# Smart Metering, Load Control and Energy-using Behaviour

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Workshop on Smart Metering
to Use Less Energy
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# Presentation Topics

- Changing energy-using behaviour
- Advanced metering and behaviour change
- Load control technology and behaviour change
- Metering and load control technology products
- Case studies: using technology to change behaviour
- Options for low cost technology programs
- Conclusions
- Information resources

# Changing Energy-using Behaviour

# What Behaviour Change?

- This presentation is concerned with achieving changes in the quantities of energy we use and the timing of when we use it
- We need to significantly increase the efficiency with which we use energy to combat global warming
- We need to change the time at which we use energy to reduce the massive expenditure required to expand electricity networks to handle peak loads
- Achieving both these goals requires significant behaviour changes

# Achieving Behaviour Change (1)

- Three approaches have typically been used to encourage people to change their energy-using behaviour:
  - information, eg publications, websites, energy information centres, energy audits, energy labelling of appliances, equipment and buildings
  - pricing, eg inclining block tariffs, and time-varying pricing, such as time of use (TOU), critical peak pricing (CPP), real-time pricing (RTP)
  - regulation, eg minimum energy efficiency performance standards (MEPS) for appliances, equipment and buildings

# Achieving Behaviour Change (2)

- The effectiveness of the three approaches has been variable:
  - information alone has generally been not very effective
  - effectiveness of pricing is variable; better results are achieved when combined with an information campaign and perception of some sort of “energy crisis”; behavioural response may reduce over time
  - regulation has been quite effective, but it forces behaviour change rather than encouraging long-term attitudinal change;  complete market transformation is required for maximum effect

# Role of Technology

- Technology is a (relatively) new factor that can greatly assist in achieving changes in energy-using behaviour
- Two types of technology can be used to achieve behaviour change:
  - advanced metering; and
  - load control technology

# Advanced Metering and Behaviour Change

# Types of Metering (1)

- **Accumulation meters** simply record energy consumption progressively over time
- **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 15 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

# Types of Metering (2)

- **Smart meters** typically include one-way or two-way communications between the energy supplier and the meter
- The communication capability enables other functionalities:
  - automated and remote meter reading
  - remote connection and disconnection
  - outage detection
  - tamper detection
  - monitoring of power quality
  - remote time synchronisation
  - an interface for an in-home display unit
  - an interface for load control devices

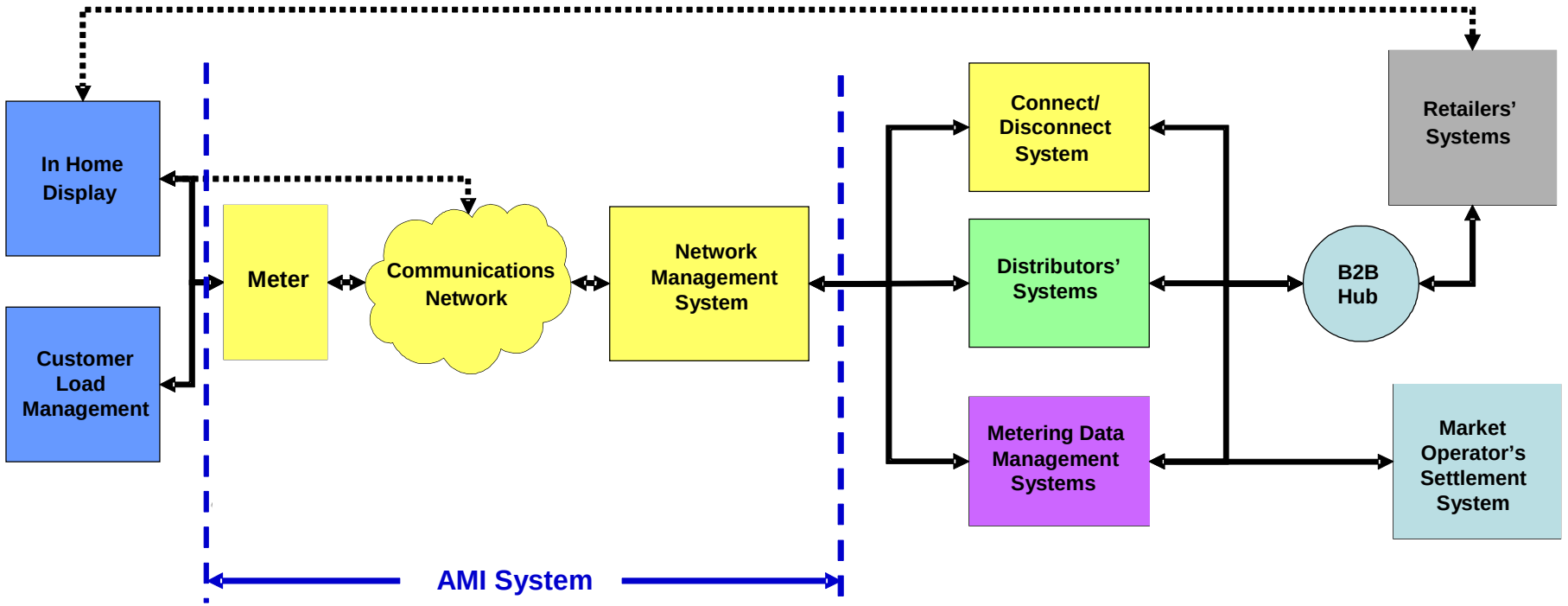
# Advanced Metering Infrastructure (1)

- A recent definition by FERC:

  *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*

- 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)

