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Gabrielle Kuiper || IEEFA Guest Contributor

Australia needs more efficient, smarter home hot water systems

- *Improving efficiency and flexibility of water heating can significantly reduce this major cost for households and for the entire electricity system.*
- *Hot water systems in Australia should be dynamically managed, to heat when there is abundant renewable electricity.*
- *Government subsidies and standards should be updated to ensure all hot water systems sold in Australia are efficient and smart, as a futureproofing and cost-saving measure.*

Water heating offers the largest flexible demand opportunity

A century after Australia's first coal-fired power station opened, household rooftop solar systems across the country collectively produce more electricity than any single coal-fired power station. Yet electricity distribution networks still rely on 1950s technology to manage household water heating with "ripple control" to soak up "excess" coal-fired electricity available overnight.

While there is abundant rooftop solar generation in the middle of the day, demand is highest in the 4pm-8pm evening peak period. Hot water systems (HWS), which account for about a quarter of household load, offer the biggest and cheapest solution for this mismatch by shifting a significant amount of the demand to the middle of the day.

While some of the solar energy generated can be stored in batteries, introducing flexible demand can reduce household energy bills, and is cheaper than storage.

For more than 70 years, ripple control has been used in most electric hot water systems by sending signals overnight to separate HWS units on controlled load circuits. This long history of overnight electric water heating demonstrates consumers' acceptance of flexible water heating.

Gas hot water systems are common, especially in southern Australia. They present a significant opportunity for efficient and smart electrification. As IEEFA analysis has shown, if gas appliances were required to be replaced with efficient electric alternatives at their end of life, the average Victorian household could save $1,200 a year on its energy bills. Heat pump hot water systems are three to four times more efficient than resistive electric (Table 1), substantially reducing electricity use. However, not all building types (especially apartments) have suitable space for heat pumps, which in most cases need to be installed outside.

Table 1: Comparison of main water heater types

Type	Peak electrical load	Cost (excluding installation)	Space requirements	Brands
Electric resistance storage	Typical rating 2.4–5.0 kW	Start at <$1000	50–400 L tank requires more space than instantaneous units. Can be installed indoors or outdoors.	Rheem, Rinnai, Stiebel Eltron
Electric heat pump	Typical rating <1 kW for heat pump and 2–5 kW for units with resistance element	$2000–4000	Usually installed outdoors, though split systems can include tank indoors and compressor outdoors. Indoor units need to be ducted for ventilation.	Chromagen, Bosch, Midea, Stiebel Eltron, Sanden, Rinnai, Daikin, Dux

Source: University of Technology Sydney (UTS)

UTS researchers developed four scenarios for the electrification of domestic hot water with flexible demand potential (Table 2). Under the Rapid Electrification scenario, with no sales of residential gas HWS after 2025, all systems are electrified and able to be dynamically managed by 2035. Consumers would save up to $6.7 billion a year by 2040, with 22 gigawatts (GW) or 45 gigawatt-hours (GWh) per day of flexible demand available, roughly two thirds of peak demand. Under the Highly Flexible scenario, $6.7 billion would also be saved, but with even more flexible demand at 24GW or 50GWh/day due to a greater use of electric resistance HWS.

Table 2: Flexible demand capacity and depth scenarios for 2040

Scenario	Flexible demand potential	Percentage of AEMO forecast	Flexible demand depth	Percentage of AEMO forecast
	(GW)	(%)	(GWh/day)	(%)
Business as Usual	9	25	19	23
Highly Flexible	24	70	50	61
Highly Efficient	17	48	34	41
Rapid Electrification	22	64	45	55

Source: University of Technology Sydney

UTS found these savings do not account for the additional system benefits from mitigating minimum demand that are difficult to quantify, such as “increased ease of managing voltage, increased efficacy of emergency frequency control schemes, and higher likelihood of having a stable load for system restart services to successfully enable grid operation after a system outage”. Also many resistive electric HWS units create high demand at night (typically from 11pm-2am) when electricity with a higher carbon intensity is used in the absence of solar.

