PERTH SOLAR CITY

ANNUAL REPORT

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Solar Cities

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Contents

PERTH SOLAR CITY

Project Implementation Manager
Mr Andrew Blaver

Program Office
Venetia Davies
Mark Goninon
Rebecca Hargrave
Jai Thomas
Luke van Zeller

Principal Registered Office
Western Power
363 Wellington Street
Perth WA 6000
GPO Box L921 Perth WA 6842

T: 1300 993 268
TTY: 1800 13 13 51 | TIS: 13 14 50
E: perthsolarcity@westernpower.com.au
www.perthsolarcity.com.au

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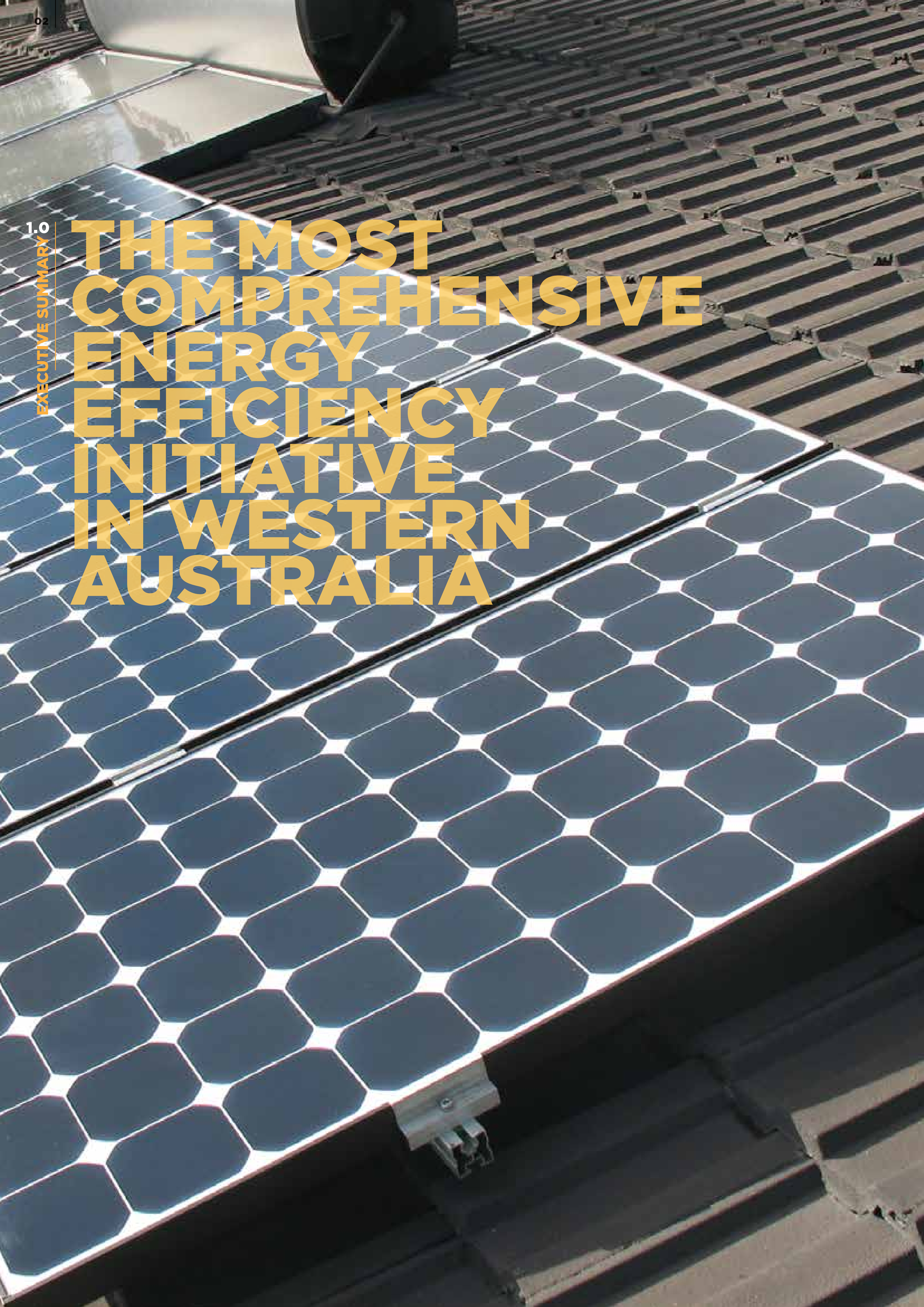
THE MOST COMPREHENSIVE ENERGY EFFICIENCY INITIATIVE IN WESTERN AUSTRALIA



EXECUTIVE SUMMARY

Perth Solar City is the most comprehensive energy efficiency initiative in Western Australia.

The broad-reaching Program developed and implemented more than 30 energy efficiency and renewable energy projects within Perth's Eastern Region.

Since its launch in November 2009, over 16,000 households participated in the Program through one or more of the innovative energy efficiency and renewable energy products, services or technical trials.

To deliver a program of this scale, a Consortia approach was used to bring together innovation, diversity and industry-leading expertise for the community. Western Power, as lead Consortium member, was accountable for the delivery of the Program on behalf of the Department of Climate Change and Energy Efficiency, as part of the Australian Government's Solar Cities initiative. Without the tremendous contribution of Consortium members, the success and benefits of the Perth Solar City program would not have been realised. On behalf of Western Power, I would like to acknowledge and sincerely thank each of the Consortium members: Botanic Gardens and Parks Authority, Eastern Metropolitan Regional Council, Mojarra, Prospero Productions, Solahart, SunPower and Synergy, for working together and delivering a quality program to households.

As a result of the community's participation, the commitment and collaboration of the Consortium, and the comprehensive capture and analysis of participation data, the Program is now able to reflect on how each of the innovative products, services and trials have contributed to meeting the Program's original objectives to:

- identify and understand barriers to the uptake of energy efficiency and renewable energy in the residential sector
- test new energy efficiency technologies by undertaking trials
- bring together industry, business, government and community to change the way we produce, use and save energy
- inform future government policy

The 2012 Annual Report is the second and final report published by Western Power, on behalf of the Perth Solar City program. This report is designed to be read as a stand alone document, without the need to refer back to the 2011 Annual Report. As such, this report summarises project delivery, and details the data analysis and comprehensive evaluation conducted to assess the entire Program.

For each of the energy efficiency products, services and trials, this report:

- provides a summary of project delivery
- accounts for achievement against project objectives
- presents key results including data analysis of the effects of interventions on electricity use and evaluation of participant experience
- shares transferrable lessons

FUNDING

Perth Solar City received $13.9 million in seed funding from the Australian Government's Solar Cities initative. A further $33.3 million of cash and in-kind support was contributed by the Perth Solar City Consortium. As at 30 September 2012, Perth Solar City had expended 95% of the allocated Australian Government funding.

THE FOLLOWING HAS BEEN ACHIEVED BY THE PERTH SOLAR CITY CONSORTIUM TO DATE:

SMART GRID TRIAL

As part of Perth Solar City, the Smart Grid Trial and the enabling smart metering infrastructure has provided significant customer benefits while also contributing to a reduction in peak demand, and increased network efficiencies.

The Smart Grid Trial installed over 9,000 smart meters in four specific locations within Perth's Eastern Region - the suburbs of Bassendean, Darlington, Forrestfield and Midland. Western Power has now proven the end-to-end smart grid technology, including the establishment of the Home Area Network as an open platform for delivering additional customer focused products and services.

During 2012 Western Power surveyed the customer response to smart grid technology. The survey found that 81% of trial participants were supportive of a wider smart meter deployment.

The results of the smart grid enabled energy efficiency trials such as the Air Conditioning Trial (ACT), the In Home Display Trial (MAX), and the Time-of-Use Tariff Trial (PowerShift) has enabled Western Power to refine the cost benefit analysis of a larger scale smart meter deployment.

AIR CONDITIONING TRIAL

Western Power and Synergy undertook an opt-in trial of the demand management of residential air-conditioners over the summers of 2010/2011 (Year one) and 2011/2012 (Year two). The trial was designed to understand the technical feasibility and cost-effectiveness of air conditioner demand management as a tool for reducing electricity consumption at times of peak demand.

The Air Conditioning Trial is the first of its kind in Australia to utilise smart grid infrastructure, and as a result participants reduced their household electricity demand at peak time by an average of 25%, or 33% of air-conditioning load.

The trial was received positively, with 87% of households willing to participate in similar trials in the future, and 1 out 3 rating their trial experience as '10 out of 10'.

IN HOME DISPLAY TRIAL

The In Home Display Trial is a Western Australia-first which provides households with real-time electricity consumption information, enabled by a smart meter. Households were provided an In Home Display (IHD) by Synergy that shows their electricity consumption in kWh and cost in real-time. The majority of IHDs were deployed to households unsolicited by mail, during the first year of the trial. The analysis post deployment indicates an average 1.5% reduction in total electricity consumption and 5% reduction during Super-Peak (2pm – 8pm weekdays).

A qualitative survey showed that 82% of participants who paired their IHD felt the device was useful in reducing their electricity use, and would recommend it to others.

TIME-OF-USE TARIFF TRIAL

PowerShift is a voluntary three-part time-of-use tariff developed by Synergy for Perth Solar City. It is the first tariff in Western Australia that seeks to more closely align electricity consumption blocks with time based costs of generation. 746 participants were recruited for the trial.

The ability to view electricity costs in real-time via an IHD, as enabled by a smart meter, provided participants with the capability to better manage their electricity use. Analysis shows an average 9% reduction in participant electricity consumption during Super-Peak. When combined with an IHD, participants achieved an average 13% reduction in electricity consumption during Super-Peak.

A qualitative survey showed that 77% of participants were willing to recommend the trial to others, and participate in the future.

SOLAR PHOTOVOLTAIC SATURATION TRIAL

Western Power's network has seen a significant increase in the connection of small scale renewable energy systems in recent times. The Solar Photovoltaic Saturation Trial is investigating the effects of a high penetration of solar PV systems on Western Power's network. The potential for effects such as localised power quality issues and voltage compliance issues need to be researched. Findings from the trial show that approximately 30% saturation of solar PV systems (by transformer size) can result in voltage rise outside of compliance limits at the customer level, but within appliance tolerance limits.

RESIDENTIAL SOLAR PHOTOVOLTAIC SYSTEMS

The Perth Solar City program together with SunPower assisted households to generate their own electricity by providing a discount on SunPower residential solar PV systems. SunPower is the premium brand in the solar PV system market place, with the highest efficiency (19%) panel. SunPower installed 673 solar PV systems at an average size of 2.30kW, for a total installed capacity of 1.56MW.

Analysis shows that the average household used 41% less electricity from the network, or 8.15kWh per day.

RESIDENTIAL SOLAR HOT WATER SYSTEMS

The Perth Solar City program together with Solahart provided a $1,100 discount (inc. GST) on family-sized Solahart solar hot water systems. Solahart installed 1,151 solar hot water systems during the Program.

Households who replaced an electric storage or electric instantaneous hot water system with an electric-boosted solar hot water system achieved an average 18% reduction in average daily electricity use.

MARKETING

The successful outcomes and customer benefits achieved through Perth Solar City could not have been realised without an accompanying broad reach marketing strategy. A campaign, 'Collective Impact', was developed which utilised community-based social marketing concepts to create a shift in community energy perceptions and attitudes, and to assist in enabling behaviour change. The Collective Impact campaign positioned Perth Solar City as the educator and enabler for households on their energy efficiency journey. The campaign included cinema advertising, local art installations, local newspaper advertisements, billboards in high traffic areas, adshels and attendance and sponsorship at local festivals. Analysis suggests that the Collective Impact campaign had a 'ripple effect' on household electricity use, with an average 1.6% reduction within the broad reach marketing area.

BEHAVIOUR CHANGE

The Living Smart Households program (Living Smart) is the intensive behaviour change program, delivered by the Western Australian Department of Transport (in partnership with the Eastern Metropolitan Regional Council), for Perth Solar City. Living Smart utilises phone-based eco-coaching to support participants to reduce their energy, water and transport use. Eco-coaches provided the right information at the right time, and set simple and measureable targets for the household through the establishment of 'social contracts'.

Households implemented a range of energy efficiency actions during and after participating in Living Smart, and achieved an average 7.5% reduction in electricity use.

A qualitative survey showed that 90% of participant rated the service as positive or strongly positive.

HOME ECO-CONSULTATIONS

Over 3,500 Perth Solar City program participants were provided with a 90 minute Home Eco-Consultation (HEC), delivered by Mojarra. The HEC enabled participants to understand what was contributing to their energy consumption and subsequently make informed decisions about energy efficiency and renewable energy.

Households implemented a range of energy efficiency actions after participating in an HEC, and achieved an average 12.3% reduction in electricity use.

A qualitative survey found that 87% of participants rated the service experience as good or very good.

ICONIC PROJECTS

To support the engagement objectives of Perth Solar City, and to promote the Australian Government's Solar Cities initiative, five solar photovoltaic (PV) installations were installed at iconic Perth locations. The selected locations are the Midland Atelier (60kW), the Central Institute of Technology (49kW), Kings Park and Botanic Garden (15kW), Perth Zoo (239kW) and Perth Arena (111kW). The combined iconic site solar PV installations have a capacity of nearly 500kW.

DEMONSTRATION PROJECTS

The Eastern Metropolitan Regional Council (EMRC) represents the six Local Government Authorities (LGAs) located within Perth's Eastern Region: the Town of Bassendean, City of Bayswater, City of Belmont, Shire of Kalamunda, Shire of Mundaring and City of Swan.

As part of Perth Solar City's engagement strategy, fifteen renewable energy and energy efficiency demonstration projects were developed for implementation by the EMRC. The installations were designed to educate the local community within Perth's Eastern Region about the benefits of energy efficiency and renewable energy. The installations varied in scope and size and are located mainly on public access buildings within the community.

SCHOOL ENGAGEMENT

Perth Solar City implemented three energy efficiency projects within schools: twenty energy audits, a school based documentary (Eco SuperStar), and an energy saving competition (Bring It Down).

Mundaring Christian College won the Bring It Down competition, saving 7,601kWh of electricity. This represented a 54% reduction on their benchmark or over $1,900 worth of electricity savings over a seven week period. The total combined energy savings of all participant schools amounted to over 64,000kWh, or over $16,000.

Numerous valuable lessons were learnt through the implementation of the Perth Solar City program. These lessons can inturn inform governments and energy utilities alike in the design of similar initiatives aimed at achieving energy efficiency, reducing peak demand or managing small scale renewable energy systems in the residential sector.

Smart grid infrastructure and the accompanying energy efficiency products and services have the real potential to transform how customers understand and use electricity.

The key lesson from the Perth Solar City program is that without fostering customer participation through education based community engagement, the successful deployment of new technologies and energy efficiency programs will be compromised.

Energy efficiency programs must engage customers to demonstrate value, encourage participation and realise benefits.

Date: 21 December 2012

Andrew Blaver

Program Implementation Manager
Perth Solar City

MESSAGE FROM WESTERN POWER'S CHIEF EXECUTIVE OFFICER

Western Power has proudly managed the Perth Solar City program since February 2009. In this short time Perth Solar City has developed and implemented more than 30 energy efficiency initiatives – from large scale solar installations to educating households on the benefits of smarter energy choices.

Western Power is committed to making a positive difference to energy affordability. To this end we are dedicated to providing customers with greater visibility and control over their energy use. Through Perth Solar City, Western Power has developed stronger connections with our customers and the community. Perth Solar City's extensive and professional community engagement programs have helped our customers make real savings and deliver ongoing behaviour change.

Over 16,000 households participated in the Program and our research has shown the strong potential for households to substantially reduce their energy consumption and electricity bills.

We have trialled a variety of different energy efficiency initiatives including solar energy, new network technologies and behaviour change programs. A key benefit of this comprehensive research is that Western Australia has a platform of solid information to support its future energy decisions.

Western Power is committed to efficiently providing a safe and reliable supply of electricity for West Australians at the lowest possible cost. Given that much of the equipment that makes up our electricity network has a 40 to 50 year life, we are constantly building and rebuilding the network – which means that we must continually plan and prepare for a distant and ever changing future.

We all have a part to play in planning for the future and incorporating more sustainable energy solutions is an important part of this. Western Power was proud to support the development of five unique and eye catching solar sites at iconic Perth locations - Perth Zoo, Kings Park, the Central Institute of Technology, the Midland Foundry, and the final installation at the new Perth Arena.

I would like to thank the Perth Solar City Consortium, ably assisted by the Program Office, for the service it has provided to our community through the delivery of a high quality Program.

Finally, I would like to thank the Australian Government for creating an important program that has invested in trials and research whilst bringing together all levels of government, industry and the community.

Paul Italiano
Chief Executive Officer, Western Power
Consortium Leader of Perth Solar City

WESTERN POWER IS COMMITTED TO MAKING A POSITIVE DIFFERENCE TO ENERGY AFFORDABILITY

PAUL ITALIANO, CHIEF EXECUTIVE OFFICER, WESTERN POWER

2.0 INTRODUCTION

Image 2-A: The Perth Solar City Program Office

The Perth Solar City Program (the Program) is the most comprehensive energy efficiency initiative in Western Australia. It is a unique partnership of industry, government and the community working together to change the way we produce, use and save energy.

Perth Solar City is part of the Australian Government's $94 million Solar Cities program designed to trial new sustainable models for the supply and use of electricity. The Solar Cities program is being implemented in seven separate electricity grid-connected areas around Australia - Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Townsville and Perth.

The Solar Cities program is administered by the Federal Department of Climate Change and Energy Efficiency (DCCEE), in partnership with local and state governments, industry, business and local communities.

The overall objectives of the Australian Government's Solar Cities program are to:

- demonstrate the environmental and economic impacts of integrating cost reflective pricing with the concentrated uptake of solar technology, energy efficiency and smart metering technologies
- identify and implement options for addressing barriers to distributed solar generation, energy efficiency and electricity demand management for grid connected urban areas

The Perth Solar City program launched in November 2009 after securing $13.9 million in seed funding from the Australian Government's Solar Cities program, and a further $33.3 million of cash and in-kind contributions from the Perth Solar City Consortium.

To support the overall objectives of the Australian Government's Solar Cities program, the Perth Solar City program objectives are to:

- identify and understand barriers to the uptake of energy efficiency and renewable energy in the residential sector of Perth's Eastern Region
- test new energy efficiency technologies by undertaking trials
- bring together industry, business, government and community to change the way we produce, use and save energy
- inform future government policy

LEADING PERTH SOLAR CITY

Perth Solar City is managed locally by Western Power – Western Australia's largest electricity distributor. Through the Funding Agreement with the DCCEE, Western Power is accountable for the overall Program delivery and manages its implementation through a dedicated Program Office.

The Perth Solar City Program Office (image 2-A) is responsible for ensuring that the activities detailed in each Consortium Agreement between Western Power and individual Consortium members are delivered on time, to a high standard, and in line with agreed funding arrangements.

The Program Office is also responsible for overall program management, including project reporting, marketing, communications, media, community engagement, quality assurance, qualitative evaluation, customer service and data management.

Positioned as the single destination for households to become more energy efficient, Perth Solar City has become a trusted educator, helping customers to attain their identified goals of reducing their energy costs and helping the environment.

A UNIQUE PARTNERSHIP OF INDUSTRY, GOVERNMENT AND THE COMMUNITY ALL WORKING TOGETHER TO CHANGE THE WAY WE PRODUCE, USE AND SAVE ENERGY

THE PERTH SOLAR CITY CONSORTIUM

Western Power is supported by a Consortium of local industry leaders including the Botanic Gardens and Parks Authority, the Eastern Metropolitan Regional Council, Mojarra, Prospero Productions, Solahart, SunPower and Synergy.

To deliver on the objectives of the Perth Solar City program, the Consortium brings together a comprehensive range of energy efficiency products, services, engagement programs and technical trials (table 2-A).

Table 2-A: Perth Solar City Consortium

Consortium Member	Activities
Western Power is Western Australia's largest electricity distributor, connecting people with energy. Western Power builds, maintains and operates the electricity network in the south west of Western Australia, bringing power to more than 1.5 million West Australians every day.	• Program management – governance, compliance, quality assurance, program reporting, data management, marketing and communications, qualitative evaluation, customer service • Smart Grid Trial • Air Conditioning Trial – technical solution • Solar Photovoltaic Saturation Trial • School energy competition – Bring it Down
The Botanic Gardens and Parks Authority is a Western Australian State Government authority established to conserve and enhance Kings Park and Botanic Garden and Bold Park with the community, and to conserve biological diversity generally.	• Kings Park Education Building
The Eastern Metropolitan Regional Council (EMRC) is a progressive and innovative regional Local Government Authority working on behalf of six member councils located in Perth's eastern suburbs: • Town of Bassendean • City of Bayswater • City of Belmont • Shire of Kalamunda • Shire of Mundaring • City of Swan Providing services in waste management, environmental management and regional development.	• Behaviour Change via the Department of Transport's Living Smart program • Demonstration projects at 15 Local Government Authority sites • Sustainable Communities Competition
Mojarra provides renewable energy and energy efficient solutions to residential and commercial clients and are based in Cannington, Western Australia.	• 3,500 Home Eco-Consultations • 20 School energy audits
Prospero Productions is one of Australia's leading independent documentary production companies based in Fremantle, Western Australia. Prospero Productions have made quality, multi-award winning documentaries and documentary series for nearly 20 years.	• Eco Superstar documentary
Solahart pioneered solar water heating in Australia in 1953 and are a leading manufacturer of solar hot water systems, supplying over 80 countries worldwide. Solahart design and manufacture virtually all solar water heaters, including many of the components in Perth, Western Australia.	• 1,190 residential solar hot water systems
SunPower has been developing world record-breaking solar technology since the 1970s. SunPower is the global leader in developing high-efficiency solar solutions for homes, businesses, commercial buildings and utilities.	• 825 residential solar PV systems • Iconic solar PV installations: - Central Institute of Technology - Midland Atelier - Perth Zoo - stage one and two
Synergy is Western Australia's largest energy retailer, with over 900,000 residential and business customers.	• 2,200 In Home Displays • 375 Air Conditioning Trial participants recruited • 1,000 Time of Use Tariff trial participants recruited • Iconic solar PV installation - Perth Arena

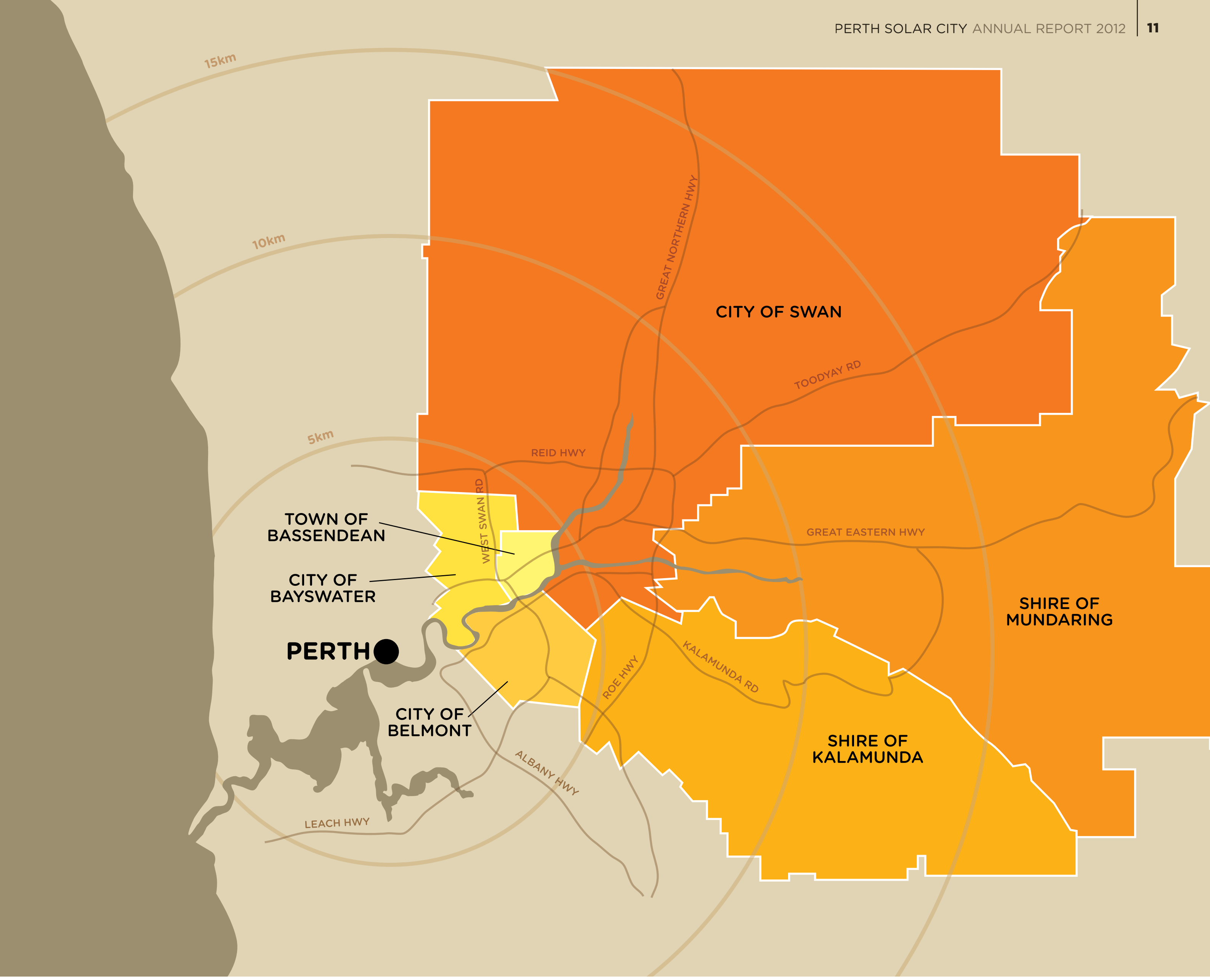


Image 2-B: Perth Solar City's target location

PERTH'S EASTERN REGION

Perth's Eastern Region was home to the Perth Solar City program, after the Eastern Metropolitan Regional Council (EMRC) was successful in its bid to host a Solar City.

Perth's Eastern Region stretches from the edge of the Perth central business district, along the Swan River, to the Swan Valley, and up to the Perth Hills (image 2-B). Home to approximately 300,000 people from diverse cultural backgrounds, Perth's Eastern Region is one of Perth's fastest growing areas. The Region encompasses 2,100 square kilometres or around one-third of the Perth metropolitan area and includes substantial parklands, river foreshore areas, national parks, state forests and water catchments.

The Region is a major transport hub, accommodating the international and domestic airport terminals and Kewdale Intermodal Freight Terminal, as well as major roads and rail infrastructure linking Perth to regional centres of the state and to the rest of Australia.

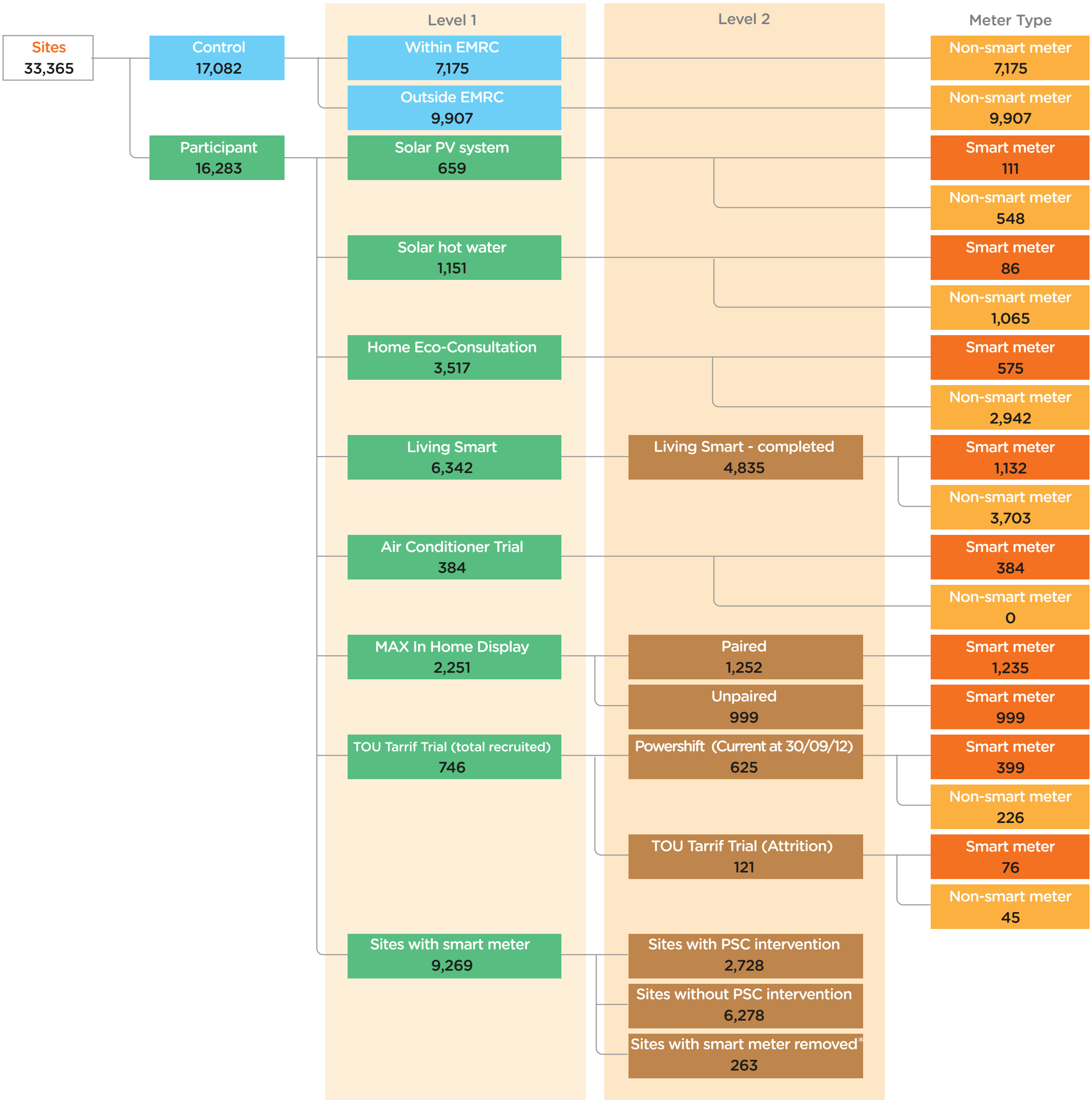
The EMRC's six member Councils include the Town of Bassendean, City of Bayswater, City of Belmont, Shire of Kalamunda, Shire of Mundaring and City of Swan.

Perth's Eastern Region is an ideal location to host a trial such as Perth Solar City, with its multiple demographic and geographic types.

PARTICIPATION IN PERTH SOLAR CITY

Between the Program launch on 5 November 2009 and the end of the community participation phase on 30 September 2012, a total of 16,283 households participated in the Perth Solar City program (image 2-C). Additionally, 17,082 households were used as a control dataset.

Image 2-C: Perth Solar City participation structure



*Testing and quality control

PROGRAM EXPENDITURE

As at 30 September 2012, the Perth Solar City program had expended $13,159,508 (94.7%) of the $13.9 million funding from the Australian Government (table 2-B).

Table 2-B Perth Solar City program expenditure to 30 September 2012

	Forecast Cash / In-Kind	Forecast DCCEE	Forecast Total	Actual Cash / In-Kind	Actual DCCEE	Actual Total
Total expenditure	$29,141,819	$13,159,508	$42,301,328	$30,945,751	$13,159,508	$44,105,258

TECH

NOLOGY

SMART GRID TRIAL
AIR CONDITIONING TRIAL
IN HOME DISPLAY TRIAL
TIME-OF-USE TARIFF TRIAL
PHOTOVOLTAIC SATURATION TRIAL
RESIDENTIAL SOLAR PV SYSTEMS
RESIDENTIAL SOLAR HOT WATER SYSTEMS

3.0 SMART GRID TRIAL

3.1 BACKGROUND

Smart grid, and the enabling smart metering infrastructure, is new technology shown to enable customers to better manage their electricity use, help reduce peak demand, facilitate the greater uptake and management of renewable generation, as well as increasing network efficiency.

Peak load growth is a significant challenge for the Western Australian electricity market, contributing to growth in the capacity requirements of the network and generation, and contributing to increased energy prices. Affordability of electricity is a growing concern.

The Perth Solar City program has provided Western Power with a unique opportunity to prove smart grid technology, and to quantify the costs and benefits that accrue to customers and the network.

Western Power's Smart Grid Trial is strategically significant for the State of Western Australia as its outcomes have contributed towards informing government and the community of the societal costs, benefits, risks, and mitigating actions associated with a broader deployment. Experience and evidence from this trial has assisted Western Power in setting a strategic direction for future planning, design and operations.

Smart grid provides an enabling platform to test the capabilities and measure the benefits to both the customer and the network. These benefits may be accrued through the application of:

- customer applications – development, deployment and customer response to electricity management tools such as In Home Displays
- community engagement – the opportunity to test and understand the most effective communications and engagement strategies for the smart meter installation, as well as the recruitment of householders to participate in one or more of the smart grid enabled products and services, such as MAX (In Home Display Trial), ACT (Demand Management Trial) and PowerShift (Time-Of-Use Tariff Trial)
- demand management - development, deployment and quantification of demand response products such as ACT, MAX, and PowerShift as tools to reduce energy consumption, particularly at peak times
- distributed generation - a Solar PV Saturation Trial to understand and manage the aggregated impact of the large-scale uptake of distributed generation by households
- distribution automation and operational efficiencies - the ability to test grid automation and remote applications to increase network efficiency, reduce costs, enhance reliability and power quality
- system integration and efficiencies - Western Power technical and business processes, including improved outage management processes and response times

In order to adequately test these applications, the meter and secure two-way communications technology was designed to align with the Ministerial Council on Energy (MCE) recommended minimum functional requirements (Appendix A) including, but not limited to:

- remote meter reading and data collection
- remote connection and disconnection of supply
- remote meter software and tariff configuration
- remote communications configuration and Home Area Network (HAN) Energy Services Portal provision and management, and HAN service provision, including real-time energy and pricing information to consumers
- demand management functions (planned and emergency) and interfaces with system management control and monitoring systems
- real time outage and restoration data integration with existing trouble call and customer management systems
- power quality measurement

2011 RE-CAP

PROGRESS

Western Power's Smart Grid Trial as part of Perth Solar City has three core objectives:

- to prove end-to-end smart grid technology including the establishment of the HAN as an open platform for delivering additional services to customers
- to understand customer response to smart grid technology
- to develop a robust cost benefit analysis for a wider roll-out of the smart grid technology

KEY RESULTS

Deployment – meter installations

As at 30 November 2011 Western Power exceeded its target of 8,767 smart meters, installing a total of 8,944 smart meters in the EMRC suburbs of Bassendean, Darlington, Forrestfield and Midland.

Operation – MCE benchmarks, HAN, network management system

As at 30 November 2011, the three key elements of the smart grid infrastructure - smart meters, communications infrastructure, and the network management system - have been successfully deployed and are operating as planned or exceeding performance benchmarks, including the HAN.

Evaluation – community engagement

A survey of 104 smart meter recipients was conducted during October 2010, with the following results:

- level of satisfaction: 82% of customers surveyed rated the smart meter installation process as either excellent, very good, good or neutral. 6% of recipients rated the process as very poor
- level of understanding regarding the benefits of the smart meter (unprompted and prompted): 62% of smart meter recipients did not understand the benefits of smart meters
- interest in receiving further smart meter related information: 88% of recipients wanted to know more about the benefits of their smart meter

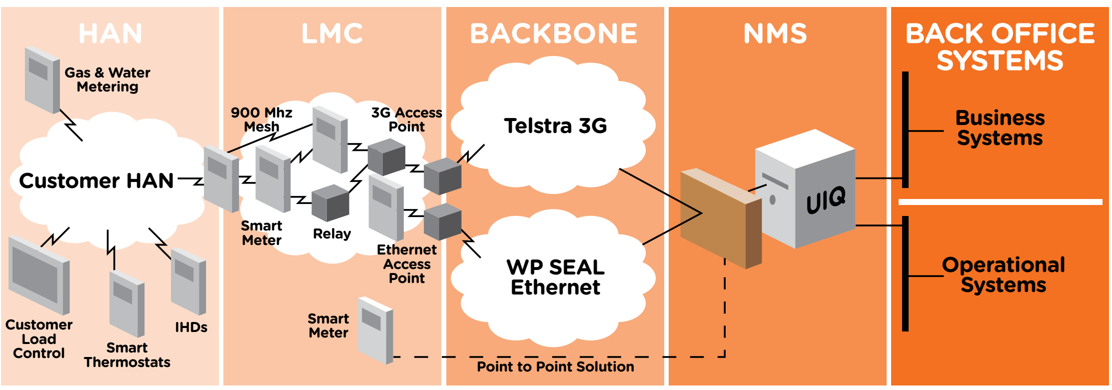
A key enabling technology of the smart grid is the smart meter and associated communications infrastructure. The Smart Grid Trial under Perth Solar City replaced basic function electronic and electro-mechanical meters with advanced function electronic meters that are communications enabled, accommodating the two-way flow of electricity and information.

The establishment of the customer HAN - an open communications platform enabled in the home by the smart meter, provides for additional services to customers. This includes access to real time energy consumption information via a number of tools such as In Home Displays, computer-based USB portals and intelligent devices, and smart-phone applications, as well as participation in incentive based appliance demand management trials (for example air-conditioners).

The smart grid end to end system designed for Perth Solar City is integrated wirelessly from the customer meter through to Western Power's network management system via a radio frequency mesh, and ethernet backbone (image 3-A).

The technology was chosen through a competitive worldwide tender process to source a best-of-breed, end-to-end application suitable for both the Western Australian energy market and local geographic conditions. The tender comprised of smart meters, the communications system and the smart grid network management system.

Image 3-A: End to end system



HAN – Home Area Network | **LMC** – Last Mile Communications (RF Mesh – Silver Springs)
Backbone Comms – Substation Equipment Access Link and 3G | **SSN** – Silver Springs Networks
NMS – SSN Network Management System for Smart Grid-AMI | **UIQ** – SSN Utility IQ Product Suite

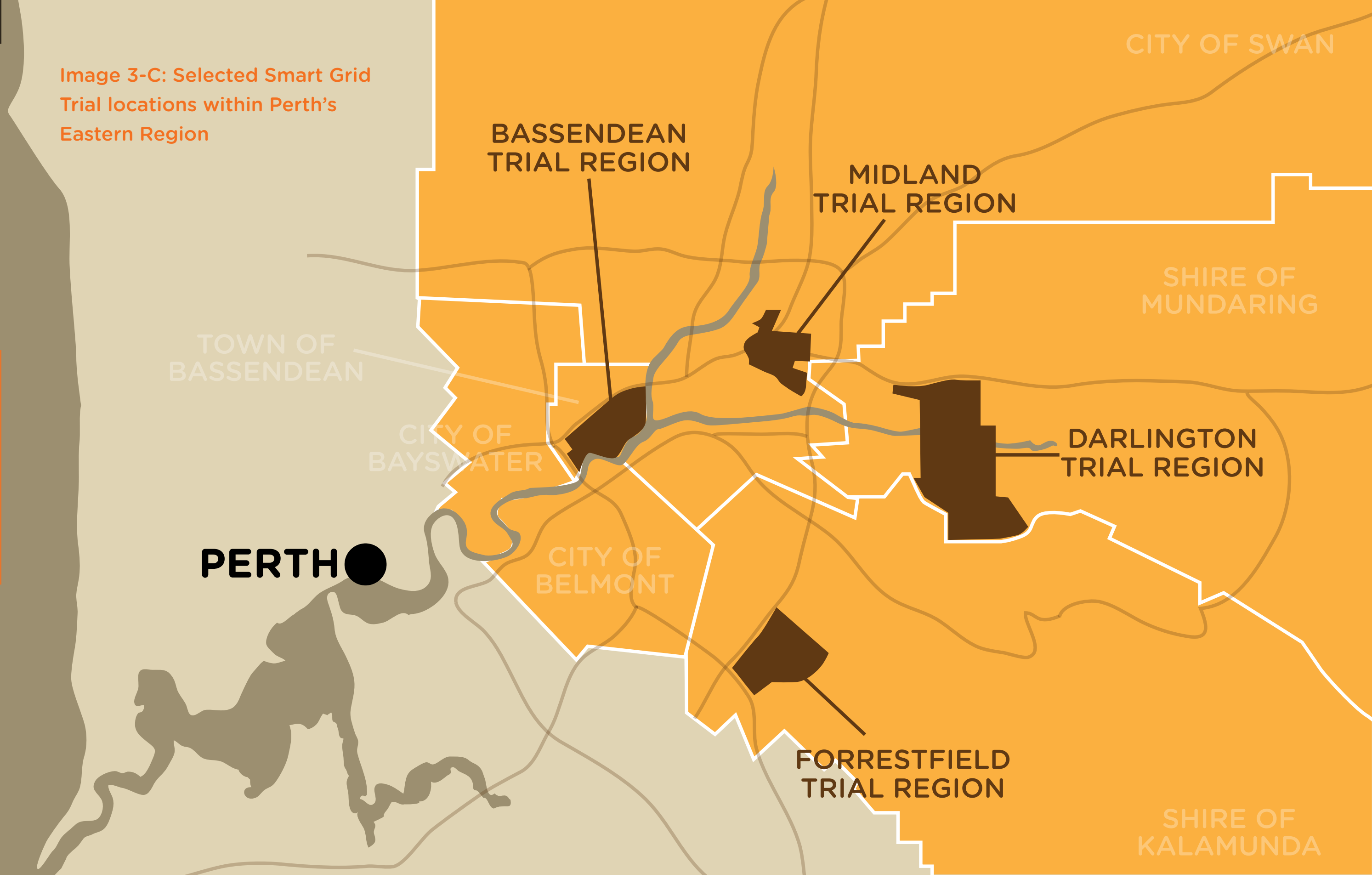
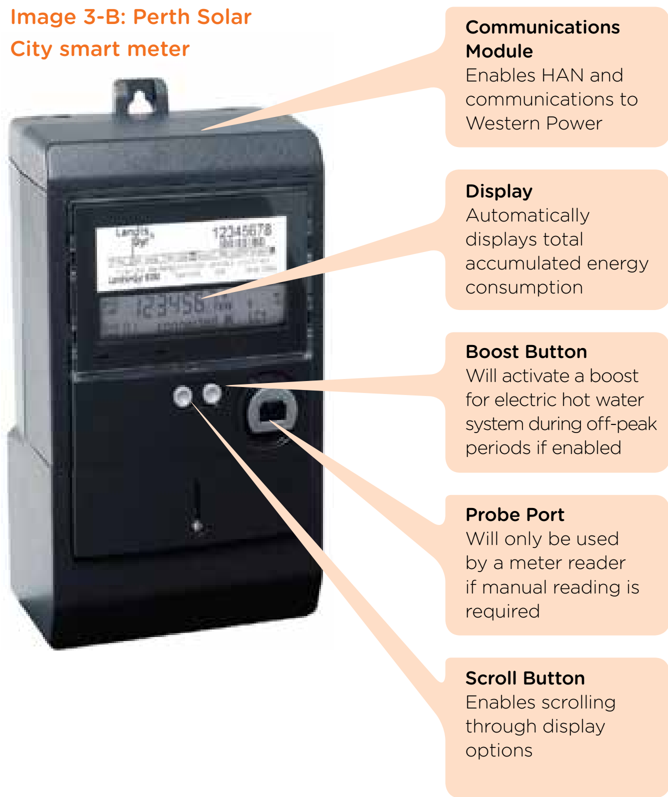


Image 3-C: Selected Smart Grid Trial locations within Perth's Eastern Region

Image 3-B: Perth Solar City smart meter



This further involved tendering for smart meters and associated communications infrastructure, field deployment services, evaluating and testing smart meters, and installing, commissioning and enabling the HAN by integrating smart meters to the communications backbone. This would provide an open and upgradable platform that aligns with MCE minimum recommended functional requirements.

As an outcome of the tender, Western Power selected Landis and Gyr to provide the smart meter (image 3-B), with Silver Springs Networks providing the smart grid network management platform.

The Smart Grid Trial has installed over 9,000 smart meters in four specific locations within Perth's Eastern Region - the suburbs of Bassendean, Darlington, Forrestfield and Midland (image 3-C).

These suburbs were selected as well-suited locations due to a strong variability between the selected locations of demographic, geographic and infrastructure factors, including:

- percentage owner/ occupier
- the Index of Relative Socio-Economic Disadvantage
- average electricity consumption
- power quality and reliability benefits
- demand response benefits
- ability to test communications technology
- sufficient number of meters

3.2 OBJECTIVES AND PROGRESS

Western Power's Smart Grid Trial as part of Perth Solar City has three core objectives:

- to prove end-to-end smart grid technology including the establishment of the HAN as an open platform for delivering additional services to customers
- to understand customer response to smart grid technology and associated energy efficiency and peak demand programs
- to develop a robust cost benefit analysis for a wider roll-out of the smart grid technology

To achieve these objectives, Western Power established Key Performance Indicators (KPIs), as outlined in table 3-A:

Table 3-A: Key Performance Indicators for the Smart Grid Trial

Key Performance Indicator	Timeframe	Status	Comments
Deployment			
Installation locations selected	2009/10	Complete	Locations selected in Bassendean, Darlington, Forrestfield and Midland
Procurement (meters, communications and system integration services) completed	2009/10	Complete	Procurement completed
Lab/ field testing of meters and communications completed	2009/10	Complete	Lab testing complete for single phase, three phase and CT meters
Pre-deployment customer notification campaign completed	2009/10	Complete	Customer notification campaign complete
Installation of 8,767 smart meters completed	2010/11	Complete	Meter installation complete. Installation target exceeded
Validation of sites completed	2010/11	Complete	Site validation audit complete
Installation of 40 point-to-point meters on iconic, demonstration and school sites	2011/12	Complete	Point-to-point meters installed on all eco-house, residential test sites, iconic, demonstration and school sites where mesh coverage was not achieved
Operation			
MCE function 1, 2 and 9 – half hour interval data recorded and remotely read	2010/11	Complete	Interval data receipt performing above benchmarks
MCE function 6 – tamper alarm detection	2011/12	Complete	Tamper alarm functionalist validated and integrated into business systems
MCE function 15 and 16 – HAN enabled	2010/11	Complete	HAN enabled with performance above SLA.
MCE function 12 – remote connect/ disconnect	2011/12	Complete	Performance above SLA
MCE function 10, 11 and 18 – appropriate import/ export and power quality data captured	2011/12	Complete	Data collection achieved
Evaluation			
Cost benefit analysis completed	2010/11	Complete	Cost benefit analysis complete
Customer notification – evaluation completed	2010/11	Complete	Evaluation completed
Business as usual operation model completed	2011/12	Complete	Metering operational processes identified and documented. Smart meters will remain ring-fenced until trial completion in June 2013.
Cost-Benefit Analysis	2011/12	Complete	Smart Grid cost benefit analysis completed. Regulatory submission for wider application of smart grid technology completed. Submission approved by Regulator.
Ongoing evaluation and data analysis of asset performance	2012/13	On track	Evaluation and analysis of asset performance included in this report
Energy efficiency/ customer benefits of HAN applications quantified	2012/13	On track	Analysis of PSC interventions included in this report

3.3 KEY RESULTS

Key results are provided below for each of the three Key Performance Indicators outlined in section 3.2:

- deployment
- operation
- evaluation

3.3.1 DEPLOYMENT

Western Power's target was to install 8,767 smart meters, along with associated communications infrastructure. As at 30 September 2012, a total of 9,276 smart meters had been installed in Bassendean, Darlington, Forrestfield and Midland (table 3-B). A breakdown of smart meter installations by type and location is provided in image 3-D.

Table 3-B: Smart meter deployment

Sub-Project	Program target	Achieved
Smart meters installed	8,767	9,276
Point to point smart meters installed	40	22

Due to the trial nature of the Program, the meter exchange rate after installation is higher than normally seen. Western Power removed or replaced 276 meters for the following reasons:

- 181 exchanged for maintenance or evaluation testing
- 32 exchanged due to an upgrade or changes to the site's power supply
- 63 removed due to site abolishment or urban development

Current Transformer smart meters

Sites with large electricity loads can require a Current Transformer (CT) meter. Perth Solar City had 32 iconic, demonstration and school sites which required a CT solution.

Western Power tested and installed 14 CT smart meters. As the meters were not commercially available at the time, Western Power had meters specifically manufactured for the trial. These CT smart meters were installed at selected Perth Solar City iconic and demonstration sites such as Midland Atelier, Kalamunda Library and Altone Park Leisure Centre.

Point to point smart meters

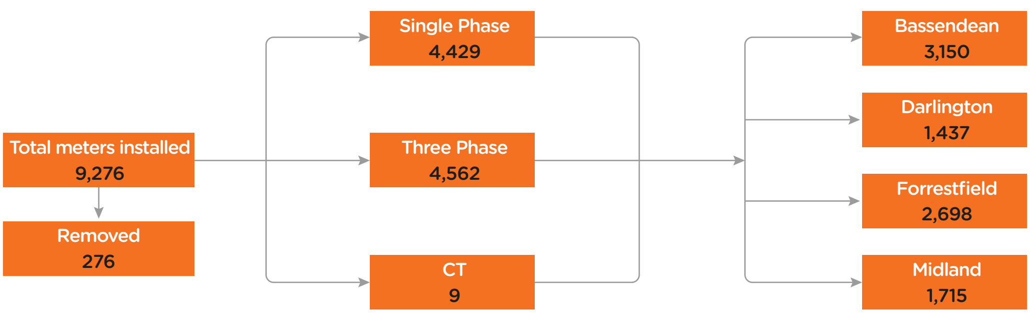
A point-to-point solution is required where a communications mesh is not available. The point to point solution utilises existing 3G carriers for remote communication, and is significantly more operationally and cost intensive when compared with a mesh solution. Western Power installed 22 point-to-point smart meter solutions, including 12 CT, three single-phase and seven three-phase meters.

Three phase gross solar PV system data

Without gross metering, it is not possible to collect the gross generation data from a solar PV system. Gross data is used to measure the performance of a system against simulations or manufacturer specifications. Western Power collected the gross output data of 46 residential solar PV systems installed at households that had a smart meter.

This was achieved at single-phase smart meter sites by configuring the spare second element in the meter to record gross solar PV system output, whilst simultaneously recording overall net measurement as per market requirements. A total of 32 single-phase sites were configured this way. At three-phase sites, a second meter is required, and a total of 14 additional meters were installed.

Image 3-D: breakdown of smart meter installations by phase and suburb



Limitations exist in some three-phase sites due to the restricted size of the meter-board preventing installation of a second meter.

3.3.2 OPERATION

The three key elements of the smart grid infrastructure - smart meters, communications infrastructure and the network management system - have been successfully deployed and are operating as planned or exceeding performance benchmarks, including the Home Area Network.

The benchmarks for each of the operational KPIs are outlined below, along with performance against these benchmarks. Overall, the Perth Solar City smart grid system has consistently exceeded performance benchmarks.

Note: the information provided below includes benchmarks and performance from Western Power's regional Smart Grid Trial under the Green Town project. The Green Town project included the installation of 2,173 smart meters in the Western Australian south coastal towns of Denmark and Walpole, which is not part of the Perth Solar City program.

MCE function 1, 2 and 9 – Half hour interval data recorded and remotely read

Interval data transfer to the Western Power back office is measured by performance against the following benchmarks:

Category	Bench-mark	Achieved
Interval data transfer - within 4 hours	99.00%	99.66%
Interval data transfer - within 24 hours	99.90%	99.91%

The performance of data transfer for the period 1 October 2011 to 30 September 2012 was above the required benchmarks (image 3-E and 3-F).

Image 3-E: Performance against Service Level Agreement benchmarks for 4 hourly data reads

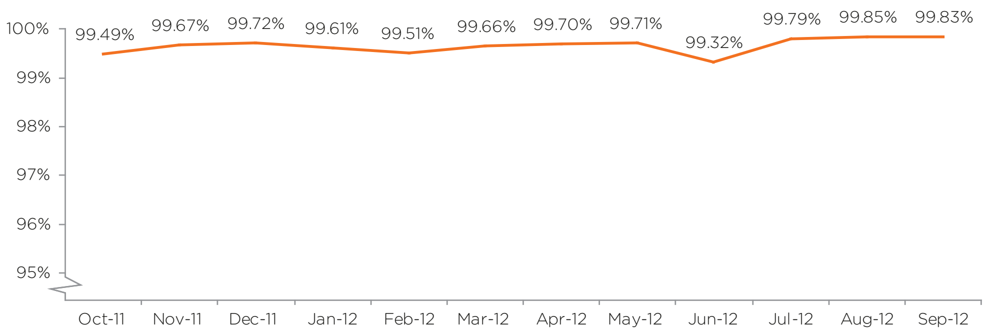
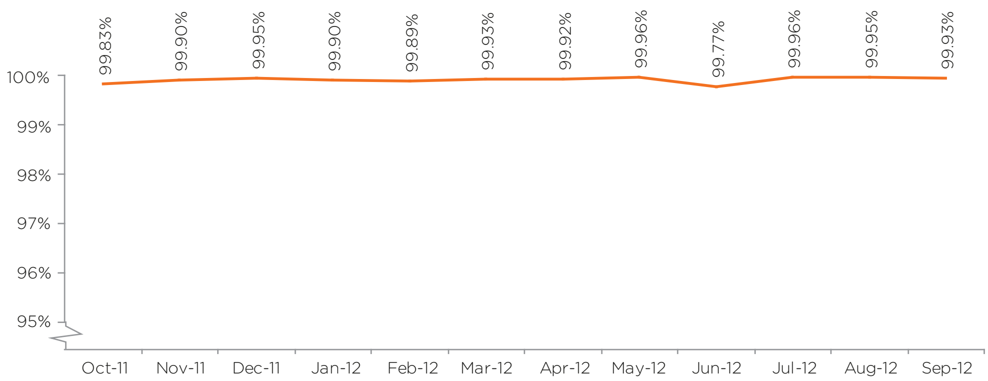


Image 3-F: Performance against Service Level Agreement benchmarks for daily interval data reads



During June 2012, Western Power transitioned smart meter interval data delivery to market daily. This has resulted in less data spikes when compared with delivery at the end of 60 day billing cycle. Daily delivery of data has also resulted in the quicker detection of meter faults.

For the 9,000 meters currently in service under Perth Solar City, Western Power would traditionally conduct meter reads every 60 days, representing a total of 54,096 reads per annum. Under the smart grid platform, interval data is recorded every half hour, representing a total of 157,680,000 intervals per annum, and a total of 3,285,000 daily reads published to market annually.

To accommodate for the significant increase in meter data, the interval data engine component of Western Power's market systems (used for commercial and contestable customers) was upgraded. Western Power's interval data capacity is within the forecast growth of industrial and commercial customers for the foreseeable future. However, any additional wider roll-out of smart meters on the SWIS would require new investment and expansion of Western Power's interval data systems.

Network Management System

The Network Management System for the Smart Grid Trial, known as Utility IQ (UIQ) is provided by Silver Springs Networks. UIQ is the central control and monitoring point for the smart meters and communications infrastructure. In the event of system down-time, Western Power would be unable to remotely read meters or issue service commands to meters, such as reconnect/ disconnect commands.

Category	Benchmark	Achieved
Network management System availability time	99.50%	99.96%

During the period 1 October 2011 to 30 September 2012, the Network Management System experienced 3.5 hours of total down time, or 0.04%, exceeding the performance benchmark (image 3-G).

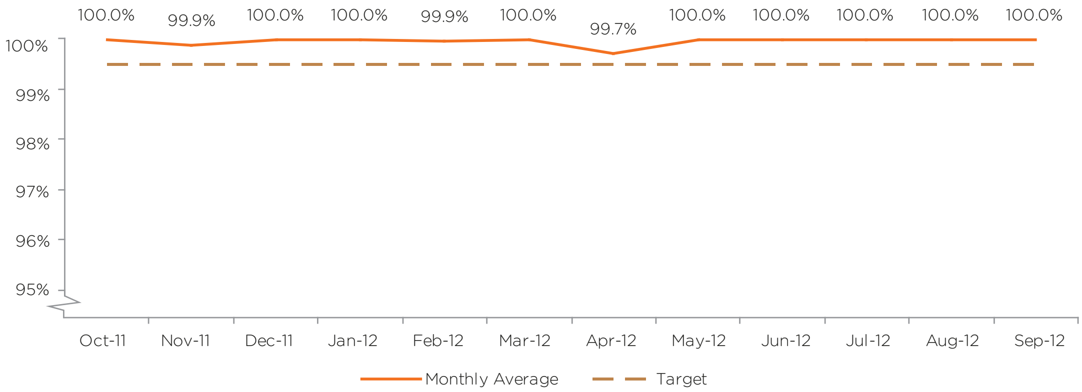
Backhaul communication infrastructure

The backhaul communication infrastructure provides the 'large pipe' communications link from the Western Power back office into the suburbs where the last mile mesh commences. This infrastructure is made up of existing Western Power fibre and microwave communication links to substations, or a public carrier 3G private ethernet cloud to redundant access entry points, which provide access into the last mile radio-frequency mesh. Backhaul communication is a critical component in the two way transfer of data between individual meters and the Western Power back office. The specific performance benchmarks for backhaul communication connection availability are:

Category	Benchmark	Achieved
Backhaul communication connection availability	99%	100%

Since the inception of the backhaul communications network in April 2010, the availability of the infrastructure has not dropped below 100%. A backhaul link failure for an ethernet access point

Image 3-G: UIQ availability



occurred in the Bassendean trial area from 3 to 17 April 2012. No loss of communication with customer meters was recorded as the Ethernet access point was backed up by the 3G access point in Bassendean.

MCE function 6 – Tamper alarm detection

Meter tampering can occur when electrical wiring in a premise is altered to bypass a meter. This can result in safety issues for meter readers and the general public through potential electric shock or fire. Detection of meter tamper can often take months and result in revenue loss and cross-subsidisation by other consumers.

A meter in the Forrestfield trial location appeared to lose communications after approximately three days following installation. A 'last gasp' message was the last recorded event from the meter. This indicated a possible tamper, as the meter had a state change from 'active' to 'unreachable', indicating a loss of communications. Following a site visit, the meter was found to have been tampered with.

The early detection of a possible tamper, in this case within three days, minimised the potential fire and safety risk for residents and resulted in minimal revenue loss. In addition, the remote detection reduced the safety risk to technicians attending the site. Western Power has completed the integration of meter tamper alarms into the metering business system. This allows automatic work allocation and investigation following receipt of a tamper alarm.

MCE function 15 and 16 - Home Area Network enabled

Interfacing with an In Home Display to provide real-time energy consumption information to households, and the load management of in-home appliances such as air-conditioners via the HAN has been achieved using an open standard (chapter 4 and 5).

The specific performance of the HAN can be measured in the time period within which a command is received remotely by a HAN-enabled device (issued from Western Power's head office). For example, commands are issued to participating air-conditioners during a load-cycling event as part of the opt-in Air Conditioning Trial (chapter 4). The specific performance benchmarks for the HAN are:

Category	Benchmark	Achieved
Command received by device – within 3 hours	90%	100%
Command received by device – within 12 hours	99%	100%
In Home Display real-time updates from meter – within 10 seconds	90%	100%

Throughout the Smart Grid Trial, the HAN operated as expected for 100% of commands where the design of the installation is within the distance limits of the HAN Zigbee wireless technology.

Some communication issues were encountered where meter points are located more than 50 metres from the home. During 2012, Western Power tested and overcame this issue with the use of an external antenna attached to the meter, or through the use of signal repeaters.

The main drawback with the repeater technology is that the repeaters require a constant power source, which would either need a plug-in or connection to the electricity wiring on the premises, or a battery/solar solution.

Through lessons learnt within the trial, Western Power has contributed to the draft Zigbee Smart Energy Profile 2.0 standard, as recommended by the Standing Council on Energy and Resources (SCER) in the national minimal functional specifications of smart meters. A future solution to overcome HAN distance issues is currently included in the draft standard, and will allow the use of the power-line connection to the residence to carry the Zigbee signal.

MCE function 12 - Remote connect and disconnect

Disconnections and reconnections can be requested by a building occupier to allow electrical or maintenance work on the property. Alternatively they may be requested by the retailer after a customer leaves a premises, or as a result of non-payment of electricity accounts. The ability to remotely disconnect and reconnect the power supply to an individual premises offers benefits to the customer and the network operator by:

- negating the requirement for a vehicle and qualified contractor to visit the site. Cost and productivity efficiencies result as not only is the time taken to carry out the work significantly reduced, but field resources can also be utilised for alternative purposes
- significantly reduced power restoration time. Power can be restored within minutes of a reconnection request being submitted. Currently, reconnection can take two business days in the Perth metropolitan area, and up to five business days for regional customers
- potentially reducing customer costs in the case of customer-requested disconnections and reconnections, as generally the cost for these services is passed on to the requestor

Targeted performance benchmarks for the remote connection and disconnection of power supply are:

Category	Benchmark	Achieved
Remote connect/ disconnect – within 10 minutes	90%	100%
Remote connect/ disconnect – within 1 hour	99%	100%
Remote connect/ dis-connect – within 6 hours	99%	100%

Over the duration of the trial, Western Power has completed remote customer connections at 275 sites and disconnections at 280 sites using the smart grid technology. In all cases, disconnection and connection commands were received and activated by the meter within zero to two minutes.

The average time to achieve remote disconnection or reconnection of power supply was 49 and 21 seconds respectively (image 3-I). This significantly exceeds the service benchmarks outlined above.

Note: disconnection time is calculated from UIQ to meter point only. Additional automation time periods for downstream commands, such as automated requests via the electricity retailer, have not been included here.

Connection and reconnection times under the business as usual approach rely on field technicians attending sites following the receipt of a service order. During 2011/12 Western Power completed 11,549 metropolitan disconnections and 11,680 reconnections. The average business as usual time to complete a metropolitan service request was five days for a disconnection, and 1.5 days for reconnection (image 3-H).

Use of the smart grid infrastructure provides the opportunity to significantly reduce this time frame, and associated costs. Western Power's Smart Grid Cost Benefit Analysis estimates the wider use of smart grid technology for remote connection and disconnection will save the electricity supply chain approximately $6 million over a 20 year period.

A manually performed metropolitan reconnection request is, on average, completed within 1.5 business days, and disconnection within 5.4 business days of the initial service request. To calculate the average number of days to complete a service request, a same day service is counted as zero days. By using AMI functionality, and subject to business process integration, the disconnection service could be improved to a same day service, complying with the prescribed times for the Western Australian metering code. The reconnection service could also be improved and offered as a potential 24/7 service if appropriate retailer, network and regulatory processes are introduced.

Image 3-H: Business as usual connect/disconnect timeframes (non-smart grid)

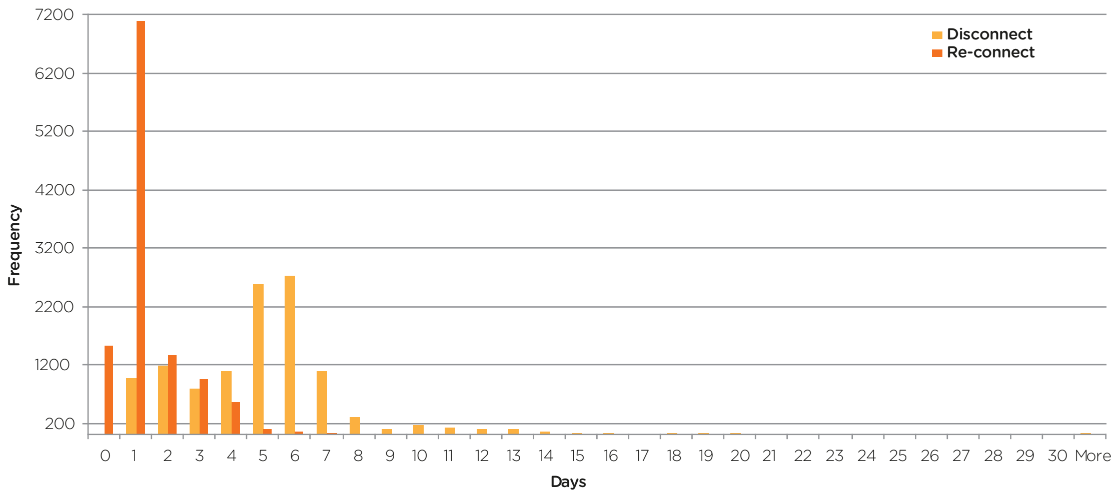
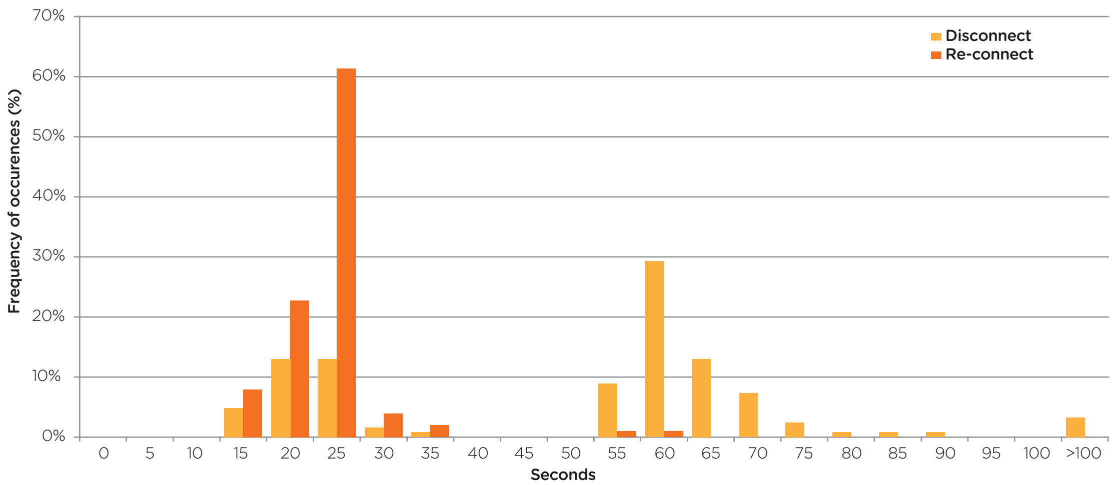


Image 3-I: Connect/disconnect timeframes (using smart grid)



MCE function 10, 11 and 18 - Appropriate import/ export and power quality data captured

The capture of power quality data provides opportunities to understand and potentially implement measures that will increase the operating efficiency of the network and reduce expenditure. Datasets captured are:

MCE function	Description	Measurement
10	Half-hour reactive interval energy measurement and recording on single and three phase meters	Reactive power (kVarh)
11	Records active energy flows both into the electricity grid and out, where the customer has installed local generation (e.g. solar PV systems)	Net import/ export (kWh)
18	Enables meters to record information in relation to quality of power supply and other events (e.g. an outage). The event log could then be read remotely.	Voltage profile Voltage events (+/ - 10% of nominal voltage - 240V)

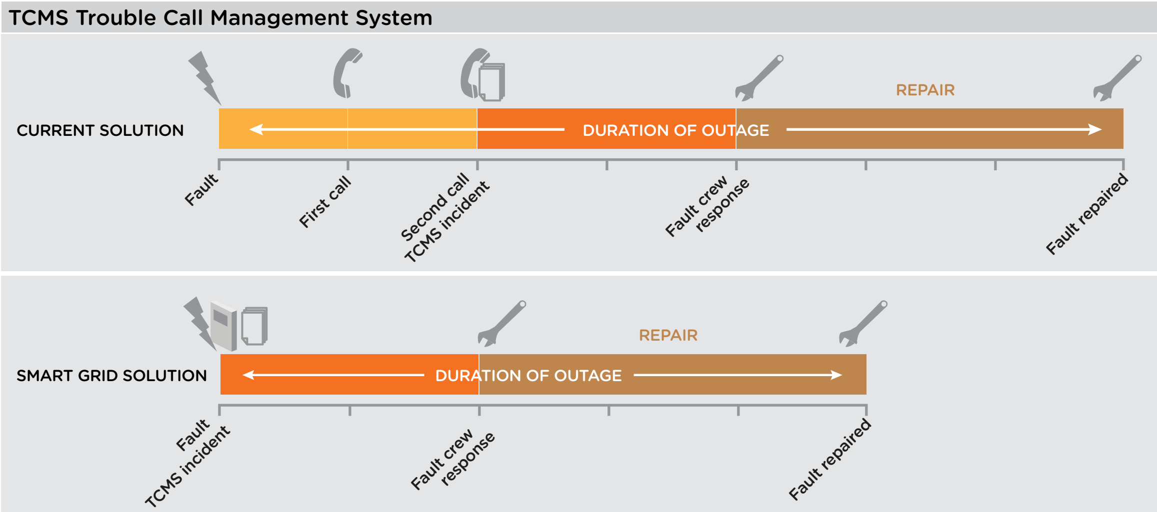


Image 3-J: Outage detection solutions

Recording these datasets provides the network operator with the ability to:

- detect power quality issues prior to customer complaints, and allow planners to identify locations for improvement
- identify voltage non-compliance and proactive remedial action
- improve identification of overloaded transformers
- validate network modelling tools and subsequently rectify identified power quality issues (section 3.3.3)
- identify phases of connection and load on each phase (section 3.3.3)
- identify locations for capacitor installations to optimise power factor and improve the capacity and efficiency of the existing network
- correlate photovoltaic system output with power quality data for the purposes of the Solar PV Saturation Trial (chapter 8)

Data capture results for the Perth Solar City Smart Grid Trial are:

Criteria	Results
MCE function 10	Successful in 100% of three phase smart meters. During February 2012, Western Power successfully captured and remotely retrieved single phase reactive power measurements for the purposes of power factor analysis
MCE function 11	Successful in 100% of renewable energy sites
MCE function 18	Successful in 100% of sites selected for PV Saturation Trial

MCE function 19 - Loss of supply detection and outage alarm

The detection of network outages is largely reliant on customers self-reporting. Initially, a single call triggers a single point fault response (low priority). When subsequent calls are received, Western Power utilises predictive modelling to determine the severity and extent of the fault, and responds accordingly.

During storm events additional secondary faults (also known as nested faults) can often occur. Secondary faults regularly affect the power supply to an individual customer (e.g. a fallen tree damaging an overhead service lead) and are mostly unrelated to the primary fault.

Currently, upon resolution of the primary fault, the ability for crews in the field to recognise any secondary faults is limited, as power supply visibility is only available at the transformer or fuse level. This can contribute to both extended outages for those affected by secondary faults and the inefficient repeated dispatching of crews to a single area.

Via the smart grid, Western Power can gain visibility into network outages at any individual meter point (image 3-J). This enables a quicker response and resolution of outages, resulting in better outcomes for customers. Upon restoration of power supply, smart metering enables the immediate visibility of any meter points without power supply caused by a secondary fault. This allows service crews to easily identify and restore power to all customers who may have otherwise remained without supply following resolution of the original fault.

Image 3-K: Anstey transformer LV network

Image 3-L: Anstey transformer distribution LV network

An example of this benefit was observed in the Darlington trial area. A fault occurred at 2:49am on 1 August 2012. Under the conventional (non-smart meter) fault resolution process, the second customer call (which was not received until 5:30am) triggered a Western Power investigation. Meanwhile, 34 smart meters sent 'last gasp' messages at 2:49am, which would have triggered a Western Power investigation and faster power restoration.

Furthermore, through smart metering, Western Power was able to identify that power had been restored to all 34 sites, and that no nested faults existed. This is particularly beneficial in the case of sensitive customers, such as those with life support equipment.

3.3.3 EVALUATION

Network benefits

Network benefits analysed during 2012 have focused on the following:

- transformer utilisation
- phase balancing
- unscheduled meter reads

Transformer utilisation

Many network businesses, including Western Power, rely on mapping tools and bi-monthly/quarterly meter reads to estimate and plan for transformer utilisation. A critically overloaded transformer is one that is nearing 135% of its nominal capacity at any time. Overloaded transformers will require reconfiguration or replacement to ensure adequate capacity and power quality is maintained. However, current mapping tools and meter readings can produce results that do not accurately reflect actual transformer peak loading.

Western Power analysed critically overloaded transformers during the summer of 2011/12, which were located in the Perth Solar City area. The Anstey transformer (image 3-K and 3-L), located in Bassendean, was forecast to reach 147% of its nominal capacity. Furthermore, plans were in development to install a new transformer and reconfigure the low voltage network accordingly.

By analysing voltage data from the smart meters, Western Power was able to determine that 40 of the 146 meters had been incorrectly mapped to the Anstey transformer. As a result of the smart meter data analysis and subsequent correction of mapping tools, reconfiguration of the local network was not required.

This method of validating network models, and integrating it into an automated dynamic network management system, can deliver ongoing network benefits and potentially delay infrastructure expenditure.

In addition, such analysis can assist Western Power in its efforts to continually improve its validation of those parts of the network to which sensitive customers are connected. This in turn further ensures customer safety during planned and unplanned outages.

Phase balancing

Electricity is supplied to residential households across three phases (red, white and blue). Electricity supply would ideally be balanced across each phase. However, single phase metered sites on a low voltage network can be unequally distributed between the three phases. This can lead to unbalanced phase loading and the underutilisation of transformers, excessive voltage drop, power quality issues and premature ageing of transformers.

Resultant issues are identified largely via customer complaints regarding power quality and overvoltage. The current methods of determining phase allocation require site visits, using costly resources. Utilising the smart grid solution, low voltage alarms at the meter point can trigger phase allocation analysis. Analysis can then be undertaken remotely using instantaneous voltage readings captured by the smart meter to determine phase allocation.

