Evaluation Procedure & Data for the TouchGrid ShowerStar Calculator

By

Wasim Saman

Emeritus Professor of Sustainable Energy Engineering
Mobile: 0478 402 191
Email: wasim.saman@unisa.edu.au
https://people.unisa.edu.au/Wasim.Saman
ABN: 16 677 307 657

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1. Introduction & project scope

TouchGrid is developing ShowerStar, a smart device that aims to improve energy and water efficiency. It can be mounted onto an existing shower pipe or showerhead and automatically detects when the shower starts. The device senses the number of times the shower is used and records the duration of water flow. Based on available data and expertise in hot water and energy use in the housing sector, an evaluation procedure and mathematical formulas are developed for calculating the following using clearly defined assumptions based on available technical, geographical, water and energy costs and climatic data. The developed procedure/formulas will deal with the 3 scenarios:

1. Historical data to evaluate
    - The average shower duration and flow rate and how they compare with recommended values.
    - Total nominal cost of energy (gas or electricity) and water per shower.
2. Annual performance estimates based on historical data, the total annual cost of energy and water consumption due to shower use will be evaluated.
3. Potential savings: the historical data is used to evaluate annual potential energy, water and total nominal annual cost savings due to adjusting shower duration or number of showers.

The procedure will be used for programming the device and incorporating it into the application associated with it, along with data inputted by the user (location, showerhead flow rate), and type of hot water system in use (gas storage, gas instantaneous, electric resistance, electric heat pump).

2. Data required for calculations

In order to evaluate the historical and anticipated performance parameters listed above, a number of datasets is required. The values quoted are based on best available data by the author on the basis of listed technical references. The costs of units of water and energy reflect the anticipated averages as from July 2024. The constants and variables are sourced as follows:

2.1 Measured by the device

- Number of showers
- Total time of water flow through the shower, seconds

2.2 Added manually by the user

- Time to fill a 10-litre bucket, seconds.
- Number of days of monitoring, days (user needs the date of installation (or resetting) and date of analysis)
- Location: Choice from: Adelaide, Brisbane, Hobart, Melbourne, Perth or Sydney
- Type of heater: Choice from: Gas storage, Gas instantaneous, Electric storage or Electric heat pump.

2.3 Constants

- Recommended shower length: 4 minutes: this value was selected on the basis of recommendation by a number of organisations/authorities [1,2] References listed in Appendix A
- Shower water outlet temperature: 41℃. This is the maximum temperature recommended by dermatologists. The water temperature will be slightly reduced on reaching the body [3,4].
- Specific heat capacity of water@ 40 oC =4.18 kJ/kg K.

2.4 Variables

- Cost of water. The cost of water per litre was evaluated on the basis of published water tariffs provided by the relevant state water utilities [5-10]. Tier 2 water tariffs were used. Allowances were made for daily connection charges based on the proportion of typical shower use as a proportion of the total domestic water consumption. An additional 5% was added to the total 2023/2024 tariffs to allow for anticipated rises in 2024/2025. There may be a case to be made for including an additional component to reflect sewerage charges associated with shower use. However, as these charges are normally based on property values which vary with location, they were not included. Table 1 below summarises the water costs used in the calculations.
- Table 1: Estimated costs of a unit of water in the capital cities ($/litre) in 2024-2025.

City	**Cost $/ltr**
Adelaide	0.03189
Brisbane	0.01830
Hobart	0.01238
Melbourne	0.04679
Perth	0.02732
Sydney	0.02804

- Average local annual water temperature. In order to evaluate the heating energy required to heat the water to 41 oC, the initial mains water temperature must be specified. This varies with season, location and time of water use. For this purpose, the year average annual temperatures (1991-2020) at the locations under consideration is used [11], based on measurements by the Australian Bureau of Meteorology.

- The values are listed in Table 2.
- Table 2: Average annual local temperatures.

