The Role of Demand Response in Electricity Market Reform

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Presentation Topics

- What is demand response?
- Why demand response?
- How does demand response work? – examples of DR programs
- Enabling technologies for demand response
- Benefits of demand response
- Barriers to demand response
- Opportunities for demand response in Australia
- Information resources
What is Demand Response?
What is Demand Response?

- Demand response is a particular type of demand management measure.
- Demand response refers to actions taken by end-use customers to reduce their demand for electricity in response to:
  - problems on the electricity network; and/or
  - high prices in the electricity market.
Focus of Demand Response

● Demand response focusses on when and where electricity is used and how much it costs:
  ► when – short term (minutes or hours) when network problems occur or prices are high
  ► where – at locations where load reductions can relieve network constraints
  ► how much – high electricity prices relative to the average price
Demand Response ≠ Energy Efficiency

Energy efficiency programs treat all energy usage equally and are not concerned with when and where energy is used and how much it costs.
Origins of Demand Response

- Demand response is the successor to generations of load management programs in Australia, Asia, Europe and North America, eg:
  - utility direct load control of customer equipment and appliances (water heaters, air conditioners, pumps and some industrial equipment)
  - interruptible and curtailable tariffs for commercial and industrial customers
Why Demand Response?
Why Demand Response? (1)

Sydney West Bulk Supply Point Load Profile

- 30 Jan 2003 (44°C Max)
- 15 Jan 2003 (29°C Max)
Why Demand Response? (2)

Predominantly Residential Load Profile

The power is in your hands
Why Demand Response? (3)

Revealed: the suburbs facing blackouts

Kirsty Naadham
Consumer writer

The decrepit condition of Sydney’s electricity networks, built more than 30 years ago and facing an upgrade bill of almost $2 billion, is putting suburbs at risk of power failure.

A map showing suburbs that will not have the substation capacity to deal with summer peaks in electricity demand within five years was presented to a conference last week by the State Government’s Sustainable Energy Development Authority (SEDA).

Hot spots forecast to have a shortage of capacity include Castle Hill, Parramatta, the Penrith area, Liverpool, Chatswood, Mona Vale, Hurstville and Caringbah.

Castle Hill, where Integral Energy says its network will be unable to cope with peaks by 2006, faces energy cuts sooner. The authority has been contracted to manage demand for power in the suburb so that Integral can defer spending $3.2 million on upgrades.

In the Castle Hill trial, businesses would be encouraged to moderate electricity use, an Integral spokesman said.

The Castle Towers shopping centre, which causes one-third of the load, will be targeted. But SEDA wants the trial extended to households.

In a separate trial, the North Ryde RSL will tomorrow switch on generator power, under a system where Energy Australia can remotely take the club off the net and put it onto the Continued Page 4.
Why Demand Response? (4)

Hours per year peak price > $1,000/MWh

Source: NEMMCO
How Does Demand Response Work?
Basics of DR Programs

● Demand response programs require end-use customers to reduce their electricity use at particular times

● Customers usually pay lower electricity tariffs in return for participating in a demand response program

● Customers may also receive payments for the availability of demand response and the load reductions actually achieved
The GoodCents® Select demand response program, developed by the GoodCents® company, has been implemented by Gulf Power in Florida.

The Florida GoodCents® program comprises four interdependent components:

- An in-home, customer-programmed, automated energy management system
- A communication gateway which rapidly communicates price changes, critical peak conditions, and other messages to program participants
- A time-varying design for electricity prices with a near real-time pricing component
- A means of recording and retrieving the requisite billing data
GoodCents® Select DR Program (2)

Three of the Major Components

SuperStat

Communications Gateway

RSVP Rate
In the Gulf Power GoodCents® Select program, customers’ appliances are switched directly from the Gulf Power control room, using a signal sent through the communications gateway.

Customers use the SuperStat control unit to set which appliances are switched and the price level at which switching will occur.

