ESTABLISHING A BASELINE FOR IMPACT EVALUATION OF WATER HEATER RULES UNDER THE ENERGY SAVING SCHEME (ESS)

For NSW Office of Environment and Heritage

GEORGE WILKENFELD AND ASSOCIATES Pty Ltd
ENERGY POLICY AND PLANNING CONSULTANTS
PO Box 460 Katoomba NSW 2780 Sydney Australia Tel (+61 2) 4782 1155
geosanna@ozemail.com.au

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Executive Summary

This aim of this report is to enable the NSW Office of Environment and Heritage (OEH) to evaluate the impact of the 2016 changes to the NSW Energy Savings Scheme (ESS) on water heater energy choice and energy efficiency in the NSW water heater market.

Originally, Energy Savings Certificates (ESCs) could only be created within the ESS through measures which reduce electricity use. Changes to the legislation passed on 20 Oct 2015 extend the ESS to 2025, expand the ESS to provide incentives to switch fuels and to save gas as well as electricity. The new Rule permits the creation of ESCs from the replacement of an existing day-rate (not off-peak, OP) electric water heater by a gas water heater, and the replacement of a gas water heater by another gas water heater, provided the new water heater meets a prescribed level of energy efficiency. There would be more ESCs for replacements of electric water heaters, and the number would be scaled to the energy efficiency of the gas water heater installed (as determined on the test in AS4552–2005 or AS/NZS 5263.1.2:2016: the lower the MJ/yr value, the higher the efficiency).

This report analyses both demand and supply in the NSW water heater market. As water heating is considered an essential household service, virtually every detached and attached dwelling has at least one water heater. For apartments, about 85% have their own water heater and the rest are supplied by a central system serving the entire building.

Electric storage water heaters (ESWHs) still account for over half the water heater stock in NSW although BASIX has virtually eliminated electric water heaters from new buildings. When these fail, about half are replaced by a new electric water heater, and the rest are replaced by solar, gas or heat pump water heaters. The new ESS measure is intended to increase the number of ESWHs replaced by gas. This will in most cases require relocation of the water heater position, a new natural gas connection (if natural gas is available at all) or the installation of LPG cylinders, which impose time and cost penalties on a choice which is usually made with the objective of reducing time and capital cost. It remains to be seen whether the value of incentives on offer will overcome these barriers. When gas water heaters fail, there is already a 75% probability that they will be replaced by another gas water heater.

A further aim of the new ESS Rule is to increase the average efficiency (i.e. lower the average MJ/yr) of new gas water heaters compared with what it would otherwise be. There is already a trend towards greater efficiency, as well as a trend from electric to gas. Therefore detecting the impacts of the new Rule on these pre-existing trends will be difficult.

The NSW (and Australian) water heater market is dominated by four foreign-owned major suppliers. Rheem accounts for about 63% of the NSW residential water heater market, Rinnai for 18%, Dux for 11%, Bosch for 4% and all other brands combined about 4%. Nearly all the electric storage water heaters sold in Australia, and the great majority of gas storage water heaters, are manufactured in NSW at the Rheem factory in Rydalmere or the Dux factory in Moss Vale. Rinnai is in the process of building an

electric water heater factory in Melbourne. The new ESS measure may constrain the market for the water heater types made in Australia
(ESWHs and GSWHs) in favour of GIWHs, all of which are imported. This is not necessarily of concern to the major suppliers, each of whom who can supply all types of water heaters.

The demand for water heaters in NSW has been modelled, based on projected population, building demolition and construction rates, the composition of the existing water heater stock and the estimated service life of each water heater type. How the market demand will be supplied by the various water heater types is a matter of judgement. The model has been calibrated with the author's best estimate of what is likely to happen in the NSW water heater market *without* the introduction of the new ESS rules, i.e. the "business as usual" (BAU) case.

However, it is emphasised that any projection can only be verified in hindsight, and *cannot be verified at all* once the ESS measures are implemented and begin to influence the market. The actual market tracking data will then reflect the "with-measures" scenario. The actual impact of the measures will be the difference between the (verifiable) with-measures trend line and the (then unverifiable) BAU projection. Therefore any impact estimates must always remain a matter of judgement.

The final part of the report discusses a market monitoring strategy to detect and quantify the impact of the proposed measure. Some of the issues could be addressed by commissioning existing research agencies (ABS, IPART or BIS Shrapnel) to undertake more frequent NSW surveys with larger samples and additional questions, but it would be more effective to work with the major suppliers to set up a new system of sales reporting..

There will also need to be some form of documentation created when a claim for ESCs is made, to substantiate that the water heater installation meets the eligibility conditions, and the number of ESCs which it is entitled to create. One reliable method of ascertaining the impact of the ESS measures would be through targeted consumer research – taking a random sample of forms and contacting both the consumer and the installer to ask more in-depth questions to probe their motivation.

To sum up, all three levels of research will be necessary to accurately monitor and evaluate the impact of the ESS Rule changes on the NSW water heater market:

1. High-level market monitoring, either through enhanced ABS, IPART or BIS Shrapnel surveys or a new data collection arrangement with the major water heater suppliers;
2. Careful design, and retention for analysis, of the application forms for ESC creation; and
3. Targeted consumer research to probe the motivation of a sample of ESC claimants and intermediaries.

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Glossary

ABS	Australian Bureau of Statistics
AGA	Australian Gas Association
AS	Australian standard
BAU	Business as usual
BIS	BIS Shrapnel
CPI	Consumer price index
DR	Day rate (electricity)
E3	Equipment Energy Efficiency (program or committee)
EIWH	Electric instantaneous water heater
ESC	Energy Saving Certificate (created under the ESS)
ESCV	Essential Services Corporation of Victoria
ESS	Energy Saving Scheme (NSW)
ESWH	Electric storage water heater
GAMAA	Gas Appliance Manufacturers Association of Australia
GEMS	Greenhouse Energy Minimum Standards (Act)
GIWH	Gas instantaneous water heater
GSWH	Gas storage water heater
GTRC	Gas Technical Regulators Committee
GWA	George Wilkenfeld and Associates
HEP	High efficiency product
HP	Heat pump
IAPMO	International Association of Plumbing and Mechanical Officials
IPART	Independent Pricing and Regulatory Tribunal
LPG	Liquefied petroleum gas
MEPS	Minimum energy performance standards
MJ	Megajoule
NCC	National Construction Code
NG	Natural gas
OEH	Office of Environment and Heritage
OP	Off-peak (electricity)
REC	Renewable Energy Certificate (created under the RET)
RET	Renewable energy target
RON	Rest of NSW
SSD	Sydney statistical division
STC	Small-scale Technology Certificate (created under the RET)
VEEC	Victorian energy efficiency certificate
VEET	Victorian energy efficiency target
WH	Water heater

1. Background

The aim of this report is to enable the NSW Office of Environment and Heritage (OEH) to evaluate the impact of recent changes to the NSW Energy Savings Scheme (ESS) on water heater energy efficiency and energy choice in the NSW water heater market. The changes are embodied in the Energy Savings Scheme (Amendment No.1) Rule 2016 (ESS 2016).

Amendments to the Electricity Supply Act (1995) passed on 20 Oct 2015 extended the ESS to 2025, expanded the ESS to provide incentives to switch fuels and to save gas, and increased the energy savings targets from 5% in 2015 to 7% in 2016 and up to 8.5% by 2019.

If the installation of efficient gas hot water systems is to be incentivised by the ESS, it will be necessary to have a baseline against which to measure the impacts on the market. OEH also needs to plan and resource evaluation activities to readily monitor, track and measure market changes to inform changes in the program implementation, if necessary, and ultimately to evaluate its effectiveness.

To this end, OEH has set the following scope for the project:

- To cover all water heater technology categories including electric, gas, solar and heat pump systems;
- While this is for evaluating the NSW market, the data needs to cover non-NSW markets to form a comparison;
- Focus on the collection of genuine quantitative and qualitative data, which will be integrated in a baseline model to project the counterfactual with existing data.

OEH wishes to have:

- Preferably, sales, prices and/or shares of high efficient products (HEP; subject to definition and categorisation), or practically best surrogate data that would be recommended by George Wilkenfeld and Associates (GWA);
- Market supply chains and HEP delivery pathways as well as identification of key influencers for purchase decisions by end-users;
- Knowledge of barriers, and attitudes of market actors toward barriers and government interventions – considering whether it is also required to extend data collection to down-stream actors in the supply chain e.g. retailers, plumbers and service providers, even end-users. These types of data, presumably from surveys, would help OEH understand whether the intervention is successful and why.

This report analyses both demand and supply in the NSW water heater market, using the best available data. It reviews the data sources, assesses their scope and reliability, and presents a quantitative model of stocks and sales based on the author's best estimates. Finally, the report proposes a strategy for improving the quality of data collections so that the impacts of the new ESS measures can be tracked.

1.1 Gas Water Heater Methods in ESS 2016 Rule

Up to now Energy Savings Certificates (ESCs) could only be created within the ESS through measures which reduce electricity use. The amended Rule Equation 1 (p7, ESS 2016) enables ESCs to be created from savings in both electricity and gas use, with "certificate conversion factors" which give different weightings to electricity and gas savings:

Electricity savings (MWh) x 1.06 + Gas savings (MWh) x 0.39

The certificate conversion factor is intended to reflect the differences in the primary energy required to deliver a unit of electricity or natural gas to end users in NSW, given the existing electricity and natural gas systems. Equation 1 implies a ratio of 2.72 (1.06/0.39) although the calculations have not been made public.

If a measure results in electricity savings but an increase in gas use (as with the replacement of an electric water heater by a gas water heater) the gas savings are negative, but because of the differences in certificate conversion factors there is still scope to create ESCs if the gas is used efficiently enough. If a measure replaces a gas water heater with a more efficient gas water heater, then the gas savings are positive.

Table 1 lists the proposed savings factors for the substitution of a gas for an electric water heater, whether in working order or not, and Table 2 lists the savings factors for the substitution of a gas for gas water heater.

For example, the removal of an electric storage water heater (ESWH) and replacement with a gas instantaneous water heater (GIWH) of 18-22 litres/min delivery that has a rated annual consumption of 18,000 MJ/hr (i.e. just over 6.3 stars equivalent) would generate, at the time of installation:

34.09 * 1.06 + (-38.08) * 0.39 = 21.3 MWh

The value of the ESCs created depends on the NSW ESC market, but assuming $25 per ESC[1] it would be $532 in this example (Figure 1). If the same new GIWH replaced an existing gas storage water heater the notional savings would be 4.52 MWh and the value of ESCs created would be $113.

The criteria which need to be met for the creation of ESCs from the substitution of a gas water heater for an electric water heater are detailed below. The requirements for gas for gas substitution are similar.

The most important consequences of these requirements are:

- If an off-peak water heater is replaced, before or at the end of life, no ESCs may be created. This is because users may be financially worse off in terms of lifetime

[1] ESCs traded at around $25 in the first half of 2016. http://greenmarkets.com.au/resources/esc-market-prices.

energy costs, even after the ESC benefit is taken into account, depending on their gas tariff and the number of other gas appliances they may have[2];;

- In dwellings using natural gas, a new GIWH must have a significantly lower annual energy use (18279 MJ or lower) to be eligible to create ESCs than a gas storage water heater (20302 MJ or lower). This reflects the existing state of the market for each type of water heater;
- In dwellings using LPG, the maximum annual energy use for either a GIWH or a GSWH is the same (18279 MJ). This reflects the fact that LPG costs are so high, that even small increments in efficiency are likely to be cost-effective.

Box 1 Text in Energy Savings Scheme (Amendment no. 1) Rule 2016

Eligibility requirements:

1. The existing electric water heater is an electric resistance storage or instantaneous water heater.
2. The existing electric water heater does not have to be in working order at time of replacement.
3. The existing electric water heater is not on a controlled load tariff (commonly known as 'off peak').

Equipment Requirements:

1. The installed End-User Equipment must be a Gas fired storage or instantaneous water heater as defined in the effective version of AS4552–2005 or AS/NZS 5263.1.2:2016.
2. The installed End-User Equipment must be listed as certified in the Gas Technical Regulators Committee's (GTRC) GTRC National Certification Database and be certified for the fuel to which it will be connected.
3. The capacity of the installed End-User Equipment in Table D10.1 can be either a stored volume for a Gas fired storage water heater or a heated flow rate for a Gas fired instantaneous water heater.
4. The installed End-User Equipment must be rated at an Annual Energy Consumption of $\leq$ 20302 MJ (equal to 5.25 stars) in accordance with the effective version of AS4552–2005 or AS/NZS 5263.1.2:2016, unless one or more of the following conditions are met, in which case installed end-user equipment must be rated an annual energy consumption of $\leq$ 18279 MJ (equivalent to 6.25 stars):
   a. the Site does not have an existing connection to a Distribution Pipeline;
   b. it will be connected to a Gas cylinder, including but not limited to liquefied petroleum gas cylinders;
   c. it is a Gas fired instantaneous water heater.
5. The installed End-User Equipment must have a capacity the same or smaller than the existing End-User Equipment it replaces.[3]
6. The installed End-User Equipment must have a warranty of at least 10 years for the cylinder or tank of a Gas fired storage water heater, or the heat exchanger of a Gas fired instantaneous water heater.

Source: ESS (2016) p98

[2] There is nothing to prevent users installing solar or heat pump water heaters and creating Small-scale Technology Certificates (STCs) under the Commonwealth Renewable Energy (Electricity) Act, but this is outside the ESS rule.

[3] Taken literally, this clause would prevent the substitution of any gas instantaneous water heater for any electric storage water heater. Table 1 does not ascribe a volumetric capacity to GIWHs, so it is not possible to demonstrate that this condition is met.

Table 1 Replacement of an existing electric water heater with a gas water heater

Capacity of installed End-User Equipment	Annual Energy consumption (MJ/yr)(a)	Electricity Savings Factor (MWh)	Gas Savings Factor (MWh)
Gas fired storage: <95 L Gas fired instantaneous <18 L/min at 25°C rise [Small]	>19797 and ≤20302	22.39	-25.38
	>19291 and ≤19797	22.39	-24.75
	>18279 and ≤19291	22.39	-24.11
	>18279 and ≤18785	22.39	-23.48
	>17774 and ≤18279	22.39	-22.85
	>17268 and ≤17774	22.39	-22.22
	>16762 and ≤17268	22.39	-21.58
	< 16762	22.39	-20.95
Gas fired storage: 95 to 140 L Gas fired instantaneous 18 to 22 L/min at 25°C rise [Medium]	>19797 and ≤20302	34.09	-42.30
	>19291 and ≤19797	34.09	-41.24
	>18279 and ≤19291	34.09	-40.19
	>18279 and ≤18785	34.09	-39.14
	>17774 and ≤18279	34.09	-38.08
	>17268 and ≤17774	34.09	-37.03
	>16762 and ≤17268	34.09	-35.97
	< 16762	34.09	-34.92
Gas fired storage: >140 L Gas fired instantaneous > 22 L/min at 25°C rise [Large]	>19797 and ≤20302	45.78	-59.21
	>19291 and ≤19797	45.78	-57.74
	>18279 and ≤19291	45.78	-56.26
	>18279 and ≤18785	45.78	-54.79
	>17774 and ≤18279	45.78	-53.31
	>17268 and ≤17774	45.78	-51.84
	>16762 and ≤17268	45.78	-50.36
	< 16762	45.78	-48.89

Source: Based on Table D.10 in ESS (2016) p99 (a) The value listed for the equipment in the GTRC National Certification Database. Shaded cells apply to gas instantaneous water heaters only

Figure 1 Estimated value of ESCs created at price of $25/ESC

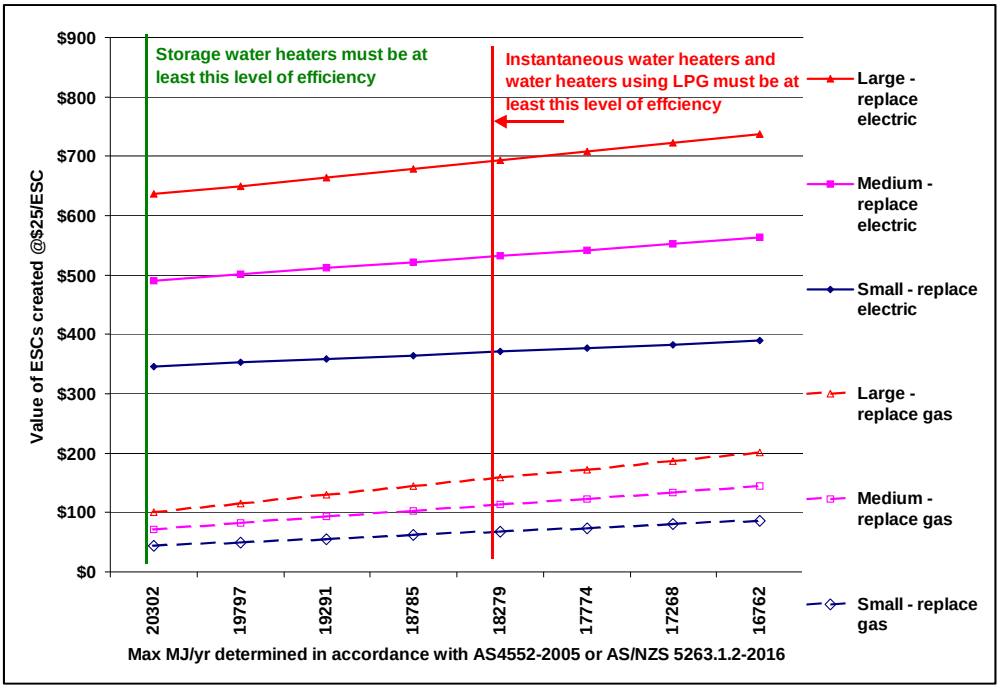


Table 2 Replacement of an existing gas water heater with a new gas water heater

Capacity of installed End-User Equipment	Annual Energy Consumption (MJ/yr)(a)	Gas Savings Factor (MWh)
Gas fired storage: <95 L Gas fired instantaneous <18 L/min at 25°C rise [Small]	>19797 and ≤20302	4.43
	>19291 and ≤19797	5.06
	>18279 and ≤19291	5.69
	>18279 and ≤18785	6.32
	>17774 and ≤18279	6.95
	>17268 and ≤17774	7.59
	>16762 and ≤17268	8.22
	< 16762	8.85
Gas fired storage: 95 to 140 L Gas fired instantaneous 18 to 22 L/min at 25°C rise [Medium]	>19797 and ≤20302	7.38
	>19291 and ≤19797	8.43
	>18279 and ≤19291	9.48
	>18279 and ≤18785	10.54
	>17774 and ≤18279	11.59
	>17268 and ≤17774	12.64
	>16762 and ≤17268	13.70
	< 16762	14.75
Gas fired storage: >140 L Gas fired instantaneous > 22 L/min at 25°C rise [Large]	>19797 and ≤20302	10.33
	>19291 and ≤19797	11.80
	>18279 and ≤19291	13.28
	>18279 and ≤18785	14.75
	>17774 and ≤18279	16.23
	>17268 and ≤17774	17.70
	>16762 and ≤17268	19.18
	< 16762	20.65

Source: Based on Table D11.1 ESS (2016) p101 (a) The value listed for the equipment in the GTRC National Certification Database. Shade cells apply to gas instantaneous water heaters only

1.2 This Report

Whenever an ESC-eligible installation occurs, there will need to be some evidence submitted to the ESS regulator, the Independent Pricing and Regulatory Tribunal (IPART) to substantiate that the installation has occurred and meets the criteria in the Rule. In the case of water heaters, the evidence is likely to come from someone in a position to have witnessed the installation – either the owner of the new water heater, the installing plumber or some other intermediary. (The use of forms as a data collection mechanism will be discussed later in the report).

However, IPART's record of water heater installations claiming ESCs will not on its own be sufficient to track the real impact of the incentive. This is because in many cases the individual would have made the same water heater choice anyway, but will (understandably) take advantage of the payment if available. The real impact will be the difference between the actual trends in the water heater market after the measure is implemented, and what the trends would have been in the absence of the measure – the "counter-factual" or "business-as-usual" (BAU) case.

The aim of this report is to clarify the historical and the existing trends and forces in the NSW water heater market and to project a BAU case that will become the counter-factual case once the new incentives created by the ESS Rule start to influence the market.

Section 2 describes the NSW water heater market, with respect to the types of water heaters available and their efficiency ratings. Section 3 describes the dynamics of the water heater market: the manufacturers and the distribution channels and the main factors involved in water heater choice and typical consumer behaviour. Section 4 describes the costs involved in installing water heaters, including the purchase price, installation and (where necessary) the costs of connection to natural gas.)

Section 5 describes the historical trends in the market over the past 10 years, including the impacts of previous market interventions (e.g. the cash rebates offered by the Commonwealth and NSW government in the late 2000s) and existing factors such as the continuing availability of Small-scale Technology Certificates (STCs) under the Commonwealth Renewable Energy Target (RET). It uses the available information to construct a projection model of the market (this is embodied in a separate Excel spreadsheet accompanying this report). The main features of the spreadsheet are described in Appendix 3.

Section 6 discusses the strategies and systems required to monitor the impact of the proposed changes to the ESS.

1.3 Data Sources

There is considerable information about the stock of water heaters in Australia, and in NSW in particular. Separate studies have been carried out by a number of entities.

The Australian Bureau of Statistics (ABS) has carried out triennial surveys of appliance stocks since 1994, in its *Environmental Issues: Energy Use and Conservation* 4602.0 series. The 2005, 2008, 2011 and 2014 surveys were used for the present study. These

survey the types of water heaters installed, but not their age or efficiency. They are referenced as ABS (year).

The 4602.0 surveys are appended to the monthly labour force survey, so they are affected by changes in sampling and polling techniques for the main survey.[4] The ABS asks respondents for "all sources of energy use for water heating", so the total number of sources adds to more than the number of households, because 2% to 3% of homes have more than one water heater. Also, the share of respondents who report that they do not know the source of energy varies from 3% to as high as 11%.

The ABS has also conducted special state appliance surveys from time to time. For NSW, the last one was in October 2006 (ABS 4621.1). The NSW sample (7,500 households) was larger than in the national survey, and the survey was conducted either face-to-face or telephone, so it was of high quality. Although there is no time series of such surveys, it does provide a useful cross-check on the results of the national ABS appliance surveys conducted around that time.

The commercial survey company BIS Shrapnel surveys both stocks and sales of water heaters biennially. The 2004, 2006, 2008, 2010, 2012 and 2014 surveys were used for the present study. They are referenced as BIS (year). The samples for NSW are larger than for other states, but still relatively small in comparison with ABS samples. For example, BIS had 1,760 NSW respondents to the 2014 survey. Up to 2010 the surveys were conducted by telephone, but from 2012 they have been online (but non-random, in that BIS contacts a stratified sample of potential respondents).