# Advanced Metering Infrastructure (2)




Components of an AMI System

# Capabilities of Smart Metering

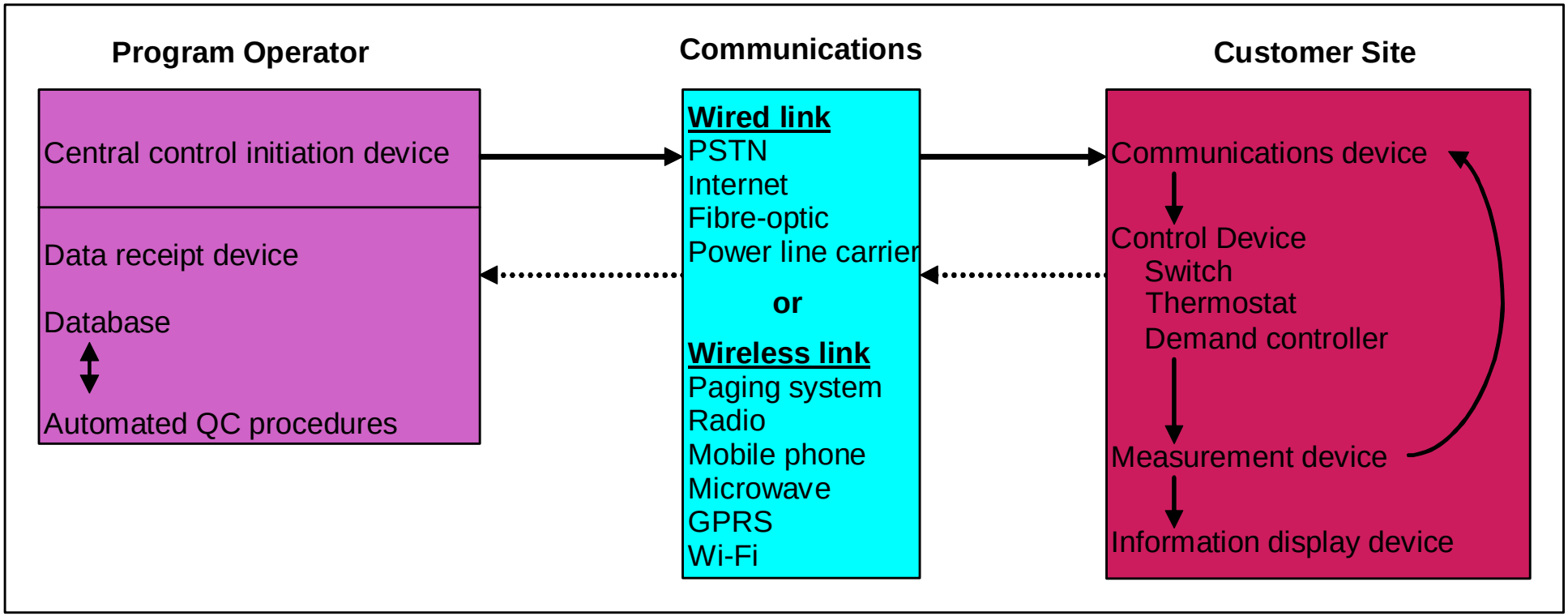
- Advanced meters enable the implementation of time-varying pricing under which the price per unit of energy varies according to the time of the day
- Seasonal variation in prices is also possible
- Time-varying tariffs send price signals to customers that reflect the underlying costs of generating, transporting and supplying electricity, enabling resources to be allocated more efficiently
- Price-based demand response programs can reduce or shape customer demand, particularly to reduce loads at peak times

# Load Control Technology and Behaviour Change

# What is Load Control?

- Load control comprises a system or program that enables end-use loads to be changed in response to particular events, eg high electricity prices or problems on the electricity network
- The operator of the load control system may be:
  - an electricity supplier or network operator
  - a market or system operator
  - a demand side response service provider; or
  - the end-user themselves

# Load Control System




Components of a Load Control System

# Capabilities of Load Control Technology (1)

- Load control technology now exists that:
  - ►automates many energy-using activities
  - ►enables a single "set and forget" decision by facility operators and householders in relation to energy use
  - ►provides energy suppliers and network operators with flexible methods to influence the quantity and timing of energy use
- Smart meters are not necessary to carry out load control; switching signals do not necessarily have to pass through the meter

# Capabilities of Load Control Technology (2)

- Switching of end-use loads can be carried out:
  - automatically, in response to a signal linked to a particular event, eg high energy prices or network constraints
  - manually, also in response to an event (the initiator of the switching requires information about the event)
- Switching may be carried out locally by the end-user, or remotely by a signal sent by a load control program operator
- 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

# Metering and Load Control Technology Products

# Technology Product Types

- Load control technology products can be classified as follows:
  - metering and information display devices
  - appliance and equipment controllers
  - integrated load control systems
- The following products 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

# Metering & Information Display Devices (1)


CCI Power-Mate

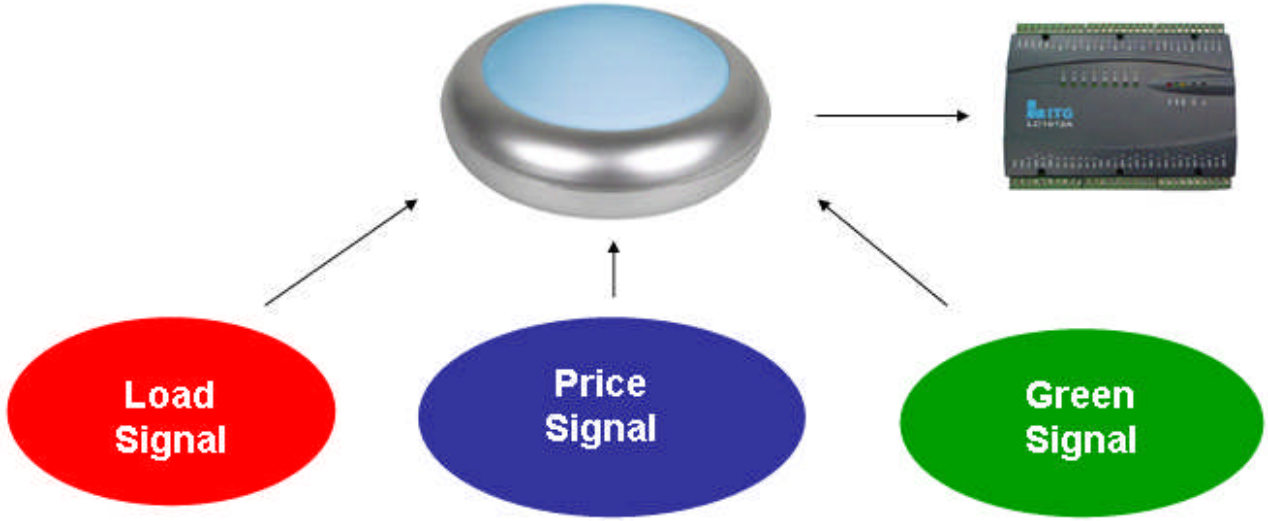
Clipsal Cent-A-Meter

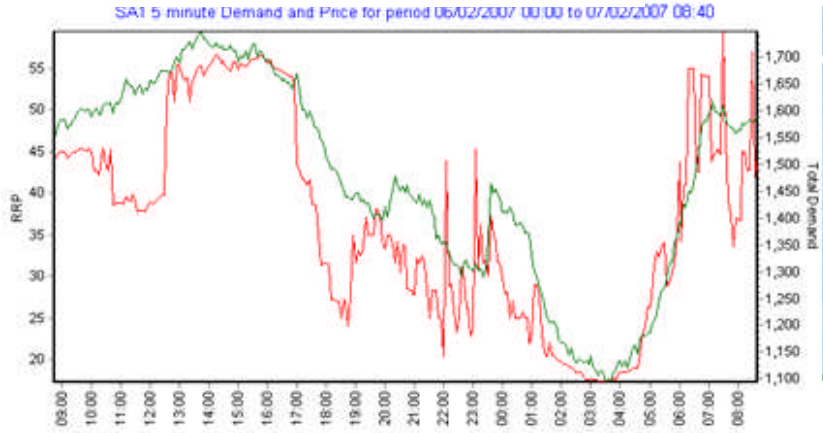
# Metering & Information Display Devices (2)


