Estimated Hot Water System Running Costs in Victoria

Prepared for
Sustainability Victoria

Version 2
April 2009

EnergyConsult PTY LTD
655 Jacksons Track
Jindivick, Victoria 3818
Australia
ABN: 18 090 579 365
Tel: +613 5628 5449
Fax: +613 9923 6175
Email: info@energyconsult.com.au

Contents

Glossary

AS/NZS 4234	Australia New Zealand Standard 4234: Heated water systems – Calculation of energy consumption.
CO2-e	Carbon dioxide equivalent emissions
Day rate	Day rate electricity tariff
GHG	Greenhouse Gas
GJ	Gigajoule - a thousand million joules, which is a measure of energy
GWA	George Wilkenfeld and Associates
high eff	High efficiency
kg	Kilogram
kWh	Kilowatt hour - one thousand watt hours, which is a measure of energy
l	Litres
LPG	Liquid Petroleum Gas
min eff	Minimum efficiency
MJ	Magajoule - a million joules, which is a measure of energy
NG	Natural Gas
OP	Off-peak electricity tariff
TOU	Time of Use electricity tariff
TRNSYS	TRNSYS is a transient system simulation program developed by the Solar Energy Laboratory at The University of Wisconsin.
TS	thermosiphon, is based on natural convection which circulates liquid without requiring a conventional pump
Zone	Climate Zone from AS/NZS 4234

Introduction

The purpose of this report is to estimate the annual energy running costs and greenhouse gas (GHG) emissions of different hot water systems in Victoria. The report updates the earlier study *Estimated Household Water Heater Energy Use, Running Costs and Emissions, Victoria Based on energy price projections, 2005-2015* (GWA 2005) prepared in May 2005 for Sustainability Victoria.

This analysis utilises many of the assumptions and methodology of the GWA 2005 study, however it differs in the following areas:

- Energy prices used to calculate the running costs are estimated from published tariffs current in 2008 – compared to the weighted average forecast from 2005 – 2015 used in the GWA 2005 study
- The energy consumption is calculated and reported for each water heater type by climate zone and hot water load. The GWA 2005 study weighted the results by households/climate zone and water heater load
- Solar water heaters and heat pump energy consumption was calculated on the basis of solar hot water savings in Zone 4, and scaled up for Zone 3 on the basis of TRNSYS modelling of units in Zone 4 and Zone 3

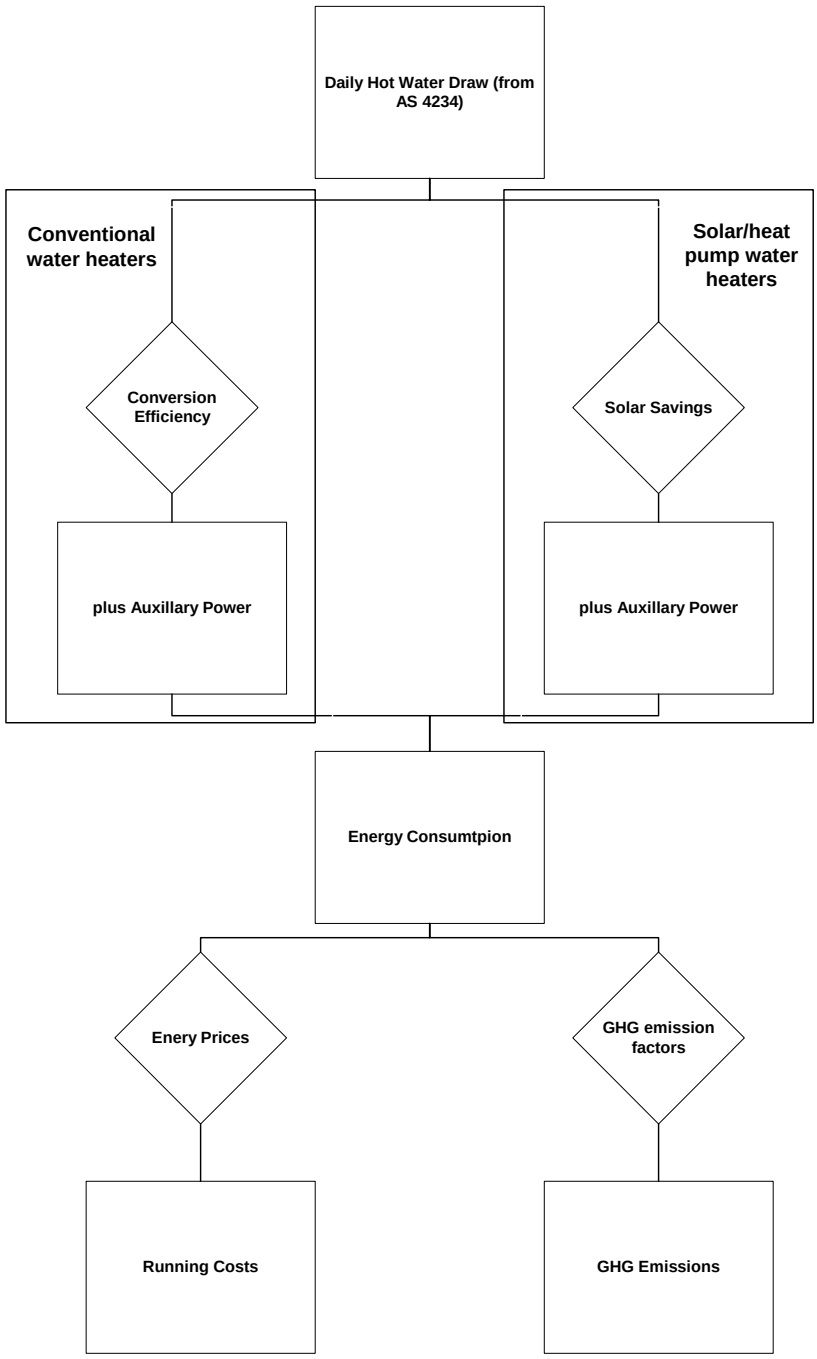
This analysis primarily provides data on the estimated energy consumption, GHG emissions and energy running costs. It does not include the purchase costs of the units and therefore no lifecycle costs are calculated.

Methodology

Overview

The energy consumption of the various water heater types was estimated according the similar methodology used in GWA 2005. The schematic of the approach is shown in Figure 1.

Figure 1: Methodology Overview



Water Heater Assumptions

The following assumptions were used for the calculation of the water heater energy consumption.

Hot Water Loads

The daily hot water peak winter loads by zone are shown in Table 1.

