one-way communication** is essential to carry out remote switching of loads;
- **two-way communication** is not essential to carry out remote switching of loads; and
- **metering** in some form is required for settlement of the financial transactions associated with load control programs.

Installing advanced meters will, by itself, do nothing to reduce greenhouse gas emissions. Emission reductions will only be achieved if installing the meters results in changing people's behaviour so that they use less energy in total. Overseas studies suggest that a national rollout of advanced meters to all electricity consumers in Australia may achieve savings of between four and 10 percent in total national electricity use, with corresponding savings in GHG emissions.

The following table (page v) shows the possible annual reductions in GHG emissions that could be achieved through a national rollout of advanced meters to all electricity consumers for savings of between four and 10 percent in total national electricity use.

Possible Annual Reductions in Greenhouse Gas Emissions from a National Rollout of Advanced Meters		
Savings in Total National Electricity Use	**Annual Reduction in Greenhouse Gas Emissions (Mt CO2-e)**	**Proportion of Total National Emissions**
4%	7.8	1.4%
6%	11.7	2.1%
8%	15.5	2.8%
10%	19.4	3.5%

To make best use of the functionalities and capabilities of advanced metering, both Chapter 7 of the *National Electricity Rules* and the *National Electricity Market Metrology Procedure* will require some modification. The report recommends particular elements that should be included in a metrology framework for the National Electricity Market.

RECOMMENDATIONS

Recommendation 1 (page 62): The NEM metrology framework should specify that the minimum metering requirement for both first tier and second tier customers is a smart meter (ie an interval meter with communications).

Recommendation 2 (page 63): The NEM metrology framework should include detailed protocols enabling and controlling both one-way and two-way communications routed through advanced meters.

Recommendation 3 (page 63): The NEM metrology framework should include detailed protocols and technology standards enabling and controlling all load control functions carried out through an advanced meter, independently of a meter, or both. The framework should also specify that load control technology products used in the NEM must be designed so that additional capabilities and functions can be added without requiring the physical replacement of whole units or parts of units.

Recommendation 4 (page 64): The NEM metrology framework should include detailed protocols and technology standards enabling and controlling the provision of real time or near-real time energy consumption information to end-use customers.

Recommendation 5 (page 64): The NEM metrology framework should provide incentives to retailers that introduce time-varying pricing for customers who have interval meters installed, and that do not dilute any time-varying pricing introduced by network businesses.

Recommendation 6 (page 64): The NEM metrology framework should include detailed protocols enabling and controlling the communication of information about time-varying prices to end-use customers.

Recommendation 7 (page 65): Electricity regulators should introduce regulatory measures to reward electricity businesses that implement demand management programs. This will enable electricity businesses to provide incentive programs that encourage customers to change their energy-using behaviour.

Recommendation 8 (page 65): Cost benefit analyses of advanced metering should include the estimated value of demand response to electricity network businesses in the future as peak loads on electricity networks grow.

Recommendation 9 (page 66): Cost benefit analyses of advanced metering should include the estimated value of greenhouse gas emission reductions to electricity businesses in the future when emissions trading is introduced on a national basis in Australia.

1. INTRODUCTION

1.1 Purpose of this Report

The Total Environment Centre (TEC) has received funding from the National Electricity Consumer Advocacy Panel to commission a report on the benefits and costs for consumers of a national rollout of interval meters, including assessment of the optimal technology choices and retail tariffs needed. While there has been previous analysis of specific aspects of interval meters, there has been no real investigation of the benefit of a rollout of interval meters at the national level, or of the benefits and costs of different time-scales for such a rollout. Neither has there been a direct focus on the potential for the reduction of greenhouse gas emissions from the rollout of interval meters in Australia. TEC has engaged Energy Futures Australia Pty Ltd to carry out this work.

1.2 Types of Meters

For most of the 100 year history of electricity and gas industries throughout the world, recording the quantities of energy consumed by end-users has been carried out by using ***accumulation meters*** which simply record energy consumption progressively over time. With this type of meter, physical readings of the meter are required at set intervals to enable calculation of the quantity of energy used during a billing period.

In Australia, most electricity and gas end-users, particularly in the residential sector, are still billed using data from accumulation meters. However, more advanced meters are increasingly being used, particularly in the commercial and industrial sectors.

Interval meters record the quantities of energy consumed over set, frequent time intervals. Typically, the minimum time interval set for recording energy consumption is every fifteen minutes and the maximum interval is every hour. Interval meters enable time-varying energy pricing in which the energy price during the day can be set at high levels during peak periods when the energy system may be constrained, and at low levels during off-peak periods when there is spare capacity in the system.

Smart meters comprise a more advanced level of metering technology. In addition to the interval metering capability, smart meters typically include one-way or two-way communications between the energy supplier and the meter. This communication capability enables a range of other functionalities that may include:

- automated and remote meter reading;
- remote connection and disconnection of the energy supply to the end-user's premises;
- outage detection to monitor the status of the energy supply;
- tamper detection to identify theft of energy from the network;
- monitoring of power quality;
- remote time synchronisation to keep the meter's internal clock accurate without requiring a site visit to check and adjust;
- an interface for a display unit in the end-user's premises that shows the current level of energy consumption, the cost of the energy being consumed, plus other information such as the tariff currently being applied;

- an interface for load control devices that can remotely switch appliances and equipment on and off.

Other functionalities that may be incorporated into smart meters include:

- a supply capacity control (circuit breaker) that disconnects the supply if the demand at the end-user's premises exceeds a set value[1];
- a capability to record quantities of energy both exported from the network to the end-user (as in normal energy supply) and imported to the network from the end-user (eg by a photovoltaic panel or other on-site generation installed at the end-user's premises).

1.3 Advanced Metering Infrastructure

A recent report by the United States Federal Energy Regulatory Commission (FERC) defines "advanced metering" as follows:

> *Advanced metering is a metering system that records customer consumption (and possibly other parameters) hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point*[2].

The key concept reflected in this definition is that advanced metering involves more than a meter than can measure energy consumption over frequent time intervals (ie an interval meter). Advanced metering refers to the full measurement and collection system, and includes customer meters (usually smart meters), communication networks, and data management systems. This full measurement and data collection system is commonly referred to as ***advanced metering infrastructure*** (AMI).

Figure 1 (page 3) shows diagrammatically the assumed scope of an AMI system in relation to the mandated rollout of AMI by electricity distributors in Victoria. For the purposes of this diagram, the distribution business (DB in the diagram) is assumed to be the Metering Data Provider.

The left of the diagram shows devices that could be in a customer's premises, including an in-home display unit and/or load management devices (which might control a range of appliances, eg pool pumps, air conditioners, dishwashers etc). These devices are considered external to an AMI system, but the AMI system is required to provide an interface or communications channel (shown as a dotted line in Figure 1) to enable the connection of such devices to retailers' systems. This connection may be through the meter, or directly through the AMI communications network, or through another communications channel. Existing controlled storage hot water heaters and storage space heating are included in the scope of an AMI system.

[1] Such an arrangement is applied routinely to most dwellings in Italy where the circuit breaker/safety switch ('salva vita') is normally set to trip when the load exceeds 3 kW.

[2] Federal Energy Regulatory Commission (2006). *Assessment of Demand Response and Advanced Metering*. Washington DC, FERC, p 17. Available at: www.ferc.gov/legal/staff-reports/demand-response.pdf

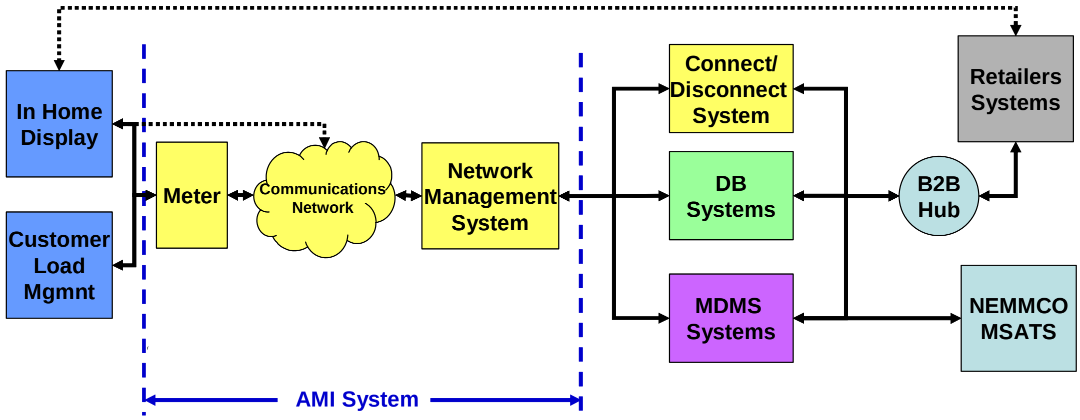

Figure 1. Scope of Mandated AMI Systems in Victoria[3]

Between the meter and the network management system a communications network cloud is shown. In some AMI systems, data concentrators would be part of this communications network.

The items on the right hand side of the diagram, including distributors' systems, retailers' systems, B2B hub and NEMMCO MSATS system are not part of the AMI system. However, the AMI functionality specification places requirements on some of these systems.

1.4 Benefits of Advanced Metering

1.4.1 Benefits for Electricity Businesses

The FERC report[4] identifies the following categories of benefits available to electricity businesses from the deployment of advanced metering technology:

- meter reading and customer service benefits;
- asset management benefits;
- ability to provide value-added services;
- outage management benefits;
- financial benefits.

Meter Reading and Customer Service Benefits

Implementation of advanced metering can significantly reduce meter reading expenses and capital expenditures, and can also increase the accuracy and timeliness of meter reading and billing. In particular, eliminating estimated bills and load profiling[5] is a key benefit available from automated meter data collection systems. Electricity

[3] Source: Victorian Department of Infrastructure (2006a). *Draft Advanced Metering Infrastructure (AMI) Minimum Statewide Functionality Specification.* Melbourne, DOI.

[4] Federal Energy Regulatory Commission (2006). *Op. cit.*

[5] Load profiling may be used when a customer does not have an interval meter. Under load profiling, the cumulative kilowatt-hours consumed by a customer in a day are allocated across each hour (or other time period) based on the aggregate consumption over time of a group of similar customers.

businesses rarely are able to accurately estimate total electricity consumption over a billing period, even using weather and historical monthly consumption data. This is especially true for residential customers during vacations and during periods when the number of household members change. Also, the actual consumption over time by an individual customer may vary markedly from the aggregate consumption of a group of similar customers. Currently, estimated bills and customer profiling, particularly in the residential sector, make it difficult for customers to obtain accurate information about their electricity consumption and significantly hinder attempts to provide incentives to customers who reduce their peak loads and/or implement energy efficiency measures.

Asset Management Benefits

Advanced metering can provide important information to assist in managing electricity network assets, particularly detailed and accurate data on customer demand and usage patterns. This enables electricity network businesses to significantly improve asset management including: proper sizing of equipment, predictive maintenance of equipment, theft detection, improved cost allocation across the customer base, and the ability to use accurate data on customer demand to defer investment in network infrastructure.

Ability to Offer Value-added Services

Advanced metering enables electricity businesses to offer new or improved services to customers with advanced metering, including additional tariff options (particularly time-varying pricing), flexible billing cycles, benchmarking of energy usage with similar customers, real time or near-real time information on actual electricity consumption and its cost, the aggregation of accounts and/or synchronization of multiple account billing and meter reading, web services based on the more timely information provided by advanced metering, and bill prediction for large and small customers, including weather forecast data.

The combination of time-varying electricity tariffs and the ability to provide real time information to customers about their actual electricity consumption and its cost (eg through an in-house display) enables electricity businesses to devise programs that provide incentives to customers who reduce their peak loads and/or implement energy efficiency measures.

Outage Management

The ability to detect outages provided by advanced metering technology can significantly improve outage management, for example by providing accurate information about the location of outages, thereby enabling more efficient scheduling of work by maintenance crews. Responding faster to small outages is another important benefit, especially in terms of improving customer service. Over time, as customers learn that AMI systems enable automatic detection and location of outages, it is expected that call centre volume during outages will be significantly reduced. When customers do call in, electricity businesses will be able to provide a better estimate of repair times.

Financial Benefits

Electricity businesses gain significant financial benefits from the implementation of advanced metering, particularly from the avoided cost of manual meter reads[6]. Financial benefits also accrue from general efficiency gains and improved cash flow from reducing the time it takes to produce a bill after the meter is read.

1.4.2 Benefits for End-use Customers

A study by Sustainability First in the United Kingdom[7] identified three categories of benefits available to end-use customers from the deployment of advanced meters:

- improvements in billing accuracy and payment arrangements;
- more comprehensive information about energy consumption; and
- dynamic market effects.

Billing Improvements

Customer benefits from improvements in billing include:

- more accurate billing which avoids underpayment (risk of debt) and overpayment (possible cash flow problems) by customers;
- no manual meter reading is required, therefore there is no need for customers to let meter readers into their property;
- more payment options for customers, eg variable direct debits from bank accounts based on actual use, might suit some customers.

More Comprehensive Information

Comprehensive information from advanced meters, such as real time information about the current energy consumption in the customer's premises and its cost, can be provided to customers via a conveniently sited in-house display or via the internet. Such information may motivate behavioural change by customers to achieve absolute reductions in energy use (energy saving) or shifting energy use to off-peak times (encouraged by time-varying pricing). Smart meters with communications functionality can also be used by electricity businesses to send messages to customers, such as information about energy saving measures, time of use tariff schedules, etc.

Dynamic Market Effects

More comprehensive data from advanced metering may have a significant impact on retail contestability by making it easier for electricity retailers to enable customer switching. This could make customers more likely to switch retailers, with a potential dynamic effect on the market. If more customers switch, retailers may have to offer

6 CRA International and Impaq Consulting (2005). *Advanced Interval Meter Communications Study*. Melbourne, CRAI International. Available at: http://www.dpi.vic.gov.au/dpi/dpinenergy.nsf/93a98744f6ec41bd4a256c8e00013aa9/e56b1c9515d349a4ca2572c10003b843/$FILE/AMI_Study.pdf

7 Owen, G. and Ward, J. (2006). *Smart Meters: Commercial, Policy and Regulatory Drivers*. London, Sustainability First.

better loyalty deals to customers who stay. Also lower costs through smart meters may enable retailers to offer better deals, reducing prices for all customers.

Advanced metering will also enable retailers to provide a wider range of value-added services, such as time-varying tariffs; energy services packages; possibly micro-generation using solar photovoltaic panels or micro-cogeneration fuelled by natural gas. These new offers could also help to induce more retailer switching with further price effects.

Advanced metering could lower costs sufficiently to facilitate market entry by new retailers, increasing the number of retailers from which customers may choose. This increased competition may also contribute to reducing retail prices.

2. PROGRESS ON IMPLEMENTING ADVANCED METERING

2.1 Electricity Industry Reform

Reform of the electricity industry in Australia commenced with the development of the National Electricity Market (NEM). Contrary to current received wisdom, it was the electricity industry itself, rather than governments, which in 1990 initiated development of a competitive wholesale electricity market. Senior managers in the industry were watching the implementation of the England and Wales electricity market and were aware of the prevailing enthusiasm among governments for micro-economic reform. Rather than waiting for governments to impose a similar competitive market on the Australian electricity industry, they advocated that the industry itself should take the initiative.

During 1990, the electricity industry established informal working groups to discuss aspects of what a competitive electricity market might look like in Australia. With the blessing of (but initially little active involvement by) governments, these industry groups were formalised into the National Grid Management Council (NGMC). In 1992, the NGMC published the first outline design of the NEM, the *National Grid Protocol*[8].

This first design for the NEM included a strong statement about the role of demand management and renewable energy in the competitive electricity market:

> *"Demand management and renewable energy options are intended to have equal opportunity alongside conventional supply-side options to satisfy future requirements. Indeed, such options have advantages in meeting short lead-time requirements*[9]*."*

However, these commitments fell by the wayside during the subsequent six years of detailed technical development and market trials. When the NEM commenced on 13 December 1998, there were no specific provisions in the market rules that enabled equal opportunities for demand management and renewable energy. In fact, the NEM is

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8 National Grid Management Council (1992). *National Grid Protocol: First Issue*. Melbourne, NGMC.

9 NGMC (1992). *op cit*, p iii.

sometimes described as "half a market" because currently there is very little demand-side participation in the market by electricity end-users[10].

The development of the NEM as a wholesale electricity market was accompanied by three other highly significant micro-economic reform measures:

- unbundling of the four functions of the electricity industry (generation, transmission, distribution, and retail supply) into separate businesses;
- the progressive introduction of competition at the retail level; starting with the largest customers, the supply of electricity to end-users was made contestable so that retailers competed to supply electricity end-use customers;
- the formalisation of economic regulation of electricity businesses; once competition was introduced into the electricity industry, the State government established new agencies to regulate the industry, replacing previously largely informal arrangements between governments and electricity businesses in relation to such matters as pricing, long term planning and investment in new capacity.

These micro-economic reform measures forced huge changes in the electricity industry. Almost overnight, generation and retailing of electricity changed from being regarded as a public service to highly commercial activities in which the various different businesses were in direct competition with each other[11].

Major issues arising from these changes include:

- the re-orientation of all electricity businesses towards a more commercial focus, including:
  - ♦ a reluctance to share technical and financial information with competing businesses, leading to reduced joint planning and cooperative R&D activities; and
  - ♦ a focus on cost cutting and more stringent investment criteria which led to reduced maintenance of assets, particularly in some network businesses;
- a sharp reduction in the benefits available to electricity businesses from undertaking demand management; each of the unbundled businesses could capture only part of the range of benefits from demand management that were previously available to vertically integrated businesses;
- the occurrence of highly volatile spot prices in the NEM in which wholesale spot prices can change from an average of $30 to $40 per megawatt-hour to a maximum of $10,000 per megawatt-hour for brief periods;
- the development of the role of electricity retailers as managers of electricity price risks for their retail customers, most of whom pay for electricity through flat tariffs which do not reflect the prices in the NEM wholesale market; and

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[10] The "perfect market" beloved of economists, but non-existent in practice, assumes that buyers of a product have perfect information and are able to participate in the market by deciding the price level above which they will not buy the product.

[11] Transmission and distribution are regarded as being natural monopolies and determinations by industry regulators attempt to mimic the effects of competitive pressures in these sectors.

- the development of financial and physical hedge products to enable market participants to manage electricity price risk.

For about four years after the introduction of the major changes to the electricity industry, governments took little action and the electricity businesses themselves were totally focussed on making the changes work. This altered in late 2002 when governments (acting through COAG and the Ministerial Council on Energy) commenced taking policy action in relation to the operation of the NEM and more generally the regulation and governance of the electricity industry. Over time, this policy action has progressively broadened and extended.

2.2 Government Policy Development

2.2.1 COAG Energy Market Review

The first major policy action by governments took place in 2002 with the commissioning by COAG of an energy market review chaired by the former Commonwealth minister, Warwick Parer. One of the issues examined in the Parer report[12] was demand side participation in the NEM. The report concluded that the low demand-side involvement in the NEM is attributable to three factors:

- in the short term the demand for electricity is inelastic - there are natural limits to the demand management capability likely to be available;
- residential consumers with the most ‘peaky’ demand face no price signals regarding their use of electricity - these consumers account for around half the load in many markets;
- consumers who offer to curtail demand cannot gain the full value of what they bring to the NEM - this is due to the current market mechanism.

The report concluded that there were few effective measures for stimulating the demand side to influence pool prices, or the need for generation, in the NEM. This was where the immediate policy focus needed to be.

The report proposed several policy measures which could be implemented to increase demand side user participation in the NEM, including:

- mandating a roll–out of interval meters for all NEM households as soon as possible;
- removing retail price caps and introducing full retail competition into all markets as soon as practicable, but in any event within the next three years;
- introducing a ‘pay–as–bid’ mechanism[13] for demand reduction into the NEM dispatch and market systems.

[12] Energy Market Review Panel (2002). *Towards a Truly National and Efficient Energy Market*. Canberra, Commonwealth of Australia.

[13] Under a ‘pay–as–bid’ mechanism for demand reductions, electricity end-use customers would make offers in the National Electricity Market to reduce their loads by a specified amount in return for a price per megawatt-hour reduction. If an offer was accepted and the load reduction was dispatched, the customer would receive the price they offered. This contrasts with the current NEM bidding system for electricity generators, where all

2.2.2 Report to COAG by the Ministerial Council on Energy

During 2003, the Ministerial Council on Energy (MCE) directed its Standing Committee of Officials (SCO) to consider three factors that would facilitate greater end user participation in the NEM.

These three factors were:

- the scope to facilitate a demand response[14] pool in the NEM;
- the costs and benefits of interval metering in the NEM; and
- alignment of retail price caps with supply costs and periodically review of the need for price caps in jurisdictions where full retail competition is operating.

In December 2003, the MCE prepared a report to COAG[15] on the reform of energy markets. In a response to the proposals in the Parer report on user participation in the NEM, the MCE recommended to COAG that:

- in all jurisdictions where full retail competition is operating, each jurisdiction should align their retail price caps with costs, and periodically review the need for price caps;
- the MCE should examine options for a demand response pool in the NEM, and consider the costs and benefits of introducing interval metering.

2.2.3 MCE User Participation Working Group Report

The MCE Standing Committee of Officials established a User Participation Working Group (UPWG) to undertake further work on end user participation in the NEM. In March 2004, the UPWG prepared a Discussion Paper[16] that proposed a set of policy directions as a path to achieve the objective of enhanced user participation.

Demand Response

The paper identified a number of concerns with the 'pay-as-bid' demand response pool proposed by the Parer report. Demand response mechanisms enable end users to be financially rewarded when they choose to switch off, or re-schedule their energy usage in response to market signals. The paper considers two potential market-based demand response mechanisms within the NEM:

- a 'pay-as-bid' mechanism that dispatches and pays for demand response in the physical energy supply market; and
- a demand side aggregation facility that brokers the demand response from a number of end users and sells this package of response in either the financial or the physical market.

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generators that are dispatched receive the price offered by the most expensive dispatched generator.

[14] Demand response comprises actions taken by end-use customers to change (usually reduce) their electricity use in response to high prices in the electricity market and/or problems on the electricity network.

[15] Ministerial Council on Energy (2003). *Report to COAG on Reform of Energy Markets*. Sydney, MCE.

[16] User Participation Working Group, Ministerial Council on Energy Standing Committee of Officials (2004). *Improving User Participation in the Australian Energy Market*. Hobart, MCE.

The benefits of both mechanisms include the potential moderation of spot prices and financial returns for end users who provide demand response. However, the UPWG was concerned that a 'pay-as-bid' mechanism raises a number of efficiency concerns, including its ability to effectively price and dispatch demand response in the spot market. Such a mechanism would require a complex and onerous series of codes and rules that would act as a barrier to effective take-up and would impose an element of uncertainty and risk for market participants. The UPWG concluded that an aggregation facility that facilitates demand response in the financial market appears a more promising mechanism to maximise available value to end users.

Interval Metering

The UPWG concluded that interval metering technology coupled with appropriate time-of-use tariffs has the potential to deliver a range of benefits to market participants. Interval meters may encourage consumers to address their energy consumption by moderating electricity load at times of high wholesale spot prices or network congestion. The reduction of peak energy demand may benefit the market in delaying the need for investment in the electricity supply industry and lessening wholesale spot price peaks. Interval meters and associated time-of-use tariffs are potentially more equitable than existing less differentiated pricing arrangements, and more cost-reflective tariffs enable consumers to gain benefits from load shifting.

The UPWG proposed to carry out an assessment of the benefits derived from the existing interval meter stock to provide information on areas where benefits of interval meters can be enhanced and which additional customer classes may benefit from greater application of interval metering technology. However, the UPWG concluded that a wide scale mandatory rollout of interval metering across all customer classes may be premature at this stage of market development.

The UPWG also concluded that low cost, remote activated load control and measurement technology may be a cost effective alternative to interval meters for the small customer classes. The UPWG proposed to further explore this concept.

Retail Pricing

The UPWG concluded that in those jurisdictions where full retail competition has been introduced, various forms of retail tariff regulation are being applied as a safety-net mechanism to ease the transition to a competitive market for small customers. The UPWG recognised the need for the development of a transparent and predictable process. Enhanced market efficiency should be promoted through the alignment of regulated retail prices with energy costs to reflect growing levels of competition. Such a defined process would also allow for periodic review of the need for retail price regulation as the retail market matures.

The UPWG proposed to develop an overarching set of policy principles, which will guide all governments where full retail competition has been introduced, to ensure transparent decision-making on retail price regulation issues.

2.2.4 Australian Government Energy White Paper

In June 2004, the Australian Government released its White Paper on energy *Securing Australia's Energy Future*[17]. This major policy statement included chapters on "Energy Efficiency[18]" and "Climate Change and Energy". The White Paper announced the establishment of the Solar Cities programme and included several relevant major policy and program decisions.

The White Paper stated that to improve Australia's energy efficiency performance, the Australian Government would:

- improve price signals for demand side management as part of reforming Australia's energy markets;
- demonstrate the potential benefits of energy efficiency and market reform through major Solar Cities trials;
- expand the range of appliances and buildings subject to minimum energy performance standards;
- continue to improve the energy efficiency of Australian Government agencies;
- increase the availability of information on the energy performance of appliances, buildings and vehicles;
- require large energy users to regularly identify and publicly report on energy efficiency opportunities;
- streamline energy reporting requirements and participation in energy efficiency and greenhouse programmes using the Greenhouse Challenge programme as a single point of entry.

The White Paper also announced that:

- a Productivity Commission inquiry would be established to provide further information on the potential benefits of, and policies to achieve, improved energy efficiency; and
- the Mandatory Renewable Energy Target would not be extended and that instead the Australian government would more directly promote the development and demonstration of a broader range of low-emission technologies through new technology development funds and the Solar Cities programme.

[17] Energy Task Force, Department of the Prime Minister and Cabinet (2004). *Securing Australia's Energy Future*. Canberra, Commonwealth of Australia.

[18] This was the first time that an Australian Government energy policy document included a major emphasis on energy efficiency.

2.2.5 MCE User Participation Policy Statement

In August 2004, the Ministerial Council on Energy released a policy statement[19] resulting from the work carried out by its User Participation Working Group. The policy statement considered two issues in particular:

- market mechanisms to promote demand response in the NEM; and
- the role of interval metering technology.

Market Mechanisms to Promote Demand Response

The MCE concluded that the current low level of end user participation in the NEM reduces effective competition and dilutes the benefits of market reform for energy consumers. Direct participation in the NEM should enable energy users to capture a greater share of the economic return achieved from reducing their energy consumption during high priced periods and network congestion. A market-based approach should allow buyers and sellers to capture the optimal value of the demand response at least-cost.

The MCE considered that a flexible and accessible market-based demand side aggregation mechanism is an attractive proposition, as it creates a secondary market to flexibly manage delivery and payment for demand response products rather than requiring additional structural changes to the existing spot market mechanism. It is also a structure that would be accessible by a broader cross-section of energy users.

The MCE agreed not to proceed with work on the Parer report's 'pay-as-bid' demand response bidding proposal. Preliminary work revealed a number of challenging design and implementation issues with no guarantee of higher levels of demand response in the NEM. A number of structural and compliance issues impose an additional element of market risk and undermine its usefulness as a mechanism to induce direct end-user participation in the wholesale spot market. The MCE concluded that the proposal does not appear to present the most efficient or least-cost approach to improving overall user participation levels.