This automated “set and forget” program provides a much more reliable demand response than programs where customers have to switch appliances themselves every time there is a critical peak event.
GoodCents® Select DR Program (4)

Residential Service Variable Pricing (RSVP)

Rate Schedule

Standard Residential Customer Charge applies: $10.00 per month

RSVP Participation Charge: $4.95 per month

Prices per kWh
(includes energy charge, fuel, ECCR, PPCC and ECRC)

Low  4.7 cents/kWh
Medium  5.9 cents/kWh
High  10.5 cents/kWh
Critical  31.4 cents/kWh

Standard Residential Rate: 6.8 cents/kWh
Residential Service Variable Pricing (RSVP) Rate
Percent of Annual Hours in Effect

Critical pricing periods are most likely to occur Monday to Friday between 6 am and 10 am (winter) and between 3 pm and 6 pm (summer)
2 February 2002 No Critical Period
18 July 2002 Critical Period 2.00 to 4.00 pm

Test Group
Control Group
Norwegian Residential DR Pilot Project (1)

- Large scale pilot project in two distribution network areas from 2001 to 2004
- Involved two network operators and six technology vendors
- Two-way communication to 10,984 residential customers using radio, PLC, GSM, GPRS and PSTN
- Automated meter reading with hourly readings
- Separate channel for direct load control of water heaters - available to 50% of customers
The residential customers involved in the pilot project were offered five possible combinations of price and load control from which they could choose:

- ToU network tariff and a standard-offer energy tariff
- ToU network tariff and spot price energy tariff
- ToU network tariff, spot price energy tariff and direct load control of water heaters
- standard-offer network tariff and spot price energy tariff
- standard-offer network tariff, spot price energy tariff and direct load control of water heaters

The two network operators offered slightly different load control options - water heaters were switched off:

- Buskerud Kraftnett AS: during the hour with the highest energy spot price plus the hour before or after
- Skagerak Energi Nett AS: during two hours in the peak load periods when the energy spot price reaches a predefined limit
Norwegian Residential DR Pilot Project (3)

- The TOU network tariff consisted of components:
  - a fixed component
  - a component for network losses; and
  - an energy-related component which was only activated during peak periods

- The TOU tariff had a two-level rate structure:
  - a peak price of NOK 0.88 (AUD 0.18) excluding VAT during peak load periods (defined as 7 to 11 am and 4 to 8 pm on working days from November to April)
  - an off-peak price of NOK 0.02 (AUD 0.004) excluding VAT in other hours of working days, weekends and holidays

- The differential between the peak and off-peak tariff was 44:1

- VAT and government and retail energy charges reduced this differential to about 3:1 in the customers' electricity bills
Norwegian Residential DR Pilot Project (4)

Tariffs in the Pilot Project (excluding VAT)

Source: Torgeir Ericson, Norwegian University of Science and Technology
Norwegian Residential DR Pilot Project (5)

- Results are for residential customers with both TOU network tariff and spot price energy tariff and load control
- Consumption is reduced during the two peak load periods
- The reduction is 12% in the morning and 14% in the afternoon
- Number of customers: 1230

Source: Seppo Kärkkäinen, VTT
Norwegian Residential DR Pilot Project (6)

- Results are for residential customers with both TOU network tariff and spot price energy tariff and no load control
- Consumption is considerably reduced during the two peak load periods
- The reduction is 35% during the morning and 31% during the afternoon
- Number of customers: 6

Source: Seppo Kärkkäinen, VTT
## Norwegian Residential DR Pilot Project (7)

### Average Load Reductions Achieved through Various Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Buskerud Kraftnett AS</th>
<th>Skagerak Energi Nett AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOU network tariff</td>
<td>~0.18 kWh/h</td>
<td>~0.18 kWh/h</td>
</tr>
<tr>
<td>Hourly spot price for energy</td>
<td>~0.6 kWh/h</td>
<td>~ 0.4 kWh/h</td>
</tr>
<tr>
<td>Direct load control of water heaters</td>
<td>~0.5 kWh/h</td>
<td>~0.57 kWh/h</td>
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<tr>
<td>TOU network tariff plus hourly spot price for energy (no load control)</td>
<td>~1 kWh/h</td>
<td>~0.3 kWh/h</td>
</tr>
</tbody>
</table>