A quality-of-service alarm from smart meters in Darlington highlighted power quality issues on the Ryecroft 2 low voltage network. Using the smart meters to identify the phase connection of single phase meters determined that load imbalance on the phases north of the transformer was causing excessive voltage drop for customers on the overloaded phase (image 3-M).

Following the analysis, Western Power was able to balance the phase allocation, thus proactively avoiding transformer degradation while enhancing power quality.

Unscheduled meter reads

Unscheduled or 'special reads' are required when customers query meter readings or when a customer moves in or out of a property. This is required for around 20-25% of sites annually. Manual reads, requiring a meter reader to attend the site, cannot always be achieved on the desired date. Further, manual reads are hand-written and entered into a database.

Under a smart grid solution, such special reads are completed remotely and on the required date. These readings also provide more accurate billing. Reduced site visits represent a quantifiable cost saving.

Western Power utilised smart meters to conduct a total of 1,255 special reads for the period 1 February to 31 July 2012 (image 3-N and 3-O). This method significantly reduced deviation from the targeted read date for business as usual special reads.

Under a wider smart meter deployment it is estimated that this will save approximately $12.9m in operational expenditure over 20 years, and result in improved customer experience.

Participant evaluation

Western Power commissioned TNS to undertake detailed participant evaluation for the Perth Solar City technical trials. This included the smart meter as the platform enabling additional energy efficiency products and services.

A total of 463 smart meter recipients were interviewed. This included households who received a smart meter and participated in a trial (In Home Display, Time-of-Use Tariff or Air Conditioning Trial) as well as those that only received a smart meter. The objectives of the analysis were to understand the following:

- perceived impact of smart meters on electricity usage and electricity bills
- participant attitudes towards smart meters
- support for smart meter technology

Perceived impact of smart meters on electricity usage and electricity bills

Approximately 36% of recipients perceived the smart meter to be a tool to help them reduce electricity use (image 3-P). A total of 37% of households perceived the smart meter to have reduced their electricity bills. A minor proportion perceived the smart meter to have increased their electricity usage (3%) and electricity bills (6%).

Participant attitudes towards smart meters

Attitudes towards smart meters were positive, with customers responding that smart meters assisted with the monitoring and subsequent reduction of electricity use (image 3-Q). The most common concern regarding smart meters were billing issues and a perceived lack of communications regarding trial outcomes.

Image 3-M: Phase loading on Ryecroft 2

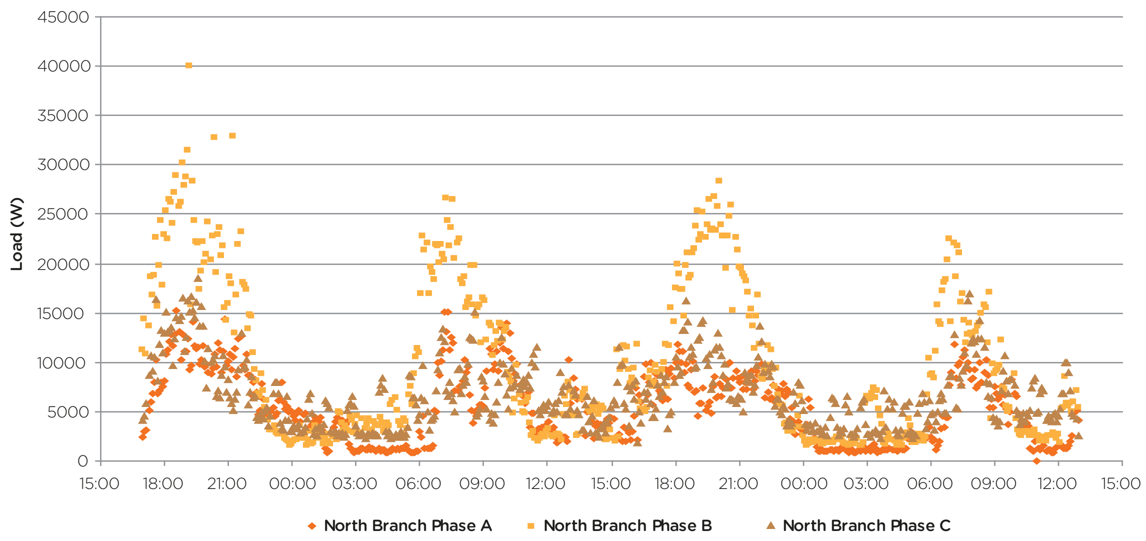


Image 3-N: Service level - Business as usual special reads

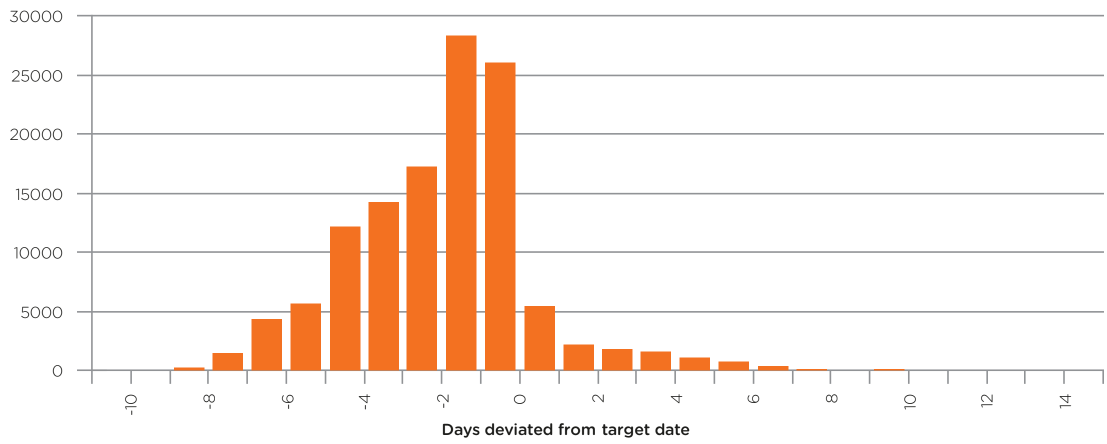


Image 3-O: Service level – smart grid special reads

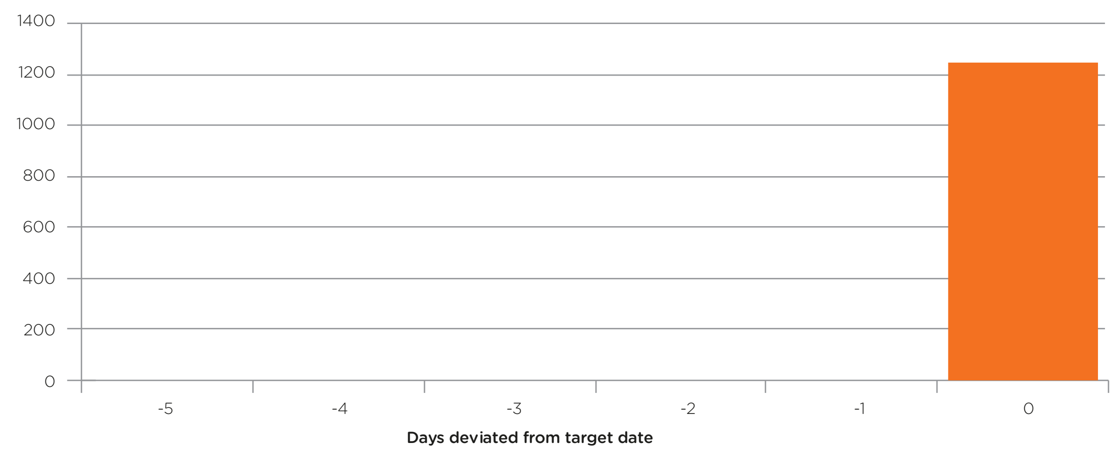


Image 3-P: Impact of smart meters on electricity use

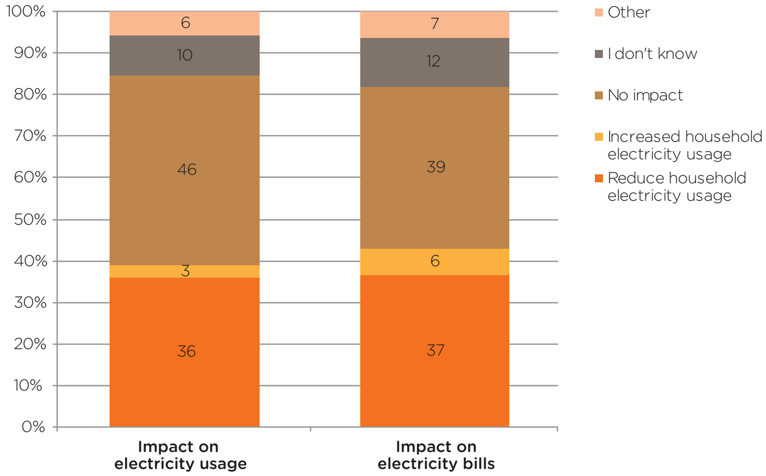


Image 3-Q: Attitudes towards smart meters

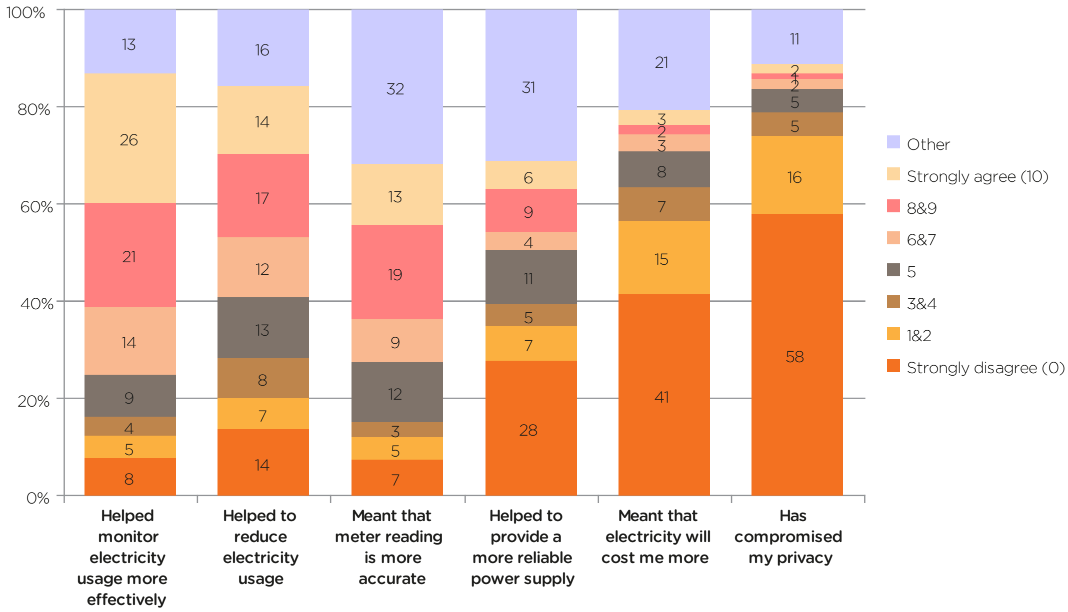


Image 3-R: Support for smart meter technology

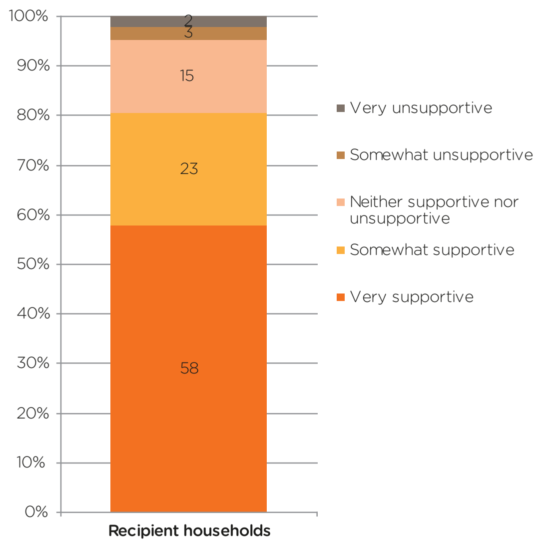
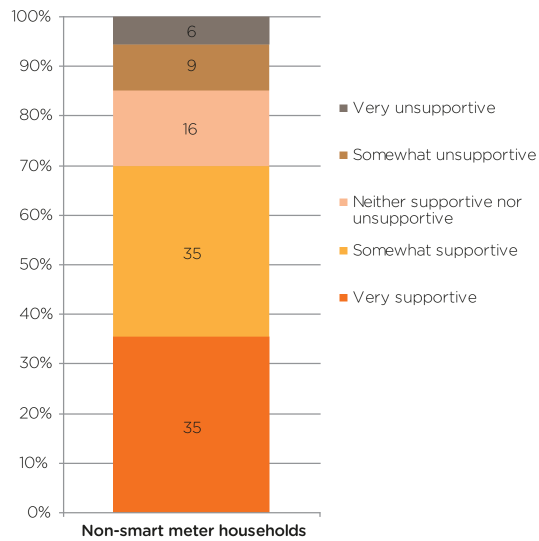


Image 3-S: Level of support for large scale rollout



Support for smart metering technology

81% of households were either 'somewhat supportive' or 'very supportive' of smart meter technology (image 3-R).

Non-smart meter households

Western Power commissioned TNS to complete a survey of households outside of the Perth Solar City trial area, to understand community attitudes to smart meters. Perth's Eastern Region, the Perth Solar City smart meter trial area, was deliberately excluded from the survey. A total of 401 households were surveyed from across the wider Perth metropolitan area.

Approximately seven in ten (68%) members of the community reported that they knew at least 'a little' about smart meters prior to the survey. Approximately three in ten (29%) members of the community reported that they knew 'nothing' about smart meters. During the survey, respondents were provided with general information on smart meters.

Approximately 70% of households surveyed were supportive of a wider smart meter deployment. A further 16% were neither supportive nor unsupportive. The majority of the community (86%) could be described as being in a state of 'positive apathy' in relation to the rollout of smart metering technology (image 3-S).

Approximately 14% of all households surveyed were likely to be unsupportive of the rollout of smart meters, for the following reasons:

- will lead to higher electricity costs (4% of all households)
- don't want to pay for installation (1%)
- invasion of privacy / security concerns (2.5%)
- money would be better spent improving existing power infrastructure (2%)
- wouldn't change how much electricity is used / unnecessary (0.5%)
- bad press from Eastern States / Today Tonight (1.5%)
- not reliable / faulty (0.5%)

Customer enquiries

As the majority of meters were installed during 2010, Western Power received few enquiries from customers for the period 1 October 2011 – 30 September 2012 (table 3-C).

Table 3-C: Smart meter related enquiries and responses (1 October 2011 - 30 September 2012)

Reason for enquiry	Number of enquiries	Western Power response/ action
Import/ export meter recently installed by customer (e.g. for Renewable Energy Buyback Scheme).	1	Western Power and Synergy refunded the cost of the import/ export meter installation if installed within the preceding 12 month period.
Perceived high bill (enquiry received via electricity retailer).	3	Investigation undertaken following each call. In all cases the meter was found to be recording consumption correctly.
Radio frequency safety.	2	Radio frequency explained to callers, including the fact that smart meters fall within safe exposure limits. Callers satisfied with explanation.
Blank display on meter.	2	Meter exchanged.
Request for register reads by customer.	1	Register reads and reading instructions provided.
Follow-up on the proposed meter installation date.	2	Installation date confirmed with recipient.
How to read meter enquiry.	2	Recipient sent 'how to read your meter' instructions via email/ post.

3.4 TRANSFERRABLE LESSONS

OVERALL PROJECT

Subject	Barrier	Outcome and/or lesson
Network modelling	BENEFIT: Validation of network mapping tools.	OUTCOME: Analysis of smart meter data enabled a more accurate network model, which in turn delivered greater efficiencies to outage management and asset utilisation. LESSON: Where available, point of connection (smart meter) information should be integrated into network mapping tools.
Network modelling	BENEFIT: Validation of the location of sensitive and life support customers.	OUTCOME: Management of outages in critical locations can be completed with reduced risk of code breaches. LESSON: Point of connection (smart meter) information reduces the risk of safety breaches.
Timeline	BARRIER: Aggressive timeline for meter deployment. As the key enabler for other technical trials, all 8,767 smart meters were scheduled to be deployed within the first six months of the Smart Grid Trial.	OUTCOME: A smaller trial in the field for a subset of the targeted meters was not completed prior to the full trial deployment. This resulted in the occurrence of technical and/ or billing impact issues on a larger scale than anticipated. LESSON: In order to test the end-to-end impact of such a new technology, a smaller subset could have been implemented prior to full deployment. This would have mitigated a number of the early teething problems experienced. The opportunity to delay the rollout of the final 477 meters (5.4% of total deployment) offered Western Power the ability to test the lessons and learnings of the initial rollout.
Product maturity	BARRIER: Western Power was a close follower behind the Victorian roll-out of single phase smart meters, however Western Power became a market leader in the deployment of three phase smart meters.	OUTCOME: SliverSprings Version of UIQ to support three phase meters was not available at the time of the three phase smart meter rollout. The mitigation strategy to manually probe reads for three phase meters failed (strategy passed in lab testing, however failed in the field). LESSON: Smart meter deployments should continue with basic readings until communications are proven. Once proven, a parallel meter reading process should be run for a minimum of one billing cycle.
Publication of interval data to market	BARRIER: Electricity retailer requested interval data for all smart meter installations from the date of installation. The version of UIQ to collect three-phase interval data was delayed.	OUTCOME: Western Power implemented a mitigation strategy to manually read three phase meters. However, the mitigation strategy (field manual data collection process) subsequently failed due to file incompatibilities, causing some delays in billing to customers. LESSON: Smart meter deployments should continue with basic readings until the end-to-end interval data transfer processes are proven and agreed by all parties. Once proven, a parallel meter reading and data transfer process should be run for a minimum of one billing cycle.

Resourcing	BARRIER: Limited experience in the Australian service consulting industry on smart grid scope, architecture and deployment.	OUTCOME: Western Power utilised additional internal resources. As a result of smart grid functions being undertaken internally, Western Power achieved cost savings of up to 30%, whilst achieving the same level of service. LESSON: Where possible, develop and maintain internal smart grid capacity and capability.
Meter installation process	BARRIER: Some cases of incomplete or mismatched site data following meter exchange.	OUTCOME: Around 0.02% of meters were installed on incorrect or mismatched sites. This resulted in late or mismatched bills. A full site audit for all deployed meters was required. LESSON: For a wider rollout, the contracted meter installer will require deployment management tools, such as wireless PDAs integrated with Western Power's asset management system, to handle 10,000 meters per month. This is required together with sufficient oversight by Western Power. Installed smart meters must be capable of being read manually.

ENGAGEMENT

Subject	Barrier	Outcome and/or lesson
Information-based engagement	BARRIER: As part of the meter exchange process, all smart meter recipients were provided with information-heavy communication materials.	OUTCOME: 62% of smart meter recipients did not understand the immediate benefits of smart meters. 88% of smart meter recipients wanted to know more about the benefits of their smart meter. LESSON: Under trial conditions in contained areas, it remains difficult to provide broad education-based engagement. However, a comprehensive education based customer engagement campaign prior to a wider roll-out is essential in raising awareness about the benefits associated with smart meters.
Technical trials	BENEFIT: Smart meter recipients were provided with the opportunity to benefit from smart grid enabled product and service trials.	OUTCOME: Demonstrated benefits of smart grid. LESSON: Smart meter roll-out must be closely followed by opportunities for customers to benefit (save money, help the environment).
Recruitment and engagement for smart meter enabled technical trials	BARRIER: Lack of clear incentives and/ or drivers for deployment partner/s.	OUTCOME: Ineffective delivery against contract milestones required significantly more contract management and oversight than anticipated. LESSON: Engagement and recruitment for smart grid enabled products and services should be undertaken by organisations for which energy efficiency and demand-side management is part of its core business or is appropriately supported by regulatory-based incentives.
Acquisition of customer energy consumption data by third parties	BARRIER: Inability for third party providers to acquire the energy consumption data of its customers.	OUTCOME: Historical consumption data not readily available to create benchmarks. LESSON: Data acquisition processes should be streamlined to allow simple customer agreement and subsequent access to historical consumption data.

SMART METERS

Subject	Barrier or Benefit	Outcome and/or lesson
Smart meter interval data	BENEFIT: Interval data delivers mutual benefit, by providing customers with the opportunity to better manage their electricity use, and networks to reduce consumption at peak time.	OUTCOME: Customers reduce electricity costs, while networks can achieve better utilisation of existing assets and potentially defer costly network augmentation. LESSON: Under a wider rollout of smart meters, interval data should be published to market as the norm.
Gross solar PV system output	BARRIER: Inability of three phase metering technology to accommodate gross metering for energy import/ export applications.	OUTCOME: To achieve gross import/ export metering in a three phase scenario requires the installation of a second meter. LESSON: A cost effective and flexible solution for 3 phase gross import/ export metering is required.
HAN / Zigbee Issues	BARRIER: On large sites, some meter points are located significant distances from the home	OUTCOME: HAN range has proven to have a limit of around 50 meters. LESSON: HAN range limitations should be anticipated, and external antennae or relay devices tested and made available as required.
Legacy systems	BARRIER: Smart meter technology specifications do not currently include support for legacy systems such as pulse output	OUTCOME: Existing hard-wired electricity monitoring systems may be incompatible with smart meters. LESSON: Work with industry to develop technical solutions to support legacy systems. Support of legacy systems could be achieved using the HAN as an interface.

COMMUNICATIONS INFRASTRUCTURE

Subject	Barrier	Outcome and/or lesson
Communications	BARRIER: 3G coverage used solely as the communications platform to support a point to point meter solution outside of the RF-mesh network is less reliable and more expensive (upfront and on-going)	OUTCOME: Loss of communication with meter, leading to increased maintenance and costs and poor overall performance. LESSON: Installation of 3G point-to-point solutions to individual premises is a technically feasible solution, however due to cost and performance issues, should only be deployed in exceptional circumstances where mesh coverage cannot be achieved.

AIR CONDITIONING TRIAL

4.1 BACKGROUND

The continuing uptake of refrigeration air conditioner systems, in particular over the last 10 to 15 years, is recognised as a key driver of increasing peak demand for electricity in the South West Interconnected Network (SWIN).

Demand for electricity is greater during hot weather, and peaks in demand correlate strongly with maximum daily temperatures. The increase in peak demand, which must be supported by costly network augmentation, has resulted in the less efficient use of existing network resources (image 4-A). For example, the top 10% of electricity supply is used less than 0.5% of the time. Western Power's network is built to cater for spikes in peak demand, which only occur during a few days in summer, as demonstrated in image 4-B.

"THE WESTERN POWER TRIAL IS THE FIRST OF ITS KIND IN AUSTRALIA… AND PROVIDES PERHAPS THE NATION'S FIRST ILLUSTRATION OF WHAT THE INTELLIGENT NETWORKS OF THE FUTURE MAY LOOK LIKE, PARTICULARLY IN REGARD TO DEMAND RESPONSE."

MARK PATERSON
CHAIR OF STANDARDS AUSTRALIA EL-054 COMMITTEE

Image 4-C demonstrates the gap in electricity demand (trial households) between the 2011 summer average and the system peak day on 25 February 2011.

As part of Perth Solar City, Western Power undertook a Demand Response (DR) trial of residential air-conditioners. Over the summer periods of 2010/2011 (Year one) and 2011/2012 (Year two), households were invited to opt-in to the trial. The Air Conditioning Trial (ACT) researched the technical feasibility and cost-effectiveness of DR as a tool for reducing electricity consumption at times of peak demand.

Participants were paid an incentive, and the trial utilised Western Power's Smart Grid (chapter 3) to wirelessly communicate with air-conditioners to cycle the compressor while the fan continued to run. The trial is the first of its kind in Australia to utilise smart grid infrastructure.

By selecting and constraining the operation of air-conditioners during certain time periods, DR of air-conditioners has the potential to significantly reduce participant aggregated electricity consumption at peak times without noticeably impacting the comfort levels of participants. The aggregated reduction of demand during times of peak use may in turn contribute to the deferment of capacity investment to supply these peaks.

2011 RE-CAP

PROGRESS

As at 30 November 2011, the first year of ACT had been completed.

6,600 smart meter households were invited to participate in Year one via an Expression of Interest (EOI) campaign. Of these, 788 EOIs were returned (11.9%). with 625 considered suitable for further assessment. A total of 202 households successfully participated in Year one of the trial (26.8% of the respondents or 3.1% of the original invitees).

KEY RESULTS

Performance of the Smart Meter Enabled DR Technology

Ten Air Conditioning Trial demand response events were run between January 2011 and March 2011. These events confirmed the end-to-end functionality of the smart grid and HAN infrastructure, including DREDs.

Effect on Peak Electricity Demand

The average reduction recorded across all events ranged between 154.64W and 891.91W per air-conditioner, or up to 20% of the peak demand of participant households.

Image 4-A: Average load per household during summer

Source: Western Power Annual Planning Report 2010/11

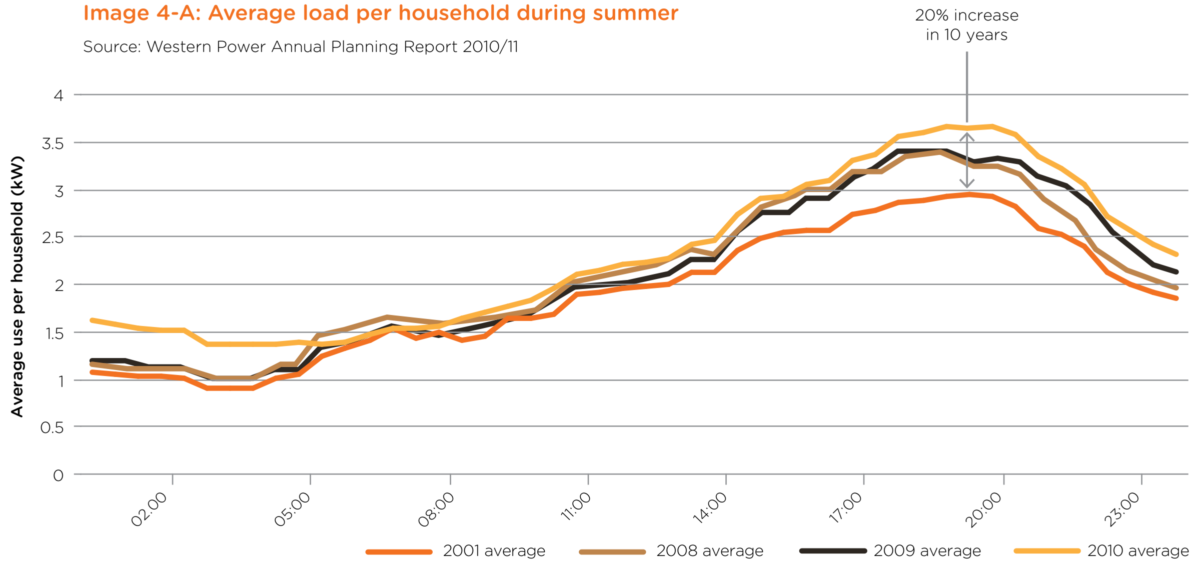


Image 4-B: System electricity demand from 1 July 2011 to 30 June 2012

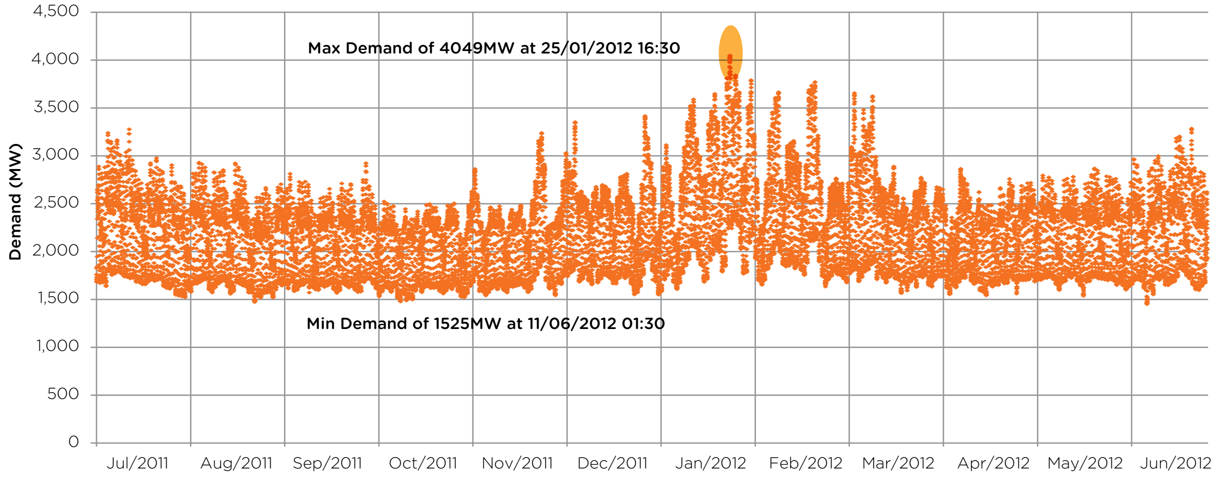


Image 4-C: 2011 Load Profile Comparison – summer average vs system peak day (25 February 2011)

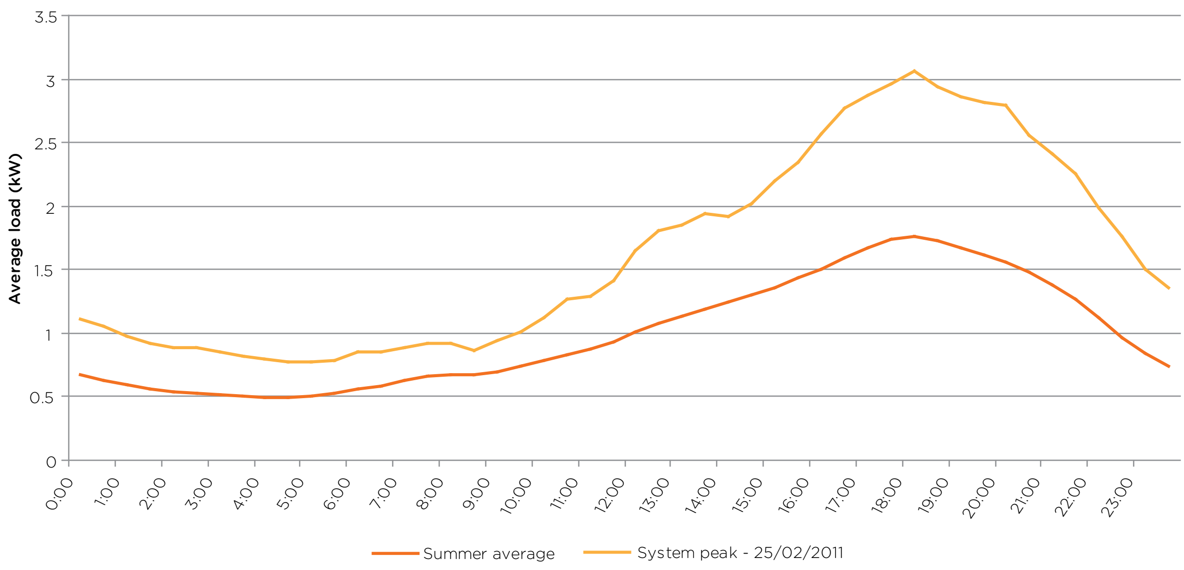
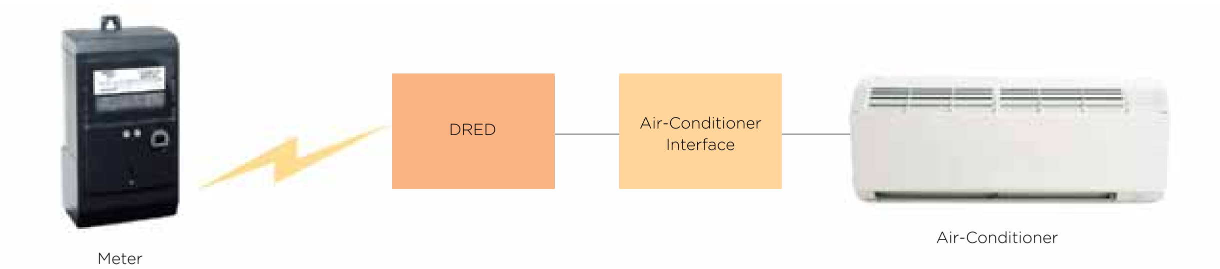


Image 4-D: End-to-end process for DR of air-conditioners



The trial uses custom-designed Demand Response Enabling Devices (DREDs) installed in the air-conditioners of eligible participants. The DRED was designed and manufactured in Australia specifically for the purposes of the Perth Solar City trial. The DREDs receive signals from the smart meter via the Home Area Network (HAN), allowing the operation of the air-conditioner's compressor to be controlled via remote signals initiated by network operators (image 4-D).

Synergy is the monopoly electricity retailer in the Western Australian South-West Interconnected System (SWIS) residential sector (for electricity users below 50MWh/annum). As a Perth Solar City Consortium member, Synergy was responsible for the engagement and recruitment of trial participants. The Air Conditioning Trial was branded ACT in the marketplace and was offered to all households who had previously received a smart meter. The financial incentive to participate in the trial was a $100 electricity bill credit in Year one and $200 in Year two.

THE DRED WAS DESIGNED AND MANUFACTURED IN AUSTRALIA SPECIFICALLY FOR THE PURPOSES OF THE PERTH SOLAR CITY TRIAL

4.2 OBJECTIVES AND PROGRESS

The key objectives of ACT were to:

- test and prove the operation of the end-to-end technology for DR of air-conditioners (Year one and two)
- measure the demand reduction achieved through the use of DR of air-conditioners (Year one and two)
- determine the potential of using DR of air-conditioners to defer costly network investment - cost of demand reduction (Year two)
- understand overall participant response, as well as the most effective means of engaging and recruiting participants to such trials (Year two)

Specific Key Performance Indicators (KPIs) of ACT included:

Activity	Key Performance Indicator	Timeframe	Progress
Technology	Procure DRED	2010/11	Complete
	Test DRED	2010/11	Complete
Recruitment	Develop marketing and communications material	2010/11	Complete
	Recruit 375 participant households	2011/12	Complete
	Install DREDs on participating households	2011/12	Complete
	Provide technical support as required	2011/12	Complete
Trial	Complete 10 load-control events	2011/12	Complete
	Pay incentive to participant households	2011/12	Complete
Evaluation	Post Implementation review of Year one and two recruitment	2011/12	Complete
	Post Implementation review of Year one and two technology performance	2011/12	Complete
	Undertake analysis on reductions in peak demand	2012/13	Complete

4.2.1 TECHNOLOGY

DRED procurement

Western Power completed a design specification for the DRED device during March 2010 and released it to tender. As a result of the tender, it was discovered that local industry knowledge and experience to develop, install and provide ongoing support for the DRED was minimal. As such, a successful vendor was selected to develop the DRED, while a separate vendor was selected for the installation and support functions.

The technical specification of the DRED and the development of prototypes for testing were completed during June 2010. Zigbee certification was also achieved for the devices, which were manufactured as two types:

- type A – for compressor control, generally suitable for non-inverter, older air-conditioners (image 4-E)
- type B – for thermister control, generally used for newer air-conditioners, and the most commonly used DRED (image 4-F)

Image 4-E: Type A DRED

Image 4-F: Type B DRED

Image 4-H: ACT 'congratulations' postcard

DRED testing

End to end testing and the ability of the DRED to pair with smart meters via the HAN was successfully completed by Western Power at the end of October 2010.

Some initial technology performance issues were uncovered, including the device losing its secure connection with the smart meter Network Management System (NMS) after two minutes, but were resolved with support from the DRED developer and NMS vendor.

4.2.2 RECRUITMENT

Marketing and communications material

6,600 smart meter households were invited to participate in Year one of the trial via an Expression of Interest (EOI) campaign that included a letter, brochure, form and reply paid envelope. This was further supported by website content, and a call centre for enquiries.

To be eligible to participate, households were required to complete an EOI form and return it to Synergy. Completion of the EOI formed part of a recruitment process. The recruitment process was refined in Year two (2012) to reduce the number of site visits required by technicians, and decrease the customer attrition rate (image 4-G).

During Year two, households that successfully prequalified (step two) received a 'Yes' pack and were scheduled for a site visit. Households that did not qualify received a 'No' pack promoting alternative energy efficiency offers available through the Perth Solar City program.

Once site visits were completed using an external contractor, and DREDs were installed (completion of step five), successful participants received a 'congratulations' postcard (image 4-H). Participants whose air-conditioners were deemed unsuitable on either of the site visits were provided with a 'regrets' postcard.

Recruitment of households

Sub-Project	Program Target	Achieved
ACT participants	375	377 (384 DREDs installed)

The total target for the Air Conditioning Trial was 375 participants. In Year one, a total of 208 participants were recruited, including seven who had two air conditioning systems.

During Year one, Synergy recruited participants primarily via a large mail out to 6,600 customers who had received a smart meter as part of the Perth Solar City program. A $200 incentive was offered to participants, $100 for each year of participation.

Although 788 EOIs were received, only about half of the potential participants had suitable air-conditioners for the trial. Further attrition occurred between the on-site assessment and installation of the communications device.

Image 4-G: ACT participation process

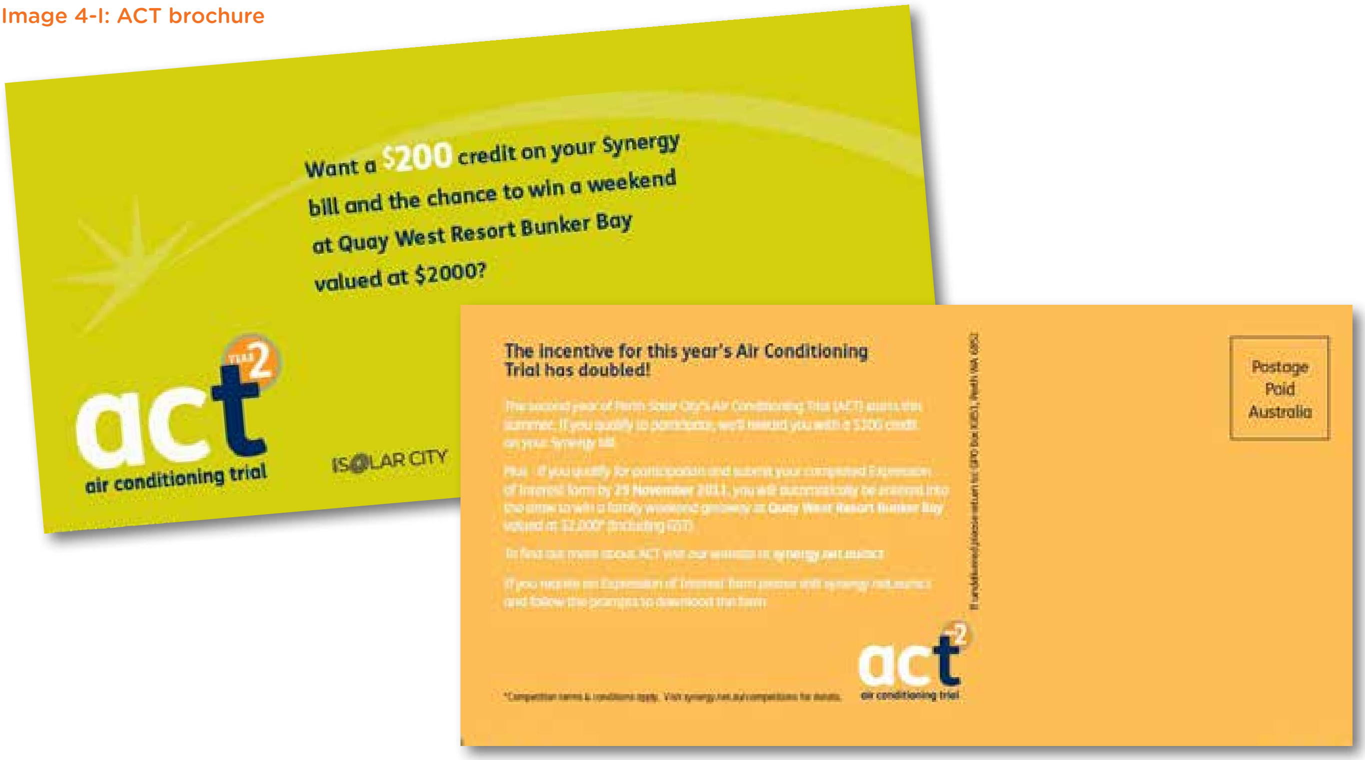
Year one

- Step 1 Expression of Interest received
- Step 2 Prequalification by Synergy
- Step 3 Site visit 1: Assessment of air-conditioner
- Step 4 Customer Agreement completed
- Step 5 Site visit 2: Installation of DRED
- Step 6 Participation in trial events
- Step 7 Payment of $100 by Synergy

Year two

- Step 1 Expression of Interest received
- Step 2 Prequalification by Synergy & Western Power
- Step 3 Site visit: Assessment of air-conditioner/ Customer agreement completed/ installation of DRED
- Step 4 Participation in trial events
- Step 5 Payment of $200 by Synergy

Image 4-I: ACT brochure



Year two of ACT continued towards the program target of 375 participants. 169 participants were recruited in Year two, bringing the total to 384 participants across 377 sites. Some households had multiple air-conditioners fitted with the DRED.

Synergy commenced recruitment for Year two of the trial via a large mail out to 5,400 customers offering an increased incentive of $200 for the single year and entry into a prize draw valued at $2,000 (image 4-I).

Low response rates prompted a revision of the marketing strategy. New initiatives implemented included:

- an outbound direct calling campaign
- advertising in local newspapers
- requesting participating households to refer a neighbour (an additional $2,000 gift voucher prize draw was available to referring households)

These initiatives increased response rates by over 400%, with improvements largely attributed to the outbound direct calling campaign.

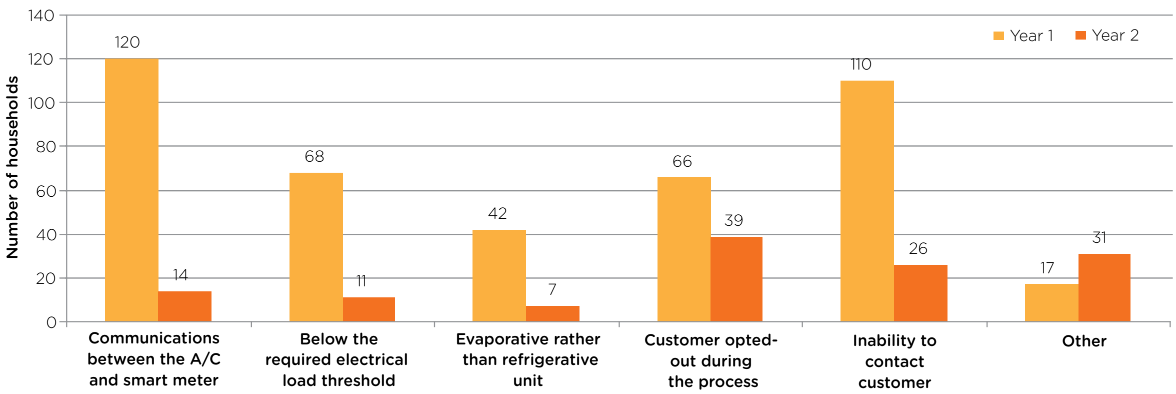
Of 595 EOIs received in Year two, 34% of the potential participants had suitable air-conditioners. However, attrition between assessment and recruitment was much lower than in Year one. This is due to the combination of on-site assessment and communications device installation into one site visit.

Expression of Interest Attrition

Of the 1,383 EOIs passed on to Western Power by Synergy, 1,006 households did not participate in the trial. The reasons for attrition included (image 4-J):

- technical
  - inability to install the DRED or communicate effectively with it due to distance or other obstacles between the air-conditioner and the Smart Meter
- unsuitable air-conditioner
  - below the required air-conditioner electrical load threshold (<1.5kW electrical capacity)
  - evaporative rather than refrigerative (compressor-based) unit
- engagement
  - inability to contact the householder
  - participant opted-out during the process

Image 4-J: Attrition by type



Installation of DREDs

DRED installation was a relatively complex process due to the presence of different brands and models of air-conditioner units, and could take anywhere between one to two hours. Generally, installation involved taking the cover off the air-conditioner unit, wiring the DRED to the unit by either cutting into the thermistor circuit or the power supply to the compressor. For installations in the ceiling, this process was considerably more involved.

Once the DRED was installed it was commissioned via a phone call to a Western Power operator, who sent a command to the smart meter to initiate a pairing window for approximately five minutes, during which time a button on the DRED must be pressed to 'pair' it to the smart meter.

Some DREDs became 'un-paired' from the smart meter and required a re-visit. This occurred during Year one due to inconsistent communication protocols between the DRED and smart meter. At the beginning of Year two, before trial events were performed, the smart meter firmware was revised and an update implemented remotely. This successfully prevented additional DREDs becoming 'un-paired'. For future implementation, an automatic pairing functionality would largely avoid the requirement for a re-visit.

4.2.3 COMMENCEMENT OF TRIAL EVENTS

Event parameters

Nineteen DR events were conducted across Year one (10) and Year two (nine) of the trial. Year one events were to test the technology and Year two events to validate ACT as a demand response tool.

Some of the key variables considered whilst designing the event plan included:

- selecting days to align with peak load periods
- time of day and event duration
- duty cycle to be applied
- mechanism used to minimise aggregate load fluctuation
- participants to be included

Selecting event days

Several factors are generally accepted as contributors to the occurrence of a peak demand day:

- Maximum daily temperature greater than 35 degrees celcius
- a hot day during the working week
- a hot day after several preceding hot days
- a hot day during the school term

Using the above factors as guidelines, Western Power staff selected 19 suitable event days across the two-year trial.

Time of day and event duration

Typically, system peak occurs at approximately 4pm while residential peak starts at around 7pm. To understand the effects of DR on both system-wide and residential peak load, events were run from 4pm to 8pm.

Duty cycle

Duty cycle refers to the ratio of time that the air-conditioner's compressor is cycled 'off' to the time it is cycled 'on'. The sum of the two intervals is the cycle time. Two duty cycles were applied in the trial:

1. 50% or 15/15: meaning 15 minutes off followed by 15 minutes on (image 4-K)
2. 67% or 10/20: meaning 10 minutes off followed by 20 minutes on (image 4-L)

Whilst the air-conditioner's compressor is off it will not draw current, providing a load reduction over the cycle period. However, the air conditioner will not provide cooling whilst the compressor is cycled off, and longer off periods have the greater potential to impact comfort levels. Establishing two alternative duty cycles provided comparative data on their respective impact on peak reduction, and provided an opportunity to assess whether participant reactions varied with the duty cycle.

Cycling configurations

The cycling configuration refers to the point of time at which a duty cycle begins once a DR event has commenced. For the trial, two different cycling configurations were used:

- randomised (image 4-M)
- non-randomised (image 4-N)

The first configuration, called randomisation, has load control commands sent to the DREDs to stagger the initiation of the event randomly for participating air-conditioners. Randomisation is relatively simple to configure and hence preferable for large scale operations.

Image 4-K: Graphical representation of the 15/15 duty cycle

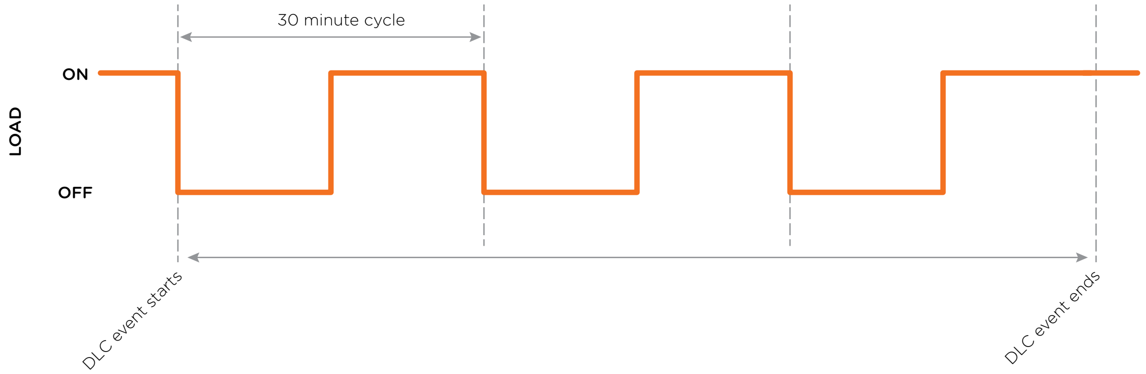


Image 4-L: Graphical representation of the 10/20 duty cycle

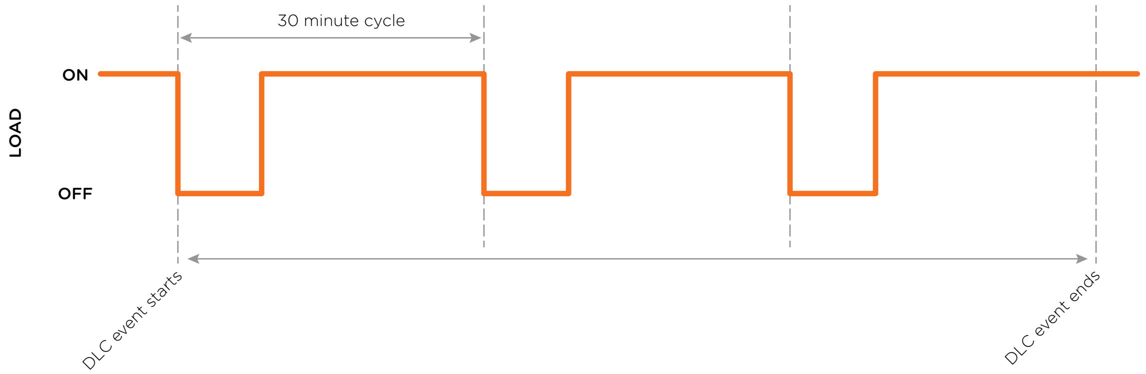


Image 4-M: Graphical representation of a 15/15 duty cycle with randomised configuration

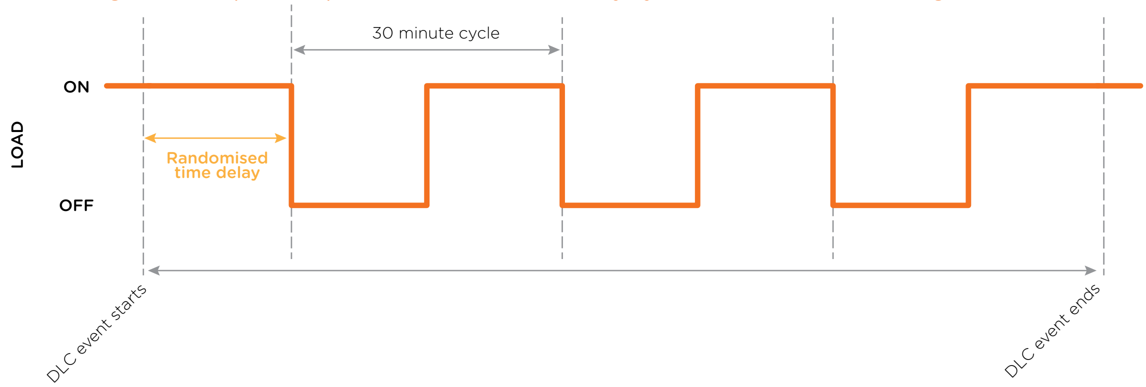
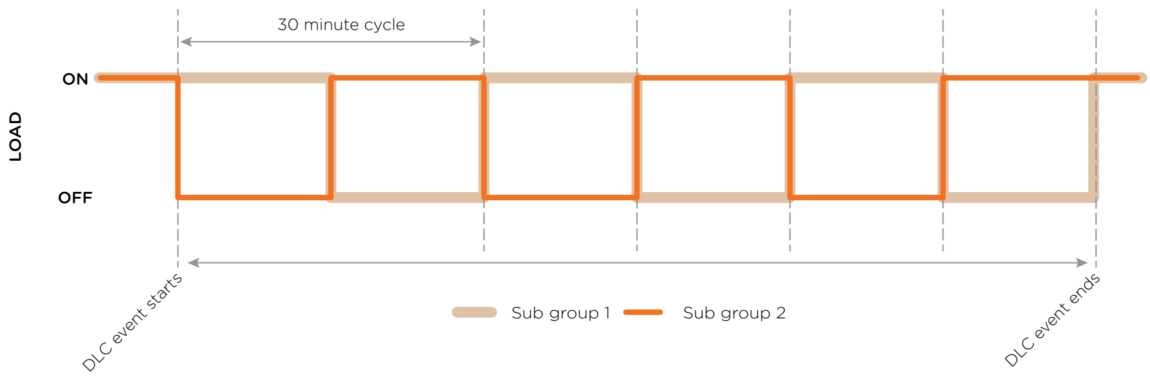


Image 4-N: Graphical representation of a non-randomised 15/15 duty cycle with 2 subgroups



Where a non-randomised configuration is specified, the participant group is divided into two subgroups for a 15/15 duty cycle, or three subgroups for a 10/20 duty cycle. Alternative event commencement times were programmed for each sub group to provide a balanced off cycle profile - as one group is cycled on, another is cycled off.

These cycling configurations in combination with the duty cycle results in four possible permutations:

1. 15/15 Randomisation
2. 15/15 Opposing
3. 10/20 Randomisation
4. 10/20 Opposing

Data comparison

The project employed two approaches using control groups for data comparison as a means of understanding what the household peak would have otherwise been.

The first control group was comprised of customers that had expressed interest in the project, and had provided air conditioner details, but had ultimately not become a participant.

To achieve an alternative control group (comprised of trial participants) two events were split into four 'half' events. For example, Event 5 was split into event 5A and event 5B, and participants were either 'active' or 'passive' (control group) in one half event, and alternated for the second half (table 4-A).

4.3 KEY RESULTS

Key results of ACT focus on:

- performance of the smart meter enabled DR technology
- probability of air-conditioner use
- peak demand reductions
- impact on network infrastructure
- participant evaluation
- future scenarios

4.3.1 PERFORMANCE OF THE SMART METER ENABLED DEMAND RESPONSE TECHNOLOGY

During Year one, 10 DR trial events were run between January and March 2011. These events were run to test and prove the technology (table 4-B).

The first six events involved smaller groups of participant's air-conditioners, and were run for between one and four hours. These events confirmed the end-to-end functionality of the smart grid and HAN (chapter 3) infrastructure, including the DREDs.

Events were initiated by a command sent remotely from Western Power to the DRED, via the smart meter. Commands were received by 100% of the selected DREDs within a two minute period, consistently above performance benchmarks. The results of the first summer trial confirmed that the smart grid infrastructure can be used for wireless demand management of air-conditioners.

4.3.2 PROBABILITY OF AIR-CONDITIONER USE

As anticipated, the probability of an air-conditioner being switched on increases as the daily temperature increases, and is not affected by size (table 4-C).

4.3.3 IMPACT OF ACT ON AVERAGE LOAD REDUCTIONS

The total air-conditioning load able to be reduced increased as the temperature increased. Maximum reductions were achieved on a 15/15 duty cycle when the temperature was between 38 and 42°C (image 4-O). Under all temperature scenarios, the 15/15 duty cycle delivers greater load reduction than 10/20.

Among the distribution of air-conditioner sizes for all participants, the most typical size ranged between 2 - 3.5kW. To determine the effect of air-conditioner size on load reduction potential, air-conditioners were separated into four electrical size categories; under 2kW, 2-3kW, 3-4kW and over 4kW.

The load reduction per air-conditioner was an average of 33% on a 15/15 duty cycle, and 18% on a

Table 4-C: Probability of air-conditioner use by size

	< 2 kW	2-3 kW	3-4 kW	> 4 kW	ALL
Number A/C On	41	81	35	21	178
Number A/C Off	32	51	23	12	118
Percent A/C On	56.16%	61.36%	60.34%	63.64%	60.14%

Table 4-A: Event list for Year two of ACT

Event No.	Date	Time of event	Duty cycle	Random configuration (Y/N – phase)	Split (Y/N)	Min daily temp (°C)	Max daily temp (°C)
1	24/01/12	2-4 pm	15/15	N-simultaneous	N	20.8	37.9
2	31/01/12	4-8 pm	15/15	N - opposing	N	17.6	35.2
3	01/02/12	4-8 pm	15/15	N - opposing	N	23.5	37.4
4	20/02/12	4-8 pm	15/15	Y	N	19.5	36.2
5A	21/02/12	4-8 pm	10/20	Y	Y	24.1	35.8
6	22/02/12	4-8 pm	10/20	Y	N	18.9	36.9
7	06/03/12	4-8 pm	15/15	N - opposing	N	17.9	38.8
5B	09/03/12	4-8 pm	10/20	N - opposing	Y	17.7	38.1
8A	12/03/12	4-8 pm	15/15	Y	Y	14.5	40.0
10	28/03/12	4-8 pm	15/15	Y	N	13.9	30.3
8B	29/03/12	4-8 pm	15/15	N - opposing	Y	18.3	32.8

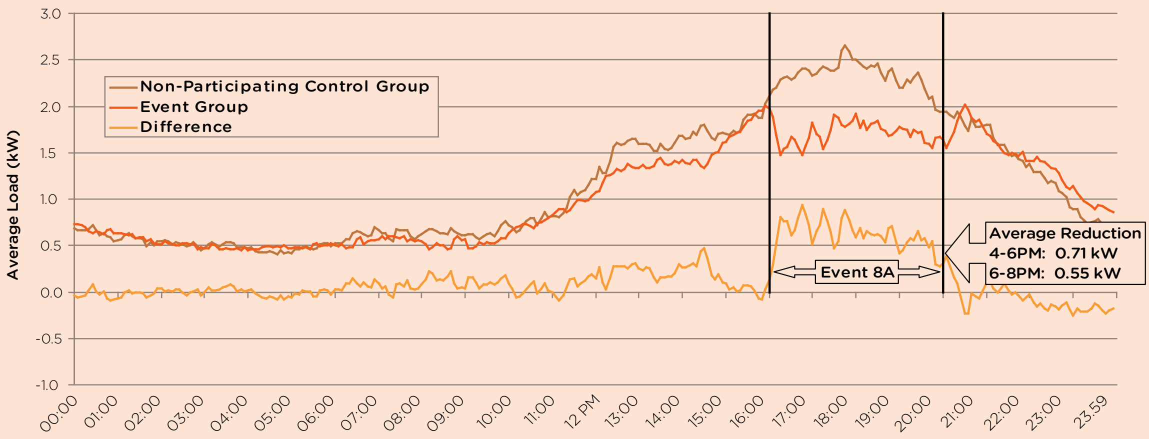
Table 4-B: Event list for Year one of ACT

Event No.	Date	Time of event	Duty Cycle	No. of households	Specific objectives and comments
1	27/01/2011	4-5 pm	15/15	20	- test systems and technology - pilot event for Zigbee technology - no randomisation
2	10/02/2011	4-5 pm	15/15	40	- test systems and technology (20 new participants) - no randomisation
3	15/02/2011	4-5:30 pm	15/15	40	- test systems and technology with a new set of customers - no randomisation
4	16/02/2011	4-5:30 pm	20/10	80	- test systems and technology with event 2 & 3 participants with a new duty cycle - randomisation
5	23/02/2011	4-7 pm	15/15	60	- test systems and technology with new participants at dispersed locations - no randomisation
6	25/02/2011	1-5 pm	20/10	50	- test systems and technology with new participants at dispersed locations - no randomisation
7	3/03/2011	2:10-6 pm	15/15	180	- test systems and technology with all available participants - no randomisation
8	09/03/2011	2:10-6 pm	15/15	185	- test systems and technology with all available participants - no randomisation
9	15/03/2011	3:10 to 7 pm	15/15	186	- test systems and technology with all available participants - randomisation
10	24/03/2011	3:10 to 7 pm	15/15	188	- test systems and technology with all available participants - randomisation

EVENT PROFILE

For event 8A, participants were divided into two sub-groups – a participant group and a control group. The maximum temperature on this day was 40°C. The Demand Response event took place between 4:00pm and 8:00pm. The event used randomised 30 minute cycles (15 minutes 'off' and 15 minutes 'on'), of the air-conditioner's compressor. Each cycle was repeated eight times over the four hour event.

The image indicates the peak demand of the active participant group (those whose air conditioners were cycled) was approximately 25% less than that of the passive group (those whose air conditioners were not cycled) during the event.



10/20 (image 4-P). Load reductions are consistent regardless of air-conditioner size. The average household reduced their overall peak demand by approximately 25% during trial events.

This indicates that larger air conditioners will provide a bigger kilowatt reduction and hence a bigger dollar per kilowatt value as compared to smaller ones. Although there are relatively few air-conditioner units greater than 4kW, their total electrical load is considerable. This suggests that future demand management strategies should initially target the larger air-conditioners and then successively include smaller units (image 4-Q).

4.3.4 IMPACT ON NETWORK INFRASTRUCTURE

The impact of demand response of residential air-conditioners on network infrastructure is variable, and is dependant upon the mix of customer types (residential or commercial) connected to the local network.

A positive impact is likely to be achieved predominantly in residential load areas, which are (or are becoming) constrained. To illustrate this, Western Power conducted two case studies on feeders which have a good representation of trial participants - Forrestfield and Hadfields. Both case studies used a 15/15 duty cycle during Air Conditioning Trial events.

The peak load day on the Forrestfield (image 4-R) and Hadfields (image 4-S) feeders were used in the analysis. Western Power extrapolated the effect of a 10% penetration of participants. This is based on a 13% EOI rate for ACT, and supported by a 20% participation rate and 33% EOI rate in SA Power Network's

Image 4-O: Average load reduction per cycling air-conditioner given daily maximum temperature

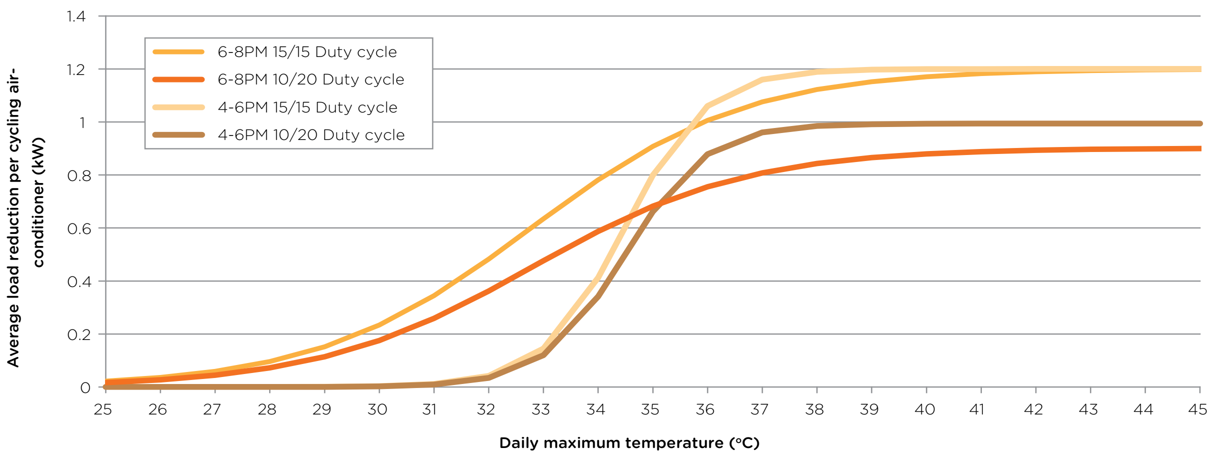


Image 4-P: Relative load reduction by air-conditioner size and duty cycle

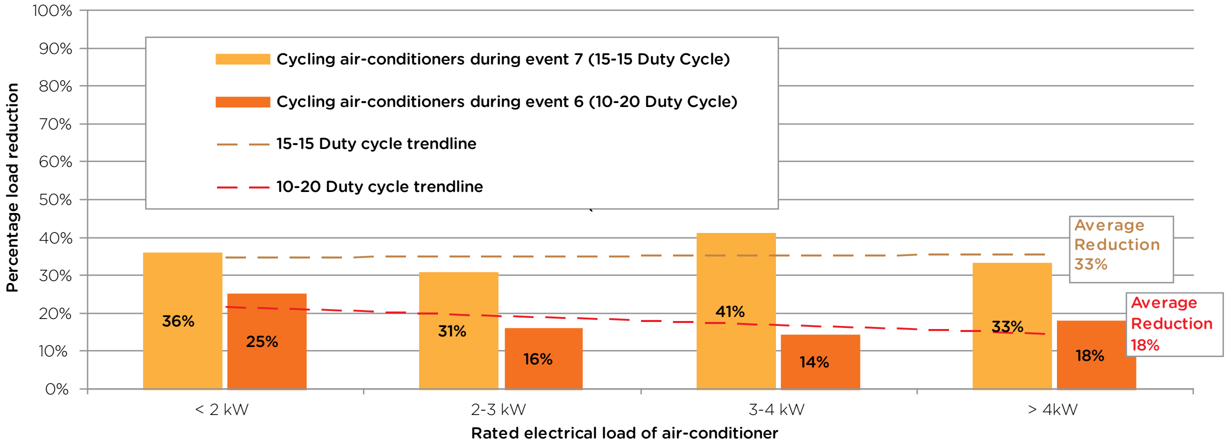


Image 4-Q: Effect of air-conditioner size and duty cycle on load reduction

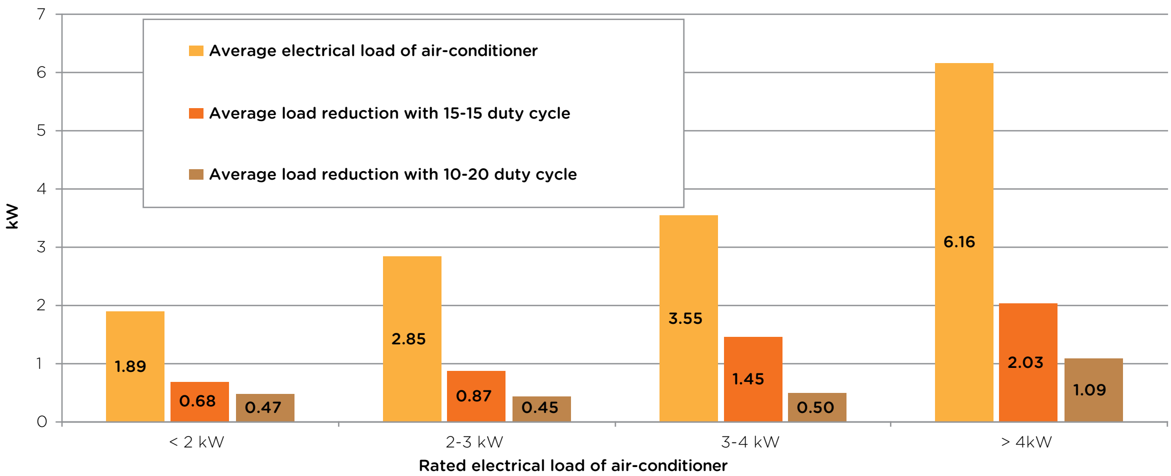


Image 4-R: Effect of demand response on Forrestfield feeder

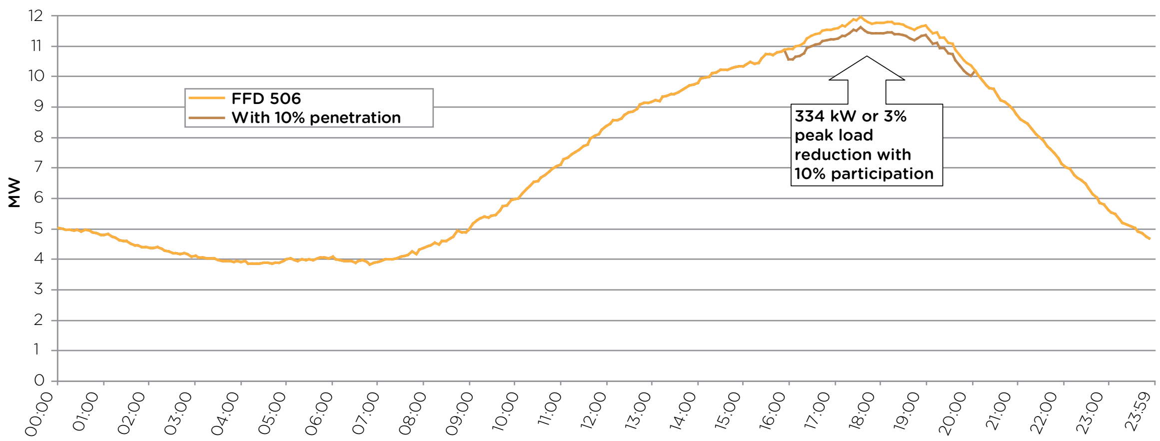
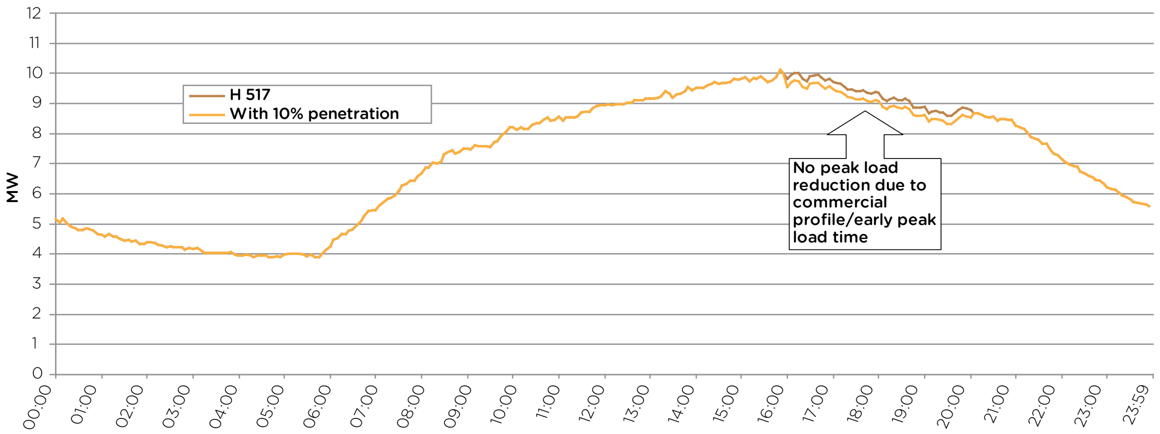


Image 4-S: Effect of demand response of air-conditioners on Hadfields feeder



2010 Glenelg Trial. It is assumed the distribution and size of air-conditioners will remain the same.

As a primarily residential feeder, the potential for deferment of augmentation on the Forrestfield feeder can be clearly defined (image 4-T).

Alternately, due to the mixed commercial and residential profile of the Hadfields feeder, peak load was reached prior to 4pm. As a result the demand response of residential air-conditioners had little effect on the peak feeder load. Given the large commercial element of this load, this feeder may be more appropriate for a demand response initiative that includes the commercial sector.

It is possible however to reduce aggregate load on both of the residentially dominated distribution transformers (image 4-U and 4-V). Even the Hadfields distribution transformer showed significant peak load reduction due to demand response. This highlights that it is possible to selectively target residential elements of the network at different scales.

The results suggest there is significant potential to defer network augmentation. The trial also showed that conducting demand response events limited to residential air-conditioners has less potential for reducing peak load on predominantly commercial feeders.

The rate of peak load growth on primarily residential feeders will determine the resultant period of deferment of network augmentation achievable as a result of the demand response of residential air-conditioners. As a result of reducing peak electricity demand by between 2.5% and 5% on the Forrestfield feeder, deferment of augmentation for up to two years would have been possible.

It should be noted that the demand response of residential air-conditioners is one of several demand management programs (including access to real-time consumption information, tariffs, education etc) that could be conducted concurrently in constrained areas.

4.3.5 PARTICIPANT EVALUATION

Perth Solar City commissioned market researcher TNS to undertake detailed participant evaluation for the Perth Solar City technical trials, including ACT. The objectives of the analysis were to understand the following:

- overall participant experience
- motivation for participation
- satisfaction during sign-up and installation
- experience during the trial
- willingness to participate in the trial in the future / recommend to others
- behaviour change

Overall participant experience

The overall participant experience of the Air Conditioning Trial was very favourable. Four out of five participants (85%) had a positive experience of the trial, with more than one third (38%) rating the experience as 10 out of 10 (image 4-W).

The top four motivations for participating in the trial (image 4-X) were; 'wanting to reduce electricity bills' (28%), 'invited to participate in the trial by Synergy' (23%), 'wanting to save energy' (15%), and 'wanting to receive the incentive (11%).

