Chapter 7
Optimize Water Efficiency and Cost Effectiveness by Using the Alternative Sustainable Innovations in Residential Dwellings

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Abstract Utilising alternative sustainable innovations, such as water efficient showerheads, waterless composing toilets, aerated faucets, water efficient dishwashers and steam washing machines opposed to the standard devices, has the ability to optimise water efficiency and reduce living expenses, while helping conserve this natural resource. This paper is to investigate if the alternative sustainable innovations can optimise water efficiency and cost effectiveness in residential dwellings. Water consumption, life cycle cost and payback periods are compared between the standard and innovative devices over a 15-year period. Local cost from the major cities in Australia is used for the calculation. It is found that $7,295–28,785 per occupant can be saved over 15 years if all devices are used across Australia, saving of up to 78.5 % can be achieved and with the minimal of only 0.10 year of payback period.

Keywords Sustainable innovations • Water efficiency • Cost effectiveness • Residential • Australia

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7.1 Introduction

It is predicted that by 2025, about 63 % of the planets population will be experiencing water stress, which impacts the dam levels and hence the overall water supply to residential dwellings around the world [1]. As a result, water price is increasing at an alarming rate and expected to increase by 50–100 % over the next 5 years [2]. Even with the aid of government water saving policies such as water restrictions and incentives to implement more efficient water usage, the water is predicted to become increasingly scarcer over the next few years [3]. It is for this reason that further research in regard to innovation and water efficient mechanisms need to be conducted to counter the impact of this decline, to benefit future generations.

7.2 Aim and Objectives

This paper investigates the water efficiency and cost effectiveness of alternative sustainable innovations in respect to residential dwellings. Five alternative sustainable innovations, including water efficient showerheads, waterless composing toilets, aerated faucets, water efficient dishwashers and steam washing machines opposed to the standard water facilities, are investigated in relation to the number of occupants within a dwelling across major cities in Australia, including Sydney, Canberra, Brisbane, Melbourne, Perth, Adelaide and Darwin. Water consumption, life cycle cost saving and payback periods are compared between the standard water facilities and the alternative sustainable innovations over a 15-year period.

7.3 Methodology

To calculate the water consumption of the water facilities, it is assumed that two showers (use twice per day per person for 8 min per cycle), two toilets (use five times per day per person for one full flush per cycle), two basins (use five times per day per person for 0.25 min per cycle), two sinks (use three times per day per person for 12 min per cycle), one dishwasher (use once per day per person for one full cycle) and one washing machine (use once per day per person for one full cycle) are installed for a typical residential dwelling [4, 5].

It is also assumed a maximum of 1 h work from a plumber (about AUD 80 / GBP 53.5) for the installation of fixtures and appliances, and on-going cost of about AUD 50/GBP 33.5 annually for hygiene and cleaning products associated with the functioning of the devices, along with any maintenance expenses that may arise for the calculation of life cycle cost of the water facilities. Inflation incurred for

the on-going cost is assumed as 3 % and future water rate rises are based on the average price increase in the past 10 years (2001–2010) from the relevant water authorizes [6–11].

After calculating the life cycle cost for the individual water facilities, the following equation is used to calculate the percentage of saving in using a particular alternative sustainable innovation.

$$\text{Percentage of saving} = \frac{(LCC_{sustainable} - LCC_{standard})}{LCC_{standard}} \times 100\ \%$$

where $LCC_{standard}$ is the life cycle costing for using the standard water facilities over 15 years; and $LCC_{sustainable}$ is the life cycle costing for using the alternative sustainable innovations over 15 years.

The payback period for the use of the alternative sustainable innovations is then calculated based on the comparison of the life cycle cost for implementing the standard water facilities and the alternative sustainable innovations. The year with the same life cycle cost is the payback period.

7.4 Findings

Table 7.1 summaries the water consumption of different types of standard water utilises and the alternative sustainable innovations. It is clearly exemplified that using the standard water utilised can result in a substantial amount of water being consumed, compared to a residential dwelling incorporating the alternative sustainable innovations. This difference in water consumption is about 233.6 kL a year for only one resident and about 1,297.7 kL a year for six occupants in a dwelling if all the alternative sustainable innovations are employed.

