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Institute for Energy Economics and Financial Analysis

Technical appendix: A focus on homes, not power plants, could halve energy bills

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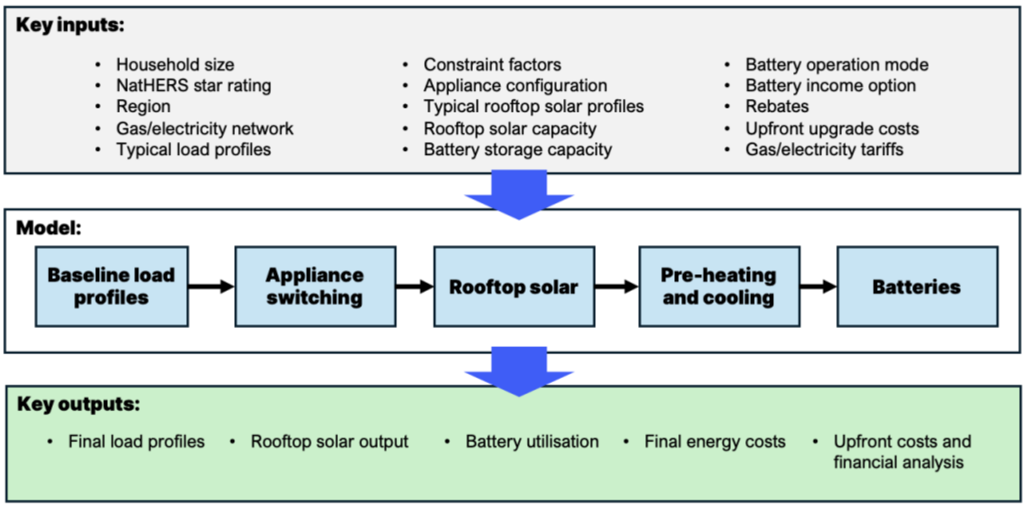
Modelling approach

The modelling in this report draws from a new IEEFA model, designed to analyse the impact of various household energy upgrades on the energy consumption patterns of a typical household. A conceptual diagram of the modelling approach is shown in Figure 1.

Figure 1: Conceptual diagram of modelling approach



The model starts with a set of hourly baseline thermal, hot water, cooking and other energy load profiles. These load profiles are provided for an average day on each month of the year and vary depending on several input assumptions including the region, household size and Nationwide House Energy Rating Scheme (NatHERS) star rating.

A configuration of household appliances is then selected for a 'baseline' and 'comparison' modelling case. The appliance selection will translate the underlying hourly load profiles into electricity and gas demand profiles based on the efficiency of the appliances.

Rooftop solar can be added to the baseline and/or comparison case. This will displace some grid electricity requirements while it is generating and may leave surplus solar generation that can be exported to the grid.

Alternatively, this surplus can be used for pre-heating and/or pre-cooling if this is enabled in the model. This will divert excess rooftop solar to heating or cooling appliances in the middle of the day, reducing evening heating and cooling loads. See 'Pre-heating and pre-cooling' section below for further details.

A battery can also be added. This will store surplus rooftop solar during the day, and discharge it to meet the household's demand in the evening and potentially overnight, if enough charge is available. Depending on the selected mode of operation, the battery can also export to and/or import from the grid. See 'Batteries' section below for further details.

The annual energy costs of the household are calculated by taking the final grid electricity consumption (import profile), grid export profile and gas consumption on an hourly basis for an average day in each month of the year, and applying actual tariffs as selected in the model. These daily costs are then aggregated into monthly and annual energy costs.

Upfront costs associated with each appliance selection or upgrade option are also tracked in the model and can be combined with the energy cost outputs for further financial analysis.

Model regions

There are 19 distinct regions available to the model. Changing the region in the model will change the underlying load profiles, as well as the availability of gas/electricity tariffs, and state government rebates. Model regions have been mapped to NatHERS climate zones, with the aim of grouping relatively similar climates together, while ensuring as broad a coverage of the population of each state and territory as possible. Where NatHERS assumptions were used in the model – for example annual thermal load limits – we took the average value for all NatHERS climate zones in that region, weighted by the number of dwellings in each zone.

The full list of regions and mapping to NatHERS zones is provided in Table 1. A small number of NatHERS zones are excluded, mainly due to low populations.