City	Average annual local temp °C
Adelaide	16.8
Brisbane	20.2
Hobart	13.1
Melbourne	14.8
Perth	18.8
Sydney	18.7

- Water heater efficiency. There are numerous sizes and models of water heaters marketed in Australia with varying thermal performance. The report considers the water heating appliances in common use in Australia; namely gas storage, gas instantaneous, electric storage and electric heat pump storage systems. The key performance parameter of the heater is its overall annual thermal efficiency which defines how much of the energy supplied is utilised as heat in the delivered hot water. This must take into account the losses during the energy conversion from gas/electricity to heat as well as the thermal losses in the storage tank and water transmission to the point of use. Table 3 provides the recommended overall thermal efficiency for the selected types. These values are based on the author's experience in water heating system design, evaluation and testing and available literature, including the results of an in-situ monitoring program carried out on water heaters for 12 months by the author's team [12].

- The values are listed in Table 3.
- Table 3: Overall thermal efficiency of water heating systems

Heater Type	Overall Efficiency (%)
Gas storage	55
Gas Instantaneous	69
Electric storage	71
Electric heat pump	196

- Cost of unit gas (2024-2025 estimate). The estimate for 2024/2025 has been based on current tariffs as specified by the average current relevant suppliers and allowing a proportion of the daily connection charges. A 10% increase is factored in for 2024/2025 in lieu of previous increases which ranged between 8.7% for Western Australia and 22.2% for Victoria for the preceding financial year [13]

- The results are summarised in Table 4.
- Table 4: Estimated costs of a unit of gas (MJ) in 2024-2025

City	Cost 2024-25 $/MJ
Adelaide	0.0646
Brisbane	0.0641
Hobart	0.0653
Melbourne	0.0536
Perth	0.0512
Sydney	0.0545

- Cost of unit electricity. The values used in evaluating the electricity unit cost (in kWhr) in 2024-2025 (listed in Table 5) are based on the default 2024-2025 values set by the Australian Energy Regulator for the Eastern mainland states [14,15]. The values incorporate the appropriate daily connection charges. The values used in the calculations were based on the draft determination which was published in March 2024. The final determination, published at the end of May2024 includes slight adjustments from the draft in some cases.
- For Hobart, the 2023/2024 standing offer electricity prices as stipulated by the Office of the Tasmanian Economic Regulator [16] were used with due allowance made for the proportion of the daily supply charge. The estimate for Perth was based on the 2023/2024 residential hot water heating tariff [17] with allowance made for the supply charge.
- The cost of electricity used throughout the calculation is based on the energy being supplied by a utility provider. Generally, the net cost will be lower if rooftop solar electricity is used for water heating.

- Table 5: Estimated costs of a unit of electricity (kWhr) in 2024-2025

City	Cost $/kWhr
Adelaide	0.5555
Brisbane	0.4396
Hobart	0.2369
Melbourne	0.4108
Perth	0.1561
Sydney	0.4546

3. Evaluation Procedure Equations

3.1 Actual data analysis for the duration of the monitoring period:

Average shower duration, minutes= total time, seconds/ (60 x number of showers)

Comparison with recommended shower duration, minutes longer or shorter= Average shower duration – 4.0 minutes: longer if positive, shorter if negative

Average shower flow rate, litre/second = 10/time to fill a 10 litre bucket

Total water used, litre = Average shower flow rate, litre/second x total time, second

Total cost of water, $= Total water used x cost of water

Temperature rise, °C = shower water temperature - average annual local temperature

Total gas energy used for heating, MJ = Average shower flow rate x total time x 4.18 x temperature rise x heater efficiency /1000

Total electrical energy used for heating, kWhr = Average shower flow rate x total time x 4.18 x temperature rise x heater efficiency/3600

Total cost of energy (gas), $ = Total gas energy x cost of unit gas

Total cost of energy (electricity), $ = Total electrical energy x cost of unit electricity

Total cost of energy and water, $ = total cost of water + total cost of energy

Total cost of energy and water per shower, $ per shower = Total cost of energy and water/number of showers

3.2 Estimated annual performance:

Total annual cost of energy and water, $ = Total cost of energy and water x (365/number of days of monitoring)