Image 4-W: Overall Participant Experience

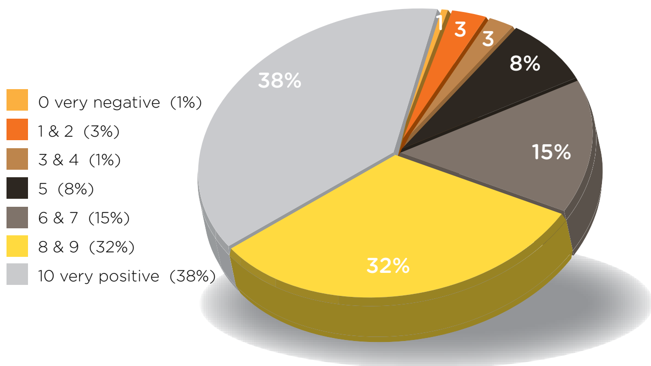


Image 4-T: Deferment of investment on Forrestfield feeder

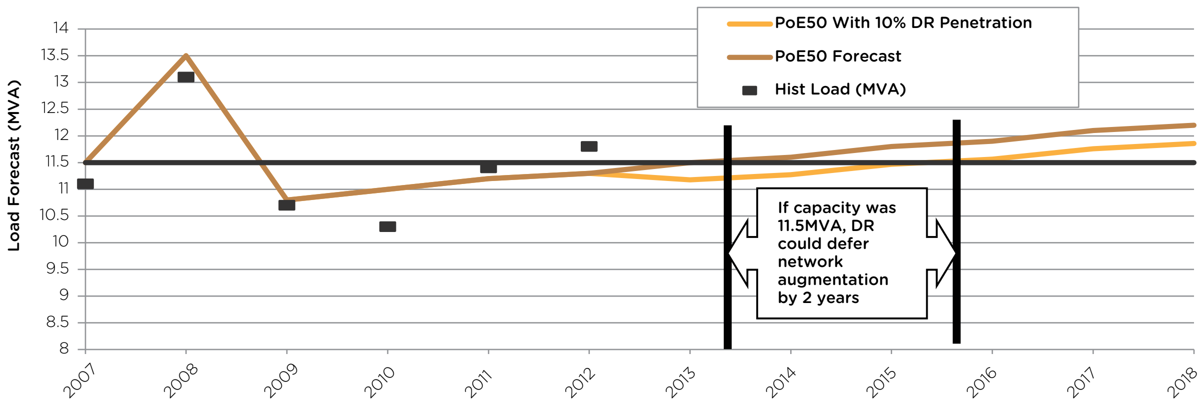


Image 4-U: Forresfield distribution transformer

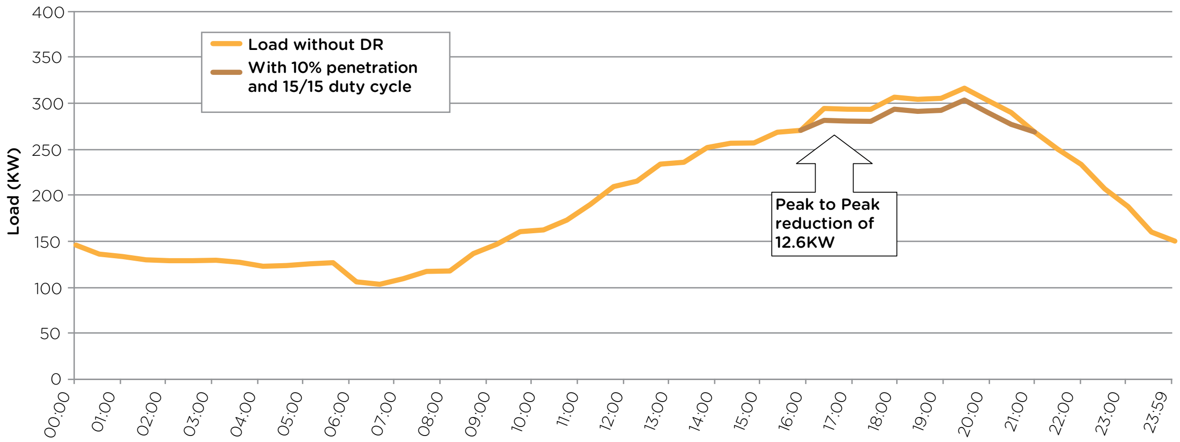


Image 4-V: Hadfields distribution transformer

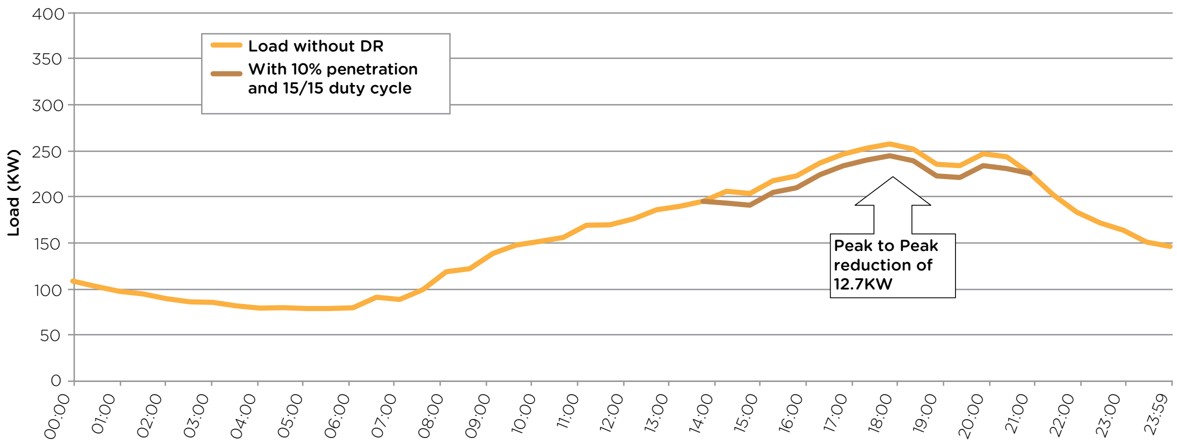
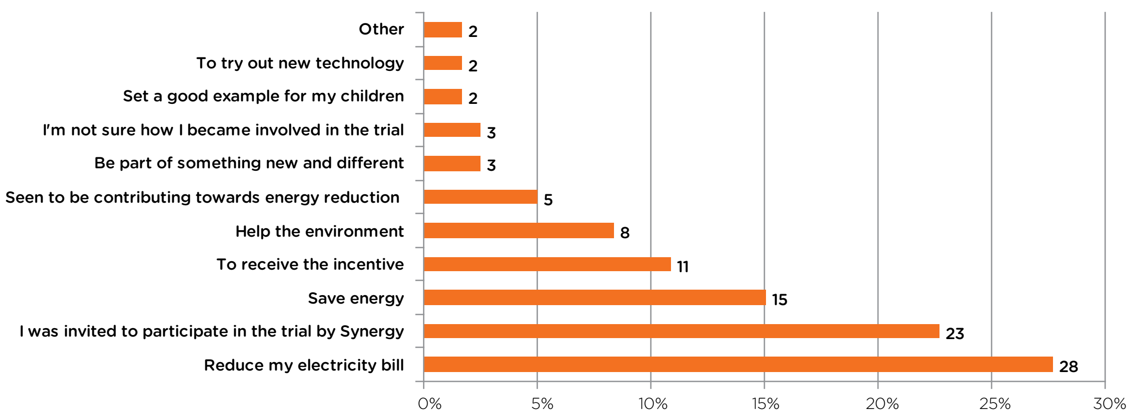


Image 4-X: Motivation for participating in ACT



Sign-up and installation

Participants felt that the sign-up and installation process for ACT was well communicated, with 87% of participants not having any concerns with being involved in the trial. However, of the 13% of households who were concerned, there were three main themes; concerns about increased electricity usage, resultant lack of control of their air-conditioner, and overall effectiveness of the trial.

90% of ACT participants were satisfied with the sign-up and installation process. In particular, participants overwhelmingly felt that the sign up and installation process was 'easy'. Of the 10% who were affected by implementation issues, the majority (75%) indicated that the issues were easily overcome.

Image 4-Y: Perceived frequency of ACT events

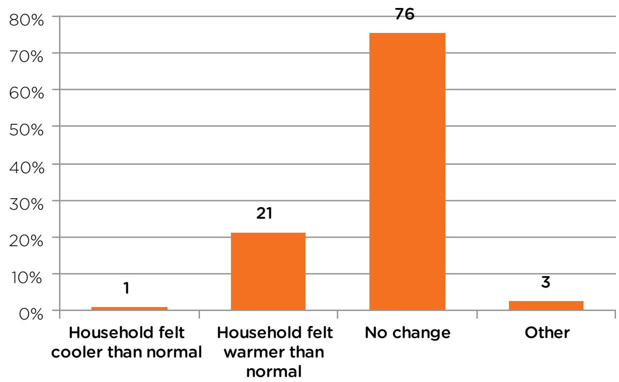
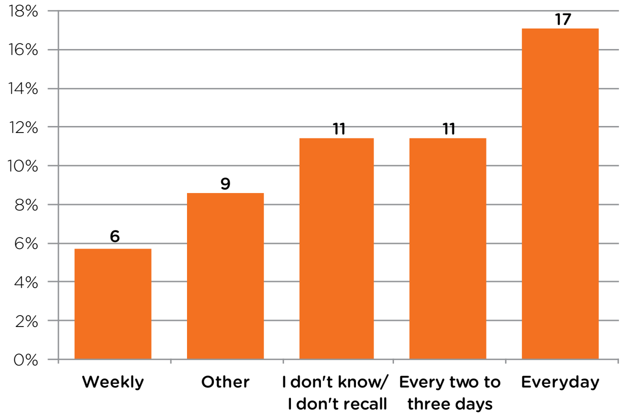


Image 4-Z: Perceived frequency of device being switched on by participants who perceived a change in their comfort levels



Experience during the trial

Over three quarters (76%) of participants indicated that they felt 'no change' in comfort levels over the trial period (image 4-Y). With no perceived reduction in amenity, the participant experience of the trial was much more likely to be positive.

Approximately one in five participants indicated that they noticed when an ACT event was activated. Of these participants, 34% perceived their air-conditioner to be cycling weekly, every two or three days, and even daily through the summer period (image 4-Z). This is significantly more often than was actually run throughout the trial.

The incentive received by ACT participants also contributed to a positive participant experience. The majority of participants (80%) felt that the incentive provided was 'about right'.

Perceived outcomes

Approximately 28% of ACT participants perceived that their electricity use decreased as a result of participating in the trial. Compared with the other Perth Solar City technical trials, In Home Display (71%) and Time-of-use Tariff (63%), this is significantly lower. However, considering the main objective of the trial was to reduce peak demand on the infrequent days of network peak (and not necessarily to reduce overall electricity consumption), this is a positive outcome.

The willingness to participate in future DR programs was significantly positive at 87% (image 4-AA). ACT participants are more willing than other trial participants to join a trial in the future. ACT participants were likely to act as strong advocates for the trial, with the majority willing to recommend the trial to other households (image 4-AA).

Impact on behaviour change

Participation in ACT increased awareness of how air-conditioners were being used by participants, and resulted in a reported sustained reduction in use for around half of participants (image 4-AB).

There was a relatively low incidence of 'modified behaviours' as a result of participation in the trial. A minority of participants set their temperature cooler and left the air-conditioner on longer than usual while participating in the trial (image 4-AC).

As a result of participation, a number of related energy efficiency actions and behaviours were undertaken by participants (image 4-AD).

Image 4-AA: Willingness to participate in ACT in the future and recommend to other households

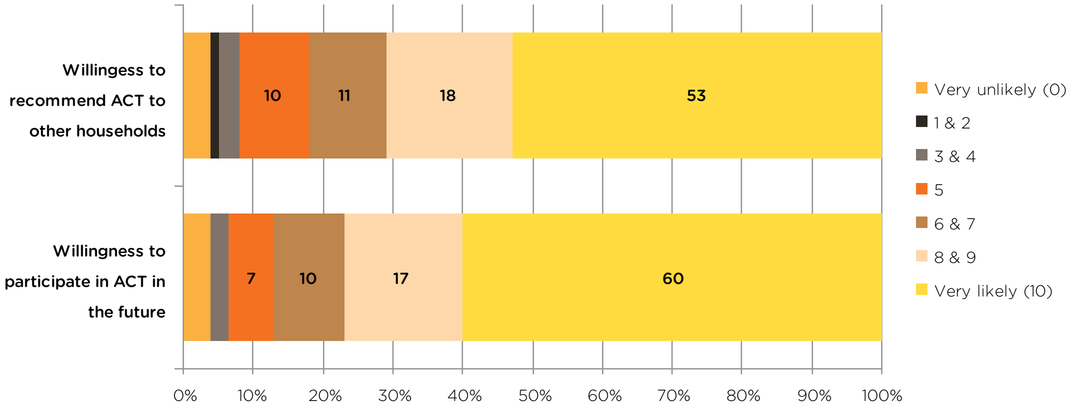


Image 4-AB: Level of behaviour change (positive)

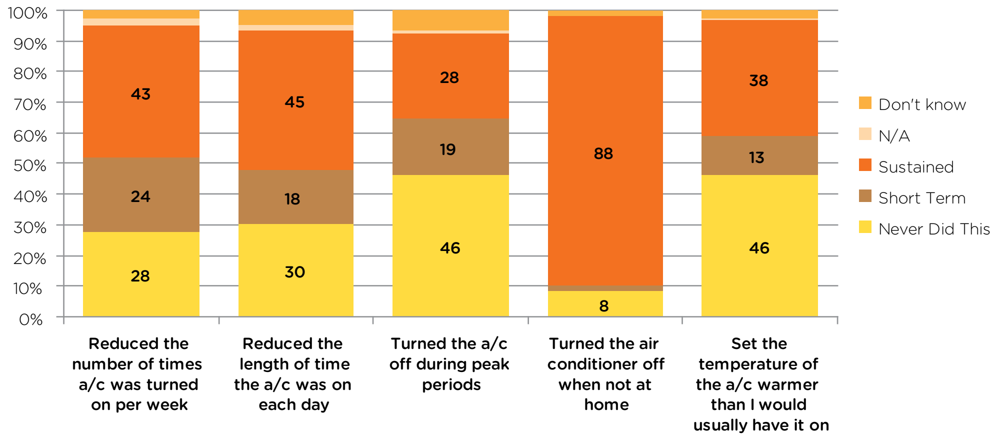


Image 4-AC: Level of behaviour change (modified)

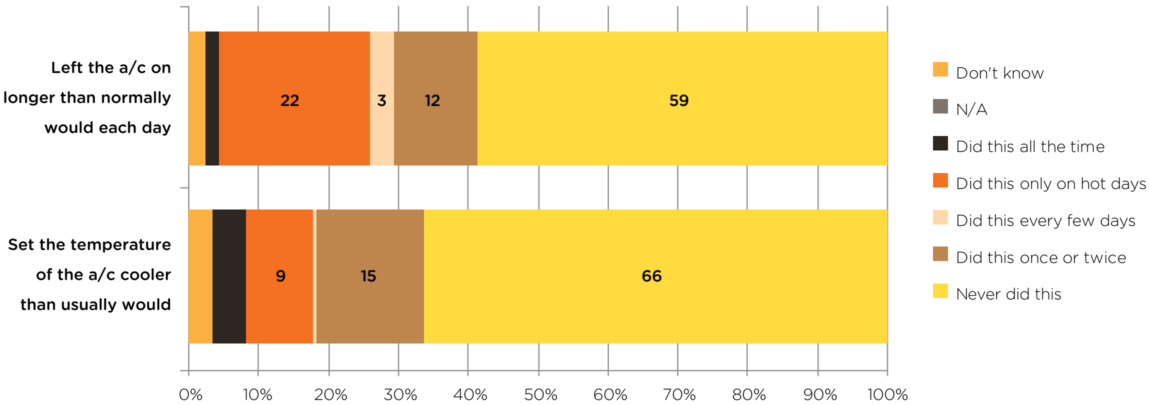
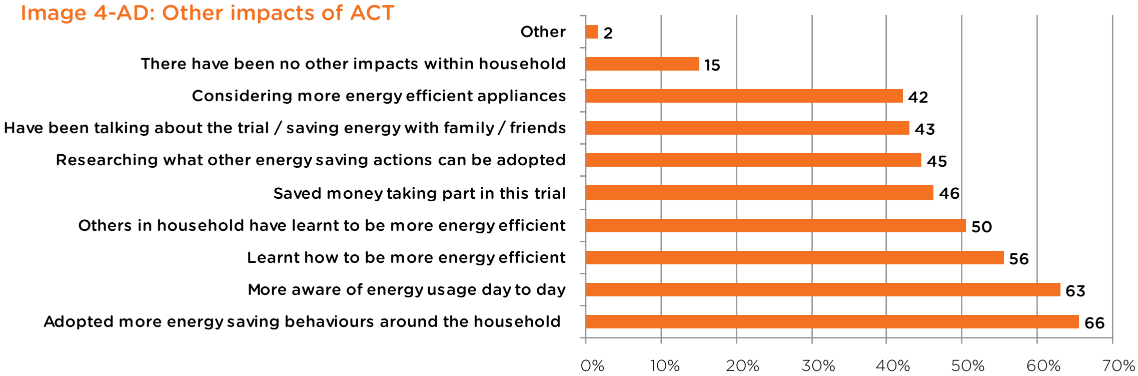


Image 4-AD: Other impacts of ACT



4.3.6 FUTURE DEPLOYMENT

To assess future deployment models and costs, two scenarios have been developed. The scenarios are based on current and developing technologies, policies and standards. These scenarios have been used to develop predictable costs on a per participant and per kilowatt peak reduction basis.

Scenario 1 models the retro-fitting of existing air-conditioners with DREDs similar to that of the trial.

Scenario 2 models air-conditioners which have been manufactured with demand response capability as per the Australian Standard AS4755.

The main difference in cost is the reduced cost of assessment and installation required under Scenario 2.

Image 4-AE: Comparative costs for large scale implementations

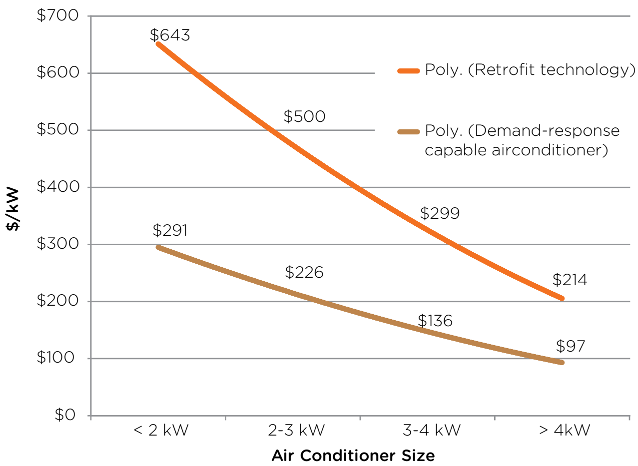
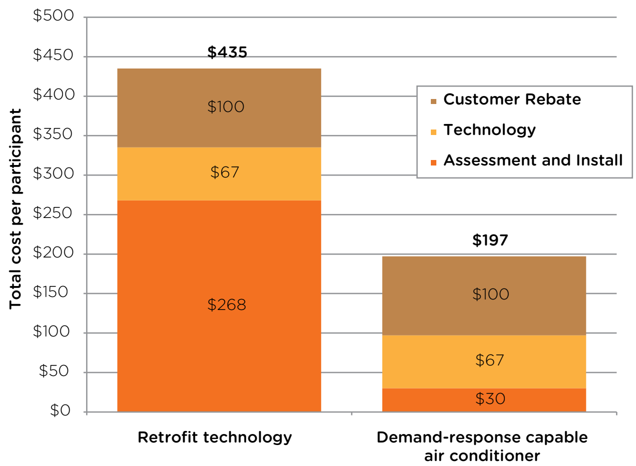


Image 4-AF: Comparative unit cost of demand reduction by air-conditioner size



Scenario 1: Retro-fitted technology

Assumptions:

- contractor achieves 80% success rate in the assessment of air-conditioners and installation of demand response enabling devices (up from 61% in ACT Year two)
- 30% reduction in technology costs due to developing market and economies of scale

Scenario 2: Demand response capable air conditioner (AS4755 compliant)

Assumptions:

- air-conditioner is manufactured with demand response capability as per AS4755
- DRED is pre-fitted at the time of air-conditioner installation
- 30% reduction in technology costs due to developing market and economies of scale

Scenario comparison

As expected, the cost associated with a residential air-conditioner demand response program is significantly less for Scenario 2 (AS4755 compliant). For the purposes of cost effectively reducing electricity use at peak time through the demand response of residential air-conditioners, Western Power supports the development and introduction of AS4755 (image 4-AE).

Further, the trial found that a 33% reduction of air conditioner load can be achieved regardless of the size of the air-conditioner (image 4-AF). Therefore the opportunity exists for Western Power to initially target larger (+3 kW) air-conditioners for demand response under Scenario 1 at a cost of approximately $200 to $300/kW of demand reduction.

4.4 TRANSFERRABLE LESSONS

4.4.1 RECRUITMENT

Subject	Barrier or Benefit	Outcome and/or lesson
Recruitment and engagement	BENEFIT: Direct mail followed by outbound calling	OUTCOME: The most effective method of recruiting participants to ACT was via direct mail in combination with a follow-up outbound phone call. LESSON: Direct mail in combination with outbound calling should be utilised as part of an overall recruitment strategy.
Recruitment and engagement	BARRIER: A high participant attrition rate occurs during a prolonged sign-up process	LESSON: A lower attrition rate can be achieved through a combination of: • obtaining accurate customer information with regards to air conditioner size and type. • merging the assessment of air conditioners with the installation of the DRED. • providing customers with access (via telephone) to technical experts during home visits.

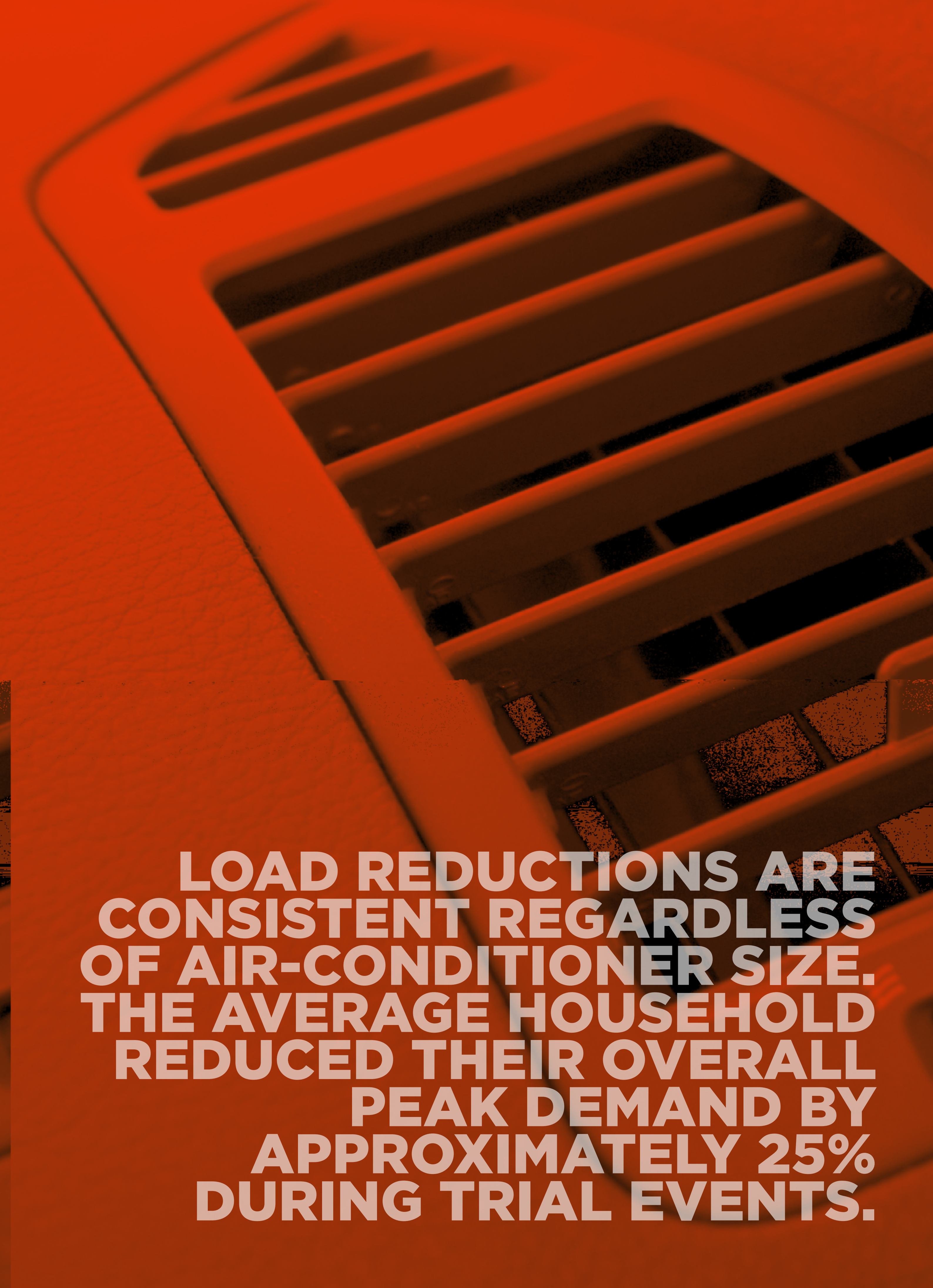
4.4.2 TECHNICAL

Subject	Barrier or Benefit	Outcome and/or lesson
Load reductions per air-conditioner	BENEFIT: A 33% reduction in air conditioner electrical load can consistently be achieved regardless of air-conditioner size	OUTCOME: Greater net load reductions are achieved for larger air-conditioners. LESSON: Future initiatives should provide an incentive to participants based on air-conditioner's size. In short, incentives paid per kilowatt of air conditioner size.
Proving the technology	BENEFIT: The end-to-end technical solution performs as designed, including the DRED, communication via the Smart Meter, and control via UIQ	OUTCOME: Nineteen DR events were successfully conducted during Year one and Year two. LESSON: Smart grid infrastructure can be utilised to conduct residential demand management.
Air-conditioner interface with smart grid	BARRIER: Interfacing with air-conditioners is complex and invasive	OUTCOME: A customised device (DRED) was required. LESSON: Use of the AS4755 standard for demand response interfaces should be mandated. Alternative DRED devices/interface should be sought to reduce the cost of remotely managing priority appliances such as air-conditioners.
Home Area Network	BARRIER: Fully enclosed metal meter boxes impede HAN performance – lost or reduced communication between smart meter and DRED	LESSON: Testing and commissioning of DREDs should include the meter box being fully closed to ensure adequate communication prior to leaving site. Where commissioning fails, a repeater or antenna (at the meter) should be installed to improve communications performance.

Subjects	Barrier or Benefit	Outcome and/or lesson
Home Area Network	BENEFIT: A signal repeater increases the range between the smart meter and other Zigbee devices	OUTCOME: 50% improvement in signal range (25 to 30 meters). LESSON: Use where signal strength is marginal or intermittent.
Customer energy saving behaviours.	BARRIER: Energy efficiency programs encouraging customers to switch off standby power can result in air conditioners being switched off at the wall	OUTCOME: When initiating a demand response event, a command is sent from Western Power via the smart meter to the DRED in the air conditioner. Commands are sent on multiple occasions, commencing from up to 24 hours prior to the scheduled event. However, if an air conditioner is switched off at the wall, the DRED command will not be received. When the air conditioner is then switched on during an event period, the DRED will not be activated. LESSON: Provide communications to customers as part of trial, requesting that air conditioners remain on stand by when not in use during summer. Note: Electricity saved during the course of events outweighs that saved on stand-by.
Pairing of the DRED and the smart meter	BARRIER Inability to remotely pair a DRED to the smart meter	OUTCOME: Once a DRED permanently loses connection with the meter ('un-pairing'), it is necessary to visit the customer site to re-commission the DRED. Un-pairing only occurred during the 10 month gap between Year one and Year two events. LESSON: Remote pairing should be added to the functional specification of the device.

4.4.3 COMMUNICATION AND SUPPORT

Subjects	Barrier	Outcome and/or lesson
Customer Feedback	BARRIER: Lack of communication of trial outcomes	OUTCOME: Participants unsure as to overall results and benefits of the trial. LESSON: Communications plan should include updates of trial progress and results to participants.



LOAD REDUCTIONS ARE CONSISTENT REGARDLESS OF AIR-CONDITIONER SIZE. THE AVERAGE HOUSEHOLD REDUCED THEIR OVERALL PEAK DEMAND BY APPROXIMATELY 25% DURING TRIAL EVENTS.

5.0 IN HOME DISPLAY TRIAL

Image 5-A: Perth Solar City standard model IHD

5.1 BACKGROUND

Households in Western Australia currently receive an electricity bill approximately every 60 days. This is a limiting factor in a householder's ability to better manage their electricity use.

Perth Solar City provided a Western Australia-first trial, to test In Home Display (IHD) technology and its impact on residential electricity use. Householders were provided an IHD that showed their electricity consumption in real-time, both in units (kWh) and in cost ($). This information allowed them to monitor and understand their electricity use (through cause and effect), which may in turn have an impact on their electricity consumption behaviour.

As a Perth Solar City Consortium member, Synergy was responsible for the procurement and deployment of IHDs, and the recruitment of trial participants. The IHD was branded MAX (MAXimise your savings) and was provided free of charge to over 2,200 households. Synergy is the single electricity retailer in the Western Australian residential sector (for energy users below 50MWh/annum).

The IHD was enabled by Western Power's Smart Grid (chapter 3). The IHD communicates wirelessly with the smart meter via the Home Area Network (HAN) to provide real time electricity consumption information. The device is portable within the home, and allows householders to view the change in consumption and cost as a result of switching appliances on or off. Western Power also provided ongoing technical support to IHD participants.

Two generations of the IHD (procured from Canadian manufacturer Energy Aware) were developed for the Perth Solar City Trial, providing:

- standard energy consumption information (generation 1 and 2)
- micro-generation information (generation 2 only)

The standard first generation IHD (image 5-A) has four main functions:

- electrical energy consumption information in units and dollars
- historical electricity consumption based on a user defined date and time
- coloured lights representing time-based tariff consumption blocks
- current tariff rate in dollars per unit

The micro-generation capable, second generation IHD has additional functionality to show the household's net generation, for example when a solar PV system is installed on the home.

Prior to participants receiving an IHD, Western Power pre-matched the IHD to their smart meter. Once the IHD was received, the householder followed a relatively simple pairing process (image 5-A).

2011 RE-CAP

PROGRESS

As at 30 November 2011, Synergy had deployed 1,931 IHDs representing 87% of their program target. 1,544 IHDs were deployed to smart meter households without the householder specifically opting in to the trial. 397 MAX units were deployed to households that specifically opted-in to the trial.

During this period, Western Power was able to test the IHD technology via its smart grid enabled Home Area Network. Western Power completed end to end system testing, functional testing and user acceptance testing for the first and second generation IHDs.

KEY RESULTS

Paring rates to 30 November 2011:

- 56% of all IHD recipients paired their device units.
- The pairing rate for IHDs when received unsolicited through the mail was significantly lower than for those households who were pre-engaged (table 5-A).

Effect on electricity consumption - preliminary analysis

Analysis was completed for 813 participant households who received and paired IHDs in the period 9 February 2011 to June 30 2011. An average of 6.82% reduction of electricity use was evident in the immediate timeframe following the deployment of the first IHDs. This equated to a $114.44 cost saving per household per year.

Table 5-A: Pairing rates for IHDs by deployment mechanism

Campaign	Type of IHD	Number of IHDs	Number of IHDs paired	Pairing rate
Group 1	First generation	201	151	75%
Group 2	First generation	100	75	75%
Group 3	First generation	1,199	590	52%
Group 4 & 5	Second generation	400	255	64%
TOTAL		**1,900**	**1,071**	**56%**

5.2 OBJECTIVES AND PROGRESS

The objectives of the In Home Display Trial under Perth Solar City are:

- to test the IHD technology via Western Power's smart grid enabled Home Area Network
- to test the customer response to the IHD as a single method of providing participants with access to real time electricity consumption information

The specific Key Performance Indicators (KPIs) developed for the trial are:

Activity	Key Performance Indicator	Timeframe	Progress
Technology	Complete HAN interoperability testing of IHD for meter and network management system	2010/11	Complete
Recruitment	Develop marketing and communications material	2010/11	Complete
	Recruit participant households	2010/11	Complete
	Deploy 2,200 IHDs	2010/11	Complete
	Provide technical support as required	2010/11	Complete
Evaluation	Understand customer response via pairing rates	2011/12	Complete
	Understand customer response via impact on electricity consumption	2011/12	Complete

5.3 KEY RESULTS

Key results for the trial will focus on:

- technology
- recruitment
- effect on electricity consumption
- participant evaluation

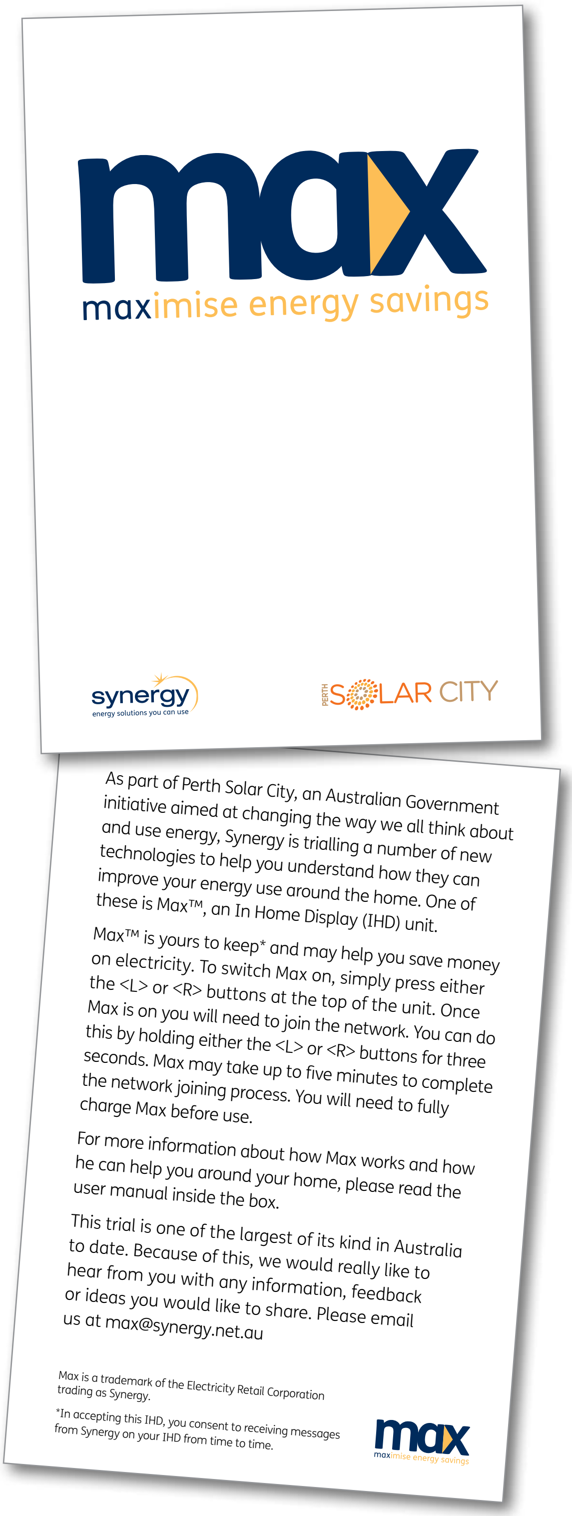
5.3.1 TECHNOLOGY

Complete interoperability testing

Western Power carried out end to end system testing, functional testing and user acceptance testing for the first generation of IHDs. The IHD communicates wirelessly with the participant household's smart meter via the HAN - an open communications platform. Prior to deployment, the IHDs required a series of laboratory-based tests to ensure successful integration with the selected smart meter and network management system (UIQ).

For second generation IHDs, Synergy and Western Power worked with the IHD manufacturer to define the requirements to enable the display of net micro-generation via the HAN, reportedly a world first application.

Image 5-B: MAX deployment letter



max
maximise energy savings

synergy
energy solutions you can use

PERTH SOLAR CITY

As part of Perth Solar City, an Australian Government initiative aimed at changing the way we all think about and use energy, Synergy is trialling a number of new technologies to help you understand how they can improve your energy use around the home. One of these is Max™, an In Home Display (IHD) unit.

Max™ is yours to keep* and may help you save money on electricity. To switch Max on, simply press either the <L> or <R> buttons at the top of the unit. Once Max is on you will need to join the network. You can do this by holding either the <L> or <R> buttons for three seconds. Max may take up to five minutes to complete the network joining process. You will need to fully charge Max before use.

For more information about how Max works and how he can help you around your home, please read the user manual inside the box.

This trial is one of the largest of its kind in Australia to date. Because of this, we would really like to hear from you with any information, feedback or ideas you would like to share. Please email us at max@synergy.net.au

Max is a trademark of the Electricity Retail Corporation trading as Synergy.

*In accepting this IHD, you consent to receiving messages from Synergy on your IHD from time to time.

max
maximise energy savings

Six Synergy and Western Power employees participated in an interoperability pilot prior to the mass deployment of IHDs. The pilot was conducted to ensure that bench-testing of IHDs in the lab had adequately uncovered any/all integration issues in the end-to-end operational process.

Considering that interoperability testing was conducted during office hours, the pilot uncovered several technical issues, for example Sunday tariffs not correctly registering in the IHD.

5.3.2 RECRUITMENT

Synergy was responsible for the engagement and subsequent recruitment of participants, as well as the deployment of IHDs as part of Perth Solar City. Synergy's target was to recruit 2,200 smart meter households to participate in the trial. Synergy developed a unique brand - MAXimise energy savings - and developed information-based marketing materials (image 5-B).

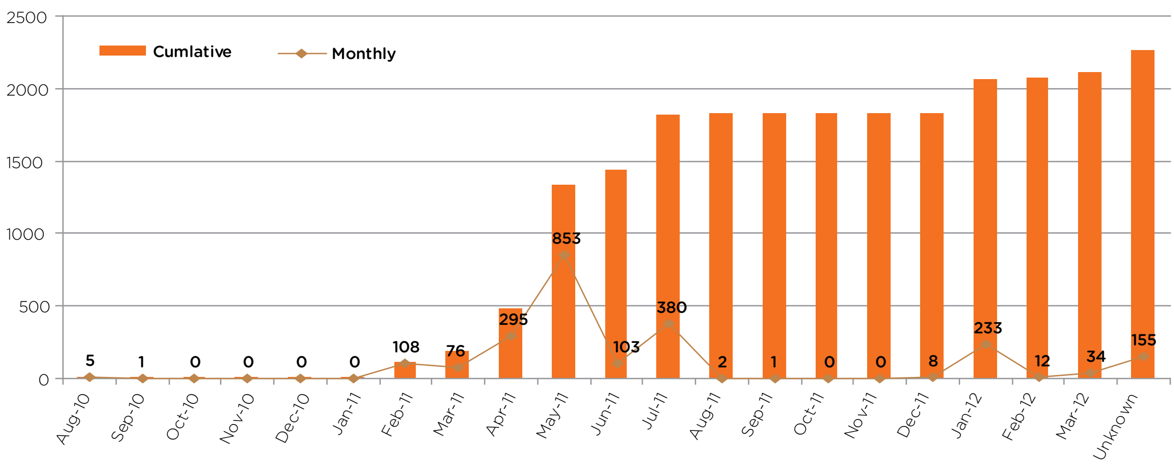
Participant recruitment methods

Synergy's main recruitment method was to package the IHD and send it unsolicited via mail to approximately 1,500 smart meter households (including 345 households with a solar PV system). These households were pre-selected by Synergy without any prior engagement, and therefore without the householder specifically opting-in to the trial. The remainder of the MAX units were deployed to households as part of various other campaigns, including as an incentive for customers to participate in trials such as ACT (chapter 4) and PowerShift (chapter 6).

Sub-Project	Program target	Achieved
IHDs deployed	2,200	2,251

The majority of IHDs were deployed during the June 2011 quarter (image 5-C).

Image 5-C: Deployment of IHDs



Pairing rates

The IHD units required a simple pairing process to calibrate the unit to the smart meter. Households were required to complete this step once in posession of their IHD. The pairing rates for IHDs show the number of households who are active participants in the trial. Recipient households who do not pair the IHD to their smart meter were not considered active participants.

The pairing rate for IHDs across all recruitment strategies was 56%. As the prominent recruitment strategy used by Synergy was to provide participants with the IHD unsolicited through the mail, a 56% take-up rate is considered high when compared with other PSC trials. This shows an initial high-level of interest in receiving a free energy efficiency product in the mail.

Technical support

As the MAX deployment partner, Synergy provided the following participant support:

- dedicated enquiry line
- initial trouble-shooting of technical issues, such as replacement of faulty units, return of unwanted units, replacement of batteries as required
- the escalation of more technical issues to Western Power, such as pairing with smart meter, loss of HAN signal, and reprogramming to support tariff changes

Western Power also provided on-going technical support for the HAN (image 5-D), as well as the technical support required to pre-pair the IHDs.

For pre-pairing, Synergy would pre-allocate an IHD to a household and inform Western Power prior to deployment. Western Power would then pre-pair the device to UIQ and request that the vendor (SilverSprings Networks) open an unlimited join window in the system to allow customer connection following receipt of their IHD. Once the join window is established, approval for dispatch was provided to Synergy. Upon receiving their IHD in the mail, the customer was required to remove the IHD from the box and complete the pairing process (image 5-A).

Image 5-D: Overview of technical support provided by Western Power

Home Area Network

UIQ ISSUE
Excessive lag time In consumption change update. UIQ vendor Issued firmware upgrade.

IHD ISSUE
No energy generation support. Enhanced IHD is generation capable.

UIQ ISSUE
Support TOU tariff pricing in Western Standard Time (not GMT). Fix UIQ 4.2.8.

HAN ISSUE
Limits of HAN coverage +50 metres for IHD joining with smart meter. External antenna on meter and Zigbee repeaters as solution.

UIQ ISSUE
Inability to set plus 300 second join window through UIQ. Workaround provided by vendor.

UIQ ISSUE
HAN certificate missing from meter NIC. Can't be joined with HAN devices. HAN certificates installed.

IHD ISSUE
IHD displays incorrect after meter reset. Limitation of IHD model. Customer required to reset IHD.

IHD ISSUE
IHD not flashing 5 minutes prior to next tariff block as per specifications. Workaround Implemented via UIQ.

UIQ and IHD Issue
Running total screen will not accurately calculate the $ used for TOU customers.

IHD ISSUE
Battery failure on enhanced IHD causes data synchronisation failure, multiple reboots and event 'storm' on UIQ. New batteries sent.

UIQ ISSUE
Electricity consumption cost not displayed on weekends. Fix UIQ 4.2.8.

- Issue identified - unsolved
- Workaround in place
- Issue solved

DURING THE SUPER-PEAK PERIOD, IHD PARTICIPANTS REDUCED THEIR ELECTRICITY USE BY 5.0%

5.3.3 EFFECT ON ELECTRICITY CONSUMPTION

Perth Solar City commissioned Data Analysis Australia (DAA) to provide analysis on the effect of the IHD on reducing overall participant electricity consumption. The analytic methodology developed and used by DAA is attached as Appendix B.

Total electricity consumption

Analysis was completed for 1,137 participant households who had paired their IHD. Participants reduced their electricity use by an average of 1.5% (image 5-E).

Table 5-B shows the extrapolated annual cost and greenhouse gas savings for participants who paired their IHD.

Table 5-B: Extrapolated annual cost and greenhouse gas emissions savings

Customer Group	Electricity cost savings per household ($/year)*	Greenhouse Gas savings (kg CO-e/year)^
IHD	$25.17	93

* Calculation based on unit cost of $0.248866 per kWh – the A1 all-time rate as at 30 September 2012
^ based on emission co-efficient of 0.92kg/CO2-e per kWh (National Greenhouse Account Factors July 2012)

This is a decrease on the 6.7% preliminary result reported in the Perth Solar City 2011 Annual Report. Several factors are likely to have contributed to this difference, including:

- increased number of participants included in 2012 analysis
- the preliminary analysis included the period of approximately 6 months post IHD deployment. The 2012 analysis includes a significantly longer period post IHD deployment
- the majority of participants were not engaged as to the opportunity and benefits of using the IHD prior to receiving it
- a significant minority of participants stopped using their IHD as a result of technical issues such as faulty battery and/or loss of pairing with the smart meter (section 5.3.4)

IHD in combination with other products and services

IHD participants who also participated in other Perth Solar City products and services (including the Home Eco-Consultation and Living Smart) reduced their average electricity consumption by 21.4%. This is nearly double that of households who participated in the Home Eco-Consultation and Living Smart programs combined (without an IHD). However, it should be noted that the sample size of the former is relatively small at 76 participants, and therefore should only be considered indicative.

Effect on Super-Peak consumption

Perth Solar City commissioned Data Analysis Australia (DAA) to provide analysis of the effect of the IHD on reducing participant electricity consumption during the allocated Super-Peak (2pm – 8pm on weekdays). The analytic methodology developed and used by DAA is attached as Appendix B.

During the Super-Peak period, IHD participants reduced their electricity use by 5.0% (image 5-F). This is supported by approximately 49% of households reporting sustained reductions in air-conditioner use as a result of using the IHD (section 5.3.4).

5.3.4 PARTICIPANT EVALUATION

Perth Solar City commissioned TNS to undertake detailed participant evaluation for the technical trials, including the IHD Trial. The objectives of the analysis were to understand the following:

- overall participant experience
- motivation for participation
- sign-up and activation
- trial impact
- trial outcomes
- behaviour change

A total of 210 IHD participants responded to a quantitative survey and 20 participants were involved in the qualitative evaluation, either in a focus group or one-on-one interview. It should be noted that 77% of quantitative survey respondents paired their IHD. This is a higher representation than the trial as a whole (56%).

Image 5-E: IHD impact on total electricity consumption

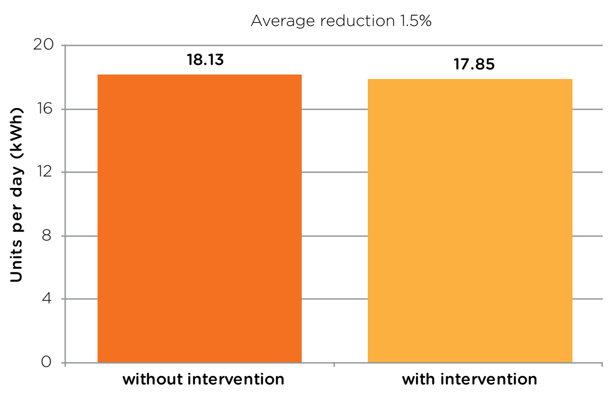
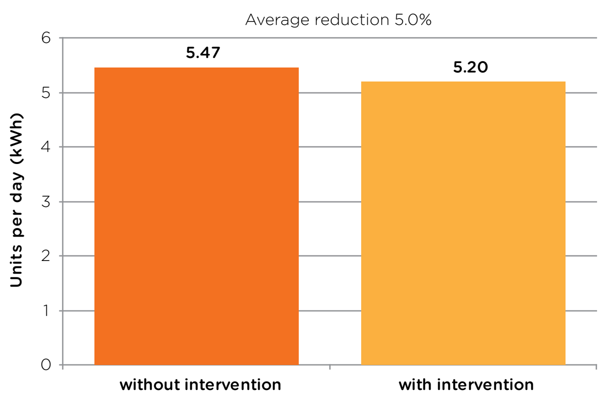


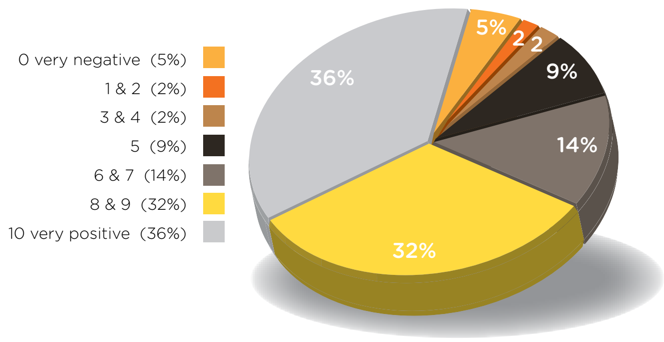
Image 5-F: IHD impact on Super-Peak



Overall participant experience

Four out of five participants (82%) had a positive experience of the trial, with more than one third (36%) rating the experience as '10 out of 10' (image 5-G).

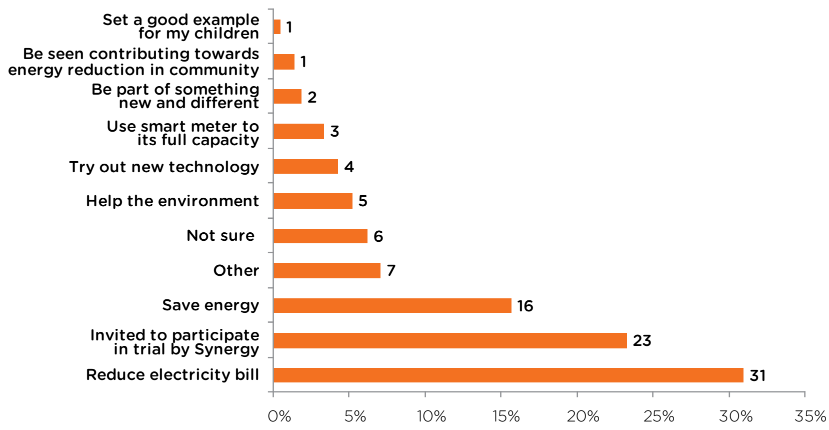
Image 5-G: Overall participant experience



Participant motivation

The most significant motivation for participation by households who paired the device was to reduce their electricity bill (31%) (image 5-H).

Image 5-H: Motivation for participating in trial

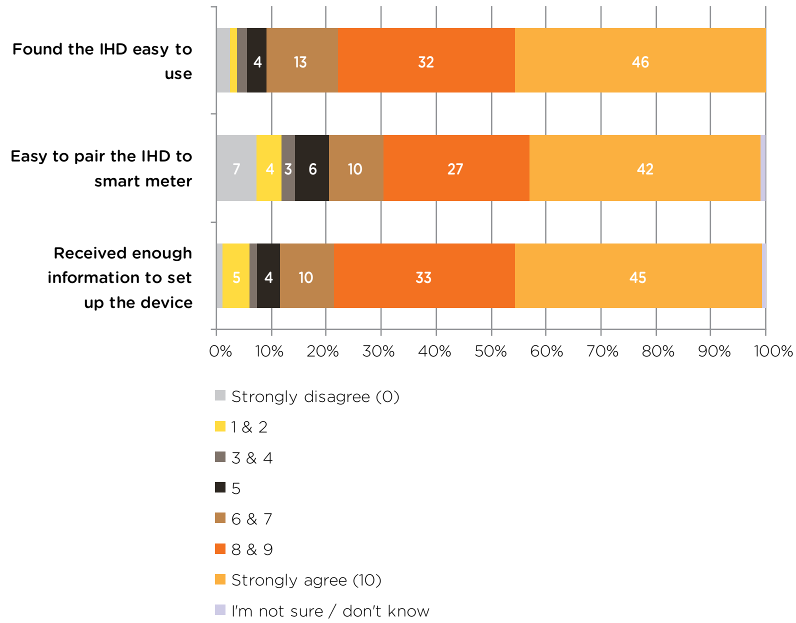


Sign-up and activation

The majority of trial participants found the sign up and activation process to be 'easy' (image 5-I). However, there were a slightly higher number of implementation issues when compared to other Perth Solar City technical trials.

Of those participants who experienced issues during the IHD Trial the most common were difficulties in pairing the device to the smart meter and maintaining the connection.

Image 5-I: Ease of sign up / activation of the IHD



Trial impact

The initial reaction of survey respondents to receiving the IHD was positive (94%), with participants typically being 'intrigued' and recognised the potential value of the device as a tool to monitor energy use. Feedback from participants included:

- "Positive. It seemed like a bonus and appreciation for taking part in the Solar City program"
- "Didn't know that it was being sent so it was a surprise"
- "Excited and intrigued with possibilities to manage our power consumption"

Survey respondents who did not pair their IHD provided some insight into the reasons (image 5-J).

Of those who paired the device, approximately 78% reported referring to it daily (image 5-K).

The majority of IHD Trial participants (71%) perceived a reduction in household electricity use. This perception is likely to have contributed to the positive experience of the overall trial.

Participant households were likely to act as strong advocates for the IHD Trial. Approximately 74% of IHD Trial participants indicated that they would be willing to participate again in the future, whilst 77% were willing to recommend the trial to others (image 5-L).

Image 5-J: Reasons for not pairing IHD

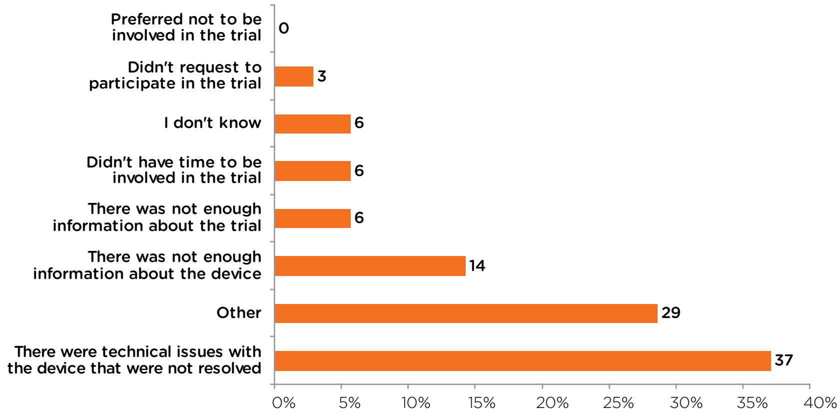


Image 5-K: Frequency of using IHD within household

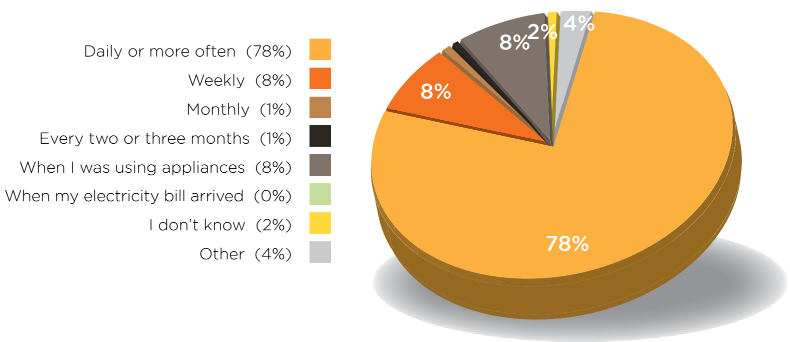
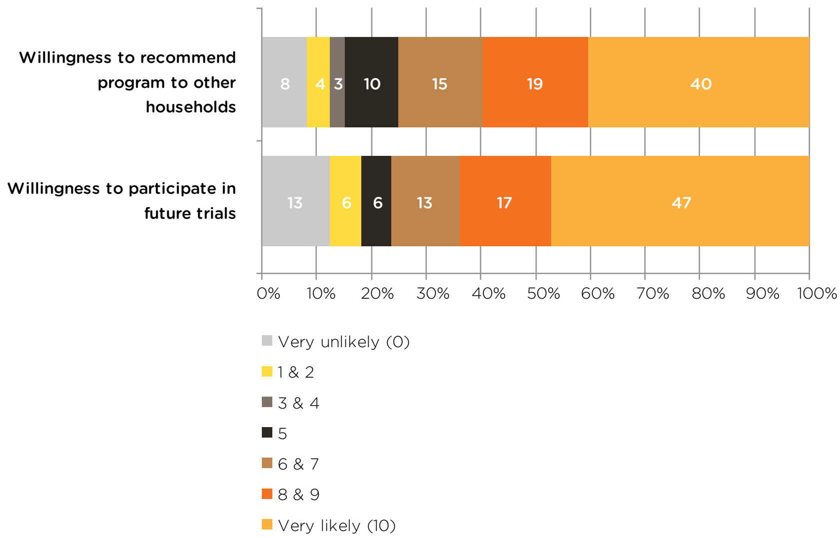


Image 5-L: Willingness to participate in IHD programs in the future and to recommend to other households



Behaviour change

The IHD Trial was successful in increasing awareness of energy use, and assisting participants to adopt energy saving behaviours around the household (image 5-M). Some of this knowledge was reported to have resulted in behaviour change. For example, some participants found it easy to reduce consumption in appliances such as air-conditioners and clothes dryers (image 5-N). However, participants reported more difficulty in reducing consumption in 'every day' appliances such as the vacuum cleaner and microwave/oven.

Image 5-M: Awareness generated by using an IHD

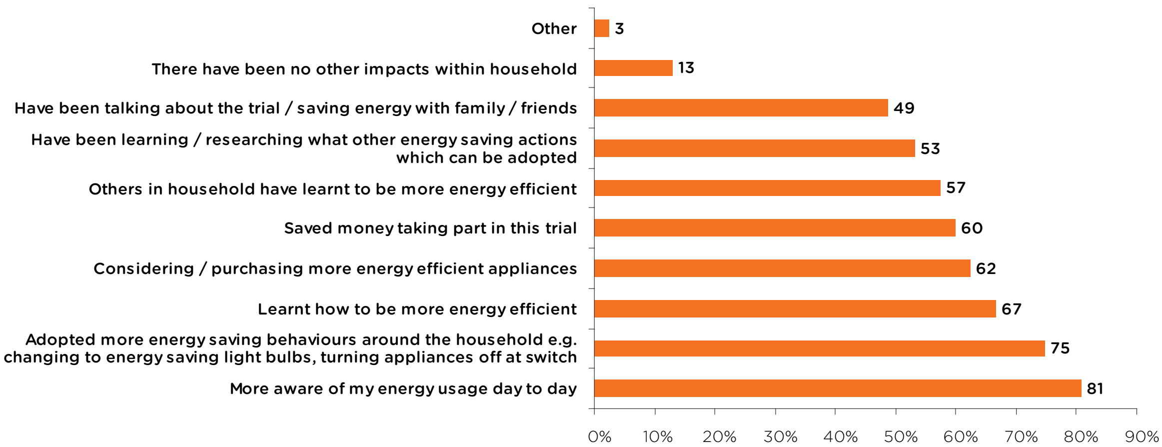
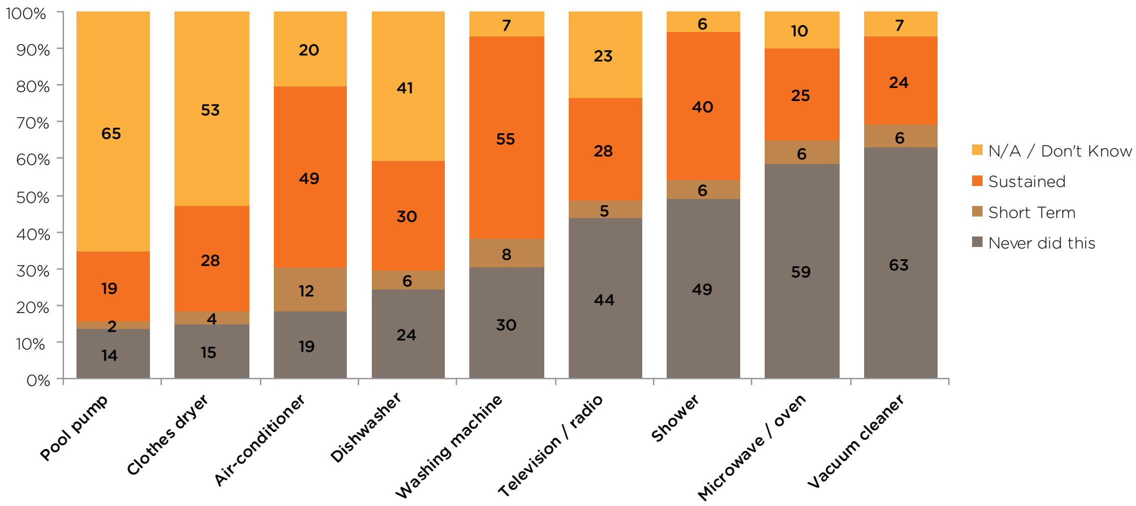
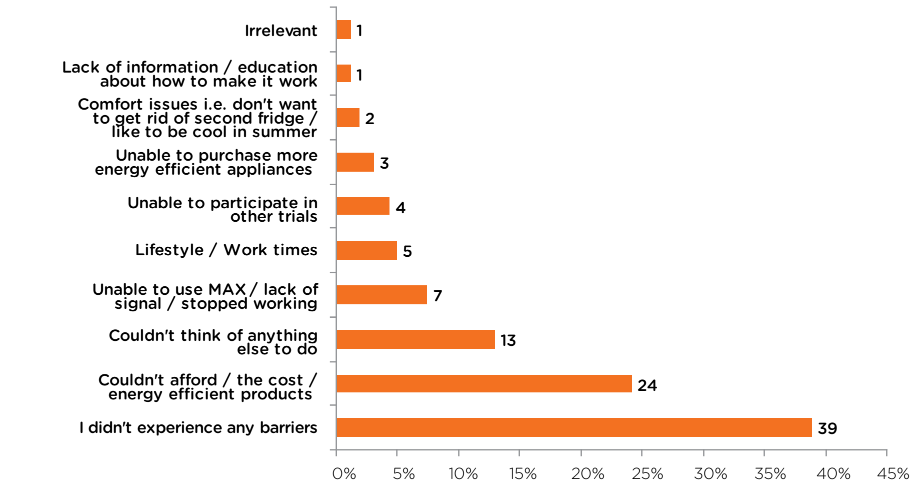


Image 5-N: Level of behaviour change, by appliance



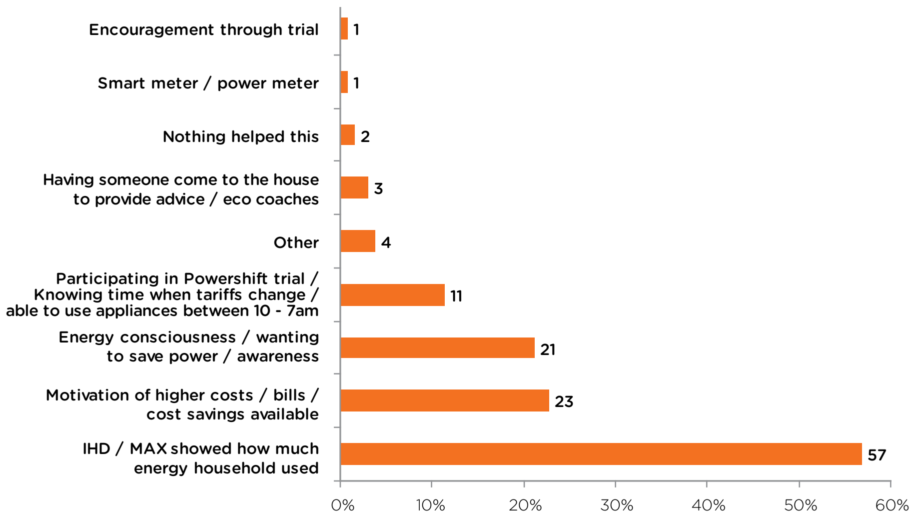
Affordability of energy efficient appliances appeared to be one of the biggest barriers preventing further behaviour change, while 'not being sure' of how to achieve further savings or make further changes was also reported (image 5-O).

Image 5-O: Barriers to behaviour change



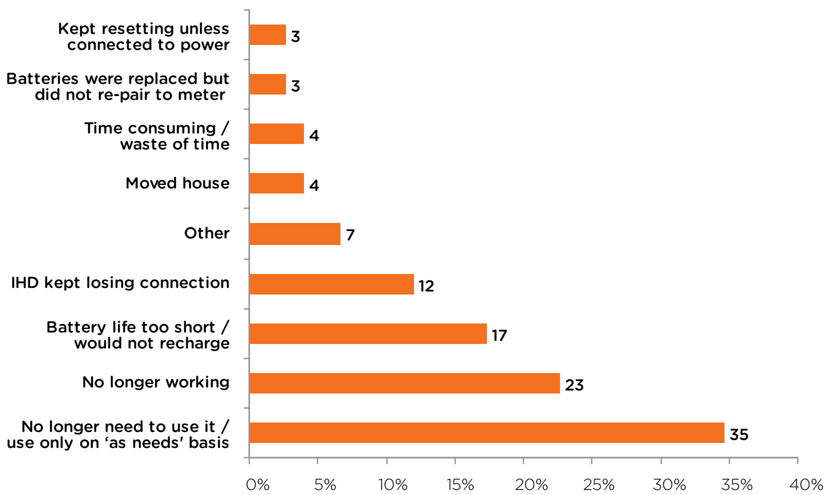
The IHD was considered to be a significant facilitator in reducing electricity use as it showed how much electricity was costing in real-time (image 5-P). Higher electricity costs and energy consciousness were also important facilitators.

Image 5-P: Facilitators to behaviour change



The biggest reason provided for ceasing or reducing use of the IHD was that it was 'no longer required', or only used on an 'as needs' basis (image 5-Q). However, technical and battery issues were also identified as significant contributors to participants no longer using their device.

Image 5-Q: Reasons for no longer using IHD



"OUR BILL HAS DROPPED FROM AROUND $100, TO ABOUT $30 - $40, WHICH IS GREAT"

5.4 TRANSFERRABLE LESSONS

The IHD Trial shows the potential benefit of providing access to real-time energy information to households. A number of recruitment and technical learnings have emerged from the IHD Trial to date.

5.4.1 RECRUITMENT

Subject	Barrier or Benefit	Outcome and/or lesson
Engagement of households by retailer	BARRIER: The majority of IHDs were sent to households unsolicited.	OUTCOME: 44% of recipients did not pair the IHD with the smart meter. LESSON: In order to maximise the benefits of IHDs, they should be made available to engaged and motivated participants via an opt-in program.
Data capture on deployment strategies	BARRIER: Limited data capture on different IHD deployment strategies.	OUTCOME: There was an inability to evaluate the success of different IHD deployment strategies (pre-engaged vs non opt-in). LESSON: Clearly define objectives for data capture with deployment partner. Closer management of deployment partner data capture process prior to, and during deployment.
Targeted deployment	BENEFIT: Reduction of electricity use at peak times.	OUTCOME: A 5% reduction in electricity consumption during peak periods was achieved. LESSON: Consider deployment of IHDs, as part of a broader demand management strategy, in areas of the network with peak demand constraints.
Engagement and recruitment	BARRIER: Lack of clear incentive and/or driver for deployment partner.	OUTCOME: The delivery of IHDs within the target area was not as effective as anticipated. LESSON: Engagement and recruitment for smart grid enabled products and services should be undertaken by organisations for which energy efficiency and demand-side management is part of core business, or is appropriately supported by regulatory-based incentives.
Consortium Agreement	BARRIER: Lack of prescriptive engagement and recruitment methodology in the Consortium Agreement.	OUTCOME: IHD deployment was undertaken to meet basic contractual targets, irrespective of the effectiveness of the method of deployment. LESSON: Contracts for the delivery of smart grid enabled products and services should include provisions for engagement and recruitment methodology.

5.4.2 TECHNICAL

Subject	Barrier or Benefit	Outcome and/or lesson
Home Area Network	BARRIER: Suitability of 2.4GHz wireless for extended HAN signal coverage.	OUTCOME: In instances where the smart meter was a significant distance from the home (typically beyond 50m), or multiple physical barriers exist (i.e. multiple walls), signal coverage was beyond the range of the wireless technology. As a result, some participants found repeated pairing attempts inconvenient, and/or were unable to continue in the trial. LESSON: Range extension can be achieved via antennas, repeaters or a wired solution, such as using the power-line connection to the residence to carry the zigbee signal.
Technical support for the deployment of new technology	BARRIER: The IHD technology is a relatively new technology in Australia	OUTCOME: Ongoing technical support, including replacement of faulty batteries, is required for the duration of the trial. LESSON: Roles and responsibilities for technical support should be clearly defined. Technical support for IHDs should be integrated into business-as-usual processes prior to larger scale deployments.
Deployment of basic function IHD	BARRIER: Lack of choice for house-holders between differing methods of providing access to real-time electricity consumption information	OUTCOME: The trial was limited to identifying the effectiveness of a basic function IHD. LESSON: Further trials should be conducted, which provide greater choice to householders including USB connections or smart-phone applications.

CASE STUDY
IN HOME DISPLAY AND TIME-OF-USE TARIFF

Scott lives with his partner and daughter and participated in the In Home Display and Time-of-Use Tariff Trials. His main motivation for participating in the trials was to reduce their carbon footprint; "we have always been quite energy conscious, and since we have moved into this house we have tried to become more self-sufficient – growing our own vegetables and having chickens". Scott was aware of similar trials being conducted in other states and was delighted when he received an invitation to participate in the trials in Perth.

Participating in the In Home Display and Time-of-Use Tariff Trials allowed Scott to reduce his household electricity bill by around two thirds:

Initially Scott signed up to participate in the Time-of-Use Tariff Trial, and then received a phone call to ask if he would like an in home display. "We were very happy to get the MAX – it has made participating in the PowerShift trial that much easier for us." The In Home Display was placed in the kitchen and was used intensively in the first few weeks to determine how much electricity each appliance was using:

"Our bill has dropped from around $100, to about $30 - $40, which is great".

"We tested each appliance by leaving it plugged in and turning everything else off – our old fridge was a major energy sucker".

Once Scott and his partner developed an understanding of how much electricity each appliance used, the In Home Display was used on a more occasional basis for spot checks. Scott would have liked the In Home Display to have an alarm to provide more instant notification when energy usage peaked:

"It would be a good reminder for our daughter if an alarm went off when she has her lights, TV, hairdryer and hair straightener on all at the same time!".

Some of the direct changes made by participating in the In Home Display and Time-of-Use Tariff Trials were the purchase of new energy efficient appliances, turning appliances off standby and using main lights less often. Scott and his family have also changed the timing of some of their activities – particularly the washing machine and cooking times:

"I have become a bit obsessive – I will stay up until 10pm just to put the washing on and we have started to cook a bit later too".

The trial has also increased general energy awareness within the household and they have taken up activities such as half filling the kettle, flushing the toilet less often and placing egg timers in the shower.

After having participated in the Perth Solar City trial, Scott is seeking more information on having solar panels and a grey water system installed.

(Scott, MAX and PowerShift, 45 – 54, Self Employed).
Source: Market research survey TNS, 2012.

6.0

TIME-OF-USE TARIFF TRIAL

6.1 BACKGROUND

PowerShift, a voluntary three-part time-of-use tariff, was developed by Synergy for Perth Solar City. PowerShift is the first tariff in Western Australia which seeks to more closely align electricity consumption blocks with time-based costs of supply. PowerShift provides customers with the financial incentive to reduce household electricity costs by shifting consumption away from times of peak demand.

Prior to PowerShift, Western Australian households on the South West Interconnected System (SWIS) had two electricity tariff choices:

- A1 tariff: a subsidised all-time tariff where customers are charged one flat rate (24.89c/kWh), regardless of when the electricity is used
- SmartPower: a four-part time-of-use (TOU) tariff where premium charges occur from 11am – 5pm on weekdays (45.88c/kWh during weekdays in summer)

Peak electricity demand on the SWIS generally occurs in summer between 4pm and 8pm on weekdays. Peak demand places significant strain on Western Power's electricity network, resulting in the inefficient use of existing network resources, and requiring costly network augmentation. Neither of the existing retail tariffs reflect the increased cost of electricity supply during peak demand periods, nor encourages households to use electricity outside of peak periods.

SHIFTING CONSUMPTION AWAY FROM TIMES OF PEAK DEMAND

The price structure, as at 30 September 2012 is shown in table 6-A.

Table 6-A: PowerShift consumption blocks and charges

Period	Time	Rate (c/kWh)
Super-Peak	Weekdays - 2pm to 8pm	40.15
Peak	Weekdays - 7am to 2pm and 8pm to 10pm Weekends - 7am to 10pm	23.08
Off-Peak	All days - 10pm to 7am	13.04

The fixed network supply charge for PowerShift is 38.23 cents per day, compared to 41.55 cents per day for the A1 tariff. This provides participants with a further incremental benefit.

Synergy is responsible for the engagement and recruitment of participants to PowerShift. Participant households require an interval capable meter which can either be a smart meter recently installed under Perth Solar City, or a reprogrammable electronic meter. There are approximately 20,000 households with interval capable meters in the Perth Solar City target area.

6.2 OBJECTIVES AND PROGRESS

The key objectives of the Time-of-Use Tariff Trial are to:

- understand the potential for a voluntary peak-demand based price signal to shift household electricity consumption (from periods of peak demand to periods of off-peak demand)
- understand the potential for a voluntary peak-demand based price signal to reduce household electricity costs

A total of 746 households were recruited to the voluntary trial, representing 74.6% of the target for participation.

2011 RE-CAP

PROGRESS

Synergy originally proposed a target of 5,000 Powershift participants within the Perth Solar City target area. However, the target was reviewed during 2010/11 and subsequently reduced to 1,000 participants. As at 30 November 2011, Synergy had recruited 427 of the targeted 1,000 households to PowerShift.

Prior to the commencement of the recruitment campaign for PowerShift, Synergy developed an interactive web-based calculator to assist households in determining the appropriateness of the product. The PowerShift calculator enables customers to see how much money they could save per annum by shifting various percentages of their consumption to off-peak periods.

Of the 427 households who signed up for PowerShift, a total of 94 households have requested to return to the A1 all-time tariff – representing an attrition rate of 22%.

KEY RESULTS

The broad objective of PowerShift is not to reduce a householder's overall electricity consumption, but rather it seeks to:

- reduce electricity consumption at times of peak demand (Super-Peak)
- reward householders for changing their electricity consumption behaviour to reduce consumption at times of peak demand

As such, preliminary analysis seeks to understand the reductions in electricity consumption at Super-Peak, as well as the effects of shifting behaviour on household electricity costs.

Analysis was completed using NEM 12 (interval) data for 334 participant households who had signed up for and remained on PowerShift in the period 1 August 2010 to 30 June 2011. The preliminary analysis shows a reduction in electricity consumption during the Super-Peak of 10.9%.

Sub-Project	Program Target	Achieved
Time-of-use tariff participants	1,000	746

PowerShift pricing review

As a result of the carbon price pass through and state-wide annual tariff price increases, a review of the PowerShift tariff rates was completed during May 2012. All PowerShift rates received the carbon price pass through, while the annual state-wide tariff increase was limited to the Super-Peak rate (table 6-B). The resultant rate changes came into effect on 1 July 2012.