Table 1: Regions available to the model, and NatHERS climate zone mapping

State/territory	Model regio	Mapped NatHERS climate zones (and representative weather station)		Other similar regions
Regions modelled in this report				
NSW	Sydney	15 – Williamtown 28 – Richmond 56 – Mascot		Newcastle, Central Coast
VIC	Melbourne	21 – Melbourne 22 – East Sale 60 – Tullamarine	62 – Moorabbin 64 – Cape Otway	Gippsland, Surf Coast
QLD	Brisbane	9 – Amberley 10 – Brisbane 19 – Charleville		Gold Coast, Sunshine Coast
WA	Perth	13 – Perth 44 – Kalgoorlie 47 – Bickley	52 – Swanbourne 54 – Mandurah	Mandurah, Kalgoorlie-Boulder
SA	Adelaide	16 – Adelaide 27 – Mildura 53 – Ceduna		Ceduna
TAS	Tasmania (labelled as Hobart in report)	23 – Launceston 26 – Hobart 67 – Low Head		
NT	Darwin	1 – Darwin 37 – Halls Creek		Katherine, Halls Creek
ACT	Canberra	24 – Canberra		
Additional regions available in the model				
NSW	Wollongong	18 – Nowra		
NSW	Riverina	21 – Melbourne 27 – Mildura 48 – Dubbo		Some of low-lying Central West NSW
VIC	Central VIC	66 – Ballarat		
VIC	Mallee	27 – Mildura		
QLD	Toowoomba	50 – Oakey		
QLD	Central QLD	7 – Rockhampton 35 – Mackay 36 – Gladstone		
QLD	Far North QLD	32 – Cairns		
WA	Geraldton	12 – Geraldton		
WA	South-west WA	49 – Katanning 55 – Esperance	57 – Manjimup 58 – Albany	
SA	Adelaide Hills	59 – Mt Lofty		
NT	Alice Springs	6 – Alice Springs		

Note: Some NatHERS climate zones were excluded where they covered only a small proportion of dwellings and could not easily be grouped with other zones. Some NatHERS climate zones cross state boundaries and may be mapped to multiple model regions.

Key model assumptions

Key assumptions underlying the modelling are outlined in Table 2, with further detail on particular assumptions in the following sections.

Table 2: Key assumptions used in the modelling

Assumption	Value and source
Average household size	TAS: 2.4 persons; NSW: 2.6 persons VIC, QLD, WA & ACT: 2.5 persons; NT: 2.8 persons *(Australian Bureau of Statistics, 2021 Census data)*
Typical energy consumption by household size	Frontier Economics, Simple electricity and gas benchmarks Used to scale load profiles under different household size assumptions.
NatHERS star rating	'Typical home': 2 stars in all regions other than Canberra, where 3 stars is assumed. Households with higher NatHERS star ratings are also modelled, as noted in the main report.
Thermal load limits by NatHERS star rating	Total annual load limits: Drawn from current NatHERS Star bands Estimates of heating versus cooling loads: Tony Isaacs Consulting Pty Ltd See 'Regions' section above for explanation of how NatHERS assumptions were mapped to model regions.
Average conditioned household floor area of an existing dwelling	Used to translate NatHERS load limits in MJ/m^2 to total household thermal loads. Estimated by taking the average conditioned floor area across new dwellings in each NatHERS climate zone from the Australian Housing Database from 2016-2024, and extrapolating to estimate the average conditioned floor area for new dwellings built in 1995 (reflecting the fact more than 50% of Australian dwellings are over 30 years old). Final values range from 83-153m^2 across NatHERS climate zones, with an average of 119m^2.
Baseline load profiles	See 'Baseline load profiles' section below.
Constraint factors	Constraint factors scale the energy consumption for heating/cooling appliances relative to the NatHERS load limit, to account for actual household energy consumption behaviours. Appliance constraint factors: Gas ducted heating: 75% (Climateworks Centre) Gas room heater: 29% (Based on the ratio of energy consumed per room heater versus per gas heater in the Residential Baseline Study (RBS) Fixed resistive electric heater: 29% (Assumed same as gas room heater) Reverse-cycle air conditioner: Varies by region[1] Region constraint factors: Canberra: 67%[2] Constraint factors were cross-checked by testing model outcomes against a range of estimates for average annual household energy consumption in each region including by St Vincent de Paul, Frontier Economics, AER, Essential Services Commission, Independent Competition and Regulatory Commission, EnergyConsult and from electricity network Regulatory Information Notices.
Household appliance configurations	See 'Household appliance configurations' section below.

[1] We assume when a household upgrades to an RCAC, it will provide the same heat as the initial heating appliance. Therefore, the constraint factor for RCACs was set to equal the constraint factor for the default gas or inefficient electric appliance in each region.
[2] Initial results based on Canberra NatHERS load limits indicated annual energy consumption that was much higher than external estimates, hence a region-specific constraint factor was introduced. This may reflect that the higher load limits in Canberra are disproportionately experienced overnight when many households limit or turn off their heating appliances.