Ampy Email ecoMeter
Home Energy Monitor


Ampy Email
EM1200 Interval Meter

# Metering & Information Display Devices (3)




Open Energy Orb

# Appliance and Equipment Controllers (1)

Enermet SWITCHit™
Appliance Controller

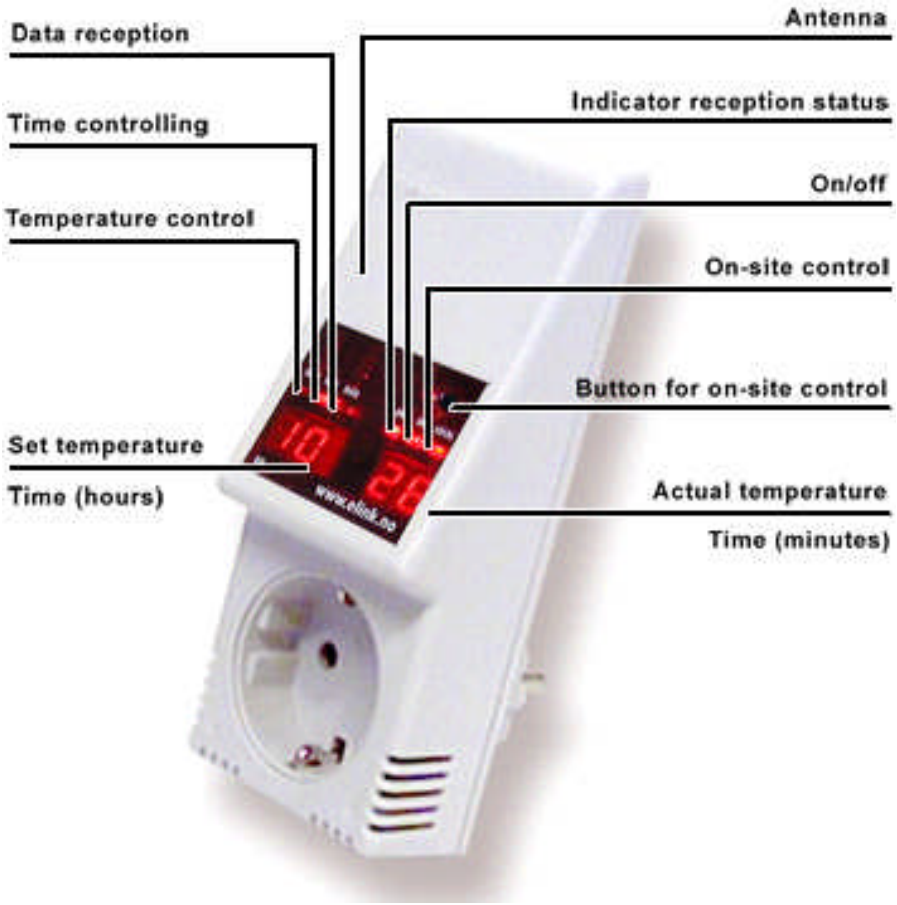
Grid Friendly™ Appliance Controller

# Appliance and Equipment Controllers (2)

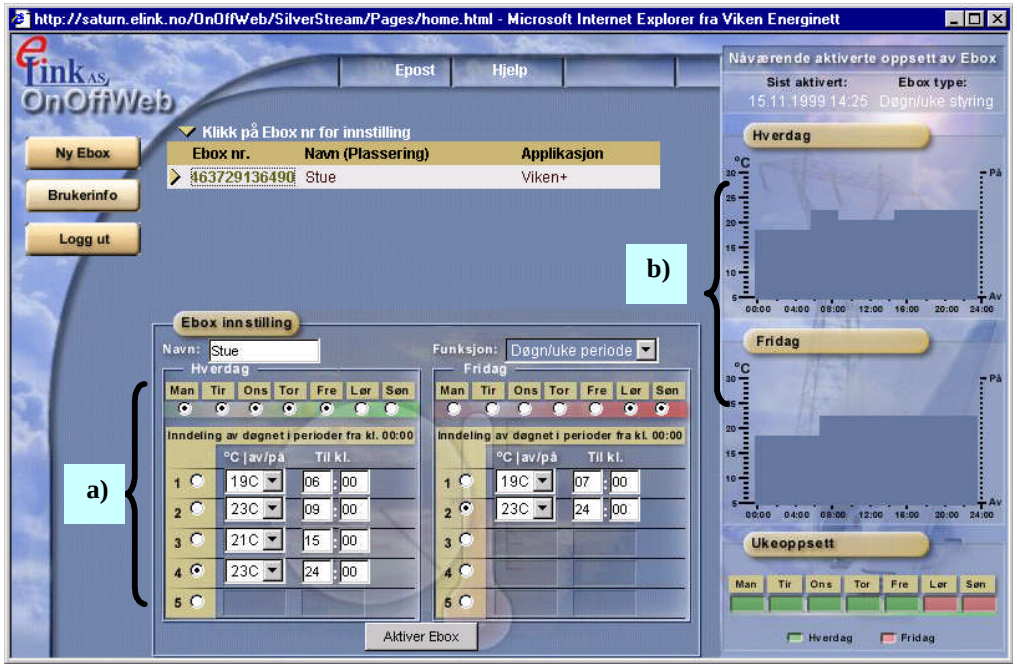

Enermet
ROA Ripple Control Receiver

Hunt Load Control Switch

# Integrated Load Control Systems (1)

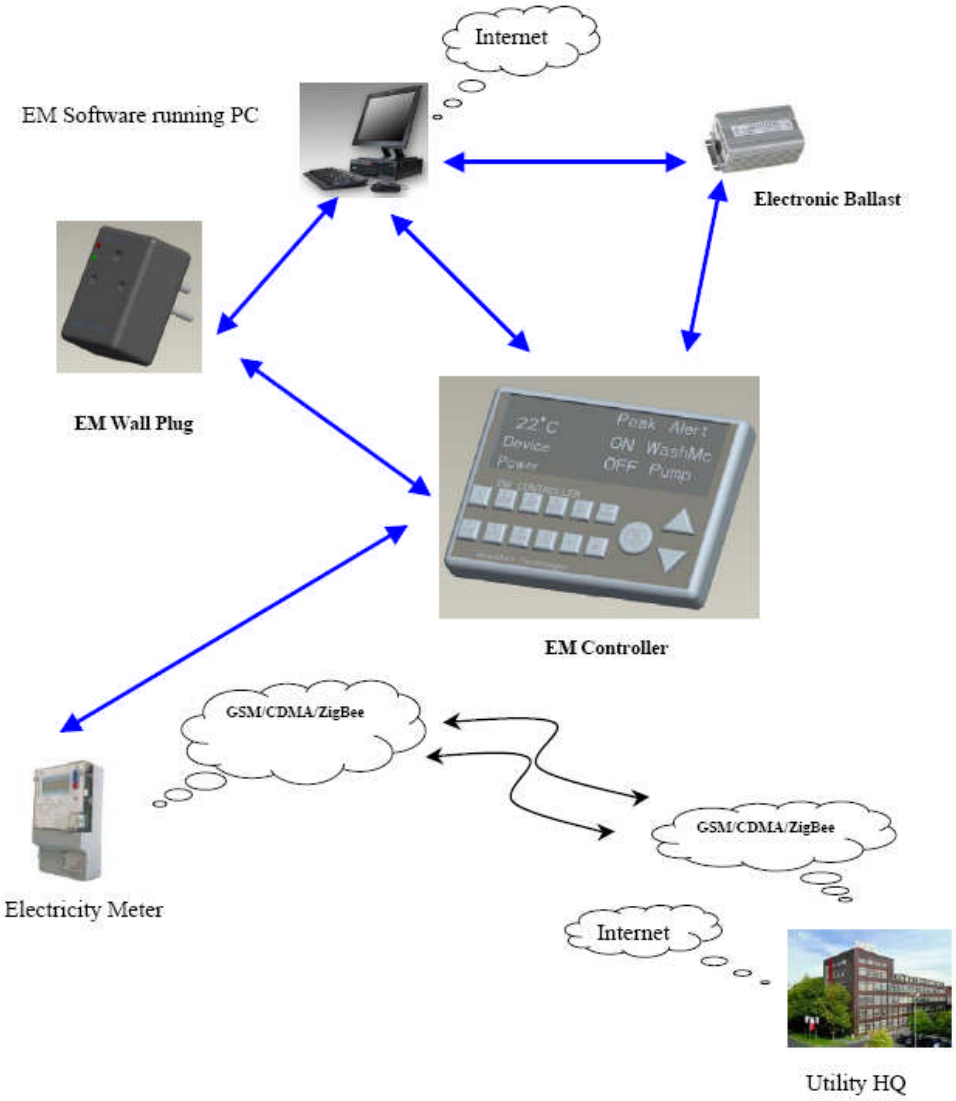


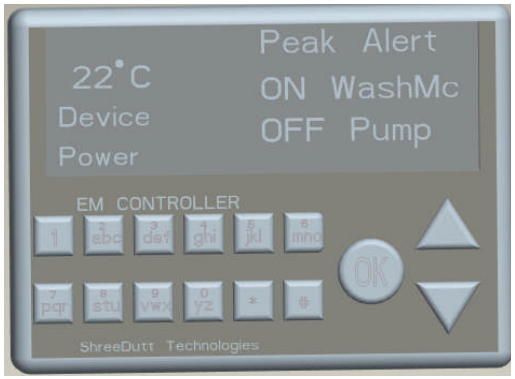

LeKeyBox
Appliance Controller