Table 1: Peak System Load (MJ/Day)

Item	Small	Medium	Large
Zone 4	25.2	42	63
Zone 3	22.5	38	57
Approx Water (litres)	120	200	300

Source: AS/NZS 4234:2008

These peak daily hot water loads were converted to average yearly loads in accordance with the methodology shown in GWA 2005. This methodology involves the use of water temperature and energy content calculations applied to the proportion of peak load by month from AS/NZS 4234.

Base on the GWA 2005 study, the small, medium and large loads are equivalent to:

- small households(1 bedroom, approx 120 l/day of hot water),
- medium households (2-3 bedrooms, approx 200 l/day of hot water); and
- large household (4+ bedrooms, approx 300 l/day of hot water)

The Annual Delivered Energy use for the analysis is shown in Table 2.

Table 2: Annual Delivered Energy (MJ/yr)

Item	Small	Medium	Large
Zone 4	8,320	13,866	20,799
Zone 3	7,428	12,546	18,819

Water Heater Characteristics

The following water heater characteristics were used for the modelling of energy consumption and the key assumptions are shown in Table 3 and Table 4.

Table 3: Conventional Water Heater Characteristics

Conventional Water Heater Systems			
Reference Water Heaters[1]	**Small**	**Medium**	**Large**
Zone 4	**MJ/yr**	**MJ/yr**	**MJ/yr**
Electric Off Peak - AS/NZS 4234		16,670	23,140
Electric Continuous - AS/NZS 4234	10,210		
Gas storage (2*) - AS/NZS 4234	18,910	26,340	35,620
Zone 3	**MJ/yr**	**MJ/yr**	**MJ/yr**
Electric Off Peak - AS/NZS 4234		15,260	21,100
Electric Continuous - AS/NZS 4234	9,207		
Gas storage (2*) - AS/NZS 4234	17,290	24,150	32,580
		Tank Heat Loss (kWh/day)	
Electric Water Heaters[2]	**Small**	**Medium**	**Large**
Electric Continuous	1.25	1.53	1.81
Electric Off Peak	2.44	2.72	2.93
Electric Dual-element Off Peak	2.64	2.92	3.13

Gas Water Heaters[2]	**Maintenance Rate (MJ/hr)**	**Combustion Efficiency (%)**
Gas storage (3*)	0.829	76%
Gas storage (5*)	0.540	84%
Gas inst (3*)	0.0	60.4%
Gas inst (5*)	0.0	73.5%

Notes: 1. Used for calculation of energy consumption by solar hot water systems
2. From Thermal Design 2009 report

Table 4: Solar/ Heat Pump Water Heater Characteristics

Solar/Heat Pump Water Heater Type	Annual Energy Savings	
	Zone 4	**Zone 3**
Heat pump (min eff)	60%	61%
Heat pump (high eff)	70%	71%
Solar-elect close coupled TS, tank boost (min eff)	60%	65%
Solar-elect close coupled TS, tank boost (high eff)	80%	85%
Solar-gas close coupled TS, tank boost (min eff)	60%	65%
Solar-gas close coupled TS, tank boost (high eff)	80%	85%
Solar-gas close coupled TS, in line boost (min eff)	60%	65%
Solar-gas close coupled TS, in line boost (high eff)	90%	95%
Solar-elect Pumped system, tank boost (min eff)	60%	65%
Solar-elect Pumped system, tank boost (high eff)	80%	85%
Solar-gas Pumped system, tank boost (min eff)	60%	65%
Solar-gas Pumped system, tank boost (high eff)	80%	85%
Solar-gas Pumped system, in line boost (min eff)	60%	65%
Solar-gas Pumped system, in line boost (high eff)	90%	95%

Solar and heat pump water heater Annual Energy Savings for the high efficiency models were obtained from the data on models registered under Sustainability Victoria's "List of systems capable of complying with the regulations" (SV 2008).

The solar systems were modelled on the basis of the requirements of minimum Annual Energy Savings of 60% in Zone 4, as this is the requirement of the Sustainability Victoria rebate program and the 5 Star regulations for new houses. The Annual Energy Savings was scaled up for Zone 3 on the basis of TRNSYS modelling of systems under constant loads in Zones 3 & 4 (Thermal Design 2007). The modelling showed that systems saved on average between 10 to 14% in Zone 3 compared to the same system in Zone 4. However, allowing for the possible reduced level of solar radiation over the southern part of Zone 3 (Northern Victoria is in the southern part of Zone 3 which includes Adelaide and Sydney), this study assumed a 5% increase in Energy Savings in Zone 3, for a solar water heater measured in Zone 4.

Energy Price and Greenhouse Gas Emission Factors

Energy Prices

The energy prices were obtained from published tariffs for all major energy retailers. The prices used in this report are estimated median prices from regulated tariffs, as shown in Table 5. This table also describes the characteristics of the tariffs.

Table 5: Median Energy Prices and Tariff Characteristics (incl. GST) 2008

Fuel Type	Times Applicable	Median (c/MJ)	Median (c/kWh)	Range
Electric- Day Rate Peak (GD/GR)	All		16.96	15.9 – 18.4
Electric- TOU Peak (GH/GL –Winner)	7 am – 11 pm weekdays		20.98	18.6 – 23.6
Electric- TOU Off Peak (GH/GL –Winner)	All other times		8.85	8.6 – 11.6
Electric- Off Peak (J, J6, JT, Y6, Y8)	Depends on Tariff		8.86	7.8 – 9.8
Gas- Natural	NA	1.09		0.97 – 1.47
Gas- LPG	NA	4.4		NA

GD/GR/GH/GL/J6/JT/Y6/Y8 – from Victorian Regulated Tariffs

GHG Emission Factors

The GHG emission factors used in the report are shown in Table 6.

Table 6: Greenhouse Gas Emission Factors 2008

Fuel Type	Victoria Emission Factors
Electricity	1.31 kg/kWh (scope 2+3)
Gas- Natural	57.3 kg/GJ (scope 1+3)
Gas- LPG	65.3 kg/GJ(scope 1+3)

Source: National Greenhouse Accounts (NGA) Factors, Department of Climate Change, Jan 2008

Weighting Factors

The average Victorian annual energy running costs and GHG emissions were determined by weighted average. The average values were determined by weighting the results by the estimated number of households by size and distribution of households by climate zone. Table 7 provides the weighting by household size and Table 8 the weighting by climate zone.