Source: Seppo Kärkkäinen, VTT
California ADRS Pilot (1)

- California trialled Advanced Demand Response Systems (ADRS) during 2003 and 2004
- ADRS systems were trialled in the residential sector and automatically reduced load based on price
- Participants in the ADRS trial were provided with a full complement of automation technology and real-time access to energy and price information
- The ADRS enabling technology included:
  - two-way communicating interval meter
  - wireless internet gateway and cable modem
  - smart thermostat(s)
  - load control and monitoring device (LCM)
  - web-enabled user interface and data management software
California ADRS Trial (2)

- The technology was programmed to automatically respond to electricity prices
- Via the Internet, pilot participants could:
  - View real time interval demand and trends in historical consumption
  - Set climate control and pool pump runtime preferences
  - Program desired response to increased electricity prices
    - Change thermostat temperature set point
    - Reschedule operation of LCM controlled appliances
- ADRS technology continuously displayed the current electricity price on the thermostat and the Web
California ADRS Trial (3)

Average Critical Peak Weekday Load Profile Jul to Sep 2004

Source: ADRS Load Impact Presentation 18 Dec 2004
Country Energy Smart Metering Trial

Ampy Email
Advanced Metering System

Smart Meter
Home Energy Monitor

Source: Cathy Zoi, Bayard Capital
Spectrum of Demand Response Options

Price signals and/or financial incentives for energy user

- EdFrance Tempo
- Ampy Email Country Energy
- California SPP
- Georgia Power
- Niagara Mohawk
- Energy Response P/L

(Direct Load Control

- Gulf Power (Florida)
- Invensys’ Goodwatts
- Comverge

- ACEA
- L&G ‘Radio Ripple’
- ENEL
- South Australia?

(Economists) (Engineers)

Source: Cathy Zoi, Bayard Capital
In the most advanced demand response programs, a third party Aggregator enrols end-use customers in demand response programs and maintains communication with both the system operator and the customers.

Communication between the system operator, the Aggregator and customers is usually automated.

Remote meter reading and telemetry enable all parties to see the impact of demand response actions in near real time.
System Operator initiates request for Demand Response

Communications system alerts third party Aggregator to request

Customer receives message from Aggregator and instructs staff to implement load reduction procedures

All parties see impacts from Demand Response in near real time

Meter records load every 5 minutes and reports data to all parties

Aggregated DR Programs (2)
Aggregated DR Programs (3)
Use of Demand Response for Reserve Capacity
Use of DR for Reserve Capacity

- Use of demand response to provide reserve capacity is growing
- Demand response is often cheaper and more flexible than using generation in the ancillary services market to provide:
  - voltage regulation
  - load following
  - frequency response
  - supplemental reserve
- Some advocates in the United States believe demand response should also be used to provide spinning reserve
● In late 1997, the Victorian Power Exchange (VPX) initiated a Capacity Support Program to provide reserve capacity against a potential shortfall of some 700 MW across Victoria and South Australia.

● VPX tendered for supply of reserve capacity and demand-side options to ensure system reliability over the 1997/98 summer.

● At the close of tenders in October 1997, approximately 150 MW of demand-side resource (of which 58 MW was considered firm load, the balance being ‘non-firm’) had been contracted for dispatch by VPX.

● This was about 1.5% of the forecast maximum demand.
The VPX Capacity Support Program made available three levels of payment:

- **availability payments**, which participants received for nominating a demand-side resource that they could make available;
- **pre-notification payments**, which participants received if the system operator told them to stand by; and
- **dispatch payments**, which participants received if they actually shed load in response to a request. Failure to deliver the minimum amounts of load reduction that had been bid resulted in financial penalties.

