Measuring savings from energy efficiency programs in NSW

2007-2013

NSW Office of Environment and Heritage

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ARTD CONSULTANTS
strategy & evaluation

Prepared by ARTD Consultants for the Office of Environment and Heritage.

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Tables and figures

Acronyms and glossary

CDA	Conditional demand analysis
CDD	Cooling Degree Days
CALD	Culturally and Linguistically Diverse
DEAS	DECCW Energy Assessment System
DECCW	NSW Department of Environment, Climate Change and Water (until 2011, then OEH)
ECM	Energy Conservation Measure
EEAP	Energy Efficiency Action Plan, the NSW Government approach to energy efficiency from 2012
EEGSP	Energy efficiency component of the NSW Government Sustainability Policy
EESBP	Energy Efficiency for Small Business Program, NSW government program targeting small businesses
ESC	Energy Savings Certificate, a tradable certificate created through the ESS from the measurement of energy savings
ESP	Energy Savings Program, NSW government program targeting medium to large businesses
EETP	Energy Efficiency Training Program, NSW government program
ESS	Energy Savings Scheme, NSW government white certificate scheme
FY	Financial Year
GBRP	Government Building Retrofit Program, NSW government program supporting energy efficiency retrofit to government agencies
GSP	NSW Government Sustainability Policy
HDD	Heating Degree Days
HPSP	Home Power Savings Program, NSW government program targeting low income households
HSRP	Home Saver Rebate Program, NSW government residential rebates program
HVAC	Heating, Ventilation and Air-conditioning
HWS	Hot Water System
IAB	Internal Audit Bureau, NSW government trading enterprise that provides audit services
IPART	Independent Pricing and Regulatory Tribunal
IPMVP	International Performance Measurement and Verification Protocol
ISF	Institute for Sustainable Futures
M&V	Measuring and Verification the process of using measurement to reliably determine actual energy savings by comparing measured use before and after implementation of a project
ME	Mixed effects modelling
MPMC	Matched pairs mean comparison
NGO	Non-government organisation
NABERS	National Australian Built Environment Rating System

OEH	Office of Environment and Heritage
PV	Photovoltaic
TLF-SGIP	Treasury Loan Fund – Sustainable Government Investment Program

Executive summary

The NSW Government is committed to improving energy efficiency, currently through the Energy Efficiency Action Plan (EEAP) which commenced in August 2013. Before the EEAP, the NSW Office of Environment and Heritage (OEH) implemented a number of energy efficiency programs that aimed to directly generate energy savings in the residential sector, the business sector and the government sector. Each program involved interventions that provided the target groups with information about energy efficiency, and offered incentives and support to undertake retrofits and change behaviour to reduce electricity consumption. This report presents the savings achieved by five of these programs.

The lack of reliable evidence of energy savings compromised confidence in investing in energy efficiency programs. Over the 2007-2013 period, OEH has developed rigorous methods for measuring and evaluating energy savings to overcome difficulties in confirming energy savings from energy efficiency programs. This report documents the improved methods that have been developed and applied.

OEH engaged ARTD Consultants as an evaluation partner to integrate, interpret and report on measurement and evaluation activities conducted between 2011 and 2014. As part of this work, ARTD undertook this evaluation as a synthesis of savings evaluation activities conducted in 2013 and 2014.

Overall finding

OEH now has far more reliable measures of energy savings. The main achievement has been to move from initially estimating the savings based on engineering estimates (deemed savings) to verified energy savings based on 'before-and-after' analysis in line with the international best practice measurement methods.

Robust measurement studies were conducted for five programs across different sectors, with varying sample sizes ranging from large samples of households to individual case studies at business and government sites. The measurements demonstrated that the interventions in each of the programs achieved real and substantial energy savings and reductions in electricity bills at these sites. The capacity to generalise these findings to all sites in each sector varied with the samples of the measurement studies—it is the strongest in the household sector.

Improved measures of savings

The programs achieved significant levels of reach into their target groups in the residential, business and government sectors. Measurement studies demonstrated that the interventions generated real savings and had the capacity to have substantial impact across the participant population.

The challenge in measuring actual energy savings from energy efficiency programs is a lack of direct measurement—only energy consumption can be measured. Energy savings are the difference between actual energy consumption and what it would have been without the intervention (the counterfactual). OEH developed and used the two international best practice methods for measuring energy savings with these programs: billing data analysis, and Measurement and Verification (M&V). Table 1 presents an overview of the measurement methods used for each program.

Table 1. Overview of measurements methods and sample sizes for each program

Program	Reach	Measurement method	Sample size
Residential sector	**Households**		
Home Saver Rebate Program– hot water system rebates	155,216	Billing data analysis	Large (n=28,083)
Home Power Savings Program	225,214	Billing data analysis	Large (n=38,347)
Business sector	**Sites**		
Energy Efficiency for Small Business Program	16,028	M&V	Large (n=1,107)
Energy Saver Program – large sites	475	M&V	Case studies (n=4)
Government sector	**Sites**		
Government Building Retrofit Program – small sites	104	M&V	Case studies (n=7)
Government Building Retrofit Program – large sites	59	M&V	

Billing data analysis

For relatively small users such as households, individual billing data from quarterly metering is available for both participants and control groups. OEH reached agreements with energy distributors to access large-scale billing data for households—a first for any government agency in Australia. This formed the basis for independent studies to estimate savings generated in the residential sector by the Home Saver Rebate Program (HSRP) for hot water system rebates, and the Home Power Savings Program (HPSP). Each program had large reach and sample sizes for participants and control groups that allowed reliable estimates based on rigorous statistical analysis.

Measurement & Verification (M&V)

M&V is most suited for medium to large sites. It uses metering data to compare baseline and after-retrofit energy consumption using an energy model of the baseline data to take account of weather related variables. The energy model in theory can also control non-weather variables. However, it is difficult to collect relevant site data due in part to the less ideal way of implementing the M&V retrospectively. It is thus difficult to exclude other factors that could have changed energy consumption, including changes in level of activity, and so has less certainty in attributing changes to the program.

OEH developed a guide for M&V[1] based on the international protocol and commissioned independent studies to estimate savings from three programs: two in the business sector—the Energy Efficiency for Small Business Program (EESBP) and the Energy Saver Program (ESP)—and one in the government sector, the Government Building Retrofit Program (GBRP). A large sample of small businesses was used for EESBP, while only a limited number of cases were measured for ESP and GBRP.

Future directions

OEH's has undertaken pioneering work in Australia in developing and applying more reliable measures of energy savings. This will have a number of future benefits. First by substantially contributing to the evidence-base of energy efficient interventions in Australia, it can inform future policy settings and the design of energy efficiency programs. Second, it will contribute to improved modelling, whether retrospectively, to understand observed changes in electricity consumption, or prospectively, to factor in the impact of energy efficiency programs in estimating future electricity demand (by electricity retailers, market operators or regulators). Finally, it can be used to continue to improve measures of energy savings and the evaluation of programs, working towards the ultimate objective of making energy efficiency a reliable and predicable energy source.

To this end, lessons from these measurements studies have shaped a set of recommendations in chapter 6 that will further improve the theory and practice of measuring energy efficiency in Australia. Some of these lessons have already informed the design of new programs, including the NSW Energy Savings Scheme which now requires savings measurement and verification in its 2014 Rule.

[1] http://www.environment.nsw.gov.au/energyefficiencyindustry/measurement-verification.htm

1. The programs and the evaluation

1.1 Policy context

Energy efficiency is a major aspect of the NSW Government 10-year strategic plan 'NSW 2021'—it flows across several goals, especially those related to the cost of living and the natural environment. Rapidly increasing electricity prices highlighted the value of energy efficiency for the public and the government. In the wider context, the energy efficiency field has been characterised by changing policy settings and uncertainty in measuring energy savings.

The NSW Government has committed to improving energy efficiency across the household, business and government sectors, through the Energy Efficiency Action Plan (EEAP) that started in August 2013. A number of energy efficiency programs had been implemented over the previous eight years. These were mainly new programs with some approaches being implemented for the first time in Australia. They have involved OEH in new strategies, increased scales of delivery and new stakeholder relationships, with a common objective: to deliver real savings to the consumers. Lessons from this experience informed the development of the EEAP.

OEH is committed to regularly evaluating its energy efficiency programs. Most of these earlier programs were covered in the 2012 evaluation of NSW energy efficiency programs or in individual program evaluations[2]. Many of these programs continued beyond June 2012, before being replaced by the EEAP. This evaluation provides more evidence of energy savings achieved.

The uncertainty around energy savings from energy efficiency programs, highlighted by the 2007 Owen Inquiry into Electricity Supply in NSW, was an important driver for better evaluation. It led to the establishment of the OEH Data and Evaluation Program in 2009, which pioneered robust approaches to measuring energy saving in Australia. The measurement studies in this report are a significant legacy of this program.