Table 6-B: June 2012 tariff pricing review – PowerShift and A1

Period	Time	Rate to 30 June 2012 (c/kWh)	Rate as at 1 July 2012 (c/kWh)
Super-Peak	Weekdays - 2pm to 8pm	36.62	40.15
Peak	Weekdays - 7am to 2pm and 8pm to 10pm Weekends - 7am to 10pm	20.83	23.08
Off-Peak	All days - 10pm to 7am	10.78	13.04
Supply charge	Per day	36.49	38.23
A1	All-time	21.87	24.89
Supply charge	Per day	36.49	41.55

Recruitment of participant households

Most existing electricity meters (mechanical) record cumulative consumption, which is then read for billing every 60 days. PowerShift requires participants to have an interval capable meter. An interval capable meter is a digital meter capable of recording electricity use by programmed time-bands, including every half-hour.

As PowerShift is a time-based tariff, whereby participants are charged different rates at different times of the day, the meter is required to be configured to record electricity consumption for these specific time periods. There are two types of interval capable meter:

- an electronic meter - requiring programming to the new time-of-use tariff time periods, and manually read every 60 days
- a smart meter - records half hourly interval data and is capable of being read remotely

To market PowerShift, Synergy identified three groups of potential participants (table 6-C).

Table 6-C: Target Groups

Group	Description	Approx no. of households	PowerShift participants
Group 1	Customers that have a basic meter installed at their home These customers would require a meter exchange	100,000	111
Group 2	Customers that have an electronic meter installed at their home	15,000	160
Group 3	Customers that have received a smart meter as part of the Program	7,000*	475

*Number of smart meters installed at time of campaign

Group 1 (basic meter) participants require a meter exchange to an interval capable meter. Participants in Group 2 and 3 have interval capable meters requiring configuration to PowerShift.

Participation – Group 1 (basic meter households)

Participation from households in Group 1 required a meter exchange costing $176.15 for a single phase meter or $276 for a three phase meter. This cost is considered a barrier to participation as it is likely to negate the savings made from changing to the PowerShift tariff in the short term. To remove this barrier, Western Power agreed to waive the meter exchange cost for up to 500 participants.

A traditional marketing campaign, which included the mass mail-out of a letter to households, was conducted in two phases. The letter included general information about PowerShift, and relied on customers understanding their own energy use across an average day as the means of assessing suitability (image 6-A).

Phase 1 was completed during April and May 2012. Phase 2 was completed during July to September 2012. A total of 17,642 households received the mass mail-out across the two campaigns, which yielded a total of 111 recruited households. The sign-up rate for this campaign was therefore 0.6%.

Participation – Group 2 (electronic meter households)

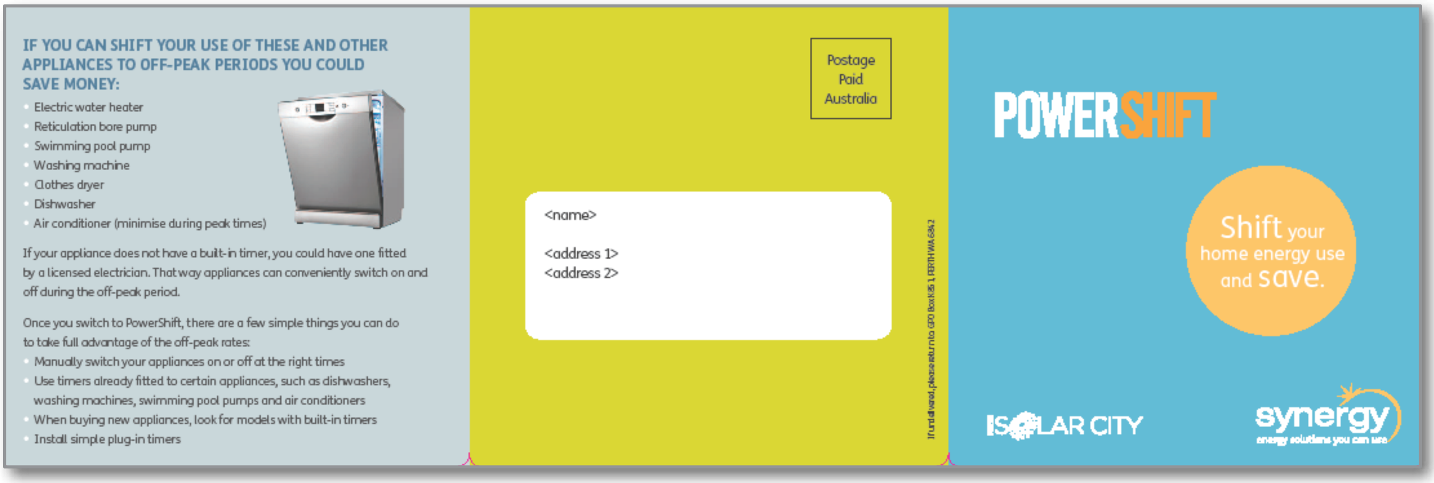
Approximately 15,000 customers within the Program target area have a reprogrammable electronic meter. Participation from households in Group 2 required a meter reprogram costing $66. Western Power and Synergy agreed to waive this cost to participants.

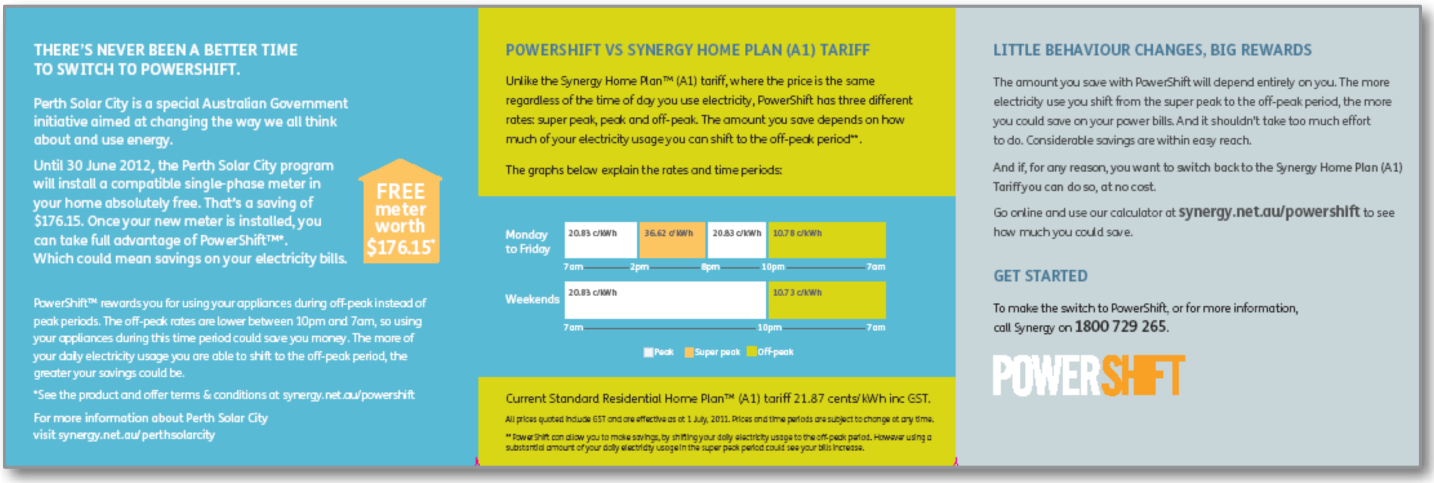
A traditional marketing campaign, which included the mass mail-out of a letter, was conducted for approximately 8,000 households. The letter included general information about PowerShift, and relied on customers understanding their own energy use across an average day as the means of assessing suitability (image 6-B). This campaign recruited 160 households, a sign-up rate of 2.0%.

Participation - Group 3 (PSC smart meter recipient households)

Analysis of a household's 30 minute interval data collected remotely via the smart meter provides a profile of the households average daily electricity use (image 6-C). This profile enables an understanding of the household's consumption at different times of the day. The PowerShift time bands can then be overlayed to the profile (image 6-D), in order to calculate the expected electricity costs for the householder on PowerShift. The

Image 6-A: PowerShift direct mailer to Group 1 households





resultant cost on PowerShift can then be compared to the cost on the A1 tariff. In short, the suitability of switching tariffs becomes easily evident.

During June 2012, this method was used to analyse smart meter households as a means of understanding who could benefit from switching to PowerShift. One full year of electricity consumption data for the period 1 June 2011 to 30 May 2012 was used to calculate electricity costs under both the PowerShift and A1 rates. An example of this analysis for the randomly selected household is provided in table 6-D. The results show that the example household could save approximately $234 per year on PowerShift based on their current consumption profile. In turn, when presented with this information, customers are able to make a more informed decision about the opportunity and benefits of switching to PowerShift.

6.0 Image 6-B: Group 2 PowerShift brochure

BROC0010SEPT10 Printed on 100% recycled post-consumer waste.

PowerShift.

Shift your energy use and save.

synergy
energy solutions you can use

SOLAR CITY

What is PowerShift?

PowerShift™ is a three part time-of-use pricing product that lets you take advantage of variable electricity rates, depending on when you use electricity.

Put simply, the more electricity you can shift to off peak, the greater your potential to save.

PowerShift™ is a key component of Synergy's commitment to trial new energy management products as part of Perth Solar City, a $73.5 million Federal Government initiative.

Synergy seeks to work with customers to encourage the more efficient use of electricity and, in particular, to help reduce peak demand.

Using power in the cheaper time periods not only means electricity bill savings, it helps ensure a more consistent and reliable energy supply.

Synergy seeks to work with customers to encourage the more efficient use of electricity and, in particular, to help reduce peak demand.

How does PowerShift work?

Unlike the flat rate Home Plan™ (A1) Tariff, where the price is the same regardless of when you use electricity, PowerShift has three different rates depending on the time of day that you use it.

A higher rate is charged during the super peak period, and the peak rate is charged at the same rate as the Home Plan™ (A1) Tariff.

However, you have the opportunity to make significant savings by using your electricity during the off-peak times as shown below:

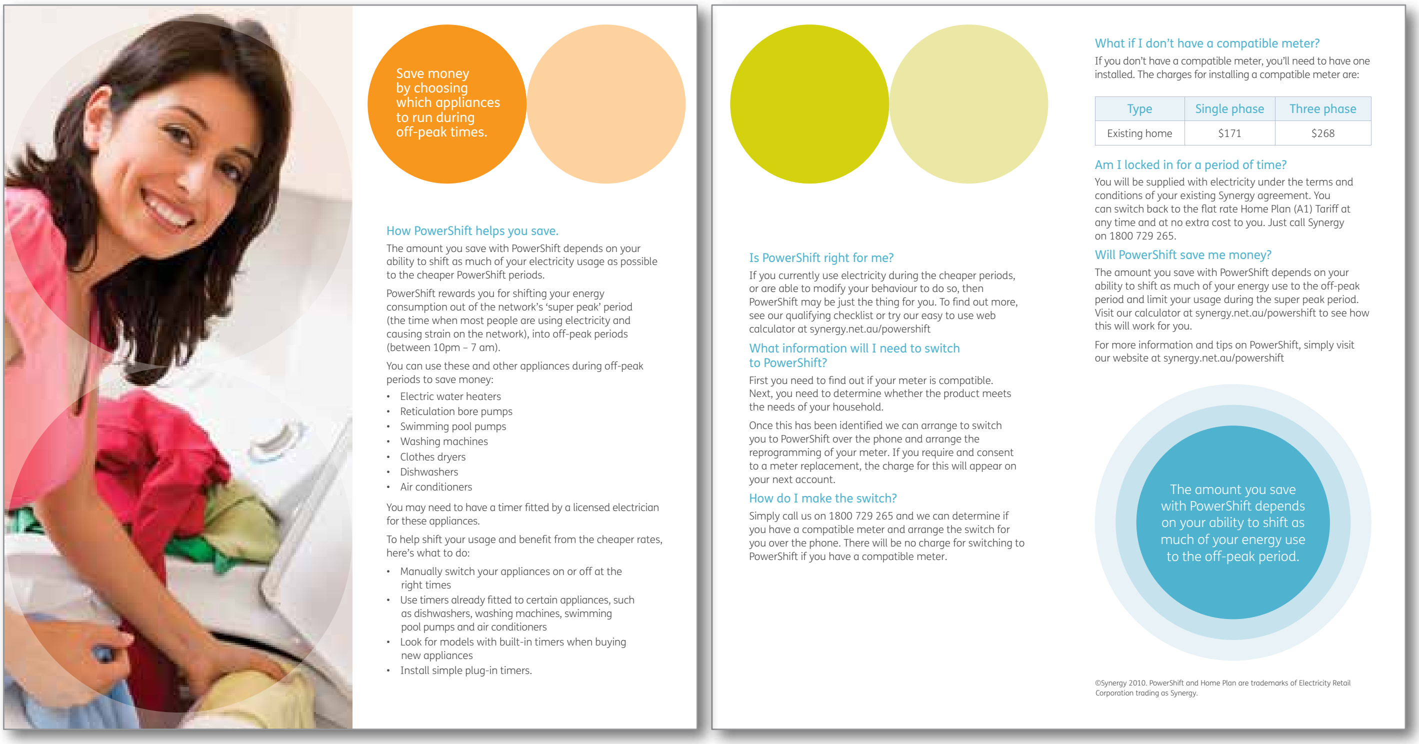
Rate	Time period	Rate
Super peak	Weekdays – 2pm to 8pm	36.62c/kWh
Peak	Weekdays – 7am to 2pm – 8pm to 10pm Weekends – 7am to 10pm	20.83c/kWh
Off-peak	All days – 10pm to 7am	10.78c/kWh
Supply charge	per day	38.23c/day

1. Weekends all year round

2. Weekdays all year round

Current Standard Residential Home Plan (A1) Tariff 20.83 cents/kWh incl. GST.

All prices quoted include GST and are effective as at 1 July 2010. Prices and time periods are subject to change at any time.



Save money by choosing which appliances to run during off-peak times.

How PowerShift helps you save.

The amount you save with PowerShift depends on your ability to shift as much of your electricity usage as possible to the cheaper PowerShift periods.

PowerShift rewards you for shifting your energy consumption out of the network's 'super peak' period (the time when most people are using electricity and causing strain on the network), into off-peak periods (between 10pm – 7 am).

You can use these and other appliances during off-peak periods to save money:

- Electric water heaters
- Reticulation bore pumps
- Swimming pool pumps
- Washing machines
- Clothes dryers
- Dishwashers
- Air conditioners

You may need to have a timer fitted by a licensed electrician for these appliances.

To help shift your usage and benefit from the cheaper rates, here's what to do:

- Manually switch your appliances on or off at the right times
- Use timers already fitted to certain appliances, such as dishwashers, washing machines, swimming pool pumps and air conditioners
- Look for models with built-in timers when buying new appliances
- Install simple plug-in timers.

Is PowerShift right for me?

If you currently use electricity during the cheaper periods, or are able to modify your behaviour to do so, then PowerShift may be just the thing for you. To find out more, see our qualifying checklist or try our easy to use web calculator at synergy.net.au/powershift

What information will I need to switch to PowerShift?

First you need to find out if your meter is compatible. Next, you need to determine whether the product meets the needs of your household.

Once this has been identified we can arrange to switch you to PowerShift over the phone and arrange the reprogramming of your meter. If you require and consent to a meter replacement, the charge for this will appear on your next account.

How do I make the switch?

Simply call us on 1800 729 265 and we can determine if you have a compatible meter and arrange the switch for you over the phone. There will be no charge for switching to PowerShift if you have a compatible meter.

What if I don't have a compatible meter?

If you don't have a compatible meter, you'll need to have one installed. The charges for installing a compatible meter are:

Type	Single phase	Three phase
Existing home	$171	$268

Am I locked in for a period of time?

You will be supplied with electricity under the terms and conditions of your existing Synergy agreement. You can switch back to the flat rate Home Plan (A1) Tariff at any time and at no extra cost to you. Just call Synergy on 1800 729 265.

Will PowerShift save me money?

The amount you save with PowerShift depends on your ability to shift as much of your energy use to the off-peak period and limit your usage during the super peak period. Visit our calculator at synergy.net.au/powershift to see how this will work for you.

For more information and tips on PowerShift, simply visit our website at synergy.net.au/powershift

The amount you save with PowerShift depends on your ability to shift as much of your energy use to the off-peak period.

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Image 6-C: Average load profile – randomly selected smart meter household

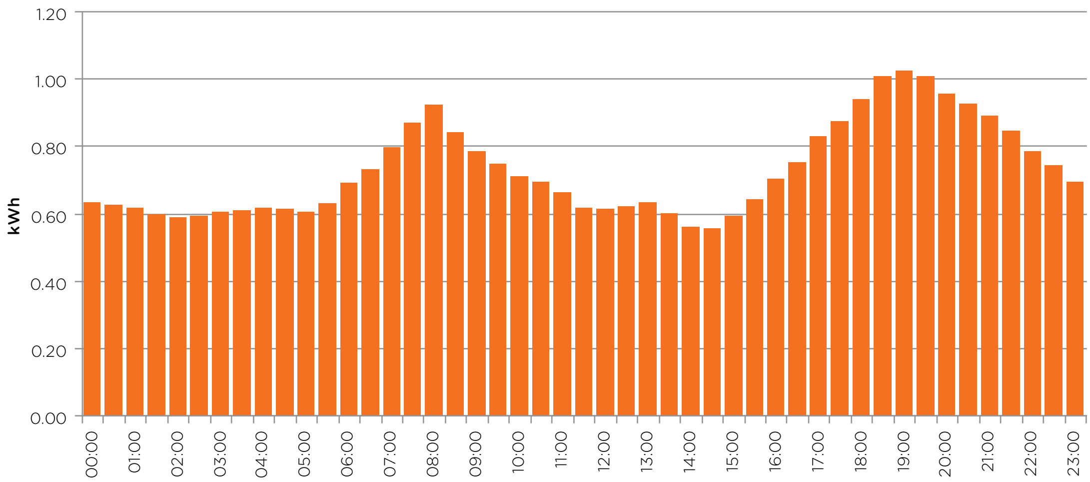


Image 6-D: Average load profile with PowerShift overlay – randomly selected smart meter household

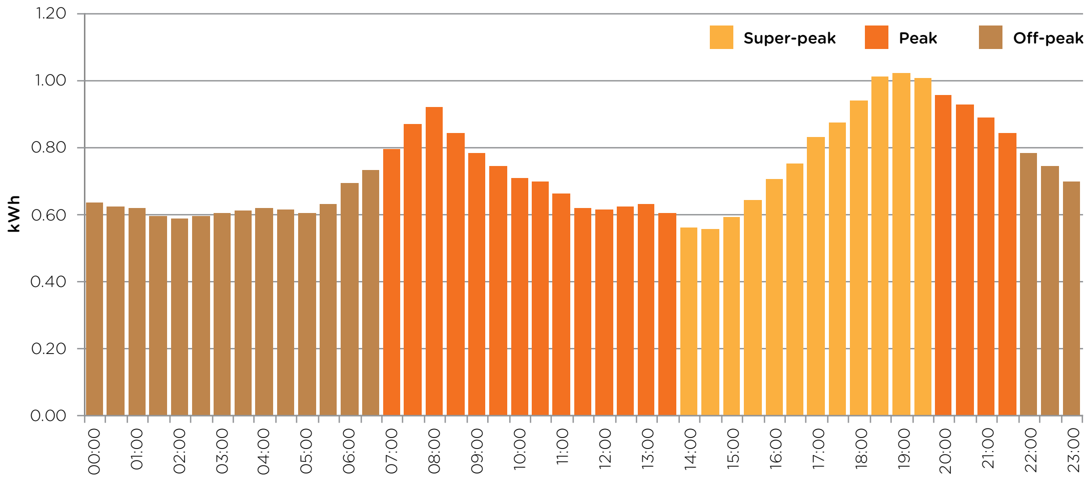
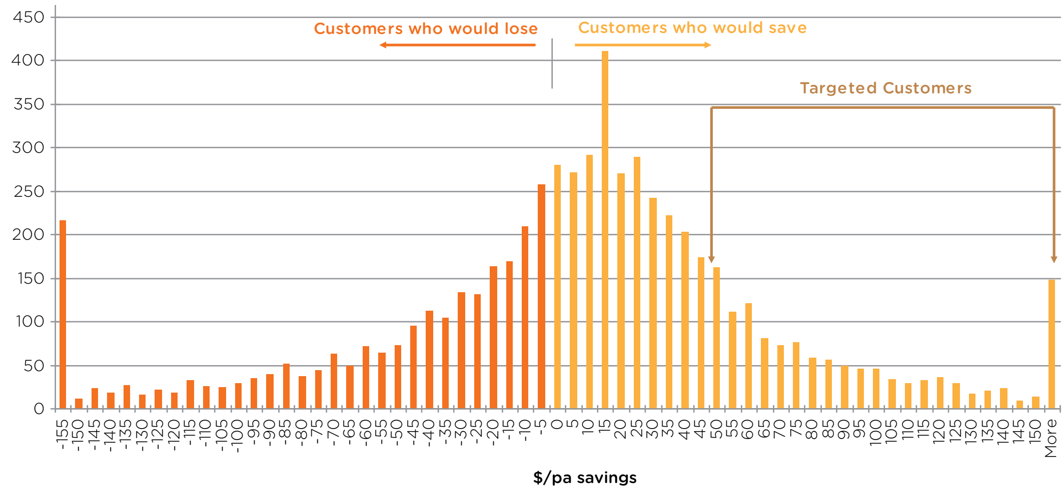


Table 6-D: Analysis of electricity costs – randomly selected household

	Household average consumption 34.92kWh/day		
	Rate ($/kWh)	Units (kWh)	Annual cost
A1 all time tariff	$0.2489	12,747	$3,172.73
PowerShift time-of-use tariff			
Super-Peak	$0.4015	2,487	$998.53
Peak - weekday	$0.2308	3,559	$821.42
Off-Peak - all days	$0.1304	4,262	$555.76
Peak - weekend	$0.2308	2,439	$562.92
Total		**12,747**	**$2,938.63**
Saving on PowerShift			$234.10
1kWh movement from Super-Peak to weekday Peak (260 weekdays in year)			
Total		**12,747**	**$2,894.25**
Saving on PowerShift with 1kWh shift			$278.48

Image 6-E: Annual cost savings based on tariff comparison for Powershift and A1



This analysis was completed for 7,041 smart meter households, and as a result it was identified that 1,295 households could save greater than $50 each per year by switching to PowerShift (table 6-E and image 6-E).

A marketing campaign was then developed to target households that demonstrated a minimum of $50 saved. Each household was sent a letter outlining the potential dollar savings from switching to PowerShift (image 6-F). Some households were also followed up with an outbound phone call.

Table 6-E: Potential savings on PowerShift for PSC smart meter households

Savings	No. of Households	% of households
$0 - $49	2,721	39%
$49 - 149	1,295	18%
$150+	230	3%
No Saving	2,795	40%
Total	**7,041**	**100%**

A total of 209 households were recruited through the campaign, a sign-up rate of 19.4%. Further, the targeted campaign using smart meter interval data resulted in more cost-effective recruitment of households than traditional methods (table 6-F).

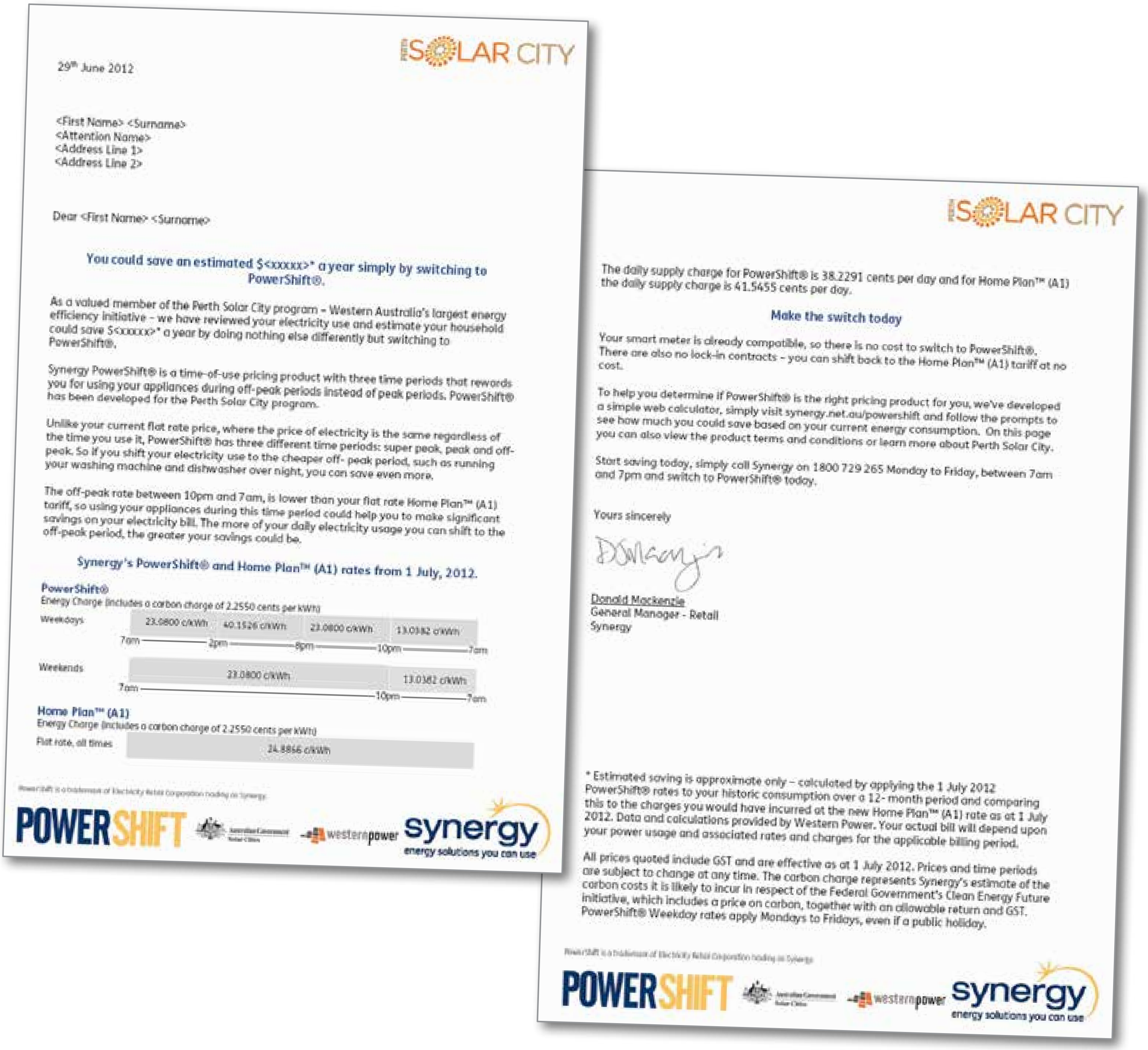
The recruitment campaign targeted households that would save money by switching to PowerShift, while maintaining their current daily electricity consumption profile, and shifting consumption away from Super-Peak periods to achieve further savings. This strategy was used to increase participation in the trial, and to understand customer acceptance. As part of the wider introduction of a voluntary time-of-use tariff, a range of consumption profiles should be targeted using interval data to encourage behaviour change. This will further maximise benefits for customers and the electricity network.

Attrition rate for PowerShift

Of the 746 PowerShift households, a total of 121 households returned to the A1 all-time tariff (as at 30 September 2012 at no cost). This represents an attrition rate of 16% (image 6-G). The attrition rate is due to a combination of the following:

- change of occupancy
- change in circumstance
- increase in electricity bill
- inability to shift consumption away from the Super-Peak period

Image 6-F: PowerShift targeted campaign letter



29th June 2012

<First Name> <Surname>
<Attention Name>
<Address Line 1>
<Address Line 2>

Dear <First Name> <Surname>

You could save an estimated $<xxxxx>* a year simply by switching to PowerShift®.

As a valued member of the Perth Solar City program – Western Australia's largest energy efficiency initiative – we have reviewed your electricity use and estimate your household could save $<xxxxx>* a year by doing nothing else differently but switching to PowerShift®.

Synergy PowerShift® is a time-of-use pricing product with three time periods that rewards you for using your appliances during off-peak periods instead of peak periods. PowerShift® has been developed for the Perth Solar City program.

Unlike your current flat rate price, where the price of electricity is the same regardless of the time you use it, PowerShift® has three different time periods: super peak, peak and off-peak. So if you shift your electricity use to the cheaper off-peak period, such as running your washing machine and dishwasher over night, you can save even more.

The off-peak rate between 10pm and 7am, is lower than your flat rate Home Plan™ (A1) tariff, so using your appliances during this time period could help you to make significant savings on your electricity bill. The more of your daily electricity usage you can shift to the off-peak period, the greater your savings could be.

Synergy's PowerShift® and Home Plan™ (A1) rates from 1 July, 2012.

PowerShift®
Energy Charge (includes a carbon charge of 2.2550 cents per kWh)

	7am–2pm	2pm–8pm	8pm–10pm	10pm–7am
Weekdays	23.0800 c/kWh	40.1526 c/kWh	23.0800 c/kWh	13.0382 c/kWh
Weekends	23.0800 c/kWh (7am–10pm)			13.0382 c/kWh

Home Plan™ (A1)
Energy Charge (includes a carbon charge of 2.2550 cents per kWh)

Flat rate, all times	24.8866 c/kWh

PowerShift is a trademark of Electricity Retail Corporation trading as Synergy

POWERSHIFT | Australian Government Solar Cities | westernpower | synergy energy solutions you can use

The daily supply charge for PowerShift® is 38.2291 cents per day and for Home Plan™ (A1) the daily supply charge is 41.5455 cents per day.

Make the switch today

Your smart meter is already compatible, so there is no cost to switch to PowerShift®. There are also no lock-in contracts – you can shift back to the Home Plan™ (A1) tariff at no cost.

To help you determine if PowerShift® is the right pricing product for you, we've developed a simple web calculator, simply visit synergy.net.au/powershift and follow the prompts to see how much you could save based on your current energy consumption. On this page you can also view the product terms and conditions or learn more about Perth Solar City.

Start saving today, simply call Synergy on 1800 729 265 Monday to Friday, between 7am and 7pm and switch to PowerShift® today.

Yours sincerely

Donald Mackenzie
General Manager - Retail
Synergy

* Estimated saving is approximate only – calculated by applying the 1 July 2012 PowerShift® rates to your historic consumption over a 12- month period and comparing this to the charges you would have incurred at the new Home Plan™ (A1) rate as at 1 July 2012. Data and calculations provided by Western Power. Your actual bill will depend upon your power usage and associated rates and charges for the applicable billing period.

All prices quoted include GST and are effective as at 1 July 2012. Prices and time periods are subject to change at any time. The carbon charge represents Synergy's estimate of the carbon costs it is likely to incur in respect of the Federal Government's Clean Energy Future initiative, which includes a price on carbon, together with an allowable return and GST. PowerShift® Weekday rates apply Mondays to Fridays, even if a public holiday.

PowerShift is a trademark of Electricity Retail Corporation trading as Synergy

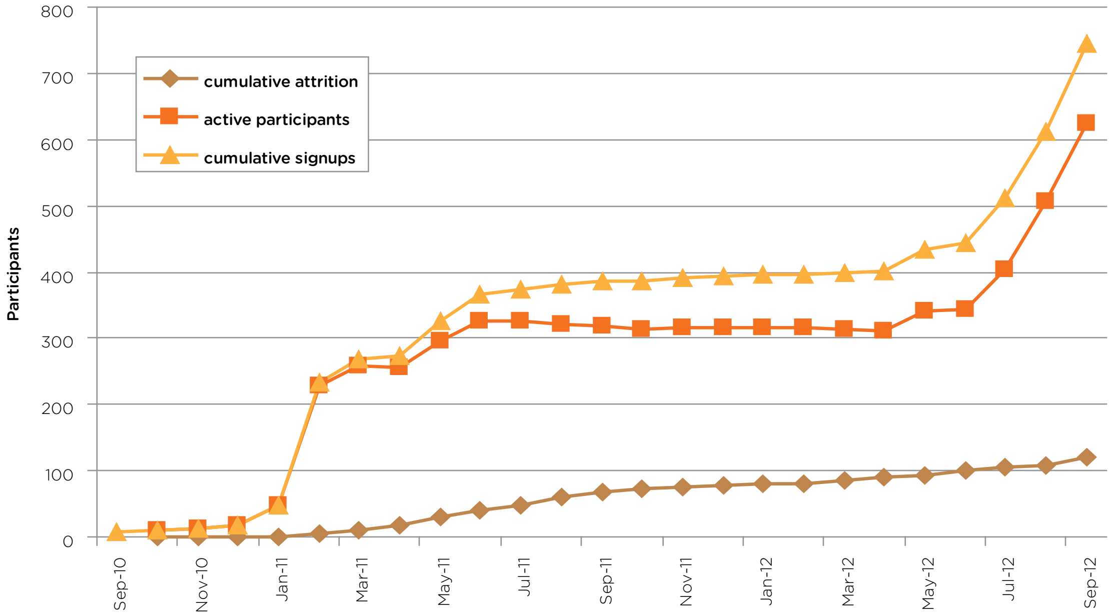
POWERSHIFT | Australian Government Solar Cities | westernpower | synergy energy solutions you can use

Table 6-F: Recruitment cost breakdown for PowerShift trial

	Cost	Households targeted	Total Acquisitions	Uptake rate	Cost per acquisition
Targeted recruitment	$11,679	1,073	209	19.4%	**$55.88**
Traditional recruitment^	$8,704	11,267	65	0.6%	**$133.91**

^Does not include additional waived costs for meter exchange

Image 6-G: Attrition rate for PowerShift



6.3 KEY RESULTS

Key results for PowerShift focus on:

- impact on consumption at time of Super-Peak
- impact on days of network peak
- participant electricity cost savings
- effect on participants total electricity consumption
- effect of additional products used in conjunction with PowerShift (In Home Display)
- participant feedback

6.3.1 IMPACT ON CONSUMPTION AT TIME OF SUPER-PEAK

The broad objective of PowerShift is to incentivise participants via a price signal to reduce electricity consumption at times of peak demand (Super-Peak).

Perth Solar City commissioned Data Analysis Australia (DAA) to analyse the effect of PowerShift on participant electricity consumption during Super-Peak (2pm – 8pm on weekdays). The analytic methodology developed and used by DAA is attached as Appendix B.

Analysis was completed using interval data for 232 participant households who had signed up for PowerShift in the period 1 August 2010 to 30 June 2012.

THE ANALYSIS SHOWS AN 8.9% AVERAGE REDUCTION IN ELECTRICITY CONSUMPTION DURING SUPER-PEAK

Table 6-G: Reduction in electricity consumption during Super-Peak

Average consumption Super-Peak Pre-*Powershift* (kWh)	Average consumption Super-Peak *Powershift* (kWh)	Reduction in Super-Peak consumption (kWh)	% reduction during Super-Peak
5.34	4.87	0.47	8.9%

The load reductions during Super-Peak accumulate to 28.7 MWh annually for the 232 participants analysed.

6.3.2 IMPACT ON DAYS OF NETWORK PEAK

A time-of-use price signal such as PowerShift does not specifically target critical peak days, but provides an on-going price signal as an incentive to change electricity consumption behaviour. However, it is questionable if customers will respond to the price signal on extreme weather days during summer, where the need for comfort may outweigh the cost. These extreme weather days are likely to correlate with days of electricity network peak.

DAA provided analysis of the effect of PowerShift on reducing consumption during the Super-Peak period on the critical demand days of 2011 and 2012 on the electricity network. The analytic methodology developed and used by DAA is attached as Appendix B.

THE ANALYSIS SHOWED THAT POWERSHIFT HOUSEHOLDS REDUCED THEIR SUPER-PEAK CONSUMPTION ON DAYS OF NETWORK PEAK BY 11.8%

6.3.3 PARTICIPANT ELECTRICITY COST SAVINGS

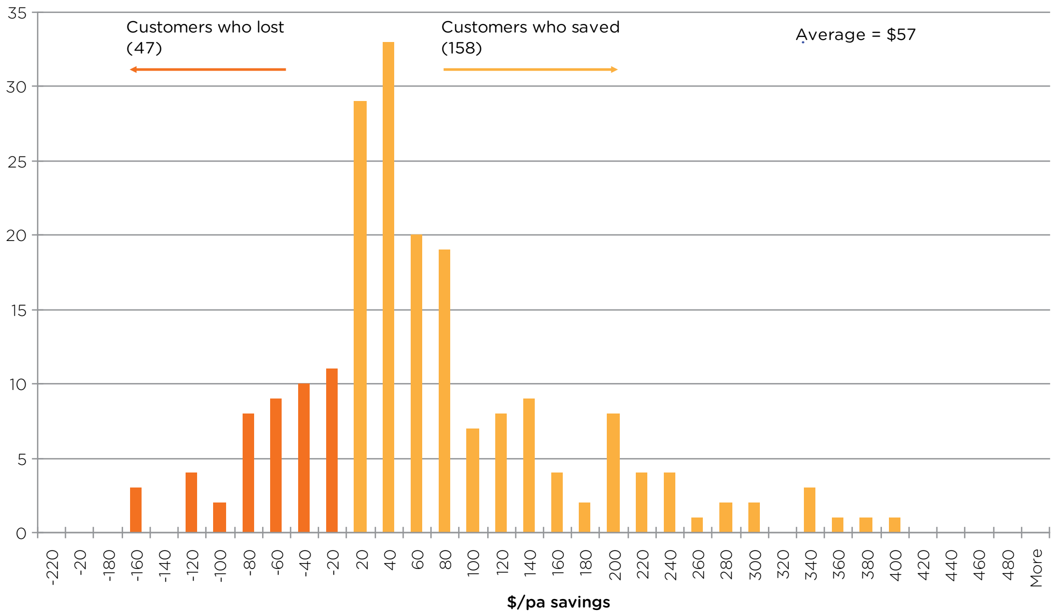
Analysis was conducted by Western Power, calculating the difference in electricity cost incurred by PowerShift households, versus staying on the standard A1 rate.

Costs were calculated for 205 smart meter households who were on the PowerShift tariff versus the A1 tariff for the full period 1 July 2011 to 30 June 2012. Image 6-H shows the amount of savings for PowerShift households relative to staying on the A1 tariff.

A total of 77% of households saved money during the 12 month period, as a result of participating in PowerShift. The average across all 205 households was a $57 saving per year. It should be noted that tariff prices were reviewed and adjusted at 1 July 2012, with the resulting rate changes likely to be more beneficial to PowerShift participants.

It is important to note that this analysis seeks to compare costs between PowerShift and the A1 tariff only. It does not take into account any additional electricity cost savings from reducing overall electricity consumption as a result of switching to PowerShift (section 6.3.4).

Image 6-H: Savings for PowerShift customers compared to A1 during 2011-12



6.3.4 EFFECT ON TOTAL ELECTRICITY CONSUMPTION

PowerShift's main objective is to incentivise households to shift their consumption away from the Super-Peak period. Time-of-use tariffs have been shown to have limited benefit for overall consumption reduction, as they largely focus on load shifting[1].

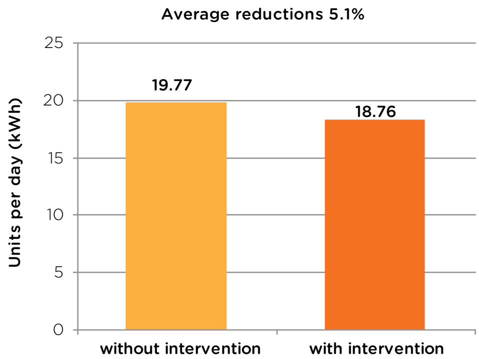
DAA provided analysis on the effect of PowerShift on reducing overall participant electricity consumption. The analytic methodology developed and used by DAA is attached as Appendix B.

The average household reduced their overall electricity use by 5.1% (image 6-I). As a result of this Perth Solar City trial, there is evidence to suggest that time-of-use tariffs can reduce electricity use at peak time, as well as reduce overall household electricity consumption.

[1] NEWSHAM, G. R. & BOWKER, B. G. 2010. The effect of utility time-varying pricing and load control strategies on residential summer peak electricity use: A review. Energy Policy, In Press, Corrected Proof.

This reduction is supported by qualitative research (section 6.3.6), whereby 68% of households reported adopting more energy saving behaviours as a result of the price signal.

Image 6-I: PowerShift – effect on overall electricity consumption



6.3.5 EFFECT OF IN HOME DISPLAY USED IN CONJUNCTION WITH POWERSHIFT

Providing households with a time-of-use tariff together with the means to view electricity costs in real time has the potential to increase reductions in electricity use at peak time.

As part of the data analysis conducted for Perth Solar City by DAA, the combined effect of the MAX In Home Display and PowerShift was analysed. Analysis shows that participants that used an In Home Display together with PowerShift saved an average of 13.1% during the Super-Peak period and 6.3% overall (table 6-H). In short, it is apparent that the combination achieves a greater result.

Table 6-H: Reduction in electricity consumption during Super-Peak

Products	Reduction during Super-Peak (kWh)	Reduction in total consumption (kWh)
PowerShift overall	8.9%	5.1%
IHD overall	4.8%	1.5%
PowerShift and IHD	13.1%	6.3%

6.3.6 PARTICIPANT FEEDBACK

Perth Solar City commissioned market researcher TNS to undertake detailed participant evaluation of the Perth Solar City technical trials, including PowerShift. The objectives of the evaluation were to understand the following:

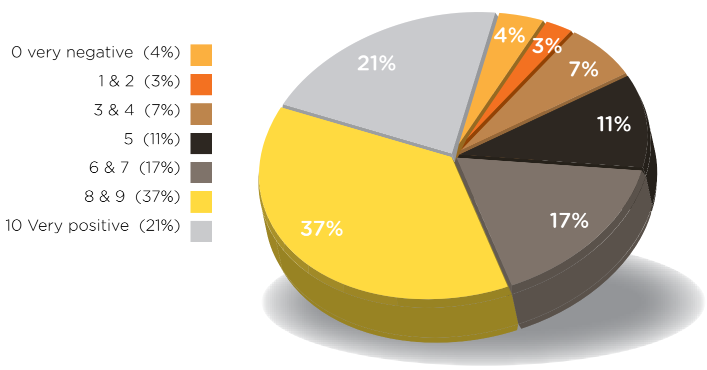
- overall participant experience
- motivation for participation
- perceived change in electricity use and electricity bills
- behaviour change
  - behaviour change implemented as a result of the trial
  - facilitators of behaviour change during the trial
  - barriers to behaviour change during the trial
- willingness to participate in future programs

A total of 72 PowerShift participants responded to the quantitative evaluation.

Overall participant experience

76% of PowerShift trial participants rated their overall Perth Solar City experience positively (image 6-J). 21% of participants rated their experience as '10 out of 10'.

Image 6-J: Overall participant experience of the PowerShift trial



Motivation for participation

The desire to reduce electricity costs (63%) was the most compelling reason for households to participate in the PowerShift trial (image 6-K). This was measurably higher when compared with other Perth Solar City technical trials. In short, participants had a high expectation that PowerShift would reduce their electricity bills.

Perceived change in electricity use and electricity bill

During the trial, 61% of PowerShift participants perceived an overall decrease in their electricity use. However, there was a significant minority (21%) that felt that PowerShift increased their electricity bill, despite perceiving reduced overall electricity use (image 6-L).

There are several reasons why decreased electricity use may not have translated to decreased electricity costs for some PowerShift participants. These include:

- inability to shift electricity use from Super-Peak periods
- reduced electricity use during lower rate periods
- tariff increases

Due to the higher expectations among PowerShift participants of reducing their electricity costs, failure to do so will likely result in higher dissatisfaction rates when compared with other Perth Solar City technical trials.

Participants experience and willingness

The overall participant experience of the PowerShift trial was positive (image 6-M). However, it had a slightly weaker positive result when compared with other Perth Solar City technical trials, as some households perceived the trial to have increased their electricity bills. This in turn resulted in a slightly lower willingness to continue with PowerShift in the future. Despite this, the majority (77%) of PowerShift participants were still willing to participate in the future, and recommend the program to other households.

Image 6-K: Motivation for participating in PowerShift trial

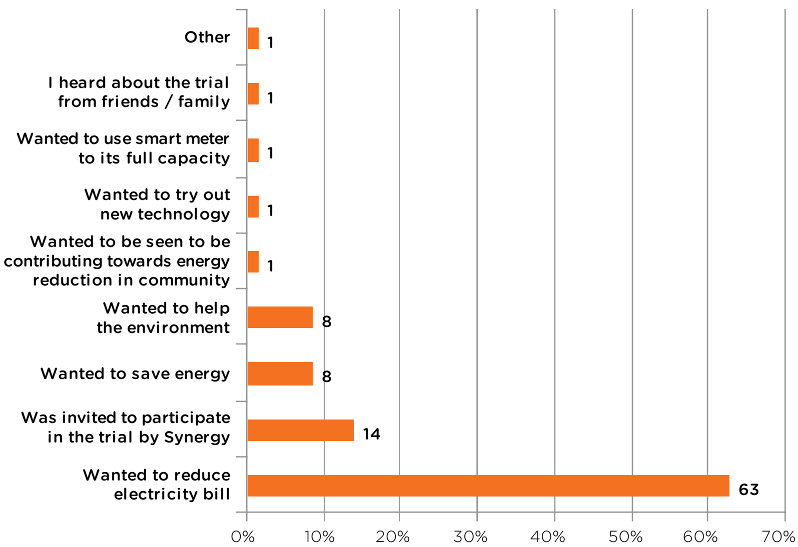
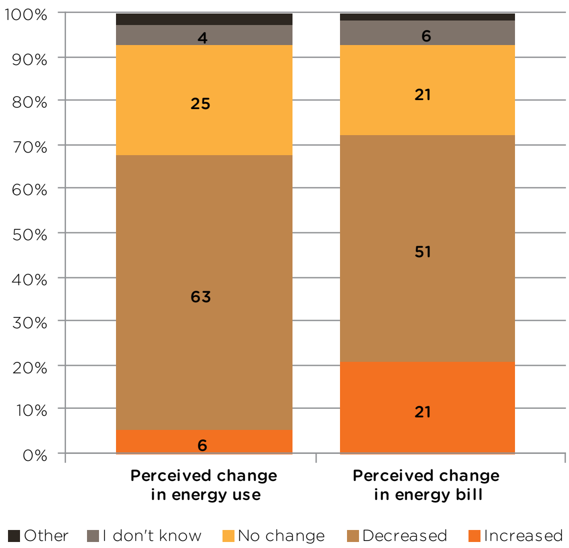


Image 6-L: Perceived change in energy use/ electricity bills



Behaviour Change

The PowerShift trial resulted in perceived sustained behaviour change (time-of-use) for the majority of participants (image 6-N). This included changing the time of day a number of large appliances, such as air conditioners and pool pumps, were used. In addition, the PowerShift trial also resulted in a number of additional positive impacts, such as adopting more energy saving behaviours (image 6-O).

Personal factors such as the motivation of cost savings and the desire to save electricity were the biggest facilitators of behaviour change for the PowerShift trial (image 6-P). Feedback from participants included:

- "knowing it would be cheaper to use major appliances during the night hours made it easier to choose to run things like pool filters and clothes dryers 'after hours'"
- "the tariff times guide we created for all family members to refer to"

The biggest reported barrier to behaviour change, particularly when using those 'everyday' appliances, was inconvenience due to lifestyle/work hours (image 6-Q).

Image 6-M: Willingness to participate in PowerShift in the future and recommend program to other households

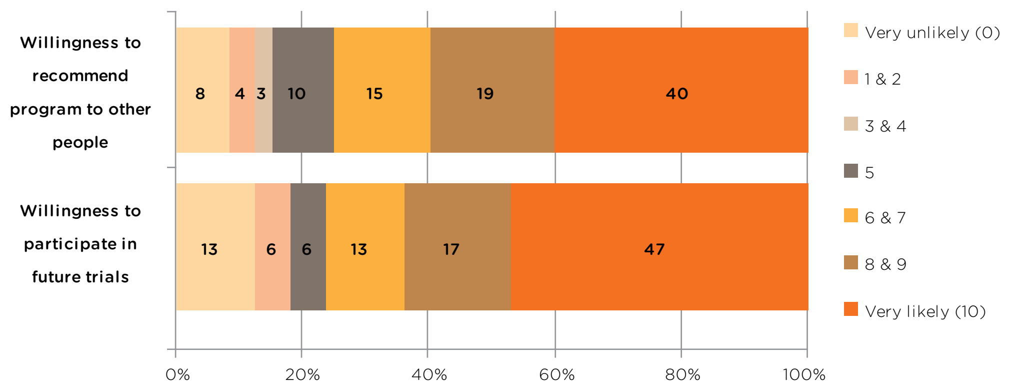


Image 6-N: Level of behaviour change, by appliance

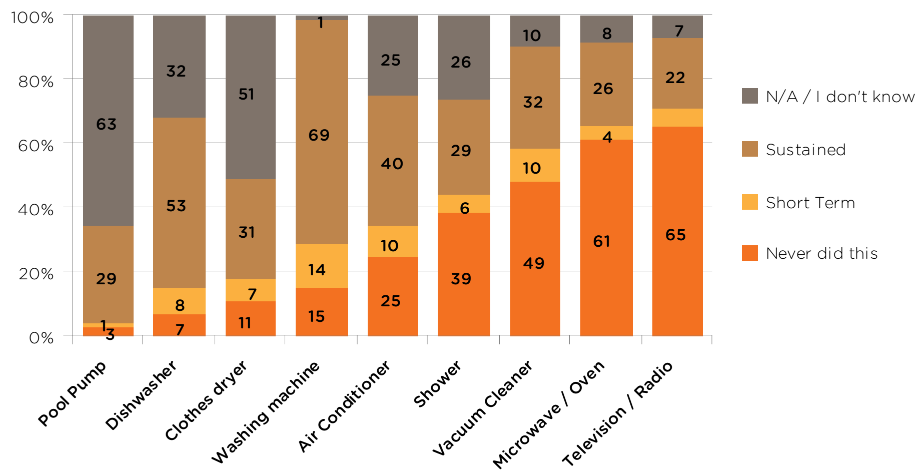


Image 6-O: Other impacts of PowerShift trial

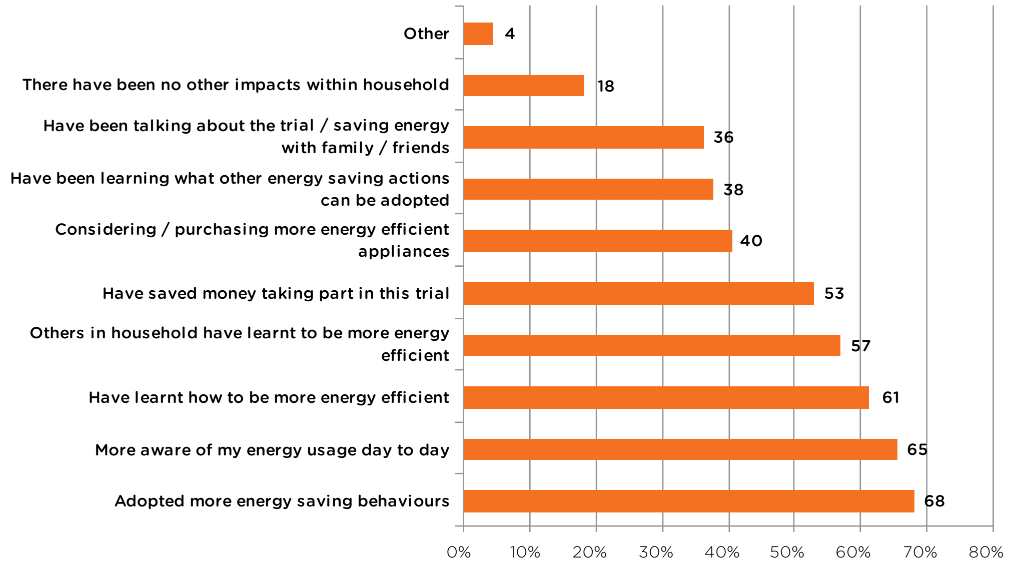


Image 6-P: Facilitators to behaviour change

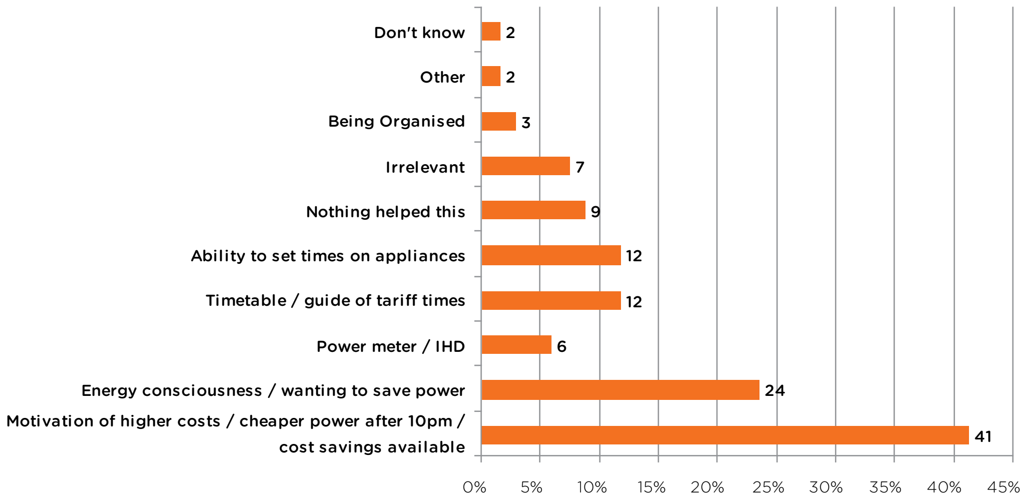
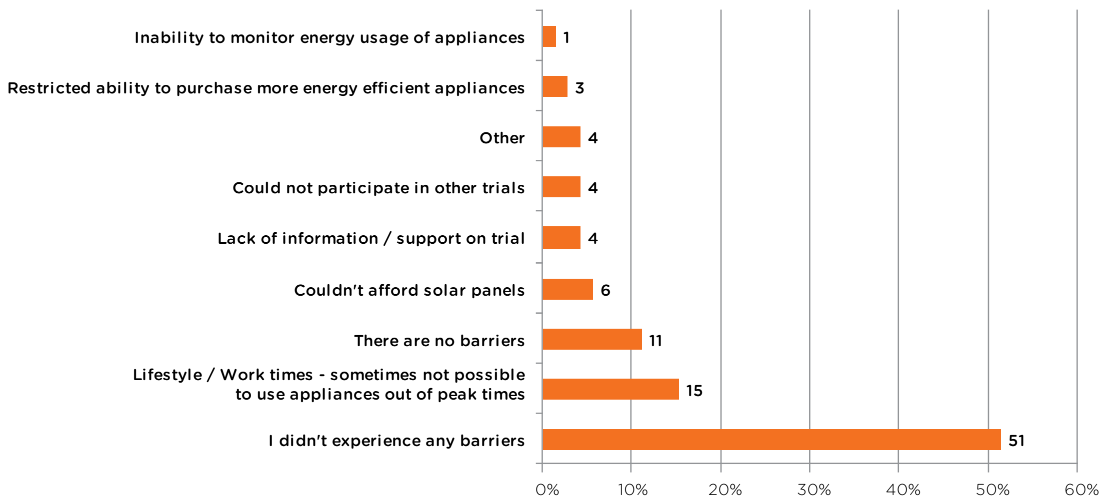


Image 6-Q: Barrier to behaviour change



6.4 TRANSFERRABLE LESSONS

Subject	Barrier	Outcome and/or lesson
Real-time display consumption and pricing	BENEFIT: The provision of real-time information via the MAX In Home Display for PowerShift households.	OUTCOME: Greater electricity savings achieved at Super-Peak and overall. LESSON: Time-of-use tariff participants should be provided with the tools enabling them to see cost in real-time.
Tariff design	BENEFIT: The design of the PowerShift tariff used a simple year-round weekday shoulder-peak-shoulder design.	LESSON: Straight forward time-of-use tariffs enable householders to better adjust to time-based pricing.
Recruitment	BENEFIT: Smart meter interval data allows targeted recruitment at lower cost.	OUTCOME: A 19.6% uptake rate was achieved through a targeted campaign using smart meter interval data. LESSON: Prior to the wider introduction of a voluntary time-of-use tariff, smart meter interval data should be used as part of a targeted recruitment campaign.
Customer opportunity	BENEFIT: Analysing smart meter interval data to provide customers with greater information upon which to base decisions.	OUTCOME: The information barrier regarding suitability for a time-of-use tariff is reduced. LESSON: Smart meter interval data is a prerequisite for enabling customers to understand the opportunity provided by a voluntary time-of-use tariff, and should be used prior to the wider introduction of a voluntary time-of-use tariff.
Participant feedback	BARRIER: Lack of feedback to participants during trial	OUTCOME: Participants requested more on-going communication regarding the trial: both for own household progress as well as overall trial results. LESSON: Time-of-use participants need to be better supported with on-going personalised information (such as via electricity bills) to understand their progress and associated costs.
Default pricing	BARRIER: The default tariff in Western Australia is still below cost-reflectivity	OUTCOME: Uptake of alternative tariffs is likely to be low. LESSON: Until standard all-time tariffs are increased to cost-reflectivity, householders are unlikely to look for alternatives.
Latency period	BARRIER: Time-of-use tariffs are not common in Western Australia	OUTCOME: Campaigns for voluntary time-of-use tariff products often have a significant latency period. LESSON: The benefits of voluntary time-of-use tariffs are not easily identifiable to a household in the Western Australian marketplace. Correct pricing and education-based engagement would help to overcome this barrier.

7.0 SOLAR PHOTOVOLTAIC SATURATION TRIAL

7.1 BACKGROUND

The uptake of residential solar photovoltaic (PV) systems in Western Australia has increased significantly in recent years (image 7-A). This is largely due to considerable PV system cost reductions to the consumer as a result of reduced manufacturing costs, increased competition in the marketplace, and various state and federal government incentives (image 7-B). As at June 2012, it was estimated that there were 127,439 PVs connected to the distribution network, with a total capacity of 251MW.

The effects of this increased penetration of small-scale residential solar PV systems on the electricity network are not fully understood. The potential for such effects as localised power quality issues and voltage compliance issues needs to be researched.

The Photovoltaic (PV) Saturation Trial is a Perth Solar City initiative seeking to investigate the effects of a high penetration of PV systems on Western Power's distribution network.

Results of a successful trial will be used to provide recommendations regarding the methods of evaluating and managing high levels of solar PV system penetration on existing low voltage networks. This would include the development of guidelines for the design of future networks to accommodate the increasing amount of distributed energy generation in Western Australia.

For the purposes of the trial, a minimum saturation level of 30% by number of customers was established (29% by transformer size). A residential distribution transformer (low voltage) was selected in one of the four existing Perth Solar City smart meter deployment locations. Smart meters enable the capture and analysis of power quality data at the household (meter point). In order to achieve the 30% saturation target, a significant discount was offered to households supplied by the targeted transformer.

Image 7-A: Uptake of solar PV systems on SWIS

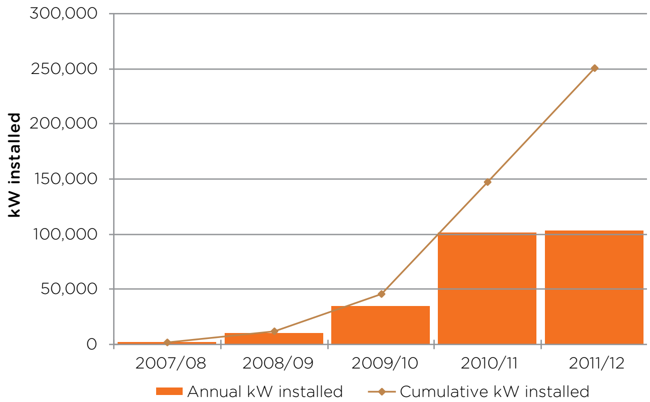
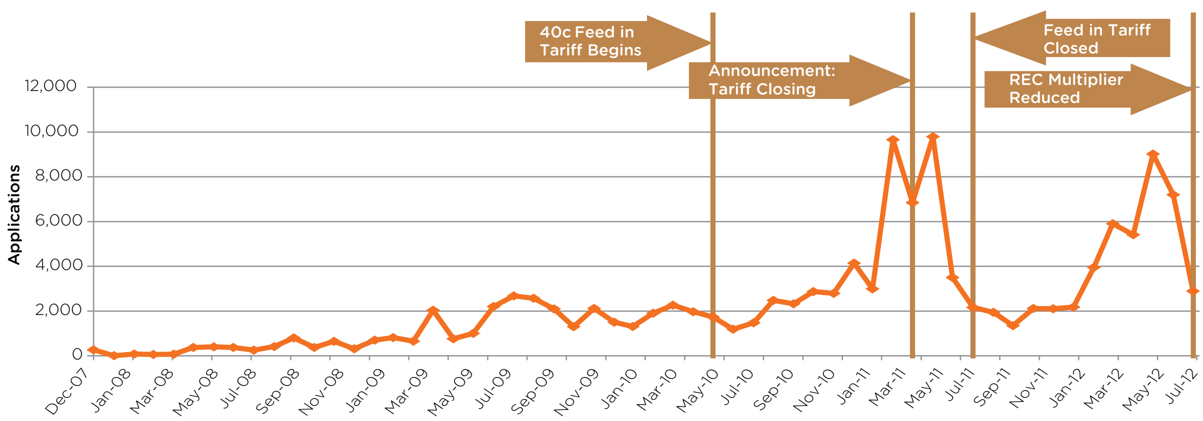


Image 7-B: Solar PV system applications received and incentives



2011 RE-CAP

PROGRESS - 2011

Participant recruitment and installation

Western Power developed a brand for the trial - Solar Collective - and partnered with Perth Solar City Consortium member SunPower to produce a compelling proposition for target households to purchase and install a solar PV system. A further solar PV system discount of $2,500 was added to the existing Program discount.

By December 2010, the minimum target of 18 participants was exceeded with a total of 20 participants recruited. All 20 solar PV systems were installed during January and February 2011. The 20 new systems combined with the five existing PV systems in the area provided a saturation level of 32% (25 solar PV systems in a total of 77 houses in the target area). The 20 solar PV systems added 35.5kW of renewable generation to the local distribution network, with the average system size being 1.7kW.

A power quality data logger was installed on the Pavetta1 distribution transformer in order to measure and evaluate network performance.

KEY RESULTS - 2011

Transformer voltage profile and compliance

Initial results show that reverse power flow into the high voltage (HV) network occurred regularly on clear days during the winter months.

The results show that short term voltage excursions outside the +6% limit occurred for at least one of the homes at the end of the low voltage (LV) network. The voltages at the customer level are within tolerance levels, and as such are not expected to cause any damage to appliances. This household connection point view, as enabled by the smart meters, flags the need to potentially address voltage regulation issues on saturated solar PV networks.

From these preliminary results it is clear that a relatively simple adjustment on the distribution transformer tap to a lower level, could allow somewhat larger PV penetration on this network while still maintaining voltages within limits for customers at the end of the LV network.

7.2 OBJECTIVES AND PROGRESS

The key objectives of the Solar PV Saturation Trial are to:

- provide research data on the performance of the local network under a high level of PV penetration
- investigate the extent to which Power Quality (PQ) issues (such as high/ low voltage and/ or voltage distortion) might occur as a result of an increasing penetration of PV systems on the electricity network
- investigate the extent to which PQ issues might effect the operation of a solar PV system

In order to achieve these objectives, specific Key Performance Indicators (KPIs) were developed for the Solar PV Saturation Trial (table 7-A).

7.3 KEY RESULTS

Key results for the Solar PV Saturation Trial focus on:

- installing the requisite number of solar PV systems in the trial area
- understanding solar PV system performance
- evaluation of Power Quality at Low Voltage transformer
- evaluation of Power Quality at customer meter
- options to Improve the capacity of the distribution network to host PV Generation
- impact of solar PV on the network peak

7.3.1 INSTALLING THE REQUISITE NUMBER OF SOLAR PV SYSTEMS IN THE TRIAL AREA

A distribution transformer in the suburb of Forrestfield was selected, known as Pavetta1, which supplies a total of 77 households. Western Power partnered with Perth Solar City Consortium member SunPower to provide an added incentive for these households to purchase and install a solar PV system, and achieve the required level of saturation for the trial. As at 30 September 2012, 34 out of 77 customers had solar PV systems installed (table 7-B and image 7-C), achieving a penetration level of 44% (by number of customers) and 29% (by transformer size).

Image 7-C: Solar PV systems installed on Pavetta1 as at 30 September 2012

Table 7-B summarises customer and solar PV system data for Pavetta 1 as of May 2012. Please note that some of the phase allocations have changed since the 2011 Annual Report due to:

- some customers being connected to a different phase due to pole replacements; and
- more accurate identification of PV phase connections of PV customers.

Table 7-B shows that both customer electricity demand (load) and solar PV system generation are not equally balanced across the three phases. The decision not to balance load and generation was

Table 7-A: Key Performance Indicators for the Solar PV Saturation Trial

Activity	Key Performance Indicator	Timeframe	Progress
Recruitment	Select target location	2010/11	Complete
	Develop communication materials	2010/11	Complete
	Achieve uptake of minimum 30% saturation	2010/11	Complete
Installation	Install solar PV systems	2010/11	Complete
	Install data loggers	2010/11	Complete
Evaluation	Undertake analysis of network impacts of saturated solar PV	2011/12	Complete
	Undertake analysis of network support provided by saturated solar PV	2011/12	Complete

Table 7-B: Solar PV system connections on Pavetta1

Customer Connection Phase	No. of Customers	No. of PV Customers	PV Capacity Installed (kW)	PV Penetration by No. of Customers	PV Penetration by Transformer Capacity
3 Phase	26	14			
Red	14	4	18.3	13%	9.16%
White	17	4	16.0	12%	7.98%
Blue	20	12	24.3	19%	12.15%
Total	**77**	**34**	**58.6**	**44%**	**29.3%**

Notes:

1. Includes single-phase and three-phase customers. Solar PV systems at three-phase locations are wired to one of the phases (b, w, r)
2. Four of the three-phase customer PV phase connections have not been confirmed and have been assumed to be distributed as follows: R-0, W-2, B-2
3. Some of the pre-existing PV system capacities have been estimated due to lack of data

intentional, in order to provide a realistic picture as to how a high penetration of solar PV systems might impact the Western Power network into the future.

7.3.2 UNDERSTANDING SOLAR PV SYSTEM PERFORMANCE (OUTPUT)

Prior to the availability of gross PV generation data collected via the smart meter, Western Power modelled the likely output of solar PV systems based on manufacturer performance specifications and average weather data. Twelve households' solar PV systems were configured using the smart meter to enable the capture of gross solar PV system generation data.

Validation of eleven months of solar PV system generation data shows a good correlation between actual and estimated yield values (image 7-D). It should be noted that for the months of October 2011 and June 2012, the actual solar PV system generation is more than 10% lower than the simulated output. This is likely a result of weather variability. The months of October 2011 and June 2012 had more overcast days than average and hence lower solar irradiation.

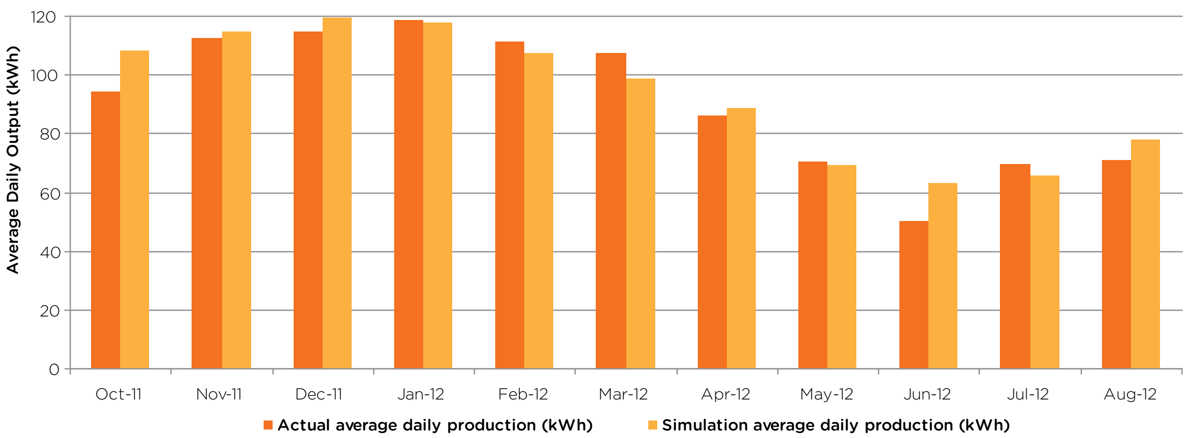
The graph does not cover a full year, as gross PV metering data was only available from October 2011.

The normalised average daily solar PV system yields are measured as kWh produced per kW of solar PV system capacity (table 7-C). Output from the trial solar PV systems tested was consistent with well performing solar PV systems in Perth.

Table 7-C: Average daily yield efficiency (kWh/kWp)

Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12
4.46	5.31	5.42	5.59	5.25	5.06	4.07	3.33	2.36	3.28	3.35

Image 7-D: Comparison of actual vs simulated solar PV system output



7.3.3 EVALUATION OF POWER QUALITY AT LOW VOLTAGE TRANSFORMER

The transformer scatter plot of load profiles across all four seasons of the year are derived from 5 minute average readings from the transformer logger (image 7-E). The scatter plots show a clear load pattern for each season. Key observations are:

- the largest amount of reverse power flow occurs during spring. This can be explained by the fact that solar PV systems operate close to their peak performance in late spring, and the load on the transformer is the lowest of the four seasons
- demand for electricity in winter and spring has predictable and consistent patterns
- demand for electricity in summer has the largest dispersion, which is due mainly to demands for cooling (air-conditioners) on the hottest days
- demand for electricity in autumn mimics spring, the difference being there are a number of hot days in early autumn that display a summer-like pattern

The largest percentage of voltage non-compliance at both the transformer and customer levels occurred during spring.

Electricity is supplied to residential households across three phases (red, white and blue). Electricity supply would ideally be balanced across each phase. On the Pavetta 1 network, it is apparent that the average transformer load and generation per phase is unbalanced (image 7-F).

Image 7-G shows what the transformer load would have been without solar PV system generation on the LV network.

It is apparent the blue phase is the most heavily loaded, while the red phase is the most lightly loaded. In addition, the largest amount of solar PV system generation occurs on the blue phase, while the least on the white phase. This unbalance is likely to have implications on customer level voltage compliance.

During spring, from early morning to early evening, the average voltage levels on the LV side of the distribution transformer show that the blue phase sits nearly one volt higher than the other two phases (image 7-H). This period of the day is somewhat coincident with the hours of solar PV system generation. However, it is unlikely that the solar PV system generation unbalance in the Pavetta 1 network alone can cause such a large voltage difference, and is likely to also be as a result of load unbalance.

Transformer compliance with power quality standards

The transformer histograms are based on 5 minute average readings provided by a data logger on the transformer (image 7-I).

The voltage histogram shows that the Pavetta 1 transformer LV voltage remained compliant for 99.6% of the time with the average voltage sitting at nearly 250V. This is fairly typical of other distribution transformers on Western Power's network with lower solar PV system penetration in the LV network. Generally the average voltage of transformers sit near the upper limit to ensure that customer voltage remains above the lower limit at times of high demand.

It can be inferred from the transformer voltage histogram that the impact of solar PV systems on transformer voltage is relatively small at the 29% penetration level (transformer load) existing in the Pavetta 1 network.