Role of Interval Metering Technology

The MCE stated that peak demand and load, which are increasingly driven by the growing penetration of air conditioners and other energy-using equipment in Australian households, are costly issues for the national energy market. Metering, complemented by remotely activated load control technology, other energy management technologies and the right price incentives, can:

- moderate demand and load by assisting consumers to voluntarily manage their energy use;
- increase user participation;
- defer investment in new generation and network capacity; and
- contribute to a more effective energy retail market.

[19] Ministerial Council on Energy Standing Committee of Officials (2004). *User Participation Policy Statement*. Canberra, MCE.

The MCE recognised the important role of interval metering and load control technologies in developing a more efficient energy market with stronger user participation and improved energy use management and endorsed further deployment of advanced interval metering technology as a long-term goal for the efficient development of the retail market.

The MCE agreed that all NEM jurisdictions which have not done so, should review the use of interval meters and assess the relative benefits of an interval meter rollout by 2007. The MCE also agreed to commission a study to identify low cost load control technology and other technologies that could assist consumers in voluntarily managing their energy use.

2.2.6 COAG Meeting February 2006

At its meeting on 10 February 2006, COAG considered a number of energy policy issues. In particular, the communiqué[20] from the meeting stated that Governments agreed to improve the price signals for energy investors and customers by:

- committing to the progressive [national] rollout of electricity smart meters to allow the introduction of time of day pricing and to allow users to respond to these prices and reduce demand for peak power;
- requesting the Ministerial Council on Energy to agree on common technical standards for smart meters and implement the rollout as may be practicable from 2007 in accordance with an implementation plan that has regard to costs and benefits and takes account of different market circumstances in each State and Territory; and
- implementing a comprehensive and enhanced MCE work program, from 2006, to establish effective demand response mechanisms in the electricity market, including network owner incentives, effectively valuing demand responses, regulation and pricing of distributed and embedded generation, and end user education.

2.2.7 MCE Smart Meters Information Paper

In January 2007, in response to the February 2006 request from COAG to provide an initial report on a smart meter rollout, the Ministerial Council on Energy (MCE) released an information paper[21] on the development of an implementation plan for the rollout of smart meters.

Objective

The information paper states that the objective for the rollout of smart meters across Australia is to improve the efficiency of the Australian Electricity Market by:

- reducing demand for peak power, with consequential infrastructure savings (e.g. network augmentation and generation) and improved security of supply;
- driving efficiency and innovation in electricity business operations;

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[20] Council of Australian Governments (2006). *Meeting 10 February 2006: Communique*. Canberra, COAG.

[21] Ministerial Council on Energy (2007). *Smart Meters - Information Paper*. Canberra, MCE. Available at: http://www.mce.gov.au/assets/documents/mceinternet/SmartMetersInfoPaper20070123163300%2Epdf

- promoting competition in electricity retail markets;
- enabling consumers to make informed choices;
- promoting energy efficiency objectives;
- improving price signals for energy investors; and
- providing a potential platform for other demand response measures.

Policy Principles

The paper also identifies the following policy principles guide the rollout of smart meters in Australia.

Benefit-Cost Analysis. The national implementation plan will be based on a single national benefit-cost analysis managed by MCE that takes into account both the different circumstances in each State and Territory and the advantages and disadvantages of a universal rollout.

Apportioning the Costs of the Smart Meter Rollout. The costs of the rollout of smart meters should be apportioned across the supply chain in accordance with where the benefits accrue, and have regard to the timeframes in which those benefits are realised.

Responsibility for the Rollout. The responsibility for the rollout should fall on a single party in each geographical area. This single party should be each distribution network service provider within its own network area. Each distributor should undertake the rollout in accord with its normal practices with regard to achieving cost efficiencies. Distributors and other parties should also be given the opportunity to provide innovative and competitive demand side solutions and other services alongside the national rollout being undertaken by the distributors.

National Oversight. MCE will establish appropriate governance arrangements at a national level including risk management, and co-ordinate activities to facilitate the rollout. At the end of each significant phase, post-implementation reviews will be undertaken to assist in managing and controlling further phases of work.

Stakeholder Consultation. The MCE should engage with stakeholders on both the supply and demand sides, and regulators and market bodies, as appropriate at each stage of the process. A draft report of the benefit-cost analysis shall be subject to public consultation.

Legislative and Regulatory Framework. The necessary legislative and regulatory frameworks to ensure the objectives of the smart-meter rollout are met must be created and put in place. This will include

- the framework for funding of the meter rollout;
- MCE instructions to the Australian Energy Market Commission regarding any changes required to the National Electricity Rules;
- preparation of national guidelines and procedures by the Australian Energy Regulator to account for the effects of the smart meter rollout on electricity distribution price reviews including, but not limited to, recovery of costs incurred by a regulated entity as a result of the rollout; and
- any jurisdictional issues such as tariff regulation and contestability arrangements.

Next Steps

The information paper set out the next steps to be taken by MCE in implementing a national rollout of smart meters.

Phase 1. MCE to establish a project group to oversee and drive the implementation of COAG policy on the smart meter rollout. The project group will then carry out the following activities.

- establish a framework for undertaking the benefit-cost analysis, including clear terms of reference;
- consider an interim policy for new and replacement meters now being installed to minimise risks of stranding;
- commence a national benefit-cost analysis, including options for functionality.

Phase 2. MCE to consider the results of the benefit-cost analysis. The project group will then carry out the following activities:

- convene an industry policy specification group to define options for specifications for the smart meter rollout, including common technical standards;
- coordinate field trials of different vendors' technologies, including meters, communications equipment, IT systems and any other supporting infrastructure;
- update specifications based on the results of field trials;
- create and put in place the necessary legislative and regulatory frameworks including any social and adjustment issues.

Phase 3. Consistent with the benefit-cost analysis, commence the rollout of new technology.

2.2.8 COAG Meeting April 2007

At its meeting on 13 April 2007, COAG agreed a response to the MCE initial report on a smart meter rollout. In the response[22], COAG endorsed a staged approach for the national mandated rollout of electricity smart meters to areas where benefits outweigh costs, as indicated by the results of the cost-benefit analysis which will be completed by the end of 2007.

Timetable for the Smart Meter Rollout

COAG-approved the following timetable for the national rollout of smart meters.

- By September 2007, MCE will agree to a national minimum functionality for smart meters, including open communication protocols to support competition. Replacement criteria for existing meters will also be agreed to minimise costs of unnecessary replacements.
- By end 2007, MCE will finalise the cost-benefit analysis.

22 Council of Australian Governments (2007). *COAG National Reform Agenda: Competition Reform April 2007*. COAG, Canberra.

- By March 2008, MCE will also agree to any specific areas where replacement and rollout may be exempt or delayed, on the basis of local factors which are demonstrated to reduce net benefits for consumers, as informed by the results of the cost-benefit analysis.
- By March 2008, MCE will agree necessary changes in the National Electricity Rules to require new and replacement meters to comply with this minimum functionality and enable the national rollout to commence.
- During 2008, MCE will implement the necessary rule changes to mandate the rollout of smart meters, consistent with the outcomes of the cost benefit analysis.
- By end 2008, replacement of existing meters with smart meters will have commenced.

Smart Meter Functionality

The COAG response to the MCE report stated that functionalities to be included in smart meters for the national rollout are yet to be determined. However, COAG noted the MCE's view that smart meters could allow for:

- two way communications interface;
- remote reading;
- remote load control;
- import and export metering;
- remote connect/disconnect;
- outage detection;
- meter tamper detection;
- remote time synchronisation; and
- quality of supply measurement and recording.

National Framework and Implementation Plan

COAG also agreed that MCE will finalise the details of the national framework and implementation plan to optimise the net benefits identified from the national rollout of smart meters. This plan will include:

- implementation roles and responsibilities;
- facilitation of new time-related tariffs to pass benefits on to consumers; and
- the required changes to the National Electricity Rules and jurisdictional arrangements, including any transitional arrangements.

To support the development of this implementation plan, MCE has formed a smart meter stakeholder working group (SMSWG) with representation from consumers, the electricity industry, regulators and market bodies. This group will advise on stakeholder priorities, technical aspects of the plan and the assessment of costs and benefits.

2.3 Action on the Ground

Currently, in Australia there are three main areas in which action on the ground is occurring in relation to installing interval meters and smart meters:

- installation of advanced meters as part of normal business by electricity companies;
- progress in Victoria towards a mandatory statewide rollout of interval meters with some “smart” functionalities;
- small scale trials carried out by individual electricity businesses.

2.3.1 Installation of Advanced Meters as Normal Business

Most electricity businesses in Australia that have responsibility for metering are installing some advanced meters as part of their current normal business practice.

For example, in NSW, EnergyAustralia is rolling out smart meters to 145,000 customers[23] with annual consumption between 15 and 160 megawatt-hours[24]. Larger customers in Energy Australia’s service territory generally already have some form of interval metering installed. EnergyAustralia is also specifying interval meters as the standard in new and replacement installations for household level customers.

As a consequence of current normal business practice by electricity businesses, there is a fleet of several hundred thousand advanced meters (mostly interval meters with some smart meters) currently installed in Australia.

2.3.2 Mandatory Rollout of AMI in Victoria

In July 2004, the Victorian electricity industry regulator, the Essential Services Commission (ESC), issued a decision[25] requiring the mandatory rollout of interval meters for Victorian electricity customers.

Scope of the Rollout

Initially, the decision required only simple interval metering technology without a communications capability to be included in the rollout. In July 2005, the Victorian Government together with the Victorian electricity distribution businesses and a range of electricity retailers commissioned a study on enhanced interval meter communications[26]. This study assessed the costs and benefits of adding remote communications to the interval metering rollout program and concluded that there was a positive societal business case for not only adding communications to interval meters but also accelerating the rollout and broadening it to all customers consuming less than 160 megawatt-hours per annum.

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[23] Beeman, E. (2007). *Smart Meters, Time-of-Use and Advanced Metering Infrastructure*. Presentation at EnergyAustralia Retailer Information Forum, Sydney, 9 May.

[24] Typically, customers who use about 15 megawatt-hours of electricity a year are small businesses with high electricity use, such as small drycleaners.

[25] Essential Services Commission Victoria (2004a). *Mandatory Rollout of Interval Meters for Electricity Customers: Final Decision*. Melbourne, ESC, July.

[26] CRA International and Impaq Consulting (2005). *Op. cit.*

Based on this business case, the Victorian Government committed to a rollout of Advanced Metering Infrastructure, commencing in 2008. The rollout will include all electricity customers consuming less than 160 megawatt-hours per annum, plus those customers consuming more than 160 megawatt-hours per annum that do not have an interval meter. This will require the installation of about 2.4 million new smart meters.. In August 2006, the Victorian Parliament amended the *Electricity Industry Act 2000* to provide powers to enable a statewide AMI rollout.

Meter Functionalities to be Included in the Rollout

In preparing for the AMI rollout, it was determined that there was a need for a statewide minimum functionality specification for AMI. This would ensure that, irrespective of the AMI technologies implemented by electricity distributors, there would be a common level of functionality so that electricity retailers could have the same retail offerings to customers across all of the distributors' service territories.

In August 2006, the Victorian Government released two documents for public comment:

- a draft specification for minimum statewide AMI functionalities[27]; and
- a draft specification for trials of AMI technology[28].

After the completion of a consultation period, a second draft[29] of the specification for minimum statewide AMI functionalities was released in December 2006. Table 1 (page 19) lists the functionalities included in this second draft.

In particular, the draft specification for the controlled load management functionality[30] states that the AMI system should provide for a continuation of existing controlled load management practices (eg off peak storage water heating and storage space heating) but also include some additional features that take advantage of AMI capabilities to enable enhanced controlled load functionality. These additional features include:

- storage in the meter of five sets of "turn on" and "turn off" times per week day and five sets of "turn on" and "turn off" times per weekend day;
- "turn on" and "turn off" times to be remotely settable for each meter separately and in groups, through the AMI communications system;
- at "turn on" times meters should react by turning on the controlled load after a randomised time delay programmable from zero to 60 minutes in one minute increments (often referred to as "spread on");

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[27] Victorian Department of Infrastructure (2006a). *Draft Advanced Metering Infrastructure (AMI) Minimum Statewide Functionality Specification.* Melbourne, DOI.

[28] Victorian Department of Infrastructure (2006b). *Draft Advanced Metering Infrastructure (AMI) Technology Trials Specification*. Melbourne, DOI.

[29] Victorian Department of Infrastructure (2006c). *Second Draft Advanced Metering Infrastructure (AMI) Minimum Statewide Functionality Specification.* Melbourne, DOI. Available at: http://www.dpi.vic.gov.au/DPI/dpinenergy.nsf/93a98744f6ec41bd4a256c8e00013aa9/c568b2cae8a7f824ca2572c10013fafe/$FILE/AMI_Statewide_Specs.pdf

[30] Victorian Department of Infrastructure (2006c). *Op cit,* p 11.

Table 1. AMI Functionalities Included in the Draft Victorian Government Specification[1]
• Import and export, active and reactive energy recording in 30 minute intervals • Remote reading of interval data (routine reads and special reads) • Customer disconnect, arming and reconnect • Time clock synchronisation • Controlled load management at meters • Quality of supply and other event recording • Supply capacity control • Interface for in-home displays or other load control • Interface to other customer points of interaction • Meter loss of supply detection and outage detection • Communications from gas and water meters • Tamper detection • Communications and data security • Customer supply monitoring
[1] As defined in: Victorian Department of Infrastructure (2006). *Second Draft Advanced Metering Infrastructure (AMI) Minimum Statewide Functionality Specification*. Melbourne, DOI.

- meters to recognise (remotely sent) "turn on" and "turn off" commands that will override the switching program stored in the meter;
- single phase controlled load meters to have a remotely enabled or disabled "boost" facility that energises the controlled load for a preset time when the customer presses a "boost" button;
- two element meters to have a terminal connected to the controlled circuit element before it passes through the controlled circuit contactor. This enables the connection of storage hot water heaters where there are dual heating elements – one at the top and one at the bottom of the tank;
- meters to have a controlled load contactor with specified minimum current and nominal voltage ratings.

This specification for the controlled load management functionality would enable distributors to use AMI systems to implement direct load control and therefore improve the sustainable use of electricity network infrastructure, eg by shifting load away from peak periods on the network. This can reduce the requirement to build otherwise under-utilised network capacity to handle short duration peak loads.

Timetable

A key aspect of the preparation for the Victorian AMI rollout is the conduct of technology trials to evaluate commercially available AMI technologies. These trials are being conducted by all the electricity distributors in Victoria and will conclude in June 2007, after a six month trial period. Following the conclusion of the trials, the statewide

AMI minimum functionality specification will be reviewed and the final specification will be released in August 2007. At the time of writing, the commencement date for the AMI rollout has not been set.

2.3.3 Small Scale Trials of Advanced Meters

Trials in Victoria

The advanced metering technology trials currently being carried out by all three electricity distributors in Victoria involve about 5,000 customer premises and 11 AMI technology vendors[31]. The purpose of the trials is to confirm that existing commercial AMI technologies, used in other countries or elsewhere in Australia, can be successfully transferred to the Victorian environment. These technology trials are measuring the performance of AMI communication systems together with several key AMI functionalities under realistic conditions.

In addition to the smart metering technology trials, a Customer Response Pricing Trial is being developed in Victoria. The purpose of this trial is to identify the basic potential for customers to respond to the enhanced information made possible by AMI on the level and pattern of electricity consumption. The Customer Response Pricing Trial has two key objectives:

- to assess customer demand responses to several new retail pricing structures based on interval consumption data; and
- to evaluate the effectiveness of several treatment options (involving the provision of information and the use of communication devices, in association with potential pricing structures) by which electricity retailers may encourage these customer demand responses.

Around 2000 customers will be recruited onto the Customer Response Trial. Responses to the trial will indicate potential bill savings available to customers and load shifting/reductions available to electricity industry.

Trials in Other States

Electricity companies in several other states are also carrying out various advanced metering trials. These include:

- trials by all three electricity distributors in NSW: EnergyAustralia, Integral Energy and Country Energy;
- trials in Queensland by ENERGEX; and
- trials in South Australia by ETSA Utilties.

In the future, advanced metering trials will also be carried out as part of the implementation of the four Solar Cities funded by the Commonwealth Government in Adelaide, Alice Springs, Blacktown (Sydney) and Townsville.

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31 Victorian Department of Primary Industries (2007). *AMI Project Bulletin No 2*. Melbourne, DPI.

3. REGULATORY INCENTIVES FOR ADVANCED METERING

3.1 Current Status of Regulation

3.1.1 Victorian ESC Decision

At present the only regulation in Australia that applies specifically to advanced metering is the July 2004 decision[32] by the Victorian Essential Services Commission (ESC) requiring the mandatory rollout of interval meters for Victorian electricity customers. The decision included provisions that enabled the interval meter rollout to be managed so that distributors are provided with adequate compensation for the cost of the rollout whilst providing incentives to achieve efficiencies in the cost and volume of meter installations.

In particular, the decision provided that, from 1 January 2006, prescribed metering services would be regulated under a separate price control mechanism from distribution use of system services. In the decision, the ESC determined a separate revenue requirement and price control for the regulation of metering services which included the expenditure associated with rolling out interval meters. This revenue requirement was developed using the ESC's building blocks approach and was then translated into a set of prescribed metering charges using forecasts of growth over the determination period.

The ESC decision also included an M-factor in an overarching price control that limits the annual increase in the average of all the distributors' prescribed metering service charges. The annual increase in the average charge is limited to CPI-X_M+M where the X_M term is determined based on the net present value of the prescribed services metering revenue requirement and the M-factor provides a mechanism to adjust the revenue requirement where more (or fewer) interval meters have been rolled out by a distributor than forecast. The M-factor was implemented because the combination of price caps and an efficiency carryover mechanism may otherwise provide an incentive for distributors not to roll out interval meters as forecast.

To facilitate the rollout of interval meters, the ESC also permitted electricity distributors to implement mandatory reassignment of customers to an interval meter tariff. Arrangements were set in place to ensure that customers are informed on the changes prior to any reassignment occurring.

The original ESC decision also provided clarity about the responsibility for providing metering services. The decision stated that electricity distributors would be exclusively responsible for providing metering services to first tier[33] customers with annual consumption less than 160 megawatt-hours who do not have an interval meter that is remotely read. Electricity retailers would have the choice as to whether the retailer or the distributor has responsibility for providing metering services to first tier customers with annual consumption greater than 160 megawatt-hours or who have an interval

[32] Essential Services Commission Victoria (2004a). *Op. cit.*

[33] First tier customers purchase electricity under franchise tariffs from a retailer that holds a franchise to supply electricity to customers located in a defined geographical service territory. Customers who choose a different retailer are termed second tier customers.

meter that is remotely read, regardless of the frequency with which that interval meter is read[34].

In explaining the reasons for its decision on the mandatory rollout of interval meters, the ESC stated that the improved metering data that these meters will provide has significant potential to improve tariff design and provide information about network constraints to enable a much more efficient and effective demand response. The rollout of interval meters will improve the information available so that efficient and effective non-network solutions to resolve network constraints will be more easily identified. Customers will also be able to choose whether to respond to improved price signals by adjusting their usage patterns or taking responsibility for the costs they impose by paying more.

3.1.2 Regulation in Other Jurisdictions

Apart from Victoria, no other jurisdiction currently has any regulation that applies specifically to advanced metering. However, some state regulators have introduced regulatory provisions that provide incentives for demand management. These provisions could act to encourage electricity businesses to use the functionalities available in advanced meters to implement demand management programs.

Regulatory Incentives for Demand Management in NSW

In New South Wales, distributors are subject to a *Demand Management Code of Practice*[35] that requires distributors to publish annual Electricity System Development Reviews. These documents identify future, specific constraints on the distributor's network. Before augmenting or reinforcing its network, the *Code* specifically requires distributors to carry out investigations to ascertain the cost-effectiveness of avoiding or postponing this work by implementing demand management (DM) strategies.

In addition, in its 2004 distribution network pricing determination, the New South Wales electricity industry regulator, the Independent Pricing and Regulatory Tribunal (IPART), provided incentives for distributors to undertake DSM. IPART introduced a D-factor into the weighted average price cap control formula that allowed distributors to recover[36]:

- non-tariff-based DM implementation costs, up to a maximum value equivalent to the expected avoided distribution costs;
- tariff-based DM implementation costs;
- revenue foregone as a result of non-tariff-based DM activities.

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34 These provisions may change following the impending transfer of the metrology coordinator's role from the jurisdictional regulators to the National Electricity Market Management Company Limited (NEMMCO) and the consequent implementation of the National Electricity Market Metrology Procedure.

35 Department of Energy, Utilities and Sustainability (2004). *Demand Management for Electricity Distributors: NSW Code of Practice*. Sydney, DEUS. Available at: www.efa.com.au/Library/DMCode3rdEd.pdf

36 Independent Pricing and Regulatory Tribunal of New South Wales (2004). *NSW Electricity Distribution Pricing 2004/05 to 2008/09: Final Report*. Sydney, IPART. Available at: www.efa.com.au/Library/IPART2004DistribRevFinalRpt.pdf

These incentives are regarded as generous and have stimulated distributors in NSW to consider implementing DM measures to defer network augmentations. However, the incentives only operate for five years. Responsibility for carrying out distribution network pricing determinations in NSW will then be transferred from IPART to the Australian Energy Regulator (AER). It is unclear what the AER's position will be in relation to providing incentives for DM.

Regulatory Incentives for Demand Management in South Australia

In South Australia, the electricity industry regulator, the Essential Services Commission of South Australia (ESCOSA) has provided $20 million for demand management initiatives by ETSA Utilities over the five-year regulatory period beginning July 2005[37]. The initiatives include:

- pilot programs for power factor correction for large customers;
- standby generation;
- direct load control of residential air conditioning and other residential systems;
- critical peak pricing for customers with interval meters already installed;
- investigation of opportunities for curtailable load control and voluntary load control initiatives;
- review of the opportunities for ETSA Utilities to act as a demand management aggregator;
- establishment of demand management capabilities within ETSA Utilities.

ESCOSA did not accept that the introduction of interval metering combined with pricing signals would provide sufficient certainty of a resulting demand reduction to permit the deferral of network augmentation. Therefore, ESCOSA determined that it was not appropriate to have a "wide scale" rollout of interval meters to all customers in South Australia at the present time. Consequently, no funding was provided for a general rollout of interval meters to all customers.

ETSA Utilities was required to submit to ESCOSA for approval a program for implementation of these DM initiatives and expenditure of the approved funding over the regulatory period. The approved funding is being treated as operating expenditure, and does not impact on ESCOSA's consideration of approved capital expenditure for network augmentation purposes in the regulatory period.

Position of the Queensland Regulator

In Queensland, the electricity industry regulator, the Queensland Competition Authority (QCA), has not provided any specific incentives for demand management. QCA states that it can help guide the establishment of efficient distribution prices which would assist DM by providing price signals to indicate areas of the network operating under capacity constraint. QCA also regards demand management expenditure as legitimate

[37] Essential Services Commission of South Australia (2004b). *Demand Management and the Electricity Distribution Network. Draft Decision*. Adelaide, ESCOSA. Available at: www.escosa.sa.gov.au/webdata/resources/files/040830-DemandMgmt_DD.pdf

network expenditure. However, QCA notes that while some regulators have recently begun to modify their regulatory approach to provide positive incentives for demand management initiatives, it is not convinced about the need to introduce such incentives into the distributor revenue cap arrangements at this time[38].

Position of the Tasmanian Regulator

In 2006, following a direction from the Tasmanian Treasurer, the Office of the Tasmanian Energy Regulator carried out an analysis of the costs and benefits of the rollout of interval meters in Tasmania[39]. The analysis showed that, for all small electricity consumers in Tasmania, no rollout scenario would produce a net benefit in comparison to the continued use of accumulation meters. Given that all scenarios produced a negative net benefit, the Regulator recommended that no interval meter rollout be mandated in Tasmania under present market conditions.

3.2 Regulatory Requirements for Advanced Metering

Regulatory requirements for advanced metering fall into two groups:

- regulation related to the installation of advanced metering by electricity businesses;
- regulation related to the provision of value-added services by electricity businesses.

3.2.1 Regulation Related to Installation of Advanced Metering

Regulation to enable and support the deployment of advanced metering by electricity businesses, should include the following major components.

Obligation to Deploy Advanced Meters

An obligation to deploy advanced meters should be imposed on the responsible electricity businesses (distributors or retailers). At a minimum, this could specify that advanced meters should be used for all new and replacement installations for target customers. However, to achieve a quicker implementation and to gain economies of scale, the obligation could specify a rollout to replace all existing meters for target customers. The obligation should include the following specifications:

- a minimum set of functionalities that the installed meters should include;
- the target customer classes who will receive the meters;
- the timetable for the deployment, including target numbers of installations to be achieved by set dates.

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[38] Queensland Competition Authority (2005). *Final Determination. Regulation of Electricity Distribution*. Brisbane, Queensland. Available at: www.qca.org.au/files/ACF14.pdf

[39] Office of the Tasmanian Energy Regulator (2006). *Costs and Benefits of the Rollout of Interval Meters in Tasmania*. Hobart, OTEG. Available at: http://www.energyregulator.tas.gov.au/domino/otter.nsf/412589df3d1f0c3aca256cca007f1278/e1ebac59b264351bca2571db0000f785/$file/imro_draft_report_v1.0.pdf

Compensation for Electricity Businesses

Electricity businesses responsible for deploying advanced meters will incur costs that they would be unable to recover in the normal course of business. Regulation should provide compensation to ensure that the businesses are financially no worse off as a result of carrying out the deployment.

A detailed cost benefit analysis of the deployment of advanced metering should be carried out to identify the costs and benefits to all stakeholders, including electricity businesses, end-use customers and society as a whole[40]. Electricity businesses will benefit from cost reductions resulting from automation of operational activities such as meter reading, connection and disconnection, outage management and load control. End-use customers may benefit from reduced electricity bills; however, to achieve these customer benefits, the deployment of advanced metering must be accompanied by appropriate pricing initiatives, customer information and education activities, and load control programs, (see section 4, page 26 and section 5, page 43). Society as a whole may benefit from possible reductions in greenhouse gas emissions (see section 6, page 56).

The results of the cost benefit analysis should be used to ensure that any compensation provided to electricity businesses is discounted by the value of any benefits gained by the businesses from the deployment of advanced metering. Subject to the cost benefit analysis, following are the major expenditure items for which electricity businesses may require compensation:

- the marginal cost of an advanced meter as compared with a standard meter;
- the cost of installing an advanced meter to replace an existing meter;
- the additional cost of any modifications required to back office IT systems to integrate data from advanced meters into existing billing and asset management systems.

Additional Power for Electricity Businesses

Electricity businesses will require the power to implement mandatory reassignment of existing customers to an advanced meter tariff once a replacement advanced meter has been installed at their premises.

Incentive for Electricity Businesses

To ensure that electricity businesses are motivated to implement the deployment of advanced meters, an incentive mechanism such as the Victorian M-factor could be included in the regulatory package (see section 3.1.1, page 21).

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[40] In its information paper on smart meters released in January 2007, the Ministerial Council on Energy proposed that the national implementation plan for the rollout of smart metering should be based on a single national benefit-cost analysis managed by MCE that takes into account both the different circumstances in each State and Territory and the advantages and disadvantages of a universal rollout. At its meeting on 13 April 2007, COAG endorsed a timetable for the national rollout of smart meters, including the completion of the cost-benefit analysis by the end of 2007.

