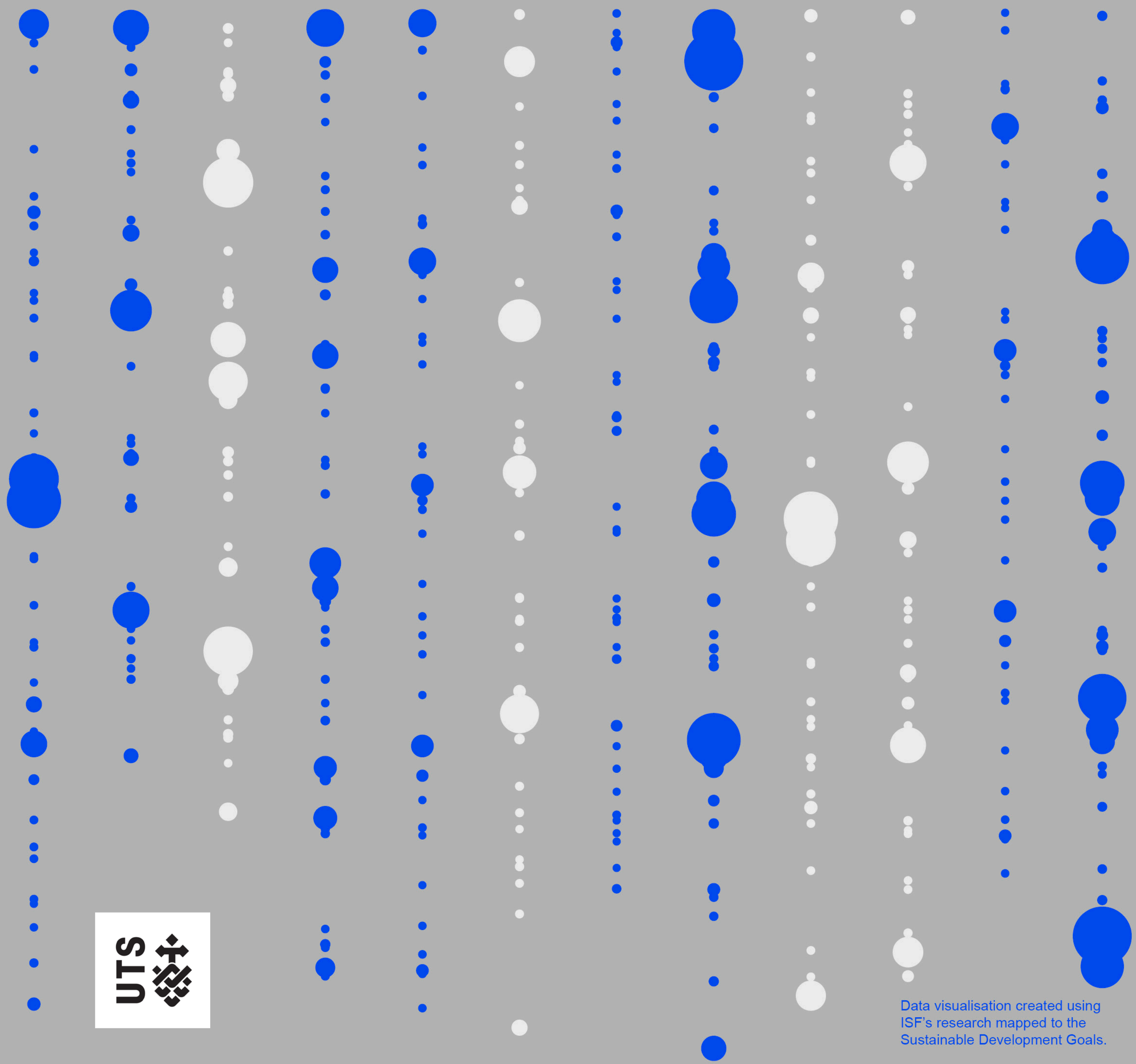

Data visualisation created using ISF's research mapped to the Sustainable Development Goals.

Institute for Sustainable Futures

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Evaluation of the environmental and economic impacts of the WELS scheme

PREPARED FOR:
Australian Government Department of Agriculture and Water Resources

About the authors

The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses and communities achieve change towards sustainable futures.
We utilise a unique combination of skills and perspectives to offer long term sustainable solutions that protect and enhance the environment, human wellbeing and social equity.

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The data provided were interpreted and analysed in good faith, and any errors or omissions are fully attributable to the authors of this report.

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Executive summary

This study is an evaluation of the Australian Government's Water Efficiency Labelling and Standards (WELS) scheme in relation to its environmental and economic impacts. The WELS scheme is a national, government-run scheme mandating water efficiency labelling for most water using fixtures and appliances in Australia. The scheme also imposes a minimum standard for some products. The study considers historical impacts since the scheme was initiated in July 2006 and projects future impact to the end of 2036-37.

A number of water efficiency labelling schemes exist around the world, however, unlike WELS most are voluntary. There is currently a renewed interest in examining their level of success and the challenges involved in implementation. This interest coincides with efforts to develop a new International Organisation for Standardisation (ISO) standard for water efficiency labelling.

In evaluating the impact of WELS, this study takes a broad view of the scheme's impacts and includes a range of other water efficiency programs, regulations and initiatives that have worked in concert with the scheme. The results presented by the study are therefore for 'WELS and associated measures'.

Figure E1 shows the modelled water savings due to WELS (and associated measures) over the period of analysis. In the current year (2017-18) the estimated saving is 112 gigalitres (GL)/year across Australia. This is the equivalent of 21% of the water supplied for all purposes in Greater Sydney (a region with a population of 5 million people) in that year. Alternatively, the current yearly saving is approximately 25% of the total volume of Sydney Harbour. These savings are anticipated to grow to 185 GL/year in 2026 and 231 GL/year in 2036.

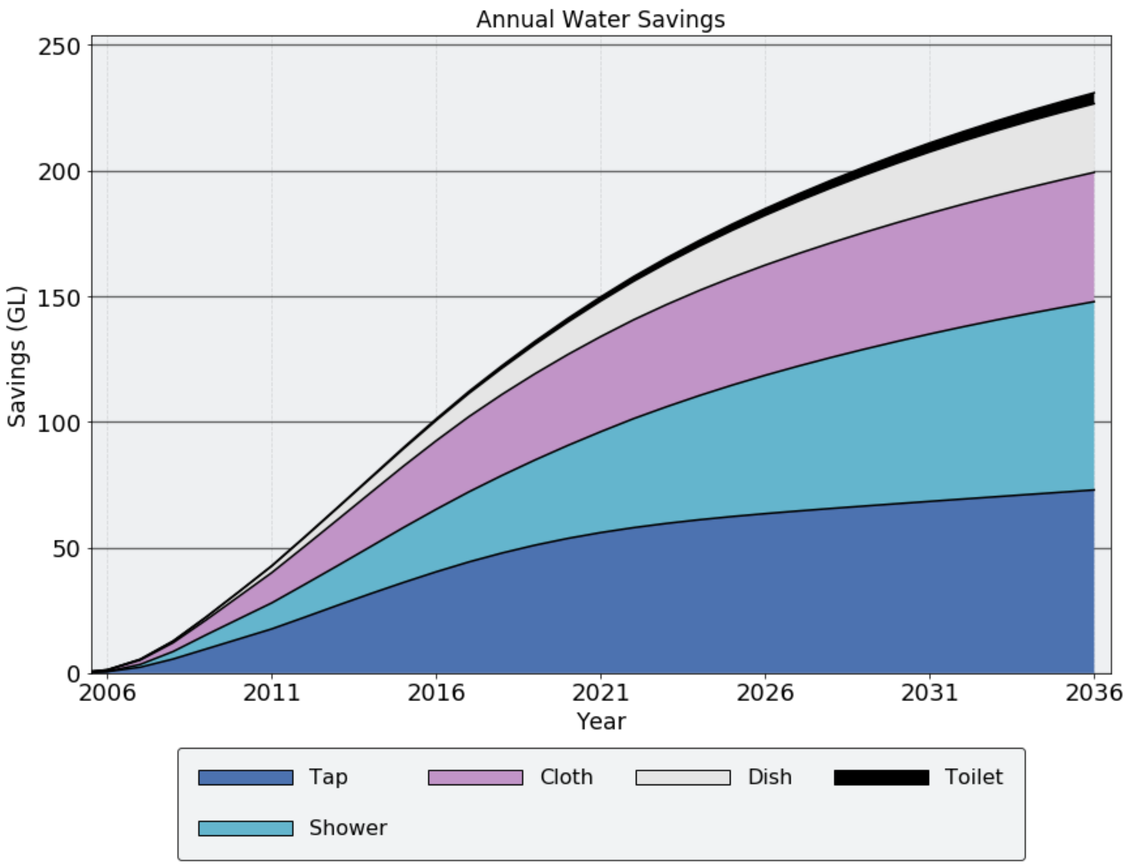

Figure E1 Water savings due to WELS rated fixtures and appliances

The largest proportion of the water savings come from taps, followed by showers and then clothes washers. Over the whole period, a growing proportion of savings come from clothes washers, dishwashers and toilets.

The estimated energy savings from WELS are shown in Figure E2. Natural gas comprises the greater proportion of the 13 petajoules (PJ)/year energy saving in 2017. This is 7.5 PJ/year, compared to 5.5 PJ/year of electricity saved. The saving is the equivalent of over 2.1 million barrels of oil. The total energy saving grow to 22.5 PJ in 2036 with 59% being natural gas.

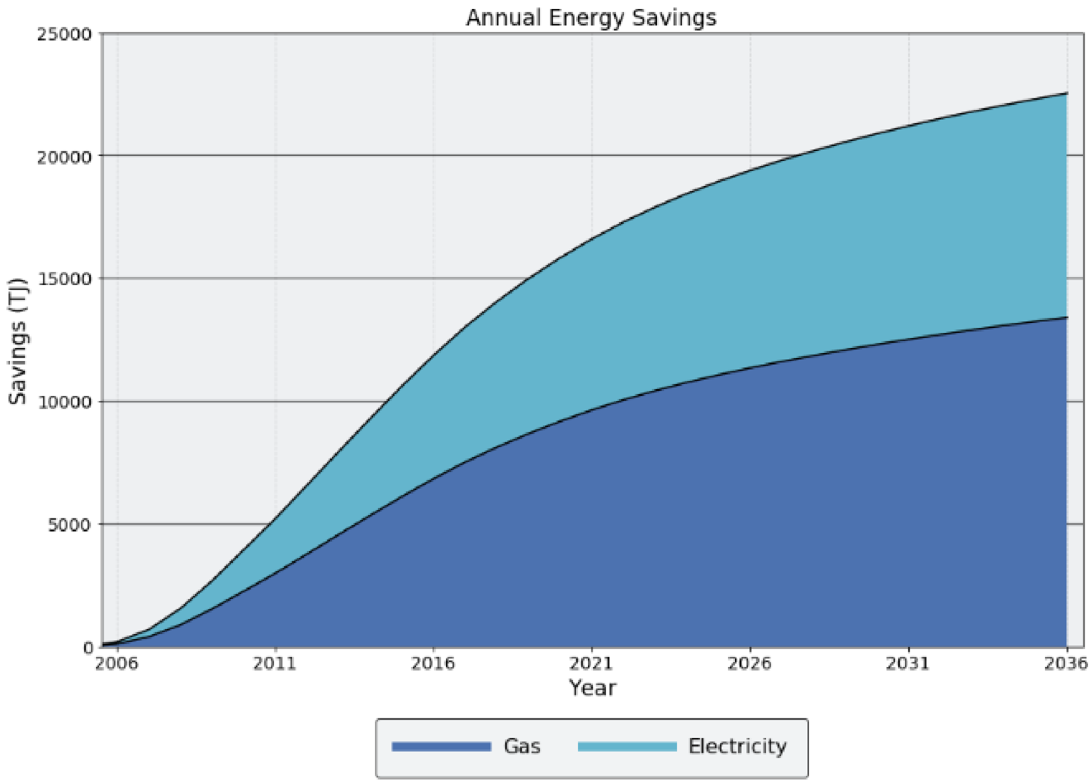

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Figure E2 Energy savings due to WELS rated fixtures and appliances

The energy savings in turn translate into greenhouse gas (GHG) savings. Table E1 shows estimates of the annual GHG savings in megatonnes (Mt) of CO_2 equivalent (Mt CO_2–e) for three sample years. The WELS scheme is estimated to have already saved 11.2 Mt (cumulative to end of 2017-18). By 2036 it is predicted that WELS will have prevented a cumulative of 57.6 Mt of emissions.

Table E1 Greenhouse emissions avoided due to WELS and associated measures

	2017 (Mt/yr)	2026 (Mt/yr)	2036 (Mt/yr)
GHG saved (CO_2 –e)	1.92	2.51	2.50

Without WELS, the additional 1.92 MT in GHG emissions in the current year would be the equivalent of adding 770,000 new cars to Australian roads.

Interestingly GHG emission savings from WELS, in its current form, are expected to peak around 2031. This is due to the trend towards more water heating by gas and the projections made in relation to GHG intensity of the energy supplies.

Figure E3 shows the impact of WELS on total water consumption by WELS rated products. This is a reasonable proxy for indoor water use in Australian households and businesses (excluding industrial use and commercial applications like laundries). Significantly, Figure E3 shows that the total water use in WELS rated products has recently passed a low point and is now growing. In 2028 it can be expect to return to its previous peak of 1200 GL per year across the country. After this time, water use is projected to continue growing. This points to the potential for considering new measures that could complement WELS and stem this growth in total demand, particularly in those jurisdictions with high population growth.

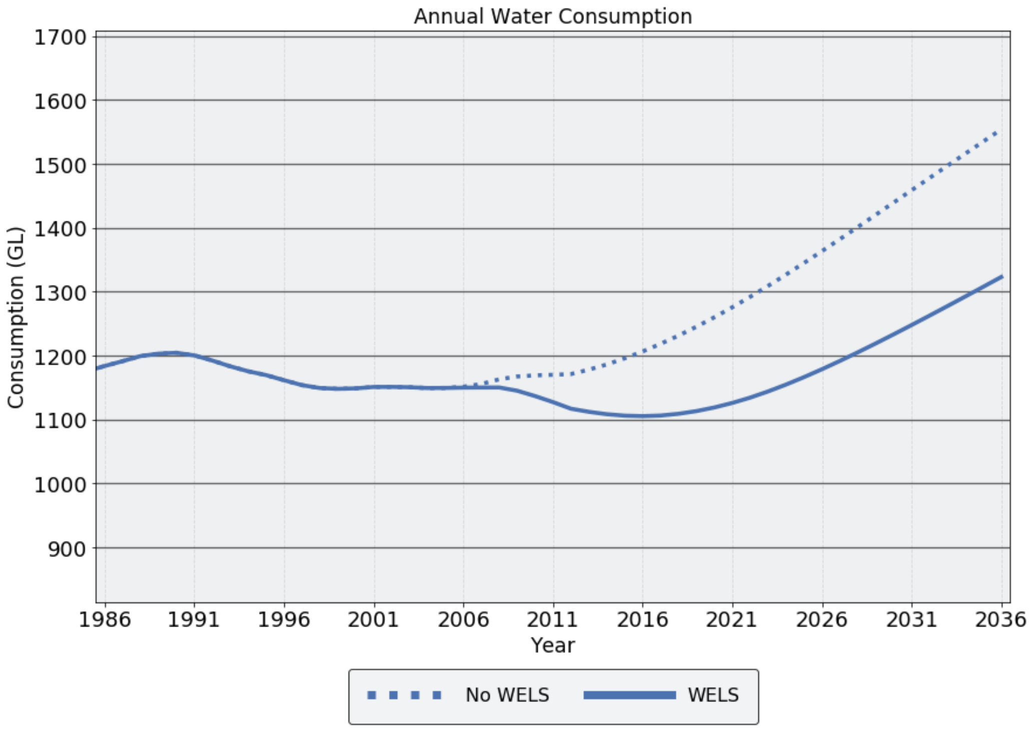

Figure E3 Total water consumption from WELS rated products

A snapshot of estimated WELS-related reductions in annual water usage, cumulative GHG emissions and annual household utility bills for three sample years is shown in Table E2.

Table E2 Snapshot of estimated water savings, GHG reductions and bill savings

	2017	2026	2036
Annual water saving (GL/yr)	112.18	184.81	230.92
Cumulative GHG saved (Mt CO_2 –e)	11.00	31.45	55.90
Annual total household utility bill savings ($M/a)	1047.93	1765.68	2638.15

As shown in the snapshots in Table E2, the current annual utility bill savings for households and businesses are $1.05 billion dollars ($B) per year. This annual saving is anticipated to increase to $2.64B per year (in nominal terms) by 2036. Electricity bills are the largest proportion of the saving, followed by natural gas and water bills. Currently, 75% of bill savings come from avoided energy use due to hot water savings. In 2036, energy bills are expected to represent 70% of the savings customers make due to WELS.

Each person in Australia is currently saving an average of $42 per year due to the increase in the water efficiency of WELS rated products since the start of the scheme. This is $168 per year for a family of four. By 2036, the predicted utility bill savings grow to $81 per person per year across the country's entire population.

Figure E4 shows the breakdown of benefits from the WELS scheme and its associated measures by type and by state or territory. The benefits are derived from water, electricity and natural gas bill savings together with valuations for GHG emissions. New South Wales (NSW), which is combined with the Australian Capital Territory (ACT), has the highest level of benefits. The differences are principally due to population, but utility price differences between the jurisdictions are also a significant factor in the differences. Per capita water savings vary only slightly between the states and territories. As a result, in Tasmania and the Northern Territory, low populations combine with low utility prices limit the total benefits.

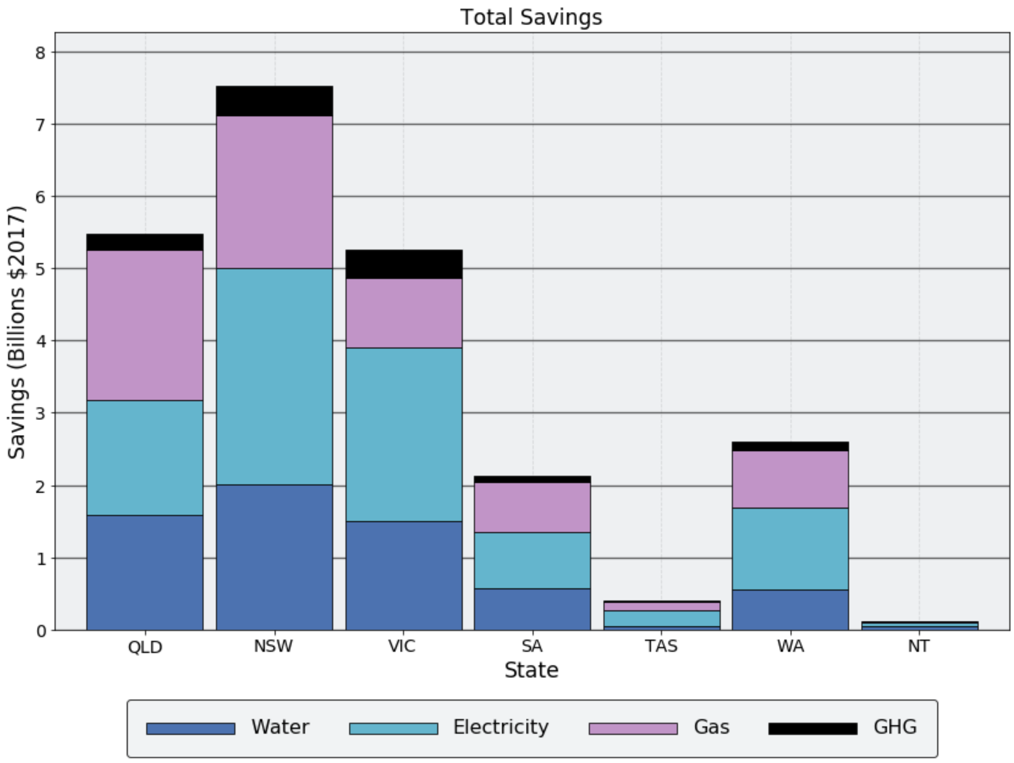

Figure E4 Total savings by state and type

Table E3 shows a summary of the evaluation of costs and benefits owing to the scheme. The table separates past and current impacts and future values. To allow a comparison, the past costs and benefits have been inflated to the current year (2017-18) dollar values and future costs/benefits are discounted back to their present value based on a 7% discount rate. The results show a benefit cost ratio of 8.8 to one for the scheme and associated measures, to date. This increases to a ratio of 96 to one, forecast to 2036.

The total costs are estimated at under $1 billion across the period of analysis, with the majority having occurred in the past. Large costs were incurred for demand management programs in Australia's Millennium Drought between 2006 and 2010. These measures associated with WELS enhanced savings due to water efficiency but also had a significant cost at the time. Supplier costs in testing and administration (in addition to WELS scheme registrations fees) are the next largest costs incurred due to the scheme.

Table E3 Summary of Cost benefit analysis results (in millions of $2017-18)

Costs and benefits	Past & Current $17-18 ($M)	Future PV $17-18 ($M)
Scheme cost	$29	$28
Supplier costs in product registration	$147	$159
Labelling cost	$5	$7
Demand management in Millennium Drought	$463	$0
Total Costs	$644	$194
Water Savings	$1,440	$5,104
Electricity Savings	$2,344	$7,093
Natural Gas Savings	$1,587	$5,429
GHG Savings	$268	$999
Total Benefits	$5,639	$18,625
Net Benefit	$4,995	$18,431
B/C ratio	8.8	96

As shown in Table E3, the total benefits for the scheme have been more than $5 billion to 2017-18 and a further $18.6 billion in benefits are forecast in the period to 2036. The breakdown, with electricity savings being the largest benefit in dollar terms followed by natural gas, water and GHG emission, is the same for both periods.

The high benefit cost ratios for WELS are maintained with sensitivity analyses of natural gas prices, GHG emission costs, water prices and discount rates. In all cases, the benefits of the scheme were significantly higher than the costs.

This study has shown the WELS scheme in Australia to be an important component of urban water management, with demand reductions that are likely to be delaying supply augmentations in multiple regions. It has shown the scheme to be highly beneficial with significant utility bill savings, both to the present day and projected into the future. The study has also shown that significant GHG emission reductions that can be attributed to the scheme.

WELS reduces per capita water use and that has reduced water demand below pre-WELS levels. However, as shown in Figure E3, as the population grows, total water demand will rise (despite the lower per capita use) and it will be necessary to either reduce per capita use further or augment water supplies.

Given the projected increase in demand from WELS labelled products, governments across Australia may wish to consider new measures that would complement the existing scheme in order to achieve additional water savings. These might be in the form of incentive programs run by water utilities, new regulations on building or plumbing or raising the minimum water efficiency standards under WELS. Ideally, future work on complementary measures or minimum standards will bring equity considerations to the fore, and capture the potential for the WELS scheme to play an even larger role in alleviating the hardship resulting from high utility bills for society's least wealthy.

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1 Introduction

In March 2018, the Australian Department of Agriculture and Water Resources (DAWR) commissioned the Institute for Sustainable Futures (ISF), University of Technology Sydney, to conduct an evaluation of the environmental and economic impact of the Water Efficiency Labelling and Standards (WELS) scheme since its commencement in July 2006, and projected 20 years to the end of 2036-37.

1.1 Objectives

This evaluation builds on the approach and methodology of a previous ISF evaluation of the scheme's environmental impact in terms of household water consumption, energy use and greenhouse gas (GHG) emissions (Fyfe *et al* 2015). The key objectives were to:

- estimate the impact of the scheme on the efficiency of water using products over time
- re-evaluate the environmental impacts (with updated data)
- estimate the impact of the scheme on the utility bills of households and businesses in Australia
- evaluate the costs and benefits of the scheme since inception, including a review and collation of all scheme costs and additional economic benefits (beyond bill savings)
- conduct a cost benefit analysis (CBA) of the scheme including sensitivity to key assumptions
- conduct a state by state analysis of reductions in water consumption, energy use, greenhouse emissions and utility bills.

1.2 Scope

As with the previous ISF evaluation, the scope of this study was the impact of the WELS scheme and associated water efficiency measures that act in concert with the scheme. The study covers all significant appliances (whitegoods) and plumbing fixtures covered by WELS. The scope of the evaluation included:

- analysis of data on product registrations in the WELS scheme database
- review and analysis of existing data sources, product stocks and sales
- development of new data sources via interviews with plumbing and whitegoods product suppliers and retailers
- modelling of water consumption and associated energy use, GHG emissions, costs and benefits due to the WELS scheme (broken down by state/territory)
- identification and documentation of non-quantifiable impacts and potential impacts of the scheme.

1.3 Approach

The following method was employed for the evaluation.

1.3.1 Review and analysis of WELS database

In order to illustrate trends in water efficient products and equipment covered by the WELS scheme, ISF reviewed the WELS database and analysed the product registrations and information contained in the database including:

- distribution of WELS ratings and water consumption of various labelled products in a time series
- yearly product registrations by WELS ratings and water consumption for various products
- analysis of WELS ratings and water consumption of product renewals and new registrations for product types
- analysis of the number of brands / products available in the highest star rating by product type over time.

1.3.2 Collection, review and analysis of sales data

ISF obtained sales data and sales data estimates from two sources to support the water consumption analysis and end-use modelling. This involved, firstly, purchasing and analysing sales tracking data (2006 – 2017) for clothes washers and dishwashers from GfK, a commercial market research firm. Secondly, estimates of sales distributions were obtained through telephone interviews with 10 key Australian-based product manufacturers / importers / suppliers and retailers.

1.3.3 Water consumption analysis/end-use modelling

The end-use models and appliance stock models used in the Fyfe *et al* (2015) study were redeveloped to estimate household water consumption for each indoor appliance and plumbing product covered by the WELS scheme. Two scenarios were compared:

- a 'with WELS' case that reflected changes since the inception of the WELS scheme and a forecast to 2036 (accounting for population and household growth)
- a 'without WELS' case that incorporated the changes already in effect in 2006, but with water use continuing in the absence of WELS, including all existing behaviour, policy settings and sales preferences as in 2006, projected with population and household growth to 2036.

1.3.4 Estimation of impact on energy use, GHG emissions and customer bills

Hot water use by customers has a large impact on energy use, associated GHG emissions and energy bills. The latest available data on hot water heating breakdown by house was sourced from the Australian Bureau of Statistics (ABS), and energy for water heating was derived from the physical requirements and known estimates of the average efficiencies of heaters by type.

The latest data on energy use and emissions by water utilities was also sourced so that the provision of water and wastewater services could be included in the analysis.

In order to estimate GHG impacts of the WELS Scheme, ISF used available official reporting of current and historical energy-related GHG emissions, and projections for future emissions.

Energy, GHG and bill savings were based on the water savings estimates from the water consumption model; customer bill savings accounted for reductions in both water and associated energy consumption.

1.3.5 State based analysis of water, energy, GHG emissions and bill savings

ISF collated available state-specific data to analyse water consumption, energy use, associated GHG emissions and bill savings for WELS labelled products and appliances for each major state and territory of Australia. This involved developing seven separate end-use models and appliance stock models for estimating water consumption.

1.3.6 Cost-benefit analysis from 2006 to 2036

A literature review was conducted to prepare a list of all the economic costs and benefits of increasing water use efficiency in general and the WELS scheme in particular. This covered both national and international literature including ISF's collection of grey literature on this topic.

A conceptual cost-benefit model was developed initially, and once confirmed by DAWR, estimates of impacts were quantified where feasible. DAWR provided information to ISF on the costs of administering the scheme. The economic analysis extended to financial analysis in terms of customer bill impacts. Analysis covered both qualitative and quantitative costs and benefits and generated net present cost/benefit of the WELS scheme over time and the benefit/cost ratio.

1.4 Outline of this report

Section 2 of this report provides background information on the WELS scheme including its origins; key features; relationship with other demand management programs; international context; and role in underpinning the development of an international water efficiency labelling standard. A summary of earlier environmental and economic evaluations is also presented as context for the current work.

Section 3 presents the outputs of analysis of the WELS database. Trends in the number of registrations each year and for each product type with their star ratings are presented graphically.

Section 4 discusses sales trends from data and estimates provided by product suppliers and retailers as well as the NSW BASIX scheme for new dwellings. Through analysis of sales percentages for different star ratings of all WELS-rated products, sales trends used in modelling for the 'with' and 'without' WELS scenarios are presented.

Estimates of water, energy and GHG savings attributable to WELS are the focus of Section 5. Data, assumptions and outputs of calculating these estimates are described.

Section 6 presents the results from ‘stock’ and ‘end use’ modelling and analysis of national water-using product stock, as well as water, electricity, natural gas, GHG emissions and consumer bill savings for the ‘with’ and ‘without’ WELS scenarios.

The results of stock and end use modelling on a state-by-state basis are provided in Section 7. As for the national analysis in the previous section, water, electricity, natural gas, GHG emissions and consumer bill savings are covered.

Section 8 reports on the economic appraisal of the costs and benefits of the WELS scheme for the period 2006 to 2036. It outlines the analysis framework and describes the quantifiable costs and benefits included in the appraisal as well as discussion of non-quantifiable costs and benefits. This section also provides the outputs of sensitivity analysis concerning water and energy/carbon pricing.

An overall discussion of the results and their implications for the future of the WELS scheme is presented in Section 9.

2 Background to the WELS scheme

This section provides a background to the evaluation. It places the WELS scheme in a global context of water efficiency labelling schemes and provides an overview of how the WELS scheme was developed in Australia. The section then considers how WELS operates with other mechanisms to manage water demand and improve water security in cities and towns across the country. The final subsection summarises the previous evaluations of the WELS scheme and situates this study relative to those earlier reviews.

2.1 Global Context

2.1.1 Overseas water efficiency labelling schemes

A number of water efficiency labelling schemes exist around the world, and there is currently a renewed interest in examining their level of success and the challenges involved in implementation. The UK Energy Saving Trust has recently prepared a matrix of global water efficiency labelling schemes as part of an independent review of the costs and benefits of water labelling options for the British Government (EST 2018). The Efficient Urban Water Management Specialist Group within the International Water Association has also conducted a review of international water efficiency labelling (IWA 2018). A brief overview of the major labelling schemes worldwide and whether evaluations have been conducted is presented in Table 1.

Table 1 Summary of water efficiency labelling schemes, globally*

Country/ies	Scheme name & year started	Governance	Evaluation of effectiveness
Australia	WELS 2006	Government-led Mandatory	Previous (2015) review reports annual savings of 147 GL of water, 20.4 Mt of carbon dioxide, and $1.39 billion in household utility bill savings by 2021.
Australia	Smart Approved Watermark 2006	NGO-led Voluntary	Successful in reducing outdoor water use. 350 products approved by an expert panel to carry the SAWM.
New Zealand	Water Efficiency Labelling and Standards Scheme 2010	Government-led Mandatory	Not evaluated
USA & Canada	WaterSense 2006	Government-led Voluntary	Since commencement, scheme has helped save 2.1 trillion gallons (approx. 8,000 GL) of water and $46.3 billion in consumer water and energy bills
China	Water Conservation Certificate 2002	Government-led Voluntary	5.28 GL in 2017 via certified toilets, taps and showers
China	China Water Efficiency Label 2018	Government-led	Too soon to evaluate. The average amount of annual water-saving is expected to reach 11 GL (million cubic meters) by 2030
Hong Kong	Water Supplies Department Water Efficient Labelling Scheme 2009	Government-led Voluntary till 2017; mandatory from 2018	No record of evaluation 650 products registered

Country/ies	Scheme name & year started	Governance	Evaluation of effectiveness
India	Water Efficient Products-India Not yet in force	Industry-led Voluntary	Not yet evaluated
Malaysia	Water Efficient Products Labelling Scheme 2013	Government-led Voluntary (to be made mandatory in 2019)	No record of evaluation, though the Government is aware that the voluntary scheme has not been effective, hence plans to make it mandatory in 2019
Portugal	ANQUIP 2008	NGO-led Voluntary	75% of toilets marketed are labelled
Singapore	Mandatory Water Efficiency Labelling Scheme (MWELS) 2009	Mandatory	Sales of the most efficient WELS rated washing machines increased from 37% in 2011 to 88% in 2016. In 2017, per person consumption was 143 L/day, down from 165 L in 2003 (Target is 140 litres by 2030)
United Arab Emirates	ESMA Water Efficiency Label 2013	Government-led Mandatory	No record of evaluation
Europe (34 countries)	The Water Label 2011	Industry-led Voluntary	During 2018, independent environmental modelling on water and energy savings is being undertaken to identify savings and potential savings of labelled products
United Kingdom	Water Technology List 2016 [put on hold in March 2018, pending a review of government policy]	Government-led (tax incentive scheme for businesses) Voluntary	As of July 2018, 3,385 products were registered with the scheme Showers, taps and toilets made up 18% of all products registered
United Kingdom	Waterwise Checkmark As Water Marque 2006 As Waterwise Recommended Checkmark 2011 [relaunched July 2018]	NGO-led Voluntary	Not formally evaluated; anecdotal evidence that it successfully drove water efficient products. Number of products certified prior to 2018 relaunch were: • Bathroom and toilet - 54 products • Kitchen - 6 products and appliances • Outdoor - 19 products

* *Source: (EST 2018, IWA 2018)*

2.1.2 New ISO standard on water efficiency

The DAWR and Standards Australia have partnered on a project to develop an international standard for water efficiency labelling through the ISO. An international standard is expected to reduce costs for businesses, increase compliance with WELS in Australia, and make it easier for new countries to implement a water efficiency labelling scheme.

A proposal for the standard was drafted with input from Singapore, China, Malaysia and New Zealand and submitted to ISO in September 2017. The proposal obtained approval from over 70% of the 18 ISO member bodies that voted, and in February 2018 the ISO Technical Management Board approved the establishment of a new project committee, ISO/PC 316, with Standards Australia as committee secretariat. Fourteen countries signed up to participate in the committee, with another 18 countries nominating as observers.

The first meeting of the committee was held in Sydney from 24-26 July 2018, with participants from Australia, the US, the UK, Singapore, Japan, China and Switzerland. A project scope was agreed, adopting a model that focuses on recommended tests for water consumption but includes a repository of standards to accommodate test requirements currently used in existing schemes. Products to be included align closely with those in Australia's WELS scheme.

The committee also agreed to establish a working group and two ad-hoc groups, one for plumbing products and one for appliances. These groups will develop testing criteria and prepare a draft of the standard, for discussion by the ISO/PC 316 committee.

2.1.3 Evaluation of overseas schemes

The Australian WELS scheme arguably provides the most information among all global schemes on the benefits, costs and achievements through a robust approach to program evaluation. Five-yearly program reviews are mandated by WELS legislation; the WELS Regulator engages independent reviewers to carry out the evaluations and publishes the reports on the scheme's website.

As indicated by Table 1, overseas schemes appear mixed in terms of whether they are evaluated and the kind of information they provide on scheme effectiveness. The US WaterSense program was evaluated by the US EPA Inspector General for the first time in 2017. The Inspector General evaluated EPA controls to assess the accuracy of WaterSense product label claims of water and energy savings, verify industry data used to estimate program accomplishments, and test the veracity of the program's annual accomplishment estimates (US EPA 2017). A key finding was that measuring success relies on reporting of sales of WaterSense labelled products and water efficiency activities by partner organisations; this reporting is at a very low level despite being a condition of their agreements with the EPA.

The European Water Label program is being independently modelled for the first time this year to identify savings and potential savings of labelled products. Evaluating water and energy savings as a result of the program has reportedly been difficult owing to the complexity and variability of water systems across 34 participating countries (IWA 2018).

2.2 WELS scheme overview

The WELS scheme is a national, government-run scheme mandated by the *Water Efficiency Labelling and Standards Act 2005* (WELS Act), and supported by national regulations, as well as WELS legislation in each Australian state and territory. The objectives of the WELS scheme are to:

- conserve water supplies by reducing water consumption;
- provide information for purchasers of water using and water saving products;
- promote the adoption of efficient and effective water use and water saving technologies.

The WELS legislation allows for a compliance system that educates and penalises when appropriate. Water use information is provided through an easily recognised and trusted labelling system that uses a star rating to indicate its level of water efficiency (see Figure 1).

Source: www.waterrating.gov.au

Figure 1 WELS product label

WELS requires all water using products covered by the scheme that are imported or manufactured in Australia since 1 July 2006 to be registered and labelled when they are supplied or offered for supply, for example through advertising. Products could initially be registered under family groups for five years. The registration and fees determination of 2013 changed the arrangements such that fixtures and appliances now have to be registered individually and registration lasts for one year only.

The scheme is administered by a dedicated team, currently located within the Department of Agriculture and Water Resources. The team manages product registrations, updates technical standards so they remain current and appropriate, and works with industry to maintain high levels of compliance with registration and labelling requirements. Information for consumers, product manufacturers, and retailers is readily available on the WELS website, http://www.waterrating.gov.au/.

The WELS scheme applies to all common water-using devices, i.e. showers, taps, flow controllers, toilets, urinals, clothes washing machines and dishwashers (see Table 2), and is implemented through:

- a technical standard (AS/NZS6400:2016 *Water-efficient products—rating and labelling*) that underpins water efficiency assessments and labelling
- provisions for testing products against the technical standard
- a system for registering water-using devices
- a program to monitor and enforce compliance with scheme requirements.

Table 2 WELS product star ratings and associated water efficiency

Product type	Unit of Measure	0 stars	1 star	2 stars	3 stars	4 stars	5 stars	6 stars
Taps and flow controllers	L/min	>16	>12 to 16	>9 to 12	>7.5 to 9	>6 to 7.5	>4.5 to 6	>1.1 to 4.5
Toilets								
• Full Flush	L/flush	N/A	≤9.5	≤9.5	≤6.5	≤4.7	≤4.7	≤4.7
• Half Flush	L/flush	N/A	≤4.5	≤4.5	≤3.5	≤3.2	-	-
• Average Flush	L/flush	N/A	≤5.5	≤4.5	≤4.0	≤3.5	≤3.0	≤2.5
Urinals	L/single stall or L/600 mm length of continuous urinal wall	> 2.5 L AND conscious, demand-driven or smart-demand flush operation	≤ 4.0 L serving two single stalls or 1200 mm length of continuous urinal wall, AND conscious, demand-driven or smart-demand flush operation and with*	≤ 2.5 L AND conscious, demand-driven or smart-demand flush operation and with*	≤ 2.0 L AND conscious, demand-driven or smart-demand flush operation and with*	≤ 1.5 L AND smart-demand flush operation and with*	≤ 1.0 L AND smart-demand flush operation and with*	≤ 1.0 L AND smart-demand operation and a urine-sensing activation device
Clothes washing machines Dishwashers	Star rating = $1 + \dfrac{\log_e (WC / BWC)}{\log_e (1-WRF)}$ ^	Rating rounded down to nearest half star						
Showers	**Unit of measure**	**0 stars**	**1 star**	**2 stars**	**3 stars**	**4 stars (Range E)**	**4 stars (Range F)**	**Not Star rated**
All showers	L/min	>16	>12 to 16	>9 to 12	>7.5 to 9	>6 to 7.5 (including compliance with spray force and coverage tests)	>4.5 to 6 (including compliance with spray force and coverage tests)	>4.5 to 7.5 AND not compliant with spray force and coverage tests OR ≤4.5

^Dishwashers: WC = water consumption of the model in litres; BWC = base water consumption = 2.5 + P × 1.6; P = number of place settings of the dishwasher; WRF = water reduction factor per additional star (17.5%) = 0.175.

^Clothes washing machines: WC = water consumption of the model in litres; BWC = base water consumption = 30 × C; C = rated load capacity of clothes washer (kg) as determined under AS 2040.1; WRF = water reduction factor per additional star (30%) = 0.3.

*A hands free activation device with a sensitivity field not greater than 300 mm from the front of the urinal.

In addition to providing water efficiency ratings, WELS stipulates minimum water efficiency standards for a number of products as well as making references to other standards that enforce some form of minimum water efficiency standard. For toilets, WELS prescribes a maximum average flush volume of 5.5 L (assuming one full flush to every four half flushes). It also requires adherence with AS/NZS 1172.2, which specifies acceptable cistern-pan models and corresponding minimum and maximum flush. To obtain a WELS rating, urinals must satisfy AS/NZS 3500.1, which requires a maximum flush volume of 2.5 L for a single stall or 600 mm wall equivalent.

The National Construction Code, through the Plumbing Code of Australia, limits flow rates of taps and showers to not more than 9 L/min, but it is not widely checked or enforced by state regulators at plumbing inspections.

Minimum water efficiency standards were introduced for clothes washing machines in 2011 whereby machines with a capacity of 5 kg or more must meet a water efficiency star rating of at least 3 stars and machines with a capacity of less than 5 kg must achieve a rating of at least 2.5 stars.

2.3 History

2.3.1 Before WELS

Before the mandatory WELS scheme came into force, a voluntary water efficiency scheme – the National Water Conservation Rating and Labelling Scheme – had been in place since 1988. The voluntary scheme was established and administered by Melbourne Metropolitan Board of Works before being taken over by Sydney Water (WELS Regulator, 2010). In 1999, administration of the scheme was transferred to the Water Services Association of Australia (WSAA).

National Water Conservation Rating and Labelling Scheme

A - Moderate level of water efficiency

AA - Good level of water efficiency

AAA - High level of water efficiency

AAAA - Very high level of water efficiency

AAAAA - Excellent level of water efficiency

It was reported at the time that this voluntary scheme was not effective in achieving significant water savings, as only a small proportion of available models were labelled (Wilkenfeld 2004). With widespread industry support for a legislated scheme, the WELS Act was passed in 2005 and the scheme became mandatory on 1 July 2006. State and territory support was required if WELS was to operate as a national scheme. Implementation of WELS as a national scheme was agreed through the 2004 intergovernmental agreement on a National Water Initiative (NWI) (COAG, 2004).

The start of WELS coincided with the worsening of a severe and prolonged drought, the 'Millennium Drought', in many parts of Australia and allowed WELS to become the standard for a number of other demand management programs brought in by governments and water utilities across the country (see section 2.4 below).

WELS and its predecessor voluntary scheme went hand-in-hand with some existing regulations and standards that contained water efficiency requirements. For the plumbing and drainage industry, the National Certification Plumbing and Drainage Products (NCPDP) Scheme was established in 1988 through a voluntary arrangement between Standards Australia and participating plumbing and drainage regulators in Australia. In 1998, the administrators of the NCPDP Scheme reaffirmed water conservation as one of the objectives for the control of plumbing products (ABCB 2014).

Building on the NCPDP Scheme, in 2004 the first Plumbing Code of Australia was released and mandated WaterMark Certification Scheme (WaterMark). Given the rigour of WaterMark certification, it later became a compulsory requirement for registering products with WELS.

Other standards in place before WELS commenced included AS 3500, which has specified the maximum allowable water use per flush for toilets since around 1993, and energy labelling which has been mandatory for washing machines and dishwashers since 1998.

As these standards were already influencing efficiency in certain product types, water savings due to WELS need to be considered as additional or marginal to those savings in assessments of scheme effectiveness.

2.3.2 Amendments to WELS

There have been some minor changes to the ratings since the original AS/NZS 6400 was released. The first amendment was made in May 2006 and changed the upper limits to full, half and average flush volumes to an average flush range. In December 2006 (Amendment 3), the toilet ratings were switched back to the original specification. Amendment 5 from June 2011 introduced the minimum standard for clothes washing machines described in section 2.2.

In 2016, AS/NZS6400 was further updated with new 4 star ratings for showers (lower flow rates than 3 star showers but need to pass spray force and coverage tests) and a 0.5 L flow rate reduction for 5 star urinals. The update also allowed for registration of 6-star toilets such as the vacuum toilets.

2.4 Wider urban water policy context

Given the policy environment WELS entered and operated in until most drought management programs ceased – between 2011 and 2013 – it is challenging to quantify water savings achieved by the scheme in isolation from the other water conservation (and related energy efficiency) programs. This section summarises urban water policies and programs linked to WELS during the Millennium Drought and beyond. It also addresses how these linkages pose challenges for attributing costs, savings and other benefits directly to WELS.

2.4.1 Drought response programs

The WELS scheme was introduced during the height of the Millennium Drought in Australia, and formed part of the broad suite of drought responses by Commonwealth, State and local governments and water utilities to reduce demand and improve water security. The drought and associated drought response efforts continued in many regions until 2010. Many demand management programs by water utilities and State governments involved the replacement of inefficient devices with efficient models relied on WELS star ratings for the product specifications. Such programs included, for example:

- home audits and subsidised retrofits with 3 star showerheads, 4 star dual-flush toilets, and flow reducing tap aerators, conducted by qualified plumbers
- showerhead swaps where residents could bring in old showerheads and their water bills to council offices or major hardware retailers and swap them for 3 star showerheads
- rebates for purchasing clothes washing machines rated 4 or 5 stars.

The extensive demand management efforts that occurred during the Millennium Drought, and how they have been accounted for in the economic evaluation of the WELS scheme, are described in some detail in section 8 of this report.

2.4.2 Energy saving programs

As the Millennium Drought started to ease, energy efficiency programs began to emerge as governments moved to reduce GHG emissions and assist low-income households to manage increases in electricity prices. One of the largest components of household energy bills is water heating, thus energy efficiency schemes have targeted inefficient showerheads to achieve low-cost energy savings. Together with previous water efficiency programs targeting showerheads, these programs have made a significant contribution to the turnover of inefficient showerhead stock.

Energy saving programs commenced in Queensland, NSW and Victoria in 2009, and all except the Victorian Energy Efficiency Target (VEET) scheme ceased by 2011-12. Like the schemes in other states, the VEET scheme encourages the efficient use of electricity and gas through accredited energy savings activities, including the installation of efficient shower heads, to generate certificates (VEECs) which are redeemable to liable parties.

2.4.3 Building and tenancy regulations impacting water efficiency

WELS ratings underpin a number of building regulations which remain in force nationally or in certain states (see Table 3).

Queensland and NSW have tenancy laws that encourage water efficiency inside the home. Under state-based tenancy legislation, landlords may charge tenants for their water use if the home has water efficient fittings. This encourages landlords to install such fittings and make sure there are no leaks.

Permanent water savings measures, or ‘water wise rules’, have been implemented in several jurisdictions around Australia, including Sydney, Adelaide, the ACT, the Lower Hunter Region, the NSW Central Coast, Cairns and a consistent regime across Victoria. The rules target efficient water behaviour rather than restricting uses, and focus on residential outdoor water use, generally garden watering. Water efficient behaviours include watering with automatic devices and sprinklers only in the early morning or evening to reduce evaporation, not hosing hard surfaces and using trigger nozzles on hoses.

Table 3 Examples of building regulations that rely on WELS

WELS-related regulation	Requirements	Where
National Construction Code (NCC) 2016 Plumbing Code of Australia Volume Three – new dwellings	Maximum 9 litres/min flow rate for showers and taps, equivalent to WELS 3 star.	Australia-wide
	Maximum 2.5 litres per flush per stall/600mm, equivalent to WELS 2 star.	Australia-wide
	Maximum 6/3 litres dual flush, equivalent to WELS 3 star.	All but Queensland
BASIX (Building Sustainability Index) – alterations and additions valued at $50,000 or more	Alterations and additions must have minimum 3 star toilets, showers and taps.	NSW
QLD Department of Housing and Public Works Sustainable Housing Laws – new dwellings	Minimum 4 star dual flush toilets Minimum 3-star showers and taps	Queensland

2.4.4 Attributing savings and costs for improved water efficiency

In light of the above linkages, and as noted by Chong *et al* (2008) in a previous evaluation of the cost effectiveness of the scheme, WELS influences consumer choice and achieves water savings through the following range of mechanisms:

- Mandatory labelling provides consumers with **information** about the water efficiency of all products covered by the scheme. This enables consumers to differentiate between models on the basis of water efficiency, and to include it as a factor (amongst other features, e.g. price) in their purchase decisions.
- WELS has also enabled the Australia-wide implementation of **minimum water efficiency standards**, in particular for toilets and washing machines.
- WELS, particularly during the Millennium Drought, underpinned **demand management programs** by water utilities, councils and state governments across Australia. These programs included extensive education and communication campaigns, product rebates, household audit and plumber retrofits and efficiency showerhead exchange offers to customers. The mandatory WELS labels provided the star ratings nomenclature that these programs were built around.
- **Building and plumbing regulations** that require minimum water efficiency of products and fixtures installed in new buildings and renovations make use of the flow rate/flush volume information included on WELS labelling, as indicated in Table 3.

In practice, these four WELS related mechanisms have worked in combination to influence which products have been and are purchased and installed in Australia and therefore the savings from water efficiency that have resulted.

In the period since its inception, the WELS scheme has been one of the multiple drivers that have promoted water efficiency in WELS related products in Australia. As shown in Figure 2 together with WELS, the Millennium Drought, other building and plumbing regulations and technical innovation have all played a part in shifting the urban water policy context. The change in context has seen plumbing fixture and appliance markets transformed; large scale demand management programs run, thus incentivising more efficient products and minimum water efficient standards on some products.

The WELS scheme has worked in concert with other drivers. The Millennium Drought made water conservation a key topic of national conversation for a number of years, but WELS labelling allowed customers to act on the shift in public consciousness towards conservation. Building and plumbing regulations for minimum product efficiency use the WELS stars ratings and labelling as nomenclature for regulation and in compliance mechanisms. The same is true for utility-run demand management programs. Technical innovation has seen new products brought onto the market but customer demand for water efficiency and the presence of mandatory labels have driven innovation into this area (at least historically)[1]. The resulting impact on water use is then a combination of WELS, related policies that use WELS labelling and circumstance (a major drought). This combination of impacts is illustrated in Figure 2.