Assumption	Value and source
Average household size	TAS: 2.4 persons VIC, QLD, WA & ACT: 2.5 persons NSW: 2.6 persons NT: 2.8 persons *(Australian Bureau of Statistics, 2021 Census data)*
Typical energy consumption by household size	Frontier Economics, Simple electricity and gas benchmarks Used to scale load profiles under different household size assumptions.
NatHERS star rating	'Typical home': 2 stars in all regions other than Canberra, where 3 stars is assumed. Households with higher NatHERS star ratings are also modelled, as noted in the main report.
Thermal load limits by NatHERS star rating	Total annual load limits: Drawn from current NatHERS Star bands Estimates of heating versus cooling loads: Tony Isaacs Consulting Pty Ltd See 'Regions' section above for explanation of how NatHERS assumptions were mapped to model regions.
Average conditioned household floor area of an existing dwelling	Used to translate NatHERS load limits in MJ/m^2 to total household thermal loads. Estimated by taking the average conditioned floor area across new dwellings in each NatHERS climate zone from the Australian Housing Database from 2016-2024, and extrapolating to estimate the average conditioned floor area for new dwellings built in 1995 (reflecting the fact more than 50% of Australian dwellings are over 30 years old). Final values range from 83-153m^2 across NatHERS climate zones, with an average of 119m^2.
Baseline load profiles	See 'Baseline load profiles' section below.
Appliance efficiencies / Coefficients of Performance	**Heating:** Gas ducted heating: 72% (based on a furnace efficiency of 90% with 20% ducting losses) Gas room heating: 95% (EnergyRating: assumed maximum furnace efficiency of a new 5-star heater) Fixed resistive electric heater: 100% (Resistive heating elements operate at 100% efficiency) Reverse-cycle air conditioner (RCAC): 3.95 CoP (Average of minimum required heating seasonal performance factors for units < 4kW and 4-7kW under Victoria's VEU scheme) **Cooling:** RCAC: 3.17 CoP (Based on the average difference in measured heating versus cooling CoP of RCACs in the GEMS database) Older-style refrigerative air-conditioner: 2.38 CoP (Assumed 25% lower efficiency than a modern unit) **Hot water:** Gas continuous flow hot water: 86% (Renew) Resistive electric hot water: 100% (Resistive heating elements operate at 100% efficiency) Heat pump hot water: 3.5 CoP (Reduced for conservatism; average CoP across available models was previously found to be 4.17) **Cooktops:** Gas cooktop: 40% (Renew) Resistive electric cooktop: 75% (Assumed to be ~7.5% less efficient than an induction cooktop) Electric induction cooktop: 80% (Renew)
Appliance purchase costs	**Heating and cooling:** Gas ducted heater: $3,372 Gas room heater: $1,214 Fixed resistive electric heater: $493 (Based on retail prices for fixed heaters >1kW from Bunnings and Appliances Online) 3-4kW RCAC: $1,086 7-8kW RCAC: $1,828 **Hot water:** Gas continuous flow hot water: $1,440 Resistive electric hot water: $1,242 (Based on retail prices from Bunnings and Appliances Online) Heat pump hot water system: $2,659 **Cooktops:** Gas cooktop: $489 Resistive electric cooktop: $417 (Based on retail prices from Bunnings) Electric induction cooktop: $607 All sources drawn from previous IEEFA modelling, adjusted for inflation, unless otherwise noted.

Assumption	Value and source
Average household size	TAS: 2.4 persons VIC, QLD, WA & ACT: 2.5 persons NSW: 2.6 persons NT: 2.8 persons *(Australian Bureau of Statistics, 2021 Census data)*
Typical energy consumption by household size	Frontier Economics, Simple electricity and gas benchmarks Used to scale load profiles under different household size assumptions.
NatHERS star rating	'Typical home': 2 stars in all regions other than Canberra, where 3 stars is assumed. Households with higher NatHERS star ratings are also modelled, as noted in the main report.
Thermal load limits by NatHERS star rating	Total annual load limits: Drawn from current NatHERS Star bands Estimates of heating versus cooling loads: Tony Isaacs Consulting Pty Ltd See 'Regions' section above for explanation of how NatHERS assumptions were mapped to model regions.
Average conditioned household floor area of an existing dwelling	Used to translate NatHERS load limits in MJ/m^2 to total household thermal loads. Estimated by taking the average conditioned floor area across new dwellings in each NatHERS climate zone from the Australian Housing Database from 2016-2024, and extrapolating to estimate the average conditioned floor area for new dwellings built in 1995 (reflecting the fact more than 50% of Australian dwellings are over 30 years old). Final values range from 83-153m^2 across NatHERS climate zones, with an average of 119m^2.
Baseline load profiles	See 'Baseline load profiles' section below.
Appliance installation costs	**Heating and cooling:** Gas ducted heater: $3,041 (GHD) Gas room heater: $379 (The Good Guys) Fixed resistive electric heater: $330 (Assume half the cost of an RCAC) RCAC: $749 (The Good Guys) **Hot water:** Gas continuous flow hot water: $975 (Sydney Plumbing & Hot Water) Resistive electric hot water: $800 (Assumed same as a heat pump) Heat pump hot water: $800 (Top end of range from Solar Choice) **Cooktops:** Gas cooktop: $269 (The Good Guys) Resistive electric cooktop: $259 (The Good Guys) Electric induction cooktop: $259 (The Good Guys) **Cost to install a new electrical circuit*:** For RCAC or cooktop: $819 (Cowley Electrical and Local Perth Electrician with a 25% margin added for conservatism) For Heat pump hot water system: $600 (SolarChoice) *Applies for all electric appliance installations except when a heat pump hot water system replaces an existing resistive electric system, or when an induction cooktop replaces an existing resistive electric cooktop.
Typical rooftop solar output profiles	Based on actual data from the Australian Energy Market Operator (extracted from NEMWEB) We assume rooftop solar profiles in the NT are similar to Queensland.
Rooftop solar costs	Installed cost for an 8kW rooftop solar system: (before rebates) Sydney: $8,756 Melbourne: $9,346 Brisbane: $9,356 Perth: $8,593 Adelaide: $8,851 Hobart: $10,733 Canberra: $8,971 Darwin: $13,897 *Based on average costs from SolarChoice as of March 2025.*
Battery functionality	See 'Batteries' section below
Battery costs	Installed cost: $1,000/kWh (before rebates) Based on a review of recent quotes for batteries between 10-15kWh shared by users of the My Efficient Electric Home Facebook group. Consistent with the range of pre-rebate installed costs for several popular battery brands as reported by SolarQuotes.
Pre-heating and cooling	See 'Pre-heating and pre-cooling' section below
Pre-heating and cooling costs	No cost: No upfront costs High cost: $149 per RCAC (Based on the cost of a Sensibo unit) Medium cost: once-off cost of $156, plus $12 per RCAC. (Based on the assumed cost to include demand response capabilities in the device and enrol it in a demand response program under a regulations-driven approach; Equipment Energy Efficiency)

