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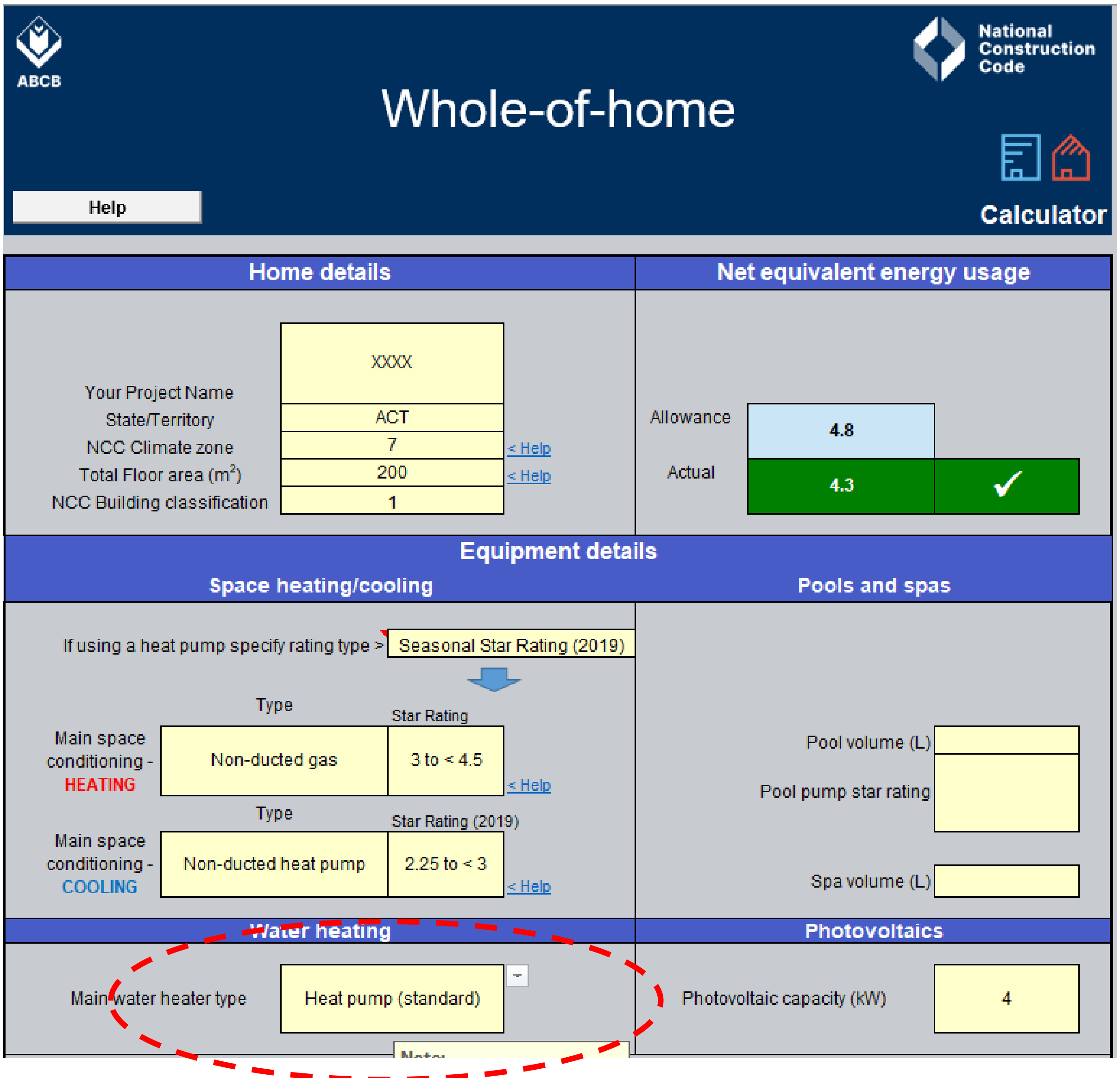
Inclusion of DTS elemental provisions (J3D14) for centralised domestic hot water systems in NCC 2025



Australian Building Codes Board
Inclusion of DTS elemental provisions (J3D14) for centralised domestic hot water systems in NCC 2025

Report prepared for:
Australian Building Codes Board

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Draft regulation text shown in this report was originally provided to the ABCB for consideration and further development. It may not reflect final provisions for public comment. The draft regulation below also may not reflect any changes following feedback received from the ABCB or various industry stakeholders.

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Abbreviations

ABCB	Australian Building Codes Board
ABCB Standard for Whole-of-Home Efficiency Factors	“the ABCB Standard”
AC	Air-conditioner
CDHW	Centralised Domestic Hot Water (System)
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DTS	Deemed-to-Satisfy provisions
EES	Energy Efficient Strategies Pty Ltd
GEMS	Greenhouse and Energy Minimum Standards (Federal)
kWh	kilowatt hour
MEPS	Minimum Energy Performance Standards
NatHERS	Nationwide House Energy Rating Scheme
NCC 2022	National Construction Code 2022
SOU	Sole-Occupancy Unit
W	watt
Whole-of-Home	WOH
ZNC	Zero Net Carbon

1 Background and current provisions

1.1 Background

In August 2023 the Australian Building Codes Board (ABCB) commissioned Energy Efficient Strategies (EES) to review National Construction Code (NCC) 2022 clauses relevant to energy usage of Sole-Occupancy Units (SOUs) in Class 2 apartment buildings with centralised domestic hot water (CDHW) systems in time for NCC 2025.

Specifically, the ABCB required a review of NCC 2022 Volume One clauses J1P3 and J3D14 and advice on how to include Deemed-to-Satisfy (DTS) Elemental Provisions for CDHW through amending the clauses and/or the ABCB Standard for Whole-of-Home (WOH) Efficiency Factors (the ABCB Standard).

Clause J1P3 of NCC 2022 Vol One (see Figure 1) sets out the maximum permissible energy value[1] requirement in respect of domestic services of a SOU of a Class 2 or Class 4 part of a building. Effectively, this clause sets out a list of “benchmark” equipment types that—if installed in a dwelling that meets the building fabric thermal performance requirements of NCC 2022—would just satisfy the J1P3 Performance Requirement.

Figure 1: Extract from NCC 2022 Vol 1 – Clause J1P3

NSW J1P3

J1P3 Energy usage of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[New for 2022]

(1) The *energy value* of the *domestic services* of a *sole-occupancy unit* of a Class 2 building or Class 4 part of a building must not exceed the *energy value* with—

(a) a 3-star ducted heat pump, rated under the 2019 GEMS determination, heating all spaces that are provided with heating; and

(b) a 3-star ducted heat pump, rated under the 2019 GEMS determination, cooling all spaces that are provided with cooling; and

(c) a 5-star instantaneous gas water heater, rated under the 2017 GEMS determination, providing all domestic hot water; and

(d) a lighting power density of 4 W/m^2 serving all internal spaces that are provided with artificial lighting.

Clause J2D2 notes that clause J1P3 can be satisfied by complying with either:

- J3D14: elemental WOH DTS method in NCC 2022 (i.e., the focus of this study), or
- J3D15: the house energy rating software DTS method in NCC 2022. Primarily NatHERS accredited tools such as AccuRATE or FirstRATE (noting that these tools are still under development in relation to WOH simulations but are expected to be available later this year).

[1] The energy value is defined in NCC 2022 as: “The net cost to society including, but not limited to, costs to the building user, the environment and energy networks”. Basically, this is the energy cost ($) to the consumer (valued according to a time of use type tariff in the case of electricity) plus an allowance for the societal cost ($) of any greenhouse gas emissions associated with the particular fuel type used.

Figure 2: Extract from NCC 2022 Vol 1 – Clause J2D2

(3) For a *sole-occupancy unit* of a Class 2 building or a Class 4 part of a building, *Performance Requirement* J1P3 is satisfied by complying with—

(a) for the net equivalent energy usage—

(i) J3D14, for a *sole-occupancy unit* of a Class 2 building or a Class 4 part of a building with a total floor area not greater than 500 m^2; or

(ii) J3D15, using *house energy rating software*; and

(b) Part J6, for *air-conditioning* and ventilation; and

(c) Part J7, for artificial lighting and power.

(4) For a Class 2 to 9 building, *Performance Requirement* J1P4 is satisfied by complying with J9D4 and J9D5.

The focus of this study is therefore the provisions of clause J3D14 in NCC 2022 and how those provisions might be adapted and/or augmented so as to accommodate CDHW systems typically found in Class 2 or the Class 4 part of a building. The provisions of J3D14 of NCC 2022 have been reproduced below (see Figure 3).

As can be seen from this elemental method in J3D14, a total of five main equipment types[2] are factored into the calculation:

- Main space conditioning (heater and or cooler)
- Main water heating
- Swimming pool pump (if present)
- Spa pump (if present)
- PVs (if present).

Summarising the method: the net equivalent energy usage of a dwelling is calculated by multiplying an equivalent energy usage factor (for space conditioning and water heating equipment) by the applicable floor area factor, adding swimming pool and spa pump energy usage factors, and subtracting the installed capacity of any photovoltaics (PV). The resultant value must be less than or equal to the allowance which is based on a 7-star rated dwelling with the benchmark equipment types noted in Figure 1 installed.

As noted, the formula incorporates a factor for determining the equivalent energy usage for various combinations of space-conditioning equipment and water heaters. This factor is known as the main space conditioning and main water heating factor (E_E) and effectively represents the number of kW of installed PV capacity that would be required to fully offset the energy value of both the nominated space-conditioning equipment and the water heating equipment per 100m^2 of floor area (up to a maximum of 500m^2 of floor area[3]). This factor is obtained from the ABCB Standard. A typical extract from this standards look-up tables of E_E values is reproduced in Figure 4. There are over 500 pages of tables covering each of the NCC eight climate zones by jurisdiction (effectively 26 combinations of State/Territory and NCC climate zone).

Figure 3: Extract from NCC 2022 Vol 1 – Clause J3D14

[2] Lighting electrical usage is also factored into the calculation (embedded in the energy factors) but this is set at a fixed value of 4W/m^2 of floor area.

[3] This method is deemed suitable only for SOUs up to a maximum of 500m^2. For dwellings of more than 500m^2 an alternative DTS method must be used.

(ii) if adjustable, is readily operated either manually, mechanically or electronically by the building occupants.

NSW J3D14

J3D14 Net equivalent energy usage of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[New for 2022]

(1) The net equivalent energy usage of a *sole-occupancy unit* of a Class 2 building or Class 4 part of a building, calculated in accordance with (a), must not exceed the allowance calculated in accordance with (b)—

(a) $(A \times E_E) + E_P + E_S - E_R$, where—

(i) A = the floor area factor obtained from multiplying the total floor area by the adjustment factor in Table J3D14a; and

(ii) E_E = the *main space conditioning* and *main water heater* efficiency factor obtained from the ABCB Standard for Whole-of-Home Efficiency Factors; and

(iii) E_P = the swimming pool pump energy usage in (2); and

(iv) E_S = the spa pump energy usage in (3); and

(v) E_R = the installed capacity of on-site photovoltaics apportioned to the *sole-occupancy unit* of a Class 2 building or Class 4 part of a building (kW); and

(b) $A \times E_F$, where—

(i) A = the floor area factor obtained from multiplying the total floor area by the adjustment factor in Table J3D14a; and

(ii) E_F = the energy factor obtained from Table J3D14b.

(2) The swimming pool pump energy usage (E_P) must be determined in accordance with the following formula: $E_P = V \times FP/1000$, where—

(a) E_P = the swimming pool pump energy usage; and

(b) V = the volume of the swimming pool to the nearest 1000 litres; and

(c) FP = the swimming pool pump factor in Table 13.6.2c of the ABCB Housing Provisions.

(3) The spa pump energy usage (E_S) must be determined in accordance with the following formula: $E_S = V \times FSB/100$,where—

(a) ES = the spa pump energy usage; and

(b) V = the volume of the spa to the nearest 100 litres; and

(c) FSB = the spa pump factor in Table 13.6.2d of the ABCB Housing Provisions.

Table J3D14a: Floor area adjustment factor for a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor
< 50	0.0123	160–169	0.0097	280–289	0.0087	400–409	0.0080
50–59	0.0119	170–179	0.0096	290–299	0.0086	410–419	0.0079
60–69	0.0116	180–189	0.0095	300–309	0.0085	420–429	0.0079
70–79	0.0113	190–199	0.0094	310–319	0.0085	430–439	0.0078

J3D14

Total floor area m²	Floor area factor	Total floor area m²	Floor area factor	Total floor area m²	Floor area factor	Total floor area m²	Floor area factor
80–89	0.0111	200–209	0.0093	320–329	0.0084	440–449	0.0078
90–99	0.0108	210–219	0.0092	330–339	0.0083	450–459	0.0077
100–109	0.0106	220–229	0.0091	340–349	0.0083	460–469	0.0077
110–119	0.0105	230–239	0.0090	350–359	0.0082	470–479	0.0077
120–129	0.0103	240–249	0.0090	360–369	0.0082	480–489	0.0076
130–139	0.0101	250–259	0.0089	370–379	0.0081	490–499	0.0076
140–149	0.0100	260–269	0.0088	380–389	0.0081	500	0.0075
150–159	0.0099	270–279	0.0087	390–399	0.0080	—	—

Table Notes

(1) The total floor area is measured within the inside face of the *external walls* of the *sole-occupancy unit* and includes any conditioned attached Class 10a building.

(2) Where values fall between ranges given, the floor area must be rounded up to the nearest whole square metres of floor area.

Table J3D14b: Energy factor for a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

Climate zone	ACT	NSW	NT	QLD	SA	TAS	Vic	WA
1	—	—	2.73	3.95	—	—	—	4.64
2	—	1.88	—	2.54	—	—	—	—
3	—	—	1.76	3.52	—	—	—	4.10
4	—	2.57	—	—	2.65	—	1.79	3.34
5	—	2.50	—	3.26	2.56	—	—	3.36
6	—	3.43	—	—	3.58	—	2.32	4.58
7	3.66	3.32	—	—	—	4.41	2.32	—
8	—	5.70	—	—	—	5.60	4.02	—

NSW J3D15

J3D15 Net equivalent energy usage for a sole-occupancy unit of a Class 2 building or Class 4 part of building – home energy rating software

[New for 2022]

A *sole-occupancy unit* of a Class 2 building or a Class 4 part of a building must achieve a whole-of-home rating of not less than 50 using *house energy rating software*.

Figure 4: Extract from the ABCB Standard

Table 6.1.2 Whole-of-home efficiency factors E_E (kW/100m^2) – *climate zone* 6 – gas heating – Victoria

Main type of heater	Main type of cooler	Electric storage (standard)	Electric storage (off peak)	Heat pump (standard)	Heat pump (off-peak)	Solar electric (standard)	Gas storage	Gas instantaneous	Solar gas
Gas – ducted < 3 Stars	Evaporative	4.708	4.334	2.934	2.844	3.260	3.756	3.452	2.503
Gas – ducted < 3 Stars	Heat pump - Ducted < 2.25 stars (< 3)	4.961	4.596	3.197	3.111	3.518	4.021	3.717	2.771
Gas – ducted < 3 Stars	Heat pump - Ducted < 3 stars (< 4.5)	4.932	4.566	3.167	3.081	3.488	3.991	3.687	2.741
Gas – ducted < 3 Stars	Heat pump - Ducted < 3.75 stars (< 6)	4.887	4.521	3.122	3.036	3.443	3.946	3.643	2.696
Gas – ducted < 3 Stars	Heat pump - Ducted ≥ 3.75 stars (≥ 6)	4.842	4.477	3.078	2.992	3.398	3.901	3.598	2.651

In Figure 4 at the head of each column is a water heater type. In total eight water heater types are covered by the ABCB Standard. These are:

- electric storage (standard)
- electric storage (off-peak)
- heat pump (standard)
- heat pump (off-peak)
- solar electric (standard)
- gas storage
- gas instantaneous
- solar gas

The available water heaters are categorised by technology type only. For those water heater technologies that exhibit a range of performance levels, the values in the table have been set according to the performance available at the low end of the performance scale for that technology type (i.e., conservative). For instance, for gas storage water heaters, the assumed performance level is 4-star rated which is in fact the minimum performance level permissible under the building/plumbing codes for installation into a new home.

