NFEE – Energy efficiency improvement potential case studies, residential water heating

Report to the

Sustainable Energy Authority Victoria

by

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Background

This report summarises the results of an analysis of household (HH) water heating energy undertaken to support the National Framework for Energy Efficiency (NFEE) by George Wilkenfeld and Associates Pty Ltd (GWA).

The aim of the analysis was to

- identify those measures for reducing household water use that have a 4-year and a 6-year flat payback from the perspective of end users (ie the additional capital cost to the user compared with the most likely or "business-as-usual" (BAU) option is less than 4 times, or 6 times, the value of the annual energy savings);
- include those measures which meet the criterion in a projection of household water heating energy use over the period 2005-14;
- calculate the total energy savings in each year of the projection period;
- calculate the total value of energy savings to users in each year of the projection period; and
- calculate the additional capital cost of products in each year of the projection period.

The results were calculated using spreadsheet models, which allow different payback periods to be modelled. Other key variables such as energy and water prices, product prices and price/efficiency ratios can also be reset.

Household Structure

The number and size of households in Australia has been projected using ABS data on population and household numbers. Three distinct categories of household – small, medium and large - have been used, so that the different levels of energy use and appliance types typically chosen by different households can be better modelled.

The main characteristics of each category and the share of the total households falling into each category in 2005 are summarised in Table 1. The shares and characteristics are projected to change over time as average household size decreases. Total water use and hot water use are modelled separately, since the installation of more water-efficient devices will usually save cold water as well as hot water (devices which save only cold water, such as more water-efficient toilet cisterns, are excluded from this analysis).

Table 1 Household categories and characteristics, 2005

Category	Characteristics (2005)			Kilolitres/HH/yr indoor water use (a)			
				Showers	Clothes Washers	Other	Total
Small HH (1 and 2 persons)	Share total HH	57.0%	Water	33.8	25.4	41.9	101.0
	Avg persons	1.5	Hot water	23.6	5.1	13.1	41.8
Med HH (3 and 4 persons)	Share total HH	32.0%	Water	78.8	54.9	97.7	231.4
	Avg persons	3.5	Hot water	55.1	11.0	30.6	96.7
Large HH (>4 persons)	Share total HH	11.0%	Water	117.5	75.8	145.8	339.1
	Avg persons	5.2	Hot water	82.3	15.2	45.6	143.0
All HH	Share total HH	100.0%	Water	57.4	40.4	71.2	168.9
Persons/HH (2005)		2.55	Hot water	40.2	8.1	22.3	70.5
Share of hot water use				57%	11%	32%	100%

(a) Based on *Regulatory Impact Statement: Proposed National System of Mandatory Water Efficiency Labelling for Selected Products, September 2003*, GWA for AGO. Excludes garden use.

Options analysed

Water use

Lower heat losses from house piping

It is estimated that in existing dwellings, 7% of the energy output of the water heater is lost from the pipework due to uninsulated pipes and inefficient layout, typically a greater than optimum distance between the water heater and the most-used draw-off points. Loss rates in existing dwellings can increase if pipe runs are lengthened rather reconfigured when replacement water heaters are moved from the original location, typically from indoors to outdoors, or from the roof space to floor level.

It is assumed that the pipe loss rate can be halved if more attention is paid to the plumbing layout of new dwellings, and if the main runs are lagged. It is assumed that all new dwellings built in 2005 and later achieve a pipe loss rate of 3.5%. This measure is estimated to be cost neutral – ie the reduction in pipe costs from shorter runs balances the costs of insulation. The impact on average loss rates across the whole dwelling stock is minor however, because such a small proportion of the stock is built new each year. For the stock as a whole average loss rates are projected to fall from 7% in 2005 to 6.4% by 2014, implying a 0.6% reduction in water heating energy demand.

Low flow shower heads

Showering accounts for about 57% of HH hot water use (see Table 1). The substitution of low-flow (“flow controlled” or FC) shower heads for conventional (“all-directional” or AD) is almost always cost-effective, usually with payback periods of a year or less even where an existing working shower is replaced. The main exceptions are households with very low water pressure (eg those not on mains supply), where a FC shower will give a flow rate no lower than an AD shower, and indeed the FC shower may not give satisfactory showering performance at all. It is assumed that 10% of HH are in this category.