Assumption	Value and source
Average household size	TAS: 2.4 persons; NSW: 2.6 persons VIC, QLD, WA & ACT: 2.5 persons; NT: 2.8 persons *(Australian Bureau of Statistics, 2021 Census data)*
Typical energy consumption by household size	Frontier Economics, Simple electricity and gas benchmarks Used to scale load profiles under different household size assumptions.
NatHERS star rating	‘Typical home’: 2 stars in all regions other than Canberra, where 3 stars is assumed. Households with higher NatHERS star ratings are also modelled, as noted in the main report.
Thermal load limits by NatHERS star rating	Total annual load limits: Drawn from current NatHERS Star bands Estimates of heating versus cooling loads: Tony Isaacs Consulting Pty Ltd See ‘Regions’ section above for explanation of how NatHERS assumptions were mapped to model regions.
Average conditioned household floor area of an existing dwelling	Used to translate NatHERS load limits in MJ/m^2 to total household thermal loads. Estimated by taking the average conditioned floor area across new dwellings in each NatHERS climate zone from the Australian Housing Database from 2016-2024, and extrapolating to estimate the average conditioned floor area for new dwellings built in 1995 (reflecting the fact more than 50% of Australian dwellings are over 30 years old). Final values range from 83-153m^2 across NatHERS climate zones, with an average of 119m^2.
Baseline load profiles	See ‘Baseline load profiles’ section below.
	See main report for further discussion on cost scenarios.
Rebates	See ‘Rebates’ section below
Electricity and gas tariffs	Collected from the top energy retailers representing the majority market share in each state/territory (January 2025):

	Electricity tariffs	Gas tariffs
Sydney, Melbourne & Adelaide:	AGL Residential Value Saver Origin Go Variable EnergyAustralia Flexi Plan	AGL Residential Value Saver Origin Go Variable EnergyAustralia Flexi Plan
Brisbane:	AGL Residential Value Saver Origin Go Variable EnergyAustralia Flexi Plan	AGL Residential Value Saver Origin Go Variable
Perth:	Synergy Home Plan/Midday Saver	AGL Value Saver Origin Basic
Hobart:	Aurora Energy Tariffs 31/41 and 93	Aurora Residential Gas
Canberra:	ActewAGL Good to Go Origin Go Variable EnergyAustralia Flexi Plan	ActewAGL Winter Saver 23% Origin Go Variable EnergyAustralia Flexi Plan
Darwin:	Jacana Energy Everyday Home/Switch to Six	Not modelled
	Tariffs were collected for each electricity and gas distribution network in the model, including both flat-rate and time-of-use electricity tariffs. All results in this report are based on the average of every valid combination of electricity and gas tariffs, across every valid combination of gas and electricity network, for each region. Flat-rate tariffs have been excluded from scenarios that include a battery. Due to an updated approach to tariffs, some Melbourne results in this report may differ slightly from a previous IEEFA report focused on Victoria.	
	The ‘Better tariffs’ scenario modelled in the report tests the impact of the following assumptions:	

Assumption	Value and source
Average household size	TAS: 2.4 persons VIC, QLD, WA & ACT: 2.5 persons NSW: 2.6 persons NT: 2.8 persons *(Australian Bureau of Statistics, 2021 Census data)*
Typical energy consumption by household size	Frontier Economics, Simple electricity and gas benchmarks Used to scale load profiles under different household size assumptions.
NatHERS star rating	'Typical home': 2 stars in all regions other than Canberra, where 3 stars is assumed. Households with higher NatHERS star ratings are also modelled, as noted in the main report.
Thermal load limits by NatHERS star rating	Total annual load limits: Drawn from current NatHERS Star bands Estimates of heating versus cooling loads: Tony Isaacs Consulting Pty Ltd See 'Regions' section above for explanation of how NatHERS assumptions were mapped to model regions.
Average conditioned household floor area of an existing dwelling	Used to translate NatHERS load limits in MJ/m^2 to total household thermal loads. Estimated by taking the average conditioned floor area across new dwellings in each NatHERS climate zone from the Australian Housing Database from 2016-2024, and extrapolating to estimate the average conditioned floor area for new dwellings built in 1995 (reflecting the fact more than 50% of Australian dwellings are over 30 years old). Final values range from 83-153m^2 across NatHERS climate zones, with an average of 119m^2.
Baseline load profiles	See 'Baseline load profiles' section below.
Alternative battery import/export prices	Imports: Batteries can import from the grid in the middle of the day based on the average wholesale electricity price between 11am and 1pm in each state observed between the period June 2023-May 2025 (based on AEMO data). NSW & ACT: 3.3 c/kWh VIC: -0.3 c/kWh QLD: 0.4 c/kWh WA[3]: -0.1 c/kWh SA: -0.1 c/kWh TAS: 5.1 c/kWh NT[4]: 1.4 c/kWh Exports: Batteries can export to the grid in the evening, earning a feed-in rate base on the average wholesale electricity price between 5pm and 9pm in each state observed between the period June 2023-May 2025 (based on AEMO data). NSW & ACT: 23.3 c/kWh VIC: 13.3 c/kWh QLD: 24.2 c/kWh WA[3]: 16.4 c/kWh SA: 19.7 c/kWh TAS: 10.4 c/kWh NT[4]: 17.9 c/kWh