These eight types cover all of the main water heater types found in Class 1 dwellings as well as those found in Class 2 dwellings where there are separate water heaters serving each SOU. However, CDHW systems i.e., a single large centralised system serving multiple SOUs in a Class 2 building, are not specifically covered in these tables.

How to best accommodate CDHW into the DTS provisions is the focus of this study.

2 Issues and Options

2.1 What CDHW system types need to be accommodated?

Fundamentally all water heating systems operate in the same manner. They all use a fuel source (either gas or electricity) to produce heat for transfer into water for domestic use. Some systems also utilize thermal solar collectors to offset some of the fuel use.

Some CDHW systems in fact use components from individual stand-alone hot water systems. For example, a series of individual stand-alone instantaneous gas water heaters or storage water heaters may be linked together via a manifold to serve multiple SOUs in a block of apartments.

Each system type can have up to four main components that impact energy use:

1. A system to produce the hot water. Options include:
    a. electric resistance heating (with or without solar boosting)
    b. electric heat pump heating (with or without solar boosting)
    c. gas heating (with or without solar boosting).
2. Whether or not there is hot water storage:
    a. with a storage tank or tanks
    b. without a storage tank.
3. A pipework system to distribute the hot water to the SOUs.
4. A pump or pumps to circulate hot water (parasitic losses associated with CDHW Systems only). This may include:
    a. where required, a pump to transfer the hot water from the heater unit to the storage tank (where present), known as a primary pump.
    b. where required, a pump to circulate hot water to SOUs via a (looped) pipework system, known as a secondary pump.

With the exception of pumps (which only CDHW systems have), both individual stand-alone and central domestic hot water systems can include the full range of options noted above, except that CDHW systems are typically larger scale versions of the individual stand-alone systems or they consist of multiple individual stand-alone scale systems that are joined together (i.e., modular or manifolded type systems).

A summary of the most common CDHW system types is shown in Table 1. To the extent possible, all of these potential systems should be accommodated in DTS elemental provisions for CDHW within NCC 2025. Some systems, such as cogeneration systems (item 20 below), are however so rare and so site-specific that they may need to be excluded as an option available under proposed DTS elemental provisions for CDHW within NCC 2025.

Table 1: Most common CDHW System Types

No.	System Name	Storage Tank	Solar boosting?	Notes (see below)
1	Single Electric Storage (Boiler)	✓	X	1
2	Manifolded Electric Storage	✓	X	1
3	Manifolded Electric Instantaneous – no storage	X	X	2
4	Manifolded Electric Instantaneous – with storage	✓	X	
5	Air-sourced Heat Pump – with storage	✓	X	1
6	Manifolded Air source heat pumps – with storage	✓	X	1
7	Solar Boosted Electric – with storage	✓	✓	1
8	Manifolded Solar Boosted Electric – with storage	✓	✓	1
9	Solar Boosted Heat Pump – with storage	✓	✓	1
10	Manifolded Solar Boosted Heat Pump – with storage	✓	✓	1
11	Gas Storage (Boiler)	✓	X	
12	Manifolded gas storage	✓	X	
13	Manifolded Gas Instantaneous – no storage	X	X	
14	Manifolded Gas Instantaneous – with storage	X	✓	
15	Solar Boosted Gas Storage	✓	✓	
16	Manifolded Solar Boosted Gas storage	✓	✓	
17	Solar Boosted Instantaneous Gas with storage	✓	✓	
18	Manifold Solar Boosted Instantaneous Gas – with storage	✓	✓	
19	Gas boosted air-sourced heat pump	✓	✓	3
20	Cogeneration system	✓	X	4

Notes

1. Electrically heated systems can be either continuous or controlled tariff (also called peak and off-peak) but off-peak is less likely to be used in CDHW systems.
2. Electric Instantaneous systems typically have a storage tank attached. Systems without a storage tank are only likely in very small developments.
3. This type of system is relatively uncommon and not seen in the individual stand-alone domestic market (i.e., serving a single dwelling only)
4. This type of system is very uncommon and would only be seen in a very large development if at all.

2.2 Options for a DTS Elemental Method

Ideally, any WOH DTS elemental method (J3D14) in relation to CDHW system types should produce outcomes that are comparable to outcomes that would be achieved using the alternative house energy software deemed-to-satisfy method in NCC 2022 (J3D15) and should broadly reflect the likely performance in the field.

By its nature, the DTS elemental method has significant limitations imposed on its accuracy compared to the house energy rating software method and, as such, divergences in outcomes between the two methods are to be expected. For example, the WOH DTS elemental method assumes a fixed 7-star level of building fabric performance (i.e. the minimum permitted), whereas in reality many Class 2 SOUs are likely to have performance levels greater than 7 stars with reduced heating and cooling loads and greater capacity to divert PV energy production to water heating tasks. Specifically in relation to water heaters, the current ABCB Standard provides only a single generic type of gas storage water heater for selection by the user. This single type assumes a 4-star level of performance (which is the current MEPS level and the minimum required for new housing). By contrast, the house energy rating software DTS method can model practically any available star rating level for gas storage water heaters. This same type of limitation also applies to other water heating technologies.

A total of four possible options or means for inclusion of CDHW systems into the WOH DTS elemental method (J3D14) have been identified. In order of increasing accuracy these are:

1. proxy method (by Applicant)
2. concordance method
3. concordance plus adjustments method
4. CDHW system-specific tables method.

These options and their practical application are discussed in more detail in the following sub-sections:

1. PROXY METHOD (BY APPLICANT)

In respect of water heaters, the proxy matching of systems would be based on the technology type of the water heater. A simple note as follows, is all that would be required to be included in either the NCC 2025 code and or the ABCB Standard:

> *If the dwelling being assessed includes a centralised domestic hot water system, assessors may proxy this by matching the closest technology type of the central service to those available in the ABCB Standard for WOH Efficiency Factors*

Pros

- Very simple, easy to implement solution.

Cons

- The requirement is somewhat vague and relies on the skill and judgement of the building surveyor to ensure that the most appropriate system has been selected as a proxy. CDHW systems are a somewhat specialised area of expertise and many building surveyors may be ill equipped to confidently make such a judgement.

- This method takes no account of the differences between the currently specified individual stand-alone domestic systems in the ABCB Standard and CDHW systems. For example, a central domestic gas storage system may have lower storage losses than a small individual stand-alone domestic system due to its larger tank size but higher pipe work losses due to the longer runs of pipework. In addition, any pump energy used in the CDHW system would not be accounted for in this method because the current provisions assume that no pumps are used.
- Some CDHW system types do not easily map onto the existing stand-alone domestic systems in the ABCB Standard (e.g. Solar Boosted Heat Pump – with storage or Gas boosted air-sourced heat pump).

2. CONCORDANCE METHOD

This method uses the same principle as the proxy method above (i.e., assumes one of the existing, specified individual stand-alone domestic hot water systems can be proxied for a CDHW system) but provides the user with a defined set of concordances between the individual stand-alone domestic systems available in the ABCB Standard and a range of CDHW system types.

Such a concordance might look something like Table 2.

Pros

- Relatively simple, easy to implement solution.
- Reduced scope for user error compared to the proxy method above.
- Less demanding of building surveyors compared to the proxy method above.

Cons

- This method takes no account of the differences between the currently specified individual stand-alone domestic systems in the ABCB Standard and CDHW systems. For example, a central domestic gas storage system may have lower storage losses than a small individual stand-alone domestic system due to its larger tank size but higher pipe work losses due to the longer runs of pipework. In addition, any pump energy used in the CDHW system would not be accounted for in this method because the current provisions assume that no pumps are used.
- Some CDHW system types do not easily map onto the existing stand-alone domestic systems in the ABCB Standard for WOH Efficiency Factors (e.g. Solar Boosted Heat Pump – with storage or Gas boosted air-sourced heat pump).

Table 2: Proposed Concordance: CDHW systems and Systems listed in the ABCB Standard

No.	Central domestic Hot Water System type	Closest matching system available in the ABCB Standard	Notes
1	Single Electric Storage (Boiler)	Electric storage (standard or off-peak)	1
2	Manifolded Electric Storage	Electric storage (standard or off-peak)	1
3	Manifolded Electric Instantaneous – no storage	Electric storage (standard or off-peak)	1
4	Manifolded Electric Instantaneous – with storage	Electric storage (standard or off-peak)	1
5	Air-sourced Heat Pump – with storage	Heat pump (standard or off-peak)	1
6	Manifolded Air source heat pumps – with storage	Heat pump (standard or off-peak)	1
7	Solar Boosted Electric – with storage	Solar Electric (standard)	2
8	Manifolded Solar Boosted Electric – with storage	Solar Electric (standard)	2
9	Solar Boosted Heat Pump – with storage	Heat pump (standard or off-peak) or Solar Electric Standard	1,2 &3
10	Manifolded Solar Boosted Heat Pump – with storage	Heat pump (standard or off-peak) or Solar Electric Standard	1,2 &3
11	Gas Storage (Boiler)	Gas Storage	
12	Manifolded gas storage	Gas Storage	
13	Manifolded Gas Instantaneous – no storage	Gas Instantaneous	
14	Manifolded Gas Instantaneous – with storage	Gas Storage	4
15	Solar Boosted Gas Storage	Solar Gas	2
16	Manifolded Solar Boosted Gas storage	Solar Gas	2
17	Solar Boosted Instantaneous Gas with storage	Solar Gas	2
18	Manifold Solar Boosted Instantaneous Gas – with storage	Solar Gas	2
19	Gas boosted air-sourced heat pump	Heat pump (standard)	5
20	Cogeneration system	Heat pump (standard)	6

Notes:

1. User to select either Standard (continuous tariff) or Off peak (controlled tariff) as applicable.
2. Some limitations may be required on the use of this option in circumstances where solar collectors provide less than 60% of the required heat input (as is assumed in the ABCB Standard)
3. Either the heat pump type option or the solar type option may be selected noting that a NatHERS WOH simulation that includes both technologies (heat pump with solar boosting) is likely to yield more favourable results.
4. Because this system type adds a storage vessel to an instantaneous gas water heater a gas storage type system is assumed.
5. This proxy assumes that the heat pump in the CDHW system does the majority of the water heating. It may however be more prudent to omit this system type from the concordance list.
6. This proxy selection is uncertain. It assumes that the waste heat from co-generation is akin to the “free” heat extracted from the air in a heat pump system and that the cogeneration waste heat provides at least 2/3 of the required heat input to water (i.e., effectively a nominal COP of 3.0 (1 unit of energy input for 3 units of heat output). It may however be more prudent to omit this system type from the concordance list.

3. CONCORDANCE PLUS ADJUSTMENTS METHOD

In this method, a concordance system as proposed in option 2 above is used but the accuracy of that method is enhanced by applying either:

- minimum standards to the CDHW system if the J3D14 method is to be used. For example, where a storage gas boiler is to be used a minimum burner

efficiency that matches that of the burner efficiency assumed in the gas storage system included in the ABCB Standard (4-star rated or 80% efficiency) may be required.
- adjustments to the results based on known differences between the proposed CDHW system and the selected proxy system in the ABCB Standard. For instance, where a CDHW system includes pumps (primary and/or secondary) a separate allowance for the pumping energy could be made in the calculations.

The main areas for applying some form of minimum standard or adjustment could be:

- Heater conversion efficiency
- Tank losses
- Pipework losses
- Added pumping energy
- Contribution of solar collectors (particularly where the collector area is relatively small)

In reality, applying adjustment factors rather than simple minimum standards is in most cases likely to be highly complex because the factors included in the ABCB Standard are in fact combined factors that cover the energy use of both a specific space conditioning type and a specific water heating type. Identifying (and then adjusting) the part of the factor in the ABCB Sstandard attributable to just the water heating component is likely to prove very difficult[4]. But in some cases an adjustment approach may be possible, this may be true in the case of pumping energy for instance that could be applied as an add-on rather than an adjustment, this is not dissimilar to the approach used to account for pool pumps in J3D14.

Pros

- Reduced scope for user error compared to the proxy method (method 1)
- Improved accuracy compared to both the proxy method (method 1) and the concordance method (method 2)
- Less demanding of building surveyors compared to the proxy method (method 1) as it would involve a simple concordance table combined with minimum standards and/or adjustment formulas.

Cons

- More complex than the proxy method or the concordance method to develop and to use (but not impractical).
- Some CDHW system types do not easily map onto the existing stand-alone domestic systems in the ABCB Standard (e.g. Solar Boosted Heat Pump – with storage or Gas boosted air-sourced heat pump).

4. CDHW SYSTEM-SPECIFIC TABLES METHOD

[4] These tables were generated by running simulations in a Whole-of-Home modelling tool that simulates energy use and production in the home on an hourly basis for an entire year.

In this ultimate method, a set of WOH efficiency factors would be tailored specifically for CDHW. Such factors could account for the known differences that exist between the energy use of the systems currently covered in the ABCB Standard (i.e., individual stand-alone systems) and CDHW systems. For example, adjustments could be made in the factors for such things as differences in conversion efficiencies, reduced tank losses, added circulation losses and circulating pump energy consumption. In addition, some more exotic system types only found in CDHW systems could be specifically covered.

The factors contained in the ABCB Standard were generated in 2020. At that time NatHERS had not produced any benchmarking tools for verifying WOH performance. The developers of the ABCB Standard instead repurposed a pre-existing WOH simulation tool developed in 2016 for Sustainability Victoria for its Zero Net Carbon (ZNC) home project. This tool might be thought of as a "First Generation WOH tool".

In theory, the ZNC tool used to generate the current factors in the ABCB Standard could be used to generate a tailored set of factors for CDHW systems. However, there are several barriers to this type of approach:

- The ZNC tool does not include specific algorithms for calculating CDHW system energy use. As such modules to undertake such calculations would need to be built into the ZNC tool first. Even if this were possible within the time frame, it should be noted that some of the other calculation methods and assumptions embedded in the first generation ZNC tool have now been superseded in the NatHERS benchmarking tools (i.e., 2nd Generation WOH tools). As such, use of the ZNC tool for this purpose will embed some additional divergences between the elemental DTS method in NCC2022 (J3D14) and the NatHERS WOH DTS method (J3D15), which is considered undesirable (convergence of methods rather than divergence of methods should be the objective).
- The setting up of specific calculations for CDHW systems in the ZNC tool could be based on the preliminary work undertaken by NatHERS for inclusion of CDHW systems in their tools (see Report entitled Department of Climate Change Energy the Environment and Water (DCCEEW) – NatHERS DHW and HVAC Methodology for Apartment shared Services – DCCEEW 2023) but this work is incomplete and a first draft is not due until the end of August 2023 with sign off by NatHERS not expected for some time after that i.e. too late for the deadline for this project. Even if this method was ready now, it would take several weeks to program it into the ZNC tool.
- Even if CDHW system modules could be built into the ZNC tool prior to the completion date for this project, the time required to run the simulations would be many weeks (if not months). The ZNC tool was adapted for batch running for the NCC 2022 project but is not optimised for batch running, which means that batch running is relatively slow in this first-generation tool. The batch running facilities available in the NatHERS benchmarking tools are significantly faster and could generate the required tables relatively quickly but modules to model CDHW systems are not expected to be available in the NatHERS benchmarking tool according to NatHERS until 2024 i.e., too late for this project.

In summary, the generation of a tailored set of factors for CDHW systems is not practical in the available time. The ideal tool for doing this (NatHERS Benchmarking tool) does not, at this stage, have modules built in for estimating CDHW system energy use and this is unlikely to be available before the end of the year. The alternative option of using the original ZNC simulation tool for this purpose is also not possible in the time available, it would be more onerous to run[5] and its results would be less accurate than the NatHERS benchmarking tool option when available (i.e., with CDHW system modules built in).

The option of using the NatHERS benchmarking tool with CDHW system modules loaded, whilst not practical to do now, is strongly recommended for the 2028 iteration of NCC. It is recommended that the entire standard be re-generated and re-issued in 2028 based on simulation runs undertaken using the NatHERS benchmarking tool as this will provide better alignment between outcomes realised using either of the NCC DTS methods, J3D14 (elemental) and J3D15 (NatHERS).