Image 7-E: Transformer load profiles by season

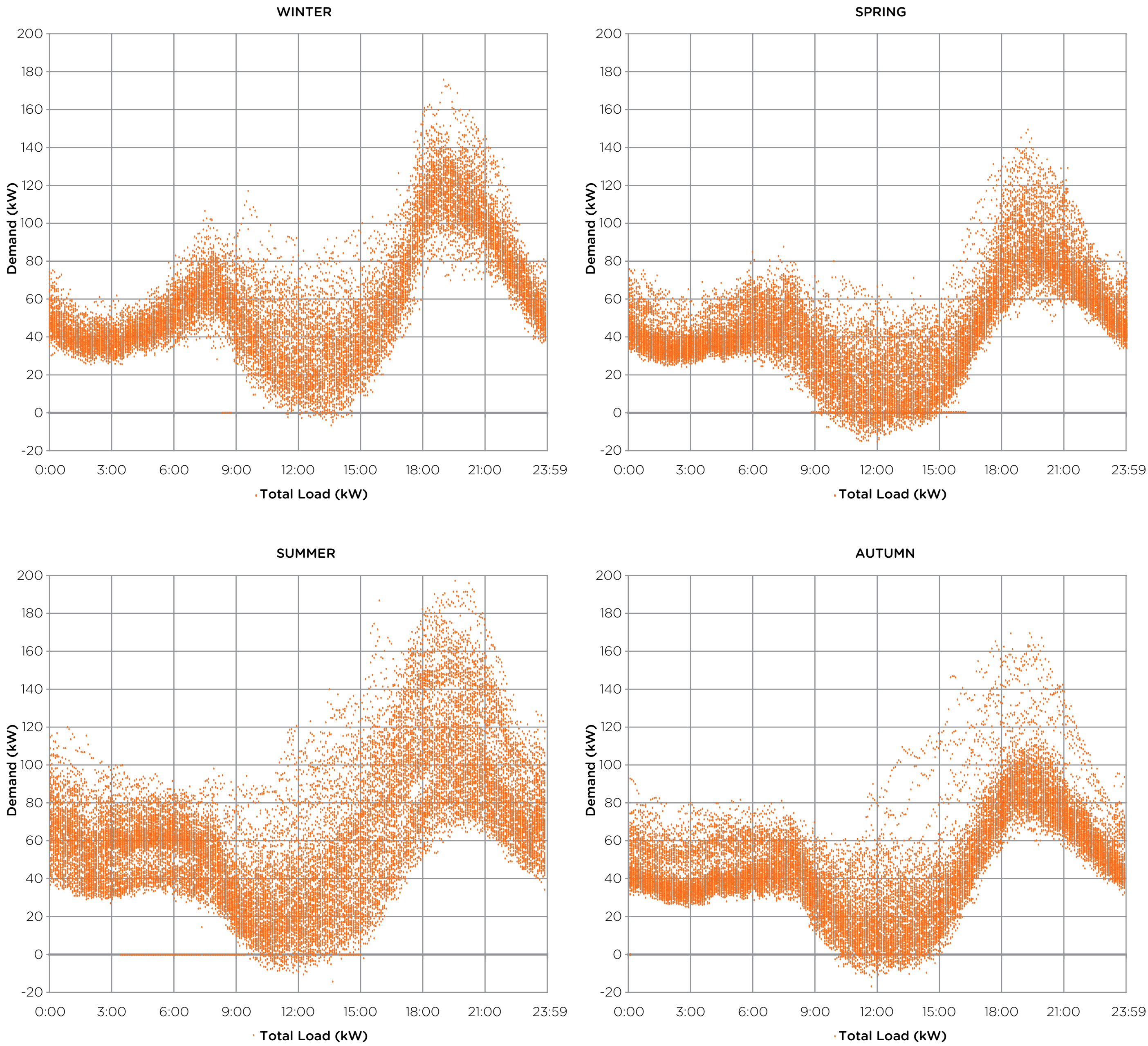


Image 7-F Transformer average daily load profile with solar PV system – spring

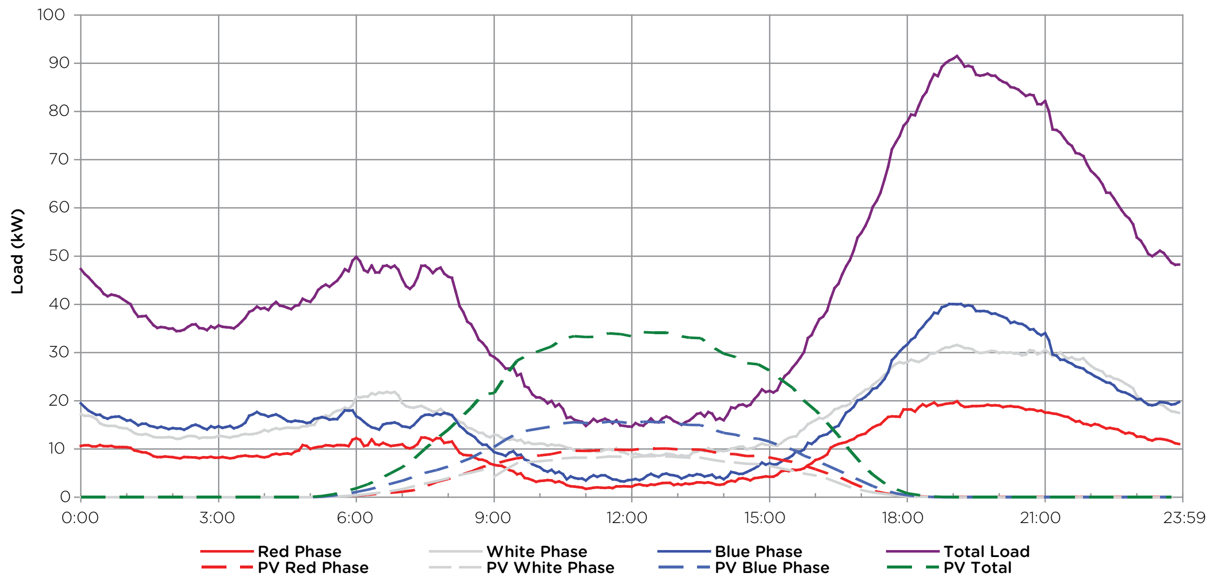


Image 7-G: Transformer average daily load profile without solar PV system – spring

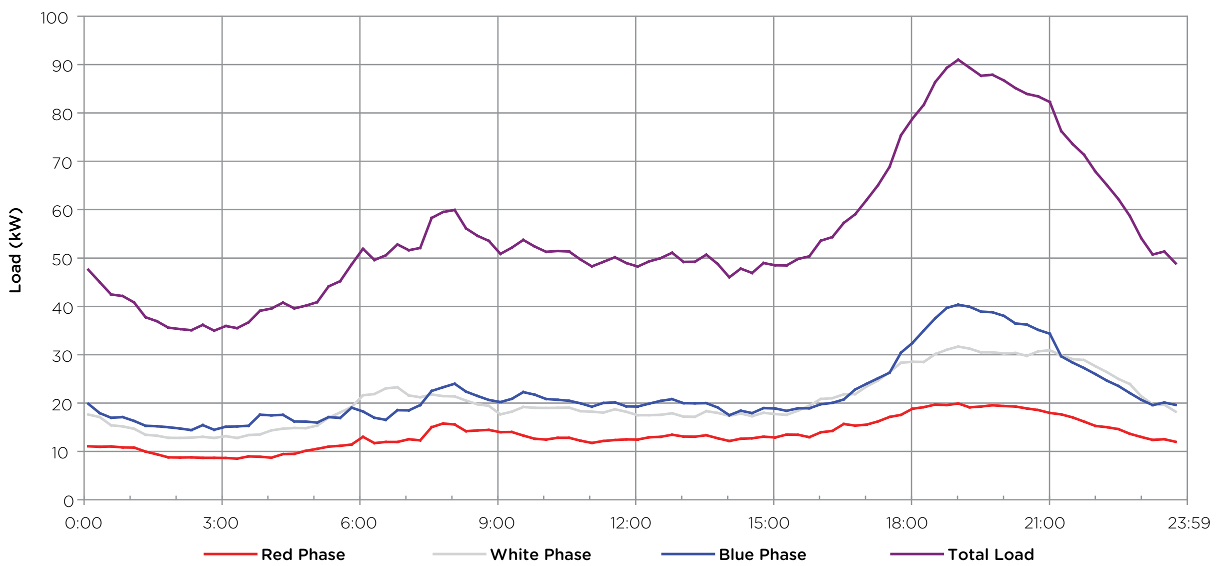


Image 7-H: Transformer average daily voltage

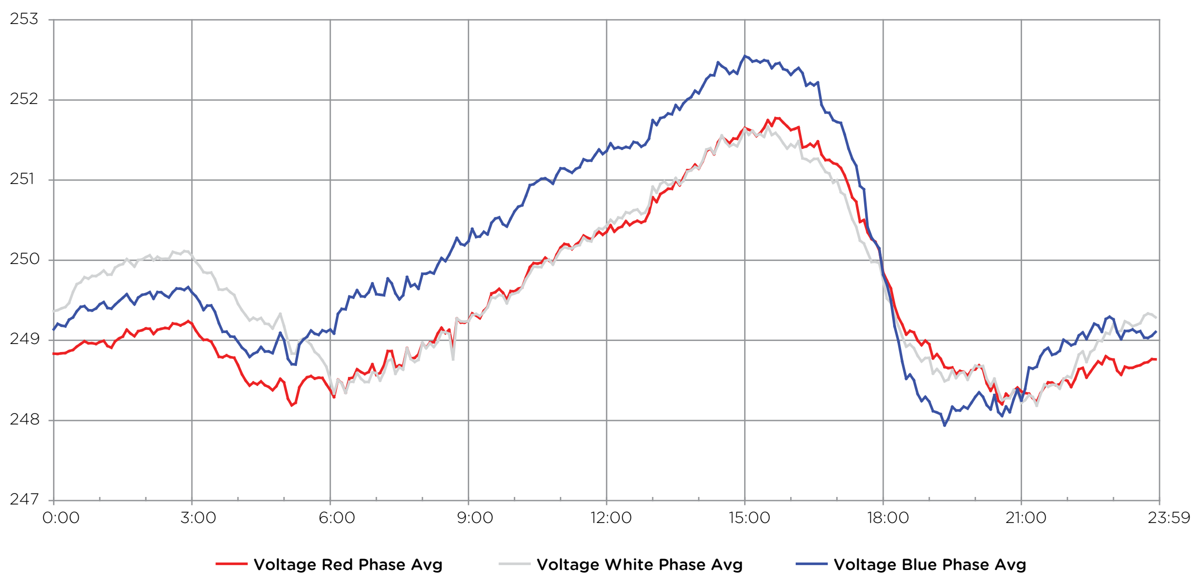


Image 7-I: Pavetta1 transformer steady state voltage histogram

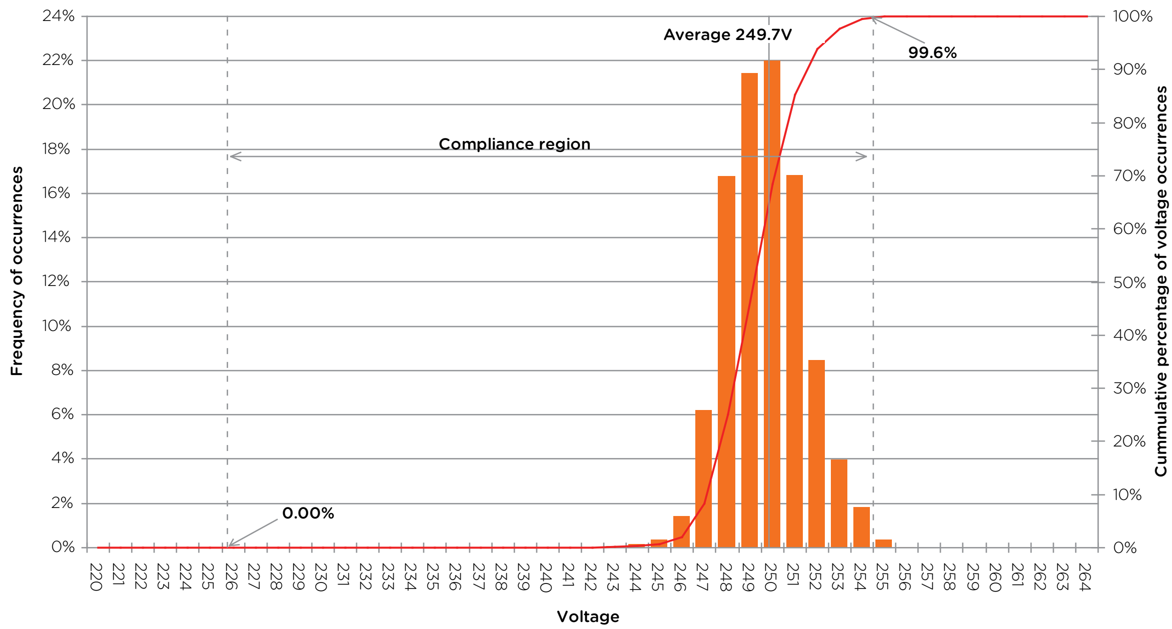
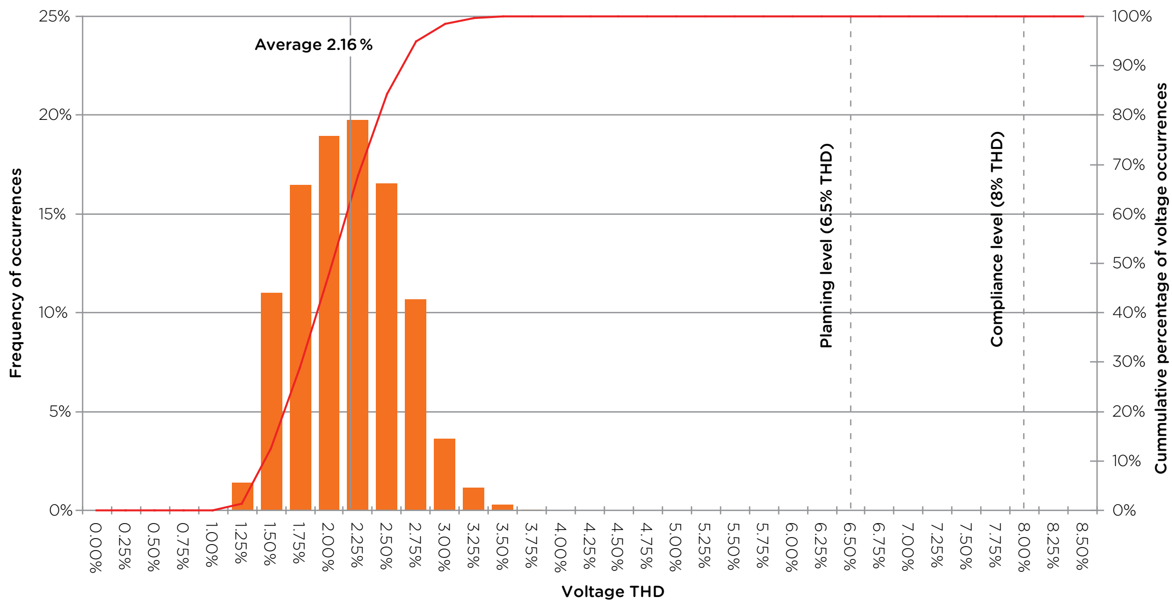


Image 7-J: Pavetta1 transformer voltage total harmonic distortion histogram



The voltage Total Harmonic Distortion (THD) histogram shows that the voltage distortion on the transformer remained well within the regulated limits at all times (image 7-J). It can be inferred that the impact of solar PV systems on transformer voltage distortion is very small at the 29% penetration level existing in Pavetta1.

7.3.4 CUSTOMER LOAD AND POWER QUALITY RESULTS

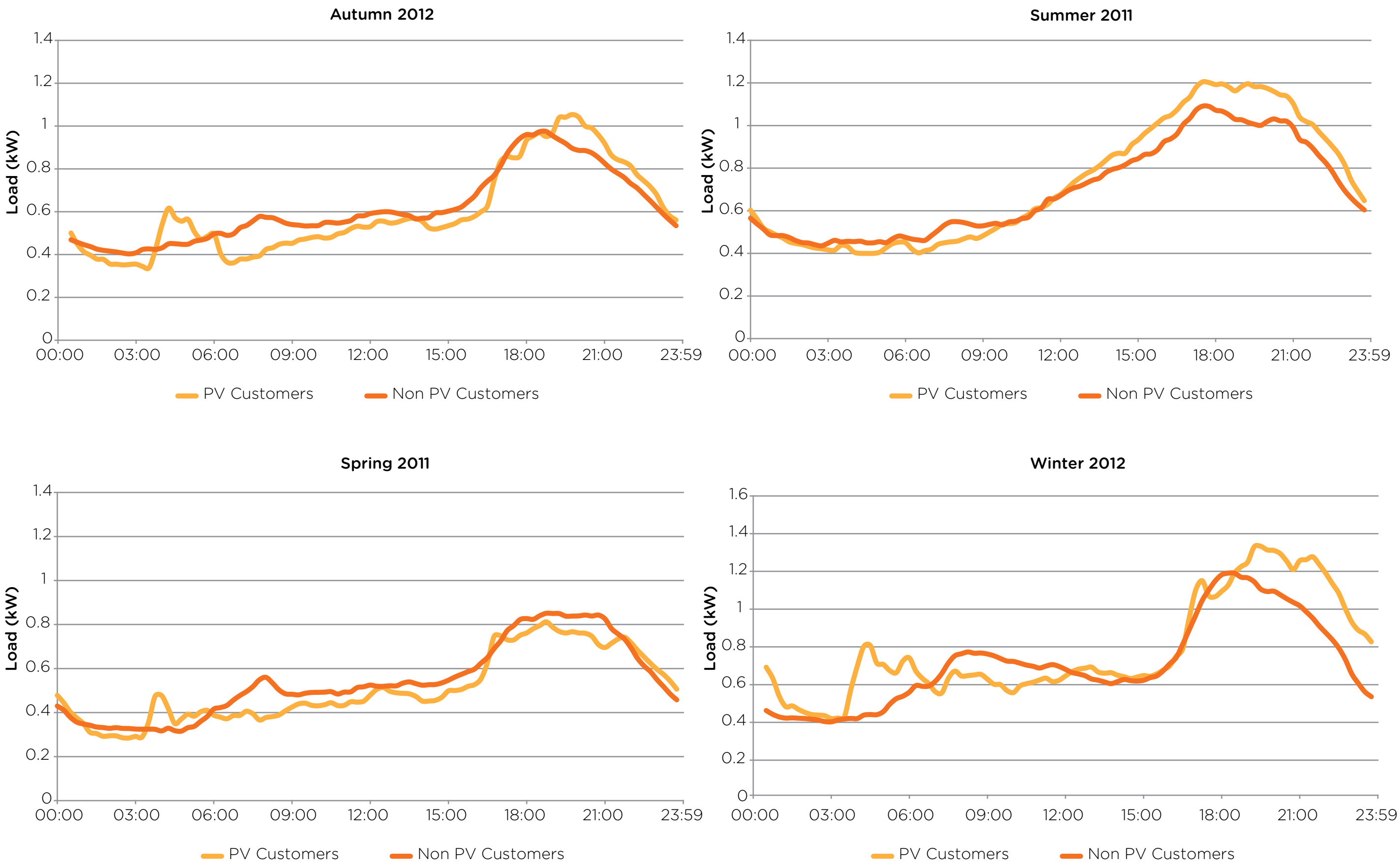
Customer load profiles

For the first time, smart metering infrastructure has enabled visibility of load and voltage profiles at the customer level.

The average load demand profiles for solar PV system and non- solar PV system customers on Pavetta 1 were calculated using data obtained from the smart meters (image 7-K). The load profile for solar PV system customers was obtained from a group of 12 solar PV customers for which gross PV metering was enabled (by wiring the output of their solar PV system to the second element of the smart meter). The orange load profile is the average demand of all non-solar PV system customers.

During winter and autumn, solar PV system customers shifted some of their demand to early morning and night time (non-sunlight) hours. This behaviour is likely to be a result of those customers maximising their revenue from the 47¢/kWh net feed-in tariff available at the time. In short, customers seeking to maximise their return under such a feed-in tariff will endeavour to use less electricity at times when their solar PV system is generating electricity. This increases the reverse power flow to the network.

Image 7-K: Comparison of average daily loads for solar PV system and non-solar PV system customers by season



Customer voltage compliance

As previously stated, the largest number of reverse power flow events occurred during spring. Additionally, the largest number of voltage non-compliance issues, all of which were high voltages above the +6% compliance limit, occurred during spring.

The two customer level histograms show the customer voltage for the entire year (image 7-L) as well as for spring (image 7-M).

The histogram confirms that solar PV system customer voltage measured at the customer meter was, on average, higher than for non-solar PV system customers. Non-solar PV system customer compliance occurred approximately 99.6% of the time, whilst solar PV system customer compliance occurred approximately 98% of the time.

It is important to note that even though voltages exceeded the +6% steady state limits, they did not approach the +10% equipment tolerance limit, and hence no risk to customer equipment resulted from the trial.

During spring, voltage compliance of the non-solar PV system customers remained the same as for the entire year at 99.6%. However, compliance for solar PV system customers was lower in the spring season (95%) when compared to the entire year (98%).

Additionally, during spring, over-voltage non-compliance occurred more frequently for customers connected to the blue phase. The blue phase has the highest daytime voltage and the most solar PV system connections.

Power quality evaluation - key findings

Key findings of the power quality evaluation are:

- over-voltage non-compliance at the customer level is increased during the occurrence of reverse power flow (i.e. grid-feeding solar PV generation) into the LV network
- the load to solar PV system generation ratio is a key factor in voltage excursions – the times of high PV generation and low load are the main contributors to voltage excursions
- given that non-solar PV system customer voltage compliance remained relatively constant throughout the year, it can be deduced that a significant proportion of voltage rise, causing over-voltage, occurs in the service lead (the wire that connects the overhead lines to the connection point on the home)
- preliminary analysis of preventative measures to address voltage non-compliance suggested a relatively simple adjustment on the distribution transformer 'tap' to a lower level. This would allow a somewhat larger PV penetration on this network while still maintaining voltages within limits for customers at the end of the LV network. However, subsequent analysis of the full year voltage shows that there is little room to 'tap' voltage down on the distribution transformer. This measure would likely reduce high voltage non-compliance at the expense of low voltage non-compliance, as each 'tap' on the distribution transformer steps the voltage by approximately 6V
- solar PV system generation has little influence on voltage harmonic distortion

Image 7-L: Pavetta1 – full year customer voltage

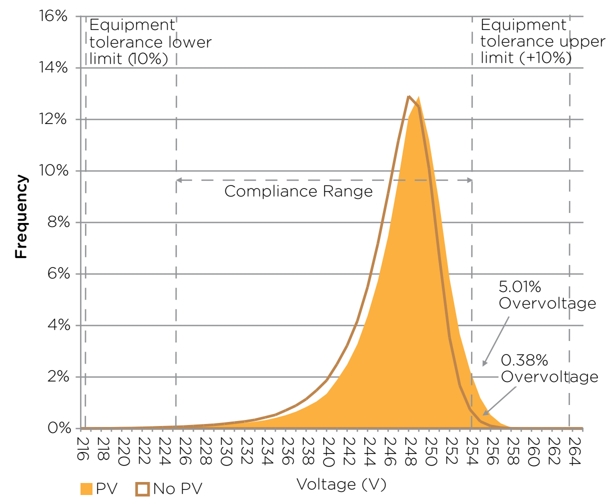
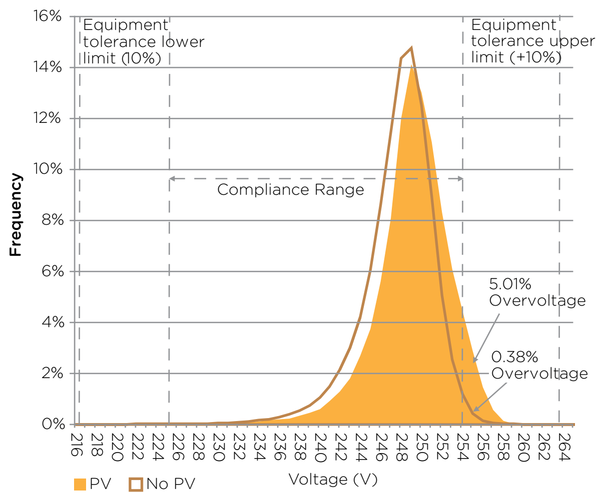


Image 7-M: Pavetta1 voltage histogram - spring



7.3.5 OPTIONS TO IMPROVE THE CAPACITY OF THE DISTRIBUTION NETWORK TO HOST SOLAR PV SYSTEM GENERATION

The findings of the trial conclude that excursions from voltage compliance limits, as a result of 29% saturation of solar PV (by transformer size), can occur. Given continued penetration of local generation on the network, such as residential solar PV systems, there is potential for voltage excursions to exceed appliance tolerance limits in the future.

As a result, a strategy to manage voltage regulation, mainly at the customer level, is required. The PV Saturation Trial has identified a range of measures to potentially manage voltage regulation on the distribution network, where there is high penetration of distributed generation such as solar PV systems. These measures include:

HV distribution network - voltage regulators

HV distribution network occurs between the substation and the point of connection with the distribution transformer. Voltage can be remotely managed by automatic voltage regulators which enables the adjustment of the voltage on the LV network.

On the edge of the network, customer voltage has a wider range of variability, and during summer these customers are susceptible to low voltages due to high loads. By introducing voltage regulation algorithms that include the level of local generation penetration, there is potential to further improve the networks capacity to absorb additional distributed generation.

Distribution transformer - automatic LV regulators

Rather than regulate voltage on the HV network (costly), it can be locally managed through the installation of automatic voltage regulators (AVRs) on the LV side of the distribution transformer. These devices dynamically adjust voltage for the distribution network to maintain pre-programmed limits. These devices would be required to accommodate and manage occurrences of reverse power flow into the network from solar PV system customers.

LV distribution lines - increase service line size

The amount that voltage drops or rises between the customer connection and the network is directly related to the cross-sectional size of the service line. In mitigating the magnitude of voltage rise experienced by solar PV system customers, it is possible to install larger service lines to customer homes.

LV distribution lines - phase balancing

During the trial, it was noted that load and solar PV system generation were not optimally balanced across all three phases. As a result, customers connected to a phase with more generation exhibited a greater frequency of over-voltage. Conversely, customers connected to a more heavily loaded phase exhibited a greater frequency of under-voltages. Note that these two scenarios are not mutually exclusive. By undertaking a phase balancing exercise, customer phase allocation is changed in order to more evenly distribute generation and loads across the three phases, which reduces the occurrence and magnitude of over and under voltage for customers.

Customer level - smart grid enabled solar PV system inverters

Smart inverters are solar PV system inverters that can form a communications link with the utility to have additional onboard functionality that enables voltage management at the customer level. With these inverters, solar PV systems have the potential to become a resource for better power quality management, rather than contributing to power quality issues. At present, these technologies and the relevant standards for their implementation are under development.

Currently, Western Power chairs the standards committee which is revising the standards for grid connected inverters (AS4777). This standard is also being aligned with the requirements of the demand response standards under development (AS4755). These standards will contain requirements and recommendations for smart functions and demand response modes for grid connected inverters that will enable better network management.

One possible voltage control strategy at the customer level would be to require solar PV system inverters to draw reactive power. This could be achieved by inverters having a volt-var droop characteristic like a static-compensator or static-var compensator.

Conclusion

In order to effectively manage the impact of an increased saturation of local generation, such as solar PV systems, a mix of the strategies could be implemented by utilities. Enhanced smart inverter policies and standards are a longer-term solution to potentially benefit customers and the network.

7.3.6 IMPACT OF SOLAR SOLAR PV SYSTEMS ON NETWORK PEAK

Western Power has utilised smart meter and Solar PV Saturation Trial data to analyse the impact of solar PV systems on the network peak. The network peak usually occurs on weekday afternoons during summer. In order to understand the impact on network peak, validation of the output of solar PV systems under summer weather conditions was required.

Analysis from the Solar PV Saturation Trial shows that during summer, the average daily maximum output is approximately 80% of the solar PV system capacity (image 7-N).

Effect of solar solar PV system orientation

The maximum daily solar PV system output can be expected if PV panels are oriented due north. In many residential installations, due north is not practical. As part of the Solar PV Saturation Trial, north-west and north-east solar orientations were tested. Both orientations were found to have similar daily kWh output. However, solar PV panels facing north-west have a greater potential to reduce afternoon peak electricity consumption.

When the network peak occurs (approximately 4:30pm), the panels facing north-east were producing approximately 20% of their average summer maximum output, whereas the panels facing north-west were producing approximately 50%. Western Power's analysis of the overall effect of solar PV systems on the network revealed that, at present, the solar PV system contribution to reducing overall peak demand is nearly 30% of the total installed solar capacity.

Effect of solar PV system on the Western Power network summer peak day

At the whole-of-network level, there is evidence to suggest that solar PV system penetration across the network resulted in an estimated peak load reduction of up to 1.52% during 2012 (image 7-O and table 7-D).

Image 7-N: Average generation per kW capacity

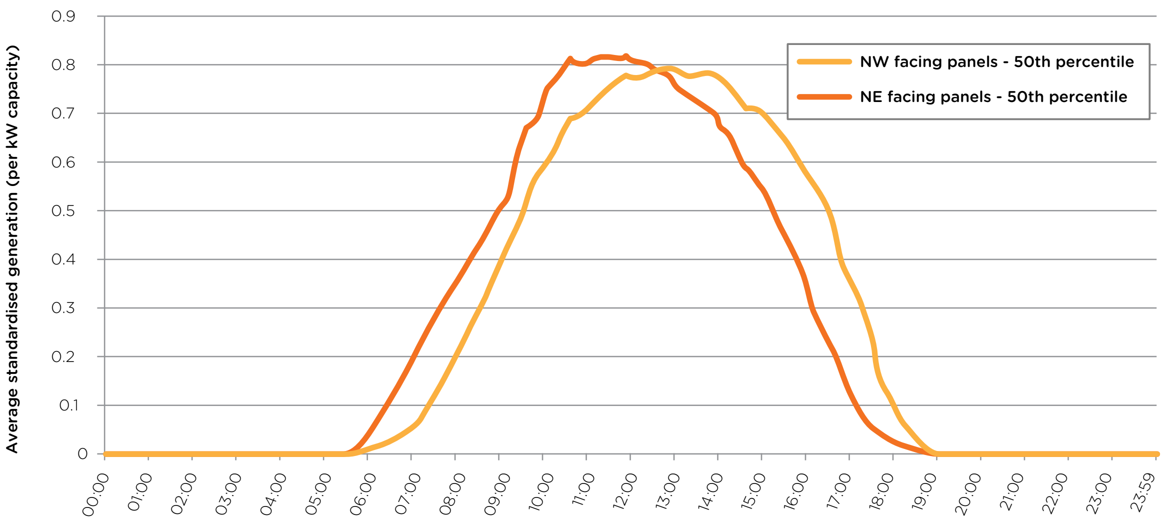


Image 7-O: Estimated impact of solar PV systems on 2012 peak day

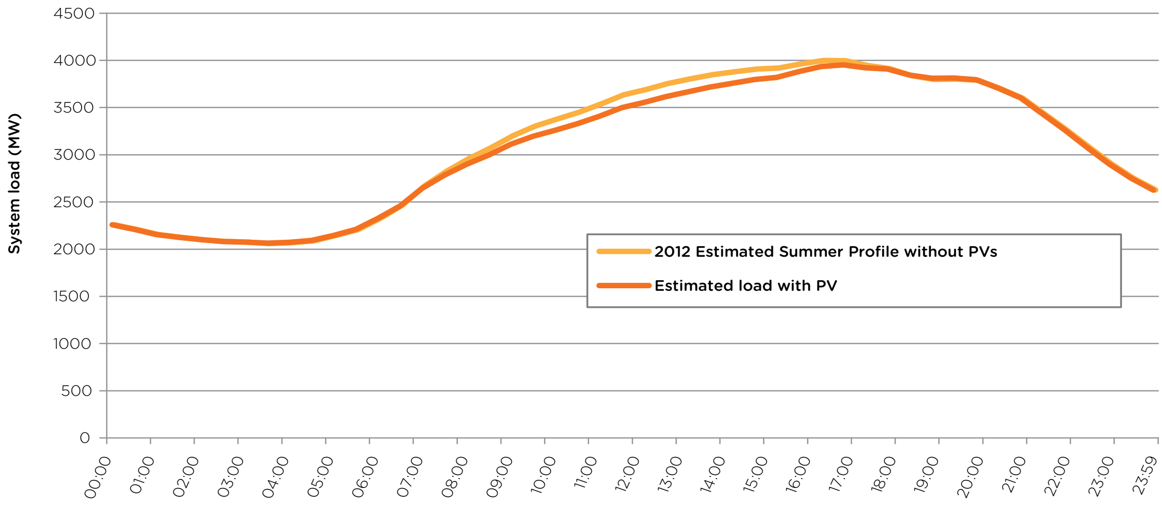


Table 7-D: Estimated impact of solar PV on 2012 Peak Day

Scenario	Peak Load (MW)	Reduction (%)	Peak Load Time
Estimated 2012 peak load without solar PV systems	3,941.3		
Estimated summer profile with solar PV systems	3,881.4	1.52%	4:45 PM
Peak load reduction from solar PV systems	59.9		

Image 7-P: Estimated impact of solar PV systems on 2017 Peak Day

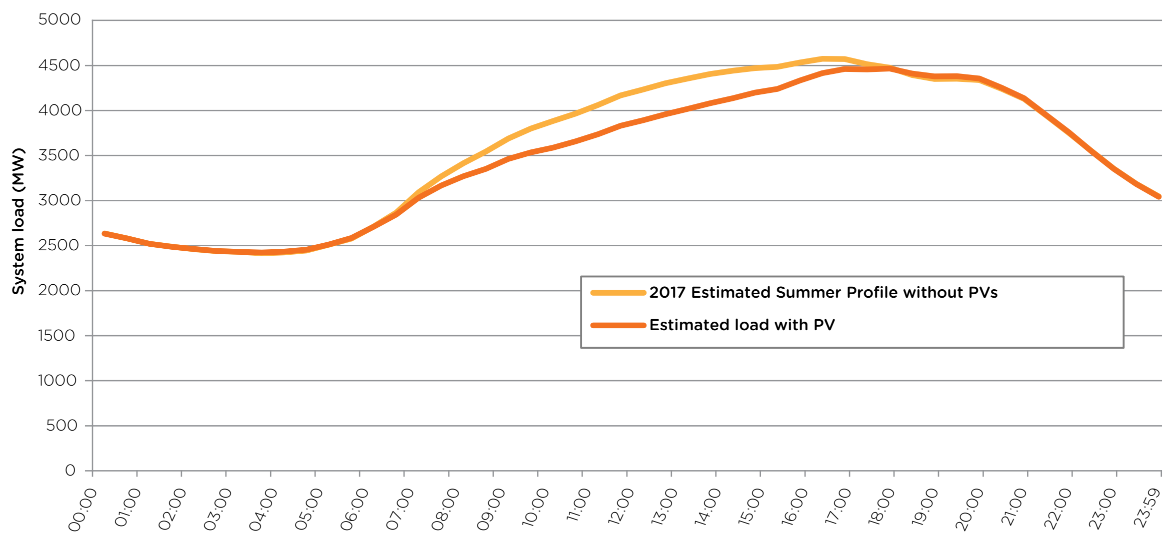


Table 7-E: Estimated impact on solar PV systems on 2017 Peak Day

Scenario	Peak Load (MW)	Reduction (%)	Peak Load Time
Estimated 2017 peak load without solar PV systems	4,584.5		
Estimated summer profile with solar PV systems	4,438.2	3.19%	4:45 PM
Peak load reduction from solar PV systems	146.3		

Image 7-Q: Padbury Substation load profile – 2012 summer peak day

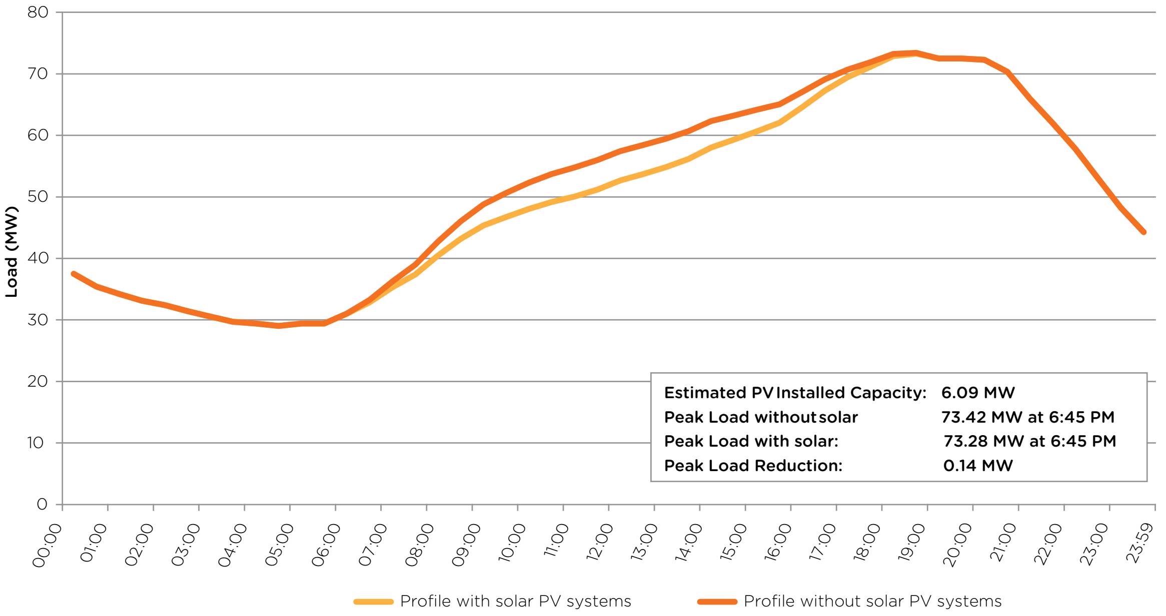


Table 7-F: Padbury substation load profile – 2012 summer peak day

Scenario	Peak Load (MW)	Reduction (%)	Peak Load Time
Estimated 2012 peak load without solar PV systems	73.42		
Estimated summer profile with solar PV systems	73.28	0.19%	6:45 PM
Peak load reduction from solar PV systems	00.14		

Solar PV system uptake has fluctuated significantly during recent years. Using a linear model based on installations to January 2012, Western Power can forecast solar PV system growth on the network through to 2017. Western Power can also forecast total demand during summer 2017. The forecast increase in solar PV system penetration may result in a peak load reduction of as much as 3.19% by 2017 (image 7-P and table 7-E).

As found in the analysis, the impact of solar PV systems on the whole of system peak largely reduces the need for the equivalent generation at the mid-afternoon (4-5pm) peak periods. However, the impact of solar PV systems on the network is more acute at the local (substation) level, and differs on a case-by-case basis, depending on the time of day of the local peak.

Substation summary

Western Power modelled the estimated impact of solar PV system generation on the actual 2012 peak day for the Padbury and Canningvale substations. These substations are amongst the 10 most prolific in terms of solar PV system penetration.

In cases where the load on the substation is primarily residential, solar PV system installations are likely to have a negligible impact on substation peak load. An example of this is the Padbury substation, which is estimated to host around 6.09MW of installed solar PV system generation as at 30 June 2012.

Modelling the impact of aggregated solar PV system found a 0.19% reduction on peak demand (image 7-Q and table 7-F). This is due to the fact that most substations that cater for a primarily residential load, such as Padbury, peak later in the day when solar PV system generation is minimal or zero.

In cases where the load on the substation is a mix of commercial and residential, the peak time is often earlier in the day. In this situation, solar PV systems are generating at their highest level. An example of a mixed-use substation is Canningvale, which is estimated to host around 6.21MW of installed solar PV generation as at 30 June 2012.

Modelling the impact of aggregated solar PV systems found a 6.24% reduction on peak demand (image 7-R and table 7-G).

Image 7-R: Canningvale substation load profile – 2012 summer peak day

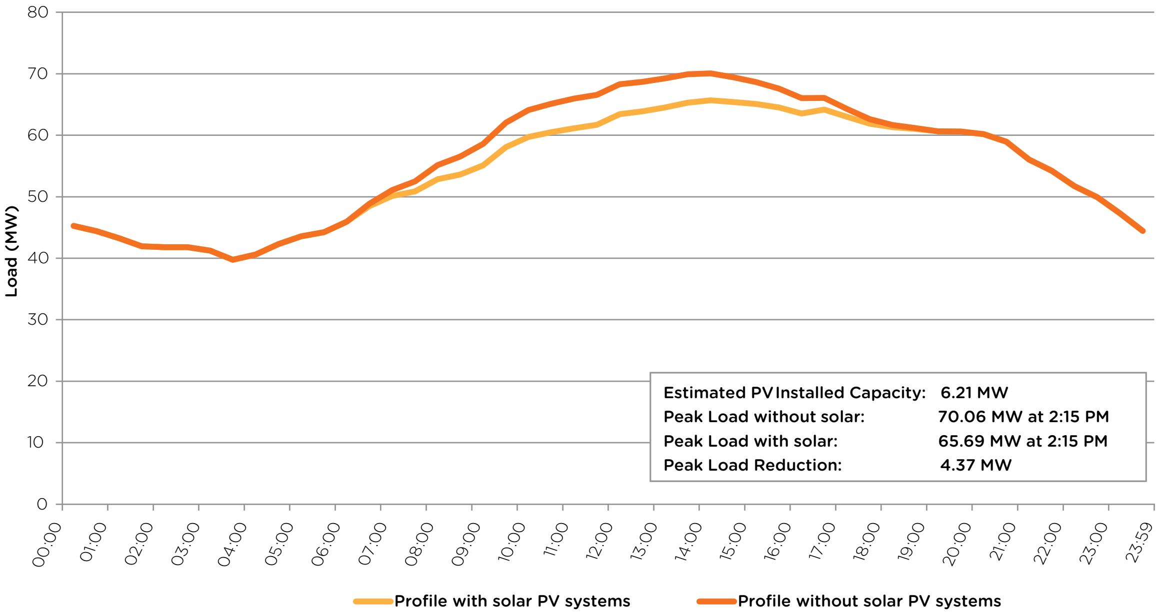


Table 7-G: Canningvale Substation load profile – 2012 summer peak day

Scenario	Peak Load (MW)	Reduction (%)	Peak Load Time
Estimated 2012 peak load without solar PV systems	70.06		
Estimated summer profile with solar PV systems	65.69	6.24%	2:15 PM
Peak load reduction from solar PV systems	4.37		

Substations that have a high concentration of solar PV systems, and a mix of residential and commercial customers, should be identified for further study, and careful consideration given to its impact when forecasting future load requirements. In instances where aggregated solar PV systems can reduce the local zone substation peak, it may enable the deferment of expenditure associated with asset upgrades.

Key findings

Key findings from the study are:

- solar PV systems are estimated to have reduced the 2012 whole-of-network peak load by up to 1.52% (59.9 MW)
- in aggregate, continued growth in the number of solar PV systems is estimated to reduce the system peak by up to 3.19% (146 MW) in 2017
- the impact of solar PV systems on substation peak load is highly dependent on the time of substation peak. For example, the impact of solar PV system on a mixed use substation may be as great as a 6.24%

7.3.7 RESEARCH AND COLLABORATION

A number of concurrent research projects are being undertaken by Curtin University, including:

- phase identification using smart meter voltages
- reactive power capability of solar PV system inverters for voltage management
- hot day load modelling
- impact of solar PV system on distribution transformer life
- use of LV regulators to address voltage compliance on networks with high solar PV system penetration

7.4 TRANSFERRABLE LESSONS

Subject	Barrier or benefit	Outcome and/or lesson
Solar PV Saturation Trial	BARRIER: Solar PV system penetration beyond 30% (by transformer size) is likely to result in excursions beyond upper voltage limits, particularly during spring.	OUTCOME: Penetration beyond trial limits are likely to result in local power quality issues requiring mitigation. LESSON: Solar PV system penetration levels should be monitored, with a mix of mitigation strategies, such as voltage regulators and phase balancing, assessed and applied as required.
Substation peak demand	BENEFIT: Where substation peak demand coincides with solar PV system output, peak demand on local substations can be reduced.	LESSON: Increased solar PV system generation should be taken into account during network forecasting and planning, as it may lead deferment of network augmentation on parts of the local network.
Smart Inverters	BENEFIT: Utilisation of smart inverter technology to assist in managing network power quality.	LESSON: Standards for grid-connected inverters (AS 4777) should include smart functionality.
Solar PV orientation	BENEFIT: Solar PV systems facing north-west produce approximately 50% of their summer maximum output at the time of network peak.	OUTCOME: West facing solar PV systems produce the most benefit in terms of reducing peak demand. LESSON: North-West facing solar PV should be considered as a demand management tool to reduce peak electricity consumption on appropriate parts of the network.

RESIDENTIAL SOLAR PHOTOVOLTAIC SYSTEMS

8.1 BACKGROUND

By installing solar photovoltaic (PV) systems, householders can generate their own electricity, and offset electricity consumption costs. This may include the export of surplus power to the local distribution network for which the householder is paid by the electricity retailer.

Perth receives an average of 7.9 sun hours per day and as such has premium conditions for generation of solar power. SunPower, with dealers located in the heart of the Perth Solar City region, is the premium brand in the solar PV market place, and has the highest efficiency panel at 20% efficiency.

Perth Solar City assisted households in Perth's Eastern Region to take full advantage of these factors by providing a financial discount on SunPower residential solar PV systems. Between April and September 2012, the residential PV discount was made available to the wider Perth metropolitan area.

This discount was made available via selected SunPower dealers in Perth's Eastern Region, and was in addition to other incentives such as Renewable Energy Certificates (RECs), and the Western Australian residential net feed-in tariff (NFiT) and Renewable Energy Buyback Scheme (REBS).

SunPower dealers received Perth Solar City customer referrals from the Living Smart program, through the Perth Solar City call centre and website, and directly from the public. The solar PV system discount was promoted through a range of broad reach marketing methods as well as through larger scale solar PV systems at iconic locations as the Perth Zoo and Midland Foundry (chapter 13).

SunPower has also sponsored other Perth Solar City initiatives such as the Sustainable Communities competition and the Eco House competition (chapter 10).

8.2 OBJECTIVES AND PROGRESS

SunPower's objective was to install a total of 825 residential solar PV systems at a minimum size of 1.05kW per system. However, due to the Western Australian Government's closure of the residential net feed-in tariff and a reduction in price of the Renewable Energy Certificates, demand for residential solar PV decreased significantly.

This decline in sales was addressed by:

- increasing the discount available on residential solar PV systems via targeted campaigns
- offering the residential solar PV discount to the wider Perth metropolitan area between April and September 2012 (chapter 10).

SunPower achieved 80% of the overall program target for residential solar PV systems.

The final quarter of the program was the largest quarter in terms of systems installed (image 8-A).

Sub-Project	Program Target	Achieved
Residential PV systems	825	659

[1] Bureau of Metrology. (2011). Climate statistics for Australian locations. Retrieved 13 December 2011, from http://www.bom.gov.au

2011 RE-CAP

PROGRESS

As at 30 November 2011, SunPower had achieved 52% of the residential PV target, installing a total of 429 systems.

Strong solar PV system sales occurred for the period January to June 2011, with a subsequent sharp decline in sales following 1 July 2011. This was concurrent with the reduction in RECs as well as the ending of the net feed-in tariff.

KEY RESULTS

As at 30 November 2011, the total installed capacity of residential solar PV systems under Perth Solar City was 976kW, with an average system size of 2.27 kW.

Preliminary analysis was undertaken using data from 6,064 smart meter households: 348 with a solar PV system and 5,716 households without a solar PV system.

Analysis indicates that for the majority of half-hour intervals where the solar PV system is generating electricity, the average interval demand was significantly less than that of customers without solar PV system generation. However, customers with solar PV system generation had slightly higher electricity demand (4.3 kW) at peak times (5:30pm – 8:30pm) than customers without (4.2 kW).

Preliminary analysis was completed for 360 households with a SunPower solar PV system installed. The analysis showed an average electricity reduction from the electricity grid of 57.9%, or 11.36 kWh per day.

8.3 KEY RESULTS

Key results for residential solar PV systems will focus on:

- system installation sizes
- demographic trends
- effect on electricity consumption
- participant satisfaction

8.3.1 SYSTEM INSTALLATION TRENDS

Average system size

The total installed capacity of residential solar PV systems under Perth Solar City was 1.56MW. The average system size installed was 2.30kW.

8.3.2 DEMOGRAPHIC TRENDS

Table 8-A shows the income band for households that purchased a solar PV system through Perth Solar City. The income band $50-001 - $100,000 was the most prevalent.

Table 8-A: Household income bands of solar PV system purchasers

Income band	Known Number	% of total
$0-20,000	19	3%
$20,001-$50,000	59	9%
$50,001-$100,000	148	22%
$100,001-$150,000	81	12%
$150,000+	45	7%
Unknown	307	47%
TOTAL	**659**	

8.3.3 ENERGY DEMAND TRENDS

Perth Solar City commissioned Data Analysis Australia (DAA) to conduct analysis on the effect of solar PV systems on electricity consumption. The analytic methodology developed and used by DAA is attached in Appendix B.

The analysis was completed for 440 households who had a solar PV system installed as part of Perth Solar City. Households with solar PV systems showed an average reduction in total consumption from the electricity grid of 41% or 8.15kWh per day. For year two, the average total reduction is less than the 58% or 11.36kWh per day observed in the first year of the trial (image 8-B).

The second year analysis comprised of a larger sample size and a longer data period. In addition, there are some external factors which may have contributed to the difference. During year one, the Western Australian net feed-in tariff was available, and provided customers with an added incentive to conserve electricity in order to maximise the export and therefore sales to the grid. The net feed-in tariff was abolished at the beginning of year two. Consequently, households were incentivised to use the electricity they generate rather than export it to the electricity network.

Table 8-B shows the average annual cost and greenhouse gas emission savings for year two of the trial.

Note: Due to different rates of purchase, calculations do not include any payment for electricity generated and exported to the electricity grid.

Table 8-B: Average annual cost and greenhouse gas emission savings for solar PV system households

Customer group	Electricity cost savings per household ($/year)*	Greenhouse Gas savings (kg CO-e/ year)^
Residential solar PV	$740.38	2,737

* Calculation based on unit cost of $0.248866 per kWh - the A1 all-time rate as at 30 September 2012

^ Based on emission co-efficient of 0.92kg/CO2-e per kWh (National Greenhouse Account Factors July 2012)

8.3.4 PARTICIPANT SATISFACTION

Image 8-C highlights the reasons households purchased a solar PV system. 'Cost-savings' was the most significant motivator to purchase a solar PV system, followed by 'doing the right thing for the environment'.

The level of satisfaction for solar PV system performance was high, with 77% indicating they were 'very satisfied' (image 8-D). This indicates that participant householders expectations for purchasing a solar PV system through Perth Solar City were met.

Image 8-A: Residential solar PV system installations by month and cumulative

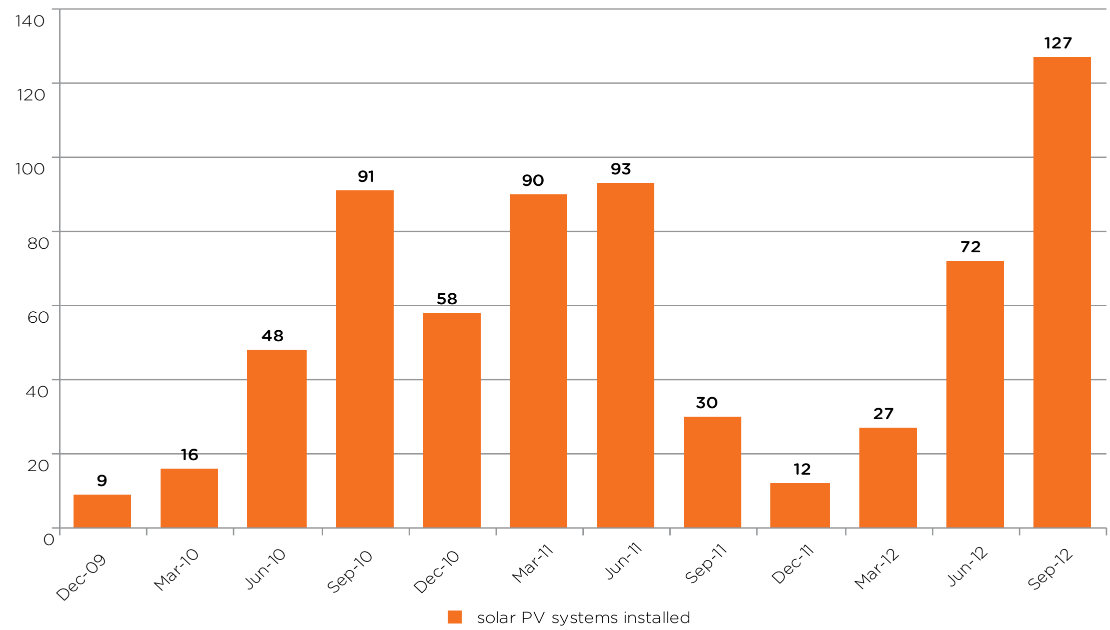


Image 8-B: Average reduction in electricity consumption fom the grid

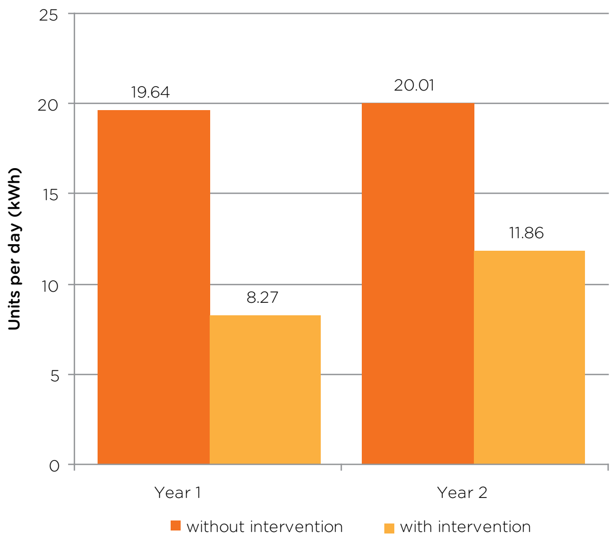


Image 8-D: Satisfaction of solar PV system performance

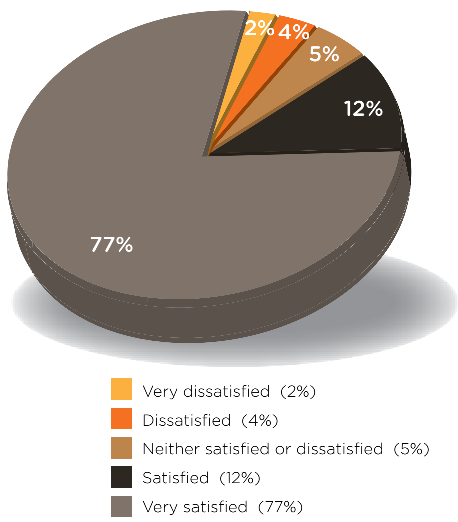
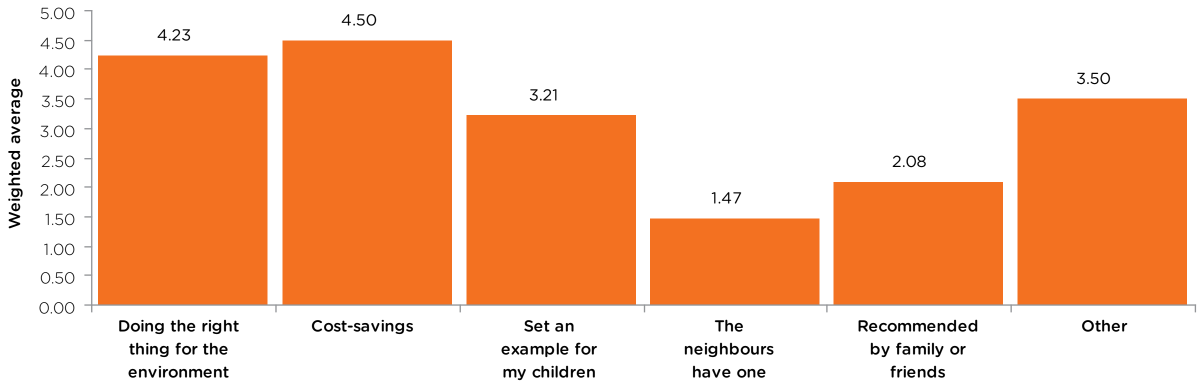


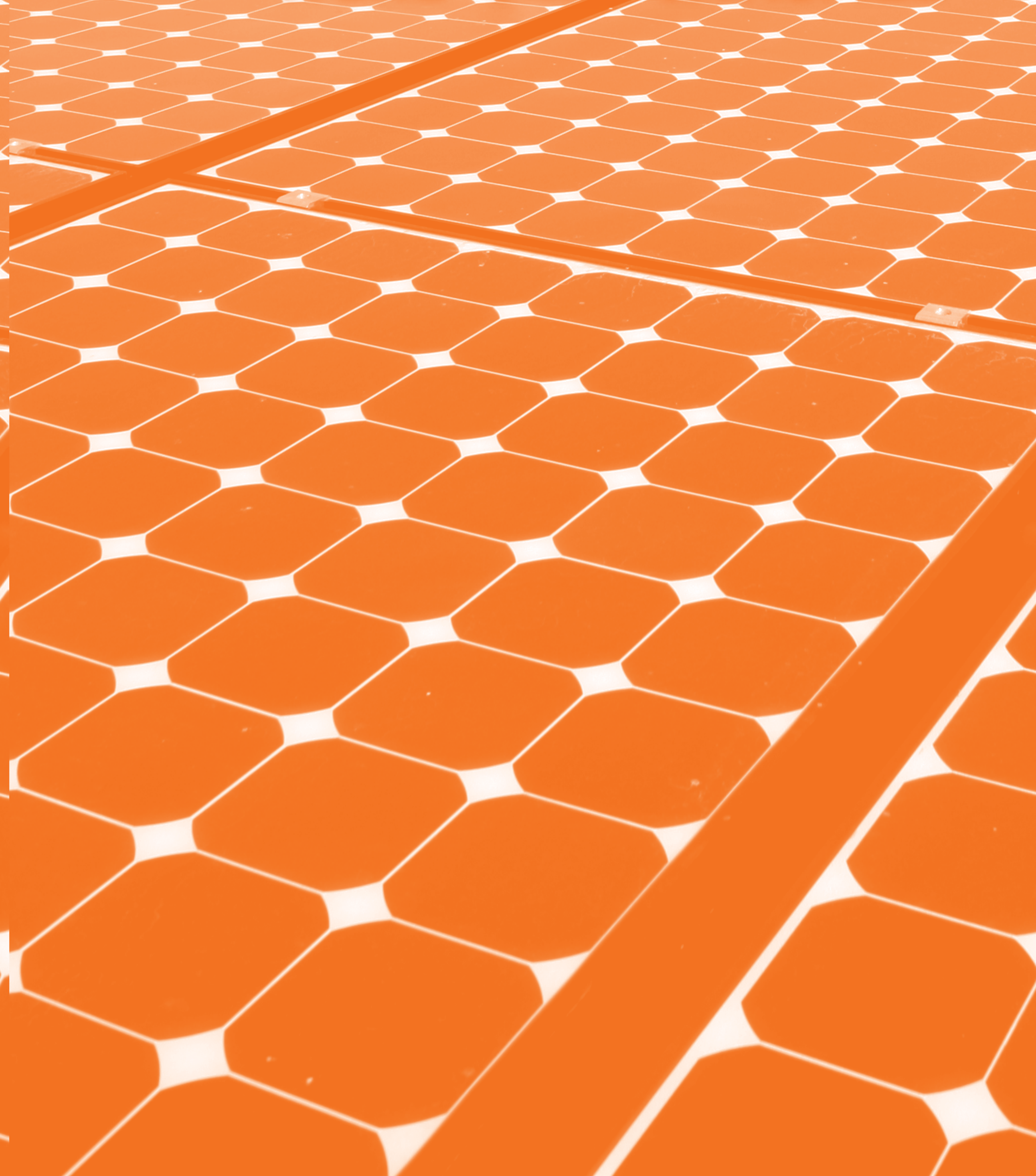
Image 8-C: Motivators for households in purchasing a solar PV system



8.4 TRANSFERABLE LESSONS

Subject	Barrier or benefit	Outcome and/or lesson
Federal and state government solar PV system rebates/ incentives	BARRIER: Impact of changes to available government rebates/incentives on solar PV system purchases.	OUTCOME: Uncertainty in the market place as to the availability of rebates/incentives. LESSON: Changes to rebates/incentives should be clearly communicated by government and industry.
Federal and state government solar PV rebates/ incentives	BENEFIT: Federal (RECs) and State Government (NFiT) rebates and incentives.	OUTCOME: Increased solar PV system sales. However, uncertainty over the continuation and/or reduction or cessation of financial incentives results in significant spikes and drops in demand. LESSON: Longer term certainty is required with respect to PV rebates and incentives.
WA net feed-in tariff	BARRIER: Through net feed-in tariffs, solar PV system households are receiving greater incentive to feed electricity into the grid, as opposed to using it directly to offset consumption.	OUTCOME: Solar PV system households are deferring electricity consumption to periods where solar PV system generation is minimal (generally late afternoons/ early evening). This has the potential to increase electricity demand at a time when the network is experiencing peak demand in certain locations. LESSON: Net feed-in tariffs may have adverse network effects. Alternative incentive models should be investigated
Premium brand	BARRIER: High cost of premium SunPower brand in competition with other brands in target area.	OUTCOME: Conversion rate of customer enquiries was relatively low, particularly after reductions in incentives and rebates. Potential participants are purchasing lower cost alternative systems. LESSON: Informational barriers regarding the benefits of purchasing a premium brand are required to be overcome.
Premium brand	BENEFIT: A premium brand offers high quality workmanship, longer warranties and professional customer service.	OUTCOME: Customer satisfaction is high. LESSON: Whilst utilising a premium solar PV system brand does have barriers, high customer satisfaction and quality service provide good outcomes for energy efficiency programs.

THE LEVEL OF SATISFACTION FOR SOLAR PV SYSTEM PERFORMANCE WAS HIGH, WITH 77% INDICATING THEY WERE 'VERY SATISFIED'



RESIDENTIAL SOLAR HOT WATER SYSTEMS

9.1 BACKGROUND

Heating water represents 25% of an average Perth household's energy costs. Solar hot water systems are proven to be more cost effective than most other storage and instantaneous systems for heating water[1]. This is particularly the case in the Perth metropolitan area which receives an average of 7.9 sun hours per day[2].

The Perth Solar City program and Solahart provided a $1,100 discount (inc. GST) on family-sized Solahart solar hot water systems to residents in Perth's Eastern Region. Solahart are a Western Australian based company which manufactures solar hot water systems in Perth.

The Perth Solar City discount is made available via selected Solahart dealers, and is offered for both gas and electric boosted solar hot water systems. The discount is provided in addition to other state and federal government rebates.

During 2010 and 2011, Solahart dealers received the bulk of Perth Solar City customer referrals from the Living Smart program, through the Perth Solar City call centre and website, and directly from the public. Methods used to promote the solar hot water discount during 2012 included local newspaper advertising (image 9-A), the Eco House open days, community workshops and direct marketing (chapter 10).

Image 9-A: Solahart local newspaper advert

[1] Australian Government. (2010). Technical Manual - Design for lifestyle and the future. Retrieved from http://www.yourhome.gov.au/technical/fs61.html

[2] Bureau of Meteorology. (2011). Climate statistics for Australian locations. Retrieved 13 December 2011, from http://www.bom.gov.au/

2011 RE-CAP

PROGRESS

As at 30 November 2011, Solahart had achieved 51% of the residential solar hot water target, installing a total of 610 systems.

KEY RESULTS

System installation trends

The vast majority of households (98%) purchased an electric boosted solar hot water system.

Type of system	Number	Percentage
Electric boosted solar	599	98%
Gas boosted solar	11	2%
Total	**610**	

Gas storage and electric storage hot water systems were the most common types of water heating system being replaced.

Demographic trends

Of the 610 participants, a total of 48% disclosed their annual household income level.

Of the known income bands, the most common was $50,001 - $100,000 annual household income.

Energy consumption trends

Preliminary analysis was completed for 175 participant households who had replaced an electric storage or electric instantaneous hot water system with an electric-boosted solar hot water system during the period 7 January 2010 to 30 June 2011. An average 15% reduction in electricity use was evident.

HEATING WATER REPRESENTS 25% OF AN AVERAGE PERTH HOUSEHOLD'S ENERGY COSTS

9.2 OBJECTIVES AND PROGRESS

Solahart's objective is to utilise the Perth Solar City discount to sell and install 1,190 family-sized solar hot water systems on households in the Perth Solar City target area.

Sub-Project	Program Target	Achieved
Residential Solar Hot Water systems	1,190	1,151

Solahart achieved 97% of their target for the Program.

The rollout of Perth Solar City products and services beyond the original target area (chapter 10) provided a significant number of sales during the final two quarters of the program (image 9-B).

9.3 KEY RESULTS

Key results for residential solar hot water systems will focus on:

- system installation trends
- demographic trends
- effect on electricity consumption
- participant satisfaction

At the time of writing this report, 1,144 out of 1,151 solar hot water system data sets were available for analysis.

9.3.1 SYSTEM INSTALLATION TRENDS

Type of system installed

The following tables show the type of solar hot water system purchased by participants in the program to date (table 9-A), and the average cost of each system type (table 9-B). The vast majority of households (98%) have purchased an electric boosted solar hot water system.

Table 9-A: Type of solar hot water system

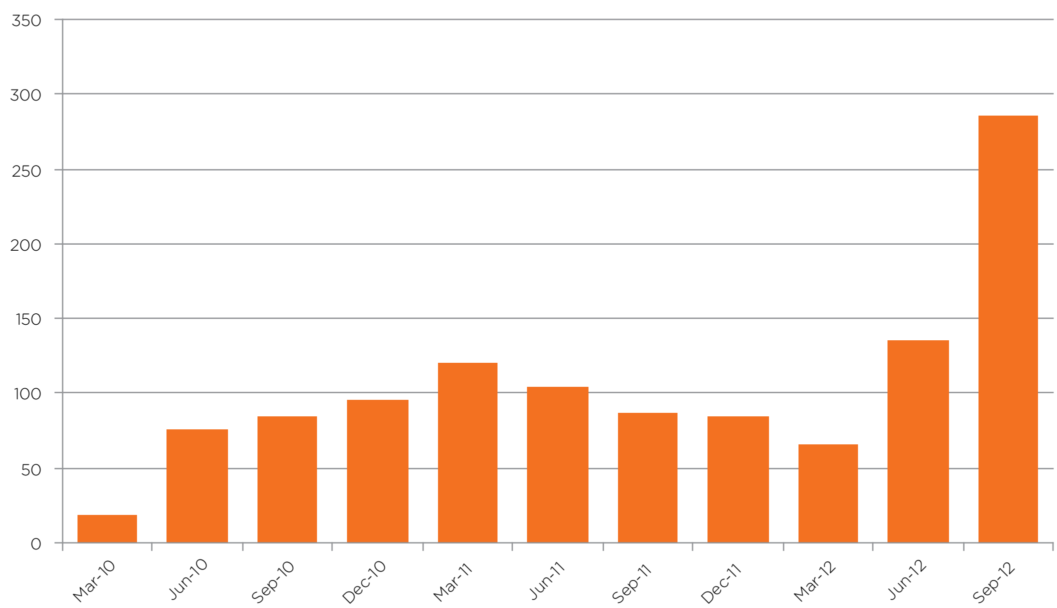
Type of system	Number	Percentage
Electric boosted solar	1,125	98%
Gas boosted solar	19	2%
Total	**1,144**	

Average cost to household

Table 9-B: Average cost to household

Average cost – electric boosted solar	$3,723.80
Average cost – gas boosted solar	$4,592.00

Image 9-B: Solar hot water systems installed by quarter



System replacements

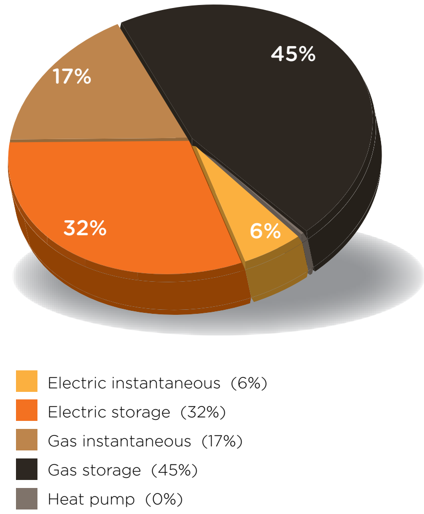
Gas storage and electric storage hot water systems are the most common types of water heaters being replaced (table 9-C).

Table 9-C: Replacement of existing hot water system by type (including unknown or new home)

System replacing	Number	Percentage
Electric Instantaneous	51	5%
Electric storage	288	25%
Gas instantaneous	152	13%
Gas storage	416	36%
Heat pump	4	0%
Unknown or new home	233	20%
Total	**1,144**	

Of the 911 systems that were installed to replace an existing hot water system (233 for new dwellings), 32% were replacing electric storage systems (image 9-C).

Image 9-C: Replacement of existing hot water system by type (excluding unknown or new home)



9.3.2 DEMOGRAPHIC TRENDS

Solar hot water system purchases by income band

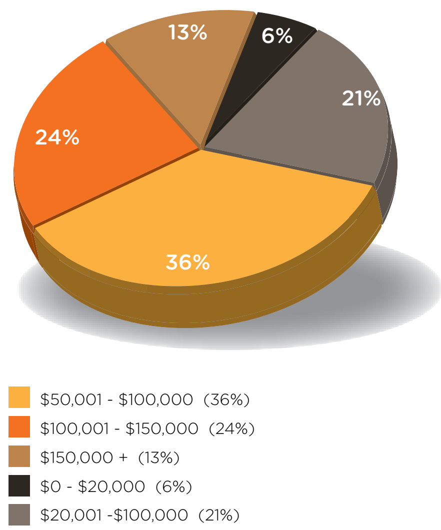
Demographic data extracted from the Program database for 1,144 participants, shows that a total of 468 (41%) disclosed their annual household income level (table 9-D).

Table 9-D: Household income bands for solar hot water participants

Income band	Number	Percentage
$0 - $20,000	27	2%
$20,001 - $50,000	98	9%
$50,001 - $100,000	169	15%
$100,001 - $150,000	112	10%
$150,000+	62	5%
unknown	676	59%
TOTAL	**1,144**	

Of the known income bands (468 participants), the most common was $50,001 - $100,000 annual household income (image 9-D).

Image 9-D: Known income bands



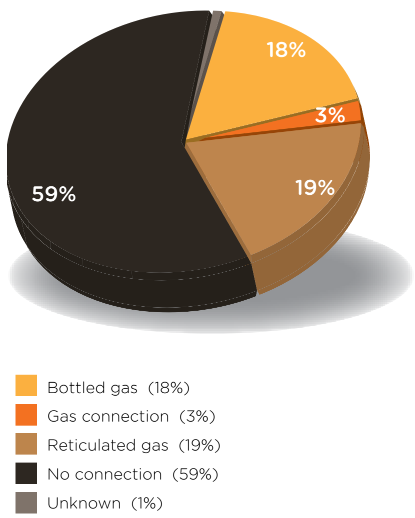
Access to reticulated gas

37% of participant households are not connected to reticulated gas or are connected to bottled gas (table 9-E and image 9-E). This is reduced from 43% of participant households in 2011.

Table 9-E: Access to reticulated gas

Gas type	Count	Percentage
Bottled gas	211	18%
Gas connection – unspecified	31	3%
Reticulated gas	670	59%
No connection	219	19%
Unknown	13	1%
TOTAL	**1,144**	

Image 9-E: Access to reticulated gas



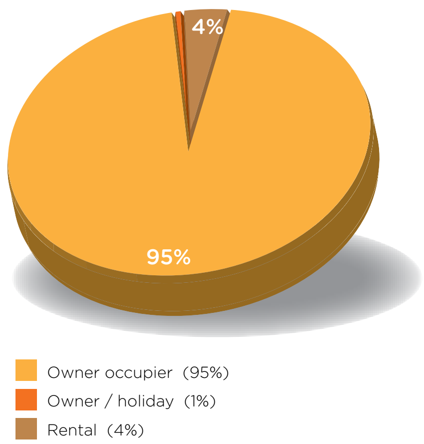
Ownership Status

92% of participant households were owner-occupied (table 9-F and Image 9-F).

Table 9-F: Ownership status (including unknown)

Gas type	Count	Percentage
Owner/Occupier	1055	92%
Owner/holiday	8	1%
Rental	46	4%
Unknown	35	3%
TOTAL	**1,144**	

Image 9-F: Ownership status (excluding unknown)



9.3.3 ENERGY CONSUMPTION TRENDS

Effect on electricity consumption – preliminary results

Perth Solar City commissioned Data Analysis Australia (DAA) to provide preliminary analysis on the effect of the installation of solar hot water systems on electricity consumption. The analytic methodology developed and used by DAA is attached in Appendix B.

In order to understand the effect of solar hot water on electricity consumption, analysis was completed for 235 participant households. These households had replaced an electric storage or electric instantaneous hot water system with an electric-boosted solar hot water system during the period 7 January 2010 to 30 June 2012. An average 18.2% reduction in electricity use is evident (image 9-G).

Image 9-G: Effect on electricity consumption

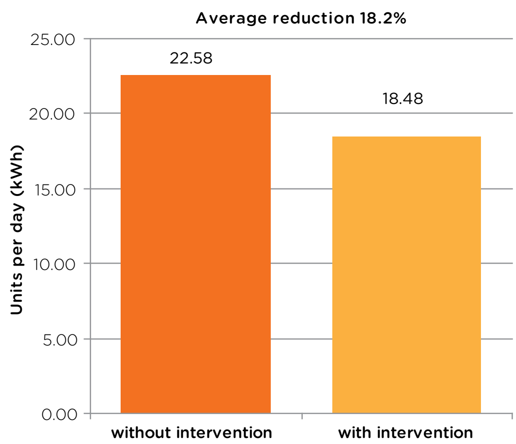


Table 9-G shows the average annual cost and greenhouse gas emission savings for the 175 participant households.

Table 9-G: Average annual cost and greenhouse gas emission savings for solar hot water households (electric to solar-electric conversion)

Customer Group	Electricity cost savings per household ($/year)*	Greenhouse Gas savings (kg CO-e/ year)^
Solar Hot Water	$372.77	1,378

* Calculation based on unit cost of $0.248866 per kWh - the A1 all-time rate as at 30 September 2012
^ Based on emission co-efficient of 0.92kg/CO2-e per kWh (National Greenhouse Account Factors July 2012)

9.3.4 Participant satisfaction

During September 2012, Perth Solar City surveyed 178 participants to understand their motivations for participation, and their subsequent satisfaction with the Program.

Survey respondents were asked to rate motivators on a scale of 1 to 5, where 1 was low and 5 was high motivation. The most significant motivator for households to purchase a solar hot water system was 'cost-savings', rating 4.57 out of 5 followed by 'doing the right thing for the environment', rating 4.31 out of 5 (image 9-H).

The level of satisfaction for solar hot water system performance was significant, with 90% indicating they were either 'satisfied' or 'very satisfied' (image 9-I). The high level of performance satisfaction suggests that expectations for purchasing a solar hot water system were met.