3.2.2 Regulation Supporting the Provision of Customer Incentive Programs

Simply installing advanced meters does nothing to influence customer energy-using behaviour. To achieve behaviour change, advanced meters must be accompanied by supporting technology and programs, including load control technology, time-varying pricing, the provision of real time information to customers about their actual electricity consumption and its cost (eg through an in-house display), and other information and education programs to encourage customers to change their behaviour (such as home energy audits). As noted in section 1.4.1 (page 3), the combination of time-varying tariffs and detailed consumption information enables electricity businesses to devise programs that provide incentives to customers who reduce their peak loads and/or implement energy efficiency measures.

Such incentive programs are essential to effectively achieve the peak load reductions and increased energy efficiency potentially available from the deployment of advanced metering. However, electricity businesses may be unwilling to introduce customer incentive programs unless they can see a clear financial benefit from doing so. Regulation which rewards electricity businesses that implement demand management programs will enable the businesses to provide incentive programs to customers. The D-factor implemented by IPART in NSW and demand management incentives implemented by ESCOSA in South Australia are examples of this type of regulation.

4. TARIFF STRUCTURES FOR ADVANCED METERING

4.1 Time-Varying Pricing

One of the major benefits of the introduction of advanced meters is that they enable the implementation of time-varying pricing of electricity. Under time-varying pricing, the price per unit of electricity varies according to the time of the day at which the consumption occurs. Seasonal variation in prices is also possible.

Varying electricity prices with the time of day is only possible if the customer has an interval meter. It is not possible with accumulation meters, because this type of meter does not record the quantities of electricity consumed during different time periods within a day.

The primary objective for exposing retail electricity customers to time-varying tariffs is to send price signals to customers that reflect the underlying costs of generating, transporting and supplying electricity. By exposing at least some customers to prices based on these marginal production costs, resources can be allocated more efficiently.

Furthermore, price-based demand response programs[41] can be used to reduce or shape customer demand. This is particularly important in some States in Australia, particularly NSW, Queensland and South Australia, where the rapidly increasing use of air conditioning on hot summer days is imposing large peak loads on electricity networks and forcing massive expenditure on network infrastructure (“poles and wires”)

[41] Demand response comprises actions taken by end-use customers to change (usually reduce) their electricity use in response to high prices in the electricity market and/or problems on the electricity network.

to cope with these peak loads. The resulting additional network capacity will be significantly under-utilised at non-peak times. Price-based demand response programs may be able to reduce some peak loads and therefore reduce the amount of investment required in network infrastructure.

4.2 Time-Varying Tariff Structures

There are three main types of time-varying tariff structures:

- time of use (TOU) pricing;
- critical peak pricing (CPP); and
- reaal time pricing (RTP).

These programs expose customers to varying levels of time-varying price exposure – the least with TOU and the most with RTP. Figure 2 (page 28) illustrates the hourly price variations customers would face under the different time-varying tariff structures.

4.2.1 Time of Use Pricing

Most time of use (TOU) tariff structures establish two or more daily periods that reflect hours when the system load is higher (peak) or lower (off-peak), and charge a higher rate during peak hours. The length of the on-peak period varies, based on the timing over the day and week of the peak system demand in the service territory of the electricity business. Off-peak hours are usually some part of the evening and night, as well as weekends. TOU tariff structures sometimes have only two prices, for peak and off-peak periods, while other tariffs include a shoulder period or partial-peak rate depending on the particular characteristics of the load.

TOU tariffs can also be implemented on a seasonal basis with prices that vary by seasons. For instance, a summer-peaking electricity business may charge a higher price during summer months than during the off-peak winter months[42].

In Australia, time of use tariffs have been used for many years for particular residential loads such as storage water heaters and, more recently, pool pumps. Because these tariffs were implemented using accumulation meters, the off-peak loads had to be specially wired to meters which only supplied power during off-peak periods. The introduction of interval and smart meters will now enable the application of TOU pricing to all loads in customers' premises.

In TOU pricing, the size of the price-spread between peak and off-peak hours should be set so that customers perceive real price signals that motivate them to change behaviour (eg switching off appliances and equipment during peak periods). The trials of time-varying pricing currently being carried out in Australia may provide some indication about the price-spreads that are required to achieve behaviour change (see section 4.3, page 31).

[42] Seasonal TOU pricing was introduced in Western Australia in the mid-1990s by the then vertically integrate utility Western Power.

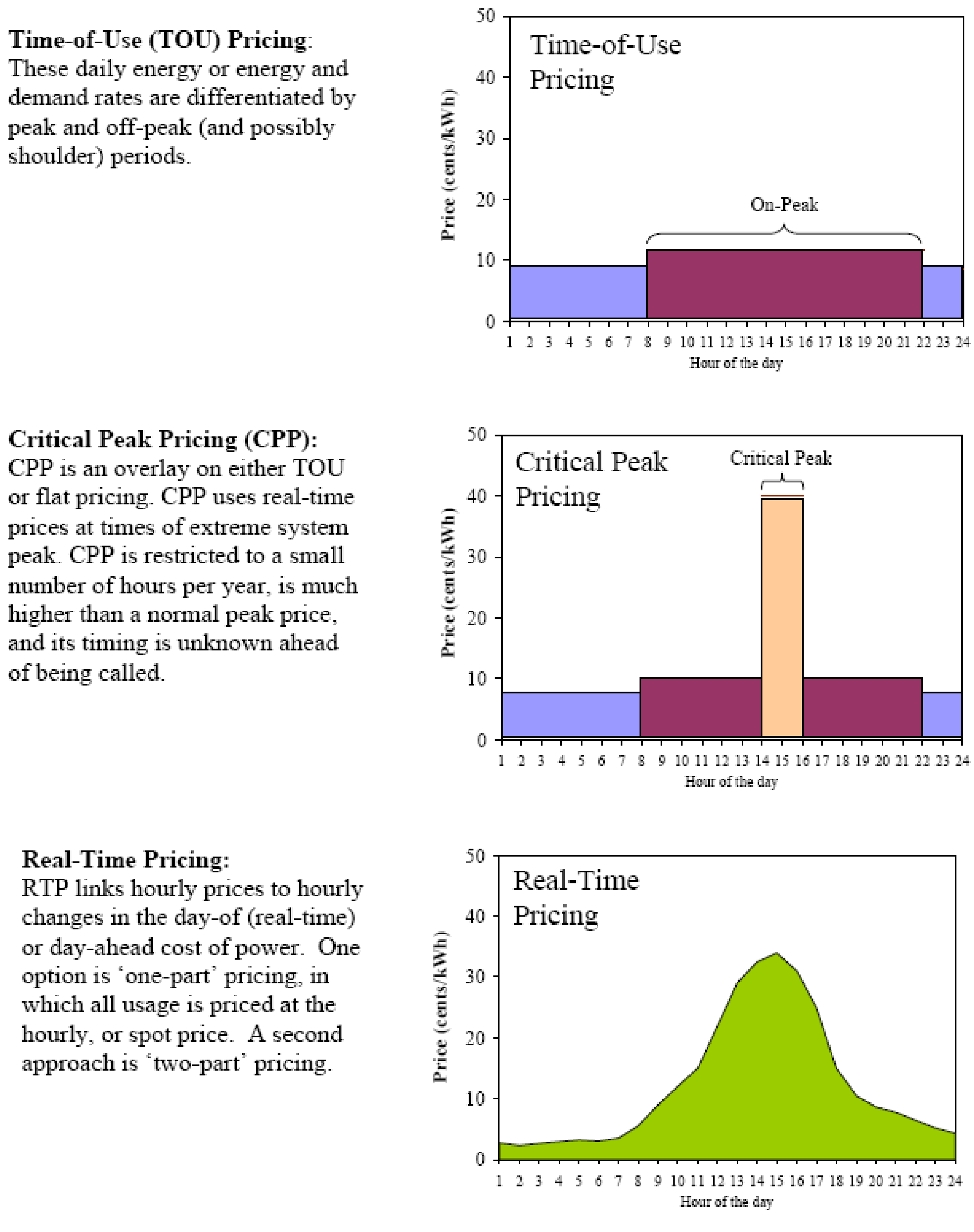

Figure 2. Typical Hourly Variation in Electricity Prices Under Time-varying Tariff Structures[43]

[43] Source: Federal Energy Regulatory Commission (2006). *Op. cit.*

Another aspect that must be addressed in introducing TOU tariffs is the financial impact on the relevant electricity businesses[44]. Ideally, TOU tariff structures should achieve two goals: customers who change behaviour should receive bill savings as an incentive, while the electricity businesses maintain the same or similar revenue levels. Achieving both these goals simultaneously can be difficult and may require some fine-tuning of tariff structures once it becomes clear how customers are reacting to the TOU tariffs.

4.2.2 Critical Peak Pricing

Critical peak pricing (CPP) is a relatively new form of pricing that can be superimposed on either a TOU or time-invariant tariff structure. CPP relies on very high critical peak prices, as compared with the ordinary peak prices in TOU pricing or the flat prices in time-invariant tariff structures. This high per-unit price is in operation during times that the electricity business (distributor or retailer) defines as critical peak periods. CPP events may be triggered by contingencies on the electricity network or high prices faced by the retailer in procuring power in the National Electricity Market (NEM).

Unlike TOU blocks, which are typically in place for 6 to 10 hours during every day of the year or season, the days in which critical peaks occur are not designated in the tariff, but dispatched as needed, on relatively short notice, for a limited number of days during the year. Electricity businesses call critical peak events in real time and customers are usually given advance notice for periods varying from a maximum of about 24 hours to a minimum of about two hours in advance of the event. Shorter or no advance notice is possible, and could be useful in relation to high price spikes in the National Electricity Market (NEM), but no retailer in Australia has so far used advance notice periods shorter than two hours.

In critical peak pricing, the size of the differential between the price during CPP events and the prices at other times is even more important than with TOU pricing. Because CPP events occur relatively infrequently, the impact of critical peak prices on electricity bills is relatively small and consequently the motivation to change behaviour can be low. However, because CPP events, by definition, are called only when electricity businesses are facing critical financial and/or operational contingencies, heavy reliance is placed on customers delivering firm peak load reductions. A tentative conclusion from the results of CPP trials carried out in several countries is that a price differential of about 10 times between the critical peak price and the off-peak price is required to achieve significant and firm peak load reductions.

Several variants of critical peak pricing have been developed in the United States[45], including:

Fixed-period CPP (CPP-F). In CPP-F, the time and duration of the price increase are predetermined, but the days when the events will be called are not. The maximum number of called days per year is also usually predetermined. CPP events are typically called on a day-ahead basis.

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[44] TOU tariffs can be introduced by either an electricity network business or a retailer, but the financial positions of both businesses are likely to be impacted by any significant behaviour changes by customers.

[45] Federal Energy Regulatory Commission (2006). *Op. cit.*

Variable-period CPP (CPP-V). In CPP-V, the time, duration, and day of the price increase are not predetermined. CPP events are usually called on a day-of basis. CPP-V is typically paired with load control devices such as communicating thermostats that allow automatic responses to critical peak prices.

Variable peak pricing (VPP). This is a recent form of critical peak pricing that has been proposed in the New England region of the United States. The off-peak and shoulder period energy prices would be set in advance for a designated length of time, such as a month or more. The price for each peak-period hour would be set each day based on the average of the relevant price in the New England wholesale electricity market, adjusted to account for delivery losses and other costs typically recovered volumetrically. The advantage of VPP is that it more directly links prices in the wholesale electricity market to retail pricing.

Critical peak rebates. In critical peak rebate programs, customers remain on fixed tariffs but receive rebates for load reductions that they produce during critical peak periods.

4.2.3 Real Time Pricing

Under real time pricing (RTP), prices vary continuously during the day, directly reflecting the wholesale price of electricity, as opposed to tariff structures such as TOU or CPP that are largely based on preset prices. In an Australian context[46], RTP would link half-hourly prices for retail customers to the half-hourly changes in the cost of purchasing electricity from the NEM. The direct connection between wholesale prices and retail tariffs introduces price responsiveness into the retail market, and serves to provide important linkages between wholesale and retail markets.

Several RTP variants are in place across the United States[47]: day-of versus day-ahead pricing, and one-part versus two-part pricing.

Day-Ahead Real Time Pricing (DA-RTP). DA-RTP customers are given one-day notice of the prices for each of the next day's 24 hours. This gives customers time to plan their responses, such as shifting use (often by shifting load to off-peak hours or by using onsite generation) or to hedge day-ahead prices with other products if they cannot curtail their demand.

Two-Part Real Time Pricing. Under two-part real time pricing, only a portion of the electricity purchased by a customer is subject to retail prices directly linked to prices in the wholesale market. Two-part RTP designs include an historical baseline for customer usage, layered with hourly prices only for marginal usage above or below the baseline. Customers thus see wholesale market prices only at the margin. Figure 3 shows how two-part RTP tariffs operate. Typically, two-part real time pricing is only applied to large commercial and industrial customers who have detailed information about past energy usage that can be used to construct an historical baseline.

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46 At the time of writing, real time pricing has not been implemented by electricity retailers in Australia. However, the small number of end-use customers who purchase electricity directly from the NEM are, in effect, experiencing real time pricing.

47 Federal Energy Regulatory Commission (2006). *Op. cit.*

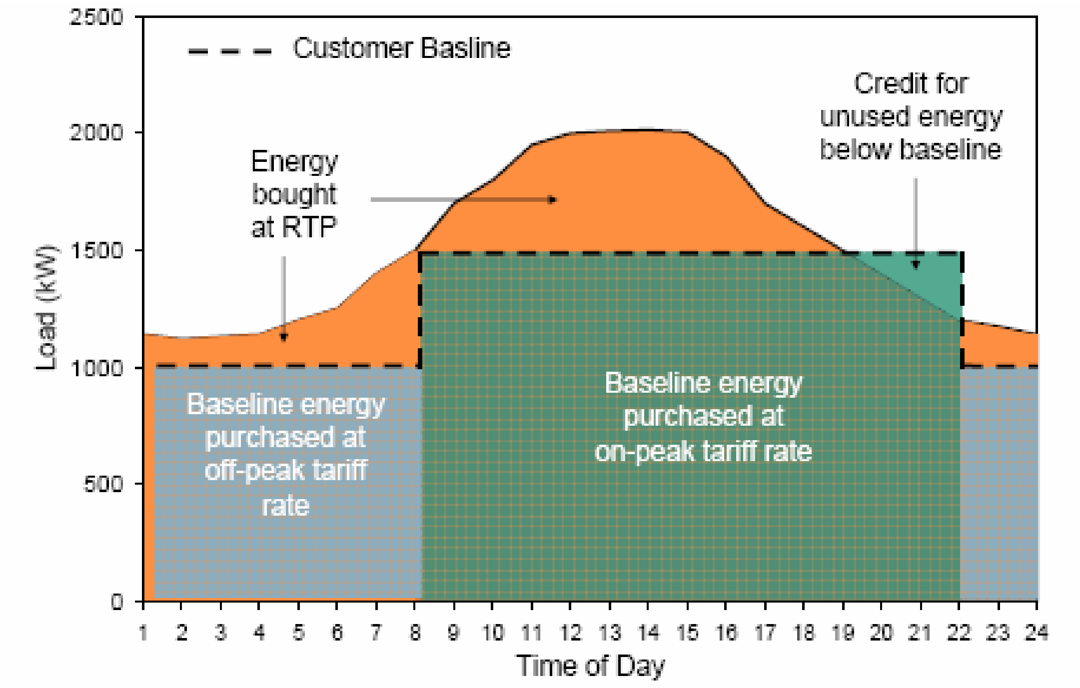

Figure 3. Typical Operation of a Two-Part Real Time Pricing Tariff[48]

The baseline design serves as a hedge for customers against real time pricing volatility, and allows them to achieve savings by curtailing their marginal use at times when prices are higher and by using more during lower-priced periods. This type of RTP design could be suitable for Australia where the NEM is characterised by occasional spikes of very high wholesale prices.

4.3 Implementation of Time-Varying Tariffs

4.3.1 Trials of Time-varying Tariffs in Australia

To date, there has been no widespread implementation of time-varying electricity tariffs in Australia, other than the availability of off-peak tariffs for specified loads in the residential sector wired to off-peak accumulation meters, such as storage water heaters and pool pumps.

However, with increasing numbers of installations of interval meters and smart meters, some electricity businesses have been conducting small-scale short-term trials of time-varying tariffs in conjunction with the advanced metering trials noted in section 2.3.3 (page 20). These trials comprise:

- trials by all three electricity distributors in NSW: Country Energy, EnergyAustralia, and Integral Energy;
- the Customer Response Pricing Trial in Victoria; and
- trials in Queensland by ENERGEX.

[48] Source: Federal Energy Regulatory Commission (2006). *Op. cit.*

Country Energy Critical Peak Pricing Trial

The Critical Peak Pricing Trial is being carried out by Country Energy in Queanbeyan and Jerrabomberra, NSW to investigate the feasibility of promoting peak load reductions by residential sector customers to relieve distribution network constraints.

In the trial, implementation of time of use and critical peak pricing tariffs required the installation of interval meters and in-home information display units in the dwellings of about 200 participants. The in-home information display unit comprises a LED alphanumeric display which provides customers with specific information about the amount of electricity they are using, and how much it is costing. A beeping sounds alerts customers to the start of a critical peak period.

Two seasonal tariff schedules are applied. In summer, the peak period is from 2 pm to 8 pm to coincide with the period of maximum use of domestic air conditioners. In winter the peak period is from 7 am to 9 am and 5 pm to 8 pm to coincide with the period of maximum use of domestic space heaters.

The tariff levels are as follows:

Off Peak:	0.0703 cents/kWh
Shoulder:	0.127 cents/kWh
Peak:	0.1887 cents/kWh
Critical Peak:	0.3774 cents/kWh

Critical peak events are called by Country Energy when the load on the local network is reaching maximum capacity or when high price events occur in the competitive wholesale electricity market. Critical peak events may be called for a maximum of 12 times per year; customers are given a minimum 2 hours notice.

Country Energy report that the results of the trial showed mixed, but mainly positive results. The results varied from customer to customer with the majority achieving a saving on their electricity bill. Illustrations of the impact of critical peak pricing (CPP) alerts are shown in Figures 4 and 5 (page 33). In both cases, demand decreased significantly during the CPP period, but increased after the end of the period. On 1 February 2006, the increase in demand resulted in a peak later in the evening that was higher than that on the comparison day without a CPP event.

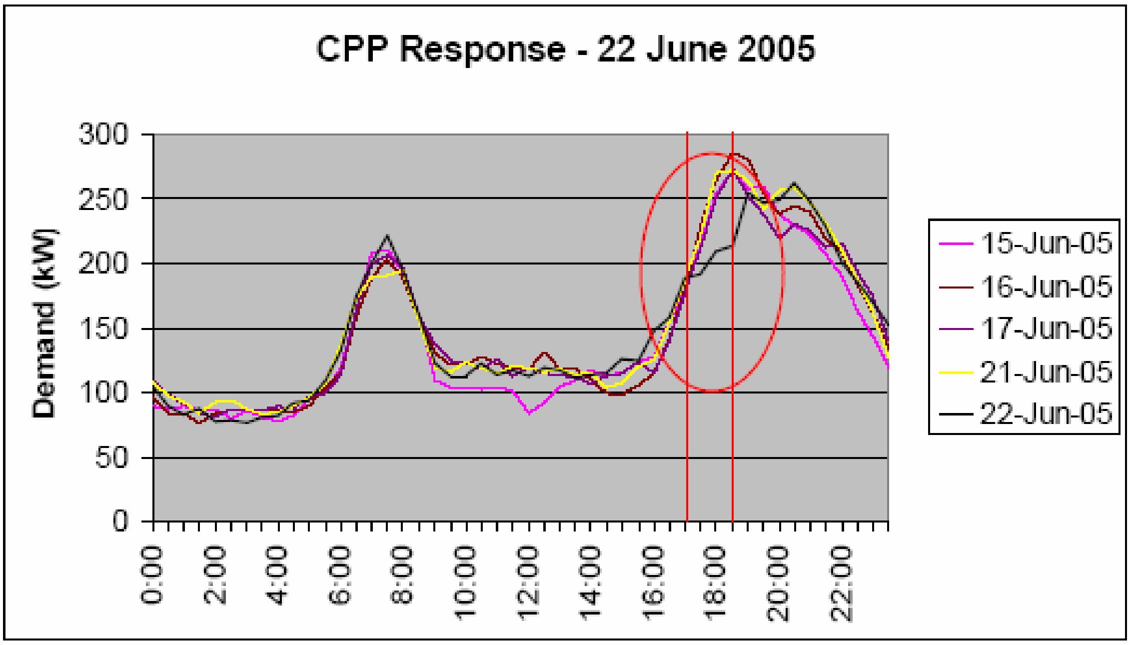

Figure 4. Impact of 22 June 2005 CPP Event in the Country Energy Trial[49]

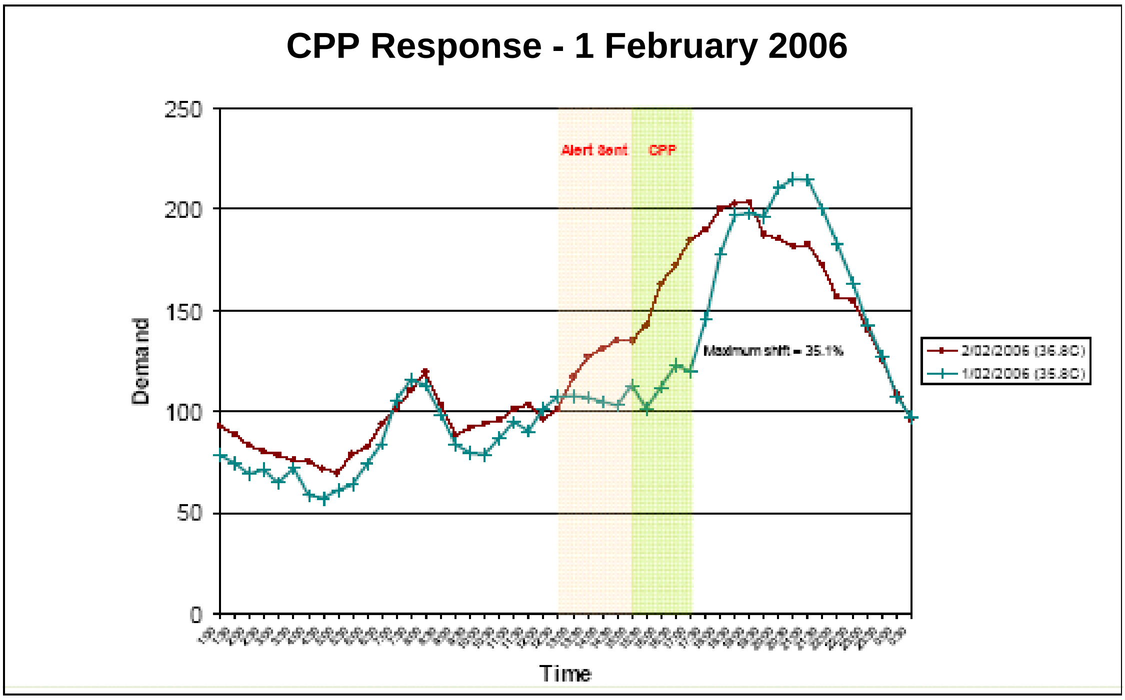

Figure 5. Impact of 1 February 2006 CPP Event in the Country Energy Trial

49 Source: Soussou, R. (2006). *Country Energy: Home Efficiency Trial in Queanbeyan*. Presentation to the Demand Response and DSM Conference, Sydney 27 to 28 March.

EnergyAustralia Strategic Pricing Study

The EnergyAustralia Strategic Pricing Study includes about 750 residential customers and 550 business customers. All have a smart meter with GPRS communications installed in their premises and some have an in-house display connected to the meter by power line carrier technology.

The experimental groups comprise:

- a control group;
- a group provided only with information about peak load reductions;
- a group placed on a seasonal TOU tariffs;
- one group placed on a medium critical peak pricing tariff with an in-house display;
- two groups placed on a high critical peak pricing tariff with and without an in-house display.

Table 2. Tariffs Schedules Used in the EnergyAustralia Trial[50]

Tariff Component	SAC ($/day)	Peak (¢/kwh)	Shoulder (¢/kwh)	Off peak (¢/kwh)
Tariff EA057 powerAlert medium (DPP-M)				
NUoS	0.128	40	3.13	2.885
Retail	0.192	60	6.37	4.615
Total	**0.32**	**100**	**9.5**	**7.5**
Tariff EA058 powerAlert high (DPP-H)				
NUoS	0.128	80	2.8	2.3
Retail	0.192	120	5.7	4.2
Total	**0.32**	**200**	**8.5**	**6.5**

The price levels for the critical peak pricing[51] tariffs are shown in Table 2. In the case of the DPP-M tariff the critical peak price level is set at 1052% of the Shoulder rate and for the DPP-H tariff the multiple is 2352%. The latter is one of the highest multiples set in any CPP tariff worldwide. The "shock" price of $2.00 per kilowatt-hour provides a stimulus for customers to manage or reduce consumption during the peak events.

Some initial results with the DPP-H tariff are shown in Figures 6 and 7 (page 35). As with the Country Energy trial, demand decreased significantly during the CPP period, but increased after the end of the period. On 22 February 2007, the reduction in peak demand was lower than on 11 January. This was probably because the temperature on 22 February was lower and therefore less discretionary load (eg from air conditioning) that could be reduced was available.

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50 Amos, Chris (2006). *Advanced Tariff Design.* Presentation to Workshop on Advanced Metering. University of NSW, Sydney, 17 May.