1.2 Evaluation of energy savings in five programs

The purpose of this report is to document the measurement of energy savings in four completed and one continuing energy efficiency programs under the EEAP, across three sectors. These programs are

1. Home Savings Rebate Program – hot water system rebates (completed)
2. Home Power Savings Program (completed)
3. Energy Efficiency for Small Business Program (completed)
4. Energy Saver Program (continuing under the EEAP)
5. Government building retrofit program (completed)

[2] http://www.environment.nsw.gov.au/energyefficiencyindustry/evaluation.htm

These programs represent an investment in energy efficiency by OEH of $203.6 million, with the Home Saver Rebate Program (HSRP, hot water system rebates) accounting for 48 per cent (Table 2).

Table 2. Energy efficiency programs covered in this evaluation report

Program	Target	Timeframe	Costs ($ million)
Residential sector			
Home Saver Rebate Program (HSRP) – hot water systems rebates	Households	Jul 2007 – Jun 2011	$98.2m
Home Power Savings Program (HPSP)	Low income households	May 2010 – Mar 2014	$53.8m
Business sector			
Energy Efficiency for Small Business Program (EESBP)	Small businesses	Feb 2009 – Dec 2012	$24.7m
Energy Saver Program (ESP)	Medium and large sites	Feb 2009 – Jun 2014 (continued under EEAP)	$19.8m
Government sector			
Government Building Retrofit Program (GBRP)	Government agencies	Jul 2009 – Dec 2012	$7m

OEH commissioned ARTD Consultants to undertake a synthesis of the most recent measurement studies (see detailed list in Appendix 1). This evaluation is a follow-up to the 2012 evaluation of NSW energy efficiency programs that synthesised and integrated the detailed evaluations of the design, implementation and early outcomes of majority of these programs (ARTD Consultants, 2012). A separate cost-benefit analysis was commissioned to consider overall benefits generated by the programs against total costs.

We are confident that the findings of this report represent reliable measures of energy savings at the measured site level, based on the underlying measurement studies described in each section.

Results and measurement methods are described for each program in detail in chapters 3, 4 and 5. Accurate measurement with a representative sample was available for three programs—the NSW Home Saver Rebate Program-hot water system rebates, the Home Power Savings Program and the Energy Efficiency for Small Business program. Savings for the other programs—Energy Saver Program and the Government Building Retrofit Program are based on engineering estimates. Measurement studies for these programs were only a limited number of site case studies.

2. Measuring energy savings

2.1 The challenge of measurement

The biggest challenge in evaluating energy efficiency programs is the lack of direct measures of savings. Energy savings are what did not happen, but only energy consumption can be measured. The difference between energy consumption and what energy consumption would have been without the intervention provides a measure of energy savings. Measuring savings needs a "before and after" approach in which a saving is determined as the difference of the energy use measured after the intervention took place and a baseline representing the energy use if the intervention had not taken place (the counterfactual).

This approach relies on (1) the availability of energy consumption data, and (2) a counterfactual baseline which can be only established through statistical modelling with historical energy data.

To address this challenge, OEH started the four year $2 million Data and Evaluation Program in 2009 to develop and apply methods to measure and evaluate energy savings and benefits achieved by energy efficiency programs.

2.2 Measurement involved major innovations

2.2.1 Internationally best practice methods were applied

As energy efficiency programs in NSW are relatively new, measurement methods and tools had to be developed and energy data collected. When the programs were designed the expected savings were deemed using engineering estimates and assumptions about the extent and effectiveness of the uptake in realising savings (*deemed savings approach*). Deemed savings are uncertain because their accuracy depends upon the initial assumptions such as engineering estimates for devices which can be undermined by many real-world factors.

OEH's Data and Evaluation Program set out to provide *verified measures* of energy savings, using two international best practice methods:[3]

- **Billing data analysis (BDA).** This method—also known as the *large-scale data analysis approach*—is a statistical analysis of large volumes of energy meter data. It

[3] For a comprehensive overview of approaches for calculating energy savings from energy efficiency programs, see the Guide developed for the US Environmental Protection Agency published in 2007: National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc. <www.epa.gov/eeactionplan>

is appropriate for relatively small and homogeneous users such as households, where small to moderate savings are expected per site, typically over large numbers of sites. OEH applied this method to the two residential programs.

- **Measurement & Verification (M&V)**. This method uses best industrial practice to verify savings as defined by the International Performance Measurement and Verification Protocol (IPMVP)[4]. It is most suited for medium to large sites where energy use is heterogeneous, measures are complex and relatively high cost, and large savings are expected. M&V requires special skills and consistent approaches, so OEH developed an Operational Guide for M&V for practitioners to standardise approaches aligned with international best practice. The Guide was tested using supervised trials with selected retrofit projects in large participants programs (business and government agency programs). Finally, OEH commissioned independent M&V studies for three business and government programs. For each program, M&V was applied to individual projects, using the most appropriate M&V option. Most of the time this was Whole Site Analysis (Option C) (Table 3).

Table 3. IMPVP M&V options

Approach	Description
Option A – Key Parameter Measurement	A simplified method involving a project-specific boundary whereby the most important parameter affecting energy savings is measured. The measured values are combined with estimates for other variables to estimate savings.
Option B- Full Parameter Measurement	A more comprehensive method involving a project-specific boundary whereby the all key parameters affecting energy savings are measured. The resulting analysis determines the change in energy use (i.e. savings) for the measurement period.
Option C – Whole Site Analysis	A whole of site approach involving linear regression analysis of monthly billing data against corresponding values for independent variables. Modelling is conducted over a 12 month cycle.
Option D – Simulation	This method is used when physical baseline measurements cannot be collected. Simulation software is used to accurately model the baseline. Once post-retrofit data is obtained, the model is adjusted for those conditions and calibrated to determine the overall error. The measured post-retrofit values are evaluated against the calibrated model depicting the baseline.

Source: Energetics (2014b)

2.2.2 OEH accessed large-scale energy consumption data

The first requirement for energy measurement studies is to access reliable energy consumption data. For these programs data could either come from metered energy consumption (billing data) regularly collected by energy network service providers, or from task-oriented on-site data logging. OEH does not own and possess billing data, while data logging incurs significant cost and needs to occur significantly ahead of the energy efficiency upgrade to capture the 'before' performance. As the M&V was

[4] http://www. evo-world.org

implemented retrospectively the 'before' data logging was not possible. To address this, OEH negotiated arrangements with NSW network service providers to access participants billing data. Negotiations for data sharing took 1.5 years, to satisfy concerns about customer privacy and provide network service providers with business benefits.

As a result, OEH was able to access the most comprehensive energy use data ever made available to a government agency in Australia.

2.2.3 Analysis required robust statistical modelling

The second element of energy savings measurement studies—establishing a counterfactual baseline—requires sophisticated statistical analysis and regression modelling. OEH developed program-specific M&V approaches that best fitted the characteristics of each program considering internal capacity, cost-effectiveness and robustness of M&V approaches, as a basis for commissioning specialists with the required measurement skills. Details of the approach for each program are in the respective chapters for residential, business and government sectors.

The differences in methods and timeframe for measurement mainly depend on the participants' characteristics and the project timeframe. In particular, programs targeting large businesses or government agencies such as ESP and GBRP deal with projects of much bigger size and with longer timeframes which leads to delays in 'before-and-after' analysis. As a result, monitoring the implementation of these projects over time is a key challenge.