Table 7: Weighting by Household Size

Household Size		
Small	Medium	Large
21.0%	64.0%	15.0%

Source: GWA 2005, Table 4

Table 8: Weighting by Climate Zone

Climate	
Zone 3	Zone 4
15.0%	85.0%

Source: Estimated based on distribution of households by AS/NZS 4234 Climate Zone

Solar and Heat Pump Water Heater Descriptions[1]

Solar-gas or solar-electric close-coupled thermosiphon (TS)

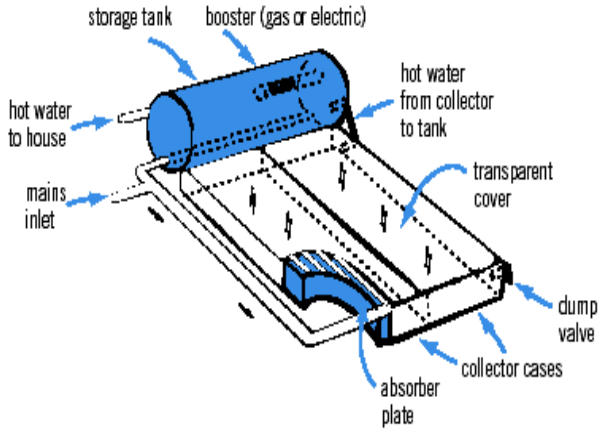
This is the most common system on the market. It consists of roof-mounted solar collectors, combined with a horizontally-mounted storage tank located immediately above these collectors.

In these solar systems a pump is not required. Heated fluid rises naturally through the solar collectors and enters the storage tank. When this happens, cooler water at the base of the storage tank is forced out and flows down to the bottom of the collectors.

Boosting can be provided by gas or electricity (preferably off-peak as it is lower cost). Boost heating in the storage tank (tank boost) should be in the top half of the tank so that solar can heat the bottom of the tank. Alternatively, boosting can be done after the solar storage tank by using a continuous flow gas heater (in-line boost) designed to accept varying inlet temperatures.

This cycle is continuously repeated while the sun is shining. Many commercially available solar hot water systems employ this cycle, commonly referred to as 'thermosiphon flow' (see Figure 2).

Figure 2: Close-coupled thermosiphon (mains pressure)



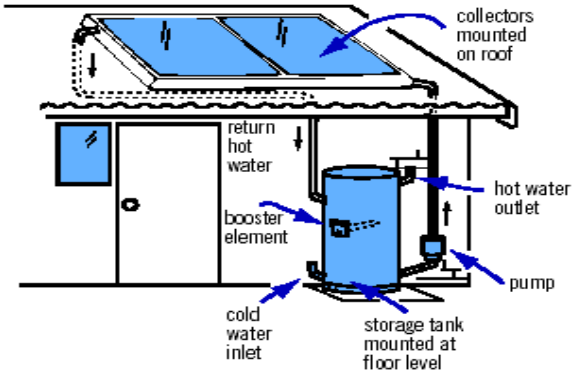
[1] Information in this section is sourced from http://www.saveenergy.vic.gov.au/getthefacts/factsheets.aspx, Solar Hot Water factsheet.

Solar-gas or solar-electric pumped systems

With a pumped system, the tank is located below the level of the collectors, usually at ground level. Water must therefore be pumped from the tank to the collectors and back by a thermostatically controlled pump. Pumps are generally small. The electricity used in pumping is included in the annual energy running costs.

The system can be boosted by electricity, usually off-peak, or gas either controlled by a timer which stops the gas burner from operating during sunshine hours or which puts the heat into the upper part of the tank (see Figure 3).

Figure 3: Forced circulation system (mains pressure pumped)



Heat pumps

A heat pump is a form of solar water heating that does not rely on direct sunlight. Instead, heat is extracted from the atmosphere using a refrigerant gas and compressor, commonly known as a heat pump. The refrigerant liquid passes through a collector absorbing heat from the atmosphere and evaporating the refrigerant to a gas in the process. The heated refrigerant gas then moves along a coil wrapped around the storage tank where it condenses into a liquid and heats the water in the storage tank. The electricity consumption is similar to a solar water heater with electric boosting consequently they are treated as electric boosted solar systems. Running costs can vary as heat pumps may need to be connected to a continuous electricity supply.

Results

The main output of this study is the estimated energy consumption by fuel, running costs and GHG emissions for various types of water heaters. The following tables show the results separately for Zone 4 and Zone 3 by household size. The average results weighted by household size are also shown for each zone. Finally the average result for Victoria weighted by household size and zone are provided (Table 15). The result tables also provide the GHG emissions intensity of the various hot water systems in terms of the GHG emissions per hot water delivered energy, in g CO_2-e/MJ. The tables provided are shown below:

The ranking of water heater by GHG emissions is shown in Figure 4 and by energy running costs in Figure 5. These figures are the estimated Victorian average, weighted by household size and climate zone.

Table 9: Results Zone 4 – Small Households (approx 120 l/day of hot water)

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	2,767		$473	3.63	436
Electric Continuous - Day rate	2,767		$469	3.63	436
Electric Off Peak	3,113		$276	4.08	490
Electric Dual-element Off Peak					
Gas storage (3*) - NG		17,930	$195	1.03	123
Gas storage (3*) - LPG		17,930	$789	1.17	141
Gas storage (5*) - NG		14,520	$158	0.83	100
Gas storage (5*) - LPG		14,520	$639	0.95	114
Gas instantaneous (3*) - NG	67	14,970	$175	0.95	114
Gas instantaneous (3*) - LPG	67	14,970	$670	1.07	128
Gas instantaneous (5*) - NG	67	12,520	$148	0.81	97
Gas instantaneous (5*) - LPG	67	12,520	$562	0.91	109
Heat pump (min eff) - Day rate	1,134		$192	1.49	179
Heat pump (high eff) - Day rate	851		$144	1.11	134
Heat pump (min eff) - TOU	1,134		$150	1.49	179
Heat pump (high eff) - TOU	851		$112	1.11	134
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,134		$125	1.49	179
Solar-elect close coupled TS, tank boost (high eff)-TOU	567		$63	0.74	89
Solar-elect close coupled TS, tank boost (min eff)-OP	1,134		$101	1.49	179
Solar-elect close coupled TS, tank boost (high eff)-OP	567		$50	0.74	89
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,134		$192	1.49	179
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	567		$96	0.74	89
Solar-gas close coupled TS, tank boost (min eff)- NG		7,564	$82	0.43	52
Solar-gas close coupled TS, tank boost (high eff)-NG		3,782	$41	0.22	26
Solar-gas close coupled TS, tank boost (min eff)- LPG		7,564	$333	0.49	59
Solar-gas close coupled TS, tank boost (high eff)-LPG		3,782	$166	0.25	30
Solar-gas close coupled TS, in line boost (min eff)- NG	52	7,378	$89	0.49	59
Solar-gas close coupled TS, in line boost (high eff)-NG	52	1,705	$27	0.17	20
Solar-gas close coupled TS, in line boost (min eff)- LPG	52	7,378	$333	0.55	66
Solar-gas close coupled TS, in line boost (high eff)-LPG	52	1,705	$84	0.18	22
Solar-elect Pumped system, tank boost (min eff)-TOU	1,134		$125	1.49	179
Solar-elect Pumped system, tank boost (high eff)-TOU	567		$63	0.74	89
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,134		$192	1.49	179
Solar-elect Pumped system, tank boost (high eff)- Day rate	567		$96	0.74	89
Solar-elect Pumped system, tank boost (min eff)-OP	1,134		$101	1.49	179
Solar-elect Pumped system, tank boost (high eff)-OP	567		$50	0.74	89
Solar-gas Pumped system, tank boost (min eff) - NG	53	7,373	$89	0.49	59
Solar-gas Pumped system, tank boost (high eff) - NG	53	3,591	$48	0.28	33
Solar-gas Pumped system, tank boost (min eff) - LPG	53	7,373	$333	0.55	66
Solar-gas Pumped system, tank boost (high eff) - LPG	53	3,591	$167	0.30	37
Solar-gas Pumped system, in line boost (min eff) - NG	105	7,187	$96	0.55	66
Solar-gas Pumped system, in line boost (high eff) - NG	105	1,514	$34	0.22	27
Solar-gas Pumped system, in line boost (min eff) - LPG	105	7,187	$334	0.61	73
Solar-gas Pumped system, in line boost (high eff) - LPG	105	1,514	$84	0.24	28