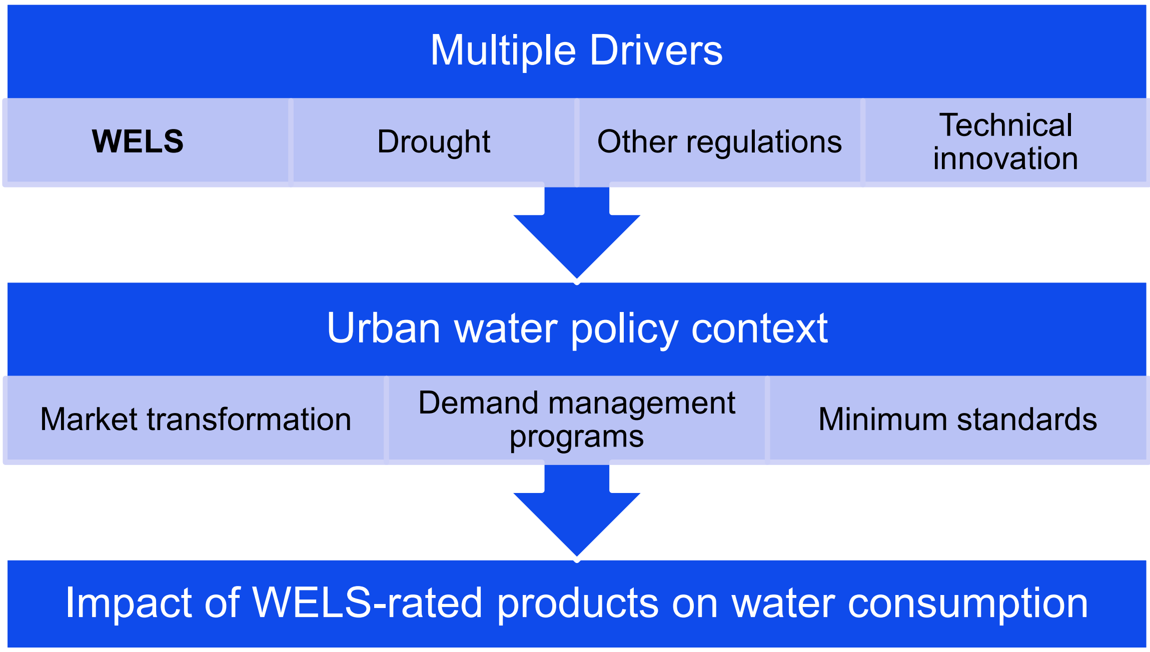


Figure 2 A range of drivers has promoted water savings in Australia

Given the interlinkages and dependencies, an attempt to attribute a proportion of water efficiency savings to the WELS scheme alone would be artificial, as would trying to attribute proportions to other measures. Instead, in this study water savings (and resultant energy and GHG savings) from the four mechanisms are all attributable to 'WELS and associated measures'. This approach is used throughout the study.

2.5 Previous evaluations

The WELS scheme was introduced following a Regulation Impact Statement (RIS) by Wilkenfeld and Associates. This Wilkenfeld study made the case for WELS by estimating the impact of the scheme on water consumption, energy use and GHG emissions. It also included a cost benefit analysis (CBA) of the proposed scheme.

Since its inception, WELS has had a number of reviews. The WELS Act mandates five-yearly reviews, the outcomes of which are used for ongoing scheme improvements. They also enable subsequent reviews to build on previous data and identify longitudinal trends. The first independent scheme review was conducted by Chris Guest in 2010 (WELS Regulator 2010) and the second was carried out by Aither in 2015 (WELS Regulator 2015).

Each of these independent reviews drew on evaluations of the economic and environmental impacts of the scheme. An analysis of the cost effectiveness of the WELS scheme was conducted by ISF in 2008 (Chong *et al* 2008), and in 2014 ISF was commissioned to conduct an evaluation of the environmental effects of WELS in terms of water consumption changes; and energy, greenhouse gas and household bill impacts associated with reduced water consumption (Fyfe *et al* 2015).

The three previous evaluations are summarised below (in ascending chronological order) to provide background to the current work, particularly in relation to the assumptions used in modelling. It should be noted that the CBA conducted in this current study is the first full economic appraisal of the scheme since its inception.

[1] Sales information gathered through interviews with industry representatives for the current evaluation suggests water efficiency is no longer a major purchasing criterion; water efficiency is seen by many consumers as a "given" and is therefore "well down the pecking order" in purchasing decisions. Style and design are now the key criteria for consumers.

2.5.1 Regulation Impact Statement 2004

In May 2004, a RIS for the [then] proposed national system of mandatory water efficiency labelling for selected products (Wilkenfeld 2004) was released by the Australian Department of Environment and Heritage. The RIS compared a "business as usual" (BAU) case, where the voluntary labelling scheme continued, against a WELS case where the regulation is implemented. The aim of the RIS was to determine whether the proposed regulation would bring about greater water (and energy) use reductions in residential and non-residential buildings than would otherwise occur under the BAU case.

Modelling of the costs and benefits considered economic as well as end user impacts from 2005-06 to 2020-21 (the extent of Australian Bureau of Statistics population projections at the time). For the economic impacts, modelling assumptions included:

- the value of water saved (potable water supply and wastewater disposal) and the value of energy saved through water efficient products were the main quantifiable economic benefits
  - benefit was the marginal cost of water supply and wastewater disposal
- the increased cost of products and costs associated with administering the scheme were the main economic costs
  - only the extra (marginal) costs involved in the manufacturing and distribution processes — such as extra testing, materials, handling and storage costs — were counted
  - price increases not related to costs, e.g. retail mark-ups and taxes, were not counted as they are only transfers from consumers to intermediaries
  - production costs (minus intermediary mark-ups) were used in economic analysis whereas product prices were used in end user analysis
  - water production costs were used in the economic analysis whereas prices were used in the end user analysis.

The study asserted that water users would be the beneficiaries from water and energy savings through acting on the information provided by WELS, but would also likely bear increased costs of products where WELS administrative costs were potentially added.

With hindsight, the changes to water efficiency of sales and stock and subsequent water savings estimates included in the RIS have been shown to be significant underestimates of actual savings achieved.

2.5.2 Cost-effectiveness of WELS 2008

After the first 18 months of WELS implementation, the Australian Government commissioned ISF to analyse the cost-effectiveness of WELS in contributing to the overarching objective of water security, in relation to other programs aimed at managing water demand and increasing supply (Chong *et al* 2008). Those programs included: outdoor water efficiency programs; indoor water efficiency exchanges, rebates and retrofits; building regulations; desalination; new storages; new recycling schemes; and residential rainwater tank programs. Chong *et al* 2008 made the case that WELS could not be evaluated in isolation of the other demand management programs and initiatives that affected customer purchase and installation of water using products.

The cost effectiveness analysis employed the following approach:

- water savings, costs and benefits analysed against a hypothetical 'no WELS' baseline
- whole-of-society net cost estimate for the various demand management and supply options
- levelised cost comparison of WELS and other programs; based on $/kl.

Calculation of water savings was based on the approach taken by Wilkenfeld (2004) but the analysis was updated with data collected since WELS had commenced. This included: clothes washer and dishwasher sales data; ABS survey data on the uptake of efficient appliances; stakeholder interviews; analysis of building regulations; and review of current literature on water security, demand management, and cost effectiveness analysis. The timeframe (2005-06 to 2020-21) of the analysis was also the same as Wilkenfeld (2004).

2.5.3 Evaluation of environmental effects of WELS 2015

In the lead up to the second independent evaluation in 2015, ISF was commissioned to undertake an evaluation of environmental effects of WELS (Fyfe *et al* 2015). The objectives of the study were to:

- characterise the changes in products registered in the WELS database since inception

- estimate changes in household water consumption related to residential appliances
- estimate energy, GHG, and household bill reductions associated with the changes in household water consumption
- explore the role of WELS in influencing the above changes.

The study involved:

- assessing the interactions between WELS and other urban water policies and planning measures
- analysis of the WELS database to determine key trends in product registrations; results confirmed a consistent shift across all product categories toward more efficient products
- primary and secondary sales data collection (2006-2013) to determine changes in product sales by WELS rating
- modelling of water consumption by WELS products in domestic settings and associated energy and GHG impacts (non-residential uses were not considered)
- financial modelling of household bill impacts.

The analysis of program and policies interacting with WELS found WELS to be critical to a wide range of initiatives. A total of 32 complementary policies were identified at that time including 19 water demand management programs; 4 energy demand management schemes; 6 building codes, regulations and rating schemes; and 3 tenancy laws. All of these measures referenced the WELS scheme.

The 2015 study found water savings of 204 GL per year by 2030, a cumulative GHG reduction of 46 megatonnes (Mt) CO_2 equivalent (CO_2 -e) by 2030, and an estimated financial benefit to Austalian households of $2 billion per annum in 2030 based on the energy and water price projections made at that time. A comparison of these results with the results of this study is presented in Table 18 (in Section 6.6).

3 Analysis of WELS database

This section details an analysis of the WELS database from its inception to 2017. Only the registrations were looked at, not sales data (see section 4 for analysis of sales data). The WELS registration data is of interest because it shows how the efficiency of registered products has changed over time. It also shows when models with a certain star rating entered the market.

3.1 WELS Database

Details of all products currently or previously registered under the WELS scheme are stored in a database, including:

- star rating
- water consumption
- registration dates
- model and brand details
- product characteristics.

Because registration and labelling under the scheme are mandatory, the WELS database provides a useful record of products in the market in Australia since 2006. The database was analysed to see how the number of models and star ratings have changed over time.

3.2 Analysis

The WELS database was analysed to look at trends in registrations for each fixture/appliance – specifically the number of registrations each year overall and for each product type and the star ratings of those registrations.

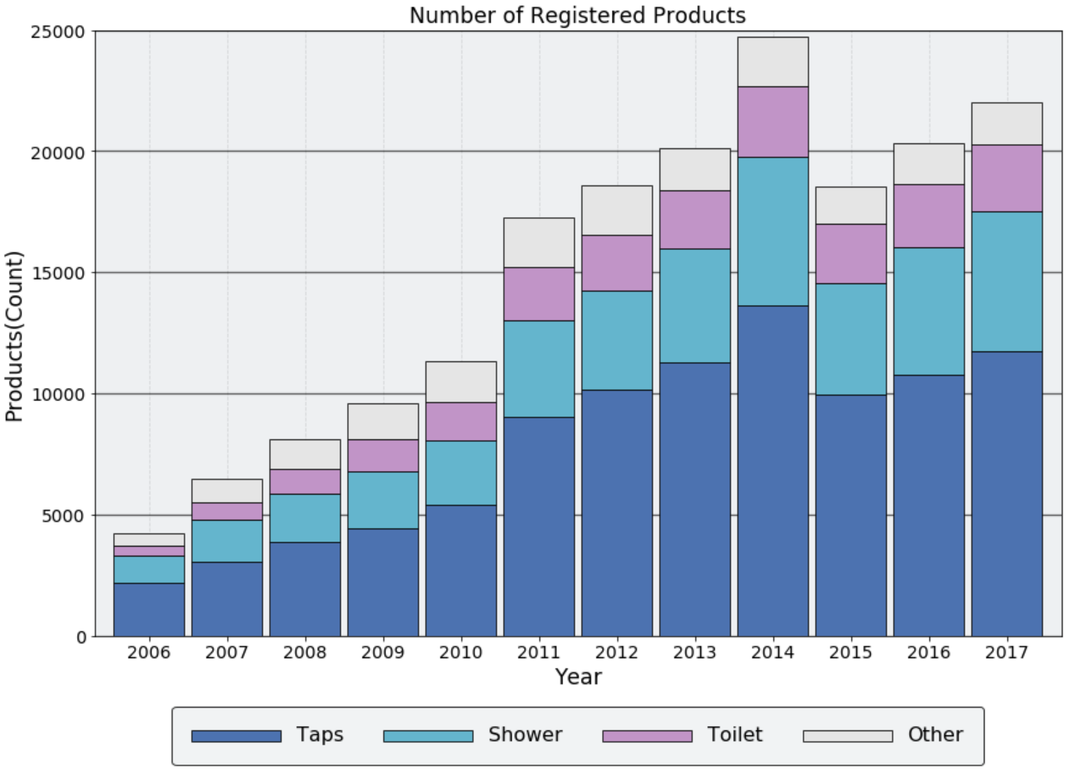
The database analysis applied the same definitions as the Fyfe *et al* 2015 study (Table 4), with the following minor changes and clarifications:

- A product was counted as registered in a particular year if it was registered for a day in that year.
- Showers that were previously rated 3 star but had flow rates in the range now rated 4 stars were labelled either 4E star or 4F star, according to which category their flow rate fell into (4e for ≥6 L/minute but <7.5 L/minute or 4f for ≥4.5 L/minute but < 6 L/minute).
- Where records had missing start or end dates, the ID was used to match an older version of the database, which had complete start and end date data.
- For duplicate product names, only the first instance was included, to account for family registrations.

Table 4 Registration status in WELS database and interpretation

Status	Interpretation
Ceasing	Product treated the same as registered until the ceasing date
Cancelled	Product is no longer available to be sold after the cancelled date
Expired	Product is no longer available to be sold after the expired date
Expiring	Product registration will expire in the coming year unless renewed, but is still available to be sold - treated the same as registered
Recommend to cancel	Product may become cancelled but is still available to be sold, treated the same as registered
Registered	Product is available to be sold
Renewed	Treated same as registered
Suspended	Product is no longer available to be sold after the suspended date

Figure 3 shows that there has been an overall increase in the number of registered products from 2006 to 2017. An exception is the drop between 2014 and 2015 when a large number of expiries occurred with the shift to single-year registrations. There are more taps registered than any other product (top graph). The products with the least registrations are urinals and flow controllers. These are seen in the bottom graph, which is a breakdown of the 'other' category from the top graph. Together, the two graphs cover the major products in the scheme.



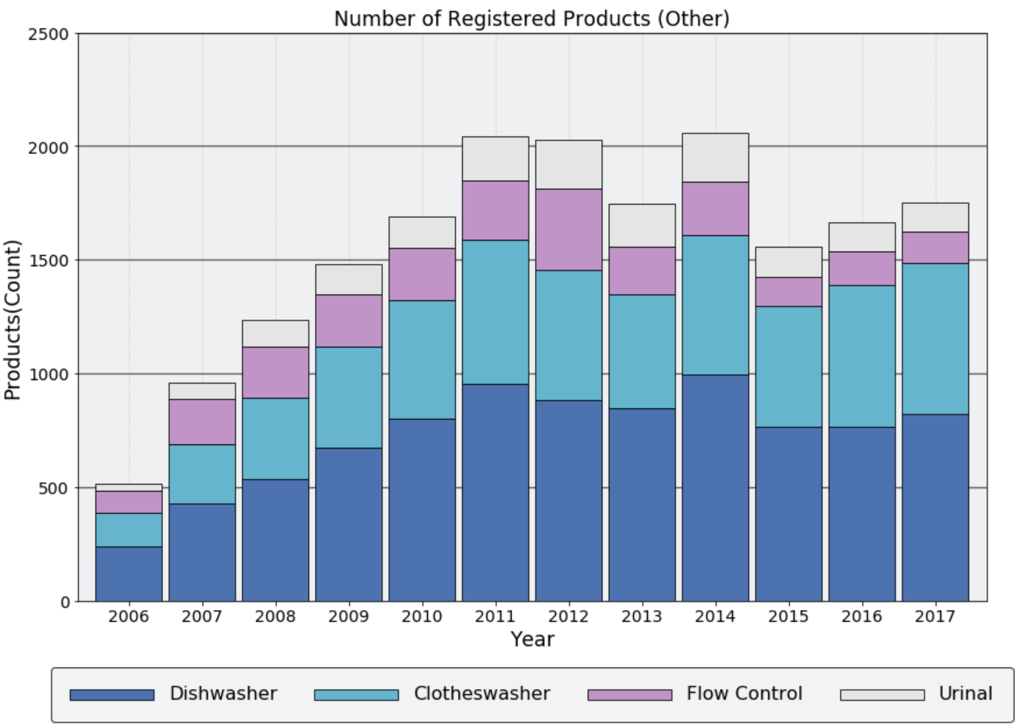


Figure 3 Number of WELS registered products

Figure 4 shows the number of WELS registrations in the database and indicates the number of new and expired registrations. There is a slight downward trend in new registrations from 2011 to 2017, with the exception of 2014, when single-year registrations were introduced. Overall there have been fewer expiries than new registrations so the total number of registrations has risen.

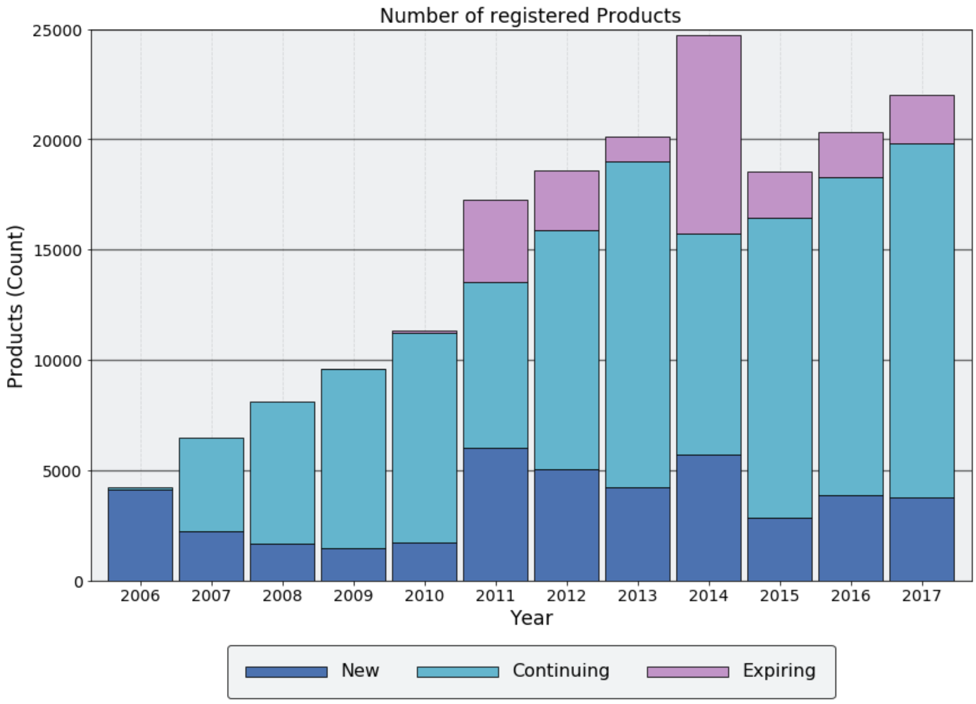


Figure 4 Number of WELS registrations

These trends in registrations are investigated for each appliance and fixture in the following sub-sections.

3.2.1 Clothes washers

It can be seen from Figure 5 that registrations of clothes washers with 2.5 stars have been very low since 2013 and sales of lower stars have been zero since 2013. This is due to the introduction of minimum performance requirements for clothes washers of 2.5 stars for machines with a capacity of less than 5 kg and 3 stars for larger machines. Four star clothes washers peaked in 2007 then decreased to 2014 before starting to increase again. This is due to a decline in 4 star front loaders as 4.5 and 5 star machines were introduced, followed by an increase in top loaders rated 4 stars. Top loaders tend to have lower star ratings, with the highest rated top loader being 4 stars, and the highest rated front loader being 5 stars. Currently, most front loaders registered are 4.5 stars while most top loaders registered are rated 4.0 stars.

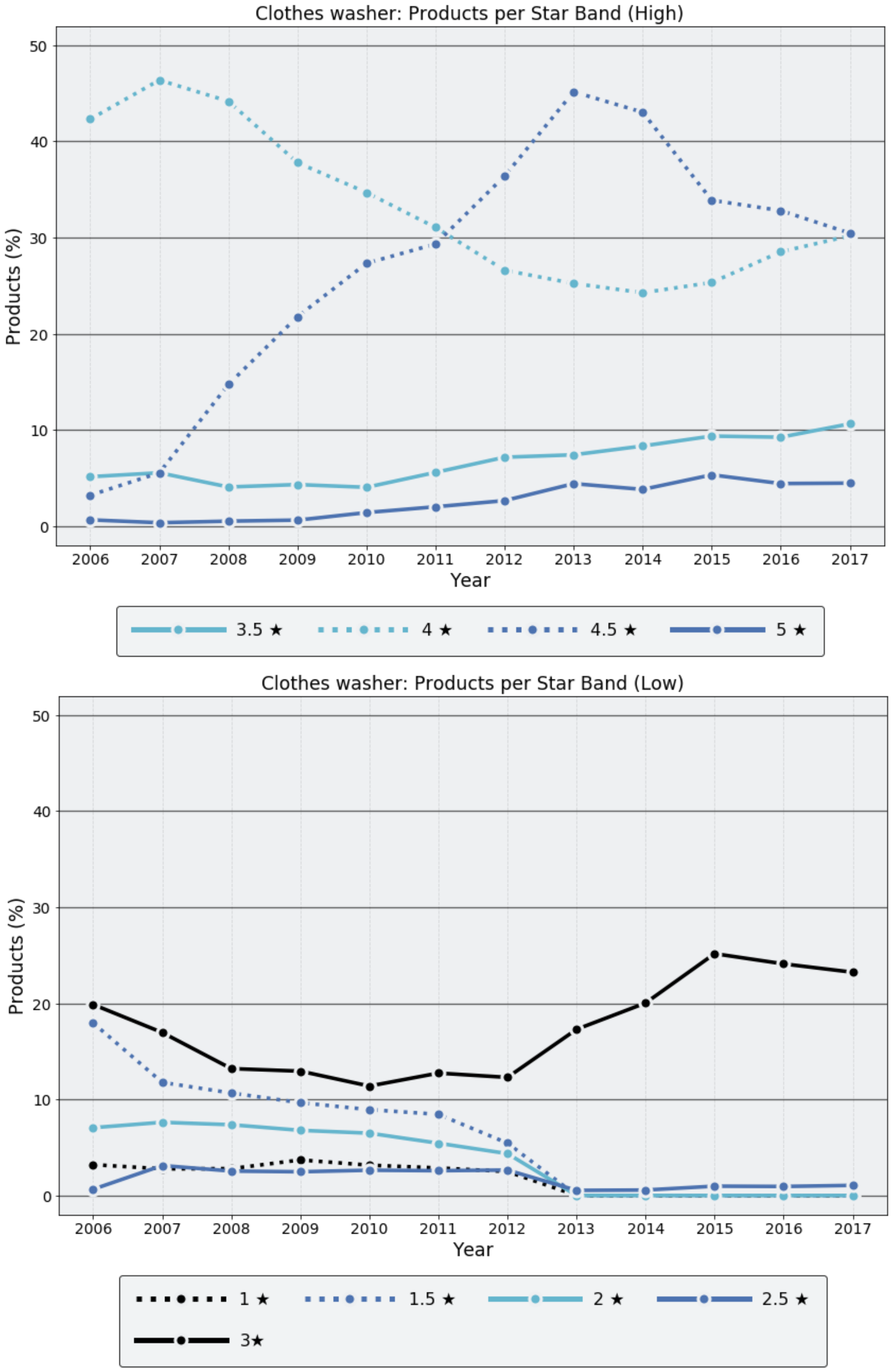


Figure 5 Star rating breakdown of registrations for clothes washers

There was a general downward trend in water use by clothes washer registrations to 2013 as seen in Figure 6 although there was a bounce back in 2014 and 2015. This small jump in the proportion of less water efficient products is driven by more top loader registrations. The increase might be a legacy issue related to a decrease in water consciousness after the end of the Millennium Drought or it might also reflect new models being brought onto the market to fill a customer demand for top loaders that are also relatively water efficient.

However the increase in 4 star top loaders together with the increase in 3 star products point to a general trend back towards top loading washers, which is a market segment that is less efficient than the market average.

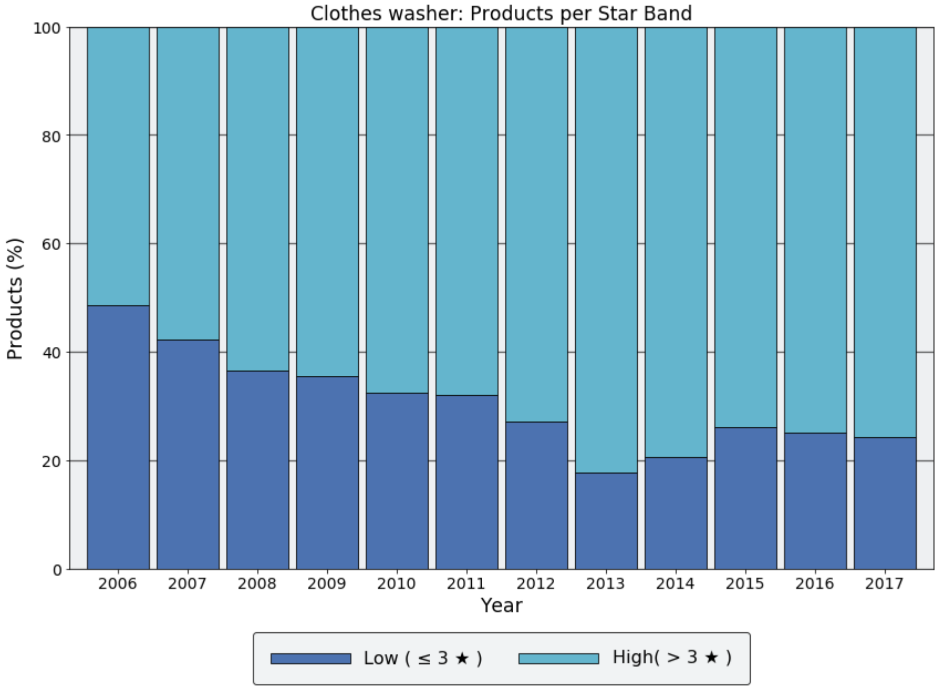


Figure 6 Trend in efficiency of clothes washer registrations

3.2.2 Dishwashers

From Figures 7 a and b, it can be seen that dishwasher registrations are dominated by 4 star, 4.5 star and 5 star models. Except for 4 star models, which increased until 2014 then started to decrease, registrations of high efficiency (more than 3.5 stars) models are increasing and registrations of low efficiency models (3 stars or less) are decreasing. Figure 8 shows this clear trend towards high efficiency registrations.

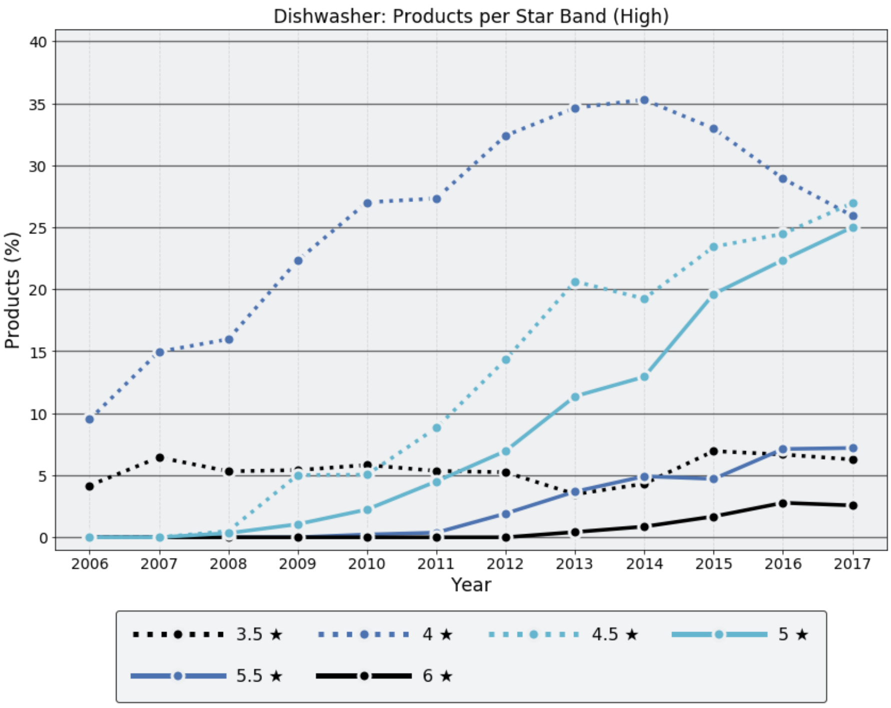


Figure 7a Star rating breakdown of registrations for dishwashers (3.5 – 6 star)

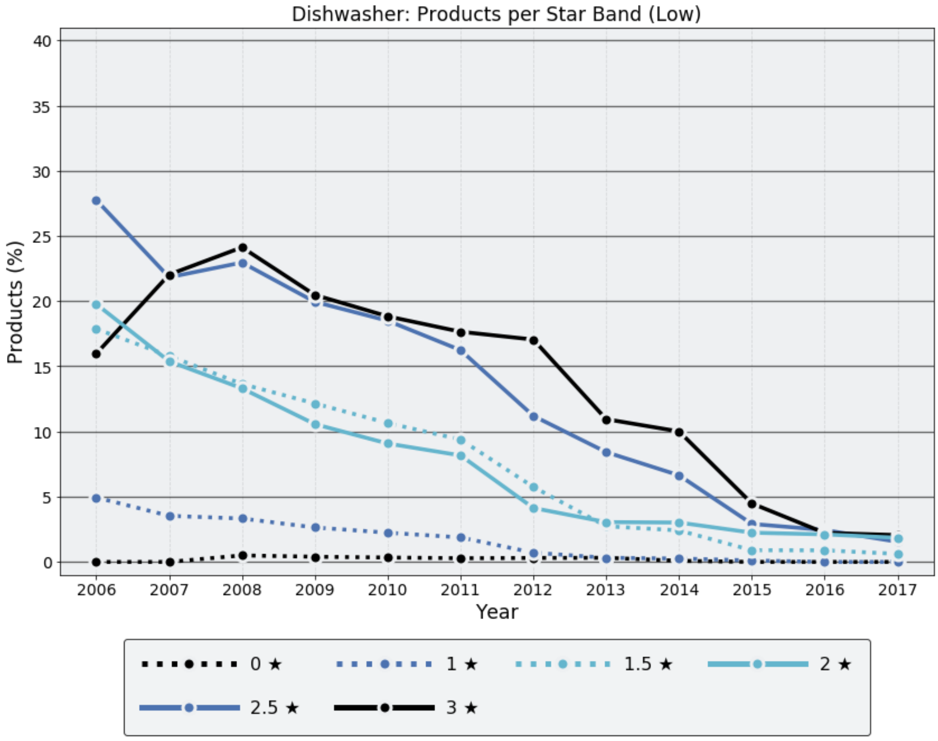


Figure 8b Star rating breakdown of registrations for dishwashers (0 – 3 star)

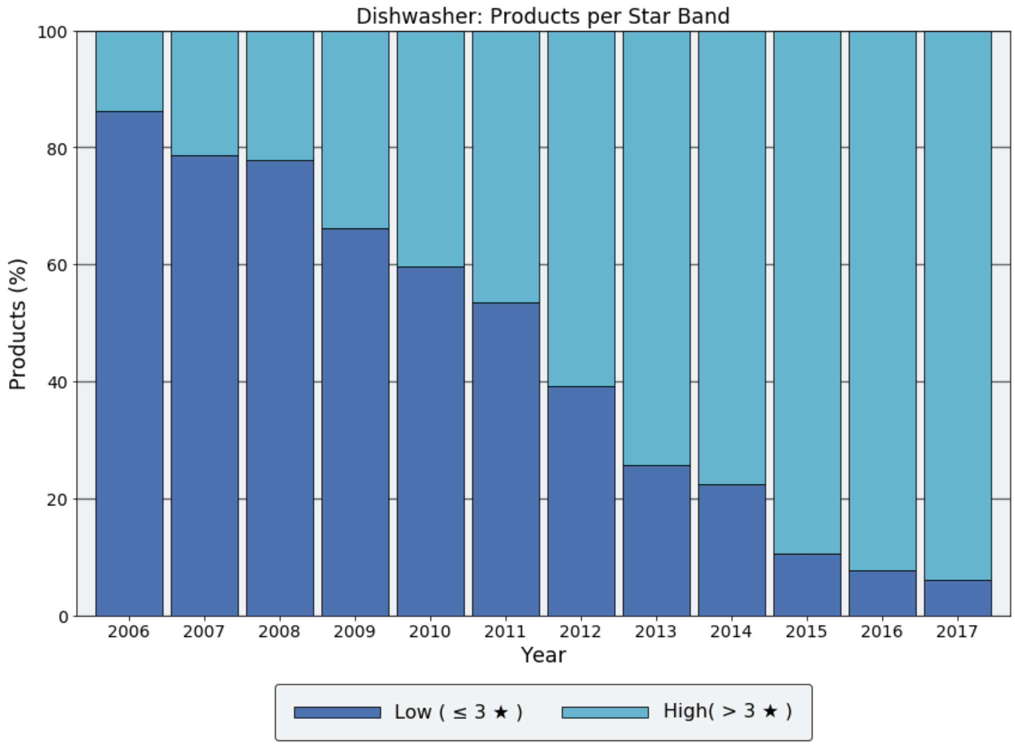


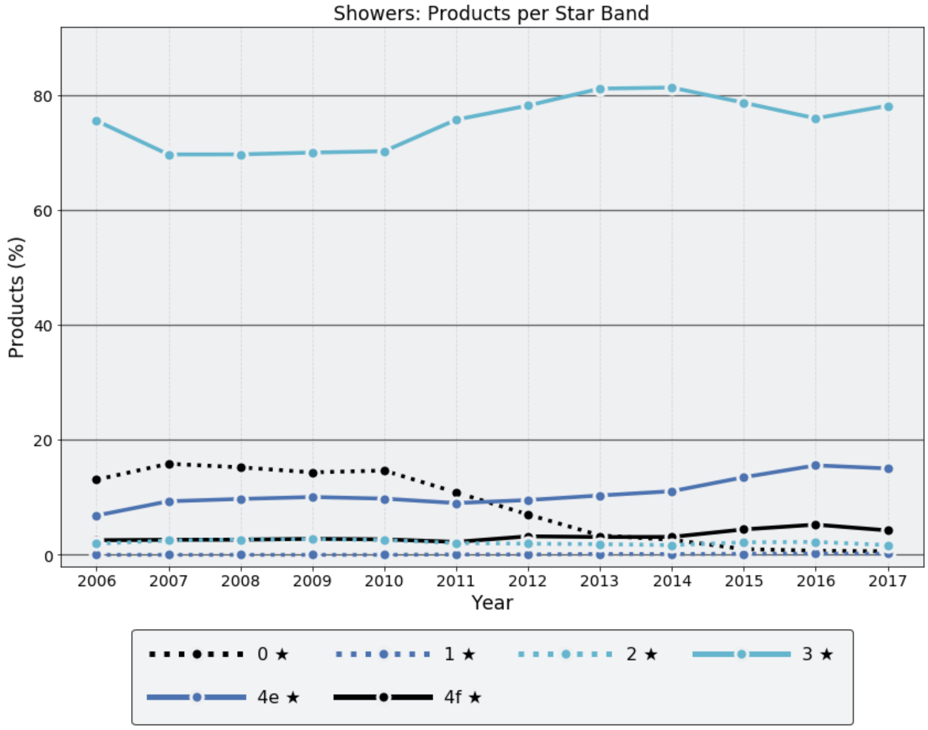
Figure 9 Trend in efficiency of dishwasher registrations

3.2.3 Showers

Trends in shower registrations by star band are shown in Figure 9 (note the lower graph is an expansion of the star band plots that are clustered between zero to 20% in the first graph, to show greater distinction).

Three star showers have dominated the market since WELS began. Until 2012, zero star rated models were the second most common, but since then the proportion of zero star rated models has decreased and registrations of four star model registrations have increased. Registrations of 2 star showers have remained at only 1.7% to 2.8% but 1 star registrations have been zero or negligible. Note that under the plumbing code of Australia, showers with a flow rate higher than 9 L/min (which is equivalent to a WELS 3 star rating) cannot be legally installed by a licensed plumber.

From Figure 10 a trend towards 4 star shower registrations can be seen, although there have been years when 4 star registrations dropped in comparison with the previous year, including 2017. Note that the 4e and 4f star bands where only introduced in 2015. Before that date those showers would have been labelled as 3 star (3 stars included flow rates in the current 3 star band as well as 4e and 4f), but for this analysis their flow rate has been used to assign a rating that matches the current star bands.



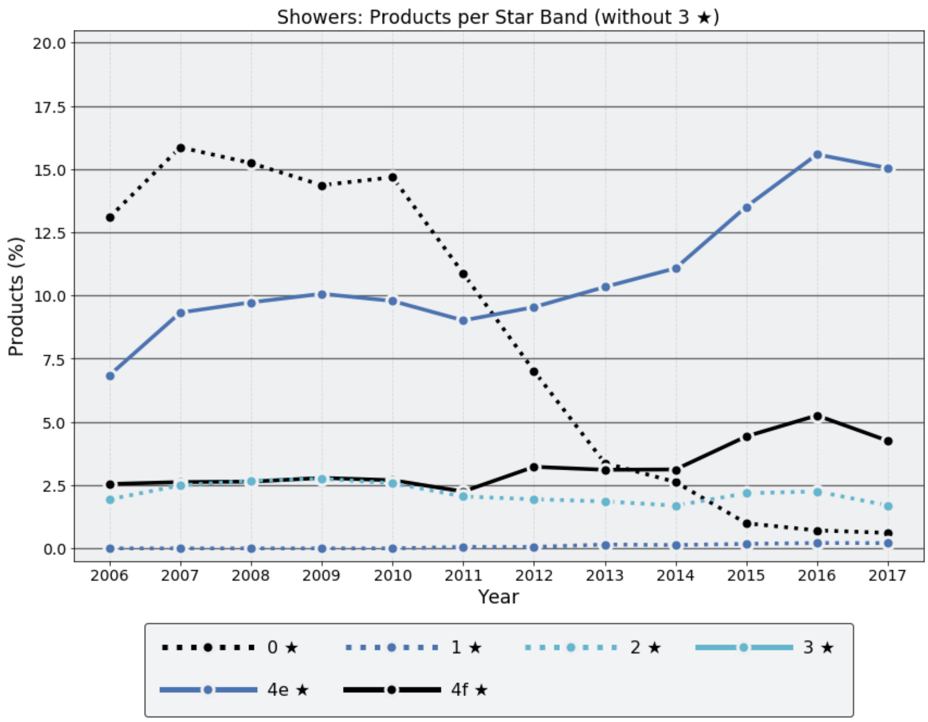


Figure 10 Star rating breakdown of registrations for showers

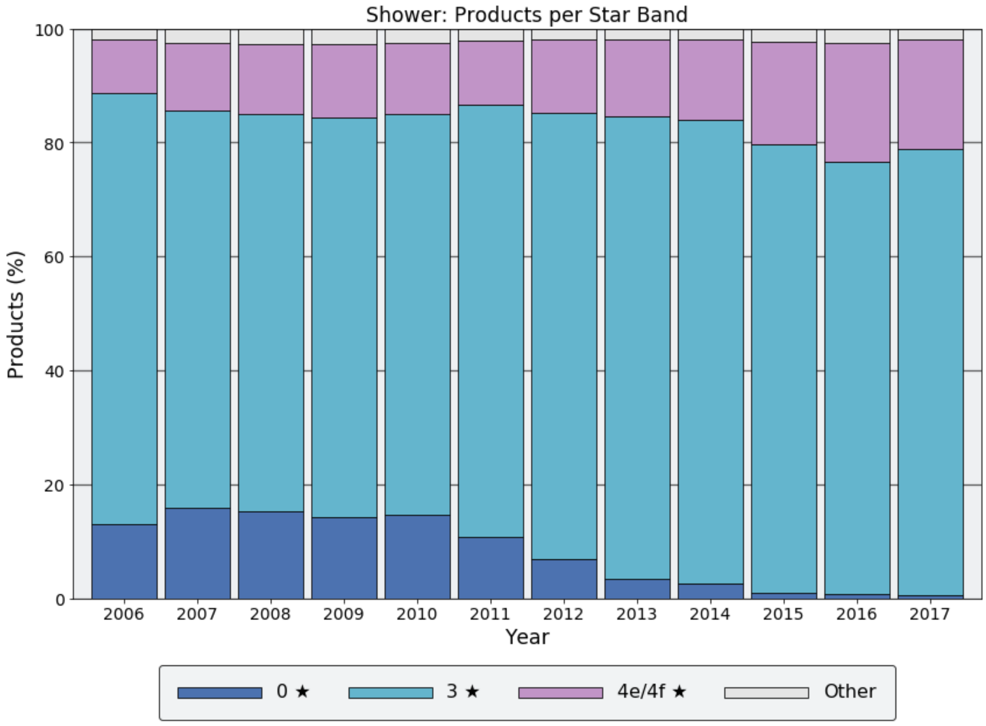


Figure 11 Trend in efficiency of shower registrations

3.2.4 Taps

The trends in tap registrations in each star band are illustrated in Figure 11. In 2006, 3 star tap registrations dominated but in 2007, 4 star tap registrations overtook and dominated until 2015 when 5 star taps took over as the most commonly registered. Three star tap registrations have been a decreasing proportion of total registrations since 2006, as have zero star taps, which became insignificant in 2013.

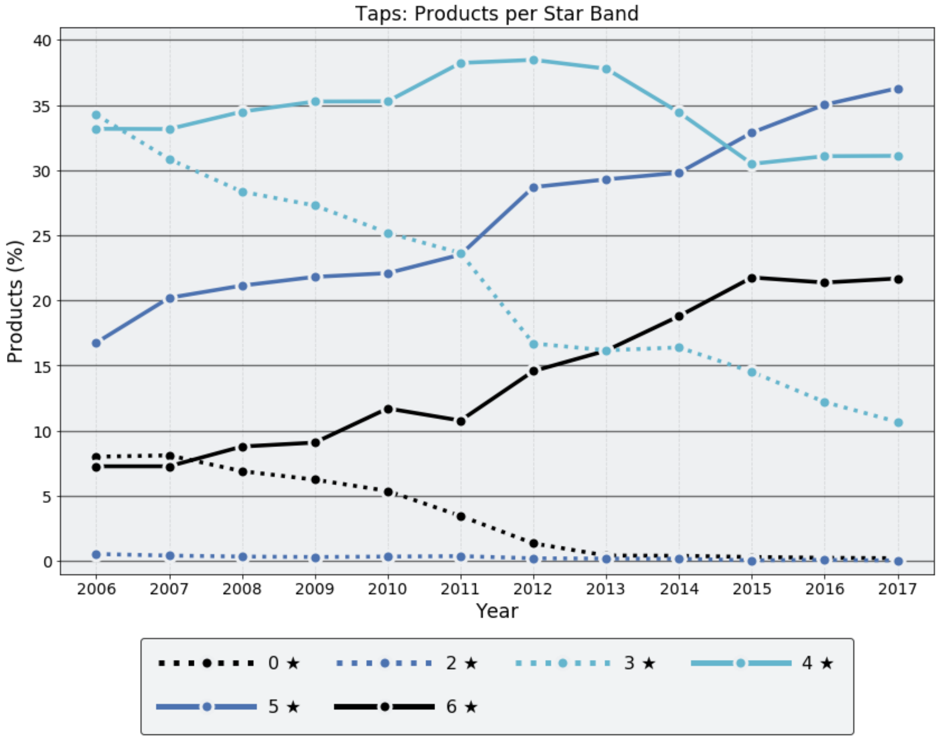


Figure 12 Star rating breakdown of registrations for taps

From Figure 12 it can be seen that in recent years (2015 to 2017) there is a noticeable shift in tap registrations from 3 star to 5 star.

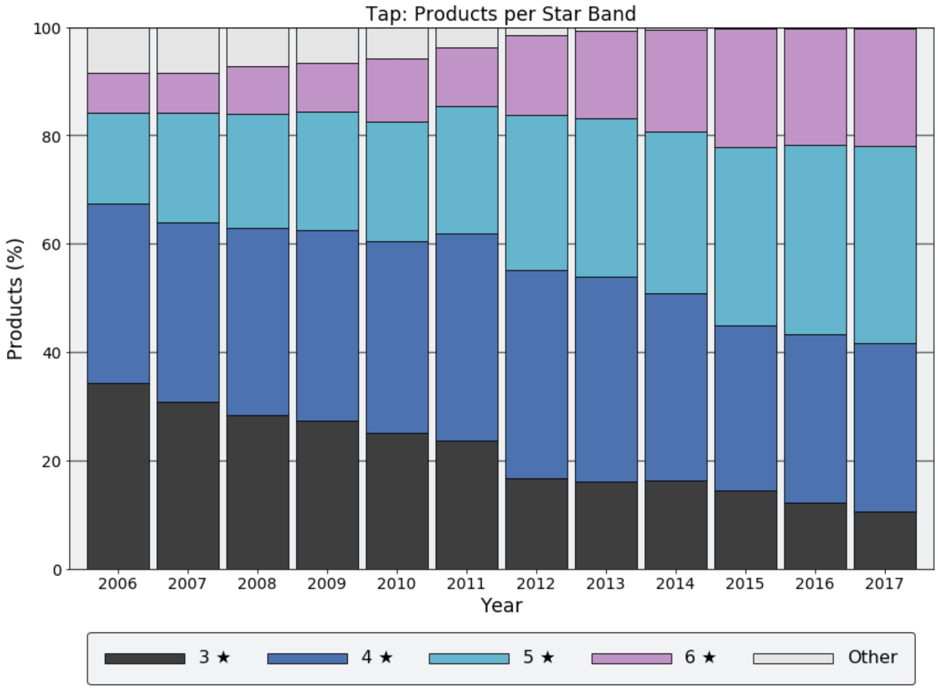


Figure 13 Trend in efficiency of tap registrations

3.2.5 Toilets

Figure 13 shows that the number of 3 star toilet registrations has been declining since 2006, with 4 star toilets making up the difference. In 2006, 3 star toilets made up around 73% of registrations and 4 star only 23%, with the remaining 4% being 1 star registrations. When 5 star toilets were first registered in 2007, they made up around 1% but since then they have not increased (rather they decreased). In 2011 registrations for 3 and 4 star models were roughly equal and by 2017, 4 star registrations were around 88% while 3 star registrations had dropped to 10%. Figure 14 shows how the combined fraction of other models (1 star and 5 star) declined from 2006 to 2012 and remained at around 1% of registrations. The minimum standard for toilets and the minimum efficiency required for toilets under the Plumbing Code of Australia is 6/3 L, which is equivalent to a WELS 3 star rating.

Note that 5 star toilets use the same amount of water per flush as 4 star but include an integrated hand basin and that 6 star toilets require special systems (they cannot be plumbed into standard household sewerage systems).

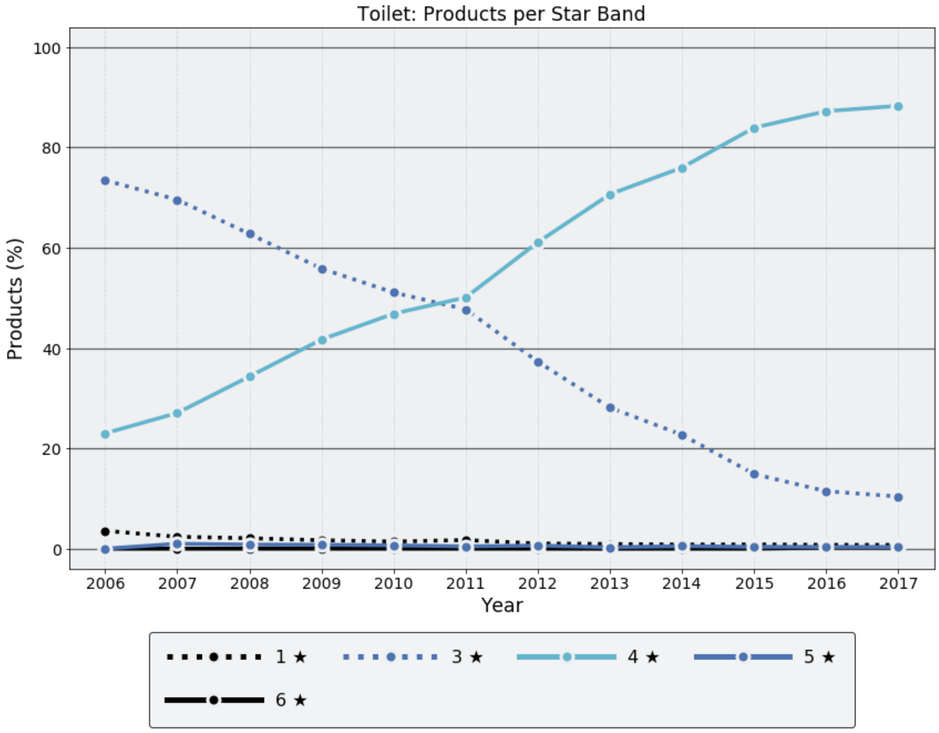


Figure 14 Star rating breakdown for toilets

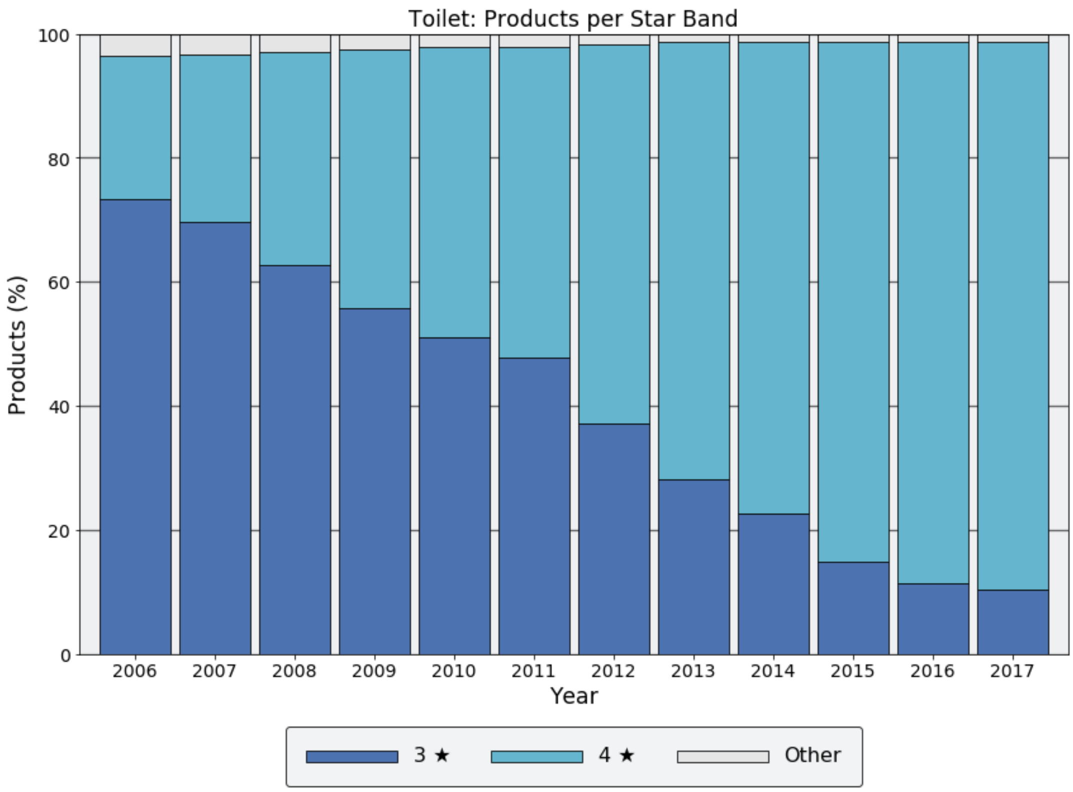


Figure 15 Trend in efficiency of toilet registrations

3.2.6 Urinals

Three star registrations make up the largest portion of urinal registrations, and this has been consistent since 2006, as can be seen in Figure 15. There has been a slow growth in 5 star urinals since 2006 and a drop off in zero star urinals since 2011. An increase in efficiency is also seen in the growth in registrations of 6 star urinals in recent years. From Figure 16 it can be seen that low efficiency (less than 3 star) urinal registrations decreased until 2014 but have been increasing again since then.