Preliminary analysis by Intellihub found wholesale energy cost savings from hot water flexibility vary from $35 a year per household in Tasmania, to $203 in South Australia (SA), with a National Electricity Market (NEM) average of $130. These savings are larger where solar electricity is diverted to charge HWS. Savings depend on the size of the solar system and HWS, but can be significant given the difference between, for example, a retail rate of 30 cents per kilowatt hour (kWh) to heat the water, and a 5c/kWh export tariff (or zero if the solar is constrained from exporting).

Even for those without solar, running a heat pump HWS during the day can help absorb "excess" solar output available in the local grid, and uses electricity with lower emissions intensity. Retailers are increasingly offering cheaper electricity during the day to incentivise this kind of behaviour. Additional savings can be found in retailers' behavioural demand response programs such as Origin's Spike and AGL's Peak Energy Rewards.

While it's not possible to calculate a standard retail saving on consumer electricity bills from flexible HWS, we know there are cost savings, especially for consumers who can heat water with their own solar or take advantage of "solar sponge" retail tariffs in the middle of the day and/or participate in retail demand response programs. Flexible hot water not only reduces costs for its owners, but for the system as a whole if it is dynamically managed to soak up renewable energy when it is abundant and network capacity is available. In these ways, flexible hot water can lower bills for all electricity system users.

No efficiency standards for solar, heat pump and electric HWS

The NEM is a long way from realising the potential of UTS's Rapid Electrification scenario, which means households are paying more than is optimum for their hot water, and all consumers are paying more for electricity than necessary .

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The most glaring omission, however, is the lack of energy efficiency requirements for solar, heat pump and electric instantaneous water heaters. A consumer looking to buy a new HWS cannot rely on a Minimum Energy Performance Standard (MEPS), as there is for electric storage hot water systems, and even for these systems the standards date from 2012.

MEPS acts like a quality standard. Without MEPS and Greenhouse and Energy Minimum Standards (GEMS), there have been concerns about many of the cheaper heat pumps on sale in Australia. The Energy Efficiency Council's new Roadmap for Heat Pump Hot Water Systems makes several recommendations to build quality and confidence in the systems on sale in Australia.

On 19 July 2024, Energy Ministers agreed to make the implementation of MEPS for heat pump HWS a high priority. This is crucial, as are arrangements that avoid "grandfathering" existing systems.

Further, there are no GEMS labelling requirements, or "star ratings", for HWS of any kind – gas or electric. A gas industry energy labelling scheme for gas hot water units is based on about 200 litres/day of hot water consumption, well above the average of about 125L. This gives the impression that most gas home storage HWS are more efficient than they actually are. Technical data on the energy efficiency performance of HWS is compiled by the Clean Energy Regulator; however it is not easily accessed, let alone understood, by consumers. GEMS labelling could help address this, but more research is needed on to how to influence consumer decision-making – especially because most decisions on HWS are made by builders or plumbers.

Star ratings and energy performance standards are important, but don't account for the flexible use of the appliance. HWS can be managed to heat at times of abundant renewable generation, which can lower consumers' energy bills and/or support the grid. This can be done in two ways:

- **Passive management** – through timers on devices or ripple control times set by distribution networks for systems on controlled load (CL) circuits and tariffs, or;
- **Dynamic management** – through dynamic ripple control via WiFi or other means where water heating periods are set by the owner, or a third party with the owner's permission, and where usage can be adjusted dynamically in response to changing conditions.

A flexible appliance is one that can be either passively or dynamically managed. But as we move to higher penetrations of renewable energy, dynamic management will become increasingly helpful. It is for this reason we have chosen to use the term "smart" for appliances that can be dynamically managed. With more variable renewables, we will likely need more smart hot water systems.

To this end, it's important that MEPS evolve to include minimum flexibility requirements for all major household appliances using modern approaches that ensure consumers retain control, including the ability to override any passive or dynamic management. Ideally, HWS would be smart (as above), interoperable (able to communicate with other devices and home energy management systems), and support verification and validation over secure two-way communications.