Web-based User Interface

# Integrated Load Control Systems (2)



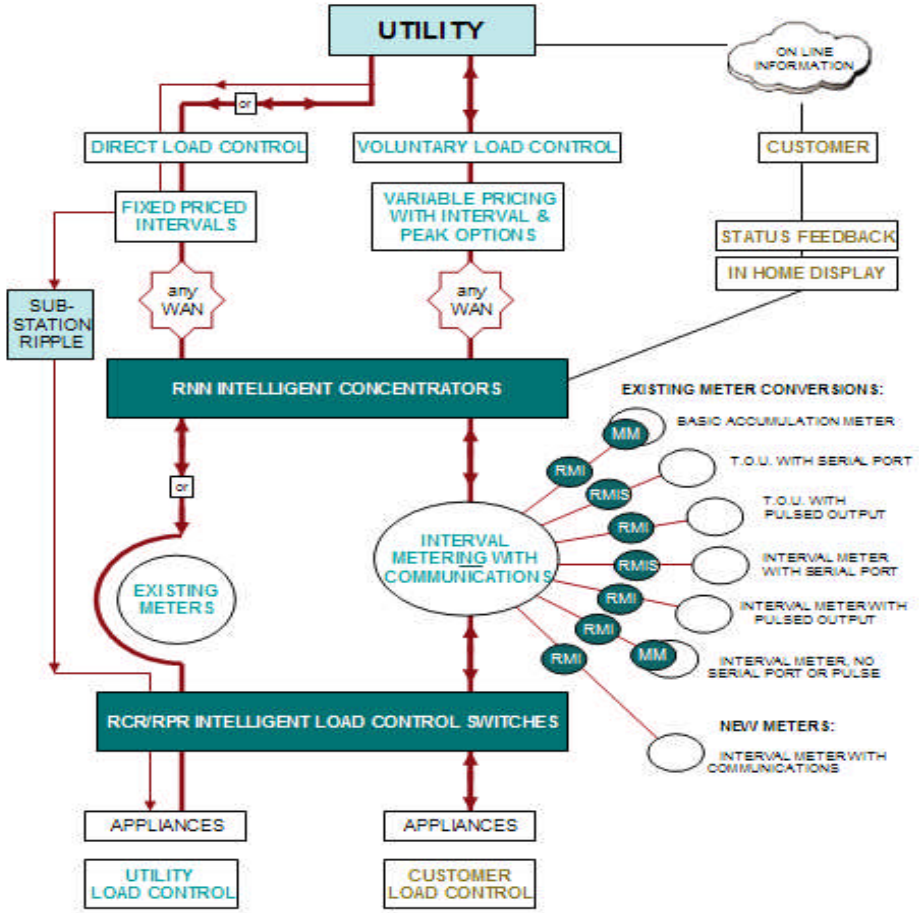




Shree Dutt Technologies
Electricity Manager

# Integrated Load Control Systems (3)

Phase 6/Tytronics Rippleband Neighbourhood Node,
Load Agent and Meter Interfaces

# Integrated Load Control Systems (4)



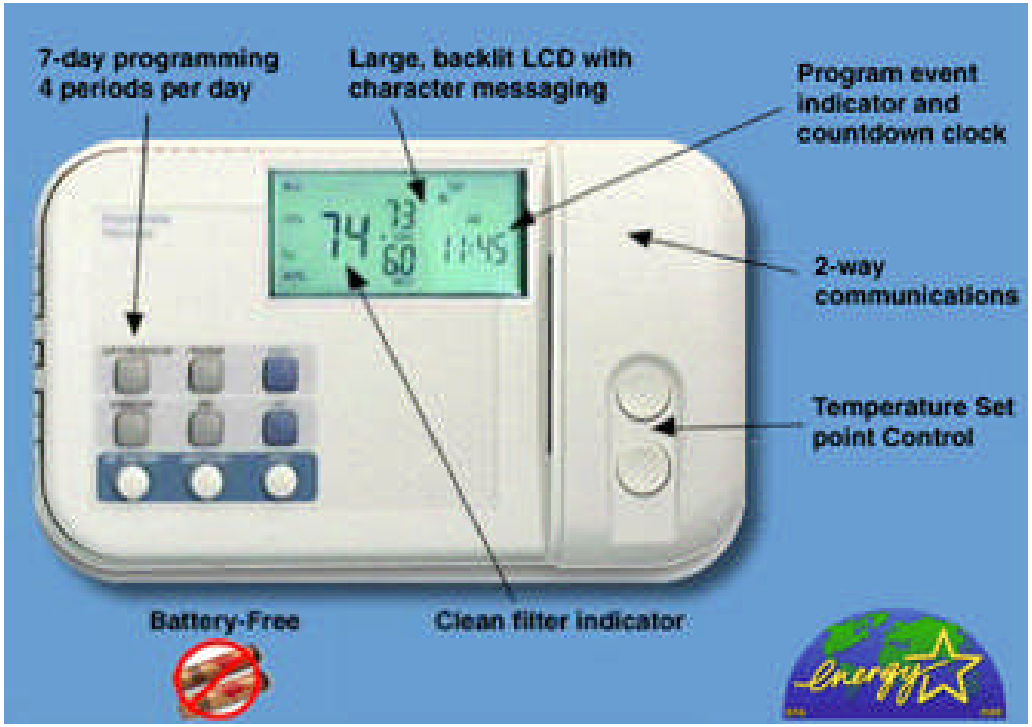

Communications Network for the Rippleband Load Control System

# Case Studies: Using Technology to Change Behaviour

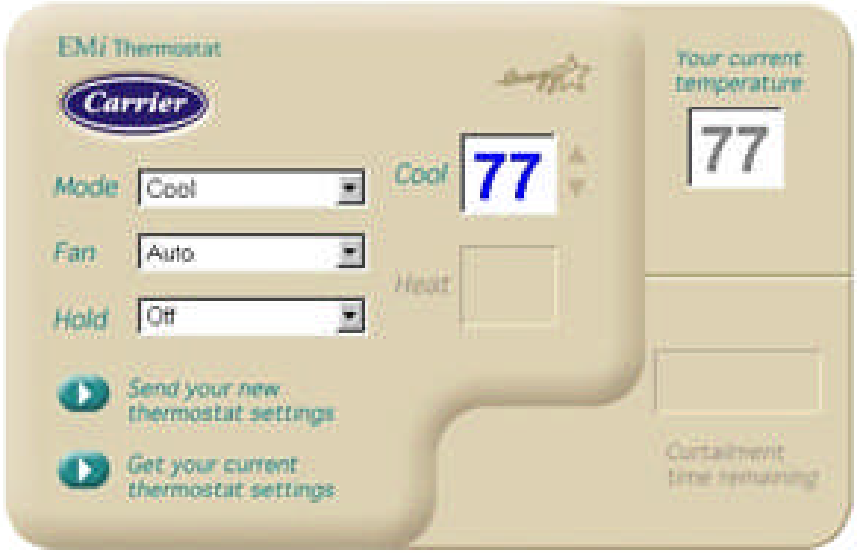
# LIPAedge Direct Load Control Program (1)

- The LIPAedge program is the largest residential/small commercial direct load control program using two-way communication in the United States
- Long Island Power Authority (LIPA) uses central control of thermostats in air-conditioning to achieve peak load reductions
- Carrier EMi thermostats are used in the LIPAedge program; they are programmable both locally and remotely through the internet; two-way communication is by radio paging
- Two-way communication allows LIPA to monitor capability and response; it also enables customers to control their individual thermostats via the internet, a benefit that motivates participation