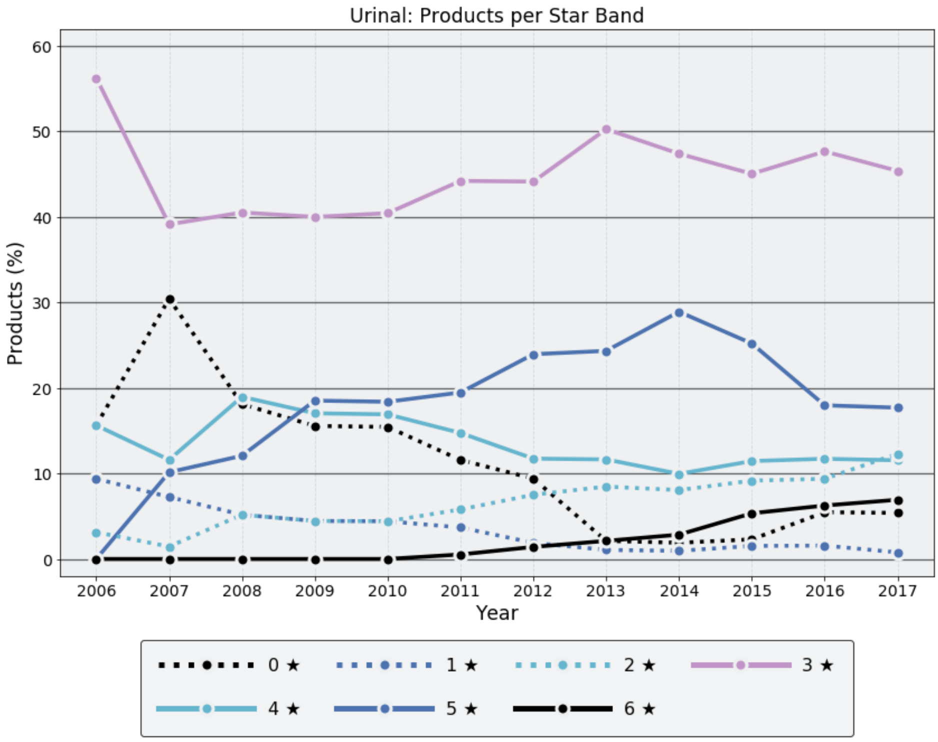


Figure 16 Star rating breakdown for urinals

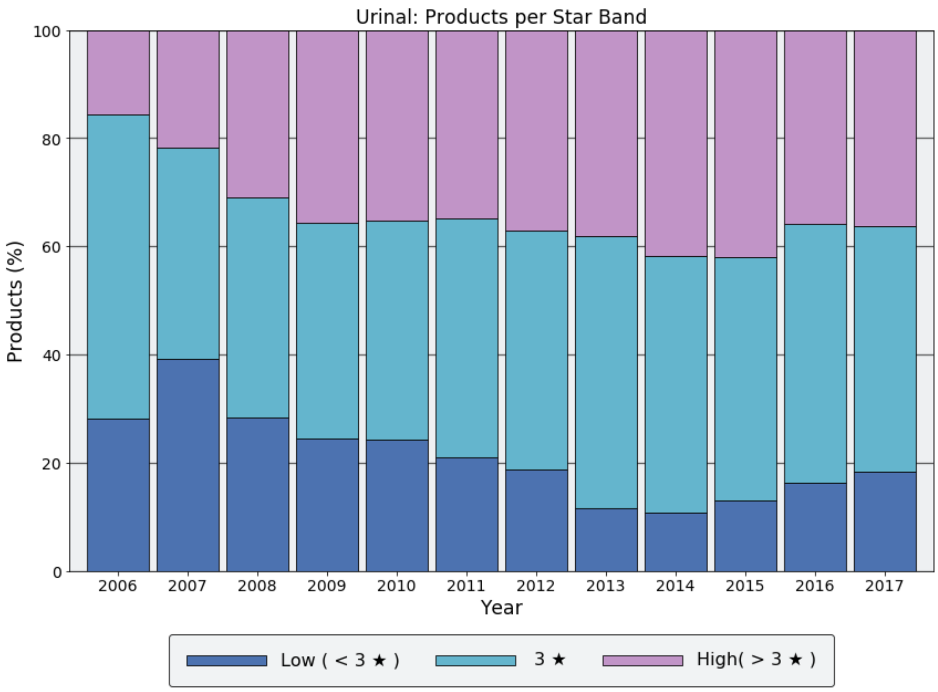


Figure 17 Trend in efficiency of urinal registrations.

3.3 Conclusions from database analysis

The analysis of registrations in the WELS database shows a general trend towards more registrations of higher star rated products year by year. This trend to increased efficiency is true for all product types.

The trend has been stronger for some products like dishwashers and toilets and less pronounced for other such as taps. Clothes washers also show a strong trend toward more efficient product registrations but with a somewhat confounding trend away from and then back towards top loading washers. This trend towards top loaders could see an increase in average water use.

The general trend towards more efficient registrations appears to be slowing for most product types in more recent years. This is particularly true for showers and toilets. There are very few registered 5 or 6 star toilets and the move from 3 to 4 star toilets appears to be slowing. There is also no strong move into 4 star showers despite a small jump in 2015 with the new star band being established.

4 Assessment of sales trends

The approach taken to estimating the impacts of the WELS scheme in this study rests on the modelling of sales trends and stock for WELS rated products together with assumptions about end uses in relation to frequency and duration of use.

This section describes the various data sets collected and the approach taken to bring these together to create sales trends by product type in the model. Data sets collected and described below are:

- interview data from product suppliers
- sales data, including purchased data for white goods plus sales data for plumbing fixtures provided on request from various parties
- data on new houses from the BASIX (Building Sustainability Index) scheme in NSW.

Sales data for white goods was available for purchase for the period 2007 to 2017 and so this data formed the basis for our sales trends for dishwashers and clothes washers. Current sales data for plumbing fixtures was gathered during interviews with retailers, manufacturers, wholesalers and one industry group (as was 2018 market share by fixture type).

We were fortunate that one major retailer provided sales data for the period 2012 to 2018, broken down by state. If the 2012-2018 data set aligned with interview information from other retailers and manufacturers, we used this data. Where this data was different from what manufacturers or other retailers reported, we concluded, for that particular fixture, the market varied significantly among individual manufacturers and retailers and so we used the market share to calculate a weighted average sales breakdown. BASIX data were also used as a cross check for the breakdown of plumbing fixture sales into new houses in NSW.

4.1 Data collected from interviews

One-to-one telephone interviews were conducted with ten product supply companies, two industry associations and one trade publication to gather data on sales trends and overall impacts of the scheme, both positive and negative. Most interviews were structured around a set of questions applicable to either plumbing products or electrical appliances (see Appendix A). Some interviewees were questioned only on specific market issues of which they had knowledge, rather than all questions in the set.

4.1.1 Market breakdown by star rating

Current shower sales data is shown in Table 5. All manufacturers and retailers indicated that 3 star showers dominate the market (90+% of sales). In the residential shower market the balance of sales is for 4e rated models. In the commercial market a small fraction of sales (0.5%) are 0 star showers.

Table 5 Shower sales according to interview answers

Interviewee	Sales percentages of star rated showers					
	0 star	1 star	2 star	3 star	4 E	4 F
Commercial plumbing products supplier	0.5%	0%	0%	93%	6.5%	0%
Plumbing products supplier E	0%	0%	0%	93%	7%	0%
Plumbing products supplier A	0%	0%	0%	95%	5%	0%
Plumbing products supplier C	0%	0%	0%	80%	18%	2%
				Hand held 60%	*35%.*	*5%*
				Fixed 100%		
Plumbing products supplier B	0%	0%	0%	90%	10%	0%

Interview data on the current sales breakdown for taps is given in Table 6. The breakdown of 3 star to 6 star taps varies across different manufacturers and retailers.

Table 6 Tap sales according to interview answers

Interviewee	Sales percentages of star rated taps						
	0 star	**1 star**	**2 star**	**3 star**	**4 star**	**5 star**	**6 star**
Commercial plumbing products supplier	0%	0%	0%	30%	3%	36%	31%
Plumbing products supplier E	0%	0%	0%	30%	60%	9%	1%
Plumbing products supplier C	0%	0%	0%	0%	20%	70%	10%
Commercial tapware supplier	0%	0%	0%	49%	0.5%	0.5%	49%
Plumbing products supplier B	0%	0%	0%	10%	70%	10%	10%

Toilet sales are shown in Table 7. There appears to be a significant difference between the residential and commercial markets (with 1 star and 3 star single flush toilets being a significant part of the commercial market) but 4 star toilets dominate both. Despite minimum standards for new toilets being 3 stars, 1 star replacement cisterns are still available (one supplier reported 0.5% of sales were 1 star).

Table 7 Toilet sales according to interview answers

Interviewee	Sales percentages of star rated toilets						
	1 star dual flush	**1 star single flush**	**3 star single flush**	**3 star dual flush**	**4 star**	**5 star**	**6 star**
Commercial plumbing products supplier	0%	12%	24%	0%	64%	0%	0%
Plumbing products supplier E	0%	0%	0%	0%	100%	0%	0%
Plumbing products supplier C	0%	0%	0%	5%	95%	0%	0%
Plumbing products supplier B	0.5%	0%	0%	2.5%	97%	0%	0%

Current urinal sales are presented in Table 8. The breakdown of sales varies between manufacturers, with 3 star urinals dominating sales for one manufacturer and 6 star dominating for the other two.

Table 8 Urinal sales according to interview answers

Interviewee	Sales percentages of star rated urinals							
	0 star	**1 star ≤4L/flush for 2 stall**	**1 star ≤7.5L/flush for 3 stall**	**2 star**	**3 star**	**4 star**	**5 star**	**6 star**
Commercial plumbing products supplier	0%	0%	0%	0%	80%	0%	20%	0%
Plumbing products supplier E	0%	0%	0%	0%	3%	3%	4%	90%
Plumbing products supplier B	1%	4%	0%	0%	35%	0%	0%	60%

Despite flow controllers not being modelled for this analysis of water and related savings, one interviewee supplied the market breakdown for their products, as shown in Table 9. Flow controllers are used to reduce the flow rate of showers and taps, and the market share seems to fall between the market distribution for showers (primarily 3 star sales) and taps (with higher 4 star and 6 star sales).

Table 9 Flow controller sales according to interview answers

Sales percentages of star rated flow controllers#						
0 star	**1 star**	**2 star**	**3 star**	**4 star**	**5 star**	**6 star**
0%	0%	0%	60%	30%	0%	20%

Note: flow controllers were not included in modelling or estimates

In order to calculate the average sales breakdown across different manufacturers and retailers, the market share of each interview participant was needed. The market share of each participant was determined from interview answers and is listed in Table 10. These numbers were used to calculate average sales data (see section 5.5 regarding sales trends). The remaining portion of the market in each sector was assumed to have the same market breakdown as the market share-weighted average.

Table 10 Estimated market share

Product category	Estimated share of plumbing fixtures market per interviewee						
	Plumbing products retailer B	**Plumbing products supplier E**	**Plumbing products supplier B**	**Commercial plumbing products supplier**	**Commercial tapware supplier**	**Plumbing products supplier D**	**Remaining**
Taps – Residential	20%	40%	20%				20%
Taps – Non-Residential				40%	10%		50%
Toilets – Residential	15%	40%	40%				5%
Toilets – Non-Residential		20%	20%	20%			40%
Showers – Residential	30%	40%	20%			10%	
Urinals – Non Residential		30%	70%				

4.2 Sales data

Two sets of sales data were included in the water use model:

- purchased sales data for white goods spanning 2007 to 2017 by state
- sales data for showers, taps and toilets for the period 2012 to 2018, provided as the fraction of sales in each star band by state. This data was provided by a major retailer of plumbing products.

The trends in sales data can be seen in Figure 17, which shows the average star band over time of the products sold, for NSW. According to this sales data, the average star rating of new taps, showers and clothes washers have not improved since 2012. The average star ratings of new toilets and dishwashers have been increasing, with the average star rating for dishwashers increasing from less than 2 stars in 2007 to 4.5 stars in 2017.

Note that toilet sales data shown Figure 17 were from a plumbing products supplier that had a much higher percentage of sales of 3 star toilets than the other suppliers interviewed, ranging from 46% to 74%, depending on the state (while other suppliers stated 5% or less - see Table 7). The actual sales data used in the model (see page 32) was a weighted average of interview data and sales data, based on estimated market share (see Table 10).

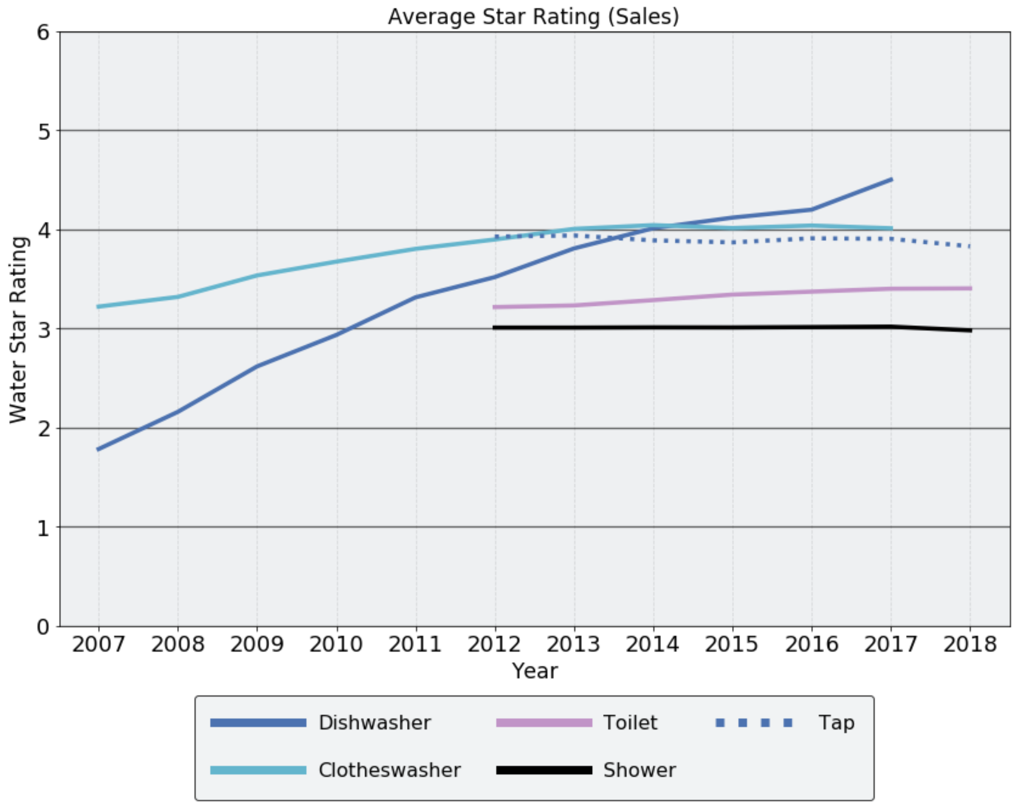


Figure 18 Average star rating of new fixtures and appliances

4.3 BASIX data

Data from the NSW BASIX scheme were available for fixtures in new houses in NSW, and were used as a cross reference for sales data developed for the model. These data come from the online BASIX tool and are the selections made by users so it represents what was promised on BASIX certificates, rather than what has been certified as installed. Note that BASIX allows installation of fixtures that are more efficient than what was specified on the BASIX Certificate (the BASIX selections are a minimum). These data will be different from average sales data because of the BASIX water and energy saving requirements (new dwellings in NSW must meet water and GHG reduction targets) but BASIX data (Table 11) may give an indication of where the market is headed.

As expected, the shower and toilet selections in new homes are more efficient than overall sales. Surprisingly the tap selections for BASIX dwellings are not more efficient than sales data – BASIX dwellings commit to more 3 star taps, fewer 4 star taps and slightly more 6 star taps. 1-2% of toilets selections were 1 or 2 star, which are not allowed to be installed under the Plumbing Code of Australia but because BASIX allows installation of fixtures that are more efficient than that specified on the BASIX Certificate, these selections do not prove that 1 or 2 star toilets were actually installed.

Table 11 BASIX data for new houses in NSW

Fixture	Percentage by year									
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Showers										
3 star	95.5%*	98.3%*	100%	100.0%	100.0%	84.2%	58.6%	55.2%	55.7%	52.9%
4 star e	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%	14.4%	16.2%	16.3%	17.5%
4 star f	0.0%	0.0%	0.0%	0.0%	0.0%	10.7%	27.0%	28.6%	28.0%	29.5%
Toilets										
1 star	1.6%	1.4%	0.8%	0.9%	0.7%	0.6%	0.7%	0.8%	0.9%	0.6%
2 star	0.0%	0.3%	1.0%	0.9%	0.6%	0.5%	0.4%	0.6%	0.5%	0.6%
3 star	81.0%	75.7%	72.9%	71.7%	69.8%	59.9%	54.5%	51.2%	43.6%	38.6%
4 star	15.7%	21.0%	24.9%	26.2%	28.5%	35.8%	37.0%	39.7%	46.5%	49.4%
5 star	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	7.1%	7.6%	8.4%	10.7%
Bathroom taps										
3 star	0.0%	27.4%	76.2%	74.9%	72.3%	67.7%	63.6%	59.0%	54.5%	47.2%
4 star	0.9%	4.8%	11.2%	12.2%	13.4%	15.4%	17.9%	19.8%	22.1%	26.7%
5 star	9.6%	9.0%	6.5%	7.8%	9.5%	11.8%	13.9%	16.2%	17.8%	19.5%
6 star	72.8%	49.4%	6.1%	5.1%	4.8%	5.1%	4.6%	5.1%	5.5%	6.6%
Kitchen taps										
3 star	78.9%	78.3%	74.7%	71.2%	68.0%	62.8%	58.6%	54.8%	52.2%	46.4%
4 star	4.4%	7.7%	14.2%	16.9%	20.0%	23.3%	26.7%	29.9%	30.5%	34.0%
5 star	8.7%	6.8%	6.1%	7.4%	7.4%	9.3%	10.7%	10.9%	12.5%	14.4%
6 star	0.0%	1.7%	4.9%	4.5%	4.6%	4.7%	4.0%	4.3%	4.8%	5.3%

*Incomplete data (missing data may be for lower rated showers)

4.4 Sales trends used in model

This subsection describes for each product type, the 'with' and 'without' WELS cases as modelled to estimate water usage.

4.4.1 Showers

4.4.1.1 With WELS

Historical shower sales data were chosen on the basis that efficient showers were first labelled in 1988 (under the voluntary AA scheme), and sales data from 2012 to 2018 were readily available. We also know the stock of efficient showers at several points from 1994 to 2013 from ABS stock survey data for 'efficient' (3 star or better) showers at seven points between 1994 and 2013 (four points before WELS began and three points after).

For the model, we increased the sales of 3 star showers linearly from 0% in 1984 to peak at 2010 (at around 98%, but varying slightly from state to state) then decreasing slightly to 2012 (the first sales data point). Sales of 4 E showers were assumed to increase linearly from 2009 to meet the sales in 2012 which were around 6%, noting that 4 F shower sales are currently negligible.

Sales of inefficient showers (0 star to 2 star) decreased in total from 100% in 1966 to 0% in 2010, with 0 star dominating first then sales shifting to 1 star and later to 2 star (validated by looking at ABS total 3 star showers and ISF's 2015 model).

In the future it was assumed that 3 star showers continue to dominate (in the absence of any policies to promote higher rated showers) with 4 E shower sales increasing linearly to 10% in 2020 then remaining flat and 4 F shower sales increasing linearly to 5% in 2023 then remaining steady.

4.4.1.2 Without WELS

It was assumed that without WELS there would be no 4 star labelled showers. The shower sales in 2005 were continued forward in the 'without WELS' case, i.e.

- 67% 3 star showers from 2005 to 2036
- 33% 2 star showers from 2005 to 2036.

The average flow rate of all shower sales was calculated for the 'with WELS' and 'without WELS' scenarios. As shown in Figure 18, there is a 10% reduction in shower water use with WELS from 2011 onwards. Between 2006 and 2036, the difference in the average flow rates for showers between the cases is around 0.7 L per minute.

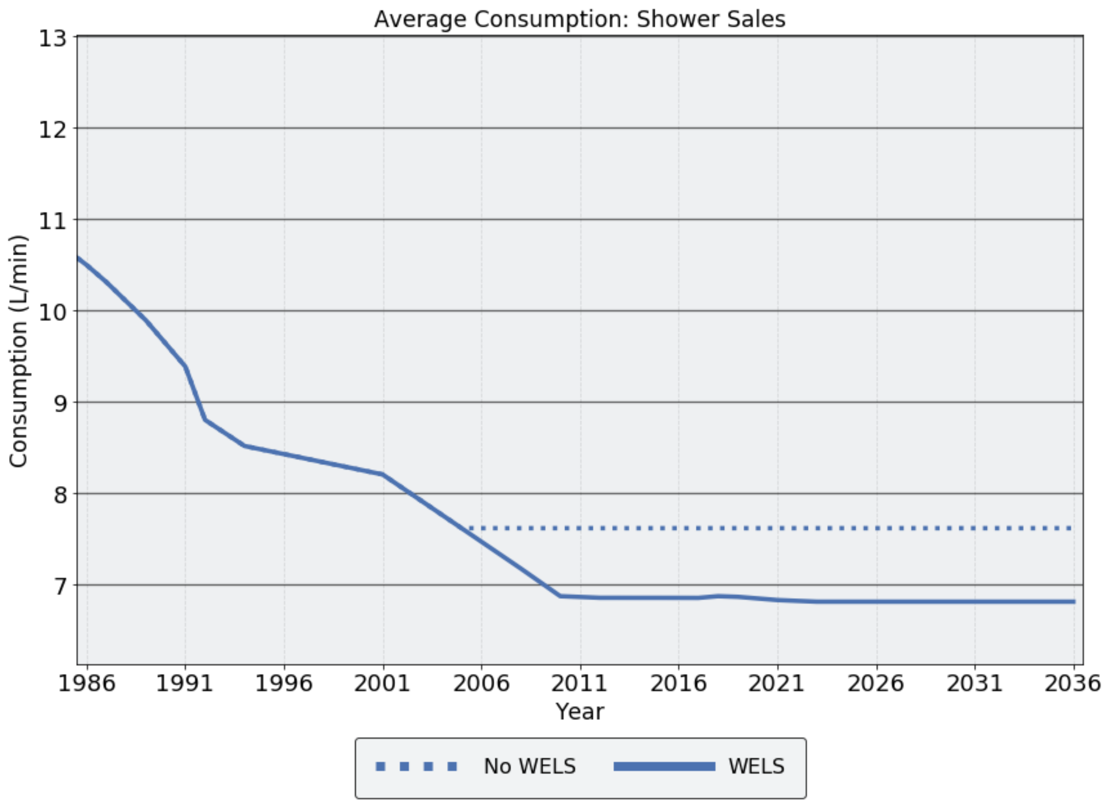


Figure 19 Average flow rate of showers sales, with and without WELS

4.4.2 Toilets

4.4.2.1 With WELS

Toilet sales pre-WELS were determined from the dates on which models appeared in the market and when particular models where made mandatory. All toilets sold were single flush until 1981-82 (0 star, average 12 L per flush). In 1982, 11/5.5 L (0 star, average 9 L per flush) toilets were introduced and made mandatory in most states, therefore all toilet sales between 1982-83 and 1990-91 are assumed to be 11/5.5 L.

All toilet sales between 1991-92 and 1994-95 are assumed to be 1 star (dual flush 9/4.5 L) as they were introduced and made mandatory at that time. In 1995-96, there is a transition period from 1 star to 3 star toilets. In 1996, 3 star toilets were made mandatory and so from 1996-97 to 2004-05, all toilets sold were 3 stars (1 star replacement cisterns were allowed but were not included in the modelling). In 2005, 4 star toilets entered the market but were not made mandatory.

Sales data from 2012 to 2018 show that 4 star toilets dominated the market in all states and that 3 star toilets made up the balance. In the model, sales of 4 star toilets for the period 2005 to 2012 increased linearly and 3 star toilets decreased linearly.

In 2007, 5 star toilets were first registered and 6 star toilets followed in 2016. Current sales data show negligible sales of these models (around 0.1%), however, in 2014 (the latest BASIX data available) 10.7% of development applications for new houses in NSW indicated (on their BASIX Certificate) that they would install a 5 star toilet.

Futures sales of 3 star toilets were assumed to remain at 2018 levels (around 10%) because of current demand (whether it is still true that in existing dwellings the plumbing system is not able to cope with lower flows (Schlunke, Lewis and Fane 2008) or just perceived to be true). Futures sales of 4 star toilets were assumed to drop slightly to 80% by 2036 and the total sales of 5 and 6 star toilets were assumed to increase to 10% (with a 5:1 ratio of 5 star to 6 star).

4.4.2.2 Without WELS

In 2005, 4 star toilets already existed but sales were low. For the 'without WELS' scenario it was assumed that 4 star toilet sales increased linearly, reaching 50% by 2036 and that 3 star toilets made up the balance. The average difference between 'with' and 'without' WELS cases is 0.41 L per flush across the period of analysis (Figure 19).

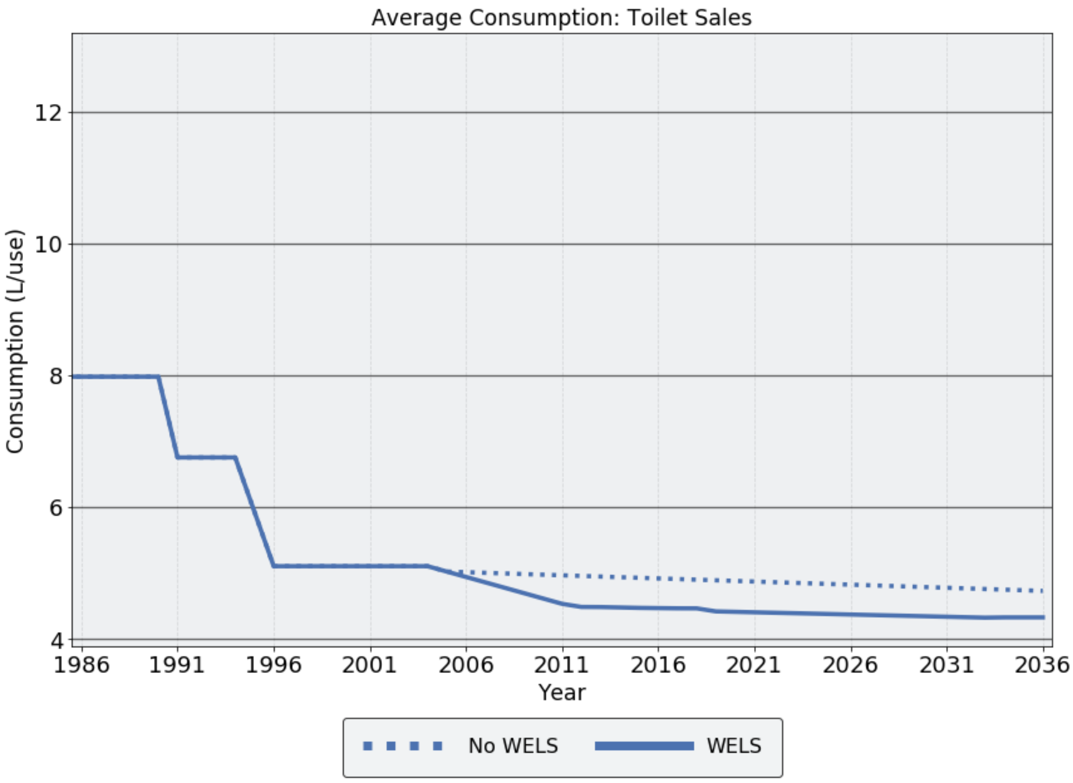


Figure 20 Average flush volume of toilet sales, with and without WELS

4.4.3 Taps

4.4.3.1 With WELS

In the 'with WELS' case there were no 0, 1 or 2 star taps sold from 2012. Before 2012 a number of assumptions were made for tap sales. The model starts in 1966 with 99% 0 star and 1% 1 star taps, with sales of 0 star taps decreasing linearly to 0% in 1996. Sales of 1 star taps increased until 1990, peaking at 94% before decreasing to zero in 2005. Sales of 2 star taps started in 1987 and increased until 2005, peaking at 90% before decreasing to zero in 2012. Sales of 3 and 4 star taps began in 2005 and increased to meet the sales data from 2012. Sales of 5 star taps began in 2007 and 6 star taps began in 2008, with both increasing to meet sales data from 2012. It was assumed that tap sales remained at 2018 levels until 2036.

4.4.3.2 Without WELS

It was assumed that without WELS there would have been no sales of 5 or 6 star taps from 2005 to 2036. It was assumed that sales of 3 star taps rose to 90% by 2012 and 4 star taps rose to 10% then remained steady (Figure 20). The difference from 2006 to 2036 between the two cases is estimated at 1.1 L per minute on average.

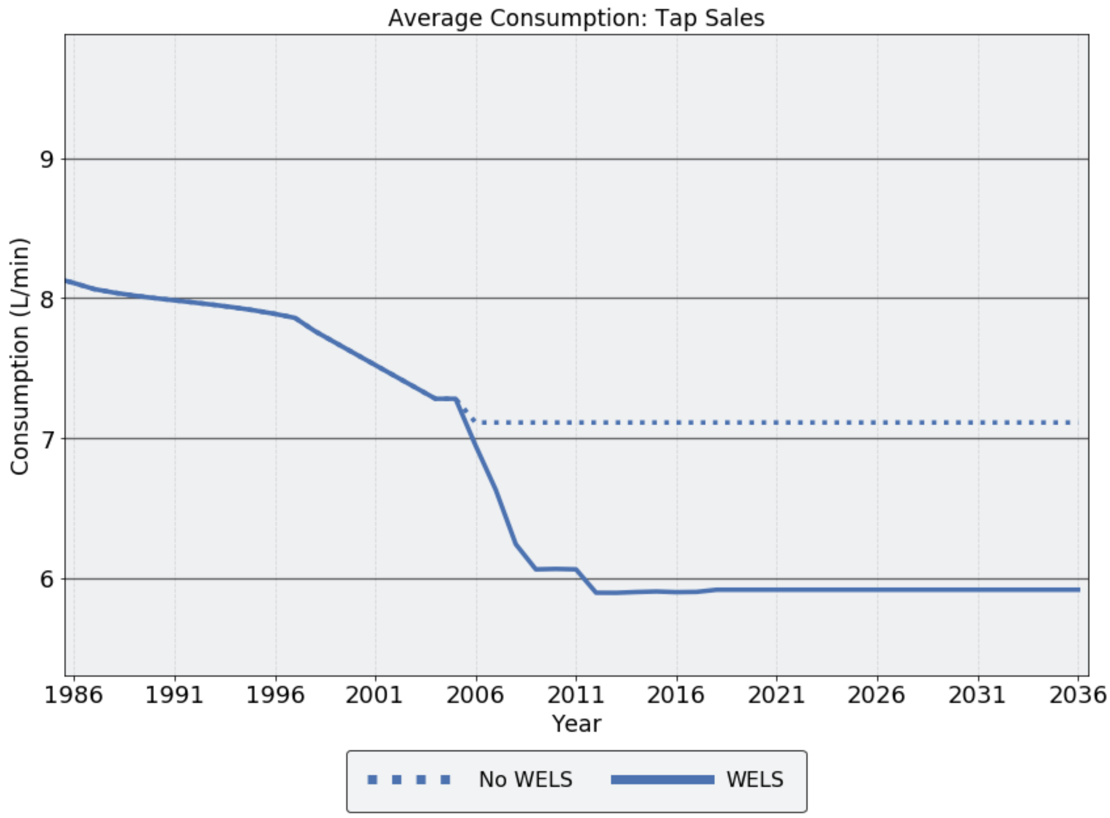


Figure 21 Average flow rate of tap sales, with and without WELS

4.4.4 Urinals

4.4.4.1 With WELS

The data used to determine urinal sales from 1966 to 2036 were a combination of sales data for 2018; WELS registration data showing that 5 star urinals became available in 2007 and 6 star urinals in 2011; as well as information that in 2005 the average flush volume of urinals sold was 2.2 L per flush, and that in 2003 efficient urinals used 2.8 L per flush and inefficient ones used 6 L per flush (Chanan, White and Howe, 2003).

Sales of all models were adjusted to fit the above sources of information, resulting in the following sales patterns:

- zero star urinals made up 100% of sales until 1999, then decreased gradually to 1% in 2008 and stayed constant until 2018
- 1 star urinal sales increased from 2000, peaking at 60% in 2002 before decreasing gradually to 3% in 2005 and remaining there until 2018
- 2 star urinals were sold from 2002 to 2004 (current sales are zero)
- 3 star urinals sales began in 2004, peaking at 93% in 2005 before gradually decreasing to match 2018 sales data
- 4 star urinals began to sell in 2006 and increased slightly, peaking at 14% in 2009 and 2010 before decreasing gradually to meet 2018 sales data (1%)

- 5 star urinals sales began in 2007 and increased gradually to 20% for the years 2011 – 2013 before decreasing to 1% in 2018
- 6 star urinal sales began in 2011 and gradually increased to 69% in 2018.

It was assumed that from 2019 to 2036, sales remained constant at 70% for 6 star, 25% for 3 star and 2.5% each for 4 and 5 star.

4.4.4.2 Without WELS

It was assumed that without WELS there would have been no 6 star urinals, that from 2006 to 2036, 4 star urinal sales would gradually eclipse 3 star urinals, and that small numbers of 0, and 1 star urinals would have continued to be sold, as follows:

- 2% of urinal sales from 2007 to 2036 would be 0 star
- 3% of urinal sales from 2005 to 2036 would be 1 star
- sales of 3 star urinals would drop gradually to 26% in 2036
- sales of 4 star urinals would increase gradually to 70% in 2036
- 5 star urinals would make up 1% of urinal sales from 2007 to 2036

The results of the average consumption per flush are shown in Figure 21. The difference grows to about 1 L in 2019 and is maintained for the projection period. Including the historical period, the average difference in flush volumes is 0.71 L between the two scenarios modelled.

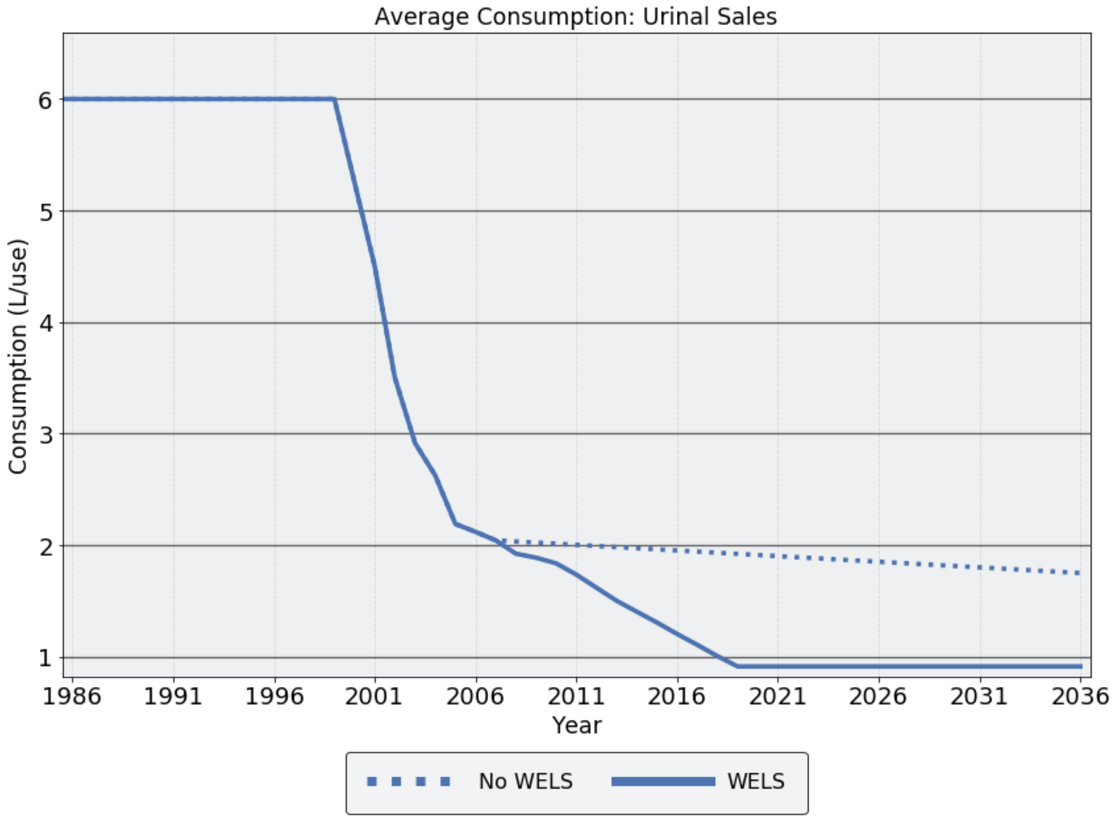


Figure 22 Average flush volume of urinal sales, with and without WELS

4.4.5 Clothes washers

4.4.5.1 With WELS

Sales data were available for clothes washers from 2007 to 2017. In the period from 1966 to 2006 it was assumed that:

- 1 star sales were steady at 10% from 1966 to 2005 before decreasing gradually to meet 2007 sales data (negligible sales from 2007)

- 1.5 star sales were 50% from 1966 to 1991 then dropped to 40% for 1992 to 1998, and to 35% until 2001. After 2001 sales gradually decreased to meet the 2007 sales data
- 2 star sales were 40% until 1991 then 50% in 1992 and 40% until 1999. From 2000 sales dropped to meet 2007 sales data
- 2.5 star sales were zero until 2007 (and less than 1% in 2007)
- 3 star sales were zero until 1992 then gradually increased to meet the 2007 data
- 3.5 star sales were zero until 2007 (and less than 1% in 2007)
- 4 star sales were zero until 2000, then increased to meet 2007 sales data
- 4.5 and 5 star sales were zero until 2007 (and sales are low in 2007).

Sales in 2036 were assumed to be 30% 3.5 star, 10% 4 star, 50% 4.5 star and 10% 5 star. Sales of 3 star clothes washers were assumed to gradually decrease to zero by 2023 and sales of higher rated washing machines were assumed to gradually increase (or decrease for 4 star) until 2031 then remain constant.

Top loaders have lower average star ratings than front loaders and so 3.5 star sales were kept until 2036 to account for people who only want a top loader washing machine (the average star rating of top loaders sold between 2007 and 2017 was 3 stars, while the average star rating of front loaders was 4.3 stars).

4.4.5.2 Without WELS

It was assumed that without WELS there would be no 4.5 or 5 star clothes washers sold during the period 2006 to 2036. It was assumed that:

- 4 star clothes washers would be 40% of the market from 2006 to 2036
- 1, 1.5 and 2 star clothes washer sales would decay to 0% by 2018
- 3 star clothes washer sales would gradually increase until they were 60% of the market.

From 2017 the average difference for the ‘with’ and ‘without’ WELS cases projected at 14.5 L per wash (Figure 22).

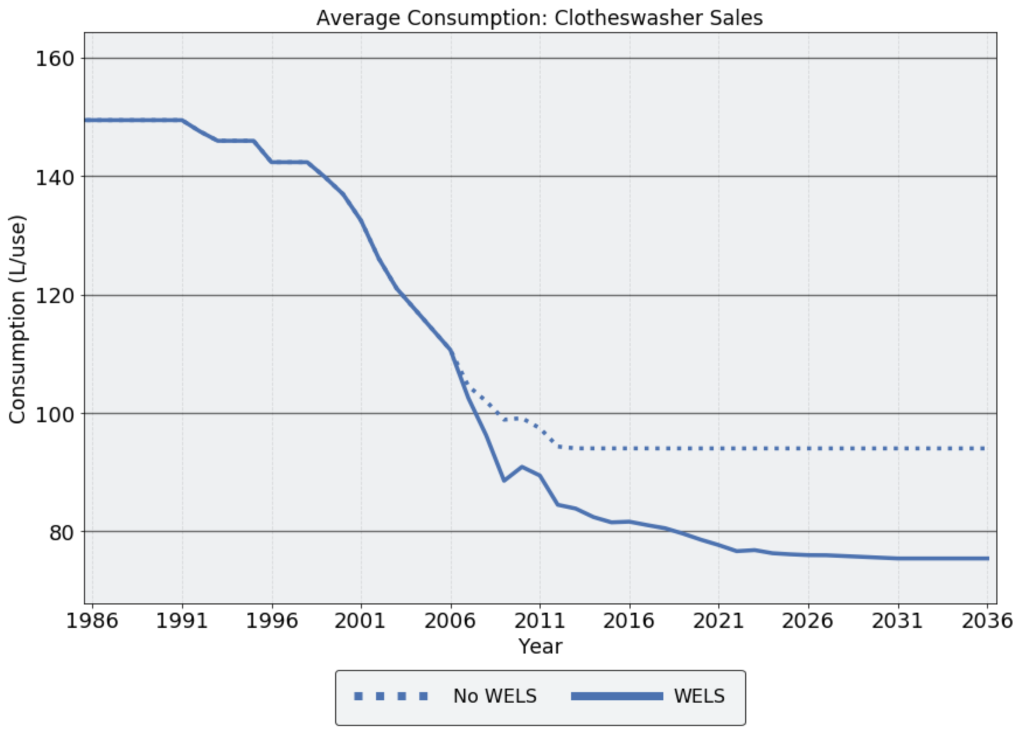


Figure 23 Average water consumption of clothes washers, with and without WELS

4.4.6 Dishwashers

4.4.6.1 With WELS

Sales data were available for dishwashers from 2007 to 2017. In the period from 1966 to 2006 it was assumed that:

- sales of 0 star rated dishwashers decreased gradually from 100% in 1996 to 1% in 1993 then stayed constant at 1% until 2006
- sales of 1 star rated dishwashers increased gradually from 4% in 1967 to 81% in 1987, remaining at 80% from 1988 to 1993 then decreasing gradually to 5% in 2000 and remaining at 5% until 2007
- sales of 1.5 star dishwashers began in 1988, peaked in 1995 at 40% and then decreased to 6% by 2006
- sales of 2 star dishwashers started in 1995, peaked at 64% in 1999 then decreased to 45% by 2006
- sales of 2.5 star dishwashers began in 2000 and increased to 20% by 2006.
- sales of 3 star dishwashers started in 2000 and increased to 14% by 2006
- sales of 3.5 star dishwashers were 1% from 2000 to 2006
- sales of 4 star dishwashers were 1% from 2000, increasing to 5 % in 2005, then increasing to 8% in 2006.
- There were no sales of 4.5+ star dishwashers before 2007.

4.4.6.2 Without WELS

It was assumed that without WELS the sales breakdown by star band would have remained the same from 2005 to 2036 (Figure 23).

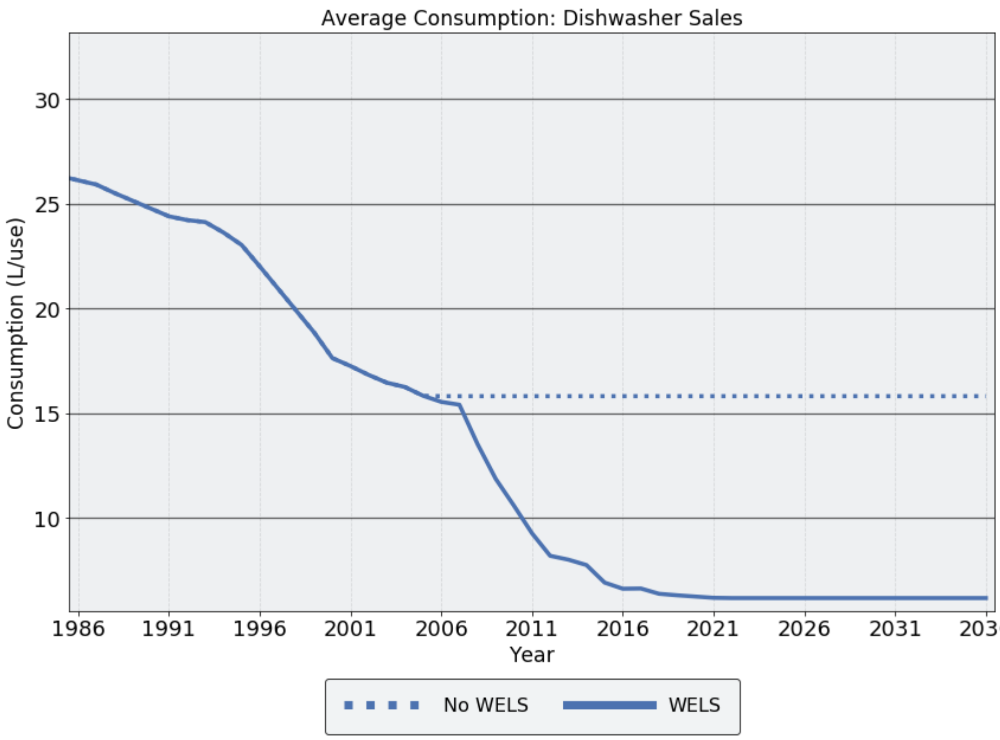


Figure 24 Average consumption of dishwashers, with and without WELS

The average difference per dishwasher run, shown in Figure 23, between the 'with' and 'without' WELS cases is 8 .5 L. This difference is expected to reach a maximum of 10 L per wash in 2021 and then be maintained into the future. This difference, together with difference in water use shown for other products, is at the core of the modelling and estimation of water savings due to the WELS scheme in this study.

5 Estimation of savings

This section describes the analysis of water use and the methods and assumptions used to estimate water savings for the ‘with’ and ‘without’ WELS modelling scenarios. It also describes how water-associated energy use and GHG emissions were calculated, with a particular focus on the differences in water heating technologies and requirements across Australian states and territories.

5.1 Water use

The modelling period for the study is from the start of WELS in July 2006 to end of June 2036. The approach used to estimate household water consumption for each indoor appliance and plumbing fixture is similar to that of Fyfe *et al* (2015) but with the following improvements:

- Each Australian State and the Northern Territory were modelled separately
- Stocks and sales of all product types were categorised and modelled individually by star rating bands as opposed to a simple efficient/inefficient split used for most product types
- Recent sales data were used to improve sales projections
- User behaviour was updated with recent end-use studies where possible. Additional distinction between water use behaviour in different states was included.

Unlike the earlier study, the current evaluation also included non-residential urinals, toilets and basin taps. The savings were determined as the difference in water use between the following two scenarios:

- a ‘with WELS’ case constructed to reflect changes that occurred following the inception of the WELS scheme. This is a forecast and hind cast of the current consumption levels. It incorporates the sales data obtained from interviews with purchased sales data as well as available end-use data from end-use and stock studies conducted across Australia in recent times. This scenario starts in 2006 with the introduction of WELS and accounts for population and household growth to 2036.
- a ‘without WELS’ case constructed to reflect the changes already in effect in 2006 when the scheme commenced but with water use continuing as it would have without the scheme. This scenario includes all existing behaviours, policy settings and sales preferences as of 2006, projected with population and household growth to 2036. It is assumed that the previous voluntary water efficiency labelling scheme, which existed in Australia before the WELS, continued.

5.1.1 Model framework

Stock modelling was used to keep track of the efficiency of clothes washers, dishwashers, showers, taps, toilets and urinals in Australia. The stock of each star band (including unrated models) of each fixture or appliance was accounted for over the period 1966 to 2036. The stock of each fixture and appliance grows with the number of dwellings and at the end of the lifetime of each fixture or appliance, it is replaced by a new model, chosen according to sales data for that point in time.

Residential and non-residential water use were calculated separately.

The water use from each fixture or appliance was calculated using average usage behaviour (for example, minutes of showering per person per day or average loads of washing per person per day) and the average efficiency of the stock of fixtures at that point in time.

For example, the average per person residential shower water use was calculated using the following formula:

$$shower\ water\ use\ \left(\frac{Litres}{person.day}\right) = average\ shower\ time\ \left(\frac{minutes}{person.day}\right) \times average\ flow\ rate\ \left(\frac{L}{minute}\right)$$

The total shower water use was calculated by multiplying the per capita shower use by population.

5.1.1.1 Residential

Residential water use was calculated using average residential behaviour data (taken from end use studies and surveys that looked at the use of showers, toilets, taps, washing machines and dishwashers at home) and stock models for the same product types.

ABS stock survey data were used to calibrate the stock models, varying appliance/fixture lifetime and sales data to match the modelled stock with real data. Stock models for end uses that are not owned by all dwellings were scaled by a saturation factor. The ABS stock data available was:

- showers: total efficient (3 star +)
- toilets: total dual flush
- dishwashers: saturation
- clothes washers: saturation.

5.1.1.2 Non-residential

There is a lack of data on non-residential end uses; ABS stock surveys only look at household fixtures and end-use studies only look at water use in homes. Data on sales of commercial fixtures for taps and toilets were provided during interviews.

A stock model was created for urinals (which were assumed to be all non-residential) but for other fixtures and appliances the following assumptions were made:

- non-residential washing machines were not WELS rated, and so their water use was not affected by WELS
- the water efficiency trends for toilets and taps were the same in non-residential buildings as in residential ones.

The water use of non-residential toilets was calculated by multiplying the average flush volume of the residential stock by a factor. The factor was calculated as the difference between the average flush volume of current commercial sales divided by the average flush volume of current residential sales (with this relative efficiency being assumed to have been constant over time). A commercial stock model was not created because of the lack of efficiency data for commercial toilets (ABS surveys are done for households, not workplaces).

The resulting factors were:

- non-residential toilets have an average flush volume that is 98% of residential ones
- non-residential taps have an average flow rate that is 109% of residential ones.

5.1.2 Data and assumptions

5.1.2.1 Behaviour

The results of end-use studies were used to determine the average water use behaviour in each state. The parameters used in the model are provided in Table 12.