Stringent requirements for heat pump HWS to meet performance, flexibility and durability standards could be applied quickly by making them a requirement to access government incentives such as the Renewable Energy Target (RET) and state schemes. This could create greater impetus than MEPS and GEMS energy labels.

The issue being discussed here is not whether or by whom HWS will be managed, but whether the HWS can be flexible. Any passive or dynamic management of a new hot water system will be the owner's choice. It is also important to note that most Australian households with electric hot water have had them passively managed by ripple control for about 70 years, and very few people would have known or objected to this.

Almost all hot water subsidy programs lack smarts

Most states offer some form of subsidies, primarily for heat pump hot water systems (Table 3). South Australia still appears to subsidise the installation of "efficient" gas HWS. Victoria is the only state to require any appliance flexibility requirements – a timer – to qualify a heat pump hot water subsidy. The lack of requirements for subsidised HWS to be "smart" is a missed opportunity to create cheap, flexible demand that grows with every subsidised HWS installed.

> **The lack of HWS management requirements in state subsidies is a missed opportunity to create cheap, flexible demand that grows with every subsidised hot water system installed.**

Table 3: HWS subsidies available in Australia by jurisdiction

Jurisdiction	Rebate scheme	Details
Common-wealth	Small Technology Certificates (STCs) for solar hot water and air-sourced heat pumps under the RET	The number of STCs awarded is based on computer modelling of the energy savings for a typical daily hot water usage pattern, historical hourly temperature data, and an assumed daily usage of about 200L, compared with typical consumption of about 125L. STC equals 1MWh of electricity, worth about $40. STCs for new installations vary depending on the size of the system, where it is installed and the year of installation (reducing to zero by 2031).
VIC	Solar Victoria rebate (Solar Homes program)	The hot water rebate of up to $1,000 is available on eligible heat pump and solar HWS where the taxable household income is less than $210,000 a year. From 1 July 2024, the list of eligible hot water products includes only those that: • are registered as being tested for energy consumption performance in accordance with AS/NZS 4234:2021 under the VEU program; • contain only low Global Warming Potential (GWP) refrigerants, i.e. below 700; and • have an end-user configurable integrated timer on the outside of the unit, or one that can be connected to a solar system to run the HWS during periods of solar generation. Note: The timer requirement is intended to enable end users to maximise self-consumption and align times of operation with their needs – a policy objective of the program. Solar Victoria recommends that the installed system should include an open communication protocol. While there is no definition provided, an open communication protocol is understood to means it is possible to communicate with the device without using proprietary signals. In Australia, a Common Smart Inverter Profile (CSIP) has been developed as a standardised minimum communication protocol for Distributed Energy Resources (DER). This recommendation is an early signal to the market that Solar Victoria may introduce a mandatory requirement regarding this. If this recommendation progresses to a mandatory requirement, industry will be consulted on which protocol(s) are appropriate and achievable.
	Victorian Energy Upgrades (VEU)	Eligible water heating activities include: • electric boosted solar replacing electric resistance (activity 1C) • heat pump replacing electric resistance (activity 1D) • heat pump replacing gas/LPG (activity 3C) • electric boosted solar replacing gas/LPG (activity 3D) Note: As most water heater upgrades in Victoria receive both a Solar Homes and VEU incentive, the Solar Victoria product requirement has become a de facto requirement for VEU. The VEU program has committed to a further review of its existing water and space heating activities in 2025.
NSW	Peak Demand Reduction Scheme (PDRS)	Installation of technologies or activities that save energy in the summer peak demand period (4pm-8pm) are eligible to create Peak Reduction Certificates (PRCs). This only requires passive management, not dynamic management for hot water to be moved outside this period. Note: Only “large heat pump water heaters” are eligible. The scheme has limited “the commercial water heater activity to larger units that cannot receive Small Scale Renewable Energy Scheme incentives”.
	Energy Savings Scheme (ESS)	Solar and heat pump water heaters became eligible under this scheme in April 2022. This only rewards energy savings not flexibility.
SA	Retailer Energy Productivity Scheme (REPS)	Replace or upgrade water heater (includes gas) Switch electric hot water systems (heat pump or resistive) to solar sponge or off-peak block tariff. The Off-Peak Controlled Load (OPCL) Tariff (Solar Sponge) tariff is based on usage from 9.30am-3.30pm with randomised start time of at least one hour. Charging is at 25% of the single rate price per kWh. The timer is managed by the retailer and the metering co-ordinator or by connecting a new or existing electric heat pump to an approved demand response aggregator.
ACT	Home Energy Support: Rebates for Homeowners	One rebate of half the total installation price, up to $2,500, for hot water heat pumps (VEU requirements). Rebate to assist ActewAGL customers to replace a conventional electric or gas HWS with a heat pump system.
QLD	Climate Smart Energy Savers (closed)	1,604 solar and heat pump HWS were given rebates under this program without any demand response capability requirements.