Table 10: Results Zone 4 – Medium Households (approx 200 l/day of hot water)

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	4,410		$754	5.78	417
Electric Continuous - Day rate	4,410		$748	5.78	417
Electric Off Peak	4,745		$420	6.22	448
Electric Dual-element Off Peak	4,864		$472	6.37	460
Gas storage (3*) - NG		24,720	$269	1.42	102
Gas storage (3*) - LPG		24,720	$1,088	1.61	116
Gas storage (5*) - NG		20,980	$229	1.20	87
Gas storage (5*) - LPG		20,980	$923	1.37	99
Gas instantaneous (3*) - NG	71	24,710	$281	1.51	109
Gas instantaneous (3*) - LPG	71	24,710	$1,099	1.71	123
Gas instantaneous (5*) - NG	71	20,620	$237	1.27	92
Gas instantaneous (5*) - LPG	71	20,620	$919	1.44	104
Heat pump (min eff) - Day rate	1,852		$314	2.43	175
Heat pump (high eff) - Day rate	1,389		$236	1.82	131
Heat pump (min eff) - TOU	1,852		$245	2.43	175
Heat pump (high eff) - TOU	1,389		$184	1.82	131
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,852		$204	2.43	175
Solar-elect close coupled TS, tank boost (high eff)-TOU	926		$102	1.21	87
Solar-elect close coupled TS, tank boost (min eff)-OP	1,852		$164	2.43	175
Solar-elect close coupled TS, tank boost (high eff)-OP	926		$82	1.21	87
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,852		$314	2.43	175
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	926		$157	1.21	87
Solar-gas close coupled TS, tank boost (min eff)- NG		10,536	$115	0.60	44
Solar-gas close coupled TS, tank boost (high eff)-NG		5,268	$57	0.30	22
Solar-gas close coupled TS, tank boost (min eff)- LPG		10,536	$464	0.69	50
Solar-gas close coupled TS, tank boost (high eff)-LPG		5,268	$232	0.34	25
Solar-gas close coupled TS, in line boost (min eff)- NG	53	10,345	$122	0.66	48
Solar-gas close coupled TS, in line boost (high eff)-NG	53	2,443	$36	0.21	15
Solar-gas close coupled TS, in line boost (min eff)- LPG	53	10,345	$464	0.74	54
Solar-gas close coupled TS, in line boost (high eff)-LPG	53	2,443	$116	0.23	17
Solar-elect Pumped system, tank boost (min eff)-TOU	1,852		$204	2.43	175
Solar-elect Pumped system, tank boost (high eff)-TOU	926		$102	1.21	87
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,852		$314	2.43	175
Solar-elect Pumped system, tank boost (high eff)- Day rate	926		$157	1.21	87
Solar-elect Pumped system, tank boost (min eff)-OP	1,852		$164	2.43	175
Solar-elect Pumped system, tank boost (high eff)-OP	926		$82	1.21	87
Solar-gas Pumped system, tank boost (min eff) - NG	62	10,312	$123	0.67	48
Solar-gas Pumped system, tank boost (high eff) - NG	62	5,044	$66	0.37	27
Solar-gas Pumped system, tank boost (min eff) - LPG	62	10,312	$464	0.75	54
Solar-gas Pumped system, tank boost (high eff) - LPG	62	5,044	$232	0.41	30
Solar-gas Pumped system, in line boost (min eff) - NG	115	10,121	$130	0.73	53
Solar-gas Pumped system, in line boost (high eff) - NG	115	2,219	$44	0.28	20
Solar-gas Pumped system, in line boost (min eff) - LPG	115	10,121	$465	0.81	59
Solar-gas Pumped system, in line boost (high eff) - LPG	115	2,219	$117	0.30	21

Table 11: Results Zone 3 – Small Households (approx 120 l/day of hot water)