51 EnergyAustralia refers to critical peak pricing as "dynamic peak pricing" (DPP).

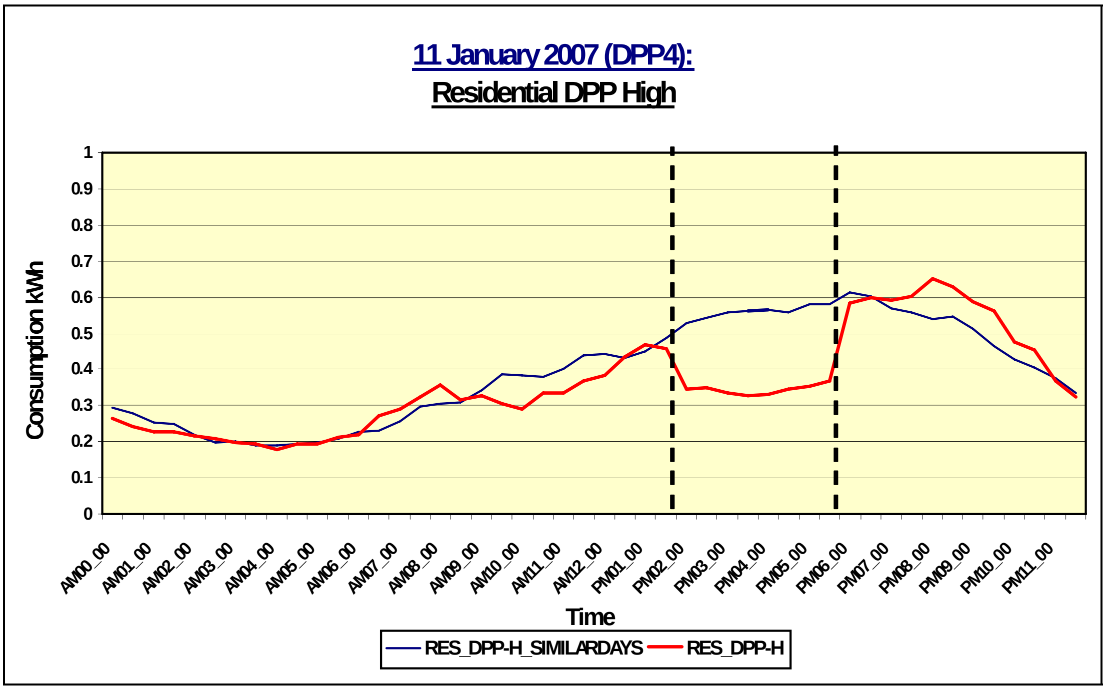

Figure 6. Impact of 11 January 2007 CPP Event in the EnergyAustralia Trial[52]

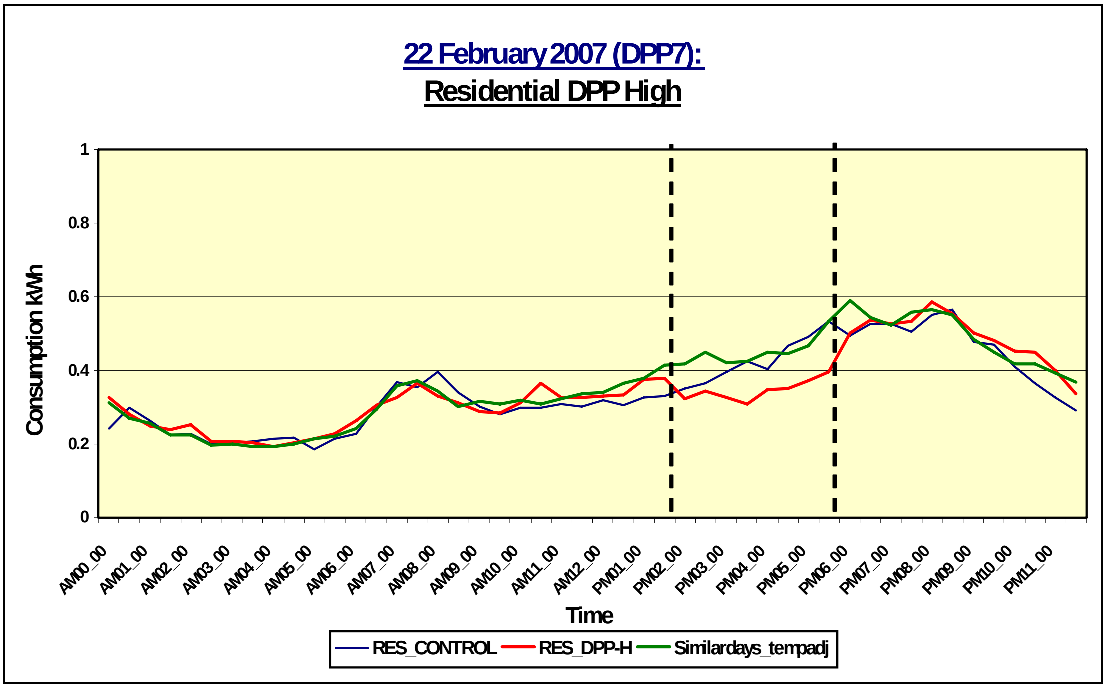

Figure 7. Impact of 22 February 2007 CPP Event in the EnergyAustralia Trial

52 Miller, A. (2007a). *Strategic Pricing Study (SPS): Demand Response Results*. Presentation to EnergyAustralia Retailer Information Forum. Sydney, 9 May.

Figure 8 shows the average percentage consumption reductions on a day with a critical peak pricing event, for three situations:

- households with the medium DPP tariff plus an in-house display (DPPM);
- households with the high DPP tariff plus an in-house display (DPPH); and
- households with the high DPP tariff and no in-house display (DPPH-NIHD).

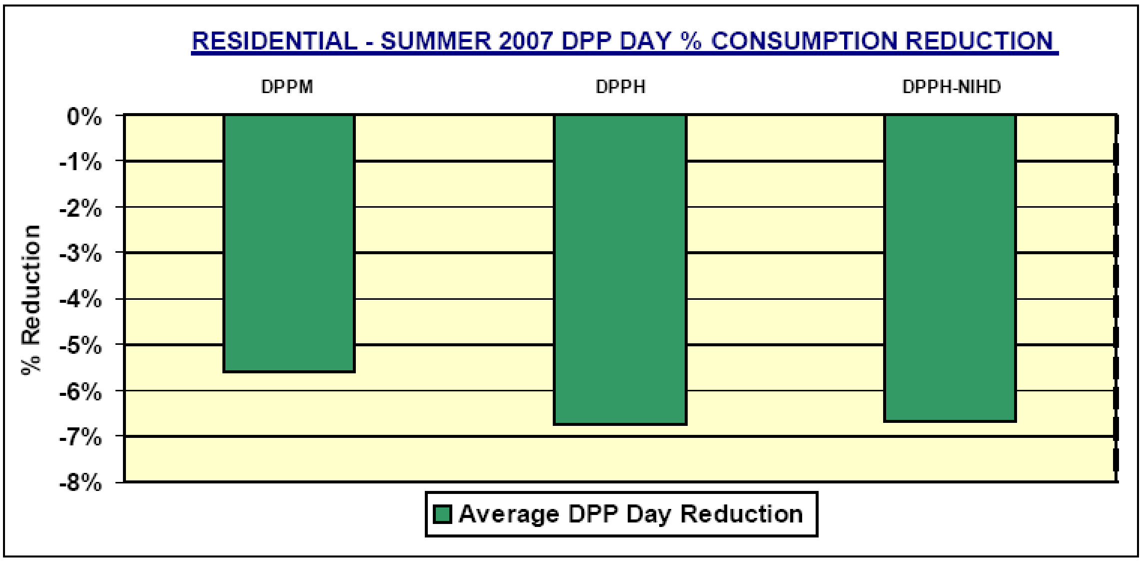

Figure 8. Average Reductions in Consumption on Days with a CPP Event in the EnergyAustralia Trial[53]

Figure 8 shows that, in summer, CPP tariffs achieved reductions in consumption during critical peak periods equivalent to reductions in total daily energy use on days with a CPP event of between 5.5% and 7.8%. The majority of this reduction came from energy conservation. On critical peak days, there was not a great deal of shifting of consumption from the critical peak period to shoulder, off-peak or non peak periods.

The EnergyAustralia trial also found that energy consumption during the critical peak period was between 21% and 25% of the total average daily consumption on non-critical peak day.

[53] Miller, A. (2007b). *Summer and Winter Demand Response from EnergyAustralia's Strategic Pricing Study*. Presentation to Demand Response and DSM Conference. Adelaide, 20 June.

Integral Energy Pricing Trials

Integral Energy is currently carrying out a critical peak pricing trial in western Sydney. The trial includes:

- 900 customers across three tariff treatments:
  - critical peak pricing;
  - critical peak pricing with in-home-display; and
  - seasonal time-of-use pricing;
- a control group of 340 customers;
- a joining incentive payment of $100 and a completion incentive payment of $200;
- a web interface for customers to see details of their electricity usage;
- comprehensive marketing and information provision;
- a survey of the demographic and appliance mix of all customers.

By mid-June 2007, five CPP[54] events have been called. Figure 9 shows the results for a CPP event on 11 January 2007[55].

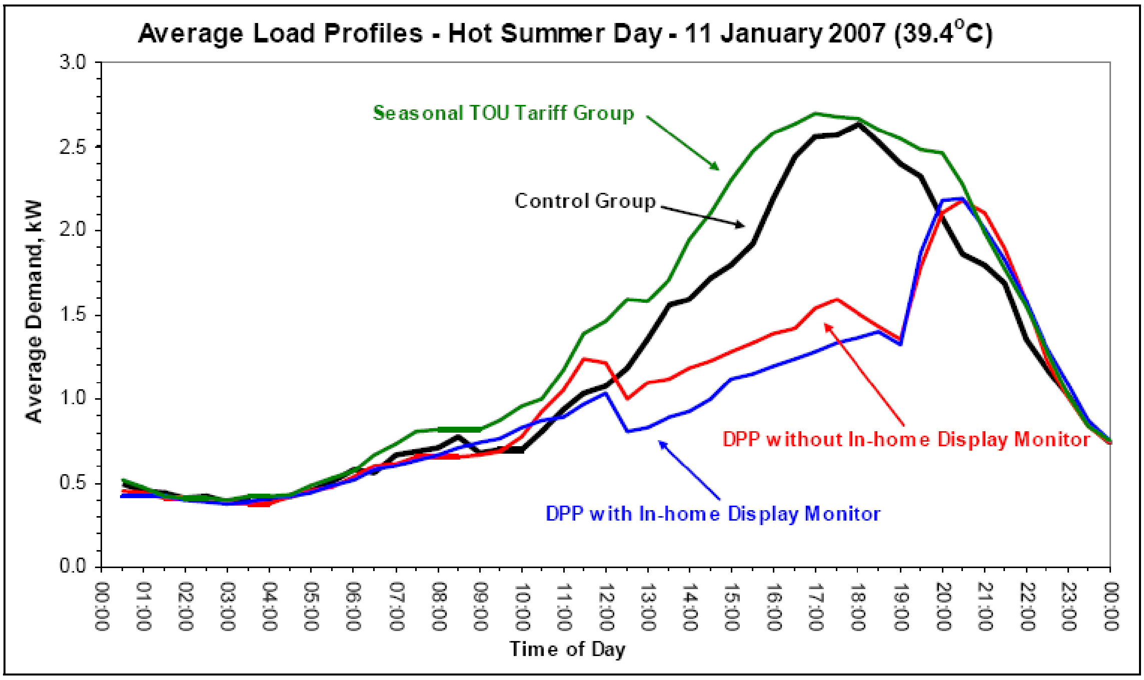

Figure 9. Impact of 11 January 2007 CPP Event in the Integral Energy Trial[56]

54 Integral Energy also refers to critical peak pricing as "dynamic peak pricing" (DPP).

55 EnergyAustralia also called a CPP event on this date.

56 Lette, S. (2007). *Integral Energy – Trials Update*. Presentation to Demand Response and DSM Conference. Adelaide, 19 June.

Integral Energy achieved similar results to Country Energy and EnergyAustralia with demand decreasing significantly during the CPP period, but increasing after the end of the period, though in the event shown in Figure 9 the after-peak was not as high as the critical peak. The reductions in demand during CPP events were found to be statistically significant. There was no statistically significant difference between the response of customers on seasonal TOU tariffs and the control group. There was also no statistically significant difference between the response of customers with or without in-house displays.

4.3.2 California Statewide Pricing Pilot

The largest and most comprehensive trial of critical peak pricing to date was carried out in California from July 2003 to December 2004[57]. This trial included 2,500 customers, involved all three investor-owned utilities in California: Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E).

The pilot tested three tariff structures:

- a TOU tariff in which the peak price was 70 percent higher than the standard price and twice as high as the off-peak price;
- a statewide TOU tariff layered with a CPP that could be dispatched with day-ahead notice up to 15 times annually; and
- a variable critical-peak tariff, targeted at a population that had already participated in a smart thermostat pilot. Critical peak events were dispatched with a four-hour advance notice and the peak period lasted from two to five hours. Customers on this tariff had the option of a free Advanced Demand Response System (ADRS) that included automated load control technology to facilitate their responses.

Figure 10 (page 39) presents the summary results of the trial for residential sector customers and demonstrates that significant peak load reductions were achieved across all groups and geographies, with and without air conditioning.

Residential customers, who had been thought to be less price-responsive than larger customers, achieved 15 percent or more reductions with high price signals on critical days; they achieved five percent reductions with more modest TOU prices. Residential customers were in fact more price responsive as a group than commercial and industrial customers, although the absolute effects on energy savings may have been higher with the latter group.

One of the objectives of the California trial was to evaluate an Advanced Demand Response System (ADRS) in the residential sector involving the automatic reduction of load based on price. The participants in the ADRS trial were provided with a full complement of automation technology and real time access to energy and price information.

[57] Federal Energy Regulatory Commission (2006). *Op. cit.*

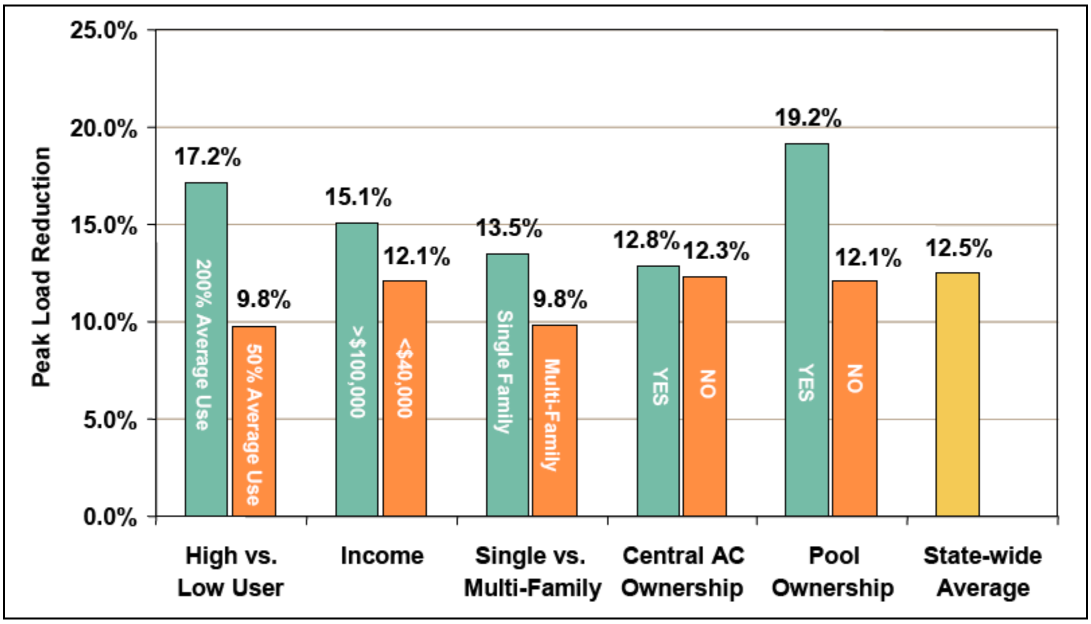

Figure 10. Peak Load Reductions by Residential Customers in the California Statewide Pricing Pilot[58]

The ADRS enabling technology included:

- a two-way communicating interval meter;
- a wireless internet gateway and cable modem;
- smart communicating thermostat(s);
- a load control and monitoring device (LCM); and
- an internet web-enabled user interface and data management software.

The ADRS technology was programmed to automatically respond to electricity prices and continuously displayed the current electricity price on the thermostat and the web.

Via the internet, the trial participants could:

- view real time interval demand and trends in historical electricity consumption;
- set climate control and pool pump runtime preferences;
- program desired responses to increased electricity prices including:
  - ♦ change thermostat temperature set-point;
  - ♦ reschedule operation of LCM controlled appliances.

The results of the ADRS trial are shown in Figure 11 (page 40).

Both remote switching of appliances using the ADRS technology and CPP pricing without remote switching resulted in reductions in demand during the ‘super peak’ period as compared with the load curve when the TOU tariff without remote switching was applied. Remote switching achieved the largest load reduction (about 1.5 kW/hr per household) while CPP pricing without remote switching achieved a smaller demand reduction (about 1.0 kW/hr per household).

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[58] Source: Federal Energy Regulatory Commission (2006). *Op. cit.*

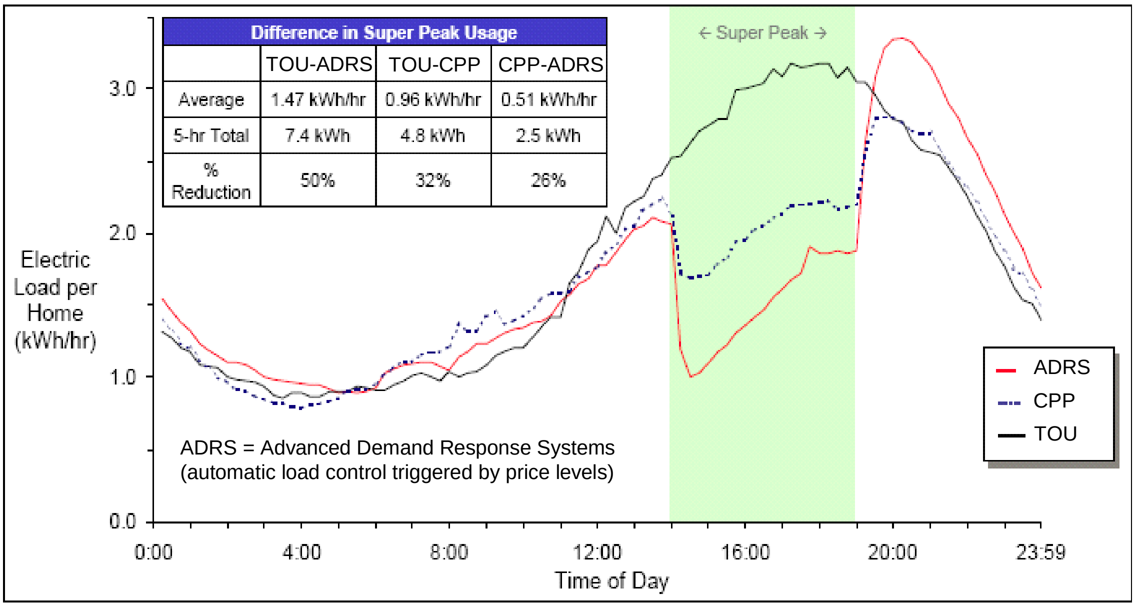

Figure 11. Results of the California ADRS Trial[59]

Similar to the results in some Australian trials, the high load reduction achieved with remote switching during the super peak period was followed in the subsequent period by a peak higher than that observed during the super peak period when the TOU tariff without remote switching was applied.

4.3.3 The Tempo Tariff in France

The Tempo tariff is a longstanding TOU and CPP tariff that has been implemented in France since the early 1990s[60]. The purpose of introducing the Tempo tariff was to enable smoothing of both annual and daily electricity load profiles, therefore reducing marginal generation and network costs.

The Tempo tariff has six rates based upon the actual weather on particular days and on hours of use. Each day of the year is colour coded. There are three colours, blue, white and red which correspond to low, medium and high electricity prices. The number of days per year of each colour is fixed - there are 300 blue days, 43 white days and 22 red days. The colour of each day is determined mostly by the electricity generator and retailer, Electricité de France, based on the forecast of electricity demand for that day - the level of demand is mainly influenced by the weather (Figure 12, page 41). Red days are usually called on the coldest days in winter. The French transmission network operator, Réseau de Transport d'Electricité (RTE), has the ability to determine the day colour if there is significant congestion on the electricity network.

[59] California Energy Commission (2004). *Response of Residential Customers to Critical Peak Pricing and Time-of-Use Rates During the Summer of 2003.* Sacramento, CEC, 13 September.

[60] Kärkkäinen, S. (ed) (2004). *Energy Efficiency and Load Curve Impacts of Commercial Development in Competitive Markets: Results from the EFFLOCOM Pilots.* EU/SAVE 132/01 EFFLOCOM Report No 7. Available at: http://www.efflocom.com/pdf/EFFLOCOM report no. 7 Pilot Results.pdf

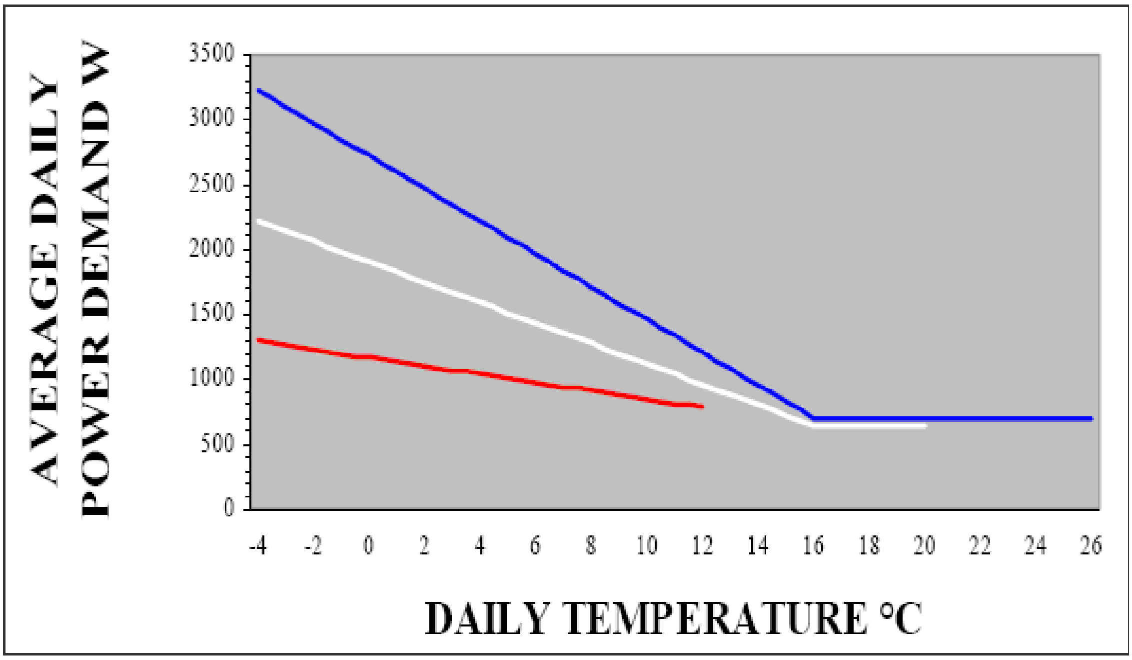

Figure 12. Tempo Customer Power Demand vs Outdoor Temperature[61]

In June 2005, the prices for electricity purchased under the Tempo tariff were as follows:

Blue days off-peak:	2.99 euro cents
Blue days normal:	3.81 euro cents
White days off-peak:	6.51 euro cents
White days normal:	7.79 euro cents
Red days off-peak:	12.42 euro cents
Red days normal:	35.46 euro cents.

There are four different versions of the Tempo tariff, depending on the metering, communications and load control equipment installed at the customer's premises:

- standard Tempo (the customer has only an electronic interval meter);
- dual energy Tempo (the customer's space-heating boiler can be switched from one energy source to another);
- thermostat Tempo (the customer has load control equipment which is able to adjust space heating and water heating loads according to the electricity price);
- comfort Tempo (the customer has a sophisticated energy controller).

Customers who choose the Tempo tariff are informed each night about the colour for the next day. At 8 pm a signal is sent down powerlines using a ripple control system. Most Tempo customers have a display unit that plugs into any power socket and picks up the signal. The display unit shows the day colour with lights, both for the current day and (from 8pm) for the next day. An (optional) beep informs the consumer if the following day will be a red day. The display unit also shows whether or not the current

[61] Giraud, D. (2004). *The Tempo Tariff*. Presentation to: EFFLOCOM Workshop. Trondheim, 10 June. Available at: http://www.efflocom.com/pdf/EDF.pdf

electricity price is at the off-peak rate. For older systems without a display unit, the information is available over the telephone or via the internet.

Customers can adjust their electricity consumption manually by switching off appliances, adjusting thermostat settings, etc. Some customers who have the necessary communications and load control equipment are able to select load control programs which enable automatic connection and disconnection of separate water-heating and space-heating circuits.

There are approximately 100,000 customers on the Tempo tariff in France. Compared with blue days, the tariff has led to a reduction in electricity consumption of 15% on white days and 45% on red days. The average reduction is 1 kW per customer.

4.4 Effectiveness of Time-varying Tariffs

The results of trials and implementations of time-varying pricing show that this pricing strategy is effective in reducing peak loads. However, with the exception of the Tempo tariff in France, all the results reported here are from pricing trials that were implemented over relatively short time periods. There are some indications from other studies that the peak load reductions achieved may decrease over time as customers lose interest in carrying out the actions necessary to reduce their peak loads. This may particularly be the case in Australia because, for most end-use customers, electricity represents a minor component of their overall costs and savings on electricity bills are likely to be non-material. Time-varying pricing coupled with load switching technology programmed to automatically respond to electricity prices (as in the California trial) may prove to be a more effective strategy for achieving customer behaviour change than pricing alone.

Also in Australia, the introduction of effective time-varying pricing is particularly complicated by the unbundling of the network and retail functions into separate electricity businesses. These separate businesses have quite different motivations for introducing time-varying pricing: network businesses want to reduce end-use customer loads at peak times on the network while retailers want to reduce loads at times of high prices in the NEM. Historical data show that high price periods in the NEM coincide with network peak times less than 50% of the time.

The bottom line of a customer electricity bill includes both network and retail charges set by the respective businesses. However, the bill is actually rendered to the customer by the retailer. The retailer can choose to pass through any time-varying pricing established by the network business, or to simply charge the customer a time-invariant price, or to introduce time-varying pricing differently structured from that of the network business. Therefore, the pricing signal to the customer provided by the introduction of time-varying pricing by a network business may be diluted by the retailer in rendering the bill to the customer.

The NEM metrology framework can assist in ensuring that time-varying pricing does provide an effective signal to encourage customers to change their behaviour. The metrology framework should provide incentives to retailers that introduce time-varying pricing for customers who have interval meters installed, and that do not dilute any time-varying pricing introduced by network businesses.

5. PLATFORMS FOR ENHANCED LOAD MANAGEMENT

5.1 Characteristics of Load Control

Load control comprises a system or program that enables end-use customer loads to be changed in response to particular events such as periods of high electricity prices or problems on the electricity network.

Load control systems have the following characteristics:

- the program operator for the load control system may be:
  - ♦ an electricity retailer or distributor;
  - ♦ a market or system operator; or
  - ♦ a demand response service provider.
- switching of end-use customer loads may be:
  - ♦ carried out *locally* by the customer manually turning down or switching off appliances and equipment in response to a request from the program operator, or
  - ♦ initiated *remotely* by a signal sent from the program operator[62] through direct communication links to the customers' electrical equipment; a second signal is sent to restore normal operation at the conclusion of a program event;
- switching of loads may involve:
  - ♦ *cycling* loads on and off according to pre-set timing schedules;
  - ♦ *reducing* loads to pre-set levels; or
  - ♦ *switching off* loads completely.

5.2 Load Control Technologies

A complete load control system consists of three basic elements as shown in Figure 13 (page 44):

- technology located at the program operator's premises;
- communications technology; and
- technology located at the customer's site.

[62] The signal may be sent manually by the program operator or automatically in response to trigger events such as exceedances of pre-set electricity price levels or pre-set load levels on particular network elements, or excursions outside pre-set frequency or voltage parameters.