Table 12 Water use behaviour assumptions used in modelling

	NSW & ACT	VIC	QLD	WA	SA	NT	TAS
Showers							
Frequency (per day)	0.845[A]	0.87[#]	0.82[^]	0.845[A]	0.87[#]	0.82[^]	0.87[#]
Duration (Minutes)	6.31[A]	6.9[#]	5.72[^]	6.31[A]	6.9[#]	5.72[^]	6.9[#]
Toilets							
Frequency (flushes per day)	3.92[^]	4.33[#]	3.51[^]	4.41[^]	4.33[#]	3.51[^]	4.33[#]
Taps							
Frequency (day)	6.8*	6.8*	6.8*	6.8*	6.8*	6.8*	6.8*

	NSW & ACT	VIC	QLD	WA	SA	NT	TAS
Duration (seconds)	22.55&	22.55&	22.55&	22.55&	22.55&	22.55&	22.55&
Dishwashers							
Frequency (house / Week)	3.62#	3.62#	4.04^	3.62#	3.62#	4.04^	3.62#
Frequency (unit / Week)	2.89#	2.79#	3.66^	3.11#	2.97#	3.66^	2.67#
Washing Machines							
Frequency (house / Week)	4.33#	4.32#	5.2^	4.25#	4.08#	5.2^	4.06#
Frequency (unit / Week)	3.46#	3.34#	4.97^	3.72#	3.56#	4.97^	3.2#

Sources:
– Roberts 2017
^ – Beal & Stewart 2014
* – Water Corporation 2010
& – Redhead 2013
A – Average of all four end-use studies

Calculation of the water consumption of fixtures and appliances was based on the WELS rated water use, but for showers and taps this was multiplied by a factor that takes into account that more efficient fixtures and appliances tend to be used differently to less efficient ones. For example, higher efficiency showers are turned on further than lower efficiency ones. For toilets, the ratio of full to half flushes was adjusted so that full flush is used more often for more efficient toilets.

The following data was used to determine the multipliers:

- Toilets: matched the average flush volume with previous modelling (Fyfe *et al* 2015 and Chong *et al* 2008)
- Showers: average flow rates were consistent with 2015 study, but 'efficient' and 'inefficient' showers were split into star bands
- Taps: split the 'efficient' and 'inefficient' categories used in the 2015 study into star bands and made water use consistent with end-use studies

The WELS rated water use and effective water use are shown in Table 13.

Table 13 Assumptions for usage of plumbing fixtures by star band

Toilet model	Unrated single flush	Unrated dual flush	1 star	3 stars	4 stars	5 stars	6 stars
Half flush (L)		5.5	4.5	3.0	3.0	n/a	n/a
Full flush (L)	12.0	11.0	9.0	6.0	4.5	3.0	2.5
Total consumption (L)	12.0	8.0	6.5	5.1	4.35	3.0	2.5

Shower model	0 stars	1 star	2 stars	3 stars	4E stars	4F stars
Minimum flow rate	16	12	9	7.5	6	4.5
Maximum flow rate	20	16	12	9	7.5	6
Fraction of max. flow	59%	70%	76%	77%	86%	100%
Effective flow rate	11.84	11.20	9.09	6.89	6.45	6.00

Tap Model	0 stars	1 star	2 stars	3 stars	4 stars	5 stars	6 stars
Minimum flow rate	16	12	9	7.5	6	4.5	1.1
Maximum flow rate	20	16	12	9	7.5	6	4.5
Fraction of max. flow	45%	50%	60%	70%	80%	90%	100%
Effective flow rate	9.0	8.0	7.2	6.3	6.0	5.4	4.5

5.1.2.2 Dwellings and population data

Demographic profiles for each state were built on publicly available ABS projections for population (table 3222) and dwellings (table 3236), as well as historical population data (table 3105). Proportions of the population living in single or multi-story dwellings, and the percentages of each dwellings type, were based on ABS census data and table 41300.

5.2 Energy and greenhouse gas emissions

5.2.1 Model framework

A hot water system stock model was created that included the common hot water system types (electric resistance, electric heat pump, gas instantaneous, gas storage, solar gas boosted, and solar electric boosted) and the most significant fuel types (electricity and gas).

The hot water system sales used in the model differed depending on whether the hot water system was going into a new or existing dwelling. The rationale is that when hot water systems fail they are usually replaced with the same kind, but in new dwellings there are rules about the type of hot water system that can be installed. Sales also differed depending on whether the hot water system was for a single dwelling or multi-unit development.

The energy used to heat water was calculated from the water demand, hot water fraction of the water used, energy required to heat water, and the following stock model outputs:

- the fraction of hot water heated by each fuel (gas or electricity)
- average efficiency for hot water systems (gas or electricity).

For example, the gas used to heat water was calculated using the following formula:

$$gas\ use\ (GJ) = water\ demand\ (ML) \times hot\ water\ fraction \times energy\ required\ to\ heat\ hot\ water\ \left(\frac{GJ}{ML}\right) \times average\ gas\ hot\ water\ efficiency\ \left(\frac{GJ}{GJ}\right) \times gas\ fraction\ of hot\ water\ stock$$

5.2.2 Data and assumptions

5.2.2.1 Appliances with internal heating

Whitegoods are increasingly moving towards self-heating over a direct hot water connections. On average, the proportion of whitegoods that heat their own water increases with improved star band (as was seen in the WELS database data). To account for this effect, hot water from a percentage of whitegoods in each star band (see Table B1 in Appendix B) is attributed to electric resistance rather than modelled from the hot water system stock model. This data is based on analysis of the WELS database and smoothed with a linear trend.

5.2.2.2 Sales and stock data for hot water systems

The National Construction Code 2016 Plumbing Code of Australia Volume Three requires that hot water systems in new houses meet greenhouse efficiency criteria that effectively rule out electric resistance hot water systems. This is achieved by requiring that the greenhouse intensity is less than 100 g CO_2-e per MJ of thermal energy. This requirement applies in Western Australia, Tasmania, South Australia and the ACT. In NSW the BASIX requirements also effectively rule out electric resistance hot water systems in all new dwellings. In Victoria new dwellings are required to either have a solar hot water system or rainwater tank.

However, electric resistance hot water systems can still be installed in existing dwellings, and in most cases when a hot water system is replaced it is with the same kind of system. Because the market for new dwellings is different to the market for replacement hot water systems, the stock model differentiates between hot water system sales for new dwellings and for existing dwellings.

Hot water system sales in new dwellings (see Appendix B, Table B2) were assumed to be the same as in Energy Efficient Strategies (2008) except for:

- NSW houses, where BASIX hot water system data were used from 2005 – 2014 and then 2014 values were carried forward to 2036
- Queensland houses from 2006 to 2013 when electric resistance hot water systems were not allowed to be installed in new houses
- Victoria from 2011, 50% of new houses were assumed to have solar hot water systems
- WA, Tas and SA from 2011, no new houses have electric resistance hot water systems.

Sales of replacement hot water systems were assumed to be the same as the hot water system they replaced in 80% of cases and for the remaining 20% of cases were assumed to be the same as the sales for new dwellings.

Hot water stock was available from ABS surveys for the years 2005, 2008, 2011, 2012 and 2014 (see Table B3 in Appendix B). The 2005, 2008, 2011 and 2014 surveys asked for the source of energy used to heat water (electricity, gas, solar, wood or other) but did not differentiate between the different types of hot water systems that use each fuel – electric resistance versus electric heat pump, gas storage versus gas instantaneous, or solar with gas boost versus solar with electric boost. The 2012 survey did differentiate between electric resistance and electric heat pump systems and so the fraction was assumed for heat pump systems in the other survey years. The split between gas (instant versus storage) and solar (gas boost versus electric boost) was taken from Wilkenfeld (2009). The resulting stock data points used to validate the model are given in Appendix B (Table B2) along with sources.

5.2.2.3 Water temperatures

It was assumed that the temperature of hot water was 50° C, which is the maximum temperature allowed to prevent scalding. Shower temperature was assumed to be 40° C (slightly above body temperature) and the average tap temperature was assumed to be 30° C (acknowledging that hot water is not always used).

The energy required to heat water depends on the starting temperature, which varies with location. The temperature values for capital cities were used (see Table B4 in Appendix B), with the average cold water temperature in each capital city being used for the whole of the state.

The energy required to heat water to 50° C and the fraction of water use that is hot water was calculated using the cold water temperatures in each state, and the temperature of the average shower and tap use. These calculated input values, as used in the modelling, are shown in Table 14.

Table 14 Energy needed for water heating by State

Capital city	Energy needed to heat hot water (kJ/L)	Shower hot water fraction	Tap hot water fraction
NSW	132.6	0.68	0.37
Victoria	141.4	0.70	0.41
Queensland	121.3	0.66	0.31
South Australia	134.3	0.69	0.38
Western Australia	122.6	0.66	0.32
Tasmania	155.2	0.73	0.46
Northern Territory	92.0	0.55	0.09
ACT	146.4	0.71	0.43

Efficiencies and lifetime assumptions for hot water heater types, used in modelling, are provided in Appendix B, Table B5.

5.2.3 Greenhouse intensity of electricity and natural gas

The greenhouse intensity of electricity in Australia was available from 1989 to 2017 and for natural gas, the greenhouse intensity factors were available from 2012 to 2017 (DEE 2017). The greenhouse intensity of natural gas from 2006 to 2012 was assumed to be the same as the 2012 values. Future GHG intensities were assumed to decrease towards 2036 in line with the Commonwealth Government's commitment to meet the 2015 Paris Agreement on Climate Change (UNFCCC 2015). This gave an approximate 30% reduction in intensity in 2036 compared to 2005 levels for all energy sources. The exception was for electricity in South Australia, where the intensity was already low and so a 30% decrease was assumed from 2012. Greenhouse intensity data inputs for this study are provided in Appendix C.

6 Results of scheme impact evaluation

This section presents results of the modelling and analysis conducted to evaluate the physical and environmental impacts of the WELS scheme. This includes the outcomes from analysis of stocks of water-using products and the estimation of Australia-wide savings for water, electricity, natural gas and GHG emissions. This results section also includes estimates of the utility bill savings to households and businesses across the country that have flowed from the scheme and can be expected in the future.

6.1 Stock

In looking at the stock analysis and results, this report details the stock trends for clothes washers, showers and taps (the largest end uses), with the results for other fixtures and appliances found in the charts in Appendix D. Stock trends in other jurisdictions were similar to NSW and so only NSW results are shown.

Figure 24 compares the predicted stock of clothes washers in NSW for the ‘with WELS’ and ‘without WELS’ scenarios. In the top row the WELS scenario is on the left and the without WELS scenario is on the right. The bottom two charts contain both scenarios and detail the difference in predictions for 3 star (left) and 4 star (right) models.

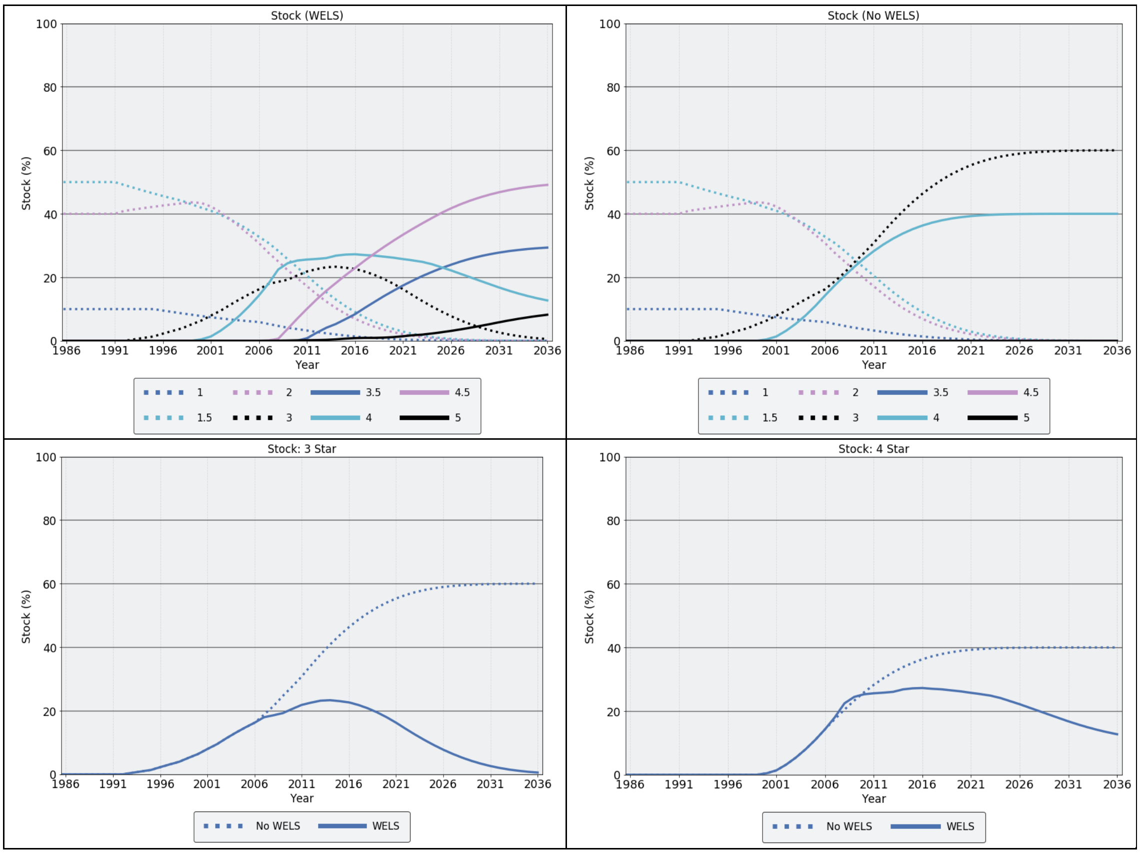


Figure 25 Clothes washer stock predictions for NSW

Figure 24 shows that with WELS, the market becomes dominated by 3.5 and 4.5 star models by 2026 (with 4 and 5 star models heading towards 10% of the stock). Without WELS, the market becomes dominated by 3 and 4 star models by 2011 and there are no 4.5 or 5 star models.

The average clothes washer water use for the ‘with WELS’ and ‘without WELS’ scenarios are shown in Figure 25. Also shown in Figure 25 is the average clothes washer water use for the scenarios modelled in

Fyfe *et al* (2015). The analyses show similar trends and totals. For the current study, although the new model starts with stock that is a little higher in average water use, by 2025 the average 'with WELS' water use has fallen below the 2015 predictions. This is because recent sales data show that the trend towards higher rated clothes washers is stronger than was predicted in Fyfe *et al* (2015). Similarly, average water use for the 'without WELS' scenario in the new model drops below the 'without WELS' scenario (in 2021) and from 2026 the difference between the water use of the 'with' and 'without' scenarios is larger for the new model than it was in Fyfe *et al* (2015).

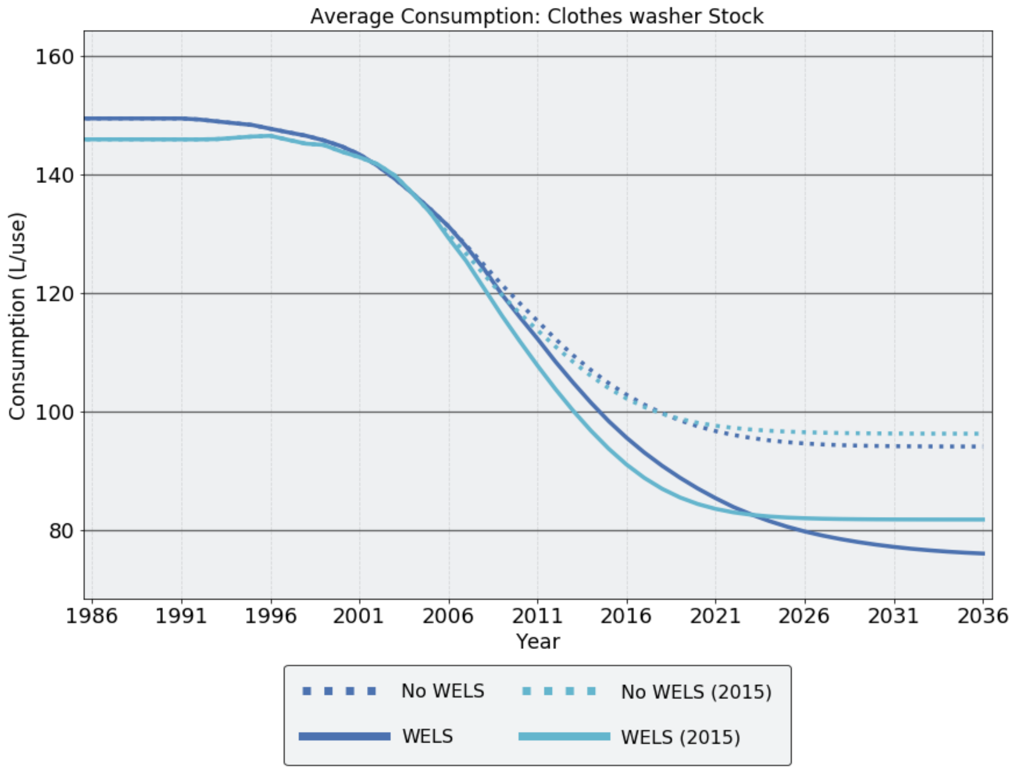


Figure 26 Comparison of average clothes washer water use per load

The shower stock for the 'with WELS' and 'without WELS' cases are compared in the top row of charts in Figure 26. The bottom row of charts show the stock of 2 and 3 star showers for each scenario. Three star showers end up dominating the stock in both scenarios, but with WELS, 3 star showers peak at 91% of shower stock in 2021 before decreasing as sales of 4 star showers rise. By 2036, 4 star showers make up 15% of stock. Without WELS, 3 star showers reach 67% of shower stock and remain there until 2036, with 2 star showers making up the difference.

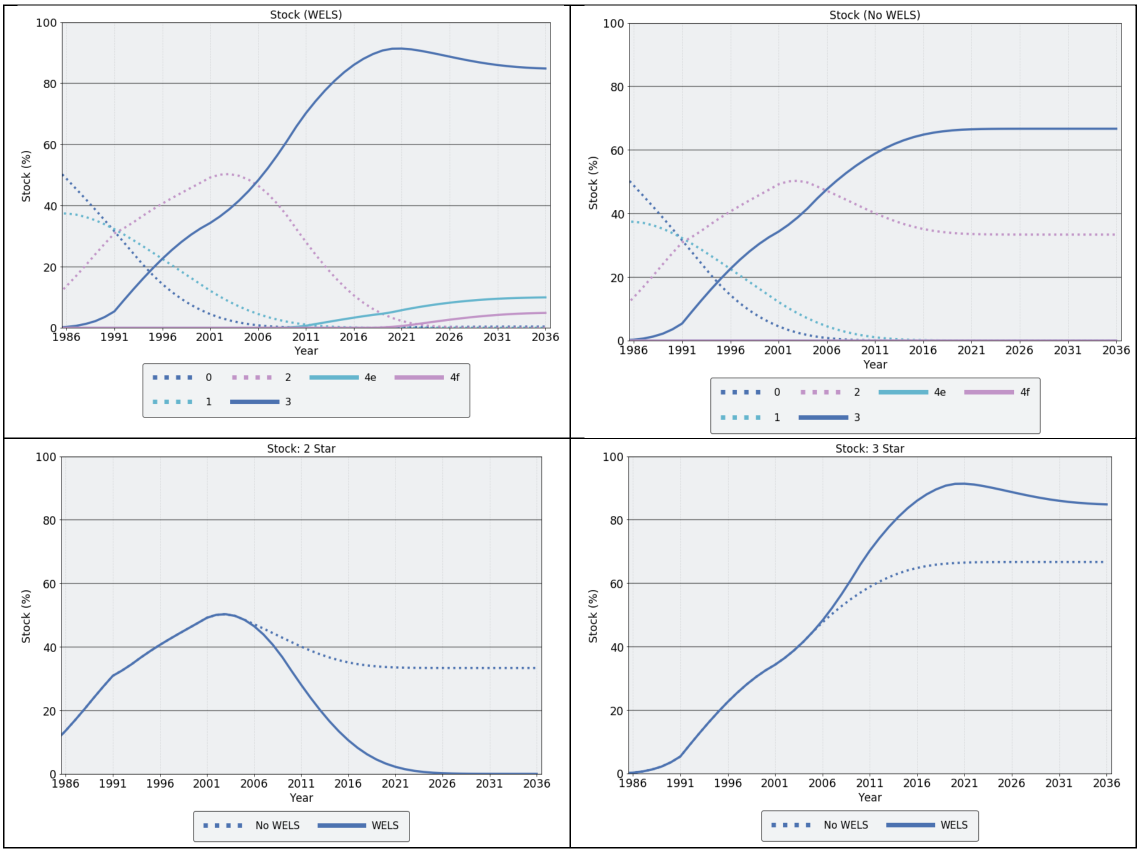


Figure 27 Shower stock predictions for NSW

The average flow rate of showers over time is shown in Figure 27. Some difference can be seen in the modelled outcomes in the current and previous evaluations. The average flow rate of shower stock in the current model starts higher than in the Fyfe *et al* (2015) model. This is because the new model looks at each star band separately while the old model only contained ‘efficient’ and ‘inefficient’ showers, with flow rates of 6.5 L per minute and 11 L per minute, respectively. In the new model the stock begins with all zero star showers, with an average flow rate of 11.84 L per minute, and as time passes these are gradually replaced by 1 star showers then 2 star showers (all which would have previously been classified as ‘inefficient’ and assigned a flow rate of 11 L per minute). Average water use for the ‘with WELS’ case in the new model drops to 6.8 L per minute in 2023 then remains constant until 2036 but in the old model average shower water use continues to drop until 2036 (although it reaches the same level in 2036 as the new model).

In the previous evaluation of WELS, higher shower water use for the ‘without WELS’ case was predicted. This was because inefficient (0, 1 and 2 star) showers were predicted to be sold until 2036 (making up 35% of sales in 2036), but this is an order of magnitude higher than current sales of inefficient showers and so is unlikely to be the case in the future.

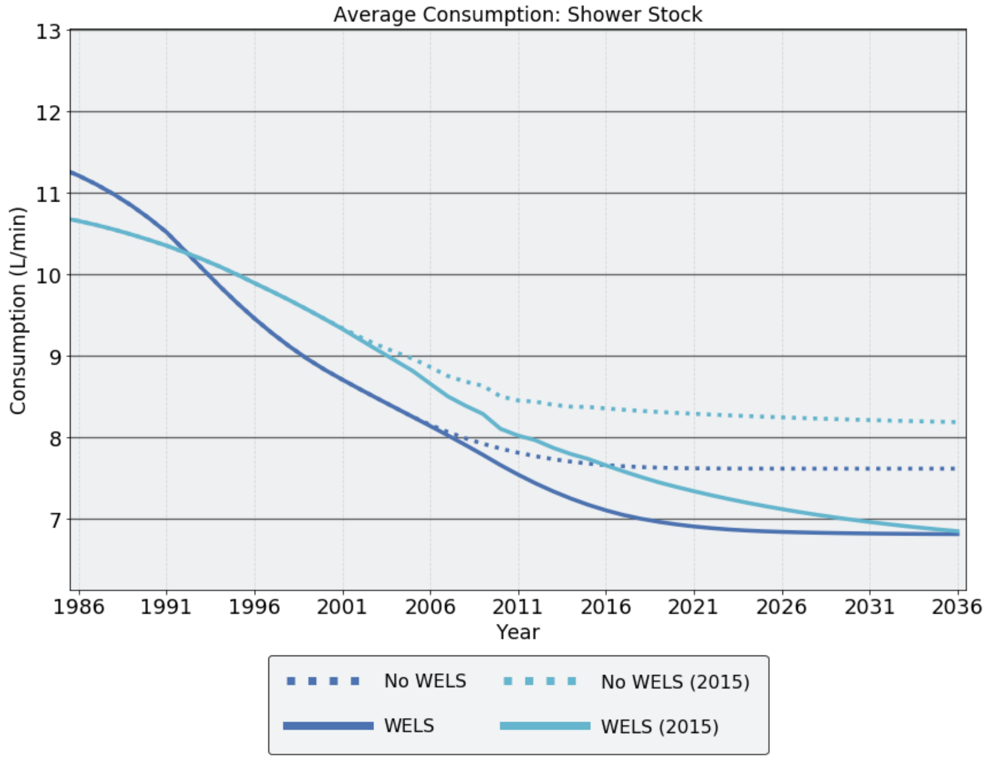


Figure 28 Comparison of average shower flow rate

The tap stock for the ‘With WELS’ and ‘Without WELS’ cases are compared in the top row in Figure 28. The bottom row has charts showing the stock of 2 and 3 star taps for each scenario. A significant difference can be seen for 2 star taps, which disappear under WELS.

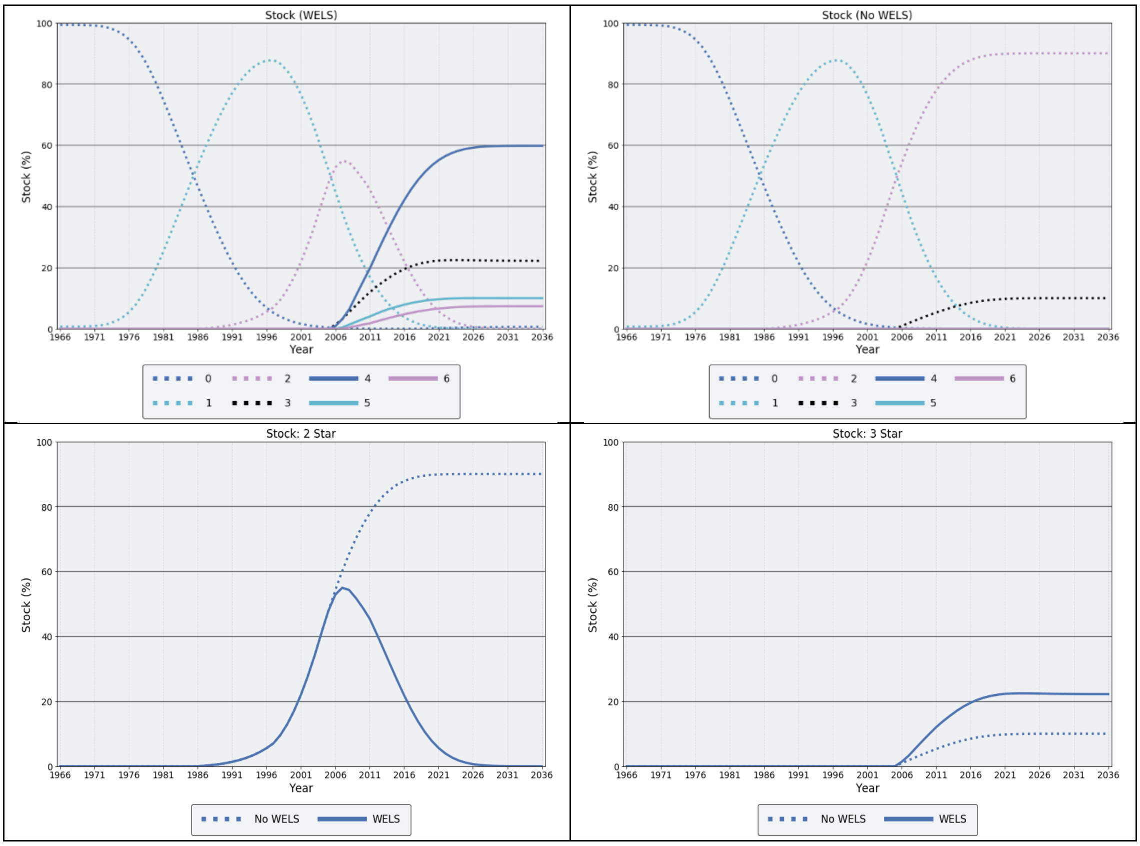


Figure 29 Tap stock predictions for NSW

Figure 29 compares average stock consumption for the Fyfe *et al* 2015 study and the current study. The large difference in totals is based on a difference in model approach, where the 2015 study modelled two classes of tap, sink and basin with on-basin tap water use modelled as being independent of water efficiency. The current study takes a different approach: acknowledging that some water use is independent of the efficiency of fixtures (such as bucket or sink filling) and so will make no difference to water savings. For this reason, only water use that is dependent on flow rate is included in the modelling. Significant for the results, the difference between 'with' and 'without' WELS cases are not great between the two studies.

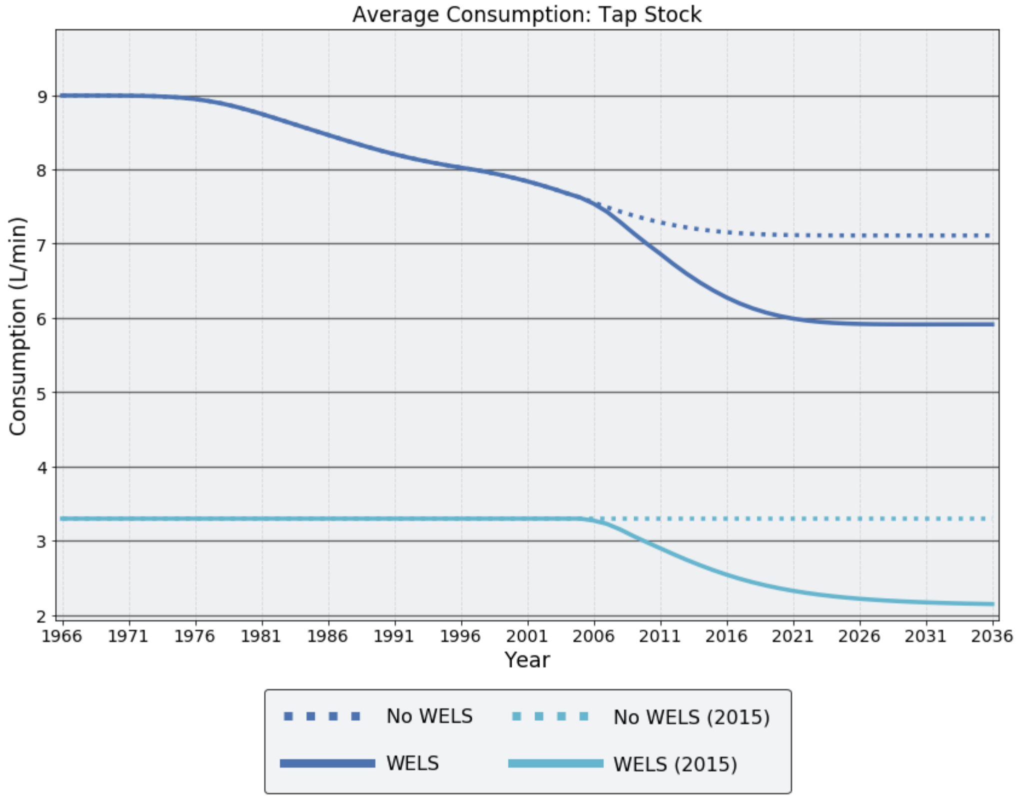


Figure 30 Comparison of tap flow rates

Stock charts for dishwaters, toilets and urinals are provided in Appendix D. The comparisons to the Fyfe *et al* 2015 modelling show a significant difference for dishwashers. The modelling in the previous study of these appliances appear to lack consistency with the stated approach (although because the overall use is low this has not real impact on total savings). The charts also show some differences for toilets but, as with taps, total savings are likely to be similar.

Some of the differences shown between the current and previous studies in figures 26, 27, and 28 as well as Appendix D can be explained by the scope of the analysis represented. Fyfe *et al* (2015) modelled Australian stocks as a whole whereas the current study did this state by state. Only the stock charts for the NSW model (which included ACT) are included in this report (as representative of the whole).

6.2 Water savings

The average per capita impact of WELS can be seen in Figure 30, where the savings as a result of WELS are broken down by fixture/appliance. The analysis predicts that by 2036, WELS will be saving 19.5 litres per person (or capita) per day across Australia on average.

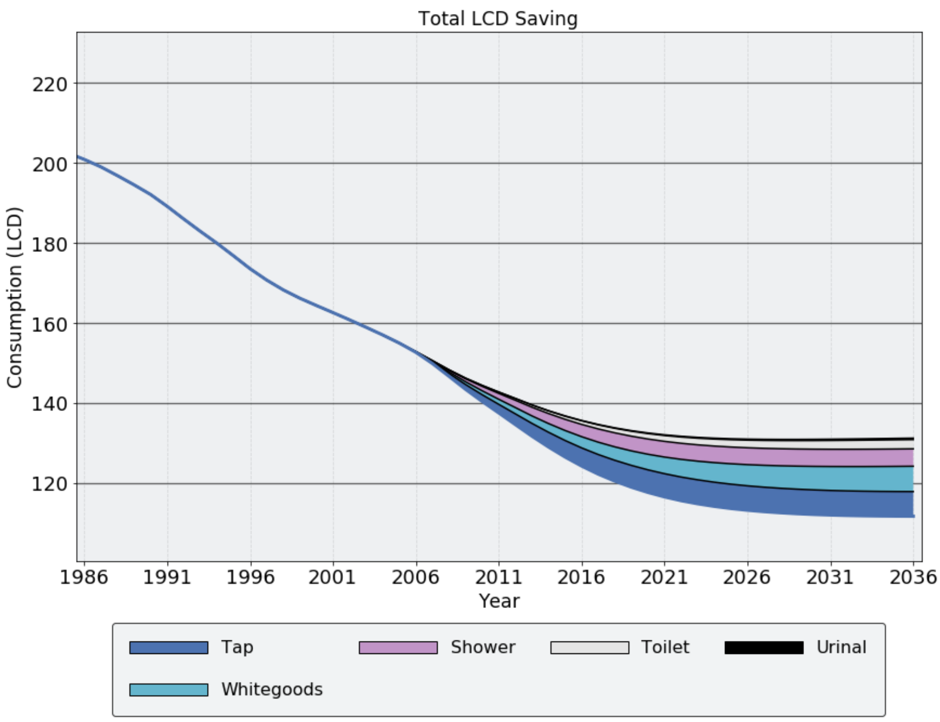


Figure 31 Total per capita water use for WELS rated fixtures and appliances

The yearly water savings resulting from WELS are shown in Figure 31. In current year (2017-18) the scheme is estimated to be saving 112 GL/year across Australia. By 2026 this is anticipated to rise to 185 GL/year and reach 231 GL/year in 2036. Savings attributable to taps are initially the highest component of total savings but as time passes, the savings arising from whitegoods take over.

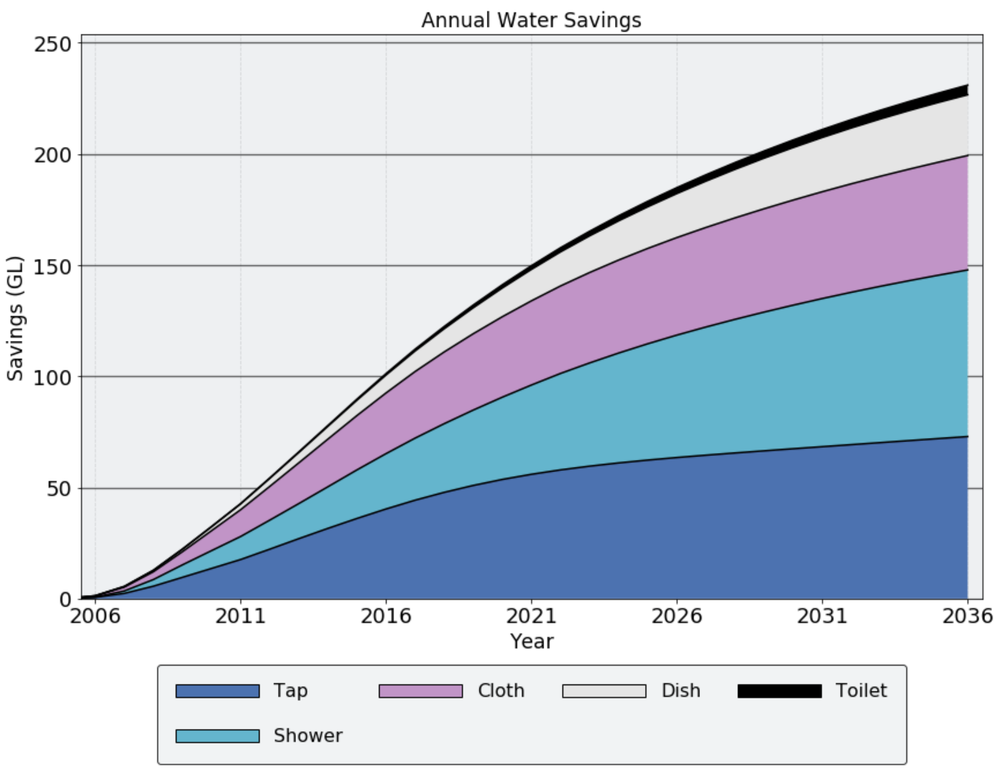


Figure 32 Yearly water savings due to WELS, all Australia

The estimated saving of 112 GL/year across Australia in 2017 is the equivalent of 21%[2] of the water supplied for all purposes in Greater Sydney (a region with a population of 5 million people) in a year. It is also approximately 25% of the total volume of Sydney Harbour.

The savings in the year 2017 as well as 2026 and 2036 are compared by product type in Table 15. The values from the previous study (Fyfe *et al* 2015) are included for comparison (but not for 2036 because the 2015 modelling only went to 2030). The most significant difference between the 2015 and 2018 results related to dishwashers, with the current study predicting savings around four times as large. One reason for the 2018 results is the advantage of including dishwasher sales data up to 2017, which showed a recent rapid improvement in efficiency.

Table 15 Snapshots of estimated annual water savings since WELS commencement

Product type	Study	2017 (GL/yr)	2026 (GL/yr)	2036 (GL/yr)
Clothes washers	2015	21.2	29.7	-
	2018	19.5	38.1	52.4
Dishwashers	2015	2.3	4.67	-
	2018	8.4	17.0	22.5
Showers	2015	35.9	61.45	-
	2018	29.9	43.9	51.5
Taps	2015	40.74	62.65	-
	2018	44.3	63.5	72.9
Toilets	2015	11.19	23.05	-
	2018	9.2	19.8	27.3
Urinals	2015	-	-	-
	2018	0.8	2.7	4.4
Total	2015	**111.3**	**181.5**	**-**
	2018	**112.2**	**184.8**	**230.9**

The total annual water consumption for WELS-rated fixtures and appliances is shown in Figure 32. The result is of interest because it combines the impact of efficiency improvements (reductions to per capita consumption) with the impact of population growth (increase in the number of water users). There was a peak in water use from WELS-rated products in 1990 of 1200 GL per year, then total water use dropped until 1999 and remained fairly steady until WELS was introduced. With WELS, total water use fell again from 2008 until 2016 before beginning to rise (owing to high population growth in Australia overwhelming per capita savings). The 1990 peak of 1200 GL is not predicted to be reached again until 2028.

In the 'without WELS' case, total water use would have increased from 2006 and reached 1200 GL in 2016. This is 12 years earlier than was expected to occur with WELS. In both the 'with WELS' and 'without WELS' scenarios however, the total water use grows steadily after returning to its previous peak.

[2] Greater Sydney had a total potable demand averaged 537GL/yr across 2015 and 2016. From the Urban National Performance Review 2016–17: Complete dataset (BOM 2017)

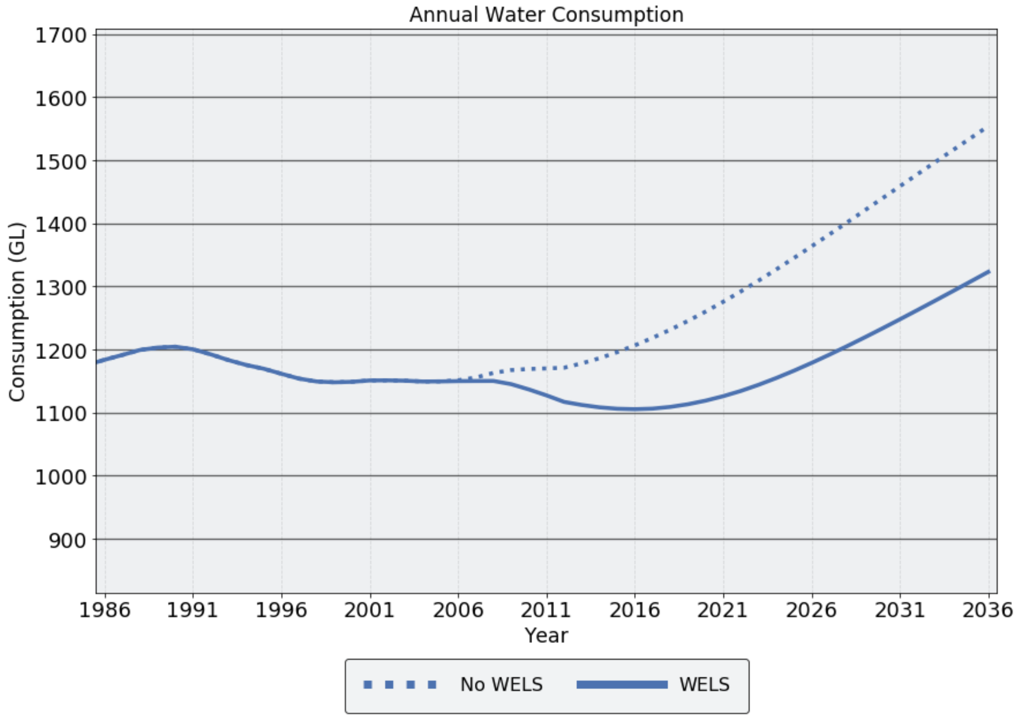


Figure 33 Total water consumption, with and without WELS

The steady growth in total demand from WELS-rated products from its low point in 2016 (Figure 32) points to a potential opportunity for further new measures that may increase the effectiveness of, or complement the current WELS scheme.

6.3 Energy and greenhouse savings

Electricity and natural gas consumption associated with hot water use by WELS-rated fixtures and appliances are shown in Figure 33 and Figure 34, respectively. Similar to water use, these trends are due to the combination of opposing influences – water efficiency improvements and population growth – but they are also influenced by trends in hot water system selection. In particular there has been a trend towards gas instantaneous heating, and away from electric resistance hot water systems. Both electricity and gas consumption reach a peak in 1990 before decreasing and then increasing again (as population growth overwhelms efficiency improvements). The combined impact of WELS and hot water system trends is to delay the time it takes to get back to the values of the 1990 peak. For gas this delay is 14 years (from 2014 without WELS to 2028 with WELS) and for electricity, the delay is more than 16 years (from 2020 to later than 2036 because electricity is still below the 1990 peak in 2036.

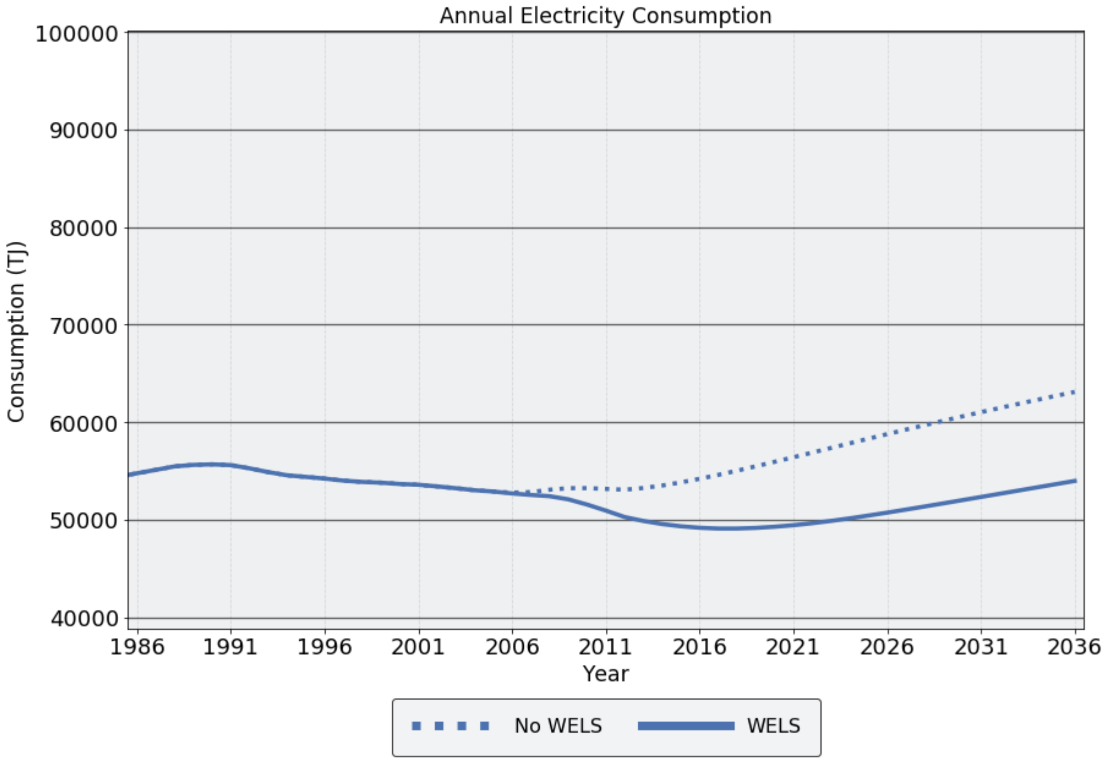


Figure 34 Electricity consumption associated with WELS 1986-2036

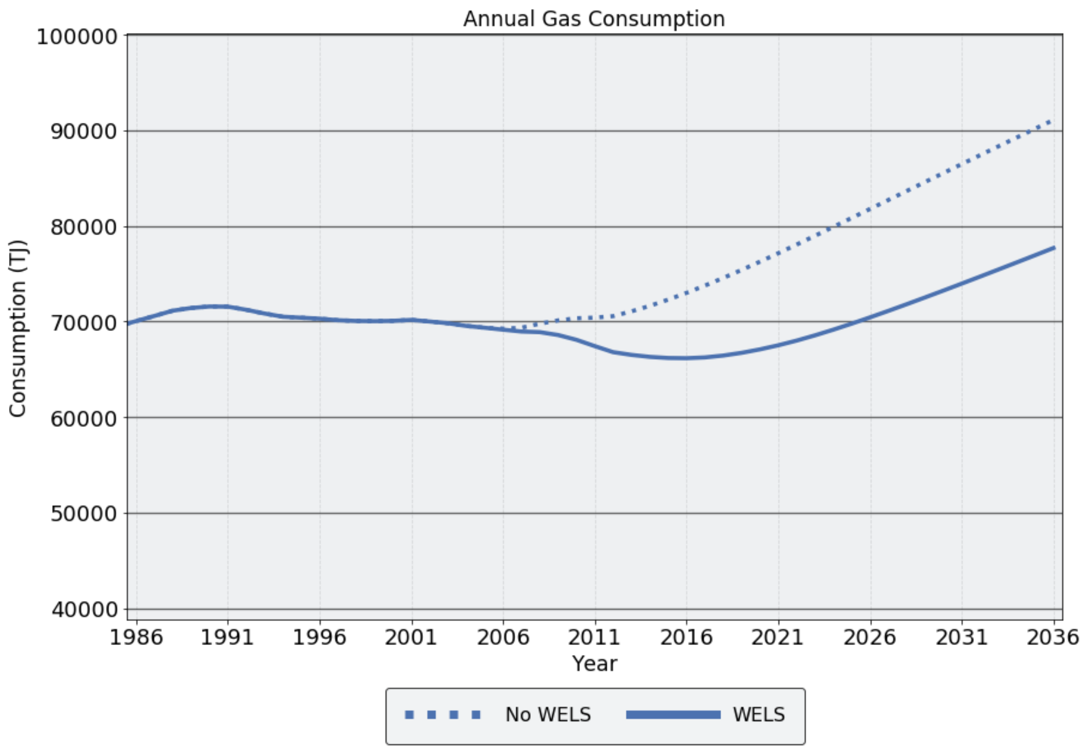


Figure 35 Gas consumption associated with WELS 1986-2036

Yearly electricity and gas savings resulting from WELS associated hot water savings are shown in Figure 35. The split between gas and electricity is determined by the hot water system stock (which is shown for each state in section 7.2).

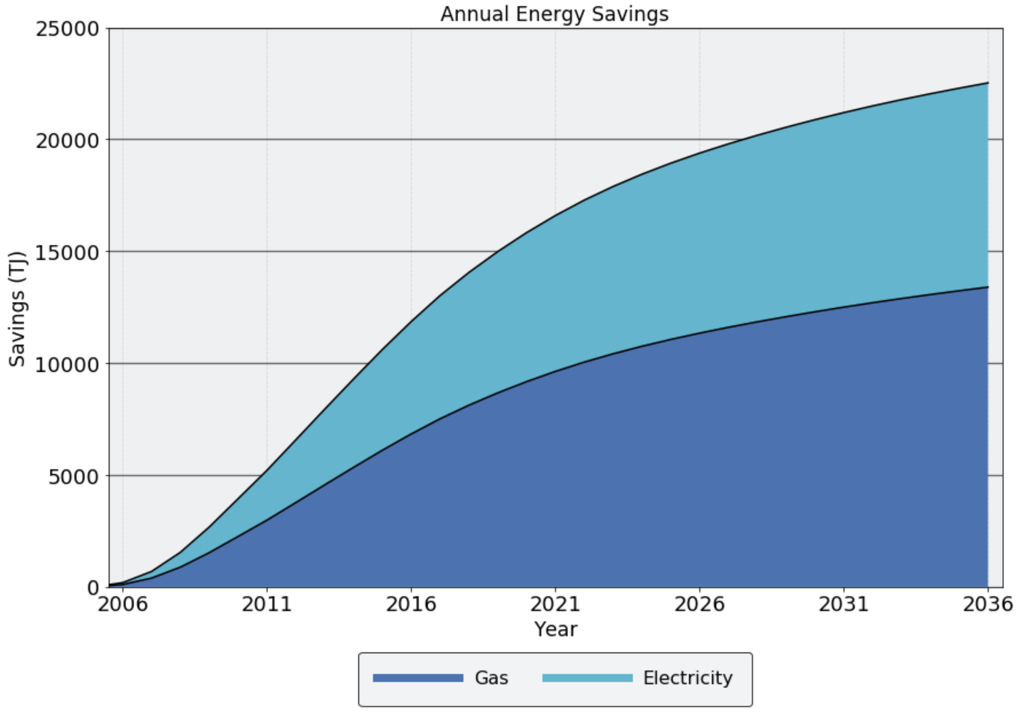


Figure 36 Yearly gas and electricity savings

The yearly electricity and natural gas savings in 2017, 2026 and 2036 are compared in Table 16. The estimates show natural gas as 58% of the current raw energy saving, growing to 59.5% in 20 years. The current year energy savings of 13 PJ are the equivalent of over 2.1 million barrels of oil[3].