Pros

- Reduced scope for user error compared to the proxy method.
- Improved accuracy compared to all other methods considered.
- Less demanding of building surveyors compared to the proxy method (method 1) i.e., set formulas and lookup tables for different central water heating scenarios.
- Able to accommodate more unusual (hybrid) systems peculiar to CDHW type systems.

Cons

- More complex than all other methods to develop.
- Methodologies for calculating energy consumption of CDHW systems are yet to be bedded down and agreed with industry by NatHERS
- This option cannot be delivered in the available time frame.

2.3 Options: Conclusions/ Recommendations

Four options for inclusion of CDHW systems in the NCC 2025 WOH DTS elemental method (J13/D14) were examined:

1. proxy method (by Applicant)
2. concordance method
3. concordance plus adjustments method
4. CDHW system specific tables method.

Option 2 was considered relatively straight forward to set-up and superior to option 1 (more accurate and less potential for user error). On that basis option 1 can be eliminated from consideration.

Option 4, whilst offering several advantages, including best accuracy and applicability, also must be ruled out on the basis that it cannot be realised in the

[5] If this pathway were undertaken, effectively you would be setting up modules to calculate CDHW system energy use in a first-generation simulation tool for a one-off purpose then repeating the exercise in a second-generation tool (NatHERS Whole-of-Home benchmarking tool).

timeframe available for the 2025 iteration of NCC 2025. The necessary methods for undertaking option 4 are unlikely to be finalised and integrated into a modelling tool until at least the end of this year.

That just leaves options 2 and 3. Option 3 offers potentially greater accuracy than option 2 provided practical methodologies for making the required adjustments and the setting of minimum standards can be determined by early September 2023.

Section 3 of this report compares stand-alone water heating systems (as used in the current DTS method) and central domestic hot water systems and examines the scope (if any) for formulating adjustments and/or the setting of minimum standards in relation to option 3 with recommendations on how to proceed (i.e. what adjustments and or minimum standards should be applied if any).

3 Comparing Stand-Alone and Central Domestic Hot Water Systems

3.1 Background

Water heaters add energy to a cold water supply to provide a source of warm to hot water to households for ablution purposes. The energy consumed by a water heater depends on a range of factors:

- the cold water temperature coming into the supply
- the hot water temperature supplied
- the volume of hot water used by the end user
- the conversion technology used to heat the water and its efficiency
- any heat losses associated with the storage of hot water prior to its use
- any heat losses associated with the distribution of hot water
- any energy consumed by pumps or auxiliaries and
- the contribution made by solar thermal collectors, where applicable.

For the purposes of the NCC, the first three parameters are pre-defined: cold water temperatures are defined by climate, hot water supply temperatures are assumed to be constant and the volume of hot water demand is a function of the number of occupants, which is defined by the floor area of the dwelling.

This section examines more closely the last five parameters and how the main technologies used to supply hot water in Class 2 buildings with a central hot water service compare with the systems that are normally used in Class 1 dwellings (i.e., stand-alone systems).

3.2 Base assumptions

The WOH methodology defines the number of occupants as a function of floor area as follows:

$$N_{Occ} = 1.525 \times \ln(A_D) - 4.533$$

Where:
N_{Occ} = number of occupants in the home (rounded to the nearest second decimal)
A_D = area of dwelling (the sum of the floor areas of all zones, excluding the garage) in m².

This equation yields an occupancy curve as shown in Figure 5. A floor area of 37.7 m² generates 1.0 occupant using this equation. For this DTS exercise, it is assumed that individual dwellings with a floor area of less than 37.7 m² will have one occupant in terms of hot water demand.

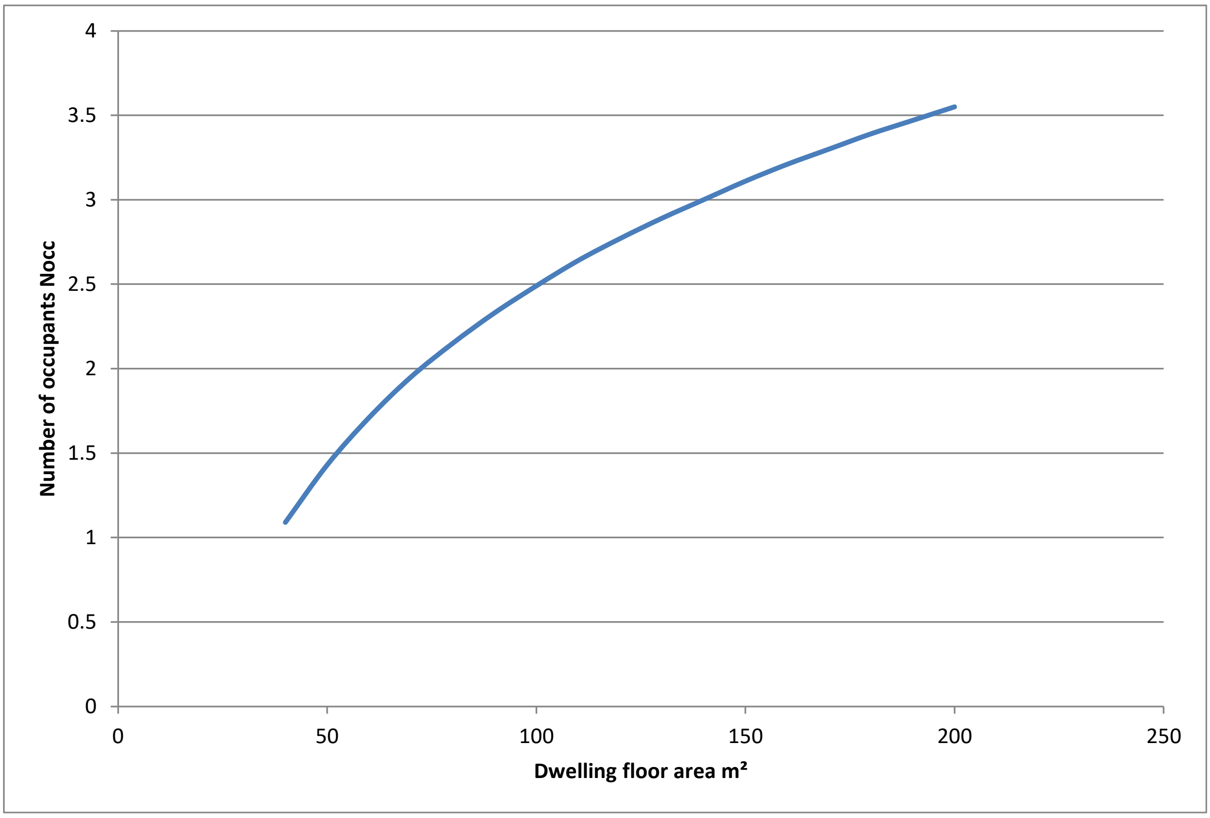

Figure 5: Number of occupants assumed by dwelling floor area

The hot water methodology defines the hot water consumption as a simple base assumption of 40 litres per person per day. Because the number of occupants per floor area is quite non-linear, the floor area of each Class 2 dwelling should ideally be considered when calculating total hot water demand.

BASIX in NSW defines three types of Class 2 dwellings:

- Low-rise – nominally 1 to 3 storeys
- Medium-rise – nominally 4 to 10 stories
- High-rise – more than 10 stories.

The type of Class 2 dwelling will impact on some of the secondary aspects of water heater performance in centrally supplied hot water system.

The original NCC modelling for hot water systems looked at a range of typical residential stand-alone hot water systems used in Class 1 dwellings. The main types of systems included in the modelling were:

- electric storage 80L (Post MEPS 1999 – continuous energisation)
- electric storage 315L (Post MEPS 1999 – off-peak energisation)
- heat pump (Standard Z4 continuous energisation)
- heat pump (Standard Z4 off-peak energisation)
- solar electric (Standard Z4 continuous energisation)
- gas storage (4 star)
- gas instantaneous (5 star) and
- gas solar (Standard).

While there are many water heaters available of these general types that may be more efficient, these base level performance models were used to develop the deemed-to-satisfy (DTS) cases. Proponents always have the option of modelling the performance of water heaters that are more efficient than these base cases using alternative methods (e.g., NatHERS WOH modelling) rather than using the DTS lookup tables. The analysis in this report is to examine typical water heater configurations for centrally supplied hot water in larger Class 2 developments and to estimate what adjustments, if any, would be required to characterise the performance of these systems for a DTS base case.

3.3 Water heater conversion efficiency

There are three main technologies that are used to heat water:

- electric resistance heating – fuel source is electricity
- gas burner – fuel source is usually natural gas, but could be LPG (unlikely in most Class 2 dwellings) and
- heat pump – fuel source is electricity, which operates a vapour compression cycle to extract heat from the environment and concentrate this in a storage vessel.

3.3.1 Electric resistance

Electric resistance heating uses a resistive element to convert electrical energy into heat energy. The element is immersed in the water to be heated. The temperature of the water is controlled by a device that turns the element off when the temperature reaches a specified limit. While there are instantaneous electric water heaters (with little or no storage), these would be fairly uncommon in central hot water systems in Class 2 dwellings due to the very large peak demands that occur at times of high coincident hot water demand (although electric instant is used in some Class 2 developments). Electric systems used in central hot water systems are typically storage type systems. As the element is fully immersed in the storage water, the conversion efficiency for all resistance hot water systems is assumed to be constant at around 98%, irrespective of the size or type of system.

Conclusion

Central hot water systems using electric resistance technology will be directly comparable to stand-alone residential systems in terms of their conversion efficiency.

3.3.2 Gas burners

Gas water heaters for residential applications are regulated for MEPS in Australia. The scope of MEPS covers storage water heaters with a capacity of more than 30 litres and a nominal energy input of not more than 50 MJ/hour. Instantaneous systems covered have a heat output of more than 47 MJ/hour and a nominal energy input of not more than 250 MJ/hour. Gas hot water systems can be split into two main types:

- storage systems and
- instantaneous systems.

In storage systems, the heat exchanger is fully immersed in the stored water, which can result in higher efficiency values, depending on the configuration. Gas storage water heaters on the Australian market generally have a conversion efficiency in the range 80% to 91%, depending on the model. For gas storage systems, input power generally ranges from 25 MJ/hour to 50 MJ/hour (7 to 14 kW) for residential systems.

Instantaneous gas systems have to fully heat cold water as it passes through a heat exchanger, so the input power required is much higher than for storage systems. Instantaneous systems generally have an input power of 120 to 200 MJ/hour (33 to 56 kW). The conversion efficiency of instantaneous systems can be as low as 75% but the best systems can achieve a burner efficiency of 95% under the test method AS/NZS5263.1.2. The burner efficiency of residential gas systems currently approved is shown in Figure 6. This illustrates that a 4-star storage system and a 5-star instantaneous system will both typically have a burner efficiency of around 80%.

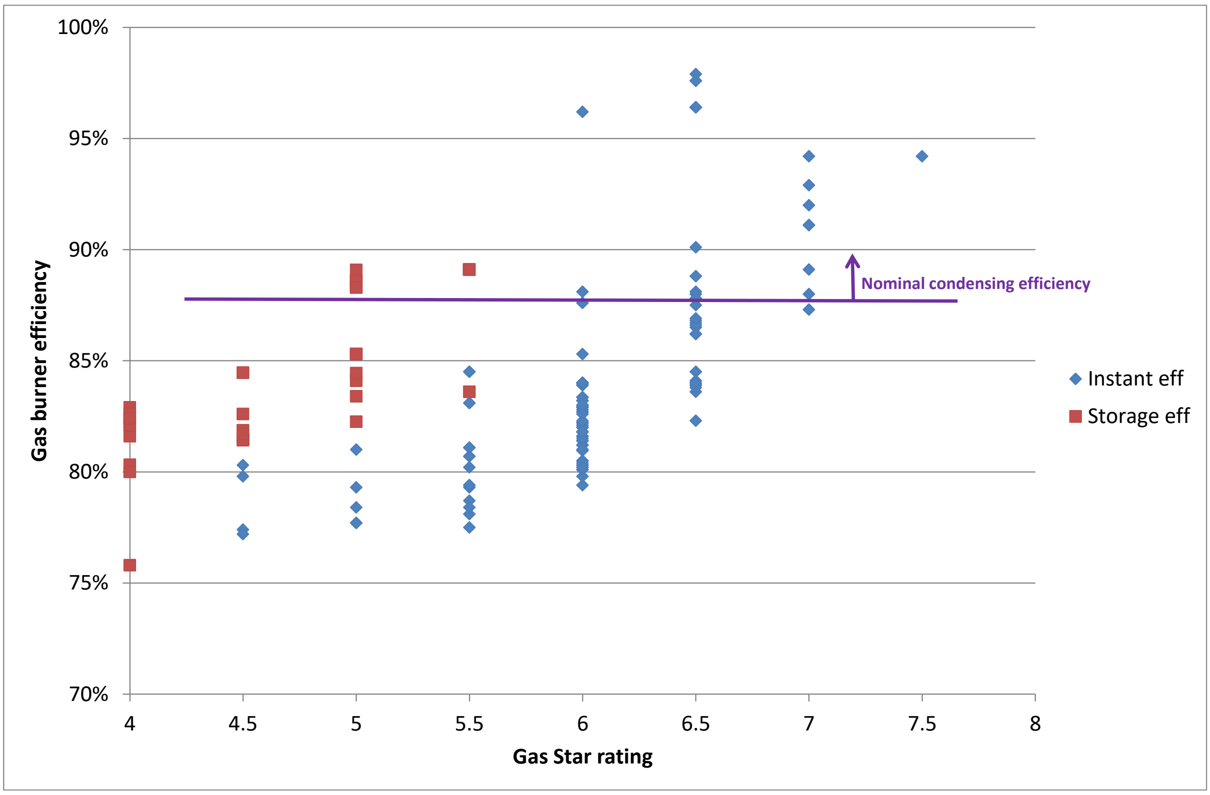

Figure 6: Gas star rating versus burner efficiency for residential gas hot water systems

Residential gas storage systems are relatively small (typically 90 litres to 170 litres storage) and are only suitable for supplying one or two residential dwellings. Larger commercial gas systems are available (around 250 litre to 300 litre storage), but these are only suitable for supplying hot water to a few (up to 5) households and they are not covered by MEPS. Larger gas systems tend to use an insulated storage tank (300 litre to 600 litre) combined with an external instantaneous gas system to heat the stored water using a circulation pump. These systems can be manifolded in order to meet a very large hot water demand.

In broad terms, the performance of gas systems used in central hot water systems are likely to be comparable to gas systems used in Class 1 dwellings, although the performance of individual systems can vary somewhat. In practical terms, where the number of dwellings exceed around 10 dwellings supplied by a central hot water system, there will be some sort of storage system to meet coincident peak hot water demands. Most commonly instantaneous gas will be combined with a hot water storage tank. Most of these larger systems will be dedicated storage tanks with heating provided by an external instantaneous system which is recirculated to keep the stored water at the required temperature. For less than 10 dwellings, instantaneous gas systems can provide hot water directly without storage when they are configured to operate in parallel to meet peak demand, but this is likely to be less common in practice.

Conclusion

Central hot water systems using gas burner technology can be considered directly comparable to stand alone residential systems (4-star storage or 5 star instantaneous) in terms of their conversion efficiency. In most cases such an assumption of comparability will in fact be a conservative assumption as many (but not all) instantaneous gas systems used to service larger central gas hot water systems are likely to be 5 stars or more.

3.3.3 Heat pumps

While heat pump water heaters have been around for many years on the fringes, they have become a much more mainstream product in recent times. Heat pumps use the vapour compressor cycle (like that used in a refrigerator or air conditioner) to collect ambient energy from outdoors and concentrate this in an insulated storage tank in the form of hot water. Because the instantaneous heating power of the heat pump system is usually limited, a storage system is needed to accumulate energy over a period in order to meet peak hot water demands. As with any heat pump system, the efficiency depends on the compressor efficiency, the design of the refrigeration system (condenser and evaporator), the refrigerant used and the temperature difference between the evaporator and condenser.

One consideration for heat pumps in a central hot water supply system is that the evaporator(s) would normally need to be located outside of the building to enable the efficient collection of ambient energy. This may present some configuration issues in larger Class 2 dwellings, especially if retrofitting was considered.