Two retailers received an availability payment, but were not required to reduce demand because the supply system capacity was sufficient to meet demand over the summer.
Levels of Demand Response in the NEM, 2004

Source: NEMMCO
DR for Reserve Capacity in the US (1)

Source: Reports by North American Electric Reliability Council and United States Energy Information Administration cited by Grayson Heffner
DR for Reserve Capacity in the US (2)

NERC Regions

- ECAR - East Central Area Reliability Coordination Agreement
- ERCOT - Electric Reliability Council of Texas
- FRCC - Florida Reliability Coordinating Council
- MAAC - Mid-Atlantic Area Council
- MAIN - Mid-America Interconnected Network
- MRO - Midwest Reliability Organization
- NPCC - Northeast Power Coordinating Council
- SERC - Southeastern Electric Reliability Council
- SPP - Southwest Power Pool
- WECC - Western Electricity Coordinating Council

Demand Response vs. Total Demand by NERC Region

<table>
<thead>
<tr>
<th>Region</th>
<th>1998</th>
<th>2001</th>
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<tr>
<td>ECAR</td>
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<td></td>
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<td>SPP</td>
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<tr>
<td>WSCC</td>
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ISO New England DR Program (1)

- Electricity customers in the service area of the New England Independent System Operator (ISO-NE) can participate in demand response programs.
- Customers participate through an Enrolling Participant which can be a NEPOOL member (such as a local utility or energy supplier) or a Demand Response Provider.
- DR Providers are companies that provide technology and services to help customers participate in the demand response programs.
- Enrolling Participants are responsible for helping customers identify the demand response program that is most suitable for their operation and enrolling them with ISO-NE.
- ISO-NE makes incentive payments to Enrolling Participants who then share the incentives with their customers. Enrolling Participants may also offer other incentives and services.
ISO New England DR Program (2)

Actions Undertaken if Asked to Curtail

- Reduced lighting
- Adjusted HVAC temps
- Adjusted refrigeration equipment
- Turned off office equipment
- Turned off fans/pumps
- Turned off elevators
- Operated generator
- Shift manufacturing processes
- Other actions taken

Reliability Programs (N=28)
Non-Participant (N=11)
Price Response (N=49)
Notice sent at 10:45 a.m.
Event Started at 11 a.m.
Resources had 30 Minutes to Respond
Event ended at 1:30 p.m.
Test Performance 20 August 2004 – Generation Only

ISO New England DR Program (4)
ISO New England DR Program (5)

Test Performance 20 August 2004 – Load Reduction Only

Time

MW

Reduction MW
Enrolled MW
Enabling Technologies for Demand Response
Enabling Technologies for DR (1)

- Enabling technologies for demand response programs generally fall into three categories: automation, monitoring and communication.
- Automation already occurs in direct load control programs; but for demand response programs more sophisticated technology with multiple control points is required.
- Monitoring and communication are newer innovations that:
  - enable more efficient operation in a dynamic environment;
  - allow the Aggregator and customers to play more active roles.
Enabling Technologies for DR (2)

- Interval metering
- Energy Information Tools
- Backup Generation
- Direct Load Control
- Communications/Notification
Enabling Technologies for DR (3)

Smart House Demand Response Trial, Denmark

- The technology uses:
  - two-way communication (GPRS, internet)
  - remote meter reading and smart house wiring
  - web-based load control system

- 25 households in the pilot project

Source: Seppo Kärkkäinen, VTT
The customer communicates with the system by Internet

The Web site includes:

- access to setting the limits for the maximum duration of interruption for up to five different control zones for different time periods of the day
- access to stop an actual interruption for some of or all the control zones
- a report on the daily, weekly and monthly use of electricity and the savings achieved through demand response

Source: Seppo Kärkkäinen, VTT
Enabling Technologies for DR (5)

Smart House Demand Response Trial, Norway

- The technology uses:
  - two-way communication (radio, GSM)
  - E-box internet connected load control unit
  - web-based load control system
- 20 households in the pilot project

Source: Seppo Kärkkäinen, VTT
The Ebox – Design and Contents

- The Ebox contains a data processor, thermostat, radio receiver, on/off relay, a clock and a display
- Load control switching can be based on a room temperature or time setting
- Each Ebox has its own unique IP address and can be configured from the internet
- When using the Ebox to control electrical heaters, the customer can set up their own day and night or weekly temperature profile on an hourly basis from a personal internet homepage
- The profile is loaded from the server to the Ebox via radio
- The customer is also able to override the profile

Source: Seppo Kärkkäinen, VTT
Each customer is able to control their own room temperature using their homepage to change settings in the Eboxes.