Table 16 Energy estimated annual water savings due to WELS and associated measures

	2017 (TJ/yr)	2026 (TJ/yr)	2036 (TJ/yr)
Electricity saved	5,505	8,045	9,126
Natural gas saved	7,511	11,340	13,397
Total	13,016	19,384	22,523

The GHG emission savings that result from savings in energy are shown in megatonnes of CO_2 equivalent in Table 17. These results are snapshot figures. Interestingly they show that the yearly savings in GHG emissions due to hot water are 40 kilotonnes (kt) lower in 2036 than in 2026. Table 17 also includes the total GHG emissions when the energy used in water supply (via utilities) is included (in the second row). The utility component is around 3% of total savings in 2017 and 2026 but rises to 4% in 2036 and this reduces the drop in total savings between 2028 and 2036 to 10 kt.

Table 17 Greenhouse savings snapshot (Mt CO_2 –e)

	2017 (Mt/yr)	2026 (Mt/yr)	2036 (Mt/yr)
Hot water savings	1.87	2.44	2.40
Total including emissions from energy use by water utilities^	1.92	2.51	2.50

^ Emissions due to energy used for water supply and wastewater (such as pumping and desalination)

[3] Calculated at http://www.kylesconverter.com/energy,-work,-and-heat/petajoules-to-barrels-of-oil-equivalent

Counting no other benefits, in 2017 the cost of avoided GHG emissions due to the WELS scheme were $8.56/tonne. This is less that the $12/tonne, that was the latest benchmark price for Australian Carbon Credit Units, from the Australian Governments emission reductions fund (Clean Energy Regulator 2018).

The GHG reduction estimates show that without WELS an additional 1.92 MT of GHG emissions would have been emitted in 2017. This would have been the equivalent of adding 770,000[4] new cars to Australian roads in that year.

The cumulative GHG gas savings from WELS-associated hot water and water utility energy savings are shown Figure 36. By the end of 2017-18, WELS was estimated to have saved 11.2 Mt of GHG from being released. By 2036 it is predicted that WELS will have prevented 57.6 Mt of emissions.

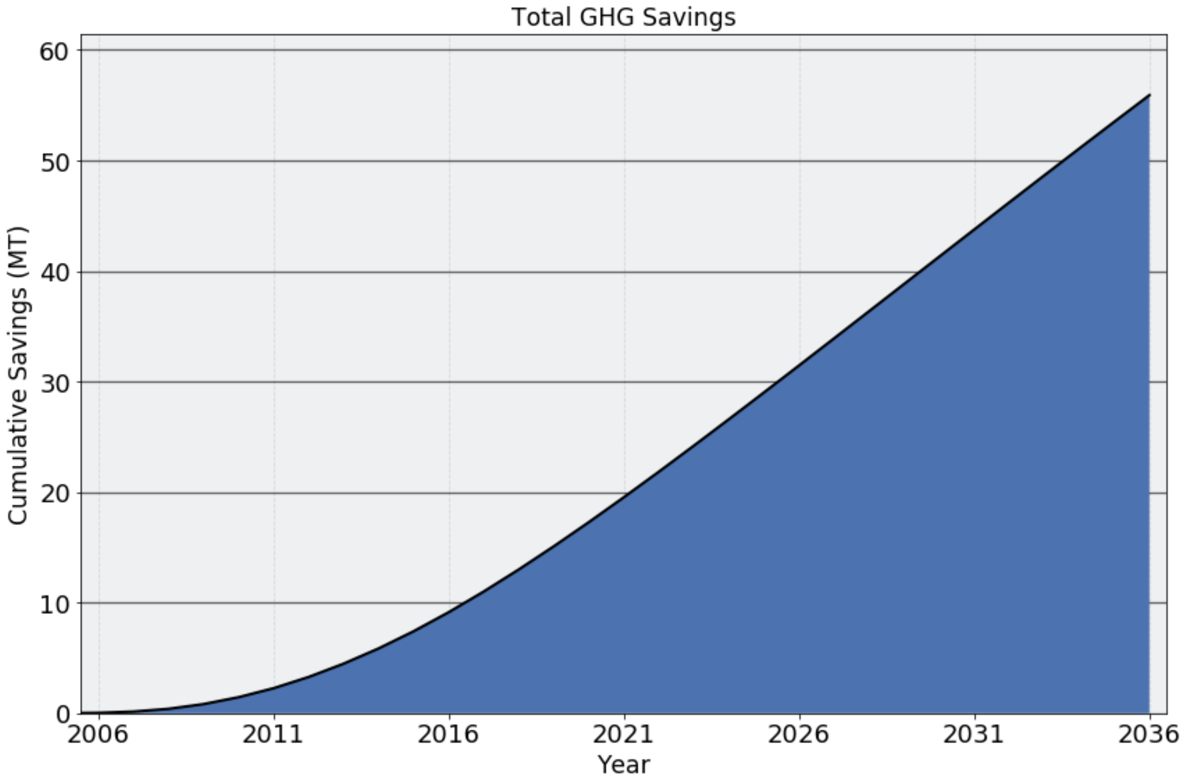


Figure 37 Cumulative GHG savings due to WELS

Figure 37 shows the yearly GHG emissions attributable to the energy consumed by water utilities and hot water used by the fixtures and appliances covered by WELS. Greenhouse gas emissions peak at 22.3 Mt in 1989 and then decrease in both cases until 2036. This decrease is due to the trend towards lower emission hot water systems as well as the predicted decrease in greenhouse intensity between 2020 and 2036. The difference between WELS and no WELS scenarios reaches 2 Mt of CO_2 –e in about 2020 and maintains at least this difference for the remainder of the forecast period.

Throughout the period of analysis, utility related emissions are only around 3% of the total. This proportion increases slightly at the end of the analysis period.

[4] The national average carbon dioxide emissions intensity from new passenger or light commercial vehicle in Australia was 181.7 g/km in 2017 (National Transport Commission 2018). The average passenger vehicle in Australia travelled 13,716 km in 2016 (from 9208.0 - Survey of Motor Vehicle Use, Australia - ABS 2017)

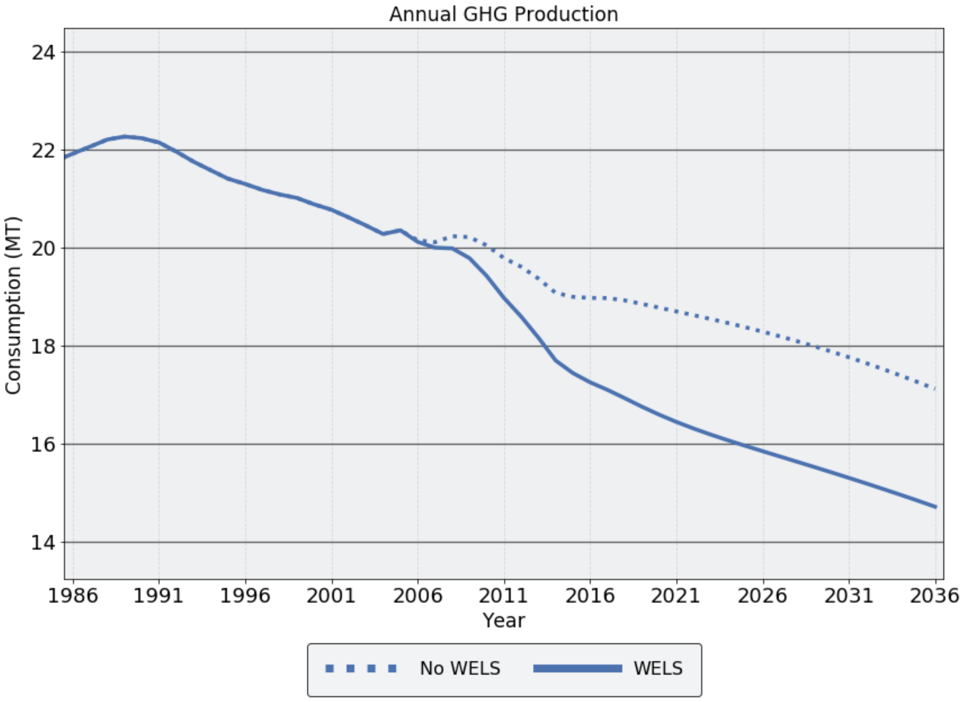


Figure 38 Total GHG emissions

The annual GHG savings breakdown for just the hot water component is shown in Figure 38. The savings owing to each fixture and appliance are shown as separate bands. The largest savings are due to reductions in hot water use by showers, followed by taps, although the total water savings due to taps exceeds that of showers. This is because the average water temperature of showers was assumed to be higher than for taps. Another interesting feature of Figure 38 is that GHG savings begin to decrease from 2030. This is because the GHG intensity of hot water is decreasing (due to a combination of the GHG intensity of electricity and gas with the fuel and efficiency of the average hot water system).

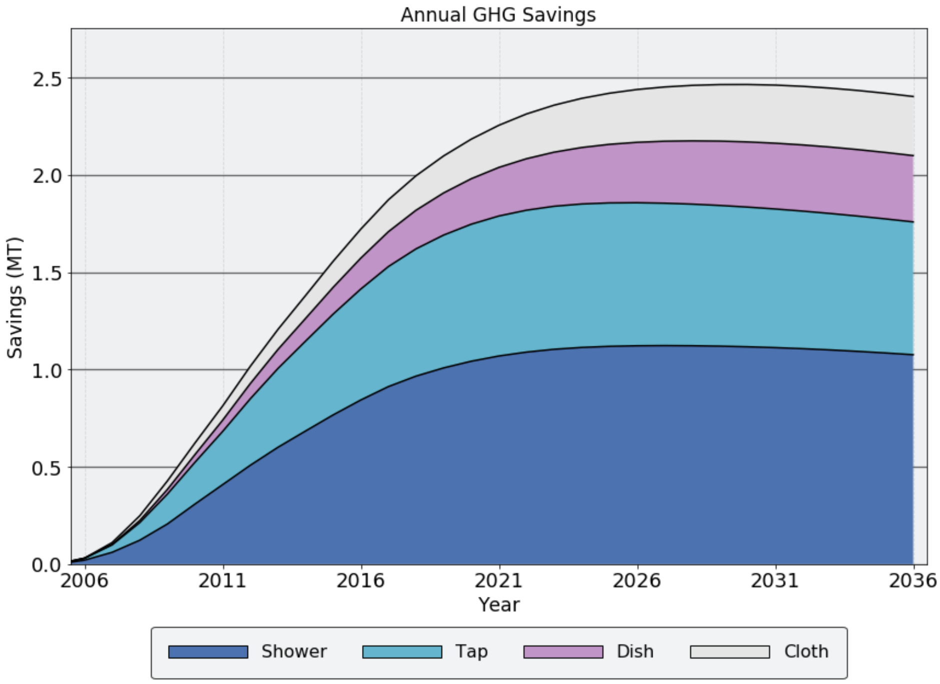


Figure 39 Yearly GHG emissions savings through WELS product hot water use

6.4 Bill savings

The methods used to estimate water, electricity and natural gas prices – the basis for calculating utility bill savings – are described in section 8.3. The water and energy savings described earlier in this section were inputs to these calculations, as well as historical prices and price projections.

The components of the utility bill savings are:

- decreased water bills due to reduced water use for clothes washers, dishwashers, showers, taps, toilets and urinals
- lower electricity bills due to reduced hot water use for clothes washers, dishwashers, showers and taps
- lower natural gas bills from reduced hot water use.

Annual bill reductions to households and businesses in Australia as a consequence of the WELS scheme are shown in Figure 39. It is estimated that in the current year the scheme is saving $1.05 billion dollars ($B) in utility bills. This annual saving is anticipated to increase to $2.64B per year by 2036 (in nominal terms, actual dollar savings that year, not the value in today's dollars).

As shown in Figure 39, electricity bills are the largest proportion of the saving followed by natural gas and water bills. This breakdown suggests the primacy of measures that can reduce hot water use, if lowering the pressure of utility bills for customers is a policy aim. In percentage terms, 75% of current bill savings are coming from avoided energy use from hot water savings. In 2036, 70% of bill savings are still expected to be the result of lower energy bills.

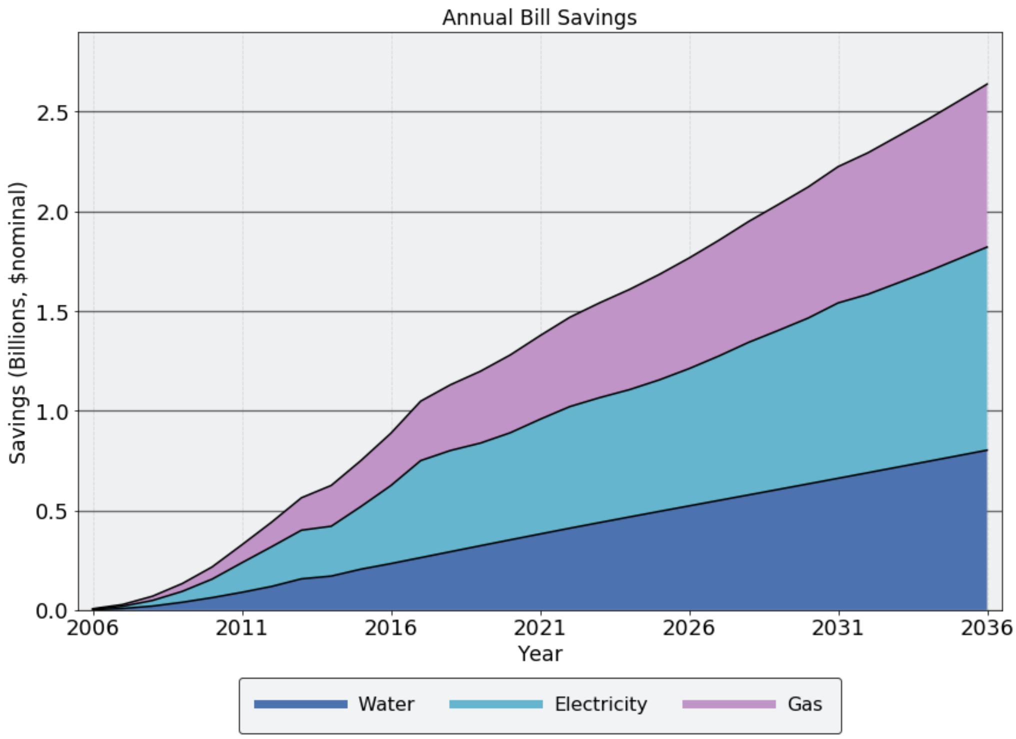


Figure 40 Annual bill savings due to WELS (nominal $)

To give a sense of proportion to the impact of the WELS scheme on the general public, an average per capita bill saving estimate has been made (Figure 40).

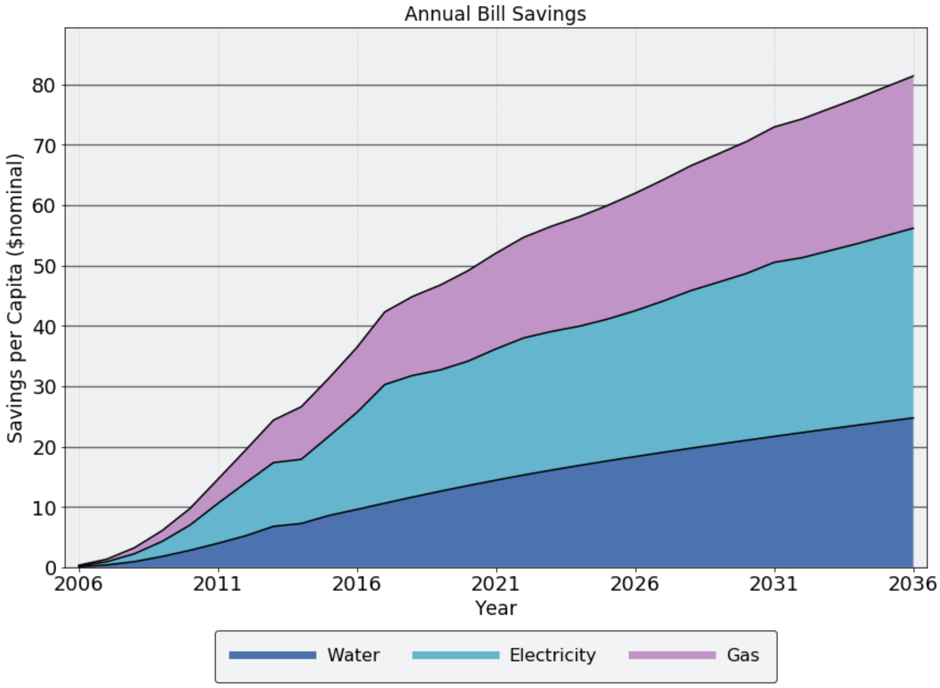


Figure 41 Annual per capita bill savings due to WELS (nominal $)

In the analysis presented in Figure 40, each person in Australia on average is currently saving about $42 per year, and for a household of two adults and two children $169 of savings per year are attributable to the WELS scheme. These estimates are somewhat rough; a small proportion of these savings would actually accrue to businesses rather than households. By the same approach, in 2036 the predicted utility bill savings grow to $81 per person per year for every person in the predicted population of Australia at that time and $325.50 per year for each four-person household.

An estimate of the cumulative bill savings due to the WELS scheme are shown in Figure 41. In nominal terms the modelling shows WELS and its associated measures have already saved Australian householders and business $5.1B to date. A further $35.6B in bill savings are predicted to the end of 2036-37.

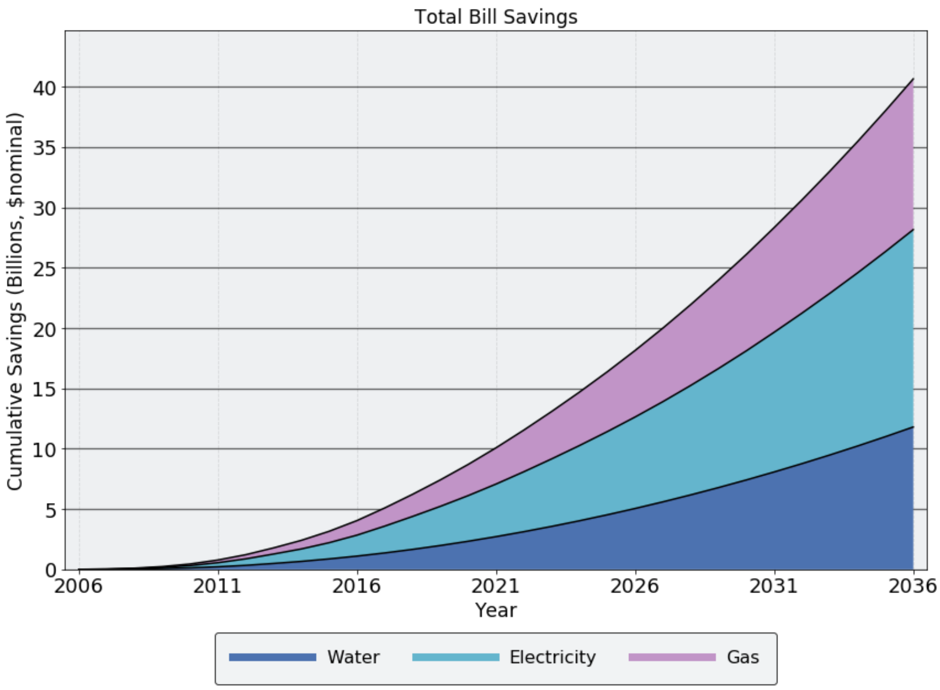


Figure 42 Cumulative bill savings due to WELS (nominal $)

6.5 Comparison with ABS water accounts

The ABS presents information on the physical and monetary supply and use of water in the Australia via a Water Account (ABS 4610.0 Water Account Australia). The Water Account provides information on water use by households as well as key industries, and breaks this down by state or territory. Water Account data are available for the period 2008-09 to 2015-16. To cross check our modelling of water use in WELS-rated products, a comparison with household water use in the Water Account was made in terms of litres per person/capita per day or LCD (Figure 42). As well as average figures for Australia as a whole (upper chart), the lower charts in Figure 42 show modelled and ABS data for average residential LCD in the Northern Territory (on the left) and Victoria (on the right).

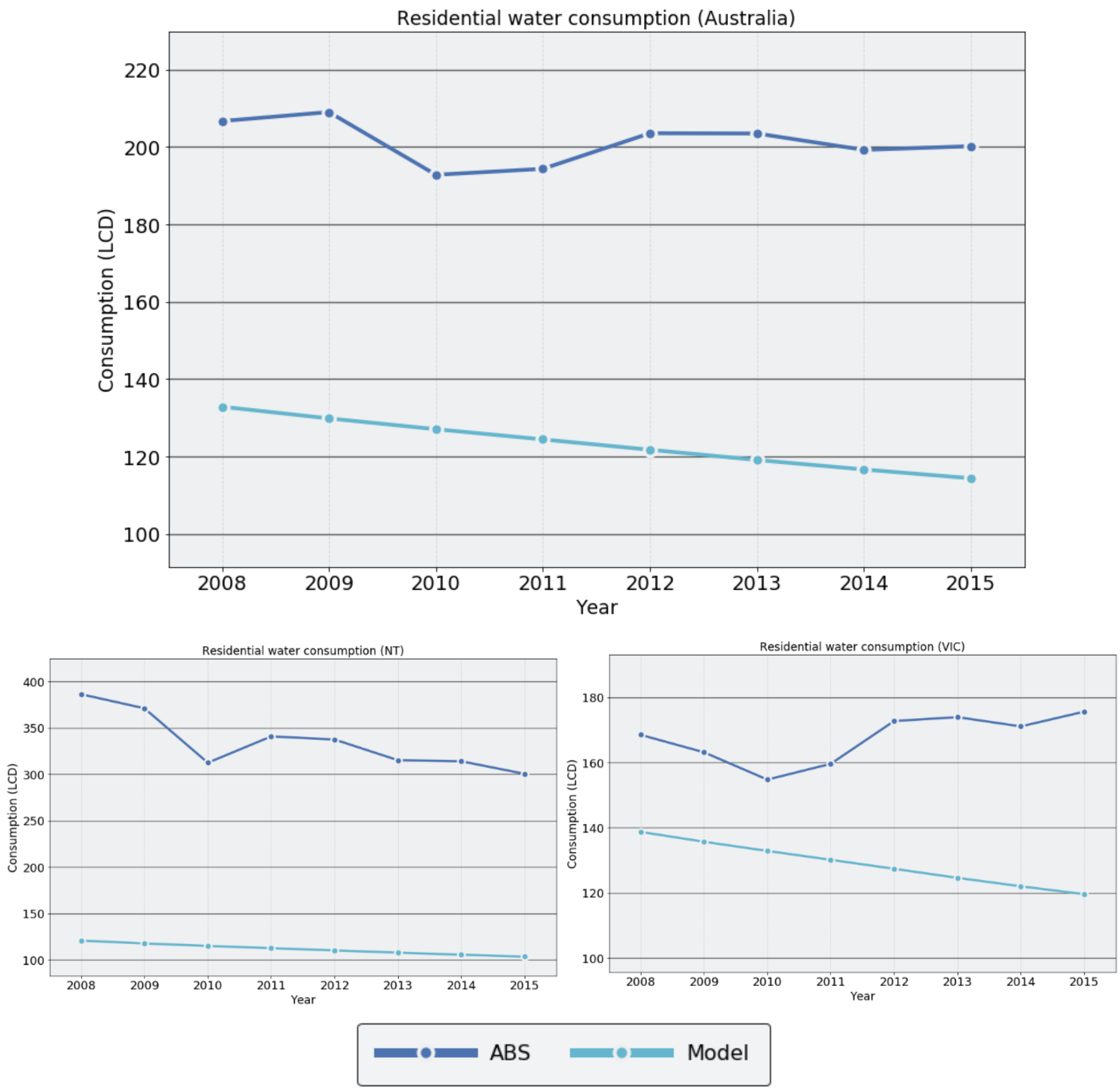


Figure 43 Comparison of modelled water use and household use from ABS water accounts

For Australia as a whole the model used in this evaluation shows LCD dropping from 133 L to 114 L from 2008 to 2015. The ABS data are higher and drops less from 207 L to 200 L. The difference in quantum is expected because the modelled data do not include outdoor use nor taps used for filling. This is even true despite the modelled data including some non-residential use. The difference in the difference, a drop of 19 L in the model versus 7 L from the ABS data can be explained by the removal of water restrictions around 2010 in many regions of Australia. The impact of water restrictions is particularly evident in the ABS data from Victoria; as shown in Figure 42, water use per capita drops slightly more quickly than the modelled use before 2010 and then rises once restrictions are removed. The Northern Territory is also included in Figure 42as a jurisdiction without water restrictions in the 2008 to 2015 period. Outdoor water use in the Territory is much higher than the Australian average and varies with climate, however the LCD trend can be seen to be dropping in a manner similar to the modelled values.

6.6 Comparison with 2015 results

The results of the current study are compared with the results of previous WELS evaluation (Fyfe *et al*, 2015) in Table 18. For the year 2013, the current study has estimated water savings to be 4 GL less than that reported by Fyfe *et al* (2015). The difference is 6%. Projected to 2012 and 2030 the savings are similar, within 2%. A number of changes in the scope of data to be included were made between the 2015 and current studies. The 2015 study included savings from WELS-rated taps used for filling basins in laundries whereas these taps were excluded from the current study. The current study did however included non-residential toilets and urinals which were not included in the 2015 study. Further, the approach to estimating water savings in the two studies was somewhat different. While both used stock and end use modelling, the current model disaggregated all product stocks to star bands rather than using categories of efficient and inefficient for many of the products. The current study also disaggregated savings into states and territories. Given the differences in modelling, the variations are minor and not unexpected.

Table 18 Comparing results of this study with the previous (Fyfe *et al* 2015) study

	Study	2013	2021	2030
Annual water saving (GL/yr)	2015	70	147	204
	2018	66	150	206
Cumulative GHG saved (Mt CO_2 –e)	2015	5.5	20.4	46.4
	2018	4.5	19.5	41.3
Annual total household utility bill savings ($M/a)	2015	520	1,390	2,063
	2018	563	1,376	2,122

As shown in Table 18, the cumulative greenhouse savings were also predicted to be somewhat lower in the current study compared to the previous. For 2013, this difference is driven by using more up-to-date data on the split between electricity and gas hot water heating. In 2030 the predicted greenhouse savings for this study were also lower, this time because the current study predicts a reduction in the greenhouse intensity of energy over time. The current study estimates higher bill savings than the 2015 study. This will be due to improved granularity of the modelling by individual state and territory in the historical period, and increases in anticipated future costs of energy in Australia in the projected period. As with the water savings, the difference in estimates for greenhouse gas and bill savings are relatively minor.

7 State based comparison

The modelling approach in this study involved developing separate stock models for fixtures/appliances and hot water systems for each Australian state and the Northern Territory. The Australian Capital Territory (ACT) was modelled as part of NSW. This resulted in seven separate end-use models and appliance stock models.

These models were populated with data suited to each jurisdiction. State-specific data included: end use and stock survey data; water heating by type; GHG intensity of energy; water and energy prices; and projected population. There were significant differences in hot water heater breakdown by type, water and energy bills and end-usage assumptions between states. Prices for water and energy also differed significantly. Both the ‘with’ and ‘without’ WELS cases were modelled at the level of each state or territory.

This section compares some of this variability in inputs as well as the different impacts of the WELS scheme between different state/territory jurisdictions.

7.1 Water use

Figure 43 shows the trend in per capita water consumption of WELS rated products with WELS in place across the states and territories in litres per capita per day (LCD) (see Section 6.5 for a comparison with total water use). The trend in water use with WELS is similar in all jurisdictions. It can be seen, however, that there is a difference in per capita water use between the jurisdictions, with South Australia and Tasmania having the highest use and the Northern Territory the lowest.

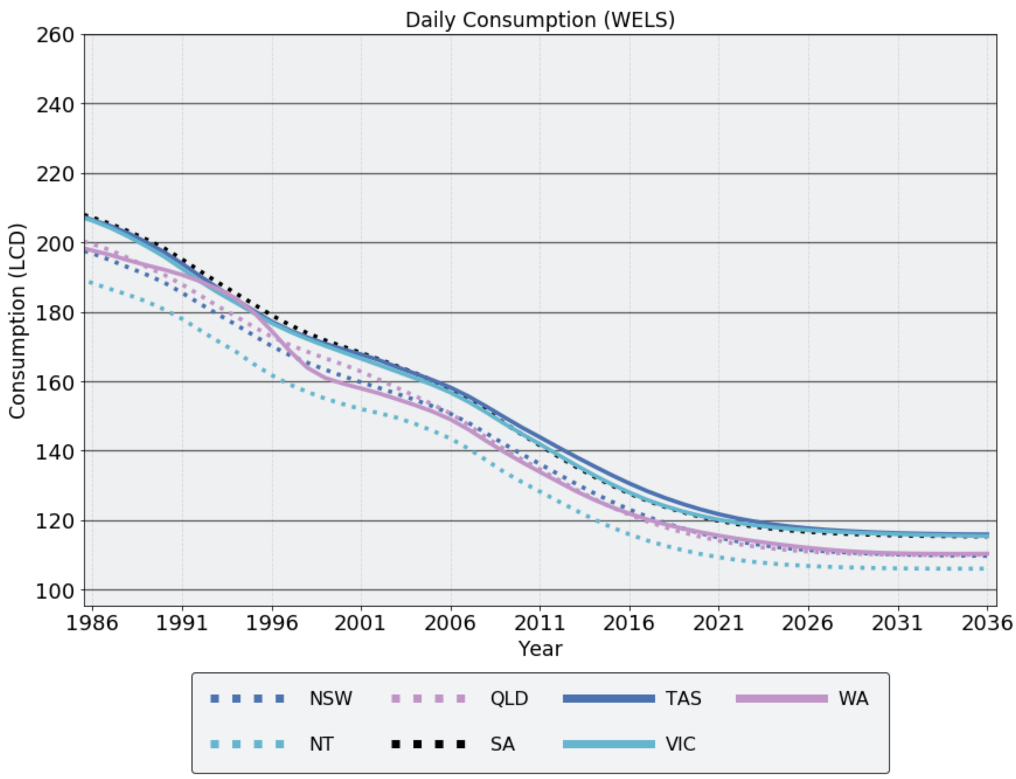


Figure 44 Per capita water consumption per state/territory

Differences between the states are minor and are driven by both end use and demographic assumptions. As seen in Table 12, the end use assumptions differed slightly between the jurisdictions. The same end use assumptions on frequency and duration were made for the Northern Territory and for Queensland. These were somewhat lower than those for Victoria, South Australia and Tasmania. NSW and Western Australia had end use assumptions in between the two groups. On demographics, the Northern Territory has a greater percentage of people living in units that Queensland, closer to the other States. Because populations in units have slightly lower recorded average use for washing machines and dishwashers (with marginally lower ownership), the resulting per capita consumption is lower. The combination therefore see the Northern Territory with the lowest WELS rated product water use per capita.

With regard to total water used by WELS-rated products, different patterns can be seen between the jurisdictions. The water use for NSW (and ACT), with WELS and without WELS, is shown in Figure 44. Water use peaked at 424 GL in 1988 then started to fall. With WELS, the fall is predicted to last until 2019 before increasing, but the value of the 1988 peak is not reached in 20 years to the end of the projection.

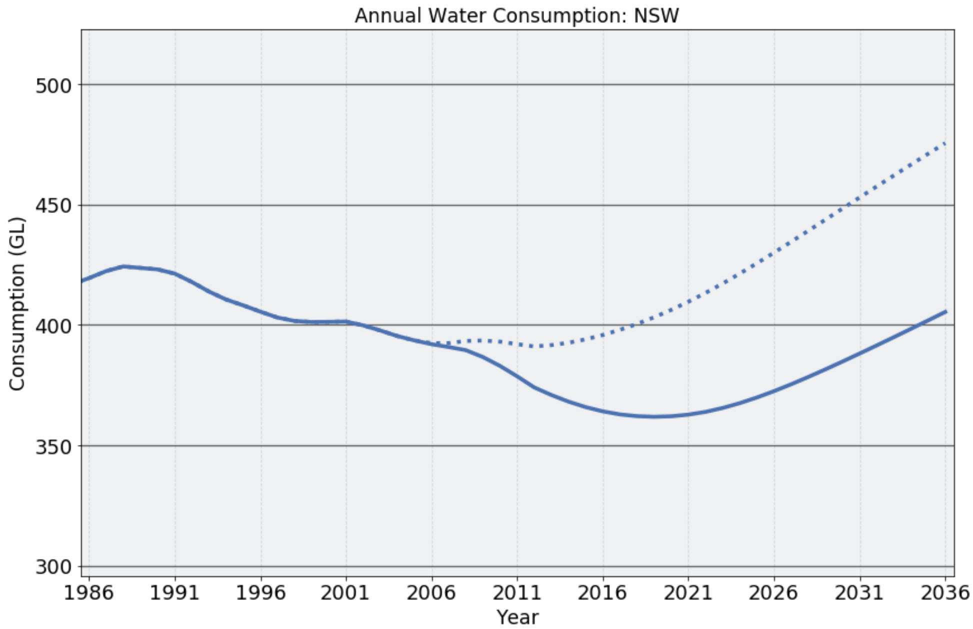


Figure 45 Annual WELS associated water consumption NSW and ACT

A comparison of NSW/ACT with the other states and territories reveals that most have a peak in water use around 1990, followed by a reduction and then an increase (see Figure 45). However the difference in demographics and population growth alter the conclusions about total usage in each state. In the states with higher population growth (Victoria, a 58% increase from 2006 to 2036; Queensland, a 71% increase from 2006 to 2036 and Western Australia, a 111% increase) total water use begins to increase sooner and then moves above the former peak usage. In WA the point at which the total water use eclipsed its previous level, and then continued to rise, is likely to have occurred in 2011. In jurisdictions with lower population growth (South Australia with 31% and Tasmania with 15% over the period), total water use does not return to its previous levels. In the Northern Territory despite the population increase by 60% from 2006 to 2036, there is a relatively flat trend for indoor water use (dominated by WELS-rated products) up to 2026. After that water use increases steadily.

State by state analyses of the impact of WELS in Figure 44 and Figure 45 indicate a need to either find additional ways to further reduce per capita consumption or augment supply. WELS has helped reduce per capita consumption but population growth means that, over time, the total water needed will increase unless further per capita reductions are made. In states with lower levels of growth, existing measures including WELS may be sufficient to manage urban water usage within current supply capacities (assuming these capacities are not reduced by external factors such as changes in climate).

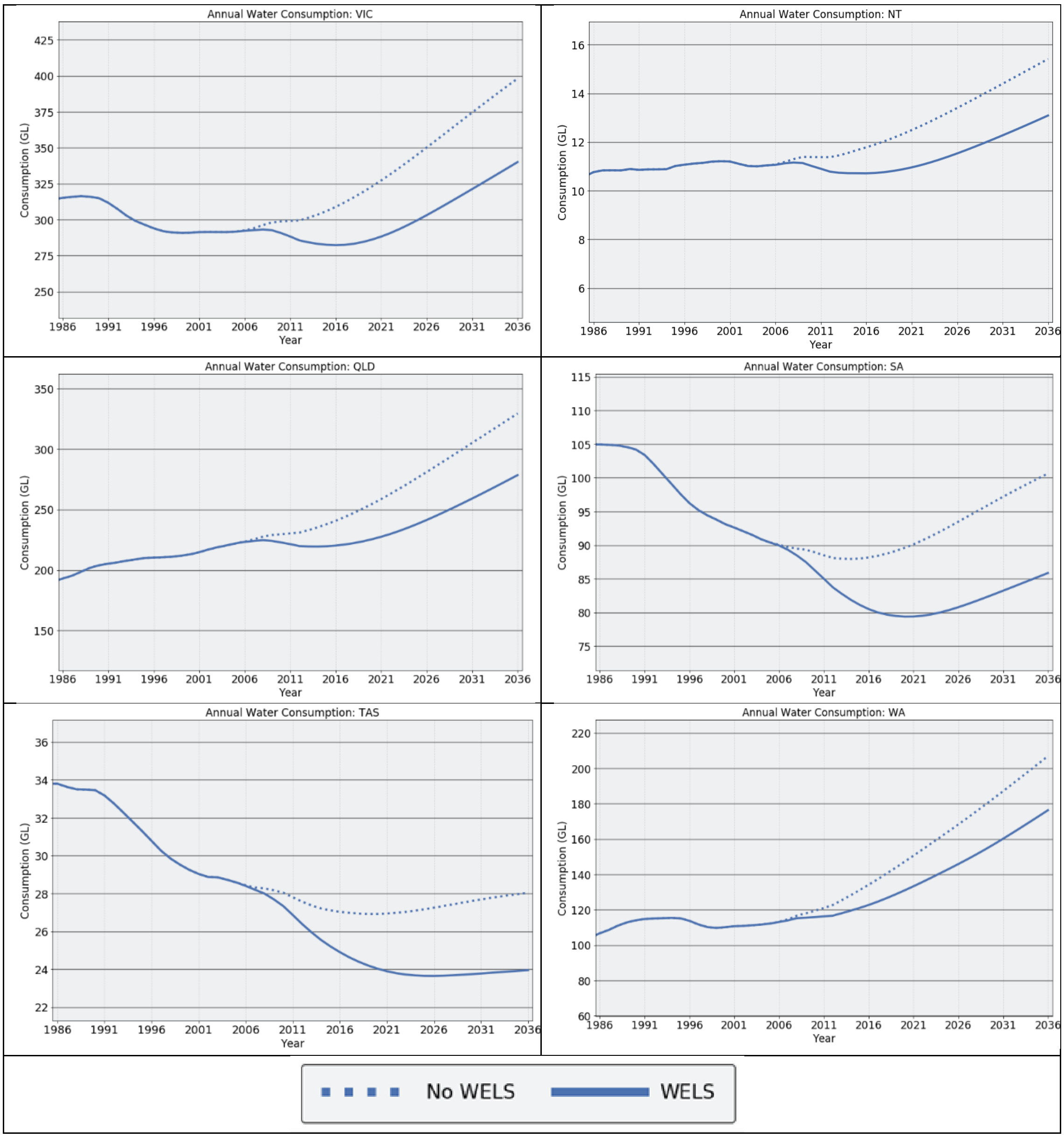


Figure 46 Annual WELS related water consumption per state/territory except NSW/ACT

7.2 Hot water systems

While not an impact of WELS, the difference in the stock of hot water systems between jurisdictions was an important input to the analysis. This stock varies significantly from state to state. The NSW hot water system stock is shown in Figure 46 and all other jurisdictions are shown in Figure 47. In NSW, electric resistance hot water systems are the most common and are predicted to remain so until 2026, when gas instantaneous hot water systems become the most common. Gas storage hot water systems increased until 2011 and then remained flat while solar and heat pump hot water systems (the most efficient hot water systems) start from very low (insignificant) fractions and increase slowly over the period.

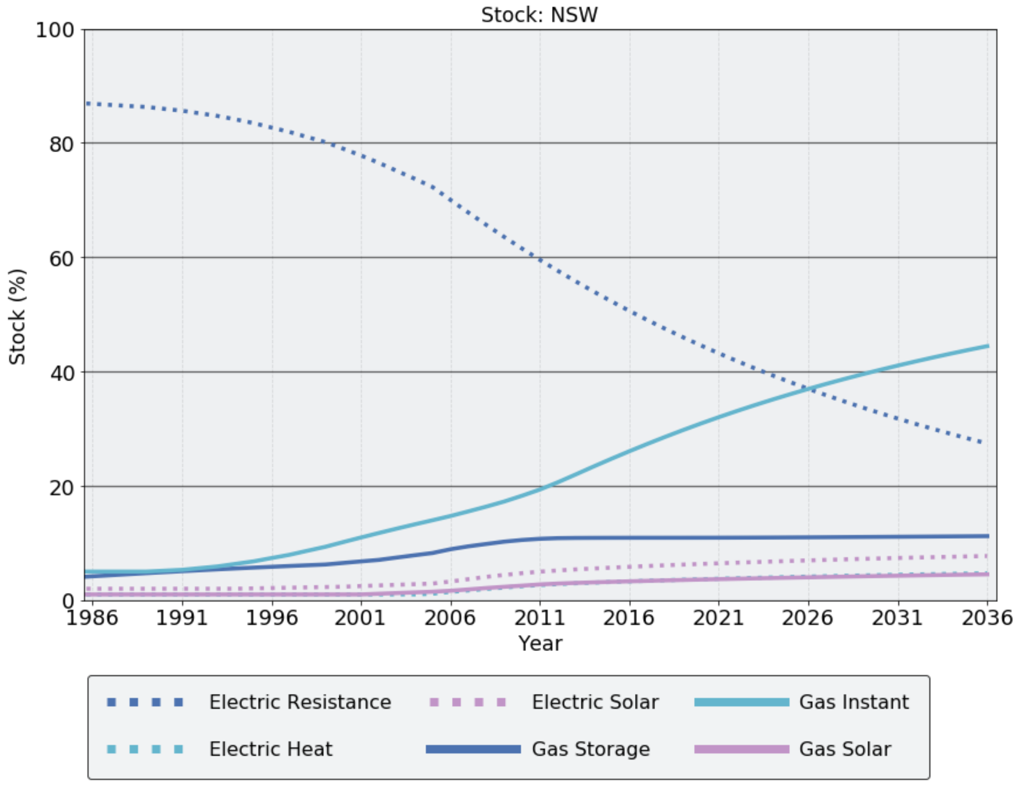


Figure 47 Hot water system stock, NSW/ACT

In Figure 47 it can be seen that the hot water system stock varies significantly from state to state. In Queensland, South Australia and Tasmania, electric resistance hot water systems are initially the most common but then the proportion of gas hot water systems increases. In Western Australia, gas hot water systems are initially the most common and over the period the proportion of electric resistance hot water systems increases. In the Northern Territory there is a similar trend except that gas hot water systems were never dominant (and solar hot water systems were more significant).

Note that no data on hot water system types were available for the period pre-WELS, but the assumptions made for that period will not have an impact on the calculated WELS savings. In particular, the proportion of instant gas heater in Victoria before the mid 1990's when the first fully electronic gas continuous flow hot water systems were introduced may be over estimate as earlier model where not as convenient. However no data exists and the stock model is simply back cast from the available data.

A likely explanation for the difference in gas and electric hot water systems is a difference in gas prices from state to state (see section 8.3.3). In Victoria the proportion of gas and electric hot water systems both decline and the proportion of solar hot water systems increases, due to policy requiring that new houses have either a rainwater tank or solar hot water system.

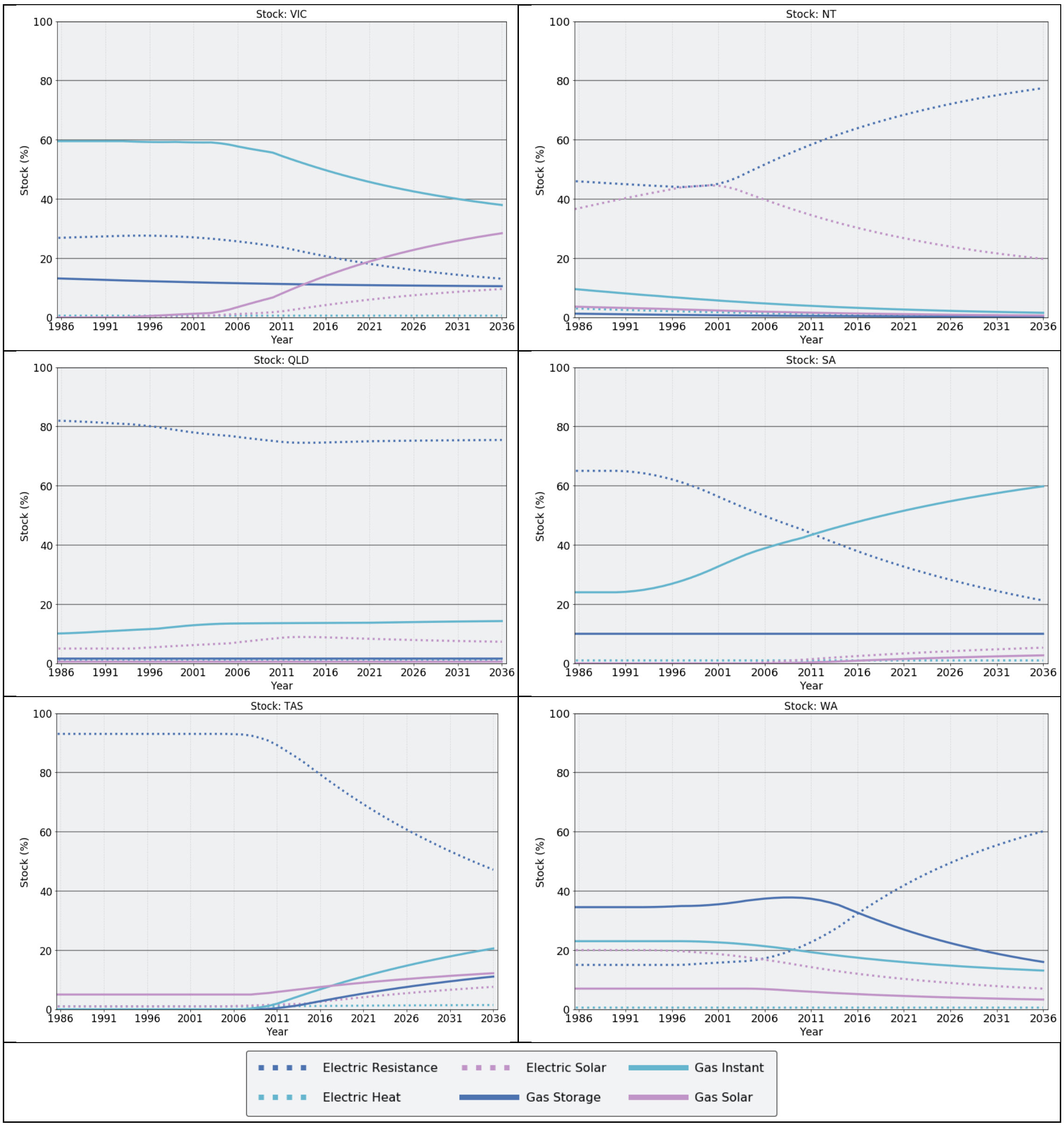


Figure 48 Hot water system stock per state/territory except NSW/ACT

7.3 Energy use

The results for energy consumption for the various states and the Northern Territory are shown in Figure 48 and Figure 49. Figure 48 shows NSW energy consumption associated with hot water for the 'with' and 'without' WELS cases. The general trends follow a similar pattern to water use except for Tasmania where gas consumption increases rapidly after 2011. This is due to an increase in the stock of gas hot water systems (including gas boosted solar), at the expense of electric resistance hot water systems.

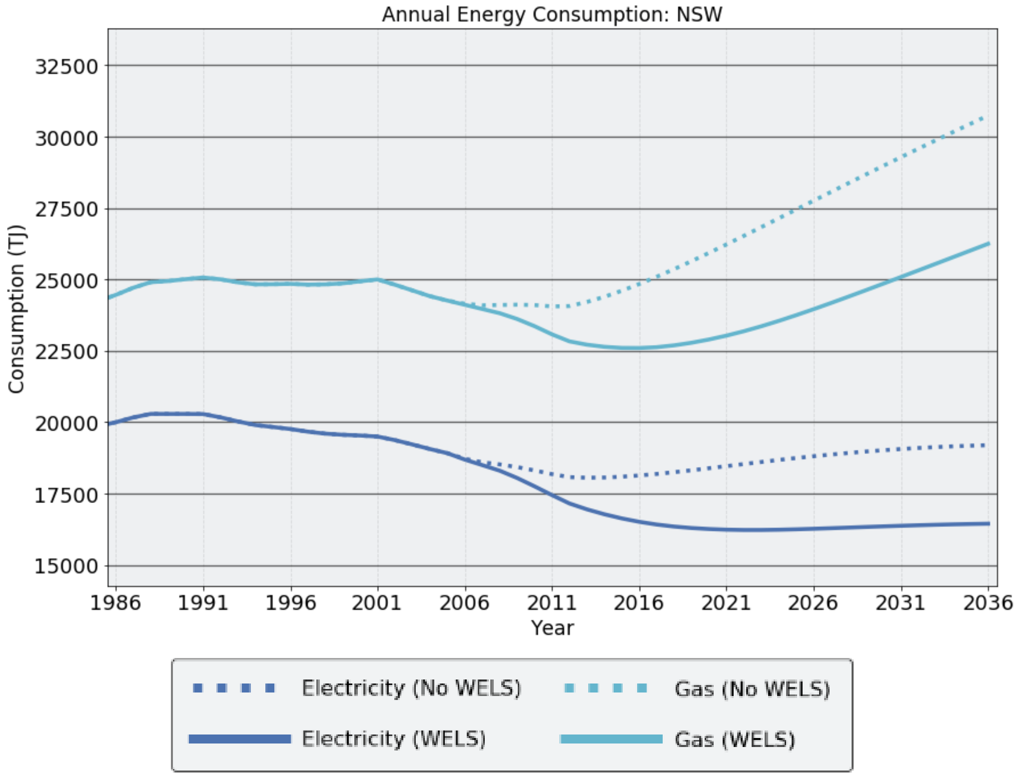


Figure 49 Energy consumption due to hot water, NSW and ACT

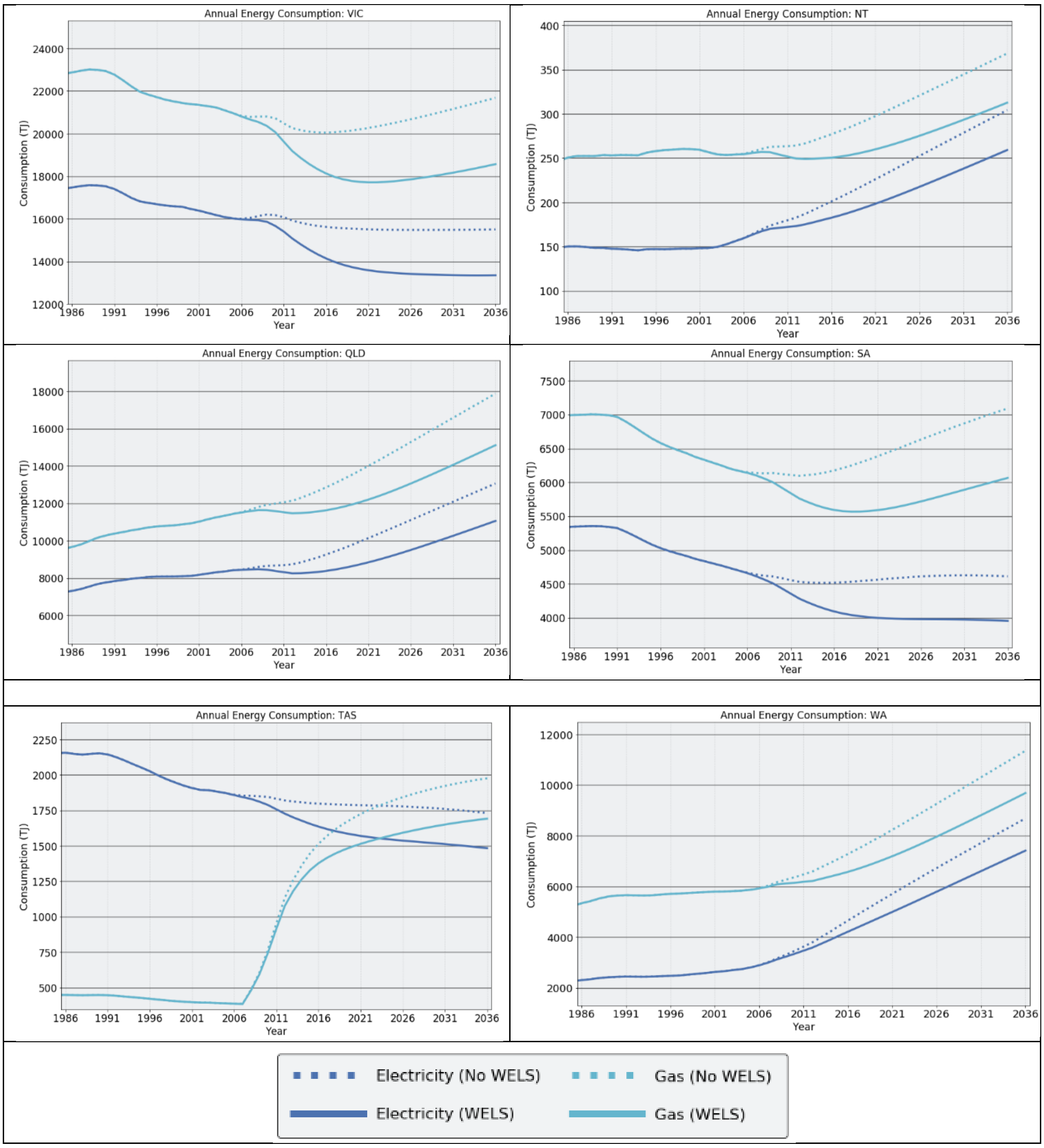


Figure 50 Energy consumption from hot water for states/territories except NSW/ACT

Figures 48 and 49 show that natural gas dominates the energy used for water heating in all states and territories except for Tasmania. The current growth in natural gas use in Tasmania is expected to see this fuel source also become the largest proportion in that state in years to come. The dominance of natural gas is particularly evident in NSW, Victoria and South Australia.