Figure 1 Projected market share of flow-controlled showers

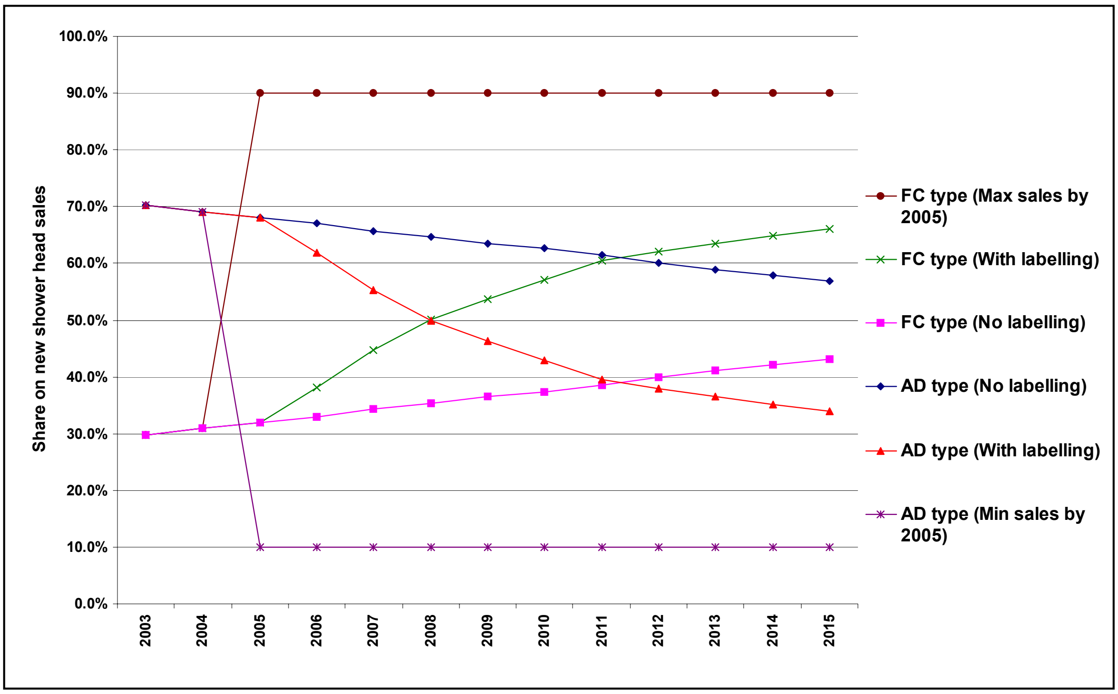
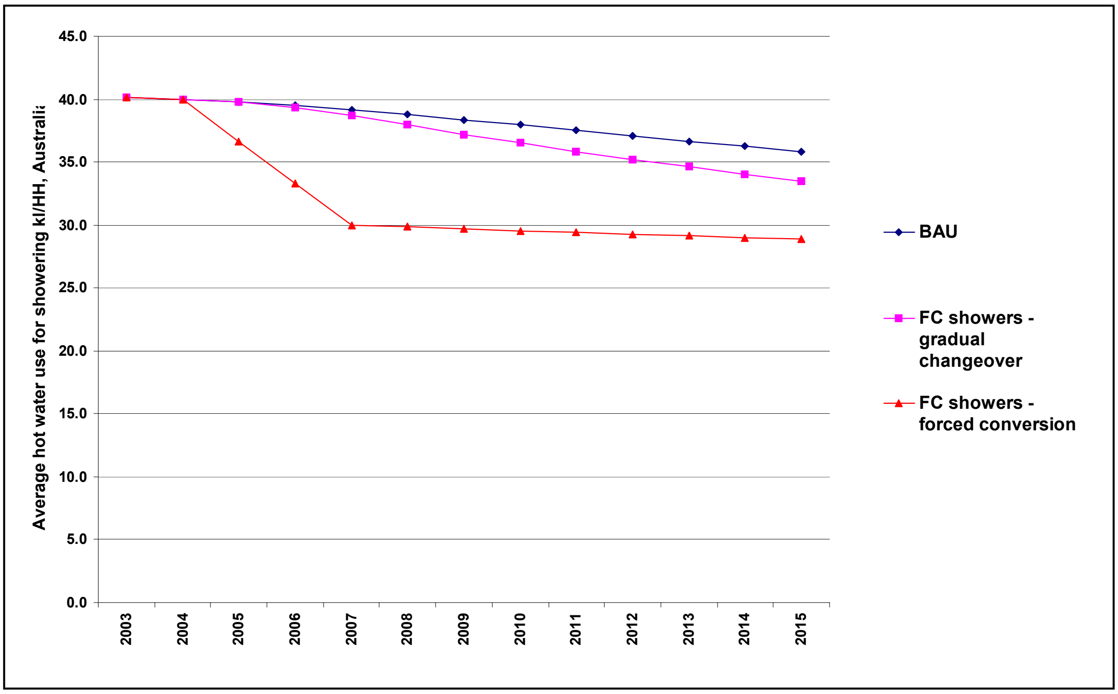


Figure 2 Projected hot water use per household for showering



About a third of the HH which can benefit from FC showers already have them, and it is projected that the BAU rate of acquisition will increase due to the impact of the national water efficiency labelling program, which the Commonwealth plans to introduce in 2005. Figure 1 illustrates the projected market shares with and without the labelling program. However, this only reflects the impact of labelling on likely consumer preferences, not the cost-effective potential of the option. Since the purchase of an FC shower is estimated to be cost-effective in 90% of purchases, if this were reflected in the market the FC market share would immediately jump to 90% (see Figure 1).

Even if the market share of FC showers reached 90% of shower purchases from 2005 on, the FC share of showers *in use* would increase only gradually (see Figure 2) because new shower heads tend to be installed only at the time of construction or bathroom renovation. However even HH that would not otherwise purchase new shower heads would be better off if they immediately discarded their AD shower and substituted a FC shower. If the entire stock of existing AD shower heads could be retrofitted over a 3 year period (excluding the 10% of households where this would not be suitable), the share of FC showers in use could rise to 90% by 2008, and the average hot water consumption for showering would fall rapidly (see Figure 2). This “forced conversion” scenario is used as the indicator of technical potential.

Clothes washers

The best indicator of the energy-efficiency of clothes washers is the litres of water used per kg of nominal wash capacity. Since most of the energy consumed in clothes washing is used for heating water, the higher the water use, the greater the energy consumed.[1] Given the tendency to washing in cold water, energy costs now account for less than half of the operating costs of clothes washers, and water for more than half.

The trend in average litres per kg of new clothes washers purchased, and average for existing units remaining in service has been projected from historical data, for both top loaders and front loaders (Figure 3). Front loaders have about half the litres per kg of top loaders. However, this apparent efficiency advantage is not fully realised as lower operating costs, because:

- Front loaders tend to use a higher proportion of warm and hot water in their operation than do top loaders; this is based partly on the historical preference for higher wash temperatures in the European countries where most front loaders are built. The hot water penalty of front loaders is coming down as suppliers make it easier for users to select warm and cold washes;

- Most front loaders have their own heating elements, so a larger share of the heated water is self-heated than for top loaders. Nearly all self-heated water is electrically heated (at day-rate tariffs), whereas imported water may be heated by day rate electricity, off-peak electricity, gas or solar; and

- Most clothes washing is done at part load, for which the litres per kg washed tend to be higher than for a full load, even with load adjustment. Top loaders with load adjustment can reduce their water consumption more or less in proportion to the load, whereas front loaders already use much less water, and cannot say halve it for a half load. As households get smaller and clothes washers larger, part load penalties are increasing. It is estimated than on average smaller households use a

[1] The better the intrinsic design of a clothes washer, the lower the temperature needed to achieve the standard levels of wash performance. The energy ratings for different models are therefore based on slightly different wash temperatures and hence differing hot water requirements. Water consumption alone has been used in order to normalise differences in wash temperature.