BIS is the only publicly available data source that reports on recent water heater sales/purchases over the previous 18 months, as distinct from stocks. The purchase sample appears to be a subset of the stock survey respondents. As only about 10% of the respondents would have purchased a water heater in any year, the sample sizes are small – only about 300 for NSW.

IPART conducted surveys of households in Sydney, the Blue Mountains and Illawarra in 2004, 2006 and 2010. The sample size for 2010 was nearly 2,200. In 2008 IPART conducted a similar survey in the Gosford-Wyong and Hunter regions, and in 2015 a survey covering the Sydney and Hunter Water Corporation areas of operation, the Gosford Council area, the Wagga/Albury region and the Northern Rivers/Mid North Coast regions. This covers a larger area of NSW than the earlier surveys, but the results were not yet been published when this report was written.[5]

The data sources listed above cover all households, irrespective of the age of dwellings. Since 2004, the BASIX scheme has been setting sustainability targets for new dwellings constructed in NSW – whether detached, attached or apartments. BASIX approvals record the type of water heater to be installed in the new dwelling. BASIX has

[4] http://www.abs.gov.au/ausstats/abs@.nsf/exnote/4602.0.55.001 From December 2012 to April 2013, the ABS conducted a trial of online electronic data collection. Respondents in one rotation group (i.e. one-eighth of the survey sample) were offered the option of self-completing their labour force survey questionnaire online instead of via a face-to-face or telephone interview. From September 2013, online electronic collection has been offered to 100% of private dwellings in each incoming rotation group. From April 2014, 100% of private dwellings were offered online electronic collection. The latest 4602.0 survey was undertaken in March 2014, so the majority of respondents had the option of online response.

[5] The results were published in November 2016.

published analyses of water heater selections and other design factors in new dwellings for the period 2004-09 (BASIX 2009, 2011, 2011a), and in alterations and additions (BASIX 2011b).

The effect of previous incentives on the NSW water heater market can be tracked, or at least inferred, from the data collected during the period of the NSW Home Saver Rebate Program, which ran from July 2007 to June 2011. Over that period, the NSW government offered rebates for the replacement of electric storage water heaters with either solar, heat pump or gas. The rebates for solar and heat pump water heaters initially varied from $600 to $1,200 according to the number of renewable energy certificates (RECs) the model were eligible to create under the Commonwealth Renewable Energy Target (RET), falling to a flat $300 from January 2010.

For gas water heaters the rebate was a flat $300 throughout. Although the incentive for a gas water heater under the ESS Rule will be comparable (see Figure 1) the relative impacts should be greater because the countervailing NSW incentive to select solar or heat pump is no longer on offer. GWA has previously analysed quarterly data up to March 2010 (GWA 2010) and total programme data have been made public by OEH. [6]

In addition to these quantitative primary data sources, the following qualitative and secondary data sources were used:

- Interviews with the major gas water heater manufacturers (Bosch, Dux, Rheem and Rinnai) and with Ausgrid.[7] The names and dates are included in Appendix 2; and

- Various product profiles, regulation impact statements and other reports on water heater technology and the water heating market published by the Equipment Energy Efficiency (E3) Program. These are referenced as they occur in the text.

[6] http://www.environment.nsw.gov.au/energyefficiencyindustry/home-data-rebates.htm
[7] GWA attempted to secure interviews with major hot water installations services but was unsuccessful despite several call-backs and reminders.

2. Technologies and Efficiency

2.1 Water Heater Types

A means of heating water for washing and other domestic purposes is considered an essential service in modern dwellings. There is a wide range of technologies capable of supplying domestic hot water. These may be classified in a number of ways, including:

- the form of energy or fuel used – the most common forms are electricity, natural gas and liquefied petroleum gas (LPG), although wood and other fuels could also be used;
- whether renewable energy (e.g. solar thermal energy) is used in association with electricity or fuel. (Water heaters using only renewable energy are not practical in NSW climates);
- whether the system maintains a volume of hot water ready for use ('storage' types) or heats the water as required ('instantaneous' or 'continuous flow');
- water storage capacity (e.g. litres) or 'delivery' capacity (e.g. litres that can be drawn off before the water falls below a given temperature);
- whether the system is designed to work with a supply of energy available at all times (e.g. 'continuous' or 'day rate' electricity) or whether it is designed to work with a time-constrained supply ('off-peak' electricity). In NSW electricity suppliers usually offer two forms of off-peak: restricted hours (OP1) where energy is available for only 7 or 8 hours overnight, and extended hours (OP2) where energy is always available except during periods of peak demand on the electricity network. The more restricted the hours, the greater the storage volume required in order to minimise the risk of running out of hot water;
- the maximum rate of energy transfer, or power (e.g. kW for electric types, MJ/hr for gas). Instantaneous water heaters (IWHs) are usually described by the litres of water they can heat every minute (l/min), typically over a 25^{o}C temperature rise. IWHs typically need 4 to 5 times the rate of energy consumption as storage water heaters, because they heat water as fast as it is drawn off, while storage water heaters have a buffer. For example, GIWHs may have a burner rating of up to 200MJ/hr, compared with 25-40 MJ/hr for gas storage water heaters. This means a GIWH needs an 18mm rather than a 12mm gas service, and an EIWH may need a 3-phase rather than a single-phase electricity supply;
- for storage types, the rate at which heat is lost from the stored water ('standing loss');
- for electric units, whether the energy is supplied to a resistance element (or more than one), a motor driving a system that collects ambient energy (a 'heat pump'), or both;
- whether the system is supplied as a single unit (as is the case with most gas and electric water heaters) or whether it is assembled from components on-site (e.g. many solar water heater systems);
- For gas, LPG and other fuel systems, whether it must be installed outside or may be installed inside with a flue that takes exhaust gases to the outside.

All types of water heaters are intended to meet the same basic task: the delivery of a given quantity of water at a given temperature as and when required. The amount of energy consumed to carry out this basic task can be determined either by physical

testing of entire systems or by calculations based on the measured performance of components.

The simplest technology for heating water is the electric storage water heater (ESWH). This has a number of characteristics which have led to its high market share in NSW: low capital cost, low installation cost, no need for a gas connection, no need for fluing and flexibility in location (indoors or outdoors). On the other hand, ESWHs may have high running costs (unless connected to off peak) and high greenhouse gas emissions if connected to a greenhouse-intensive electricity supply. There is no real technical difference between ESWHs operating on different tariffs, except that the utilities and water heater suppliers recommend larger storage tanks as a condition of connection to OP, to minimise the risk that the user will run out of hot water between reheating periods.

Virtually all separate dwellings in NSW ("Class 1" dwellings have at least one water heater.[8] A few have secondary water heaters to serve outlets so remote from the main water heater that the time delay to get hot water would be unacceptable. Most apartments ("Class 2 dwellings') also have their own water heaters, although systems where each apartment is served from a central water heater installation are becoming increasingly common. The central installations could be banks of domestic-size water heaters or special commercial-scale boilers.

Table 3 Water heater market segments

Dwelling Type	Water Heating Delivered Energy	Water heater type
Class 1	Electricity	Electric resistance storage – continuous tariff (uncontrolled)
		Electric resistance storage – off-peak 1 tariff (controlled)
		Electric resistance storage – off-peak 2 tariff (controlled)
	Electricity	Solar with electric boost continuous tariff (uncontrolled)
		Solar with electric boost – off-peak 1 tariff (controlled)
		Solar with electric boost – off-peak 2 tariff (controlled)
	Electricity	Heat pump with electric boost continuous tariff (uncontrolled)
		Heat pump with electric boost – off-peak 1 tariff (controlled)
		Heat pump with electric boost – off-peak 2 tariff (controlled)
	Natural gas	Storage (SWH)
		Instantaneous (IWH)
		Solar with gas boost
	LPG	Storage (SWH)
		Instantaneous (IWH)
		Solar with LPG boost
Class 2	Separate systems	ALL TYPES AS FOR CLASS 1, plus:
		Electric resistance instantaneous
Class 2	Central systems	Central systems with circulation to individual apartments – could be any of the energy configurations in Class 1, but on larger scale

[8] Under the National Construction Code a Class 1 building is not located above or below another dwelling, or another class of building other than a private garage. Class 1 buildings may be attached to other Class 1 buildings or buildings of other classes. A Class 2 dwelling is a sole-occupancy unit used for residential purposes located over another sole-occupancy unit used for residential purposes, within a Class 2 building. Class 2 buildings can also be single-storey attached dwellings.

The range of common energy types and configurations installed in dwellings in NSW is summarised in Table 3. Of course, the same types of water heaters may also be installed in non-residential buildings: offices, shops, restaurants, hotels, hospitals, sport facilities, factories and anywhere else that a supply of hot water is required.

2.2 Water heater energy efficiency

It is difficult to apply the same measure of energy-efficiency to all of the water heater types in Table 3. In fact, policy makers and consumers themselves often conflate a number of related but distinct issues: the use of renewable energy, technical efficiency, the greenhouse gas-intensity of the delivered energy form and the running cost, all of which can be measured in different ways.

Comparisons between water heating technology types are more likely to be made on the basis of renewable energy use and greenhouse-gas intensity than technical efficiency:

- The eligibility of solar and heat pump water heaters under the RET scheme was justified on the basis of their use of ambient renewable energy, not because they were more efficient versions of electric storage water heaters;
- The rebates offered for the replacement of electric water heaters by solar and heat pump water heaters under the Commonwealth Energy Efficient Homes and Renewable Energy Bonus Schemes between 2009 and 2012 were advertised on the basis of their lower emissions-intensity and their use of renewables, not their relative efficiency (GWA 2010);
- BASIX ranks water heater types on the basis of their greenhouse-gas intensity; relative efficiency within types is secondary;[9]
- The National Construction Code (NCC) prohibits the installation of electric resistance water heaters in new dwellings on the basis of their high greenhouse gas-intensity, not on the basis of their efficiency (GWA 2012).

The technical efficiency of water heaters may be measured in different ways: at the point of end use or taking into account the process of energy extraction, production and transport. End use efficiency is a characteristic of the water heater itself, and can be determined using standard tests (although the nominal patterns of hot water use built into those tests may not reflect actual usage).[10] Calculating the share of energy initially extracted from nature (the "primary energy") that is delivered to point of end use (the "delivered energy" cannot be measured with standard tests. Any calculation requires a number of methodological assumptions.[11]

Comparing the relative efficiency of electric resistance water heaters and their gas counterparts is complex, and depends on what metrics are chosen: end-use efficiency or some metric related to the energy system as a whole, such as primary energy efficiency or the relative greenhouse gas-intensity per unit of energy delivered and converted to useful energy services.

[9] https://www.basix.nsw.gov.au/basixcms/basix-help-notes/energy.html?id=360
[10] This is an unavoidable factor in all energy efficiency test standards.
[11] For example, a proportion of the natural gas extracted at the gas field is used to power the on-field treatment plant and the pipeline compression equipment. However, a significant amount of electricity is also consumed: should the primary energy used to generate that electricity also be added to the primary energy content of the gas for the purpose of the calculation?

Another justification for intervention in the market is the fact that most water heater purchases are made under conditions where capital costs (purchase plus installation) dominate, and running costs are ignored or heavily discounted. This form of market failure has been well documented in the past (GWA 2009) and recent interviews with manufacturers confirm that it still dominates consumer purchase behaviour.

Energy efficiency is more directly comparable within technology types (electric and gas, storage and instantaneous) than between them. Within electricity types, there is little difference between the energy efficiency of ESWH models. All are built to the same mandatory minimum energy performance standards (MEPS) and are all largely identical in their task efficiency.[12] For gas water heaters however, there are real energy efficiency differences between and within sub-types:

- The least efficient group is naturally aspirated gas storage water heaters designed for internal installation. Enough heat has to be left in the flue gases to give them sufficient energy to escape through the flue to the outside. This group generally has the highest MJ/yr ratings and the lowest star ratings – typically 3* to 4*;

- Storage water heaters designed for outside installation can be more efficient because there are no constraints on the venting of the flue gases. The designs on the market rate between 4* and 5*. The highest rated models are designed to maximise the heat exchange from the burner and the flue gas to the storage tank;

- Conventional gas instantaneous water heaters have no gas standing losses, and fan-forced air flow to the burners. The least efficient models on the market rate 5*, and over 60% of all models are now rated 6* (Table 5), including models designed for internal installation;

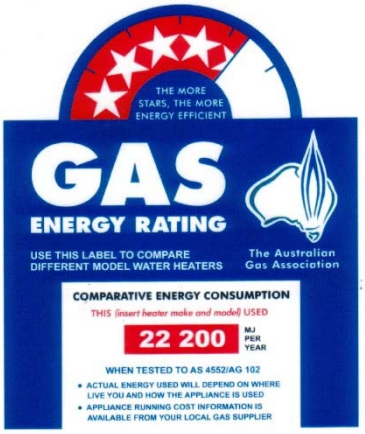
- The most efficient technology is condensing instantaneous water heaters. The conversion efficiency can be as high as 93-95%, which approaches the physical limits of combustion technology. As the name implies, so much heat is extracted from the flue gases and transferred to the water that the gases condense and need to be disposed of safely.[13] Prices are significantly higher than for conventional GIWHs, because corrosion-resistant material have to be used, and the condensate drain adds to installation costs.

[12] The MEPS (for standing heat loss) are enforced under the Commonwealth Greenhouse Energy and Minimum Standards (GEMS) Act 2012. The task efficiency of a water heater takes into account both conversion efficiency and standing heat losses.
[13] Condensing units generate up to 5 litres of mildly acidic condensate per hour, which needs to be discharged to the sewer, stormwater drain or a gravel pit (Rinnai 2013).

2.3 Efficiency ratings for gas water heaters

A "Gas Energy Guide" label for water heaters was introduced in 1985 under the auspices of the AGA. In 1989 it was replaced with a new AGA "Gas Energy Rating" label similar in general design to the electrical appliance energy labels, introduced by the NSW and Victoria governments in 1986. There are gas energy rating labels for space heaters, ducted heaters and water heaters. The design features a star rating, and an annual energy gas consumption value (Figure 2).

Figure 2 Gas Energy Rating Label



The committee of Commonwealth, state, territory and New Zealand officials which manages the national equipment energy efficiency program (E3) has been considering bringing gas appliances within the program since 2000 (GWA 2000). To this end, the GEMS Act 2012 gives the Commonwealth Minister the power to regulate gas products.

In the mid 2000s the E3 committee commissioned several studies to investigate the ability of AS4552-2005 to support a regulatory program. After a number of inter-laboratory comparison tests, it concluded that the test (which until recently was still the basis for all published energy ratings for gas water heaters) was not sufficiently repeatable or reproducible. In 2007 E3 proposed a number of changes to the test (Harrington 2007). These have been incorporated into AS/NZS 5263.1.2:2016 *Gas fired water heaters for hot water supply and /or central heating*, which has replaced AS4552-2005.[14] However, products certified under AS4552-2005 will remain certified until their certification expires or is cancelled. Given the fact that nearly all GIWHs sold in Australia are made overseas and designed for a global market, it is most unlikely that the changes in the standard in themselves will influence product design or efficiency, even if a model rated a slightly different MJ/yr value if tested to the new standard.

In 2009 the E3 committee recommended the adoption of MEPS at the 4 star level for gas water heaters, in the expectation that the new test would be published by 2010 (E3 2009). Even though the revised test was not published in time, in 2013 the Minister made a GEMS determination effectively making 4* the MEPS level for:

[14] http://infostore.saiglobal.com/store/Details.aspx?ProductID=1841118

- Gas storage water heaters with a nominal gas consumption of not more than 50 MJ/hr and a capacity of at least 30 litres, excluding those "certified only for installation indoors", and
- Gas instantaneous water heaters with a nominal gas consumption of not more than 250 MJ/hr or with a heat output of at least 13.1 kW (GEMS 2013).

These MEPS levels were so lenient as to have no practical impact on the market, even when first implemented. It is assumed that the GEMS determination will need to be revised to refer to AS/NZS 5623 rather than AS4552. Otherwise as new models are introduced they would still need to be tested under the now superseded AS4552 to demonstrate compliance with the current GEMS determination. Such a revision would offer the opportunity to revise the MEPS levels so that they actually impacted on the market, but the E3 program has now effectively withdrawn from the gas sector.[15]

The 2013 determination stated "There are no GEMS labelling requirements for products covered by this Determination". This means that gas energy labelling program continues under the control of the industry or the Gas Technical Regulators Committee (see below) – it is not clear which.

Whether for MEPS or labelling a product first had to be tested to AS4552-2005 (or AS/NZS 5263) to calculate the MJ/yr that it would consume to supply 200 litres of hot water per day per day (raised 45ºK above the inlet water temperature – i.e. 13,760 MJ/yr useful energy embodied in hot water). The tests and calculation methods differ for GSWHs and GIWHs.

The MJ/yr value so determined is then compared with a "reference" water heater which would use 28,900 MJ/y to supply the same amount of hot water.[16] The reference value was set equivalent to 1 star on the gas label. To obtain 2 stars, a water heater must use at least 7% (2,023 MJ/yr) less than the reference value, and to obtain 3 stars a water heater must use another 2,023 MJ/yr less and so on (Table 4). This simple arithmetic progression is no longer used in the electrical appliance energy labelling program, where the reduction in energy use required for each additional star is a constant percentage (e.g. a 3* product must use 20% less energy than a 2* product, and a 4* product must use 20% less energy than a 3* product, as so on).

Table 4 Gas efficiency ratings – water heaters

Star rating	Max MJ/yr (a)	% of reference saved	% saving compared with next lowest star
1	28.900 (Reference value)	0%	
2	26,877	7-13.9%	7.0%
3	24,854	14-20.9%	7.5%
4	22,831	21-27.9%	8.1%
5	20,808	28-34-9%	8.9%
6	18,785	>=35%	9.7%

(a) To deliver 13,760 MJ/yr useful energy as hot water

[15] Personal communication to the author.
[16] Such a unit actually existed once, but it disappeared from the market over 20 years ago (GWA 2000).

AS4552 and AS/NZS 5623 also set out how the rating is converted to the number of stars on the gas energy label, and how these stars are to be displayed. The space for each full star occupies 30º of arc. A water heater which consumes 28,900 MJ or more is rated 1 full star. A water heater which consumes 18,785 MJ/yr *or less* is rated 6 full stars, irrespective of how little gas it may use. A label rating higher than 6 stars is not possible under the present rules, no matter how little gas the unit consumes.

There are 150º of arc from the 1 star rating (0% saving compared with the reference) to the 6 star rating (35% saving). Therefore each additional percentage point saving allows the blue bar behind the stars to advance a further 150/35 = 4.28 degrees of arc. Originally, manufacturers were free to locate the end of the band at the exact point along the arc that corresponded to the % of reference value saved. The AGA then tightened the rules so that there were only 10 possible fixed division points between stars. Some manufacturers quote these decimal division, e.g. they might advertise a model as "5.6 stars".[17]

It is logically not possible to claim a product as rating any more than 6 stars because the label scale does not advance past 6 full stars. Some manufacturers have claimed star ratings above 6 (e.g. 6.3) and even above 7, even though the AS4552 and AS/NZS 5623 star rating scale does not allow for a label with more than 6 stars.[18] They do this by applying the principle which the AGA used to develop the star rating algorithms – that each additional 7% in savings compared with the reference value deserves another star. However, this is inconsistent with AS4552 or AS/NZS 5623, which cap the scale at 6.0 stars. The AGA has pointed out that this is the case, and has requested that it be clarified in the standard.[19]

If the standards were to permit a gas efficiency rating of higher than 6, the design of the label would need to change to permit the visual display of more than 6 stars. This is the case with the electrical appliance labels, which now allow for the display of an additional "coronet" of up to 4 more stars for products classified as "super-efficient". Thus there is considerable confusion regarding the rating and energy labelling of gas water heaters. The ESS Rule circumvents this by defining eligibility to create numbers of ESCs in terms of MJ/yr values rather than star ratings. Since most supplier literature reports star ratings (often erroneously expressed as a value higher than 6) rather than MJ/yr values, the ESS Rule has to reference a published directory. This is further discussed below.

2.4 Efficiency Registration and Listing

[17] In 2012 the Gas Technical Regulators Committee (GTRC) issued a technical guidance bulletin which stated that the second decimal place of the star rating should be rounded: "A calculated result of 4.95 stars would result in an energy star rating of 5 stars whilst a calculated result of 4.94 stars would result in an energy star rating of 4.9 stars." (GTRC 2012). By contrast, the electrical appliance energy labelling rules only permit complete stars and complete half stars to be shown, and only rounding down is permitted – e.g. if a product is calculated to rate 5.8 stars it can still only display 5 full and one half star. Market research has found that very few consumers can distinguish decimal increments on labels, and half-star increments are more effective (WSRS 2008).

[18] http://www.chromagen.com.au/images/PDF_BROCHURES/Chromagen-Component-Spec-Sheet/Daesung%20Continuous%20Flow%20Gas%20Water%20Heater.pdf

[19] http://www.aga.asn.au/?wid=81&func=viewSubmission&sid=57

When gas labelling was first introduced, the AGA was the only non-government agency authorised by gas regulators to test gas appliances for safety and energy efficiency and to certify them with the Gasmark symbol. This monopoly was removed about 10 years ago, and the following agencies now test and certify gas appliances:

- AGA http://www.aga.asn.au/
- Standards Australia (SAI Global) http://register.saiglobal.com/
- International Association of Plumbing and Mechanical Officials (IAPMO) http://forms.iapmo.org/ocna/listing/
- Global-Mark http://www.global-mark.com.au/en-au/documentcentre/certificatesearch.aspx

Recently the GTRC established a central register of all certified gas products. Including water heaters. The new ESS Rule specifies that "the installed end-user equipment must be listed as certified in the Gas Technical Regulators Committee's GTRC National Certification Database and be certified for the fuel to which it will be connected."

By implication, the MJ/yr value listed in the GTRC database is the relevant one for determining whether a given model meets the eligibility requirements and how many ESCs its installation may create. However, it is not possible for a user to view a complete listing of models with their MJ/yr values. The GTRC database requires the user to enter one or more of the following fields (without any explanation):

- Certificate number:
- Certifier (with a drop-down menu of the agencies listed above):
- Certificate holder:
- Trade name:
- Model number:
- Equipment class (with a drop-down menu of two options only: Appliance and Component)
- Description.