The charts in Figure 49 show that total energy use for hot water needed by WELS-rated products is growing in several jurisdictions (Queensland, Northern Territory and Western Australia). This growth is tempered by the WELS scheme, but over time, more energy is being used. In NSW, Victoria and South Australia the total energy use in water heating related to WELS products is less in 2036 than in 1987. For NSW, at least, this is only true because of the impact of WELS and associated water efficiency measures on water usage.

7.4 Greenhouse gas emissions

Emissions attributed to water consumed by WELS rated fixtures and appliances are illustrated in Figure 50 for NSW and the ACT and Figure 51 for all other jurisdictions. These GHG emission figures include water heating with electricity and natural gas for showers, taps and whitegoods; and emissions by utilities from providing water.

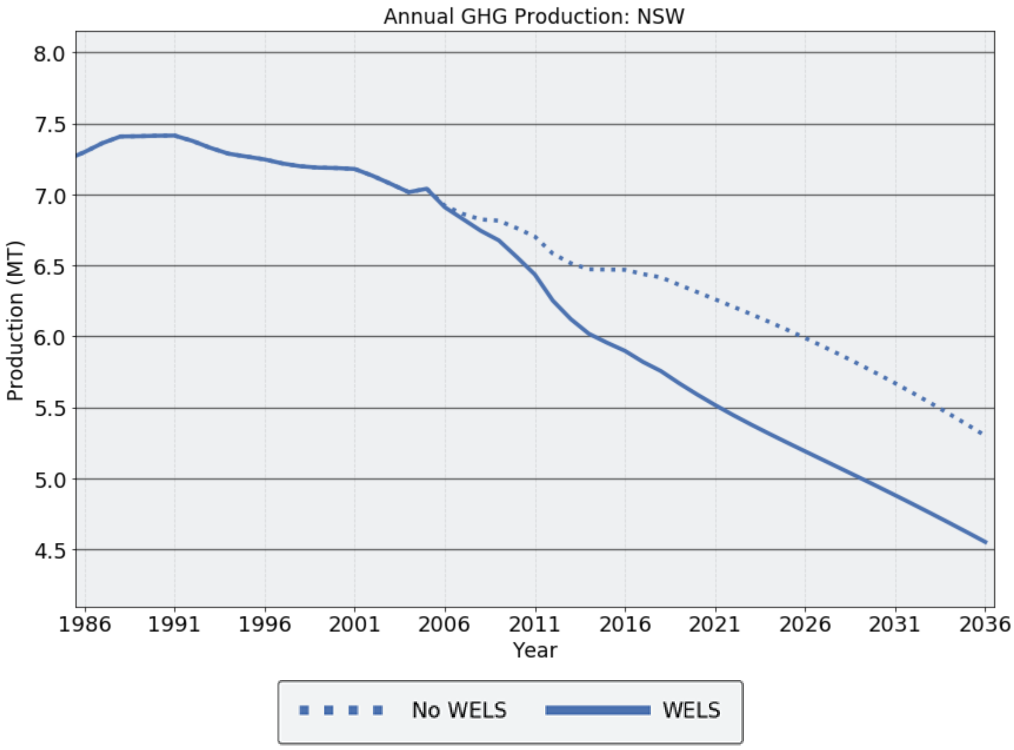


Figure 51 Greenhouse gas emissions with/without WELS for NSW/ACT

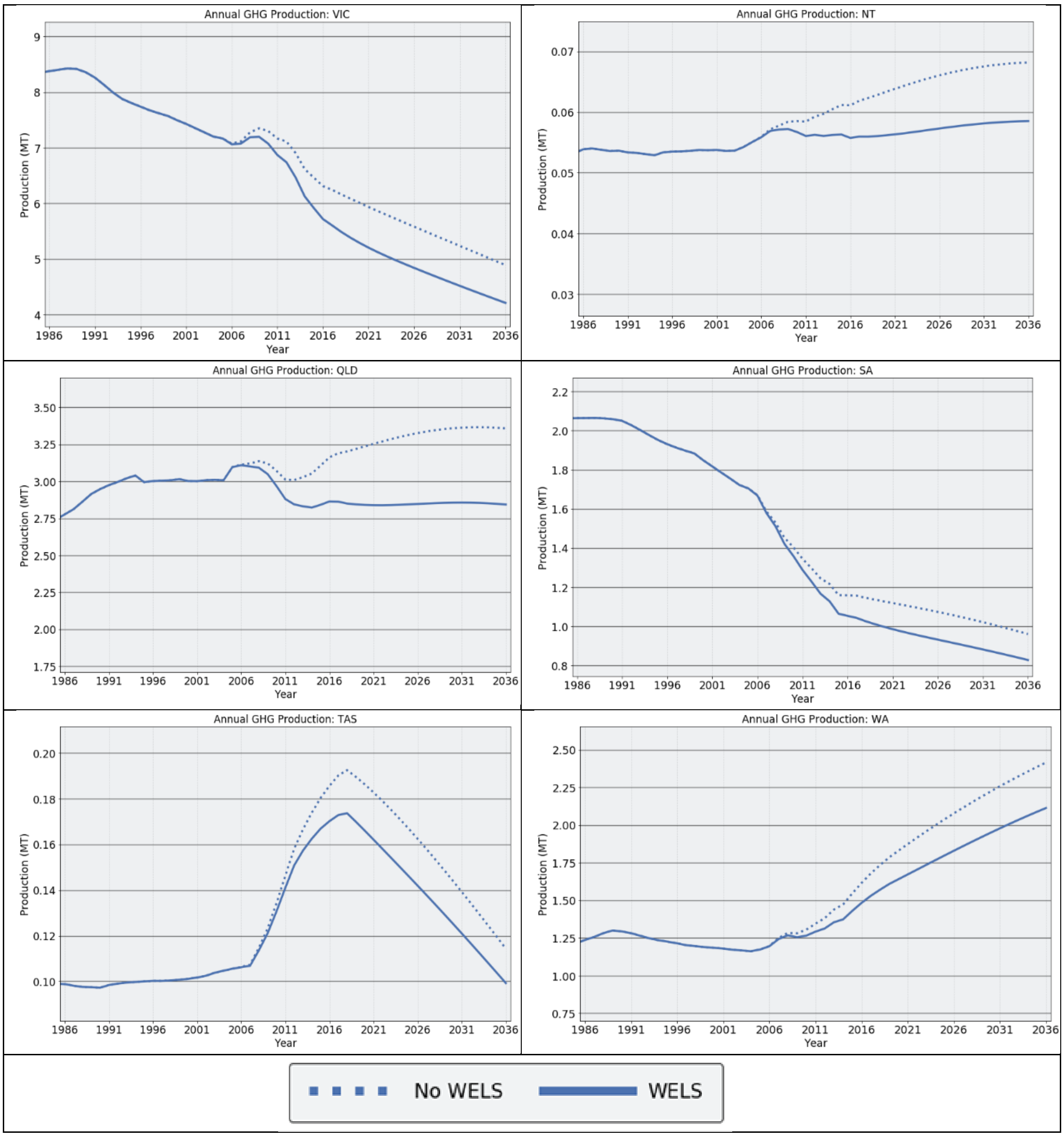


Figure 52 GHG emissions, with/without WELS for states/territories except NSW/ACT

Figures 50 and 51 show a range of varying trends between the states and territories in WELS product-related GHG emissions. NSW, Victoria and South Australia all show decreasing trends in total emissions even without WELS. Queensland and the Northern Territory show that the WELS scheme and associated measures keep overall WELS product-related GHG emissions relatively steady over time. Western Australia shows a growth in emissions tempered only slightly by WELS. Tasmania shows a rapid growth in WELS product-related emissions in recent years (due to increased carbon intensity of the electricity used in that state) followed by an equally rapid fall, in the future, as natural gas water heating becomes more common. The WELS scheme has only a minor impact on this trend in Tasmania.

7.5 Bill savings

The annual bill savings from the scheme are shown for NSW/ACT in Figure 52 and the other states and territories in Figure 53. The per capita and cumulative bill savings are provided in Table 19.

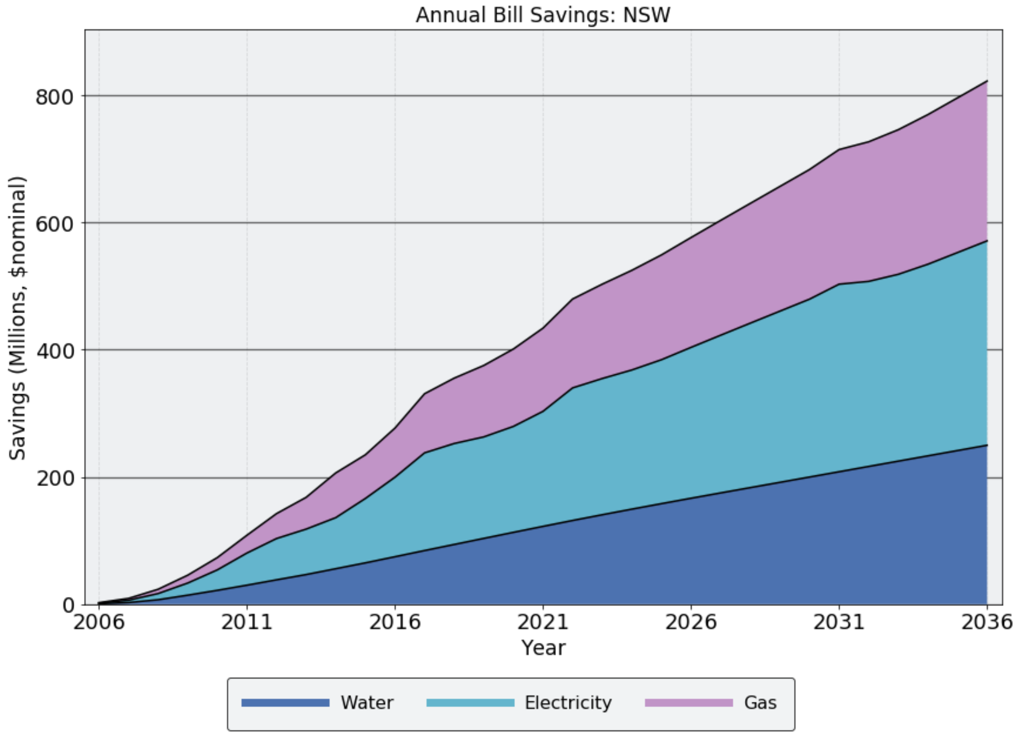


Figure 53 Annual bill savings in NSW and ACT (nominal)

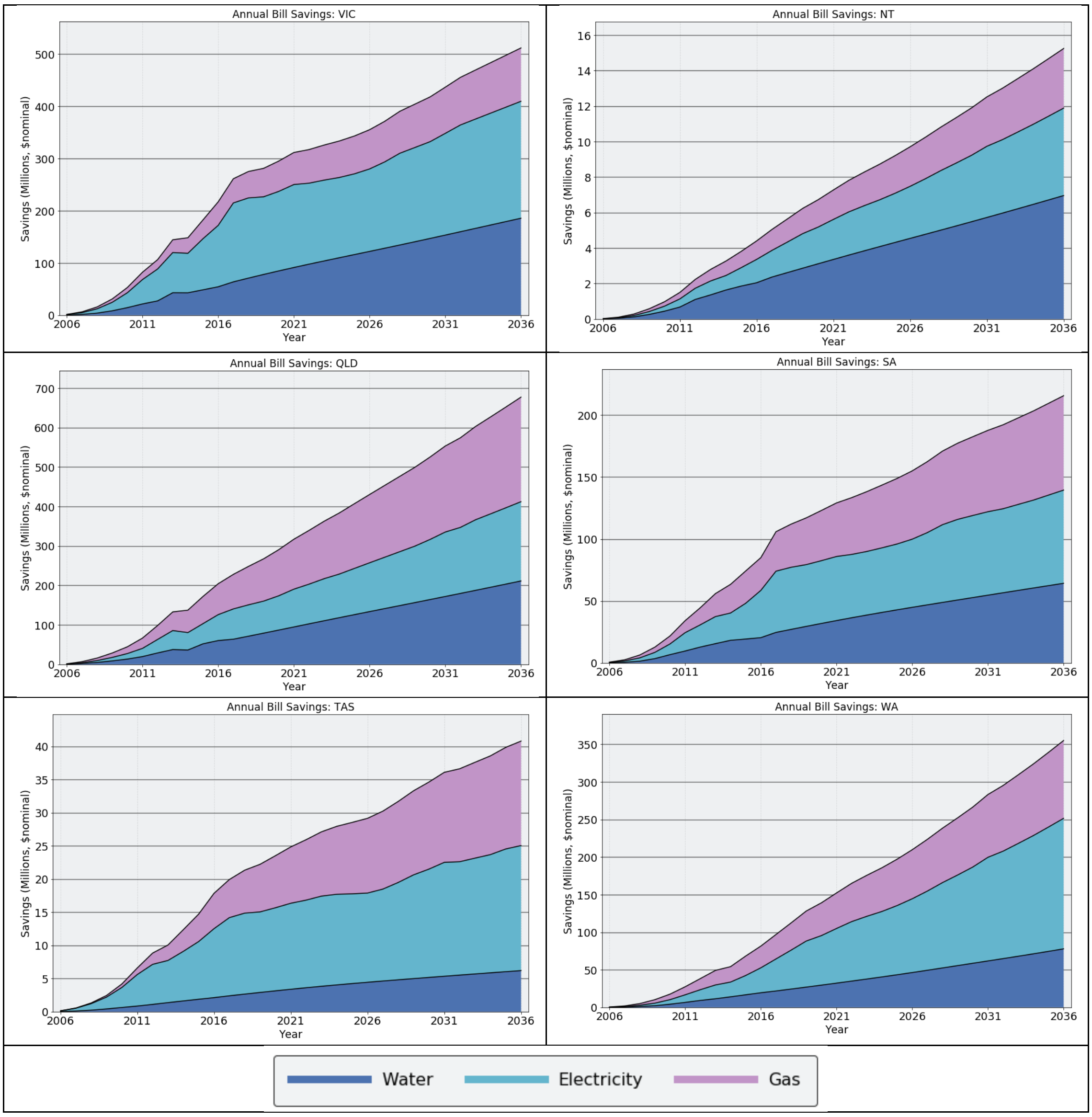


Figure 54 Bill savings for all states/territories except NSW/ACT

Table 19 Per capita utility bill savings attributable to WELS and associated measures

State or territory	2017	2026	2036
NSW/ACT	$40.30	$62.95	$81.28
Victoria	$42.52	$50.15	$63.48
Queensland	$45.06	$72.27	$97.78
Tasmania	$37.95	$53.00	$72.15
Northern Territory	$19.63	$32.85	$45.12
South Australia	$60.69	$81.71	$105.77
Western Australia	$34.19	$58.87	$81.18

Table 19 shows the differences in the average per person savings in utility bills between the states and territories. The differences reflect variation in the sources of savings across jurisdictions. Currently bill savings are highest in South Australia and three times as high per person than in the Northern Territory. This differential decreases somewhat across the future projections but remains significant.

Figures 52 and 53 illustrate the reasons for differences between the jurisdictions. Electricity savings predominate in NSW/ACT, Victoria and Western Australia. Recent prices of electricity in South Australia also drive the higher bill savings in that state. Despite the relative low use of natural gas for water heating in Queensland, high retail prices drive significant savings in total gas bills. In the jurisdictions with lower overall savings (and lower utility bills) water savings make up the largest proportion of the savings.

7.6 Conclusions from modelled savings

The results of the evaluation of impacts due to the WELS scheme and its associated measures are that it is currently saving significant volumes of potable water in households and business across Australia. These water savings, particularly where hot water is saved, are also driving energy savings, which in turn can be shown to reduce GHG emissions.

The scheme is currently saving on average 12.4 L per person per day across Australia. This is predicted to grow to 19.5 L per person per day by 2036. Total water savings are currently estimated at about 112 GL per year. This is predicted to more than double to 231 GL per year in 20 years. Despite these significant water savings, the total water use by WELS-rated products across the country is predicted to reach its pre-WELS level in 2023 and then continue to rise. The increase in water use is driven by population growth. The distribution of that population growth is variable across jurisdictions. The state-by-state comparison suggests that to avoid a need to augment supply, additional measures complementary to WELS would be needed such as additional demand management programs or building regulations in those states with fast growing populations.

The analysis showed large savings in energy use, particularly for water heating. Natural gas was the largest source of energy use and therefore savings, but electricity was also important. There was a slight trend to more natural gas use and therefore more natural gas energy savings over the period of analysis. The yearly savings in energy in the year 2017 are 13 PJ, and 22.5 PJ in 2036. The estimates show natural gas, as 58% of the current raw energy saving, grow to 59.5% in 20 years.

Estimation of the quantity of GHG emissions avoided as a result of the WELS scheme indicated a current yearly reduction of 1.92 Mt. This is projected to grow to about 2.55 Mt as hot water savings grow before decreasing somewhat, driven by a decrease in GHG intensity of the key energy sources.

The evaluation of bill savings for households and businesses found reduced electricity use led to the largest proportion of the savings owing to WELS. Electricity currently accounts for 46% of total utility bill savings from the scheme. This is all due to reduced electricity consumption for heating water that is used in WELS-rated products or in some cases, water heating within appliances. A further 28% of bill savings come from avoided natural gas usage also for water heating. Only 25% of current bill savings attributed to the WELS scheme are due directly to the water saving.

The dominance of energy savings in the utility bill savings explain why such a significant difference was found between states in per capita savings. Despite relatively similar reductions in water use per person across jurisdictions, the variation in types of water heating and variation in prices paid for electricity and natural gas in different states saw the current per capita bill saving vary from over $60 per year in South Australia to less than $20 per year in the Northern Territory. The other states were much closer to the Australian average of about $42 per year or $169 per year in a household of two adults and two children.

The outputs of the modelling are provided in table form in Appendix E.

8 Analysis of costs and benefits

This section presents an economic appraisal of the costs and benefits of the WELS scheme from its inception in 2006 projected to 2036. The analysis deviates from a standard cost benefit analysis (CBA) in considering both future and historical economic impacts due to the WELS scheme. For reporting, the evaluation groups past economic impacts, since the schemes inception, with impacts that are occurring in the 'current' year of the study, 2017-18. Looking forward, future impacts are projected and discounted back to present value. Across the evaluation all results are thereby normalised A$2017-18 dollars.

The reason for an approach that considers both future and historical economic impacts is that the study seeks to evaluate the existing scheme in its current form. Unlike a usual CBA, it does not consider a range of potential options or specific changes to the WELS regulations in order to inform a particular policy decision.

The section describes the:

- approach or framework used for the evaluation of costs and benefits
- estimation of costs associated with the WELS scheme
- calculation of benefits resulting from the scheme
- results of the analyses of costs and benefits including sensitivity analysis
- distribution of costs and benefits among parties.

8.1 Framework for analysis

The framework for evaluating the costs and benefits of WELS is outlined in terms of the:

- attribution of costs and benefits to the scheme
- valuation of the water, energy and GHG emissions avoided as a result of the scheme
- boundaries of analysis, including which costs and benefits are incorporated, and how past and future impacts are treated.

Following the estimation of water, energy and GHG emission savings, described in section 5, the economic appraisal takes as its base case a scenario where the voluntary labelling scheme, which existed in Australia before WELS, continued and was not being replaced by a mandatory labelling scheme. This 'without WELS' base case is compared to the 'with WELS' scenario that actually occurred.

8.1.1 Attribution

This study attributes all improvements in water efficiency for WELS-rated products to the 'with WELS' case, in comparison to the base (without WELS) case. In doing so, the study acknowledges that WELS does not act alone in improving water efficiency in plumbing products and water-using appliances in Australia.

As described in section 2, WELS influences consumer choice and achieves water savings through a range of mechanisms, including providing a:

- clear information label of the relative water efficiency of all products for customers
- minimum water efficiency standard for toilets and washing machines
- ratings nomenclature on which water utilities, councils and state governments have developed demand management programs
- reference for state government regulation of new buildings and plumbing practices.

As was argued by Chong *et al* (2008) these mechanisms work in combination to influence water using products that are purchased and installed in Australia. Following the approaches taken in both the Chong *et al* (2008) and Fyfe *et al* (2015) studies, this evaluation does not attribute a proportion of gains in water efficiency in Australia to WELS and attribute other proportions to other mechanisms. Instead, all water savings arising from more-efficient WELS rated products are reported and evaluated. This evaluation is therefore of 'the WELS scheme and associated complementary measures' rather than the WELS scheme alone.

Attributing savings from the four mechanisms nested under the WELS scheme requires an equivalent consideration of the costs associated with those mechanisms. Those costs are additional to the costs directly resulting from the labelling and minimum standards aspects of WELS. Where significant, the additional costs of related complementary mechanisms are accounted for in the economic appraisal.

In considering attribution, the context of the WELS scheme's introduction is also important. WELS was introduced at the height of one of the worst droughts in Australia's recorded history. Many regions were impacted by severe water shortages, including the major cities. During the Millennium Drought, governments and water utilities sought to secure water supplies by controlling demand and then, eventually in most major cities, by building large new climate independent supplies. The demand-side efforts included:

- demand management programs
- state government regulations on buildings, plumbing and rental properties
- drought restrictions and campaigns urging water conservation.

New supplies were predominantly desalination plants, with the substantial costs of these augmentations resulting in increased water prices in many regions after the end of the drought. The influence of this historical context upon attribution of water efficiency savings and the associated costs and benefits in this study is described further below.

8.1.1.1 Demand management programs

During the Millennium Drought, water utilities, councils and state governments across Australia conducted demand management programs, many of which targeted WELS appliances and fixtures. From 2006, WELS labels provided the star rating nomenclature that programs were built around.

While some demand management programs were in place in the 1990s, major demand management programs were not implemented in Australia before Sydney Water commenced its water efficiency initiatives in 1999 (Sydney Water 2012). Large-scale programs were developed in most metropolitan regions impacted by the Millennium Drought including in Victoria, New South Wales, South Australia, South East Queensland and the southern part of Western Australia. Across the country, demand management programs targeting WELS-rated products took various forms. These included: rebates to encourage the purchase of efficient products; efficient showerhead giveaways or exchanges; home and business audits; and subsidised retrofits.

Over the decade to 2011, Sydney Water implemented some of the largest demand management programs known at that time. These programs peaked in the years between 2006-7 and 2008-9. By 2011 the reported savings across all of its programs covering residential, business, pressure and leakage management were over 43 GL/yr (Sydney Water 2012). The scale of Sydney Water's programs is demonstrated by its residential retrofit program. This program saw 480,000 households or 30% of greater Sydney's housing stock retrofitted with efficient showers, taps and in some cases toilets over the 11-year life of the program (Sydney Water 2012). The peak period for the program was again the years between 2006-7 and 2008-9. This program, using WELS-rated products resulted in water savings of over 10 GL/yr.

To estimate the cost of programs targeting WELS-rated products, this study has used estimates of the cost of Sydney Water's demand management programs over time. Sydney Water provided annually collated information about costs and water savings for individual program elements. Across the country the Sydney Water program is the only large scale demand management effort with detailed annualised information in the public domain.

Since the Millennium Drought ended, investment in demand management programs has declined significantly (Turner *et al* 2016). In 2018, there are no programs of significant scale targeting fittings and appliances covered by WELS. Sydney Water's household retrofit program, for example, is now running on a commercial basis with full cost recovery (Boerema 2018). Other utilities have scaled programs back to target vulnerable customers and manage hardship rather than driving general water savings (Goodwin & Sterling 2018).

For the purpose of this study, the costs of demand management programs from 2010 onwards are considered negligible. Further, for the purpose of analysis an assumption has been made that no new large-scale demand management efforts by water utilities, councils or state governments occur in the period to 2036.

8.1.1.2 State Government regulations

The WELS scheme is referenced in state government regulations targeting new buildings (e.g. BASIX in NSW), plumbing works and rental properties. These generally require a minimum water efficiency of products and fixtures that are installed in new buildings or renovations, or require minimum efficiency levels in rental properties (before a renter can be charged for water use).

For the study, the marginal costs of administering and complying with those parts of the building, plumbing and property regulations specific to WELS products have been considered to be minimal because WELS related matters are only a minor proportion of the scope of these regulations.

8.1.1.3 Restrictions and water conservation campaigns

Water restrictions in Australia have historically targeted outdoor water usage by prohibiting certain forms of use (such as sprinklers) or by limiting the days of week or times of use. Restrictions typically become more stringent with increasing water scarcity in a region.

During the Millennium Drought, restrictions generally targeted outdoor use but also included public awareness campaigns encouraging water conservation. A feature of these campaigns in the Millennium Drought was promotion of personal or household water use targets in some jurisdictions. Even in areas without explicit targets on water use, significant reductions in indoor water could be found in the restrictions period (Beatty *et al* 2011).

The modelling approach taken in this study estimates water use from sales data rather than actual metered consumption. It therefore does not account for potential changes in indoor water use behaviours during drought (beyond that seen in end use studies). Some impact on the choice of water using products for purchase by customers can be expected as a consequence of drought. However, without evidence to draw on, this study does not seek to apportion a part of savings resulting from purchases of water efficient products by customers motivated by perceptions of drought. Instead, all savings are attributed to the WELS scheme based the scheme facilitating the purchase of more water efficient products, regardless of customer motivations.

8.1.1.4 Increases in prices

Residential water price increases were relatively high in the period towards the end of the Millennium Drought and immediately after. As noted at the time, by the Productivity Commission (2011), '*the level of water prices has increased in recent years due to factors including the need to pay off large supply augmentation projects, the move to full cost recovery, replacing ageing assets, maintenance catch up, and general inflationary pressures. The price increases have been relatively large in some places and this is likely to continue in coming years, with prices set to increase by as much as 20 per cent a year*'[5].

Despite these changes in price, a substantive impact on indoor water demand is unlikely, with the price elasticity of water generally low for Australian households (Abrams *et al* 2012) and even lower for indoor uses.

More recently energy prices have risen steeply in Australia and this has been a significant concern for some customers. The extent to which customers make the connection between energy prices and hot water usage, however, is not well understood. Further, for residential customers, the focus has been on electricity price increases rather than gas, as residential gas prices are strongly regulated in many jurisdictions. This study has found that gas hot water heating is the dominant technology across most jurisdictions and that this dominance is set to increase.

The study has not included an impact of water or energy prices on water usage. However, the relative impact of price on the proportion of electricity to gas water heating in various states is likely evident in the stock data used, and would explain part of the state-by-state differences seen (see sub-sections 7.2 and 7.3 above).

8.1.2 Valuation of water, energy and GHG savings

As described in section 5, this study has estimated water use of the main products covered by the WELS scheme (showers, taps, toilets, urinals, dishwashers and clothes washers) for each state/territory and for Australia as a whole. From the water use modelling, electricity and natural gas usage for hot water and GHG emissions from this energy usage (as well from utility water supply) are then estimated.

Figure 54 shows this diagrammatically; stock and end-use models generate estimates of total water use and hot water use. These are combined with hot water heater stock models to give energy use by type and by state. The energy use is translated into GHG emissions based on quantities of fuel by type and emissions factors for each state. The water, energy and GHG savings due to the WELS scheme (and the associated measures it underpins) are calculated by taking the difference between the 'with WELS' and

[5] Page 31 Australian Urban Water Sector, Productivity Commission Inquiry Report Volume 1 No 55 31 August 2011

'without WELS' scenarios. The net savings for water, electricity, natural gas and GHG emissions are then valued in dollar terms and compared to the cost of the WELS scheme and associated mechanisms.

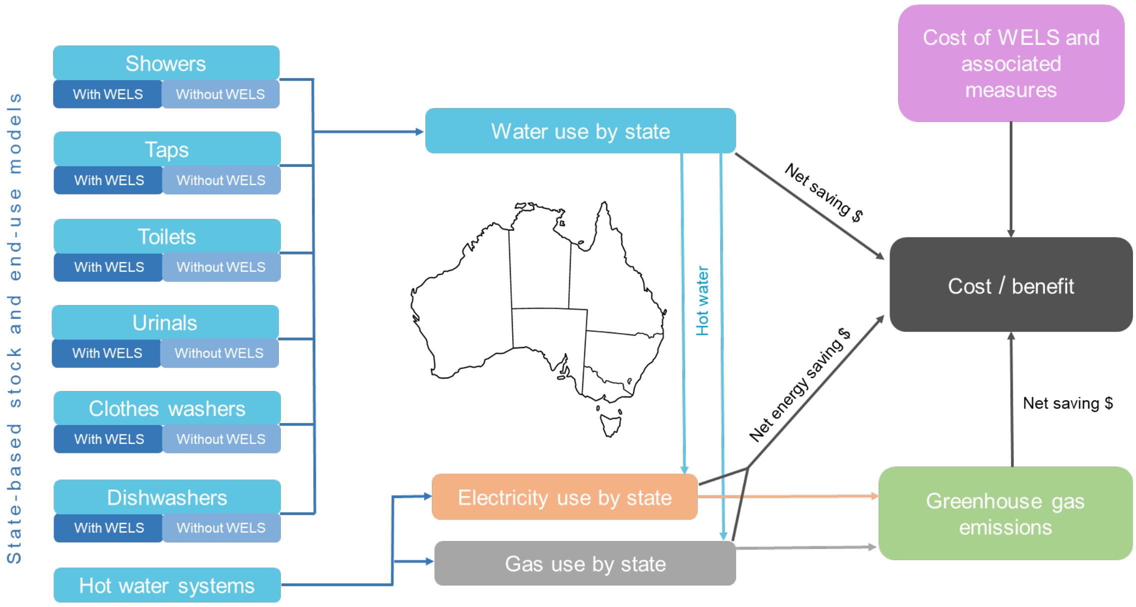


Figure 55 Water, energy and GHG savings model

8.1.2.1 Value of water savings

The value of water saved as a result of WELS has been estimated using the volumetric retail price of water paid by customers across Australia. This approach is based on the assumption that retail water prices represent a reasonable approximation of the long run marginal cost (LRMC) of water supply in each region and therefore the value of water. In regions where independent pricing regulators exist, LRMC is a key reference for water pricing (IPART, 2015; Murray, K. and Tooth, R, 2015). Previous evaluations of the impact of the WELS scheme (Wilkenfeld 2004; Chong *et al* 2008; Fyfe *et al* 2015), have also used retail water prices as a proxy for the value of the water saved by the scheme.

This study acknowledges that this approach to valuing water has the potential to somewhat underestimate on the value of water saved by the WELS scheme. This is because the WELS scheme is already established and will have an impact on both historical water demand and future forecasts. To the extent that retail prices are designed to approximate LRMC, these prices will be somewhat lower due to WELS. Similarly, some investments in water and wastewater assets might reasonably be expected to have been delayed or avoided as a result of WELS. These avoided costs will have also resulted in somewhat lower water prices.

A 'without WELS' scenario could be expected to have a higher demand and so, all other things being equal, have a somewhat higher average LRMC[6] across the country. This is because the capital cost of augmentations could be expected to be required sooner in a 'without WELS' scenario than in the current 'with WELS' situation. An estimate of the significance of this impact in relation to large-scale supply augmentations is described for two case study regions – South East Queensland and Greater Sydney – in boxes 1 and 2 (section 8.3.1, and tested via sensitivity analyses (see results in sub-sections 8.4.2 to 8.4.5).

There is a further possible benefit of WELS during a severe drought which has also not been tested. This is the potential for the scheme to avoid regions triggering expensive emergency drought supplies. Greater Sydney's Metropolitan Water Plan, for example, includes a trigger to build the second stage of Sydney's desalination plant if the combined surface water storages fall to 35% full (NSW Government 2017). This 250 ML/day addition to potable supplies could cost more than a billion dollars in capital alone.

However potentially significant, it is not possible quantify these "drought resilience" benefits in this study. To do so, the likelihood of a second major drought in Australia during the period of analysis would need to

[6] Long run marginal cost can be calculated by Turvey or Average incremental cost (AIC) methods. AIC is the more common. It is defined as the present value of the stream of capital and operating costs which will be incurred in the future in order to provide for estimated additional demand divided by present value of that forecast additional demand. The time value of money means that sooner costs will be higher in present value calculations. This means the LRMC can be expected to rise as augmentation is approached.

be established. This is an exercise beyond the scope of the current study. The analysis has instead assumed no droughts of the scale of the Millennium Drought occurring again in Australia before 2036.

8.1.2.2 Value of electricity and natural gas savings

Energy savings have been estimated by ‘fuel’ type (electricity or natural gas) and by state. The estimated value of these savings is based on expected bill impacts to customers. Differences in residential electricity or natural gas prices across Australian states have been accounted for in the historical prices and in future projections.

A level of uncertainty in the trajectory of future energy prices exists. This seems a particular issue for natural gas where current differences among the states are high. The impact of a shift toward higher or lower natural gas prices has therefore been tested in the sensitivity analysis.

8.1.2.3 Value of GHG savings

Greenhouse gas savings are derived from the WELS scheme’s effect on reduced water utility energy use in the supply of water, and from the reduced energy use in water heating with high water efficiencies. The energy and GHG savings from lower hot water use will far exceed the savings associated with reduced potable water supply.

The value of GHG emissions in the period of analysis remains uncertain and a number of approaches to valuing emissions can be taken in the Australian context.

One approach is to use the current prices of Australian Carbon Credit Units from the most recent Emissions Reduction Fund auction (Clean Energy Regulator 2018). This approach would see an average price of about $12 per tonne of CO_2-e in $2016-17. Another approach is to use European carbon price data (Sandbag.org.uk 2018) for historical GHG values.

For projections of GHG values, an implied carbon cost can be estimated from electricity market modelling (Jacobs 2017). This is for meeting Australia’s Paris emissions reduction targets in the electricity sector alone. Alternatively, the cost of carbon necessary to meet Paris commitments globally in all sectors has been estimated (CPLC 2017) and these much higher values can be used in a forecast of the value of GHG emissions.

Drawing on these different approaches, this study develops three price scenarios for GHG emissions and conducts a sensitivity analysis. In all scenarios, the historical policy of carbon pricing in Australia in 2013 and 2014 is accounted for, in order to avoid double counting additional GHG prices with the electricity price during that period.

8.1.3 Boundaries of the analysis

Defining a boundary to the analysis makes clear which costs and benefits are to be included in the CBA. This definition is necessary to avoid double counting of transfers between parties internal to the study. The analysis is also bounded temporally. The study evaluates impacts in the 30-year period from 2006 to 2036.

Figure 55 illustrates costs and benefits that are included in the analysis. Costs that have been quantified are shown in pink. The benefits that are quantified are shown in green. These include prices for water and energy and externality benefits to society as a whole from reduced GHG emissions. Transfer payments between parties, that are not included in the CBA are shown in blue. A dotted line to ‘change in water supply cost without WELS’ indicates the sensitivity analysis for shifting LRMCs and therefore water prices to estimate the ‘without WELS’ case.

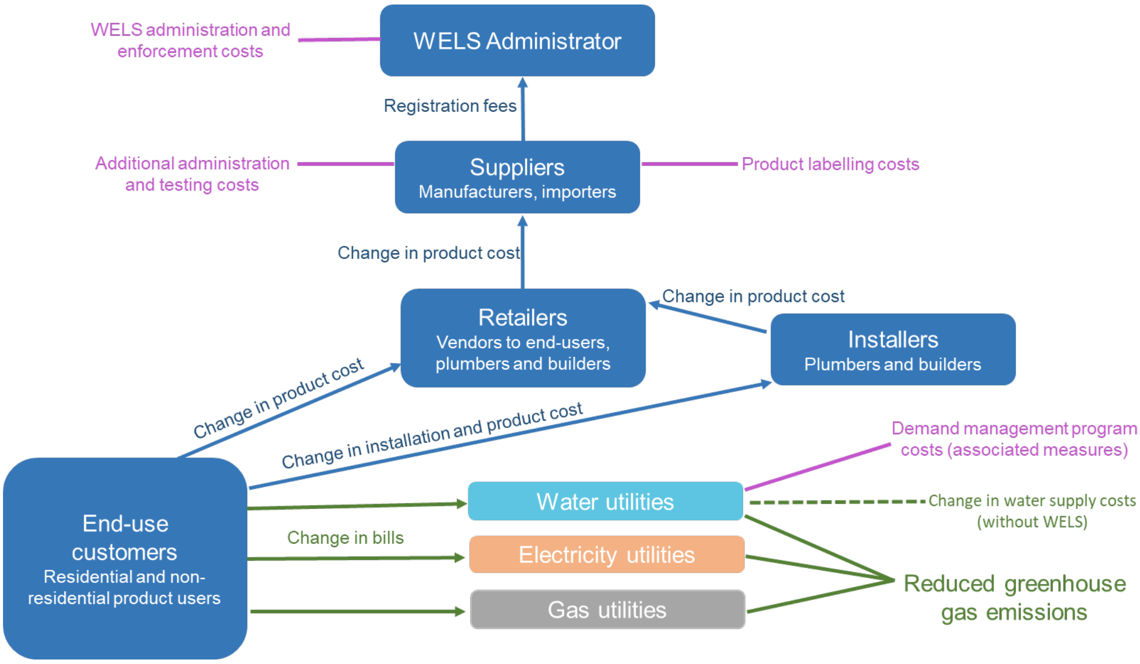


Figure 56 Conceptual approach for evaluation of costs and benefits

The costs and benefits attributed to the WELS scheme are summarised in Table 20. The table also includes actual and potential costs that have not been quantified (shaded orange).

As stated above, the economic appraisal in this study is unusual in that it seeks to evaluate a regulatory mechanism, the WELS scheme, which has been in place for 12 years and no changes are proposed at this time. It also seeks to project the future impacts of the scheme for a further 18 years. The total analysis period is therefore 30 years, from July 2006 to July 2036, and includes estimates of past, current and future costs and benefits. The historical impacts due to the WELS scheme are estimated using collated data and modelling, with all costs and benefits converted to real $2017-18 dollars based on the historical inflation rate (ABS Cat No 6401.0).

Estimation of future impact is based on projections of known trends in water and energy savings together with trends in prices. Future costs and benefits are discounted to present values ($2017-18 dollars) based on a discount rate of 7% for the central analysis with sensitivities at 3% and 10% (Australian Government, 2016a). As reported, the total cost and benefit figures are a sum of the past values (in real terms) and the discounted present values of future values.

Table 20 Costs and benefits included in the analysis

Impact (cost or benefit)	Description of impact	Party incurring cost/benefit	Included in quantitative analysis
Avoided water supply (and wastewater) costs	Reduced operating costs due to the reduced volume of water supply. This includes the cost of energy tariffs from water utilities operations. Also includes avoided/delayed investments in water supply infrastructure	Benefit to Customers and (to a lesser extent) water utility	Yes included based on the proxy of retail water prices.
Avoided cost of heating water	Reduced operating costs for energy used in water heating. Electricity and gas tariffs.	Benefit to Customers	Yes included based on the proxy of retail Electricity and gas prices

Impact (cost or benefit)	Description of impact	Party incurring cost/benefit	Included in quantitative analysis
Reduced GHG emissions	Energy related emission from water heating and water utilities operations	Benefit - Society in general	Yes based on two potential scenarios for the value of GG emissions
Scheme administration, costs	Cost for Commonwealth to administer, enforce, and promote the WELS scheme	Cost to DWAR and State Gov.	Yes based on budgeted costs from Commonwealth and its predecessors
Demand management program costs	Cost of demand programs by water utilities, Councils and State Governments during Millennium drought	Cost to water utilities	Yes using Sydney Water's program in the period as a proxy
Supplier registration fees	Registration fees paid to register products for WELS scheme	Cost to product suppliers	No – this represents a transfer payment to DAWR (included in scheme costs)
Additional supplier cost of Scheme	Internal administration and labour (registration and scheme compliance)	Cost to product suppliers	Yes
	Costs of printing and affixing labels		Yes
	Direct testing costs (additional to WaterMark)		Yes
Increased product and installation costs	Additional costs associated with more water efficient products either for purchase or installation	Potential cost to customers	Tested in interviews and not found to be significance
Additional time taken with low flow taps and showers	Some stakeholders have noted in previous studies that low-flow taps having a negative impact on waiting times for volume-dependent end uses	Potential cost to customers	No - Impact considered insignificant for labelling scheme
Possible sewer damage due to reduced flows	Reduced sewage flows within utility sewage systems may cause damage to sewers.	Potential cost to Water utilities	No - Impact considered insignificant for labelling scheme
Loss of sales for some plumbing product suppliers	Sales will be negatively impacted for some plumbing product suppliers. Others will see increases.	Possible cost to product suppliers	No – this cost represents a transfer from one group to another

8.2 Costs associated with the scheme

As described in the analysis framework (section 8.1), there is a range of costs associated with the WELS scheme. The costs quantified in the economic appraisal are:

- direct costs to the Commonwealth Government for administering the scheme (partly offset by registration fees for fixtures and appliances and also payments from the State and Territory governments)
- associated costs for demand management efforts by water utilities and others during the Millennium Drought, which are intrinsically linked to the savings of the scheme
- additional costs to suppliers of fixtures and appliances as a consequence of the scheme.

The approach to quantifying each of these costs in set out below. There are also further impacts of the scheme that negatively affect some parties but are difficult to quantify in monetary terms. These non-quantifiable impacts are described qualitatively.

8.2.1 Costs of administering the scheme

The Commonwealth Government has an annual operating budget for administering the WELS scheme, which covers all administration, communication, compliance and enforcement costs. The scheme administration costs used in the analysis were provided by DAWR, drawing actual budget data and material provided in the WELS scheme strategic plan for 2012-15 and strategic plan 2016-17 to 2018-19 (Australian Government 2012 and 2016b). Table 21 lists the annual costs (a mixture of planned and actual budgets) since commencement of the scheme.

Table 21 Annual costs for scheme administration 2005-06 to 2018-19 (nominal $)

Year	Budget	Year	Budget
2005 – 2006	$1,875,000*	2012 – 2013	$1,996,000
2006 – 2007	$1,875,000*	2013 – 2014	$1,910,000
2007 – 2008	$1,875,000*	2014 – 2015	$1,960,000
2008 – 2009	$1,875,000*	2015 – 2016	$1,430,000
2009 – 2010	$2,220,000	2016 – 2017	$1,740,000
2010 – 2011	$2,285,000 **	2017 – 2018	$1,810,00
2011 – 2012	$2,350,000	2018 – 2019	$1,946,000

* DAWR aggregated budget ($7,500,000) for the first four years.

**Costs data not available – an average of 2009-10 and 2011-12 was adopted.

The direct costs of the scheme have typically been just under $2 million per year, with a few higher years around 2009-2012. For the analysis, future costs are projected as increasing at a nominal rate of 4% per year, on the advice of DAWR.

The budget is funded by three major sources: registration fees paid by appliance and plumbing product suppliers; direct funding by the Commonwealth Government; and contributions from each of the states and territories. Registration fees contribute approximately 80% of the total annual budget, with states and territories contributing 10% and the Commonwealth contributing the remaining 10%.

8.2.2 Cost of demand programs during the Millennium Drought

As described above, over the decade to 2011 Sydney Water implemented some of the world's largest demand management programs aimed at increasing the water use efficiency of its customers. Most of Sydney Water's estimates of program savings are based on empirical studies using customer metering data. These therefore enable an evaluation of actual savings.

Table 22 includes Sydney Water's reported costs for programs from 2006-07 until their large scale schemes ceased with the end of the drought in 2010-11 (Sydney Water 2012). Only programs that relied on WELS appliances and fixtures are included.

Table 22 Sydney Water demand management targeting WELS products ($1000 Nominal)

Program	2006	2007	2008	2009	2010
Residential					
WaterFix retrofit	12,455	8,593	1,963	1,415	1,376
DIY Water Saving Kits	1,839	753	244	76	3
Washing Machine Rebate	7,381	10,642	6,588	4,808	16
Toilet Replacement Service	454	18	4,943	6,143	3,944
Dual-Flush Toilet Rebate				307	1,269
Education	94	1,723	-	-	-
Business					
Smart Rinse	228	563	1,128	802	288
BizFix	200	2	308	723	370
Hospitals Sustainability Initiative				15	37
School					
Every Drop Counts in Schools	261	238	200	318	221
School Amenities Replacement				63	25
Pilots					
HiRise retrofit			247	697	228
Council Partnerships			1,233	535	381
Total	**22,912**	**22,532**	**16,854**	**15,902**	**8,158**

For this study, the costs of programs were apportioned across the population serviced by Sydney Water to give per capita costs per year. To estimate costs across the country, these per capita figures were used as a proxy for investment in demand management during the Millennium Drought in those regions impacted by significant water scarcity. Because Sydney Water, like other large metropolitan utilities, was highly active in demand management during the drought, these costs may be an overestimate of the scale of investment in non-metropolitan areas. However, state governments, such as the NSW Government, were also actively running programs and funded water saving projects in regional areas during the period (NSW Government 2012)

8.2.3 Additional costs to product suppliers

In interviews with plumbing products and white goods manufacturers and suppliers, a range of additional costs to their businesses were mentioned. Some of these were quantifiable and some were not. For larger manufacturers the impacts of WELS tend to filter throughout their businesses, from marketing where ideas and costs for new products are developed, to design, research and development which needs to meet performance standards using the least amount of water (as well as energy for white goods). Iterations in design to meet those standards add extra costs which are difficult to quantify, however, they are generally recoverable because of the large turnover of these businesses.

For small to medium sized companies, WELS compliance adds significant proportional costs through the need for product testing, labelling (including printing and reprinting when labelling specifications change), and human resources to manage these processes.

Some interviewees suggested the following WELS associated costs to their businesses:

- up to $400,000 per year for testing, etc. to bring in 50 to 100 new products
- $190,000 annually, inclusive of registration fees, product testing, printing of labels, staff salaries and overall cost of ensuring product components meet the WELS standard (AS/NZS 6400:2016)

- $120,000 annually, adding about 13 cents to each tap or shower sold in total (out of nearly one million items, which is fairly large turnover)
- for manufacturers of higher value tapware products, in a niche commercial market with lower sales volumes, additional costs could be in the order of $3.50 to $6.50 per item.

Many of these costs, including registration fees, are transfer payments so are not included in full in the CBA. Other costs are additional, for testing products and administration but are not necessarily differentiated between various schemes. This means some cost may include cost for testing for WaterMark and the Australian Energy Ratings Label. From data gathered via interviews, cost estimates for the following two compliance activities (on top of registration fees) were included in the CBA analysis:

- cost of testing and administration per registration
- cost of labelling each product or appliance.

Estimates of these additional costs, broken down into taps and showers; toilets; and clothes and dish washers are provided in Table 23.

Table 23 Additional costs to product and appliance suppliers

Cost category	Taps and showers	Toilets	Clothes and dish washers
Additional cost for testing and administration per registration	$3,000	$6,000	$9,000
Labelling cost per product or appliance	$0.05	$0.15	$0.15

Conservative estimates rather than definitive costs were included in the analysis because it was not possible to standardise the data provided by interviewees. The companies who participated had varying capacities to isolate WELS related costs from broader costs of research, development, quality assurance or administration. In particular, compliance activities associated with WaterMark certification are generally combined with WELS, and are often carried out by a member of staff responsible for these and other quality assurance and regulatory matters. Similarly, for white goods the costs of water and energy labelling can be hard to disassociate.

8.2.4 Non-quantified costs of scheme

Overall there is broad industry support for the WELS scheme owing to its community benefits in reducing water consumption and water bills as well as the creation of a level playing field where customers have confidence in the water efficiency claims of products. However, there are also views that industry unfairly carries the financial burden of the scheme through registration fees, while communities reap the benefits through greater water supply security and reduced spending on water infrastructure.