Image 9-H: Participant motivation for purchase

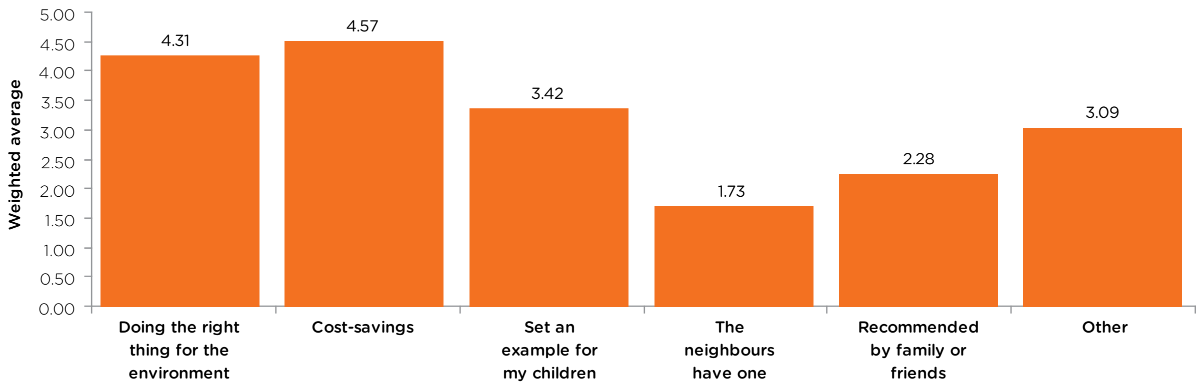
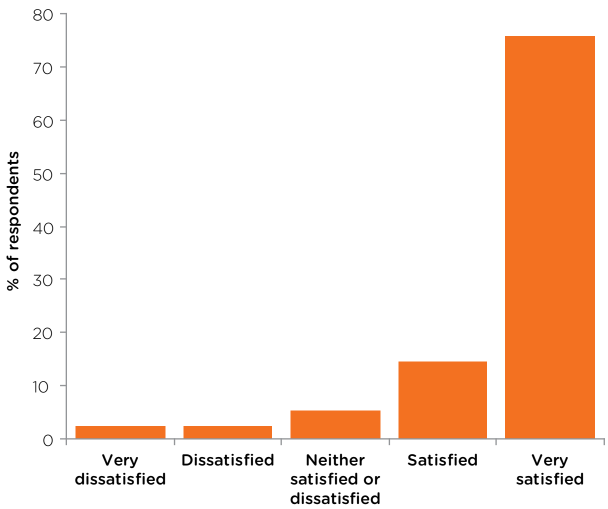


Image 9-I: Satisfaction of system performance



9.4 TRANSFERRABLE LESSONS

Subject	Barrier or benefit	Outcome and/or lesson
Purchase of solar hot water systems	BARRIER: The split incentive barrier between renters and landlords.	OUTCOME: The majority (92%) of participants were owner occupier households. LESSON: Alternative subsidies for landlords to increase energy efficiency of rental properties should be trialled.
Community engagement	BENEFIT: Grassroots community engagement activities, such as the Eco House open day and community workshops, provided excellent engagement opportunities for Solahart dealers.	OUTCOME: Customers engaged with Perth Solar City solar hot water dealers directly. LESSON: Grassroots community activities which enable direct engagement between customers and service providers are an effective method of overcoming information barriers.
Federal and state government rebates/ incentives	BARRIER: Changes to available government rebates/ incentives.	OUTCOME: Uncertainty in the market place as to the availability of rebates/incentives. This resulted in confusion about applicable rebates and subsequently reduced sales activity. LESSON: Changes to rebates/incentives should be clearly communicated by government and industry.
Installation by booster type	BARRIER: 37% of households either have no access to reticulated gas or bottled gas only. Gas boosted solar hot water systems (average cost $4,614.91) are more expensive than electric boosted (average cost $3,557.50).	OUTCOME: 98% of solar hot water system purchases were for electric boosted solar hot water systems. LESSON: Equal value rebates for both electric and gas solar hot water systems encourage purchase of the lower-cost option.
Competition with solar PV systems	BARRIER: Solar PV systems have greater incentives in the market place (state government feed-in tariff and federal government RECS multiplier).	OUTCOME: Households tend to make a single major investment in solar technology, and are selecting solar PV systems due to perceived greater benefit. LESSON: Informational barriers as to the relative benefits of solar hot water must be overcome to achieve greater market penetration.
System replacement	BARRIER: Perceived high cost of solar hot water systems combined with sunk cost of existing hot water system.	OUTCOME: The Living Smart program has shown that households are waiting until their existing hot water system breaks down before replacing with solar. LESSON: Information barriers on the benefits of changing to solar are still required to be overcome.

HOUSEHOLDS WHO REPLACED AN ELECTRIC STORAGE OR ELECTRIC INSTANTANEOUS HOT WATER SYSTEM WITH AN ELECTRIC BOOSTED SOLAR HOT WATER SYSTEM SHOWED AN 18.2% REDUCTION IN ELECTRICITY USE

ENGA

AGEMENT

MARKETING
BEHAVIOUR CHANGE
HOME ECO-CONSULTATIONS
ICONIC PROJECTS
DEMONSTRATION PROJECTS
SCHOOLS ENGAGEMENT

10.0 MARKETING

10.1 BACKGROUND

Since its launch in 2009, the Perth Solar City program has been promoted through the delivery of a marketing strategy utilising community-based social marketing concepts. In 2010, the Collective Impact campaign was launched to show residents of Perth's Eastern region that their individual actions, however small, are part of something greater – a 'collective impact'. It positioned Perth Solar City as the educator and enabler of the energy efficiency journey for households, and promoted the Program's products and services.

The objectives of the Perth Solar City marketing strategy were to:

- create awareness of the Perth Solar City program
- promote Solar Cities as an Australian Government initiative and provide due recognition for it's leadership and funding of the Program
- showcase iconic and demonstration solar PV system installations
- build general knowledge of the energy efficiency products and services being offered under the program
- create excitement about the benefits of the Program for households and the wider community to encourage participation

The Perth Solar City Program Office is responsible for the delivery of the marketing strategy, including the Collective Impact campaign, on behalf of the Consortium. The campaign included extensive advertising in local newspapers and cinemas, on billboards on major roads, train stations and bus stops, as well as sponsorship of local community events and direct mail campaigns.

10.2 OBJECTIVES AND PROGRESS

With the conclusion of Perth Solar City's broad reach marketing campaign – Collective Impact – in December 2011, the primary focus for 2012 shifted from raising awareness to direct marketing of the remaining energy efficiency products and services for the final operational year of the Program.

10.3 EXTENDING THE PERTH SOLAR CITY BOUNDARIES

Extensive community engagement and promotion of Perth Solar City's products and services occurred within the target area (Perth's Eastern Region) since the Program's commencement in November 2009. By January 2012 it was determined that most households likely to participate in the Program from within the original target area had done so.

Commencing in April 2012, the Program's boundaries were expanded to include the wider Perth metropolitan area. The expanded rollout included the commercial products and services (Home Eco-Consultations, solar hot water and solar PV systems) which would be available until 30 September 2012. Participation in technical trials continued to be limited to the original target area within Perth's Eastern Region - being those households who had received a smart meter under the Program.

While all residents within the Perth metropolitan region were eligible to participate in the Program, marketing activities were focused within the central residential corridors, in a geographically phased approach to enable customers to be more effectively serviced by the Consortium.

Perth Solar City's community participation phase concluded on 30 September 2012.

Marketing

A multi-faceted marketing strategy was developed leveraging the Perth Solar City brand and the continued high levels of media interest. The extended rollout was promoted to residents of the Perth metropolitan region through the use of local advertising, online marketing, direct mail, community workshops and media.

Advertising

Print advertising was developed in a phased approach from April until August 2012. Each phase grouped local newspapers into geographical regions

2011 RE-CAP

PROGRESS

The Perth Solar City Program Office is responsible for the delivery of the marketing strategy, on behalf of the Consortium. Marketing strategies undertaken to 30 November 2011 included:

- The two phase Collect Impact campaign
- Direct mail
- Eco House
- Online marketing and communications
- Media and events

The two phase, 'Collective Impact' campaign was established by the Program Office to demonstrate to residents of Perth's Eastern Region that their individual actions, however small, are part of something greater.

Collective Impact Phase 1 – raising awareness

Between February and August 2010 Phase 1 was delivered and was designed to introduce the Perth Solar City brand to the community. The Phase 1 campaign featured key messages from Perth Solar City, its Consortium and energy efficiency concepts.

Collective Impact Phase II – direct engagement

Phase II was delivered from February to August 2011 and was designed to leverage the brand strength and community awareness established in Phase I.

KEY RESULTS

Collective Impact

Measurement	2011	2010
Program awareness – level of awareness when prompted	41%	51%
Program recognition – level of awareness of the Program name	73%	49%
Program satisfaction – level of customer satisfaction	81%	80%
Information source – how did customers hear about the Program		
• Internet	33%	7%
• Local newspaper	20%	20%
• Direct mail	2%	54%
Motivators – what motivates customers to act		
• To save money	68%	63%
• To help the environment	36%	42%
Barriers – what inhibits customers to act		
• Costs too much money	44%	52%
• Already energy efficient	13%	24%
Energy efficiency actions – level of community implementation		
• Dry your clothes on the line, not the dryer*	97%	-
• Switch to energy efficient lighting	90%	87%
• Wash your clothes in cool water	83%	82%
• Turn off standby power	82%	79%
• Install a waterwise showerhead (and shower quicker)	75%	69%
• Adjust your heating/cooling temperature	70%	67%
• Lower your hot water heater thermostat by 20 degrees*	41%	-
• Turn off your second fridge	33%	29%
• Run your pool pump two hours less each day*	16%	-
Information source – preferred communication channel		
• Direct mail into letterbox	65%	65%
• Local newspaper	47%	48%
• Email	38%	27%
Future interest – interest in finding more about the Program	84%	82%

*New questions in 2011

Direct Mail

Direct Marketing Method	Customer response rate
Direct mail	1.7%
Direct mail + newspaper advertising	2.1%
Direct mail + out-bound telemarketing	10.0%*

*tested for Home Eco-Consultations only

to allow Consortium members to better manage the scheduling of participant visits. In addition the phased approach enabled momentum to be maintained, and participant enquiry volumes to be managed over the extended rollout period. Advertisements featured the three commercial products and services – home eco-consultations, solar hot water and solar PV systems (image 10-A).

In addition, targeted advertising was developed for solar hot water systems, highlighting the exclusive $1,100 discount. The advertisement ran in all 16 metropolitan Community Newspapers in July and August 2012. The campaign was effective with solar hot water referrals increasing by 49% in the week following the advertising (image 10-B)

Increased financial incentives

To promote community participation, and to overcome the identified barrier of cost (Synovate, 2011), additional incentives were used to encourage the purchase of solar PV systems.

Households in the Perth metropolitan region were offered a $500 incentive in addition to SunPower's Perth Solar City $0.20 per watt discount. To allow the Program to understand actual solar PV system performance via gross metering of solar PV output, smart meter households were offered a greater incentive of $1,500 in addition to SunPower's $0.20 per watt discount. Smart meter households saved a further $300 as they did not require a meter exchange.

The increased financial incentive was effective in improving referral levels with a 71% increase measured. In the week following the direct mail campaign to households (image 10-C) the Perth Solar City call centre received 176 calls - the largest number of calls since the commencement of the program (average 43 calls per week).

Direct mail

With 65% of participants rating direct mail (DM) as their preferred communications channel in 2010 and 2011, additional DM campaigns were implemented in 2012.

To ensure the security of customer data at all times, the Perth Solar City Program Office, resourced by Western Power, managed all direct mail campaigns on behalf of the Consortium.

Segmentation was conducted for each of the campaigns to ensure that the households targeted were not on the National Do Not Call Register, had not previously participated in the Program, and were eligible for the specific product (for example, all multi-story dwellings were excluded from the solar PV and solar hot water system direct mail campaigns due to inability to install).

Evaluation of the 2010 and 2011 direct mail campaigns showed that success significantly increased when followed by outbound tele-marketing (as tested for Home Eco-Consultations).

Given this, additional direct mail campaigns, followed by a personal phone call, were implemented in 2012 for Home Eco-Consultations and solar PV systems. This strategy again proved successful, with the overall target of 3,500 Home Eco-Consultations being reached 10 weeks before the Program close.

Online

Given the community interest in receiving information via online channels such as websites, email and social media sites (Synovate, 2011), online marketing was a large component of the extended rollout plan.

The website was refreshed in January 2012 and an e-signup form was added. The electronic form allowed customers to register their interest for a solar hot water system, solar PV system and/ or HEC at their convenience, without having to call the Perth Solar City contact centre (embedded within Western Power). Over 35% of referrals during the extended rollout were generated online.

Community workshops

Through its extensive work with the local community, the Program learnt that while many residents are interested in energy efficiency and investing in solar products, most are unsure about available rebates and technology and whom to trust to gather factual and unbiased information.

Perth Solar City hosted a series of community workshop in partnership with the local councils (EMRC, City of Belmont and Town of Cambridge), SunPower, Solahart, Mojarra. These workshops were entitled 'learn the facts about solar, not the spin' (image 10-D), and were designed to give community members the opportunity to learn about energy efficient behaviours, solar technology, and the current rebates available, in an informative setting.

Over 200 community members attended the three workshops. Feedback from attendees was positive, with 73% rating the workshop as 'good' or 'very good'.

Image 10-A: Extended rollout advertising

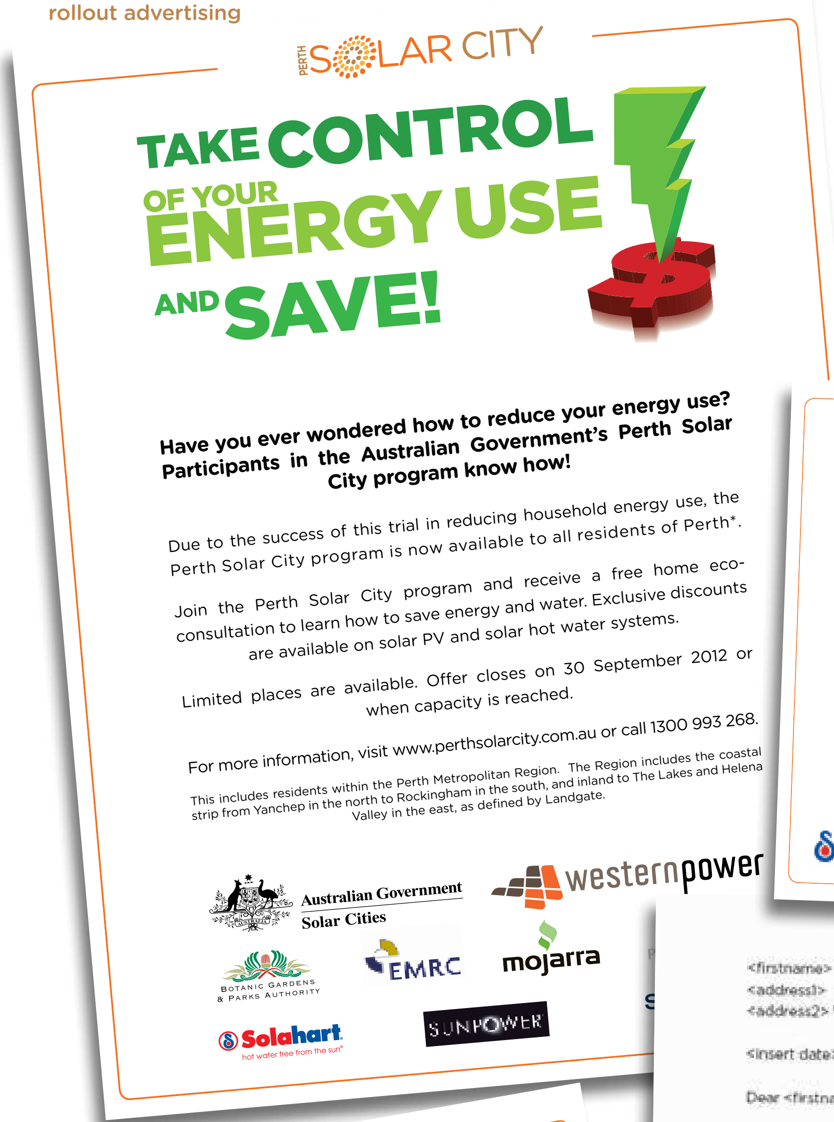


Image 10-B: Solahart advertising

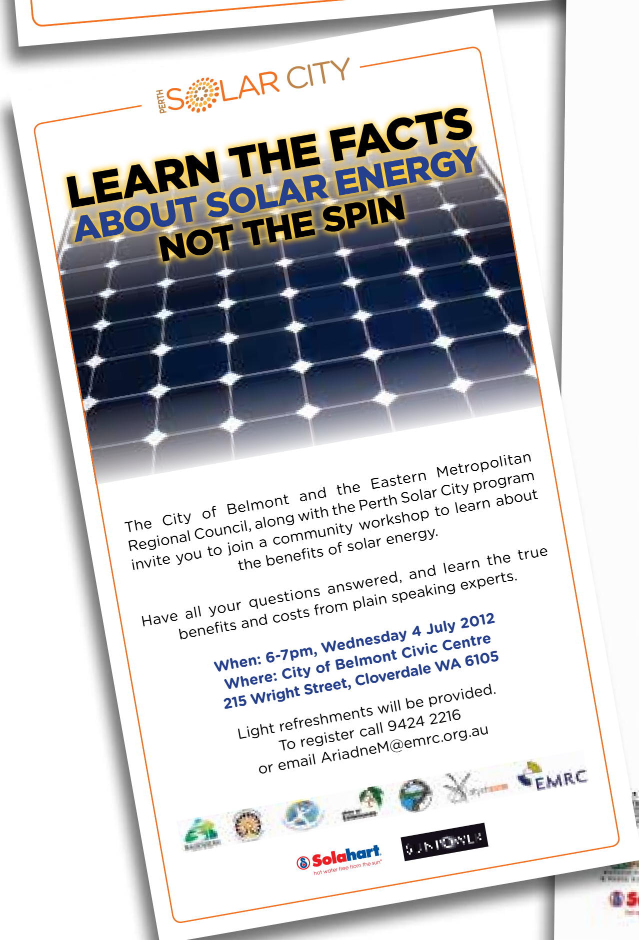


Image 10-D: Community workshop advertising

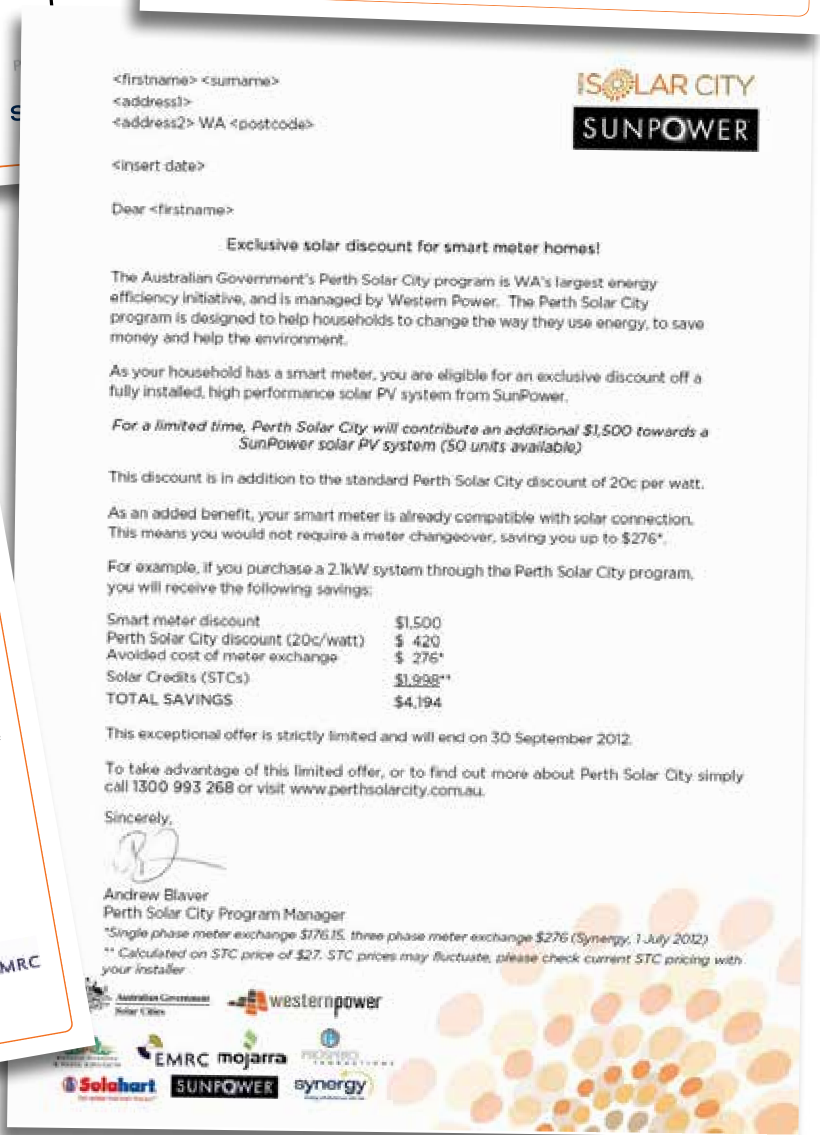


Image 10-C: SunPower direct mail

10.4 ECO HOUSE

Aimed at educating the community, the Eco House is a showcase for sustainable living and features each Perth Solar City product, service and smart grid enabled energy efficiency tools (image 10-E). The Eco House provided visitors with a tactile demonstration of how they can reduce their energy use (image 10-F).

Eco House was launched in January 2011 as a competition, encouraging residents to nominate their home to receive a $50,000 home eco-makeover, and participate in a 12 month energy efficiency education program. In return the winning household would open their home four times over 12 months to educate the community about the practical opportunities for energy efficiency.

Image 10-E: The Perth Solar City team with David and Hannah Roberts, and Josh Byrne

Image 10-F: The Eco House's summer savers – solar PV system, external awnings and water tank

Eco House open day

Ideally, the Program was looking for a typical energy *inefficient* Perth home, to showcase to the community a range of energy efficient actions from simple behaviour change, to generating their own electricity.

The third and final Eco House was held on Sunday 20 May 2012 and was attended by over 200 residents from across Perth. ABC1 TV's Josh Byrne conducted a free community workshop on living sustainably, which was attended by over 70 residents.

Since the first open day in September 2011, over 850 members of the community visited the Eco House. Industry experts were present at each event to provide in-person advice, and to answer specific customer queries.

A high number of Perth Solar City product and service referrals were generated from the Eco House open days.

The Eco House provides a tangible example of how a combination of energy efficient technology and education can result in significant reductions to energy consumption. Through a combination of technology and 'doing things differently', the Roberts family reduced their summer electricity costs by almost 50% - a saving of over $500.

Significant media interest from major television networks followed the final open day event. This resulted in an exclusive feature story on the Eco House, as well as requests for additional interviews on winter energy efficiency tips.

10.5 ONLINE MARKETING AND COMMUNICATIONS

Online marketing and communications is interactive and provides instant information to a broad audience, at low cost.

The Perth Solar City website (image 10-G) has received over 148,000 unique visitors since its launch in November 2009, with over 481,000 page views. Visitors are viewing on average 3.8 pages per visit, with average viewing times of 1:36 minutes.

Social networking continues to be a valuable communications tool, with its ability to reach large numbers of people at little to no cost. The Perth Solar City Facebook page has over 200 'likes' and has been used to communicate special events, offers and news from the Program. In turn, customers have used the page to engage with the Program, asking questions, posting photos and promoting their own sustainability events.

Over 1,500 community members are registered to receive a quarterly e-newletter from Perth Solar City, with 42% of recipients opening the email on average and 10% clicking through to the website.

Image 10-G: The Perth Solar City website

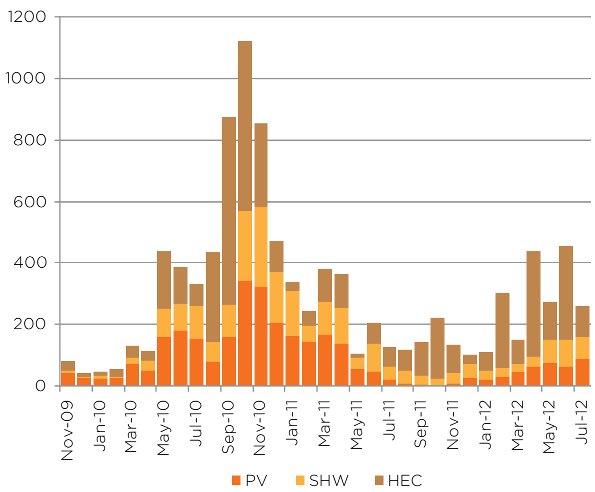
Image 10-H: 2012 excerpt of media headlines

10.6 MEDIA AND EVENTS

Media interest in Perth Solar City during 2012 continued, with particularly strong support from local newspapers within Perth's Eastern Region (image 10-H).

Regular editorial articles ran across the six local newspapers, showing support for the Program and highlighting milestones and events.

Image 10-I: Customer call volumes to Perth Solar City call centre by product or service



10.7 2012 KEY RESULTS

Since the launch of the Perth Solar City program in November 2009, over 6,700 customer calls have been received by the call centre, generating over 10,400 product and service referrals (image 10-I).

Analysis suggests that the 'Collective Impact' campaign had a 'ripple effect' on household electricity use, with an average 1.6% reduction within the broad reach marketing area.

Extending the boundaries of the Perth Solar City program into the broader Perth metropolitan region proved successful, with three-quarters of the referrals generated from 10 April until 30 September 2012 being from outside the original target area.

As at 30 September 2012, 16,283 households had participated in the Perth Solar City program.

Referrals: 5 Nov 2009 – 30 September 2012	
Solar PV systems	3,314
Solar hot water systems	2,565
Home eco-consultation	4,562
Total referrals	10,441
Total calls handled	6,746

	Target area: East Metro 9 December 2009 – 9 April 2012		Extended boundary: Perth Metro 10 April – 30 September 2012	
	Sales from inside EMRC %	Sales from outside EMRC %	Sales from inside EMRC %	Sales from outside EMRC %
Solar PV system	100	0	20%	80%
Solar hot water system	100	0	29%	71%
Home eco-consultation	100	0	28%	72%

AS AT 30 SEPTEMBER 2012, 16,283 HOUSEHOLDS HAD PARTICIPATED IN THE PERTH SOLAR CITY PROGRAM

10.8 TRANSFERABLE LESSONS

Subject	Barrier or benefit	Outcome and lesson
Eco House and community workshops	BENEFIT: Grassroots community engagement achieves mutually beneficial outcomes	OUTCOME: Over 850 people visited the Eco House open days. Over 200 people attended solar energy workshops Customers took the advantage of the opportunity to engage with industry experts, and valuable, mutually beneficial relationships were established LESSON: Grassroots community engagement initiatives are critical in establishing and maintaining a trustful and effective relationship with customers Grassroots community engagement initiatives, particularly tactile projects such as Eco House, should be used when developing similar programs
Online communications	BENEFIT: High penetration, low cost communications channel	OUTCOME: 30% of Eco House visitors heard about the community open day via online communications channels Over 35% of referrals during the extended rollout were generated online LESSON: Online communications tools such as websites, social networking sites and email are valuable, low cost communications tools and should be utilised for future programs
Direct marketing	BENEFIT: Direct marketing followed by an outbound telephone call	OUTCOME: An increase in response rates from 2% to 10% for direct mail when followed by an outbound telephone call LESSON: To maximise the return on investment for direct mail campaigns, it is recommended that letters are followed by a personal phone call
Marketing	BENEFIT: Broad reach marketing campaigns increase Program awareness	OUTCOME: Perth Solar City's Collective Impact campaign created 51% customer awareness in its first year (2010) LESSON: Broad reach marketing campaigns, such as Collective Impact, are effective in establishing brand, increasing community awareness and promoting energy efficiency and renewable energy Broad reach marketing campaigns utilising CBSM concepts should be used when establishing similar programs
Marketing	BARRIER: Broad reach marketing alone does not generate significant referrals	OUTCOME: Perth Solar City's broad reach marketing campaign did not generate a significant number of referrals for products and services LESSON: Broad reach marketing must be supported by a well planned direct marketing and/or community engagement strategy to leverage the awareness raised, promote the commercial products and services and generate referrals
Direct marketing	BARRIER: No provision for marketing funds in Consortium Agreements	OUTCOME: Individual Consortium members did not provide sufficient funds for marketing their products or services to generate the required number of customer referrals to meet contractual targets LESSON: Marketing budgets to support the promotion of commercial products and services, should be clearly outlined, and provisioned for, in Consortium Agreements

11.0 BEHAVIOUR CHANGE TRIAL

11.1 BACKGROUND

The Living Smart Households program (Living Smart) is the intensive behaviour change program, delivered by the Western Australian Department of Transport (in partnership with the Eastern Metropolitan Regional Council), for Perth Solar City. Living Smart empowers participating households within Perth's Eastern Region to reduce their demand for energy, water, waste services and car-based travel.

Living Smart was developed by the WA Department of Transport (DOT) to test the effectiveness of engaging households in behaviour change across broad sustainability topics including energy and water efficiency, reduced car use and improved waste management. It built upon the DOT's proven TravelSmart Household program that had delivered a 10% reduction in car trips within targeted communities of more than 200,000 households across the Perth Metropolitan area. It also drew upon the transformational Living Smart small group sustainability courses developed by the Southern Metropolitan Regional Council, City of Fremantle, Murdoch University and the Meeting Place.

A Living Smart demonstration project was delivered in 2008/09 in the Perth suburbs Joondalup and Mandurah, which achieved strong engagement with around 60% of participating households. Changes in behaviour were achieved with households reporting adopting such new actions as switching off standby power and purchasing a solar PV system.

As part of Perth Solar City, Living Smart was offered to 10,000 households across Perth's Eastern Region with over 6,000 choosing to take part in the program's interactive features from April 2010 through to April 2011. The key principles of Living Smart's telephone based eco-coaching include:

- understanding households motivations for changing their behaviour
- building effective relationships with households through coaching conversations
- facilitating self-directed conversations that provide households with the right information and advice at the right time
- setting simple and measureable targets for the household through the establishment of 'social contracts' and the provision of localised benchmarks

11.2 OBJECTIVES

Living Smart's objectives for Perth Solar City are to:

- act as a mechanism for referrals to other Perth Solar City products and services
- identify and understand barriers relating to the adoption of energy efficiency behaviours and uptake of energy efficiency products and services
- understand the effect of such a targeted behaviour change program on household energy consumption

2011 RE-CAP

PROGRESS

In 2010/11 Department of Transport offered their intensive behaviour change program, Living Smart Households, to 10,000 households across Perth's Eastern Region. 6,000 households chose to take part in the program's interactive features from April 2010 through to April 2011. Progress made against the Living Smart Key Performance Indicators (KPIs) is detailed below.

LIVING SMART KPIs FOR 2011

Living Smart KPIs	Project Target	Actual
Living Smart target (engagement letter)	10,000	30,000
Contact (by phone)	9,000	12,253
Interest	7,500	7,770
Participate (personalised info delivery)	6,000	6,342
Total interactive feedback on meter readings	22,500	25,112
Referrals for Home Eco-Consultations	2,000	2,088
Referrals for solar PV systems	1,400	1,146
Referrals for workshops	250	1,104
Exit surveys	250	251
Positive feedback from exit surveys	90%	89.4%

KEY RESULTS FOR 2011

Preliminary analysis was completed for 4,768 households who had participated in the Living Smart program. An average reduction in electricity use of 8.5% was evident. This is equivalent to a $122.50 cost saving and a Greenhouse Gas saving of 521 kg CO_2-e per household per year.

11.3 IMPLEMENTATION METHODOLOGY

The Living Smart implementation methodology for Perth Solar City is composed of the following elements (image 11-A):

- preparation (research and materials)
- introduction to the community and recruitment of households
- delivery, feedback and coaching
- wrap-up
- program evaluation

Image 11-A: Living Smart Program Methodology

	MONTH	PROGRAM METHODOLOGY
Preparation	1 - 2	BARRIER AND BENEFIT RESEARCH; MATERIAL DESIGN
Introduction and recruitment	3	INVITATION LETTER; MATERIAL SELECTION
	4	INFORMATION PACK DELIVERY
	5	AGREEMENT PHONE CALL
Delivery, feedback and eco-coaching	6 - 13	UTILITY METER READING
	6 - 13	FEEDBACK LETTER DELIVERY
	6 - 13	ECO-COACHING PHONE CALLS
	6 - 13	OFFER OF ADDITIONAL SERVICES
Wrap-up	14	FINAL LETTER DELIVERY
Evaluation	15 - 18	QUALITATIVE AND QUANTITATIVE EVALUATION

Feedback is repeated five times

Each of these elements, and the associated implementation actions, are outlined in the following sections.

11.3.1 PREPARATION

Location selection

In the design of the program, Living Smart targeted 'hard to reach' segments of the community. Living Smart was deployed in the middle to lower socio-economic status suburbs within the Perth Solar City Region. Household incomes in this group ranged between $620 and $1,400 per week (average $960) and the proportion of rentals ranged between 11% and 46% (average 28%).

The selection of target suburbs was determined geographically by the inclusion of a relatively equal target population in each of the six local government areas within the Region. Further, locations were selected based on the physical grouping of target populations for cost effective meter readings, home information delivery and home eco-consultation visits.

As a result, six clustered locations across 17 suburbs were selected as targeted locations for the program (image 11-B). Households outside of these targeted locations were able to participate in a seven-week Living Smart course that was offered in each local government area.

Image 11-B: Living Smart targeted locations within the Perth Solar City Region

Research

Research included the collection of baseline behaviour data on household energy, water, waste and travel use. This was conducted to identify the most likely barriers and benefits to the adoption of new behaviours by households in Perth's Eastern Region.

Comprehensive approaches were developed including personalised information and materials, eco-coaching scripts and eco-coaching skills in order to decrease actual and perceived barriers while maximising benefits to be gained by households that adopt each new behaviour.

Eco-Coach training

A workshop was conducted by sustainability experts to develop the conversation guides for Eco-Coaches to engage and motivate households to make energy efficiency changes and to take up other Perth Solar City product and service offerings.

Training of the Eco Coaches took place in May 2010. 35 coaches participated in an intensive training course which included three days of behavioural psychology and program content training, and two days of coaching, briefing and role playing.

Material development

Extensive work was conducted in the development of behaviour change tools (leaflets and prompts) that would contribute to energy efficiency behaviour outcomes. In addition to materials guiding specific actions, a 'pledge sticker' was developed to enable households to take stock of their sustainability actions, and make a public demonstration (on their outdoor Sulo bin) of their participation in Perth Solar City.

A total of 28 unique leaflets and prompts were created as behaviour change tools, including 'Solutions to stand-by power' (image 11-C).

Database development

The materials, behaviour change actions and coaching conversation guides were integrated into a project/client management system used by eco-coaches during the eco-coaching calls.

Image 11-C: Living Smart educational resource: solutions to standby power

Living Smart PERTH SOLAR CITY

The master switch can cut standby power losses

Solutions to standby power

WHAT IS STANDBY POWER?

Standby power is consumed by an appliance when it is plugged in but not in operation. Many appliances use energy even when they are not in use simply to maintain a convenient 'ready' or 'standby' state. If an appliance has a glowing light, responds to a remote or is warm to touch when not in use, then it is in standby mode and consuming power.

This includes a television switched off by remote control that is awaiting an instruction from the remote to reactivate; or a computer that is shut down, but not off at the wall switch.

WHY SWITCH OFF?

By simply switching off at the main switch or wall socket after each use, you could save over 600 kilograms of greenhouse gas per year – that's the equivalent of planting five trees and maintaining them for 100 years. Also, standby power is about 10% of the typical household energy bill which costs you about $150 a year for things you're not even using!

Switch off everything except your reticulation controller, DVD player and a clock and each year:

save 640 kg CO_2 | it's like planting 5 trees | cut your bills by $145

HOW CAN I REDUCE STANDBY POWER?

Manual Solutions

- If the appliance has a master switch (like the power button on the front of many television sets) switch that off.
- If there is no master switch – turn it off at the wall (no need to unplug from the socket).
- If the wall socket is hard to reach – buy a power board with individual switches that can be put in an easy to reach position.
- If several appliances have clocks on them – choose the ones to turn off (perhaps switch the microwave and radio off at the wall, but keep the oven clock on).

Government of Western Australia Department of Transport

For more Living Smart information go to: www.transport.wa.gov.au/livingsmart

Individual switches can be easier to reach than the wall switch

- Group appliances that can be switched off and those that can't on separate power boards.

TANYA'S TIP: Label your power boards and cords so that you don't accidentally turn off appliances such as computers or clocks when in use.

Automatic solutions

Several power saving devices are available from your local hardware store or by searching online.

- Remote controlled and foot pedal power boards enable you to turn standby power off easily. Although having the remote function does consume some power, the overall saving outweighs the energy usage.
- Standby power saver products are now available that detect when appliances are in standby mode and automatically switch them off after five minutes
- Check energy ratings when buying new appliances. For more on energy ratings go to www.energyrating.gov.au.

DO I HAVE TO TURN EVERYTHING OFF?

Wasted power is reduced by turning off everything that is not in use (such as entertainment, office, whitegoods and heating/cooling equipment). Choose to leave on just the things that are time controlled (like reticulation and video recorders).

HINT – place the Living Smart door hanger on the bathroom or front door to remind you to switch everything off last thing at night or when you go out.

During 2010/11, Living Smart will be offered to around 10,000 households in Perth's eastern region as part of the Perth Solar City program. For more information on this Australian Government initiative, please call 1300 993 268 or visit perthsolarcity.com.au. The Living Smart Ambassadors are Tanya Ha (expert in environmental living and the author of *Greeniology* and *Green Stuff for Kids*) and Josh Byrne (sustainability specialist, presenter on ABC TV's *Gardening Australia* program and author of *The Green Gardener*).The information in this brochure is provided in good faith. However the accuracy or appropriateness of the information is not guaranteed. The Living Smart brand has been developed by The Meeting Place Community Centre, the City of Fremantle, Murdoch University and Southern Metropolitan Regional Council to support a suite of programs developing capacity in community sustainability.

PRINTED ON RECYCLED PAPER

11.3.2 PROGRAM INTRODUCTION AND RECRUITMENT

The main engagement phase of the program began with 30,000 letters of invitation sent, followed by a phone call to a target group of 10,000 households, from which 6,342 households were recruited. Each letter (image 11-D) offered extensive energy and water saving information leaflets together with other Perth Solar City product and service offerings (not including smart meter enabled technical trials). The specific information requested by the recruited household is compiled into individualised packs (including a number of free prompts). Packs were hand-delivered by bicycle to each participating resident's front door where a short conversation was held, welcoming the resident to the program and explaining the contents of their individualised pack.

Follow-up phone conversations were positive. Over 90% of households initially recruited to the program were interested in participating further in the meter reading and eco-coaching aspect of the program.

Image 11-D Living Smart invitation to participate leaflet included in original mail-out


More great Living Smart services to choose from

Please send me:

Information on booking a Free Home Eco-consultation to tailor an eco-makeover plan for my home

Information on exclusive Perth Solar City discounted solar hot water specials

Information on Perth Solar City Photovoltaic (rooftop solar panel) specials

Please invite me to:

Free Living Smart courses and workshops on sustainable living and communities

When you deliver this information to my home, please:

Attach a Living Smart action sticker to my green bin

Now please:

- Send back your completed forms in the reply paid envelope
- Provide the best phone number to call you on
- Choose your Living Smart gift below

Living Smart gift

Important note: The Living Smart program is only available to the first 6,000 households who send back this order form. Please indicate your preference for one of the gifts below (subject to availability):

True Green book on 100 everyday ways to contribute to a healthier planet. OR Living Smart reusable water bottle.

Thank you for choosing to take part in the Living Smart program.

Further information: PO Box 228, Cloverdale, WA 6985 Telephone: 9469 5000

If your address is incorrect on the front, please provide correct address here:

Address:

This letter is printed on 100% recycled paper

April/May 2010

Perth Solar City and Living Smart – Acting on Climate Change

Would you like to take part in a free program that will help you cut your bills and make your home more comfortable and healthy? Are you concerned about the environment and the impact of climate change, but are unclear on where to start?

This is where the Living Smart program can help.

Perth Solar City is an Australian Government program helping to change the way we generate and use energy. The Department of Transport and the Town of Bassendean are offering the first 6,000 households that respond to this invitation the chance to take part in the innovative program, Living Smart.

Living Smart will provide you with information and ideas specially tailored so you can start saving water and energy – now and over the next 12 months. The information could include:

- Practical guides to energy saving actions for your home;
- Handy 'waterwise' information and products;
- Information on how to recycle and reduce waste;
- Local travel options; and
- Free 'eco coaching' and tips on how to eco-retrofit your home easily and at low cost.

'How do I get involved?'

- You can select the items you want to receive on the next pages and return by mail in the reply paid envelope, or
- You can simply phone the Living Smart hotline on 9469 5000 (7 days 9am – 6pm).

Once you receive your delivery, you'll be part of the growing Living Smart community and someone from the Living Smart team will phone you in the next few weeks. This is your opportunity to reduce your bills, have a more comfortable home, and tackle climate change. For more information on the Australian Government's Perth Solar City Program, visit perthsolarcity.com.au.

We look forward to welcoming you to the program.

The Perth Solar City Living Smart Team

Living Smart Acting on climate change

Reply to: PO Box 228, Cloverdale, WA 6985 Telephone: 9469 5000

SOLAR CITY

Living Smart

Are you interested in:

- Reducing your impact on the environment? Yes No
- Reducing your energy bills? Yes No
- Saving energy and water? Yes No
- Creating a more comfortable home? Yes No

Tick the guides and ideas that you need to start to cut your bills and to save energy and water. We will send just the things you choose – all for free.

Please send me:

Energy saving guides and ideas

An introduction to saving energy – easy ways to save energy around the home without spending a cent

Solutions to standby power – reducing about 10% of your energy bill

Energy efficient lighting – what and how can I do it?

How to convert downlights to a more energy efficient option – maintaining style with 'greener' lighting options

How to adjust your water heater – to save money and greenhouse gases

Upgrade to an energy efficient hot water system – how, why, how much?

Natural heating and cooling for a comfortable home – staying warm in winter and cool in summer without the need for excessive heating and cooling

Installing a photovoltaic (PV) system for your home – rooftop solar power – what, how, how much?

How to choose the best electricity tariff for you and the environment – green power

Water saving guides and ideas

An introduction to saving water – easy ways to save water around the home often without spending a cent

How to install a waterwise showerhead – what type do I need and how to do it?

A 4 minute shower timer – to help the whole family!

Your guide to waterwise gardening – what to plant, how to water and more

Installing a rainwater tank – working out size, space and cost

Other resources

Living Smart – how much money can I save? What can I do to stop wasting money on bills?

Living Smart – how can I help the planet? Actions to reduce your household's environmental impact

How to read your bills and track your consumption – of water, gas and electricity

Star rate your home ready for an eco-makeover – a simple self audit of water and energy use in your home

Home orientation compass – where to put blinds and trees to keep the house cool in summer

A hardware store discount voucher for your local area – to make small changes easier

A garden centre discount voucher for your local area – to make small changes in the garden easier

My action list – pledging the changes that you would like to make

Standby power reminder – to hang on the door as a reminder to turn off

Please turn over...

11.3.3 DELIVERY, FEEDBACK AND COACHING

The delivery, feedback and coaching stage of the Living Smart program was the key mechanism for implementing the behaviour change methodology. This methodology seeks to facilitate change in an ongoing, multi-step, self-directed manner (image 11-E and table 11-A). Image 11-H highlights the contact regime of Living Smart.

Households that opted into the eco-coaching component of the program were provided with five rounds of meter reading feedback via an individualised letter (image 11-G). The letter included the household's daily energy and water consumption levels, comparisons to the neighbourhood average, as well as the most efficient households. Motivational language and seasonal tips to reduce their use were also included.

Each letter was followed up with an eco-coaching call to discuss the benchmarked meter reading, and explore energy, water, transport and waste efficient actions that the household is motivated to implement. Eco-Coaches were trained not to suggest actions for households, they were instead to encourage households to identify their own consumption-related concerns and explore possible solutions and/ or actions.

Eco-Coaches would record the identified actions to be taken by the householder, and advise that the actions would be followed-up during the next coaching call - thereby establishing a 'social contract.' This approach built self-efficacy and confidence in the participant, and helped to build a relationship of trust and rapport with the Eco-Coach. This in turn marked possible the adoption of further, more complicated future actions.

The meter reading feedback letters and coaching calls used benchmarking of similar sized households in the participants local area as a means of comparison. This was combined with simple communication tools (smiley faces, how to guides, active listening), to re-enforce positive behaviour change or trigger new behaviour change actions. Image 11-F shows a typical meter reading feedback letter that was received by the household prior to the coaching call.

A total of 4,985 households participated in the feedback phase of the program.

Image 11-E: Living Smart behaviour change model for participants

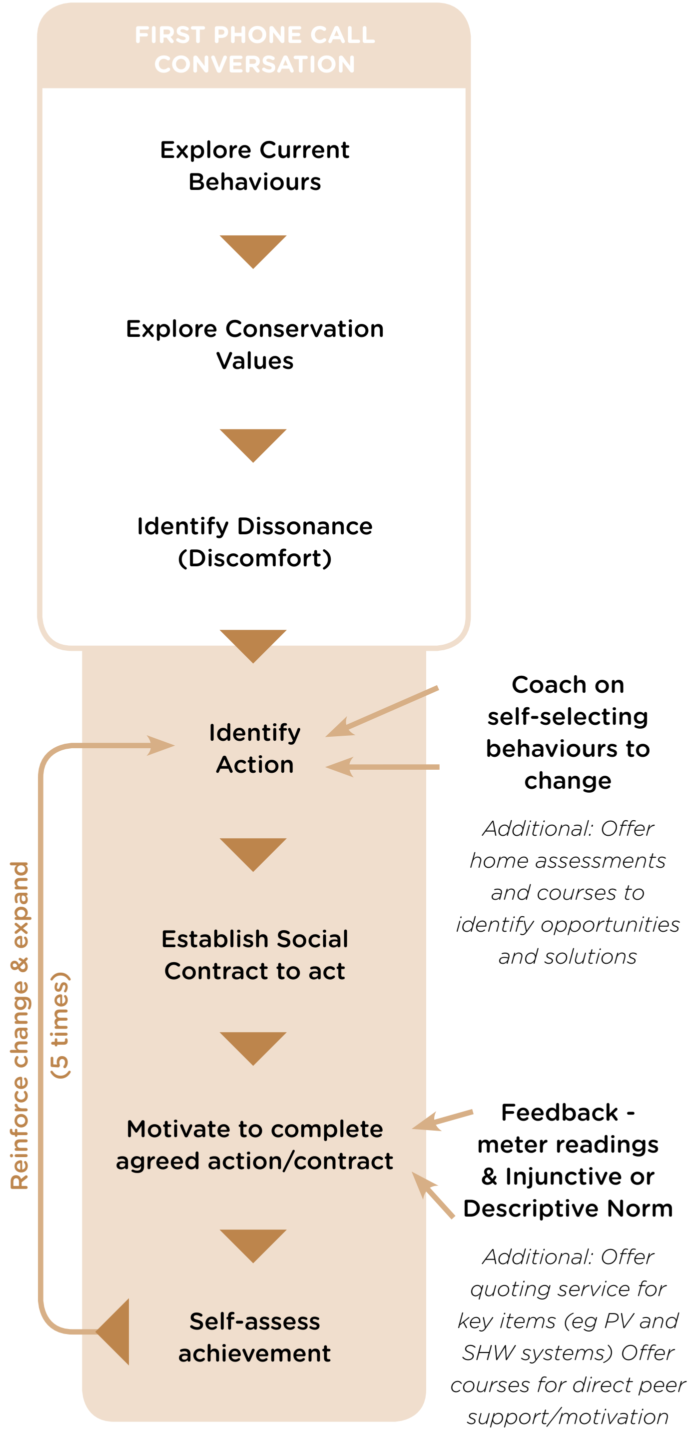


Table 11-A: Contact regime for the Living Smart program

Contact	Purpose
Letter	Announcement and list of materials: information about Living Smart and an order form/list for tools
Telephone	Encouragement Call: If list not sent back (these people also received an agreement call)
Telephone	Agreement call: recruited households for coaching and meter reading/ collect demographic information (verbal consent is captured)
Home delivery	Deliver: selected tools ordered by households either over the telephone or specified on the returned lists (additional tools ordered on the phone would be posted)
Letter	First feedback letter: incorporated personalised feedback, utilities data and a Department of Transport newsletter
Telephone	First coaching call: summary of last period, collected details of actions and suggest other project offerings (i.e. home Eco-Consultation and referrals to for solar hot water/solar PV offerings)
Letter	Second feedback letter: incorporated personalised feedback, utilities data and a Department of Transport newsletter
Telephone	Second coaching call: summary of last period, collected details of actions and suggested other project offerings
Letter	Third feedback letter: incorporated personalised feedback, utilities data, newsletter and selection sheet for transport and waste tools
Telephone	Third coaching call: summary of last period, collected details of actions, suggested other project offerings and assisted with goal setting/ encourage uptake of waste and transport tools
Letter	Fourth feedback letter: incorporated personalised feedback, utilities data and a Department of Transport newsletter
Telephone	Fourth coaching call: summary of last period, collect details of actions and suggest other project offerings
Letter	Fifth feedback letter: incorporating personalised feedback, utilities data and a newsletter
Telephone	Fifth coaching call: summary of last period, collect details of actions and suggested other project offerings
Letter	Final feedback letter: summary of individual and collective impacts of participating households in terms of dollars, water, units of energy and greenhouse gas emissions; connected participants to opportunities/groups

1.3.4 WRAP-UP

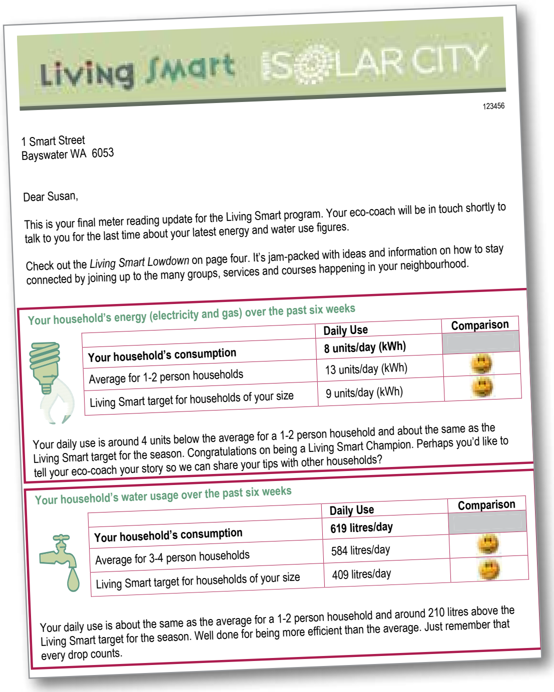
At the conclusion of the five rounds of telephone based eco-coaching, Living Smart households were provided with personalised feedback on their individual and collective community achievements over the preceding 12 months of the program. This final letter detailed each household's achieved actions, their future intended actions, and their corresponding financial and environmental savings.

Collective savings were also calculated to reinforce the fact that households were part of a larger program and their individual actions contributed to a significant outcome across the Region. Households were encouraged to join local community groups and were given another opportunity to take up Perth Solar City product and service offerings including free home eco-consultations, and discounted solar hot water and solar PV systems.

11.3.5 PROGRAM EVALUATION

Thorough pre-program evaluation was conducted to calculate baseline energy, water, travel and waste behaviours so as to accurately calculate Living Smart's impact. Qualitative data, such as self-reported actions, was collected throughout the program to track effectiveness and refine the implementation methodology to best suit the target community.

The Living Smart program concluded in April 2011. 250 face-to-face exit surveys are currently being compiled to measure top-line program engagement levels, as well as the overall impact of the program.



Living Smart SOLAR CITY

123456

1 Smart Street
Bayswater WA 6053

Dear Susan,

This is your final meter reading update for the Living Smart program. Your eco-coach will be in touch shortly to talk to you for the last time about your latest energy and water use figures.

Check out the *Living Smart Lowdown* on page four. It's jam-packed with ideas and information on how to stay connected by joining up to the many groups, services and courses happening in your neighbourhood.

Your household's energy (electricity and gas) over the past six weeks

	Daily Use	Comparison
Your household's consumption	**8 units/day (kWh)**	
Average for 1-2 person households	13 units/day (kWh)	
Living Smart target for households of your size	9 units/day (kWh)	

Your daily use is around 4 units below the average for a 1-2 person household and about the same as the Living Smart target for the season. Congratulations on being a Living Smart Champion. Perhaps you'd like to tell your eco-coach your story so we can share your tips with other households?

Your household's water usage over the past six weeks

	Daily Use	Comparison
Your household's consumption	**619 litres/day**	
Average for 3-4 person households	584 litres/day	
Living Smart target for households of your size	409 litres/day	

Your daily use is about the same as the average for a 1-2 person household and around 210 litres above the Living Smart target for the season. Well done for being more efficient than the average. Just remember that every drop counts.

Image 11-F: Living Smart meter reading feedback letter example

11.4 KEY PERFORMANCE INDICATORS AND PROGRESS

To achieve Living Smart's objectives, Key Performance Indicators (KPIs) were developed. The KPIs were established as a combination of inputs (for example letters sent to contact households) and outcomes (for example uptake of a referral to a Home Eco-Consultation). KPIs are shown in the 2011 re-cap.

11.5 KEY RESULTS

Key results from the Living Smart program will focus on:

- referrals to other Perth Solar City products and services
- uptake of energy efficiency actions and responses to the Living Smart services
- effect of Living Smart on electricity consumption of participants
- cost effectiveness of Living Smart as a behaviour change program

11.5.1 REFERRALS TO OTHER PSC PRODUCTS AND SERVICES

One of the objectives of the Living Smart program is to encourage the participation in additional energy efficiency products, such as efficient lighting, solar hot water and solar PV. In short, as a result of participating in Living Smart, households come to understand the benefit of different energy efficiency products and services, and to implement them based on the circumstances of their household.

As part of providing participants with the right tools (information and support) at the right time, Living Smart referred participants to other Perth Solar City products and services, including seven-week Living Smart courses (table 11-B).

The Living Smart program provided over 2,000 referrals to Perth Solar City's free Home Eco-Consultation (table 11-B). The Referrals Converted column shows the number of households who actually participated (i.e. completed a Home Eco-Consultation). Due to the Home Eco-Consultation provider under resourcing the booking service, only 52% of referrals were converted. This is well below the 90% achieved by the Living Smart demonstration project in 2008/09.

Table 11-B: Referrals generated by the Living Smart program

Product	Referral target	Referrals achieved	Referrals converted	Conversion%
Home Eco-Consultation	2,000	2,088	1,084	52%
Solar PV systems	1,400	1,146	57	5%
Solar hot water systems	1,200	657	48	7%
Living Smart courses	300	1,104	N/A	N/A

The referral rate for the solar PV and solar hot water components of the program were high, however the actual conversion rate (uptake of the offering) was low. In total, 371 participating households reported purchasing a solar PV system (57 taking up the Program offering) and 125 reported purchasing a solar hot water system (48 taking up the Program offering) while participating in the Living Smart program. Many households reported a preference for lower cost solar PV systems, and wanted to wait for their current hot water system to breakdown before upgrading to solar.

Image 11-G demonstrates the age distribution of Living Smart households who received a HEC. The age group 25-34 had the highest participation rate all age groups.

All six of the Living Smart seven-week courses were well attended, achieving a total of 238 participants. As a demonstration of the ongoing legacy of the Living Smart courses, participants from the Mundaring, Swan, Bassendean and Bayswater courses have developed 'Living Smarties' groups and continue to meet regularly to share ideas, stories, and tools and motivate one another to take sustainability action locally.

11.5.2 UPTAKE OF ENERGY EFFICIENCY ACTIONS AND RESPONSES TO THE LIVING SMART PROGRAM

Participating households self-report energy efficiency actions through the coaching calls (image 11-H). Self-reporting provides a valuable insight into the uptake of energy efficiency actions, to be verified by the analysis of electricity consumption data. A total of 7,782 self reported household energy efficiency actions were undertaken by Living Smart over the five coaching calls. Actions with the greatest uptake were:

- switching off standby power – adopted by 36% of participants or 64% of those participants not already switching off standby power
- taking shorter showers (four minutes) – adopted by 25% of participants or 56% of those not already taking shorter showers
- installing CFL globes in main lighting areas – adopted by 19% of households or 52% of those that do not already have CFL globes installed
- installing a water efficient showerhead – adopted by 10% of participants or 21% of those with high flow showerheads
- setting water heater thermostats to 60 degrees or less – adopted by 14% of households or 16% of those for whom it would be possible

Image 11-G: Age distribution for converted Living Smart HEC referrals

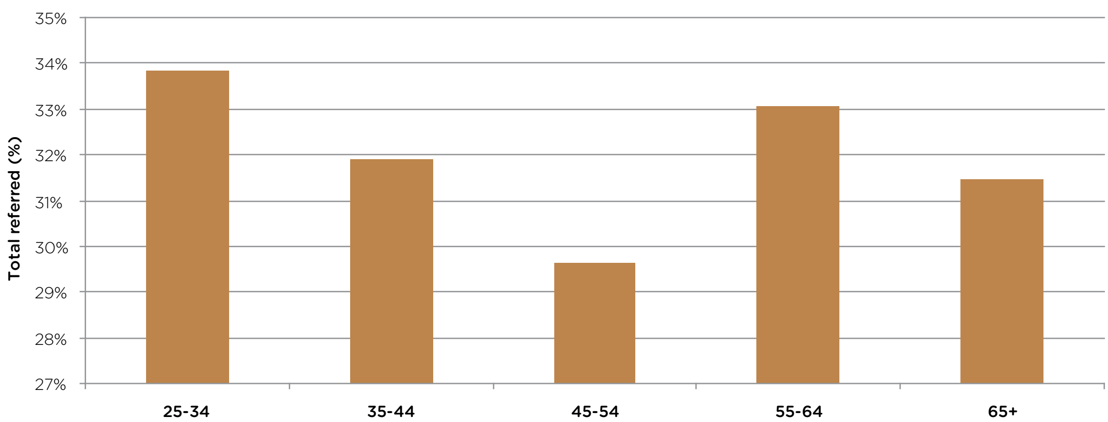
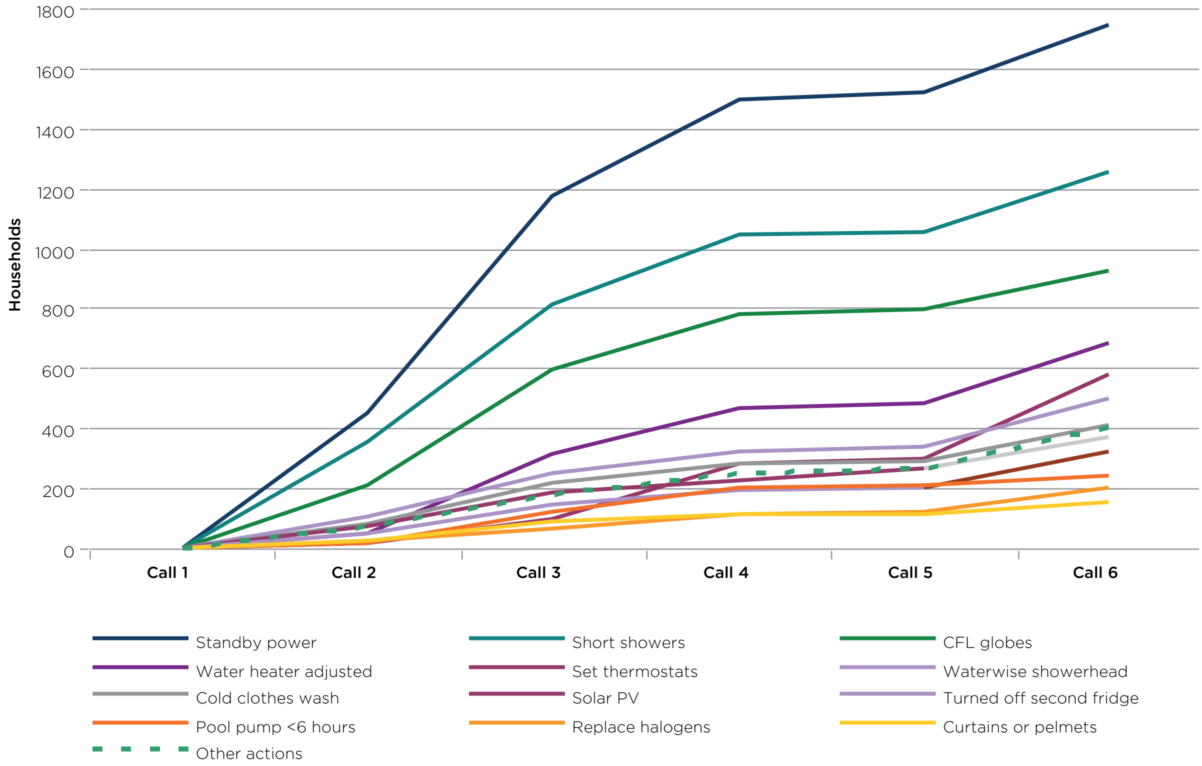


Image 11-H: Energy Actions reported by Living Smart participants



Validation of the self reported changes has been conducted using meter readings from participating households.

A quality survey was conducted through 251 face to face interviews with a random selection of participants representing a quota sample of households. Across nine headline measures of service quality (including reliability, responsiveness, knowledge, empathy and professionalism) 89.4% of responses were positive or strongly positive. Quality survey respondents rated the individual aspects of the service highly (table 11-C).

Of those participating in the meter reading and coaching feedback, 97% found the feedback letter easy to understand and 82% felt that it encouraged them to reduce their energy use. When considering the impacts of Living Smart participation overall, 87% reported that they felt they had achieved some energy reduction with 21% perceiving a 'large' reduction and 39% a 'moderate' reduction. Perceived reductions were larger for energy and water (87%) than for waste (57%) and car use (35%).

Interest in the program was motivated by 'doing the right thing by the environment' (60%), 'cost savings' (44%), 'set an example to my children' (13%), 'join in with others' (13%) and to 'find out how we are doing' (8%) – respondents could offer more than one motivation.

Table 11-C: Survey response to individual Living Smart aspects

	Relevant sample (utilised this service)	Very/ quite interesting	Very/ quite useful
Meter reading letters	232	85%	80%
Phone calls (coaching)	221	78%	77%
Home Consultation	113	84%	82%
Community Course	35	94%	91%
Final letter	207	80%	80%

11.4.3 EFFECT ON ELECTRICITY CONSUMPTION

Perth Solar City commissioned Data Analysis Australia (DAA) to provide analysis on the effect of Living Smart on reducing overall participant electricity consumption. The analytic methodology developed and used by DAA is attached as Appendix B.

Analysis was completed for households who participated in the Living Smart program. An average of 7.5% reduction was evident for all Living Smart participants (4,985) who commenced the coaching program. The average reduction for Living Smart participants (3,705) who participated in the full coaching call phase of the program was 8.0% (image 11-I).

Image 11-I: Living smart – Effect on electricity consumption.

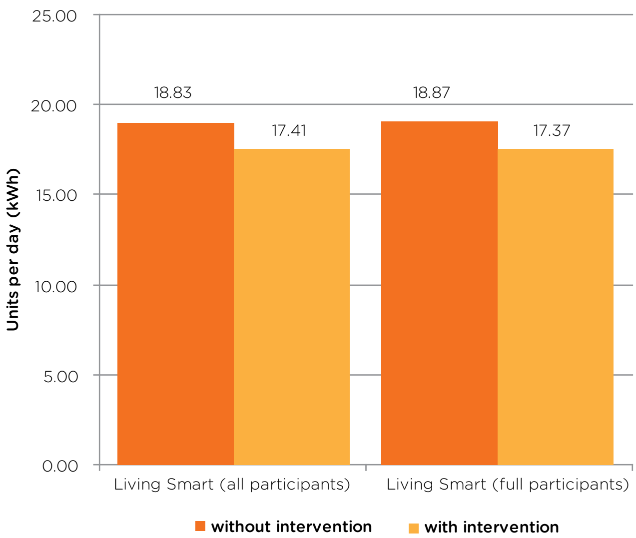


Table 11-D shows the extrapolated annual cost and greenhouse gas saving for Living Smart participants.

Table 11-D: Annual cost and greenhouse gas emissions savings

Customer group	Electricity cost savings per household ($/year)*	Greenhouse gas savings (kg CO-e/year)^
Living Smart (full participants)	$136.36	504
Living Smart (all participants)	$128.80	476

* Calculation based on unit cost of $0.248866 per kWh – the A1 all-time rate as at 30 September 2012

^ based on emission co-efficient of 0.92kg/CO2-e per kWh – National Greenhouse Account Factors July 2012

The Living Smart results (for both all and full participants) are the combined effect of the eco-coaching, and the subsequent energy efficiency actions implemented by participants. Households reported implementing a range of energy efficiency actions during and following participation in the Living Smart program. These actions included, but are not limited to, switching off standby power, taking shorter showers (four minutes), installing CFL globes in main lighting areas, installing a water efficient showerhead, installing solar hot water systems, and installing a solar PV system.

Top Savers

DAA completed analysis illustrating electricity consumption changes on Living Smart participant segments. The analytic methodology developed and used by DAA us attached as Appendix B. Segments included are:

- top 50% of relative electricity savers – two years post-Living Smart commencement
- top 10% of relative electricity savers – two years post-Living Smart commencement

The top 10% of Living Smart participants reduced their electricity use by an average of 33%. 54% of the

THE TOP 10% OF LIVING SMART PARTICIPANTS REDUCED THEIR ELECTRICITY USE BY AN AVERAGE OF 33%

Table 11-E: Living Smart Household costs associated with energy related program elements

Service Element	Cost
Project Establishment: database, logistics, staffing, training and contact and segmentation phases	$400,000
Field, delivery and agreement call: distribution centre, information deliveries and follow up calls	$300,000
Interactive Phase: Coaching and feedback on energy consumption	$500,000
Energy Materials and prompts: Instructional leaflets, checklists, thermometers	$90,000
Special meter readings	$90,000
Energy data evaluation	$50,000
Project design and management of energy components	$615,806
Total Energy Service Cost Delivery	$2,045,806
TOTAL COST PER HOUSEHOLD	$322.58*

*Based on 6,342 households participating in the information phase of the Living Smart Program of which 4,985 received a coaching call.

top 10% of savers installed a solar PV system as well as implementing other energy efficiency actions. 46% achieved these savings through behaviour change and other energy efficiency products not including solar PV.

The top 50% of Living Smart participants reduced their electricity use by an average of 17%.

11.5.4 COST OF PROGRAM

Living Smart has been designed as an 'all-of-lifestyle' integrated behaviour change program and as such, difficulties lie in accurately separating the project into topic-based elements (energy, water, travel and waste) for the following reasons:

- The broader framing of Living Smart could lead to increased program participation in comparison to single topic interventions. Some households will not participate in an energy-only project due to a variety of factors, including the perception that they already use low amounts of energy, or that energy conservation is not high on their list of priorities. However, they may participate in a project that targets whole of home sustainability or water and/or travel and subsequently come to perceive energy conservation as important.
- Small achievements in one topic area may increase the likelihood of 'spillover' into other topics (e.g. "I just learnt how to fix my leaking tap, maybe now I can change those lightbulbs").
- Significant economies of scale exist in packaging together multiple topics as project inputs and can share common project activities (such as office set up, database design, resource development/delivery etc).

Costs outlined in the Table 11-E are those associated with the provision of energy related program elements of the Living Smart Households program only. Each funded program element listed is required in order to deliver an 'energy only' service.

Additional behaviour change outcomes

The approximate cost per household of the Living Smart Households program, including all non-energy related program costs, such as the waste, water and travel components is:

Total Program Delivery Cost	Cost Per Household
$3,360,540	$529.88

The key Living Smart behaviour change outcomes for non-energy related behaviours through the trial are:

- Water – 3.9% reduction - 14kL/annum net saving against local control (Department of Transport)
- Travel – 4.3% reduction in car as driver trips versus control (Synovate)

11.4 TRANSFERRABLE LESSONS

Through its implementation as part of Perth Solar City, Living Smart has:

- built community capacity to adopt energy efficiency behaviours and low cost technologies
- overcome information and motivational barriers relating to the adoption of solar technologies (photovoltaic and solar hot water systems)
- motivated and connected households to suppliers of other Perth Solar City Program offerings including home eco-consultations, solar technology products, events and workshops.

Subject	Barrier or benefit	Outcome and/or lesson
Referrals to other Perth Solar City products and services	BENEFIT: Living Smart provides referrals to other Perth Solar City products and services.	OUTCOME: Significant numbers of referrals to other Perth Solar City products and services. LESSON: Large-scale, multi-product energy efficiency programs benefit from Living Smart style engagement. Living Smart is more cost-effective than information-based broad reach marketing in creating referrals to additional energy efficiency products and services.
Technical trials	BARRIER: Living Smart and the Perth Solar City technical trials were not aligned	OUTCOME: The Living Smart program did not provide direct access to technical trials such as the Air Conditioning or In Home Display Trials LESSON: It would be beneficial to test the inclusion of Living Smart style programs in achieving referrals to smart meter enabled technical trials. Living Smart's sustainability objectives are broad, and are not focused solely on reducing electricity consumption.
Technical trials	BARRIER: Living Smart and the Perth Solar City technical trials were not aligned. BENEFIT: The community is strongly engaged in water conservation, and the broad approach can be leveraged to encourage energy efficiency behaviours.	OUTCOME: It is unclear whether the integrated sustainability model increases or reduces the energy efficiency outcomes of coaching. LESSON: The broad sustainability frame of Living Smart attracts very high levels of engagement and reduces the risk of households declining an energy coaching program that comes shortly after a separate travel or water program. Further testing of integrated and sequential programs is required.
Capacity building	BENEFIT: Living Smart provides interactive community-based sustainable living courses.	OUTCOME: Ongoing legacy of the Living Smart courses. Participants from Mundaring, Swan, Bassendean and Bayswater continue to meet regularly to share ideas, stories, and tools and motivate one another to take action locally. LESSON: Courses build ongoing community capacity by identifying local champions and encouraging them to adopt sustainable behaviours and build grassroots support for clean technology.

TRUSTFUL RELATIONSHIPS WITH PARTICIPANTS ARE REQUIRED TO FACILITATE BEHAVIOUR CHANGE

CASE STUDY – LIVING SMART

CHRISTINE HENDROFF

Household summary

- Involved in the Perth Solar City Living Smart program.
- Two parent, two child family.
- Additional difficulties include: Husband awaiting kidney transplant, youngest son has autism, not a lot of disposable income.
- Achieved great savings through various small behaviour changes – not a lot of fiscal investment or retro-fitting.

About joining the program

"I was a bit cautious too because my husband is waiting for a transplant and my son has autism, so I was really hesitant to take something on board that was going to take time and a lot of effort because I didn't have any of either."

"So they just asked me initially what pamphlets I would like and information on how we could make small changes around the house to reduce our resource use and save money, and I thought: why not? I'll give it a shot; we can always save some money."

"I'm from the country so sort of fairly practical already and always looking out on how we can help the environment and getting our children involved in that. So I think it was, the idea appealed to me I just wasn't sure how much effort and time it was going to take."

Pamphlets

"They sent around the welcome pack and the first few pamphlets on the target areas that I indicated my interest in... So basically we just started going through the pamphlets to sort of see what we weren't doing and little things that we could implement."

"I felt they were well presented and well designed and were appealing which was good. A lot of the information I was already aware of, but there were some things that I could take out of it and that we did implement."

Water

"Basically we went through all the pamphlets we requested and implemented all the things that we could but we found that there were some that we couldn't address. Like the water saving showerhead, because we have an old water heater and it was causing too much back pressure so the water heater wasn't working, it wasn't heating water because there was too much pressure for it. So we had to go back to the non restricting shower head. Unfortunately due to my husband's health condition we can't afford to upgrade to a solar system"

So your whole family was getting involved in different things?

"Yeah, and getting the kids more conscious about it. They're only little, 7 and 4 but my eldest is coming to an age where he can understand the reasoning behind it a little more. That was good, they enjoy peeling labels off tins and bottles and remembering which bin are for what. So it became more of a conscious team effort really, which was good."

Impacts/motivations

"We started to see some impacts on our bills and utilities and that motivated us to keep going. Feedback letters from the Program as well as the utilities when we were receiving bills from Synergy and Alinta gas, there wasn't much we could do about the water – we're pretty miserly anyway. Once we started seeing the bills coming down even though the tariffs were increasing we thought we were on the right track and really making progress. So it was really good – everyone else complaining that their bills were going up and ours were actually going down!"

"It was good to see it – one advantage of having someone calling up and having the letters come with smiley faces and all that was knowing that there are other people out there also doing it. I think that when you sort of know that you're sort of part of a collective, and you're all working together you sort of feel that you're actually making a difference. Where as sometimes when it's just you yourself, it's like 'why do I bother really?! I'm just one person or one family, it doesn't matter what we do'. I think by having a program there you know that there are other people out there that are also doing this as well and seeing that combined effort, what everyone was doing and how many trees that it was worth –it was good. That sort of spurred me on."

"I think some of the other sustainability ideas that are out in the community have really helped. I think Josh Byrne is doing a lot and we managed to attend one of his sustainability expos. Basically just being in the program made us much more aware of what was going on in the community in general as well. And taking advantage of other things, like free seed banks and things like that. We probably wouldn't have seen if we had not been thinking about it so much."