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	2,520		$431	3.30	444
Electric Continuous - Day rate	2,520		$427	3.30	444
Electric Off Peak	2,865		$254	3.75	505
Electric Dual-element Off Peak					
Gas storage (3*) - NG		16,410	$179	0.94	127
Gas storage (3*) - LPG		16,410	$722	1.07	144
Gas storage (5*) - NG		13,180	$144	0.76	102
Gas storage (5*) - LPG		13,180	$580	0.86	116
Gas instantaneous (3*) - NG	67	13,420	$158	0.86	115
Gas instantaneous (3*) - LPG	67	13,420	$602	0.96	130
Gas instantaneous (5*) - NG	67	11,220	$134	0.73	98
Gas instantaneous (5*) - LPG	67	11,220	$505	0.82	110
Heat pump (min eff) - Day rate	997		$169	1.31	176
Heat pump (high eff) - Day rate	742		$126	0.97	131
Heat pump (min eff) - TOU	997		$132	1.31	176
Heat pump (high eff) - TOU	742		$98	0.97	131
Solar-elect close coupled TS, tank boost (min eff)-TOU	895		$99	1.17	158
Solar-elect close coupled TS, tank boost (high eff)-TOU	384		$42	0.50	68
Solar-elect close coupled TS, tank boost (min eff)-OP	895		$79	1.17	158
Solar-elect close coupled TS, tank boost (high eff)-OP	384		$34	0.50	68
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	895		$152	1.17	158
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	384		$65	0.50	68
Solar-gas close coupled TS, tank boost (min eff)- NG		6,052	$66	0.35	47
Solar-gas close coupled TS, tank boost (high eff)-NG		2,594	$28	0.15	20
Solar-gas close coupled TS, tank boost (min eff)- LPG		6,052	$266	0.40	53
Solar-gas close coupled TS, tank boost (high eff)-LPG		2,594	$114	0.17	23
Solar-gas close coupled TS, in line boost (min eff)- NG	52	5,866	$73	0.40	54
Solar-gas close coupled TS, in line boost (high eff)-NG	52	679	$16	0.11	14
Solar-gas close coupled TS, in line boost (min eff)- LPG	52	5,866	$267	0.45	61
Solar-gas close coupled TS, in line boost (high eff)-LPG	52	679	$39	0.11	15
Solar-elect Pumped system, tank boost (min eff)-TOU	895		$99	1.17	158
Solar-elect Pumped system, tank boost (high eff)-TOU	384		$42	0.50	68
Solar-elect Pumped system, tank boost (min eff)- Day rate	895		$152	1.17	158
Solar-elect Pumped system, tank boost (high eff)- Day rate	384		$65	0.50	68
Solar-elect Pumped system, tank boost (min eff)-OP	895		$79	1.17	158
Solar-elect Pumped system, tank boost (high eff)-OP	384		$34	0.50	68
Solar-gas Pumped system, tank boost (min eff) - NG	53	5,861	$73	0.41	55
Solar-gas Pumped system, tank boost (high eff) - NG	53	2,403	$35	0.21	28
Solar-gas Pumped system, tank boost (min eff) - LPG	53	5,861	$267	0.45	61
Solar-gas Pumped system, tank boost (high eff) - LPG	53	2,403	$115	0.23	30
Solar-gas Pumped system, in line boost (min eff) - NG	105	5,675	$80	0.46	62
Solar-gas Pumped system, in line boost (high eff) - NG	105	488	$23	0.17	22
Solar-gas Pumped system, in line boost (min eff) - LPG	105	5,675	$267	0.51	68
Solar-gas Pumped system, in line boost (high eff) - LPG	105	488	$39	0.17	23

Table 12: Results Zone 3 – Medium Households (approx 200 l/day of hot water)

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	4,043		$691	5.30	422
Electric Continuous - Day rate	4,043		$686	5.30	422
Electric Off Peak	4,378		$388	5.74	457
Electric Dual-element Off Peak	4,497		$436	5.89	470
Gas storage (3*) - NG		22,680	$247	1.30	104
Gas storage (3*) - LPG		22,680	$998	1.48	118
Gas storage (5*) - NG		19,170	$209	1.10	88
Gas storage (5*) - LPG		19,170	$843	1.25	100
Gas instantaneous (3*) - NG	71	22,400	$256	1.38	110
Gas instantaneous (3*) - LPG	71	22,400	$998	1.56	124
Gas instantaneous (5*) - NG	71	18,700	$216	1.16	93
Gas instantaneous (5*) - LPG	71	18,700	$835	1.31	105
Heat pump (min eff) - Day rate	1,653		$280	2.17	173
Heat pump (high eff) - Day rate	1,229		$208	1.61	128
Heat pump (min eff) - TOU	1,653		$218	2.17	173
Heat pump (high eff) - TOU	1,229		$162	1.61	128
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,484		$164	1.94	155
Solar-elect close coupled TS, tank boost (high eff)-TOU	636		$70	0.83	66
Solar-elect close coupled TS, tank boost (min eff)-OP	1,484		$131	1.94	155
Solar-elect close coupled TS, tank boost (high eff)-OP	636		$56	0.83	66
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,484		$252	1.94	155
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	636		$108	0.83	66
Solar-gas close coupled TS, tank boost (min eff)- NG		8,453	$92	0.48	39
Solar-gas close coupled TS, tank boost (high eff)-NG		3,623	$39	0.21	17
Solar-gas close coupled TS, tank boost (min eff)- LPG		8,453	$372	0.55	44
Solar-gas close coupled TS, tank boost (high eff)-LPG		3,623	$159	0.24	19
Solar-gas close coupled TS, in line boost (min eff)- NG	53	8,262	$99	0.54	43
Solar-gas close coupled TS, in line boost (high eff)-NG	53	1,017	$20	0.13	10
Solar-gas close coupled TS, in line boost (min eff)- LPG	53	8,262	$373	0.61	49
Solar-gas close coupled TS, in line boost (high eff)-LPG	53	1,017	$54	0.14	11
Solar-elect Pumped system, tank boost (min eff)-TOU	1,484		$164	1.94	155
Solar-elect Pumped system, tank boost (high eff)-TOU	636		$70	0.83	66
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,484		$252	1.94	155
Solar-elect Pumped system, tank boost (high eff)- Day rate	636		$108	0.83	66
Solar-elect Pumped system, tank boost (min eff)-OP	1,484		$131	1.94	155
Solar-elect Pumped system, tank boost (high eff)-OP	636		$56	0.83	66
Solar-gas Pumped system, tank boost (min eff) - NG	62	8,229	$100	0.55	44
Solar-gas Pumped system, tank boost (high eff) - NG	62	3,399	$48	0.28	22
Solar-gas Pumped system, tank boost (min eff) - LPG	62	8,229	$373	0.62	49
Solar-gas Pumped system, tank boost (high eff) - LPG	62	3,399	$160	0.30	24
Solar-gas Pumped system, in line boost (min eff) - NG	115	8,038	$107	0.61	49
Solar-gas Pumped system, in line boost (high eff) - NG	115	793	$28	0.20	16
Solar-gas Pumped system, in line boost (min eff) - LPG	115	8,038	$373	0.68	54
Solar-gas Pumped system, in line boost (high eff) - LPG	115	793	$54	0.20	16