An unfamiliar user presented with this menu will find it difficult to locate any given water heater, let alone a listing of all eligible water heaters. In fact, the most efficient way to search is to type "water heater" into the Description field. This will give a list of 111 results – not of actual water heaters, but certificate numbers and holders.[20] Clicking on the certificate number will give a list of the water heater models with their MJ/yr values, registered under that certificate. Most manufacturers have models listed under more than one certificate, so the user would need to work through all of them if they wanted a comprehensive list of all water heater models and their MJ/yr values. As an added complication, European-style combi boilers, which heat water mainly for central heating, are also classified as water heaters, and some of the certificates registered by the popular gas water heater brands are for these products.

Table 5 indicates the number of GIWH and GSWH heater models certified by each agency, and the number of those that meet the ESS eligibility requirements. This was compiled by searching manually through each of the 111 certificates listed on the GTRC site.

[20] http://equipment.gtrc.gov.au/default.aspx Accessed 25 May 2016,

Therefore, while the GTRC database is a vital resource for the ESS regulator and for professional participants (the water heater manufacturers, retailers and larger installers who have an interest in advertising and advising consumers which models are compliant) it is not very accessible for smaller plumbing businesses and for consumers who wish to do their own research.

The accessibility of the GTRC register may or may not limit the impact of the new ESS Rule on product choice. If suppliers deem the commercial value of identifying eligible models to be high, they may indicate those models in their brochures and advertising, and also help explain to consumers the eligibility requirements (e.g. the off-peak tariff and natural gas vs LPG requirements). However, if they do not, it may be necessary to consider establishing a website listing all eligible products, to assist consumers and plumbers, as the Essential Services Corporation of Victoria (ESCV) has done.

The ESCV maintains a list of gas water heaters eligible to create Victorian Energy Efficiency Certificates (VEECs) under the VEET, when installed in place of an electric water heater (https://www.veet.vic.gov.au/public/productregistrysearch.aspx.) These are all rated 5 stars or higher, in accordance with the VEET rules
The E3 program also maintains a register of all gas water heaters complying with the GEMS determination (www.energyrating.gov.au). However, very few of the entries list the MJ/yr values.

Table 5 Existing listings of gas water heaters

	AGA(a)	IAPMO(b)	SAI Global(b)	GlobalMark(b)	GTRC (e)	ESCV	Energyrating
Star ratings listed?	Yes	Yes	No	Yes	Yes	Yes	No
MJ/yr listed?	Yes	Yes	Yes	Yes	Yes	No	Some
Number of GIWHs listed	241	63	252	0	556	456	494
Number of GSWHs listed	116	0	0	95	211	152	275
Number of 6* GIWHs listed	105	58	181	0	344	NA	NA
Number of eligible GIWHs	25	23	78	0	126	NA	47
Number of eligible GSWHs	22	0	0	72	94	NA	8
Share of GIWHs eligible for ESS	10%	37%	30%	NA	23%	NA	22% (c)
Share of GSWHs eligible for ESS	19%	NA	NA	76%	45%	NA	13% (d)
Accessibility	Downloadable pdf file	Downloadable pdf file	Downloadable xls file	Downloadable pdf file	Online search only	Downloadable xls file	Online search Downloadable csv file
Coverage	Only products registered with AGA	Only products registered with IAPMO	Only products registered with SAI	Only products registered with GlobalMark	All registered products	All gas water heaters rated 5* or more	All gas water heaters rated 4* or more

All registers accessed 25 May 2016. (a) From pdf downloaded from AGA website. (b) Accessed via http://equipment.gtrc.gov.au/default.aspx (c) Of the 215 GIWH models for which MJ/yr data are given. (d) Of the 61 GSWH models for which MJ/yr data given. (e) sum of cells to the left.

3. Market Segmentation and Dynamics

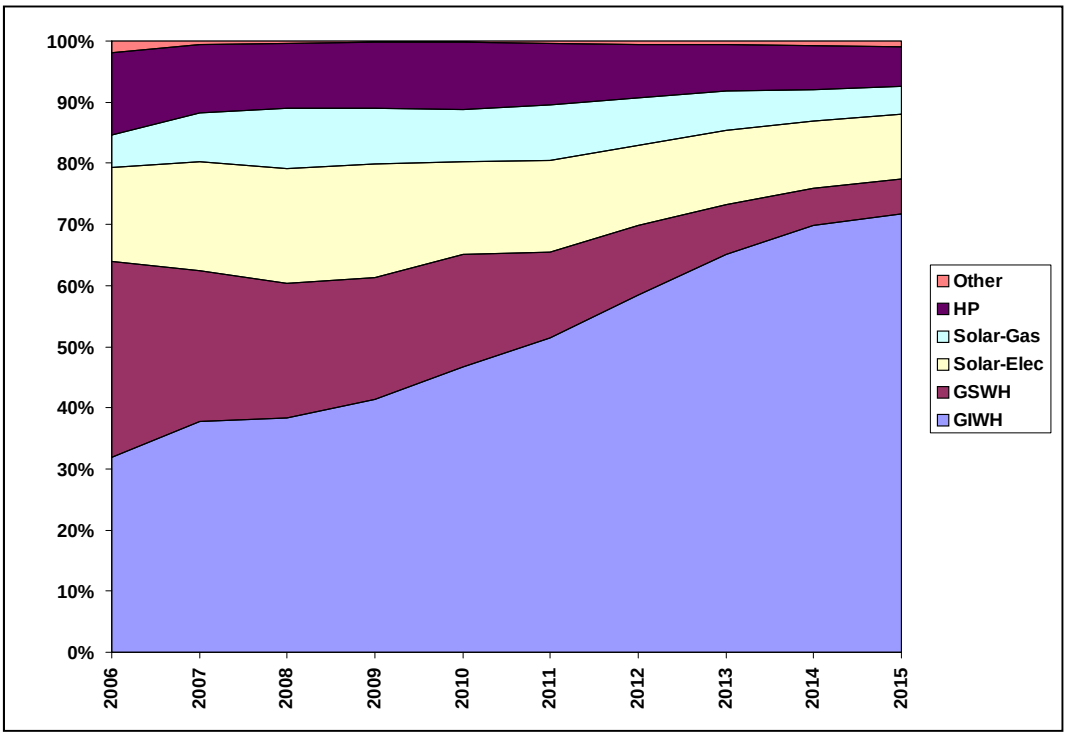
3.1 Market Segmentation

3.1.1 New construction and alterations – separate dwellings

Since October 2005 the NSW Government's BASIX scheme has required all new dwellings in the State to commit to mandatory water and emission targets. To obtain development approval, new home designs must document the means by which the building will use 40% less water and be responsible for emitting 40% less greenhouse gas than an average pre-BASIX home. New swimming pools over 40,000 litres and renovations worth over $50,000 are also subject to BASIX.

The water heating component of BASIX makes it almost impossible to comply using an electric resistance water heater, and this has virtually eliminated that type of water heaters from new dwellings. Figure 3 illustrates the shares of water heater types installed in new dwellings over the 10 years from July 2005 to July 2015. The gas water heater share increased from 64% in 2005 to 77% in 2015. Conversely, the solar share declined from a peak of 28% in 2009 to 15% in 2015. The heat pump share also declined, from 13% to 6%. The GIWH share of gas water heaters increased from about half in 2005 to about 93% in 2015. Adding the number of gas and solar-gas water heaters indicates that the share of new dwellings using gas (whether NG or LPG is not indicated) increased from 69% in 2015 to 82% in 2015.

Figure 3 Water heaters installed in new single dwellings in NSW, 2005-2015



Source: BASIX (2015)

About 28% of BASIX certificates for additions and alterations included a change of water heater (BASIX 2011b). Data are only available for the period 2005-08. The water heater type share over that period (Table 6) was very similar to the pattern for new dwellings.

Table 6 New water heaters installed in altered single dwellings, NSW 2005-08

Type	Share
Solar	27.2%
Gas	65.4%
Heat pump	7.2%
Wood	0.2%
Total	**100.0%**

Source: BASIX (2011b)

3.1.2 New construction – apartments

New apartment buildings ("multiple dwellings") are also subject to BASIX rules. Nearly half of new apartments built between 2005 and 2008 were supplied with hot water from a central system, and most of the rest by separate gas water heaters (Table 7). Although the type of gas water heater is not recorded, the space limitations of apartments suggests that the great majority would have been GIWHs, because these are more compact than GSWHs and can be wall-mounted (usually on an external wall).

Of the central systems, about 8% were reported as heat pump installations, 13% solar and 79% gas-fired[21]. Therefore about 84% of new apartments would have had their hot water heated by gas, either directly or via a central system.

Table 7 Water heaters installed in new multiple dwellings, NSW 2005-08

Type	Share
Central	48.0%
Solar	3.3%
Gas	45.9%
Heat pump	2.6%
Electric	0.2%
Total	**100.0%**

Source: BASIX (2011)

3.1.3 Replacements

[21] There are no reliable data on the type or configuration of central gas-fired installations in use. There are design guides published by gas utilities, e.g. https://jemena.com.au/getattachment/fa5fa351-ccc0-4fe7-aaa6-bf7b08bf8764/Design-guide-for-gas-centralised-hot-water-systems.aspx. Rinnai offers a range of large-capacity versions of its domestic GIWHs with manifolding and common controls – see http://www.rinnai.com.au/media/747054/Commercial_Reference_Guide.pdf. Rheem also offers manifolded GIWH options, as well as large-capacity GSWHs with high recovery rates (up to 200 MJ/hr, compared with 25-40 MJ/hr for residential GSWHs) and purpose-made commercial boilers rated up to 4,000 MJ/hr from its commercial division, Raypak – see http://www.rheem.com.au/commercial-gas-water-heaters.

Replacement installations in existing buildings account for the great majority of the water heater market in NSW. There are no regulatory constraints on water heater replacements in NSW, so owners are free to select any technology type.[22] Replacement decisions are usually rushed, because the very high value which occupants place on continuing availability of hot water limits the time available for research, selection and installation. Decisions tend to be made under capital constraint: failures are rarely anticipated or budgeted for, so the cheapest capital cost option is often preferred even if it is known to have higher lifetime costs (GWA 2010). Historically, the most common replacement has been 'like for like', although that tendency is weakening somewhat.

Intermediaries exert a major influence on replacement choice. BIS (2012) reported that when a water heater fails in NSW, 40% of home occupants contact a plumber first, 27% a hot water specialist and 16% an energy retailer; only about 7% go to appliance retailers or hardware stores, where they might see actual products. If the failed water heater is electric, the tendency to consult a plumber first is even greater.

Capital cost and waiting times are the major factors determining the choice of replacement (GWA 2009, WSRS 2008). According to industry sources, the plumber will usually advise that 'like for like' replacement is the quickest and the cheapest, since the existing water and energy connections do not need to be changed. This has been a major barrier to changing from electric to gas water heating, since apart from the additional cost of getting a gas pipe to the location of the water heater it may take several days from the time of contacting the natural gas utility to getting a connection.[23]

Gas utilities and suppliers of gas water heaters have developed several methods for addressing this barrier: installing the new natural gas water heater and running it from a compressed natural gas bottle for several days until the connection is completed, or installing a temporary LPG water heater with an LPG bottle and installing the final water heater only when the natural gas connection is completed.[24]

When an existing gas storage water heater fails, it is very likely that it will be replaced by another gas water heater. However, if the failed water heater is of the storage type, there will be barriers to replacing it with an instantaneous type:

- the need for an electrical connection to run the electronic controls, ignition and combustion fans on the GIWH[25];

[22] The only jurisdiction with regulatory limitations on the replacement market is South Australia, which since July 2009 has required most replacement water heaters to be of 'low emission' types such as heat pump, solar or high efficiency gas (5* or better). Homes in and near Adelaide can only install conventional electric water heaters where the system being replaced is located inside the dwelling or in the roof space or, if outside, is within 3 metres of neighbours' windows or doors. https://www.sa.gov.au/topics/water-energy-and-environment/electrical-gas-and-plumbing-safety-and-technical-regulation/plumbing-trades/residential-water-heater-requirements/water-heater-installation-requirements

[23] LPG cylinders take less time to set up, but electric to LPG substitution is less financially attractive than electric to natural gas: the running costs of LPG can be as high or higher than day rate electricity.

[24] One water heater manufacturer indicated that these methods have not been very successful.

[25] There are some GIWH models which use pilot lights, piezo ignition or batteries and so do not require an electrical connection, but these tend to be older, less efficient models. Newer designs all use electronic controls and combustion air fans, so they need power.

- the need for a larger diameter gas supply from the gas meter: GWSHs can operate with a 12mm supply, but the much higher gas consumption rates of GIWHs require an 18mm supply; and
- in the case of a condensing GIWH, the installation of a condensate line.

The relative costs are analysed in Chapter 4.

The data compiled by BIS show that the tendency to replace like with like water heaters has been weakening, at least for Australia as a whole (the sample sets for individual states are too small to be meaningful) (Figure 6, Figure 7). Electric water heaters were the most likely to be replaced by a different type – initially gas, but from 2008 solar and, for a brief period, heat pump.

The nation-wide surge in market share of solar and heat pump water heaters after 2008 was due to two main factors.

- The inclusion of solar and heat pump water heaters in the Renewable Energy Target, so making them eligible to create RECs, irrespective of whether the building is new or the type of water heater replaced; and
- The availability of Commonwealth Government cash rebates between February 2009 and June 2012 for the purchase of solar and heat pump water heaters if replacing existing electric water heaters, (Table 8).

Table 8 Commonwealth general rebate categories and amounts

Water Heater Type	3 February 2009 – September 2009	September 2009 – February 2010	February 2010 – June 2012
Solar-electric, Solar-gas, >= 20 RECs	$ 1,600	$ 1,600	$ 1,000
Heat pump, >= 20 RECs	$1,600	$ 1,000	$ 600
Eligibility	Owners only (a)	Owners only (a)	Owners only (a)
Mode of Payment	Reimbursement on proof of payment	Reimbursement on proof of payment	Reimbursement on proof of payment

(a) Tenant could apply with written permission of owner

Some states also offered additional rebates that could be used in conjunction with the Commonwealth rebates. NSW had the largest and most generous program, running from July 2007 to June 2011 (Table 9). Although the NSW scheme covered gas as well, solar and heat pump water heaters made up about 86% of NSW rebates (see Figure 5).

The NSW rebate contributed about the same proportion of the purchase cost (about 20%) for all water heater types. The Commonwealth rebate was larger and covered a larger proportion of the net cost – up to 40% for heat pumps, before the heat pump rebate was reduced in September 2009. The combination of the two rebates meant that for a while buyers in NSW contributed less than 40% of the cost of solar-electric and heat pump water heaters, even before the subsidy from RECs is factored in. With the value of RECs, the purchaser contribution was as low as 26% (GWA 2010).

Figure 4 and Figure 5 illustrate the sensitivity of buyers to the availability and the level of rebates, both absolute and relative. Figure 4 shows that during the rebate period

(2007-2011) the solar and heat pump share of the water heater replacement market surged, and then fell away once the rebates were withdrawn. The likelihood of the solar and heat pump water heaters installed during the incentives period being replaced by the same type is uncertain. Although solar water heaters have nearly as high a "loyalty" factor as gas (Figure 6), the loyalty factor for heat pumps appears to be falling to the same level as other electric water heaters. In any case, the replacement data so far would cover units installed before the rebate period, so the installing households would already have had a predisposition to solar or heat pump.

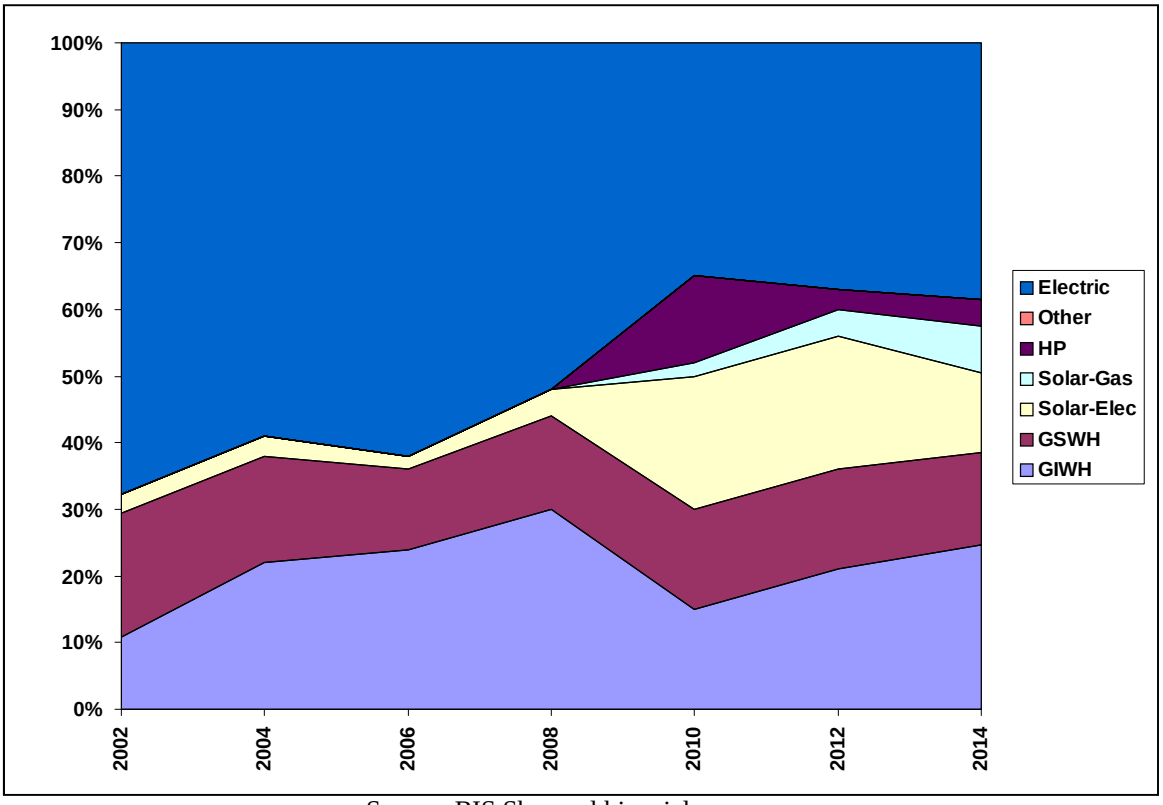
Those who purchased solar and heat pump water heaters on the strength of cash rebates may be less inclined to replace them with the same types in future, when they find that they need to bear much more of the capital cost. Heat pumps in particular have the lowest loyalty factor of any type. It remains to be seen how many households revert to electric or gas water heating when their solar or heat pump water heater fails. In fact, the NSW market seems to have started swinging back to electric and gas by 2014.

Table 9 NSW Rebate categories and amounts

Water Heater Type	Categories	1 Oct 2007 – 14 Jan 2010	15 Jan 2010 – 30 June 2011
Solar-electric, Solar-gas, Heat Pump	<20 RECs	$ 0	$ 0
	20-27 RECs	$ 600	$ 300
	28-35 RECs	$ 800	$ 300
	36-43 RECs	$ 1000	$ 300
	>43 RECs	$ 1200	$ 300
Natural gas, LPG	< 5.0 stars	$ 0	$ 300
	>= 5.0 stars	$ 300	$ 300
Eligibility		Owners only	Owners only (a)(b)
Mode of Payment		Reimbursement on proof of payment	Reimbursement on proof of payment OR Proof of deferred payment

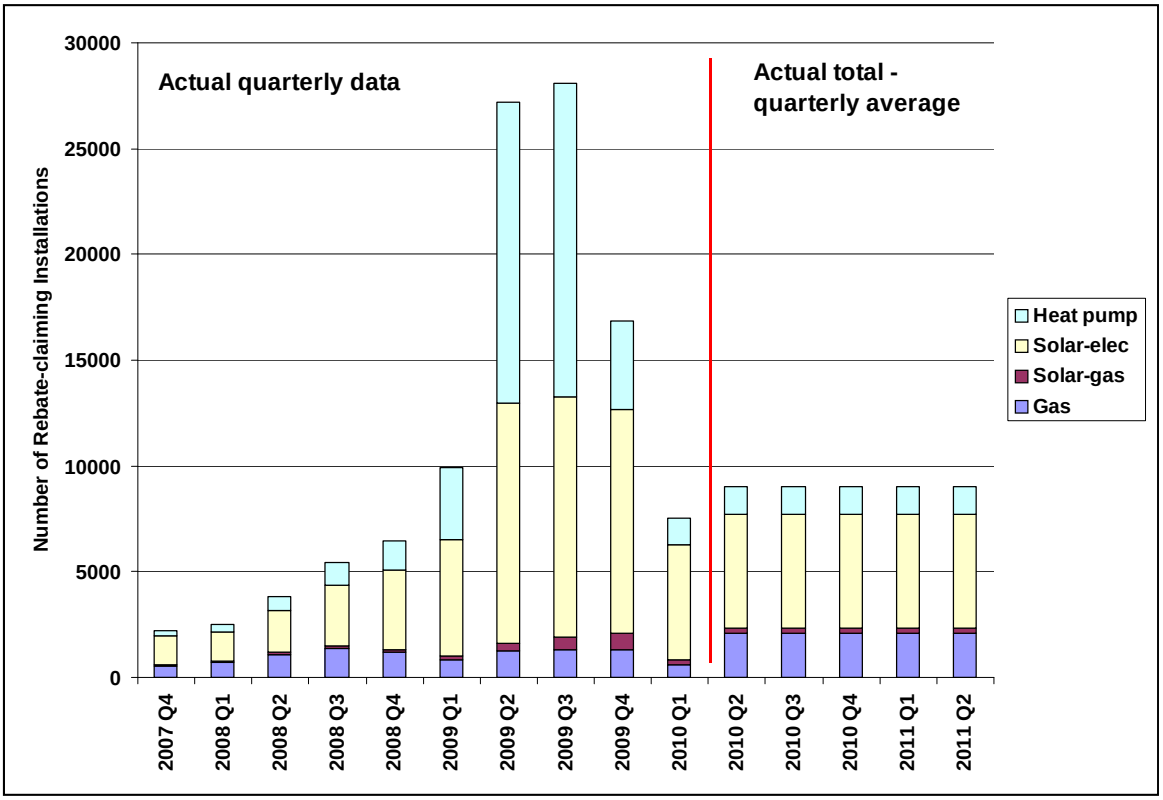
Source: NSW 2007, NSW 2010 (a) Tenant can apply with written permission of owner (b) Rebates also available for purchase of rainwater tanks (up to $1500), hot water circulators ($150), dual flush toilets ($200), and clothes washers (up to $150 – terminated 30 June 2010). Total rebate eligibility per householder capped at $1500.