Heat pumps are included in the Renewable Energy Target legislation. Air-source heat pump models are eligible for small-scale technology certificates (STCs) under the Small-scale Renewable Energy Scheme when their performance is submitted to the Clean Energy Regulator (CER)[6]. These are currently limited to a storage capacity of 425 litres. CER listed systems are really only suitable for supplying up to three dwellings, so will be less commonly used in central hot water systems. While the CER listing is useful, the only data it contains is the number of STCs each model earns in each of the five climate zones specified in AS/NZS4234. Most (but not all) of the heat pump systems on the CER register are medium size under the AS/NZS4234 definitions. To qualify for STCs under the RET, solar water heaters and heat pumps systems must achieve a minimum 60% solar contribution in Zone 3 (this equates to a 60% reduction in energy consumption relative to the same size reference electric storage system). For a medium-sized heat pump system, this equates to 25.4 STCs in Zone 3 (which covers Sydney, Adelaide and Perth). Medium-sized heat pumps earn from 25 STCs to as many as 35 STCs in Zone 3. As illustrated in Figure 7, small changes in the STCs earned result in significant changes in the overall system efficiency (COP) for a heat pump water heater, especially for higher STC levels.

[6] For a listing of air source heat pumps compiled by the Clean Energy Regulator, see https://www.cleanenergyregulator.gov.au/RET/Scheme-participants-and-industry/Agents-and-installers/Small-scale-systems-eligible-for-certificates/Register-of-solar-water-heaters

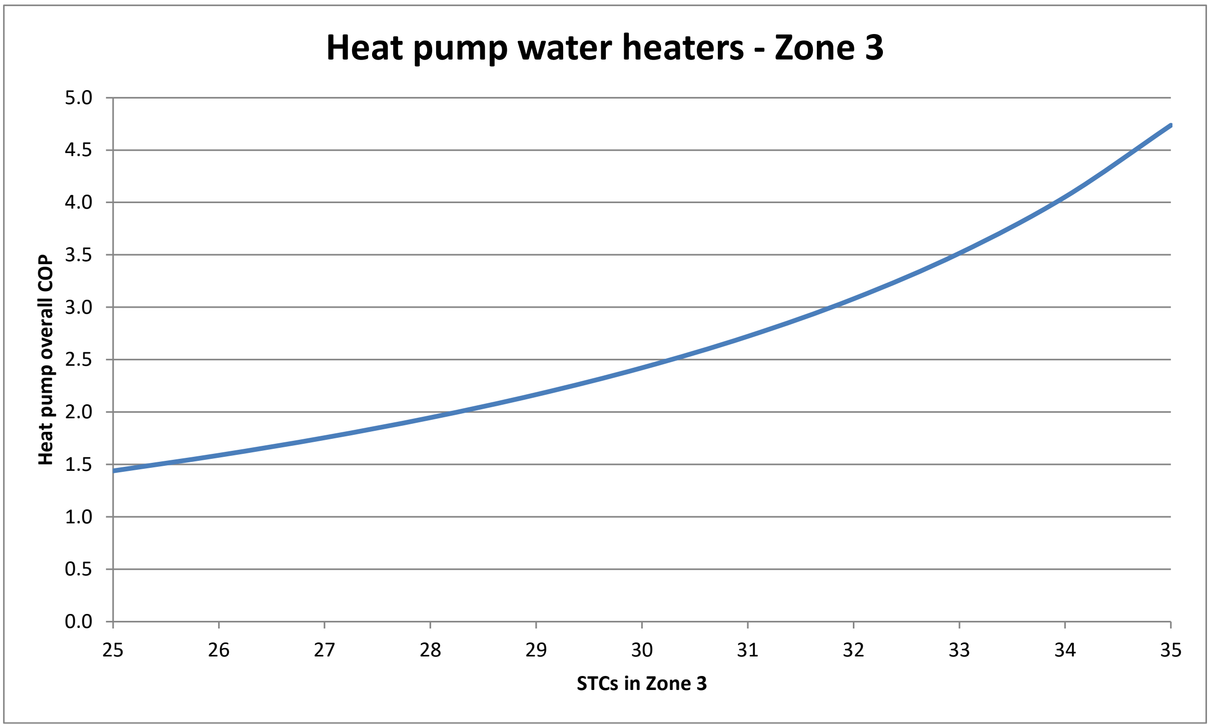

Figure 7: STCs versus overall system COP for heat pump water heaters in AS/NZS4234 Zone 3

The range of system efficiencies on the market certainly spans the range shown in Figure 7, with systems at 33 STCs and above in the colder climates being high quality R744 (Carbon Dioxide) refrigerant systems. The distribution of heat pump models on the CER register is illustrated in Figure 8.

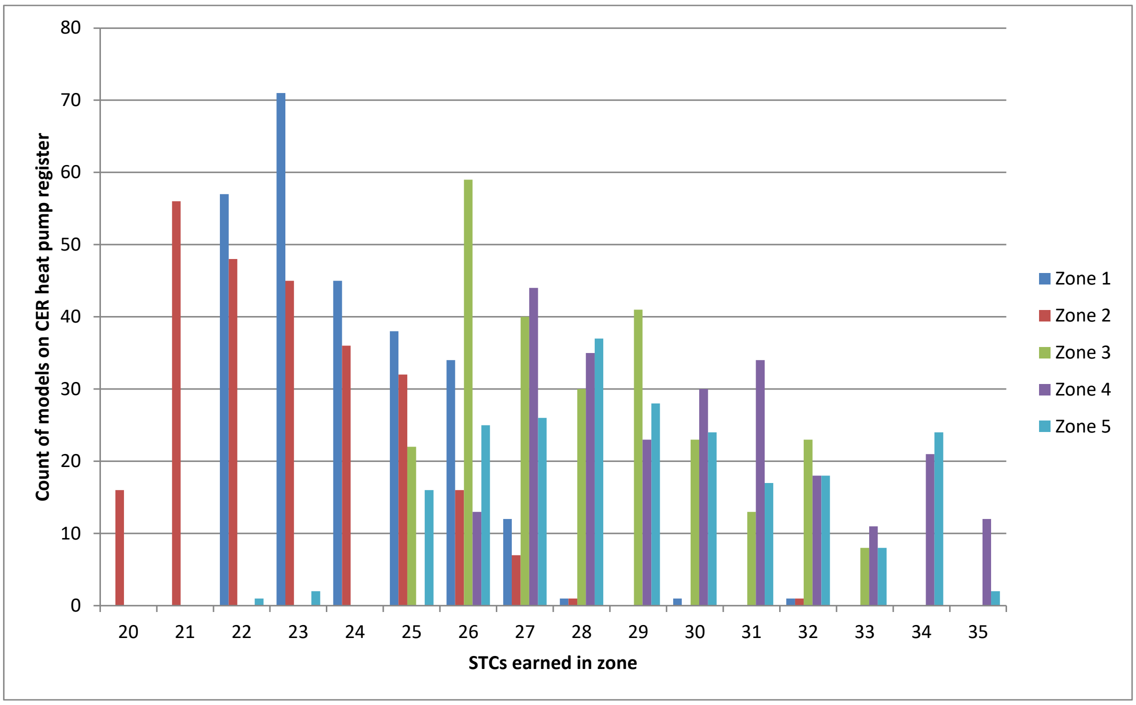

Figure 8: Distribution of heat pump water heater models on the CER register

The climate zone and hot water demand defined in AS/NZS4234 does have a significant impact on heat pump water heater apparent performance in each zone. However, when model-by-model data is examined and corrected for climate zone, in most cases the data suggests that the overall performance in each climate zone is remarkably similar for most models. There are a handful of models that have significantly lower performance in Zone 4 and/or Zone 5 (colder climates). In some cases, models are not listed in Zone 4 and/or 5, indicating poor cold weather performance.

It is important to note that the data from the CER register allows the calculation of the overall COP for a given number of STCs, but this includes tanks heat losses and the energy consumption of other auxiliaries. Of most interest for this analysis is the marginal COP – the additional energy used by the water heater to heat each additional unit of hot water demand. The marginal COP will be somewhat higher than the overall COP calculated above. Based on an analysis of a range of test lab and simulation data, the ratio of marginal COP to overall COP is around 1.2 for most typical heat pump water heater systems when operating at full load. This puts the typical marginal COP for climate zones 1 to 3 at around 2.6 and the typical marginal COP for climate zones 4 and 5 at around 2.4. This is close to the base assumptions included for DTS heat pump water heaters in NCC 2022.

Heat pumps were originally assumed to have a COP of 2.5 – 3 in the NCC 2022 calculations. BASIX are assuming for CDHW systems a range of 2.25 to 3.75, which is broader than the range assumed in NCC but appears likely to be broadly reflective of the products available on the market.

CUNDALL

20°C is selected as the ambient condition as this represents the mean air temperature in Sydney.

65°C is selected as the leaving water temperature to ensure legionella control

The following COPs are proposed to be introduced as drop down options in BASIX as shown in Table 4.

Table 4: Proposed Heat Pump options and X^1 factor for shw3 zone

Option	COP used in energy calculation	X^1 factor for shw3 zone
Heat Pump (2.0 < COP ≤ 2.5)	2.25	30.587
Heat Pump (2.5 < COP ≤ 3.0)	2.75	25.026
Heat Pump (3.0 < COP ≤ 3.5)	3.25	21.176
Heat Pump (3.5 < COP ≤ 4.0)	3.75	18.352

Source: Table 4 from BASIX 2021 Update Project No. 1029114 by Cundall

More recent analysis by DCCEEW consultants (Bridgeford Group, 2023) has found that system COPs range from 2.3 to 3.9 as shown in Figure 9. Large central hot water heat pump plants with an output of up to 100 kW are available – these would be highly suitable for Class 2 central hot water and also in commercial buildings[7]. This data is better suited to the development of specific modelling tool that can take

[7] For example of a large carbon dioxide refrigerant (R744) hot water system see https://www.lyncbywatts.com/dfsmedia/0533dbba17714b1ab581ab07a4cbb521/155543-source/aegis-air-source-tds

into account the performance impact of the system efficiency of specific models where this data is provided. But the lower end of the benchmark values are comparable to those used in the NCC 2022 modelling so is suitable for assessing a DTS base case.

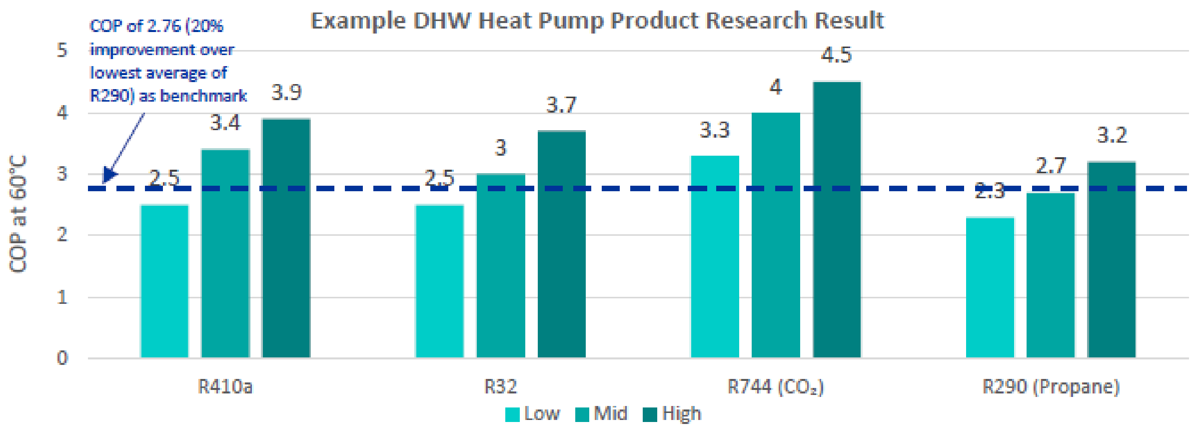

Figure 9: Benchmark COP performance of a range of heat pump systems
Figure notes: Source is Figure 7 from NatHERS DHW and HVAC Methodology for Apartment Shared Services, Bridgeford Group (V1.4, 24 July 2023)

Conclusion

In terms of the conversion efficiency, it would appear that the base assumptions embedded in the NCC 2022 DTS method are still broadly representative of low to middle performance heat pump systems on offer. This is also corroborated by the analysis of the CER heat pump register for smaller domestic systems. But residential sized heat pumps covered by the CER are less likely to be deployed in central Class 2 hot water systems because of their limited capacity. Larger commercial systems are likely to be more common.

Central hot water systems using heat pump technology can be considered directly comparable to the performance of the stand-alone residential heat pump system assumed in the NCC 2022 DTS method in terms of their conversion efficiency. In most cases such an assumption of comparability will in fact be a quite conservative assumption as most large central heat pump hot water systems are likely to be more efficient than that assumed in the NCC 2022 DTS method.

3.4 Storage Losses

Where hot water is stored in an insulated tank, there will be ongoing heat losses through the tank wall and via hot fittings and fixtures that penetrate the insulation. For domestic electric storage systems, maximum permitted heat losses are mandated through MEPS and MEPS levels set out in AS/NZS4692.2 as shown in Table 3. Heat losses for gas storage systems are a bit more complex as the heat exchanger and the flue form a column that rises through the stored water (to maximise heat exchange during combustion) and most storage systems use a pilot light, so there is some ongoing convection heat loss through the flue in addition to the radiation heat losses through the tank wall and fittings (the pilot light does put some of its energy into the stored water).

Table 3: Maximum heat loss specified in AS/NZS4692.2 for electric hot water storage tanks

Rated HW delivery L	Max heat loss kWh/day
25	1.04
31.5	1.11
40	1.18
50	1.25
63	1.39
80	1.53
100	1.67
125	1.81
160	2.02
200	2.23
250	2.44
315	2.72
400	2.93
500	3.21
630	3.49

Table notes: source: Table A1 of AS/NZS4692.2:2005 for mains pressure water heaters. Heat loss values shown can be increased by 0.2 kWh/day for each additional heating element (where there are more than 1) and by 0.2 kWh/day for each temperature/pressure relief valve mounted on the hot part of the tank. These heat loss levels broadly equate to a shell insulation of around 50mm of polyurethane.

Tanks of 315 litres or more when used in Class 1 dwellings are typically operated on some sort of controlled tariff (off peak) where the electricity utility offers a lower energy rate for a limited period of energisation during each 24 hours. Off peak systems can be operated on time clocks (e.g., Victoria and South Australia) or using utility switching (e.g., ripple control controlled by utilities in NSW and Queensland). While hot water storage tanks that are larger than 630 litres are possible (especially for large scale commercial or industrial applications), these would be unusual in most residential applications as there are dimensional constraints to get larger systems through doorways. Heat loss from off peak systems with a limited energisation profile will be slightly lower than for a tank with a continuous energisation profile as heat losses will be reduced during the day as hot water is consumed and displaced by cold water. This effect is usually modest (less than 10% except for very large hot water demands).

In contrast, the best gas storage hot water systems have a maintenance rate of around 8 MJ/day, which equates to 2.2 kWh/day (equivalent to a 160 litre electric storage system with a MEPS of 2.02 kWh/day), but the gas heat loss equivalent is closer to 3 kWh/day once the difference in hot water storage temperature in the relevant test standards is taken into account.

Larger storage tanks are expected to have a lower heat loss per litre of stored water as heat loss is primarily driven by tank surface area and the surface area per litre stored declines quickly as the tank size increases. This effect is illustrated in Figure 10. There are also some fixed losses through penetrations, so the volume-related effect does not account for all changes in heat loss. The base case of a typical small electric storage tank operating on continuous tariff[8] modelled for NCC is an 80 litre system, which has a heat loss of 0.019 kWh/litre/day. Larger systems, 400 to 600 litres, have a heat loss of about one third of this value.