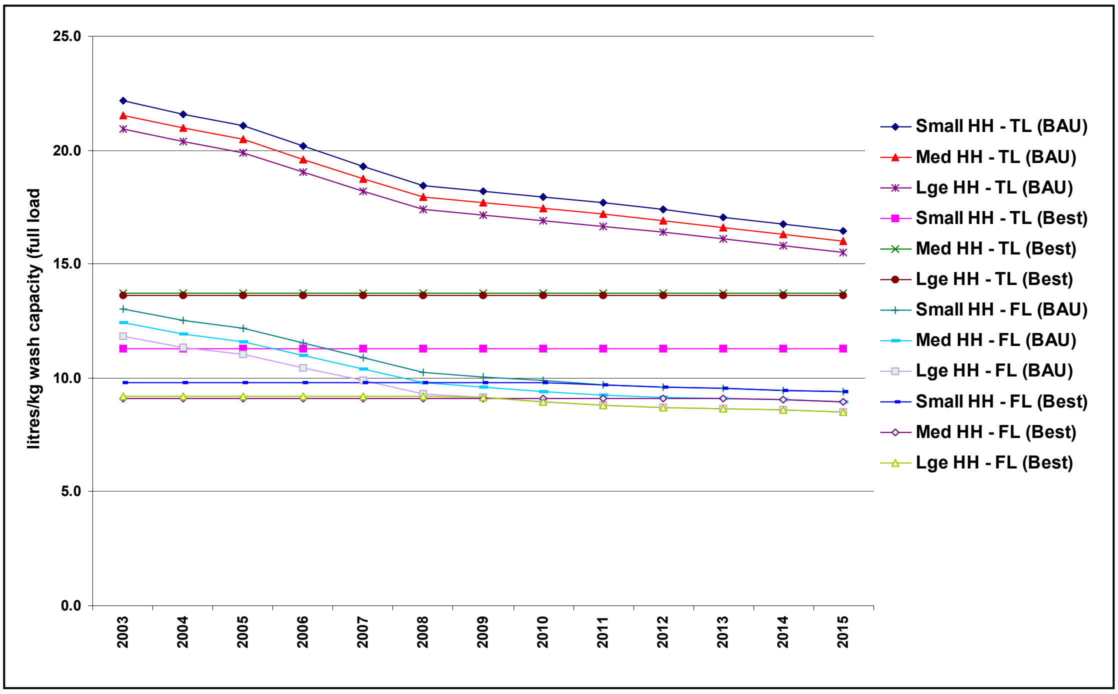
lower proportion of the capacity of their clothes washers, and so incur higher part load penalty factors.

These factors are reflected in the modelling using the adjustment factors in Table 2

Table 2 Adjustment factors for cold water and part load clothes washing

		Top loader		Front loader	
		2003	2015	2003	2015
Heated share of water used		20%	20%	40%	40%
Imported share of heated water		90%	90%	60%	60%
Self-heated share of hot water		10%	10%	40%	40%
Part load energy penalty adjustment factor	Small HH	1.20	1.30	1.40	1.50
	Med HH	1.15	1.25	1.35	1.45
	Large HH	1.10	1.20	1.30	1.40

Figure 3 Projected litres per kg full load capacity, new clothes washers



Basis of modelling

The model determines, for each of household size and clothes washer type, whether it is cost-effective to substitute a "best" (most energy-efficient) clothes washer model for one of BAU average efficiency. It sums annual water heating energy costs (both import and self-heating) and water/wastewater costs for the two options, and applies a purchase price penalty to the more efficient, according to the price/efficiency formula discussed later. If the saving in annual running costs multiplied by the payback period exceeds the price penalty, then that option is adopted for all purchases in that year.

The cost-effectiveness of substituting front loader purchases for top loader purchases was also analysed, but because of the large differences between the average prices for the two types, this option is not cost-effective for any sizes under either 4 or 6 year payback, even though the price difference is projected to reduce.

The substitution of more water-efficient clothes washers leads to some reductions in electricity consumption for self-heated water, in addition to reductions in water taken from the hot water system. This additional energy saving has also been quantified and costed, even though strictly speaking it would be accounted as a reduction in appliance energy consumption rather than in water heating energy consumption.

Water Heaters

The option of using more efficient water heaters was tested *after* the cost-effective reductions in hot water consumption were applied first. This means that some water heating options that may be cost-effective at BAU levels of household hot water use are no longer cost-effective once household hot water consumption is reduced, since the value of energy saved for the same additional capital cost is less.

Gas water heaters

The market shares of gas storage water heaters (SWH) and instantaneous water heaters (IWH) are projected separately. In general the average purchase price of IWHs are higher than for SWHs serving a household of similar size (Table 3), but the actual cost differentials are uncertain. The products are not completely substitutable due to differences in warranty and other features, and installation costs can vary considerably, determined partly by the location of the previous water heater (the great majority of water heaters are purchased as replacements rather than for new dwellings).

Table 3 Comparison of gas storage and instantaneous water heaters

	SWH			IWH			IWH compared with SWH						
	Delivery litres	Avg cost $ (a)	Avg rating	Litres/ min	Avg cost $ (a)	Avg rating	Cost diff $	Rating diff	MJ/yr at full load	Load (b)	MJ/yr diff	$/yr saving	Pay back years
Small HH	90	750	3.3	10-16	850	4.8	100	1.50	3030	53%	-1606	20.9	4.8
Med HH	130-135	850	3.8	18-22	1040	5.2	190	1.40	2828	122%	-3450	44.9	4.2
Large HH	150-170	1020	3.7	24-32	1320	5.2	300	1.50	3030	181%	-5484	71.3	4.2

(a) Actual retail prices estimated from the wholesale price lists of Bosch, Dux, Rheem and Rinnai, and prices advertised by Energex and Origin in late 2003.[2] Only outdoor models compared. (b) Related to standard delivery of 200 litres per day: after water efficiency measure applied

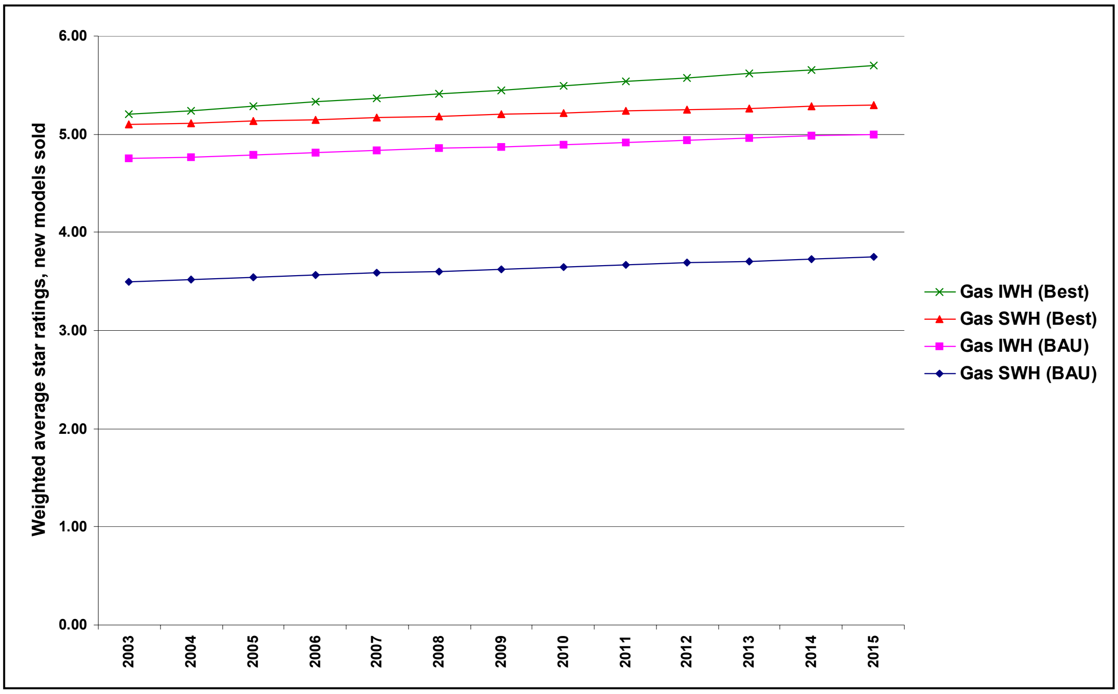
Although IWHs cost somewhat more to buy, they are usually cheaper to run. An IWH can consume 1600 to 5500 MJ/yr less than a SWH of similar capability, and substituting the IWH for the SWH may meet the 6 year criterion. The cost-effectiveness substituting an IWH for a SWH is greatly increased when the deterioration of SWH efficiency at low loads is taken into account. As Figure 7 illustrates, the average daily hot water use of Small HHs is already well below the "standard" delivery of 200 litres/day, which is used as the basis for establishing the efficiency of gas water heaters, and would be even lower once water efficiency measures are implemented.