The network operator is able to override the customer’s Ebox settings over a limited time period.

The network operator remotely controls the Eboxes according to the metered load in the local substation.

Source: Seppo Kärkkäinen, VTT
Enabling Technologies for DR (8)

Enermet Ripple Control Power Point Receiver

Trial Version Features
- Plug in Design
- Congestion Indication
- Switch Rating 16A
- Pre Programmed Ripple Control Receiver
- Override Button
Enabling Technologies for DR (9)

Grid Friendly™ Controller for Appliances
The Australian Household Electricity Load-management Platform (A-HELP) has been established to:

- develop **open standards** for communication between electricity suppliers and individual appliances in Australia
- get the standards accepted by all key stakeholders (local and international) and widely implemented
- facilitate the introduction into Australia (by utilities or governments) of programs to:
  - better manage peak load from residential and small business air conditioners (economic efficiency)
  - equitably recover costs of electricity infrastructure (equity)
  - protect the electricity network in emergencies (public safety)
A-Help Stakeholders

- **Product suppliers**
  - AREMA, AEEMA, CESA + individual firms
- **Government agencies**
  - AGO, NAEEEC, NFEE
    (Understand that load management may be greenhouse-neutral at best)
- **Electricity suppliers**
  - ENA, ERAA + individual distributors
- **Others**
  - CDC, Standards Australia, EUAA etc
A-Help Objectives

- Make demand response capability a desirable (eventually mandatory) feature in:
  - air conditioners
  - other products with large, curtailable electricity loads (e.g., pool pumps, day-rate water heaters)
- Implement in three stages:
  - Mode 1: Concentrate on new appliances
  - Mode 2: Achieve consistency with demand response measures to target existing appliance stock
  - Mode 3: Operate directly or via a ‘Smart’ controller or meter
A-Help Mode 1 - New Appliances

Source: George Wilkenfeld, GWA
A-Help Mode 2 – Retrofit Existing Appliances

Source: George Wilkenfeld, GWA
A-Help Mode 3 – Smart Controller or Meter

Source: George Wilkenfeld, GWA
Energy Smart Home Wiring Platform (1)

Source: Copper Development Centre
The Energy Smart wiring platform will enable:

- an energy provider to send a signal to a home appliance when maximum demand is approached;
- service companies to monitor and service appliances on-line;
- householders to have greater access to, and control of, appliance operation in the home.
Energy Smart Home Wiring Platform (3)

Instructions sent via:
- Ripple current
- PSDN
- Internet

Industry to jointly and individually develop a standardised software card to install into the control hubs (e.g. Clipsal, HPM, Hills, Krone) to interpret and send message.

Industry to discuss what standard to be adopted.

Stage 1 – on/off device
Stage 2 – change device settings

Source: Copper Development Centre
Benefits of Demand Response
Benefits of Demand Response (1)

- Many parties receive benefits from demand response programs:
  - end-use customers who participate in DR programs
  - electricity retailers and network owners
  - electricity system/market operators
  - electricity regulators and policy makers
Benefits of Demand Response (2)

For electricity retailers and network owners, DR programs provide:

► a physical insurance hedge against energy market volatility
► cost savings from lower market clearing prices and increased operating flexibility, system efficiency and asset utilisation
► improved reliability during periods of generation shortages or network congestion
► deferral of costly (and difficult to site) new generation or network capacity
► a dampening effect on lumpy, asset-intensive and thus inherently cyclical energy markets
Benefits of Demand Response (3)

Impact of Demand Response on Market Clearing Price

Source: Grayson Heffner, World Bank
Benefits of Demand Response (4)