2.3 Increasingly reliable estimates of energy savings

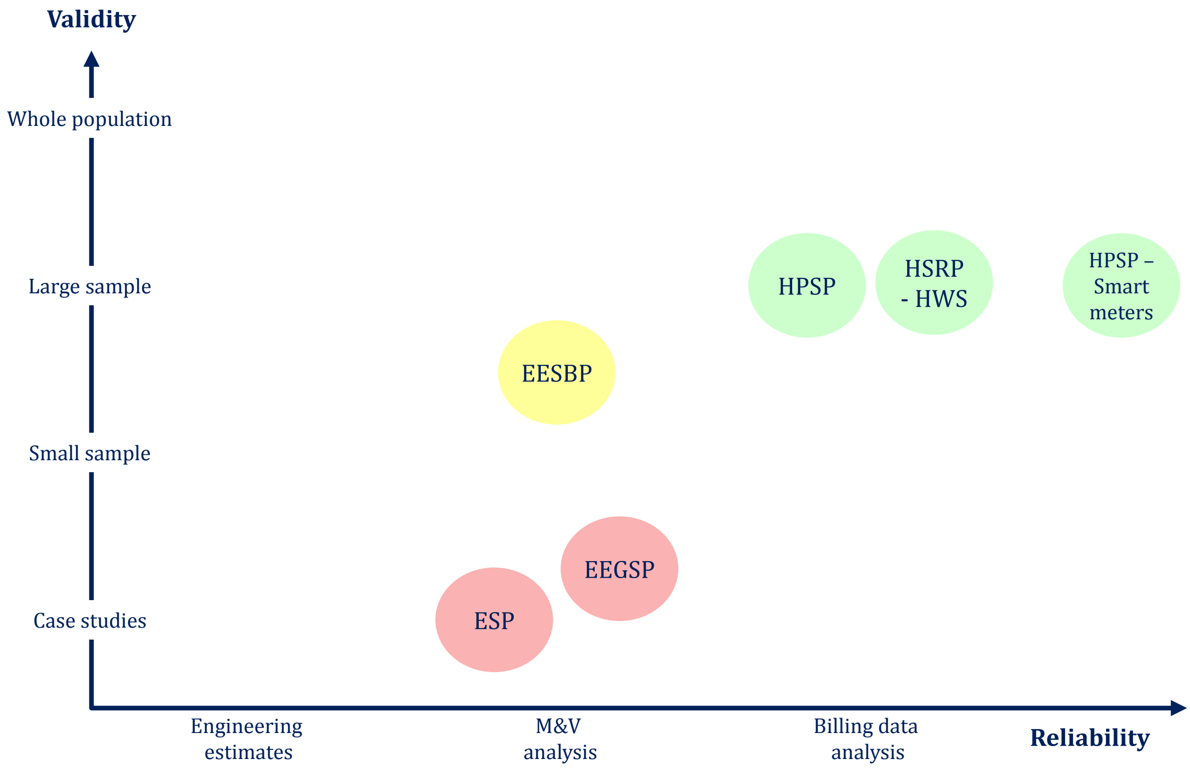
These measurement studies substantially improved the reliability of estimates of energy savings by the programs. The main achievement has been to move from initially estimating the savings based on engineering estimates (deemed savings) to verified energy savings based on 'before-and-after' analysis in line with the international best practice measurement methods.

To demonstrate this progress, the programs are positioned on a matrix showing the method used to measure savings in terms of

- **Reliability**, that reflects the accuracy of the estimates as measures of the impact of the program, in particular in terms of the ability to attribute changes in electricity consumption to participation in the program. This is essentially done through before-and-after analysis, which is common to both methods used (BDA and M&V), the main difference being that BDA can use a control group.
- **Validity**, that corresponds to the extent to which the study samples were representative of the overall participant population. This is determined by the sampling methods: single case studies, small or large sample. As represented in Figure 1, estimates of energy savings are based on actual measures of energy use from: representative samples of households for HPSP and the Home Saver Rebate

Program (for hot water system rebates); a large sample of businesses for the Energy Efficiency Small Business program, and individual large site case studies for the Energy Saver Program and the Energy Efficiency Government program.

Figure 1. Matrix of methods to measure energy savings from energy efficiency programs



The diagram shows the direction of progress from lower left (where all the programs started in 2009) to the upper right. The most reliable and valid measurement method (top right corner) would be a program that has smart meters installed in each participant's premises—allowing accurate reporting on electricity consumption for every single participant. At this stage this ideal is not yet feasible or cost-effective.

The methods used addressed past concerns that engineering estimates tend to overestimate direct energy savings and disregard 'rebound' effects, when some savings are taken back as an increased level of services e.g. increased thermal comfort. [5] Before and after analysis (including measurement and verification and billing data analysis) measure actual or net energy use, including immediate rebound effects. Some of the methods used also address persistence of savings when the analysis used multiple years of data after the energy efficiency action (e.g. for all household billing data analysis reported).

[5] Because an increased level of service is a benefit, OEH conducted also some preliminary research to quantify the non-energy benefits of energy efficiency to NSW households, in line with methods used internationally.

Another issue to further improve the accuracy of the savings attributed to programs is to exclude free-riders (participants who would have taken action without participating in the program anyway) and include spill-over effects to non-program participants. While there are some methods available to estimate these, such as self-reporting studies or econometric analysis, they require additional data collection, which again needs to balance the additional costs against the value of more accurate information.[6]

OEH's increasingly reliable estimates of energy savings have reduced uncertainty around energy savings from these programs, and provided more reliable information that can inform the design of future programs. They can also contribute to improve modelling, whether retrospectively, to understand the reasons behind the drop in electricity demand in recent years, that was largely not anticipated[7]; or prospectively, to factor in the impact of energy efficiency programs in estimating future electricity demand, by electricity retailers, market operators or regulators.

[6] National Action Plan for Energy Efficiency (2007). Model Energy Efficiency Program Impact Evaluation Guide. Prepared by Steven R. Schiller, Schiller Consulting, Inc., www.epa.gov/eeactionplan
[7] http://theconversation.com/why-is-electricity-consumption-decreasing-in-australia-20998

3. The residential sector

3.1 Home Saver Rebate Program

3.1.1 Program design and implementation

The NSW Home Saver Rebate Program (HSRP) was a $170m scheme delivered between 1 July 2007 and 30 June 2011 that provided rebates to NSW households to purchase items to reduce their energy and water use. Products eligible for rebates included

- Solar, heat pump and gas hot water systems replacing electric systems
- Replacement of single-flush toilets with new 4 star dual flush toilets
- Hot water circulation units for instantaneous gas hot water heaters
- Rainwater tanks
- Ceiling insulation
- Water efficient washing machines.

The program reached a total of 332,239 households over four years, which is equivalent to one in eight (12.5%) households in NSW. Some rebates were in operation for longer time periods than others. The most popular items over the whole program period were hot water systems that represented almost half (47%) of all rebates paid (Table 4).

Table 4. Number of HSRP rebates paid, by type of item

Rebate	Duration of rebate (months)	Rebates paid	Percentage of rebates paid
Hot water system	45	155,216	47%
Washing machine	23	76,638	23%
Rainwater tank	48	52,828	16%
Ceiling insulation	21	26,094	8%
Dual flush toilet	18	21,440	6%
Hot water circulator	18	23	0.01%
Total		332,239	100%

Based on an online survey of rebate recipients (n=1,938), the 2012 evaluation of the HSRP found that the large majority of participants were satisfied with the scope and range of rebates available. Items eligible for rebates were easy to retrofit and represented the highest opportunities to reduce water and energy usage.

3.1.2 How energy savings were measured

OEH commissioned the Institute for Sustainable Futures (ISF) to conduct a statistical analysis of billing data of participants who received a rebate for a hot water system (HWS).[8] The sample was participating households in the Ausgrid electricity distribution area, based on the agreement reached with this electricity provider. As the performance of hot water systems is influenced by climate, the results are primarily representative of the Ausgrid area[9]. Ausgrid provided billing data for 51,358 participants that received a HWS rebate, of which 38,347 were included in the sample for analysis. The main reasons for exclusion were the absence of National Metering Identifier (NMI) or Delivery Point Identifier (DPID).

The primary methodology used to estimate savings was mixed effects (ME) modelling—an extension of conventional regression modelling—controlling for other factors such as climate and household characteristics, in particular occupancy. A matched pairs mean comparison (MPMC) methodology was also used to validate the ME findings where appropriate.

3.1.3 Electricity and bill savings achieved

On average HSRP participants that had rebates for hot water systems achieved substantial savings, between 14 and 29 per cent depending on the type of hot water system (Table 5).

Table 5. Results from HSRP billing data analysis for hot water systems rebates: verified participants electricity savings

Rebated hot water system	Population size	Sample size	Average electricity savings		Average saving in household consumption
			per day	per year	
Electric-boosted Solar	82,444	15,682	4.11 kWh	1,500 kWh	16%
Heat Pump	48,226	12,715	3.69 kWh	1,347 kWh	14%
Gas – instantaneous or storage	20,641	8,698	7.4 kWh	2,717 kWh	29%
Gas – boosted Solar	3,891	1,252	6.43 kWh	2,348 kWh	25%

Source: Population size: URBIS (2012); electricity savings: Fyfe, J. et al. (2013).

[8] Savings were measured only for rebates on hot water system because of issues with other types of rebate. For ceiling insulation, the co-existence of a large Commonwealth insulation program in the later phase of the program made the analysis of the effect of the NSW program difficult. The washing machine rebate appeared to follow a boom and bust cycle, indicating a high risk of free-ridership.

[9] Sydney metropolitan area, Hornsby, Gosford, Wyong, Lake Macquarie, Newcastle, Port Stephens, Maitland, Cessnock, Singleton, Muswellbrook and Upper Hunter.

For all systems, except electric-boosted solar, savings increased with the number of occupants—use of energy for hot water was strongly correlated with the number of people in the house. For electric-boosted solar, more people in a household meant that more electric boosting is required to meet the increased demand. This finding is in line with an analysis conducted by Energy Australia in 2009 on savings generated from the installation of heat pump and electric-boosted solar hot water systems installed by some of their customers between December 2006 and June 2008.[10]

The analysis also found that savings declined slightly over time, by about 0.5kWh/day for each year post the installation of the new hot water system. A key reason seems to be the general decline in residential electricity consumption. Another likely factor was efficiency improvements in hot water systems and showerheads in non-participating households.