A number of interviewees stated that while the direct WELS costs have an obvious financial impact, especially registration fees for smaller businesses, there are also hidden costs and some potentially perverse outcomes for market competition that need to be considered in any evaluation of the impacts of the scheme. These include:

- water efficiency not necessarily being high on the list of criteria for customer choice; many sales are driven more by price, design features, style and (for electrical appliances) energy efficiency. There is an additional cost in having to innovate in water efficiency and the features customers differentiate on
- delayed release of new products, and consequential loss of consumer access to novel products as well as revenue for suppliers, attributed to issues with technical expertise necessary to assess and register these products under WELS
- reduced product diversification and consequential loss of market choice with smaller suppliers in particular, because of the current requirement to register every new product regardless of whether the “new” features have any impact on water efficiency, e.g. colour or spout length of a tap
- inhibiting business growth because smaller suppliers choose not to release additional products because they would be pushed into higher WELS registration tiers which cost them more
- negative impacts on customers when non-compliant products remain in the market despite the current level of compliance enforcement; overseas plumbing products can be purchased online without WELS registration

- independent or smaller plumbing product retailers can be left with superseded stock that is no longer registered by the supplier, thus risk both WELS non-compliance and loss of revenue if stock can no longer be legally sold.

Other areas of frustration for suppliers are where WELS doubles up with other schemes creating higher costs to them, and in general, with no benefits. In particular they noted:

- unnecessary administration costs for having to register plumbing products with both WELS and WaterMark, including duplication of effort because licence renewals for the two schemes occur at different times of the year
- avoidable registration and administration costs for electrical appliance manufacturers who need to register clothes washers and dishwashers for both water and energy efficiency; they have to provide the same information to two different government departments because these ratings schemes are administered separately.

8.3 Benefits of the scheme

The benefits of the WELS scheme have been estimated using prices for water, electricity, natural gas and GHG emissions. Numerous sources have been drawn upon to develop data sets for both historical and future prices and these are described below. Sensitivities to key pricing assumptions are included in cost benefit results in subsection 8.4.

8.3.1 Water prices

Water prices for the CBA were derived from historical price data sourced, where possible, from the Urban Water National Performance Report datasets collated by the Australian Bureau of Meteorology (BOM 2018). Historical price data for South Australia from 2006 to 2012 was sourced separately, from the South Australian Government Gazette and Essential Services Commission[7]. Water prices for Tasmania were extrapolated retrospectively from recent prices (2015 and 2016). This was considered reasonable given that these prices are particularly low. In most jurisdictions, prices vary with location and analyses of this dataset gave average prices per kilolitre sold in each state/territory in the years of interest.

The historical price data were nominal, meaning that these were the actual prices paid by customers at the time. The nominal prices have been converted into current year values ($2017-18) so that the impact of inflation is removed and the real price increases for water over the period are evident (see Figure 56).

[7] South Australian prices for 2006 to 2010 are taken from the South Australia Government gazette. 2011 and 2012, are taken from a 2012 Essential Services Commission (ESC) report. Volumetric prices in the historical period in South Australia were consistent across the state and included either two or three pricing tiers. From 2006 to 2011, tier two volumetric prices have been used in the analysis based on ESC reports from 2005 and 2012. These indicate tier two approximates the LRMC. Likewise an average of the tier one and two price is used for 2012 based on commentary in the 2012 ESC report.

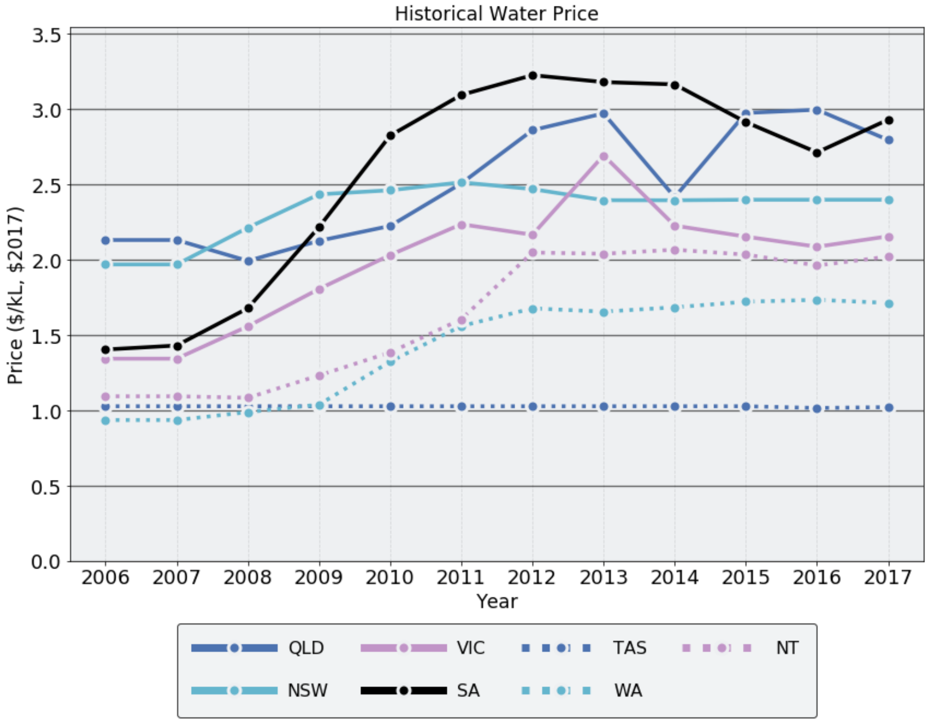


Figure 57 Historical residential water prices by state (in $2017-18)

The future projections of price included in the analysis assumed a CPI increase (with future prices reported in nominal terms in (Figure 57). These future prices were discounted back to present values in the analysis.

It should be noted that some reporting bias is inherent in the approach taken as larger water utilities and metropolitan utilities, in particular, are more consistent in reporting their data to BOM than smaller water service providers in regional areas. It should also be noted that for the year 2016-17, data were incomplete for New South Wales, and for a number of jurisdictions it was necessary to backcast from more recent prices to 2006-07.

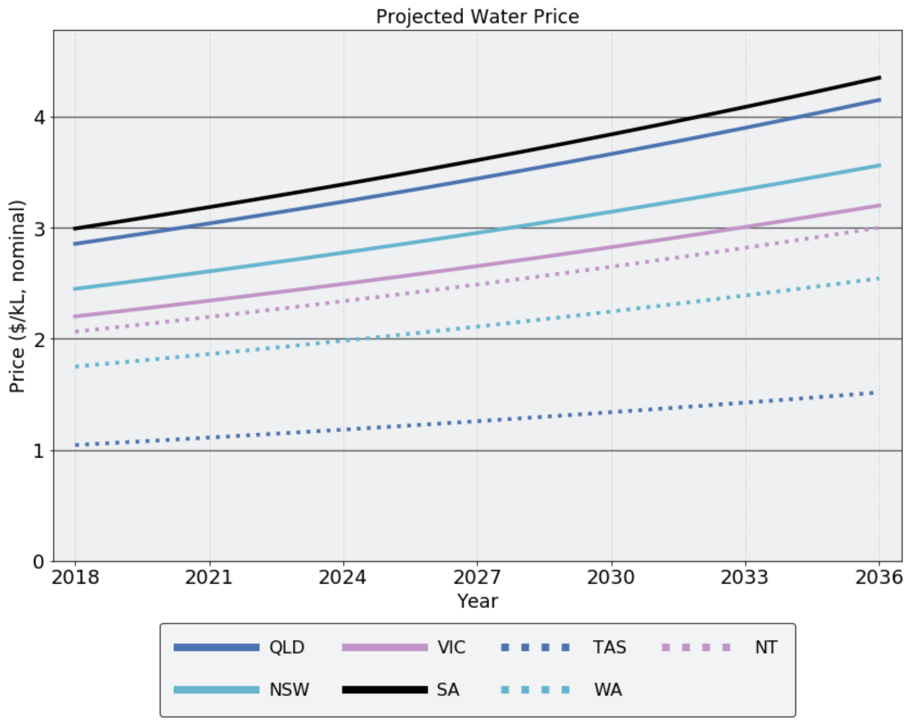


Figure 58 Projected residential water prices by state (nominal $)

As discussed in sub-section 8.1.2.1, this study acknowledges that taking current water prices as a proxy for the value of water in urban regions has the potential to underestimate the value of water saved by the WELS scheme. This is because the WELS scheme could be expected to already act to reduce water prices, due to the lower overall demand. To test the scale of this effect, two case studies are considered in the boxes below.

In box one the case study of South East Queensland is summarised. Available analysis from that region shows that a 30 L per person per day shift in demand would change supply augmentation timing by 10 years. This estimate is used to calculate a change in the long run marginal cost of supply based on a hypothetical supply augmentation.

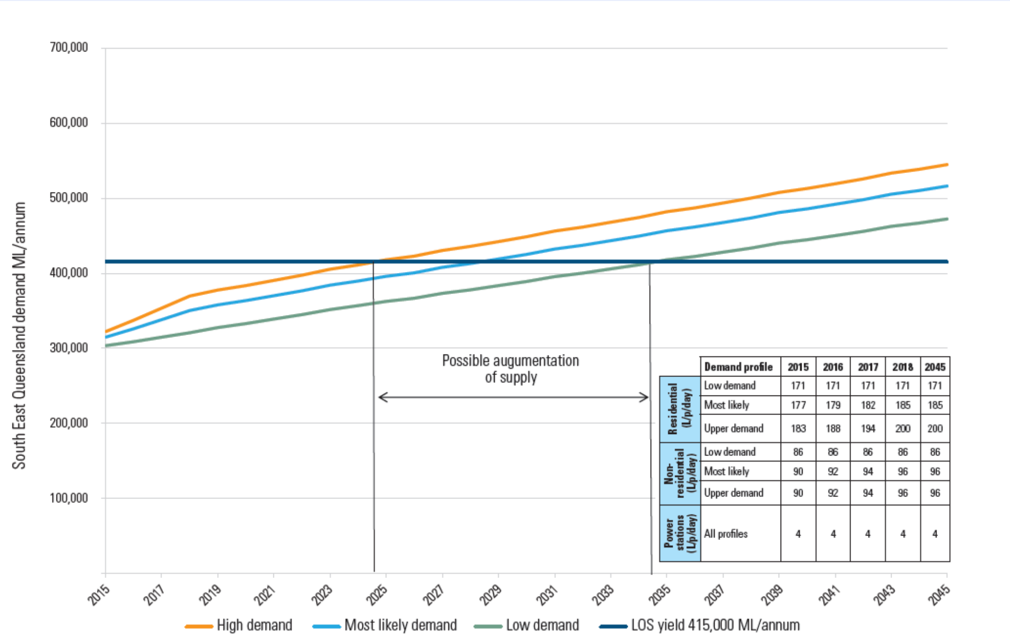
The case study in box two is Greater Sydney. Here the actual per person water saving due to WELS from the modelling described above in section 5 is added to the current mid case (business as usual) demand forecast. Again, the change in the long run marginal cost of supply based on a hypothetical supply augmentation is estimated. The results of the analysis of these two case studies is used to inform the sensitivity analysis of water prices in section 8.4.4.

Box 1: Value of Water Case Study 1 – Water security planning for South East Queensland

South East Queensland (SEQ) covers an area of about 22,400 km^2 from Noosa in the north to the Gold Coast in the south, and west to the Somerset, Lockyer Valley and Scenic Rim local government areas. Currently home to about 3.4 million people, SEQ has experienced significant population growth over the last 20 years, and is predicted to exceed 5 million by 2050. Like much of Australia, SEQ was severely affected by the Millennium Drought; this led to a change in government policy toward planning for long-term water security. In 2014, the Queensland Government legislated level of service (LOS) objectives for SEQ's water supply system. The bulk water provider to the region, Seqwater, was required to prepare its first water security program in 2015 to demonstrate how the LOS would be met over the ensuing 30 years. An updated program was released in 2017.

The water security program is based on supply-demand modelling, and explores a range of scenarios such as variable population growth rates, per person daily water consumption (residential and non-residential), operating rules for the interconnected supply system, capacity of the existing system and additional supply needs in the future. System capacity is termed 'LOS yield' which is the maximum annual average volume of water that can be supplied while meeting the levels of service objectives.

The graph below is the output of preliminary supply-demand modelling for the first water security program. It shows a possible delay of 10 years for supply augmentation with a reduction of 30 LCD in per capita per day demand. The difference between high and low cases include water conservation measures such as including higher WELS-rated devices in all new buildings as well as assumptions about outdoor water use behaviour.



	Demand profile	2015	2016	2017	2018	2045
Residential (L/p/day)	Low demand	171	171	171	171	171
	Most likely	177	179	182	185	185
	Upper demand	183	188	194	200	200
Non-residential (L/p/day)	Low demand	86	86	86	86	86
	Most likely	90	92	94	96	96
	Upper demand	90	92	94	96	96
Power stations (L/p/day)	All profiles	4	4	4	4	4

Figure sourced from Water for Life – SEQ's Water Security Program 2015-2045 (Version 1, 2015)

The results in the figure above show a difference in per capita demand of 30 L/p/day resulted in a delay in supply augmentation by 10 years from 2025 to 2035. If we knew the cost of the next supply augmentation, these figures could be used to estimate the impact of changing the per capita demand on the LRMC of supply in this region.

For illustration if we assume a supply augmentation costing $1.5 billion* then the difference between augmenting supply in 2025 compared to 2035 would be in order of **$400M** in present value terms. This would however only change the LRMC of supply in the region by **$0.14** per kilolitre or about **5%** of the retail price of water.

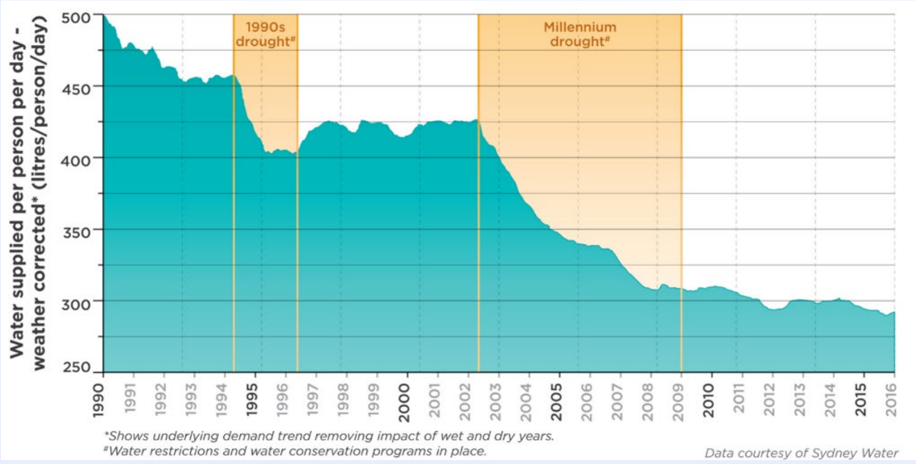
*This augmentation cost is not drawn from SEQ water security program and is used only for illustrative purposes.

Box 2: Value of Water Case Study 2 – Metropolitan Water Plan for Greater Sydney

The Metropolitan Water Plan for Greater Sydney is the NSW Government's plan to secure water for around 5 million people and the environment of the region which encompasses the Sydney metropolitan area, Blue Mountains and the Illawarra. First developed in 2004 and reviewed in 2006 in response to the Millennium Drought, the plan has been revised two further times (2010 and 2017) as the water security situation has changed. The 2017 Metropolitan Water Plan sets out a portfolio of measures and strategies (supply and demand) to manage water supplies as the population grows, and to respond effectively in future droughts. The portfolio is underpinned by:

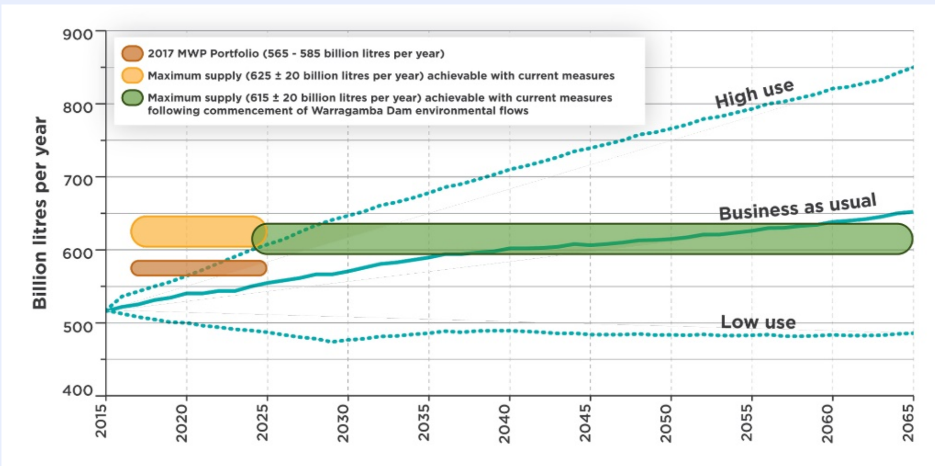
- the outcomes of community engagement on visions for the region and preferences for certain supply and demand options over others
- customised hydro-economic modelling for optimising supply and demand measures at least cost
- cost-benefit analyses for key strategies such as the introduction of variable environmental flow releases from the region's main water storage, Warragamba Dam.

It can be seen from the following figure from the plan that per person water use has declined markedly since 1990.



Of particular note is that water use since the end of the Millennium Drought has not returned to pre-drought levels. This shows the demand management measures implemented during the drought have had a lasting impact through ongoing water saving behaviours by the community; increasingly efficient water using appliances supported by the WELS Scheme; and associated measures such as BASIX for new housing as well as Water Wise Rules for outdoor water use.

The impact of this sustained reduction in per capita water use is significant in terms of the total annual volume of water needed to supply Greater Sydney as seen in the following figure. This figure also shows that, with environmental flow releases commencing from Warragamba Dam in 2024, the measures in the current MWP could supply a maximum of 615 GL per year (plus or minus 20 GL).



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Value of Water Case Study 2 (continued)

Given the uncertainties in the demand forecast and maximum supply, a range of LRMCs could be calculated from the supply-demand figure for Greater Sydney. For illustration, however, if we take the maximum supply as 615 GL/yr and a mid-case (business as usual) demand forecast as reasonable, then a new source of supply would not be needed until around 2048.

It is then possible to look at the impact of WELS and associated measures on the Greater Sydney forecast. This is possible by adding the different between our modelled 'with WELS case' and 'without WELS case'. Based on per person figures for NSW and Greater Sydney population forecasts, it can be seen that demand would be about 35 GL higher in 2026 and 42 GL higher in 2036. This would in turn shift the augmentation timing to 2030.

Again for illustration if a supply augmentation costing $1.5 billion* is assumed, then the difference between the 'without WELS' case with an augmenting supply in 2030 compared to the 'with WELS' case in 2048 would be in order of **$411 million** in present value terms. The 'with WELS' case would shift the LRMC of supply in the Greater Sydney region by **$0.54** per kilolitre or about a **25%** increase in the retail price of water.

*As with Box 1, this augmentation cost is not drawn from 2017 Metropolitan Water Plan and is used only for illustrative purpose.

8.3.2 Electricity prices

Electricity saving estimates were derived using historical and future projections as reported for Queensland, New South Wales, Victoria, South Australia and Tasmania by Jacobs Consulting for the Australian Energy Market Operator, AEMO (Jacobs 2017). The Jacobs index, which included years 1981-2035, was used to extrapolate actual prices (c/kWh) using *Australian Energy Market Commission* (AEMC) pricing data (AEMC 2017) for years 2015-2019. The AEMC data had assumed retirement of the Hazelwood power station, which did occur.

The AEMC data did not however cover all regions of Australia, with the Queensland data relating only to south-east Queensland, and no data included for Western Australia or the Northern Territory. The missing regions are relatively small therefore proxy values were derived from a population-weighted average using the remaining states.

The Jacobs data assumes residential prices will fall in all states and territories to 2030. The fall would be driven by more renewable energy generation coming on line, at which point prices are expected to level out due to anticipated closures of a number of large coal-fired power stations. Nominal prices were converted into real values ($2017-18) for the historical period and retained as nominal prices for future projections (see Figure 58 and Figure 59).

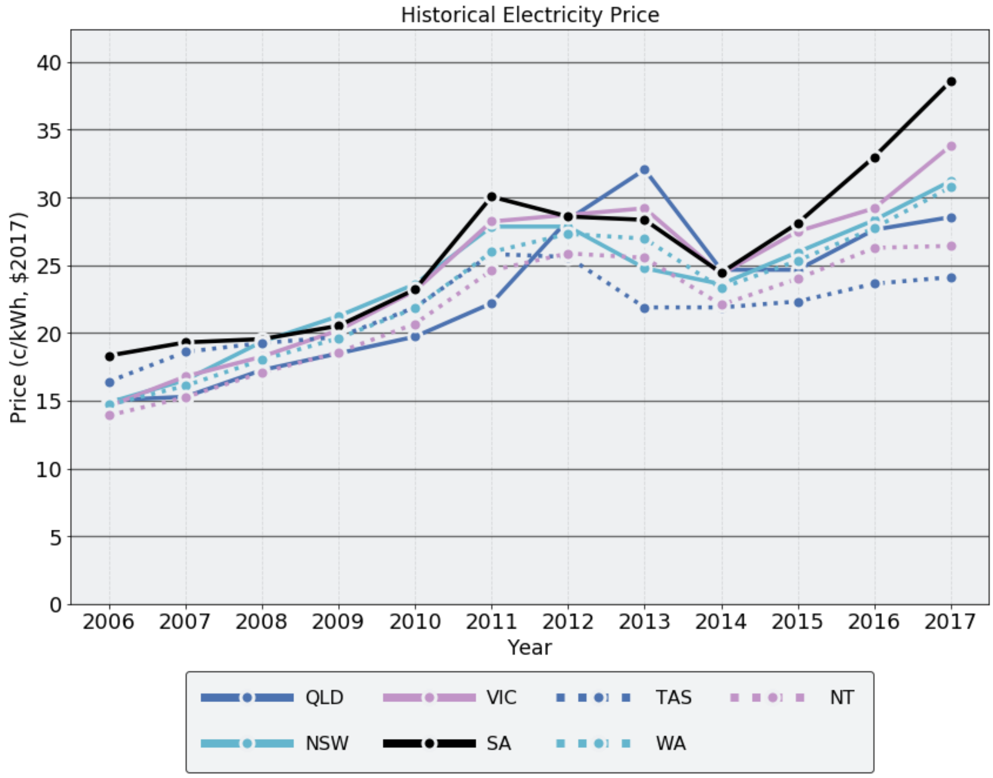

Figure 59 Historical residential electricity prices by state*

*QLD data is the SEQ region, and data for WA and NT are derived from population-weighted averages for the remaining states.

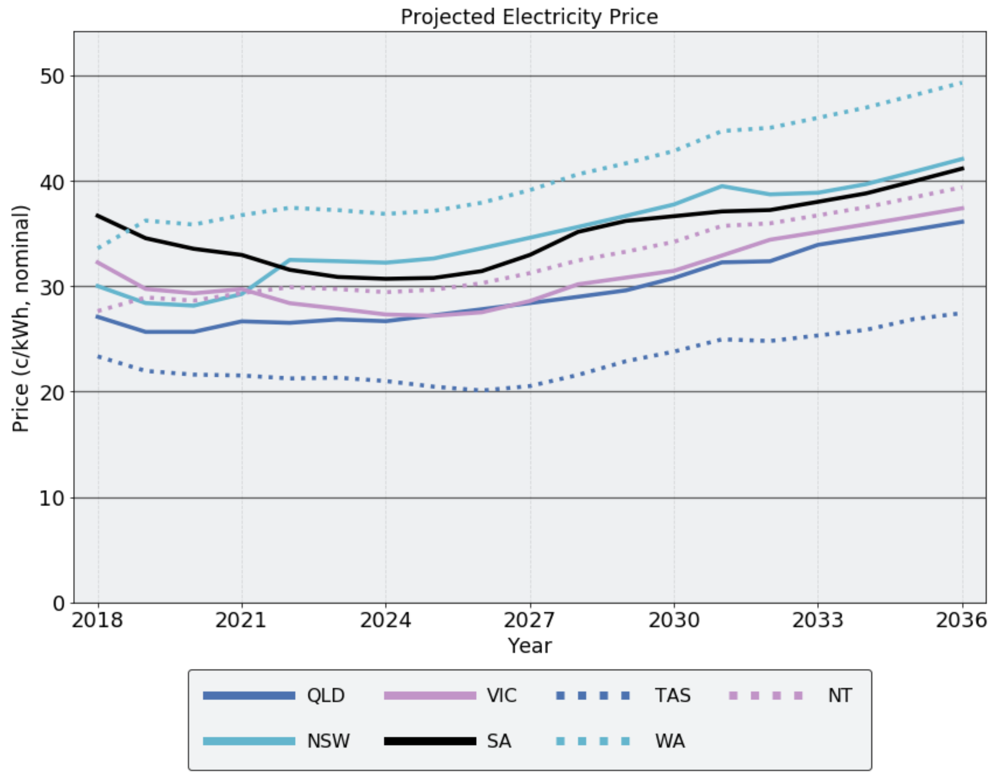

Figure 60 Projected residential electricity prices by State (nominal $) *

*QLD data is the SEQ region, and data for WA and NT are derived from population-weighted averages for the remaining states.

8.3.3 Natural gas prices

Gas prices were derived from Commonwealth data reported by Oakley Greenwood (2018), which contained gas prices for all states from 2006-present (in c/MJ, indexed to $2017-18 (Figure 60). Future projections are reported in nominal terms (Figure 61).

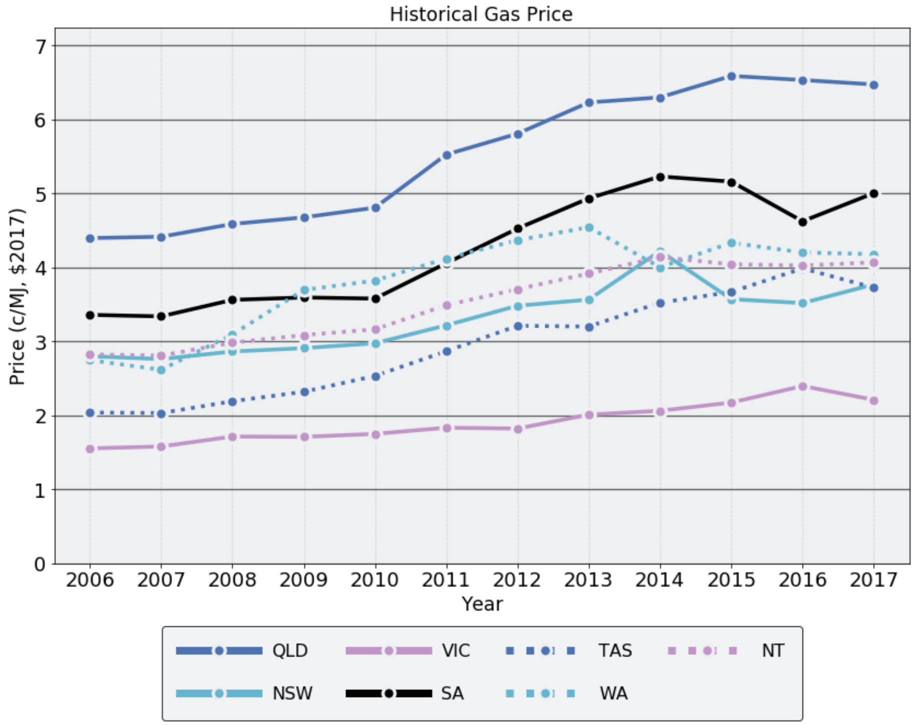

Figure 61 Historical residential natural gas prices by state#

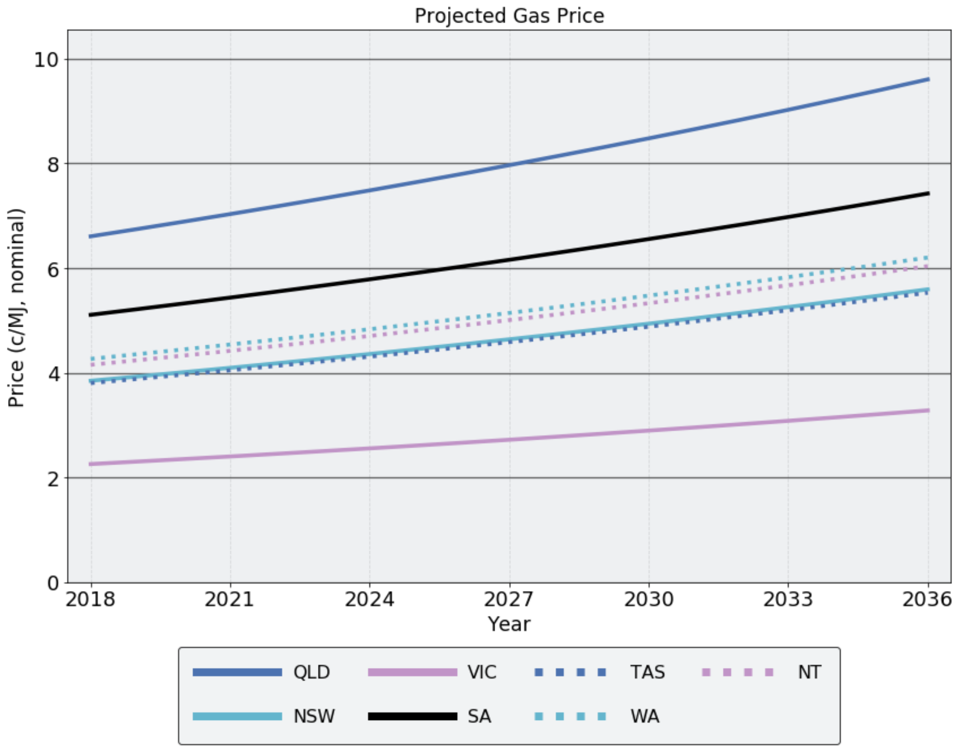

Figure 62 Projected residential natural gas prices by state (nominal $)#

Data for Northern Territory is a derived, population-weighted average of the states.

8.3.4 Valuing Greenhouse gas emissions

Greenhouse gas values for the base case scenario were derived from European carbon pricing (Sandbag.org.uk 2018) in combination with the Jacobs modelling for 2030 emissions reduction targets (Jacobs 2017). This project began with a carbon price of $25, increasing to a predicted peak of $45 in 2029 using a linear interpolation.

In light of the uncertainty of this central case, two additional carbon price scenarios were constructed and tested. The results are outlined in section 8.4. A low scenario was derived from a projection based on a real value of $12/tonne of CO_2-e.from current prices of Australian Carbon Credit Units (Clean Energy Regulator 2018). A high scenario was derived from values taken from the midline of the High-Level Commission on Carbon Prices projections for the price of carbon needed to meet global emissions targets across all sectors (CPLC, 2017). This work on a global carbon price was supported by the World Bank and suggests a price increase in real terms of at least US$40–80/tonne of CO_{2-e} by 2020 and US$50–100/tonne by 2030.

The three scenarios, shown in Figure 62, include:

- Base case - derived from EU market price and Jacobs modelling
- Low - $12 per tonne in 2016-17 adjusted for CPI
- High - based on CPLC (2017).

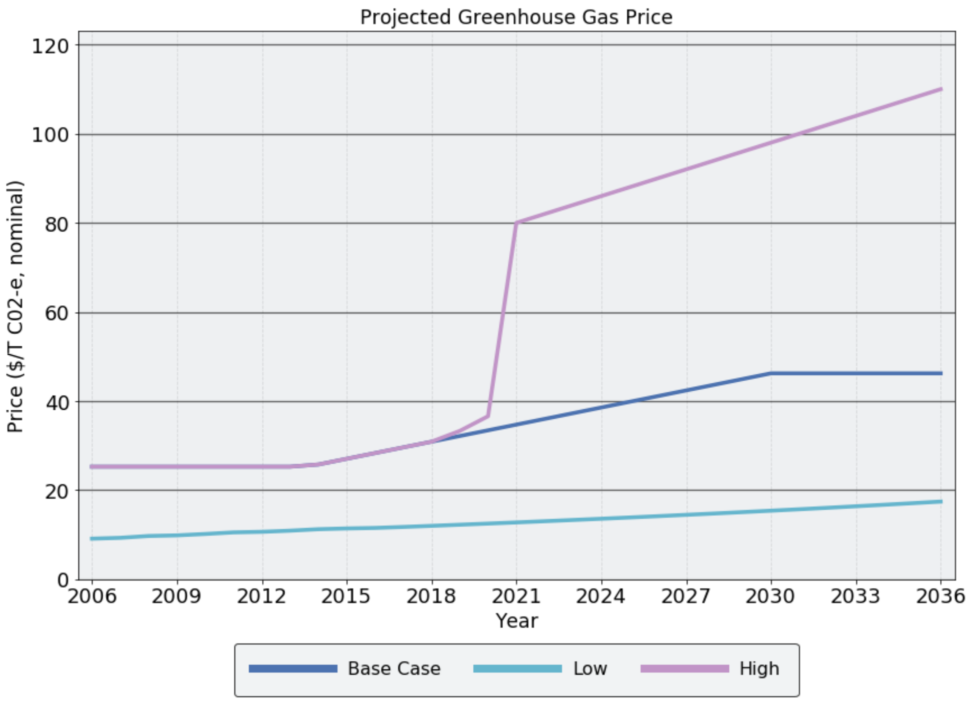

Figure 63 Projected greenhouse gas prices per tonne of CO_2-e (nominal)

8.4 Cost benefit results

The results of analyses suggest that the WELS scheme and associated measures have had a total benefit to cost ratio of 29 in real terms ($2017-18) for the whole period of analysis. Projected to 2036, the ratio is even higher at 96 to one for benefits to costs. These high ratios are driven by the level of benefits that are seen to flow from the scheme and water efficient policies and initiatives linked to it.

Table 24 separates past and current year impacts from the future values. To allow a comparison, the past costs and benefits have been inflated to the current year (2017-18) dollar value and future costs/benefits are discounted back to their present value (PV) based on a 7% discount rate. The results show the net benefit of the scheme to date has been $5 billion. A further $18.4 billion net benefit is forecast to 2036. Energy-related benefits are the largest proportion of these, with water savings also significant. In contrast, the cost of the scheme and associated mechanisms are estimated at under a billion dollars over the period of analysis. The greatest costs are in the past and were associated with the demand management effort during the Millennium Drought. This is why for the current and historical period, the higher costs associated with demand management programs give a benefit cost ratio of 8.8 (2006 to present).

Table 24 Cost benefit analysis summary of results

	Total $17-18 ($M)	Past & current $17-18 ($M)	Future PV $17-18 ($M)
Costs			
Scheme cost	$57	$29	$28
Supplier costs per reg.	$307	$147	$159
Labelling cost	$12	$5	$7
Program Costs	$463	$463	$0
Total Costs	$838	**$644**	**$194**
Benefits			
Water Savings	$6,545	$1,440	$5,104
Electricity Savings	$9,437	$2,344	$7,093
Gas Savings	$7,016	$1,587	$5,429
GHG Savings	$1,266	$268	$999
Total Benefits	**$24,264**	**$5,639**	**$18,625**
Net Benefit	**$23,426**	**$4,995**	**$18,431**
B/C ratio	**29**	**8.8**	**96**

8.4.1 Breakdown of cost and benefits

Figure 63 displays the proportion of total benefits (savings for each benefit type) by state. While total savings from reductions in water use alone are significant ($6.3B), benefits in energy and natural gas savings comprise the highest proportion of benefit types calculated ($9B and $6.8B, respectively). Unsurprisingly, as the most populous state, New South Wales has the highest proportion of savings across all benefit types (water, energy, gas and GHG).

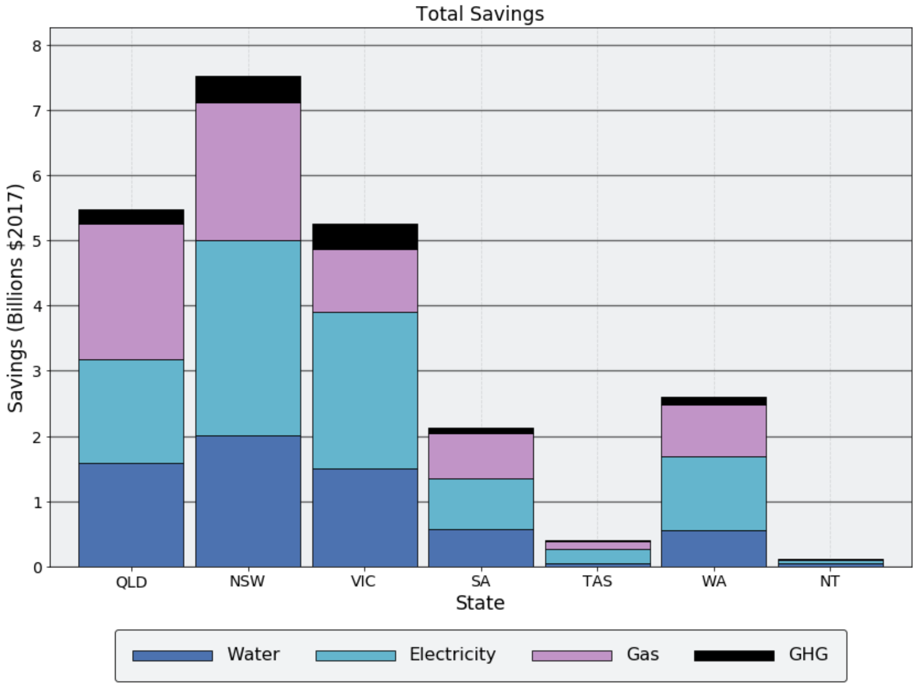

Figure 64 Proportion of total benefits per state for water, energy and GHG

Table 25 shows the proportional contributions of each benefit type (water, energy, gas and GHG savings) to total, past to current, and future savings. It is clear from these figures that the proportions contributed by each benefit type are relatively consistent across the period of analysis. The only change is a slight decrease in the proportion of benefits from electricity saved.

Table 25 Contributions to total, future and past benefits by saving type ($2017-18)

	Total	Past & current	Future PV
Water Savings	27%	26%	27%
Electricity Savings	39%	42%	38%
Gas Savings	29%	28%	29%
GHG Savings	5%	5%	5%

Figure 64 (comprising (a), (b), (c) and (d)) illustrates the savings for each benefit type by state, for both historical (past and current) and future projections (2006-2017 and 2018-2036, in $M and $2017-18). Proportions of future costs are larger due to the longer time period (12 years for accumulation of past benefits versus 18 years for accumulation of future benefits).

For water savings (Figure 64a) New South Wales is expected to achieve total savings of $2B from the period 2006-2036, and Queensland is expected to achieve $1.59B – more than Victoria's $1.5B estimated savings. South Australia and Western Australia are expected to return similar cost savings for water under the WELS scheme.

New South Wales is estimated to benefit from close to $3B in total electricity savings from the period 2006-2036 (Figure 64b); the most of any state and almost double that of Queensland ($1.58B). Western Australia's total electricity savings are expected to be high ($1.1B), though appear proportionately similar to South Australia ($791M) when the populations of these two states are considered.

For natural gas, however, the proportions of savings across states differ. Queensland's savings in gas costs closely mirror the more populous state of New South Wales ($2.01B and $2.1B, respectively), potentially reflecting characteristics particular to Queensland's gas pricing structures - Figure 64c).

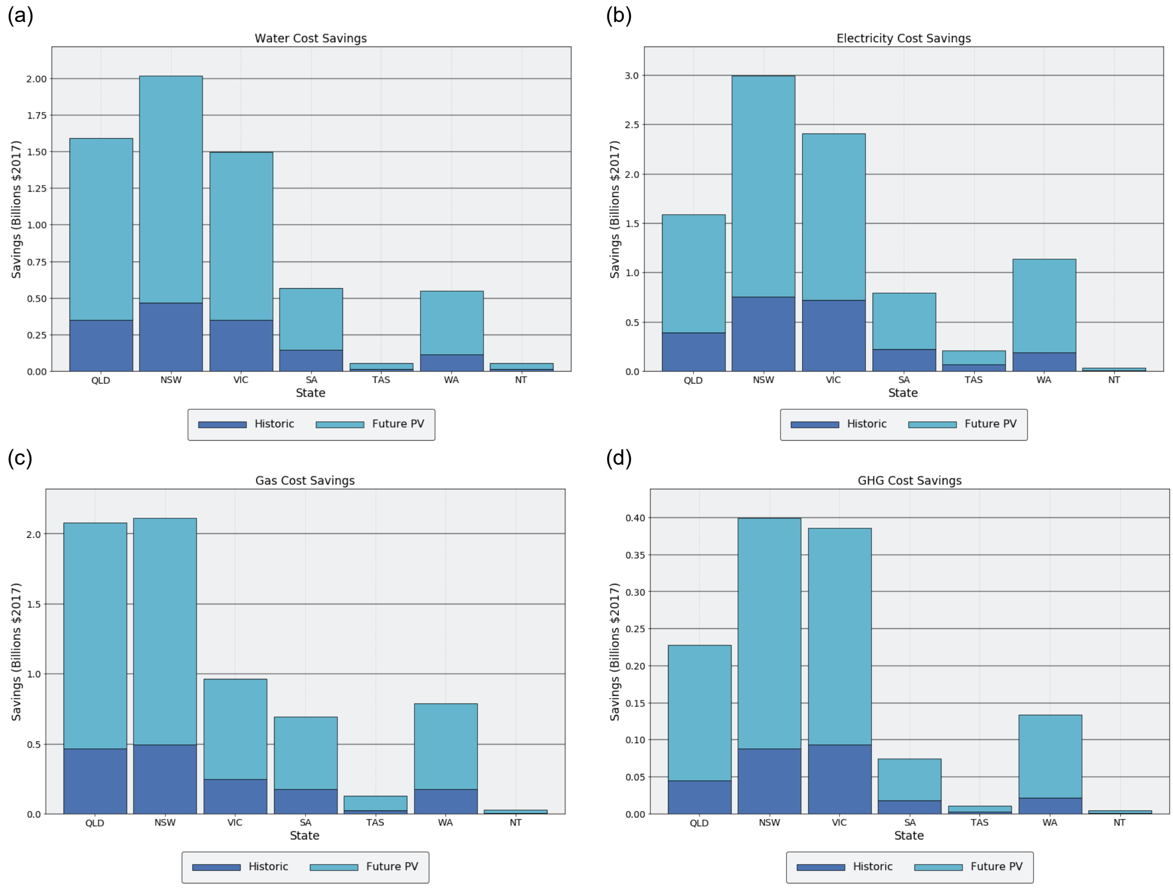

Figure 65 Historical and future savings (a) water; (b) electricity; (c) natural gas; (d) GHG

Across the graphs in Figure 64, the proportion of future benefits is higher than historical benefits. This is despite the 7% discount rate applied to bring future benefits back to present values. The reason is the greater number of years (12 historical and 18 future) and the growing volumes of savings each year.

8.4.2 Sensitivity to carbon price

As outlined in section 8.3.4, three scenarios were constructed in order to compare the impact of the baseline (EU pricing and Jacobs electricity sector meeting Paris target scenario) with a 'low' and a 'high' scenario. As expected, the low carbon price (based on a real $12/tonne value) results in a lower benefit/cost ratio compared to the base case for both the past and future periods. However, the impact is small, with a drop from 29 to 28 (Table 26). Even for the high carbon prices proposed by the CPLC (2017) with a global price in 2017 dollars of $80US of CO_2-e in 2030, results are minor with an increase to 30 in the benefit cost ratio (see Table 26). The results of the analysis are therefore not sensitive to carbon price assumptions.

Table 26 Sensitivity analysis for 'low' and 'high' carbon price scenarios

	Total $17-18 ($M)	Past & Current $17-18 ($M)	Future PV $17-18 ($M)
Costs			
Total Costs	$838	$644	$194
Benefits			
GHG Savings	$482	$127	$355
Total Benefits	$23,480	$5,498	$17,981
B/C ratio (low)	**28**	**8.6**	**93**
GHG Savings	$2,394	$310	$2,083
Total Benefits	$25,391	$5,682	$19,709
B/C ratio (high)	**30**	**8.8**	**101**

8.4.3 Sensitivity to natural gas price

Natural gas prices differed considerably between states (up to three times between Queensland and Victoria in 2017). It could be argued that this differential might be expected to narrow in coming years. To better ascertain the impact of this factor upon the results, sensitivity analyses were conducted for 'low' and 'high' future natural gas pricing scenarios (Table 27). The impact of changes to natural gas price are not insignificant. If all states move toward current lower end natural gas prices (3c/MJ), the total benefit/cost ratio would reduce from 29 to 26. If all states move towards the current high end of retail natural gas pricing (on par with Queensland's projections for 2036 i.e. 9c/MJ), the total benefit cost ratio of the WELS scheme would be increases to 33.

Table 27 Sensitivity analysis for natural gas price – trajectories to 3c/MJ and 9c/MJ by 2036

	Total $17-18 ($M)	Past & Current $17-18 ($M)	Future PV $17-18 ($M)
Costs			
Total Costs	$838	$644	$194
Benefits			
Gas Savings	$4,551	$1,587	$2,964

	Total $17-18 ($M)	Past & Current $17-18 ($M)	Future PV $17-18 ($M)
Total Benefits	$21,799	$5,639	$16,159
B/C ratio	**26**	**8.8**	**83**
Gas Savings	$10,261	$1,587	$8,674
Total Benefits	$27,509	$5,639	$21,870
B/C ratio	**33**	**8.8**	**113**

Electricity and natural gas prices have been volatile in Australia over recent years and the future outlooks for both remain unclear. This is due in part to the policy uncertainty that exists in relation to electricity and natural gas at state and commonwealth government levels at this time. The global outlook in relation to natural gas is also a factor.

While a formal electricity pricing sensitivity analysis has not been conducted, the results of this study are shown to be relatively sensitive to energy pricing assumptions.

8.4.4 Sensitivity to water price

Owing to the potential for a 'feedback loop' from the WELS scheme to water pricing, a sensitivity analysis was undertaken with higher water prices. Drawing from the case studies of South East Queensland and Greater Sydney (see boxes 1 and 2 in sub-section 8.3.1) it is apparent that the impact on LRMC of high levels of demand will vary significantly between regions from negligible in many to significant in others.

To test the potential impact, an average 15% higher price scenario was used as an estimate of what retail water prices might have been had WELS and associated mechanisms never been implemented. Table 28 presents the results of this analysis, which includes an increase in the total benefit cost ratio to 30 (from 29). This impact is likely to be an upper end estimate of the water pricing influence due to WELS.

Table 28 Sensitivity analysis for water price with across-the-board 15% increase

	Total $17-18 ($M)	Past & Current $17-18 ($M)	Future PV $17-18 ($M)
Costs			
Total Costs	$838	$644	$194
Benefits			
Water Savings	$7,526	$1,657	$5,870
Total Benefits	$25,245	$5,855	$19,391
B/C ratio	**30**	**9.1**	**100**

The results of the water pricing sensitivity analysis show that the energy price assumptions are more significant to the results of the study than a possible underestimate of the value of water in the analysis.

8.4.5 Sensitivity to discount rate

The impact of the discount rate on the benefit/cost results is similar to that of changes to natural gas prices and larger than the impact of carbon and water pricing. Table 29 displays the results of adjusting the discount rate from 0.07 to 0.04 and 0.1 for future and total costs and benefits. The benefit/cost ratio for the total (2006-2036) period remains high, being between 34 and 25 across the discount rate range.

Table 29 Sensitivity analysis for discount rate at 4% and 10% (compared to 7%)

	Total $17-18 ($M)		Future PV $17-18 ($M)	
Discount rate	**4%**	**10%**	**4%**	**10%**
Scheme costs	$64	$51	$35	$22
Supplier costs per reg.	$351	$275	$203	$128
Labelling costs	$14	$11	$9	$6
Program costs	$463	$463	$0	$0
Total costs	**$892**	**$800**	**$248**	**$156**
Water savings	$8,226	$5,398	$6,785	$3,957
Electricity savings	$11,664	$7,908	$9,320	$5,564
Gas savings	$8,771	$5,815	$7,184	$4,228
GHG savings	$1,570	$1,056	$1,302	$788
Total benefits	**$30,231**	**$20,176**	**$24,592**	**$14,537**
B/C ratio	**34**	**25**	**99**	**93**

8.4.6 Equity considerations

In general, a CBA aims to measure economic efficiency outcomes or resource allocation impacts of a given project or regulatory change. It does this by estimating the dollar value of gains and losses to all parties affected by the intervention and testing, via sensitivity analyses, whether the sum is positive or the benefits exceed the costs under a range of scenarios (Australian Government 2016a).

The usual CBA method, as applied in this study, aggregates costs and benefits across parties without regard to the equity of the distribution of those impacts. It assumes that a dollar is worth the same to everyone. This allows an evaluation to be made in terms of economic or allocative efficiency. CBAs however commonly involve a separate assessment of distributional effects or equity implications (Australian Government 2016a). The separation of allocative and distributive impacts is considered useful, as there is no consensus about how to weight equity effects relative to societal net benefit.

In relation to WELS the distribution of costs and benefits can be considered in terms of the:

- impacts on different groups of product suppliers
- distribution of impacts between product suppliers, as a whole, and the rest of society
- equity considerations between sub-groups of product purchasers or water users.

Each of these are considered in turn, below.

As stated in section 8.2, a number of product suppliers interviewed for the study highlight that WELS not only had a direct financial cost for them through registration fees and additional costs, it also had a disproportionate impact on smaller suppliers. This was because these small suppliers had an inability to absorb the cost of the scheme and pass them on to customers. Their lack of market share meant that WELS registration costs became a key constraint for them introducing new product types or variations. This disproportionate impact on new and smaller suppliers might be expected to also impact the level of competition in the plumbing product and appliance market to a degree.

A significant proportion of product suppliers interviewed raised equity concerns about the funding of the WELS scheme via registration fees. This approach to funding the scheme means that a large proportion of the scheme costs sit with wholesalers, importers, and manufacturers of WELS-rated products. The benefits of the scheme, however, can be seen to flow principally to customers in lower bills but also water utilities with a decreased need for supply system augmentations. Various interviewees made the case that on equity grounds, the state and territory governments and water utilities should fund WELS, rather than the plumbing products and appliance industries.

Despite these concerns about equity, most interviewees also stated that their costs due to the WELS scheme were passed through to product purchasers. These purchasers are water uses and also generally utility bill payers, who are in turn the main beneficiaries of the scheme.

With all product purchasers paying for the scheme, an equity consideration may exist between groups of purchasers / water users. This study did not model the impact of the WELS scheme across socio-demographic groups. However, it is reasonable to assume that product labels will be most useful for customers with some level of discretionary income to choose between product types. Product labelling will only be of equal benefit across all socio-demographic groups in product classes where no price premium for water efficiency exists.

Some evidence for higher indoor water use with lower socio-demographic groups does exist in Australian studies. An end-use study of four different communities on the Gold Coast, Queensland, found that lower socio-demographic groups tended to use slightly more water than higher socio-demographic groups in most of the end use categories analysed with the exception of outdoor use (Willis *et al* 2013).