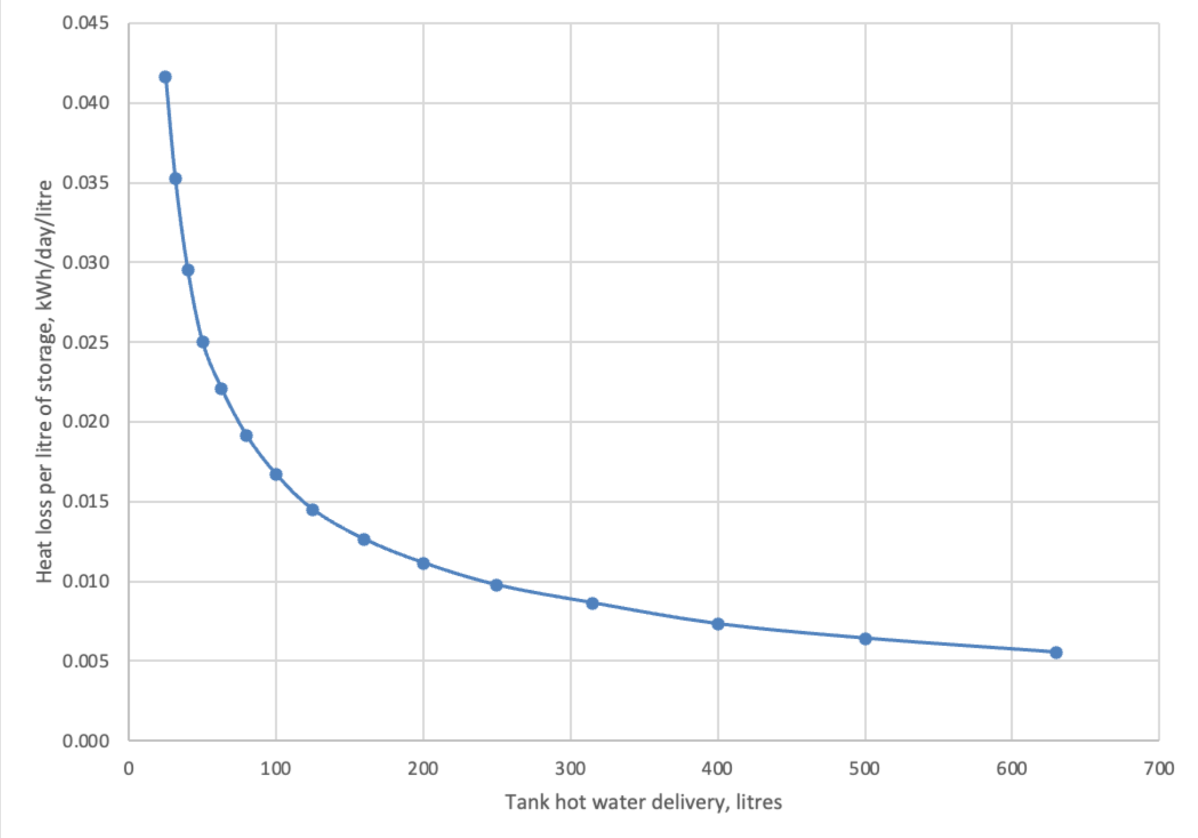

Figure 10: Heat loss per litre of storage as specified in AS/NZS4692.2
Source: Author calculations based on AS/NZS4692.2 permitted heat loss values for mains pressure units.

Based on author analysis of some guidance provided by BASIX on the design of central hot water systems, it is possible to estimate the likely minimum hot water storage volume per Class 2 dwellings as set out in Figure 11 (note the logarithmic scale on the Y axis). The suggested storage volume per apartment for a large apartment block (more than 100 flats) is very small compared to a stand-alone system of 80 litres, which would be required to service a single apartment. This shows that the heat loss from central systems, especially larger ones, are likely to be considerably lower than for stand-alone hot water systems. However, it is important to bear in mind that heat losses from storage tanks only make up a relatively modest proportion of total hot water system input energy. For example, an 80 litre electric storage system delivering an average household hot water demand, heat losses will make up around 15% to 20% of total energy consumption. Heat losses per apartment for central systems are likely to be half to one tenth of this value, depending on the system size. This is driven by the lower storage requirement per flat for central hot water systems (Figure 11) AND the lower heat loss per litre stored for central hot water systems (Figure 10), which will most likely use a series of large manifolded storage tanks.

[8] In a single Class 2 dwelling with its own electric storage hot water system, an 80 litre system is quite typical and this would nearly always operate on a continuous tariff.

Conclusion

Central hot water systems with storage will almost certainly have lower storage (tank) losses per litre of delivered hot water than those that were assumed for Class 1 stand-alone systems in the current NCC 2022 DTS method. This makes the use of existing NCC 2022 DTS tables for central hot water systems with storage a somewhat conservative approach in respect of tank losses.

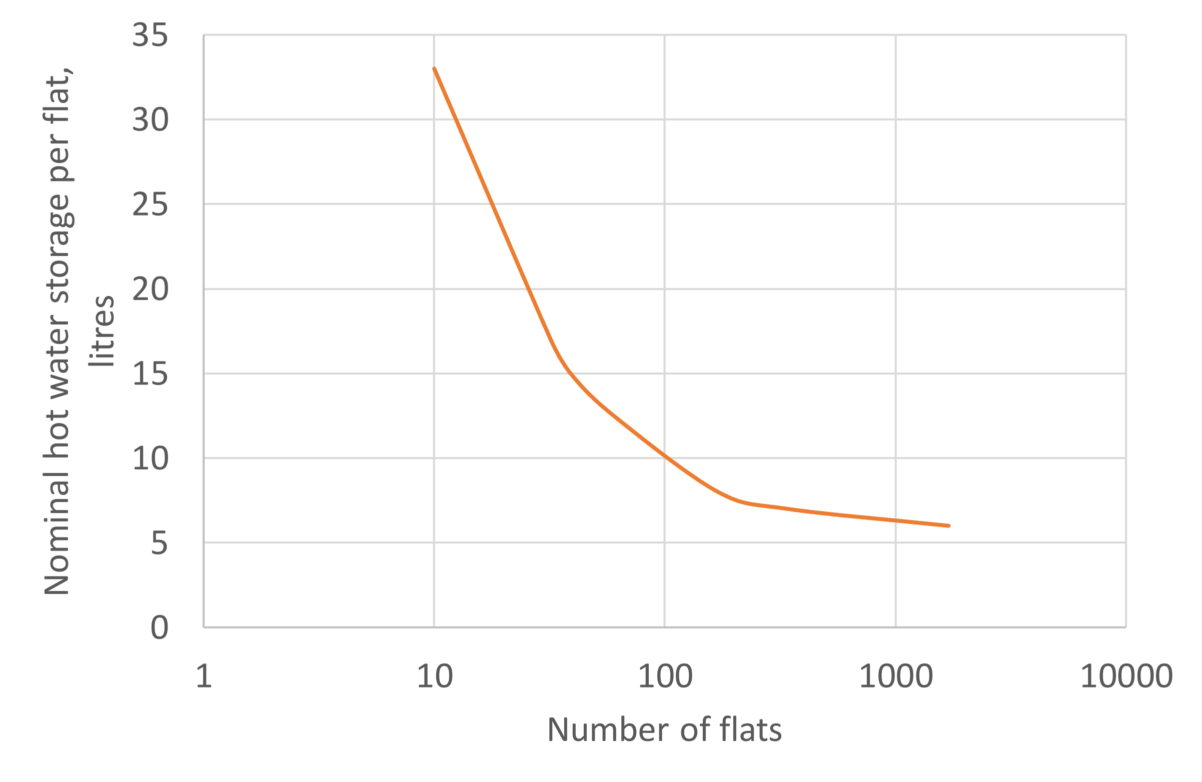

Figure 11: Estimated minimum hot water storage requirement per dwelling for central hot water systems in Class 2 buildings.

3.5 Distribution Losses

Distribution losses occur in a hot water system where the pipe to a hot water supply point fills with hot water during use and this then cools down once the flow stops, even where the supply pipe is well insulated. These sorts of losses occur in all residential and commercial systems, except where the hot water is stored or generated very close to the supply point(s). Distribution losses are estimated to be of the order of 11% in a typical Class 1 home, but this is somewhat dependent on the layout of the plumbing system and hot water pipe lengths, pipe diameters and frequency of hot water use at each supply point (George Wilkenfeld and Associates, 2005). For modelling purposes, these types of distribution losses are typically included in total hot water demand (so they are NOT specifically modelled as a separate parameter). For central hot water systems in Class 2 dwellings, the distribution losses within the dwelling itself are likely to be lower than a Class 1 dwelling because the average floor area is much smaller and the pipe runs are shorter (but the hot water demand is also lower, so in a relative sense, distribution losses are likely to be comparable). These type of distribution losses are not considered separately in this report and are not explicitly quantified.

The other type of distribution losses that are specific to central hot water systems in Class 2 dwellings are the additional heat losses that occur in the distribution pipes from the central hot water plant room to the point of connection at each dwelling where hot water is taken off. In some cases, these pipe runs may be considerable (many tens of metres). To ensure that hot water is available on a continuous basis at the point of connection to each dwelling, the most common configuration is to have a closed hot water loop which circulates hot water on a continuous basis from the central hot water system, past the take off point for each of the dwellings supplied. Any unused hot water is returned to the hot water system for reheating. The heat loss that occurs during circulation is made up by the water heating system and is added to the hot water demand. As these distribution pipes are supplying many dwellings, they will be large diameter, designed to cope with the maximum coincident hot water demand that is likely to occur and are usually well insulated. Without this type of circulation system, individual dwellings that are further from the hot water plant would have to purge a large length of pipe of cooled water if there had not been any hot water use in the building for some period (e.g., overnight).

The other possible configuration is a so-called open loop hot water system. These are uncommon and are most likely to be found in small buildings where the central hot water system was retrofitted. In an open loop system, hot water is pumped from the central supply past each of the dwellings to be supplied (same as closed loop). The difference is that any unused hot water is then dissipated back into the cold-water supply for the building (usually at a point that is remote from the central hot water supply system). This type of system is not very efficient as unused hot water is effectively dumped into the cold-water supply (which may not find its way back to the central water heater) and the cold water can become quite warm. Negative impacts can be ameliorated to some extent by slowing the hot water pump out rate considerably at times of low hot water demand. These types of systems are not considered further in this report.

There are two elements of energy losses associated with this type of circulating system. The first is the heat loss, which manifests as a temperature drop in the water circulating around the loop and results in additional energy to heat the return water back to its storage temperature. The power can be calculated as a function of the flow rate and the temperature drop when there is no hot water demand in the dwellings that are supplied. When one or more dwellings are demanding hot water, the flow rate in the loop past each of these dwellings will slow somewhat and this will affect the heat loss slightly. However, there are several approaches to hot water circulation systems and their energy consumption and energy efficiency varies considerably. The heat losses in a circulating hot water system are affected by the control system used. The most common types are continuous circulators (least efficient), pre-programmed timers (that limit pumping to times when hot water demand is most common), thermostatic controls (that activate pumping when temperatures in defined points on the circulation loop fall to a defined level), and on demand switches, which sense when end users are demanding hot water (Coomes Consulting Group, 2008). Some systems may use a combination of these types of controls to optimise performance and minimise energy consumption. Initial analysis has showed that total losses (pumping and heat loss but dominated by pumping losses) varied by up to a factor of 10 for an on-demand with thermostatic controls (best) to a continuous circulation system (worst) (The Allen Consulting Group, 2009). The highly variable performance of different control systems makes generalising their performance somewhat difficult.

The second element of energy consumption associated with this type of system is electricity consumed by a circulating pump. This energy is considered in the next section of this report, which deals specifically with pump energy.

To estimate heat loss from pipes would normally require a series of complex calculations. However, BASIX assumes that 0.40 MJ of gas energy is consumed for delivering 1 L of hot water in a building that comprises of one or more sets of supply and return piping thermally insulated to the minimum level mandated by BCA. This figure has reportedly been confirmed through a number if empirical studies of central hot water systems in NSW. This provides a reasonable basis for estimating the additional energy consumption associated with circulating closed loop systems in larger central hot water systems.

BASIX documentation for central hot water systems notes:

$$CF = \frac{E_{HW}}{HW_{vol} \times 365} \qquad (6.3.10)$$

Where *CF* is the common factor (0.4 MJ per litre hot water) and E_{HW} is the annual energy consumption of the water heater and HW_{vol} is the volume of hot water delivered per day (in litres) (BASIX 2018).
BASIX documentation also sets out the basis for calculating the annual hot water use for a central hot water system in Equation 6.3.12 as follows:

$$E_{HW} = A' \times \left(HW_{vol} + HW_{pipeloss}\right)^2 + B' \times \left(HW_{vol} + HW_{pipeloss}\right) + C' \qquad (6.3.12)$$

The coefficients *A'*, *B'* and *C'* depend on the system type. For non-solar systems, the value of *A'* is assumed to be zero. The units of *B'* are in MJ/(year.(litre/day)) while *C'* are standing losses in MJ/year. The value of $HW_{pipeloss}$ can be estimated by rearranging Equations 6.3.10 and 6.3.12 for typical values for different system types as follows:

$$HW_{pipeloss} = \frac{(CF \times HW_{vol} \times 365 - B' \times HW_{vol} - C')}{B'}$$

Note that the units for $HW_{pipeloss}$ are in litres of hot water per day, which is an equivalent additional hot water demand that can be attributed to circulating pipe heat loss.

For a gas storage system, which was used to develop the value of *CF* of 0.4 (as benchmark for the least acceptable performance), the value of *B'* is 90.5 and the value of *C'* is around 5000. This gives a value for $HW_{pipeloss}$ that is equivalent to around a 50% increase in the hot water demand. The value estimated using this approach is highly sensitive to the assumed value of CF. For a CF value of 0.35, the value of $HW_{pipeloss}$ is 35% and for a CF value of 0.30, the value of $HW_{pipeloss}$ is 20%. The simplest way to think of this is that the energy embodied per litre of hot water is around 0.19 MJ per litre, then there is conversion losses (for a gas system at 75% burner efficiency), this is an additional 0.063 MJ per litre, plus storage losses, which will be quite small per litre delivered in a large gas storage system. Circulating losses are on top of these values and appear as an equivalent hot water demand on the system. This is delivered at the system marginal COP value (gas at around 0.75, electric resistance at 1.0, heat pump at 2.5 to 3). Moderate efficiency gas systems would easily be able to meet the assumed CF of 0.4 once circulating losses are included.

The profile for electric systems will be quite different and the value of CF for heat pump systems will be very different again because the marginal efficiency and heat loss profile is driven by the COP of around 3, so a value for CF of around 0.1 to 0.15 might be a reasonable estimate. BASIX do not appear to provide estimates of CF for different hot water system types.

A paper published in the 12th Nordic Symposium on Building Physics (Burke et al 2020), examined circulating heat losses for hot water systems in apartments in Sweden. The paper examines the circulating heat loss in 134 apartments, with 34 of these built after 2015. It compares the estimated heat loss with the measured heat loss values in most cases. A few measured outliers were identified, primarily because the hot water circulation systems had been incorrectly configured and were dumping energy into other parts of the building. Swedish efficiency regulations put a cap on hot water circulation heat losses of 4 kWh/year per m² of flat conditioned floor area. Most of the newer buildings (after 2015) had circulation heat losses under this cap, with an average of 3.8 kWh/year/m² once the outliers were removed. For a typical Swedish flat of 68 m², this equates to 258 kWh/year or 930 MJ/year. The assumed hot water use under NCC for this sized apartment is 5200 MJ/year (embodied hot water energy only). This represents 18% additional hot water load equivalent to account for circulating heat losses. This share of heat loss increases as the floor area increases as the occupancy function assumes that hot water demand per m² of floor area decreases as apartment size increases while circulation losses remain constant per m² of floor area.

While it is accepted that Swedish flats and Australian flats are likely to be somewhat different, circulating heat losses for central hot water systems could reasonably be expected to be broadly comparable (although these types of systems are more common in Northern Europe and they are likely to be built to a high energy efficiency specification than would be the case in many Australian constructions). However, the internal temperatures within apartment blocks are likely to be comparable in broad terms due to high levels of space conditioning in Sweden, which is one of the main factors dictating heat loss.

Conclusion

Central hot water systems that service more than 10 apartments are highly likely to use storage systems to meet hot water peak demands. As the number of apartments serviced grow, the relative heat loss from storage tanks decreases rapidly, because the required storage volume per dwelling decreases and the heat loss per litre stored decreases as storage tank sizes increase. For large central hot water plant servicing 50 or more apartments, the storage heat losses per litre of hot water delivered becomes very small relative to stand alone hot water systems.