If all standard water facilities are replaced with the alternative sustainable innovations, the life cycle cost from AUD 7,294.6 / GBP 4,881.9 (in Perth) to AUD 28,785.4 / GBP 19,264.6 (in Adelaide) could be saved over a 15-year period per person (see Table 7.2).

The alternative sustainable innovations are predominately the most suitable devices to be used across Australia, except waterless composting toilets (with negative saving). This is due to a long term cost being saved. It is clear that cost can be saved up to 78.5 % and increases in respect to occupants (see Table 7.3).

If the residential dwelling is using all the alternative sustainable innovations, Occupants can save between 26 % (in Perth) and 51 % (in Adelaide) over a 15-year period. This is a prime indicator that cost effectiveness can be optimised by using the alternative sustainable innovations.

Table 7.1 Difference in water consumptions for the standard water utilises and the alternative sustainable innovations

	Standard water facilities (kL) (A)	Alternative sustainable innovations (kL) (B)	Difference in water consumption (kL) (A–B)
A standard showerhead versus a water efficient showerhead			
1	146.0	35.0	111.0
2	292.0	70.1	221.9
3	438.0	105.1	332.9
4	584.0	140.2	443.8
5	730.0	175.2	554.8
6	876.0	210.2	665.8
A single flush toilet versus a waterless composting toilet			
1	21.9	0.0	21.9
2	43.8	0.0	43.8
3	65.7	0.0	65.7
4	87.6	0.0	87.6
5	109.5	0.0	109.5
6	131.4	0.0	131.4
A standard basin outlet versus a basin aerated faucet			
1	3.4	0.9	2.5
2	6.8	1.8	5.0
3	10.3	2.7	7.5
4	13.7	3.7	10.0
5	17.1	4.6	12.5
6	20.5	5.5	15.1
A standard sink outlet versus a sink aerated faucet			
1	98.6	26.3	72.3
2	197.1	52.6	144.5
3	295.7	78.8	216.8
4	394.2	105.1	289.1
5	492.8	131.4	361.4
6	591.3	157.7	433.6
A standard dishwasher versus a water efficient dishwasher			
1–4	7.3	3.7	3.7
5–6	36.5	18.3	18.3
A standard washing machine versus a steam washing machine			
1–4	50.4	28.1	22.3
5–6	251.9	140.5	111.3

The alternative sustainable innovations not only can achieve life cycle cost saving, but also with reasonable payback periods between 0.10 year (for the water efficient shower in Adelaide) and 57.79 year (for the basin aerated faucet in Perth) (see Table 7.4). The payback periods vary in different cities and are dependent on their local water prices.

Table 7.2 Life cycle cost saving for the alternative sustainable innovations compared to the standard water facilities in a typical residential dwelling for one occupant (in AUD)

Device	Sydney	Canberra	Brisbane	Melbourne	Perth	Adelaide	Darwin
Shower	$7,242.5	$7,698.9	$11,408.2	$8,003.9	$2,472.6	$12,131.7	$3,295.4
Toilet	−$315.0	−$224.9	$507.2	−$164.7	−$1,256.4	$650.0	−$1,094.0
Basin	$28.5	$186.7	$270.6	$193.6	$68.6	$287.0	$87.2
Sink	$4,391.7	$4,836.9	$7,252.8	$5,035.5	$1,432.9	$7,724.1	$1,968.8
Dishwasher	$1,390.5	$1,405.5	$1,527.5	$1,415.6	$1,233.6	$1,551.3	$1,260.7
Washing machine	$3,967.3	$4,058.8	$4,803.1	$4,120.1	$3,010.1	$4,948.3	$3,175.3
Total	$17,907.3	18,922.7	$27,175.5	$19,601.3	$7,294.6	$28,785.4	$9,125.4