Figure 4 Replacement water heaters installed in existing dwellings, NSW 2002-14



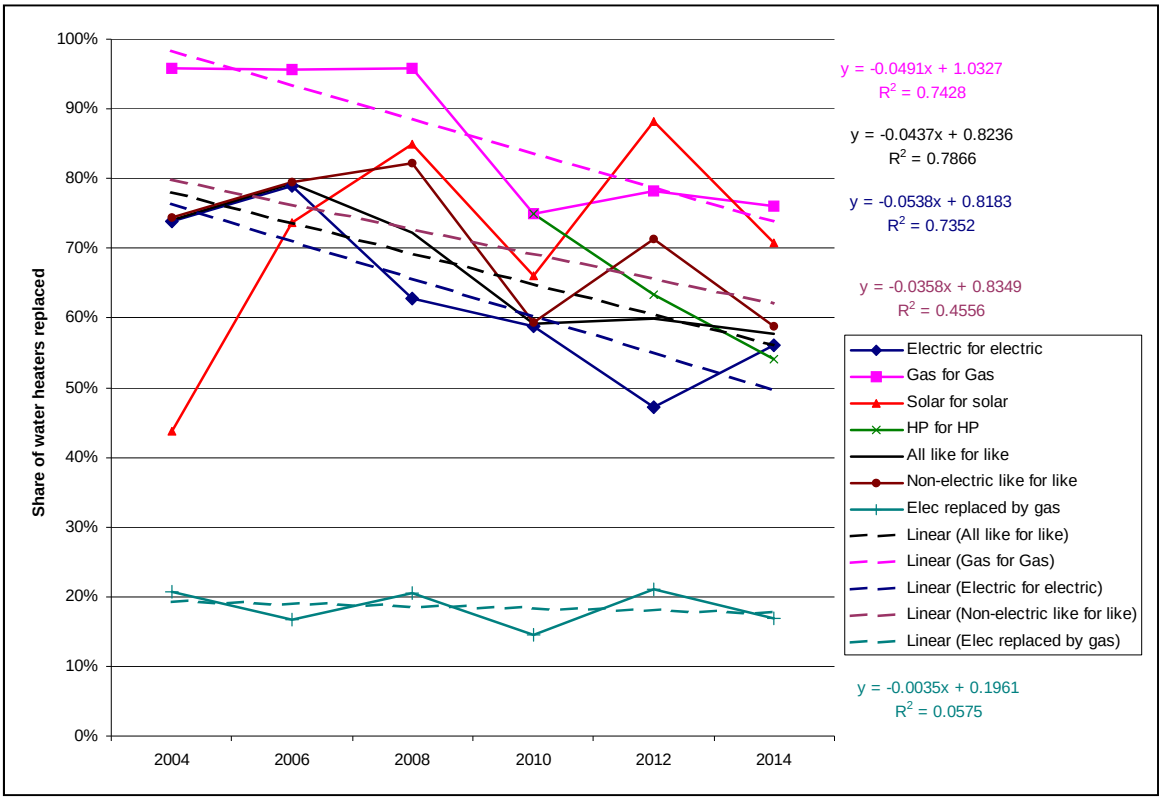
Source: BIS Shrapnel biennial surveys

Figure 5 NSW water heater rebate takeups, 2007-12



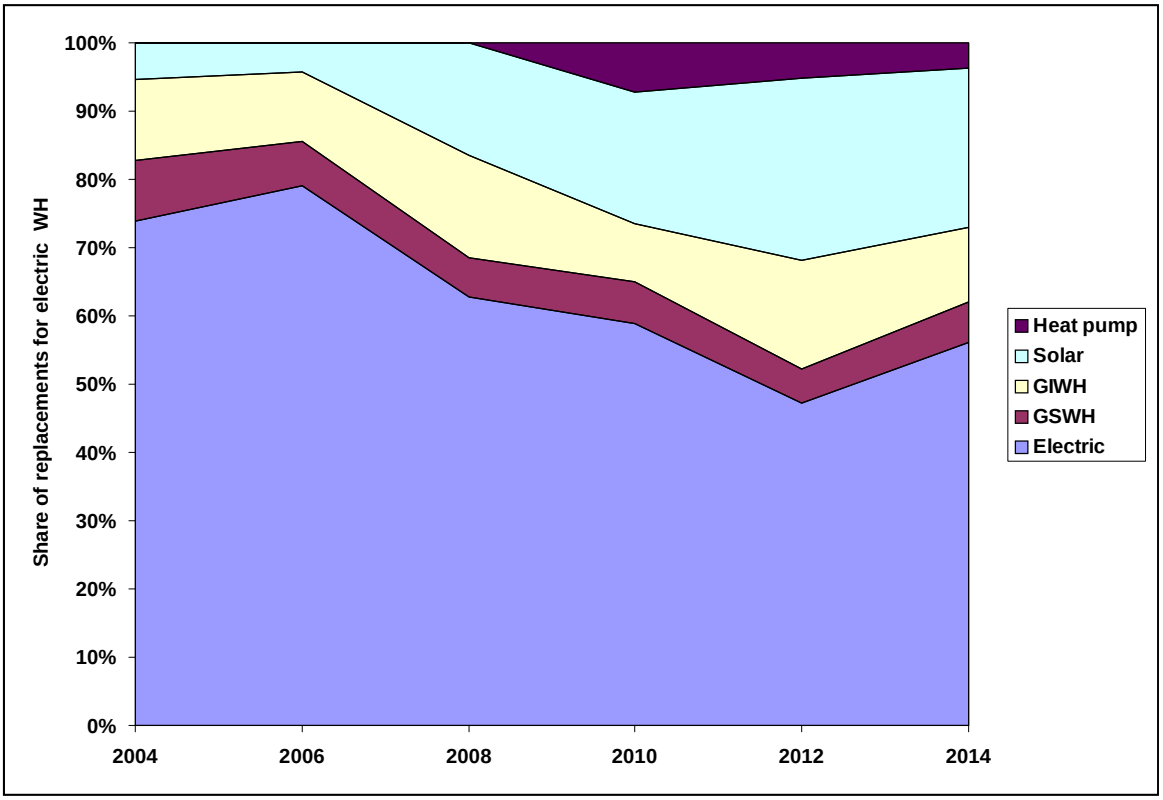
Source: OEH data published and unpublished

Figure 6 'Like for like' water heater replacement rates, Australia 2002-14



Source: Derived by author from BIS Shrapnel biennial surveys

Figure 7 Replacements for electric water heaters, Australia 2002-14



Source: Derived by author from BIS Shrapnel biennial surveys

3.2 Market Dynamics

3.2.1 Manufacturers and Importers

According to BIS (2012) Rheem-owned brands accounted for about 63% of the NSW residential water heater market, Rinnai for 18%, Dux for 11%, Bosch for 4% and all other brands combined about 4%.

The four major water heater suppliers are now all foreign-owned. Originally incorporated in Melbourne in 1936, Rheem Australia was purchased in 1988 by Southcorp (then SA Brewing Holdings) and sold in 2001 to Rheem USA, which is a wholly owned subsidiary of the private Japanese company Paloma.[26]

Rheem supplies all types of water heater, with the exception of electric instantaneous.[27] Over the past 20 years it has acquired several of its Australian competitors, including Aquamax (gas water heaters, based in Melbourne), Solahart and Solar Edwards (both originally based in Perth). Rheem now manufactures electric storage, gas storage, solar and heat pump water heaters at Rydalmere, western Sydney, and stainless steel tank water heaters at Moorabbin in Melbourne (previously the Aquamax factory). Rheem does not manufacture gas instantaneous water heaters in Australia, but imports them from Paloma factories in Asia.

Rheem Australia also has a joint venture manufacturing plant in Ho Chi Minh City in Vietnam, mainly for electric and solar water heaters for the Asia Pacific market. In Australia, the company sells water heaters under the Rheem, Vulcan, Aquamax, Solahart, Edwards, Everhot and Paloma brands.

Rinnai Australia was established in 1971 as a wholly owned subsidiary of the Rinnai Corporation of Japan.[28] It first entered the Australian market with gas space heaters and GIWHs, all manufactured in Japan, but has since added the full range of types to its product line (except EIWHs). It sources GSWHs from Rinnai factories in China.

Rinnai sells GIWHs only under the Rinnai brand, but also uses Hotflo and Flowmaster brands for its GSWH and ESWH products. In September 2015 Rinnai Australia announced the construction of a new facility to manufacture electric water heaters and space heating and cooling products at Braeside, Melbourne.[29]

Rinnai sources stated that they have noticed a resurgence in the ESWH market in Victoria and elsewhere, and expect it to continue for the following reasons:

- increasing gas prices (moving to world parity via the links to LNG exports);
- the falling greenhouse-intensity of electricity supply as the use of renewable energy for generation increases;

[26] Paloma is owned by the Kobayashi family, which established the company in Nagoya in 1911.
[27] Rheem US has recently bought a company (Eemax) that makes EIWHs so this may change in time.
[28] Rinnai Corporation, also based in Nagoya, is a public company. It was established in 1920.
[29] http://www.rinnai.com.au/news-offers/rinnai-to-establish-major-new-melbourne-manufacturing-facility/

- in Victoria, gas utilities are no longer automatically connecting new housing estates, now that the Victorian Government subsidies for this have stopped; and
- there is less need for a gas connection, now that reverse cycle air conditioning is becoming a popular alternative to ducted heating space heating (and has the advantage of cooling as well), and induction cooking is making inroads into the traditional gas cooktop market.

The Dux water heater company was originally established in 1915. The company was later acquired by GWA International, a plumbing and building products company (its other well-known brands include Caroma, Dorf and Fowler). Dux manufactures electric, heat pump and gas storage water heaters at Moss Vale, south of Sydney.

In December 2014 GWA International sold the water heater business to the Noritz Corporation of Japan.[30] Noritz specialises in GIWH products, sold under the Noritz and Harman brands. Dux sells a complete range of water heaters (except EIWHs) under the Dux and Thermann brands (Thermann is exclusive to the Reece plumbing products group).

Robert Bosch (Australia) Pty Ltd is a regional subsidiary of the global automotive and electrical products group Bosch gmbh, based in Germany. The Bosch Hot Water and Heating division supplies GIWHs and heat pump water heaters in Australia, as well as hydronic space heating products (which distribute heat via radiators or underfloor pipes – some models also provide domestic hot water).[31]

Bosch manufactures and sources GIWHs in several countries, and has a policy of supplying each market from the nearest source. In Australia's case, some models come from Bosch-owned factories in China, and others from Noritz, which purchased Dux in 2014. Given that Noritz now owns Dux, it is questionable whether this arrangement of supplying product to Bosch, a direct competitor, can continue.

Other GIWH suppliers account for only a small minority of the Australian water heater market. Douglas, based in Perth, manufactures one 5.4* model, and several importers of GIWHs manufactured in Korea (Deasung Celtic Enersys), Japan (Purpose Company, trading under the Takagi brand in Japan) or China (Wuhai, Midea). These imports are sold not under the manufacturer brand names but are rebadged by smaller local water heater companies (e.g. Chromagen, Apricus, Quantum) and either sold on their own or as the gas booster for solar products. The local subsidiary of the global appliance company Electrolux has also entered the water heater market under the Kelvinator brand, offering solar (both electric and gas-boosted), heat pumps and GIWHs sourced from other manufacturers.

There are a few participants in the water heater market who do not offer gas water heaters. These tend to specialise in heat pump or EIWH products (e.g. Stiebel Eltron, which offers both).

[30] The Noritz Company, established in 1951 as Noritsu Bath Industry, is based in Kobe.

[31] These gas-fired 'Combi' boilers are common in Europe, but have only recently been introduced in Australia. The main market is Victoria, which has a tradition of gas whole-house space heating, usually with ducted hot-air furnaces. The operation of the combi unit for the provision of domestic hot water alone during the non-heating months incurs a loss of energy-efficiency.

The tendency in the water heater industry, in both the major and the minor brands, has been toward offering a complete product range so a customer who inquires after one type (e.g. solar, electric or gas) can still be retained if they change to a different type. This has forced brands best known for one product type, such as Apricus and Chromagen (solar) and Quantum (heat pump) to diversify their product offerings.

The fact that most suppliers offer a complete range of product types might suggests that they would be relatively indifferent to the shifts in the market that may be prompted by the proposed new ESS incentives. However, this is not necessarily the case.

Any shift away from electric storage water heating could reduce demand for the products manufactured in Australia by Rheem, Dux and (in the near future) Rinnai. This could undermine their economies of scale and place pressure on their manufacturing operations, which also make storage tanks for their solar and heat pump models.

If sales are diverted to eligible gas storage models, there would be some compensating increase in demand for the most efficient of Rheem's and Dux's locally manufactured GSWHs. (Rinnai does not offer an eligible GSWH at present). However, all sales diversions to GIWHs would be met by imports. While water heater suppliers would be easily able to supply this demand, the average price of imported products is less than for locally made products, so revenue and profits may fall – except to the extent that some of the value of ESCs created could be captured in the form of higher margins, as has occurred with RECs/STCs (GWA 2010).

It is also likely that some suppliers would lose overall market share if there were shifts from one type to another. For example, Rheem brands had about three quarters of both the ESWH and GSWH markets in 2012, but only 30% of the GIWH market.[32] Dux had 8-12% of the ESWH and GSWH market, but only 2% of the GIWH market. The major beneficiaries from any shift to GIWH would probably be Rinnai (with at least 35% of the market – industry sources suggest this is higher), Rheem (30%) and Bosch (25%).

3.2.2 Intermediaries

None of the major suppliers sell direct to the public, although some maintain a network of company-branded installers and service agents who can also sell products. BIS reports that "local plumbers" accounted for 32% of sales to the public in NSW in 2012, and "hot water specialists" for 29%, adding that "…the distinction between a plumber and a hot water specialist can be a grey area; for example, the same business will often appear in the Yellow Pages under both headings" (BIS 2012).

In fact, self-described "hot water specialists" tend to fall into three groups:

- those that advertise their ability to replace common water heater types quickly and at short notice, which suggests that they would favour like-for-like replacements;

[32] Based on BIS (2012) national survey results. BIS does not publish market shares by type for individual States, because of low sample numbers.

- those specialising in supplying and installing solar or heat pump water heating, which they market as outside the mainstream and so requiring greater knowledge and expertise; and
- suppliers selling over the internet to plumbers, or to householders who purchase water heaters for others to install.

The other major sources of water heaters reported by consumers were energy retailers (17%), plumbing supply stores (6%), electrical retailers (4%), hardware stores (2%) and builders (4%). However, local plumbers, the smaller hot water specialists and most builders obtain their water heaters in turn from plumbing supply stores, so consumers are not in a position to know the ultimate source or channel. The water heater industry confirms that the major plumbing supply chains such as Reece, Plumbtech or Tradelink are in fact their largest direct customers for ESWHs, GSWHs and GIWHs. The hardware chains (Bunnings, Masters) and the larger hot water specialists (e.g. Australian Hot Water) also purchase direct from the manufacturers.

Tracking sales to States through intermediaries is difficult. For example, Reece has a warehouse in Melbourne and in Brisbane (a new one is being built in Perth). NSW may be supplied from either, so suppliers to Reece do not know where their products are ultimately installed.

4 Costs and Pricing

4.1 Water Heater Price components

The components of the price which consumers pay for a replacement water heater are:

- The supply price, including the cost of delivery;
- The installation cost;
- The cost of a new gas connection if required;
- Less the value (as passed on) of any government or other incentive payments.

Each of these components is flexible, and depends on how the service is bundled. For example, if the consumer engages a plumber, a hot water specialist, an energy utility or a builder to arrange supply and installation, they may well be charged a single price covering all of the above elements. Even if the price is itemised, it may not be completely transparent. Installers may quote the "list price" of water heaters, for example, whereas they will nearly always purchase them at a discount.

Consumers themselves can also purchase water heaters at discounted prices, but they need to factor in delivery charges (which can be substantial, especially for storage water heaters) and delays (if ordered on-line), and will need to separately engage a plumber. If the consumer supplies the water heater the plumbers is not able to secure any of the difference between the discount price and the list, and so may well charge more for the installation and negate some of the potential savings.

Table 10 summarises the on-line advertised prices for 62 water heaters, from five plumbing product suppliers and AGL. In some cases the same model was advertised by more than one supplier. The "small, medium and large" groupings correspond to the ESS categories in Table 1. Only 2 of the 26 GSWH models and 5 of the 26 GIWH models would be eligible to create ESCs under the new Rule.

Table 10 Advertised on-line prices for typical water heaters, January 2016

Water heater type	Number in sample	Avg litres or l/min	Avg stars	Avg MJ/yr	Avg advertised price $ (a)	2009 actual price estimates $ (c)
Medium GSWH	13	133	4.5	21830	1061	1155-1210
Large GSWH	13	164	4.4	21961	1115	
Small GIWH	9	15.1	5.4	19657	770	990-1210
Medium GIWH	7	20.4	5.7	18746	895	
Large GSWH	10	25.9	5.9	18902	937	
Large ESWH (b)	10	306	NA	NA	1110	1045-1265

(a) Includes GST; excludes delivery (b) 250-315 litre (c) GWA (2009)

The advertised prices for all storage water heater types, whether gas or electric, are remarkably similar. The prices of GIWHs as a group are significantly lower, and vary with flow rate. However, there was no correlation between price and the efficiency of gas water heaters (as indicated by the MJ/yr value) – see Appendix 2.[33]

[33] There was only one price advertised for a condensing GIWH. It was $900 higher than the next most expensive Large GIWH, so it is treated as an outlier and not plotted in the price-efficiency graph. It is

Some suppliers also quote a higher "former" or "list" price for some models, to show that the advertised price is a discount. Table 11 summarises the average "discounts" for the 31 cases where this occurred. The "discounts" were significantly higher for gas products than for electric. A wide "discounting" margin gives more scope for suppliers to absorb some of the value of ESCs by reducing the apparent discount. For example, suppliers could leave list prices unchanged but raise advertised (i.e. real) prices by $100, say, and use this as the starting point for applying the benefit of the ESCs. These practices could occur at any point in the supply chain, or indeed at more than one point. If the average discounting margin is $400, a fall of $100 would be hard to detect.

Table 10 also indicates the average water heater prices estimated for a 2009 regulation impact statement on phasing out greenhouse-intensive water heaters (GWA 2009). As there has been little movement in the relevant segment of the consumer price index (CPI) since then, these estimates should still be reasonably current, i.e. any changes should reflect real market conditions rather than inflation.[34] They suggest that the price of storage water heaters, nearly all of which are made in Australia, have fallen only slightly, whereas the price of GIWHs, which are all imported, have fallen significantly since 2009. This would be consistent with the patterns for other appliance types.

Table 11 List prices and apparent discounts

	Number where comparison possible	Average "List" price $	Average advertised price $(a)	Average "Discount" $
GSWH	6	1568	1121	448
GIWH	17	1148	787	361
ESWH (b)	6	1141	959	182

(a) These cases are a subset of those in Table 10 so average values are different. (b) 250-315 litres (c) GWA (2009)

The supply price is only part of the cost of replacing a water heater. It also needs to be installed. Plumbers do not quote installation costs publicly, for obvious reasons: every situation is slightly different. However, AGL quotes a *minimum* installed price for a range of electric and gas water heaters (Table 12).[35] Notably there are no installed prices quoted for GIWHs, since many installations would require a new electricity supply or a larger diameter supply from the gas meter if replacing a GSWH, and a condensate drain for condensing products.

The installation plus delivery component of the combined "installed price" offered by AGL can be inferred by subtracting the average "supply price" for that category of product. These are somewhat higher than the installation costs estimated in 2009, suggesting that there is some additional risk margin built in.

understood that the average difference is about $500, and one supplier is planning to introduce a condensing GIWH at a premium of about $150.

[34] The all-groups CPI (weighted average of 8 capital cities) increased by 15% in the 6 year to September 2015. However, Furnishings, Household Equipment and Services increased by less than 2% (ABS).

[35] http://aglsmarterliving.com.au/hot-water/ states that "installation offers are subject to site inspection and must have sufficient access for installation, accessible to power point and safety switch must be in existence.[sic] Installed pricing includes delivery. Product only pricing does not include delivery and a charge will be incurred."

Table 12 Implied installation costs

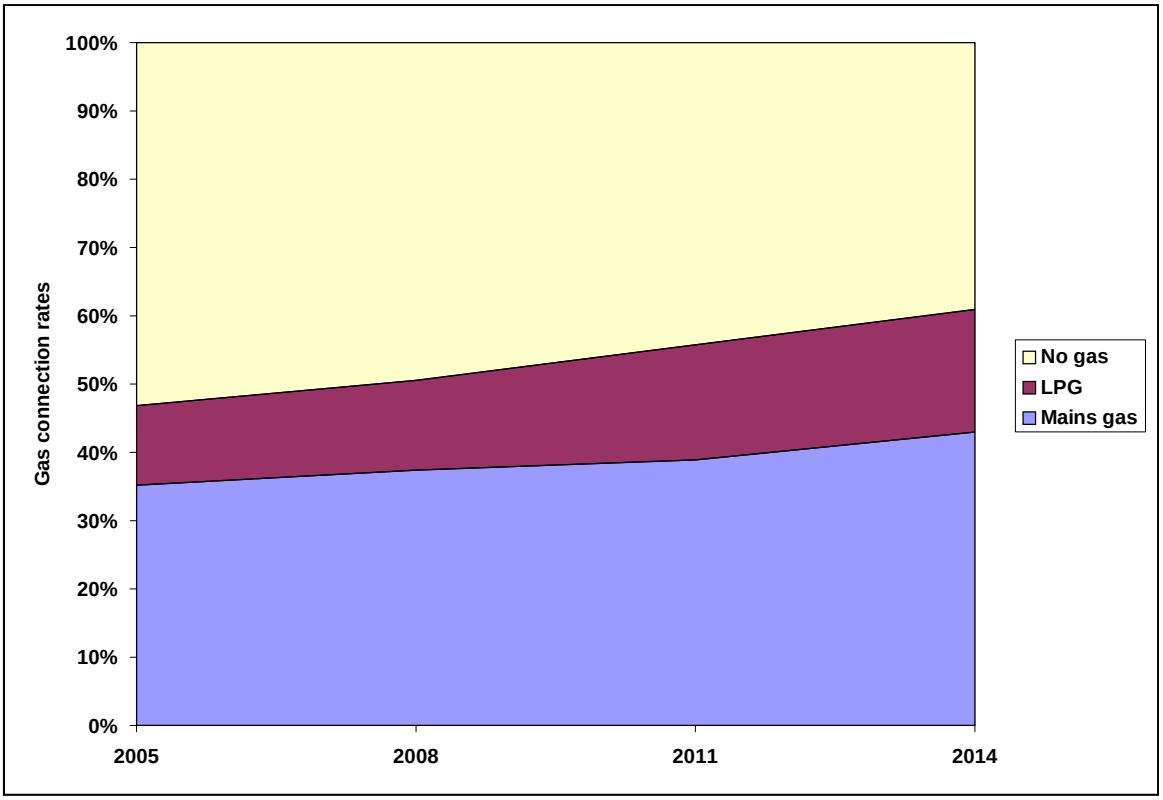
	Average "Installed" price $	Average advertised price $ (a)	Average "List" price $ (a)	Implied installation cost $ (b)	2009 Estimates
GSWH	1762	1088	1568	674	550 (c)
GIWH	NA	NA	NA	NA	650 (c)
ESWH	1719	1016	1449	703	440-495

(a) These cases are a subset of those in Table 10 so average values are different. (b) Assuming WH supplied at advertised price (c) From GWA (2009). Assumes gas present at the dwelling, but does not assume reuse of all connections at WH position – "drop-in" costs are lower.