Seeing smiley faces

"Yeah! Oh, good, good. It wasn't as satisfying as seeing the improvements around the house. I think, it was good to see it, but I already knew it. We could tell around the house, the rubbish bin wasn't as full but the recycling bin was a lot fuller. We sort of knew what was happening from what was happening around the house and I wasn't having to shout at the kids every second to turn that light off – they were doing it themselves."

Friends and Family

"We told them some of the things that we were doing and when we started seeing big impacts on our utility bills I think the people sort of started to sit up and take notice then. Cos everyone is quite conscious now of resources and bills these days and I think they were a little bit more interested after they could see how much they could save."

Would you say that the Living Smart program helped you see ways round the factors of your household and lifestyle that made it difficult for you to live sustainably?

"Yes it reinforced some of the things that we were already doing which was really good. It made us think outside of the box for other solutions that weren't at hand like putting the foam in, so it just made us more generally aware. It gave us some good ideas about how we could make small changes, that because of our circumstances we couldn't do anything that cost us a lot of money, that took us a lot of time and so it was good to see that there were little things out there, small changes that we could make that could make a big difference."

CASE STUDY – LIVING SMART

CHRISTINE HENDROFF

So lots of small changes all add up?

"Yeah! And it doesn't take too long to...it doesn't take too many repeats of a new behaviour for it to start to become a natural behaviour and it just becomes second nature after awhile. I think especially for our kids, I'm from the country so we were always very careful with water because we only had a dam. We got electricity off a generator, so I have a better understanding of managing resources but I think the children and children in general have no idea – of where food comes from, of where energy comes from, and the consequences of wasting it. I think it's fantastic if people can be educated and therefore be educating their children as well."

"ULTIMATELY WE'RE LEAVING THIS WORLD FOR THEM SO WE NEED TO SHOW THEM HOW TO LOOK AFTER IT PROPERLY AS WELL."

"By knowing that there is more people out there encourages people that it's more a collective and you're not the lonely old person wasting your time. Also looking at past programs and looking at the savings they've made. Showing those and saying basically in the last 12 months we've saved this many kilos or tonnes of CO_2 going into the atmosphere which is equivalent to this many trees or whatever. People can see it's making a difference. Maybe even getting schools onboard!"

Foam in air conditioning vents

"We have a very little house and we have insulation and very dark curtains to stop as much air escaping as we can. The year prior we had used (door) snakes and dressing gowns to keep the house warmer. But because of my husband's health I've really got to keep it reasonable otherwise he's just going to get sick. I found that we had our gas heater on all the time and quite often early in the morning and it would stay on till 10 o'clock and I was fighting a losing battle keeping the house warm. So then every year we closed the vents on evaporating air con but I knew that there had to be air escaping out through the top, because it's not a fabulous seal. We tried to come up with some ideas for how we could seal it ourselves, either using plastic or something. My husband said that we could use foam. So I ran around and went to Clark Rubber and I told them what we were trying to do, it cost $21 and they cut it for free. We took one vent out and put it in and straight away you could tell the difference. Just opening the front door you could sort of feel suction. It just changed everything in the house and the ambient temperature was just massive. In the end over the winter we used (the heater) one or two times for really bitterly cold nights, and then we just used hot water bottles. Basically we used the heater two or three times and that was it. You just take the foam out again when it comes back to summer. So it's ready to go for next year, it's going to last years."

"There are ones available to purchase but they're quite expensive - $70 per vent, and we had 5-6 vents so that would be a lot of money! So it was all we could afford at the time but it made such a massive difference and yeah it was comfortably warm and I made roast for dinner and I bake my own bread so I would do that to bring the ambient temperature up and dressing gowns and hot water bottles and we're all good and comfortable. It can be done and we saved a bundle! We were really happy with it; it's such a simple solution."

Comments on possible improvements

"It was after I had finished the program that I found the DoT (Department of Transport) webpage, where you've got all of the pamphlets. I wish I had known about that before! Because I didn't want any hard copies that I then had to throw away. To be able to go online and be able to look at all of them and not have to pick a couple on the phone would have been better for two reasons: 1 – that really put me under pressure because I had to pick something and 2 – I then felt guilty when I had to throw them away. So I wish I had then maybe been sent an overview; or maybe one pamphlet saying these are all the resources we have, this is the webpage – knock yourself out. Or even a fridge magnet or something, I think a fridge magnet would be good because people use them all the time, you see it everyday. Little things like turn off that light. I don't know, build something funky into it, with the webpage on it so that people can say “oh, ok I wonder how I can save stuff with my fridge? Or how I can save money with my washing” and you could just jump straight onto the page.”

“I would definitely recommend an online option. People are really busy and a lot of both parents working, kids in day care. They’re really time poor but if they could actually jump online and do things it would be a bit more appealing.”

Coaching calls

“It was a really difficult time of day, it was generally at dinnertime. It’s always going to be hard to find a good time to call someone but I found I couldn’t or didn’t go into as much detail as I would have liked because I was trying to cook dinner and look after two kids at the same time and things like that. But they were basically just going through our results and discussing different things that we could look at next. They were just touching base I think to sort of see that we were still alive and still on the plan!”

12.0 HOME ECO-CONSULTATIONS

12.1 BACKGROUND

The energy consumption of a household is driven by the behaviour of its occupants, specifically the use of different appliances in the home. Often, households are unaware of how much electricity or gas a particular appliance requires to operate, or how the way it is used affects overall household energy consumption and subsequent costs.

As part of the Perth Solar City program, the Home Eco-Consultation (HEC) was designed to assist participants to understand their own energy consumption. The HEC provides householders with the opportunity to understand what is contributing to their current energy use. A follow up tailored report provides participants with information on what changes they can make to reduce energy use.

The HEC is delivered free to households as a once-off education–based engagement tool that seeks to help participant households to:

- benchmark their energy and water consumption based on the National Australian Building Environmental Rating Scheme (NABERS)
- understand which appliances in their home are the most energy inefficient
- understand how the householders usage of these appliances affects their energy use
- combines findings to determine the best value-for-money behavioural and technological changes that could be implemented to reduce energy consumption, save money and decrease greenhouse gas emissions

The HEC follows the Australian Standard guidelines for energy auditing, and is comprised of the following characteristics:

- two assessors present in the home
- a 90 minute consultation
- report consolidating the findings of the HEC are mailed within three weeks of the consultation being completed

The HEC also provides participants with an opportunity to understand more about the Program, including participation in other products, services and technical trials.

Mojarra is the Perth Solar City Consortium member responsible for the administration and delivery of the HEC to eligible households in Perth's Eastern Region. Since the start of the Program, Mojarra has been provided with referrals from the Program call centre, the Living Smart program, collaboration with other Consortium members and via Mojarra's own recruitment campaigns. Mojarra's recruitment campaigns during 2012 largely focused on introductory direct marketing letters to eligible households, followed up by a phone call.

12.2 OBJECTIVES AND PROGRESS

Mojarra's main objective for the Program was to complete 3,500 HECs. Mojarra has also undertaken 20 school energy audits.

Sub-Project	Program Target	Achieved
HECs	3,500	3,517

Mojarra exceeded the target for the program during June 2012.

2011 RE-CAP

PROGRESS

As at 30 November 2011, Mojarra completed 2,497 Home Eco-Consultations, representing 71% of their target.

The total number of HEC leads recorded in the Perth Solar City database at 30 November 2011 was 3,251, with 2,497 successfully converted into completed assessments. This represented a conversion rate of 71%. The majority of referrals for the HEC came from the Living Smart program – 2,088 in total (77%).

KEY RESULTS

Key participation statistics to 30 November 2011:

- 47% of participants in the free HEC service were either single or dual occupant households
- 42% of participants in the free HEC service have completed a tertiary education
- 60% of participant households were employed full-time, part-time or self-employed. 20% of participant households were retired
- only 322 households, or 14% of HEC participants, responded when asked about their household income level

Effect on electricity consumption - preliminary analysis

Analysis was completed for 762 participant households who had received a free HEC in the period 4 December 2009 to 30 June 2011. In order to effectively measure the relative effects of the HEC on participant electricity use, the analysis did not include any HEC participant households who also participated in the Living Smart program. The preliminary analysis showed a 7.8% reduction in the average daily electricity use of participant households.

THE ANALYSIS SHOWS A 12.3% REDUCTION IN THE AVERAGE DAILY ELECTRICITY USE OF PARTICIPANT HOUSEHOLDS

12.3 KEY RESULTS

Key results for HECs will focus on:

- Customer recruitment
- Electricity consumption trends
- Participant feedback
- Demographic trends

12.3.1 CUSTOMER RECRUITMENT

Living Smart provided the bulk of HEC referrals during 2010/11 (77% of referrals to June 2011). Following completion of the Living Smart program in June 2011, Mojarra utilised 'warm telemarketing', which entailed a letter being mailed directly to eligible households, followed closely by a phone call to encourage participation in the free service.

In addition, Perth Solar City engagement events, such as the Eco House open day provided households with the opportunity to sign-up for HECs.

Image 12-A: HECs completed by quarter

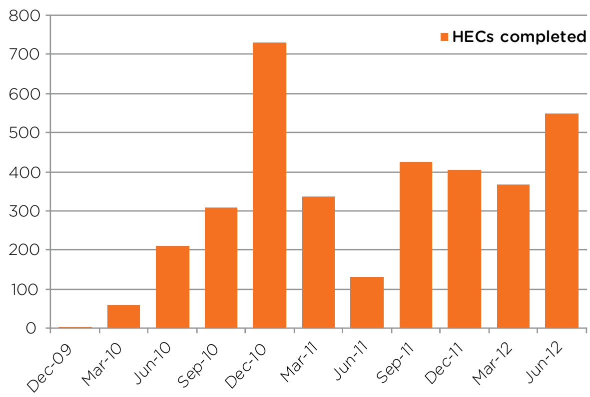
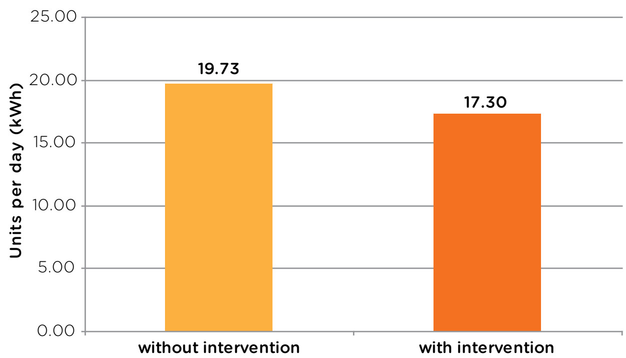


Image 12-B: Effect on electricity consumption



12.3.2 ELECTRICITY CONSUMPTION TRENDS

Effect on participant electricity consumption

The Program commissioned Data Analysis Australia (DAA) to provide analysis on the effects of HECs on electricity consumption. The analytic methodology developed and used by DAA is attached as Appendix B.

Analysis was completed for 2,593 participant households who had received a free HEC. The analysis shows a 12.3% reduction in the average daily electricity use of participant households (image 12-B). Part of the 12.3% reduction is attributed to a range of energy efficiency actions (such as switching off stand-by power, installing more efficient lighting, or installing a solar PV and/or solar hot water system, etc.) implemented by the participant household after completing the HEC.

Table 12-A shows the extrapolated annual cost and greenhouse gas savings for HEC participants (non-Living Smart), based on the preliminary results.

Table 12-A: Extrapolated annual cost and greenhouse gas emissions savings

Customer Group	Electricity cost savings per household ($/year)*	Greenhouse Gas savings (kg CO-e/year)^
HEC	$220.84	816

* Calculation based on unit cost of $0.248866 per kWh – the A1 all-time rate as at 30 September 2012

^ based on emission co-efficient of 0.92kg/CO2-e per kWh – National Greenhouse Account Factors July 2012

12.3.3 PARTICIPANT FEEDBACK

Perth Solar City undertook a survey of HEC participants during June 2012. The survey was sent to all households who had participated in a HEC, for completion either online or via return mail. A total of 635 households completed the survey.

The purpose of the survey was to:

- determine if participants adopted energy efficient recommendations provided through the HECs
- determine if participants' perceived a reduction in energy costs as a result of implementation of HEC recommendations
- understand if participants found HECs to be a useful tool in support of their objective to reduce energy use

The results of the survey found that HEC participants had a good (43%) or very good (44%) experience of the program (image 12-C).

A text analysis of comments show the most common responses were that the HEC was "interesting", "worthwhile", "excellent" and "useful". Respondents found the Home Eco-Consultants as "professional" and "knowledgeable". Requests for a follow-up consultation were also a common response from participants.

Survey respondents were asked if they perceived any reductions in their energy bills due to the implementation of HEC recommendations (image 12-D). 69% of all respondents perceived a reduction in their energy bill. These perceived reductions occurred despite concurrent tariff increases of 22.5% for electricity and 25% for gas.

69% of respondents who received a HEC report, indicated that they no longer refer to it.

HEC participants were provided with recommendations during and at the completion of their consultation. 80% reported that they implemented some or all of these verbal recommendations (image 12-E). The most common verbal recommendations implemented were:

- install energy efficient light globes
- turn-off standby power
- install a solar photovoltaic system

Participants were provided with a written report, summarising the results of the HEC and providing additional recommendations. Of the 635 respondents, over 15% indicated that they did not receive their HEC report (image 12-F). Of respondents who did receive a report, 76% indicated that they implemented some or all of these written recommendations. The most common written recommendations implemented were:

- turn-off standby power
- install energy efficient light globes
- install a solar photovoltaic system

The importance of feedback via the report subsequent to the consultation was evident. Feedback via the report provided an opportunity to leverage and re-enforce the momentum generated by the consultation to support the participant to continue their progress towards energy efficiency.

Participants reported that cost was the most common barrier to implementing recommendations.

Image 12-C: Overall Participant experience

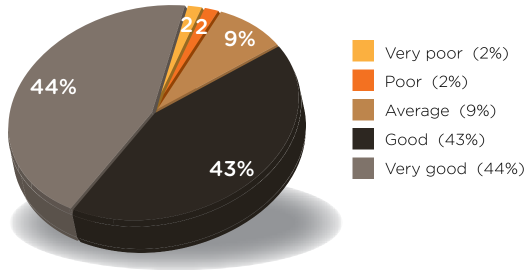


Image 12-D: Perceived reduction of energy use by participants

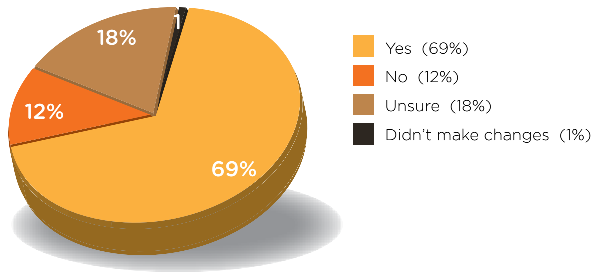


Image 12-E: Verbal recommendations implemented by HEC participants

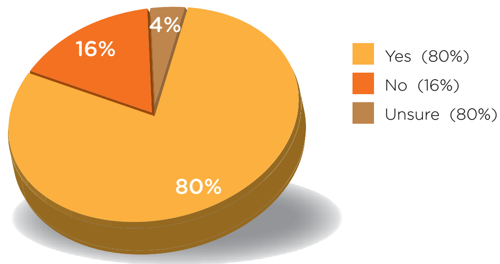
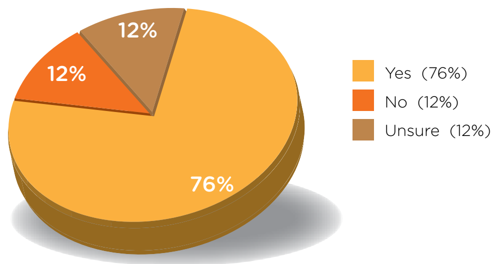


Image 12-F: Report recommendations implemented by HEC participants



12.3.4 DEMOGRAPHIC TRENDS

Household size

50% of participants in the HEC service were either single or dual occupant households (image 12-G), up from 47% in 2011.

Education levels

41% of participants in the free HEC service have completed a tertiary education (image 12-H), down slightly from 42% in 2011.

Employment status

61% of participant households were employed full-time, part-time or self-employed (image 12-I). 20% of participant households were retired.

Income levels

1,447 participant households, or 41% of HEC participants, responded when asked about their household income level (image 12-J). This has increased significantly on the 14% reported in the 2011 Perth Solar City Annual Results report, as a result of improved data collection processes.

40% of participant households were from middle income ($50,001 - $100,000) households.

Ownership status

83% of participant households are owner occupier households (image 12-K).

Participation levels

HEC participants were spread across 152 suburbs. The suburb of Bassendean was the largest suburb for HEC participation, with 11% total participants (table 12-B).

Table 12-B: Top 5 suburbs

Suburb	Total	% of total
Bassendean	395	11%
Bayswater	280	8%
Forrestfield	223	6%
Swan View	149	4%
Ballajura	136	4%

Image 12-G: Household size

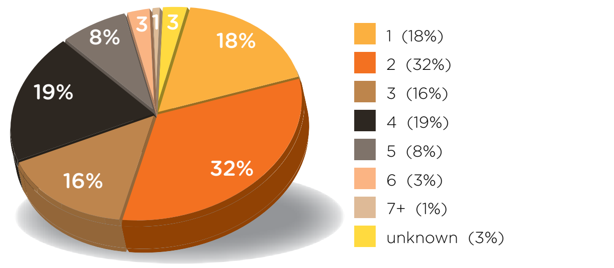


Image 12-H: Education level

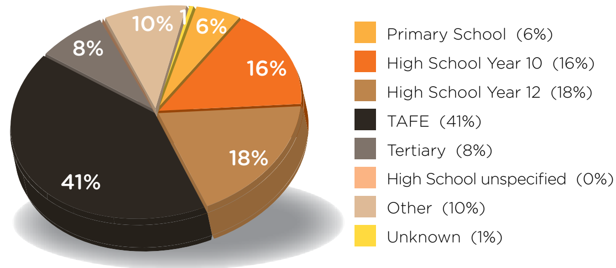


Image 12-I: Employment status

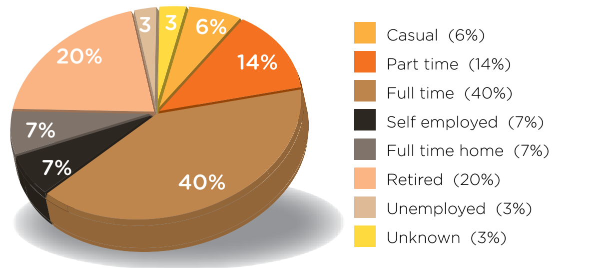


Image 12-J: Annual household income

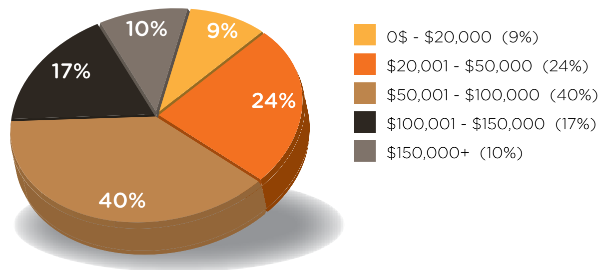
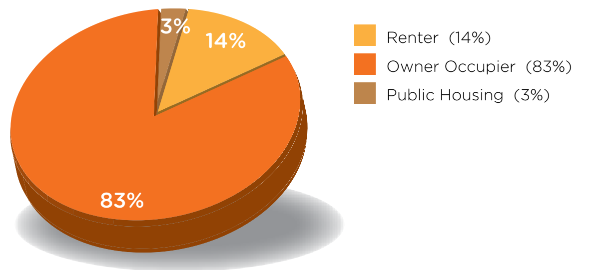


Image 12-K: Ownership status



12.4 TRANSFERRABLE LESSONS

Subjects	Barrier or benefit	Outcome and lesson
HEC participation	BARRIER: Split incentives for households who are renters or public housing tenants.	OUTCOME: 83% of participants in the HEC service were homeowners. LESSON: An enduring barrier for renters to energy efficiency services is the split-incentive between tenants and landlords. This highlights the lack of public understanding of the role that behaviour change plays in reducing energy use, and the general perception that technical solutions are the primary way of reducing energy consumption Therefore, it is essential that targeted communications and engagement specific to renters or public housing tenants is developed.
Implementation of HEC recommendations	BENEFIT: The three most reported implemented recommendations were standby power, energy efficient light globes and the installation of solar photovoltaic systems.	OUTCOME: Participants implemented a range of energy efficiency actions - from simple behaviour change (low cost – high repetition) through to major investments in energy efficiency technology (high cost – low repetition). LESSON: The HEC provides an opportunity for a broad demographic to receive energy efficiency advice tailored to their own circumstances.
Living Smart Program	BENEFIT: The Living Smart program's eco-coaching provided households with an opportunity to sign up for a free HEC.	OUTCOME: Living Smart has provided the majority of HEC referrals to date. LESSON: When compared with broad reach marketing and advertising, a targeted education-based engagement program is a more cost-effective means of generating referrals for HECs.
Scheduling HECs	BARRIER: Underestimation by HEC provider of resources required to meet significant increase in referral volumes as a result of behaviour change program.	OUTCOME: 52% of referred households were converted into completed HECs. LESSON: Contracts need to be more prescriptive regarding performance targets (for example percentage conversion rates) or consider third party suppliers to cope with increased demand.

ICONIC PROJECTS

13.1 BACKGROUND

To support the objectives of Perth Solar City, and to promote the Australian Government's Solar Cities program, five iconic Perth locations were selected for prominent solar photovoltaic (PV) installations to maximise community engagement and promote renewable energy (table 13-A).

The selected locations are the Midland Atelier, the Central Institute of Technology, Kings Park and Botanic Garden, Perth Zoo and Perth Arena. Together they provide over 450kW of grid connected renewable energy capacity.

Table 13-A: Iconic projects

Iconic site	Project	Consortium member	Completion date	Estimated annual cost savings ($/year)^	Estimated annual GHG emissions savings (kg CO_2-e/year)
Central Institute of Technology	49kW solar PV system	SunPower	April 2010	$23,677	68,543
Midland Atelier	60kW solar PV system	SunPower	May 2010	$29,377	85,045
Perth Zoo stage one	90.9kW solar PV system	SunPower	March 2011	$44,285	128,202
Perth Zoo stage two	147.8kW solar PV system	SunPower	June 2012	$72,006	208,451
Kings Park and Botanic Garden	Energy efficient education building including 15kW solar PV	BGPA	June 2012	$7,308	21,155*
Perth Arena	111kW solar PV system	Synergy	November 2012	$54,078	156,550

^Cost savings based on avoided expenditure only. Cost savings calculated at large business (M1) rate of 31.78c/kWh – current as at 30 September 2012

"Based on emission co-efficient of 0.92kg/CO2-e per kWh – National Greenhouse Account Factors July 2012

*solar PV system only.

2011 RE-CAP

Perth Solar City completed installations at Midland Atelier (60kW), the Central Institute of Technology (49kW) and Perth Zoo stage I (90.9kW).

CENTRAL INSTITUTE OF TECHNOLOGY

The 48.6kW solar PV system at the Central Institute of Technology was launched in April 2010 (image 13-A). The Central Institute of Technology is the major training provider in Perth for technicians installing solar PV panels. This Perth Solar City installation is connected to the grid, and will provide hands-on experience for students.

Image 13-A:
Central Institute of Technology's 48.6kW system

MIDLAND ATELIER

The 60kW solar power system at the Midland Atelier launched in May 2010 and powers artisans working within the building (image 13-B). This important Western Australian state heritage site is over 100 years old, and offers an exciting juxtaposition of old industry with renewable solar technology.

Image 13-B:
Midland Foundry's 60kW solar PV system

PERTH ZOO

The 90.9kW installation at Perth Zoo was launched in March 2011. As part of stage 1, 303 panels have been installed across eight Zoo buildings including the elephant barn (image 13-C), Reptile Encounter building, conference centre, reception building, retail shop, operations building and maintenance workshops.

Image 13-C: Perth Zoo stage one

Image 13-D: Perth Zoo stage 2

13.2 PERTH ZOO

Perth Zoo attracts over 630,000 visitors each year, and is well positioned to showcase sustainable ways of living.

An integral part of this iconic project is the provision of supporting educational material, including on-site and website-based information, on solar energy, and real-time displays of solar energy production at Perth Zoo.

Stage 1 incorporated 90.9kW of solar PV on various buildings around Perth Zoo. Stage 2 incorporated a dedicated bus port structure housing 147.8kW on the northern boundary of the Zoo premise. Stage 2 achieved successful connection to the Network and was launched on 5 July 2012 (image 13-D).

13.3 RIO TINTO NATURESCAPE KINGS PARK

As part of the Rio Tinto Naturescape Kings Park, Perth Solar City has partially funded the design and construction of an education building. The building incorporates energy efficient design, smart metering and a 15kW solar PV system (image 13-E). The education building will be used to host energy, environment and sustainability education sessions for school groups. The official launch of the Kings Park Education building and education programs was held on 5 June 2012, World Environment Day.

The Naturescape in Kings Park is a popular attraction, with more 70,000 people visiting the site between 1 January and 30 September 2012. The site has been particularly popular during the school holiday periods with more than 10,000 visitors attending the site in the July 2012 school holidays.

Image 13-D: Perth Zoo stage 2

Image 13-E: Kings Park Education building

Image 13-F: Kings Park Education building – solar metering pole

The site features two solar-related interpretive artworks; the interpretive metering pole in the education building (image 13-F) and the skylight in the community shelter. The form of the metering pole is based on the aerial root system of the native Grass Tree (Xanthorrhoea). The pole is made up of three tubes, one inside the other, featuring coloured LED lights, each representing a component of the building's energy production or consumption:

- Green – Solar energy generated
- Red – Air-conditioning power consumption
- Blue – General power consumption

The height of each light column increases or decreases accordingly to reflect actual power levels at any time.

Education Program

The Botanic Gardens and Parks Authority, with assistance from Perth Solar City, developed an education program for year five to eight students designed to define energy, and explore renewable and non-renewable energy sources. The 'Solar Powered Life' program commenced delivery on 24 July 2012, and included a teacher's resource pack (image 13-G).

Awards

The BGPA's cross-sector partnership for Rio Tinto Naturescape Kings Park has been awarded the 2012 winner of the Excellence in Parks Award – Economic Partnership by international peak body for park management, the Parks Forum. This award recognises the effectiveness of the partnership in providing an innovative and sustainable solution to encourage the community to engage with the natural environment.

Image 13-G: Solar Powered Life – teachers pack

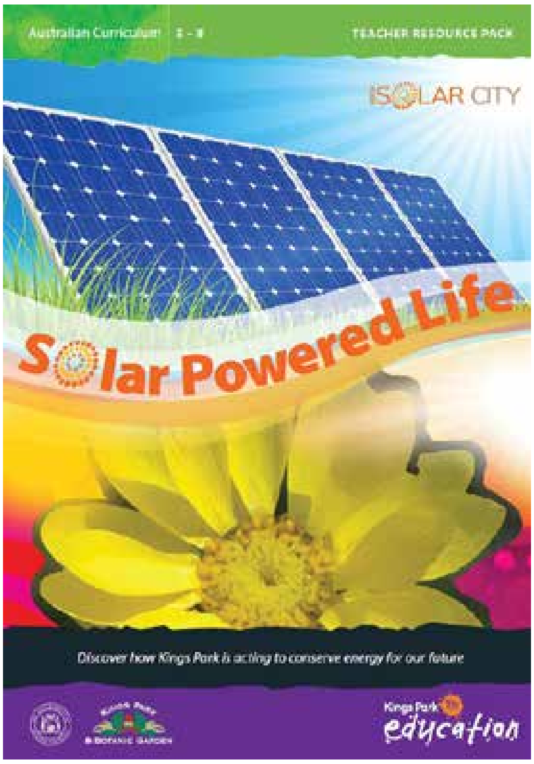


Image 13-H: Perth Arena

13.4 PERTH ARENA

The new Perth Arena is an iconic building providing a world class facility attracting national and international sporting and entertainment events to Perth (image 13-H).

This new state of the art indoor sporting and entertainment arena was launched to the public during November 2012. Its prime location within the Perth CBD provides an excellent opportunity to showcase the benefits of solar energy, and Perth Solar City.

A 111kW solar PV system has been installed on the new Perth Arena by Synergy, as part of their contribution to Perth Solar City (image 13-I). Perth Solar City will launch the system to the general public during early 2013, and will implement a promotional solar PV system giveaway competition to people who attend the site.

Image 13-I: Perth Arena – solar PV system

13.5 TRANSFERRABLE LESSONS

Subject	Barrier or benefit	Outcome and/or lessons
Community engagement	BENEFIT: Iconic solar PV installations are an excellent opportunity to engage and educate the broader community about the benefits of solar energy as well as the Perth Solar City program.	OUTCOME: Larger scale solar installations at iconic Perth locations have attracted significant attention from the community, key stakeholders and the media. LESSON: Iconic projects are a key tool to engaging and educating the community, and should be used in similar programs.
Larger-scale PV connection process (>30kW)	BARRIER: Lack of streamlined or clear processes within and between electricity distribution and retail organisations for processing solar PV system connection applications for systems larger than 30kW (particularly systems which seek to export excess power to the network).	OUTCOME: Confusion and misunderstanding for applicants which have resulted in delays to projects. LESSON: Trials such as Perth Solar City are critical to uncover and resolve process gaps for the integration of new technology.

ICONIC PROJECTS ARE A KEY TOOL FOR ENGAGING AND EDUCATING THE COMMUNITY

14.0 DEMONSTRATION PROJECTS 2011 RECAP

9 kW Solar PV Tracking System at Red Hill Waste Management Facility

14.1 BACKGROUND

To engage the local community within Perth's Eastern Region about the benefits of energy efficiency and renewable energy, fifteen demonstration projects were implemented by the Eastern Metropolitan Regional Council (EMRC) as part of Perth Solar City. Whilst they varied in scope and size, all are located within the community and mostly on public access buildings.

The EMRC represents the six Local Government Authorities (LGAs) located within Perth's Eastern Region: the Town of Bassendean, City of Bayswater, City of Belmont, Shire of Kalamunda, Shire of Mundaring and City of Swan.

The demonstration projects allow the community to see renewable energy and energy efficiency in action within their community, and assist local councils to actively understand and reduce their energy expenditure and environmental footprint. Each project includes interpretive displays and engagement materials to promote energy efficiency as well as the Perth Solar City program.

Progress

In order to demonstrate a range of energy efficiency opportunities, projects included solar PV system installations (fixed and tracking), solar water heating and energy efficiency lighting retrofits.

Fifteen demonstration projects have been completed for Perth Solar City (table 14-A).

DEMONSTRATION PROJECTS ALLOW THE COMMUNITY TO SEE ENERGY EFFICIENCY IN ACTION WITHIN THEIR COMMUNITY

Table 14-A: Demonstration projects

No.	Name of Demonstration Site	Project	Completion date	Est. annual energy savings ($/year)^	Est. annual GHG emissions savings (t CO2-e/year)*
1	Bassendean Memorial Library	3.6kW PV system	July 2010	$1,493	5,320
2	Ashfield Reserve	4kW PV system	July 2010	$1,697	6,045
3	Maylands Multi-Purpose Centre	15kW PV system	June 2010	$5,849	24,726
4	Ruth Faulkner Library	4kW PV system	June 2010	$1,697	6,045
5	Belmont Oasis Leisure Centre	Solar water heating Energy efficient lighting retrofit	Dec 2010 May 2011	$117,604	383,510
6	Midland Public Library	1kW PV system	June 2010	$476	1,527
7	Ellenbrook Community Library	2kW PV system	June 2010	$952	3,055
8	Altone Park Leisure Centre	10kW PV system Energy efficient lighting retrofit	June 2010	$4,288	113,000
9	Mundaring Administration Centre	16.1kW PV system	June 2010	$6,893	25,770
10	Kalamunda Administration Centre	Energy Management System	June 2011	TBD	73,000
11	Red Hill Waste Management Centre	9.1kW tracking PV system	April 2011	$4,592	18,070
12	EMRC Administration Centre	9.1kW PV system	March 2011	$3,281	13,900
13	Swan View Youth Centre	5kW solar PV system	August 2011	$2,144	7,638
14	Kalamunda Library	2.1kW solar PV system Sola-tube daylighting system	April 2011 December 2011	$1,337	4,823
15	Hazelmere recycling centre	Solar PV system – 4.4kW	February 2012	$2,082	7,070

^estimated figures provided by the EMRC – electricity tariffs vary by council/project
*estimated figures provided by the EMRC utilising National Greenhouse Account Factors July 2011

14.4 TRANSFERRABLE LESSONS

Activity	Barrier or benefit	Outcome and/or lessons
Local government tender processes	BARRIER: Extensive tender process relative to project scope and value	OUTCOME: Response to LGA tenders for solar PV system demonstration projects was limited, particularly at times of high PV demand. LESSON: LGAs should consider refining or simplifying procurement processes to achieve greater rates of response from solar PV system suppliers,
Community engagement	BENEFIT: Demonstration projects engage and educate the local community about energy efficiency and renewable energy.	OUTCOME: Renewable energy installations within the local community have provided ongoing engagement opportunities with local residents. LESSON: Demonstration projects are a key tool to engaging and educating the local community, and should be part of similar programs.
Installation of small scale renewable energy systems	BENEFIT: Demonstration projects assist local councils to actively understand and reduce their energy expenditure	OUTCOME: The installation of renewable energy systems on LGA buildings has reduced the associated operational expenditure on energy (for example, City of Belmont's 69% reduction in gas consumption). LESSON: Demonstration projects should be part of similar programs.

SCHOOLS ENGAGEMENT 2011 RECAP

15.1 PROGRESS

School energy audits

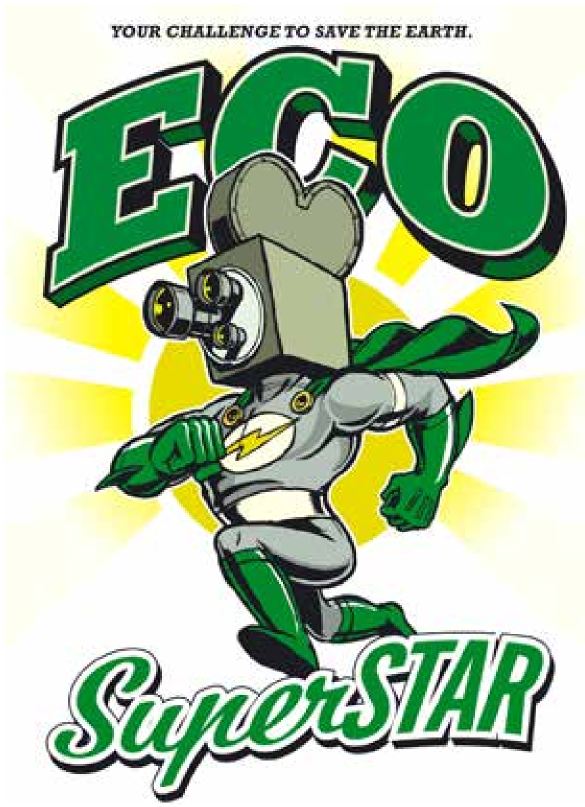
Perth Solar City recruited a total of 20 schools within Perth's Eastern Region to receive a free school energy audit. The school types included:

- government primary school - 11
- non-government primary school - 3
- government high school - 5
- non-government high school - 1

Mojarra, a Perth Solar City Consortium member, was engaged to complete the school energy audits. The audit involved a certified assessor examining the school's historical energy consumption, general patterns of electricity use by students and staff, as well as an audit of appliances such as air-conditioners.

An audit report was compiled, highlighting high energy consuming areas within the school (for example lighting, heating and cooling), and recommended the most cost effective actions to reduce energy consumption and improve energy efficiency.

Image 15-A: Eco Superstar logo



Eco Superstar documentary

Prospero Productions, a Perth Solar City Consortium member, was engaged to design and produce a high school-based documentary focused on finding an environmental champion. Eco Superstar promoted awareness of energy efficiency, broader environmental issues, as well as the Perth Solar City program. In order to engage students, Prospero Productions designed the documentary with reality-TV style approach and branding (image 15-A), pitting students in a competition to determine an environmental champion.

The competition was launched at three different schools during March 2010, and was supported by online media tools such as social networking sites and a dedicated website. Eco Superstar finalists were judged online by the community, based on their environmental message, their creativity and ability to inspire. The subsequent Eco Superstar documentary follows the two finalists during their two-week challenge to make their school and home more eco-friendly, reduce their energy use (benchmarked daily on the Eco Superstar website) and organise an eco-event.

After some fierce competition, Perth Solar City was pleased to announce Sarah Brown from

Image 15-B: Bring It Down branding

Mundaring Christian College as the winner of Eco Superstar 2010. Nate Wood from Helena College was the runner-up. The Eco Superstar documentary premiered on 20 October 2011 at the Astor Theatre, with over 200 people in attendance (image 15-D).

The Eco Superstar DVD can be used as an education tool for junior to middle secondary classes including environmental studies, media studies and society and environment. Prospero Productions worked with the Australian Teachers of Media to develop a study guide to accompany the Eco Superstar DVD. Using the resource will help students be better able to:

- identify environmental issues in the community
- decide how these environmental problems might be addressed at the personal and local levels
- apply the ideas and values of Eco Superstar to their own homes and school communities

Bring It Down energy challenge

Western Power designed and implemented Bring It Down as a school-based electricity reduction challenge to test the response to access to real-time electricity consumption information (image 15-B). The competition between schools focused on achieving energy reductions through the use of real-time electricity consumption information via a web-based display.

The competition structure included the following components:

- entry was open to a minimum of five and a maximum of eight schools
- the competition ran for seven weeks towards the end of term three and early term four (12 September to 31 October 2011), which included a two-week school holiday period
- participation was free for all schools – all display and monitoring equipment was installed and will be provided to schools beyond the life of the competition through to 30 June 2013
- the competition used a weekly points structure as a means of maintaining motivation throughout the competition
- schools were benchmarked based on school energy consumption for the same seven week period over the previous three years
- the winning school would receive $10,000 of energy efficiency upgrades, as identified in their Perth Solar City school energy audit

The real-time energy display formed the key technology component of the competition. It allowed schools to see what their energy use was on a daily basis in comparison to their own benchmarks, as well as the performance of other competing schools. Additionally, by using time-based intervals, schools were also able to understand their electricity consumption during non-school hours and weekends. As a result, schools were able to identify areas for energy efficiency during these periods. The display technology provides real time energy consumption information to users via a web-based dashboard (image 15-C).

Image 15-C: Bring It Down web-based display

Image 15-D: Host John Robertson and the two finalists at the premiere

Schools were supported by ongoing engagement during the competition to focus on energy saving initiatives, and help them to utilise the real-time display. Support for participating schools included:

- a technology user guide and briefing pack to prepare for the competition
- weekly updates about the progress of each competing school
- weekly tips on how to potentially reduce energy use
- competition posters with energy saving tips
- a post competition evaluation on the schools performance including insight into energy use trends over different time periods (including weekend and school holiday periods)

Mundaring Christian College won the Bring it Down challenge (table 15-A), winning all seven rounds. This included a 60% reduction in their benchmarked electricity use in the final week of the competition. Their total energy savings over the seven week period was 7,601kWh, representing a 54% reduction or over $1,900 of electricity savings.

Mundaring Christian College was able to achieve significant electricity savings through a range of initiatives, including switching lights off in empty rooms, taking out one fluorescent tube from double tube fixtures where practicable, using an incentive for staff to be aware of heater/air-conditioner use (without compromising student comfort), and students being given monitor roles to switch lights off in empty rooms and inform the teacher of the error of their ways.

Key results focus on the electricity savings achieved through the Bring It Down challenge.

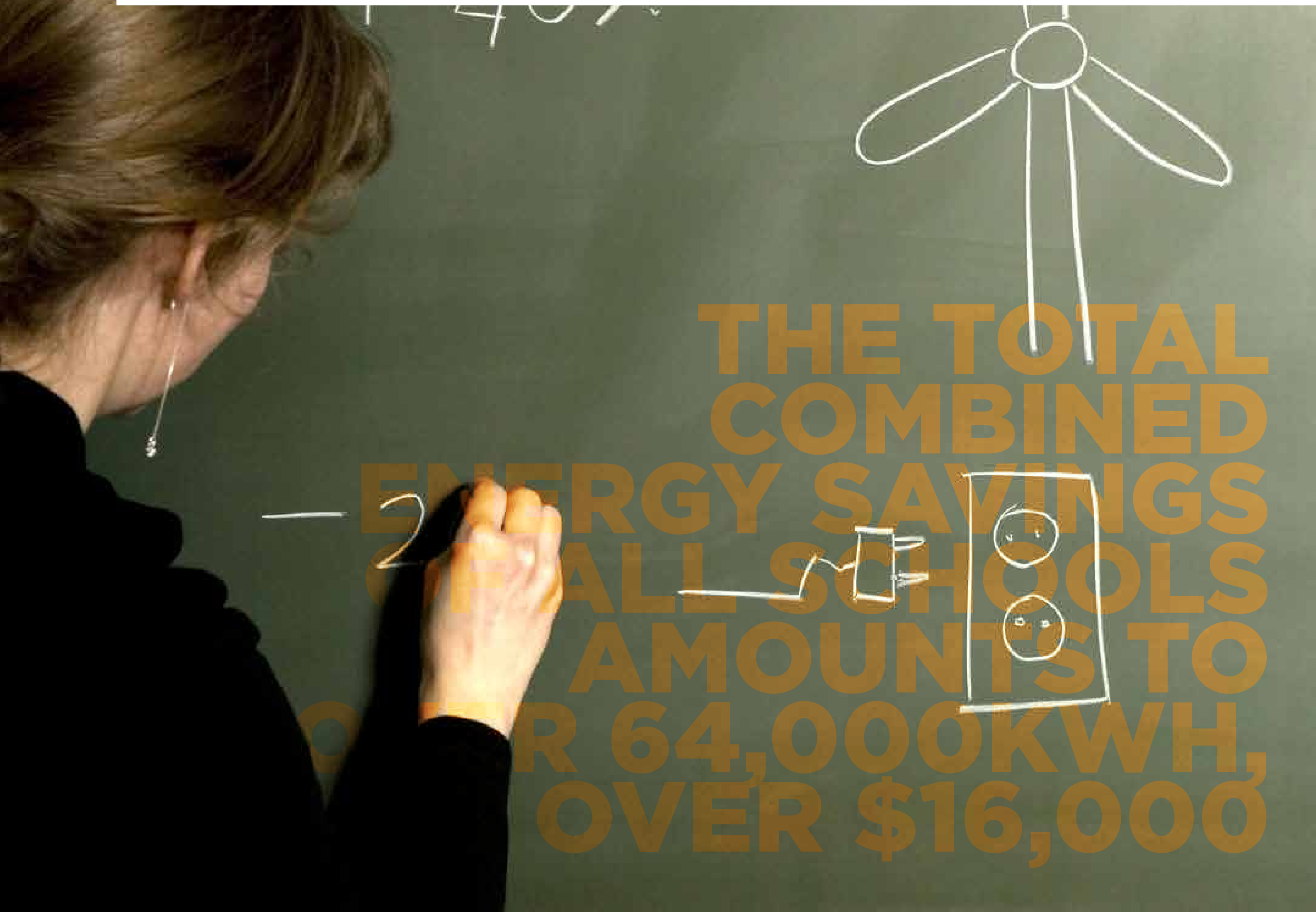
Table 15-A: Overall results

School	Benchmark (kWh)	Actual (kWh)	Saving (kWh)	% Reduction	Cost saving ($)
Mundaring	14,200	6,599	7,601	54%	$1,900.37
Hillside	9,570	5,237	4,333	45%	$1,083.22
Swan View	46,840	29,829	17,011	36%	$4,252.72
Upper Swan	17,150	11,501	5,649	33%	$1,412.13
Woodbridge	16,360	12,198	4,162	25%	$1,040.46
Weld Square	10,400	8,219	2,181	21%	$545.33
Ballajura	146,300	122,740	23,560	16%	$5,889.92
TOTAL	260,820	196,323	64,497	25%	$16,124.14

Notes: Savings based on a rate of $0.25c/kWh

15.4 TRANSFERRABLE LESSONS

Activity	Barrier or benefit	Outcome and/or lessons
School energy competition	BENEFIT: Access to real-time electricity consumption information within a competition setting	OUTCOME: Energy savings were significant. LESSON: The provision of real-time electricity consumption data, with historical benchmarks, is a useful tool in helping schools to understand, and then reduce, their electricity use.
Grant facilitation	BARRIER: Competing curriculum activities and the time-poor nature of school staff	OUTCOME: Accessing energy efficiency grants appears to be a low priority among schools. LESSON: Even with significant school engagement, information and time barriers remain.
Bring It Down competition structure	BARRIER: Large schools participating in Bring It Down made significant electricity savings however, as a proportion of their electricity consumption, these savings were relatively low.	OUTCOME: Larger schools with high electricity consumption benchmarks were disadvantaged in the competition. LESSON: Future competitions should include recognition of both relative savings and absolute savings.



THE TOTAL COMBINED ENERGY SAVINGS OF ALL SCHOOLS AMOUNTS TO OVER 64,000KWH, OVER $16,000

APPENDIX

MINISTERIAL COUNCIL ON ENERGY

NATIONAL MINIMUM FUNCTIONALITY FOR SMART METERS

Functionality		Description
1-8	Core functions	1. Half hourly consumption measurement & recording 2. Remote reading 3. Local reading – hand-held device 4. Local reading – meter display. 5. Communications and data security. 6. Tamper detection. 7. Remote time clock synchronisation. 8. Load management at meter – dedicated control circuit.
9	Daily read	Daily remote collection of the previous trading days energy data
10	Power factor phase	Half-hour reactive interval energy measurement and recording on single and three phase meters.
11	Import Export	Records active energy flows both into the electricity grid and out, where the customer has installed local generation (eg, solar cells).
12	Remote connect/ disconnect	Allows the power to a customer’s premise to be connected or disconnected remotely
13	Supply capacity control	Provides the ability to limit power to individual customers, for example in recovery from a black out to manage stability and allow recovery power for emergency services.
14	Load management at meters – dedicated control circuit	Supports existing arrangements for load control of electric storage water heating and space heating systems. This functionality allows more rapid and flexible use of load control than in the core case.
15	Home Area network	The capability to interface with an in-home display or other in-home device via a home area network (HAN) using an open standard
16	In home display	An in-home display, provided as part of the national roll-out, provides a communications interface with the home owner.
17	Water and gas metering	Gas and water meters would be able to be read remotely, via a communications interface in the electricity meter.
18	Quality of supply and other event recording	Enables meters to record information in relation to quality of supply and other events (eg: outage). The event log could then be read remotely.
19	Loss of supply detection and outage alarm	Enable a loss of supply to the meter and system outages to be detected.
20	Real time service checking	The meter can be "pinged" remotely in real time in order to check the presence of supply to a meter.

DATA STATISTICS

ANALYSIS MATHEMATICS

AUSTRALIA INFORMATION

STRATEGIC INFORMATION CONSULTANTS

Project:

[illegible]

[illegible]

[illegible]

Client: [illegible]

Project: [illegible]

Consultants: [illegible]

Executive Summary

Perth Solar City (PSC) is part of the Australian Government's $94 million Solar Cities programme designed to trial new sustainable models for the supply and use of electricity. Households in Perth's eastern corridor, which includes the Town of Bassendean, City of Bayswater, City of Belmont, Shire of Kalamunda and the City of Swan, were targeted under the Perth Solar City programme. The trial aspect requires objective evaluation of the performance of Perth Solar City, based upon the data collected as part of the project. This report covers a detailed statistical analysis of the quantitative results of PSC, with a focus on actual changes in electricity consumption.

The analysis involved assembling the equivalent of almost 135,000 household years of electricity data (across approximately 30,000 customers), with a substantial proportion of this being very detailed half hourly readings from Smart Meters. The analysis needed to consider a number of interventions that might be taken at the household level, at varying times. As well as participant households, a large number of controls were included in the analysis, both internal and external to the target area. Additionally, electricity data is notoriously irregular and has complex structures both spatially and temporally. Collectively, these considerations provided a number of challenges in the analysis.

The analysis was centred on a statistical model that explained, to the fullest extent possible, the variations in electricity use between households and over time. This model incorporated terms for long term trend, seasonality in demand, the effects of weather and, of course, the interventions with their interactions. The model was applied to the participant data and the control data collectively, providing an analysis equivalent to a Before-After Control-Intervention (BACI) analysis as is commonly used in evaluations. This provided a reasonable means of compensating for other effects, such as tariff changes, that may impact upon all households.

In parallel to this, simplified analyses were used to profile specific groups and to provide confirmation that the main model was giving adequate answers.

The methods used by Data Analysis Australia were a development of those used in the interim analysis carried out in late 2011 (our project WPNETWORKS/13). Quite apart from the substantially greater volume of data available for the current analysis, the methodology has also been enhanced, particularly through the more thorough cleansing of the data to focus on relevant metering periods, more complete treatment of interactions between interventions and the use of the statistical technique of mixed models to more accurately handle the randomness and correlation structures in the data.

Total Consumption

The overall findings were that most interventions had effects that were both statistically significant and practically significant on total household consumption. The one exception to this was the In-Home Displays (IHDs) that had minimal effect except for particular circumstances such as in conjunction with the PowerShift tariff.

The following table gives the estimated savings from the model.

Intervention	Number of Households	Electricity Saving
Living Smart	4,985	7.5%
Home Eco Consultation (HEC)	2,593	12.3%
Living Smart and HEC	1,137	10.2%
IHD (paired devices only)	1,137	1.5%
Solar Photovoltaic Systems (PV)	440	40.7%
PowerShift Tariff	351	5.1%
Solar Hot Water Systems (electric-electric) (SHW)	235	18.2%

Table 1. Summary of intervention effects on total household electricity consumption.

Note that the number of households given is the final number of households available for analysis once all data cleansing and processing has taken place – not the total number of households that took up the intervention. See Section 2.1.3 for more details.

It is clear that solar photovoltaic systems provide the greatest overall saving for a household, albeit at the greatest capital cost.

While the analysis provided estimates of the individual contributions of various interventions, a number of these were interventions promoted under the general banner of Living Smart or the HEC. Living Smart and the HEC were implemented as education-based engagement programs that identified and promoted behaviour change and energy efficient technology specifically tailored for the participants' situation. These services were also a pathway for other PSC interventions. Although it is difficult to confirm the causality in detail, it is likely that a number of these were taken up as a result of information provided and direct referrals. If it is assumed that all the interventions in Living Smart households were due to Living Smart, then the savings that can be attributed to Living Smart are 7.5%.

This same philosophy was applied to the evaluation of HEC – so that the savings of 12.3% for the households that had HEC are due to not just the consultation they received, but also the effect of all the other interventions they took up – excluding Living Smart as there was no pathway for someone who received a HEC to then become a Living Smart participant. The difference between the results for these two is primarily due to the take-up in PV (both PSC and non-PSC systems); double the proportion of HEC households installed a PV system compared to Living Smart households. Therefore, either HEC was a better mechanism for encouraging households to take up PV (regardless of whether it was a PSC PV system or not) or those households were naturally more likely to take up PV. It is likely that it is a combination of the two and provides some insight into the type of household that took up HEC.

An estimated 1.6% saving was achieved due to the diffusion or ripple effect, whereby households in the target area were influenced to reduce their energy demand even though they were not formal participants.

Profiling of the top saving households found that PV (both PSC and non-PSC) is highly prevalent, and that the majority of these households participated in a number of other interventions. Furthermore, the occupants of these households were generally older and earned more, possibly explaining why there was a significant take-up of PV as they were the households that could afford the capital costs associated with the purchase.

Super Peak Consumption

The analysis also examined the effects the interventions had on Super Peak consumption (which is between 2pm and 8pm (inclusive) on weekdays only); that is, how has an intervention helped shift energy consumption from the Super Peak period to other periods during the day? Of particular interest is the effect the PowerShift tariff and IHDs (including their combined effect) have had, as well as Living Smart and HEC. Table 2 gives the estimates of savings on Super Peak consumption. As expected, both IHDs and the PowerShift tariff had greater impact on Super Peak consumption than total consumption, with the effects essentially additive for the households that had both the PowerShift tariff coupled with the IHD.

Intervention	Number of Households	Electricity Saving
IHD (paired)	1,137	4.8%
PowerShift	232	8.9%
IHD and PowerShift	165	13.1%
Living Smart	1,365	6.4%
HEC	541	7.7%

Table 2. Summary of intervention effects on Super Peak household electricity consumption.

The number of households given is less than the number of households available for the total consumption analysis; Super Peak consumption can only be measured for households with a smart meter installed. Consequently, there were no external controls available to include in the Super Peak consumption analysis and very little (if any) Super Peak consumption data for a participant household prior to their sign-up to their first intervention; the analysis is essentially limited to a comparison of the internal controls to the participants after the intervention. Consequently, it is not possible to account for any changes in the behaviour of the internal controls during the period (and therefore measure the diffusion effect) and have a limited understanding of the behaviour of the participant households (with respect to their Super Peak consumption) prior to taking part in an intervention.

On the top ten days of network peak during the 2011 and 2012 summers, customers on the PowerShift tariff *reduced* their daily Super Peak consumption by an average of 12% compared to their estimated consumption had they remained on the A1 tariff. However, it was noted that the households that took up PowerShift had a larger Super Peak consumption than the A1 households during the summer peak days, which suggests by switching to the PowerShift tariff, these households had a greater incentive to change their consumption behaviour. Therefore, the results should be considered an upper bound as it is not clear that such savings would be observed in the other A1 households should they switch to the PowerShift tariff.

Future Analysis

It is noted that while most of these estimates of savings are in line with the interim analysis conducted in late 2011, there are differences, particularly for photovoltaic installations, with the saving dropping from 60% to 40%. While much of this change is due to the richer data set and the more complete attribution of savings to particular interventions, there may also be an effect of households adapting their behaviour to take advantage of the lower overall energy bills.

This highlights the value of repeating this analysis in (say) one or two years to better understand the long term effects. A longer term analysis may also be able to investigate how the energy saving effects persist beyond a change of occupancy of a dwelling. (The current analysis focuses exclusively upon the household itself, excluding data post a change in occupancy.) Also, such an analysis could make use of the soon to be available 2011 detailed Census data. Other questions that could be addressed by the analysis might include the fine structure of power shifting associated with time-of-use tariffs and further consideration of interactions of the interventions with weather and the time of the year to better understand the effects on system peaks and general variations in savings throughout the year.

Data Analysis Australia believes there is merit in conducting such an analysis in the future.

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1. Introduction

1.1 Perth Solar City

Households in Perth's eastern corridor, which includes the Town of Bassendean, City of Bayswater, City of Belmont, Shire of Kalamunda and the City of Swan, were targeted under the Perth Solar City programme.

The overarching Solar Cities programme has the following objectives:

- To demonstrate the environmental and economic effects of combining cost reflective pricing with the widespread use of solar technology, energy efficiency and smart meters; and
- To find out what barriers exist regarding energy efficiency, electricity demand management and the use of solar technology, among businesses and householders in different parts of Australia, and test ways to deal with these barriers.

The specific objectives of the Perth Solar City programme are to:

- Identify and understand barriers to the uptake of energy efficiency and renewable energy in the residential sector of Perth's Eastern Region;
- Test new energy efficiency technologies and undertake trials;
- Inform future government policy; and
- Bring together industry, business, government and community to change the way we produce, use and save energy.

Reducing customer electricity use not only benefits the customer and the environment but the reduced network demand allows energy distributors such as Western Power to use existing resources more efficiently, thus reducing network expansion costs.

The Perth Solar City programme was designed to not only achieve worthwhile immediate savings but also to enable the accurate quantification of those savings. To that end, selected households in Bassendean, Darlington, Forrestfield and Midland received smart meters as part of the PSC programme. Smart meters are considered as information collection devices and enabling products for other interventions but *not* interventions in their own right.

1.1.1 Interventions

A number of distinct interventions were trialled as part of Perth Solar City.

Living Smart

Living Smart is a behavioural change programme that was delivered over a 13-month period from 1st May 2010 to 31st May 2011. Households were partially self-selected, with ten thousand households invited to participate in the programme. Participation levels ranged from signing up to the programme to undertaking between one and five coaching conversations (with five coaching conversations defining full participation). The Living Smart programme is considered an umbrella programme – that is, participation in Living Smart may lead to a household taking up other interventions.

Home Eco Consultations

The Home Eco Consultations programme (HEC) was another behavioural change programme implemented under PSC; it was a single consultation and participants were self-selected. Likewise to Living Smart, participation in other interventions by HEC participants could be considered a result of participating in HEC.

PowerShift Time-of-Use Tariff

PowerShift is a three-part time-of-use tariff developed by Synergy for PSC. The three periods are Super Peak (2pm to 8pm, weekdays), Off Peak (10pm to 7am, everyday) and On Peak (all other times). Households were self-selected but also required a smart meter.

In-Home Displays

The type of in-home display used in PSC provides real-time information on instantaneous electricity consumption and the corresponding cost based on the household's current tariff. The IHD is only available to those households with a smart meter. The majority of households were targeted by Synergy and were mailed an IHD, whilst some additional households also opted into the scheme. Households had to pair their device with their smart meter before they became active.

Solar Photovoltaic Systems

An attractive rebate was offered on particular PV systems as part of the PSC programme to encourage households to install these systems. However, households were free to install alternative PV systems should they desire.

Solar Hot Water Systems

A rebate was offered on particular SHW systems as part of the PSC programme, the focus of which was on households replacing their existing electric hot water system with an electric boosted SHW.

1.1.2 Recruitment

Households in the Perth Solar City area were selected or self-selected by a variety of different means to take part in one or more of the programmes or technology trials offered under the PSC programme. The numbers of participant households for each intervention are presented in Table 3. The total number of participating households is 9,135.

Intervention	Participant Households
Living Smart	5,042
Home Eco Consultation (*HEC*)	2,722
In-Home Display (*IHD*)	2,216
Solar Photovoltaic Systems (*PV*)	478
PowerShift (*PS*)	367
Solar Hot Water (electric to electric replacement) (*SHW*)	247
Total Participants	**9,135**

Table 3. Count of participant households for each of the PSC interventions. The total number of participants is less than the sum of the participating households for each intervention as a household can participate in multiple interventions.

From within this region, there were approximately 12,500 households selected as controls (these were termed internal controls). A further 10,000 households (termed external controls) were selected from suburbs with similar demographics outside of, but nearby to, this region as households within the PSC target region could reasonably be expected to be somewhat effected by wide spread media and social diffusion.

1.2 Role of Data Analysis Australia

Data Analysis Australia was contracted by Western Power Networks, initially in November 2011, to assist in the evaluation of the set of energy efficiency products, services and trials developed and implemented by the Perth Solar City programme that were listed in Section 1.1.1 and Table 3. In May 2012, Data Analysis Australia was approached to perform a more comprehensive and in depth analysis of the individual and combined effects of the interventions.

Overarching aims of the analysis are to investigate the impacts of PSC on reducing overall electricity consumption and peak demands, as well as to profile households who were top energy savers.

Specific questions to be answered are:

1. Compared with controls, how have:
   i. In-Home Displays;
   ii. Solar PV systems;
   iii. Solar Hot Water systems (electric-to-electric transitions);
   iv. Living Smart; and
   v. Home Eco-Consultations;

   participant households changed their behaviour as measured by average consumption per day?
2. What is the profile of the top 10% and top 50% of savers for Living Smart, Home Eco-Consultation, PowerShift and IHD households?

3. Compared with appropriate controls, how have PowerShift tariff participant households changed their energy use *at Super Peak times*?

   Related to this, how did PowerShift households change their *Super Peak* energy use *on summer peak days* compared to A1 households?

The analysis does not attempt to directly make inferences that can be applied beyond the region covered by the PSC project. This area has particular demographic, economic and climatic properties and no consideration is given to how it may be representative of Perth as a whole.

2. Methodology

Prior to any analysis, Data Analysis Australia produced an analysis plan[1] outlining the approach to be used, the enhancements to be made from the interim analysis, and where decisions were yet to be made, the options that would be explored. This section describes the final methodology used in the evaluation and details the statistical decisions made.

The methods used by Data Analysis Australia were a development of those used in the interim analysis carried out in late 2011[2]. That approach involved the use of a statistical regression model that simultaneously incorporated the effects of the interventions, the seasonal variations in demand and the weather. In addition, the interim analysis included some simpler tabulations that explored the specific effects of some interventions.

The model was applied to the participant data and the control data collectively, providing an analysis equivalent to a Before-After Control-Intervention (BACI) analysis as is commonly used in evaluations. This provided a reasonable means of compensating for other effects, such as electricity price changes that may impact upon all households.

That methodology was enhanced for this final analysis in several directions:

- A greater volume of data was used and greater attention applied to data cleansing;
- The regression model more comprehensively covered possible interactions between interventions;
- A mixed model approach was used to improve estimates and to better assess statistical significance; and
- A model prediction approach was used, which enabled quantification of the effects of interventions in the presence of interactions, as well as for interventions on their own.

These enhancements amount to a significant increase in both the sophistication and the statistical power of the analysis, resulting in more definitive results.

[1] Data Analysis Australia (2012), *Perth solar city data analysis plan*, WPNETWORKS/16, Data Analysis Australia, Perth.

[2] Data Analysis Australia (2011), *Perth solar cities phase 1 analysis*, WPNETWORKS/13, Data Analysis Australia, Perth.

2.1 Data Preparation

There are five data types used in the analysis:

- Consumption data;
- Intervention details;
- Weather data;
- ABS Census 2011 data; and
- Seasonality effects.

Substantially more data was available then was used in the interim analysis. Not only was there an additional year of post-intervention data, billing data was extended back to 2006 instead of 2008. The additional data automatically provided greater statistical power.

The consumption data was provided in a mix of two formats: approximately bimonthly data for older style electro-mechanical meters (NEM13) and 30 minute interval data for smart meters (NEM12). Consumption was defined as total exports minus total imports for the meter period – i.e. net consumption of electricity by the household exported from the grid.

The sheer volume of data meant that a level of aggregation was required before it could be analysed. While the interim analysis aggregated interval metering data to daily totals, the current analysis aggregated to weekly totals to permit the use of more sophisticated models. The result was that a single record represented the net consumption (aggregated across all meters at a property[3]) for a time period, which was a week for interval data, or approximately 60 days otherwise.

This aggregation not only reduced the volume of data significantly, but also reduced the disparity between the meter period lengths for NEM12 and NEM13 from around a factor of 60 to a factor of around 8 or 9. Furthermore, it largely removed any day of week effect that may have been present in the consumption data. This data compression had a negligible impact on the statistical power of the analyses.

Super Peak consumption was also treated in the same way as total consumption for the NEM12 data – that is, the net Super Peak consumption was aggregated over all meters and over a week for a household.

Programme, trial or installation dates were provided for each of the interventions for analysis as well as for smart meters that were rolled out as part of the PSC programme. This data was accompanied with some information on the participation level of households.

[3] A property may have more than one meter for reasons such as: sites that co-exist as a residential and commercial premises (e.g. home business); strata complexes where each meter measures consumption for an individual premise (sometimes with an additional meter for common property). On balance it was decided to be the best way to deal with this data.

A single date, at the household level, was provided for HEC (the audit date), and smart meters, IHD, PV and SHW (the installation date). For PowerShift, the date the household switched to the PowerShift tariff was provided along with the date the household ceased to be on the tariff (if applicable). For Living Smart, only the PSC programme start and end dates were provided (i.e. specific information for a household was not).

For Living Smart, as individual registration and withdrawal dates (if applicable) were not known, it was assumed for the analysis that all Living Smart households started on 01/05/2010 and ended on 31/05/2011. In reality, a household could have been part of the programme for a shorter period – the only additional information available to us were the households that received a minimum of one coaching call, and of those that received all five coaching calls.

It is possible to identify any premises with a PV system (and its installation date) due to the Renewable Energy Buyback Scheme (REBS) whereby households can sell excess energy generated by their PV systems back to the grid. Therefore, all households identified in the analysis that had a PV system installed, whether it be a PSC PV system or otherwise, could be identified. This was desirable for two reasons:

- The objective of the analysis was to measure the effect of the presence of a PV system versus the absence; and
- PSC participants may have "shopped around" electing to purchase a different PV system than was offered through PSC but this purchase may have been the result of PSC (such as a purchase that was a result of taking part in the Living Smart programme).

For installation of the solar hot water systems, the data provided included the installation date as well as the type of system installed and the type of system it was replacing, as the evaluation is focused only on electric-to-electric replacements.

Weather data was sourced from the Bureau of Meteorology (BoM). The closest weather station to the PSC target region is Perth Airport and daily maxima and minima temperatures (°C), rainfall (mm) and relative humidity at 9am and 3pm were used. For each household's metering periods, the average weather observed during that period was joined to the data. For example, if the metering period was for the week 18/07/2011 to 24/07/2011 (inclusive), then the average maximum temperature would be calculated for that period.

To represent seasonal variations in both consumption and weather, a sixth order Fourier series (which is a series of sine and cosine curves of increasing frequency) was used[4].

[4] Fourier series are a fundamental mathematical construct used to model periodic phenomena. Further information is available from many sources, including http://en.wikipedia.org/wiki/Fourier_series

Finally, data was obtained from the Australian Bureau of Statistics 2011 Census of population and housing to obtain household demographic data at the SA1 level[5]. Geo-coordinates for the majority of households were provided by Western Power to assign a household to a SA1 – where geo-coordinates were not available the address was manually assigned to a SA1.

The final data structure was as follows:

- Net total consumption and net Super Peak consumption were aggregated over the metering period and over multiple meters (if applicable) for each household, resulting in each record representing a single time period for a household – with multiple records for each household;
- A period was defined as one week (7 days) for NEM12 data and the original period for the NEM13 data, with start and end dates of the metering period retained;
- Participation variables for each of the interventions (including interactions) representing the proportion of the time period that a particular intervention (or combination of interventions for the interaction terms) was active;
- Terms representing the average weather conditions for the time period;
- Annual cycle terms for the time period; and
- Household demographic data[6] obtained from the 2011 Census at the SA1 level.

2.1.1 Data Exclusions

The meter data provided contains readings for multiple registers for some meters. For the NEM12 data, the multiple registers measure import and export in different units such as kWh and kVAh. Only those with a unit of measure of kWh were retained.

For the NEM13 data, the different registers measure total, peak, high shoulder, low shoulder and off-peak consumptions for both import and export. A complexity arose where for some meters both the total and the individual peak, high/low shoulders and off-peak consumptions were recorded, for some only the individual components were recorded, and for others not all of the registers were present. For ease of analysis, only the total consumption registers were retained for the NEM13 meter reads, which only impacted a tiny fraction of meters.

Western Power provided the property type for each property (in the target and control suburbs) and only those that were clearly labelled as domestic properties were retained in the analysis; properties labelled as commercial, vacant or unknown were treated as non-residential. Despite the exclusion of the non-residential

[5] Statistical Area 1 (SA1) in the new Census geography is analogous under the new geography to the old Collection Districts (CDs), and typically consists of approximately 200 households.

[6] The household demographic data used was average number of occupants per household, median weekly household income and median household age for that household's SA1.

properties, it was found that there remained some individual meter reads with very large average daily consumption (both positive and negative). Data Analysis Australia excluded all individual net meter reads that had an average daily consumption greater than or equal to 150 kWh or less than or equal to -40 kWh[7] for the period.

Some very long meter period lengths were identified (up to approximately 1,200 days in some cases). A limit of 150 days was applied to exclude very long meter read periods.

In summary the exclusions were:

- Records whose units of measure were not kWh;
- NEM13 records that were not for the total consumption registers;
- Properties that were not clearly identifiable as residential;
- Meter reads with a period length exceeding 150 days; and
- Meter reads with an average daily consumptions exceeding 150 kWh or -40 kWh.

2.1.2 Household Identification

Since many of the interventions target human behaviour, only data corresponding to households occupying the dwelling at the time of the first intervention recorded for a NMI[8] were included[9]. These households were identified using the information on account changes within a NMI, as provided by Western Power. The restriction to a single household was achieved by excluding data *prior* to a change in account holder in the pre-intervention period, and excluding data *post* a change in account holder after the intervention has taken place. For the control group NMIs, the period that contained the 1st May 2010 was chosen (to reflect the commencement of Living Smart). Therefore, a NMI now represents a single household for the purposes of the analysis.

2.1.3 Limitations

There are some limitations imposed on the analysis by the data. For instance, it is not certain that all non-residential properties have been removed, and there is also a known bias in the occurrence of these properties in the internal controls. When these internal controls were initially selected, they were not limited to residential

[7] Recognising that it is possible for households on holiday (for example) with an active PV system to be generating more electricity than they use over an extended period.

[8] A National Meter Identifier (NMI) is used to identify a property. As only residential properties are of interest, and that almost all residential properties have only a single household present, it is assumed that a NMI is equivalent to a household for the purposes of the analysis.

[9] It is arguable that interventions such as Solar Hot Water Systems and photovoltaic systems will remain in the dwelling for the benefit of the new occupants. However, this would have significantly complicated the analysis since there would be a need to allow for household attributes that are different.

properties, unlike external controls and the original list of households approached to be part of PSC.

Another data imposed limitation is that the intervention dates do not reflect the date that a decision to take up the intervention was made. Whilst for some interventions the household could not benefit until their install (such as PV or SHW), others may trigger a change in behaviour before the intervention has started (such as HEC or Living Smart). Also, a significant limitation is the lack of official registration and withdrawal dates for the Living Smart participants. The compromise of using fixed start and end dates for these participants is not ideal – the identification of the full participants helps as part of the evaluation, but not as part of the modelling.

The lack of specific dates has potentially led to the exclusion of some participating households for Living Smart. The algorithm used to identify the active household at a property is not perfect. For example, it is possible to have the situation where a household moves out of a property shortly after 1st May 2010 (the date used to mark the start of Living Smart), and it was the household moving in that actually signed up to Living Smart. So these people are still part of the programme but have moved house.

This situation isn't limited to just Living Smart, but can apply to any situation where two interventions have been signed up to by the property by two distinct households. Consider the following example, household A receives a HEC and subsequently moves to a new property, replaced by household B (at the same original property) who signs up to PowerShift. Consequently, all records relating to the second household would have been lost and for the purposes of the PowerShift intervention a participant would have been lost.

It is also not possible to track households when they move house, so whilst it is expected that the PV and SHW interventions will stay with the physical property, the other interventions (HEC, Living Smart and PowerShift) will move with the household and any such behaviours will be lost as they are not tracked to their new property.

It is for these reasons, along with the exclusions, why the number of households available for analysis is different to the number of households that signed up for an intervention.

Participants may have purchased a different SHW system than what was offered through the PSC programme. Whilst information is available for all PSC solar hot water systems installed, nothing is known about other hot water systems that the participant or control households may have installed. Therefore, it is not possible to analyse the effect of SHW in the same manner as PV.

There are three points at which **all** meter readings for a property/household may be excluded: Non-residential property; all consumptions are extreme; and all readings are not associated with the active household.

This has an effect on the number of households that are then available for analysis. Table 4 provides a breakdown of the number of households lost for a particular intervention, as well as the total number of participants overall[10].

Intervention	Initial Count	Non-Residential	Extreme Consumption	Not Active Household	Final Count
Living Smart	5,042	0	0	57	4,985
HEC	2,722	7	0	122	2,593
IHD (all mailed)	2,216	1	0	134	2,081
IHD (paired)	1,231	1	0	93	1,137
PV	478	4	0	34	440
PowerShift	367	0	0	16	351
SHW (electric-to-electric)	247	4	1	7	235
All participants	**9,135**	**22**	**1**	**85**	**9,027**

Table 4. Number of participant households in the exclusion categories by intervention.

The biggest loss of households (within an intervention) occurs when identifying the active household at a property using the move-in/out/vacant property data provided by Western Power. A total of 85 participants were removed as this data indicated that there was no active household at the time of the first intervention for that property. Other losses were a likely consequence of using a fixed start date for Living Smart. In total, there were 108 participant households removed from the data for the final analysis.

2.2 Intention to treat

With trials such as this there is always a question of the degree to which participants actually participate. This includes situations where a participant may be physically unable to take advantage of some interventions even when willing. This can lead to the temptation to restrict the definition of participants to those passing an additional threshold of active or full participants, causing artificially inflated positive results to be obtained.

However, the general approach must be to include *all* formal participants, since this is likely to reflect the levels of participation that would be achieved in practice outside a trial. This principle is often termed "intention to treat", coming from the clinical trials area[11]. The cohort of formal participants were considered as those households deemed appropriate to trial an intervention (including being given the opportunity to), as opposed to those households who actually did.

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[10] The number of 'All participants' is not the sum of the households across all interventions as many households participated in multiple interventions.

[11] Clinical trials are able to take this a step further, randomising who is given a treatment and using a placebo to hide the fact. Such rigour is simply not feasible in this trial, where virtually all participation was self-selecting.

For each of the interventions, the definitions below were used to define those that were considered a participant of the trial:

- Living Smart – any household that signed up for Living Smart and received at least one coaching call;
- HEC – any household that received a home eco-consultation;
- IHD – any household that was mailed an IHD or voluntarily signed up for an IHD, regardless of whether they paired the device or not;
- PV – any household that was received a PV system through the PSC programme office;
- PowerShift – any household that remained part of PowerShift for a minimum of 30 days (it was recognised that some households could have been signed up inadvertently or were incorrectly put on the PowerShift tariff); and
- SHW – any household that received a replacement SHW system as part of PSC.

It should be noted that for IHD, the analysis acknowledged whether a household paired their device or not. Similarly, for SHW, the analysis acknowledged the original hot water system (whether it was electric, gas or unknown) and the replacement system (whether it was electric boosted SHW or gas boosted SHW).