The ISF study also included estimates of savings on participants' electricity bills. This required taking into consideration the type of tariff (continuous or off-peak) participants were on before and after the change in hot water system. Comparison between tariff data from OEH program data and Ausgrid billing data showed that many households had a limited understanding of which electricity tariff they were actually using: 28 per cent of participants incorrectly nominated their pre-intervention tariff.

Based on actual information from Ausgrid about participants' tariff, ISF estimated the average amount participants saved on their annual electricity bill, according to the type of hot water system rebated and their original tariff (Table 6). It is important to keep in mind that these are electricity savings. Households switching to gas hot water systems (first two lines in italic) would have seen a consequent increase in gas costs, which would potentially offset electricity savings.

Table 6. HSRP estimated participants' annual electricity bill savings for hot water systems rebates, by original tariff type

Rebated hot water system	Original tariff		
	Off-peak 1	Off-peak 2	Continuous
*Gas - instantaneous or storage**	*$302*	*$398*	*$729*
*Solar Gas boost**	*$261*	*$344*	*$660*
Solar Electric OP1	$172	$282	$639
Solar Electric OP2	$118	$227	$586
Solar Electric continuous	-$72	$38	$403
Heat Pump OP1	$149	$251	$572
Heat Pump OP2	$95	$197	$525

[10] Energy Australia (2009). Efficiency of electrically boosted solar and heat pump hot water systems. Prepared for DEWHA.

Rebated hot water system	Original tariff		
	Off-peak 1	Off-peak 2	Continuous
Heat Pump Continuous	-$62	$7	$361

Source: Fyfe, J. et al. (2013).

Note: * Additional gas costs are not included

3.2 Home Power Savings Program

3.2.1 Program design and implementation

The Home Power Savings Program (HPSP) had an initial budget of $63m and the stated objective of helping 220,000 low-income households across the state to reduce their power usage and save up to 20 per cent on their energy bills.

Participating households received free

- a **home power assessment** through an on-site visit by an energy expert, which takes about an hour and shows the householder how much their appliances cost to run and where savings can be made
- a **Power Savings Kit** (PSK), worth up to $200, installed by the energy expert. The kit included a calico bag, four Compact Florescent Light (CFL) globes (bayonet or Edison screw cap Globes), two door snakes, a stand-by saver power board, a shower timer a thermometer and optional items: a set of draught-proof strips for doors or windows, a low flow shower head (hand held or wall mounted) and tap aerators
- a **Power Savings Action Plan**, which lists free and low-cost ways for the household to save power, money and cut carbon pollution.

OEH managed the program, and contractor Fieldforce delivered the energy assessment services. Delivery commenced in May 2010 and finished in April 2014, having reached 225,214 participants. Regular performance monitoring and audit processes showed that participants were highly satisfied with the program (over 95 per cent satisfied).

3.2.2 How energy savings were measured

OEH engaged in an ambitious program of billing data analysis to accurately measure the extent of savings achieved by participants. The Institute for Sustainable Futures (ISF) was commissioned to undertake rigorous statistical analysis of participants' electricity billing data in three phases. Phase 1 and 2 aimed at estimating overall savings achieved by participants. Phase 3 provided refined analysis on participants electricity consumption based on interval-meter[11] reading.

[11] Interval-meter reading provides a continuous record of electricity consumption for an individual household over each day.

ISF undertook the Phase 1 study in 2012 using a sample of 23,529 participants who were recruited into the program before January 2012 and consented to their electricity billing data being used for evaluation.[12] The Phase 2 study was conducted in 2013, with a sample of 28,083 households, incorporating Phase 1 data plus additional data up until mid-2013.[13] ISF conducted the Phase 3 analysis in 2014 using interval-meter data provided by Ausgrid on a sample of 3,887 participants meeting the data requirements.[14] The main sets of primary data were: OEH program participant data (including demographics, dwelling characteristics and energy use) and electricity billing data provided by electricity providers Ausgrid, Endeavour Energy and Essential Energy. The data sets were linked through participants' national meter identifier (NMI) code.

The Phase 1 analysis was based on two different approaches: mixed effects modelling and matched pairs mean comparison. Phase 2 relied solely on mixed effects modelling, which is considered best practice in energy billing data analysis. The savings analysis used monthly (individual) household consumption as the dependent variable and aggregated non-participant consumption, climate zone, season and HPSP program participation as explanatory variables. The Phase 2 study included a conditional demand analysis (CDA) model to explore the relationships between electricity consumption, household characteristics and appliance ownership and usage. The Phase 3 interval data analysis described in detail the electricity consumption of HPSP participants and examined possible HPSP effects across the day, season and by temperature. It assessed the impact of the program by using a matched pairs mean comparison (MPMC): each HPSP household in the sample was matched with a non-participant household, that had similar consumption before entering the HPSP, to serve as a paired control.

3.2.3 Electricity and bill savings achieved

Analysis of participants billing data (Phase 2) shows that, on average, participating household are saving 0.6kWh a day, making a 4.3% saving on average household consumption. Households that received the full Power Savings Kit saved an average of 1kWh per day, or 6.4% of average household consumption. Results of the Phase 2 study are similar to those of Phase 1 (Table 7), indicating no decay over this time period.

Table 7. Results from HPSP billing data analysis Phase 1 and Phase 2: verified participants electricity savings

	Phase 1 July 2010 – December 2011	Phase 2 July 2010 – June 2013
Sample size (number of households)	23,529	28,083
Overall program savings		

[12] Rickwood, P. et al. (2012)
[13] Fyfe, J. et al. (2014)
[14] Rickwood, P., Mohr, S. (2014)

	Phase 1 July 2010 – December 2011	Phase 2 July 2010 – June 2013
Average electricity savings per day	0.57kWh	0.6kWh
Average saving in household consumption	3.8%	4.3%
Full Power saving kit savings		
Average electricity savings per day	1.1kWh	1.0kWh
Average saving in household consumption	7.3%	6.4%

Source: Fyfe, J. et al. (2014)

Savings by demographics

When considering participants characteristics, savings were higher for:

- older householders
- larger dwellings
- owner occupiers
- average occupancy households
- the cooler months of the year

Analysis by age group shows that savings are highest among householders over 45, which could be related to a higher degree of control over energy usage, and more time spent at home. Household in smaller dwellings achieved less savings: for instance studios made 'negative' savings, indicating that energy usage was already constrained in such dwellings.

Savings by kit items

Savings by PSK items were analysed. Kit items with the most statistically significant contribution to savings were showerheads (2.3%) and door perimeter seals (2.2%). Tap aerators also had a small impact (1.4%), which is likely due to 81 per cent of households having to wash dishes by hand (not owning a dishwasher). These results show that small kit items can make a real contribution to energy savings.

Comparing results between Phase 1 and Phase 2 shows that savings from CFLs and showerheads decreased, most likely because standards for light bulbs and hot water systems had generally improved and because the Energy Savings Scheme contributed to wide scale adoption of efficient showerheads in this period, reducing aggregated non-participant consumption. Both studies found that standby power boards did not generate savings. While standby consumption accounts for about 10 per cent of electricity consumption in a typical household, savings from a single power board are expected to be limited, in particular because most large standby appliances (e.g. Wi-Fi modems or TV set top boxes) are not turned off.

Almost 40 per cent of the savings (2.5% out of the 6.4% total average savings) were not attributed to specific kit items and are likely to be due to behaviour change, in particular improvements in heating and cooling practices. However, some changes in energy use behaviour may be supported by kit items, e.g. door seals, shower timer, which makes the attribution of savings more difficult.

Savings by appliances

The conditional demand analysis (CDA) offered further insights into the impacts of different appliances:

- Additional TVs and fridges each use around 1-2 kWh/d, or around 10 per cent of average daily household consumption (14.7 kWh/ d)
- Dishwashers can add almost 3 kWh/d to average household consumption when used frequently
- Water heating for washing machines increases electricity consumption by 25-40%
- Clothes dryers are highly energy intensive, using on average approximately 1.6 kWh/person/d
- Pumps and heating on swimming pools and spas add considerably to the average electricity consumption.
- Savings from solar hot water systems are not as large as would be expected, most likely because households don't use them optimally to ensure the sun rather than the electric booster heats most of the water.
- Living rooms consistently require more energy to heat than bedrooms
- Overnight space heating and cooling contribute significantly to household demand
- Portable heaters are as energy intensive as other types of heater and when used overnight can actually use more energy when covering multiple rooms, presumably due to the absence of intelligent temperature control.

Savings by behaviour

The interval data analysis (Phase 3) provided additional insights into the behaviour of HPSP participants. The electricity consumption of HPSP participants was similar to non-participants in a number of ways. Both groups have significantly reduced their base level of consumption, with consumption falling by around a third over the 2008-2014 period for both groups. An important aspect of this reduction is that summer cooling demand has lessened which is having a significant impact on peak demand and subsequently should have important consequences for network investments. HPSP participants are also as sensitive to changes in temperature and prices (price elasticity) as non-HPSP households.