4.2 Gas Connection Rates and Costs

Conversion from electric to gas water heating will require either a connection to the natural gas network or access to a bottled LPG supply. According to the ABS, the share of NSW dwellings using natural gas increased from about 35% in 2005 to 43% in 2014, and the share using LPG grew even faster – from 12% in 2005 to 18% in 2014 (Figure 8).

Figure 8 Share of NSW dwellings using natural gas and LPG



Source: ABS 46020 series.

The regional availability of gas varies considerably. Table 13 summarises the ABS data for 2014. As would be expected, natural gas connection rates are much higher in Sydney than in the rest of NSW, while LPG usage rates are much higher outside Sydney – although a significant share of dwellings within the Sydney Statistical Division report using LPG. The IPART surveys of dwellings in Sydney, the Blue Mountains and Illawarra indicate natural gas connection rates similar to those reported for Sydney by the ABS, but somewhat lower LPG usage rates.

The IPART natural gas connection rates for the Hunter and Central Coast region resemble those reported by ABS for the rest of NSW but again the LPG rates are somewhat lower. Therefore, either LPG usage rates in other regions of NSW are very high, or ABS has over-estimated them. According to IPART, at least 15% of the dwellings in Sydney, the Blue Mountains and the Illawarra were potentially connectable to natural gas in 2003, and up to 26% (if all the "don't' knows" were in fact on the line of mains.)

The presence of a natural gas connection or LPG in a dwelling does not necessarily mean it is used for water heating, however. IPART indicates that about a quarter of gas/LPG dwellings in its sample region still used electric water heating 2010, down from 28% in 2003. These could obviously be replaced by gas water heating without incurring the cost of a new connection. Where a new natural gas connection is required, there may or may not be an up-front cost to the consumer. GWA (2009) estimated the average real cost of a new natural gas connection at about $1,000 for dwellings on the line of mains. At the time, gas utilities typically charged consumers about $400, and recovered the remainder in the gas price. However, during promotion periods, consumers may be charged nothing if they install high-consumption appliances such as water heaters or space heaters at the time of connection (cooking alone is not sufficient).

Table 13 Gas connection and connectability rates, regional

	ABS 2014			IPART Syd, Blue Mtns, Illawarra			IPART
	SSD	RON	NSW	2003	2006	2010	2008 (a)
Mains gas	51.0%	31.3%	42.9%	50.0%	52.9%	49.3%	28.7%
LPG	12.0%	27.1%	18.0%	4.7%	3.8%	4.8%	9.4%
Not using gas	37.0%	41.6%	39.1%	45.3%	43.3%	45.9%	61.9%
On line of gas mains	NA	NA	NA	15%	NA	NA	NA
Not on line	NA	NA	NA	19%	NA	NA	NA
Don't know	NA	NA	NA	11%	NA	NA	NA
Share of gas HH with electric water heating				28%	27%	25%	

(a) Hunter, Gosford and Wyong

4.3 Total Costs and Potential ESC Value

Given the variability of the cost components, it is difficult to predict the cost differentials between replacement water heater options, and the role that the availability of ESCs may have in changing those differentials and altering consumer decisions. Table 14 summarises, for medium water heaters, one set of plausible cost assumptions based on the values in Table 10 to Table 12.

Table 15 uses these value to compare the costs of replacing an existing water heater ESWH, GSWH or GIWH with either another of the same type (which is the "neutral" or zero-net-cost option in each case) or changing to a different type. In situations where ESCs may be created, the value of these is also taken into account, along with the estimated price premium to purchase a gas water heater that is ESC-eligible compared with one which is not (based on the relationships in Appendix 1).

In gas for gas replacements, the ESCs created are about the same magnitude as the estimated premium to purchase a model that is efficient enough to be eligible. Where a gas water heater replaces an electric, the value of ESCs created is significant. If gas is already connected to the dwelling, the value of ESCs more than offsets the additional installation costs, so the householder is better off in terms of capital costs (as indicated by the green backgrounds). However, if gas is not connected, the value of ESCs is not sufficient to fully cover the connection costs.

Table 14 Indicative costs of changing or retaining water heater type, with ESCs

Original	Replace-ment	Gas conn-ection $	Supply $ (a)	Install-ation $	Drop-in Saving (b)	Net install-ation $	Gross total cost $	ESCs available $ (c)	Net cost if eligible $	Effici-ency cost (d)	Net cost inelig-ible $ (e)
ESWH 160	ESWH 160	0	909	440	75	365	1274	NA	NA	NA	1274
GSWH 130	ESWH 160	0	909	440	0	440	1349	NA	NA	NA	1349
ESWH 160	GSWH 130	0	1061	550	0	550	1611	491	1120	100	1511
ESWH 160	GSWH 130	400	1061	550	0	550	2011	491	1520	100	1911
ESWH 160	GIWH 20	0	895	660	0	660	1555	532	1023	75	1480
ESWH 160	GIWH 20	400	895	660	0	660	1955	532	1423	75	1880
GSWH 130	GIWH 20	0	895	660	0	660	1555	127	1428	75	1480
GIWH 20	GSWH 130	0	1061	550	100	450	1511	72	1439	100	1411
GIWH 20	GIWH 20	0	895	660	100	560	1455	127	1328	75	1380
GSWH 130	GSWH 130	0	1061	550	75	475	1536	72	1464	100	1436

(a) From current average prices – mostly ineligible products (b) Reduction in installation cost for "drop-in" replacements (c) If water heater meets minimum efficiency criteria for eligibility, at $25 per ESC. (d) Estimated cost premium for water heater which just meets ESC eligibility criteria. (e) For water heater that does not meet ESC eligibility criteria.

Table 15 Cost differential compared with like for like replacements

Starting Water Heater	Replace with ESWH 160	Gas already connected				New gas connection			
		GSWH 130 4.5*	GSWH 130 5.25*	GIWH 18-22 5.75*	GIWH 18-22 6.25*	GSWH 130 4.5*	GSWH 130 5.25*	GIWH 18-22 5.75*	GIWH 18-22 6.25*
ESWH 160	0	237	-154	206	-251	637	246	606	149
GSWH 130	-115	0	28	-4	-56	NA	NA	NA	NA
GIWH 18-22	21	39	11	0	-52	NA	NA	NA	NA

Finally, it should be noted that these calculations are based on capital costs alone, without taking into account the running costs and lifetime costs of the water heater, for two reasons:

- Consumer research indicates that capital cost (including the effects of rebates or incentives) is the dominant factor in replacement water heater choice, and most consumers are unaware of or ignore running cost differences (WSRS 2008); and

- Consumers are not necessarily better off by selecting a gas water heater in place of an electric water heater, even one which uses day rate tariffs, if they are small hot water users, have to incur the cost of gas connection and have no other gas appliances. This is because the full gas standing charges and the higher initial tariff steps[36] would be borne by the water heater, so the effective price per MJ can be so high it negates any running cost advantages, and possibly even negates the value of the ESCs received initially.

[36] Gas retail tariffs are structured so that the first tranche of daily energy use costs more. For example, the first 20 MJ/day may be charged at 3.5 c/MJ, the next 20 MJ/day at 2.3 c/MJ and further usage at 2.1 c/MJ (with daily usage calculated from the quarterly meter reading). If a household that already cooks and heats with gas adds a gas water heater, all the additional gas use may be charged at 2.1c/MJ. If the water heater is the first gas appliance, the average tariff will be higher, approaching 3.5 c/MJ, depending on usage.

It is outside the scope of the present study to determine whether the proposed changes to the ESS make either the direct beneficiaries of ESCs or the NSW community at large better off financially or economically.

5. Modelling

5.1 Historical trends

Estimates of the breakdown of the NSW water heater stock vary considerably between the main data sources: the ABS national household surveys, BIS Shrapnel and IPART (which only covers some regions of NSW, while the others cover the entire state). Figure 9 illustrates the estimates from all three sources covering the period 2004-14 (the intervals between actual survey years for each series have been linearly interpolated). It is apparent that even the estimates for the most common types (electric and gas) can vary by over 10 percentage points from one source to another. The set of single points for 2006 represent a special NSW-only survey, which happen to agree with the BIS series more than the ABS national surveys.

The ABS series shows an anomaly in 2014. It indicates a sharp increase in ownership of electric water heaters after 2011, which is counter to the BIS trend. Even if electricity's share of the new water heater market stabilised after years of decline (as shown in Figure 4) it would still take many years for the stock share to increase. Therefore the ABS 2014 national stock survey must be considered suspect, at least with regard to the electric/gas split. It is considered that the overall BIS trend is likely to be accurate, although the rapid increase in gas water heater ownership in 2008, and the equally rapid reversal in 2010, are likely to be sampling artefacts. Even if market shares change rapidly from one year to the next, stock shares move much more slowly.

The author's best estimates of the historical trends in NSW water heater ownership are indicated by the dashed lines in Figure 9. (The excel linear statistical trend lines, which have been omitted for clarity, closely match the BIS statistical trend lines[37]).

The ESS Rule states that incentives are only available where a gas or LPG water heater replaces an electric water heater that is *not* connected to a controlled load (off-peak) tariff (Box 1). Data on the number of electricity users with OP tariffs is published annually by Ausgrid, but not by the other NSW network operators (Endeavour and Essential).[38] In 2015 Ausgrid served about 1.48 million residential customers, a little over half the estimated 2.87 million dwelling in NSW. About a third of all Ausgrid residential customers were connected to an OP tariff, but the ratio in the local government areas in the SSD was about 30%, while outside the SSD (in the lower Hunter region) it was close to 60% (Figure 11).

The Ausgrid data also indicate the average electrical energy supplied on each OP tariff in 2015 was 2,217 kWh (7,983 MJ). This is the only public data set that directly indicates energy delivered to water heaters. At this low level of annual usage the efficiency of OP ESWHs of 250 to 315 litres is about 70% (Morrison 2007), because the heat losses are fairly constant irrespective of the hot water drawn off. If so, the average useful energy delivered as hot water was about 5,600 MJ/yr, or less than half the standard delivery assumed for rating gas water heaters (the horizontal line on Figure 12). This should be kept in mind when calculating energy saving from the ESS measure.

[37] The R^2 values for the BIS trend lines are 0.901 (Elec total), 0.5473 (Gas total) and 0.8985 (Solar/other).
[38] http://www.ausgrid.com.au/Common/About-us/Corporate-information/Data-to-share/Average-electricity-use.aspx

Figure 9 Estimated type shares of residential water heater stock, NSW 2004-14

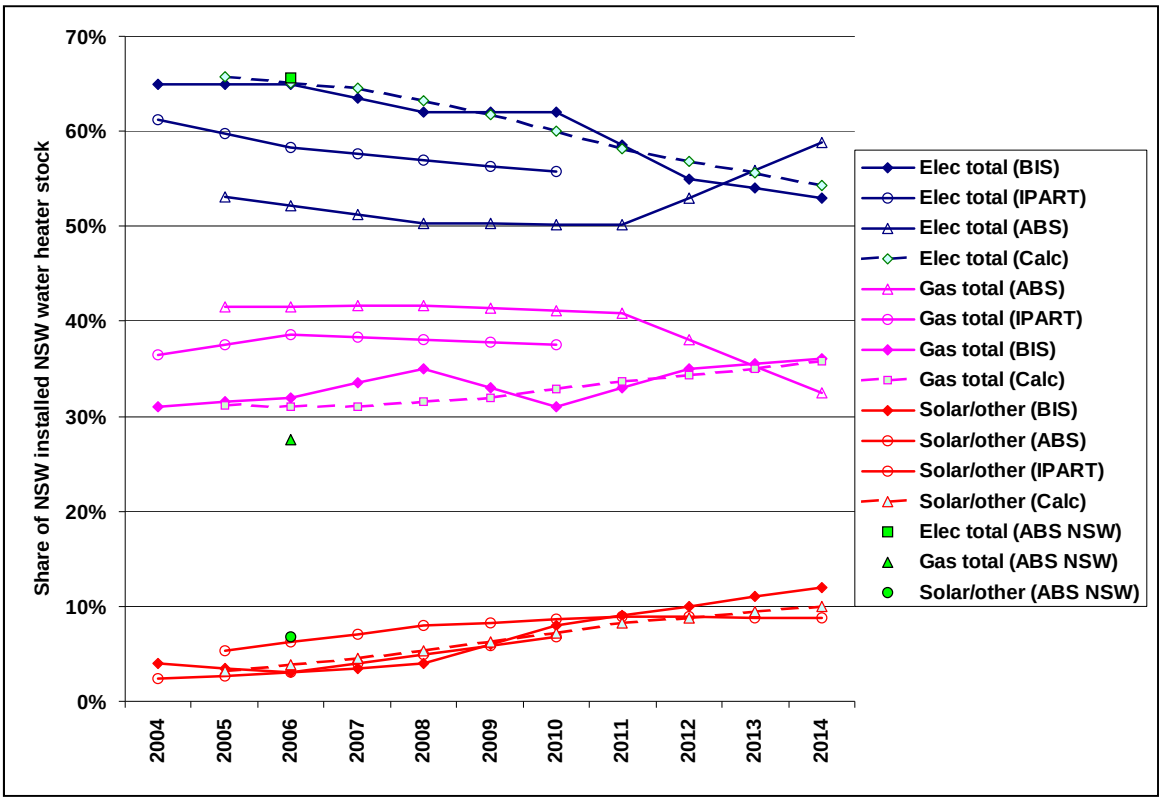
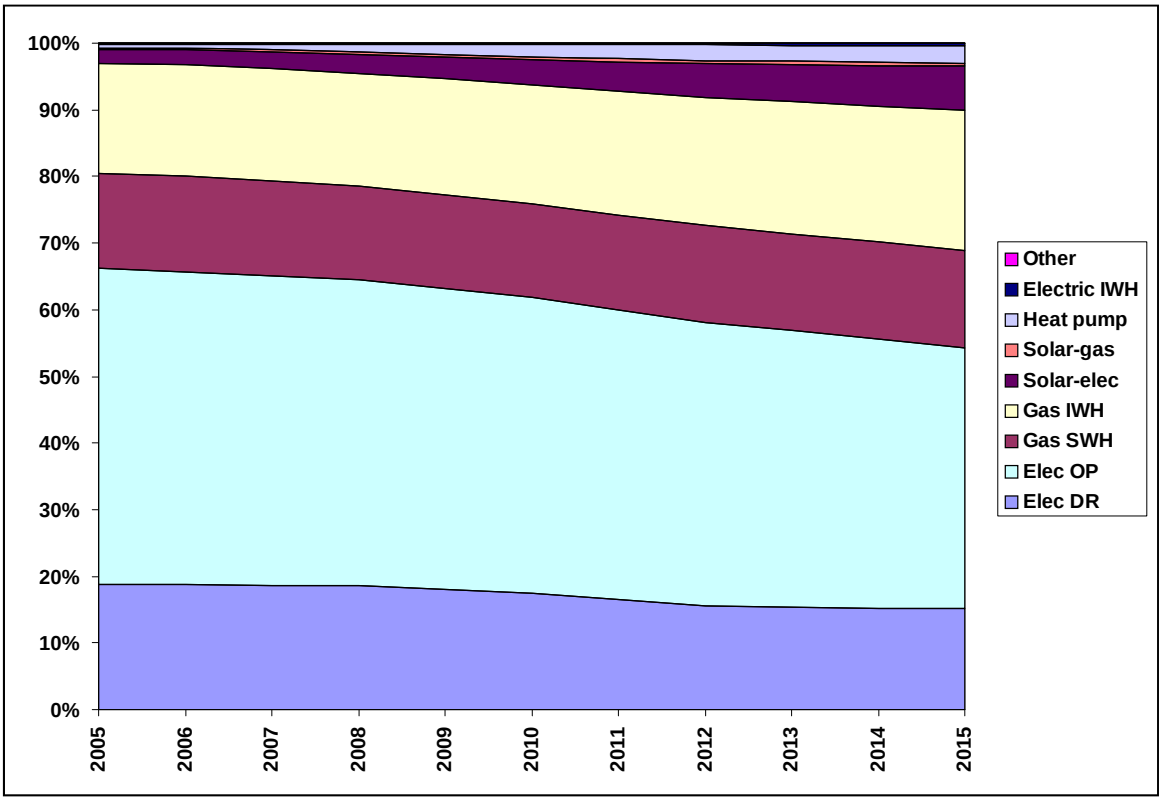


Figure 10 Estimated stock share, NSW 2005-15



Excludes central systems.

Figure 11 Number of OP water heaters and share of user with OP, Ausgrid region

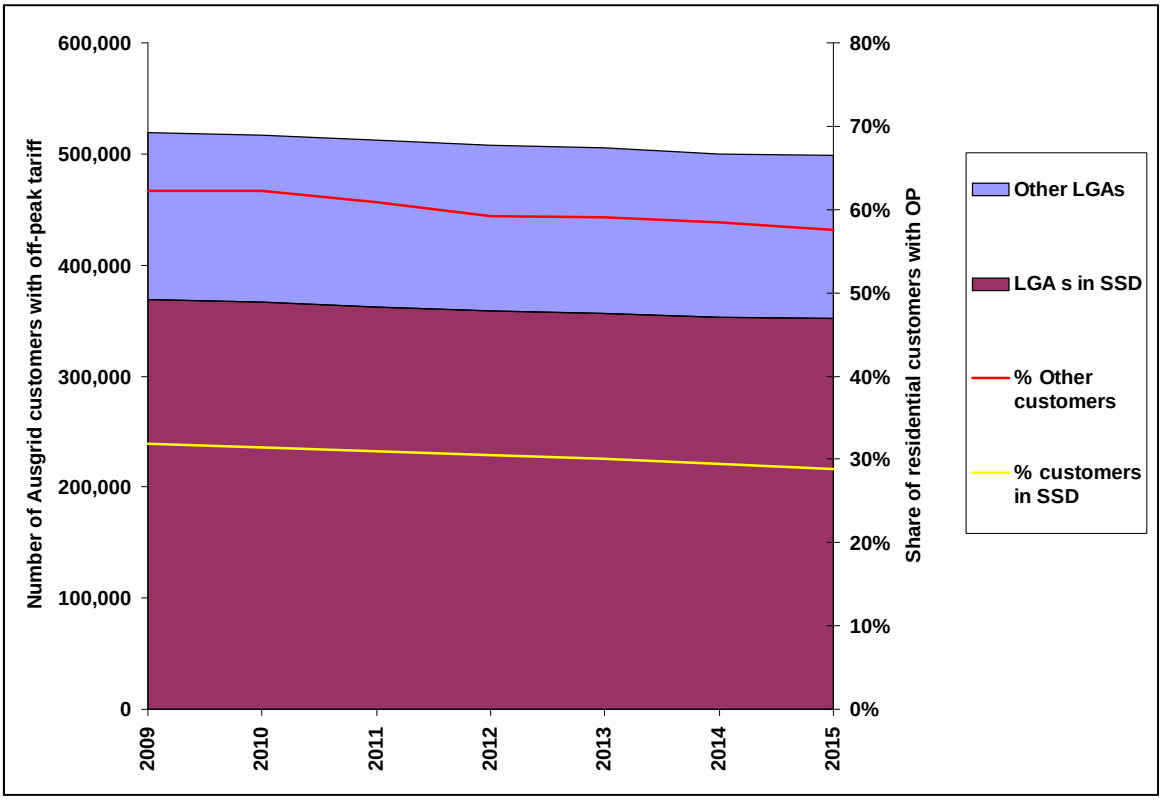
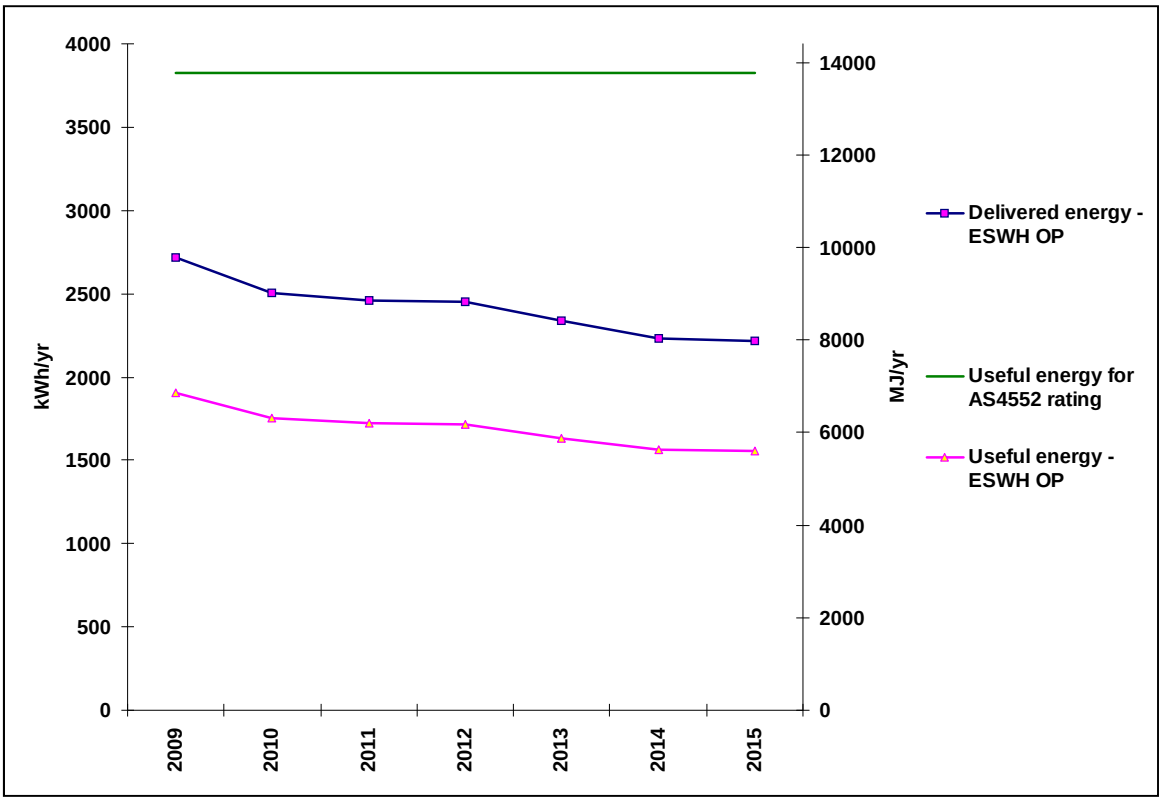


Figure 12 Average annual energy use by OP water heaters, Ausgrid region


4000
3500
3000
2500
2000
1500
1000
500
0
kWh/yr
14000
12000
10000
8000
6000
4000
2000
0
MJ/yr
2009
2010
2011
2012
2013
2014
2015
Delivered energy - ESWH OP
Useful energy for AS4552 rating
Useful energy - ESWH OP

5.2 Projections of dwellings and water heater demand

The NSW dwelling stock has been divided into two segments for modelling purposes:

1. Dwellings in existence up to the end of 2015; and
2. Dwellings built after the beginning of 2016.

The water heater ownership of the first group (some of which were constructed under the BASIX rules) is covered by the existing survey data. Indeed, some of the decline in electric share of the overall annual market (illustrated in Figure 4) is due to the virtual exclusion of electric water heaters from the new dwelling market when BASIX was introduced in 2005 (Figure 3).