The white certificate schemes (VEUs, EES and REPS) can only incentivise the direct greenhouse gas emissions reductions resulting from an upgrade. They use weighted average emissions factors rather than time-of-use emissions, focusing on the annual decline in greenhouse intensity of the electricity supply. There are significant questions as to whether this is the most appropriate way to subsidise efficient appliances into the future, given the:

- overall decline of the greenhouse intensity of the electricity grid;
- increased variability of the greenhouse intensity of grid-supplied electricity during the day (usually lowest in the middle of the day); and
- the growing value of demand flexibility as variable renewable energy supply increases.

If these schemes accounted for the variation in greenhouse intensity of electricity supply across the day, it would drive adoption of flexible demand, including water heating, at the best times to reduce emissions.

Hot water tariffs still mostly night-time controlled load

As most electric HWS are on separate controlled load (CL) circuits and CL distribution tariffs, they have traditionally been heated at night, instead of in the solar peak in the middle of the day. There have been some changes to daytime water heating, and it is unclear what proportion of hot water heating on CL now occurs during the day. For example, Queensland has an overnight CL Tariff 31 for all large electric hot water systems (>250L) even, while the day-night CL Tariff 33 is commonly used for pool pumps, electric HWS (>125L), heat pump HWS (>270L and solar HWS >160L).

Energy Queensland is developing new schedules for hot water systems on CL tariffs to ensure HWS are off during the evening peak, and heating during the daytime solar peak. However, there is no detail or timeframe in Ergon Energy and Energex's 2023-24 Demand Management Plan on how it will provide "greater choice to customers with new solutions enabled through our DERMS [DER management system], DOE [dynamic operating envelopes] and new market platform".

Tasmania's Tariff 93 offers the same price from 10am-4pm on weekdays as the overnight tariff. Energy efficiency expert Alan Pears, senior industry fellow at RMIT University, says a heat pump HWS running on this tariff during the day should cost a third as much to run as an overnight off-peak HWS there.

Separate to controlled load, several distribution networks (South Australia Power Networks, Endeavour, Ausgrid, Energy Queensland, Citipower, United and PowerCor) now offer or are trialling cheap "solar soak" tariffs in the middle of the day, but these are not necessarily passed on to retail tariffs. More work needs to be done to make sure the appropriate tariffs are available to incentivise flexible hot water consumption.

Most heat pump HWS sold in Australia are already 'smart'

The hot water market in Australia is dominated by Rheem, whose brands include Solahart, Vulcan, Aquamax, Raypak and Everhot. In terms of heat pumps sold in Australia, most brands other than Rheem have WiFi controls on at least some models (Table 4). This enables dynamic management of the hot water system. A Wi-Fi microcontroller costs less than US$2 (excluding management software/apps).