Baseline load profiles

Hourly time-of-use profiles for various energy end-uses were used as an input to the model. These reflect consumption patterns for an average day on each month of the year and vary by region.

Comprehensive data on underlying energy consumption patterns for Australian households is generally poor. However, we have taken considerable effort to review a wide range of data sources to develop a best estimate for typical load profiles for each region in the model.

The sources used are summarised in Table 3 and discussed in the following sections.

[3] Based on data for the Wholesale Electricity Market (WEM).
[4] No data available; based on simple national average across other jurisdictions.

Table 3: Data sources for underlying sub-load profiles.

Sub-load profile	Source/s
Space heating and space cooling	Mohseni et al. Residential load profiles for Heyfield, Victoria. May 2023. Hourly space conditioning loads were extracted, interpolated by month and separated into heating and cooling loads. A regression against Bureau of Meteorology (BoM) hourly temperature data was undertaken for each hour of the day, and used to synthesise a load profile shape for each NatHERS climate zone. Final load profiles were then normalised based on NatHERS thermal load limits and heating/cooling splits.
Hot water	**'Uncontrolled' profile:** Mohseni et al. Residential load profiles for Heyfield, Victoria. May 2023. Hourly 'day-rate' electric hot water system loads were extracted and interpolated by month. **'Midday-optimised' profile:** Analysis of data provided by Solar Analytics Pty Ltd. Circuit-level electricity consumption data for Victorian and Tasmanian sites were provided by Solar Analytics. Hot water circuit data was filtered for outliers, and separated based on sites where load peaked between 10am and 3pm. **Extrapolation of both profiles to other regions:** In each case, a regression against BoM hourly temperature data was undertaken for each hour of the day, and used to synthesise load profile shapes for each NatHERS climate zone. Final load profiles were then normalised based on average resistive electric hot water system consumption data for each state/territory in the RBS.
Cooking	EnergyConsult. 2021 Residential Baseline Study. November 2022. Cooking time-of-use data by state/territory was extracted from the RBS and interpolated by month. This was normalised against annual energy consumption per oven, cooktop and microwave from the RBS to produce two profiles per state/territory: Cooktops, and other cooking appliances.
Lighting	EnergyConsult. 2021 Residential Baseline Study. November 2022. Lighting time-of-use data by state/territory was extracted from the RBS and interpolated by month. This was normalised against annual energy consumption for lighting per household from the RBS for each state/territory.
Other loads	EnergyConsult. 2021 Residential Baseline Study. November 2022. Time-of-use data by state/territory for all other energy loads (home entertainment, IT, whitegoods and other equipment) was extracted from the RBS and interpolated by month. This was normalised against annual energy consumption for those appliances per household from the RBS, and aggregated into a single load profile per state/territory.

Detailed notes on load profile sources

2021 Residential Baseline Study (RBS)

The 2021 Residential Baseline Study (RBS) provides a dataset of hourly household energy demand, disaggregated by state, end-use, season and weekday/weekend.

This is the most complete and convenient data source available. The RBS was used as the source for cooking, lighting and other load profiles. Annual consumption data from the RBS was also used to normalise hot water load profiles derived from Mohseni et al and Solar Analytics.

The RBS itself draws on a number of external data sources, several of which overlap with other sources discussed below. Due to some of the limitations of these sources discussed below, we did not draw directly on the RBS for space conditioning or hot water load profiles.

Solar Analytics circuit consumption data

Solar Analytics provided IEEFA with one year's worth of five-minute circuit-level consumption data for a large sample size of Victorian and Tasmanian households.

As this dataset includes real consumption data from households with a Solar Analytics monitoring device, it was a useful comparison source. However, we chose not to draw directly from Solar Analytics data for most load profiles.

This was due to the potential for the sample to be biased towards households that have installed solar and are highly engaged energy consumers. This could mean their consumption patterns are not typical of most households. There may also be biases towards demographic groups that are more likely to have solar panels, and the dataset is likely to include very few renters.

We did however use Solar Analytics data to produce a load profile for 'midday-optimised' hot water systems – as there was a clear cohort of Solar Analytics sites where the majority of hot water system load occurred in the middle of the day, likely representing the use of timer controls or some form of active management.