[2] The assistance of Dux, Rheem, Rinnai and Bosch in providing price data is gratefully acknowledged.

The efficiency of a SWH falls off rapidly as load falls, since nearly the same amount of energy is still needed to make up standing losses irrespective of the amount of water heated for draw-off. On the other hand the efficiency of IWHs is barely affected at low loads.[3] Furthermore there is a wide range of flow rates available for IWHs (from 10 to 32 litres/minute in 9 discrete steps) whereas SWH are clustered in the three size bands indicated in Table 3.[4] This means that the probability of matching capacity to load, both at the time of selection and over the operating life, is higher with an IWH than a SWH.

The BAU weighted average AGA star rating of new gas water heaters sold is projected in Figure 4, along with the trend in average star ratings that would occur if buyers purchased the most efficient ("Best") model. The spreadsheet calculates the annual savings in gas consumption from the substitution of the best for the BAU model, in each of the small, medium and large HH categories. A price penalty is also calculated, according to the price-efficiency relationships discussed below. If the apparent saving in annual running costs multiplied by the payback period exceeds the price penalty, then that option is adopted for all purchases in that year.

Figure 4 Projected weighted average star ratings of gas water heaters



Medium and Large HH use more hot water than the standard 200 litres/day, so the actual operating efficiencies gas water heaters in those HH should be close to and possibly even higher than the efficiency at standard delivery. With Small HH on the other hand the daily delivery is only about half the standard, so the actual efficiency will

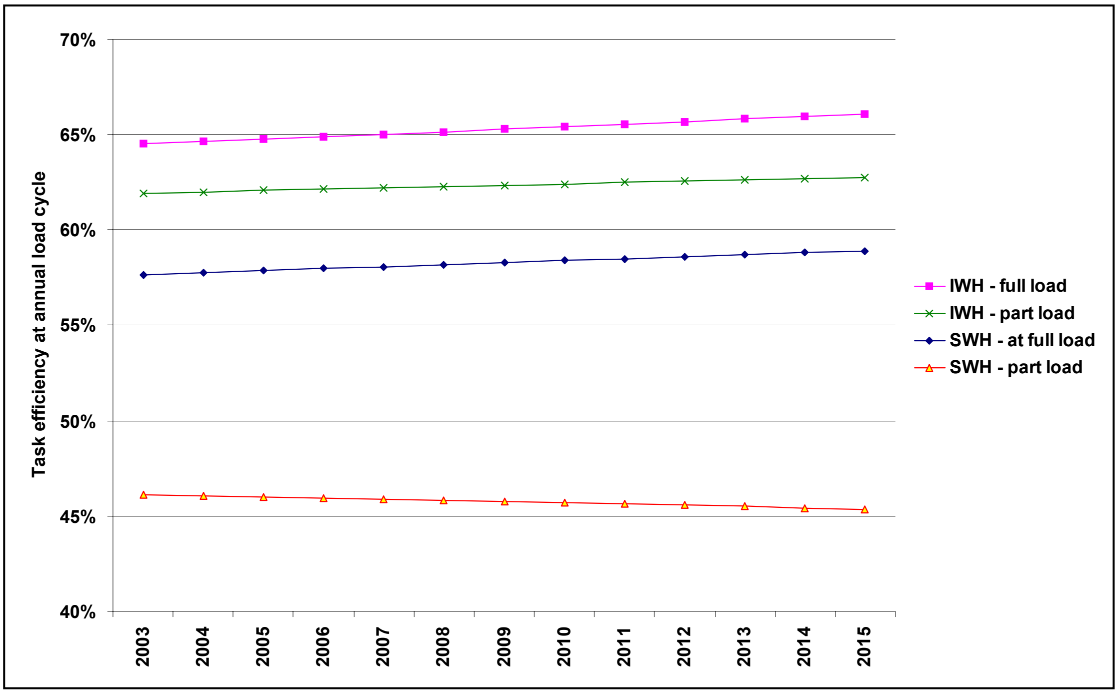
[3] There is a detailed comparison of part load effects of efficiency in *Response to Driving Energy Efficiency Improvements in Domestic Gas Appliances*, Rinnai Australia submission to SEAV, November 2003

[4] There are some SWH models which can be adjusted to different tasks by changing the storage temperature, but these are designed for HH which move between "medium" and "large" hot water use, not for small HH.

be significantly lower than the efficiency at standard delivery. The drop-off in efficiency will be greater for SWH than for IWH (Figure 5).

The full load efficiencies of gas water heaters installed in Small HH are projected to increase in line with general market trends (Figure 4) but once the effects of declining water use are taken into account the task efficiency will rise more slowly or, in the case of SWH may actually fall. This widening efficiency advantage makes it increasingly cost-effective to substitute IWH for SWG in Small HH. It has been assumed that IWHs displace SWHs in 90% of the cases where a SWH would otherwise have been installed in Small HHs (there would always be some cases where an IWH is unsuitable or unacceptable for some reason).

Figure 5 Estimated actual task efficiency for gas SWH and IWH, Small HH



Electric water heaters

All electric storage water heaters heat water with near 100% efficiency, so efficiency differences between models are determined solely by the standing heat loss. It is assumed that the alternative to a BAU electric storage water heater (one which meets the proposed 2005 MEPS levels for water heaters up to 80 litres, and the 1999 MEPS levels for larger units) is one with 40% lower heat loss. A price penalty is also calculated, according to the price-efficiency relationships discussed below. If the apparent saving in annual running costs multiplied by the payback period exceeds the price penalty, then that option is adopted for all purchases in that year.