3.3 Estimated potential annual savings:

Shower duration reduction time, minutes = Average shower duration – 4.0 minutes

Annual water saving, litre = Total water used, litre x (shower duration reduction time/Average shower duration) X (365/number of days of monitoring)

Annual energy reduction (gas), MJ= Total gas energy used for heating x (shower duration reduction time/Average shower duration) X (365/number of days of monitoring)

Annual energy reduction (electricity), kWh = Total electrical energy used for heating x (shower duration reduction time/Average shower duration) X (365/number of days of monitoring)

Total annual savings $ per year = Total annual cost of energy and water x (shower duration reduction time/ Average shower duration)

4. Sample Calculation

A specific case study of shower use and potential savings in Adelaide demonstrates how the methodology employed in this report can be used to evaluate the running costs and potential savings.

Data Used in the Sample Calculation

Measured by the device

- Number of showers: 150
- Total time of water flow in shower, seconds: 90 000
- Measured and added manually:
- Time to fill a 10-litre bucket, seconds: 50
- Number of days of monitoring: 90
- Location: Adelaide
- Type of heater: gas storage

Constants

- Recommended shower length: 4 minutes
- Shower water temperature: 41oC
- Specific heat capacity of water@ 40 oC : 4.18 kJ/kg K

Variables

- Cost of litre of water ($/litre)

City	Cost $/ltr
Adelaide	0.003189
Brisbane	0.001830
Hobart	0.001238
Melbourne	0.004679
Perth	0.002732
Sydney	0.002804

- Average annual local inlet water temperature (oC)

City	Average annual local temp °C
Adelaide	16.8
Brisbane	20.2
Hobart	13.1
Melbourne	14.8
Perth	18.8
Sydney	18.7

- Water heater efficiency

Heater Type	Efficiency
Gas storage	0.55
Gas Instantaneous	0.69
Electric storage	0.71
Electric heat pump	1.96

- Cost of unit gas ($/MJ)

City	Cost
Adelaide	0.0646
Brisbane	0.0641
Hobart	0.0653
Melbourne	0.0536
Perth	0.0512
Sydney	0.0545

- Cost of unit electricity ($/kWhr)

City	Cost $/kWhr
Adelaide	0.5555
Brisbane	0.4396
Hobart	0.2369
Melbourne	0.4108
Perth	0.1561
Sydney	0.4546

- Sample evaluation procedure
    - Actual data analysis for the duration of the monitoring period.
    - Average shower duration, minutes= total time, seconds/ (60 x number of showers)
    - 90000/ (60 x 150) = 10 minutes
    - Comparison with recommended shower duration, minutes longer or shorter= Average shower duration – 4.0 minutes: longer if positive, shorter if negative 10-4= 6 minutes longer than recommended
    - Average shower flow rate, litre/second = 10/time to fill 10 litre bucket 10/50=0.2 litre/second
    - Total water used, litre = Average shower flow rate, litre/second x total time, second 0.2 x 90 000=18 000 litre
    - Total cost of water, $= Total water used x cost of water ($/ltr) 18 000 x 0.003189 = $57.402
    - Temperature rise, °C = shower water temperature - average annual local temperature 41- 16.8 = 24.2°C
    - Total gas energy used for heating, MJ = total water used x 4.18 x temperature rise x heater efficiency /1000 18 000 x 4.18 x 24.2 x 0.55)/1000 = 1 001.44 MJ
    - Total cost of energy (gas), $ = Total gas energy x cost of unit gas 1 001.44 x 0.0646 = $64.69
    - Total cost of energy and water, $ = total cost of water + total cost of energy 57.402 +64.693 = $122.10
    - Total cost of energy and water per shower, $ per shower = Total cost of energy and water/number of showers 122.1/150 = $0.81

- Estimated annual performance
    - Total annual cost of energy and water, $ = Total cost of energy and water X (365/number of days of monitoring) 122.10 x 365 / 60 = $742.78