Phase 3 billing data analysis confirmed the impact of key behaviours on electricity consumption:

- those reporting taking shorter showers use less electricity
- those reporting frequent or overnight heating use more electricity during the common heating hours (5pm-10pm).

- those who reported being 'comfortable' use less electricity than others. This somewhat 'counter-intuitive' finding suggests that those heating frequently or overnight are doing so because of poorly insulated dwellings.

Interestingly, the age group reporting the lowest level of comfort were not the older households but households in the 25-34 age bracket.

Analysis by time of the day and across seasons shows savings all the time. However, savings were higher on hot summer days between noon and 8pm and on winter evenings, which suggests that some savings were due to changes in cooling and heating behaviour potentially supported by the installation of door seals.

In terms of responding to price changes, it appeared that HPSP participants had a similar price elasticity than non-participant households, with moderate responsiveness to changes in prices across the groups analysed (between -0.42 and -0.47 price elasticity[15] over the 2008-2014 period). In general, it appears that HPSP participants are on the cheapest tariff for their consumption profile (time of use or including block tariff); or they would achieve very modest gains ($0-15 per quarter) by switching. However, likely changes in price structure are expected to impact low-income household harder than other households. With the overall decline in electricity consumption, electricity utilities may consider compensating losses by increasing fixed daily services, instead of per-kWh charges that would exacerbate the problem. It is expected that this shift to fixed costs will impact hardest on low-income households as they will have limited ability to avoid this higher charge compared to other households that could afford installing their own solar PV power generation or disconnect from the grid overall.

[15] Price elasticity is the ratio of percentage change in electricity consumption (kWh) over percentage change in the unit electricity price (cent/kWh).

4. The business sector

4.1 Energy Efficiency for Small Business Program

4.1.1 Program design and implementation

Between February 2009 and December 2012, OEH delivered the Energy Efficiency for Small Business Program (EESBP) to eligible small and medium sized businesses (energy use of up to $20,000 per year (or 160 MWh) or up to 10 full time staff). It provided participating businesses with

- a subsidised energy assessment and tailored energy action plan with energy and cost saving recommendations
- rebates for the implementation of recommendations with greater than a two-year payback period
- up to 4-hours facilitation support to coordinate the installation of energy efficient technologies and equipment e.g. obtaining quotes, managing the installation and completing paperwork to apply for subsidies.

Rebates were available for lighting, HVAC (heating, ventilation and air-conditioning), motors, air compressors, commercial refrigeration, boilers, hot water systems or insulation. The maximum rebate was $2,000 for businesses with up to $5,000 spent on electricity per annum and $5,000 for businesses spending between $5,000 and $20,000 on electricity per annum.

The program was initially funded with a $15m budget for a target of 6,000 small to medium sized businesses registered by 2011. It was extended to December 2012 with actual costs reaching $24,719,857. In total, 17,600 businesses completed energy assessments as part of the program.[16]

The key challenge for the program was lifting the rate of conversion from registration to rebates for retrofits. Major refinements to the program design were implemented in July 2010—in particular around assessors incentives and the addition of a 4-hours free coordination support—and significantly improved the conversion rate (from 2 per cent of registered businesses requesting rebates as at the end of June 2010 to 24 per cent at the end of the program).

Participant satisfaction was high. Independent survey research by Databuild in May-June 2012 found that 78 per cent of businesses were satisfied or very satisfied with the assessor and 80 per cent with the recommendations (n=301).

[16] According to the Energetics report (Energetics, 2014b), out of the EESBP population considered (n=16,028), 19% per cent (n=3,088) claimed rebates.

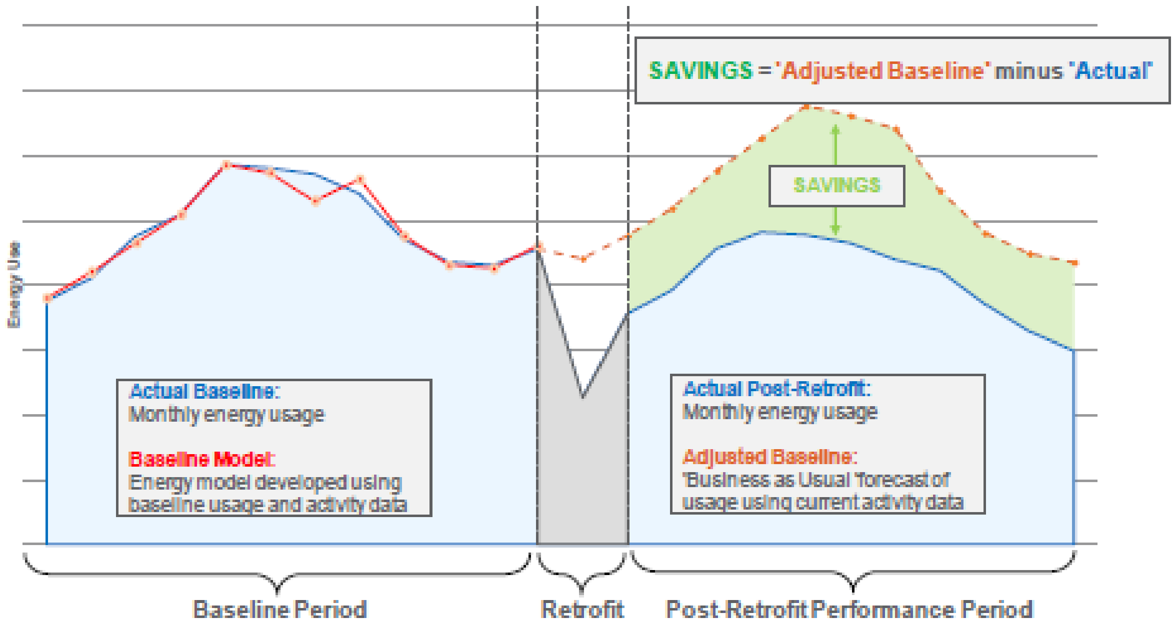
4.1.2 How energy savings were measured

For each EESBP participant, the initial energy assessment included an estimation of predicted annual energy savings (in kWh saved) and cost savings (in $) that could be generated from implementing recommended actions, based on engineering estimates.

To assess the real impact on the program, based on participants' actual implementation of actions, OEH commissioned Energetics to conduct an M&V study to confirm electricity and bill savings achieved by EESBP participants that claimed rebates. The study included a regression analysis to determine annualised electricity savings, as well as a specific focus on peak demand savings. After filtering out businesses that didn't meet data matching (between OEH program data set and energy retailers billing data) or quality criteria, 1,107 businesses were included in the analysis.

The overall Measurement & Verification approach is based on a before-and-after analysis where savings are estimated through the difference between baseline and post-retrofit electricity consumption. As shown in Figure 2, baseline usage is adjusted to reflect current activity data (what would have happened in the same context if the retrofit didn't happen) to ensure comparability between like-to-like in a similar activity context.

Figure 2. M&V method applied to the Energy Efficiency for Small Business Program



Source: Energetics (2014a)

Energetics applied the option C, known as the 'whole facility method', from the International Performance and Verification Protocol (IPMVP) to estimate electricity savings, using regression analysis of energy use within the physical boundary of the 'whole facility' against routine variables. The reason for choosing the 'whole facility' option was that the M&V was implemented retrospectively, which implied that data logging for a period before the upgrade was not possible. Besides, this option was less costly than data logging as utilities' billing data for the whole facility was readily available. However, the 'whole facility method' was not the best option for some sites where savings achieved were low relative to the whole facility energy consumption so that energy savings may not be statistically confirmed using the utility billing data for the whole facility.

To adjust the baseline, four energy models were developed based on the number of Cooling Degree Days (CDDs), the number of Heating Degree Days (HDDs) and the number of days within each calendar month. The model that demonstrates the highest correlation against the actual baseline energy use is selected as the preferred model. In some cases, none of the four models produced a suitable linear relationship. These sites (n=459 out of 1,107 sites analysed) were identified as 'No model' and savings were estimated by simply subtracting the post-retrofit electricity usage from the baseline usage.

Savings were estimated using this approach for the first 12 months period following the retrofit implementation, as well as for the last 12 months period, i.e. the most recent twelve month period for which electricity consumption was available. Consequent impact on bills is estimated by applying an average rate of $0.20/kWh to the estimated savings.