Table 7.3 Percentage of saving for using the alternative sustainable innovations for the major cities in Australia

Device	Number of occupants (Percentage of saving)					
Sydney	1	2	3	4	5	6
Shower	73.7%	74.8%	75.2%	75.4%	75.5%	75.6%
Toilet	-10.3%	23.8%	41.8%	52.9%	60.5%	66.0%
Basin	27.2%	39.2%	46.0%	50.6%	53.9%	56.3%
Sink	68.9%	71.1%	71.8%	72.2%	72.4%	72.6%
Dishwasher	15.6%	17.3%	18.8%	20.2%	21.4%	22.6%
Washing machine	31.4%	33.9%	35.6%	36.9%	37.8%	38.5%
Canberra						
Shower	73.9%	74.9%	75.3%	75.4%	75.6%	75.6%
Toilet	- 7.1%	.26 8%	44.4%	55.2%	62.5%	67.7%
Basin	28.7%	40.3%	47.1%	51.6%	54.7%	57.1%
Sink	69.2%	71.2%	71.9%	72.2%	72.5%	72.6%
Dishwasher	15.7%	17.5%	19.1%	20.5%	21.8%	23.0%
Washing machine	31.6%	34.2%	35.9%	37.1%	38.0%	38.7%
Brisbane						
Shower	74.5%	75.3%	75.5%	75.6%	75.7%	75.7%
Toilet	13.1%	44.5%	59.2%	67.7%	73.3%	77.3%
Basin	35.3%	47.1%	53.3%	57.1%	59.7%	61.6%
Sink	70.5%	71.9%	72.4%	72.6%	72.7%	72.8%
Dishwasher	16.6%	19.1%	21.2%	23.0%	24.7%	26.1%
Washing machine	33.0%	35.9%	37.6%	38.7%	39.5%	40.1%
Melbourne						
Shower	73.9%	74.9%	75.3%	75.5%	75.6%	75.6%
Toilet	-5.1%	28.7%	46.0%	56.6%	63.7%	68.8%
Basin	29.3%	41.0%	47.7%	52.1%	55.3%	57.6%
Sink	69.3%	71.3%	71.9%	72.3%	72.5%	72.6%
Dishwasher	15.8%	17.6%	19.3%	20.7%	22.1%	23.3%
Washing machine	31.7%	34.4%	36.1%	37.3%	38.2%	38.9%

(continued)

Table 7.3 (continued)

Perth						
Shower	69.7%	72.5%	73.6%	74.2%	74.5%	74.8%
Toilet	-59.4%	-32.5%	-13.4%	0.8%	11%	20.8%
Basin	14.0%	21.1%	26.7%	31.2%	35.0%	38.1%
Sink	61.0%	66.5%	68.6%	69.8%	70.4%	70.9%
Dishwasher	14.3%	14.9%	15.5%	16.0%	16.6%	17.1%
Washing machine	28.7%	30.0%	31.2%	32.1%	32.9%	33.7%
Adelaide						
Shower	74.6%	75.3%	75.5%	75.6%	75.7%	75.8%
Toilet	16.2%	46.9%	61.2%	69.4%	74.8%	78.5%
Basin	36.4%	48.1%	54.2%	57.9%	60.4%	62.2%
Sink	70.7%	72.0%	72.4%	72.6%	72.8%	72.9%
Dishwasher	16.8%	19.4%	21.6%	23.5%	25.2%	26.6%
Washing machine	33.3%	36.2%	37.9%	39.0%	39.7%	40.3%
Darwin						
Shower	71.2%	73.4%	74.2%	74.6%	74.9%	75.1%
Toilet	-4.8%	-17.5%	2.5%	16.7%	27.3%	35.5%
Basin	16.9%	25.5%	31.8%	36.6%	40.5%	43.6%
Sink	63.9%	68.3%	69.9%	70.7%	71.2%	71.6%
Dishwasher	14.6%	15.3%	16.1%	16.8%	17.5%	18.2%
Washing machine	29.2%	30.9%	32.2%	33.3%	34.2%	35.0%