Table 4: Comparison of heat pump HSW dynamic controls

Heat pump brand	User interface/timer/WiFi controls – if any
Rheem, Solahart, Vulcan and Everhot	Two of five Rheem models have touch screen LED display with variable temperature control. (Rheem models with WiFi controls are available for sale in the US but not in Australia.) Four of five Solahart models have touch screens. Both Everhot models have touch screens. No smarts with Vulcan
Apricus	Real time power usage monitoring capability and screen controller with app
Chromagen	Controller with optional app on three of seven models
Dux	WiFi controller and app
Emerald	WiFi controller and app
Rinnai	One model with WiFi-enabled Timer Function
iStore	LCD displays with four operating modes
NeoPower	WiFi controller and app
Reclaim	WiFi controller and app on one model, controller and timer on another, base model has five pre-set timer options and optional Wi-Fi Controller upgrade
Rinnai	One model with WiFi-enabled timer function
Sanden	WiFi controller and app
Stiebel Eltron	Separate controller available for HWS and heating/cooling heat pumps
Thermann	WiFi controller and app for electric storage but not heat pump hot water
Vanward	Intelligent control: operated by microcomputer, which can turn on or off according to the user's needs and tank temperature
Wiseliving	Timer or WiFi

A Rheem trial with South Australia Power Networks (SAPN) to control residential HWS with time switches, which could not be controlled dynamically or remotely, was halted due to insufficient customer numbers. Rheem already manufactures heat pump HWS with WiFi connectivity and energy management apps in the US, and claims to have the most efficient hot water system in North America.

Requiring HWS to be smart would help give consumers control over their systems and would futureproof flexible demand capacity in the electricity system. Ideally, a smart HWS would have a user-friendly, adjustable interface – an app, web portal or touch screen – as is proposed for a variety of household appliances in the UK from 2026.

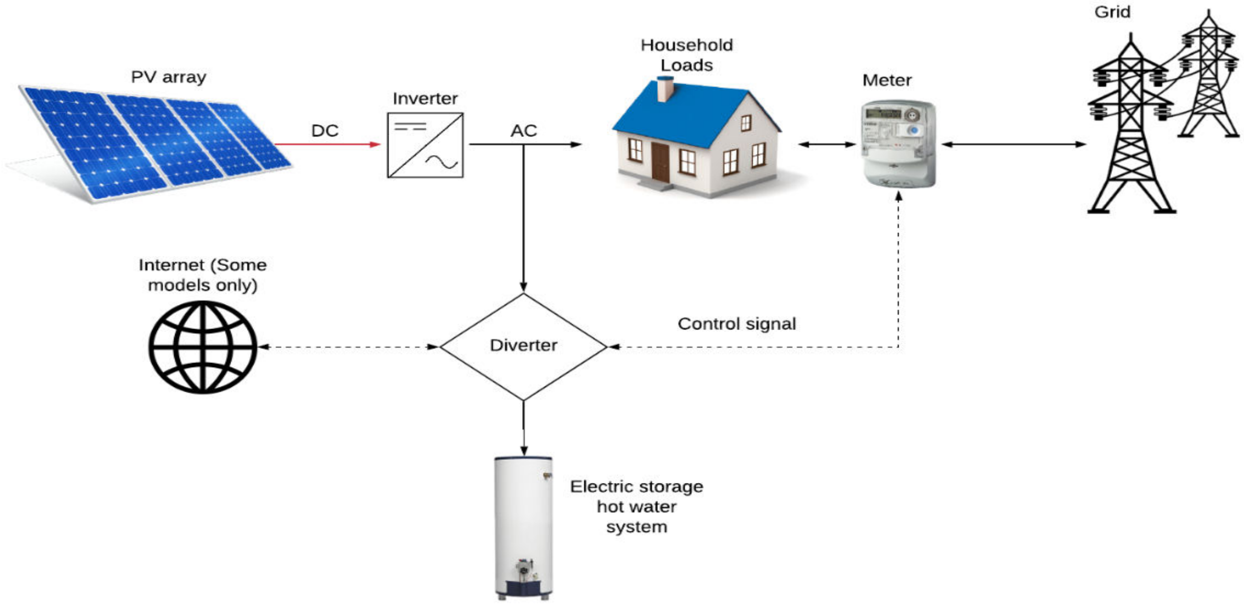
Electric hot water management technology options

Since the 1950s, electric hot water systems have been on controlled load circuits and tariffs, able to be remotely controlled by distribution networks. With electrification, households with gas hot water will be choosing whether to put their new electric hot water systems onto the main electrical circuit or on the controlled load circuit. This choice will be informed by whether they have a household solar system.