The method suited the characteristics of the program (difficult to identify a suitable control group due to the specificity of each business), but had some limitations that should be kept in mind when interpreting the results:

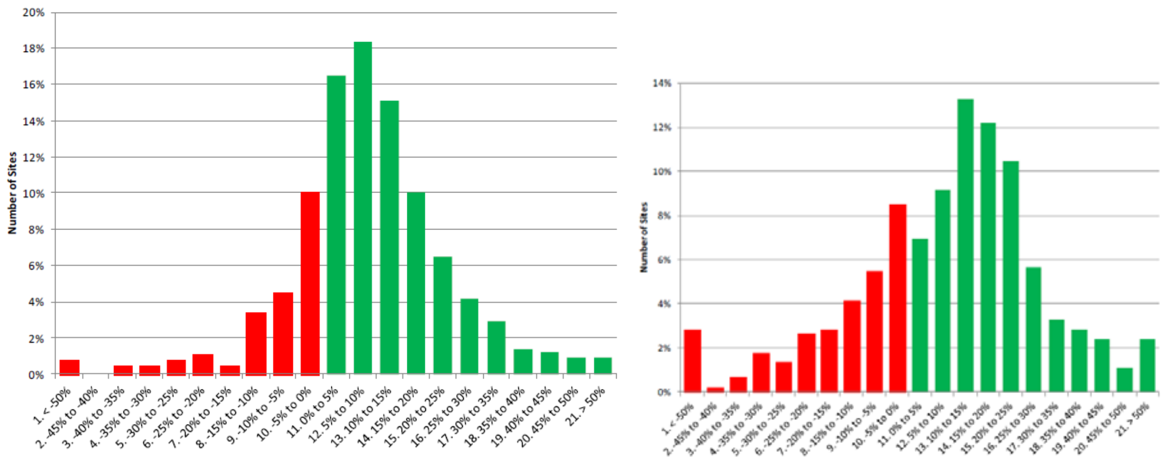
- only businesses that have accessed a rebate from the EESBP (3,008 out of the 16,028 total EESBP participants)
- IMPVP Option C requires site savings to be important enough to be detected through bill metering (10% was the benchmark used in this case)
- model used to adjust baseline consumption only considered weather and days related variables, not site-related variables such as production or occupancy changes
- assumes that measured change in electricity usage is due to participation in the EESBP and claiming a rebate
- bill savings were estimated by applying a fixed average rate of $0.2/kWh which doesn't reflect the diversity of electricity tariffs.

4.1.3 Electricity and bill savings achieved

Measurement analysis conducted for 1,107 sites (648 modelled, 459 not modelled) shows that on average businesses saved 7.4 per cent in the first twelve months period and 9.4 per cent in the last twelve months period. The last twelve months period is expected to more accurately capture the full annual savings. The fact that savings estimates for first and last twelve months are aligned and even show an increase in savings is a strong indicator for program persistence.

Energetics noted the variations in savings across sites (some even showed negative savings), likely due to changes in production levels that were not captured by the energy model. However, Energetics was confident of stronger validity at the aggregate level as they are based on a comprehensive program-wide dataset. Figure 3 shows the distribution of savings for both modelled and non-modelled sites, with positive savings in green and negative in red. The normal distribution of savings (bell curve) confirms the quality of the data analysed.

Figure 3. Histogram of site savings for modelled (left) and non-modelled EESBP sites



Source: Energetics (2014a)

The specific analysis on peak demand was not conclusive across the whole EESBP population, due to the low number of sites meeting modelling requirements (n=5).

4.2 Energy Saver Program

4.2.1 Program design and implementation

The Energy Saver Program (ESP) targeted medium and large businesses (using between 160 megawatts-hour to 10GWh per annum in electricity or spending more than $60,000 a year on electricity). It started in February 2009 with an initial budget of $20 million and an original target of 800 site audits by June 2013. Under the new Energy Efficiency Action Plan, Energy Saver continued to offer similar services during 2013-14, reaching 540 site audits by the end of June 2014.

The ESP provided subsidised energy audits and facilitation to guide, promote and prepare business cases for investment in energy efficiency. It also set up a panel of energy efficiency auditors who recommended upgrades and improved procedures, identify potential for funding from the Energy Saving Scheme (ESS), and supported businesses to act on the recommendations. Eligible businesses payed a $500 application fee for an energy efficiency audit, and ESP provided a 50 per cent subsidy for the audit as well as for the technical support (capped at $4,000), and subsidised energy efficiency training at $100 a course per participant, or $50 per participant in regional areas.[17]

In 2012 a participant survey (n=100) showed a high satisfaction towards the program, with 92% of respondents very satisfied or satisfied. Over two thirds of participants felt that they would not have taken the action they did without the support of the program.[18]

4.2.2 How energy savings were measured

As part of their initial energy audits, ESP participants received an estimation of energy savings (kWh electricity and MJ gas) that could be achieved by implementing the recommended projects. To measure the real impact of the program and confirm actual energy and cost savings, OEH commissioned Energetics to conduct an M&V at four sites. The studies confirmed electricity savings from 10.7 to 23.5 per cent (Table 8).

Method used

Every energy audit included an M&V plan. However the M&V plan was mostly not in a satisfactory status owing to the lack of M&V expertise by the energy auditors, and was therefore not used and implemented. To mitigate the situation, Energy Saver Program team undertook a small scale M&V trial project overcoming difficulties in retrospectively collecting M&V data from a selected number of business sites. It was [19]

- A large commercial office building in Macquarie Park
- A workers club located approximately 200km south west of Sydney
- A conference and function centre in the Sydney central business district
- A manufacturer of mobile garbage bins with a facility in regional NSW.

For each of these four sites, Energetics, in coordination with OEH and the site contacts,

- – reviewed the M&V plan
- – collected historical energy consumption data from energy retailers and data relating to site-specific activities from the site's operational teams
- – conducted the M&V analysis
- – prepared an individual M&V report.

Savings are measured as the difference between an adjusted baseline and the actual post-retrofit usage. The critical step in this approach is to develop an energy model to predict energy usage in relation to influencing variables, and use this to calculate the adjusted baseline. Four options are available from the International Performance

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[17] http://www.environment.nsw.gov.au/resources/business/140061energysaver.pdf
[18] Databuild, January 2013
[19] For confidentiality reasons, selected businesses have been de-identified.

Measurement and Verification Protocol (IPMVP), and an iterative approach was used to select the best option for each site considering the characteristics of the site and the retrofit project (see Table 3). Option C (whole site analysis) was selected for three sites, and Option B for the manufacturing site.

4.2.3 Electricity and bill savings achieved

Overall results of the M&V analysis conducted for the four ESP selected sites are presented in Table 8. For each site, the table presents the scope for measurement, the costs (initial estimates and actual costs), electricity and costs savings. The selected businesses implemented various types of energy conservation measures (ECM) including lighting upgrades, cooling or heating retrofits. Electricity was the primary energy source addressed, but gas savings that may have resulted from interactive effects were also measured (not presented in this summary table).

M&V analysis qualifies the savings in terms of certainty around the savings figure. Uncertainty arises from physical limitations or data errors due to equipment inaccuracies, sampling and adjustment procedures. In statistical terms, uncertainty is an estimate of the deviation from the stated value to its actual value and is expressed through the degree of precision (the range within the measured value is expected to deviate from) and the level of confidence in this range of precision. For example, the commercial office building project achieved a 10.7 per cent electricity savings measured over four months, with the analysis providing high certainty (95% confidence interval) with the true value of the savings within a range of plus or minus 9.2 per cent.

Compared to the initial estimates from the energy audits, annualised verified savings are lower, but real and still substantial:

- 275MWh annual verified savings compared to 290MWh initially estimated for the commercial office building
- 498MWh verified savings against 514MWh initially estimated for the workers club
- 407MWh verified savings against 719MWh initially estimated for the conference and function centre (however, the initial lighting project may have not been fully implemented, thus limiting the comparability of the two figures)
- Verified savings were not annualised for the manufacturing site.

Table 8. Energy Saver Program – verified electricity savings at four selected sites

Site	Scope	Costs		Electricity savings				Costs savings* ($k)
		Initial estimates ($k)	Actual costs ($k)	Verified savings	Timeframe for verified savings	Verified electricity savings (%)	Baseline model uncertainty (95% CI)	
Commercial office building	14,630m²	$490k	$910k	91.6MWh	4 months	10.7%	±9.2%	$13.7k
Workers Club	N/A	$354k	$303	456.7MWh	11 months	21.3%	±7.2%	$68.5k
Conference and function centre	2,282m²	$485.7k	N/A	406.6MWh	12 months	23.5%	±14.5%	$61k
Manufacturer of mobile garbage bins	Line 1	$12.4k	N/A	0.249kWh/unit	14 days	21.7%	±38.7%	N/A
	Line 2		N/A	0.06kWh/unit	11 days	16.5%	±34.4%	N/A

Source: Energetics (2014b) * Costs savings are estimated based on an average rate of $0.15/kWh

5. The government sector

The NSW Government Sustainability Policy (GSP) set targets for NSW Government agencies for greenhouse gas emissions from building energy use, water, environmental performance of buildings, cleaner government fleet, waste, recycling and purchasing. This report covers the energy efficiency component of the GSP (EEGSP).