In contrast, once central hot water systems have to service more than 10 apartments, it seems to be very common that closed loop hot water circulation systems become necessary to ensure that hot water is delivered to flats that are further from the hot water plant in a timely manner and to avoid the need to purge cooled dead water from hot water pipes where there has been no hot water demand for some period. The additional energy required to make up these heat losses appears to be in the range 18% to 30%, depending on the system design and configuration. BASIX data appears to be quite conservative in that it will result in high estimated circulation losses, depending on the assumed value of CF (30% to 50% additional hot water demand). Swedish data suggests that circulating heat losses would range from 18% in a small apartment to as much as 25% in a large apartment.

The NCC modelling for hot water has been based on stand-alone hot water systems servicing single households. For storage systems, heat losses typically make up 20% to 30% of the total energy consumption. For example, in an apartment of 100 m^2 the daily hot water demand is assumed to be 18.8 MJ/day or 5.2 kWh. The permitted heat loss for an 80-litre electric storage system is 1.53 kWh/day (+0.2 for a hot side TP/R valve). After adjusting for storage temperatures (because in use heat loss is likely to be cooler than measured in the ABCB Standard) the heat loss in normal use will equate to around 30% of the total hot water energy.

For the purposes of deemed-to-satisfy modelling, in the absence of better data, it would appear that data for stand-alone systems can be used to approximate central hot water systems in terms of overall heat loss. For larger central systems, storage heat losses are very small per litre of hot water delivered but these will be offset by increased circulating heat losses from closed loop systems, which appear to be essential for larger Class 2 buildings with a central hot water plant. It appears that circulating heat losses in large central hot water systems are of a similar magnitude to storage losses in single dwelling stand-alone systems used for NCC modelling.

3.6 Pump Energy

There are two types of pump energy that occur in central hot water systems in Class 2 dwellings. Primary pump energy is where water is circulated between a storage tank and a heating unit (e.g., a gas instantaneous water heater) that is external to the storage tank. Secondary pump energy is used to circulate hot water from the central hot water system to the dwellings that are being supplied, usually via a closed loop system.

BASIX documentation sets out a basis for each of these pumping elements, which have been generally adapted for base case calculations in this report.

Primary circulation pumping

BASIX assumes that primary pumping energy is zero for the following system types:

- gas or electric instantaneous serving <7 apartment units (no storage)
- solar (gas or electric boosted) serving < 20 units (auxiliary energy included in performance benchmarks)
- heat pump, air sourced or solar boosted (heating in tank or auxiliary energy included in performance benchmarks) and
- manifolded gas storage or electric storage (heating occurs in tank).

This appears to be a reasonable assumption as these systems will be able to heat water internally without the need for circulation to an external heating system. Note that many solar thermal and heat pump systems have remote collectors or evaporators and will have some pumping energy associated with them, but this is only small and this energy is already taken into account in the overall energy calculations that are used to determine solar contribution, so they are not considered further. Large central heat pump systems will have a storage system that is separate from the heating unit, so these types may have some primary circulation pumping energy.

For other types of systems other than those listed above, BASIX assumes that primary pump energy is 1 kWh per kL of hot water supplied. 1 kL of hot water is approximately 190 MJ, so 1 kWh of electrical pump energy (=3.6 MJ of electricity) is an increase of 1.9% of the hot water demand (this does not include any losses or other energy consumed in the production of hot water).

Secondary circulation pumping

As set out in BASIX documentation, a secondary circulation pump is used to circulate hot water through the supply and return risers of a multiple-unit building so that adequately heated water is always available at the point of connection to each dwelling. Similar to primary circulation pump energy, secondary circulation pump energy is defined in terms of energy consumed for pumping per kL of hot water delivered. Secondary circulation pump energy is assumed to be smaller for smaller developments as set out in Table 4.

Table 4: Assumed secondary circulation pump energy (*$PE_{secondary}$*)

Building size →	Few dwellings	Few dwellings	Interpolated	Many dwellings	Many dwellings
Building type ↓	# dwellings (n)	$PE_{secondary}$	$PE_{secondary}$	# dwellings (n)	$PE_{secondary}$
Low-rise (1-3 storeys)	≤ 10	0.00	$0 + \frac{(n-10)}{40} \times 0.6$	≥ 50	0.60
Medium-rise (4 to 10 storeys)	≤ 20	0.60	$0.6 + \frac{(n-20)}{80} \times 0.2$	≥ 100	0.80
High-rise (>10 storeys)	≤ 100	0.80	$0.8 + \frac{(n-100)}{300} \times 0.2$	≥ 400	1.00

Table notes: Secondary circulation pump energy ($PE_{secondary}$) is in kWh of pump energy per kL of hot water supplied. The number of dwellings in the development supplied by the central hot water system is *n*. Source Table 6.39, BASIX documentation, Section 6: Energy & Greenhouse Gas Emissions for central hot water systems (2018).

These energy consumption estimates are likely to be fairly conservative in that they are likely to reflect the performance of a continuous circulation system. Systems with sophisticated controls make have somewhat lower pumping energy (and lower associated heat losses in circulating pipes) as noted in the previous section.

Conclusion

Electrical energy consumed for pumping purposes is peculiar to CDHW and is not factored into the existing DTS method in NCC 2022. This energy consumption is however relatively small, between 2% and 4% (depending on system configuration) of total energy associated with hot water demand.

There are two main options for dealing with this:

1. For simplicity this relatively small amount of energy could be ignored. Whilst this will tend to underestimate total energy consumption, this approach has the advantage of negating the need for any PVs to be installed in circumstances where a developer chooses to install the benchmark water

heating system (5 star rated gas instantaneous system in combination with a benchmark heating/cooling system)

2. Alternatively, a calculation of the required installed PV capacity needed to offset the pumping energy consumption could form part of the DTS method for CDHW systems in a similar fashion to the way that pool pump energy is factored into the DTS calculation (i.e., as an add-on). This may mean that some Class 2 dwellings will require the installation of a small amount of additional PV that would not otherwise be required if pumping energy was not factored in. This requirement would however be relatively modest as a combined primary and secondary pumping system (i.e., worst-case scenario) is expected to consume only about 50kWh per annum per apartment. This would require about 125W of installed PV capacity to offset the cost associated with delivering 50 kWh/annum (assumes approximately 1500 kWh generated for each kW of installed capacity and that 25% of PV generation is directly consumed by the pumps and the remaining 75% is exported to the grid at about 1/6 the value of imported electricity). This means that a standard domestic sized 6kW capacity PV system could offset the pumping requirements associated with a block of 50 apartments. Also, because the pumping system would be connected to the common property power supply system the set-up of the PV system in terms of metering arrangements would be relatively straight forward compared to delivering PV generated electricity to behind the meters of individual apartments.

3.7 Solar contribution

Solar thermal systems use primarily direct solar radiation to heat a dark metal plate (usually steel) that is bonded to a copper water pipe that circulates water from a storage tank and transfers heat energy back to the storage vessel. Collectors are glazed to maximise heat gain and the metal plate can be treated with selective coatings to enhance heat gain. Systems can operate on a thermosiphon principle (typically where the storage tank is located above the collector and heated water drives circulation via convection – so called close coupled systems) or using a pump where the tank is located some distance from the collector (remote systems). The most common residential hot water solar collectors available are flat plate and have an aperture (area) of around 2 m² per collector and most systems are typically made up of 2 collectors (with a total aperture of around 4 m² per household). As a benchmark, an average 200 m² Class 1 dwelling would have a solar collector of around 4 m², equating to around 1 m² of collector area for each 50 m² of floor area.

Solar thermal systems that are dedicated to a single dwelling are relatively uncommon in Class 2 dwellings because access to the roof space is often quite difficult in a multi-storey configuration, except perhaps for dwellings on the top level. A BIS Oxford Economics report *The Hot Water Systems Market in Australia* (July 2022) found that only 5% of Class 2 households (noted as Flats/Units) had solar water heaters compared to 14% of households in detached dwellings (noting that this data is self-reported). Many of these will be on low-rise apartments, which will predominantly have dedicated water heaters for each dwelling.

Using a base assumption that 20% of a roof area may be available for solar thermal collectors on a Class 2 dwelling, it would appear that low-rise apartments up to 3 storeys should have no trouble accommodating a reasonable sized array of solar thermal collectors. However, most low-rise apartments are unlikely to have centrally provided services for hot water, so this is not likely to be a common situation in practice.

Medium-rise apartments (4 to 10 storeys) are more likely to have centrally provided services for hot water, but the available roof area per dwelling is likely to be quite constrained. For high-rise apartments of more than 10 storeys, many will have centrally provided services for hot water, but the available roof area is likely to be highly constrained and difficult to access. Heat loss between the collectors and the storage tank can be significant where the central hot water plant is located far from the solar collectors.

The complexity with a solar thermal system feeding into centrally provided services for hot water is that the solar collectors need to have a storage vessel to accumulate solar thermal energy and, for the highest efficiency of operation, the stored water needs to be as cold as possible to allow the solar thermal to transfer the maximum amount of energy. If, for example, a gas instantaneous system was keeping the stored hot water supply at 60°C continuously, drawing this water into the solar collector would result in little heat gain except on the hottest day. For stand-alone solar systems, a single storage tank is used and hot water generated is circulated at low speed into the storage tank ensuring good stratification (hot water at the top and cold water at the bottom). This works where the hot water demand is small relative to the tank storage volume.

In central hot water systems, the total hot water demand is relatively high comparted to the volume of stored hot water. In this case solar thermal collectors in a central hot water system need to operate on a separate pre-heater tank that then feeds into the main hot water storage system as hot water is used because the primary hot water storage needs to be kept at its operating temperature. This requires additional storage and some associated extra heat loss for solar thermal systems linked to a central hot water system. Even if the preheater tank only increases the cold-water supply temperature by a modest amount, this will save significant energy on the main hot water system (by effectively pre-warming the cold water supply). While it is technically feasible and probably fairly efficient, there is additional capital required and more sophisticated control systems need to be installed.

The solar contribution provided by solar thermal systems is very non-linear for small hot water loads with large collector areas. However, for larger hot water demands, the solar contribution is fairly linear in proportion to the collector area provided, as illustrated in Figure 12.

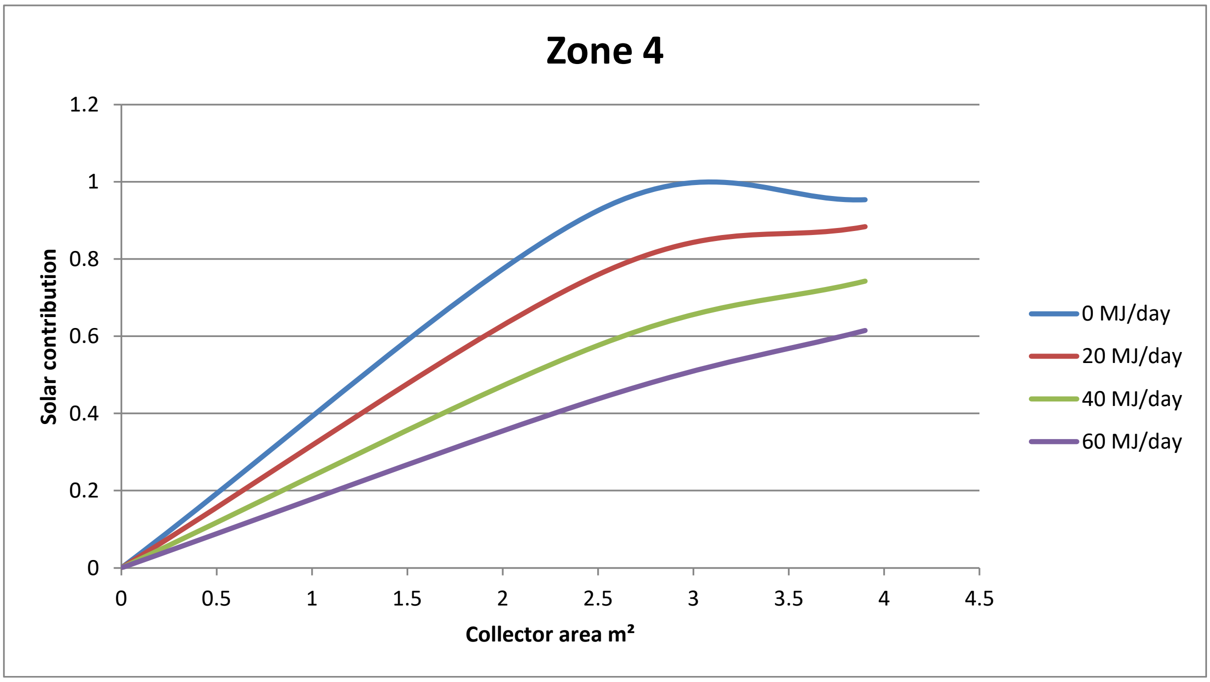

Figure 12: Change in solar contribution with changes in collector area for different hot water demands

Conclusion

The current DTS method in NCC 2022 assumes that any solar boosted system has a solar contribution minimum of 60% in Zone 3, which is the minimum requirement for solar water heaters registered with the CER. Whilst this is reasonable for a Class 1 dwelling, for a Class 2 dwelling, particularly mid- and high-rise blocks, this is by no means certain due to constraints in available roof area.

A proposed approach for central hot water systems with solar thermal boosting, in terms of assumptions for DTS, is to calculate the solar contribution for a solar system in Zone 3 to qualify for STCs (60%) and to assume that this is achieved where the solar collector area exceeds 0.02 m^2 per m^2 of total dwelling floor area (i.e. 1m^2 per 50m^2 of floor area) supplied by the central hot water system.

The assumed solar contribution decreases linearly as that ratio decreases, resulting in a solar contribution of 0% where the solar collector area is 0 m^2. In terms of the existing DTS tables, this can be generated by weighting the base solar water heater performance and the conventional water heater performance in proportion to the ratio of solar collector area to floor area. For example, if a central hot water system had a solar collector area of 0.01 m^2 per m^2 of floor area serviced, this could be represented by a 0.5 weighting of a solar systems and a 0.5 weighting of a conventional system without solar. This weighting is represented as:

Solar weighting = $\frac{Area_{solar}}{0.02}$

Conventional weighting = 1 – Solar weighting

Where $Area_{solar}$ is the ratio of the total solar collector area to the total floor area in m^2 of Class 2 dwellings that are serviced by that solar water heater boosted central hot water system. Where $Area_{solar}$ is greater than 0.02, then the DTS approach should assume 100% solar water heater system type and zero conventional water heater system type weightings.

3.8 Summary / Findings

3.8.1 Summary

Based on the analysis in the preceding sections it appears that a DTS method for CDHW systems could reasonably be based on a concordance type methodology that equates commonly available CDHW systems with the range of stand-alone systems already covered in the NCC 2022 DTS method J3D14. There are, however, differences between the two types of domestic hot water systems and some adjustments to the methodology and/or minimum standards may be warranted to account for these differences.

In summary:

- Conversion Efficiency: CDHW systems are either directly comparable or (in most cases) slightly more efficient than the stand alone residential hot water systems assumed in the current NCC 2022 DTS method i.e., in respect of this parameter, application of the existing NCC 2022 DTS methodology to CDHW systems would be a conservative approach.
- Storage Losses: Storage losses from CDHW systems will almost always be lower than those that were assumed for Class 1 stand-alone hot water systems in the current NCC 2022 DTS method i.e., in respect of this parameter, application of the existing NCC 2022 DTS methodology to CDHW systems would be a conservative approach.
- Distribution Losses: distribution (circulation) losses from CDHW system from the central hot water system to the point of connection of the dwelling[9] will be higher than those that were assumed for Class 1 stand-alone hot water systems in the current NCC 2022 DTS method as these are assumed to be zero. However, it appears that circulation heat losses in central hot water systems are of a similar magnitude (in terms of the equivalent additional hot water demand) to storage heat losses in single dwelling stand-alone storage systems, so it can be assumed for modelling purposes that the application of the existing NCC 2022 DTS methodology to CDHW systems would provide broadly equivalent overall heat losses (storage plus circulation losses) compared to stand alone systems.
- Pump Energy: unlike stand-alone systems, many CDHW systems use circulating pumps. The energy use associated with such pumps, whilst quite modest (2-4% of total hot water energy demand), is not currently factored into the existing NCC 2022 DTS methodology.
- Solar Contribution: The current DTS method in NCC 2022 assumes that any solar boosted system has a solar contribution minimum of 60% in Zone 3. Whilst this is reasonable for a Class 1 dwelling, for a Class 2 dwelling,

[9] These circulation losses do not include water or energy losses from the distribution of hot water from the point of connection to the end use within the dwelling, which are accounted for in the assumed hot water demand for both Class 1 and Class 2 dwellings.

particularly medium-rise and high-rise blocks, this is by no means certain due to constraints in available roof area. Some form of adjustment in respect of the energy use associated with solar boosted systems when used in a CDHW system is warranted.