Table 7.4 Payback periods for the alternative sustainable innovations compared to the standard water facilities

	Number of occupants					
Facilities	1	2	3	4	5	6
Sydney						
Shower	0.77	0.39	0.26	0.19	0.15	0.13
Toilet	21.27	10.64	7.09	5.32	4.26	3.55
Basin	17.64	8.82	5.88	4.41	3.53	2.94
Sink	1.64	0.82	0.55	0.41	0.33	0.27
Dishwasher	10.19				5.10	
Washing machine	5.16				2.58	
Canberra						
Shower	0.78	0.38	0.26	0.19	0.15	0.13
Toilet	20.54	10.27	6.85	5.14	4.11	3.42
Basin	16.35	8.17	5.45	4.09	3.27	2.72
Sink	1.64	0.82	0.55	0.41	0.33	0.27
Dishwasher	10.24				5.12	
Washing machine	5.19				2.59	

(continued)

Table 7.4 (continued)

	Number of occupants					
Facilities	1	2	3	4	5	6
Brisbane						
Shower	0.67	0.34	0.22	0.17	0.14	0.11
Toilet	15.38	7.69	5.13	3.84	3.08	2.56
Basin	13.54	6.77	4.51	3.39	2.71	2.26
Sink	2.68	1.34	0.89	0.67	0.54	0.45
Dishwasher	10.61				5.30	
Washing machine	5.45				2.73	
Melbourne						
Shower	0.84	0.42	0.28	0.21	0.17	0.14
Toilet	19.63	9.81	6.54	4.91	3.93	3.27
Basin	16.82	8.41	5.61	4.21	3.36	2.80
Sink	1.51	0.76	0.50	0.38	0.30	0.25
Dishwasher	10.24				5.12	
Washing machine	5.12				2.56	
Perth						
Shower	1.37	0.69	0.46	0.34	0.27	0.23
Toilet	38.19	19.10	12.73	9.55	7.64	6.37
Basin	57.79	28.90	19.26	14.45	11.56	9.63
Sink	1.32	0.66	0.44	0.33	0.26	0.22
Dishwasher	11.45				5.72	
Washing machine	6.33				3.17	
Adelaide						
Shower	0.60	0.30	0.20	0.15	0.12	0.10
Toilet	15.90	7.95	5.30	3.97	3.18	2.65
Basin	12.02	6.01	4.01	3.00	2.40	2.00
Sink	0.89	0.44	0.30	0.22	0.18	0.15
Dishwasher	10.72				5.36	
Washing machine	5.59				2.79	
Darwin						
Shower	1.20	0.60	0.40	0.30	0.24	0.20
Toilet	37.65	18.83	12.55	9.41	7.53	6.28
Basin	26.53	13.26	8.84	6.63	5.31	4.42
Sink	2.12	1.06	0.71	0.53	0.42	0.35
Dishwasher	9.53				4.77	
Washing machine	6.38				3.19	

7.5 Conclusion

This paper demonstrated that the alternative sustainable innovations optimise water efficiency and cost effectiveness in residential dwellings, by reducing water consumption and wastage. The alternative sustainable innovations studied were low flow showerheads, waterless composting toilets, flow restricted/aerated faucets, water efficient dishwashers and steam washing machines. Achieving this in households

today is becoming imperative, as demand and population continue to put stress on water supply across the vast majority of Australia. Portray comparisons between the standard water facilities and the alternative sustainable innovations in the cities of Sydney, Canberra, Brisbane, Melbourne, Perth, Adelaide and Darwin were conducted on their water consumption, life cycle costing, payback period and percentage of saving. It was found that the savings over the 15-year period ranged from $7,294.565 to $ 28,785.369 between cities, which is a considerable saving as this value is for a dwellings with a single occupant. It is clear that sustainable innovations can optimise water efficiency and cost effectiveness in residential dwellings. Overall, the results obtained illustrate that water efficiency and cost effectiveness can be improved, by adopting the use of the alternative sustainable innovations.

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