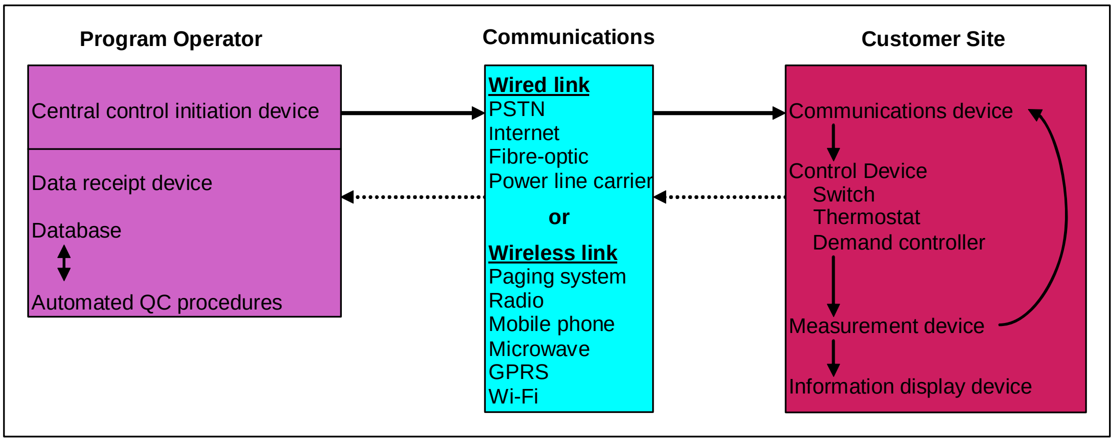

Figure 13. Load Control System Components[63]

5.2.1 *Technology at the Program Operator's Premises*

Load control technology at the program operator's premises has two functions:

- **Load Control Initiation:** The program operator must be able to generate and send signals to initiate (and terminate) a load control program event. With locally-switched load control, the signals are sent to the customer, and can be as simple as phone calls or email messages. With remotely-switched load control, coded signals are sent directly to the customers' appliances and equipment and instruct them how to respond. In Australia, ripple control signals have been used for over 50 years to remotely switch off-peak water heaters. Ripple control works by superimposing a small coded audio frequency wave on to the normal 240 volt 50 herz electricity supply. Signals are sent very slowly to ensure reliable reception by ripple control receivers located anywhere on the electricity network.
- **Data Receipt and Storage:** For operational and billing purposes, the program operator requires data about the quantity and timing of load reductions achieved through the load control program. Some load control systems include two-way communication links between the program operator and the controlled loads which allow this data to be collected in near real time. However, many load control programs have only one-way communications and rely on data acquired some time after load control events, eg from electricity meters at customer sites.

5.2.2 *Communications Technology*

Communication technology for load control programs enables signals to be sent by the program operator and, if the communications links are two-way, also enables the program operator to receive data from the controlled loads.

63 Modified from: Lockheed Martin Aspen (2006). *Demand Response Enabling Technologies for Small-Medium Businesses*. Rockville, Maryland, LMA. Available at: www.energetics.com/madri/pdfs/LMADRT_060506.pdf

A range of wired and wireless communications technologies can be used in load control programs, as shown in Figure 11 (page 40). Costs vary quite widely depending on the actual communications technology used.

5.2.3 Technology at the Customer Site

Load control technology at the customer site has four functions:

- **Communications:** Signals sent by the program operator must be received at the customer site and conveyed to selected customers' appliances and equipment. If the communications technology is two-way, it will also enable communication of information about the controlled loads back to the program operator, including data from a load measurement device, such as an electricity meter, and verification that remote switching has been successful.
- **Controlling Appliances and Equipment:** The appliances or equipment which are to be controlled must be able to respond to the signals sent by the program operator. With locally-switched load control, the customer will simply use the existing switches in the appliances or equipment to manually turn them down or switch them off. With remotely-switched load control, a range of control devices that can respond to signals from the program operator may be attached to the appliances or equipment. These devices may include simple on-off switches, programmable thermostats, and sophisticated programmable demand controllers.
- **Load Measurement:** The program operator must be able to measure the load reductions achieved through the load control program. This requires a load measurement device which is usually an electricity meter. Accumulation meters (designated as Type 6 meters in Australia) measure total energy consumption but the information is recorded relatively infrequently when the meter is read. With accumulation meters, statistical methods must be used to estimate the load reductions resulting from a load control program. Interval meters (designated as Type 1 to 5 meters in Australia) automatically measure and record energy use over many, relatively short, time intervals. Interval meters can be used to directly measure load reductions resulting from a load control program.
- **Information Display:** Some load control programs make use of information display devices ("in-house displays") to provide information to end-use customers about their electricity usage and costs. The information provided may include: the current electricity tariff, the current energy consumption in the customer's premises, the cost of the current energy consumption, and various messages and alerts about load control events, times at which TOU tariff levels will change, etc.

5.3 Load Control Programs

5.3.1 ETSA Utilities Residential Direct Load Control Trials - Australia

ETSA Utilities is undertaking trials of residential air conditioner cycling to assist with the summer supply/demand imbalance coupled with an extremely peaky load profile in South Australia.

The objectives of the first stage of the trial, in early 2006, were to test a range of times and cycle periods, analyse load profile impacts and carry out detailed customer impact studies. The trial involved 40 volunteer residential customers in Adelaide, comprising a mix of ETSA Utilities staff and customer participants. The customers were recruited by demographic, geographic area and equipment type. Two direct load control systems were purchased from the United States, one each from Comverge and CSE. Two-way communication was achieved using the ETSA Utilities mobile radio network, selected for ease and low cost. Figure 14 shows the results when air conditioners were interrupted for 15 minutes in every 30 minutes during the peak period. Significant load reductions were achieved in the early evening peak.

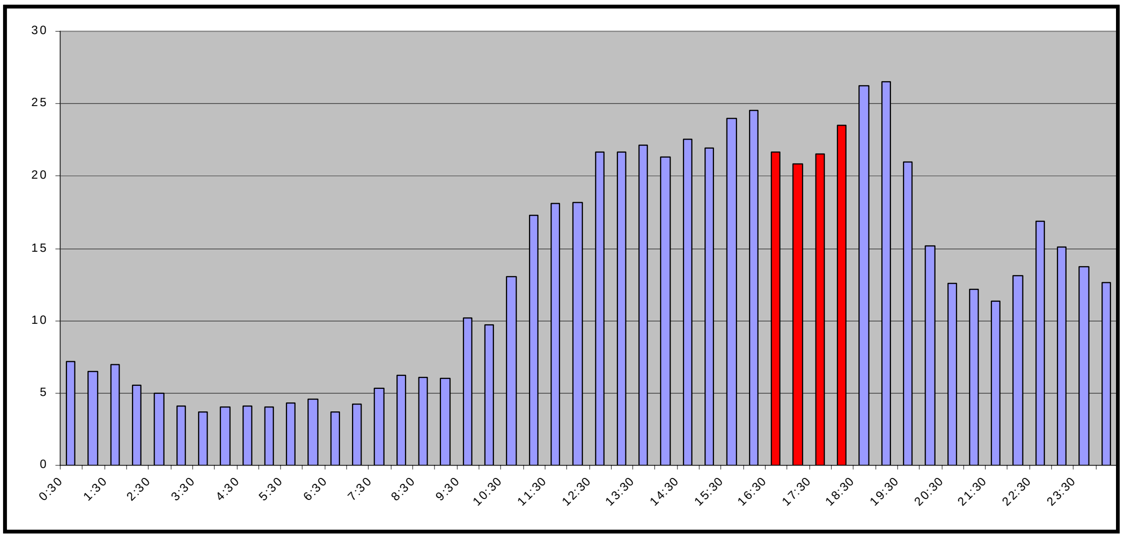

Figure 14. Results of the First Stage of the ETSA Air Conditioner Cycling Trials[64]

The second stage of the trial was carried out during the 2006/07 summer period. Residential customers from the Glenelg and Morphetville areas of Adelaide were recruited through an advertising campaign. Participants received an incentive payment of $100.

64 Twisk, R. (2007). *ETSA Utilities Demand Management Program*. Presentation to Demand Response and DSM Conference. Adelaide, 20 June.

New load control technology was designed and manufactured in Adelaide for the trial by Saab Systems. The technology enabled cycling of air conditioning compressors while leaving the fan running continuously. The fan continued to circulate air and the customers were not aware when the compressor was turned off. Devices were switched in a random sequence when signals were sent through a public radio station. The communication system for the trial is shown in Figure 15. The system was able to switch devices based on substation, product group or individual customer level.

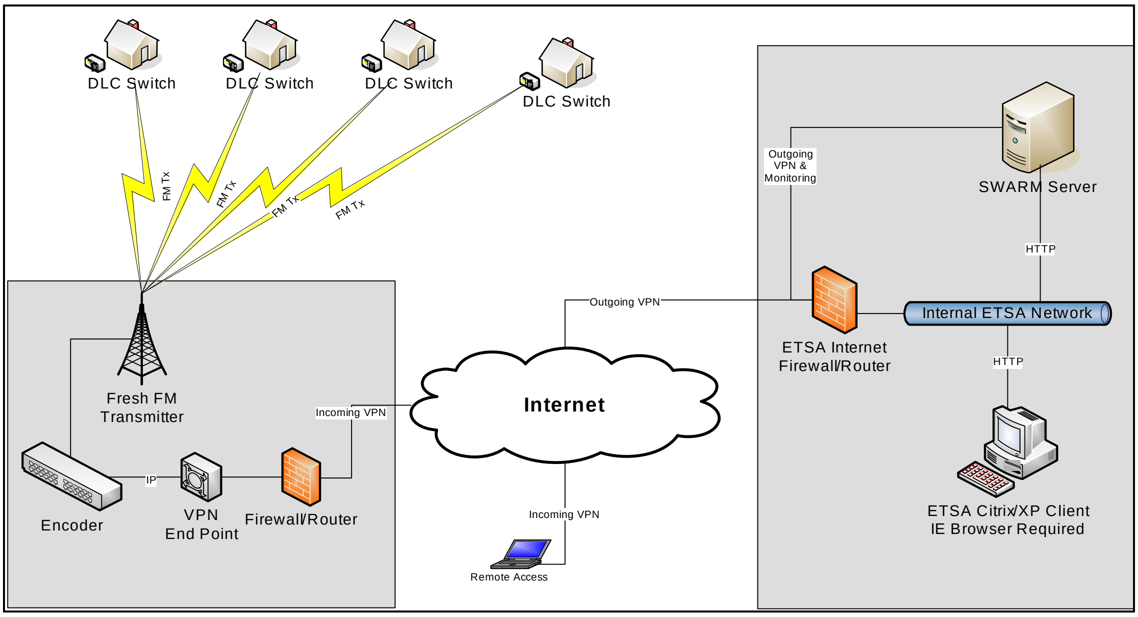

Figure 15. Communication System for the Second Stage of the ETSA Air Conditioner Cycling Trials[65]

Various switching periods were used in the second trial to assess the impacts of different switching protocols:

- 8 minutes off in 30 minutes;
- 15 minutes off in 30 minutes ('normal' switching period used in the United States);
- 30 minutes off in 60 minutes – used twice on selected street transformers;
- 25 minutes off in 60 minutes – used for one period.

Switching of 15 minutes off in 30 minutes was tested on four occasions and no customer complaints were received regarding comfort levels. ETSA Utilities concluded that residential air conditioning customers can sustain that level of switching.

Figure 16 (page 48) shows the results from two warm days and one hot day in January and March 2007. Cycling the air conditioners on a warm day significantly reduced the load during the peak period compared with no cycling.

[65] Twisk, R. (2007). Op. cit..

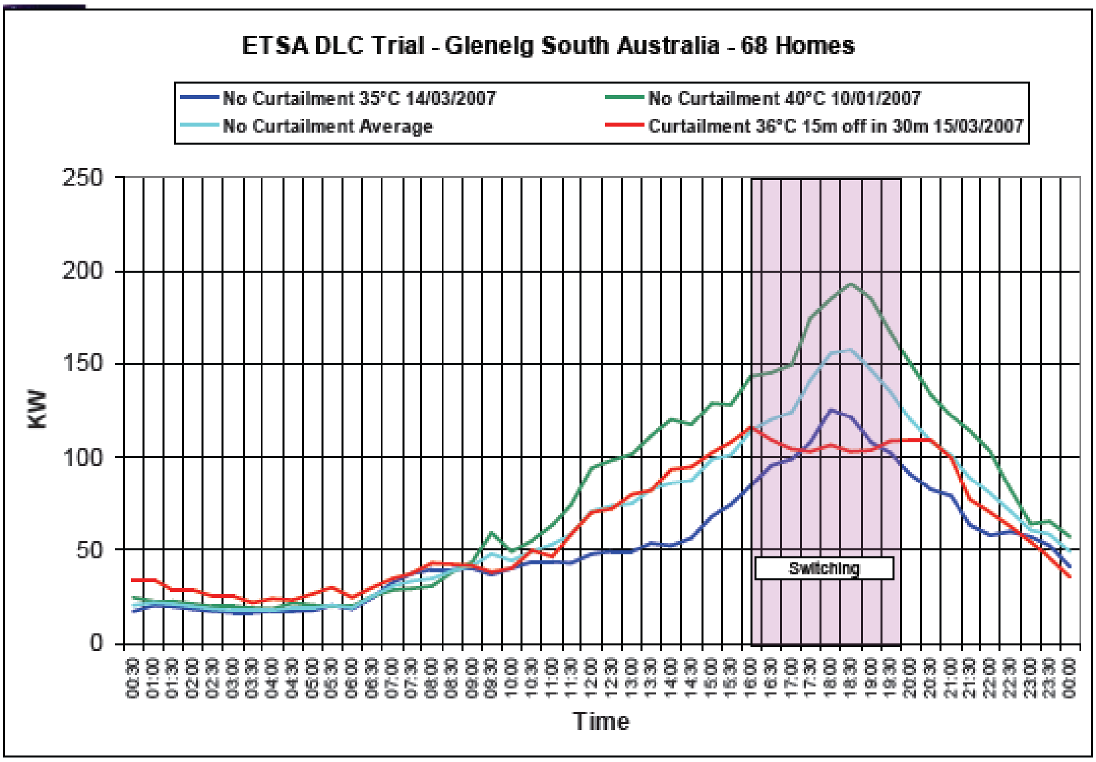

Figure 16. Results of the Second Stage of the ETSA Air Conditioner Cycling Trials[66]

5.3.2 LIPAedge Direct Load Control Program - USA

The LIPAedge program was developed by Long Island Power Authority (LIPA) to use central control of residential and small commercial air-conditioning thermostats to achieve peak load reduction[67].

The system operator communicates with the demand-side resource through an internet-based system. Two-way radio pagers controlled through the internet are used to transmit a curtailment order to 20,000 thermostats and to receive acknowledgment and monitoring information. Thermostats can be addressed individually, in groups, or in total. This important advantage provides both flexibility and speed. The thermostats can take immediate action or adjust their schedules for future action, depending on what the system operator ordered.

The thermostat is fully programmable by the customer and an internet-based remote interface is provided for customer interaction. Customers can also override curtailment events. This feature appears to be important to gain customer acceptance and it probably increases the reliability benefit. The system operator can block overrides if necessary.

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66 Twisk, R. (2007). Op. cit.

67 Long Island Power Authority (2002). *LIPAedge*. PowerPoint presentation to the New York Independent System Operator Price-Responsive Load Working Group, November 21. Available at: www.nyiso.com/public/archive/webdocs/committees/Price-Responsive_Load_WG/2002-11-21/3_lipa_presentation.pdf

The LIPAedge program is available for residential central air conditioning customers and small business customers, though the program is now closed to new participants. Customers who sign up to the LIPAedge program receive a Carrier ComfortChoice thermostat and installation free of charge. Customers also receive a one-time bonus payment of USD 25 (residential customers) or USD 50 (small commercial customers).

LiPAedge customers agree to have their central air conditioning system adjusted between the hours of 2 pm and 6 pm for a maximum of seven days throughout the four month summer season. Customers have access to a dedicated web page for their thermostat and are able to remotely change the set point of their air conditioner whenever they want.

For a summer load curtailment, the system operator might send a command at 9:00 am directing all thermostats to move their set points up 4 degrees, starting at 2:00 pm and ending at 6:00 pm. Alternatively, the system operator could send a command directing all thermostats to completely curtail immediately. The command is received and acted upon by all loads, providing full response within about 90 seconds. This is far faster than generator response, which typically requires a 10-minute ramp time.

LIPA estimates that it has about 20,400 residential customers and about 3,000 commercial and small industrial customers enrolled in the LIPAedge program and the program achieves about 25 MW of peak load reduction.

5.3.3 Sacramento Peak Corps - USA

The Sacramento Residential Peak Corps program was initiated by the Sacramento Municipal Utility District (SMUD) in 1979 to address needle peaks in the load on Sacramento's electricity network[68]. The Peak Corps program has now been operating for 28 years and it has such longstanding community acceptance that it has become the default option for new residential air conditioner installations in SMUD's service territory.

The Peak Corps program involves direct load control cycling of residential central air conditioners during selected summer afternoons. Residential customers apply to become Peak Corps members and allow the utility to install a cycling device and send a radio signal to cycle their central air conditioners by switching them off and on at times determined by the utility.

Cycling can occur periodically during the day or on weekends. On a "typical" cycling day, cycling occurs for between 2 1/2 and 4 hours. When an air conditioner is being cycled, this is indicated by a flashing green light on the cycling device. To cater for special household occasions, customers can elect to be taken off the Peak Corps program for one day only during the summer without losing their savings. Customers must provide two days notice to SMUD if they want to utilise this option.

The program currently offers three cycling options with the program participants receiving discounts on their June through September electric bills. In addition to the monthly discount, Peak Corps members receive additional savings (up to USD3.00) each day their air conditioner is cycled.

[68] The Results Center (1994). *Sacramento Municipal District Residential Peak Corps*: Profile # 83. Available at: http://sol.crest.org/efficiency/irt/83.pdf

SMUD estimates that it has about 100,000 residential customers enrolled in the Peak Corps program and the program achieves about 200 MW of peak load reduction.

5.3.4 Effectiveness of Load Control Programs

Load control programs that involve remote switching of customer loads, like the three programs outlined in this section, are obviously effective in achieving peak load reductions. They offer customers a single "set and forget" decision making option which is much more attractive than programs that rely on the customer to manually switch appliances and equipment each time there are high electricity prices or messages from a system operator.

When the load control infrastructure includes interval metering, load control programs can be made even more attractive to customers by enabling systems in which customers can themselves set the price levels at which loads will be automatically switched. Such a system was used in the California ADRS trial described in section 4.3.2 (page 38).

5.4 Technology Review

The survey in the Appendix (page 75) identifies and reviews a number of low cost technology products that enable various load control functions. The products described in this survey have been chosen to represent the broad range of existing applications for load control technology. Several conclusions can be drawn from the detailed product information contained in the Appendix.

- **Interval metering** is not necessary to carry out load control functions. There are many products available that can carry out simple remote switching of loads. Some of the products in the survey can carry out remote switching that is automatically triggered by threshold events, including high price levels and network constraints, without requiring a connection to an interval meter, or even to any type of meter. However, where interval metering with communications capability is available, information about threshold events can be transmitted through the meter. Interval metering also enables the implementation of "set and forget" load control programs in which customers can themselves set the price levels at which loads will be automatically switched.

- **One-way communication** is essential to carry out remote switching of loads. A one-way communication link is required to transmit control signals from the program operator to the connected loads. Depending on the specific capability of the communications technology, a one-way communication link can also be used to transmit information about threshold events, such as high price levels and network constraints, without requiring a connection to a meter.

- **Two-way communication** is not essential to carry out remote switching of loads. However, it can greatly assist with the management of a load control program by enabling the transmission of information back to the program operator about whether remote switching has been successful and about the current status of the connected load. If the return communication link is connected through an interval meter, the program operator can also receive specific information about the quantity and timing of any load reduction achieved.

- **Metering** in some form is required for settlement of the financial transactions associated with load control programs. Accumulation meters are sufficient when the only information required is the quantity of energy used over the billing period. Interval metering may be required if time-varying pricing is in place, particularly with CPP and RTP, and when TOU pricing applies to all loads at the customer site, rather than to particular specified loads. However, some technology products are now available that can provide pulsed output from legacy electro-mechanical accumulation meters (eg the Rippleband Load Control System, see page 92). Theoretically, this output could be integrated over specified time periods to generate data similar to that obtained from an interval meter.

5.5 Options for Low Cost Load Control Programs

The following options for low cost load control programs have been developed to take account of the differences among Australian jurisdictions in the availability of existing load control infrastructure and also different potential scenarios, eg whether or not a mass rollout of smart meters is planned:

- distribution of low cost information display devices;
- installation of frequency sensors in household appliances;
- rollout of low cost plug-in appliance controllers;
- rollout of smart air conditioner thermostats;
- promotion of integrated direct load control systems.

5.5.1 Distribution of Low Cost Information Display Devices

Purpose: To raise end-use customers' awareness about their electricity usage and cost and encourage a change in their electricity-using behaviour.

Target Audience: Primarily residential customers, though small businesses could also be targeted.

Technology: A device that displays information to end-use customers about their electricity usage and costs, and may also provide information about other factors such as greenhouse gas emissions resulting from a customer's electricity usage.

Communications: None

Type of Metering Required: None

Infrastructure Required: None

Pricing Initiatives: Could be accompanied by the introduction of time-varying price structures, eg TOU, RTP and/or CPP.

Education and Awareness Raising: The distribution of the information display devices should be accompanied by a promotion and education campaign encouraging customers to change their electricity-using behaviour.

Examples of Technology Products: Power-Mate™ (see page 75); Cent-A-Meter™ (see page 77)

Indicative Cost: AUD 60 to AUD 200 per customer site; the higher cost includes installation where required. In addition, there would be the cost of any promotion and education campaign.

Likely Effectiveness: The effectiveness of the promotion and education campaign would be crucial in determining how successful this option is in changing customers' behaviour. Any behavioural changes may not persist over time because they would require customers to undertake manual switching of appliances and equipment.

5.5.2 Installation of Frequency Sensors in Household Appliances

Purpose: To achieve automated switching of household appliances in response to system frequency variations.

Target Audience: Manufacturers of household appliances

Technology: A device comprising a circuit board containing a simple computer chip that can sense frequency disturbances on an electricity network and can turn an appliance off for a few minutes to allow the network to stabilize during a crisis; the sensor can be installed in appliances that regularly cycle on and off during normal use, so that end-use customers will not notice when the device is in operation.

Communications: None

Type of Metering Required: None

Infrastructure Required: None

Pricing Initiatives: None required

Education and Awareness Raising: The large scale incorporation of frequency sensors in household appliances could be accompanied by an education campaign explaining the technology to householders.

Examples of Technology Products: Grid Friendly™ appliance controller (see page 80)

Indicative Cost: About AUD 2.00 per appliance in large manufacturing quantities plus the cost of any education campaign. There would be no installation or maintenance costs for the frequency sensors since they would be installed by appliance manufacturers.

Likely Effectiveness: The effectiveness of the technology has been proven through test installations and field trials. The effectiveness of the rollout program will depend on the willingness of appliance manufacturers to incorporate the technology into their products and its acceptance by householders.

5.5.3 Rollout of Low Cost Plug-in Appliance Controllers

Purpose: To enable low cost direct load control of appliances and equipment.

Target Audience: Primarily residential customers, though small businesses could also be targeted.

Technology: A device that plugs into an electrical wall socket; an appliance is plugged into the device which then receives ripple control signals sent through powerlines by the program operator.

Communications: One-way

Type of Metering Required: None

Infrastructure Required: Ripple control infrastructure (already existing in NSW, Queensland and South Australia; would have to be installed in other jurisdictions)

Pricing Initiatives: The introduction of time-varying price structures, eg TOU, RTP and/or CPP, is not essential but could act to motivate customers to install the controllers. Alternatively, or in addition, incentive payments could be used.

Education and Awareness Raising: The rollout of the appliance controllers could be accompanied by a promotion and education campaign explaining the purpose and objectives of the program and encouraging customers not to override load control signals from the program operator.

Examples of Technology Products: SWITCHit™ (see page 82); Rippleband Plug-in Relay (see page 92)

Indicative Cost: AUD 26 to AUD 50 per connected appliance or piece of equipment plus the cost of any promotion and education campaign. There would be no installation or maintenance costs for the plug-in appliance controllers. In jurisdictions which do not have already existing ripple control infrastructure, this would also have to be installed and this would add to the program cost.

Likely Effectiveness: Once the appliance controllers are installed, load reductions are highly likely to persist over time because the switching of appliances and equipment would be automated. However, it would always be possible for customers to override load control events by simply unplugging the controllers.

5.5.4 Rollout of Smart Air Conditioner Thermostats

Purpose: To enable low cost direct load control of air conditioners.

Target Audience: Residential and small commercial customers

Technology: A device that operates as a standard programmable thermostat, but also includes two-way communications with the load control program operator. The thermostat and the associated control system are capable of performing either: cycling control, whereby a fixed allowable maximum on-cycle is maintained, or temperature control, whereby the set-point of the thermostat can be remotely adjusted. The customer can also program the thermostat directly using controls on the thermostat itself or through the internet.

Communications: Two-way

Type of Metering Required: None

Infrastructure Required: Two-way communications infrastructure (eg radio paging, mobile phone communications or broadband internet)

Pricing Initiatives: Introduction of time-varying price structures, eg TOU, RTP or CPP would be required to motivate customers to install the thermostats. Alternatively, or in addition, incentive payments could be used.

Education and Awareness Raising: The rollout of the thermostats could be accompanied by a promotion and education campaign explaining the purpose and objectives of the program and encouraging customers not to override load control signals from the program operator.

Examples of Technology Products: ComfortChoice^{SM} Demand Management Solution (see page 85)

Indicative Cost: AUD 250 to AUD 300 per thermostat plus a monthly fee for use of the control software of about AUD 1.00 to AUD 4.00 per thermostat (based on US prices). In addition, there would be costs for installing and maintenance of the thermostats plus costs for using an existing communications network or installing a new network.

Likely Effectiveness: Once the thermostats are installed, load reductions are highly likely to persist over time because the switching of the air conditioners would be automated. However, it would always be possible for customers to override load control events by adjusting the controls on the thermostats.

5.5.5 Promotion of Integrated Direct Load Control Systems

Purpose: To enable relatively complex demand response programs.

Target Audience: Primarily residential and small commercial customers, but could be extended to larger customers at additional cost

Technology: Integrated load control systems combining appliance and equipment controllers with two-way communications technology to enable remote-switching of appliances and transmission of data from the controlled loads to the program operator. These systems provide flexible management solutions for complex load control programs.

Communications: Two-way

Type of Metering Required: Interval

Infrastructure Required: Two-way communications infrastructure (eg radio paging, mobile phone communications, broadband internet, two-way advanced ripple control or power line carrier)

Pricing Initiatives: Introduction of time-varying price structures, eg TOU, RTP or CPP would be required to motivate customers to install the necessary load control equipment. Alternatively, or in addition, incentive payments could be used.

Education and Awareness Raising: The rollout of the technology should be accompanied by a promotion and education campaign explaining the purpose and objectives of the planned demand response program(s)

Examples of Technology Products: LeKey Energy Management System (see page 89); SD Electricity Manager (see page 90); Rippleband Load Control System[69] (see page 92).

[69] This product can also use data from legacy electro-mechanical accumulation meters.

Indicative Cost: Highly variable depending on the load control equipment and communications and control systems installed. A typical range for a low cost integrated direct load control system might be AUD 300 to AUD 600 per customer site plus the cost of any promotion and education campaign. In addition, there would be costs for the use or installation of a communications network.

Likely Effectiveness: Once the load control equipment is installed, demand responses are highly likely to persist over time because the switching of appliances and equipment would be automated. However, it may be possible for customers to override load control events, depending on the specific equipment installed.

5.6 Creating a Forward Path for Load Control Technology

The product survey of low cost load control technology in the Appendix (page 75) demonstrates that considerable product design and development is currently taking place. Much of this development is being carried out by information and communications technology firms rather than by firms traditionally involved in designing, developing and manufacturing equipment for the electricity industry.