3.8.2 Key Findings

Finding 1
Overall better conversion efficiencies and lower storage losses associated with CDHW systems compared to stand-alone residential hot water systems (as assumed in the current NCC 2022 DTS method) will tend to counterbalance the greater distribution (circulation) losses associated with CDHWs. On this basis, differences in relation to these 3 parameters can reasonably be ignored for the purposes of formulating a DTS methodology for CDHW systems.

Finding 2
Given that the roof area available for solar thermal panels can be quite limited in a Class 2 building, provision in the DTS method for adjustments due to reduced solar contributions associated with solar boosted CDHW system installations are warranted.

Finding 3
Circulating pumps are a feature unique to many CDHW systems and are not at present accounted for in the NCC 2022 DTS method. Consideration should be given to factoring in such energy use, noting however that the added energy consumption is relatively small (2-4%) and omission of this factor in the interest of simplicity may be warranted.

4 Recommended DTS Solution

Based on the findings from the preceding sections, the proposed DTS method for determining the net equivalent energy usage of a SOU of a Class 2 building or Class 4 part of a building with a CDHW system is an adaptation of the current NCC 2022 DTS method.

The proposed method utilizes the same ABCB Standard but applies a concordance approach to match CDHW systems to the eight stand-alone systems as currently listed in the ABCB Standard. Analysis in the preceding chapters of this report indicates that such an approach will have only a minor impact on the accuracy of the net equivalent energy usage provided that a few additional factors are taken into account in the calculus, namely:

- An adjustment for solar boosted systems where the solar contributions associated with the solar boosted CDHW system is less than 60% in AS/NZS4234 Zone 3 (as is currently assumed in the ABCB Standard)
- The factoring in of the energy use associated with circulating pumps where present.

The proposed revised formula for calculating the net equivalent energy usage of a SOU of a Class 2 building or Class 4 part of a building is as follows:

$$(A \times E_E) + E_P + E_S + E_C - E_R - E_{RC}$$

where—

A = the floor area factor (for CDHW systems this is unchanged from current DTS provisions)

E_E = the main space conditioning and main water heater efficiency factor obtained from the ABCB Standard (for CDHW systems this is unchanged except that some additional provisions relating to system type selection and calculation of factors in relation to solar boosted CDHW systems – see Section 4.1 below)

E_P = the swimming pool pump energy usage (for CDHW systems this is unchanged from current DTS provisions)

E_S = the spa pump energy usage (for CDHW systems this is unchanged from current DTS provisions)

E_C = the CDHW systems circulating pumping energy usage (this is a new provision specific to CDHW systems – see Section 4.2 below)

E_R = the installed capacity of on-site photovoltaics apportioned to the SOU of a Class 2 building or Class 4 part of a building (for CDHW systems a second photovoltaics factor E_{RC} specific to CDHW systems has now been added - see below)

E_{RC} = the installed capacity of on-site photovoltaics dedicated to a central domestic hot water (CDHW) systems circulating pumps energy requirements to service the pumping energy consumption in respect of a SOU of a Class 2 building or Class 4 part of a building (this is a new provision specific to CDHW systems – see Section 4.3 below)

The proposed draft method in full is detailed in Appendix 1 – Proposed Changes to DTS Method and a worked example is provided in Appendix 2 – Worked Example

4.1 Changes to the E_E factor

In the proposed new DTS method, in respect of a SOU of a Class 2 building or Class 4 part of a building serviced by a central domestic hot water (CDHW) system, the use of the ABCB Standard is to be subject to two additional provisions as follows:

Additional provision 1
The type of water heater to be applied when using the ABCB Standard shall be as per the concordance table (see Table 2).

Additional provision 2
Where the central domestic hot water system includes solar boosting then the whole-of-house efficiency factor shall be determined by weighting the base solar water heater performance and the conventional water heater performance (i.e. same system type as the solar system but without collectors) in proportion to the ratio of solar collector area to floor area (where the benchmark for 100% solar boosted type hot water system is $1m^2$ collector area per $50m^2$ of floor area). If the CDHW system includes 0.02 m^2 of collector area per m^2 of floor area or more, then the base solar water heater option available in the current NCC 2022 DTS method is weighted at 100%. This weighting declines in a linear fashion as the collector area per m^2 of floor area decreases from 0.02 m^2 to zero at which point the conventional water heater is weighted at 100%.

This is proposed to be determined in accordance with the following formula:

$E_E = F_1 \times P_1 + F_2 \times P_2$

where—

E_E = the main space conditioning and main water heater efficiency factor; and

F_1 = The WOH Efficiency factor (from the ABCB Standard) for the type of <u>solar</u> boosted water heater

F_2 = The WOH Efficiency factor (from the from the ABCB Standard) for –

- In the case of solar boosted CDHW systems that use heat pump type heating as the auxiliary heating source a Heat Pump (Standard) type water heater[10]
- In the case of solar boosted CDHW systems that use gas type heating as the auxiliary heating source a Gas Storage type water heater

[10] This particular set-up (solar with heat pump auxiliary) cannot be accurately modelled using this method and the energy use will be overestimated (i.e., a very conservative estimate). A user would be better off using DTS method J3D15 (house energy software). However, if a user wants to use this elemental method it is recommended that the following caveat be applied so as to reduce the over-estimate of energy usage: "Where the main space conditioning and main water heater efficiency factor for the heat pump (F_2) is less than that of the solar boosted system (F_1) then set P_1 to zero and P_2 to 1".

- For all other types of solar boosted CDHW systems, an Electric Storage (Standard) type water heater

P_1 = The Solar percentage factor which must be determined in accordance with the following formula: *P1 = (AC / AS) / 0.02,*

where –

P_1 = The Solar percentage factor (note: irrespective of the values of AC and AS this factor cannot exceed 1.0)

A_C = The total area of all solar thermal collectors connected to the water heating system (m^2)

A_S = The total floor area of all SOU's serviced by the central domestic hot water system (m^2)

P_2 = The Non-solar percentage factor which must be determined in accordance with the following formula:
P2 = 1 – P1

where –

- P2 = The Non-Solar percentage factor
- P1 = The Solar percentage factor (note: this factor cannot exceed 1.0)

4.2 Circulating Pumping Energy Usage – E_C factor

An adjustment in respect of the energy use associated with circulating pumps, including both primary and secondary type pumps is now included in the DTS formula. Circulating pump energy associated with CDHW systems is formulated as an add-on to the calculation in the current method with separate components for both primary and secondary circulating pumps.

This is proposed to be determined in accordance with the following formula:

$E_C = LF \times (C_P + C_S \times NF)$

where—

E_C = the central domestic hot water (CDHW) systems circulating pumping energy usage.

LF = Hot water load factor. This is the portion of the annual electrical energy consumption of the circulating pump required to service the particular SOU. This is determined via a lookup table that correlates the floor area of the particular SOU with its hot water load factor (see Table 5).

The hot water load factors in the table are calculated firstly by correlating the floor area of the SOU with an equivalent number of occupants (as per the method used in the NCC 2022 DTS method – this is a non-linear relationship – see Figure 13) and in turn this is correlated with a hot water demand (assuming 40 litres per person/day).

Pump input energy factors per 1000 litres of hot water demand (derived from BASIX and assumed to be 1kWh/1000 litres pumped[11]) are then applied to determine the hot water load factor.

C_P = The primary circulating pump energy factor (if no primary circulating pump then C_P =0). This is a measure of the capacity of installed PV required to offset the societal cost of operating a CDHW systems circulating pump as needed to service the particular SOU.
This factor is determined via a lookup table based on the particular climate zone and jurisdiction in which the SOU is located (see Table 6).

The circulating pump energy factor takes into account the PV production per kW of installed PV capacity (according to the climate zone – these were derived from the analysis undertaken for the development of the NCC 2022 WOH provisions (EES 2021) and ranged from 1167 to 1666 kWh/kW installed PV capacity) and the relative societal cost values (also derived from the analysis undertaken for the development of the NCC 2022 WOH provisions (EES 2021)) of the:

- electrical consumption of the pump directly offset by the PV installation (assumed to constitute 25% of the PVs electricity production which is considered to be relatively conservative); and
- the remaining PV production (i.e., 75%) which is assumed to be exported to the grid

C_S = The secondary circulating pump energy factor (if no secondary circulating pump then C_S =0). This is determined using the same lookup table as used for determining the primary circulating pump energy factor (see above) and is based on the same principles.

NF = The total number of SOUs factor. This factor adjusts the pump input energy factors per 1000 litres of hot water demand according to the total number of SOUs serviced by the CDHW system. The base value of 1kWh/1000 litres (BASIX) applies to large developments. For smaller developments (with shorter pipe runs) this value is reduced as follows (this is a simplification of the method used by BASIX):

- less than 100 SOUs served = 0.6
- 100 to less than 400 SOUs served = 0.8
- 400 or more SOUs served = 1.0

Table 5: Hot Water Load Factors

Total floor area m^2	Load Factor*	Total floor area m^2	Load Factor	Total floor area m^2	Load Factor	Total floor area m^2	Load Factor
< 50	0.20	160–169	0.48	280–289	0.59	400–409	0.66
50–59	0.22	170–179	0.49	290–299	0.60	410–419	0.67
60–69	0.25	180–189	0.51	300–309	0.60	420–429	0.67
70–79	0.28	190–199	0.52	310–319	0.61	430–439	0.68
80–89	0.31	200–209	0.53	320–329	0.61	440–449	0.69

[11] This value applies to primary circulating pumps and represents a worst-case scenario for secondary pumps which applies in large developments with long pipe runs. This value is reduced for smaller developments via the NF factor (see below).

90–99	0.34	210–219	0.54	330–339	0.62	450–459	0.69
100–109	0.37	220–229	0.55	340–349	0.62	460–469	0.70
110–119	0.39	230–239	0.56	350–359	0.63	470–479	0.71
120–129	0.41	240–249	0.56	360–369	0.63	480–489	0.72
130–139	0.43	250–259	0.57	370–379	0.64	490–499	0.72
140–149	0.45	260–269	0.58	380–389	0.65	500	0.73
150–159	0.47	270–279	0.58	390–399	0.65	—	

* Load factor represents how many 100,000 litres of hot water is consumed per annum

Figure 13: Correlation between Floor Area and Number of Occupants (NCC 2022)

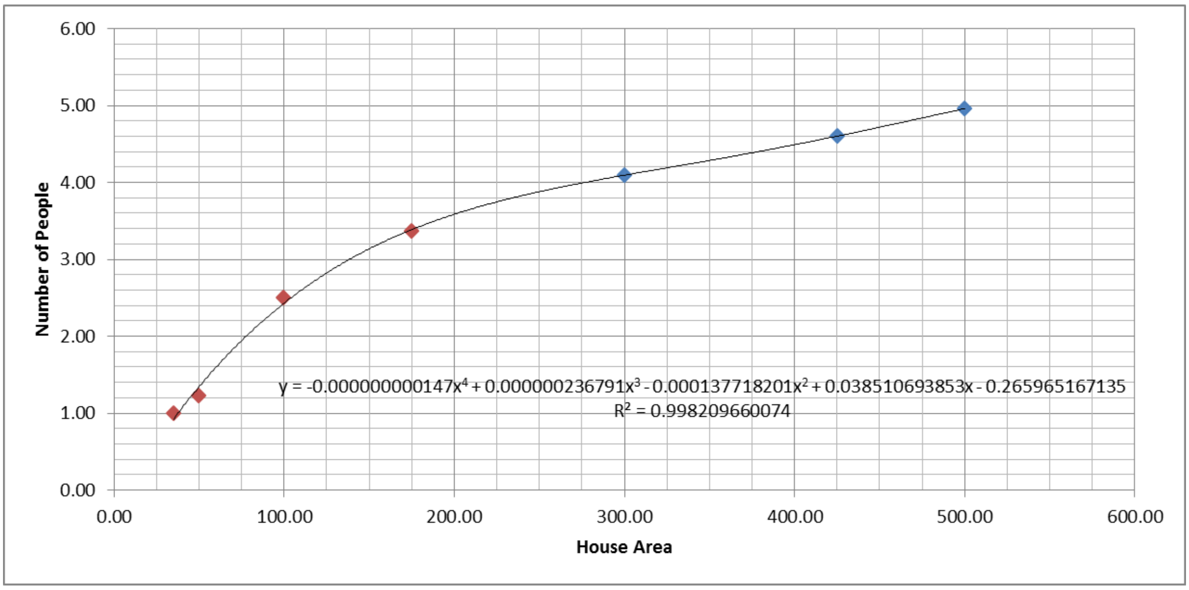

Table 6: Energy factor* for a Circulating Pump in a CDHW System (C_P or C_S)

Climate zone	ACT	NSW	NT	QLD	SA	TAS	Vic	WA
1	—	—	0.064	0.115	—	—	—	0.148
2	—	0.131	—	0.113	—	—	—	—
3	—	—	0.06	0.104	—	—	—	0.139
4	—	0.134	—	—	0.138	—	0.112	0.153
5	—	0.15	—	0.129	0.147	—	—	0.153
6	—	0.161	—	—	0.167	—	0.135	0.184
7	0.131	0.173	—	—	—	0.146	0.145	—
8	—	0.155	—	—	—	0.131	0.13	—

* The energy factor represents the estimated installed PV capacity needed to fully offset the societal cost of operating a circulating pump that pumps 100,000 litres of hot water per annum.

4.3 *Installed capacity of on-site photovoltaics E_R & E_{RC} Factors*

The NCC 2022 DTS method currently includes a factor to account for the installed capacity of on-site photovoltaics (E_R). In the revised method for CDHW systems it is proposed to split this factor into two components as follows:

E_R = the installed capacity of on-site photovoltaics apportioned to the SOU of a Class 2 building or Class 4 part of a building. This effectively provides an offset to the equipment energy usage. This is unchanged from current DTS provisions except that a second photovoltaics factor E_{RC} specific to CDHW systems has now been added - see below)

E_{RC} = the installed capacity of on-site photovoltaics dedicated to a central domestic hot water (CDHW) systems circulating pumps energy requirements to service the pumping energy consumption in respect of a SOU of a Class 2 building or Class 4 part of a building. This is a new provision specific to CDHW systems. In this case the PV must be directly connected via the electrical meter that services common area equipment in the building (including the CDHW circulating pump/s).

This is an important addition because in some cases, the only offsetting required by PVs may be in respect of circulating pumps that are invariably connected to a buildings common area meter rather than any one single SOUs meter. This provision does not preclude the offsetting via PVs connected behind individual SOU's meters (i.e., the E_R Factor) it is simply an additional option open to building designers.

One caveat that needs to be applied in respect of this provision is that the value of E_{R2} cannot exceed the central domestic hot water (CDHW) systems circulating pumping energy usage (E_C). That is, credit is only available up to the total energy usage assumed for the circulating pumps.

5 Recommendations for future development

The work undertaken in this report has been undertaken to inform changes to the existing WOH DTS Provisions, more refined provisions could be developed in future by undertaking the following recommendations:

Recommendation 1

It is recommended for the 2028 iteration of the NCC that a set of WOH efficiency factors should be tailored specifically for CDHW systems. Such factors could account for the known differences that exist between the energy use of the systems currently covered in the ABCB Standard (i.e., individual stand-alone systems) and CDHW. In addition, some more exotic system types only found in centralised systems could be specifically covered.