Electricity distribution network substation load profiles

Most electricity distribution networks in Australia provide actual half-hourly load data for each substation zone on their network. This data can provide a useful guide for typical household energy consumption patterns. However, substation zones typically include a combination of residential, commercial and industrial loads which can be difficult to separate. Several substation zones in suburban Melbourne were identified that comprised more than 80% residentially-zoned land.[5] However, the dominance of gas heating in Victoria means that these datasets were unlikely to accurately reflect winter heating loads.

[5] Specifically, five zones in United Energy's network (North Brighton, Ormond, Surrey Hills, Bentleigh and Elsternwick) and two in CitiPower's network (Armadale and Riversdale). Based on GIS analysis of substation zone areas and Victorian Planning Scheme zones.

Substation load profiles were not used as an explicit input to the model. However, they were used as a key comparison point to evaluate our final chosen load profiles.

CSIRO household energy consumption survey data

A 2012-13 CSIRO study monitored half-hourly household energy consumption patterns for 209 households in Melbourne, Brisbane and Adelaide – including some circuit-level data. This provided another useful reference point. However, it was not used as a direct input as it is relatively outdated, hot water data was unavailable, it was limited to only three cities, and the Melbourne sample lacked space heating data due to the use of gas heaters.

Half-hourly Victorian gas demand data

A recurring limitation of the above datasets is the fact that heating loads are very under-represented in electricity consumption data for Victoria. The choice of robust, representative heading load profiles is particularly important in Victoria given its cool climate and potential for large gas loads to be electrified.

However, as the residential sector is the largest user of gas in Victoria, and heating is the largest source of residential gas consumption, aggregated statewide gas demand data can provide a useful reference point for gas heating consumption patterns.

Half-hourly Declared Wholesale Gas Market (DWGM) withdrawal data for Victoria was extracted from AEMO. This was a useful comparison point which – for example – indicated a strong likelihood that winter heating loads in Victoria follow an initial peak in the morning, followed by a higher peak in the early evening.

Regional household energy consumption studies

Several detailed studies of household energy consumption have been undertaken by researchers. These typically focus on a set sample of households in a particular region.

One such study we have drawn from is the 'MyTown Microgrid' study led by University of Technology, Sydney – specifically its study of residential load profiles in the town of Heyfield, Victoria. This study was particularly useful as it provided aggregated load profile data for a sample of houses using actual energy monitoring devices.

Unlike the Solar Analytics dataset, these devices were provided to households by researchers. This is likely to provide a more representative sample of households, compared to a sample of households that have chosen to purchase the devices for their own use.

Additionally, the town of Heyfield does not have a reticulated gas network. This means the data is likely to provide a reasonably accurate reflection of winter heating loads in a cool climate region (geographically close to Melbourne) that are predominantly met via electricity.

We opted to use space conditioning load profiles from the Heyfield study as a basis for determining the shape of typical thermal load profiles, and uncontrolled hot water load profiles. These profiles were used to estimate load profile shapes for all regions in the model with transformations as described in Table 3. The magnitude of thermal loads was determined by calibrating these shapes to regional NatHERS load limits.

When comparing these load profiles with other data sources, it was found that the shape of heating load profiles was reasonably consistent with the AEMO aggregated gas demand profiles for Victoria. Where there were differences between the Heyfield profiles and other sources, these differences matched our expectations, given the limitations of those sources.

Household appliance configurations

Table 4 describes the configuration of appliances that were assumed for a dual-fuel, inefficient electric and efficient electric home in each region.

Households use energy in diverse ways and will each have their own appliance configurations and behaviours. It is difficult to capture this level of diversity in any modelling approach. Our approach aims to present configurations that are likely to be broadly representative of a large number of households in each region.

Households that consume gas are particularly exposed to rising energy prices, and exploring the financial implications of shifting away from gas appliances was a particular focus for this report. Therefore, in regions where residential gas consumption is relatively common, our modelling starts with a 'dual-fuel' (gas and electricity) home as a base case.

In Brisbane, Hobart and Darwin where residential gas consumption is very limited, an 'inefficient electric' home was instead modelled as a base case.

We assumed the choice of heater in a dual-fuel home aligned to the most common type of gas heating appliance in that state according to the RBS (gas ducted heating or gas room heating).

We then assumed that a home with gas ducted heating would replace that system with three RCACs, and a home with a gas room heater or fixed resistive electric heater would replace the system with two RCACs.[6]

In most regions except for cooler climates, we assumed households have an existing RCAC for cooling. When the household upgrades its heating appliances to RCACs, we account for the avoided cost of having to purchase a new dedicated cooling appliance.

In Melbourne and Canberra we assume the household has a pre-existing older-style refrigerative air conditioner, and in Hobart we assume no pre-existing cooling appliance. We assume that after upgrading to RCACs for heating, those RCACs will also be used for cooling. However we do not include the avoided cost of having to purchase a new dedicated cooling appliance.