# LIPAedge Direct Load Control Program (2)




Carrier EMi Thermostat




Web-based User Interface

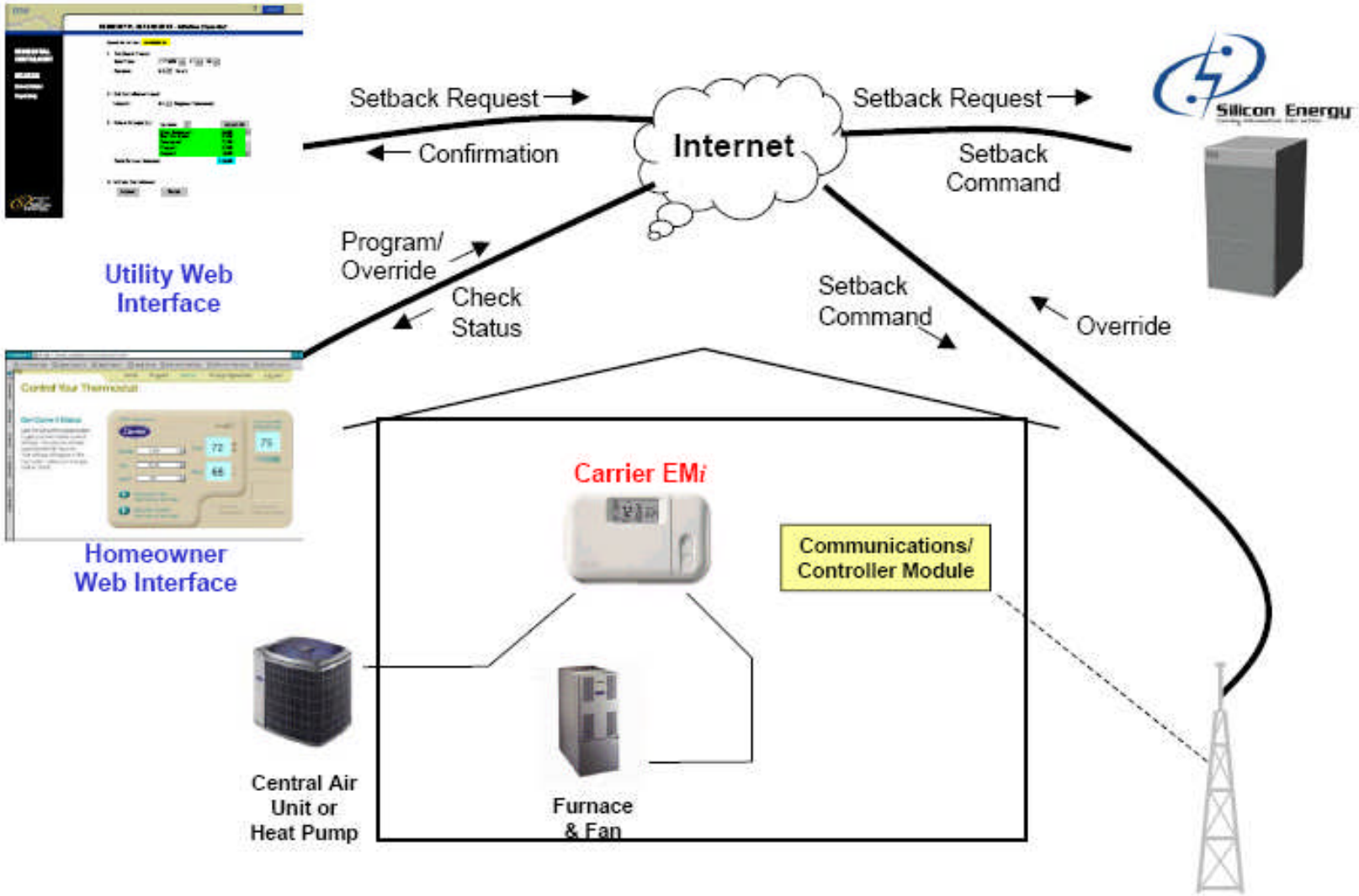
# LIPAedge Direct Load Control Program (3)

- LIPA customers receive a thermostat and installation free of charge, plus a one-time bonus payment of USD 25 (residential) or USD 50 (small commercial)
- Customers agree to have their central air conditioning systems adjusted between 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 at any time, overriding the LIPA setting
- About 20,400 residential and 3,000 commercial and small industrial customers are enrolled in the LIPAedge program, delivering about 25 MW of peak load reduction

# LIPAedge Direct Load Control Program (4)

- The LIPA system operator uses a web-based control system; two-way pagers are used to transmit curtailment commands to 20,000 thermostats and to receive acknowledgment and monitoring information
- 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
- Commands are received and acted upon by all loads, providing full response within about 90 seconds; in contrast a generator response requires a 10-minute ramp time

# LIPAedge Direct Load Control Program (5)



# California ADRS Trial (1)

- One of the trials carried out in 2003 and 2004 as part of the California Statewide Peak Pricing Trials evaluated an Advanced Demand Response System (ADRS) in the residential sector
- The ADRS technology was capable of automatically reducing load whenever a price level set by the householder was exceeded, providing a one-time “set and forget” solution
- The current electricity price was continuously displayed on a thermostat and a household homepage accessible through the internet

# California ADRS Trial (2)

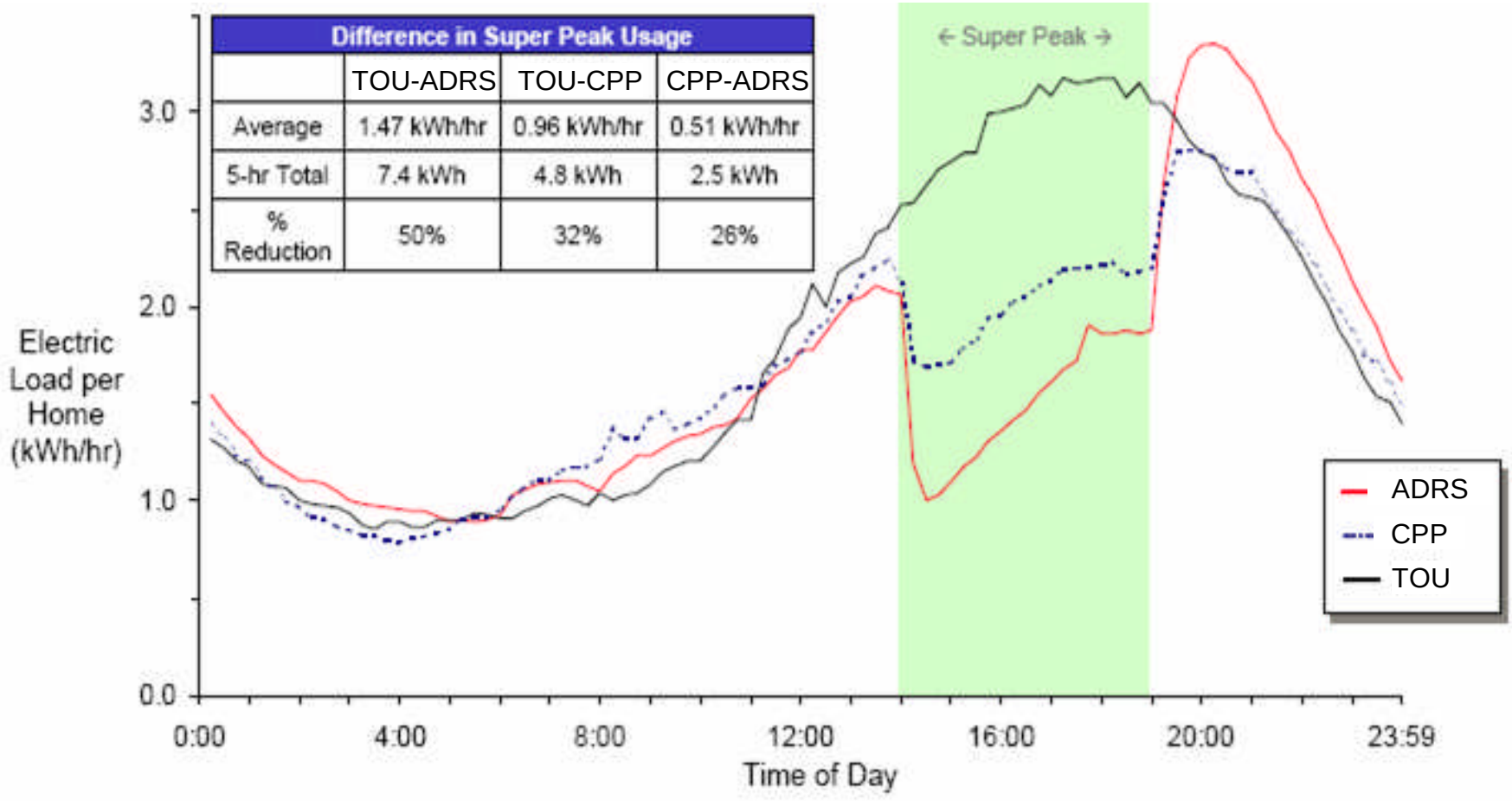
- The ADRS technology included:
  - two-way communicating interval meter
  - wireless internet gateway and cable modem
  - smart thermostat(s)
  - load control and monitoring device (LCM)
  - web-enabled user interface and data management software