There are eight standard electric SWH capacities between 50 litres and 315 litres delivery and three tariff levels, but to simplify the calculations these were collapsed to the combinations in Table 4. The estimated share of the electric SWH stock in each if these categories is in Table 5. It is necessary to differentiate the number of water heaters from the share of hot water produced, because total capital costs are determined by the former but the value of total energy saved by the latter.

The relative cost-effectiveness of the various options is sensitive to the electricity tariff as well as to the capital and installation costs of the electric water heaters themselves. The adoption of the lower heat loss option is not cost-effective for large HH using the restricted hours off peak ("OP1") tariff, because of the relatively low price per unit of OP energy saved.

Table 4 Categories of electric water heating analysed

Household and tariff category	Type of water heater	Tariff
Small	50 litre (2005 MEPS) 40% lower heat loss Heat pump Heat pump	Day rate Day rate Day rate OP2
Medium /Day rate	125 litre 40% lower heat loss Heat pump Heat pump	Day rate Day rate Day rate OP2
Medium /OP 2	160 litre 40% lower heat loss Heat pump Heat pump	OP 2 OP 2 Day rate OP2
Medium /OP 1	250 litre 40% lower heat loss Heat pump Heat pump	OP 1 OP 1 Day rate OP2
Large	315 litre 40% lower heat loss Heat pump Heat pump	OP 1 OP 1 Day rate OP2

Table 5 Estimated allocation of electric water heaters and water heating

Storage water heater option and tariff	Share of water heaters	Share of hot water produced
Small - dayrate	39.4%	18.7%
Medium - dayrate	15.6%	19.6%
Medium – OP2	10.4%	13.0%
Medium - OP1	26.0%	32.6%
Large - OP 1	8.6%	16.1%

The electric heat pump water heater option was compared with each of the 5 storage water heater options. The heat pump is not cost-effective for any HH category or tariff class under the 4 year payback criterion. For a 6 year payback the outcomes are sensitive to the availability of an OP2 tariff, which is not available in all supply areas.[5] A heat pump with an OP2 tariff is cost-effective against a continuous tariff storage water heater for a medium HH, but if OP2 is available then logically it could also be

[5] EnergyAustralia, for one, no longer offers an extended hours tariff to new customers in NSW, although existing customers on the tariff can remain.

used in storage water heater, against which the heat pump would not be cost-effective. Heat pumps on OP2 are not cost-effective against storage water heaters on OP1 - even though they consume much less energy the cost of each unit of energy is higher, and the capital costs are also much higher.[6]

Energy and water prices

The payback calculations were carried out using the energy and water prices in Table 6. The energy prices are based on capital city supply authority tariffs at the end of 2003. The water prices are the highest currently in force (ie those in Melbourne). Although other water supply authorities may have lower freshwater charges, and may not yet have a usage-based wastewater charge at all, all are moving in that direction. The value of hot water savings was calculated from the weighted average of the cost of hot water supplied by all the water heaters in the stock (electric, gas SWH, gas IWH and solar).

Table 6 Estimated energy and water prices –Australian averages

	Marginal tariffs (a)		
Electricity	130 $/MWh	13.0 c/kWh	0.036 $/MJ
Elec OP 2 (b)	75 $/MWh	7.5 c/kWh	0.021 $/MJ
Elec OP 1 (c)	55 $/MWh	5.5 c/kWh	0.015 $/MJ
Gas	13 $/GJ	1.3 c/MJ	0.013 $/MJ
Water	1.0 $/kl		
Wastewater	0.6 $/kl		
Combined water	1.6 $/kl		

(a) Excluding standing charges and first high-cost or low-cost blocks (b) Extended hour off-peak – energy available at all times except peak hours (c) Restricted hours off-peak – energy only available overnight.

Product prices and price-efficiency relationships

One critical variable in calculating payback periods and cost-effectiveness is the assumed relationship between increases in product energy-efficiency and increases in product price. The Price/Efficiency (P/E) ratio is the ratio of the % increase in purchase price for a given % increase in efficiency. A P/E ratio of 1 would mean that if efficiency doubles, so does price. However, the findings of cost-benefit studies carried out as part of the Regulation Impact Statements for Minimum Energy Performance Standards indicates that in practice P/E ratios are far lower than 1.

In general, the simpler the product the higher the P/E ratio, since there will be fewer opportunities to improve efficiency by different designs or arrangement of elements, and greater reliance on more and/or better materials. The P/E ratios for clothes washers are estimated to be fairly low. For example, the BAU average water intensity of top-loader washing machines purchased in 2005 is estimated at about 21 litres/kg clothes capacity, and if the most efficient top loaders on the market used 14 litres/kg capacity they would be (21/14-1) = 50% more efficient. A P/E ratio of 0.2 would mean that that the price of the more efficient alternative would be (0.2 x 50) = 10% higher.

[6] The substitution of solar-electric for electric was not analysed, since the Brief stated (correctly, in our view) that "in absence of subsidies, not cost effective compared with electric and gas system".

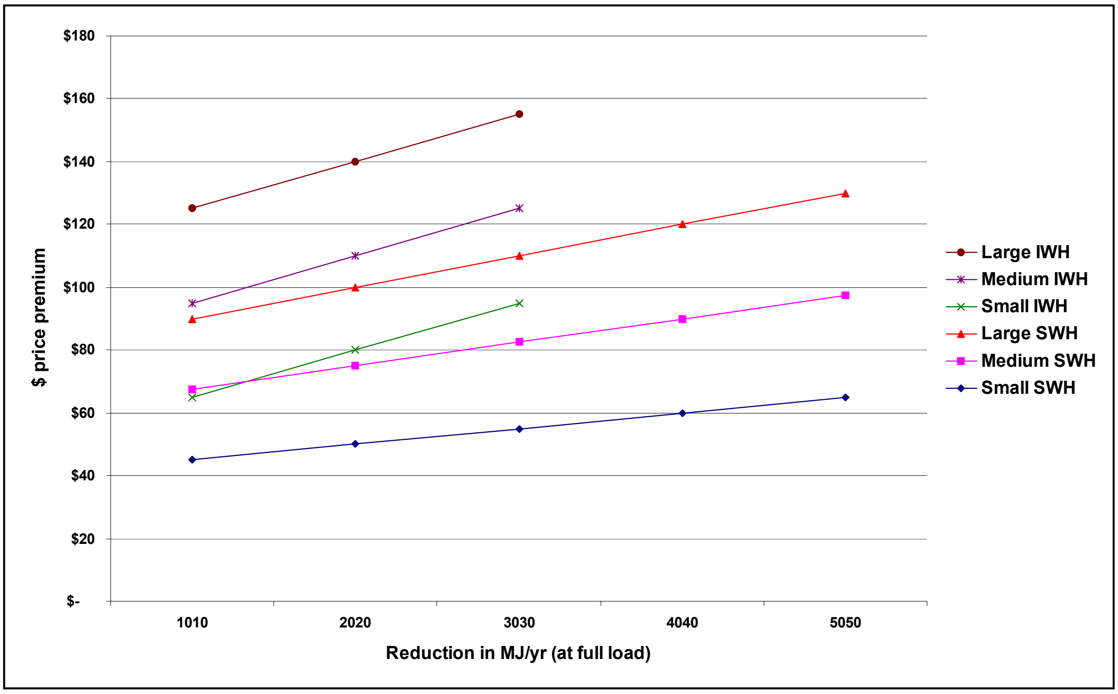
The P/E ratios for electric storage water heaters are somewhat higher because increasing efficiency almost always relies on more and/or more effective insulation, which then needs to be wrapped in more steel etc. For shower heads, a flow-controlled (FC) model may use 9 litres per minute compared with 20 litres per minute for an AD models. This is an efficiency premium of (20/9-1) = 122%. If a standard FC shower costs $40, compared with $20 for an AD shower of equivalent quality, then the P/E ratio is (100/122) = 0.82. The estimated P/E ratios are summarised in Table 7.