This makes our financial analysis more conservative for those regions, when considering that some homes will in fact have a pre-existing RCAC for cooling. However, this ensures the financial

[6] The number of RCACs does not impact the energy consumption in the model, which is drawn from the baseline load profiles. However, it does impact the upfront cost of appliance switching.

outcomes in our report remain useful in relation to households with no cooling, or households that may not choose to upgrade their dedicated cooling appliance at end of life.

Table 4: Household appliance configurations modelled in the report.

	Dual-fuel home	Inefficient electric home	Efficient electric home
Sydney	• 1 x gas room heater • 1 x RCAC (for cooling only) • 1 x gas continuous flow hot water system • 1 x gas cooktop	*Not modelled*	• 2 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Melbourne	• 1 x gas ducted heater • 1 x older refrigerative air conditioner • 1 x gas continuous flow hot water system • 1 x gas cooktop	*Not modelled*	• 3 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Brisbane	*Not modelled*	• 1 x fixed resistive electric heater • 1 x RCAC (for cooling only) • 1 x resistive electric storage water heater • 1 x resistive electric cooktop	• 2 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Perth	• 1 x gas room heater • 1 x RCAC (for cooling only) • 1 x gas continuous flow hot water system • 1 x gas cooktop	*Not modelled*	• 2 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Adelaide	• 1 x gas room heater • 1 x RCAC (for cooling only) • 1 x gas continuous flow hot water system • 1 x gas cooktop	*Not modelled*	• 2 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Hobart	*Not modelled*	• 1 x fixed resistive electric heater • No cooling appliance • 1 x resistive electric storage water heater • 1 x resistive electric cooktop	• 2 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Canberra	• 1 x gas ducted heater • 1 x older refrigerative air conditioner • 1 x gas continuous flow hot water system • 1 x gas cooktop	*Not modelled*	• 3 x RCACs (for heating and cooling) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop
Darwin	*Not modelled*	• No heating appliance • 1x RCAC (for cooling only) • 1 x resistive electric storage water heater • 1 x resistive electric cooktop	• No heating appliance • 1x RCAC (for cooling only) • 1 x heat pump hot water system (optimised for midday operation) • 1 x induction cooktop

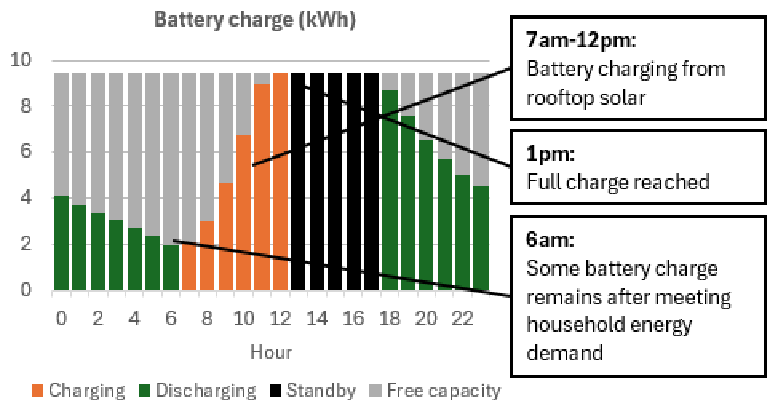
Batteries

Three modes of battery operation are available to the model.

Self-consumption only:

Under this mode, the household will divert all excess rooftop solar consumption to the battery, until the battery is fully charged or there is no more rooftop solar available. The battery will then be discharged from the earliest available opportunity (i.e. in the evening), until it is either fully discharged, or until it is time to start recharging the battery the following day (Figure 2).

Figure 2: Example battery charge diagram under 'self-consumption only' mode



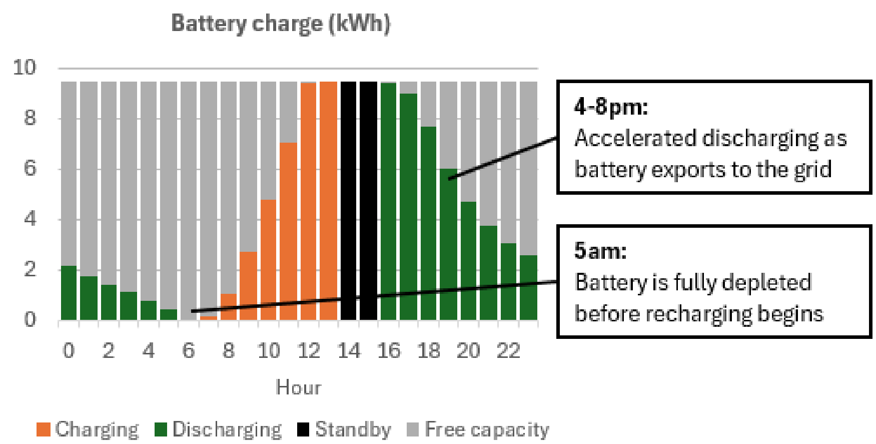
Note: Based on an efficient electric home in Sydney with 8kW solar and a 10kWh battery, in January.

Battery exports enabled:

This mode initially follows the behaviour in the previous mode. However, if any excess charge is forecast to remain at the end of the battery's charging cycle, this will be utilised to export to the grid during the evening peak period.