Households with solar and with electric hot water

For households with rooftop solar and an electric HWS, electricity generated behind-the-meter can be diverted to the HWS if the hot water is taken off the CL circuit and added to the main circuit. Several "diverters" are available in Australia to switch some or all of rooftop solar- generated electricity to the HWS rather than exporting to the grid. These include the Solar Edge hot water controller, Catch Control, ENERMAX SMARTcube, AC•THOR and myenergi eddi, but the cost tends to outweigh the potential financial savings. Some diverters work in conjunction with a timer to ensure water is heated sufficiently in off-peak periods when insufficient solar power is available. In addition, some smart inverters, such as Fronius Ohmpilot, use load monitoring and smart relays to activate the HWS when solar generation is available.

Figure 1: How a solar HWS diverter works



Source: EnergyConsult

Research at the University of New South Wales suggests that on average Australian households use 6kWh of energy for 142L of hot water daily. In 2021, modelling with a standard inefficient hot water technology and a small 4.5kW rooftop solar system found that excess solar generation could provide almost half (48%) of daily water heating for a typical family, equivalent to a 28% increase in solar self-consumption. The average rooftop solar system sold in Australia is now over 9kW, and with a heat pump HWS, rooftop solar could provide all the water heating for a relatively small increase in solar self-consumption.

Solar is now used for heating water at scale in Australia as electricians switch HWS from CL to general supply when installing rooftop solar. In doing so, many install a costly diverter to direct solar-generated electricity to the HWS in the middle of the day. Alternatively, some smart inverters essentially treat the home HWS like a battery, storing heat in hot water until it is needed.

In South Australia, up to a quarter of CL hot water is inactive, while in NSW it is about 15%-20%. If these HWS use abundant solar during the day instead of off-peak fossil-fuel power at night, everyone benefits.

Households without solar

The abundance of solar generation in the middle of the day means wholesale power prices are often negative, and retail tariffs with low daytime prices are increasingly available. For households without solar, there are two passive management options to take advantage of this:

- Distribution businesses can adjust ripple control settings to use energy in the middle of the day instead of the middle of the night; and/or
- Consumers can hire an electrician to take their HWS off CL and use a timer to run it outside the 4pm-8pm evening peak.

Alternatively, hot water can be controlled dynamically via a switch in a smart meter, for example by a distribution business. AGL is actively controlling 140MW of hot water systems through an integration with PLUS ES-managed smart meters across SA and NSW. The hot water is being given a chance to run through the daytime to be supplied by solar generation.

The need to move to dynamic management for futureproofing

The benefits of passive management – using timers to set a daily water heating schedule – decrease where renewable generation is more variable on a daily or seasonal basis. For example, in the southern Australian winter there are regular multi-day periods of low solar generation. A 9kW solar system may only provide about 18kWh/day (less in bad weather) and so a heat pump HWS competes with space heating and lighting for the available solar output. So, there may be times that passively managed heat pump hot water timers set for the middle of the day may not always produce an optimal result, such as in winter in Victoria.

However, Victoria is developing offshore wind power, with the first farms due to commence generation in 2032. These are expected to generate electricity 55% or more of the time. Further, Victoria experienced 7% of negative price intervals in the second quarter of 2024. This is when dynamic management – i.e. systems that can respond to market signals – come into their own. For example, if Victoria had a very windy period and negative wholesale prices, it might be beneficial to heat water in that period. These considerations are particularly important given the number of HWS in Victoria and South Australia that need to be electrified.

Theoretically, dynamic management of HWS should deliver the greatest benefits. As WiFi controllers are cheap, it is a “no regrets” measure for Australia to futureproof HWS by ensuring they are smart, i.e. able to be dynamically managed.

Cybersecurity will be critical. Energy and Climate Change Ministers have agreed to implement cybersecurity standards by 2026 as part of the Consumer Energy Resources Roadmap. These standards should include smart systems.