The new ESS Rule should impact on the water heating preferences of the first group, since these dwellings have water heaters that will need to be replaced over the period for which the ESS is legislated (i.e. to 2025). As the second group will all be built after 2015, by 2025 nearly all will still have their original water heaters (and virtually none of them electric). Therefore they will not be in a position to take advantage of the ESS incentives. However, the modelling period has been extended to 2035, so the potential impact of the ESS incentives on the replacement of water heaters installed in post-2015 dwellings can be modelled, to test the effects of extending the ESS measures past 2025.

The number of dwellings in the first group will decline with demolitions and the number in the second group will increase with new construction. The sum of the two groups is the total number of dwellings in existence in NSW in any year. Figure 14 indicates the total and the number built while BASIX is in force (above the line). By 2035 BASIX-affected dwellings will account for at least 38% of NSW dwellings – more if BASIX-affected renovations are included.[39]

ABS reports new dwelling approvals for detached, attached and apartment dwellings for NSW (SSD and rest of NSW) quarterly (Figure 13), and construction rates have been inferred assuming a one-year lag between approval and completion, and assuming that 5% of approved development never takes place (based on the author's previous research). Future dwelling requirements have been modelled on the basis of ABS population projections (Figure 15). The demolition rate is therefore derived from the difference between the total number of dwellings and the construction rate. For simplicity the model assigns one water heater (or water heating service, in the case of some apartments) to every dwelling, even though it is known that about 3% of dwellings have two water heaters.

The model then generates the total number of water heaters required each year as the sum of replacements needed for failed water heaters and the water heaters installed in new dwellings built that year. The number of water heaters retired each year through end-of-life failure, and hence the number of replacements required, is generated on the

[39] Nearly 37,700 BASIX alterations and addition certificates were issued between October 2006 and February 2010, or a rate of about 11,000 per year (compared with about 30,000 new construction certificates per year). About 27% of the certificates including new works involved the hot water system (BASIX 2011b). If all of these involved changing the water heater, then alterations and additions would account for about 3,000 water heaters annually out of a total market of about 300,000 units.

basis of estimated average service lives. These are set at 12 yrs for GIWHs, 14 yrs for solar, 8 yrs for heat pump and 10 yrs for all other types (GWA 2009). In practice, service lives vary from year to year, due to both physical factors (e.g. the introduction of new materials or manufacturing processes that result in earlier or later failure) or behavioural factors (e.g. a significant number of householders scrapped working electric water heaters in the period 2009-12 to take advantage of the rebates available for the purchase of solar and pump water heaters).

Figure 13 Building approvals, NSW 2001-2015

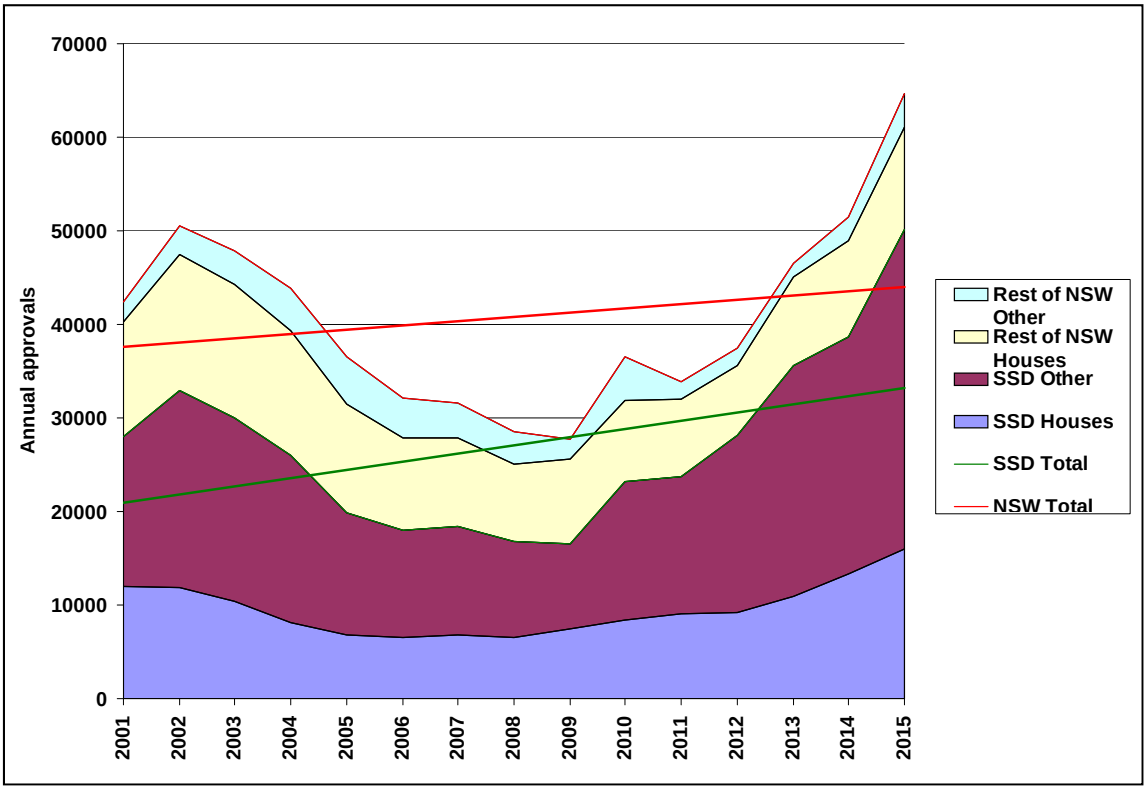


Figure 14 Estimated dwelling types, NSW 2005-2035

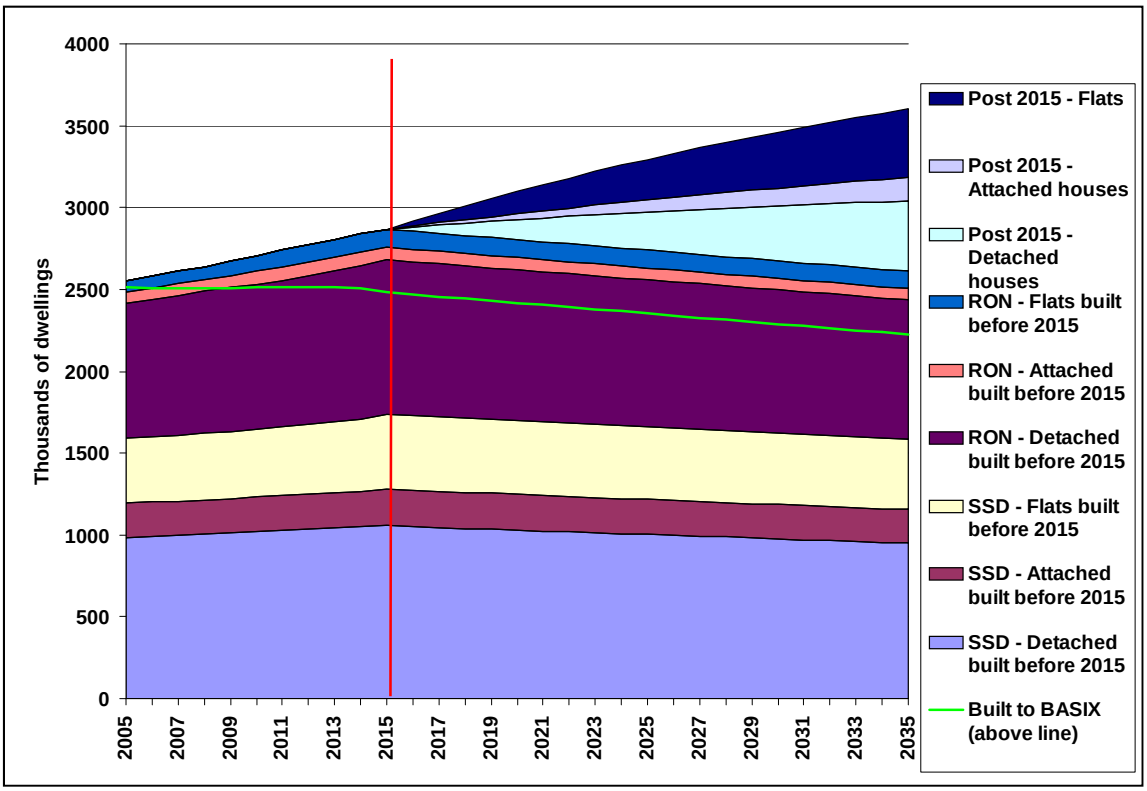


Figure 15 ABS population projections, NSW

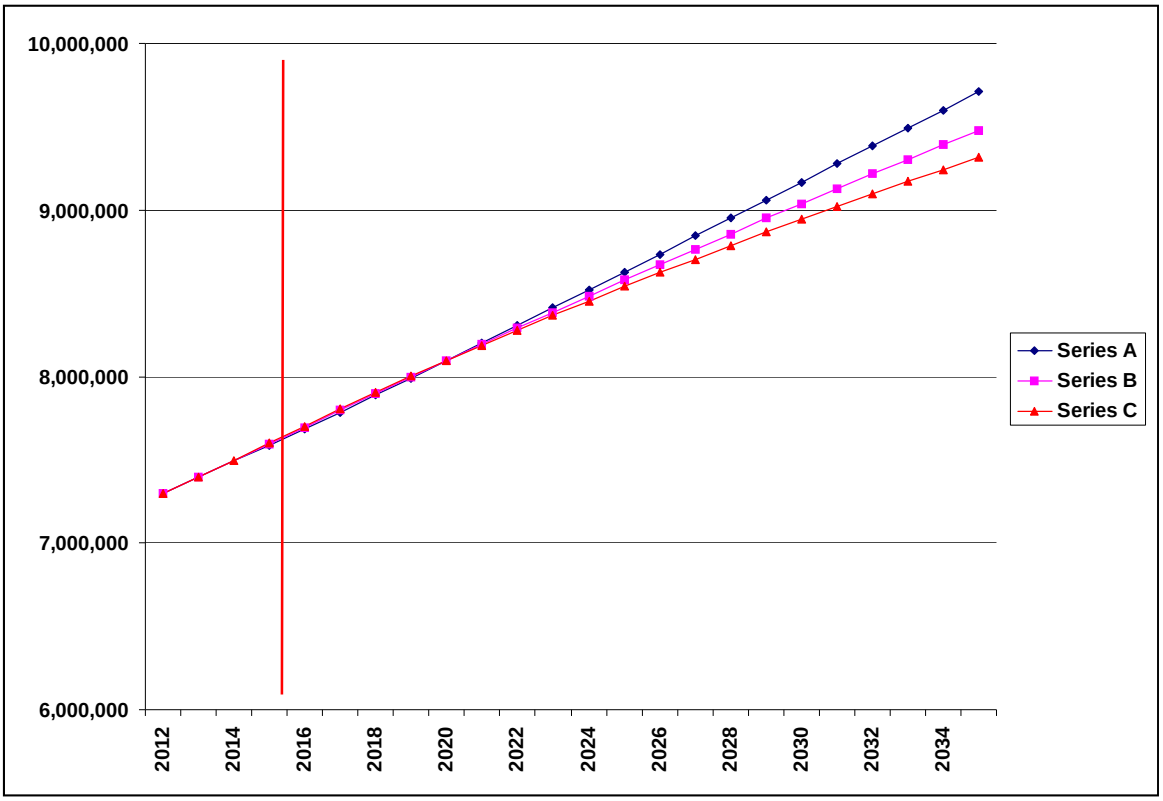
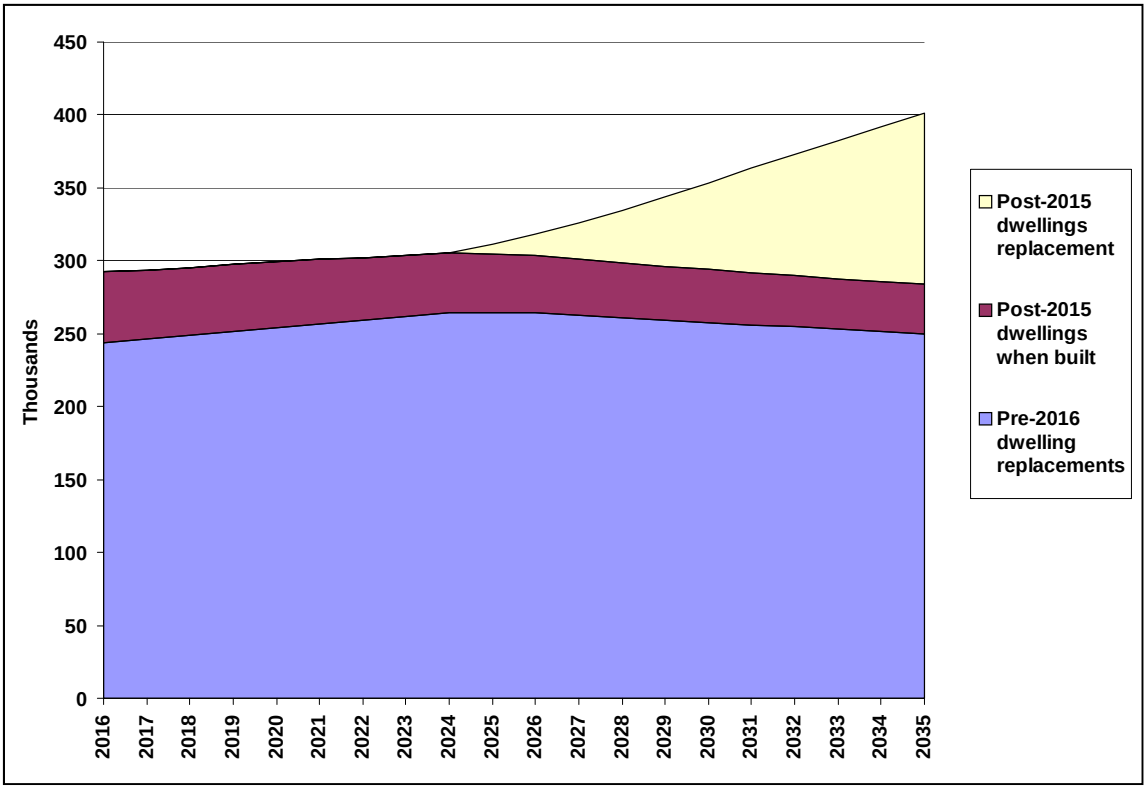


Figure 16 Number of water heaters required for NSW residential market



5.3 Water heater market share projections

The model generates the number of water heaters required each year, but it is up to the operator to set the market share for each of 11 types of separate water heaters and, for apartments, an additional category of "central" water heaters, undifferentiated by energy type (see Table 16). For dwellings built before December 2015, it is necessary to enter estimated market shares for replacement water heaters dwellings for the years 2016, 2020, 2025, 2030 and 2035. The shares in the intermediate years are interpolated linearly. For dwellings built from January 2016 it is only necessary to enter estimated market shares for replacement water heaters for the years 2016 and 2035, and the shares in the intermediate years are interpolated linearly. As this group is built under BASIX rules it is close to saturation with gas water heating already, and water heater energy type shares will probably remain fairly constant over the dwelling lifetime.

Table 16 Water heater categories modelled separately

	Dwellings built to Dec 2015			Dwellings built from Jan 2016		
	Detached	Attached	Apartments	Detached	Attached	Apartments
ESWH DR	✓	✓	✓	✓	✓	✓
ESWH OP	✓	✓	✓	✓	✓	✓
GSWH - NG	✓	✓	✓	✓	✓	✓
GIWH - NG	✓	✓	✓	✓	✓	✓
GSWH - LPG	✓	✓	✓	✓	✓	✓
GIWH - LPG	✓	✓	✓	✓	✓	✓
Sol-elec	✓	✓	✓	✓	✓	✓
Sol-gas NG	✓	✓	✓	✓	✓	✓
Sol-gas NLPG	✓	✓	✓	✓	✓	✓
Heat pump	✓	✓	✓	✓	✓	✓
EIWH	✓	✓	✓	✓	✓	✓
Central	NA	NA	✓	NA	NA	✓

NG and LPG gas water heaters are differentiated in the modelling, even though the ESS Rule applies to both, so that stock shares can be checked against natural gas connection rates and LPG usage rates. Off-peak (OP) and Day Rate (DR) ESWHs are also differentiated, because the ESS incentives do not apply to replacement of OP water heaters. Dwelling location (SSD vs RON) is not differentiated in the projection modelling – NSW is treated as a single region.

Any market share projections are a matter of judgement. The model has been calibrated with the author's best estimate of what is likely to happen in the NSW water heater market without the introduction of the incentives in the ESS Rule, i.e. the "business as usual" (BAU) case, based on:

- Continuation of previous market trends;
- The future consequences of previous events (e.g. the surge and then fall in solar and heat pump installations illustrated in Figure 5);
- Automatic limiters built into the model, e.g. the number of retirements of any given water heater type in any year cannot exceed the number still remaining in the stock at the end of the previous year, and the number of water heaters (plus water heating services accessing central water heaters) must add to the number of dwellings.

However, it is emphasised that the BAU projection can only be verified in hindsight, and *will not be verifiable at all* if the ESS incentives are accessed and begin to influence the market. The actual market tracking data will then reflect the "with-measures" scenario. The actual impact of the measures will be the difference between the (verifiable) with-measures trend line and the (then unverifiable) BAU projection. Therefore any impact estimates must always remain a matter of judgement.

Projecting the impact of the proposed measures is outside the scope of this study. The following diagrams illustrate the BAU projections together with a plausible (not a predicted) with-measures case.

Figure 17 illustrates the projected BAU trend in market shares, which has been steadily trending away from electricity and toward gas (especially GIWHs) for the past decade (Figure 4). It also illustrates a plausible change in the trend under the impact of the ESS incentives. The change illustrated would amount to about 61,000 fewer ESWH sales in NSW over the period 2016-25 compared with BAU, 25,000 extra GSWH sales and 36,000 extra GIWH sales. The number of installations for which ESCs would be claimable is several times greater, but where claims are for actions that would have been taken anyway, they are captured in the BAU trend.

Figure 18 illustrates the estimated BAU trend in average MJ/yr for the various categories of gas water heater. The starting point is based on advice from industry sources that:

- Most GIWHs sold are now rated "low 6*"; and
- About 15% of GSWH sales are indoor models rated 3*, 50% are outdoor models rated 4* and 35% are outdoor models rated 5*.

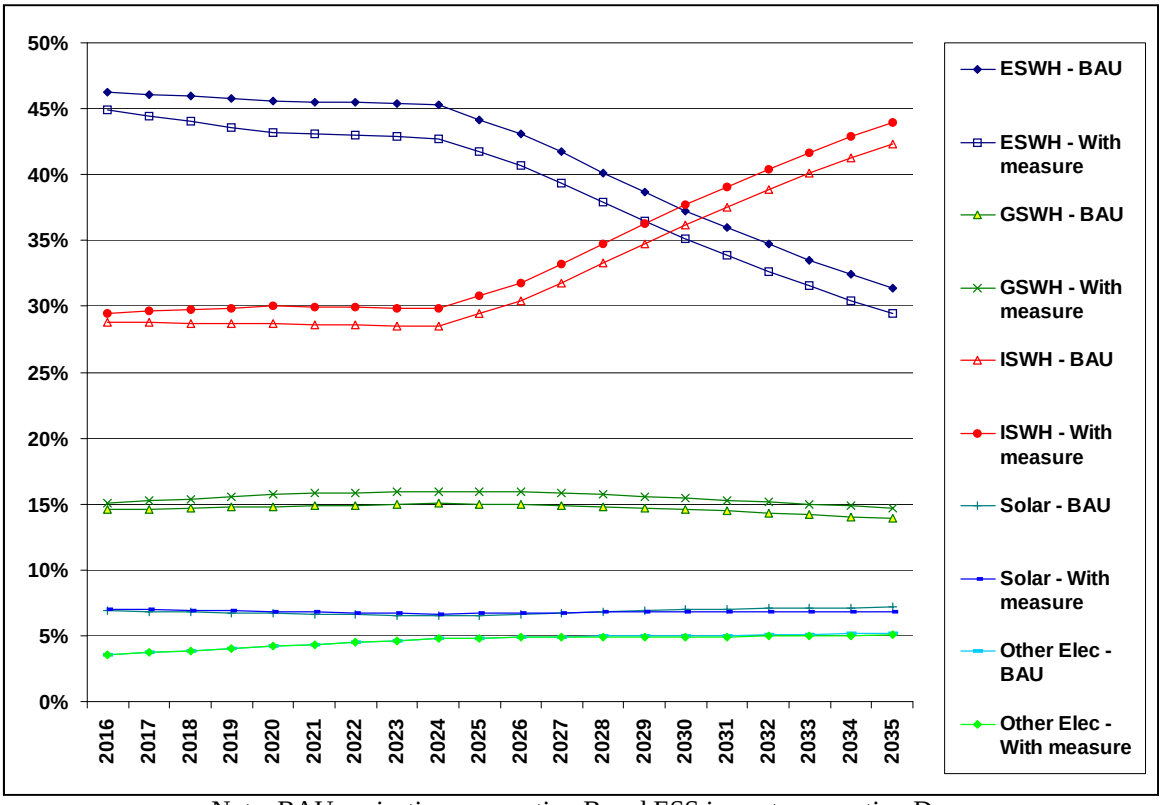
However, industry sources were interviewed before the ESS Rule was finalised, so there was no opportunity to ask if they had identified the proportion of their sales that were of ESC-eligible models (i.e. rated less than 20,302 MJ/yr for GSWHs and less than 18,729 GWh/yr for GIWHs).