# California ADRS Trial (3)

- Via the Internet, participants in the ADRS Trial 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

# California ADRS Trial (4)

## Average Critical Peak Weekday Load Profile Jul to Sep 2004




Source: ADRS Load Impact Presentation 18 Dec 2004

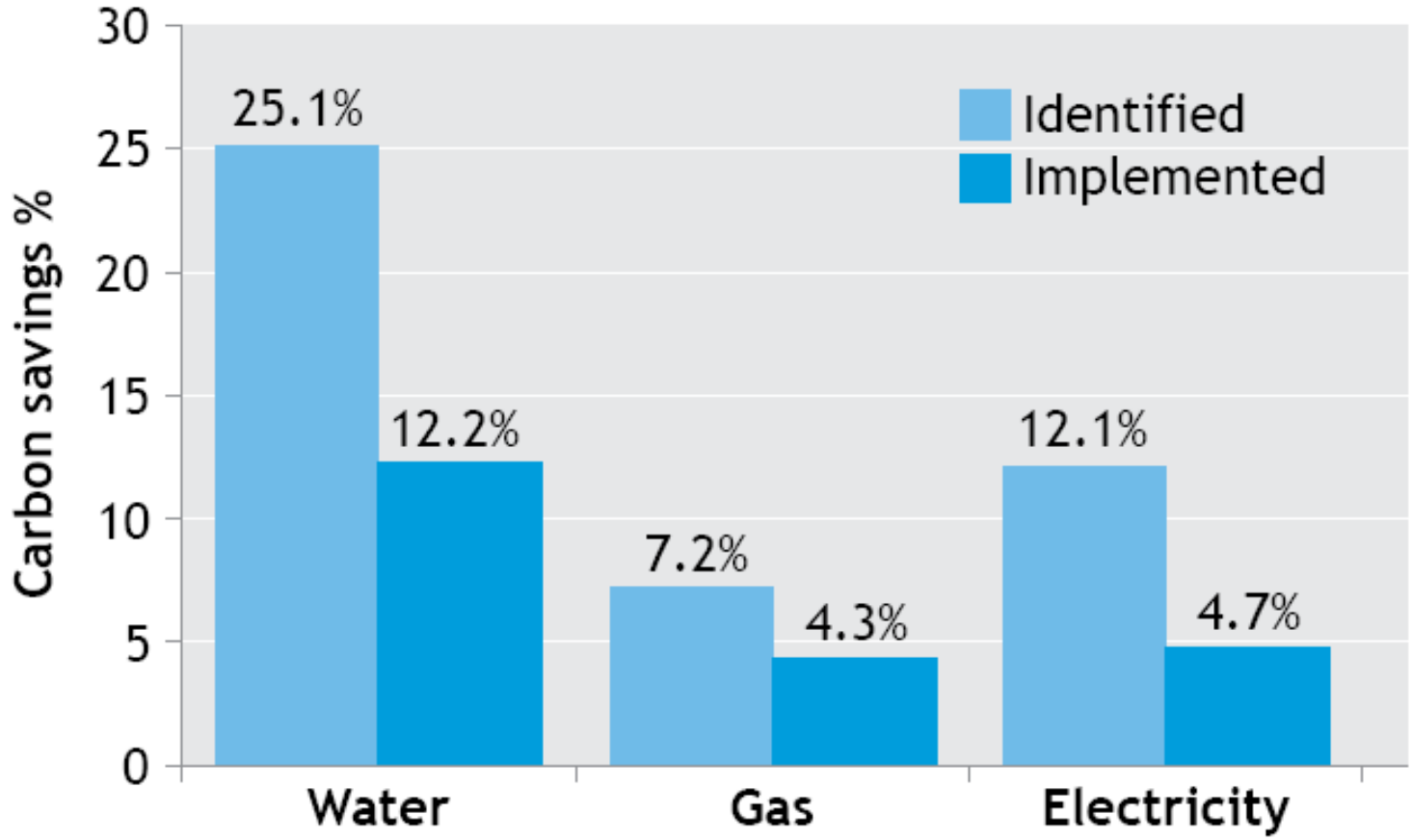
# Carbon Trust Smart Metering Trial (1)

- This study, carried out from 2004 to 2006 by the United Kingdom Carbon Trust, was unusual in that it focussed on savings in total energy use rather than peak load reductions
- The study investigated how smart metering can enable businesses to identify energy, cost and carbon savings by providing detailed information about the way in which they use their energy
- A total of 582 advanced meters were installed in small and medium enterprises (SMEs) across the UK and metering services were provided to these sites by seven different consortia