For end-use customers, DR programs provide:

► **access to** the same or similar price signals provided to supply-side producers

► **payments** for availability and actual demand reductions as well as reduced electricity tariffs

► improved **understanding and control** of day to day electricity use (with investment in enabling technologies such as interval metering, energy management technology and energy information tools)

► increased **customer choice** in relation to dealing with high electricity prices
Benefits of Demand Response (5)

Annual Value of 100 hours of Demand Response based on 1999-2001 Wholesale Market Prices

Source: Grayson Heffner, World Bank
Barriers to Demand Response
Customer-related Barriers

- Most customers on retail tariffs never see wholesale electricity market prices and are therefore unaware of the value of demand response.
- Most small customers never see their load profile, because installing interval metering without subsidies is too costly.
- Participating in a DR program can be complex (though this may be mitigated by a third part Aggregator).
- End-use customers must typically make additional investments in enabling technology to maximise responsiveness.
Market-related Barriers

**Conclusions from a 2003 IEA Study**

- Current market designs do not enable demand response due to:
  - out-dated metering and related technologies
  - a lack of real-time price information reaching consumers
  - regulated retail prices while wholesale markets have largely been deregulated
  - system operators focussed on supply-side resources
  - a legacy where DR is not considered important
- Significant investment is needed in DR infrastructure to enable markets to communicate the value and cost of electricity
- Governments and regulators are key in enabling DR:
  - benefits of DR are dispersed among different market players
  - current markets will not develop a meaningful DR capability without facilitation
Opportunities for Demand Response in Australia
Other DR Trials in Australia (1)

Energex
- Has trialed both ToU tariffs and direct load control in the residential sector
- Is planning further trials using the Enermet SWITCHit™ device for direct load control
- Results may be used to develop new ToU tariffs
- Results not publicly available until decisions made on possible new tariffs

Integral Energy
- Planning a trial of smart meters, possibly with displays and direct load control
Other DR Trials in Australia (2)

EnergyAustralia

- Has introduced a ToU network tariff which requires an interval meter
- All new connections and meter replacements receive an interval meter
- Complete roll-out of interval meters may take up to 30 years
- Also planning trials of smart meters with displays and direct load control
Sydney DM&P Project

- The Demand Management and Planning Project was required under the 2002 conditions of consent for a major upgrade of the electricity supply to the Sydney CBD.
- The DM&P project was established jointly by Energy Australia, TransGrid and DIPNR/DEUS to investigate options for peak load reductions in the inner Sydney region.
- The DM&P project recently called for proposals for residential peak load reduction projects in a contiguous area of inner metropolitan Sydney.
- Peak load reduction projects may include smart metering and load control, possibly with automation at the household level.
Solar Cities Projects (1)

- Commonwealth funding of $75 million is available for a minimum of four Solar Cities projects around Australia.
- Solar Cities projects must include smart metering and load management measures (including cost reflective pricing).
- The deadline for Expressions of Interest for Solar Cities projects was 22 July.
- Projects in the submitted EOIs include a range of smart metering and load control measures.
Solar Cities Projects (2)

- **Smart metering** measures include:
  - interval meters with two-way communications
  - display units showing energy consumption and price information
- **Load control** measures include:
  - simple “ripple control” PLC technologies
  - Phase 6 PLC-based system which enables control of individual appliances and integrates with legacy accumulation meters
  - CSIRO “intelligent agents” which provide an interactive monitoring and control environment to optimally manage demand response
  - Energy Response proprietary software
Information Resources
Information Resources (1)

● David Crossley: crossley@efa.com.au


● Energy Response Pty Ltd is the only demand response aggregator currently operating in Australia: www.energyresponse.com.au
The International Energy Agency DSM Programme carries out multi-national research projects on demand management. Website for information about the IEA DSM Programme: http://dsm.iea.org

The IEA DSM Programme has recently initiated two research projects on demand response and network-driven DSM. Website for information about participating in these IEA projects: www.efa.com.au/aieac.html