Table 13: Results Zone 4 – Weighted by Households

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	4,369		$747	5.72	419
Electric Continuous - Day rate	4,369		$741	5.72	419
Electric Off Peak	4,702		$417	6.16	454
Electric Dual-element Off Peak	4,143		$402	5.43	359
Gas storage (3*) - NG		24,572	$268	1.41	105
Gas storage (3*) - LPG		24,572	$1,081	1.60	120
Gas storage (5*) - NG		20,835	$227	1.19	88
Gas storage (5*) - LPG		20,835	$917	1.36	101
Gas inst (3*) - NG	71	24,489	$279	1.50	109
Gas inst (3*) - LPG	71	24,489	$1,090	1.69	124
Gas inst (5*) - NG	71	20,431	$235	1.26	93
Gas inst (5*) - LPG	71	20,431	$911	1.43	104
Heat pump (min eff) - Day rate	1,809		$307	2.37	174
Heat pump (high eff) - Day rate	1,357		$230	1.78	130
Heat pump (min eff) - TOU	1,809		$239	2.37	174
Heat pump (high eff) - TOU	1,357		$179	1.78	130
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,809		$200	2.37	174
Solar-elect close coupled TS, tank boost (high eff)-TOU	905		$100	1.19	87
Solar-elect close coupled TS, tank boost (min eff)-OP	1,809		$160	2.37	174
Solar-elect close coupled TS, tank boost (high eff)-OP	905		$80	1.19	87
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,809		$307	2.37	174
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	905		$153	1.19	87
Solar-gas close coupled TS, tank boost (min eff)- NG		10,469	$114	0.60	45
Solar-gas close coupled TS, tank boost (high eff)-NG		5,234	$57	0.30	22
Solar-gas close coupled TS, tank boost (min eff)- LPG		10,469	$461	0.68	51
Solar-gas close coupled TS, tank boost (high eff)-LPG		5,234	$230	0.34	25
Solar-gas close coupled TS, in line boost (min eff)- NG	53	10,278	$121	0.66	49
Solar-gas close coupled TS, in line boost (high eff)-NG	53	2,427	$35	0.21	16
Solar-gas close coupled TS, in line boost (min eff)- LPG	53	10,278	$461	0.74	55
Solar-gas close coupled TS, in line boost (high eff)-LPG	53	2,427	$116	0.23	17
Solar-elect Pumped system, tank boost (min eff)-TOU	1,809		$200	2.37	174
Solar-elect Pumped system, tank boost (high eff)-TOU	905		$100	1.19	87
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,809		$307	2.37	174
Solar-elect Pumped system, tank boost (high eff)- Day rate	905		$153	1.19	87
Solar-elect Pumped system, tank boost (min eff)-OP	1,809		$160	2.37	174
Solar-elect Pumped system, tank boost (high eff)-OP	905		$80	1.19	87
Solar-gas Pumped system, tank boost (min eff) - NG	60	10,252	$122	0.67	50
Solar-gas Pumped system, tank boost (high eff) - NG	60	5,017	$65	0.37	27
Solar-gas Pumped system, tank boost (min eff) - LPG	60	10,252	$461	0.75	56
Solar-gas Pumped system, tank boost (high eff) - LPG	60	5,017	$231	0.41	30
Solar-gas Pumped system, in line boost (min eff) - NG	113	10,061	$129	0.72	54
Solar-gas Pumped system, in line boost (high eff) - NG	113	2,210	$43	0.27	21
Solar-gas Pumped system, in line boost (min eff) - LPG	113	10,061	$462	0.81	60
Solar-gas Pumped system, in line boost (high eff) - LPG	113	2,210	$116	0.29	22

Table 14: Results Zone 3 – Weighted by Households

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	4,000		$684	5.24	425
Electric Continuous - Day rate	4,000		$678	5.24	425
Electric Off Peak	4,332		$384	5.68	463
Electric Dual-element Off Peak	3,825		$371	5.01	366
Gas storage (3*) - NG		22,520	$245	1.29	107
Gas storage (3*) - LPG		22,520	$991	1.47	122
Gas storage (5*) - NG		19,010	$207	1.09	89
Gas storage (5*) - LPG		19,010	$836	1.24	102
Gas inst (3*) - NG	71	22,163	$254	1.36	110
Gas inst (3*) - LPG	71	22,163	$987	1.54	125
Gas inst (5*) - NG	71	18,500	$214	1.15	94
Gas inst (5*) - LPG	71	18,500	$826	1.30	106
Heat pump (min eff) - Day rate	1,610		$273	2.11	171
Heat pump (high eff) - Day rate	1,197		$203	1.57	127
Heat pump (min eff) - TOU	1,610		$213	2.11	171
Heat pump (high eff) - TOU	1,197		$158	1.57	127
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,445		$159	1.89	154
Solar-elect close coupled TS, tank boost (high eff)-TOU	619		$68	0.81	66
Solar-elect close coupled TS, tank boost (min eff)-OP	1,445		$128	1.89	154
Solar-elect close coupled TS, tank boost (high eff)-OP	619		$55	0.81	66
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,445		$245	1.89	154
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	619		$105	0.81	66
Solar-gas close coupled TS, tank boost (min eff)- NG		8,391	$91	0.48	40
Solar-gas close coupled TS, tank boost (high eff)-NG		3,596	$39	0.21	17
Solar-gas close coupled TS, tank boost (min eff)- LPG		8,391	$369	0.55	45
Solar-gas close coupled TS, tank boost (high eff)-LPG		3,596	$158	0.23	19
Solar-gas close coupled TS, in line boost (min eff)- NG	53	8,200	$98	0.54	45
Solar-gas close coupled TS, in line boost (high eff)-NG	53	1,008	$20	0.13	11
Solar-gas close coupled TS, in line boost (min eff)- LPG	53	8,200	$370	0.60	50
Solar-gas close coupled TS, in line boost (high eff)-LPG	53	1,008	$53	0.14	11
Solar-elect Pumped system, tank boost (min eff)-TOU	1,445		$159	1.89	154
Solar-elect Pumped system, tank boost (high eff)-TOU	619		$68	0.81	66
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,445		$245	1.89	154
Solar-elect Pumped system, tank boost (high eff)- Day rate	619		$105	0.81	66
Solar-elect Pumped system, tank boost (min eff)-OP	1,445		$128	1.89	154
Solar-elect Pumped system, tank boost (high eff)-OP	619		$55	0.81	66
Solar-gas Pumped system, tank boost (min eff) - NG	60	8,174	$99	0.55	45
Solar-gas Pumped system, tank boost (high eff) - NG	60	3,379	$47	0.27	23
Solar-gas Pumped system, tank boost (min eff) - LPG	60	8,174	$370	0.61	51
Solar-gas Pumped system, tank boost (high eff) - LPG	60	3,379	$159	0.30	25
Solar-gas Pumped system, in line boost (min eff) - NG	113	7,983	$106	0.61	50
Solar-gas Pumped system, in line boost (high eff) - NG	113	791	$28	0.19	16
Solar-gas Pumped system, in line boost (min eff) - LPG	113	7,983	$370	0.67	56
Solar-gas Pumped system, in line boost (high eff) - LPG	113	791	$54	0.20	17