Trials under way on retrofitting HWS

Several hot water management trials are under way or have been completed with Australian Renewable Energy Agency (ARENA) funding, for households with and without solar. Four trials (PLUS ES/AGL, Endeavour, United, Intellihub) use smart meters; one (Rheem) uses time switches; one (Energy Masters) uses a locally manufactured retrofit device; and one (GreenSync/Intellihub) is via the OEM Cloud. While these trials may be useful for retrofitting smarts to existing HWS, quality standards are needed to ensure new systems are efficient, smart and secure.

Policy options and recommendations

Electrification of many household appliances presents a significant opportunity. Now is the time for governments to act as electrification accelerates. Water heaters are a major contributor to household energy costs. More efficient water heaters offer significant savings. Through government requirements, smart water heaters can support further savings. Making these measures a priority will futureproof Australian homes by better aligning electricity demand with a growing variable renewable energy supply.

Given the increasing variability of generation and of the greenhouse intensity of electricity by time of day and by season, the switch to dynamic management of hot water systems is vital as we move rapidly to 82% renewable electricity supply by 2030. IEEFA recommends:

1. The South Australian government should immediately cease subsidising the purchase of gas hot water systems.
2. State governments in Victoria, NSW and South Australia expand their existing white certificate schemes (VEU, ESS and REPS) and the federal government expand the RET to include a requirement that heat pump HWS can be dynamically managed. Certificates could be created whenever a water heater is added to a Virtual Power Program (VPP) or a DNSP control program. Those with solar are already incentivised to self-consume so would not be eligible. A similar incentive is being implemented for batteries when they are included in VPPs under the NSW PDRS from 1 November 2024.
3. State governments in Victoria, NSW and South Australia should consider changing the calculation method of their white certificate schemes (VEU, ESS and REPS) to account for the variation in greenhouse intensity of electricity supply by time of day.
4. Solar Victoria should consider updating its hot water subsidy requirement from timers for heat pump hot water to other requirements for dynamic management (e.g. open communication protocol) as part of the further review of its water and space heating activities in 2025.
5. Alongside the urgent Greenhouse and Energy Minimum Standards Determination for heat pump HWS, which Energy Ministers have agreed, a Minimum Standards Determination should be made for solar and electric instantaneous HWS.
6. Governments should provide information to enable consumers to compare across types of hot water heaters (e.g. to compare running costs of a resistive electric water heater or solar-electric with a heat pump in winter as well as overall).
7. As recommended in the Energy Efficiency Council's Roadmap for Heat Pump Hot Water Systems, governments should fund a heat pump HWS roadmap for commercial and residential strata buildings.
8. All HWS sold in Australia should be required to be installed so that they can be dynamically managed unless there is a rooftop solar system installed whereby passive management may be sufficient. Either way, the movement should be towards requiring the sale of flexible smart HWS to reduce emissions and costs for consumers. The federal government in conjunction with state and territory governments should investigate which of the following "smart" requirements for HWS product systems should be put in place nationally (probably via the GEMS Act):
    - Communication capability/open communication protocol, such as WiFi connectivity, especially for heat pump HWS given that most brands already offer this;
    - Connection to a smart meter as an alternative form of dynamic management;
    - Connection to a home energy management system (HEMS) as an alternative form of dynamic management; and
    - Installation of a solar diverter with timer or other control system as an alternative form of passive or dynamic management.

Above and beyond these standards, a national strategy for domestic hot water is needed, including national measures around workforce, trade training and regulations, as set out in the Roadmap for Heat Pump Hot Water Systems.

It is important for these requirements to be in place as soon as possible given how fast households are electrifying. It would be an enormous missed opportunity if newly electrified hot water systems were not able to be used as a flexible resource.

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

About the Author

Dr Gabrielle Kuiper is a DER Specialist and a Director at The Superpower Institute. She is an energy, sustainability and climate change professional with over twenty years' experience in the corporate world, government and non-government organisations and academia. She was previously the DER Strategy Specialist with the Energy Security Board.