One consequence of this is that product lifetimes for newly-developed load control equipment are much shorter than those for other equipment in the electricity industry. Traditionally, lifetimes of 50 years or more have been expected for equipment such as electro-mechanical electricity meters. In contrast, lifetimes for electronic meters are now expected to be about 15 years. Some of the electronic equipment now being developed for load control applications may be superseded in three to five years (typical lifetimes in the ICT industry) not because the equipment breaks down but because new, cheaper products able to carry out more functions have been developed.

The rapidly increasing availability of sophisticated load control equipment at comparatively low cost, opens up major opportunities to implement load control programs. However, given the diversity of products available, there is a danger that too rapid deployment of load control technology without a clearly defined strategy may result in a range of problems, including:

- a **"rail gauge" problem** in which multiple different proprietary load control products are installed that are unable to interface with each other;
- a **stranded assets problem** in which existing load control equipment currently installed in the Australian electricity industry becomes uneconomic and has to be replaced with more cost-effective technology; and
- an **uneconomic lifetimes problem** in which the short lifetimes of new load control products force massive and costly physical replacement and re-installation programs on a regular basis.

To prevent such problems occurring, a national policy development process should be established to create a forward path for the implementation of load control technology in the Australian electricity industry. Such a policy development process should aim to ensure:

- that open standards and protocols are developed for all the important load control functions and that load control equipment installed in the Australian electricity industry complies with these standards and protocols;
- that technology products are developed to expand existing load control functions and add new functions to equipment already in use in the Australian electricity industry, eg the existing extensive ripple control infrastructure in NSW, Queensland and South Australia, and the existing very large stock of accumulation meters;
- that new load control technology products are designed so that additional capabilities and functions can be added without requiring the physical replacement of whole units or parts of units, eg changes could be made by using communication links to implement mass upgrades of firmware installed in load control products.

6. GREENHOUSE IMPACTS OF ADVANCED METERS

6.1 Will Advanced Meters Reduce GHG Emissions?

Claims are often made that advanced meters will reduce greenhouse gas (GHG) emissions. For example, in April 2007, when announcing a trial involving 50 Melbourne households testing smart water, gas and electricity meters, the Victorian Premier, Steve Bracks said: "This technology is the way of the future and will revolutionise our energy and water use. It will help further secure our water supplies and reduce greenhouse gas emissions."[70]

However, determining whether advanced meters will reduce GHG emissions is actually quite a complicated issue. Installing advanced electricity meters will, by itself, do nothing to reduce GHG emissions. Emission reductions will only be achieved if installing the meters results in changing people's behaviour so that they use less energy in total than they would use without the meters. As previous sections of this report have shown, changing people's behaviour after installing advanced meters requires various supporting measures, such as time-varying pricing, additional enabling technology such as in-house displays and automatic load control devices, and customer information and education programs.

Determining whether installing advanced meters and the associated pricing measures, enabling technology and information an education programs actually leads to reduced total energy use is also a complicated matter. Advanced metering is most often directed to achieve behavioural changes leading to peak load reduction rather than reductions in total energy use. Peak load reductions may simply lead to load shifting with no reduction in total energy use. Estimating the impact of load shifting on GHG emissions is complicated because it requires precise information about differences in the carbon intensity of the marginal generation plant between peak and off-peak periods. Any change in GHG emissions resulting from load shifting could be either a reduction or an increase and is likely to be small relative to the reductions that could be achieved from savings in total energy use.

[70] Office of the Victorian Premier (2007). *Smart Meters to Cut Bills and help the Environment*. Media Release. Melbourne, 17 April.

6.2 GHG Emission Reductions from Energy Savings

Despite the difficulties outlined in the previous section, it is possible to calculate the GHG emission reductions from installing advanced meters if the resulting savings in total energy use are known. Only one study has been carried out worldwide that measured the quantity of GHG emission reduction actually achieved following the installation of advanced meters.

6.2.1 Carbon Trust Study of Carbon Savings from Advanced Meters

This study, carried out by the United Kingdom Carbon Trust, was unusual in that it focussed on savings in total energy use rather than peak load reductions[71]. In particular, the study investigated how advanced metering can enable businesses to identify energy, cost and carbon savings by providing detailed information about the way in which they use their energy.

From 2004 to 2006 the Carbon Trust carried out the first UK field trial of advanced metering for small and medium enterprise (SME) end-users. The trial aimed to demonstrate the potential benefits of the technology and understand the business case for encouraging widespread adoption of advanced metering by SMEs. A total of 582 advanced meters were installed in SMEs across the UK and metering services were provided to these sites by seven different consortia.

The SMEs involved in the trial used advanced metering to identify an average of 12% carbon savings and implemented an average of 5% carbon savings through reduced consumption of electricity, gas and water. The SMEs achieved average annual financial savings of over GBP1,000 (AUD2,400) and average annual carbon savings of 8.5 tonnes of carbon dioxide equivalent per site.

Detailed results of the savings achieved are shown in Figures 17 and 18 (page 58). Figure 17 shows the average annual percentage carbon savings for all sites in the trial and Figure 18 shows the average annual absolute carbon savings per site in tonnes of carbon dioxide equivalent.

[71] The Carbon Trust (2007). *Advanced Metering for SMEs: Carbon and Cost Savings*. London, the Trust. Available at: http://www.carbontrust.co.uk/Publicsites/cScape.CT.PublicationsOrdering/PublicationAudit.aspx?id=CTC713

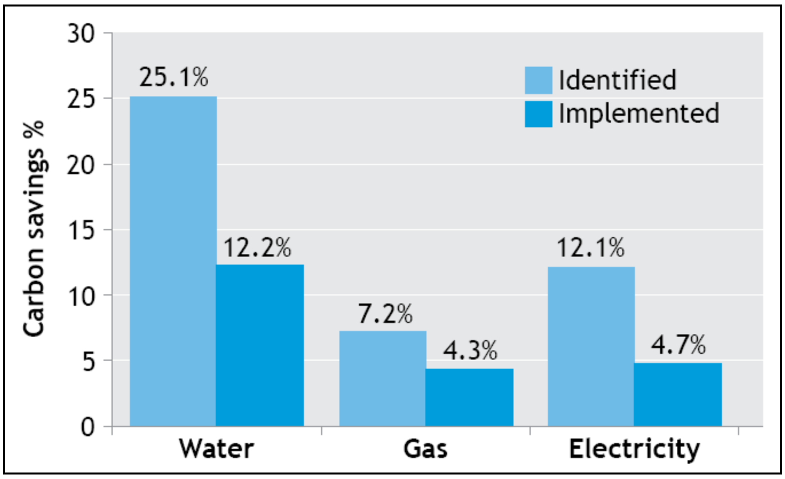

Figure 17. Average Annual Percentage Carbon Savings for All Sites in the Carbon Trust Trial[72]

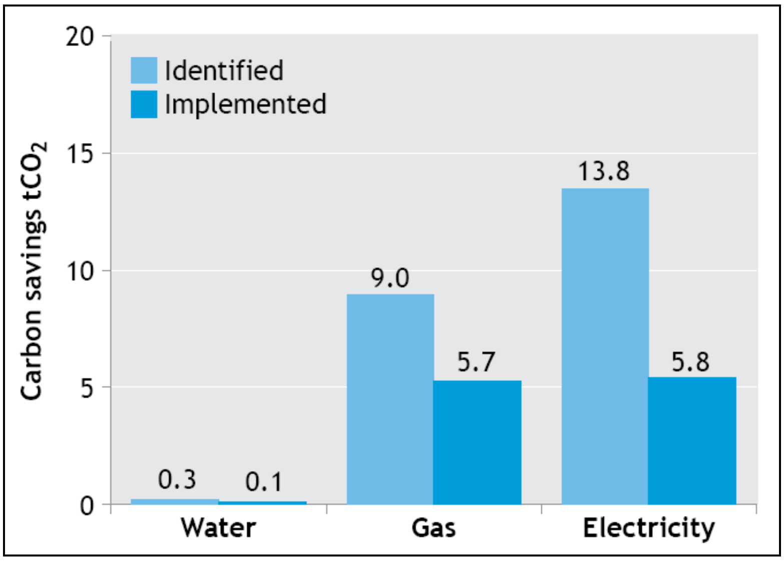

Figure 18. Average Annual Absolute Carbon Savings for All Sites in the Carbon Trust Trial[73]

In addition to the actual installation of advanced metering, a variety of different metering services were included in the trial, ranging from basic data provision to detailed advice on energy saving communicated through phone calls and site visits. The highest energy savings were achieved by providing energy consumption profiles and energy saving recommendations via email. This is a significant finding which suggests that, in the future, low-cost metering services could be provided using automated systems.

[72] Source: The Carbon Trust (2007). *Op. cit.*
[73] Source: The Carbon Trust (2007). *Op. cit.*

Figure 19 shows the process followed in the trial. Data from the meters were collected and analysed to identify and quantify possible savings, saving measures were implemented, further data were collected and reviewed until all viable savings were identified and implemented.

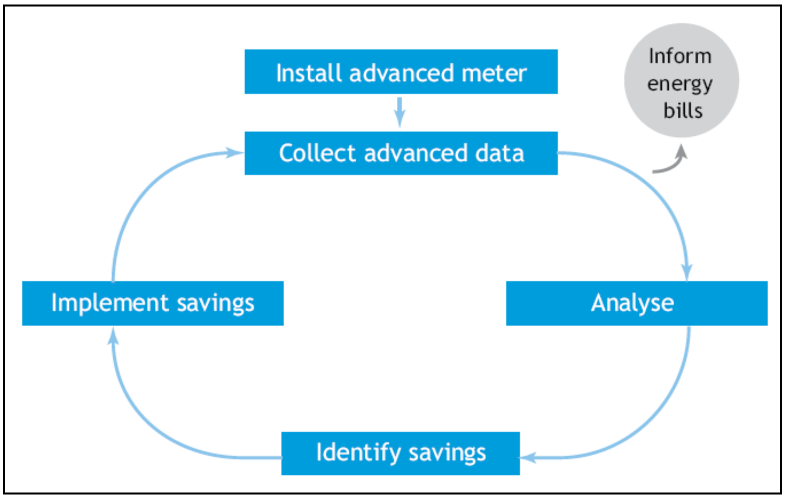

Figure 19. Process for Using Advanced Metering to Identify and Implement Savings[74]

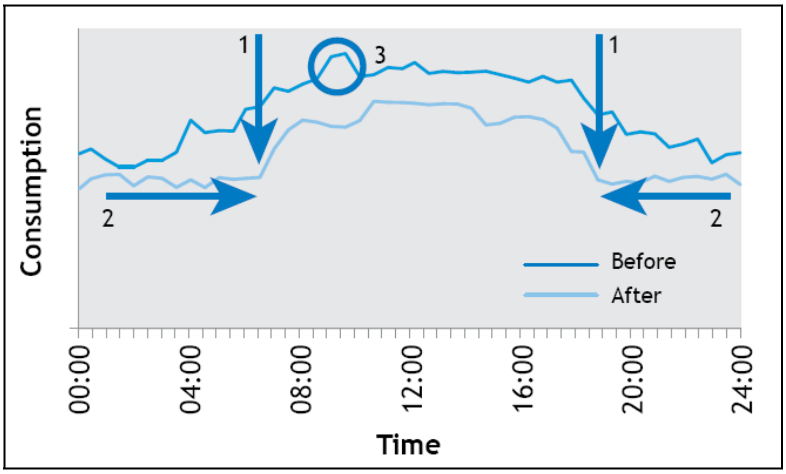

Figure 20. Using Half-hourly Profile Data to Identify Possible Energy Savings[75]

Figure 20 shows how detailed half-hourly profile data from advanced metering was used to identify energy savings. Three key types of potential energy saving measures (corresponding to the numbers in Figure 20) could be derived from advanced meter data:

1. **Base load reductions** – the overall base load of the site could be studied and reduced, for example, by identifying unnecessary constant energy use.

[74] Source: The Carbon Trust (2007). *Op. cit.*
[75] Source: The Carbon Trust (2007). *Op. cit.*

2. **Process optimisation** – the profile could be used to identify what equipment is running and when. Altering the start-up and shutdown times of key processes and equipment could reduce consumption by limiting the duration of high-energy use at the start and end of working schedules.
3. **Peak usage reduction** – the profile could be used to analyse timings and frequencies to establish the causes of peaks in energy usage, and understanding the causes in terms of specific activities or equipment.

The Carbon Trust study is a good example of what can be achieved if advanced meters are actively used for data monitoring, collection and analysis as part of a comprehensive program focussed on realising energy savings[76].

6.2.2 Other Studies of Energy Savings from Advanced Metering

Several other studies have focussed on estimating the energy savings achievable if advanced meters are used more passively than in the Carbon Trust trial. Most of these studies focussed on the residential sector. These studies did not actually measure the energy savings achieved following the installation of advanced metering. Rather, the studies relied on data for energy savings achieved in situations where additional information was provided about energy use by individual households. This was thought to be similar to the information that would be provided by an in-house display attached to an advanced meter.

The study by Sustainability First in the United Kingdom[77] summarised reviews of over 50 individual studies in a range of countries in which additional information about household energy use was provided. In 21 studies that involved direct feedback about energy use (including smart meter installations but also other methods such as using TV/internet and prepayment meters) the majority showed savings in total energy use in the range of five to 14 percent.

A study of this type was carried out in Ontario, Canada between July 2004 and September 2005. In the largest such study ever completed in Canada, Hydro One equipped 500 homes with low-cost in-house display technology. The technology wirelessly transmitted data from the building's outside electricity meter to a portable in-house display, allowing householders to directly see how much electricity they were consuming on a "live" basis. The displays cost less than CAD100 (AUD110) per home and can be self-installed, so are a much cheaper option than advanced metering, although clearly they do not have the full functionality of smart meters. Total energy consumption in households participating in the study was compared to consumption in the same seasons and months in the previous year. Hydro One found that participants in the project reduced their energy use by between 7 per cent and 10 per cent.

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[76] In Australia, such a service is offered by EP&T Pty Ltd. This company both manufactures advanced meters and provides a metering data monitoring, collection and analysis service focussed on achieving energy and cost savings. The service is used mainly by owners and operators of large commercial sector buildings. See the EP&T website at: www.eptglobal.com/productview.aspx?prodid=68

[77] Owen, G. and Ward, J. (2006). *Op. cit.*

6.3 Possible GHG Emission Reductions from Advanced Metering in Australia

Detailed studies of actual energy savings following the installation of advanced meters have not been carried out in Australia because the focus to date has been on achieving peak load reductions rather than overall energy savings. The EnergyAustralia pricing trial did find that critical peak pricing led to reductions of between 5.5% and 7.8% in total daily energy consumption on days when a CPP event was called (see page 36). However, since only 12 CPP events will be called in a year, this result provides little indication of the impact of the installation of interval meters coupled with time-varying pricing on overall annual energy consumption.

Therefore, it is unclear whether energy savings and GHG emission reductions similar to those reported in overseas studies could be achieved in Australia. However, if similar results could be realised, it is possible that savings of between four and 10 percent in total national electricity use could be achieved from a national rollout of advanced meters to all electricity consumers in Australia.

In 2005, Australia's GHG emissions from the generation of purchased electricity were 194.3 Mt CO2-e and total national emissions across all sectors were 559.1 Mt CO2-e[78]. Table 3 shows the possible annual reductions in GHG emissions that could be achieved through a national rollout of advanced meters to all electricity consumers for savings of between four and 10 percent in total national electricity use.

Table 3. Possible Annual Reductions in Greenhouse Gas Emissions from a National Rollout of Advanced Meters

Savings in Total National Electricity Use	Annual Reduction in Greenhouse Gas Emissions (Mt CO2-e)	Proportion of Total National Emissions
4%	7.8	1.4%
6%	11.7	2.1%
8%	15.5	2.8%
10%	19.4	3.5%

[78] Australian Greenhouse Office (2007). *Australia's Greenhouse Accounts: National Inventory by Economic Sector 2005*. Canberra, AGO.

7. RECOMMENDATIONS FOR A NEM METROLOGY FRAMEWORK

Until recently, metrology in the National Electricity Market was governed by nine jurisdictional and NEMMCO metrology procedures. First tier metrology requirements, where a consumer is supplied by their local retailer, were defined by 20 separate jurisdictional codes and rules[79]. This complicated situation was rationalised on 1 January 2007, when the role of the Metrology Coordinator under the *National Electricity Rules* was transferred from jurisdictional regulators to NEMMCO.

To coincide with this transfer, NEMMCO published a *National Electricity Market Metrology Procedure*[80]. Metrology in the NEM is now governed by both Chapter 7 of the *National Electricity Rules* and by the *Procedure.* To make best use of the functionalities and capabilities of advanced metering, both the *Rules* and the *Procedure* will require some modification. The purpose of this section of the report is to recommend particular elements that should be included in a metrology framework for the NEM. However, this does not include recommending specific wording for amendments to the *Rules* and the *Procedure*.

7.1 Metering Technology

At its meeting in February 2006, COAG committed to the progressive [national] rollout of electricity smart meters[81]. Given the range of benefits available from advanced metering identified in this report, there is a strong qualitative case for a national rollout of smart meters (defined as interval meters with communications functionality). To gain the maximum benefits available from advanced metering, a complete advanced metering infrastructure, as illustrated in Figure 1 (page 3) will be required.

Recommendation 1: The NEM metrology framework should specify that the minimum metering requirement for both first tier and second tier customers is a smart meter (ie an interval meter with communications).

7.2 Communications Facility

As shown in previous sections of this report, enabling communications between the energy supplier and the meter greatly increases both the functionality of a metering installation and the benefits available. In particular, a communications facility enables automated and remote meter reading, remote connection and disconnection, outage detection, monitoring of power quality, tamper detection and direct load control through the meter.

Most of these functions can be achieved with one-way communication from the meter to the energy supplier. However, load control requires, at a minimum, one-way

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79 National Electricity Market Management Company (2006a). *NEM Metrology Programme Plan*. Sydney, NEMMCO. Available at: http://www.nemmco.com.au/meteringandretail/640-0082.htm

80 National Electricity Market Management Company (2006b). *National Electricity Market Metrology Procedure*. Sydney, NEMMCO. Available at: http://www.nemmco.com.au/meteringandretail/640-0123.pdf

81 Council of Australian Governments (2006). *Op cit*.

communication in the other direction from the energy supplier to the meter. Also, two-way communication can greatly assist with the management of a load control program by enabling the transmission of information back to the program operator about whether remote switching has been successful, the quantity and timing of any load reduction achieved, and the current status of the connected load. Therefore, if load control is to be carried out through the meter, a two-way communications link is required.

Recommendation 2: The NEM metrology framework should include detailed protocols enabling and controlling both one-way and two-way communications routed through advanced meters.

7.3 Enhanced Load Management Capability

As noted in section 5.3 (page 46), interval metering is not necessary to carry out load control functions to achieve enhanced load management. There are many products available that can carry out simple remote switching of loads (see Appendix, page 75). Some of these products can carry out remote switching that is automatically triggered by threshold events, including high price levels and network constraints, without requiring a connection to an interval meter, or even to any type of meter. However, where interval metering with communications capability is available, information about threshold events can be transmitted through the meter. Interval metering also enables the implementation of "set and forget" load control programs in which customers can themselves set the price levels at which loads will be automatically switched (see page 50).

Section 5.5 (page 51) showed that the rapidly increasing availability of sophisticated load control equipment at comparatively low cost, opens up major opportunities to implement enhanced load management. However, given the diversity of products available, there is a danger that too rapid deployment of load control technology without a clearly defined strategy may result in a range of problems, including a "rail gauge" problem, a stranded assets problem, and an uneconomic lifetimes problem. The NEM metrology framework has a role to play in ensuring that these problems do not occur.

Recommendation 3: The NEM metrology framework should include detailed protocols and technology standards enabling and controlling all load control functions carried out through an advanced meter, independently of a meter, or both. The framework should also specify that load control technology products used in the NEM must be designed so that additional capabilities and functions can be added without requiring the physical replacement of whole units or parts of units.

7.4 Information about Energy Consumption

One of the major benefits available from advanced metering is the ability to provide end-use customers with real time or near-real time information about their energy consumption and its cost. Several sections of this report have stressed the importance of the combination of detailed consumption information and time-varying tariffs in enabling electricity businesses to devise programs that provide incentives to customers who reduce their peak loads and/or implement energy efficiency measures. The NEM metrology framework can support this activity by facilitating the use of technology to provide energy consumption information to customers.

Recommendation 4: The NEM metrology framework should include detailed protocols and technology standards enabling and controlling the provision of real time or near-real time energy consumption information to end-use customers.

7.5 Time-Varying Pricing

Another major benefit available from the introduction of advanced meters is that they enable the implementation of time-varying pricing of electricity. The importance of time-varying tariffs in encouraging end-use customers to reduce their peak loads and/or implement energy efficiency measures has been mentioned repeatedly in this report. However, as pointed out in section 4.4 (page 42), the introduction of effective time-varying pricing in Australia is particularly complicated by the unbundling of the network and retail functions into separate electricity businesses with quite different motivations for introducing time-varying pricing. In particular, the pricing signal to the customer provided by the introduction of time-varying pricing by a network business may be diluted by the retailer in rendering the bill to the customer. The NEM metrology framework can assist in ensuring that time-varying pricing does provide an effective signal to encourage customers to change their behaviour.

Recommendation 5. The NEM metrology framework should provide incentives to retailers that introduce time-varying pricing for customers who have interval meters installed, and that do not dilute any time-varying pricing introduced by network businesses.

The metrology framework can also facilitate the communication of information about time-varying tariffs to customers.

Recommendation 6: The NEM metrology framework should include detailed protocols enabling and controlling the communication of information about time-varying prices to end-use customers.

7.6 Customer Incentive Programs

Simply installing advanced meters does nothing to influence customer energy-using behaviour. To achieve behaviour change, electricity businesses must devise programs that provide incentives to customers who reduce their peak loads and/or implement energy efficiency measures. Such incentive programs are essential to effectively achieve the peak load reductions and increased energy efficiency potentially available from the deployment of advanced metering. However, electricity businesses may be unwilling to introduce customer incentive programs unless they can see a clear financial benefit from doing so. Regulation which rewards electricity businesses that implement demand management programs will encourage the businesses to provide incentive programs to customers. The D-factor implemented by IPART in NSW (see page 22) and demand management incentives implemented by ESCOSA in South Australia (see page 23) are examples of this type of regulation.

Recommendation 7. Electricity regulators should introduce regulatory measures to reward electricity businesses that implement demand management programs. This will enable electricity businesses to provide incentive programs that encourage customers to change their energy-using behaviour.

7.7 Cost Benefit Analysis

At its meeting in April 2007, COAG endorsed a staged approach for the national mandated rollout of electricity smart meters to areas where benefits outweigh costs, as indicated by the results of a quantitative cost-benefit analysis[82]. However, a positive cost-benefit result has been achieved only in Victoria[83]. In Tasmania, a cost-benefit analysis showed that, for all small electricity consumers, no rollout scenario would produce a net benefit in comparison to the continued use of accumulation meters[84].

Cost benefit analyses of advanced metering are most often carried out from the perspective of electricity businesses rather than in relation to society as a whole. Such analyses typically show negative or only marginally positive financial benefits for electricity businesses. However, this is likely to change in the future as benefits from two particular items increase:

- the value of demand response in deferring electricity network augmentations; and
- the value of greenhouse gas emission reductions in relation to a national emissions trading scheme.

7.7.1 Value of Network Augmentation Deferral

Current cost benefit analyses of advanced metering may not identify the full value of demand response in deferring electricity network augmentations. For example, the Victorian cost benefit analysis found that the most significant benefits to electricity businesses were the avoided costs of manual meter reading and manual connection and disconnection of the energy supply to the end-user’s premises. Demand response benefits accounted for only seven percent of total benefits[85]. However, as peak loads on electricity networks grow, there will be more opportunities to use demand response to defer network augmentations and the value of demand response to electricity network businesses will increase.

Recommendation 8. Cost benefit analyses of advanced metering should include the estimated value of demand response to electricity network businesses in the future as peak loads on electricity networks grow.

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[82] Council of Australian Governments (2007). *Op. cit.*

[83] CRA International and Impaq Consulting (2005). *Op. cit.*

[84] Office of the Tasmanian Energy Regulator (2006). *Op.cit.*

[85] CRA International and Impaq Consulting (2005). *Op. cit.*

7.7.2 Value of GHG Emissions Reductions

Current cost benefit analyses of advanced metering do not ascribe any benefit for greenhouse gas emission reductions. At present, such reductions only have a value to electricity businesses in NSW, where retailers are required by legislation to meet mandatory targets for reducing greenhouse gas emissions resulting from the electricity they supply. In the near future, an emissions trading scheme will be introduced on a national basis in Australia. Therefore, cost benefit analyses will have to ascribe a value to GHG emission reductions.

Recommendation 9. Cost benefit analyses of advanced metering should include the estimated value of greenhouse gas emission reductions to electricity businesses in the future when emissions trading is introduced on a national basis in Australia.

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ABBREVIATIONS ACRONYMS AND GLOSSARY

Accumulation meter	A meter that records energy consumption progressively over time. The energy consumption information is accessed relatively infrequently only when the meter is read.
ADRS	Advanced Demand Response Systems (load control systems used in the California Statewide Pricing Pilot)
Advanced metering	A metering system that records customer consumption (and possibly other parameters) hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point
Advanced metering infrastructure	A full measurement and data collection system comprising customer meters (usually smart meters), communication networks, and data management systems.
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
AMI	Advanced metering infrastructure
AMR	Automated meter reading
AUD	Australian dollar
B2B	Business to business
CAD	Canadian dollar
CDMA	Code division multiple access (a type of mobile phone technology)
COAG	Council of Australian Governments
CPP	Critical peak pricing
Critical peak pricing	A form of time-varying pricing that can be superimposed on either a time of use or time-invariant tariff structure. Critical peak pricing relies on very high critical peak prices, as compared with the ordinary peak prices in time of use pricing or the flat prices in time-invariant tariff structures. This high per-unit price is in operation during times that the electricity business (distributor or retailer) defines as critical peak periods. Critical peak pricing events may be triggered by contingencies on the electricity network or high prices faced by the retailer in procuring power in the National Electricity Market.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D-factor	An incentive measure implemented in NSW by the Independent Pricing and Regulatory Tribunal to encourage increased utilisation of demand management (DM). The D-factor is a component of the weighted average price cap control formula that allows

	electricity distributors to recover non-tariff-based DM implementation costs, up to a maximum value equivalent to the expected avoided distribution costs; tariff-based DM implementation costs; and revenue foregone as a result of non-tariff-based DM activities.
DB	(Electricity) distribution business
Demand management	Actions taken on the customer's side of the meter to change the amount or timing of energy consumption. Demand management programs offer a variety of measures that can reduce energy consumption and consumer energy bills. Electricity demand management strategies aim to maximize end-use efficiency to avoid or postpone the requirement to expand or augment the electricity network or to construct new electricity generating plant.
Demand response	Actions taken by end-use customers to change (usually reduce) their electricity use in response to high prices in the electricity market and/or problems on the electricity network.
DM	Demand management
DNSP	(Electricity) distribution network service provider
DPP	Dynamic peak pricing
Dynamic peak pricing	Another name for critical peak pricing
ESC	Essential Services Commission (Victoria)
ESCOSA	Essential Services Commission of South Australia
FERC	Federal Energy Regulatory Commission (USA)
First tier customers	A customer who purchases electricity under franchise tariffs from a first tier retailer.
First tier retailer	A retailer that holds a franchise to supply electricity to customers within a defined geographical service territory.
GBP	United Kingdom pound
GHG	Greenhouse gas
GPRS	General packet radio service (a type of mobile data transmission technology)
HVAC	Heating, ventilation and cooling
ICT	Information and communications technology
IT	Information technology
Interval meter	A meter that records the quantities of energy consumed over set, frequent time intervals.