Table 15: Results – Average of Victoria Weighted by Zone and Households

System Type	Electricity	Gas	Costs	CO2	GHG/MJ
Units	kWh pa	MJ pa	$ pa	T pa	g CO_2-e/MJ
Electric Continuous - TOU	4,314		$738	5.65	420
Electric Continuous - Day rate	4,314		$732	5.65	420
Electric Off Peak	4,646		$412	6.09	455
Electric Dual-element Off Peak	4,095		$397	5.36	360
Gas storage (3*) - NG		24,264	$264	1.39	105
Gas storage (3*) - LPG		24,264	$1,068	1.58	120
Gas storage (5*) - NG		20,562	$224	1.18	89
Gas storage (5*) - LPG		20,562	$905	1.34	101
Gas inst (3*) - NG	71	24,140	$275	1.48	110
Gas inst (3*) - LPG	71	24,140	$1,074	1.67	124
Gas inst (5*) - NG	71	20,141	$232	1.25	93
Gas inst (5*) - LPG	71	20,141	$898	1.41	105
Heat pump (min eff) - Day rate	1,779		$302	2.33	173
Heat pump (high eff) - Day rate	1,333		$226	1.75	130
Heat pump (min eff) - TOU	1,779		$235	2.33	173
Heat pump (high eff) - TOU	1,333		$176	1.75	130
Solar-elect close coupled TS, tank boost (min eff)-TOU	1,755		$194	2.30	171
Solar-elect close coupled TS, tank boost (high eff)-TOU	862		$95	1.13	84
Solar-elect close coupled TS, tank boost (min eff)-OP	1,755		$155	2.30	171
Solar-elect close coupled TS, tank boost (high eff)-OP	862		$76	1.13	84
Solar-elect close coupled TS, tank boost (min eff)- Day Rate	1,755		$298	2.30	171
Solar-elect close coupled TS, tank boost (high eff)- Day Rate	862		$146	1.13	84
Solar-gas close coupled TS, tank boost (min eff)- NG		10,157	$111	0.58	44
Solar-gas close coupled TS, tank boost (high eff)-NG		4,989	$54	0.29	22
Solar-gas close coupled TS, tank boost (min eff)- LPG		10,157	$447	0.66	50
Solar-gas close coupled TS, tank boost (high eff)-LPG		4,989	$219	0.33	25
Solar-gas close coupled TS, in line boost (min eff)- NG	53	9,966	$118	0.64	49
Solar-gas close coupled TS, in line boost (high eff)-NG	53	2,214	$33	0.20	15
Solar-gas close coupled TS, in line boost (min eff)- LPG	53	9,966	$448	0.72	55
Solar-gas close coupled TS, in line boost (high eff)-LPG	53	2,214	$106	0.21	16
Solar-elect Pumped system, tank boost (min eff)-TOU	1,755		$194	2.30	171
Solar-elect Pumped system, tank boost (high eff)-TOU	862		$95	1.13	84
Solar-elect Pumped system, tank boost (min eff)- Day rate	1,755		$298	2.30	171
Solar-elect Pumped system, tank boost (high eff)- Day rate	862		$146	1.13	84
Solar-elect Pumped system, tank boost (min eff)-OP	1,755		$155	2.30	171
Solar-elect Pumped system, tank boost (high eff)-OP	862		$76	1.13	84
Solar-gas Pumped system, tank boost (min eff) - NG	60	9,940	$119	0.65	49
Solar-gas Pumped system, tank boost (high eff) - NG	60	4,772	$62	0.35	27
Solar-gas Pumped system, tank boost (min eff) - LPG	60	9,940	$448	0.73	55
Solar-gas Pumped system, tank boost (high eff) - LPG	60	4,772	$220	0.39	30
Solar-gas Pumped system, in line boost (min eff) - NG	113	9,749	$125	0.71	54
Solar-gas Pumped system, in line boost (high eff) - NG	113	1,997	$41	0.26	20
Solar-gas Pumped system, in line boost (min eff) - LPG	113	9,749	$448	0.78	60
Solar-gas Pumped system, in line boost (high eff) - LPG	113	1,997	$107	0.28	21