Table 7 Assumed price/efficiency ratios for various products

Product	Assumed Price/Efficiency Ratio
Top loader washing machine	0.20
Front loader washing machine	0.25
Electric storage water heater	0.35
Shower head (FC vs AD)	0.82

The price-efficiency ratios for gas water heaters were derived by analysis of wholesale prices for Bosch, Dux, Rheem and Rinnai brand water heaters. Prices and efficiencies were compared between pairs of models that differed only in their warranty periods, efficiencies, and other factors such as indoor vs outdoor installation. From this a set of P/E relationships embodied in the lines in Figure 6 were derived. These express the expected increase in water heater sale price as the gas consumed to deliver the standard water heating task (13750 MJ/yr) falls. Each 2020 MJ reduction in annual gas use represents a one star increase in the gas efficiency rating. The lines for instantaneous water heaters have only been developed over 3030 MJ/yr (1.5 stars), because that is the maximum scope for improvement between BAU and most efficient on the market (see Figure 4).

Figure 6 Assumed price/efficiency ratios for gas water heaters



Summary of outputs

Options meeting payback criteria

Figure 3 summarises those options which meet the 4 year and 6 year payback criteria, respectively. The options that become cost-effective as a result of extending the payback period shown in bold. It is apparent that there are little additional savings from increasing the payback period from 4 to 6 years, or indeed to 8 years.

Table 8 Summary of measures passing 4 and 6 year payback

Measure	Sub-measure	Household category	4 yr payback	6 yr payback
Plumbing layout design and lagging to reduce pipe losses in new dwellings built in 2005 and later		S	Yes	Yes
		M	Yes	Yes
		L	Yes	Yes
Showers – substitution of Flow Controlled for All Directional in all suitable HH in Australia between 2005 and 2008, then 90% FC market share		S	Yes	Yes
		M	Yes	Yes
		L	Yes	Yes
Clothes washers – substitution of highest efficiency model on market for BAU average efficiency model, new units purchased in 2005 and later	Top loaders	S	No	**Yes**
		M	Yes	Yes
		L	Yes	Yes
	Front loaders	S	No	No
		M	Yes	Yes
		L	Yes	Yes
Clothes washers – substitution of front loaders for top loaders, new units purchased in 2005 and later		S	No	No
		M	No	No
		L	No	No
Gas water heaters – substitution of instantaneous types for storage types in 90% of cases where SWH would otherwise be purchased		S	Yes	Yes
		M	No	No
		L	No	No
Gas water heaters – substitution of highest efficiency model on market for BAU average efficiency model, new units purchased in 2005 and later	Storage	S	Yes	Yes
		M	Yes	Yes
		L	Yes	Yes
	Instant-aneous	S	No	No
		M	No	No
		L	No	**Yes**
Electric water heating – substitution of more highly insulated storage water heater for model of BAU heat loss (taking into account higher MEPS levels to be introduced in 2005)	Day rate(a)	S	Yes	Yes
	Day rate(a)	M	Yes	Yes
	OP 2(a)	M	Yes	Yes
	OP 1(a)	M	No	No
	OP 1(a)	L	No	No
Electric water heating – substitution of heat pump for storage water heater Electric water heating – substitution of	Day rate(a)	S	No	No
	Day rate(a)	M	No	No (b)
	OP2(a)	M	No	No (b)
	OP1(a)	M	No	No (c)
	OP1 (a)	L	No	No (c)

(a) Lowest cost electricity tariff available (b) At medium delivery, heat pump with OP2 tariff is cost-effective against storage water heater with day rate tariff, but if OP2 available to the storage water heater as well, then HP/OP2 not cost-effective. HP/OP2 not cost-effective against OP1

Energy savings and costs

The projected reductions in average daily HH hot water consumption from implementing the hot water conservation measures discussed are illustrated in Figure 7. The national reductions in household water heating gas and electricity consumption from these hot water savings, coupled with the progressive installation of more efficient water heaters where these meet the payback criteria, are illustrated in Figure 8. As Figure 9 shows, these savings are projected to reach 21.2 PJ per year by 2015. This represents about 14.9% energy savings below BAU for a 4 year payback. The effect of extending the payback period to 6 years is minimal – the energy saved in 2015 increases to 22.1 PJ (15.5% below BAU).

The majority of the energy and cost savings are projected to come from reduced hot water consumption rather than the from more efficient water heaters (Figure 9). This is because:

- As hot water consumption falls, some water heater efficiency measures which would have met the payback criteria at BAU hot water consumption are no longer cost-effective: this particularly impacts on heat pumps because of their high capital costs;

- The average efficiency of gas water heaters are projected to increase in any case, under the influence of measures such as improved labelling, so somewhat limiting the scope for further improvements;

- The average efficiency of small electric gas water heaters is projected to increase in any case, under the influence of higher MEPS levels to be introduced in 2005, so somewhat limiting the scope for further improvements;

- The market share of instantaneous gas water heaters is projected to increase in any case, so somewhat limiting the scope for further shifts to IWH;

- The availability of off-peak tariffs for medium and large electric water heaters limits the cost-effectiveness of some efficiency improvements from the perspective of end users.