Five programs in the EEGSP directly address energy efficiency:

- NABERS[20] rating of office building
- Green lease schedules for tenanted buildings
- Treasury Loan Fund – Sustainable Government Investment Program (TLF-SGIP)
- Government Building Retrofit Program (GBRP)
- The Schools Energy Efficiency program.

While individual programs were developed to address specific purposes and differ in settings, the common features were NSW Government agencies addressing whole of government targets to reduce greenhouse gas emissions; and OEH providing expert technical advice to meet the targets.

The Government Building Retrofit Program (GBRP) was the only EEGSP program that had a measurement study, as part of OEH effort to verify electricity savings.

5.1 The Government Building Retrofit Program

5.1.1 Program design and implementation

In 2010, the Minister for the Environment approved the 2 year Government Building Retrofit Program (GBRP). The program had two streams, one that covers audit costs for large sites on the provision the agency agrees to apply for funding to the TLF; and the other that cover both audit and implementation costs for small front line service delivery sites. Under the large sites stream, OEH coordinated and funded an audit to identify cost-effective projects. The resulting audit report provides the agency with the specifications and business case required in the TLF-SGIP application form. To avoid the risk of having participating agencies not progressing to implementation, OEH required the agency to commit to apply for a TLF-SGIP loan to receive the audit. The program was delivered until end of June 2012 for the small site component and December 2012 for the large sites.

The program reached 104 small sites (580 projects) and 59 large sites (35 projects) (reports to June 2013). Feedback from participating agency representatives was very

[20] NABERS is the National Australian Built Environment Rating System

positive: they appreciated the expertise and funding provided to undertake building retrofits and ultimately save the organisation money.

5.1.2 How energy savings were measured

Measurement and Verification was critical to the business model of GBRP projects for energy efficiency. OEH built an M&V capacity in the Sustainable Government team, that undertook an M&V trial with a sample of seven projects. To ensure the rigor, OEH commissioned Energetics to review the M&V modelling and the final M&V report. The seven sites are: four police stations, one sport and recreation centre, one hospital and the Australian Museum in Sydney.

Method used

Energetics applied the Option C methodology (whole site method) which has the assumption that savings are expected to be higher than 10 per cent. As for any M&V analysis, savings are calculated as the difference between post-retrofit usage and adjusted baseline usage. For the GBSRP study, an energy model was developed and tested for each site to adjust baseline usage, based on routine and non-routine variables.

5.1.3 Electricity and bill savings achieved

Electricity savings range from 9.1 to 26.1 per cent, with a payback of the implementation costs estimated between 4.5 and 9.2 years (Table 9) with information about the retrofit (main technology and costs), estimated savings with a qualification in terms of certainty, cost savings for the measurement period with an estimated payback period. Timeframe for measurement vary between projects, from 3 to 18 months, so percentage of savings and payback period are the most appropriate indicators for comparison across sites.

These results show that the savings are real. However, the variance in savings is marked, even between sites with similar characteristics. In particular, the four police stations (out of eighteen that participated in the program) had similar types of retrofit but savings varied substantially, from 11.4 per cent in Wollongong to 26.1 per cent in Newcastle.

Table 9. Government Building Retrofit Program – verified electricity savings in seven selected sites

Site	Retrofit	Implementation costs ($k)	Electricity savings				Cost savings	
			Verified savings (MWh)	Timeframe for verified savings	Verified electricity savings (%)	Baseline model uncertainty (95% CI)	Costs savings* ($k)	Payback (years)
Newcastle Police Station	Lighting	$359k	294.9MWh	8 months	26.1%	11.1%	$53k	4.5
Charlestown Police Station	Lighting	$41.7k	29.4MWh	10 months	23.7%	8.3%	$5.3k	6.5
Nowra Police Station	Lighting	$71.5k	38MWh	9 months	11.6%	11.1%	$6.8k	7.8
Wollongong Police Station	Lighting	$118k	75.6MWh	8 months	11.4%	5.9%	$13.6k	5.8
Westmead Hospital	Central cooling system	$1,560k	2,586MWh	18 months	12.7%	19.1%	$465.5k	5.0
Myuna Bay Sports Centre	Lighting, hot water and space heating	$94.4k	85.2MWh	18 months	9.1%	16%	$15.3k	9.2
Australian Museum	Space conditioning	$1,790.5k	291.2MWh	3 months	21.3%	5.6%	$52.4k	N/A

Source: Energetics (2014c) * Costs savings are estimated based on an average rate of $0.18/kWh

6. Lessons for measuring energy savings

6.1 Best practice methods were developed and implemented

Responding to the need for more reliable data on energy savings from energy efficiency programs, OEH made a strong commitment to better measurement in the form of a $2 million Data and Evaluation Program established in 2009. A primary task was to develop and apply rigorous measures of energy saving. Other tasks included evaluation planning, evaluation integration and interpretation (including the work to produce this report and the preceding 2012 report), economic analysis and modelling, and an experimental market impact study. This report presents the results of the savings measurement studies and demonstrates that this was a worthwhile effort generating far more reliable measures of energy savings.

Since 2009, OEH has made significant progress in developing and applying best practice methods to produce more reliable energy savings estimates through billing data analysis for small users, and M&V for medium to large sites based on international protocols. It is resulting in highly credible measures that will increasingly generate more reliable data on actual energy savings.

Sophisticated statistical analysis is needed, particularly to measure relatively small changes which can nevertheless aggregate across a large population into substantial energy savings. The amount and quality of the data provided allowed for detailed analysis with very high certainty and accuracy.

The process was relatively slow in the first years and reflected in the work needed to build capacity and to negotiate the engagement of participants, partners and suppliers:

- program participants need to provide consent for their data to be used
- electricity distributors need to agree to provide billing data and be satisfied that privacy of customers is protected
- service providers with high-level expertise to undertake measurement and analysis need to be identified and engaged
- program managers need to see the value of the measurement studies and understand what is needed to put them in place, including consent arrangements for participants.

To facilitate the engagement process for using M&V, OEH developed a comprehensive guide applicable to Australian conditions, and conducted workshops with program managers and service providers.

6.2 Improving the measurements

This experience was a first of its kind in Australia, both in scope—applied systematically across all types of energy efficiency programs—and in the rigour of the methods. In generated a range of practical and theoretical lessons about applying these methods in the Australian context that should make future measurement studies more efficient and more effective. These are discussed and lead to a set of recommendations under

- data collection
- analysis
- interpretation
- evaluation

6.2.1 Data collection

A prerequisite to robust measurement of energy savings is to access quality data. Two types of data should be distinguished: program data and energy consumption data.

Program delivery and site characteristics

Overall, the data OEH collected from participants as part of the program delivery, in particular through energy audits, offered a sound platform for analysis. Data collected around participants' household, dwelling or site characteristics were of considerable breadth. The measurement studies identified only a few additional fields that were missing and could have been included in the program data collection process. For example, for the HSRP hot water system rebates, additional information about whether solar systems were split systems or roof top thermosiphon systems would have allowed for more refined analysis. In terms of quality, the main field that offered room for improvement was the information on electricity tariff. The HSRP billing data analysis showed that households had a poor understanding of their current electricity tariff. As a consequence, other ways to collect this information should be used: either through energy assessors or installer for retrofit programs where the installer could verify the previous and new tariff for the equipment.

Energy consumption

Accessing reliable energy consumption data was much more challenging. This can only be done firstly with the participants' consent, and secondly through unique identifiers such as National Metering Identifier (NMI) and Delivery Point Identifier (DPI) that can be used to link program participant data with energy consumption data. To make sure that these key fields are systematically collected, their provision should be a pre-requisite to receive a rebate or participate in the program.

For business programs, participant consent and NMI is not sufficient. M&V studies require stronger engagement with participants to ensure timely provision of data, in particular activity-related data that will be used for the analysis. The ESP M&V trial study in particular suffered from delays and wrong data. This could be avoided by earlier planning and in general by better engagement with participants in the measurement process.

These additional requirements should be considered when engaging participants in the program, making it as efficient and seamless as possible for them. Verifying savings should not create an unnecessary burden for the participants, and have limited cost implications for the program to make it cost-effective. M&V is now required by the Energy Savings Scheme if businesses wish to access the full incentives available for larger energy savings projects.[21]

Data sharing

Access to the actual electricity consumption data is only possible through NSW network service providers (the distributors). They are publicly owned and relatively stable, with only three of them operating in NSW. OEH had to develop data sharing agreements with the distributors. This took a long time, especially for the HPSP, partly because the data is at individual level and requires consent and de-identification. Energy consumption data is private and can only be acquired on a voluntary consent basis. For future initiatives OEH will be able to build on these existing data agreements and partnerships, saving substantial time and effort. In other cases where no data agreement pre-exists, program designers should anticipate the time and resources required to access this data, and factor this into the evaluation strategy.