An appliance stock and end-use survey of customers by Roberts (2017) also found an apparent relationship between water usage and household income. Again, in this Victoria case, lower incomes correlated with higher per capita demand. Of four groups, households in the high-income group used on average five or six litres per person per day more than the two middle-income groupings. The lower-income group, however, used 11 litres more per person per day more than the high-income group. The study questioned whether this higher per capita usage in the lower income group might reflect a lower capability to purchase higher efficiency appliances.

These studies, while in no way conclusive of an impact due to WELS and associated measures, are interesting in light of international studies. These have tended to report the opposite trend, with wealthier residents using more water (e.g. Kenney *et al* 2008; Kim *et al* 2008).

The scale of the benefits from the WELS scheme to utility bill payers are so significant (see section 8.3) that all water users can be expected to be benefitting from WELS. The studies from South East Queensland and Victoria, however, suggest that lower socio-demographic groups may not be benefitting as much as others are, from water efficiency in their homes.

If Australian governments had an objective to see WELS play a greater role in elevating utility bills for society’s least wealthy there are a range of measures, beyond mandatory labelling, they could consider. These include complementary measures to the scheme such targeted demand management programs run by water utilities and other programs targeted at socio-demographic challenged groups. Likewise, governments could consider whether raising some existing minimum water efficiency standards or introducing new minimum standards under the WELS scheme might have positive equity implications.

9 Discussion

The analyses in this study shows that the WELS scheme is having a significant impact on water usage across urban Australia.

The conservation of water supplies was associated with an even larger (in value terms) saving in energy usage, mostly from avoided water heating. In turn, the reduced energy usage flows through to a substantial decrease in GHG emissions. To evaluate the environmental and economic impact of the WELS scheme, this study has covered water, electricity, natural gas and GHG savings as well as the associated costs and benefits. The study has considered both the past performance of WELS from its inception in 2006 as well as projected future impacts to 2036.

As part of the evaluation of the WELS schemes impacts, registrations in the WELS database were analysed in Section 3. The data showed a general trend towards more registrations of higher star rated products year by year. This trend to increased efficiency was true for all product types. In the most recent years, the trend to more efficient registrations however, was shown to be slowing for most product types. This was more the case for plumbing products registrations than for white goods.

In section 4, analysis of sales data collected from various sources for this study, showed the average star rating of new taps, and showers have remained constant since about 2012. The average star ratings of new toilets are increasing but very slowly. Average water use for new urinal, clothes washer and dishwasher sales is decreasing but is anticipated to plateau in the next few years.

The core of the study is an evaluation of material and energy impacts from the scheme. This analysis rests on the modelling of sales trends and stock for WELS-rated products together with assumptions about end uses in relation to frequency and duration of use. The study takes 'as given' the interlinkages and dependencies between WELS and other water efficiency initiatives across Australia. Fyfe *et al* (2015) found a total of 32 policies or measures referencing WELS including demand management programs, energy efficiency schemes, building regulations and tenancy laws. The study therefore has not sought to apportion some savings to the WELS scheme and others to related measures. Instead, the study attributes all savings to 'WELS and associated measures'.

The modelled water savings due to WELS in Section 6 showed current year (2017-18) savings of 112 GL per year across Australia, which is very similar to the 111 GL predicted by Fyfe *et al* (2015). This is expected to rise to 231 GL/year in 20 years' time. Despite these significant savings, the total water use in WELS-rated products has recently passed a low point and is now growing due to population growth – the per capita water consumption is decreasing but an increasing number of people means the total water use is increasing. In 2028 it can be expected to return to its previous peak of 1200 GL per year across the country (previously reached in 1990). Compared to the 'without WELS' case, the scheme and associated measures will have delayed this return to peak level in WELS rated products by 12 years. Critically, driven by population growth, even with WELS, the total water use grows steadily after returning to its previous peak.

Section 6 also includes results for energy use, GHG emission and bill savings. In the current year, the total energy saved from less hot water use was 13 PJ with 58% being natural gas and the remainder electricity. GHG savings increase to a peak around 2031 at 2.55 Mt per year avoided, then decrease somewhat. Throughout the period of analysis the emissions due to water utility energy use for water supply and wastewater collection are only around 3% of the total.

The state by state analyses of the impact of WELS points to potential complementary measures to WELS, such as in those states with fast growing populations. Although per capita water use has reduced and will reduce further, population growth will mean that the total water demand will increase in some states. In those states, decisions will be needed to either augment centralised supplies or investigate measures to further reduce per capita potable use. This might be via promoting greater water efficiency in new developments and/or requiring localised sources of supply such as rain tanks or recycled water in new growth areas. In contrast, states with lower levels of growth may find WELS and related measures to be sufficient to manage urban water use within current levels into the future.

The analysis of household bills found that the saving from 'WELS and associated measures' were having a substantial impact on utility bills for households and businesses across Australia. The financial impacts or 'bill savings' of reduced water and energy were estimated at $1.05 billion per year in 2017, and projected to reach $2.64 billion per year in 2036. This amounts to savings of $42 per person in 2017 and $81 per person in 2036.

The total of these bill savings far exceeded the costs attributed to the scheme. The economic evaluation estimated a net benefit of over $23 billion (accounting for both past and future costs and benefits) in present value terms. Sensitivity analyses conducted did not impact the conclusions of a significant net benefit and high benefit cost ratio, i.e.

- carbon pricing was not an important factor
- natural gas prices had the largest impact
- an increase of 15% to water prices has less impact than the other factors tested
- impact of adjustments to discount rate have more impact than carbon pricing, but less than that of the price of natural gas.

Interviews conducted as part of the study suggest some areas where the WELS scheme might be improved in the future. The threat of non-compliance and of unapproved products coming into Australia was a concern with many stakeholders. Likewise the need for enforcement and concerns about whether enforcement levels were adequate, to the potential of non-compliant products being imported presented multiple challenges. A particular concern existed with direct sales from overseas either via developer imports or online. The potential to integrate WELS with WaterMark was also raised by a number of stakeholders. As WaterMark regulates installations by plumbers, such a linkage might address some of the concerns about enforcement.

The interviews also raised equity questions about the WELS scheme. As the interviewees were predominantly product suppliers, their focus was the question about cost distribution between large and small suppliers and among suppliers and other parties. Equity considerations also exist with customer groups, with a potential existing for lower socio-demographic groups not benefitting as much as other water users from WELS and its associated measures.

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Appendix A: Interview questions

General

1. What is your role in your organisation and how does it relate to water efficient fixtures?
2. What do you think is driving the current market in WELS products? Can you foresee any drivers that would make the market less efficient, or more efficient?

Market

1. What would you estimate the current size of the Australian market in terms of total numbers [of devices relevant to your company] sold?
2. What proportion of the Australian market [of devices relevant to your company] does your company represent (% items sold)?
3. What proportion (or number) of products manufactured/imported/sold by your company would be:

Taps			Showers	
Star rating	% or number			% or number
0			0 Star (> 16 L/min)	
1			1 star (12-16 L/min)	
2			2 star (9 - 12 L/min)	
3			3 star (>7.5 but <= 9.0 L/min)	
4			4 star (> 6.0 but <= 7.5 L/min)	
5			4 star (> 4.5 but <= 6.0 L/min)	
6				

Toilets	
Toilet type	% or number
1-star 9/4.5L replacement cisterns	
1-star 5.5L single flush	
3-star 4L single flush	
3-star 6/3 L dual flush toilets	
4-star dual flush toilets (4.5/3 L)	
5-star toilets	
6-star toilets	

Urinals

Stars	Urinal type	% or number
0	>2.5 L/ flush (per 600mm wall)	
1	<= 4L /flush for 2 stalls	
1	<= 7.5L/flush for 3 stalls	
2	<=2.5 L/flush for single stall/600mm wall	
3	<=2 L/flush for single stall/600mm wall	

4	<=1.5 L/flush for single stall/600mm wall	
5	<=1 L/flush for single stall/600mm wall	
6	<=1 L/flush for single stall/600mm wall with urine sensor	

Dishwashers

Star rating	% or number
0	
0.5	
1	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	
6.0	

Clothes washers

Star rating	% or number
0	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

4. Do you think your sales reflect sales in the broader market? Comment on any key differences?
5. How does the market vary from State to State?
6. What proportion of taps/showers/ toilets/urinals go into residential compared to non-residential markets (specify whether answer relates to company sales or sales in the market as a whole)?
7. Do you know what share of the market is imported?
8. How have sales changed over time, particularly since 2006 when WELS was introduced?

Natural penetration

9. The number of efficient products on the market has been increasing over time. Without WELS what do you think would be the ultimate market penetration of 3 Star and above products, particularly in the residential sector?

Other impacts and consequences

10. Can you comment on the impacts (positive and negative) of WELS on your company and the Australian market more broadly? e.g. stimulating development of new products, increasing sales of efficient products, discontinuation of particular models/styles, improving/reducing quality, more/less imports?
11. What are the costs associated with WELS? (Registration costs, testing costs, labelling costs, anything else?) Overall costs and cost per unit, if possible.

Element of WELS	Overall cost to your business	Cost per unit
Registration		
Testing		
Labelling		
Anything else? (please add) Displays, etc.		
WELS elements combined		

New and competing products

12. Do you see any new products coming onto the market that will dramatically change household water use?

Showers only:

13. High end 'luxury' high water uses occupy a particular niche in the market. Do you think these will grow to represent a significant proportion of showers in the residential sector?
14. How common do you think showers fitted with two (or more) independent showerhead and tap fittings are?

Efficiency programs

15. How have utility and government water efficiency programs affected your sales? (Which programs?)

Appendix B: Water heating data

Table B1 Percentage of white goods in each star band that heat their own water

Star Band	Dishwashers (%)	Clothes washers (%)
0	0	-
1	0	0
1.5	1	0
2	1	0
2.5	1	2.59
3	7.7	8.87
3.5	11.31	15.16
4	14.93	21.44
4.5	18.55	27.73
5	22.16	34.01
5.5	25.78	-
6	29.39	-

Table B2 Sources of hot water system stock data

Years	Source
2005, 2008, 2011	Table 9. 4602055001DO001_201103 Environmental Issues: Energy Use and Conservation, Mar 2011
2014	Table 3. 4602055001DO001_201403 Environmental Issues: Energy Use and Conservation, Mar 2014
2012	Table 19. 4670.0 - Household Energy Consumption Survey, 2012
All years	Gas breakdown (instant vs storage) from Wilkenfeld (2009)
All years	Solar breakdown (gas boost vs elect boost) from Wilkenfeld (2009)

Table B3 Assumed share of water heater type by state in new homes from 2006 to 2020

New South Wales							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	56.1%	8.7%	16.6%	1.4%	1.8%	3.1%	12.4%
2011	61.0%	9.8%	18.6%	1.4%	2.4%	4.2%	2.6%
2012	56.0%	10.5%	19.9%	1.4%	2.3%	3.9%	6.3%
2014	59.0%	9.9%	18.9%	1.4%	2.9%	4.9%	3.4%
Victoria							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	27.6%	11.1%	53.1%	0.4%	4.4%	1.3%	5.4%
2011	27.0%	11.3%	54.5%	0.4%	6.4%	1.8%	3.2%
2012	22.5%	11.9%	57.2%	0.4%	9.7%	2.8%	2.4%

2014	25.2%	10.8%	51.9%	0.4%	12.3%	3.6%	5.0%
Queensland							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	58.3%	1.2%	10.4%	1.3%	0.3%	5.9%	20.6%
2011	71.8%	1.6%	13.5%	1.3%	0.3%	7.2%	1.8%
2012	71.2%	1.5%	12.6%	1.3%	0.4%	7.9%	2.2%
2014	73.2%	1.6%	13.6%	1.3%	0.3%	6.3%	1.6%
South Australia							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	42.0%	9.3%	39.6%	1.0%	0.0%	0.0%	7.8%
2011	42.2%	9.4%	40.1%	1.0%	0.8%	1.9%	1.2%
2012	39.0%	10.1%	43.0%	1.0%	0.9%	2.1%	0.2%
2014	39.0%	9.5%	40.6%	1.0%	1.0%	2.2%	3.0%
Western Australia							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	18.8%	36.0%	20.4%	0.3%	6.9%	16.6%	4.5%
2011	24.4%	34.2%	19.4%	0.3%	6.5%	15.6%	3.0%
2012	15.1%	40.8%	23.2%	0.3%	6.0%	14.3%	3.4%
2014	31.2%	31.3%	17.8%	0.3%	5.3%	12.7%	4.4%
Tasmania							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	80.3%	0.0%	0.0%	2.1%	4.5%	1.3%	14.2%
2011	93.0%	0.4%	1.8%	2.1%	4.7%	1.3%	0.0%
2012	85.5%	1.2%	5.6%	2.1%	8.3%	2.4%	0.8%
2014	86.0%	1.0%	4.8%	2.1%	8.3%	2.4%	1.5%
Northern Territory							
Year	Electric resistance	Gas storage	Gas instant	Heat pump	Solar gas	Solar electric	Other, including wood
2008	35.9%	0.6%	5.1%	0.0%	1.8%	37.0%	5.7%
2011	53.3%	0.0%	0.0%	0.0%	1.5%	31.5%	1.8%
2012	47.7%	0.3%	2.3%	0.0%	1.7%	34.8%	0.0%
2014	63.5%	0.4%	3.7%	0.0%	1.0%	20.9%	3.6%

Table B4. Average cold water temperature (Energy Efficient Strategies 2008), table 14)

Capital city	Average cold water temperature (ºC)
Sydney	18.3
Melbourne	16.2
Brisbane	21
Adelaide	17.9
Perth	20.7
Hobart	12.9
Darwin	28
Canberra	15

Table B5 Hot water system efficiencies and lifetimes used in the stock model

Hot water system type	Efficiency (mid-range from table 9 of Wilkenfeld (2009)	Lifetime (from Appendix 4 of Wilkenfeld (2009))
Electric resistance	0.87	11
Gas storage	0.665	10
Gas instantaneous	0.675	12
Solar, electric boosted	5.85	12
Solar, gas boosted	4.25	12
Electric heat pump	2.85	10

Appendix C: GHG intensity tabulated inputs

Table C1 Greenhouse gas intensity of electricity trends used in model (July 2017 National Greenhouse Gas Accounts Factors is the source of past data with assumed decrease to meet 2030 reduction target of 28%)

Year	Greenhouse intensity of electricity, kg CO_2/GJ							
	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
2006	279	365	285	264	265	39	230	279
2007	278	367	283	248	270	68	226	278
2008	277	375	281	237	264	94	223	277
2009	278	378	277	221	251	92	220	278
2010	277	376	270	212	241	78	216	277
2011	276	371	262	201	233	66	217	276
2012	271	372	260	192	231	51	214	271
2013	269	362	258	181	225	35	212	269
2014	266	346	256	175	217	39	209	266
2016	263	329	257	162	212	47	203	263
2017	263.0	325.5	254.1	160.6	210.7	45.2	200.9	259.7
2018	259.5	322.0	251.3	159.2	209.5	43.4	198.8	256.4
2019	256.1	318.5	248.4	157.9	208.2	41.6	196.7	253.2
2020	252.6	315.0	245.5	156.5	207.0	39.8	194.6	249.9
2021	249.2	311.5	242.6	155.1	205.7	38.1	192.5	246.6
2022	245.7	308.0	239.8	153.7	204.5	36.3	190.4	243.3
2023	242.3	304.5	236.9	152.3	203.2	34.5	188.3	240.0
2024	238.8	301.0	234.0	151.0	202.0	32.7	186.2	236.8
2025	235.4	297.5	231.1	149.6	200.7	30.9	184.1	233.5
2026	231.9	294.0	228.3	148.2	199.5	29.1	182.0	230.2
2027	228.5	290.5	225.4	146.8	198.2	27.3	179.9	226.9
2028	225.0	287.0	222.5	145.4	196.9	25.5	177.8	223.6
2029	221.6	283.5	219.6	144.1	195.7	23.7	175.7	220.4
2030	218.1	280.0	216.8	142.7	194.4	21.9	173.6	217.1
2031	214.7	276.5	213.9	141.3	193.2	20.2	171.5	213.8
2032	211.2	273.0	211.0	139.9	191.9	18.4	169.4	210.5
2033	207.8	269.5	208.1	138.5	190.7	16.6	167.3	207.2
2034	204.3	266.0	205.3	137.2	189.4	14.8	165.2	204.0
2035	200.9	262.5	202.4	135.8	188.2	13.0	163.1	200.7
2036	197.4	259	199.5	134.4	186.9	11.2	161	197.4

Table C2 Greenhouse intensity of gas trends used in model (July 2017 National Greenhouse Gas Accounts Factors is the source of past data with assumed decrease to meet 2030 reduction target of 28%)

Year	Greenhouse intensity of gas, kg CO_2/GJ							
	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
2006	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2007	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2008	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2009	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2010	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2011	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2012	65.5	55.3	59.9	61.7	55.3	61.7	61.7	65.5
2013	64.1	55.2	60.0	61.7	55.3	61.7	61.7	64.1
2014	64.1	55.2	60.0	61.7	55.3	61.7	61.7	64.1
2015	64.3	55.4	60.2	61.9	55.5	61.9	61.9	64.3
2016	64.3	55.4	60.2	61.9	55.5	61.9	61.9	64.3
2017	64.3	55.4	60.2	61.9	55.5	61.9	61.9	64.3
2018	64.5	54.5	59.0	60.8	54.5	60.8	60.8	64.5
2019	63.5	53.6	58.0	59.8	53.6	59.8	59.8	63.5
2020	62.4	52.7	57.1	58.8	52.7	58.8	58.8	62.4
2021	61.4	51.8	56.1	57.8	51.8	57.8	57.8	61.4
2022	60.4	51.0	55.2	56.9	51.0	56.9	56.9	60.4
2023	59.3	50.1	54.3	55.9	50.1	55.9	55.9	59.3
2024	58.3	49.2	53.3	54.9	49.2	54.9	54.9	58.3
2025	57.3	48.3	52.4	53.9	48.3	53.9	53.9	57.3
2026	56.2	47.5	51.4	53.0	47.5	53.0	53.0	56.2
2027	55.2	46.6	50.5	52.0	46.6	52.0	52.0	55.2
2028	54.1	45.7	49.5	51.0	45.7	51.0	51.0	54.1
2029	53.1	44.8	48.6	50.0	44.8	50.0	50.0	53.1
2030	52.1	44.0	47.6	49.1	44.0	49.1	49.1	52.1
2031	51.0	43.1	46.7	48.1	43.1	48.1	48.1	51.0
2032	50.0	42.2	45.7	47.1	42.2	47.1	47.1	50.0
2033	49.0	41.4	44.8	46.1	41.4	46.1	46.1	49.0
2034	47.9	40.5	43.8	45.2	40.5	45.2	45.2	47.9
2035	46.9	39.6	42.9	44.2	39.6	44.2	44.2	46.9
2036	45.9	38.7	42.0	43.2	38.7	43.2	43.2	45.9

Appendix D: Stock charts

The charts below compare the predicted stock of dishwashers, toilets and urinals in NSW for the ‘with WELS’ and ‘without WELS’ scenarios. In the top row in each is the WELS scenario is on the left and the without WELS scenario is on the right.

The bottom two charts contain both scenarios and detail the difference in predictions for the most significant models.

Also included are charts that compare the current study to the Fyfe *et al* 2015 evaluation of WELS.

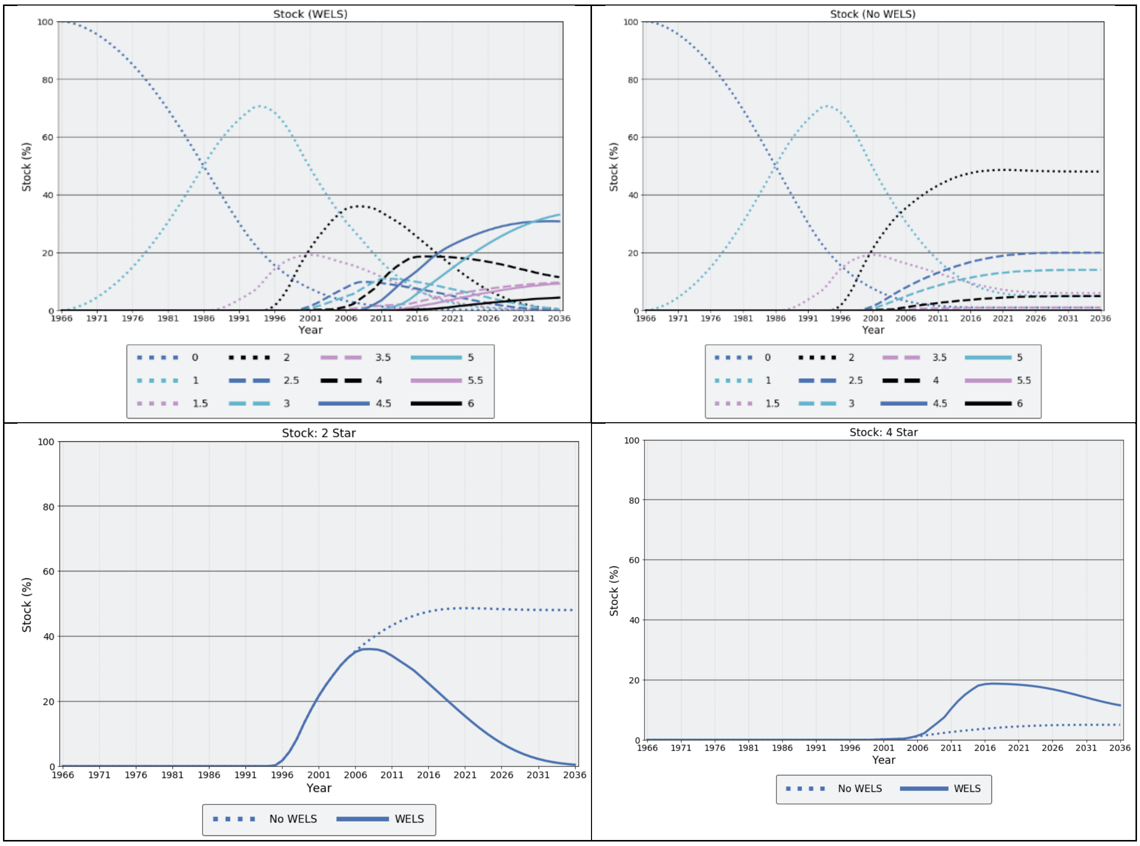

Figure D1 Dishwasher stock predictions for NSW

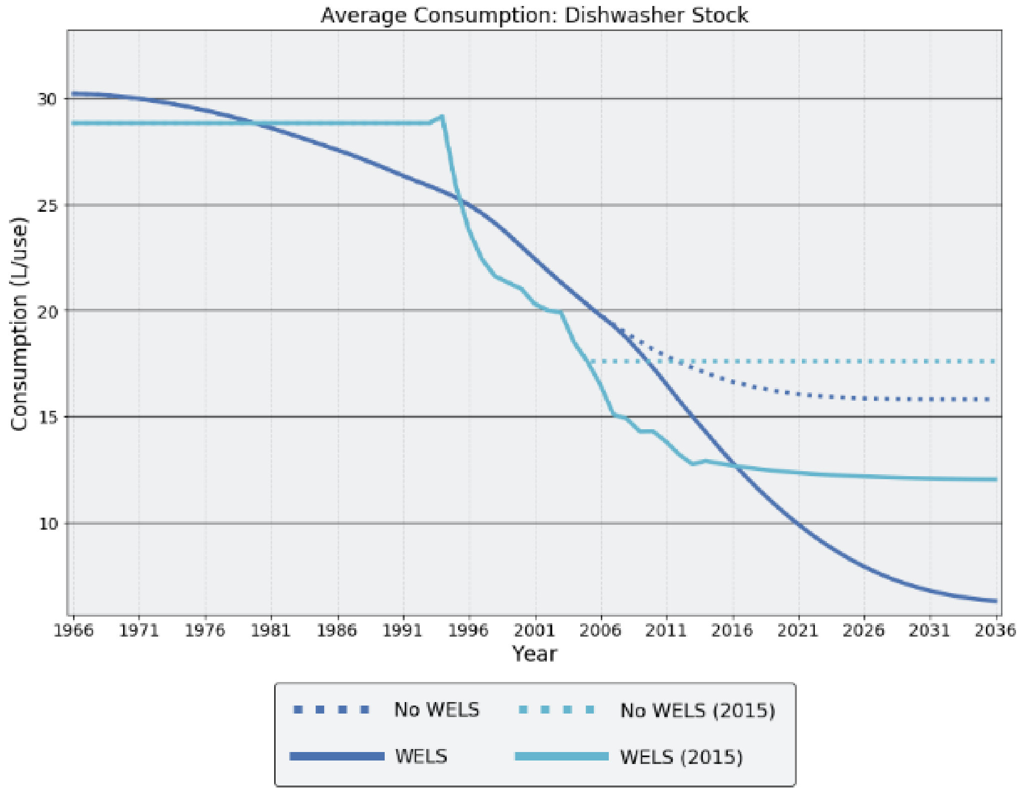

Figure D2 Average dishwasher water use per load comparison

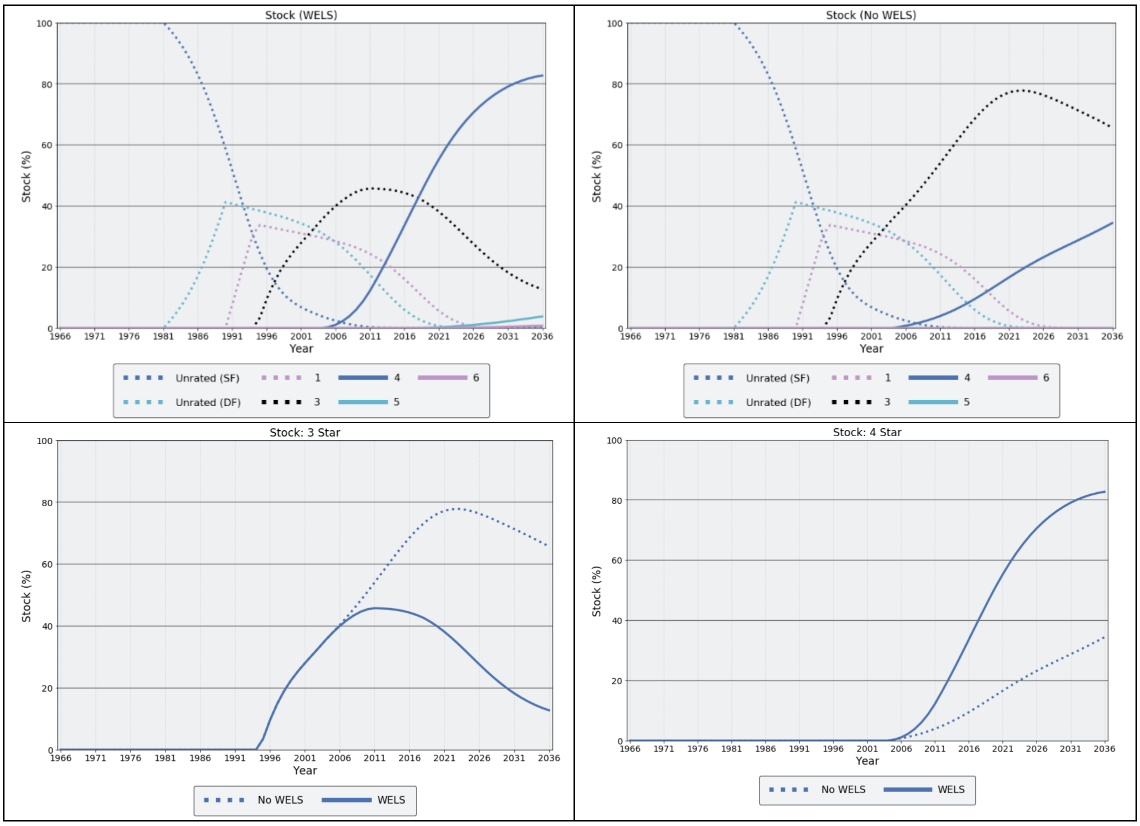

Figure D3 Toilet stock predictions for NSW

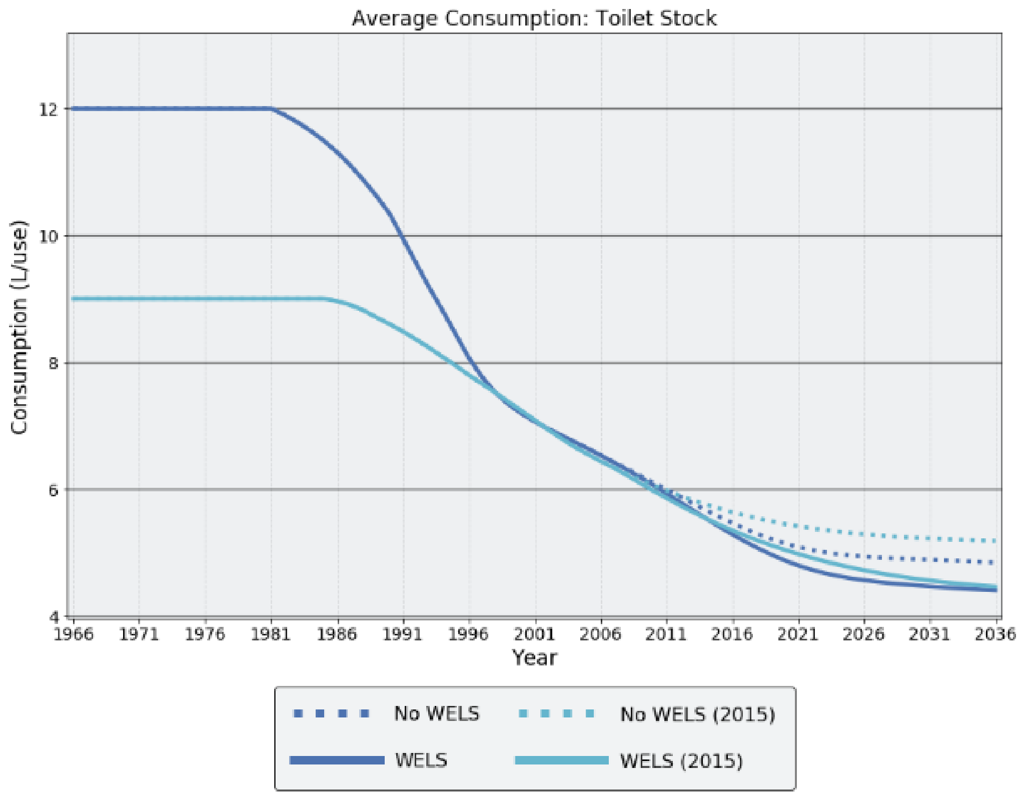

Figure D4 Comparison of average toilet flush volumes

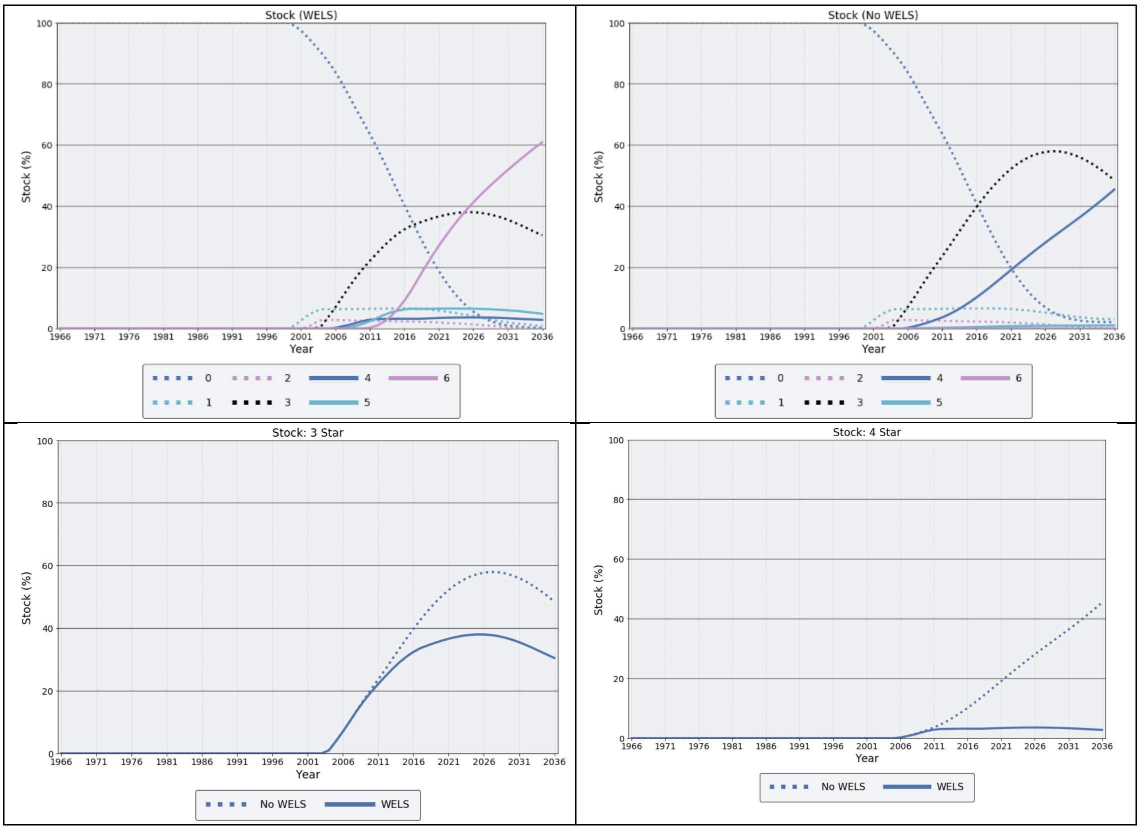

Figure D5 Urinal stock predictions for NSW

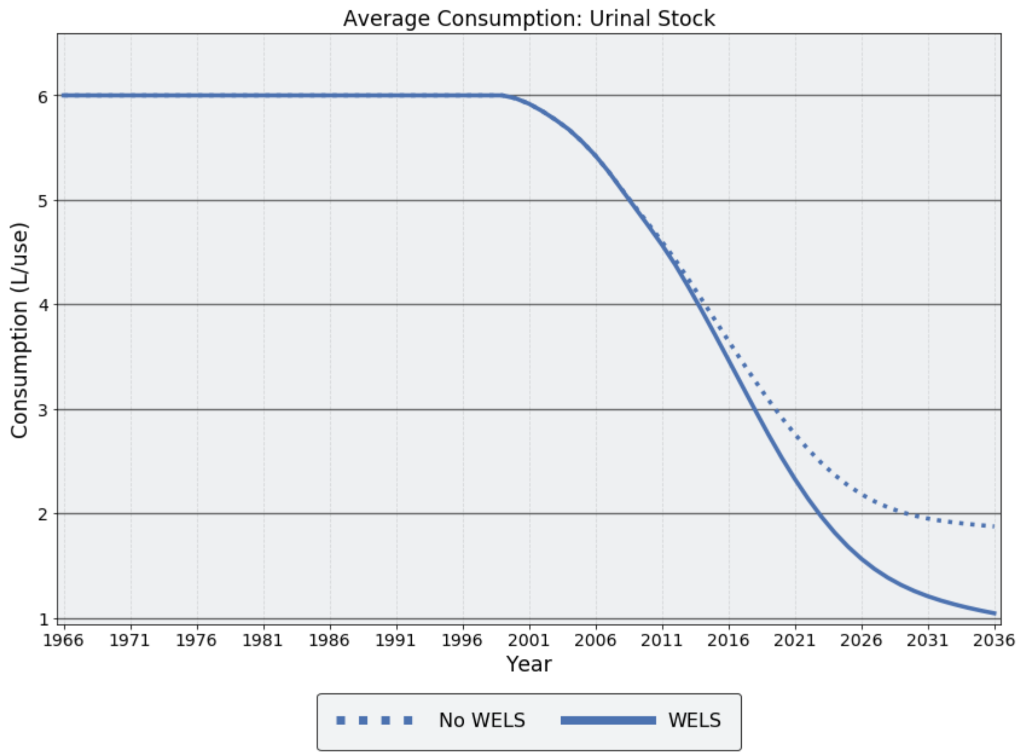

Figure D6 Urinal stock predictions comparison

Appendix E: Results tables

Table E 1 Predicted water savings, by state.

Year	Water savings, GL/yr							
	NSW	VIC	QLD	SA	WA	TAS	NT	Total
2006	0.44	0.33	0.25	0.10	0.14	0.03	0.01	1.29
2007	1.61	1.35	1.30	0.41	0.63	0.12	0.06	5.47
2008	3.83	3.08	2.96	1.02	1.43	0.27	0.14	12.74
2009	6.86	5.47	4.88	1.84	2.49	0.48	0.25	22.27
2010	10.08	8.10	6.84	2.69	3.61	0.71	0.37	32.39
2011	13.37	10.84	8.83	3.49	4.76	0.93	0.48	42.70
2012	17.04	13.89	11.12	4.36	6.03	1.18	0.59	54.22
2013	20.74	17.04	13.45	5.21	7.37	1.42	0.71	65.96
2014	24.47	20.24	15.82	6.06	8.74	1.66	0.83	77.83
2015	28.17	23.48	18.21	6.88	10.11	1.90	0.95	89.70
2016	31.73	26.62	20.53	7.67	11.44	2.13	1.07	101.19
2017	35.14	29.61	22.79	8.40	12.72	2.35	1.17	112.18
2018	38.32	32.27	24.99	9.04	13.92	2.54	1.27	122.36
2019	41.35	34.73	27.13	9.65	15.09	2.72	1.36	132.03
2020	44.22	36.96	29.19	10.21	16.22	2.89	1.45	141.14
2021	46.91	39.00	31.18	10.72	17.31	3.05	1.53	149.71
2022	49.43	40.87	33.10	11.20	18.39	3.19	1.61	157.79
2023	51.72	42.56	34.88	11.63	19.42	3.31	1.68	165.20
2024	53.84	44.13	36.57	12.02	20.43	3.42	1.75	172.16
2025	55.78	45.61	38.16	12.37	21.43	3.52	1.81	178.68
2026	57.57	47.01	39.65	12.69	22.42	3.60	1.87	184.81
2027	59.22	48.34	41.05	12.98	23.40	3.68	1.92	190.60
2028	60.76	49.63	42.38	13.25	24.35	3.75	1.97	196.09
2029	62.21	50.87	43.64	13.50	25.26	3.81	2.02	201.30
2030	63.57	52.06	44.83	13.73	26.12	3.86	2.07	206.25
2031	64.86	53.21	45.98	13.94	26.94	3.91	2.12	210.95
2032	66.07	54.30	47.06	14.13	27.71	3.96	2.16	215.40
2033	67.21	55.33	48.10	14.32	28.46	4.00	2.21	219.62
2034	68.26	56.30	49.08	14.48	29.19	4.03	2.25	223.60
2035	69.24	57.21	50.02	14.63	29.91	4.06	2.28	227.36
2036	70.16	58.06	50.92	14.77	30.61	4.09	2.32	230.92

Table E 2. Predicted cumulative GHG savings, by state.

Year	Cumulative GHG saving, Mt CO_2 –e							
	NSW	VIC	QLD	SA	WA	TAS	NT	Total
2006	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.03
2007	0.05	0.05	0.02	0.01	0.01	0.00	0.00	0.14
2008	0.13	0.14	0.07	0.03	0.02	0.00	0.00	0.39
2009	0.26	0.29	0.14	0.06	0.05	0.00	0.00	0.82
2010	0.47	0.52	0.24	0.11	0.09	0.01	0.00	1.44
2011	0.73	0.82	0.38	0.16	0.14	0.01	0.01	2.25
2012	1.07	1.19	0.54	0.23	0.21	0.02	0.01	3.27
2013	1.46	1.63	0.74	0.31	0.30	0.03	0.01	4.47
2014	1.91	2.12	0.97	0.40	0.39	0.04	0.02	5.85
2015	2.43	2.67	1.23	0.49	0.51	0.05	0.02	7.41
2016	3.00	3.26	1.53	0.60	0.64	0.07	0.03	9.13
2017	3.62	3.90	1.86	0.71	0.79	0.09	0.03	11.00
2018	4.28	4.57	2.21	0.83	0.96	0.11	0.04	12.99
2019	4.97	5.27	2.59	0.96	1.13	0.13	0.05	15.09
2020	5.69	5.99	2.98	1.09	1.32	0.15	0.05	17.27
2021	6.44	6.72	3.40	1.22	1.52	0.17	0.06	19.53
2022	7.20	7.46	3.83	1.36	1.73	0.19	0.07	21.84
2023	7.98	8.21	4.27	1.50	1.96	0.21	0.08	24.20
2024	8.77	8.95	4.73	1.64	2.19	0.23	0.09	26.59
2025	9.56	9.69	5.20	1.78	2.43	0.25	0.09	29.01
2026	10.36	10.44	5.68	1.92	2.68	0.27	0.10	31.45
2027	11.16	11.17	6.17	2.06	2.93	0.29	0.11	33.90
2028	11.96	11.91	6.66	2.20	3.19	0.31	0.12	36.36
2029	12.75	12.64	7.16	2.34	3.46	0.33	0.13	38.82
2030	13.55	13.36	7.67	2.48	3.74	0.35	0.14	41.28
2031	14.34	14.08	8.17	2.62	4.02	0.37	0.15	43.74
2032	15.12	14.79	8.68	2.76	4.30	0.38	0.16	46.20
2033	15.89	15.50	9.20	2.90	4.59	0.40	0.17	48.64
2034	16.66	16.19	9.71	3.03	4.88	0.42	0.18	51.08
2035	17.42	16.88	10.23	3.17	5.18	0.43	0.19	53.49
2036	18.17	17.56	10.74	3.30	5.48	0.45	0.20	55.90

Table E 3. Predicted annual electricity savings, by state.

Year	Annual electricity saving (TJ/a)							
	NSW	VIC	QLD	SA	WA	TAS	NT	Total
2006	29.03	25.31	13.01	7.22	4.72	2.87	0.23	82.38
2007	98.30	89.62	54.03	25.55	17.95	10.11	0.82	296.38
2008	219.64	197.52	120.83	59.34	41.29	22.36	2.00	662.97
2009	380.83	342.64	202.16	104.16	73.98	38.49	3.68	1145.94
2010	558.44	506.67	290.98	152.84	113.73	56.65	5.62	1684.93
2011	734.99	671.01	380.20	199.68	157.42	74.55	7.57	2225.41
2012	922.31	843.22	477.79	248.38	206.95	93.33	9.65	2801.64
2013	1107.01	1013.04	577.41	295.90	261.54	111.60	11.80	3378.30
2014	1286.70	1177.66	677.45	341.37	319.22	129.28	14.01	3945.68
2015	1459.90	1335.48	777.32	384.62	379.65	146.06	16.23	4499.27
2016	1622.06	1480.54	874.44	424.93	439.82	161.73	18.40	5021.93
2017	1771.26	1609.34	967.44	461.23	498.91	176.00	20.48	5504.66
2018	1903.22	1714.62	1055.64	491.86	555.14	188.34	22.40	5931.21
2019	2021.88	1800.60	1138.76	519.30	609.38	199.14	24.22	6313.28
2020	2128.79	1869.87	1217.94	543.53	661.91	208.63	25.98	6656.66
2021	2224.27	1924.51	1293.13	564.74	712.57	216.86	27.67	6963.74
2022	2308.38	1967.09	1364.15	583.01	761.18	223.84	29.29	7236.94
2023	2380.67	1999.92	1429.74	598.26	807.19	229.58	30.80	7476.16
2024	2442.63	2026.06	1490.86	610.95	850.89	234.23	32.23	7687.86
2025	2495.39	2047.59	1547.59	621.38	892.41	237.93	33.59	7875.87
2026	2540.43	2066.03	1600.44	629.92	932.03	240.84	34.86	8044.57
2027	2578.89	2082.20	1649.76	636.86	969.97	243.10	36.07	8196.85
2028	2612.10	2096.73	1696.23	642.52	1006.58	244.83	37.23	8336.22
2029	2640.84	2109.78	1740.26	647.11	1042.07	246.14	38.34	8464.54
2030	2665.71	2121.36	1782.22	650.77	1076.61	247.09	39.41	8583.16
2031	2687.13	2131.37	1822.41	653.63	1110.33	247.74	40.43	8693.05
2032	2705.19	2139.59	1860.86	655.72	1143.20	248.11	41.42	8794.09
2033	2720.15	2146.03	1897.82	657.12	1175.33	248.22	42.37	8887.04
2034	2732.29	2150.80	1933.52	657.91	1206.80	248.12	43.28	8972.72
2035	2741.85	2154.18	1968.18	658.16	1237.70	247.82	44.17	9052.05
2036	2749.12	2156.46	2002.00	657.94	1268.14	247.34	45.04	9126.03

Table E 4. Predicted annual gas savings, by state.

Year	Annual gas saving (TJ/a)							
	NSW	VIC	QLD	SA	WA	TAS	NT	Total
2006	37.48	32.97	17.77	9.51	9.79	0.60	0.37	108.49
2007	127.60	116.40	74.62	33.83	37.72	2.11	1.36	393.64
2008	286.85	255.57	167.61	78.90	84.76	5.87	3.31	882.87
2009	500.89	441.79	281.34	139.08	147.72	12.65	6.02	1529.49
2010	739.14	652.28	406.07	204.78	218.96	23.62	8.97	2253.82
2011	978.38	859.80	532.08	268.63	292.53	38.80	11.82	2982.04
2012	1236.14	1080.06	670.08	335.46	371.79	58.18	14.77	3766.49
2013	1494.77	1300.85	810.06	401.29	455.00	77.61	17.74	4557.31
2014	1750.46	1516.64	949.92	464.78	538.92	97.52	20.70	5338.93
2015	2001.14	1725.61	1089.43	525.86	621.89	117.46	23.62	6105.01
2016	2240.27	1920.05	1223.96	583.52	702.08	136.48	26.41	6832.77
2017	2464.92	2095.48	1352.41	636.26	778.70	154.27	29.02	7511.05
2018	2668.86	2242.16	1473.92	681.74	849.58	170.27	31.36	8117.89
2019	2857.16	2365.52	1588.12	723.35	916.62	184.79	33.53	8669.08
2020	3031.72	2468.64	1696.61	761.02	980.54	197.98	35.59	9172.09
2021	3192.70	2553.88	1799.40	794.95	1041.33	209.87	37.54	9629.67
2022	3339.95	2624.37	1896.45	825.26	1098.94	220.44	39.37	10044.79
2023	3472.36	2682.70	1985.85	851.74	1152.66	229.70	41.06	10416.07
2024	3591.94	2732.86	2069.01	875.00	1203.12	237.76	42.63	10752.31
2025	3699.99	2777.39	2146.05	895.42	1250.55	244.76	44.08	11058.26
2026	3798.43	2818.25	2217.72	913.49	1295.43	250.87	45.43	11339.63
2027	3888.71	2856.42	2284.47	929.58	1338.10	256.21	46.70	11600.20
2028	3972.61	2892.76	2347.28	944.12	1379.08	260.94	47.89	11844.69
2029	4051.15	2927.45	2406.71	957.39	1418.67	265.15	49.02	12075.54
2030	4125.09	2960.43	2463.26	969.58	1457.10	268.93	50.10	12294.49
2031	4194.96	2991.55	2517.37	980.85	1494.56	272.33	51.13	12502.74
2032	4260.74	3020.38	2569.06	991.21	1531.01	275.39	52.10	12699.88
2033	4322.74	3046.87	2618.67	1000.76	1566.58	278.14	53.04	12886.81
2034	4381.28	3071.12	2666.54	1009.61	1601.41	280.60	53.94	13064.51
2035	4436.68	3093.43	2712.98	1017.85	1635.61	282.82	54.80	13234.16
2036	4489.28	3114.15	2758.26	1025.57	1669.30	284.80	55.63	13397.01

Table E 5. Predicted annual household utility bill savings, by state.

Year	Annual total household utility bill savings ($M/a)							
	NSW	VIC	QLD	SA	WA	TAS	NT	Total
2006	2.41	1.53	1.44	0.65	0.46	0.13	0.03	6.65
2007	9.09	6.34	6.78	2.51	1.93	0.56	0.11	27.30
2008	23.43	15.77	15.94	6.38	5.02	1.32	0.28	68.13
2009	45.56	31.06	28.76	12.74	10.23	2.45	0.58	131.39
2010	73.22	53.01	44.50	21.76	17.60	4.18	0.98	215.24
2011	108.35	82.27	66.62	34.10	27.40	6.59	1.50	326.84
2012	142.34	106.44	98.58	44.55	38.26	8.84	2.24	441.25
2013	167.93	144.51	132.94	55.94	49.17	10.05	2.80	563.33
2014	206.29	148.35	137.42	63.41	54.19	12.37	3.27	625.29
2015	234.79	182.65	172.21	74.21	68.31	14.72	3.82	750.70
2016	276.79	217.13	204.32	84.96	81.54	17.85	4.41	886.98
2017	330.78	261.34	227.97	105.89	96.97	19.93	5.05	1047.93
2018	355.28	275.29	248.22	112.02	112.41	21.34	5.64	1130.20
2019	375.22	281.32	267.43	117.06	128.20	22.23	6.24	1197.69
2020	401.06	295.25	290.62	123.04	139.11	23.53	6.72	1279.32
2021	433.89	311.67	317.10	129.12	152.27	24.85	7.28	1376.18
2022	479.66	317.26	339.40	133.37	165.09	25.94	7.82	1468.54
2023	502.97	325.96	362.72	138.22	175.73	27.13	8.28	1541.00
2024	524.74	333.67	383.67	143.51	185.78	27.96	8.72	1608.04
2025	548.96	343.30	407.15	148.89	197.17	28.55	9.20	1683.22
2026	576.31	355.30	430.42	154.98	209.79	29.16	9.71	1765.68
2027	603.23	371.41	453.49	162.44	223.60	30.24	10.25	1854.66
2028	629.94	390.64	476.52	170.94	238.46	31.71	10.82	1949.02
2029	656.55	404.37	499.59	177.32	252.22	33.32	11.35	2034.72
2030	683.16	418.20	525.51	182.53	266.52	34.63	11.90	2122.46
2031	714.53	436.79	553.27	187.68	283.23	36.10	12.52	2224.12
2032	726.79	455.60	574.17	192.16	295.24	36.63	13.00	2293.60
2033	745.78	469.72	602.76	197.74	309.42	37.61	13.54	2376.58
2034	769.52	483.80	627.19	203.30	323.88	38.57	14.09	2460.35
2035	795.83	497.86	651.96	209.46	339.32	39.86	14.67	2548.96
2036	822.26	511.95	677.13	215.65	355.11	40.81	15.25	2638.15