The advantages of providing a tailored set of WOH efficiency factors for CDHW systems in the ABCB Standard include:

- Reduced scope for user error compared to the concordance method recommended in this report for 2025.
- Improved accuracy compared to all other methods considered in this report
- Less demanding of building surveyors compared to the concordance method recommended in this report for 2025 i.e., set formulas and lookup tables for different central water heating scenarios.

Recommendation 2

As noted in Section 2 of this report, the developers of the ABCB Standard used a “First Generation WOH tool” to generate the tables, whereas the developers of the house energy software Deemed-to-Satisfy method (J3D15) use “Second Generation WOH tools” as endorsed by NatHERS. Given this, it is recommended that all tables in the ABCB Standard be re-generated and re published in 2028 using the latest NatHERS benchmarking tool with CDHW system modules loaded (these should be available in 2024) to generate the tables. This will provide enhanced alignment between J3D14: elemental WOH Deemed-to-Satisfy method and J3D15: the house energy software deemed- to-satisfy method.

Recommendation 3

The use of solar boosting in CDHW systems is not well understood, particularly in respect of the collector areas utilized. Some market research in this area would be helpful.

6 References

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7 Appendices

7.1 Appendix 1 – Proposed Changes to DTS Method

Note: The following text has been taken directly from NCC 2022 Volume 1 clause J3D14 and then modified in accordance with the recommendations contained within this report. The changes have been applied using tracked changes to assist the reader in discern the exact extent of changes to the original text.

J3D14 Net equivalent energy usage of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[New for 2022]

(1) The net equivalent energy usage of a *sole-occupancy unit* of a Class 2 building or Class 4 part of a building, calculated in accordance with (a), must not exceed the allowance calculated in accordance with (b)—

(a) $(A \times E_E) + E_P + E_S + E_C - E_R - E_{RC}$, where—

(i) A = the floor area factor obtained from multiplying the total floor area by the adjustment factor in Table J3D14a; and

(ii) E_E = the *main space conditioning* and *main water heater* efficiency factor obtained from the ABCB Standard for WOH Efficiency Factors. In respect of a *sole-occupancy unit* of a Class 2 building or Class 4 part of a building serviced by a central domestic hot water (CDHW) system, the use of the ABCB Standard for WOH Efficiency Factors is subject to the provisions in (5); and

(iii) E_P = the swimming pool pump energy usage in (2); and

(iv) E_S = the spa pump energy usage in (3); and

(v) E_C = where applicable, the central domestic hot water (CDHW) systems circulating pumping energy usage in (4); and

(vi) E_R = the installed capacity of on-site photovoltaics apportioned to the *sole-occupancy unit* of a Class 2 building or Class 4 part of a building (kW); and

(vii) E_{RC} = the installed capacity of on-site photovoltaics dedicated to a central domestic hot water (CDHW) systems circulating pumps energy requirements to service the pumping energy consumption in respect of a sole-occupancy unit of a Class 2 building or Class 4 part of a building (kW). This value cannot exceed the central domestic hot water (CDHW) systems circulating pumping energy usage (E_C*) in (4). The PV must be directly connected via the electrical meter that services common area equipment in the building (including the CDHW circulating pump/s)*

(b) $A \times E_F$, where—

(i) A = the floor area factor obtained from multiplying the total floor area by the adjustment factor in Table J3D14a; and

(ii) E_F = the energy factor obtained from Table J3D14b**.**

(2) The swimming pool pump energy usage (EP) must be determined in accordance with the following formula:

$E_P = V \times FP/1000$, where—

(a) E_P = the swimming pool pump energy usage; and

(b) V = the volume of the swimming pool to the nearest 1000 litres; and

(c) FP = the swimming pool pump factor in Table 13.6.2c of the ABCB Housing Provisions.

(3) The spa pump energy usage (E_S) must be determined in accordance with the following formula: $E_S = V \times FSB/100$

,where—

(a) ES = the spa pump energy usage; and

(b) V = the volume of the spa to the nearest 100 litres; and

(c) FSB = the spa pump factor in Table 13.6.2d of the ABCB Housing Provisions.

(4) The central domestic hot water (CDHW) systems circulating pumping energy (E_C) includes for energy consumption of up to two different pump types:

(i) Primary pump energy, where water is circulated between a storage tank and a heating unit (e.g. a gas instantaneous water heater) that is external to the storage tank.

(ii) Secondary pump energy, this is used to circulate hot water from the central hot water system to the dwellings that are being supplied, usually via a closed loop system.

Circulating pumping energy (E_C) must be determined in accordance with the following formula:

$E_C = LF \times (C_P + C_S \times NF)$ where—

(a) E_C = the central domestic hot water (CDHW) systems circulating pumping energy usage; and

(b) LF = Hot water load factor in Table J3D14d

(c) C_P = The primary circulating pump energy factor in Table J3D14e (if no primary circulating pump then C_P=0); and

(d) C_S = The secondary circulating pump energy factor in Table J3D14e (if no secondary circulating pump then C_S=0)

(e) *NF = The total number of SOU's factor. To be calculated according to the number of SOU's serviced by the CDHW system as follows:*

(iii) *< 100 SOUs served = 0.6*

(iv) *100 to < 400 SOUs served = 0.8*

(v) *400 or more SOUs served = 1.0*

(5) Where a *sole-occupancy unit* of a Class 2 building or Class 4 part of a building is serviced by a central domestic hot water system then use of the ABCB Standard for WOH Efficiency Factors is subject to the following provisions

(a) the type of water heater to be applied when using the ABCB Standard for WOH Efficiency Factors shall be in accordance with table J3D14c

(b) where the central domestic hot water system includes solar boosting (types 7,8,9,10,15,16,17 and 18 in table J3D14c) then the whole-of-house efficiency factor shall be determined in accordance with the following formula: $E_E = F_1 \times P_1 + F_2 \times P_2$ where—

(i) E_E = the *main space conditioning* and *main water heater* efficiency factor; and

(ii) F_1 = The WOH Efficiency factor (from the ABCB Standard for WOH Efficiency Factors) for the type of solar boosted water heater

(iii) F_2 = The WOH Efficiency factor (from the from the ABCB Standard for WOH Efficiency Factors) for –

- *In the case of solar boosted CDHW systems that use heat pump type heating as the auxiliary heating source a Heat Pump (Standard) type water heater. Where the main space conditioning and main water heater efficiency factor for the heat pump (F_2) is less than that of the solar boosted system (F_1) then set P_1 to zero and P_2 to 1. Note: DTS method J3D15 (house energy software) is likely to provide significantly lower net equivalent energy usage results in respect of solar water heaters with auxiliary heating from a heat pump than this DTS method.*
- *In the case of solar boosted CDHW systems that use gas type heating as the auxiliary heating source a Gas Storage type water heater*
- *For all other types of solar boosted CDHW systems, an Electric Storage (Standard) type water heater*

(iv) P_1 = The Solar percentage factor which must be determined in accordance with the following formula: $P_1 = (A_C / A_S) / 0.02$, where –

- P_1 = The Solar percentage factor (note: irrespective of the values of A_C and A_S this factor cannot exceed 1.0)
- A_C = The total area of all solar thermal collectors connected to the water heating system (m^2)
- A_S = The total floor area of all SOU's serviced by the central domestic hot water system (m^2)

(v) P_2 = The Non Solar percentage factor which must be determined in accordance with the following formula: $P_2 = 1 - P_1$ where –

- P_2 = The Non-Solar percentage factor
- P_1 = The Solar percentage factor (note: this factor cannot exceed 1.0)

Table J3D14a: Floor area adjustment factor for a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor	Total floor area m^2	Floor area factor
< 50	0.0123	160–169	0.0097	280–289	0.0087	400–409	0.0080
50–59	0.0119	170–179	0.0096	290–299	0.0086	410–419	0.0079
60–69	0.0116	180–189	0.0095	300–309	0.0085	420–429	0.0079
70–79	0.0113	190–199	0.0094	310–319	0.0085	430–439	0.0078
80–89	0.0111	200–209	0.0093	320–329	0.0084	440–449	0.0078
90–99	0.0108	210–219	0.0092	330–339	0.0083	450–459	0.0077
100–109	0.0106	220–229	0.0091	340–349	0.0083	460–469	0.0077
110–119	0.0105	230–239	0.0090	350–359	0.0082	470–479	0.0077
120–129	0.0103	240–249	0.0090	360–369	0.0082	480–489	0.0076
130–139	0.0101	250–259	0.0089	370–379	0.0081	490–499	0.0076
140–149	0.0100	260–269	0.0088	380–389	0.0081	500	0.0075
150–159	0.0099	270–279	0.0087	390–399	0.0080	—	—

Table Notes

(1) The total floor area is measured within the inside face of the *external walls* of the *sole-occupancy unit* and includes any conditioned attached Class 10a building.

(2) Where values fall between ranges given, the floor area must be rounded up to the nearest whole square metres of floor area.

Table J3D14b: Energy factor for a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

Climate zone	ACT	NSW	NT	QLD	SA	TAS	Vic	WA
1	—	—	2.73	3.95	—	—	—	4.64
2	—	1.88	—	2.54	—	—	—	—
3	—	—	1.76	3.52	—	—	—	4.10
4	—	2.57	—	—	2.65	—	1.79	3.34
5	—	2.50	—	3.26	2.56	—	—	3.36
6	—	3.43	—	—	3.58	—	2.32	4.58
7	3.66	3.32	—	—	—	4.41	2.32	—
8	—	5.70	—	—	—	5.60	4.02	—

Table J3D14c: Type of water heater to be applied when using the ABCB Standard for WOH Efficiency Factors with CDHW systems

CDHW System Number	Type of Central Domestic Hot Water System	Equivalent Stand-alone domestic hot water system type (as defined in the ABCB Standard for WOH Efficiency Factors) to be applied
1	Single Electric Storage (Boiler)	Electric storage (standard or off-peak*)
2	Manifolded Electric Storage	Electric storage (standard or off-peak*)
3	Manifolded Electric Instantaneous – no storage	Electric storage (standard or off-peak*)
4	Manifolded Electric Instantaneous – with storage	Electric storage (standard or off-peak*)
5	Air-sourced Heat Pump – with storage	Heat pump (standard or off-peak*)
6	Manifolded Air source heat pumps – with storage	Heat pump (standard or off-peak*)
7	Solar Boosted Electric – with storage	Solar Electric (standard)
8	Manifolded Solar Boosted Electric – with storage	Solar Electric (standard)
9	Solar Boosted Heat Pump – with storage	Either, Solar Electric (standard) or Heat pump (standard or off-peak*)
10	Manifolded Solar Boosted Heat Pump – with storage	Either, Solar Electric (standard) or Heat pump (standard or off-peak*)
11	Gas Storage (Boiler)	Gas Storage
12	Manifolded gas storage	Gas Storage
13	Manifolded Gas Instantaneous – no storage	Gas Instantaneous
14	Manifolded Gas Instantaneous – with storage	Gas Storage
15	Solar Boosted Gas Storage	Solar Gas
16	Manifolded Solar Boosted Gas storage	Solar Gas
17	Solar Boosted Instantaneous Gas with storage	Solar Gas
18	Manifold Solar Boosted Instantaneous Gas – with storage	Solar Gas
19	Gas boosted air-sourced heat pump	Heat pump (standard)
20	All other electrically heated types of CDHW system	Electric storage (standard or off-peak*)
21	All other gas heated types of CDHW system	Gas Storage

* Select standard or off-peak type as applicable to the particular CDHW system electrical metering type

to be used – generally this will be a standard, not an off-peak system type.

Table J3D14d: Hot Water Load Factor for a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

Total floor area m^2	Load Factor	Total floor area m^2	Load Factor	Total floor area m^2	Load Factor	Total floor area m^2	Load Factor
< 50	0.20	160–169	0.48	280–289	0.59	400–409	0.66
50–59	0.22	170–179	0.49	290–299	0.60	410–419	0.67
60–69	0.25	180–189	0.51	300–309	0.60	420–429	0.67
70–79	0.28	190–199	0.52	310–319	0.61	430–439	0.68
80–89	0.31	200–209	0.53	320–329	0.61	440–449	0.69
90–99	0.34	210–219	0.54	330–339	0.62	450–459	0.69
100–109	0.37	220–229	0.55	340–349	0.62	460–469	0.70
110–119	0.39	230–239	0.56	350–359	0.63	470–479	0.71
120–129	0.41	240–249	0.56	360–369	0.63	480–489	0.72
130–139	0.43	250–259	0.57	370–379	0.64	490–499	0.72
140–149	0.45	260–269	0.58	380–389	0.65	500	0.73
150–159	0.47	270–279	0.58	390–399	0.65	—	

Table Notes

(1) The total floor area is measured within the inside face of the *external walls* of the *sole-occupancy unit* and includes any conditioned attached Class 10a building.

(2) Where values fall between ranges given, the floor area must be rounded up to the nearest whole square metres of floor area.

Table J3D14e: Energy factor for a Circulating Pump in a CDHW System (C_P or C_S)

Climate zone	ACT	NSW	NT	QLD	SA	TAS	Vic	WA
1	—	—	0.064	0.115	—	—	—	0.148
2	—	0.131	—	0.113	—	—	—	—
3	—	—	0.06	0.104	—	—	—	0.139
4	—	0.134	—	—	0.138	—	0.112	0.153
5	—	0.15	—	0.129	0.147	—	—	0.153
6	—	0.161	—	—	0.167	—	0.135	0.184
7	0.131	0.173	—	—	—	0.146	0.145	—
8	—	0.155	—	—	—	0.131	0.13	—

7.2 Appendix 2 – Worked Example

BUILDING INFORMATION

GENERAL	Building Classification	2	
	Number of apartments	50	units
	Total Floor Area (A_S)	3750	
	State	Victoria	
	Climate Zone	6	
	SOU Floor Area	75	m^2
SPACE COND	Space Heater Type	Non ducted heat pump	
	Space Heater Performance	3	stars
	Space Cooler Type	Non ducted heat pump	
	Space Cooler Performance	3	stars
WATER HEATING	CDHW System Type	Solar Boosted Electric – with storage	
	Equivalent Stand-Alone Water Heater	Electrically boosted Solar	source Table JD314c
	Solar Thermal panel area (A_C)	65	m^2
	Primary circulating pump	No	
	Secondary circulating pump	Yes	
OTHER	Pool	Nil	
	SPA	Nil	
PVs	PVs servicing SOUs (E_{R1})	0	kW
	PVs servicing CDHW circulating pump (E_{R2})	0	kW

CALCULATION

	Net Equivalent Energy	**$(A \times E_E) + E_P + E_S + E_C - E_{R1} - E_{R2}$**	
STEP 1	**Determine A - the floor area factor**		
	Floor area adjustment Factor	75	
	Floor area adjustment Factor	0.0113	source Table JD314a
	Floor Area Factor (A)	**0.8475**	
STEP 2	**Determine E_E - main space and water heating factor ($E_E = F_1 \times P_1 + F_2 \times P_2$)**		
	E_E for solar system (F_1)	2.027	source: Standard
	E_E for non solar system (F_2)	3.467	source: Standard
	P_1 ($A_C/A_S/0.02$)	0.867	
	P_2 ($1 - P_1$)	0.133	
	E_E (weighted $= F_1 \times P_1 + F_2 \times P_2$)	**2.219**	
STEP 3	**Determine Pool pump energy usage (E_P)**	**0**	
STEP 4	**DetermineSpa pump energy usage (E_S)**	**0**	
STEP 5	**Determine Circulating pump energy usage ($E_C = LF \times (C_P + C_S \times NF)$)**		
	Hot water load factor (LF)	0.28	source Table JD314d
	The primary circulating pump energy (C_P)	0	
	The secondary circulating pump energy (C_S)	0.135	source Table JD314e
	No. of SOU Factor (NF)	0.6	source clause J3D14 (4)(e)
	Circulating pump energy usage (E_C)	**0.02268**	
RESULT	**Net Equivalent Energy**	**1.9032825**	

Allowance

	Allowance = A x E_F		
	Floor Area Factor (A) - see above	0.8475	
	Energy Factor (E_F)	2.32	source Table JD314b
	Allowance (A x E_F)	**1.9662**	
OUTCOME	**Net Equivalent Energy is less than the Allowance - therefore no PV is required**		