Of the original 6,367 households that signed up to Living Smart (and received the initial information pack), around 1,475 withdrew from the programme before ever receiving a coaching call and were not formally considered part of the programme for this analysis. However, whilst approximately 150 did not proceed to receive a coaching call, they participated in at least one other intervention and as a result their consumption data was provided to Data Analysis Australia. Unfortunately, it was not possible to adequately identify these households explicitly and so they have also been classed as participants of Living Smart despite not receiving a coaching call. The magnitude of any bias associated with this should be small.

Households who only received a smart meter and were not classed as being a participant for any of the other interventions (using the definitions above) were not classed as participants of PSC. Conversely, any of the households originally identified as an internal control but later participated in at least one of the interventions were considered a participant and no longer a control. All those who did not participate using this definition were considered controls.

2.3 Modelling

A regression model was developed to estimate the direct effect that each of the interventions has had on household consumption, whilst controlling for the effects of weather, seasonality, household demographics, long-term trends and other (immeasurable) effects via the use of both the internal and external controls. The model was applied to the participant data and the control data collectively, providing an analysis equivalent to a conventional BACI analysis. Furthermore, a term was introduced which measured the indirect savings PSC achieved in households in the target area not directly involved in an intervention. This is also known as diffusion or ripple-effect.

Within the analysis plan were a number of statistical areas that would be investigated as part of the final analysis. The ultimate decisions were to use:

- **Average daily consumption** rather than aggregated consumption for a metering period;
- **Absolute** effects rather than relative effects for the interventions at the household level;
- **A linear model assuming a Normal distribution** (with no logarithmic transformation) rather than a generalised linear model with a gamma distribution (and logarithmic transform);
- **Random effects** to compensate for the correlations that exist between readings within the same household;
- **Weights** proportional to the metering period length (raised to a power[12]) to account for the difference between period lengths associated with NEM12 and NEM13 data; and
- NEM12 data **aggregated to a weekly** level.

A key component of the modelling was to ensure that the interventions were parameterised appropriately and that all relevant interactions between the interventions were included to allow the proper evaluation of the effect of multiple products on a household. The basis of this parameterisation is to have an indicator variable for an intervention which represents the proportion of a metering period that the intervention was active for a particular household (if at all), allowing the effect **directly attributable** to an intervention to be estimated.

Whilst this approach was unchanged between the interim and current analyses, the actual terms used were reviewed in detail to ensure that they captured possible changes (such as distinguishing between an intervention being in an active phase or a post intervention phase) and that all reasonable interactions were allowed for. Appendix B provides more information on the parameterisation of the intervention variables (and interactions).

Living Smart and HEC were interacted with all interventions plus PowerShift and IHD (giving three-way interactions). The only other interaction included was the two way interaction of PowerShift and IHD – no other interactions were required for the purposes of the evaluation. An interaction between two interventions represents the period during which *both* (or all) of the interventions were active.

Whilst the interim analysis used standard linear regression, the final analysis was enhanced to incorporate what are known as "random effects", giving a mixed model. The random effects account for the variations in base consumption between households that are expected to occur, but are individually unpredictable. By

[12] Analysis showed that a power of 0.129 was appropriate.

incorporating these random effects, the intervention effects are estimated slightly more accurately and the statistical measures of significance are much more accurate.

The analysis kept to this simple version of random effects. Whilst more sophisticated versions are theoretically feasible, they were not practical to apply to a data set of this size.

The same model framework was applied to both average daily consumption (for measuring the direct effect on total consumption) and average daily Super Peak consumption. However, unlike for total consumption (which can use both NEM12 and NEM13 consumption data), there were no external controls available to include in the Super Peak consumption analysis (they did not have smart meters installed) and very little (if any) Super Peak consumption data for a participant household prior to their sign-up to their first intervention; the analysis is essentially limited to a comparison of the internal controls to the participants after the intervention (i.e. no before and no external controls). Consequently, it is not possible to account for any changes in the behaviour of the internal controls during the period (and therefore measure the diffusion effect) and have a limited understanding of the behaviour of the participant households (with respect to their Super Peak consumption) prior to taking part in an intervention.

2.3.1 Summer Peak Days

Analysis of the effect the PowerShift tariff has had on Super Peak consumption during summer peak days in comparison to the A1 tariff used a similar approach but with a slightly simplified model. No weather or seasonality effects were included in the model as the consumption was observed on the same days for all households included in the model (which was limited to those households with a smart meter and identifiable as being either a PowerShift customer or an A1 customer[13]). However, all other variables were retained, in particular the intervention terms (and associated interactions). As the analysis required consumption for particular days, the NEM12 data was aggregated to the daily level, and as all metering periods were of the same length it was no longer necessary to include weights.

Additional variables included were two factor variables: one representing whether the metering period belonged to the 2011 summer or the 2012 summer, the other representing whether the metering period was for a PowerShift tariff or an A1 tariff.

Information was provided to identify and remove from the analysis households that participated in the direct load control experiment or were on the SmartPower tariff, allowing a comparison between PowerShift and A1 households.

Finally, as with the main Super Peak analysis, there were no external controls available to include in the analysis (they did not have smart meters installed) and

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[13] It was assumed that all households not on either the PowerShift tariff or the Smart Power tariff were on the A1 tariff. There may have been a small minority on other tariffs if all non-residential properties were not eliminated.

very little (if any) consumption data for a PowerShift household prior to their change over to the PowerShift tariff.

2.4 Evaluation

The statistical model was sufficiently detailed that it could then be used to understand not only direct effects (which were the focus of the interim analysis) but also complex interactions between interventions. To complement this, a new model-based approach was used for the evaluation of the interventions, utilising the output from the main statistical model. The evaluation of the interventions was restricted to the households that were used in the modelling process, thus omitting those that had been part of the exclusions. This was a necessary step as part of the estimation process is to use average consumption for a household which is obtained from the model process – thus this information would not have been available for the households excluded.

Effectively, the participant data was set up for a "typical year[14]" and the model was used to predict consumption with interventions variously set to be present or absent. Aggregates of the predicted consumption could then be used to quantify likely real effects, and thus give the savings presented in this report.

To provide the estimated effects, for each of the interventions[15], the estimation process was as follows:

1. Identify the cohort of participant households for the particular intervention of interest;
2. Use the model to estimate electricity consumption for a typical year for each and every household in that participant cohort **with** the interventions they subscribed to in place for the whole year;
3. For each of these households, again using the model, estimate their electricity consumption over the same period **without** the intervention of interest (keep other interventions they subscribed to as active); and
4. Compare the total consumption across all of these households over this period **with** their intervention in place against the total consumptions for each of the interventions **without** the intervention in place to obtain the estimated savings for the intervention of interest.

This process allows the direct measurement of the effect an intervention had (over the allotted time period) on the households that signed up to the intervention – it is not diluted by including other participant households that did not take up the particular intervention of interest.

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[14] A typical year was defined by taking the average weather for each day of the year over the last fifteen years. However, such a year is actually very non-typical as it will not allow the possibility of extreme weather. Due to the structure of the model, this is not an issue (as weather is not interacted with the intervention variables) and this will not bias the estimated savings.

[15] Living Smart, HEC, SHW, PV, PowerShift or IHD.

Care was required to analyse the effects of Living Smart. As Living Smart is viewed as a suite of interventions, the effect of those that were on Living Smart and also took up any of HEC, PV (both PSC and non-PSC PV), and SHW also needed to be included as part of the estimated savings to be attributed to Living Smart. If a household had a smart meter, then the effects of IHD and PowerShift were also included. So for Living Smart, given that the interactions with all other interventions were included in the model, point 3 above effectively means that a household's 'without' consumption also meant without HEC, PV (both PSC and non-PSC PV), IHD, PowerShift and SHW (if the household had signed up to these). This is different to say PV, where the estimated savings are for those households that took up PV, regardless of whether they were part of Living Smart or not.

Much the same approach for Living Smart was applied when estimating the effects of HEC. However, as households could not be referred to Living Smart via a HEC (only the other way around), the effects of Living Smart were not included when estimating the effects of HEC.

2.5 Top Savers

Using the main regression model described in Section 2.3, it was possible to estimate the weather and seasonally corrected average daily consumptions for each household for the period prior to its first intervention and the period after, thus deriving its relative savings (or increase) to overall consumption. It was important to weather and seasonally correct these consumptions to ensure that the calculation of savings was not affected by changes in weather from year to year and where there were instances of less than complete years' data for a household.

These relative savings were then used to identify the top saving households (either the top 10% or top 50%) for Living Smart, HEC, IHD and PowerShift, ready for profiling to identify common characteristics of these households and to make inferences about the reasons why these households were able to perform so well.

2.6 Auxiliary Analysis

An auxiliary Before-After Control-Intervention (BACI) analysis was performed in which the average daily consumption of the participants of an intervention was compared to the two control groups over three distinct 12-month periods:

- Before – 01/06/2009 to 31/05/2010;
- During – 01/06/2010 to 31/05/2011; and
- After – 01/06/2011 to 31/05/2012.

This approach was taken to eliminate any seasonality effects (by looking at whole years) and to estimate the between year effects (by comparing participants against controls).

The limitation of this approach is that these periods do not necessarily represent a full 12 months prior to the start of an intervention for a particular household; hence the periods are only an approximation of the true before, during and after periods for a household.

The analysis compares average daily consumptions for the 12 months before Living Smart began (01/06/2009 to 31/05/2010), during Living Smart (01/06/2010 to 31/05/2011) and after Living Smart (01/06/2011 to 31/05/2012) for each of the interventions. Whilst the three periods are not exact (Living Smart took place over a 13 month period), whole years have been used to avoid the effect of seasonality and average daily consumptions are based on meter reads that fall completely within the specified periods. Those meter reads that straddle a period have been excluded for the purposes of this analysis. The behaviours of the internal and external controls during these periods have been provided for context – they give indicative effects of the weather from period to period as any apparent effect in these analyses for the interventions may include weather effects (either enhancing or dampening the apparent effect).

It should be stressed that the purpose of this approach is to provide a simplistic analysis that can be used as a reference to the more complicated, main analysis. The results should only be treated as indicative of the savings actually achieved as part of the PSC programme. Appendix A contains the results of this analysis.

3. Results

The main analysis methodology for PSC is described in more detail in Section 2.3, but can be summarised as follows:

1. Use a regression model to estimate the direct effect each of the interventions (and their interactions) has on electricity consumption;
2. Using this model, estimate the annualised savings for a typical year for each of the participants in each of the interventions; and
3. Calculate the average savings for each of the interventions.

This approach is applied to both the analysis of total consumption and Super Peak consumption (Sections 3.1 and 3.2). The analysis of the effect the PowerShift tariff had on total consumption summer peak days in comparison to the A1 tariff (Section 3.3) and the profiling of the top savers (Section 3.4) are also covered in this section.

The use of both internal and external controls in the analysis meant that it was possible to estimate the diffusion or ripple effect whereby households in the target area were influenced to reduce their energy demand even though they were not formal participants. This was estimated at 1.6%.

3.1 Total Consumption

For each intervention, Table 5 shows the number of households included in the evaluation (i.e. the number of households who took up the measure and were eligible for analysis[16]), the estimated total annual consumption across all of these households in the presence and absence of the intervention, and the corresponding absolute and relative savings attributed. Note that as the households used in the evaluation of each measure vary, it is only appropriate to consider the relative or percentage savings when comparing different interventions. The relative savings are also presented graphically in Figure 1 (page 19). All of these results are statistically significant at the 95% confidence level.

[16] See Section 2.1.3 for reasons why some participating households were excluded.

Intervention	Number of Households	With Intervention (MWh)	Without Intervention (MWh)	Savings (MWh)	Savings (%)
Living Smart	4,985	31,684	34,264	2,580	7.5
Living Smart (full participants)	3,705	23,490	25,520	2,030	8.0
HEC	2,593	16,371	18,672	2,301	12.3
IHD (all mailed)	2,081	13,742	13,894	152	1.1
IHD (paired)	1,137	7,408	7,523	115	1.5
PV	440	1,905	3,214	1,309	40.7
PowerShift	351	2,403	2,533	130	5.1
SHW (electric-to-electric)	235	1,585	1,937	352	18.2

Table 5. Total consumption savings associated with individual PSC interventions.

Unsurprisingly, PSC PV exhibited the greatest effect with households achieving a 41% reduction in their electricity consumption. SHW (electric-to-electric) achieved the next greatest saving at 18%, followed by HEC at 12%. The Living Smart programme showed a 7% to 8% saving, depending on the level of participation, while a 5% saving could be attributed to the PowerShift tariff. The effect for IHDs was small, with those participants who paired the device experiencing less than a 2% reduction in consumption.

The average direct saving associated with the non-PSC PV systems is 28% (based on 1,535 participant households installing these systems), which is lower than the PSC PV systems savings of 41%. This is likely due to the fact that the PSC PV systems were typically 2.2kW compared to the 1.5kW typically installed for non-PSC PV systems. These had a significant take up with some 2,000 PC systems (both PSC and non-PSC) being installed in the approximately 9,000 participant households included in the analysis.

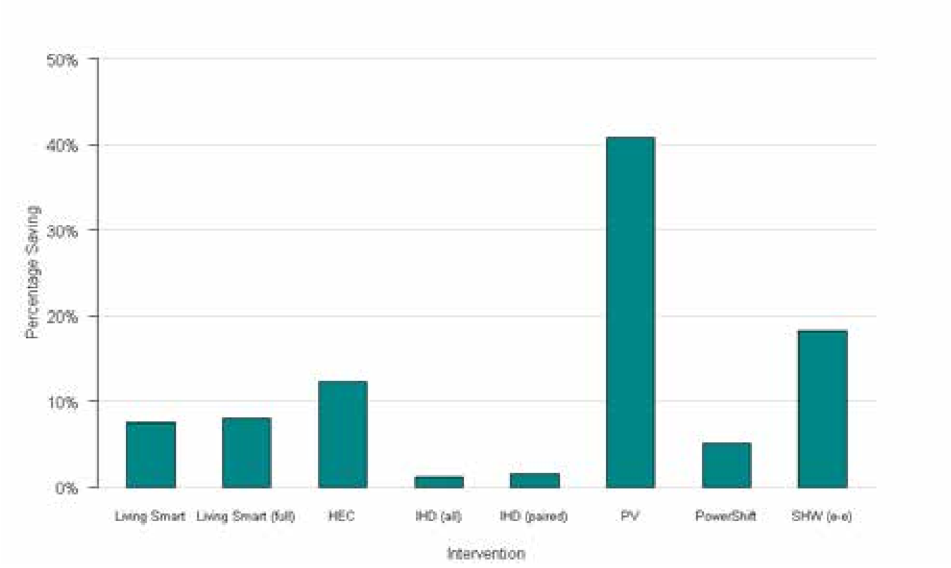

Figure 1. Total consumption savings associated with individual PSC interventions.

Full participants of Living Smart are defined as those who completed the five eco-coaching calls. Those who signed up to Living Smart and received at least one eco-coaching call, but did not complete all five eco-coaching calls, are included in the 'all participants' list along with the full participants. Therefore, 'full participants' are a subset of 'all participants'. The Living Smart results (for both all and full participants) are the combined effect of the eco-coaching and the other interventions that a household signed up to. It is assumed for the analysis that the household signed up to these interventions as a consequence of being part of Living Smart, regardless of whether a household may have taken up another intervention without the encouragement of Living Smart. This is a limitation in the analysis of a real-world trial such as Perth Solar City. Particularly important in this aspect is that the effect of non-PSC PV systems installed by households (participating in Living Smart) should be attributed to Living Smart. The same argument is applied to the evaluation of HEC, noting that Living Smart effects are not attributed to HEC for these households (as noted in Section 2.4).

The proportion of Living Smart and HEC participants that also participated in the other interventions are given in Table 6 below. It is clear from Table 6 that despite the overlap between the two groups, the main reason HEC achieved a higher saving than Living Smart overall is because more than double the proportion of HEC households installed a PV system of some description (29% versus 14%). Therefore, either HEC was a better mechanism for encouraging households to take up PV (regardless of whether it was a PSC PV system or not) or those households were naturally more likely to take up PV. It is likely that it is a combination of the two and provides some insight into the type of household that took up HEC.

Intervention	Living Smart Participants	HEC Participants
Living Smart (all participants)	100.0%	43.8%
Living Smart (full participants)	74.3%	39.2%
HEC	22.8%	100.0%
IHD (paired)	4.2%	6.2%
IHD (all)	7.1%	8.1%
PV	1.4%	5.1%
Non-PSC PV	12.8%	24.1%
PowerShift	1.3%	1.8%
SHW (electric-to-electric)	0.3%	1.3%

Table 6. Proportion of the Living Smart and HEC participants that took up the different interventions.

To understand the effect of a household receiving a HEC and being part of Living Smart (where *all* Living Smart participants are considered), Living Smart participants who did not receive a HEC were compared to those that did receive a HEC. Similarly, households that received a HEC but did not participate in Living Smart were also compared against participants of Living Smart that received a HEC. A further comparison of these groups with Living Smart participants who received a HEC **and** who also had a paired IHD was also undertaken. PowerShift and IHD (paired) in combination were also evaluated. Table 7 presents the results from these comparisons and the savings are also displayed in Figure 2. The overall results for full participants of Living Smart, HEC, paired IHDs and PowerShift are also given as a reference (and are identical to those given in Table 5).

Intervention	Number of Households	With Intervention (MWh)	Without Intervention (MWh)	Savings (MWh)	Savings (%)
Living Smart no HEC	3,848	16,963	18,233	1,271	6.7
HEC no Living Smart	1,456	9,844	11,693	1,849	16.3
Living Smart & HEC	1,137	6,527	7,287	759	10.2
Living Smart, HEC & IHD	76	392	496	104	21.4
IHD & PowerShift	165	1,093	1,167	74	6.3
Living Smart – Overall	4,985	31,684	34,264	2,580	7.5
HEC – Overall	2,593	16,371	18,979	2,608	13.7
IHD (paired) – Overall	1,137	7,408	7,523	115	1.5
PowerShift – Overall	351	2,403	2,533	130	5.1

Table 7. Total consumption savings associated with PSC interventions in combination (using all Living Smart participants and paired IHDs).

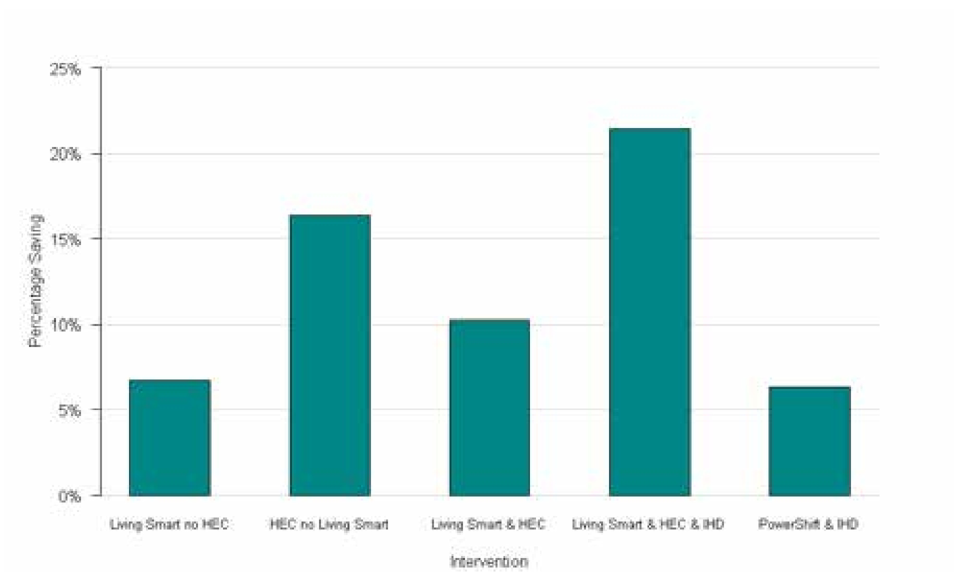

Figure 2. Total consumption savings associated with PSC interventions in combination (using all Living Smart participants and paired IHDs).

Households that had a paired IHD in conjunction with the PowerShift tariff were found to save, on average, 6.3% – similar to the 6.6% obtained by summing the two individual effects for these together. This is suggestive that these effects are essentially additive and that there is a benefit from having the two products in tandem. A similar effect would be expected for savings to Super Peak consumption (see below).

Comparing Living Smart and HEC and the combination of the two at a household is a little more complicated. Caution is required in making direct comparisons between the cohorts identified in Table 7 – the savings seen for these also include the effects of the other interventions the households in these cohorts signed up to. If the distributions of these additional interventions are not the same across the cohorts, then a cohort effect is interfering in the analysis.

A cleaner approach, using the same cohorts, is to estimate the direct effects for Living Smart, HEC and Living Smart and HEC *without* the effects of the other interventions included. This analysis showed that behavioural change savings for Living Smart participants (with no HEC) was 4% compared to the 8% savings for HEC participants with no Living Smart. The saving for households who participated in both HEC and Living Smart was 5%, indicating that there was **no additional benefit** for a household receiving HEC *and* being on the Living Smart programme. Any differences observed between the two groups in Table 7 are a consequence of the different interventions that the households participated in. However, it is likely that there is a bias associated with the type of household that chose to only receive a HEC and not participate in Living Smart versus those that chose to participate in Living Smart (with or without HEC) – again, suggestive that there are distinct differences between the two cohorts. This isn't a surprise; there will be some households who will be more responsive to HEC – a short, detailed consultation – compared to other households who prefer Living Smart – a long term, education programme which provides consistent messages and feedback to encourage energy reduction.

3.2 Super Peak

Whilst the primary focus of the analysis of Super Peak consumption is the effect the PowerShift tariff and IHDs have had, the effects the other interventions had on Super Peak consumption were also investigated. Using the same methodology for the total consumption, a summary of the savings achieved to Super Peak consumption is given in Table 8 below, and graphically in Figure 3. All results are statistically significant at the 95% confidence level.

Photovoltaic systems and solar hot water systems had the biggest effect on Super Peak consumption, continuing the pattern observed for the total consumption. This is to be expected – the Super Peak period is from 2pm to 8pm (weekdays), during a significant proportion of which it is expected that solar power is at its peak. However, the number of households available for the analysis of the effect PV and SHW have on Super Peak consumption is small at just 72 and 28 respectively. The results for these two interventions should be treated as indicative rather than absolute; they demonstrate that whilst there is a clear effect, there is insufficient evidence to allow inferences on the savings made to Super Peak consumption in a wider community to be made. For comparison, there were 512 households that installed a non-PSC PV system which saved (on average) these households 13.8% of their Super Peak consumption.

Living Smart and HEC households achieved similar savings of between 6 and 8%, with full Living Smart participants being much closer to the HEC savings. Whilst the

Living Smart savings align well with the savings observed for overall consumption, the HEC savings are lower, suggesting that HEC has a smaller effect on Super Peak consumption than total consumption. Removing the effects of the other interventions that these households may have had (i.e. retaining the behavioural change component only), the effects Living Smart and HEC had on Super Peak consumption were both not found to be statistically significant, meaning that any savings observed were a consequence of the other interventions those households participated in. This means that these households were potentially reliant on these interventions to reduce their Super Peak consumption, whilst both Living Smart and HEC achieved an additional boost to savings (beyond the effect of the other interventions) for total consumption.

Intervention	Number of Households	With Intervention (MWh)	Without Intervention (MWh)	Savings (MWh)	Savings (%)
Living Smart	1,365	1,795	1,918	124	6.4
Living Smart (full participants)	855	1,125	1,211	86	7.1
HEC	541	742	804	62	7.7
IHD (all mailed)	2,081	2,848	2,948	100	3.4
IHD (paired)	1,137	1,538	1,616	78	4.8
PV	72	73	97	24	25.0
PowerShift	232	294	322	29	8.9
SHW (electric-to-electric)	28	42	52	10	18.5

Table 8. Super peak consumption savings associated with individual PSC interventions.

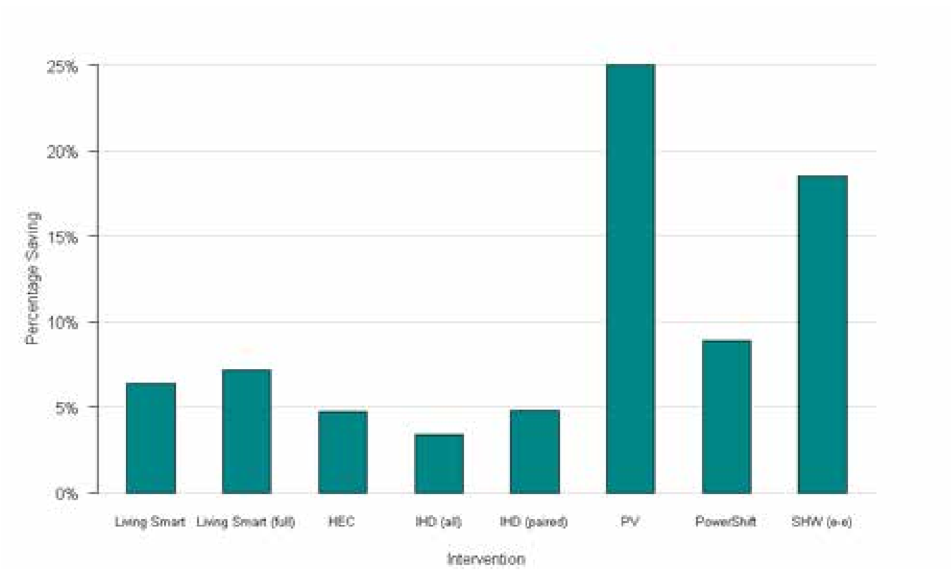

Figure 3. Super peak consumption savings associated with individual PSC interventions.

As intended, the PowerShift tariff had a bigger impact on Super Peak consumption than total consumption, reducing Super Peak consumption by 9%. Similarly, IHDs had a bigger effect on Super Peak with a saving of 5% for the devices that were paired. We can see from Table 9 below that the combined effect of these is a saving of around 13%. These savings are in line with expectations as these interventions were tailored specifically for reducing Super Peak consumption – particularly the combination of the PowerShift tariff and the instantaneous feedback provided by the IHD. The results also show that there is almost no loss in potential savings when the two are combined compared to their individual effects, meaning it is advantageous for a household to have both of these. Indeed, over 70% of the households in the analysis that took up PowerShift also used a paired IHD.

Whilst only a small number of households were participants of Living Smart, HEC and had a paired IHD, they had an average saving of 17%, suggesting that the feedback provided by the IHD helps boost the effect of Living Smart and HEC.

All of these results are presented in Table 9 and Figure 4 below.

Intervention	Number of Households	With Intervention (MWh)	Without Intervention (MWh)	Savings (MWh)	Savings (%)
PowerShift no IHD	67	82	92	10	10.7
IHD no PowerShift	972	1,326	1,398	72	5.2
PowerShift & IHD	165	212	244	32	13.1
Living Smart & HEC & IHD	76	85	101	16	16.6

Table 9. Super peak consumption savings associated with PSC interventions in combination (restricted to full Living Smart participants and paired IHDs).

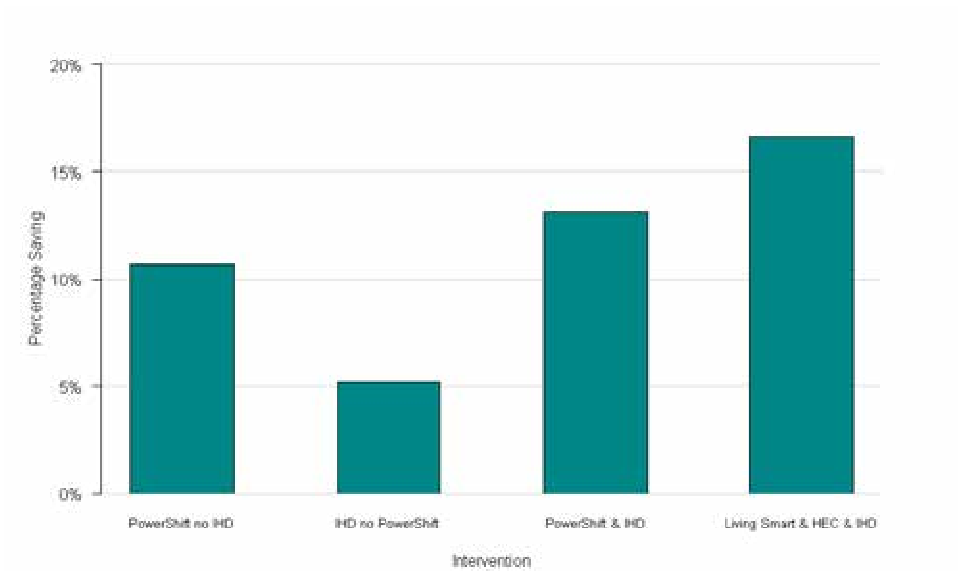

Figure 4. Super peak consumption savings associated with PSC interventions in combination (restricted to full Living Smart participants and paired IHDs).

3.3 Summer Peak Days

The summer peak days[17] analysis compared the Super Peak energy consumed on the summer peak days by the PowerShift tariff customers against those on the A1 tariff. It is assumed that all households not on the PowerShift tariff or directly identifiable as being on the Smart Power tariff are on the standard A1 tariff.

The approach Data Analysis Australia used is defined in Section 2.3.1. Customers on the PowerShift tariff *reduced* their daily Super Peak consumption by an average of **1.1 kWh** compared to their estimated consumption had they remained on the A1 tariff. As the average summer peak day Super Peak consumption for these households was 9.4 kWh, this translates into a saving of **11.8%**.

However, the average summer peak day Super Peak consumption for A1 households was 8.8 kWh meaning that the households that took up PowerShift had a larger Super Peak consumption than the A1 households. This is suggestive that these households had a greater incentive to change their consumption behaviour during the Super Peak period when switching to the PowerShift tariff. Therefore, the results should be considered an upper bound as it is not clear that such savings would be observed in the other A1 households should they switch to the PowerShift tariff.

3.4 Top Savers

The total relative savings achieved by each of the participating households was estimated (see Section 2.5). These savings include the effect of all the interventions that a household participated in – it is not possible to apportion the savings to the different interventions at the household level.

A profile of the top saving households that participated in Living Smart, HEC, PowerShift and IHDs (paired only) is presented below. Some common traits of these top saving households are that PV (both PSC and non-PSC) is highly prevalent, and that the majority of these households participated in a number of other interventions. Furthermore, the residents of these households were generally older (median household age) and, importantly, earned more (median household income), possibly explaining why there was a significant take-up of PV as they were the households that could afford the capital costs associated with the purchase.

Whilst the top saving households generally had a larger average consumption prior to an intervention, they were not limited to the larger consumers. A range of consumers from as low as 9 units per day to as high as 100 units per day were found to be top savers.

There were a number of households that may not have had a sufficient number of readings either before or after an intervention (or at all) to allow a reliable estimate of their pre- or post-intervention consumption to be made. For this reason, the profiling

[17] Only summer peak days for the 2011 and 2012 summers were considered and these were defined by Western Power.

is unable to use the complete number of participants for an intervention used in the main analysis.

3.4.1 Living Smart

For Living Smart, the best saving households (the top 10%) achieved an average saving of 33%, compared to the top 50% who saved 17%. This difference was primarily due to the take up in PV (both PSC and non-PSC); over half (54%) of the top 10% savers had PV system, compared to just only around a quarter (24%) of the top 50% having a PV system.

In general, the Living Smart top savers didn't participate in many of the other interventions (beyond PV), with over a third of the top 10% not participating in any other intervention whatsoever. This rises to nearly 60% for the top 50%, meaning the majority of these households only relied on the information provided by the eco-coaching calls to help them reduce their electricity consumption.

Surprisingly, there was almost no difference between the household demographics of these two top saver groups, and indeed to the rest of the Living Smart participants. Therefore, the Living Smart households that saved the most were generally the households that installed a PV system.

3.4.2 Home Eco Consultations

The top 10% savers of HEC households had an average saving of 45% – with the top five households saving in excess of 80% – whilst the top 50% of savers had an average saving of 23%. Of the top 10% saving households, 8 out of 10 of these installed a PV system, while less than half (46%) of the top 50% saving household installed a PV system.

Living Smart engagement was lower with the top 10% savers (22%) than the top 50% savers (39%), but nearly 95% of these were full participants – much higher than the overall average of around 75%. This suggests that these households that participated were committed to completing the Living Smart programme.

It is also not surprising that 7 out of 8 of the top 10% savers participated in another intervention. That was primarily PV and/or Living Smart, with only around 1 in 12 households with a paired IHD.

The top 10% households were generally older and more affluent, suggesting that they were better placed to install a PV system as they were more likely to be able to afford the capital costs associated, and it was PV that was the biggest influence on whether a household was part of the best savers or not.

3.4.3 In-Home Displays

The best performing households (top 10%) with an in-home display were able to achieve savings of 40%, compared to 21% for the top 50% savers. Again, this is driven by the take-up of PV, with over two-thirds of the top 10% savers installing a PV system (both PSC and non-PSC) compared to 38% for the top 50% savers.

Interestingly, fewer top 10% households were on the PowerShift tariff compared to the top 50% (10% and 14% respectively). However, more of the top 10% households were involved in Living Smart and/or HEC (38%) compared to the top 50% savers (27%). Also, around 4 out of 5 top 10% households were involved in at least one other intervention compared to 3 out of 5 of the top 50% households.

There was almost no difference between the household demographics of these two top saver groups, and indeed to the rest of the IHD participants. Therefore, the IHD households that saved the most were generally the households that installed a PV system.

3.4.4 PowerShift

For the households that took up the PowerShift tariff, the top 10% savers achieved an average saving of 45%, compared to 24% for the top 50% savers. Again, this was driven by the take-up of PV which was 72% for the top 10% and 43% for the top 50%. Interestingly, none of the top 10% of savers installed a PSC PV system.

All of the top 10% savers participated in at least one other intervention compared to 9 out of 10 of the top 50% households. Participation in Living Smart and/or HEC was approximately the same for both groups of savers at around a quarter of the households.

Interestingly, whilst the top 10% saving household were generally older, the top 50% had a larger household income, suggesting that those that earned less were more likely to take-up PowerShift to take advantage of the additional cost reductions the tariff could offer if Super Peak consumption was reduced.

4. Summary

In general, the interventions that formed part of the Perth Solar City programme were effective in reducing electricity consumption. Some had smaller contributions than others in reducing overall electricity consumption, such as IHD and PowerShift, but these had bigger contributions in reducing Super Peak consumption. The single biggest effect on reducing a household's electricity consumption is PV. The PV systems offered through the Perth Solar City programme achieved average household savings of 41%.

The take-up of PV is also the primary reason for the combined effect of the households receiving a home eco-consultation being greater than the Living Smart households – twice as many of HEC households installed a PV compared to the Living Smart households. Whilst around 20% of Living Smart household also received a HEC, it is clear that the increased prevalence in PV is driving the overall savings for these groups, where HEC households saved 12% compared to 8% for Living Smart households. Unfortunately, as all households chose whether to participate in an intervention or not (i.e. self-selecting), it is not possible to tell whether home eco-consultations are a better mechanism for encouraging the install of PV compared to Living Smart, or whether there is a bias inherent in the type of household that received a HEC is already predisposed to installing PV.

Whilst both the in-home displays and PowerShift tariffs had limited effect on total consumption (1.5% and 5% respectively), they both had a much bigger impact on Super Peak consumption, achieving savings of 5% and 9% respectively. Furthermore, these effects were essentially found to be additive in the households that had both. PowerShift also helped households save around 12% of their Super Peak consumption on summer peak days compared to those that were on the standard A1 tariff.

Some common traits of the top saving households are that PV (both PSC and non-PSC) is highly prevalent, and that the majority of these households participated in a number of other interventions. Furthermore, these households were generally older (median household age) and, importantly, earned more (median household income), possibly explaining why there was a significant take-up of PV as they were the households that could afford the capital costs associated.

Finally, it was possible to estimate the diffusion (or ripple) effect (caused by the promotion and activity of Perth Solar City) on households in the target area which were influenced to reduce their total energy demand even though they were not formal participants. This was estimated at 1.6%.

Appendix A. Auxiliary Analysis Results

Presented below is a comparison of average daily consumptions for the 12 months before Living Smart began (01/06/2009 to 31/05/2010), during Living Smart (01/06/2010 to 31/05/2011) and after Living Smart (01/06/2011 to 31/05/2012) for each of the interventions. Whilst the three periods are not exact (Living Smart took place over a 13 month period), whole years have been used to avoid the effect of seasonality and average daily consumptions are based on meter reads that fall completely within the specified periods. Those meter reads that straddle a period have been excluded for the purposes of this analysis. The behaviours of the internal and external controls during these periods have been provided for context – they give indicative effects of the weather from period to period as any apparent effect in these analyses for the interventions may include weather effects (either enhancing or dampening the apparent effect).

It should be stressed that the purpose of this approach is to provide a simplistic analysis that can be used as a reference to the more complicated, main analysis. The results here should only be treated as indicative of the savings actually achieved as part of the PSC programme.

As can be seen in Table 10 and Figure 5, every intervention saw a response when comparing the average daily consumptions both during and after the interventions with before the interventions. Unsurprisingly, PV provided the greatest savings in average household daily consumption – reducing average daily consumption down from 18.8 kWh to 14.6 kWh during Living Smart to 9.0 kWh after Living Smart.

Intervention	Before Living Smart	During Living Smart	After Living Smart
HEC	18.8	17.5	14.9
IHD	18.5	17.3	15.6
PV	18.8	14.6	9.0
SHW	20.8	19.2	16.7
PowerShift	21.4	19.3	18.0
Living Smart	17.5	16.5	14.8
Internal Control	17.6	17.1	15.6
External Control	16.5	16.2	14.8

Table 10. Average daily consumption (in kWh) for participants in each intervention plus controls before, during, and after Living Smart.

The comparative analysis also showed that both control groups also had a reduction in average household daily consumption, reducing by approximately 2.5% during Living Smart, and reducing by approximately 8.5% when comparing before Living Smart to after Living Smart. This reduction may be due to variations in the weather and/or other underlying factors.

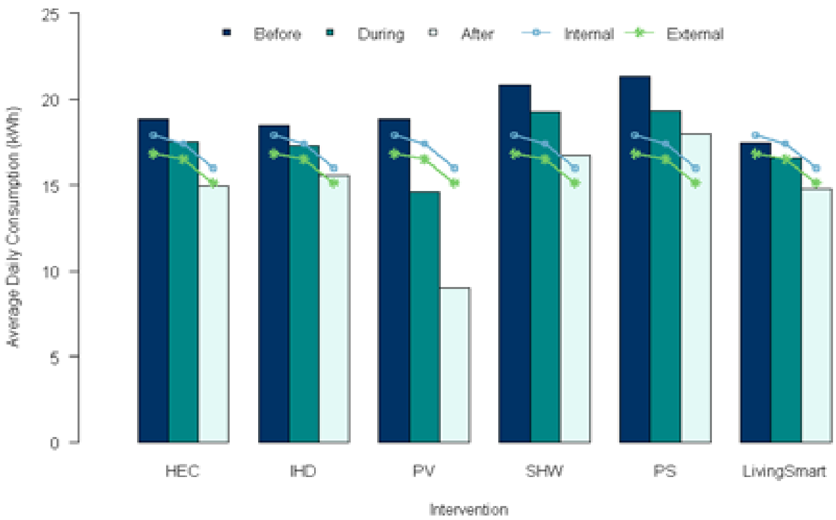

Figure 5. Average daily consumption (in kWh) for interventions and controls before, during, and after Living Smart.

Figure 6 presents the relative percentage savings in average daily consumption for each of the interventions (using the households that participated in the particular intervention). The savings have been adjusted for the 'year' effect as seen in the controls – that is the relative savings have been adjusted downwards by 2.5% (during vs. before) and 8.5% (after vs. before). Despite these downward adjustments, all the interventions have had a positive impact on the average daily household consumption with PV systems having the highest impact, demonstrating a saving of more than 40% when comparing the average daily consumptions of those that took up PV post-Living Smart to their consumptions pre-Living Smart.

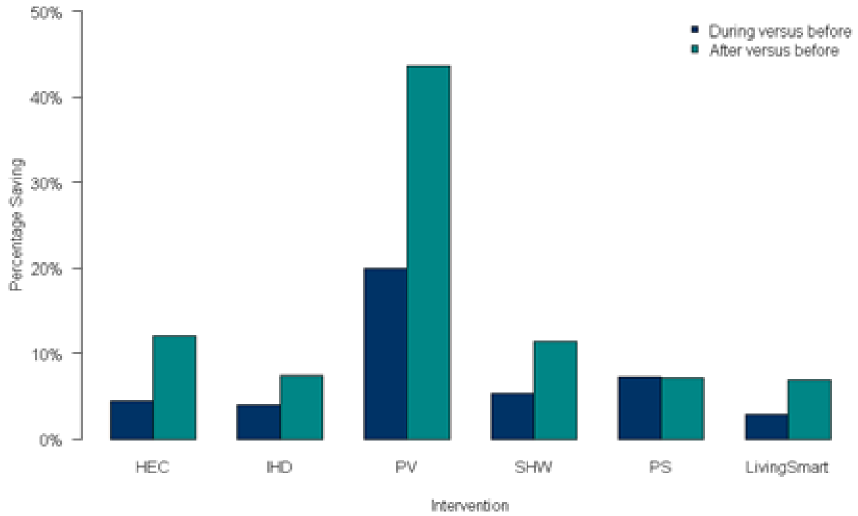

Figure 6. Percentage savings in average daily household consumption when comparing both during and after Living Smart consumptions to before Living Smart consumptions.

The percentage savings given in Figure 6 are provided in Table 11 below.

Intervention	During vs. Before Living Smart	After vs. Before Living Smart
HEC	4.39%	12.14%
IHD	4.00%	7.36%
PV	19.93%	43.65%
SHW	5.37%	11.39%
PowerShift Tariff	7.26%	7.20%
Living Smart	2.81%	6.96%

Table 11. Percentage savings for participants in each intervention (correcting for changes in controls' behaviour) for during vs. before Living Smart and after vs. before Living Smart.

It is evident that the savings for all interventions are significantly greater in the period after Living Smart than compared to during Living Smart, with the exception of PowerShift which is fairly consistent throughout two periods. This suggests that the savings took some time to take hold within the Living Smart period – an unsurprising result as many households did not sign up to the interventions or have their retrofits installed at the start of the 'during' period, but rather it was an ongoing process (and still is).

Looking at the savings observed after Living Smart compared to before Living Smart, we can see that the two main interventions of HEC and Living Smart itself saved **12.14%** and **6.96%** respectively.

Appendix B. Parameterisation of Interventions

Some interventions only have an active period, yet the PSC programme office needs to know the long-term effects, not just the short-term effects during the active period. For example, Living Smart was only active for 13 months, yet the objective of evaluation is to understand the long-term effects on a household, not the effect during the coaching period. Additionally, it is known that many household installed PV systems as a consequence of being part of Living Smart – yet many did not choose the PV systems offered as part of the PSC programme. However, the evaluation of Living Smart should include the effects of these non-PSC PV systems and so they need to be clearly identified and incorporated into the modelling. A summary of how the interventions were parameterised is provided below:

- HEC: A single indicator variable representing the proportion of a metering period from when HEC took place.
- Living Smart: Two indicator variables, the first represents the active period[18] whilst the second represents the period since Living Smart took place. Therefore, the first will be a zero post 31st May 2011, whilst the second will continue to be a one beyond this date.
- PowerShift: A single indicator variable representing the proportion of a metering period that the PowerShift tariff was active (withdrawal dates were known).
- IHD: Two indicator variables, the first representing the period from when a household was mailed an IHD, the second representing the period from when the household paired the IHD.
- PV: Two indicator variables, the first representing the period from when a PSC PV system was installed, the second representing the period from when a non-PSC PV system was installed.
- SHW: Five indicator variables, the first three representing the period from when the replacement SHW was installed – one each for whether the previous system was electric, gas or other/unknown. The other two represent the period from when the replacement SHW was installed – one each for the replacement system being electric boosted or gas boosted. As well as providing estimates of savings, this gives direct estimates of electricity consumed by various systems.

Living Smart and HEC were interacted with all interventions plus PowerShift and IHD (giving three-way interactions). The only other interaction included was the two-way interaction of PowerShift and IHD – no other interactions were required for the purposes of the evaluation. All the intervention variables listed above were used in the interactions, meaning an interaction represents the period from which *both* of the interventions were active.

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[18] This was fixed as 01/05/2010 to 31/05/2011 for all participating households (regardless of participation levels).

Appendix C. Parameter Estimates

The tables below provide the parameter estimates of the fixed effects of the two statistical regression models used for the main results given in Sections 3.1 and 3.2. Both models included a random effect term for the household (these coefficients are not displayed as there were approximately 30,000 households included in the analysis).

Parameter Group	Parameter	Estimate	Standard Error	p-Value	Statistically Significant?
	Intercept	-7.588	2.078	0.0003	Yes
Trend	trend	0.007	0.000	<.0001	Yes
	trend*trend	0.000	0.000	<.0001	Yes
Target & Participation groups	target	-1.698	0.157	<.0001	Yes
	target*participant	-0.088	0.142	0.5332	No
	diffusion	-0.274	0.037	<.0001	Yes
Smart Meter	SM	0.028	0.040	0.4854	No
ABS	median_age	0.127	0.010	<.0001	Yes
	median_HH_wk_income	0.006	0.000	<.0001	Yes
	ave_HH_size	0.826	0.075	<.0001	Yes
Intervention Main Effects	Living Smart (LS)	-0.579	0.055	<.0001	Yes
	Living Smart active period (LSac)	0.414	0.049	<.0001	Yes
	HEC	-1.144	0.098	<.0001	Yes
	IHD (paired) (IHD)	-0.312	0.079	<.0001	Yes
	IHD (mailed) (IHDmail)	-0.172	0.057	0.0027	Yes
	PowerShift active period (PSac)	-0.830	0.169	<.0001	Yes
	PSC PV (PVsc)	-8.761	0.169	<.0001	Yes
	Non-PSC PV (PVnsc)	-4.347	0.097	<.0001	Yes
	fromSHWe	-6.737	0.874	<.0001	Yes
	fromSHWg	-0.786	0.850	0.3550	No
	fromSHWn	-2.325	0.886	0.0087	Yes
	toSHWe	2.426	0.856	0.0046	Yes
	Non-PSC PV and non-participants (PVnsc*participant)	-2.006	0.125	<.0001	Yes
Intervention Interactions	LSHEC	1.234	0.142	<.0001	Yes
	LSacHEC	0.087	0.124	0.4815	No
	IHDPSac	0.783	0.221	0.0004	Yes
	LSIHD	0.663	0.210	0.0016	Yes
	LSIHDmail	0.156	0.157	0.3209	No
	LSPSac	0.570	0.487	0.2415	No
	LSPVsc	1.790	0.428	<.0001	Yes
	LSPVnsc	-0.884	0.169	<.0001	Yes
	LSfromSHWe	6.597	0.970	<.0001	Yes

	LSfromSHWg	1.372	0.543	0.0115	Yes
	LSfromSHWn	2.506	1.137	0.0275	Yes
	LSacIHD	-2.139	0.695	0.0021	Yes
	LSacIHDmail	0.202	0.428	0.6373	No
	LSacPS	3.108	1.215	0.0105	Yes
	LSacPSac	-3.058	1.358	0.0244	Yes
	LSacPVsc	-1.218	0.525	0.0203	Yes
	LSacPVnsc	0.345	0.210	0.1002	No
	LSacfromSHWe	-7.868	1.327	<.0001	Yes
	LSacfromSHWg	-3.298	0.680	<.0001	Yes
	LSacfromSHWn	-5.035	1.008	<.0001	Yes
	HECIHD	0.985	0.277	0.0004	Yes
	HECIHDmail	0.555	0.252	0.0276	Yes
	HECPSac	-0.554	1.173	0.6364	No
	HECPVsc	2.252	0.330	<.0001	Yes
	HECPVnsc	-1.943	0.185	<.0001	Yes
	HECfromSHWe	3.592	1.856	0.0529	No
	HECfromSHWg	-0.838	1.844	0.6494	No
	HECfromSHWn	2.885	1.560	0.0644	No
	HECtoSHWe	-2.660	1.780	0.1351	No
	LSIHDPSac	-0.489	0.649	0.4510	No
	LSacIHDPSac	1.461	1.027	0.1550	No
	HECIHDPSac	-0.728	1.266	0.5656	No
	LSHECIHD	-2.066	0.460	<.0001	Yes
	LSHECIHDmail	0.587	0.400	0.1428	No
	LSHECPSac	1.619	1.441	0.2611	No
	LSHECPVsc	-3.096	0.674	<.0001	Yes
	LSHECPVnsc	0.847	0.303	0.0052	Yes
	LSHECfromSHWe	-6.763	1.578	<.0001	Yes
	LSHECfromSHWg	0.909	1.097	0.4072	No
	LSHECfromSHWn	-0.885	1.871	0.6364	No
	LSacHECIHD	3.651	1.325	0.0059	Yes
	LSacHECIHDmail	-2.133	0.965	0.0271	Yes
	LSacHECPSac	-2.704	1.224	0.0272	Yes
	LSacHECPVsc	0.576	0.791	0.4667	No
	LSacHECPVnsc	-0.328	0.411	0.4243	No
	LSacHECfromSHWe	8.713	2.606	0.0008	Yes
	LSacHECfromSHWg	2.019	1.061	0.0569	No
	LSacHECfromSHWn	2.347	2.962	0.4283	No
	LSHECIHDPSac	-1.741	1.653	0.2924	No
	LSacHECIHDPSac	0.523	1.917	0.7850	No
Weather Main Effects	max	-0.596	0.076	<.0001	Yes
	min	0.336	0.011	<.0001	Yes

	rain	-0.015	0.049	0.7593	No
	hot35	1.099	0.043	<.0001	Yes
	hot25	-0.482	0.161	0.0027	Yes
	rainday	3.293	0.307	<.0001	Yes
	rainsqrt	-0.308	0.272	0.2567	No
	humid9am	-0.077	0.006	<.0001	Yes
	humid3pm	0.023	0.006	0.0002	Yes
Seasonality Main Effects	sa1	24.491	2.551	<.0001	Yes
	sa2	21.823	3.109	<.0001	Yes
	sa3	-7.401	2.397	0.0020	Yes
	sa4	-23.758	1.826	<.0001	Yes
	sa5	-8.230	1.399	<.0001	Yes
	sa6	2.753	0.765	0.0003	Yes
	ca1	12.828	2.804	<.0001	Yes
	ca2	-13.423	2.028	<.0001	Yes
	ca3	-22.343	2.418	<.0001	Yes
	ca4	-9.828	2.232	<.0001	Yes
	ca5	5.538	1.565	0.0004	Yes
	ca6	5.339	0.796	<.0001	Yes
Weather & Seasonality Interactions	max*ca1	-0.485	0.113	<.0001	Yes
	max*ca2	0.730	0.082	<.0001	Yes
	max*ca3	1.068	0.098	<.0001	Yes
	max*ca4	0.483	0.091	<.0001	Yes
	max*ca5	-0.269	0.064	<.0001	Yes
	max*ca6	-0.250	0.032	<.0001	Yes
	max*sa1	-0.930	0.102	<.0001	Yes
	max*sa2	-0.798	0.125	<.0001	Yes
	max*sa3	0.414	0.096	<.0001	Yes
	max*sa4	1.062	0.075	<.0001	Yes
	max*sa5	0.581	0.057	<.0001	Yes
	max*sa6	-0.118	0.031	0.0002	Yes
	min*ca1	0.416	0.014	<.0001	Yes
	min*ca2	-0.120	0.014	<.0001	Yes
	min*ca3	-0.413	0.015	<.0001	Yes
	min*ca4	-0.167	0.016	<.0001	Yes
	min*ca5	0.036	0.016	0.0215	Yes
	min*ca6	0.033	0.014	0.0171	Yes
	min*sa1	0.384	0.015	<.0001	Yes
	min*sa2	0.308	0.016	<.0001	Yes
	min*sa3	-0.065	0.015	<.0001	Yes
	min*sa4	-0.269	0.015	<.0001	Yes
	min*sa5	-0.257	0.015	<.0001	Yes
	min*sa6	0.071	0.016	<.0001	Yes

rain*ca1	0.313	0.071	<.0001	Yes
rain*ca2	0.549	0.076	<.0001	Yes
rain*ca3	0.439	0.082	<.0001	Yes
rain*ca4	-0.154	0.091	0.0895	No
rain*ca5	0.338	0.089	0.0002	Yes
rain*ca6	0.616	0.061	<.0001	Yes
rain*sa1	-0.098	0.065	0.1330	No
rain*sa2	-0.313	0.070	<.0001	Yes
rain*sa3	-0.611	0.073	<.0001	Yes
rain*sa4	-0.198	0.070	0.0045	Yes
rain*sa5	-0.076	0.075	0.3150	No
rain*sa6	-0.009	0.071	0.8970	No
hot25*ca1	1.308	0.269	<.0001	Yes
hot25*ca2	-1.485	0.203	<.0001	Yes
hot25*ca3	-0.547	0.156	0.0005	Yes
hot25*ca4	-0.372	0.138	0.0069	Yes
hot25*ca5	0.579	0.073	<.0001	Yes
hot25*ca6	0.180	0.033	<.0001	Yes
hot25*sa1	1.052	0.135	<.0001	Yes
hot25*sa2	-0.257	0.185	0.1630	No
hot25*sa3	-0.160	0.180	0.3765	No
hot25*sa4	-1.089	0.143	<.0001	Yes
hot25*sa5	-0.686	0.077	<.0001	Yes
hot25*sa6	0.147	0.032	<.0001	Yes
rainday*ca1	6.787	0.460	<.0001	Yes
rainday*ca2	4.996	0.446	<.0001	Yes
rainday*ca3	3.823	0.473	<.0001	Yes
rainday*ca4	-0.515	0.495	0.2982	No
rainday*ca5	2.119	0.516	<.0001	Yes
rainday*ca6	1.299	0.371	0.0005	Yes
rainday*sa1	1.538	0.355	<.0001	Yes
rainday*sa2	0.364	0.363	0.3170	No
rainday*sa3	-1.591	0.356	<.0001	Yes
rainday*sa4	-1.260	0.405	0.0019	Yes
rainday*sa5	2.397	0.376	<.0001	Yes
rainday*sa6	-2.442	0.417	<.0001	Yes
rainsqrt*ca1	-1.490	0.383	0.0001	Yes
rainsqrt*ca2	-2.233	0.395	<.0001	Yes
rainsqrt*ca3	-2.162	0.432	<.0001	Yes
rainsqrt*ca4	0.573	0.453	0.2059	No
rainsqrt*ca5	-1.541	0.466	0.0009	Yes
rainsqrt*ca6	-2.841	0.320	<.0001	Yes
rainsqrt*sa1	0.744	0.357	0.0375	Yes

	rainsqrt*sa2	2.324	0.367	<.0001	Yes
	rainsqrt*sa3	3.607	0.353	<.0001	Yes
	rainsqrt*sa4	1.691	0.371	<.0001	Yes
	rainsqrt*sa5	0.250	0.365	0.4930	No
	rainsqrt*sa6	0.197	0.374	0.5992	No
	hot25*humid9am	0.008	0.002	<.0001	Yes
	hot25*humid3pm	-0.011	0.002	<.0001	Yes
	humid9am*ca1	-0.129	0.008	<.0001	Yes
	humid9am*ca2	-0.046	0.004	<.0001	Yes
	humid9am*ca3	-0.035	0.004	<.0001	Yes
	humid9am*ca4	-0.015	0.004	0.0002	Yes
	humid9am*ca5	-0.042	0.005	<.0001	Yes
	humid9am*ca6	-0.094	0.004	<.0001	Yes
	humid9am*sa1	-0.097	0.005	<.0001	Yes
	humid9am*sa2	-0.016	0.004	0.0003	Yes
	humid9am*sa3	0.016	0.004	<.0001	Yes
	humid9am*sa4	0.066	0.004	<.0001	Yes
	humid9am*sa5	0.001	0.004	0.7300	No
	humid9am*sa6	-0.003	0.004	0.4636	No
	humid3pm*ca1	0.034	0.008	<.0001	Yes
	humid3pm*ca2	0.034	0.004	<.0001	Yes
	humid3pm*ca3	0.048	0.004	<.0001	Yes
	humid3pm*ca4	0.021	0.005	<.0001	Yes
	humid3pm*ca5	0.037	0.005	<.0001	Yes
	humid3pm*ca6	0.135	0.005	<.0001	Yes
	humid3pm*sa1	0.009	0.005	0.0750	No
	humid3pm*sa2	-0.062	0.005	<.0001	Yes
	humid3pm*sa3	-0.018	0.004	<.0001	Yes
	humid3pm*sa4	-0.038	0.004	<.0001	Yes
	humid3pm*sa5	-0.076	0.005	<.0001	Yes
	humid3pm*sa6	0.004	0.005	0.3952	No

Table 12. Parameter estimates for the total consumption regression model.

Parameter Group	Parameter	Estimate	Standard Error	p-Value	Statistically Significant?
	Intercept	35.721	3.996	<.0001	Yes
Trend	trend	-0.005	0.001	<.0001	Yes
	trend*trend	0.000	0.000	<.0001	Yes
Target & Participation groups	target	0.001	1.341	0.9991	No
	diffusion	0.866	0.100	<.0001	Yes
Smart Meter	SM	-3.342	0.424	<.0001	Yes
ABS	median_age	0.033	0.007	<.0001	Yes
	median_HH_wk_income	0.002	0.000	<.0001	Yes

	ave_HH_size	0.015	0.049	0.7665	No
Intervention Main Effects	Living Smart (LS)	-0.108	0.092	0.2443	No
	Living Smart active period (LSac)	0.096	0.017	<.0001	Yes
	HEC	-0.064	0.051	0.2027	No
	IHD (paired) (IHD)	-0.131	0.022	<.0001	Yes
	IHD (mailed) (IHDmail)	-0.094	0.016	<.0001	Yes
	PowerShift active period (PSac)	-0.232	0.052	<.0001	Yes
	PSC PV (PVsc)	-1.060	0.096	<.0001	Yes
	Non-PSC PV (PVnsc)	-0.357	0.036	<.0001	Yes
	fromSHWe	1.008	0.964	0.2959	No
	fromSHWg	3.202	0.937	0.0006	Yes
	fromSHWn	2.974	0.969	0.0021	Yes
	toSHWe	-2.557	0.952	0.0072	Yes
	Non-PSC PV and non-participants (PVnsc*participant)	-0.393	0.052	<.0001	Yes
Intervention Interactions	LSHEC	0.019	0.072	0.7963	No
	LSacHEC	0.178	0.041	<.0001	Yes
	IHDPSac	0.057	0.064	0.3755	No
	LSIHD	0.028	0.059	0.6358	No
	LSIHDmail	0.187	0.045	<.0001	Yes
	LSPSac	-0.061	0.152	0.6901	No
	LSPVsc	-0.024	0.185	0.8988	No
	LSPVnsc	-0.356	0.066	<.0001	Yes
	LSfromSHWe	5.743	0.466	<.0001	Yes
	LSfromSHWg	-0.435	0.285	0.1271	No
	LSfromSHWn	-1.903	0.482	<.0001	Yes
	LSacIHD	-0.380	0.183	0.0378	Yes
	LSacIHDmail	0.013	0.113	0.9113	No
	LSacPS	0.543	0.321	0.0908	No
	LSacPSac	-0.564	0.361	0.1179	No
	LSacPVsc	-0.385	0.167	0.0211	Yes
	LSacPVnsc	0.029	0.074	0.6893	No
	LSacfromSHWe	-1.601	0.434	0.0002	Yes
	LSacfromSHWg	-0.792	0.213	0.0002	Yes
	LSacfromSHWn	-1.443	0.287	<.0001	Yes
	HECIHD	0.116	0.078	0.1363	No
	HECIHDmail	0.011	0.070	0.8781	No
	HECPSac	-0.078	0.328	0.8121	No
	HECPVsc	0.820	0.143	<.0001	Yes
	HECPVnsc	-0.456	0.079	<.0001	Yes
	HECfromSHWe	-2.786	1.110	0.0121	Yes

	HECfromSHWg	-5.835	1.097	<.0001	Yes
	HECfromSHWn	-2.926	1.048	0.0052	Yes
	HECtoSHWe	3.827	1.084	0.0004	Yes
	LSIHDPSac	0.104	0.194	0.5906	No
	LSacIHDPSac	0.071	0.273	0.7953	No
	HECIHDPSac	0.188	0.352	0.5923	No
	LSHECIHD	-0.317	0.130	0.0149	Yes
	LSHECIHDmail	0.228	0.115	0.0476	Yes
	LSHECPSac	0.195	0.420	0.6415	No
	LSHECPVsc	-0.605	0.276	0.0282	Yes
	LSHECPVnsc	0.377	0.122	0.0020	Yes
	LSHECfromSHWe	-5.782	0.673	<.0001	Yes
	LSHECfromSHWg	2.014	0.530	0.0001	Yes
	LSHECfromSHWn	-0.168	0.678	0.8038	No
	LSacHECIHD	0.809	0.350	0.0206	Yes
	LSacHECIHDmail	-0.617	0.256	0.0158	Yes
	LSacHECPSac	-0.865	0.348	0.0128	Yes
	LSacHECPVsc	0.183	0.244	0.4518	No
	LSacHECPVnsc	0.055	0.143	0.6989	No
	LSacHECfromSHWe	1.525	0.889	0.0863	No
	LSacHECfromSHWg	0.264	0.315	0.4017	No
	LSacHECfromSHWn	0.984	0.789	0.2124	No
	LSHECIHDPSac	-0.806	0.475	0.0899	No
	LSacHECIHDPSac	0.968	0.522	0.0638	No
Weather Main Effects	max	-0.376	0.116	0.0011	Yes
	min	0.138	0.004	<.0001	Yes
	rain	-0.049	0.028	0.0804	No
	hot35	0.287	0.014	<.0001	Yes
	hot25	2.111	0.169	<.0001	Yes
	rainday	-0.080	0.119	0.5018	No
	rainsqrt	0.346	0.130	0.0079	Yes
	humid9am	-0.034	0.002	<.0001	Yes
	humid3pm	0.021	0.002	<.0001	Yes
Seasonality Main Effects	sa1	-6.168	3.065	0.0442	Yes
	sa2	-0.824	3.977	0.8359	No
	sa3	7.658	2.966	0.0098	Yes
	sa4	7.316	1.707	<.0001	Yes
	sa5	2.622	0.924	0.0045	Yes
	sa6	0.152	0.358	0.6710	No
	ca1	21.819	4.562	<.0001	Yes
	ca2	26.235	2.537	<.0001	Yes
	ca3	24.695	2.088	<.0001	Yes

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	ca4	12.293	1.743	<.0001	Yes
	ca5	4.224	0.933	<.0001	Yes
	ca6	-0.146	0.321	0.6504	No
Weather & Seasonality Interactions	max*ca1	-0.889	0.182	<.0001	Yes
	max*ca2	-1.027	0.102	<.0001	Yes
	max*ca3	-0.940	0.084	<.0001	Yes
	max*ca4	-0.459	0.070	<.0001	Yes
	max*ca5	-0.147	0.037	<.0001	Yes
	max*ca6	-0.012	0.013	0.3682	No
	max*sa1	0.249	0.122	0.0415	Yes
	max*sa2	0.030	0.159	0.8503	No
	max*sa3	-0.321	0.119	0.0069	Yes
	max*sa4	-0.250	0.069	0.0003	Yes
	max*sa5	-0.029	0.037	0.4418	No
	max*sa6	0.015	0.014	0.3014	No
	min*ca1	0.201	0.005	<.0001	Yes
	min*ca2	0.057	0.005	<.0001	Yes
	min*ca3	-0.154	0.005	<.0001	Yes
	min*ca4	-0.172	0.005	<.0001	Yes
	min*ca5	-0.137	0.005	<.0001	Yes
	min*ca6	-0.013	0.004	0.0022	Yes
	min*sa1	0.085	0.005	<.0001	Yes
	min*sa2	0.107	0.005	<.0001	Yes
	min*sa3	0.020	0.005	<.0001	Yes
	min*sa4	-0.081	0.005	<.0001	Yes
	min*sa5	-0.128	0.005	<.0001	Yes
	min*sa6	-0.039	0.005	<.0001	Yes
	rain*ca1	-0.119	0.031	0.0001	Yes
	rain*ca2	-0.135	0.041	0.0011	Yes
	rain*ca3	0.175	0.054	0.0012	Yes
	rain*ca4	0.160	0.044	0.0003	Yes
	rain*ca5	-0.084	0.033	0.0109	Yes
	rain*ca6	-0.154	0.025	<.0001	Yes
	rain*sa1	-0.148	0.050	0.0034	Yes
	rain*sa2	-0.351	0.049	<.0001	Yes
	rain*sa3	-0.143	0.032	<.0001	Yes
	rain*sa4	0.017	0.037	0.6530	No
	rain*sa5	-0.007	0.039	0.8634	No
	rain*sa6	0.150	0.026	<.0001	Yes
	hot25*ca1	-2.687	0.297	<.0001	Yes
	hot25*ca2	3.391	0.202	<.0001	Yes
	hot25*ca3	-0.325	0.143	0.0229	Yes

hot25*ca4	1.302	0.097	<.0001	Yes
hot25*ca5	0.037	0.048	0.4389	No
hot25*ca6	0.079	0.013	<.0001	Yes
hot25*sa1	-1.128	0.142	<.0001	Yes
hot25*sa2	1.054	0.186	<.0001	Yes
hot25*sa3	-0.749	0.157	<.0001	Yes
hot25*sa4	0.887	0.091	<.0001	Yes
hot25*sa5	-0.174	0.051	0.0007	Yes
hot25*sa6	0.103	0.014	<.0001	Yes
rainday*ca1	1.003	0.175	<.0001	Yes
rainday*ca2	0.653	0.174	0.0002	Yes
rainday*ca3	2.715	0.183	<.0001	Yes
rainday*ca4	0.915	0.195	<.0001	Yes
rainday*ca5	1.100	0.190	<.0001	Yes
rainday*ca6	-0.643	0.123	<.0001	Yes
rainday*sa1	-0.674	0.151	<.0001	Yes
rainday*sa2	-1.104	0.149	<.0001	Yes
rainday*sa3	-0.353	0.136	0.0095	Yes
rainday*sa4	0.388	0.138	0.0049	Yes
rainday*sa5	0.992	0.133	<.0001	Yes
rainday*sa6	-0.159	0.137	0.2440	No
rainsqrt*ca1	0.552	0.158	0.0005	Yes
rainsqrt*ca2	0.344	0.190	0.0703	No
rainsqrt*ca3	-1.086	0.242	<.0001	Yes
rainsqrt*ca4	-0.737	0.205	0.0003	Yes
rainsqrt*ca5	-0.019	0.171	0.9128	No
rainsqrt*ca6	0.318	0.119	0.0075	Yes
rainsqrt*sa1	0.834	0.221	0.0002	Yes
rainsqrt*sa2	1.574	0.216	<.0001	Yes
rainsqrt*sa3	0.425	0.145	0.0033	Yes
rainsqrt*sa4	0.018	0.168	0.9130	No
rainsqrt*sa5	0.285	0.169	0.0905	No
rainsqrt*sa6	-0.429	0.129	0.0009	Yes
hot25*humid9am	0.005	0.001	<.0001	Yes
hot25*humid3pm	-0.007	0.001	<.0001	Yes
humid9am*ca1	-0.050	0.003	<.0001	Yes
humid9am*ca2	-0.025	0.001	<.0001	Yes
humid9am*ca3	-0.002	0.001	0.2276	No
humid9am*ca4	0.017	0.002	<.0001	Yes
humid9am*ca5	0.014	0.002	<.0001	Yes
humid9am*ca6	0.006	0.001	<.0001	Yes
humid9am*sa1	-0.017	0.002	<.0001	Yes

humid9am*sa2	-0.003	0.002	0.1027	No
humid9am*sa3	0.005	0.001	0.0011	Yes
humid9am*sa4	0.000	0.001	0.8599	No
humid9am*sa5	0.002	0.001	0.2067	No
humid9am*sa6	-0.003	0.001	0.0270	Yes
humid3pm*ca1	0.015	0.003	<.0001	Yes
humid3pm*ca2	0.022	0.001	<.0001	Yes
humid3pm*ca3	0.004	0.001	0.0057	Yes
humid3pm*ca4	0.015	0.001	<.0001	Yes
humid3pm*ca5	0.003	0.001	0.0213	Yes
humid3pm*ca6	0.019	0.001	<.0001	Yes
humid3pm*sa1	0.012	0.002	<.0001	Yes
humid3pm*sa2	-0.009	0.002	<.0001	Yes
humid3pm*sa3	0.003	0.001	0.0132	Yes
humid3pm*sa4	0.010	0.001	<.0001	Yes
humid3pm*sa5	-0.009	0.001	<.0001	Yes
humid3pm*sa6	0.011	0.001	<.0001	Yes

Table 13. Parameter estimates for the Super Peak consumption regression model.

ACRONYM GLOSSARY

ACT - Air-Conditioner Trial

CBSM - Community Based Social Marketing

CT - Current Transformer

DCCEE - Department of Climate Change and Energy Efficiency

DM - Direct Marketing

DR - Demand Response

DRED - Demand Response Enabling Device

EOI - Expression Of Interest

ERA - Economic Regulation Authority

HAN - Home Area Network

HW - High Voltage

IHD - In Home Display

kW - Kilowatt

kWh - Kilowatt Hour

KPIs - Key Performance Indicators

LMC - Last Mile Communication

LV - Low Voltage

MAX - MAXimise your savings

MCE - Ministerial Council on Energy

MW - Megawatt

MWh - Megawatt Hour

NMI - National Meter Identifier

NMS - Network Management System

PQ - Power Quality

PV - Photovoltaic

RF - Radio Frequency

SLA - Service Level Agreement

SSN - Silver Springs Network

SWIS - South West Interconnected System

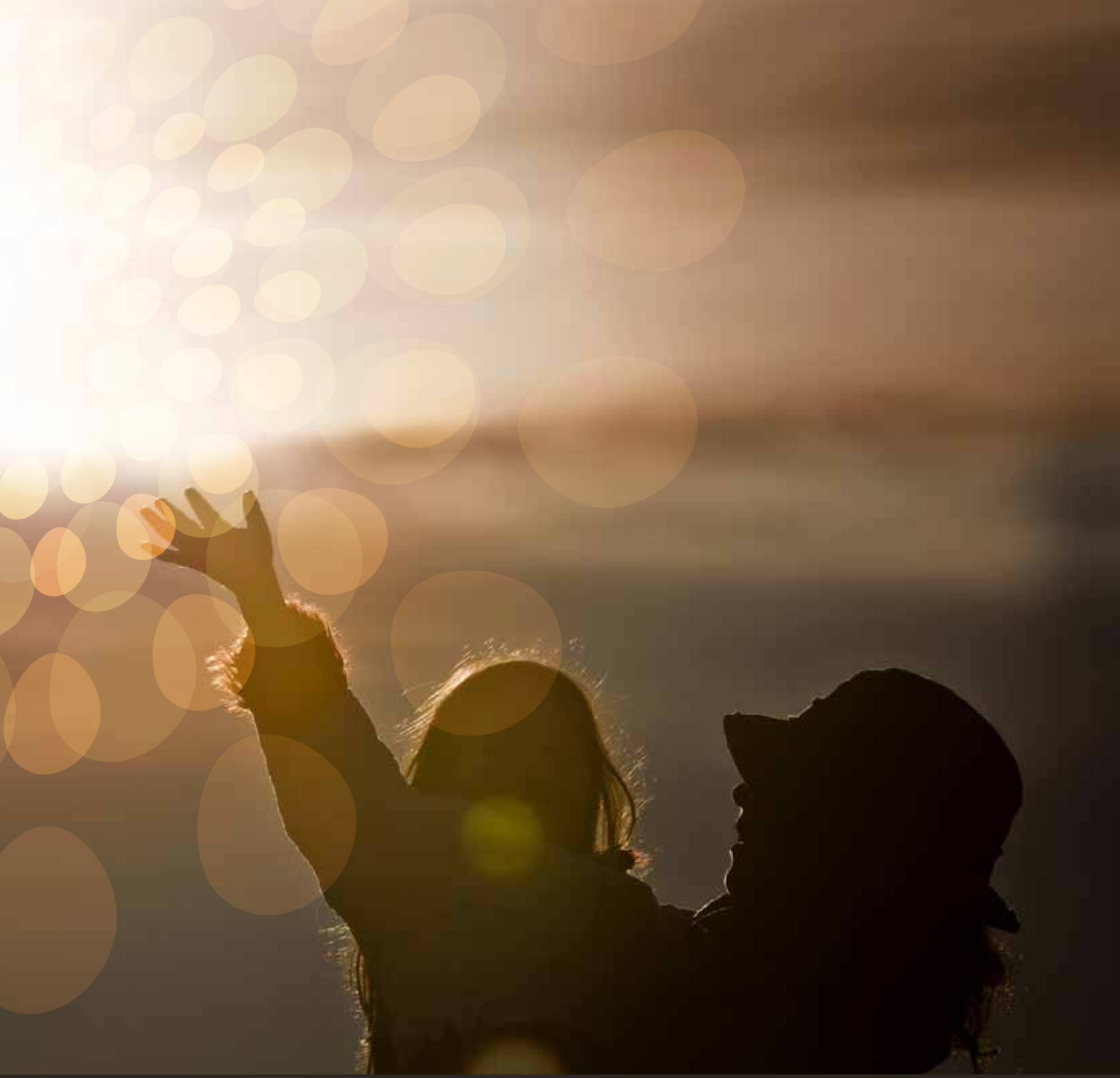
THD - Total Harmonic Distortion

TOU - Time Of Use

UIQ - Utility IQ Product Suite (Network Management System)

V - Volts

W - Watt



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