- Estimated potential Annual Savings
    - Shower duration reduction time, minutes = Average shower duration – 4.0 minutes. 10-4 = 6 minutes
    - Annual water saving, litre = Total water used, litre x (shower duration reduction time/Average shower duration) X (365/number of days of monitoring). 18 000 x (6/10) x (365/60) = 65 700 litre
    - Annual energy reduction (gas), MJ= Total gas energy used for heating x (shower duration reduction time/Average shower duration) X (365/number of days of monitoring). 1 001.44 x (6/10) x (365/60) = 3 655. 26 MJ.
    - Total annual savings $ per year = Total annual cost of energy and water x (shower duration reduction time/ Average shower duration). 742.78 (6/10) = $445.67

5. Impact of sustainable showers

According to available statistics [18-22], Australia currently has 10.57 million households, with 2.5 persons per household. On average Australians shower 8 times per week with an average showing time of 7.3 minutes. 14% of the homes use gas storage heaters, with 24% powered by gas instantaneous systems. 45% use electrical storage heaters with 4% employ heat pump electric heaters.

Assuming that 2 showers are taken per household per day using a typical 3 star rated shower (9 litre/minute), the total annual water use for showering is 47.8 kilolitre/year. If 4 minute showers are taken instead of 7.3 minutes, the resulting water saved per household will be 21.6 kilolitre/year. This equates to an impressive 45% saving in water for showering with associated savings in cost of water provision and heating. For all Australian households, this equates to 228.5 million kilo litres/ year which is equivalent to 91 418 Olympic swimming pools of saved treated mains water.

Turning to energy savings, typical Australian households which use electrical water heating will save over 2kWh per day by taking 4 minute showers; with over 12% reduction of overall domestic consumption and associated cost saving. The overall national impact is equivalent to taking 717 000 homes off the electrical grid. The energy savings for households using natural gas for water heating is typically 1,207 MJ/year. With a national domestic natural gas supply of 195 Peta Joule per year, this is equivalent to a 2.9% reduction of the domestic gas supply and translates to cutting the gas supply from 133 000 households.

In addition to the substantial cost savings to individual households, the national implications on infrastructure costs in providing and delivering mains water and energy to dwellings are considerable as the provision of water and energy for showering are estimated to account for 44% of the total household water provision and 21% of the total household energy supply [23]. With Perth relying on desalination to cover half of its water needs, and desalination plants operating in all major Australian cities, the energy associated with water desalination (4.2kWh/kl [24]) needs to be included in the evaluation of the costs of water provision and the opportunities for cost cutting and emissions reduction associated with taking sustainable showers.

With the world, including Australia, heading towards serious reductions in greenhouse gas emissions, taking shorter showers by the majority of the population has a potential of reducing the overall national household emissions if a conventional mix (natural gas/electricity) is being used for water heating.

6. Summary and conclusions

This technical report has provided the methodology employed in evaluating the energy and costs associated with showering in the 6 Australian state capitals (Adelaide, Brisbane, Hobart, Melbourne, Perth and Sydney). This includes a detailed description of the methodology, assumptions used with justification, sources of data provided and references.

The calculation demonstrates how taking shorter and less showers can dramatically reduce the energy and water consumption, and cost associated with this everyday activity. Using the ShowerStar as a means for behaviour change is an effective tool for saving vital resources, costs and impacting positively on the environment.

The values used in the evaluation are our best estimate for July 2024. With regular adjustments of energy and water tariffs, it is recommended that the values quoted in Tables 1,4 and 5 be reviewed annually to reflect the tariffs of water, gas and electricity in the designated locations.

Having established the evaluation procedure, it can be readily applied to other locations within and outside Australia using the same or other systems of units. With more public awareness of climate change and the need to reduce greenhouse gas emissions associated with energy use, both on the national and international fronts, the report has demonstrated the potential significant impacts of having shorter showers on the household greenhouse gas emissions. It is recommended to add an estimate of the carbon emissions and emissions reductions due to less showers and/or taking shorter showers to the showerStar calculator.

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