A declining trend on MJ/yr indicates an increase in average energy-efficiency. There is already a trend in this direction, and it is assumed that the proposed measure accelerates the trend by giving some buyers of gas water heaters the incentive to seek out a more efficient product than otherwise. Separate MJ/yr trends can be projected for all gas water heaters expected to be available on the market and for the subset that would be eligible to attract ESCs.

It is apparent from comparing Figure 19 with Figure 20 and Figure 21 with Figure 22 that changes in water heater market share and stocks due to the likely impact of the ESS incentives would be subtle and difficult to detect, even with more accurate data than is currently available.[40] In the light of these limitations, a strategy for tracking impacts is discussed in the next chapter.

[40] In Figure 19 the sales of DR ESWHS in 2035 is 40,020 while in Figure 20 the corresponding value is 33,070. In Figure 21 the stock of DR ESWHS in 2035 is 386,200 while in Figure 22 it is 290,000.

Figure 17 Projected water heater market shares



Note: BAU projection assumption B and ESS impact assumption D

Figure 18 Projected average MJ/yr for gas water heaters

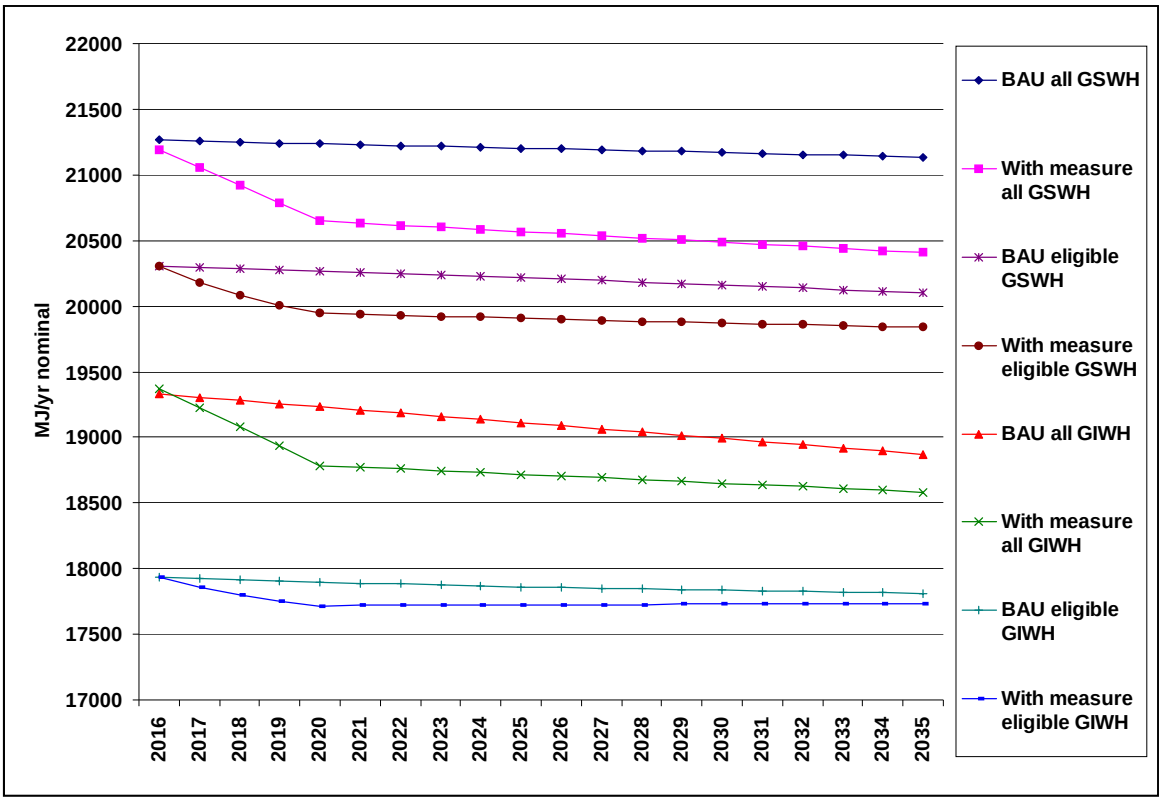


Figure 19 Projected water heater sales, NSW, BAU case

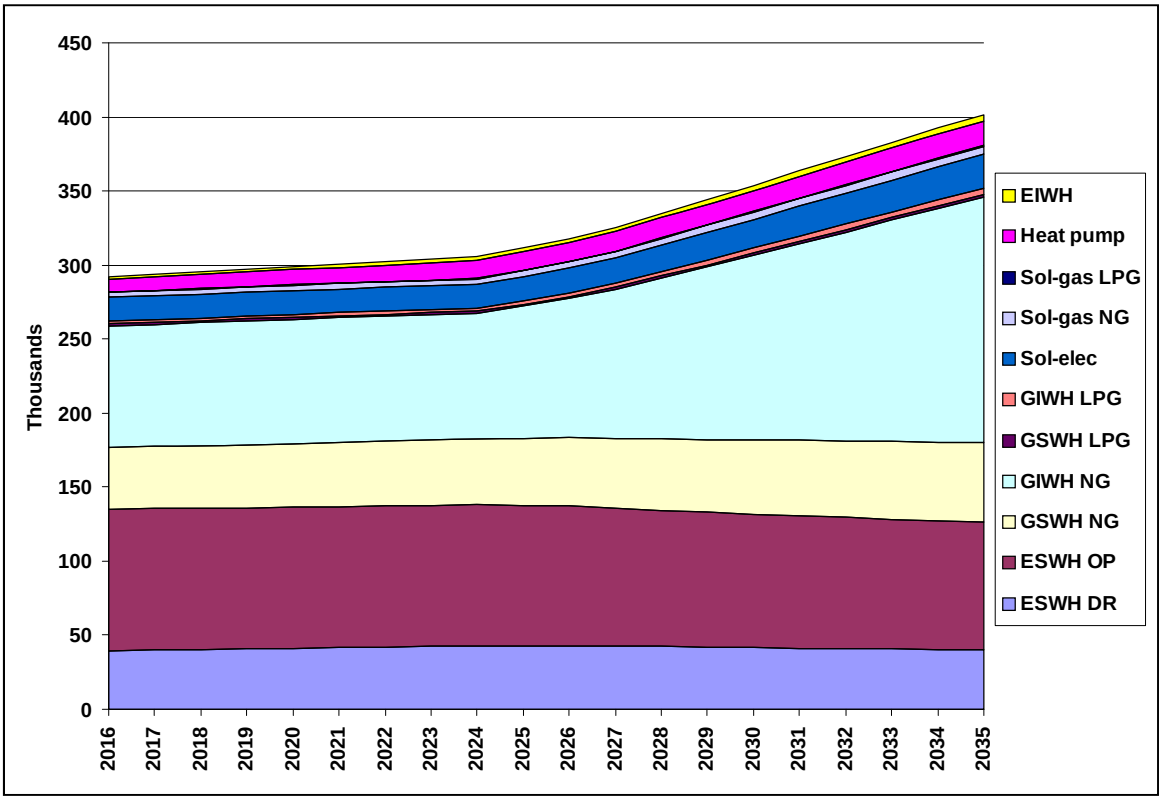


Figure 20 Projected water heater sales, NSW, Illustrative "with measures" case

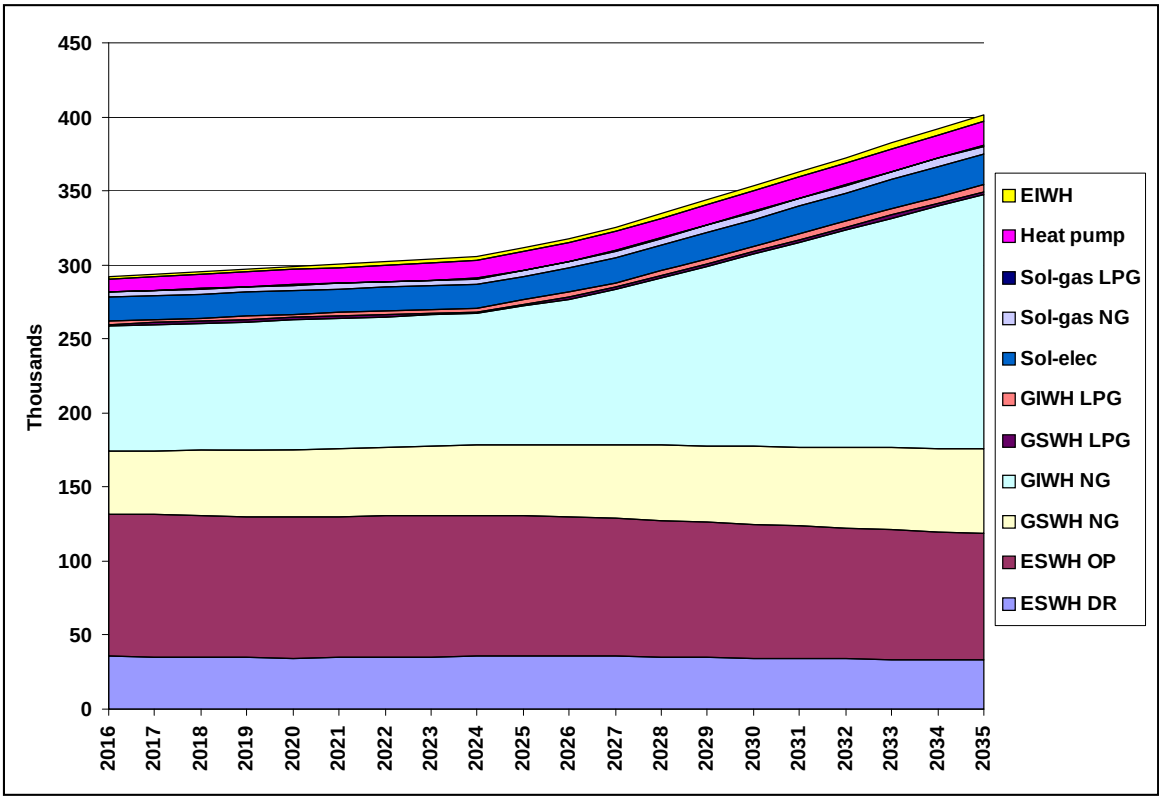


Figure 21 Projected water heater stocks, NSW, BAU case

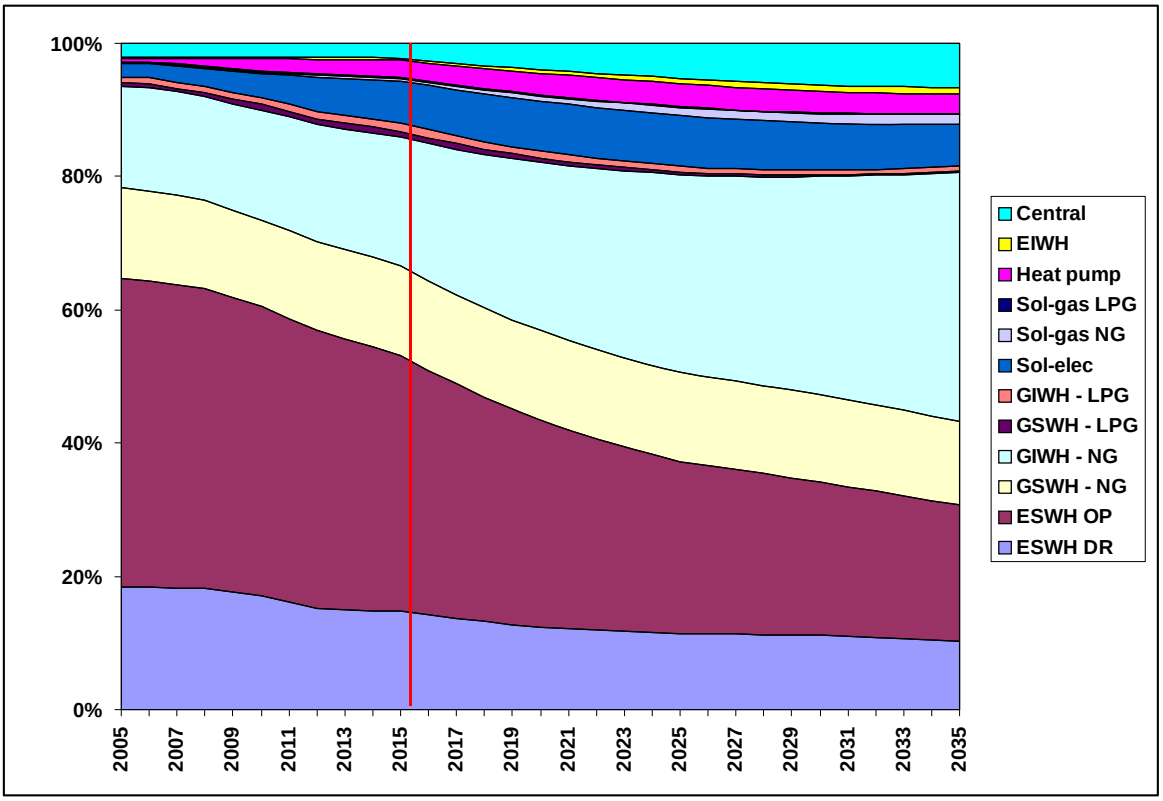
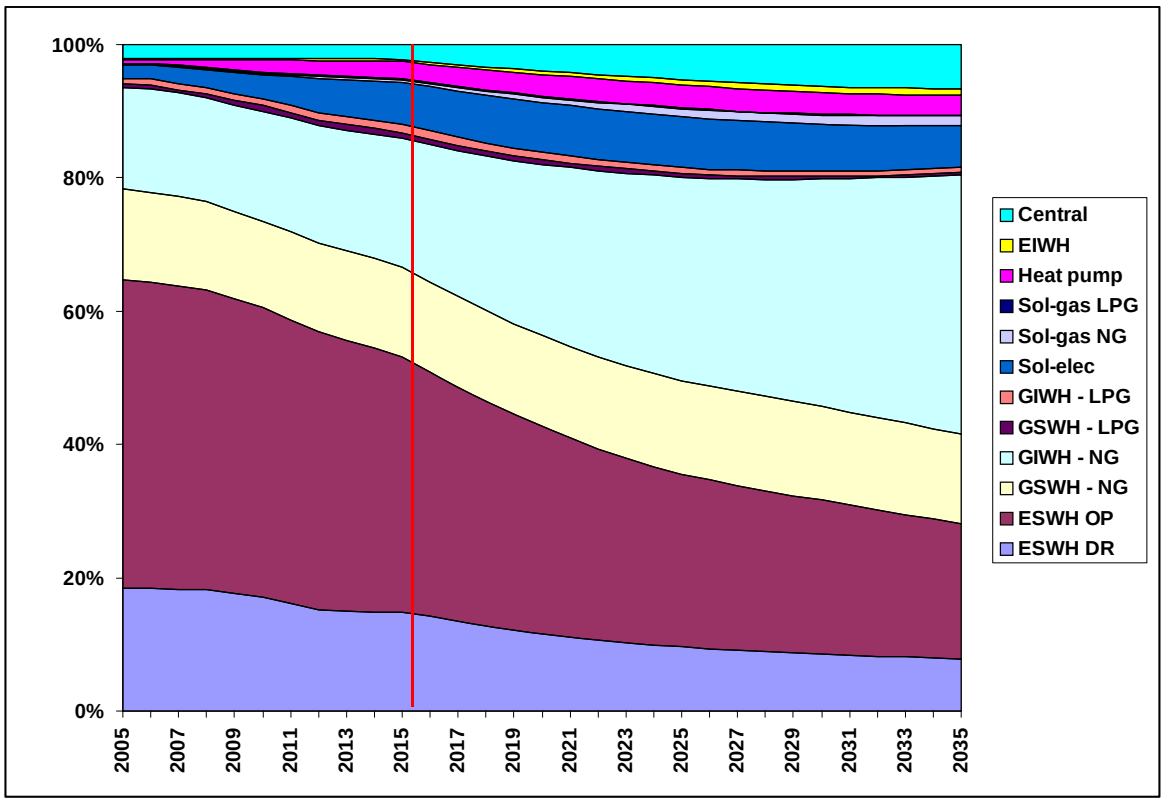


Figure 22 Projected water heater stocks, NSW, Illustrative "with measures" case



6. Impact tracking strategies

6.1 Market Changes

It is very unlikely that the impact of the measures can be tracked using existing data sources alone. This is because:

- Any market changes are likely to be relatively small in relation to the scale of the market – i.e. of the order of a few thousand in a NSW market of over 300,000 units annually;

- The impact would strengthen trends already under way – a shift from electricity to gas and a fall in the average MJ/yr of gas WHs – rather than introduce entirely new products or reverse existing market trends. These trends are already under way, although they vary in strength from year to year (Figure 4), so several years of close monitoring would be required before the impact of the measures could be detected at this level (although impacts could be detected earlier by other means, as discussed later);

- There is no current industry-wide sales data collection system; the only market monitoring currently available (BIS Shrapnel) relies on a relatively small sample, the error margin of which may well be significantly greater than the magnitude of the changes to be detected;

- There are limitations on the accuracy of supplier knowledge of the location of installations, since most of their sales are to intermediaries (e.g. to national chains, who may ship products across State borders) and very few direct to consumers.

To address these issues, OEH could adopt one or both of two strategies.

The first strategy is to negotiate with the organisations that are (or have been) active in surveying the water NSW heater market to make their survey practices more suited to detecting the expected market changes. These organisations are the ABS, IPART and BIS Shrapnel.

The ABS has now discontinued its national household energy surveys, due to funding constraints and declining contributions from client departments such as Industry, Innovation and Science. OEH could approach the ABS to undertake new NSW-only surveys, to continue the 4621.1 series last published in 2006. If OEH were the main sponsor ABS would no doubt be responsive to adding questions about water heater purchases in the previous year or two to seek information about the reasons for the choice of water heater, and awareness of the ESC incentives.

IPART has also undertaken a series of surveys covering selected regions of NSW. The 2015 survey, to be published soon, would provide a pre-measure baseline of water heater ownership. If the survey were repeated in, say, 2018 then changes in ownership should be apparent, and the survey could possibly be designed to elicit information from households who had recently installed a replacement water heater. However, IPART

tends to change the geographical coverage of its surveys, so to eliminate the impact of this variable the next survey should cover the same region as the 2015 survey.

BIS Shrapnel may be the most promising agency to work with, since they already undertake a regular biennial water heaters market survey, and as a commercial organisation need to be responsive to their clients' needs. OEH could commission BIS to increase their NSW sample size, starting with 2016, and to undertake NSW surveys annually rather than biennially. BIS has in the past added questions when requested to do so by the E3 Committee (which regularly purchases its survey reports).

While increases in sample size, frequency and number of question may be adequate to track changes in type shares and possibly probe the reasons for purchase, they could not reliably detect changes in average gas water heater efficiency. Water heater purchasers may recall (or think they recall) the star rating of a gas water heater they had installed in the previous 12 months, but very few would accurately recall the MJ/yr rating unless they (or the interviewer) physically inspected the unit to check the gas star label (if still attached) or, if not, the make and model number. If the latter, it would require a further step to match the model number to the registered MJ/yr value (not always straightforward).

The second strategy is to work with the major suppliers (Rheem, Rinnai, Dux and Bosch) to set up a system of sales reporting. The suppliers have discussed this previously within the Gas Appliance Manufacturers Association of Australia (GAMAA), of which they are all members. Efforts have failed because there are so few major players that each could infer the market shares of the others if aggregated data were made available to all. Rheem would be in a particularly strong position to do this because of its dominance of several segments of the market.

During discussions with industry sources for the present project, it was put to them that one way to avoid giving commercial advantage to any one company would be through a "blind" collection system, in which the companies would report sales to OEH but OEH would not report the aggregated data back to the companies. The incentive for the companies would be the understanding that the Government would need this data to understand the impact of the ESS incentives, which would financially advantage the industry by injecting additional funds (as ESC value) into the water heater market.

In interviews, most suppliers agreed to at least consider the possibility of participating in a reporting system on the conditions that:[41]

- There were legally enforceable confidentiality provisions binding OEH;
- The reporting only covered NSW;
- The data were only used for the purpose of tracking the impacts of this program; and
- The other major suppliers also participated.

If such a data collection system could be set up, it would provide more accurate market data than BIS Shrapnel (subject to the geographical distribution uncertainties above).

[41] Rheem, Dux and Bosch indicated they would consider a proposal from OEH. The matter was not raised in the interview with Rinnai.

Furthermore, the suppliers have data for previous years, so pre-measure trend lines could be constructed with regard to both sales and, for gas water heaters, average MJ/yr. This would not be possible from BIS Shrapnel data alone, the quality of which can only be improved prospectively, not retrospectively.

6.2 Changes in Consumer Behaviour

There will obviously need to be some form of documentation created at the time of installation, to substantiate that the installation meets the eligibility conditions for creation of ESCs, and the number of ESCs which it is entitled to create.

The documentation will need to be signed by an authorised person (the owner or tenant of the premises, and the plumber or serviceperson) and either lodged with the ESS regulator (IPART) or retained by the person or company registering the ESCs, so that it can be produced and inspected during an audit if required. The application forms developed for the NSW Hot Water System Rebate scheme, which terminated in mid 2012, and the Commonwealth Renewable Energy Regulator STC creation authorisation forms provides useful models.

The questions on the NSW Hot Water System Rebate form were grouped as follows:

- Applicant details, including whether the applicant is the owner or tenant of the premises. Tenants were required to attach the written permission of the "landlord." The same information would be required for an ESC form.

- Rebate payment option (e.g. cheque or direct payment to an account). The rebate was a fixed amount according to a published schedule of payments. The value of ESCs, however, is uncertain at the time of their creation – the price will be determined by the ESC market. How much value is returned to the customer, and when, is at the discretion of the water heater suppliers and installers. Some installers may simply calculate a discount on paper and subtract it from the total invoice, while others may charge full price but send the form to a third party (e.g. an ESC broker, who may also be the manufacturer) who sends a payment to the consumer in due course.