Figure 4: Hot Water System GHG Emissions (T pa) - Weighted Average for Victoria

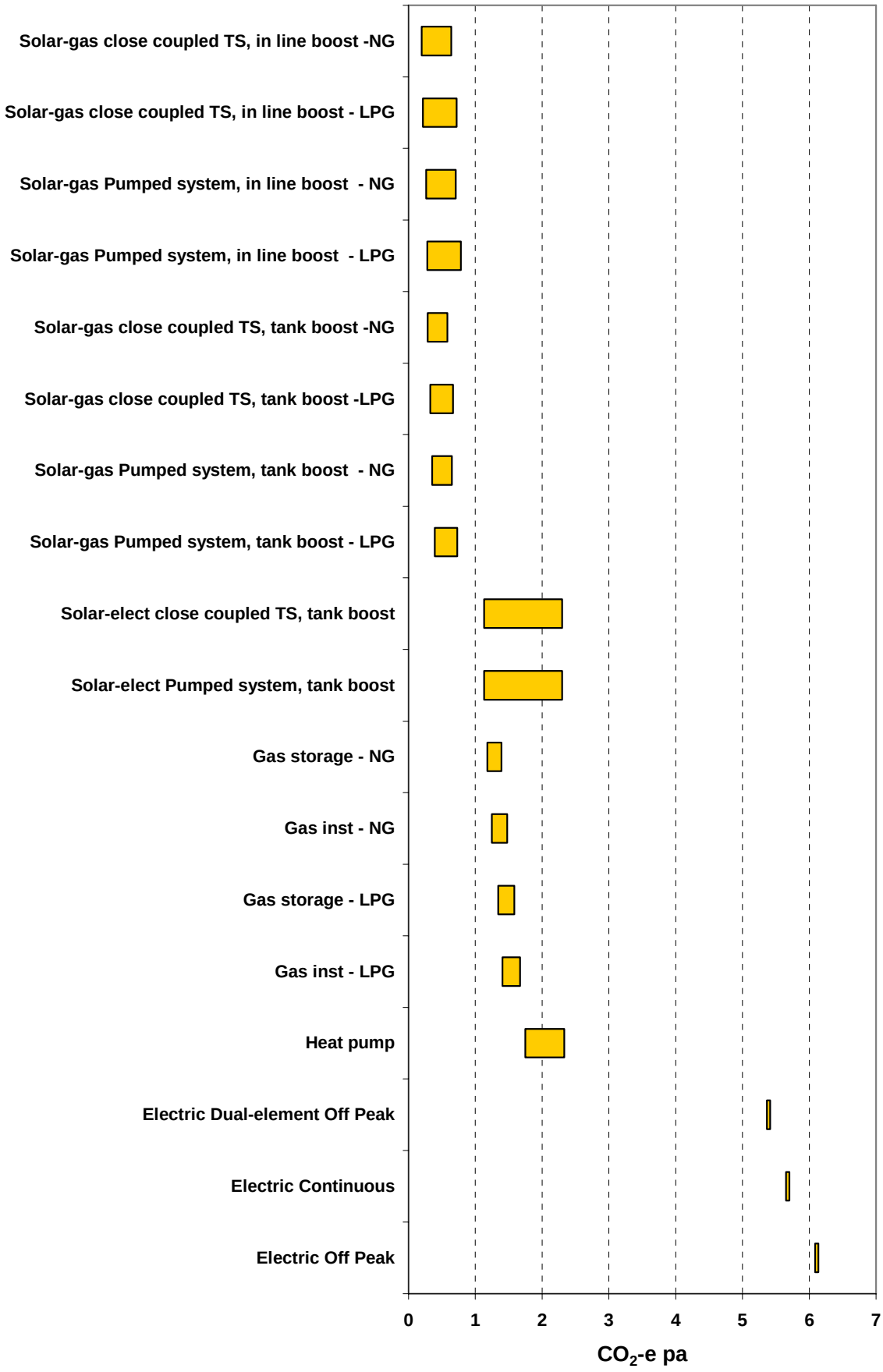
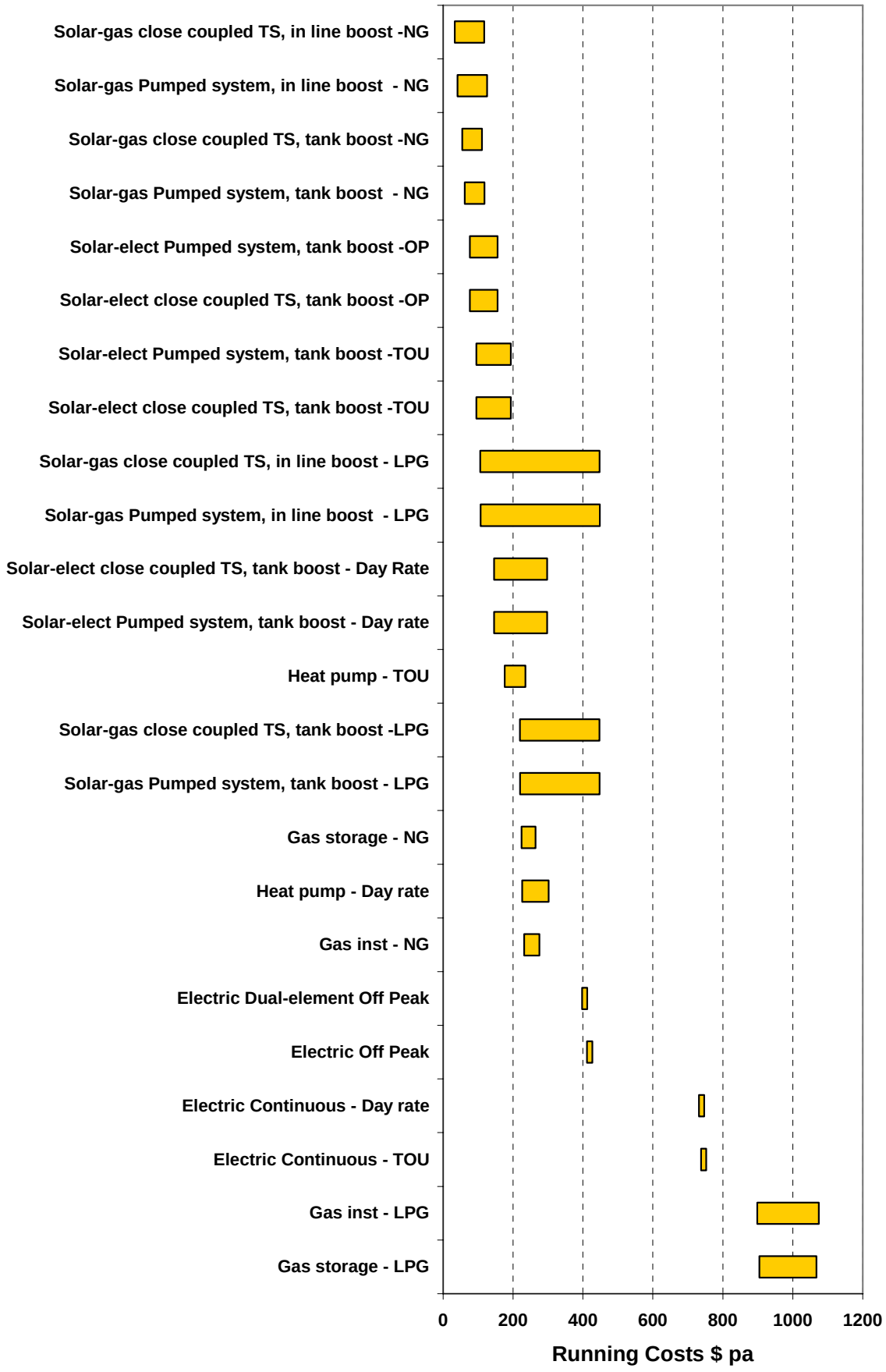


Figure 5: Hot Water System Energy Costs ($ pa) - Weighted Average for Victoria



References

AS/NZS 4234 Heated water systems – Calculation of energy consumption. 2008.

GWA 2005, *Estimated Household Water Heater Energy Use, Running Costs and Emissions, Victoria Based on energy price projections, 2005-2015*. George Wilkenfeld and Associates for Sustainability Victoria, Melbourne, May 2005

SV 2008, *List of systems capable of complying with the regulations.* Sourced from http://www.sustainability.vic.gov.au/www/html/2025-compliant-solar-hot-water-systems.asp?intSiteID=4

Thermal Design 2007, *Annual Energy Use Of Domestic Water Heaters* prepared for The Australian Greenhouse Office by Graham Morrison, Thermal Design Pty Ltd, 31-August 2007, commercial-in-confidence, not available for public.

Thermal Design 2009, *Gas and Electric Domestic Water Heater Energy Use* prepared for Sustainability Victoria by Graham Morrison, Thermal Design Pty Ltd, 4 March 2009