# Carbon Trust Smart Metering Trial (2)

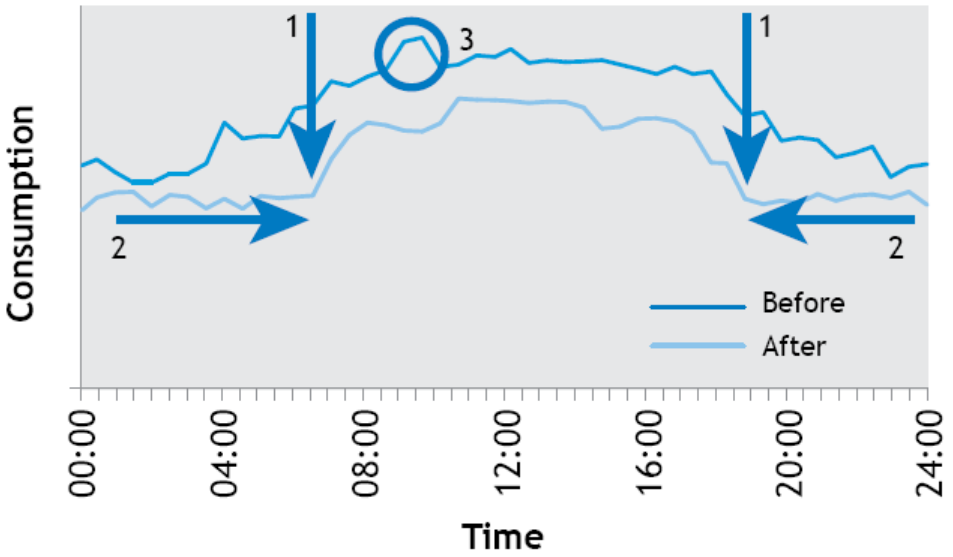
- In addition to the installation of smart meters, a variety of different metering services were included in the trial, ranging from basic data provision to detailed advice on energy saving communicated through phone calls and site visits
- The highest energy savings were achieved by providing energy 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

# Carbon Trust Smart Metering Trial (3)




Average Annual Percentage Carbon Savings for All Sites

# Carbon Trust Smart Metering Trial (4)




1. **Base load reductions** – the overall base load of the site could be reduced by identifying excessive constant energy use
2. **Process optimisation** – the profile could be used to identify what equipment is running and when; altering start-up and shutdown times could reduce consumption by limiting the duration of high-energy use at the start and end of shifts
3. **Peak usage reduction** – the profile could be used to analyse timings and frequencies to establish the causes of peaks in energy usage, and identifying specific activities/equipment contributing to the peaks

# Options for Low Cost Technology Programs

# Distribution of Low Cost Information Display Devices

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

Target Audience: Primarily residential; small businesses could also be targeted

Technology: Device that displays information about electricity use and costs, and may also provide information about other factors, eg greenhouse gas emissions

Communications: None

Type of Metering Required: None

Infrastructure Required: None

Pricing Initiatives: Time-varying price structures, eg TOU, RTP and/or CPP

Education and Awareness Raising: Promotion and education campaign encouraging customers to change their electricity-using behaviour

Examples of Technology Products: Power-Mate™; Cent-A-Meter™; Open Energy Orb

Indicative Cost: EUR40 to EUR130 per customer site

# 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: Computer chip that senses frequency disturbances on the network and turns an appliance off for a few minutes to allow the network to stabilise during a crisis

Communications: None

Type of Metering Required: None

Infrastructure Required: None

Pricing Initiatives: None required

Education and Awareness Raising: Education campaign explaining the technology to householders

Examples of Technology Products: Grid Friendly™ appliance controller

Indicative Cost: About EUR1.50 per appliance in large manufacturing quantities plus the cost of any education campaign

# Roll Out of Low Cost Plug-in Appliance Controllers

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

Target Audience: Primarily residential; small businesses could also be targeted

Technology: Plug-in device that enables remote control of appliances through power line signalling

Communications: One-way

Type of Metering Required: None

Infrastructure Required: Ripple control infrastructure

Pricing Initiatives: Time-varying price structures and/or incentive payments required to motivate customers to install the controllers

Education and Awareness Raising: Promotion and education campaign explaining the purpose and objectives of the program and encouraging customers not to override load control signals

Examples of Technology Products: SWITCHit™; Rippleband Plug-in Relay

Indicative Cost: EUR15 to EUR30 per connected appliance or piece of equipment plus the cost of an education campaign and any infrastructure required

# Roll Out of Smart Air Conditioner Thermostats

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

Target Audience: Residential and small commercial customers

Technology: Programmable thermostat with two-way communications

Communications: Two-way

Type of Metering Required: None

Infrastructure Required: Two-way communications infrastructure

Pricing Initiatives: Time-varying price structures and/or incentive payments required to motivate customers to install the thermostats

Education and Awareness Raising: Promotion and education campaign explaining the purpose and objectives of the program and encouraging customers not to override load control signals

Examples of Technology Products: ComfortChoice Demand Management Solution

Indicative Cost: EUR160 to EUR190 per thermostat; additional costs for installing and maintenance of the thermostats and for the communications network

# Promotion of Integrated Direct Load Control Systems

Purpose: To enable relatively complex demand side response programs.

Target Audience: Primarily residential and small commercial customers

Technology: Integrated load control system combining appliance and equipment controllers with two-way communications technology

Communications: Two-way

Type of Metering Required: Interval

Infrastructure Required: Two-way communications infrastructure

Pricing Initiatives: Time-varying price structures, eg TOU, RTP or CPP would be required to motivate customers to install the equipment; alternatively, or in addition, incentive payments could be used

Education and Awareness Raising: Promotion and education campaign explaining the purpose and objectives of the planned DSR program

Examples of Technology Products: LeKey Energy Management System; SD Electricity Manager; Rippleband Load Control System

Indicative Cost: Range EUR200 to EUR400 per site plus the costs for an education campaign and communications network

# Conclusions

# Metering and Load Control (1)

- **Interval metering** is necessary to implement time-varying pricing
- **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** (not necessarily through a meter) is essential to carry out remote switching of loads

# Metering and Load Control (2)

- **Two-way communication** is not essential to carry out remote switching of loads but it can provide valuable information to the program operator about the results of the switching
- **Metering** in some form is required for settlement of the financial transactions associated with load control programs

# Smart Metering and Saving Energy

- Installing smart meters will, by itself, do nothing to save energy
- Energy savings will only be achieved if installing the meters results in changing people's behaviour so that they use less energy in total
- Some studies suggest that rolling out advanced meters to all electricity consumers in a country may achieve savings of between 4% and 10% in total national electricity use
- However, energy savings can only be achieved if the installation of the meters is accompanied by supporting technology and programs, such as information displays, time-varying pricing, energy audits and particularly some form of load control

# Information Resources

# Information Resources

- David Crossley: crossley@efa.com.au
- Energy Futures Australia, my company's website: www.efa.com.au
- The International Energy Agency DSM Programme carries out multi-national research projects on demand side management. Website for information about the IEA DSM Programme: www.ieadsm.org
- The IEA DSM Programme is currently undertaking a research project on using advanced metering and load control to support electricity networks. Website for information about this project: www.ieadsm.org/ViewTask.aspx?ID=16&Task=15&Sort=0