- Physical details of the replaced water heater, to confirm that it is an eligible situation (i.e. that it is electric or gas, and if electric it is/was not on an OP tariff). The NSW Hot Water System Rebate form also asked about the estimated age of the replaced system (which would have been more useful if other details had also been noted – e.g. the year of manufacture stamped on ESWH compliance plates).

- The Rebate form also asked "why did you replace this system" but did not allow multiple responses, and did not ask whether the consumer was influenced in their selection by the availability of the cash rebate. It should be possible to reframe these questions to better tease out motivation.

- New water heater details ("plumber to complete"). This could include additional questions, such as "what is the model", "was it necessary to install a new power

point", "was it necessary to install a new gas connection", "was it necessary to increase the gas service diameter" and "was it necessary to install a condensate line". Also, basic price information should be sought – at least the total invoice value of the installation, and preferably separate components for water heater supply, installation and the ESC value (if any) deducted at the time of installation. This would help with subsequent evaluation of the measure.

- Installer declaration, including contact details and license number and signature.

- Property owner/tenant declaration and signature.

If the forms are properly designed, the compilation of the data in them will accurately indicate the number of claims made under the ESS Rule, and the average size and MJ/yr of the new gas water heaters installed. The fact that the form was completed is also evidence that the installer and consumer were aware of the availability of ESCs. However, this will NOT on its own indicate:

- Whether the overall market trend is different from the pre-existing trend: only comparison with the supplier data (as discussed before) will show this; or

- Whether the consumer (or the advising installer) actually changed their water heater preference or advice in response to the availability of ESCs.

While the responses on the form (if the questions are well framed) will give some indication of the latter, the only reliable method is through targeted consumer research – taking a random sample of forms and contacting both the consumer and the installer to ask more in-depth questions and to probe their motivation.

To sum up, all three levels of research will be necessary to accurately monitor and evaluate the impact of the ESS incentives on the NSW water heater market:

1. High-level market monitoring, either through enhanced surveys or a new data collection arrangement with the major water heater suppliers;

2. Careful design, and retention for analysis, of the application forms for ESC creation; and

3. Targeted consumer research to probe the motivation of a sample of ESC claimants and intermediaries.

*****

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Appendix 1 – Persons consulted

Rheem

Alan Law, Technical Manager
18 December 2015

Rinnai

Chris Blogg, Executive Technical Advisor
Leon Bogers, Executive Technical Manager
17 December 2015

Lucas van Raay, National Sales Operations Manager
23 December 2015

Bosch

John Lake, General Manager, Oceania
Anthony Edwards, Technical Manager
17 December 2015

Dux

Peter Faase, Marketing Manager
6 February 2016

Ausgrid

Robert Simpson, Demand Management Development Engineer
14 December 2015

Appendix 2 – Water Heater Prices

The following diagrams plot the price and efficiency for the 62 water heater models described in Table 10. These are based on an internet search in January 2016 for models with advertised supply-only prices, as distinct from installed prices. Only one complete price list was found (Thermann brand).

Figure 23 Medium gas storage water heaters – price vs gas consumption

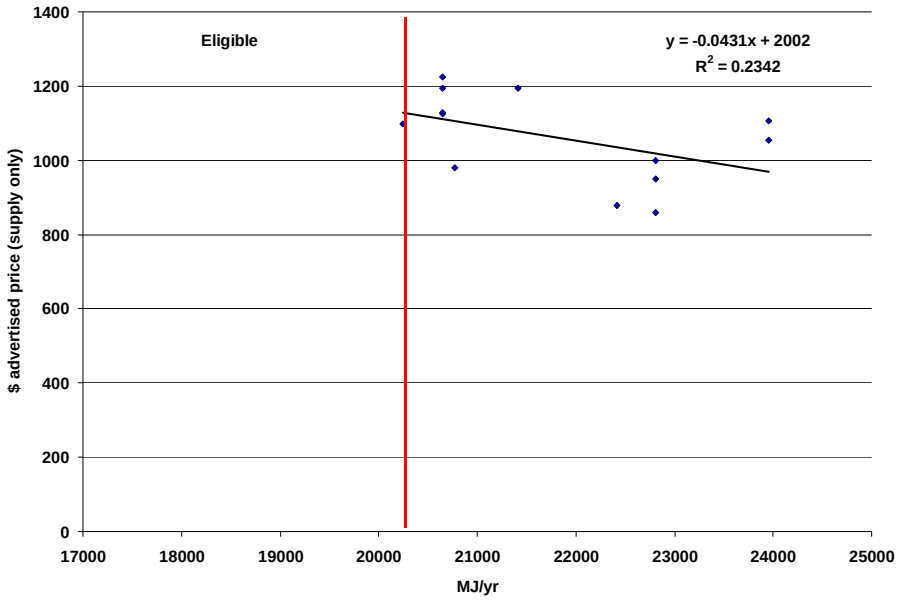


Figure 24 Large gas storage water heaters – price vs gas consumption

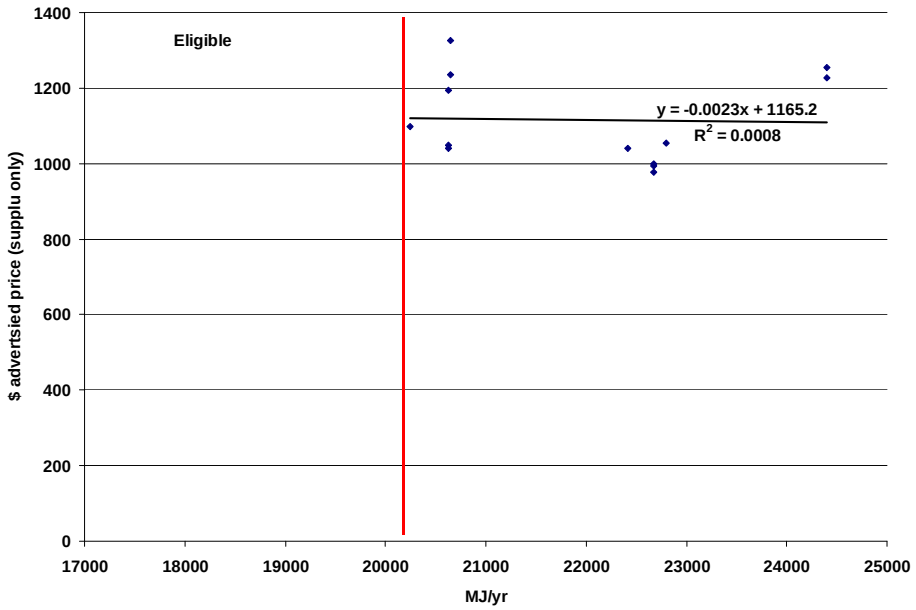


Figure 25 Small gas instantaneous water heaters – price vs gas consumption

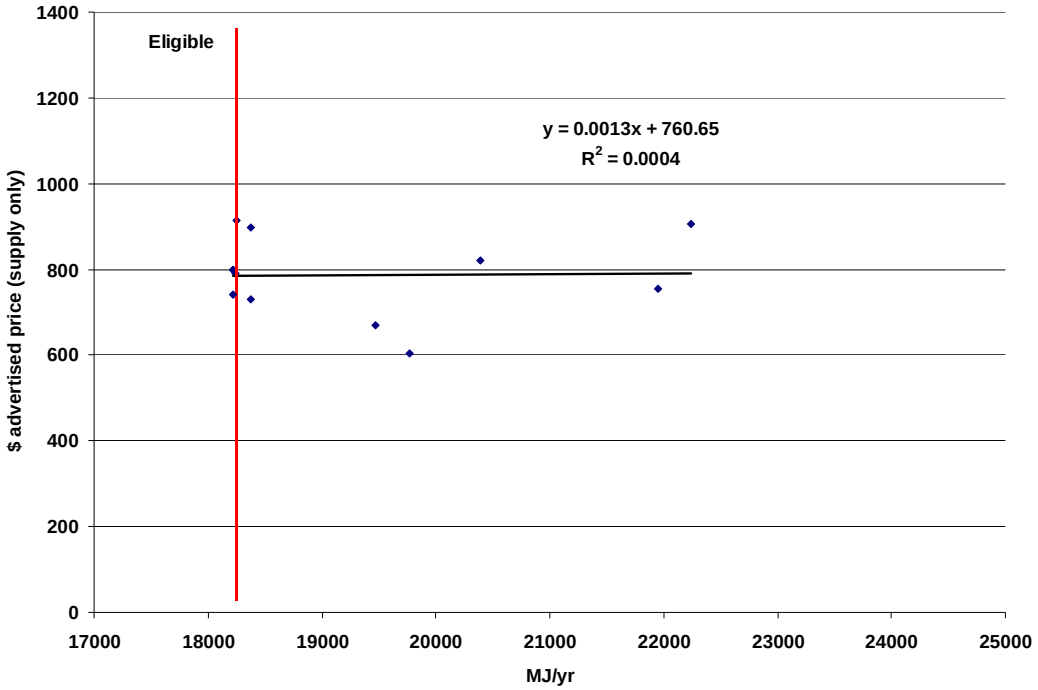


Figure 26 Medium gas instantaneous water heater – price vs gas consumption

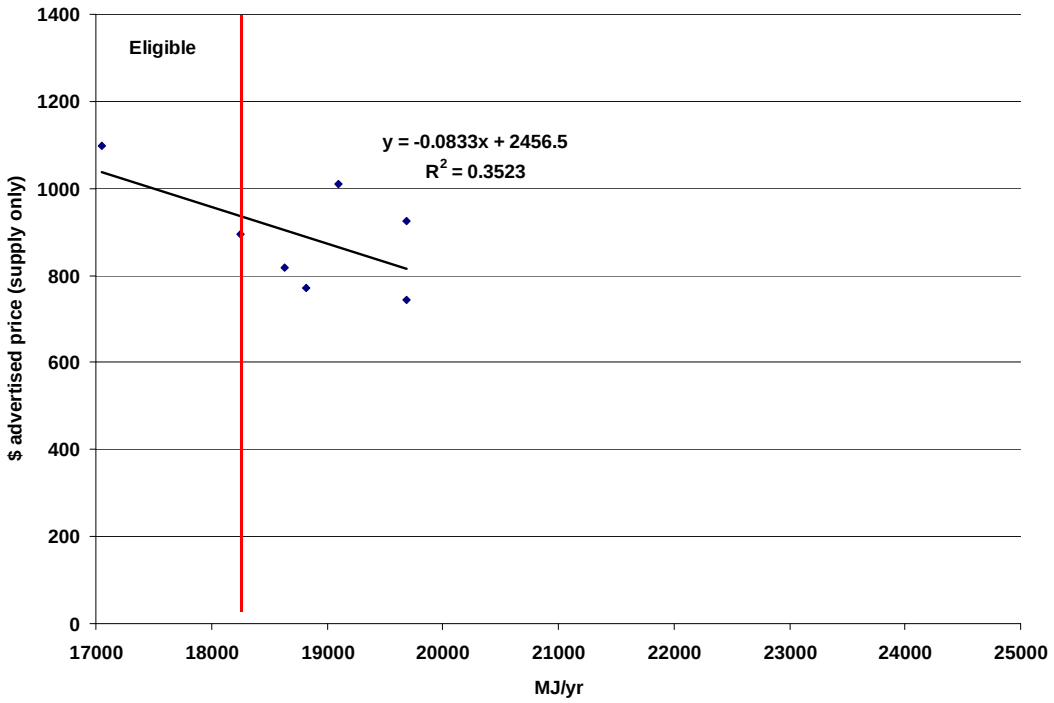


Figure 27 Large gas instantaneous water heaters – price vs gas consumption

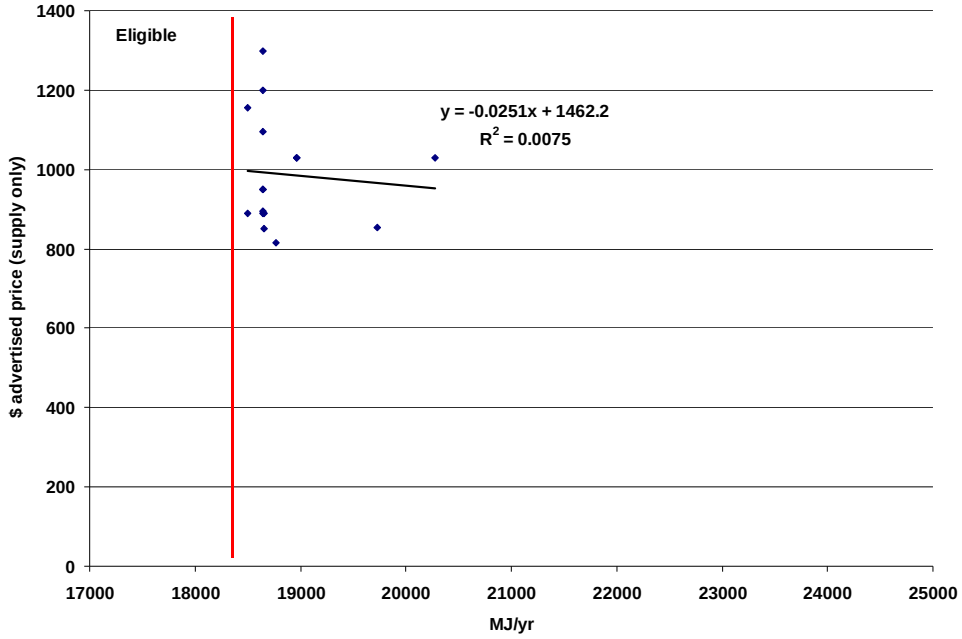
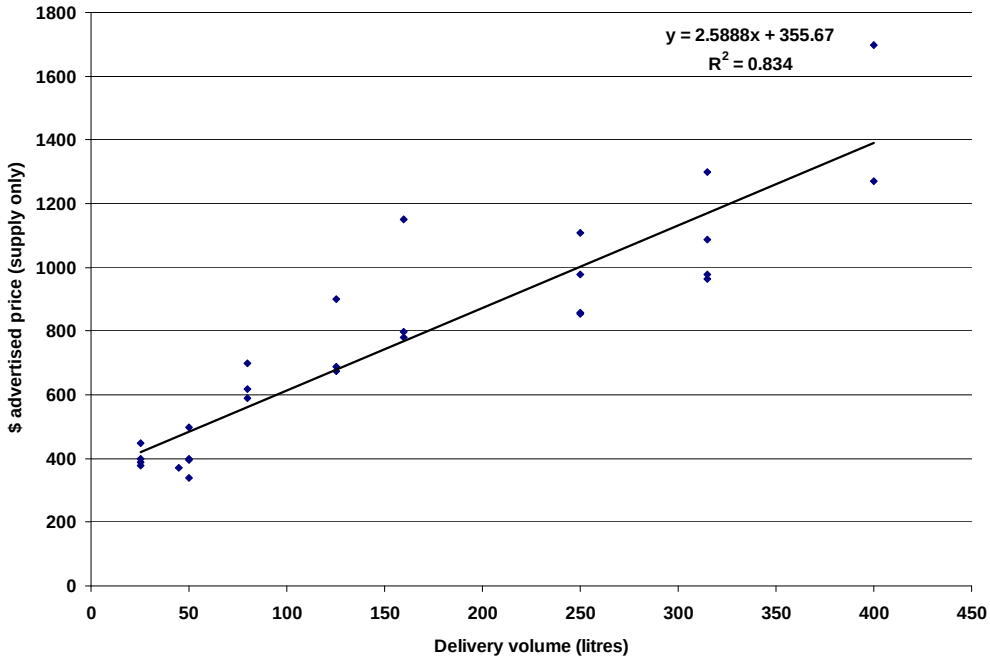


Figure 28 Electric storage water heaters – price vs volume



Appendix 3 – Description of the Model

All diagrams and tables in this reports are derived from the model, which is embodied in the spreadsheet [NSW ESS Water Heater estimates V3.xls]. This contains:

- calculations of the value of ESCs created by various gas water heater installation options.
- data on water heater prices
- historical data on the stocks and sales of water heaters in Australia and NSW.
- population and dwellings projections
- the projection calculations model of the water heater market.

All values which can be changed by the operator are shown in red, highlighted in yellow. Values shown in dark blue, highlighted in light blue, are taken from other worksheets on the same spreadsheet or from linked data (including ABS data). All other values are internally generated by formulae.

The main input assumptions are on the worksheet called INPUTS. They are:

- Share of pre-2016 dwellings removed from the stock each year (i.e. demolished). Separate values can be set for the three main dwelling types (detached, attached and apartments) and for two regions - Sydney Statistical Division (SSD) and Rest of NSW (RON).
- Share of ABS housing approvals actually resulting in construction (historically this has been about 95%).
- Population projection selected (ABS published 3 series – A (highest) to B (lowest).
- Number of dwellings expected to be built in 2022, 2029 and 2035, by dwelling type and region.
- Dwellings in existence to end of 2015 – historical water heater stock - percentage breakdown of 11 water heater types, by dwelling type and region.
- Dwellings constructed 2016 and later (assume subject to existing BASIX rules) – expected percentage breakdown of water heaters installed at time of construction (11 types plus share of new apartments served from central systems).
- Average service life for each type of water heater, for dwellings built before and after end of 2015. Service life for each type can be varied– e.g. a water heater of a given type installed in 2025 can be given a different service life to one of the same type installed in the period 2006-11, and the service life for intermediate years will be linearly interpolated. The service life factor reflects the possibility that materials or durability may change over time (e.g. in response to the rule proposal that only gas water heaters with 10 year warranty on the heat exchanger will be eligible to create ESCs). The longer the service life the lower the demand for replacements water heaters, so this affects the total market demand in the model. Also, shifts in market share from water heaters with a short service life (e.g. ESWHs, currently set at 10 years) to those with longer lives (e.g. GIWHs, set at 12 years and solar, set at 14 years) will result in a lower total market size than if the average service life remains constant. These values are differentiated by dwelling type, but not by region – i.e. they apply to all of NSW).
- Dwellings in existence to end of 2015 – projected BAU market share for replacement water heaters. All of NSW (i.e. is not differentiated by region). The

operator needs to specify values in 2016, 2020, 2025, 2030 and 2035. Other years are linearly interpolated.

- As above, but projected with measures market share for replacement water heaters (i.e. lower % for ESWH and higher % for GIWH and GSWH).
- Dwellings constructed 2016 and later – projected BAU market share for replacement water heaters (i.e. after the water heater installed at time of construction fails). All of NSW (i.e. is not differentiated by region, but is differentiated by dwelling type). The operator needs to specify values in 2025, 2030 and 2035. Other years are linearly interpolated. Note these values only impact in the period after 2025, because it is assumed that all dwellings constructed after 2016 will retain their original water heater until then.
- As above, but projected with measures market share for replacement water heaters. As post-2016 dwellings will have virtually no ESWHs, the gains in GIWH and GSWH market share are assumed to be small, and come at the expense of solar and heat pump.
- Share of new GSWHs installed that are in the "Medium" volume range as defined in the proposed ESS rules (95-140 litres). The "Small" and "Large" shares are automatically calculated.
- Share of new GIWHs installed that are in the "Medium" flow rate range as defined in the proposed ESS rules (18-22 litres/min). The "Small" and "Large" shares are automatically calculated.
- The BAU share of sales in each efficiency (MJ/yr) band for GSWHs and GIWHs, in 2016 and 2035 (intermediate year linearly interpolated), under BAU.
- The with-measures share of sales in each efficiency (MJ/yr) band for GSWHs and GIWHs, in 2016, 2020 and 2035 (intermediate year linearly interpolated). The extra year point (2020) is to allow modelling where change is rapid at first but then slows as gas water heaters approach their technical limits.

Switching from "BAU" to "With-Measures" cases

The cell named "Switch" (cell AS338 on worksheet CALCS) allows the operator to set the model to either BAU (0) or With-measures (1) with respect to the modelling of the market for water heaters in the dwelling stock built pre-2016.

The cell named "Newswitch" (cell AS69 on worksheet NEW Replace) allows the operator to set the model to either BAU (0) or With-measures (1) with respect to the modelling of the market for replacement water heaters in the dwelling stock built after 2015 (assuming that the proposed ESS rules remain in place after 2025).

Note that the measure would not impact new water heaters installed at the time of construction, which are subject only to BASIX, so there is no switch for this segment.

Macros

Macro 2 runs the model for BAU first and then "with-measures," and records the main outputs for both. The market share of main water heater types under the two cases is plotted in Figure 17 (i.e. the Macro sets both Switch and Newswitch to 0, records main values, resets both Switch and Newswitch to 1, records main values, and then resets both Switch and Newswitch to 0 and stops.) Macro 1 does the same, but only operates

Switch. Newswitch can be left at 0 throughout, to simulate a case where the measure does not apply to replacement water heaters in dwellings built after 2016.

ESC estimates

The model estimates the number of electric-to-gas conversions and the number of gas-to-gas replacements, under BAU and With-measures. All of these cases would be eligible to create ESCs, provided that the gas water heater installed is in an eligible MJ/yr band (the model calculates the "eligible" share based on the input estimates for sales by efficiency band). If the operator inputs:

- the % of electric to gas installations that would have been made anyway, but which will claim ESCs (at cell O489, worksheet CALCs) – currently set at 90%;
- the % of gas to gas installation that would have been made anyway, but which will claim ESCs (at cell O208, worksheet CALCs) – currently set at 90%;
- the % of additional GSWH water heater installations that will claim ESCs (at cell R817 and R818) – currently set at 90% in 2016, rising to 95% by 2025; and
- the % of additional GIWH water heater installations that will claim ESCs (at cell R819 and R820) currently set at 90% in 2016, rising to 95% by 2025

the model will calculate the total annual value of ESCs that would be claimed each year, and a cumulative value. This value indicates the potential share of the total ESS budget that could be absorbed by this measure. Dividing this total cost by the number of extra gas water heaters installed as a result of the measure will give the actual ESC cost per additional water heater, taking into account any ESCs that might be claimed by "free riders" who would have installed gas water heaters anyway.

Internal adjustment factors

Given the complexity of the model, and the fact that the projections run on from historical data sources that are not themselves internally consistent, there are some balancing factors to maintain internal consistency – e.g. so that the number of water heaters in the stock matches the number of dwellings in existence (averaged over time, if not strictly in every year). These balancing factors are at AK330, AK332 and AK334 of the worksheet CALCs, and at AK61, AK64 and AK67 of the worksheet NEW Replace.

If there is a non-zero value to the immediate left of any of these balancing cells it indicates that there is a mismatch between the number of water heaters and the number of dwellings. The values can be brought back into balance by using the "goal seek" function on each pair of cells. For example, if AJ61 shows a value of –2 instead of 0, then

Place the cursor on AJ61
Select "Goal seek"
Set "To value" = 0
Set "By changing cell" = AK61, and accept the calculated factor.

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