IPART	Independent Pricing and Regulatory Tribunal of New South Wales
kW	Kilowatt
kWh	Kilowatt-hour
LCD	Liquid crystal display
LCM	Load control and monitoring device
Load (electrical)	1. A device connected to the output of an electrical circuit, eg an electrical appliance. 2. The amount of electrical power required by connected electrical equipment.
Load control	A system or program that enables end-use customer loads to be changed in response to particular events such as periods of high electricity prices or problems on the electricity network.
Load reduction	A reduction in the amount of electrical power required by connected electrical equipment.
M-factor	An overarching price control implemented in Victoria by the Essential Services Commission that limits the annual increase in the average of all the electricity distributors' prescribed metering service charges. The M-factor provides a mechanism to adjust the revenue requirement where more (or fewer) interval meters have been rolled out by a distributor than forecast. The M-factor was implemented because the combination of price caps and an efficiency carryover mechanism may otherwise provide an incentive for distributors not to roll out interval meters as forecast.
MCE	Ministerial Council on Energy
MDMS	Meter Data Management System
MSATS	Market Settlement and Transfer Solution (a computer system that supports the settlement of the wholesale National Electricity Market according to the National Electricity Market Rules)
Mt CO2-e	Megatonnes of carbon dioxide equivalent
MW	Megawatt
MWh	Megawatt-hour
NEM	(Australian) National Electricity Market
NEMMCO	National Electricity Market Management Company
NGMC	National Grid Management Council (the former electricity industry organisation that developed the first design for the National Electricity Market in 1992)
NSP	(Electricity) network service provider

NUoS	Network use of system
PLC	Power line carrier (a type of technology for transmitting data across power lines)
Power (electrical)	Rate at which energy is released or consumed, expressed in watts.
PNNL	Pacific Northwest National Laboratory (an agency of the United States Department of Energy)
PSTN	Public switched telephone network
QCA	Queensland Competition Authority
Real time pricing	A form of time-varying pricing in which prices vary continuously during the day, directly reflecting the wholesale price of electricity, as opposed to tariff structures such as time of use or critical peak pricing that are largely based on preset prices. In an Australian context, real time pricing would link half-hourly prices for retail customers to the half-hourly changes in the cost of purchasing electricity from the National Electricity Market.
Ripple control	A type of system applied to electrical networks to control loads. A small coded audio frequency wave is superimposed on to the normal 240 volt 50 herz electricity supply and travels through the network along powerlines. Signals are sent very slowly to ensure reliable reception by ripple control receivers located anywhere on the electricity network. Receivers are typically located in customer switchboards or even in individual appliances. The receivers are linked to switches that enable switching of circuits or individual appliances according to the coding implemented by the program operator.
RTE	The French transmission network operator, Réseau de Transport d'Electricité
RTP	Real time pricing
SAC	System Availability Charge
SCO	Standing Committee of Officials of the Ministerial Council on Energy
Second tier customer	A customer who purchases electricity under contact from a second tier retailer.
Second tier retailer	A retailer that supplies electricity under contract to customers located in the service territory of a first tier retailer.
Smart meter	A meter that includes, in addition to an interval metering capability, one-way or two-way communications between the energy supplier and the meter.
SME	Small to medium enterprise

SMSWG	Smart Meter Stakeholder Working Group of the Ministerial Council on Energy
Super peak	Another name for critical peak
tCO2	Tonnes of carbon dioxide
TEC	Total Environment Centre Inc
Tempo tariff	A longstanding time of use and critical peak pricing tariff that has been implemented in France since the early 1990s.
Time of use pricing	A form of time-varying pricing in which tariff structures include two or more daily periods that reflect hours when the system load is higher (peak) or lower (off-peak), and charge a higher price during peak hours. A shoulder period or partial-peak price may also be included. TOU tariffs can also be implemented on a seasonal basis with prices that vary by seasons.
TOU	Time of use
UPWG	User Participation Working Group of the Ministerial Council on Energy
USD	United States dollar
W	Watt
WAN	Wide area network
Wi-Fi	The embedded technology of wireless local area networks.

APPENDIX

EXAMPLES OF LOW COST LOAD CONTROL TECHNOLOGY PRODUCTS

This Appendix identifies and reviews a number of low cost technology products that enable various load control functions and which could either be used with AMI systems or could provide load control functionalities without requiring an AMI system. However, this survey of products is not intended be a comprehensive. The products described here have been chosen to represent the broad range of existing applications for load control technology. There are many other similar products available on the world market.

The products are classified as follows:

- information display devices (see page 75);
- appliance and equipment controllers (see page 80); and
- integrated load control systems (see page 85).

A.1 INFORMATION DISPLAY DEVICES

Information display devices provide information to end-use customers about their electricity usage and costs, and may also provide information about other factors such as greenhouse gas emissions resulting from a customer's electricity usage.

The relevance of information display devices to load control is that access to increased information may induce customers to change their electricity usage in response to high prices in the electricity market; and/or problems on the electricity network.

A1.1 Power-Mate™

Developer and Manufacturer: Computer Control Instrumentation (CCI)

Country of Origin: Australia

Function: Information display

Communications: None

Type of Metering Required: None

Description: The Power-Mate™ (Figure A.1, page 76) provides various measurements for all types of equipment and appliances. The Power-Mate is plugged into a power point and then appliances and equipment can be plugged into the Power-Mate.

End-use customers can input electricity tariffs and greenhouse gas conversion factor and the Power-Mate then estimates and displays hourly, quarterly and yearly running costs and greenhouse gas emissions.

Figure A.1 Power-Mate™

The Power-Mate has several main menu modes: Instantaneous Volts, Current, Power, Energy, Cost, Greenhouse Gas and Elapsed Time. When in these main modes extra information is available from 3 other colour-coded buttons. Whilst in Volts, Current and Power modes, the maximum and minimum values can be displayed. When in the Cost, Energy and Greenhouse Gas modes, the hourly, quarterly and yearly amounts can be displayed.

The standard Power-Mate has a resolution down to 0.1W. For the more professional or industrial markets, the Power-Mate is available with a higher precision resolution down to 1/10000 Amp or 1/100 Watt. Units are supplied for either 10 Amp (2.4kW) or 15 Amp (3.6kW) applications. Internally all current and voltage conversions are to 24 bit precision, with digital filtering.

CCI are currently finalising the addition of a communication connector to the Power-Mate which will allow connection to a computer for direct analysis of usage / power / cost etc. CCI also intends to design a next generation unit which will essentially comprise an intelligent socket wired into a house / office environment, or a device similar to a timer unit that plugs into an existing wall socket. These units will communicate via the house wiring back to a local computer / data collection point, for further logging, analysis etc.

Deployment: Energy South Australia assisted CCI with the development of the Power-Mate prototype and purchased the first 230 production line units. These are being used by home energy auditors participating in the Energy Friends Program and the Energy Efficiency Program for Low Income Households.

Indicative Costs: CCI has provided the following information. Currently the Power-Mate is made in Australia in batch quantities of 250 and the retail price for one-off quantities is AUD 346 plus GST. The wholesale price for 100+ quantities is AUD 186 each for the 10 Amp unit. For larger quantities the approximate wholesale prices would be:

1,000 units AUD 120 each
4,000 units AUD 70 each
50,000 units AUD 58 each

Further Information: http://www.power-mate.com.au

A1.2 Cent-A-Meter™

Developer: Wireless Monitors Australia Pty Ltd

Manufacturer: Chinese manufacturer of electronic products

Distributor: Clipsal

Country of Origin: Australia

Function: Information display

Communications: One-way using low power radio within customer's premises

Type of Metering Required: None

Description: The Cent-A-Meter™ is an electronic device which measures electricity use and displays the cost per hour on a portable display located inside the home or small business. The information displayed includes: power consumption, cost per hour of electricity usage, corresponding greenhouse gas emissions, and indoor ambient temperature and humidity.

Figure A.2 Components of the Cent-A-Meter™

The Cent-A-Meter comprises a sensor, wireless transmitter and receiver (Figure A.2, page 77). The sensor is a clip-on current transformer that samples the electric current on each active phase wire inside the switchboard. These readings are aggregated and relayed by the 433 MHz wireless transmitter to the remote receiver/monitor.

End-use customers can input specific country currency, voltage, electricity tariff rate, greenhouse gas conversion factor and peak load alarm value. The receiver computes the approximate power use, energy cost and greenhouse gas emissions and displays the results on a large portable LCD screen.

The alarm feature included in the unit can be set to a pre-determined level and when exceeded during peak periods can act as a signal to induce a voluntary load reduction, when supported by appropriately targeted educational campaigns.

The Cent-A-Meter is not an accumulation revenue meter and cannot be used to check electricity bills. However, it may be used to monitor individual circuits of metered premises to estimate their share of electricity use.

Deployment: The Cent-A-Meter is recommended by electricity utilities and environmental organisations in Australia, Canada, New Zealand, USA and UK.

Indicative Costs: The retail price of the Cent-a-Meter is about AUD 150 plus an installation cost of about AUD 75, making a total electrician installed cost of about AUD 225. Lower prices are available for bulk purchase for installation programs involving large numbers of subsidised Cent-a-Meters.

Further Information: http://www.centameter.com.au

A1.3 ecoMeter Home Energy Monitor

Developer and Manufacturer: Amy Email Metering

Country of Origin: Australia

Function: Information display

Communications: One-way

Type of Metering Required: Interval

Description: The ecoMeter Home Energy Monitor is an information display unit that communicates with an interval electricity meter in the end-use customer's home or premises through power line carrier technology.

The ecoMeter (Figure A.3, page 79) plugs into any power socket and is about the size of a regular wall phone. The main component of the ecoMeter is an LED alphanumeric display which provides customers with specific information about the amount of electricity they are using, and how much it is costing. This information is obtained from the electricity meter to which the ecoMeter is connected. The ecoMeter also includes green, amber, and red LED lights which show customers whether they are using electricity at low, medium, or high prices, corresponding to off peak/shoulder, peak and critical peak tariffs. A beeping sounds alerts customers to the start of a critical peak period.

Figure A.3 Ampy Email ecoMeter Home Energy Monitor

Ampy Email also offers the EM1200 series of interval electricity meters (Figure A.4) that can be connected to the ecoMeter. These meters incorporate up to two relays and a ripple controller to provide the capability to remotely switch appliances and equipment.

Figure A.4 Ampy Email EM1200 Interval Meter

Deployment: An early version of the ecoMeter was used in critical peak pricing trials carried out in Queanbeyan by Country Energy during 2005 and 2006.

Indicative Costs: Ampy Email Metering provided the following prices.

ecoMeter: AUD 550 to AUD 750 per metering point

EM1200 series meter: AUD 450 to AUD 650 per metering point

Further Information: Brendan King <brendan.king@ampymetering.com.au>

A2. APPLIANCE AND EQUIPMENT CONTROLLERS

Appliance and equipment controllers enable remote switching of the appliances and equipment to which they are connected. There are several different types of controllers, including simple on-off switches, programmable thermostats, and sophisticated programmable demand controllers.

In load control programs, appliances and equipment may be remotely cycled, turned down or switched off by a signal sent by the program operator to large numbers of controllers. The signal may be sent manually by the program operator or automatically in response to trigger events such as exceedances of pre-set electricity price levels or pre-set load levels on particular network elements, or excursions outside pre-set frequency or voltage parameters.

A2.1 Grid Friendly™ Appliance Controller

Developer: Pacific Northwest National Laboratory (PNNL), United States Department of Energy

Manufacturer: None at this stage

Country of Origin: United States

Function: Automated switching of appliances in response to system frequency variations

Communications: None required

Type of Metering Required: None

Description: The Grid Friendly™ appliance controller (Figure A.5, page 81) is a five by six centimetre circuit board which contains a simple computer chip that can sense frequency disturbances on an electricity network and can turn an appliance off for a few minutes to allow the network to stabilize during a crisis.

Grid Friendly controllers can be installed in appliances that regularly cycle on and off during normal use, so that end-use customers will not notice when the Grid Friendly device is in operation. Customers actually become an integral part of electricity network operations.

Figure A.5 Grid Friendly™ Appliance Controller

Grid Friendly appliances can replace spinning reserve by providing automatic demand response to rebalance demand to match available supply almost instantaneously (within a half-second) when a crisis occurs. This is an improvement over the approximately 30 seconds it currently takes for power plants kept on standby to come up to speed. Grid-Friendly™ controllers can also be programmed to delay restart instead of all coming on at once after a power outage.

The present version of the Grid Friendly controller is configured to rapidly create an alert signal when the frequency of the network's voltage signal exceeds a user-defined threshold. Because Grid Friendly appliances assess the stability of the network using only the voltage available within the appliance, there is no need for costly communications to a regional control centre.

Deployment: The Grid Friendly controller has been tested in a laboratory environment and several field trials and is ready for licensing and installation in the next generation of appliances. PNNL is currently working with appliance manufacturers and utilities to use Grid Friendly Appliances in a variety of test-bed and demonstration projects.

Indicative Costs: The prototype Grid Friendly™ board cost about USD 44 (AUD 58) to build in very limited quantities for a regional field demonstration. However, this is not a commercial price. Through research, the cost of the board will be greatly reduced and new functions will be added to the device. PNNL expects that eventually manufacturers will be able to add Grid Friendly™ functionality to appliances for USD 1 to USD 2 (AUD 1.30 to AUD 2.60) per unit in large manufacturing quantities.

Further Information: http://gridwise.pnl.gov/technologies/transactive_controls.stm
http://gridwise.pnl.gov/docs/pnnlsa36565.pdf

A2.2 SWITCHit™ Appliance Controller

Developer and Supplier: Enermet

Country of Origin: Australia

Functions: Remote switching of appliances

Communications: One-way, using ripple control

Type of Metering Required: None

Description: The SWITCHit™ appliance controller (Figure A.6) is a pre-programmed ripple control receiver and switching device intended for use primarily within the residential sector to control home appliances and other devices. The SWITCHit can also be used in the commercial and industrial sectors with appliances or equipment that plug into a standard 240 volt 10 amp power point.

Figure A.6 Enermet SWITCHit™ Appliance Controller

The SWITCHit is plugged into any power point and an appliance or other device is plugged into the SWITCHit. The appliance can then be remotely switched by ripple control signals sent through power lines by the load control program operator.

The SWITCHit can be pre-programmed to suit several different types of appliances. So far, two versions of the SWITCHit have been developed: one for pool pumps and the other for appliances and air-conditioners. Both versions have a rotary switch on the back that is used to select the particular ripple control coding that the SWITCHit will respond to and hence the type of device that is to be controlled.

For pool pumps, the slot of the switch is turned to match the size of pool - 'Small Pool', 'Medium Pool' or 'Large Pool'. For air-conditioners, the slot of the switch is turned to 'A/C Cycle'. For other appliances, the slot of the switch is turned to 'Appliance Cycle'. Peak period control is available in both versions of the SWITCHit by turning the slot of the switch to 'Peak Period Off'.

Figure A.7 Enermet ROA Ripple Control Receiver

Enermet also offers the ROA hard-wired ripple control receiver (Figure A.7) that can be combined with a switching device to control three-phase appliances and equipment such as larger air conditioners.

Deployment: At present, Energex is using the SWITCHit appliance controller in residential sector load control trials in Brisbane.

Indicative Costs: Enermet provided the following prices.

SWITCHit individual unit price: AUD 50 each.
SWITCHit mass rollout price: AUD 26 each.
ROA receiver individual unit price: AUD 60 each.
Three phase switching device for ROA receiver:
AUD 20 to AUD 80 each.

In addition, a ‘greenfields’ load control program using the SWITCHit and/or the ROA receiver would incur additional costs in establishing the ripple control infrastructure. However, electricity distributors in NSW, Queensland and South Australia already have this infrastructure in place for controlling off-peak water heaters.

Further Information: Garry Burke <garry.burke@enermet.com.au>

A2.3 Hunt Load Control Switch

Manufacturer: Hunt Technologies

Distributor: Ampy Email Metering

Country of Origin: United States

Functions: Remote switching of appliances

Communications: Two-way, using power line carrier

Type of Metering Required: None

Description: The Hunt Load Control Switch (Figure A.8) provides stand alone power line carrier-based remote switching of installed appliances including heat pumps, air conditioners and other significant loads in the home or business.

Figure A.8 Hunt Load Control Switch

Hunt Technologies' bi-directional power line carrier technology provides remote switching of appliances and equipment plus validation that the load control commands have occurred. Each relay accommodates trigger or cycle-based schedules, which may be defined for weekdays, Saturdays and Sundays. Two schedule sets may be stored for each relay.

Deployment: The Hunt Load Control Switch has been used extensively in demand response programs in the United States.

Indicative Costs: Ampy Email Metering provided the following prices.

Hunt Load Control Switch: AUD150 to AUD 250 per metering point.

In addition, a 'greenfields' load control program using the Hunt Load Control Switch would incur additional costs in establishing the power line carrier infrastructure.

Further Information: Brendan King <brendan.king@ampymetering.com.au>

A3. INTEGRATED LOAD CONTROL SYSTEMS

Integrated load control systems combine appliance and equipment controllers with two-way communications technology to enable remote-switching of appliances and transmission of data from the controlled loads to the program operator. These systems provide flexible management solutions for complex load control programs.

A3.1 ComfortChoice^{SM} Demand Management Solution

Manufacturer: Carrier

Country of Origin: United States

Function: Controlling and remote switching of air conditioners

Communications: Two-way, using radio and the internet

Type of Metering Required: None

Description: The ComfortChoice^{SM} Demand Management Solution comprises control and communications technology that enables load control of air conditioners in homes and small commercial premises.

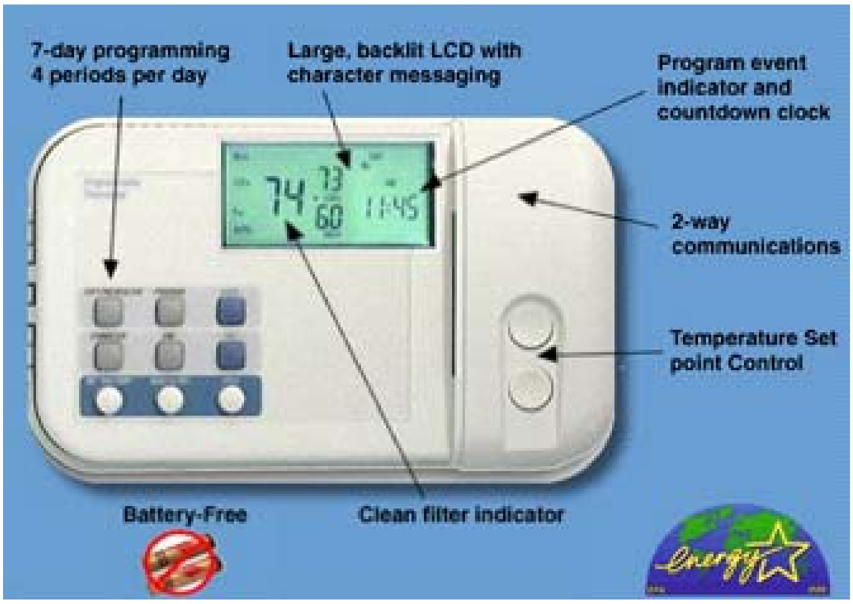

Figure A.9 Carrier EMi Thermostat

At the heart of the system is Carrier's 7-day programmable digital thermostat, EMi (short for Energy Management Interface). EMi thermostats (Figure A.9) are used to control the operation of air conditioners at end-use customers' homes or premises. The thermostats have internet functionality and two-way wireless paging.

The EMi thermostat operates as a standard programmable thermostat, but also features remote access through an I/O board installed in the home/business that communicates with the thermostat and transmits and receives radio signals through a commercial pager communication network. The paging system communicates the system status and transfers data (including temperature set-point, ambient temperature, and hourly runtimes for air conditioner compressors) between the EMi thermostat and the load control program operator.

EMi thermostats and the corresponding control system are capable of performing either:

- **cycling control**, whereby a fixed allowable maximum on-cycle (typically 50%) is maintained per hour or half hour, or
- **temperature control**, whereby the set-point of the thermostat can be remotely adjusted by a specific number of degrees.

Carrier provides the ComfortChoice Manager software, which is a internet-based application designed for use by program operators in performing load control of air conditioners by remote programming of EMi thermostats. During load control events, the program operator can access the ComfortChoice system using any standard web browser. The program operator logs in to a designated URL to access ComfortChoice's load control initiation web page. The ComfortChoice system will then use two-way wireless paging communication to adjust the EMi thermostat set-points. While a load control event is in progress, the program operator can monitor the amount of estimated load reduction in real time.

The two-way system provides real time verification, tamper detection, run-time data, remote diagnostic capability and overall higher utility and customer satisfaction. In contrast to one-way systems. the program operator will always know exactly how many air conditioners in customers' homes and premises can be deployed for demand reduction, without resorting to costly field surveys.

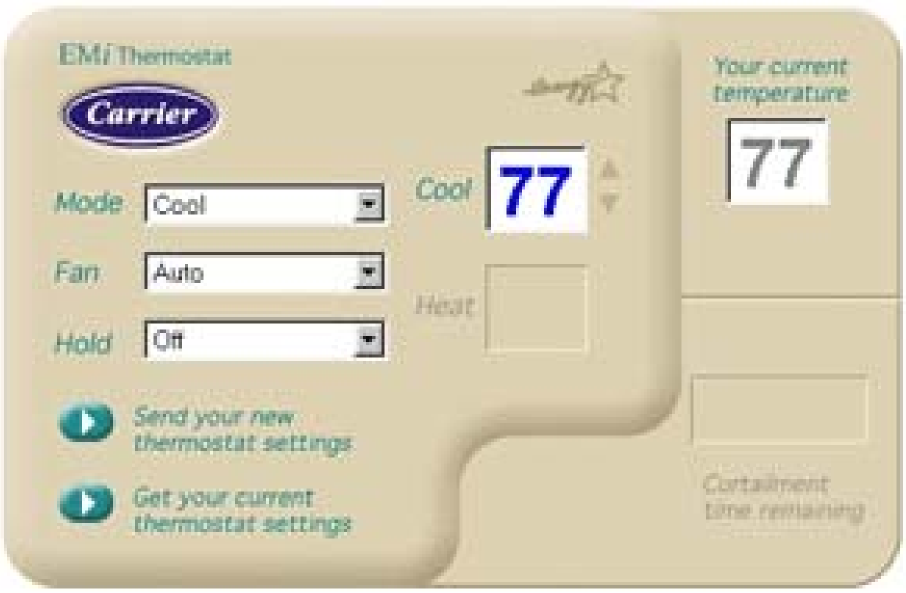

Figure A.10 Web-based User Interface for the Carrier EMi Thermostat

End-use customers can program their EMi thermostats directly using controls on the thermostat itself to specify different temperature set-points to compensate for times when homes or premises will be unoccupied or unused. The thermostat also includes web-based control software (Figure A.10, page 86), which allows customers to remotely view or change thermostat settings using any standard web browser. Customers retain control of their thermostats and can override set-point changes made by the load control program operator at any time, either locally at the thermostat or remotely via the web.

When a customer overrides the set-point changes, this will be logged into a database for future usage by the program operator. These override records can be used to make real time adjustments to the estimated load reduction of the load control event in progress. This allows program operators to extend or expand load control events to achieve the desired load reduction. Program operators can also designate load control events to be non-overrideable, in which case customers will not be able to override the new set-point setting.

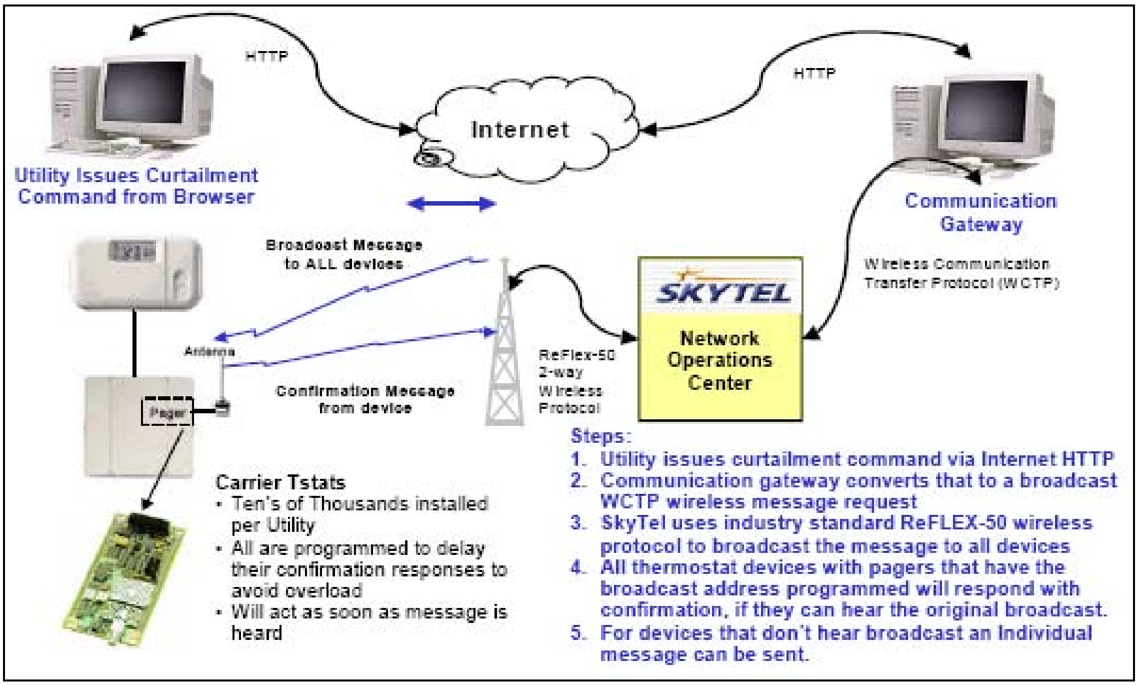

Figure A.11 Broadcast Message Flow in the ComfortChoice System

Figure A.11 represents the overall ComfortChoice system configuration showing message flows to and from the EMi thermostats. When a load control event is initiated, a software program causes a broadcast pager signal to be transmitted to a receiver (I/O board with paging module) located at each participating customer's home or premises. The pager signal triggers a shift of the thermostats' set-points, or initiates cycling action, which results in load reductions. A pager signal is sent back from each unit indicating that the instruction was received. The system also reports the operating times of the air conditioners' compressors, and whether the customer overrode the program operator's signal.

Deployment: The ComfortChoice system has been used in demand response programs and trials by several utilities in the United States since 2001.

Full deployments of the ComfortChoice system include:

- Long Island Power Authority – 24,000 residential, 4,400 small business
- ConEdison – New York City – 14,000 residential, expanding to 12,000 small Business
- Southern California Edison – 9,000 small business
- San Diego Gas & Electric – 5,000 residential

Ongoing pilot programs with the ComfortChoice system include:

- Public Services Gas & Electric – New Jersey – 120 residential, 140 small business
- Colorado Springs – 500 residential
- Nevada Power – 600 residential
- City of Anaheim, California – 100 small business

Indicative Costs: Carrier has provided the following indicative costs for ComfortChoice system purchased in the United States.