Collection of more reliable data would increase the size of samples available for analysis by reducing the number of participants excluded because of data issues, and so increase the statistical power and scope of the analysis. In addition to changes in the processes, future measurement strategies should consider adding quality control measures, in particular around key fields such as NMI or electricity tariffs.

6.2.2 Analysis

Based on the data collected, different types of method can be applied for the before-and-after analysis, according to the characteristics of the participant population and control group. International best practices offer a range of modelling options.

For billing data analysis that is used for households or small businesses, mixed effects (ME) modelling was the most suitable approach, in the context of unbalanced panel data (combined cross-sectional and longitudinal data) produced from merging program participants' datasets with electricity retailers billing data. By contrast the matched pairs means comparison (MPMC) procedure, while being conceptually simple (calculating savings as before-after, control-participant differences in consumption) is computationally intensive, and was mainly used to validate results from the ME modelling.[22]

[21] The new Project Impact Assessment with Measurement and Verification Method started on 1 July 2014. See http://www.ess.nsw.gov.au/Scheme_Changes/ESS_Rules_2014
[22] Fyfe, J. et al. (2014)

M&V requires an iterative process to identify the most appropriate option, considering the characteristics of the project, the data available and the benefits/ limitations of each option. This is not straightforward and involves an iterative analytical approach to explore the project boundaries and identify appropriate variables explaining variations in energy use. When the most appropriate option is identified, a correlation model has to be designed, adjusting it progressively to obtain a like-for-like comparison. In the M&V studies commissioned by OEH, the Option C (whole site) approach was selected for most business and government sites. However, it may not be appropriate for all project configurations, in particular if it does not show verifiable savings in the order of more than 10% that this option requires. If M&V is not planned along with the early planning of energy efficiency upgrades, Option C is most likely to be the only possible option. OEH has since learnt that it would be better to develop the M&V plan during the planning of the energy efficiency upgrade by the energy service provider.

6.2.3 Interpretation

Measures of savings need to be put in the context of background influences when interpreting the data. In particular, a downward trend in electricity consumption has been observed in Australia since the mid-2000s.[23] In this context, energy efficiency programs had less scope for additional energy savings.

The 'rebound' or 'take-back' effect is another explanatory factor for lower than expected savings by households. This occurs when households take back some of the potential energy savings from an intervention as an increased level of service, in particular through increased comfort. It is understood that M&V and billing data analysis might capture rebound effect to some extent as the analysis usually covers one or more years after the implementation against baseline usage or a control group. Data collection and analysis over longer time periods may be needed to ascertain persistence of energy savings.

Some measurement studies showed a great variance in the results. For example, verified savings from small businesses varied a lot across sectors and types of businesses. Even within specific sectors, the small sample sizes make it difficult to make broader findings. Generalising results across the participant population should therefore be considered with care, in particular when samples are small. Extrapolation to broader levels (sectors or overall program participant population) should give consideration to validity characteristics and limitations of measurement studies, in particular sample sizes and variance in the results.

[23] The Australian Energy Market Operator states that a range of factors have contributed to the decline including structural change in the economy, increases in rooftop PV systems and energy efficiency savings. See: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report-2013. Households and businesses also adjusted to rising electricity prices during the period of this report.

6.2.4 Evaluation

Accurate measurement greatly contributes to improve the profile and certainty around energy efficiency programs that affect high numbers of participants in the general population. However, a combination of qualitative and quantitative analysis is needed to explore the uptake by different types of participants, understand the mechanisms behind what worked and what did not work, and finally identify areas for improvement. For example, where measured savings fall significantly below expectation, an assessment of the process of implementing the savings will provide insights to inform a future improvement. Ultimately, combining robust outcome measures with other evaluation methods as part of an overall evaluation strategy would dramatically improve the explanatory power by telling the full story of a program.

6.3 Recommendations

These lessons from the 2009-2014 experience point to recommendations for improving future measurement of energy saving in five areas: selection of measurement method, data collection, data analysis, interpretation and evaluation (Table 10).

Table 10. Recommendations for measurement and evaluation of energy efficiency programs

Nr.	Recommendation
Planning and scoping	
1	Integrate savings confirmation into project planning to ensure data capture is fit for purpose and supported by participants. ▪ Scope out a savings confirmation plan that is appropriate to the value, nature and complexity of the project during project planning ▪ Minimise cost by integrating data collection in project preparation (for baseline) and implementation ▪ Use it as a form of quality assurance to build client's confidence ▪ Communicate it well to the participants
2	Select the most appropriate method (billing data analysis or M&V) considering the ▪ characteristics of the participants population (size, variance in energy consumption, etc.) ▪ control group ▪ data available ▪ costs implied for data collection and analysis ▪ expectations in terms of reliability and validity of estimates.
3	Choose the most appropriate option for M&V of larger projects.
Data collection and analysis	
2	Make the provision of National Metering Identifier (NMI) or other key identifiers a prerequisite to access a rebate or participate in a program

Nr.	Recommendation
3	Collect systematic consent from program participants to access historical billing data and take part in follow-up research
4	Collect reliable information about participants' electricity tariffs when using third party providers involved in the delivery of the program (e.g. installers of rebated items)
5	Involve researcher and evaluators early on in the design process to identify useful data fields for collection and analysis
6	Establish quality controls (random audits) around key fields such as NMI and electricity tariffs to ensure data quality
7	Initiate discussions with electricity retailers early on to establish robust data sharing agreements and a partnership relationship
8	Identify the most appropriate modelling method (best practice for the type of data collected): ▪ Mixed effects (ME) modelling for billing data analysis, in the context of unbalanced panel data (combined cross-sectional and longitudinal data) produced from merging program participants' datasets with electricity retailers billing data. ▪ Matched pairs means comparison (MPMC) to validate results from ME modelling.
Interpretation	
9	Consider background influences when interpreting results, in particular general trends in energy consumption, e.g. demand drop, rise in electricity prices
10	To explain results or patterns, combine quantitative methods (e.g. regression analysis of billing data) with qualitative methods to collect data from participants (e.g. to assess increased comfort, persistence, free rider and spill over effects to program non-participants).
Evaluation	
11	Complement quantitative analysis with qualitative methods to gain a deeper understand of the program mechanisms
12	Tell the whole story of the program (design, effectiveness, cost-effectiveness, impact) combining learnings from a range of methods that would include robust measurement methods, but not only.

Appendix 1. Evaluation reports

This evaluation synthesis is based on the following reports (program evaluations or measurement and verification analyses) prepared for the NSW Office of Environment and Heritage.

1. Cross sectors

ARTD Consultants, 2012, *NSW Energy Efficiency Programs 2012 Evaluation Report*

2. Residential sector

Home Power Savings Program (HPSP)

ARTD Consultants, 2012, *Interim Evaluation of the Home Power Savings Program*

Fyfe, J., Milne, G., Mohr, S., Rickwood, P. and Jackson, M., 2014, *Savings analysis of the home power savings program – Phase 2*, Institute for Sustainable Futures, University of Technology Sydney.

Rickwood, P., Mohr, S., Nguyen, M., Milne, G., 2012, *Evaluation of the home power savings program – Phase 2*, Institute for Sustainable Futures, University of Technology Sydney.

Rickwood, P., Mohr, S., 2014, *Home Power Savings Program Interval Data Analysis – Draft report*, Institute for Sustainable Futures, University of Technology Sydney.

Home Saver Rebate Program

Rudland, S., Harkness, C., Collins, D., Mackin, C., 2012, *Evaluation of the NSW Home Saver Rebate Program*, prepared for the NSW Office of Environment and Heritage by Urbis

Fyfe, J., Mohr, S., Milne, G., Rickwood, P., 2013, *Quantitative analysis of electricity savings from the Home Saver Rebates Program*, prepared for the NSW Office of Environment and Heritage by the Institute for Sustainable Futures, UTS.

3. Business sector

Energy Efficiency for Small Business Program (EESBP)

Fawcett, J., Carter, R., McGuire, M., 2010, *Evaluation of the DECCW 'Energy Efficiency for Small Businesses' Program*, Databuild

Vohra, S., Pendrick, G., Netherwood, K., Michaelis, C., 2011, *Evaluation of the DECCW Energy Saver Program – Final Draft Report,* Databuild

Hindson, J., Becchio, S., Carter, R., Harper, J., Kenington, D., 2012, *Energy Efficiency for Small Business Evaluation of the Program – Phase II,* Databuild

Energetics, 2014a, *Measurement and verification of energy savings within the Energy Efficiency for Small Business Program – Phase 2.*

Energy Saver Program (ESP)

Energetics, 2014b, *Measurement and Verification of savings from select Energy Saver audits Summary Report*

4. Government sector

NSW Government Sustainability Policy (GSP)

Optimiss Consulting, 2012, *Government building retrofit program 2012 – Review of small sites pilot: Lessons Learnt.*

Energetics, 2014c, *Measurement and Verification of Energy Savings from Energy Efficiency Projects at selected NSW Government sites*.