The value of energy savings to end users is projected to exceed $427 million per year by 2105 (Figure 11). The additional capital costs are highest at the beginning of the period, as AD shower heads are replaced by FC types, and then decline to about $75 million per annum. The accumulated costs and savings are summarised in Table 9.

Table 9 Projected costs and savings over 10 year period (undiscounted)

	Period 2005-14	
	4 yr payback	6 yr payback
Costs	$M 1,038	$M 1,335
Savings	$M 3,480	$M 3,614
Savings/costs	3.4	2.7

Figure 7 Daily hot water use – BAU and 4 year payback options

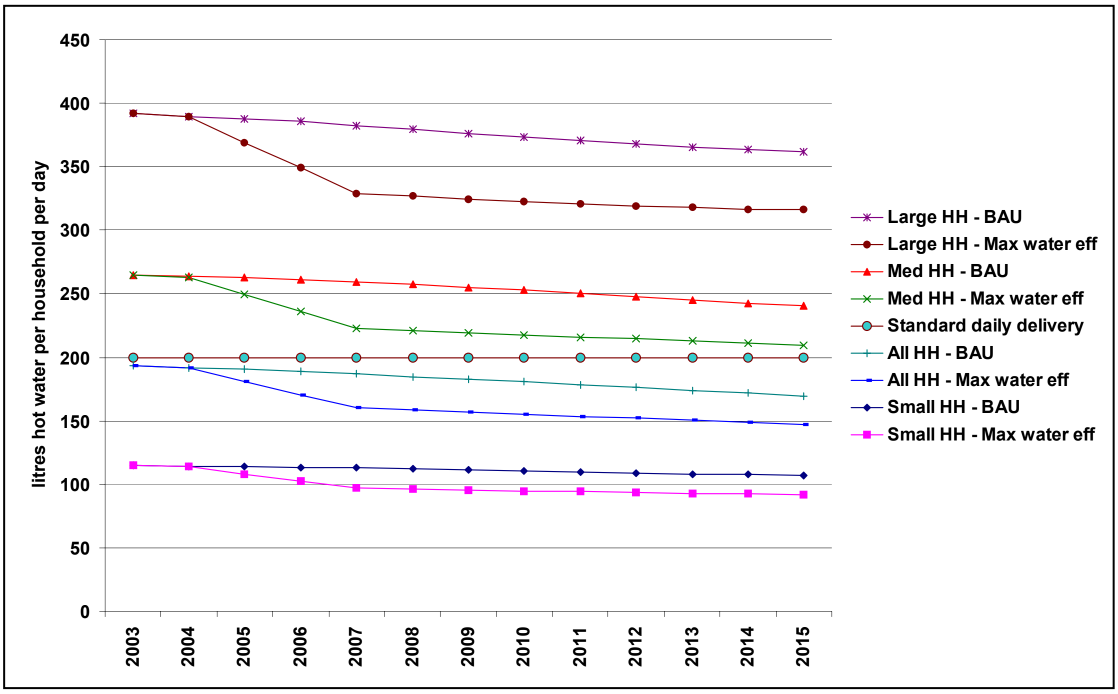


Figure 8 Annual water heating energy use – BAU and with 4 year payback options

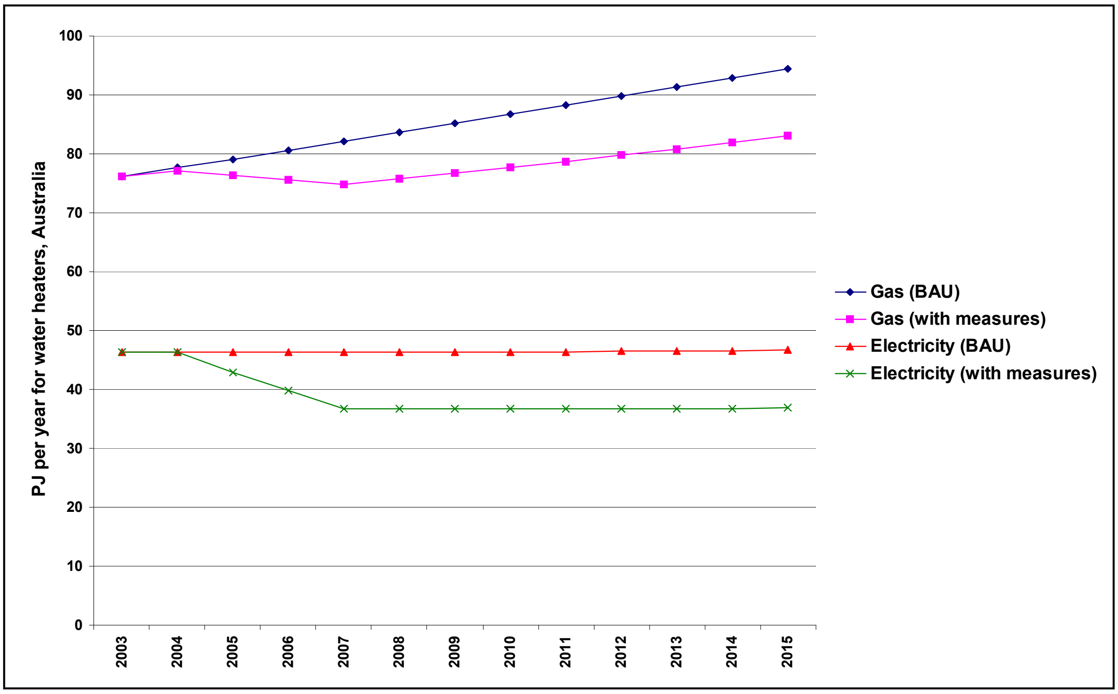


Figure 9 Reduction in water heating energy – 4 payback options

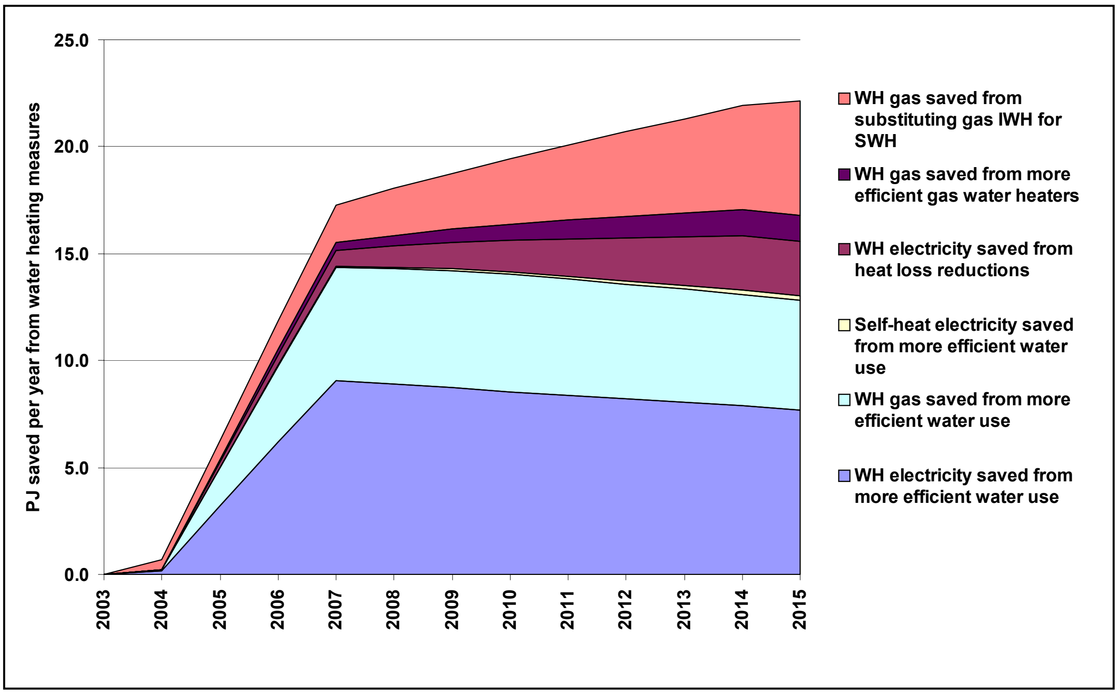


Figure 10 % reduction in water heating energy – 4 yr and 6 yr payback options

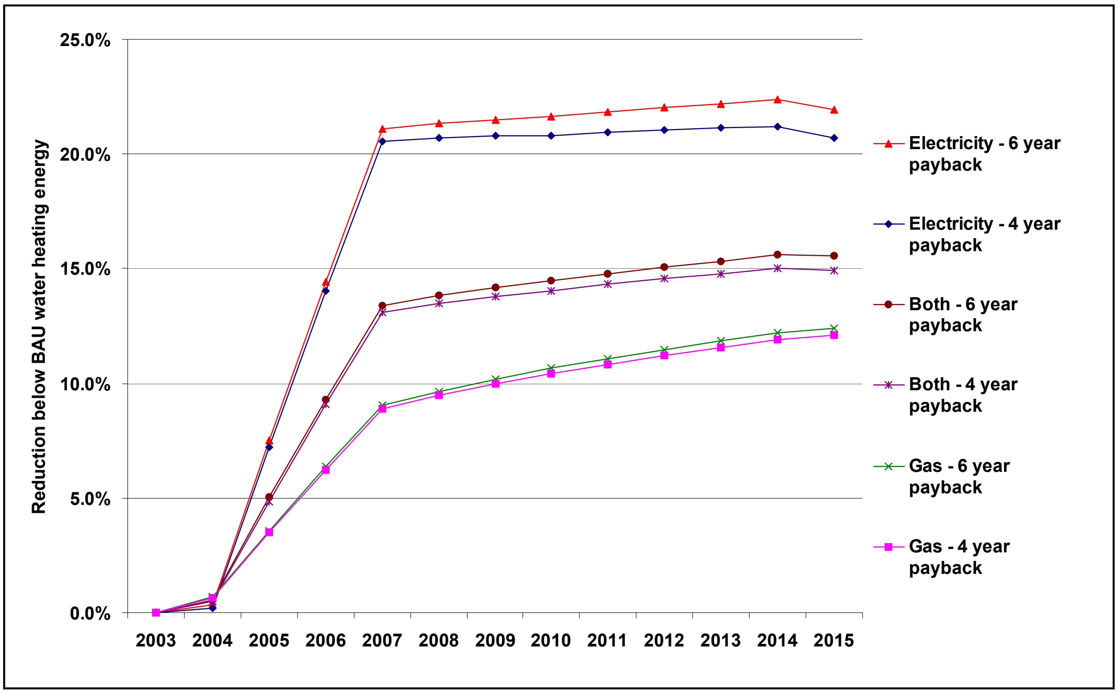
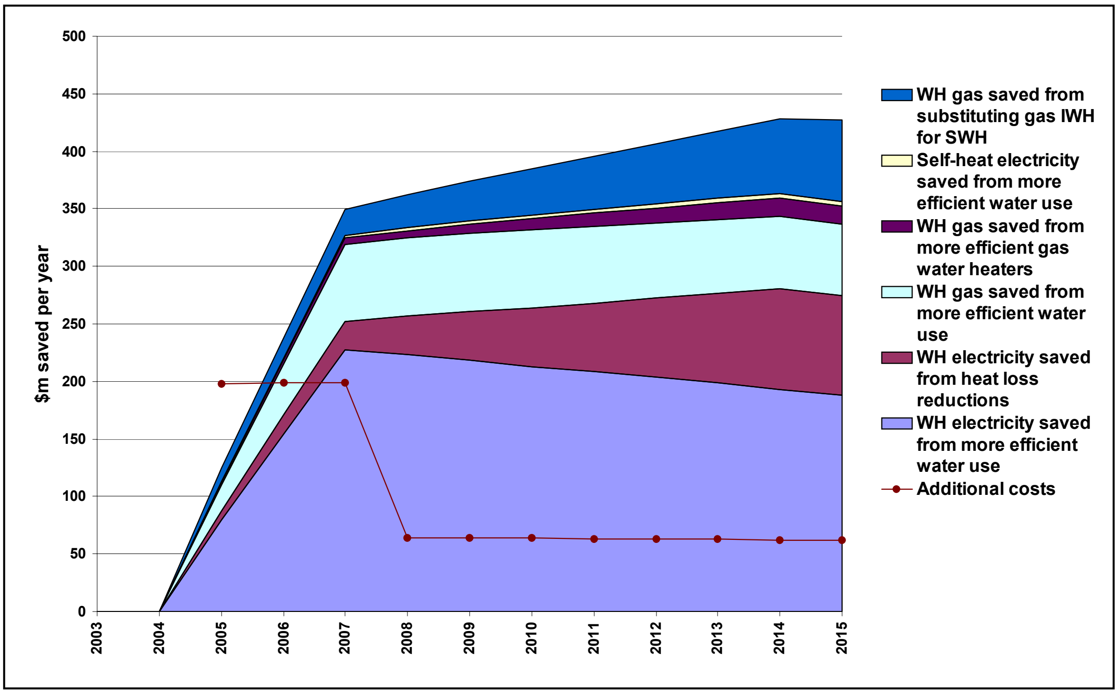


Figure 11 Value of energy saved and additional investment costs, 4 yr payback options



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