Estimated Pricing 1,000 Units

Description	Qty	Unit of Measure	Pricing
ComfortChoice EMi programmable thermostats with communications and control capabilities	1,000	Units	USD 226 (AUD 297)
ComfortChoice Manager software license and hosting	1	Monthly fee	USD 3000 (AUD 3938)
SkyTel paging network monthly communication fee	1	Per unit per month	USD1.50 (AUD 1.97)

Estimated Pricing 50,000 Units

Description	Qty	Unit of Measure	Pricing
ComfortChoice EMi programmable thermostats with communications and control capabilities	50,000	Units	USD 195 (AUD 256)
ComfortChoice Manager software license and hosting	1	Monthly fee	USD 6,000 (AUD 7876)
SkyTel paging network monthly communication fee	1	Per unit per month	USD 1.15 (AUD 1.51)

Note: The current Carrier ComfortChoice product works only with the SkyTel network which is only available in the United States. An alternate solution using either broadband internet or mobile phone communications would need to be developed for the Australian market. The pricing for such an alternative is unknown at present.

Further Information: http://www.comfortchoice.carrier.com

Raymond Archacki <raymond.archacki@carrier.com>

A3.2 LeKey Energy Management System

Manufacturer: ELink AS

Country of Origin: Norway

Functions: Real time monitoring and measurement of energy consumption; remote switching of appliances and equipment

Communications: Two-way, using radio and the internet

Type of Metering Required: Interval

Description: The LeKey Energy Management System comprises the LeKey energy management software and the LeKeyBox appliance controller.

The LeKey internet-based energy management software carries out real time monitoring, measurement, data capture and display of energy consumption information. Because the LeKey system is developed using real time two-way communication, a load control program operator can at any time use the internet to access information about the status of each individual controlled load. This allows the program operator to control all loads effectively based on price information and network capacity. The operator can enter contractual information like mandates, triggers, predefined load groups, load attributes, etc into the LeKey software. This information can then be used to automatically send load control initiation signals and/or to send warning messages to customer sites.

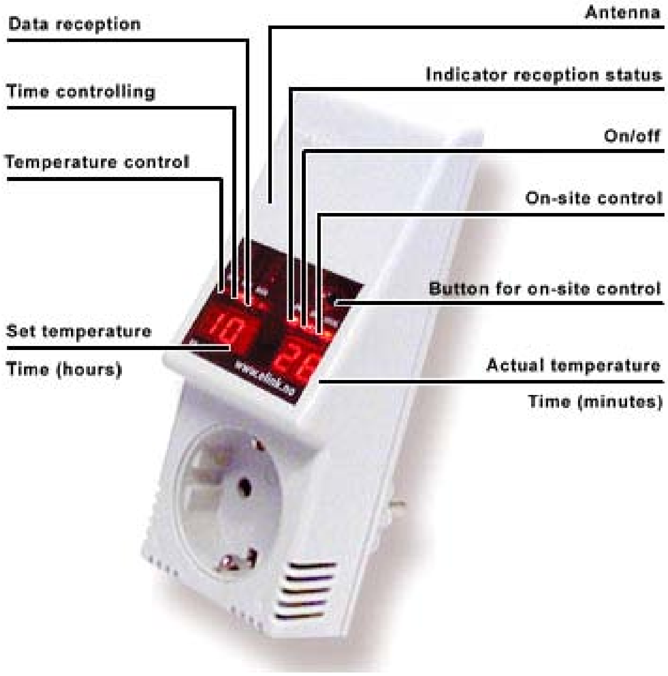

Figure A.12 LeKeyBox Appliance Controller

The LeKeyBox (Figure A.12) is a plug-in appliance controller with radio and internet communication which also includes a timer and a thermostat. A load control program operator can send a radio signal to remotely switch appliances and equipment plugged into multiple LeKeyBoxes. The program operator can also remotely change the settings of the thermostats included in LeKeyBoxes.

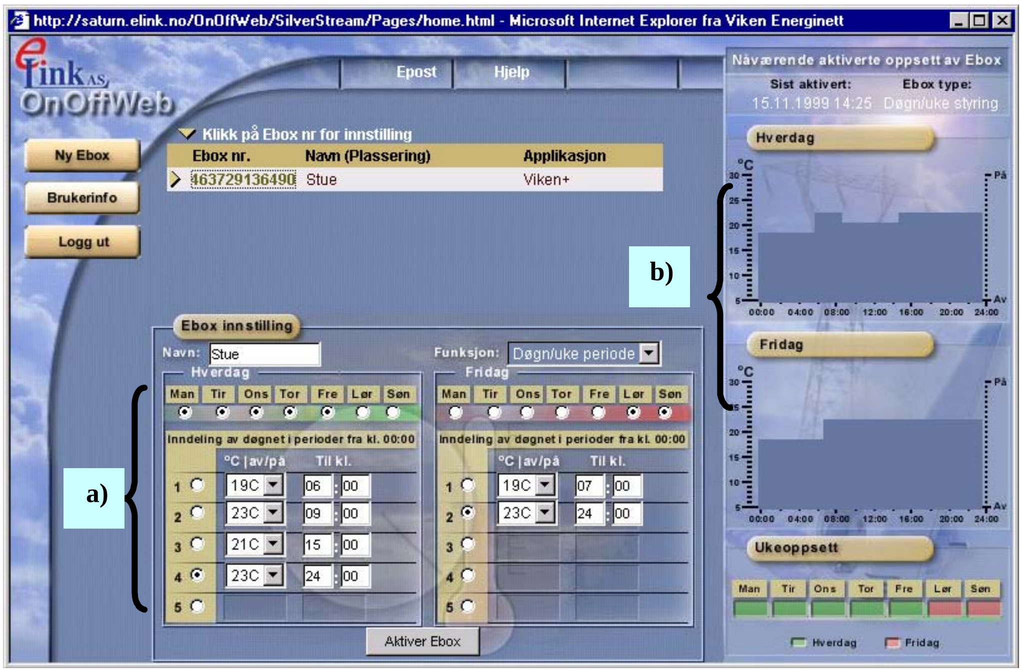

Figure A.13 Web-based User Interface for the LeKeyBox

Individual end-use customers can use a personal webpage (Figure A.13) to program the settings of LeKeyBox units located in their homes or premises; changes to the settings are transmitted to the units over the radio network. Customers can also change settings locally by using buttons on the LeKeyBox itself.

Deployment: LeKeyBoxes were one of the load control technologies used in a large scale trial in 10,000 homes in Norway during 2004 and 2005.

Indicative Costs: No cost information is currently available.

Further Information: www.elink.no/index.php?page=2-1

A3.3 SD Electricity Manager

Developer and Manufacturer: ShreeDutt Technologies Pvt Ltd

Country of Origin: India

Function: Real time monitoring and measurement of energy consumption; remote switching of appliances and equipment

Communications: Two-way using the internet, mobile phone technology and wireless mesh networking

Type of Metering Required: Interval meters with advanced metering infrastructure

Description: The SD Electricity Manager is a wireless mesh networking-based energy management solution than can be used in the residential, commercial and industrial sectors.

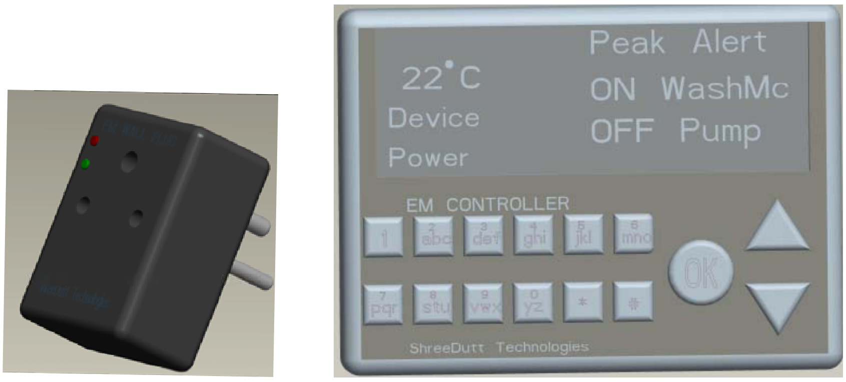

Figure A.14 Components of the SD Electricity Manager

The components of the SD Electricity Manager (Figure A.14) are:

- the **EM Wall Plug Module** – a plug-in unit that can be used with any electrical appliance or equipment; and
- the **EM Controller –** a controlling device that doubles up as thermostat.

The **EM Wall Plug Module** is designed to control and monitor the energy usage of an appliance or piece of equipment that is plugged into it. The module contains a remotely-addressable switch that provides On, Off and Variable Load functions. The module also calculates the actual electricity consumed by the appliance or equipment and meets the specification requirements for Class 1 AC Watt-hour meters.

The **EM Controller** is a wall-mounted unit capable of managing multiple EM Wall Plug Modules. The Controller provides start-up and coordination functions for the wireless mesh network and can also double up as thermostat. It is also connected to the electricity meter in the customer's home or premises using a standard metering interface. The load control program operator can send signals to the EM Controller through the electricity meter or through the internet.

The SD Electricity Manager communications network is shown in Figure A.15 (page 92). The EM Controller receives signals from the load control program operator:

- through the internet using the Electricity Manager software running on a personal computer; or
- through advanced metering communications using mobile phone technology (GPRS or CDMA).

The Controller then sends control commands to the EM Wall Plug Modules in the customer's home or premises through wireless mesh networking based on the ZigBee standard. The wireless mesh networking system adds reliability in data transmission without the need for direct point-to-point communication.

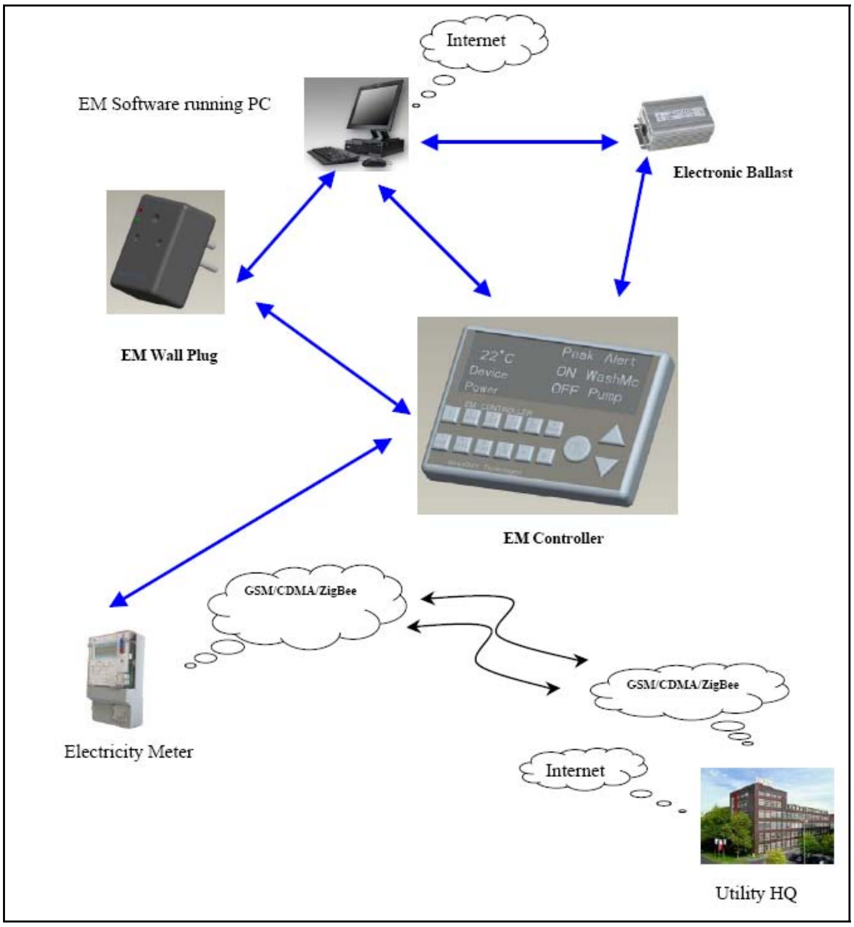

Figure A.15 SD Electricity Manager Communications Network

Deployment: Not yet deployed in large number.

Indicative Costs: ShreeDutt Technologies has provided the following prices for a pack comprising one EM Wall Plug and one EM Controller:

10,000 packs below USD 140 (AUD 186)

50,000 packs below USD 100 (AUD 139)

Further Information: www.shreedutttech.com
Tejus Karnik <mailto:tejuskarnik@shreedutttech.com>

A3.4 Rippleband Load Control System

Developer: Phase 6

Manufacturer: Tytronics (a division of the Tyree Group)

Country of Origin: Australia

Function: Real time monitoring and measurement of energy consumption; remote switching of appliances and equipment

Communications: Two-way, using Rippleband (an advanced form of ripple control)

Type of Metering Required: Can use data from both accumulation and interval meters

Description: The Rippleband Load Control System comprises a local network load control and communications technology, designed specifically to deliver strong and reliable signals over any distance within the natural envelope of existing low-voltage powerlines.

Rippleband is an advanced form of ripple control that can deliver two-way communications, in contrast to the one-way communication delivered by standard ripple control systems. Rippleband operates 800 times faster than standard ripple control and has a symmetric path design, which means that signals go forward and back at the same rate. Rippleband travels any distance on the low-voltage network and does not require repeaters.

Figure A.16 Rippleband Neighbourhood Node, Load Agent and Meter Interfaces

The Rippleband Load Control System comprises a range of products (Figure A.16), including:

- for appliance control:
  - ♦ **Rippleband Load Agent –** a hard-wired programmable load control switch;
  - ♦ **Rippleband Plug-in Relay –** a plug-in programmable load control switch;
- for meter communications:
  - ♦ **Rippleband Meter Interface –** modems for meter data communications and load control;
  - ♦ **Meter Mouse** – an optical sensor that provides pulsed output from legacy electro-mechanical accumulation meters;

- communications gateway:
  - **Rippleband Neighbourhood Node** – an intelligent data concentrator with load control that can link to any WAN or meter format, and is also compatible with existing one-way power line carrier systems;
- control software:
  - **Demandor Utility Information System** (developed by OpenEnergy Pty Ltd) – load management software that can be used to deliver one- or two-way load control through Rippleband Load Agents. Demandor monitors electricity market prices or network loads and sends notifications when prices or loads satisfy given rules (eg go outside a certain range). Notifications can be sent via any WAN to Rippleband Load Agents commanding them to turn electrical appliances and equipment off or on.

Rippleband products are all designed to meet the needs of an advanced meter infrastructure (AMI) using powerlines as the carrier, and are compatible with the OpenAMI formats developed in the United States. Rippleband products are engineered for two-way load control, irrespective of whether only a one-way application is required.

All Rippleband products are intelligent and individually addressable up to IPV6 protocols, enabling addressing down to appliance level. Rippleband products are remotely programmable to implement changes in pricing, cycling and other variables as they occur.

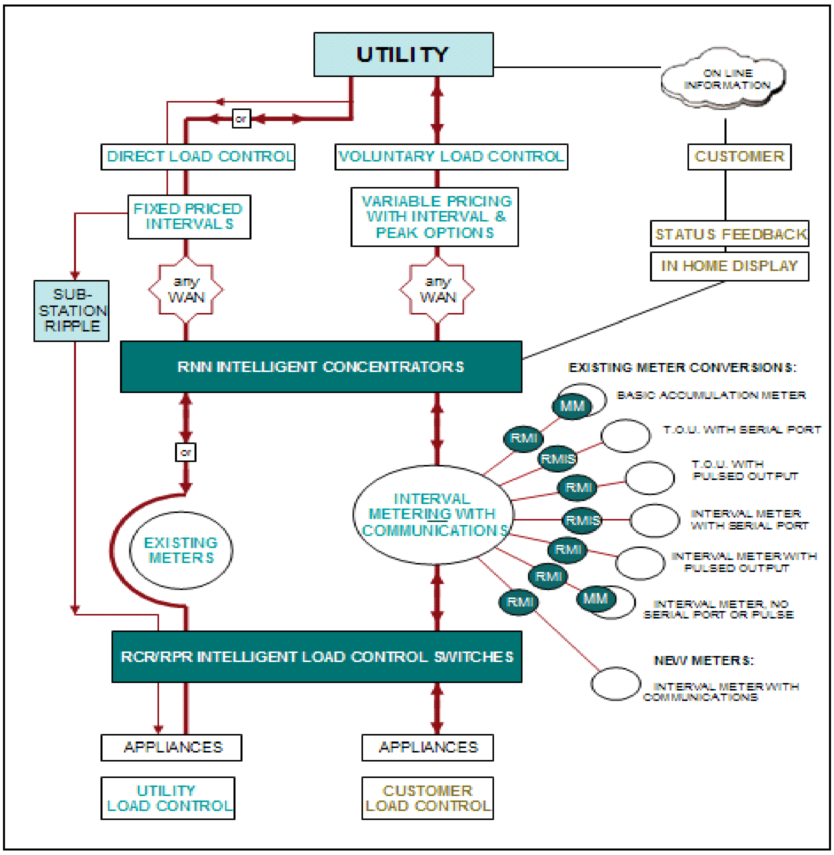

Figure A.17 Communications Network for the Rippleband Load Control System

Figure A.17 (page 94) shows the communications network for the Rippleband Load Control System which can operate one-way or two-way and can also use existing standard ripple control and any WAN format. The network can provide direct load control without requiring connection to electricity meters, and also enable a move to full AMI and variable pricing, without any system redundancy.

Deployment: Rippleband products are currently being used by a major Australian electricity distributor in large-scale demand response trials.

Indicative Costs: Phase 6 have provided the following indicative prices.

Quantity:	1,000	5,000	50,000
Rippleband Cycle Relay	AUD 78	AUD 65	AUD 53
Rippleband Plug-in Relay		AUD 53	AUD 44
Meter Mouse	AUD 56	AUD 42	AUD 29
Rippleband Meter Interface	AUD 85	AUD 62	AUD 49
Quantity:	**100**	**1,000**	**5,000**
Rippleband Neighbourhood Nodes	AUD 334	AUD 290	AUD 215

In addition, a 'greenfields' load control program using Rippleband products would incur additional costs in establishing the ripple control infrastructure. However, electricity distributors in NSW, Queensland and South Australia already have this infrastructure in place for controlling off-peak water heaters.

Further Information: Paul Wiszniak <pwiszniak@tytronics.com.au>
Christopher Bean <chris@phase6.com.au>
Ewan Parsons: <ewan@phase6.com.au>

A3.5 GridAgent Distributed Energy Management and Control System

Developer: CSIRO Energy Transformed Flagship

Manufacturer: None at present

Country of Origin: Australia

Function: Automated control of appliances

Communications: Two way, will work with any modern communications technology, from wireless to broadband over powerlines

Type of Metering Required: None required

Description: CSIRO's Energy Transformed Flagship is working on developing a distributed intelligence platform to aggregate and control on-site energy assets in a way that suits electricity retailers and distributors but also allows end-use customers to control and choose how their electricity supply is handled.

The platform and its capabilities are based on "intelligent agent" technology, particularly the installation of software to create an intelligent device situated in customers' homes or premises. Software agents sense, compute, switch, and communicate with each other across the premises to automatically switch loads and on-site generators according to an energy savings policy decided by, and optimised for, each customer.

An agent monitors the energy consumption of each appliance or piece of equipment in the premises and communicates to the rest of the agent system its capability to turn on or off and/or shed load. All these responses are aggregated into a system-wide response. As system needs change, new price signals or other cost functions can be communicated to the local agents, and depending on the customer preferences that steer these agents, they can choose how they will contribute to the overall response.

The actual control of appliances and equipment requires additional hardware into which the software intelligence can be installed. CSIRO uses a variety of hardware technologies in deploying the GridAgents system.

- **Wireless sensor network technology** is used to sense and communicate local environmental data (such as temperature, humidity, and room occupancy) back to agents. CSIRO's own wireless sensor devices, called *Flecks*, are able to form a robust radio communications environment amongst themselves, avoiding the need for expensive cable runs and other installation overheads.
- **Embedded computing devices** are used to deploy the actual agents that interface to electrical loads and generators. CSIRO uses a variety of computing devices, from consumer-PDA based devices, to embedded industrial controllers, in deploying the GridAgents system, where the particular device chosen is matched to the application environment. Considerations here include physical appearance, the need for a screen for local user interaction, and robustness in harsh environments. Overriding these is consideration of the cost of the hardware; CSIRO contends that for a distributed agent-based control system to enjoy widescale uptake, the hardware used must be as cheap as possible.
- **Interfacing hardware** is used to interface the distributed agents to the actual loads and generators they control. The GridAgents generally use relatively simple interfaces to the local load or generator ("on/off", "up/down", etc), leaving detailed plant operational considerations to the local device. Physical interfaces include wired serial communications, wireless Bluetooth based communications, and industry-standard communications protocols.

The software agents are managed through a web-based management console (Figure A.18, page 97). This enables the customer to "drill-down" to a particular agent and see exactly what it, and the unit it is controlling, is doing at a particular time. The console includes a Business Rule Editor, which allows the customer to create business rules for the system of agents, such as "Enable HVAC during the hours 9.00 am to

6.00 pm". A Utility Rate Editor enables the creation of complex tariff structures representing the actual tariff that applies to the customer. The business rules and tariff structures are inputs to the agent system and constrain how the agents can control appliances and equipment in the customers' homes or premises.

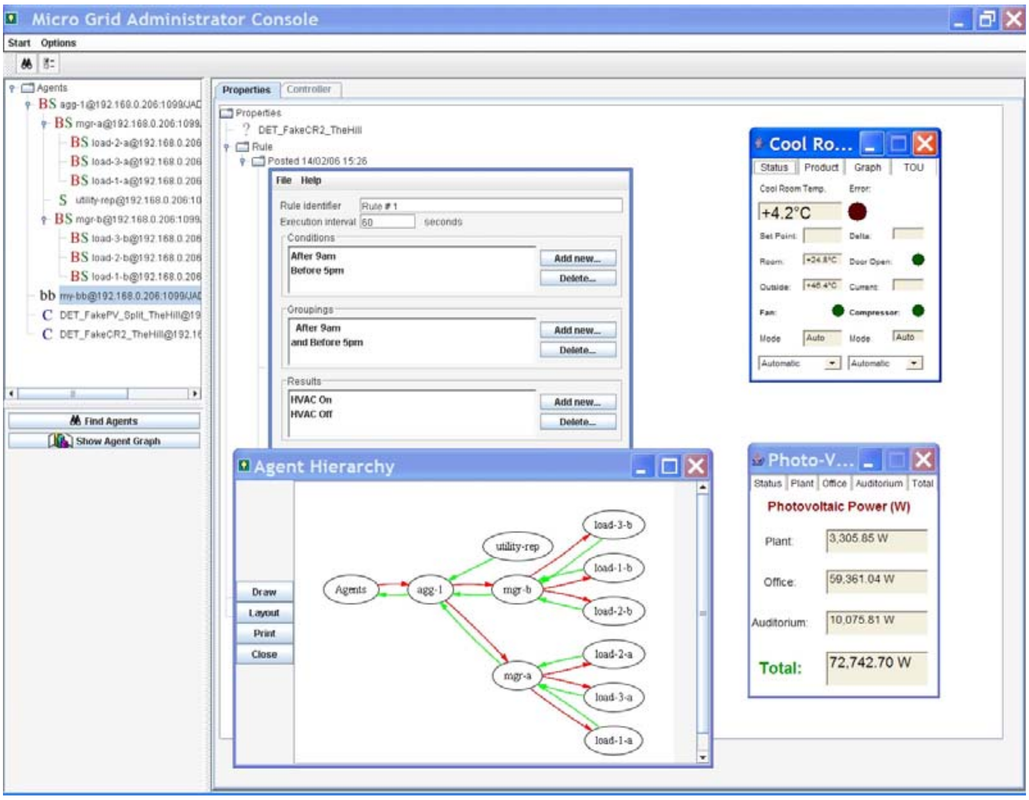

Figure A.18 Web-based Management Console for the CSIRO GridAgents

The system includes very intelligent algorithms that enable aggregation of thousands of disparate loads and generators across the whole electricity distribution network into one aggregated response, with system wide benefits, whilst still considering the local constraints of those loads and generators. The aim is to provide a firm demand response, whilst still incorporating user preferences.

System-wide benefits include:

- the ability to aggregate supply and demand from groups of customers to flatten out peak demand; and
- the formation of intelligent islands or mini-grids that can survive supply disconnections and that continue to provide services during contingencies on the main network.

Deployment: Working with US-based software developer Infotility, CSIRO has completed the first release of the GridAgents software framework. CSIRO is building a demonstration system at the CSIRO Energy Centre in Newcastle (Figure A.19, page 98), putting a gas micro-turbine, photovoltaic arrays, and a wind generator under agent control, along with two cool rooms and a zone of a building climate system. This will form a mini-grid coordinating supply and demand and reacting intelligently to electricity market or retail contract price signals. CSIRO has also trialled the system with a major Australian electricity business, and is looking for partners to work together on a large-scale trial of this technology.

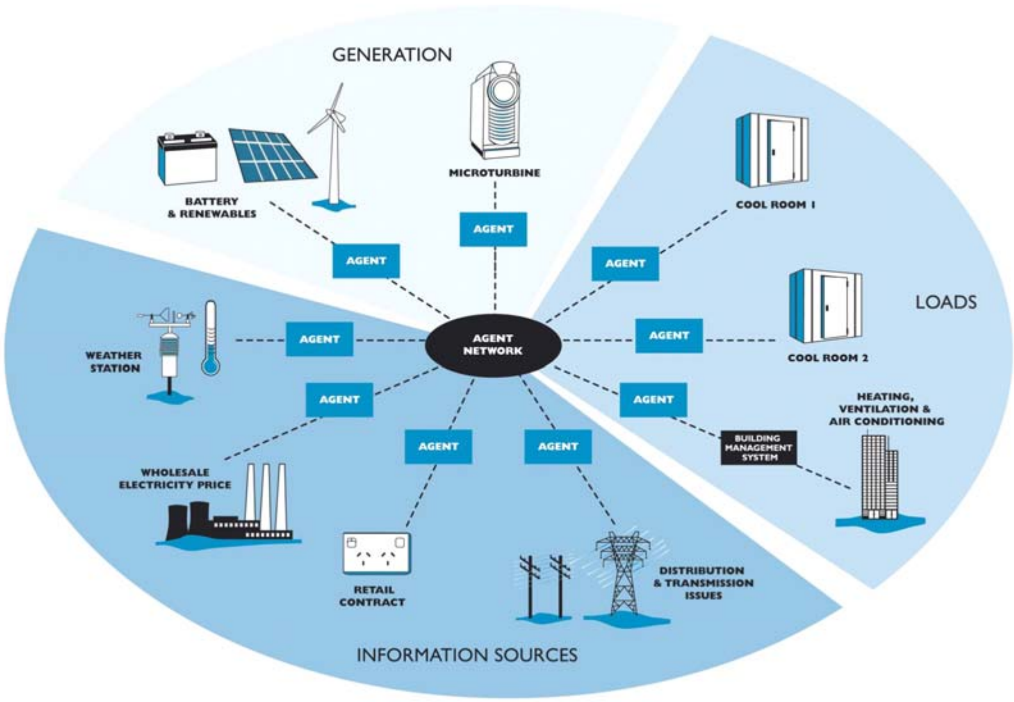

Figure A.19 Demonstration GridAgent System at the CSIRO Energy Centre

Indicative Costs: Because the Distributed Energy Management and Control System is currently still at the R&D stage, no cost information is currently available.

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