The ideal timing for evening peak exports was determined by analysing monthly statewide operational demand data from AEMO and determining the amount and timing of demand reduction that would achieve a 10% reduction in peak evening demand. The result was used to determine an 'ideal' distribution of energy exports from the battery that would contribute to offsetting peak demand, typically spread across the 5pm-9pm period.

Figure 3: Example battery charge diagram under 'exports enabled' mode



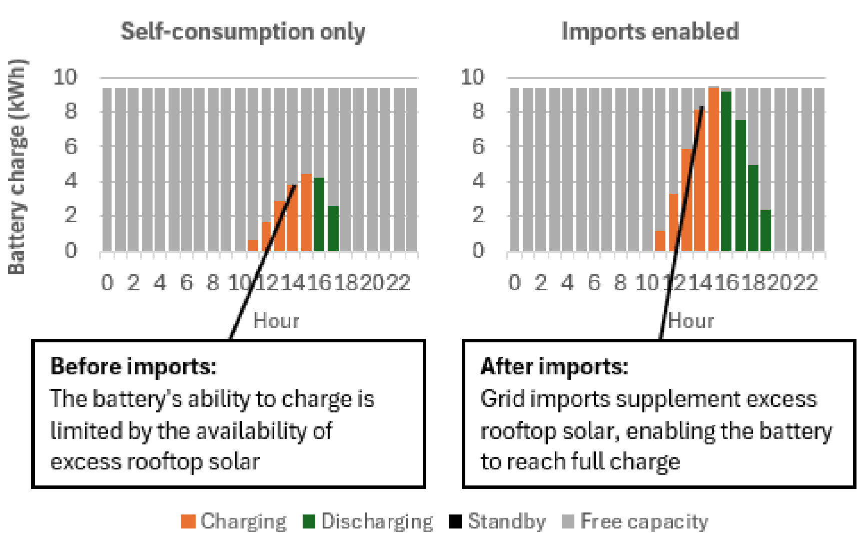
Note: Based on an efficient electric home in Sydney with 8kW solar and a 10kWh battery, in January.

Battery imports and exports enabled:

This mode follows the behaviour of the previous modes. However, if the battery is unable to reach full charge after consuming all the household's excess rooftop solar, it will supplement this by importing enough electricity from the grid during the midday period to achieve a full charge.

The ideal timing for midday imports was determined by analysing monthly statewide operational demand data from AEMO, and determining the amount and timing of additional demand that would achieve a 10% increase in minimum midday demand. The result was used to determine an 'ideal' distribution of energy exports from the battery that would contribute to raising minimum demand, typically spread across the 10am-3pm period.

Figure 4: Example battery charge diagrams showing the impact of enabling imports



Note: Based on an efficient electric home in Melbourne with 8kW solar and a 10kWh battery, in July.

Pre-heating and pre-cooling

The most comprehensive study of the potential for pre-heating and pre-cooling of Australian homes is the RACE for 2030 Opportunity Assessment: Residential solar pre-cooling and pre-heating (Wilmot et al.). This study provides detailed modelling of the technical potential and financial viability of using surplus solar energy to pre-heat and pre-cool a sample of home archetypes in different regions of Australia.

Critically for our purposes, the study examines the efficiency of solar pre-heating and pre-cooling, measured in terms of the reduction in air conditioning load proportional to the amount of solar power diverted. This efficiency is influenced by the amount of heat loss that occurs between the time of the house being pre-heated and cooled, and the evening period. This itself is a product of the thermal efficiency properties of the home.

In our approach, pre-heating and pre-cooling is modelled by first taking the underlying electricity demand for cooling and heating and the surplus rooftop solar production of the household.

We then select an appropriate pre-heating or pre-cooling efficiency ratio from Wilmot et al. depending on the NatHERS star rating and location of the household, to determine how much of the evening's cooling or heating load can be offset.

We then deduct that load from the household's evening heating and/or cooling demand, based on a 'decay function' shape, reflecting the fact that a percentage of the added heat or coolth from pre-heating and pre-cooling would be lost per hour.

As an additional filter, we assume pre-heating and cooling is not possible for a home with a NatHERS star rating of 2 or lower and is only 50% effective for a 3-star equivalent home. All pre-heating and cooling results in the report are modelled using a 5-star home as the base case.

As an output, we can then see how much rooftop solar has been diverted to pre-heating or pre-cooling in the middle of the day and can see a reduction in overall electricity demand for heating or cooling in the evening.

Rebates

The financial results included in the report explore the impact of federal and state rebates for household energy upgrades. The model includes the rebate programs in Table 5.

Table 5: Government rebate schemes included in the modelling

Jurisdiction	Program	Application in model
Federal	Small-Scale Renewable Energy Scheme (SRES)	**Rooftop solar:** We assume installing rooftop solar generates small-scale technology certificates (STCs) in accordance with the Clean Energy Regulator's STC calculator for each region, with an assumed price of $39.90/STC. **Heat pump hot water systems:** We assume installing a heat pump generates STCs in accordance with the Clean Energy Regulator's STC calculator for each region, with an assumed price of $39.90/STC. **Residential batteries:** We assume batteries 5kWh or higher generate a rebate of $330/kWh (as estimated by SolarQuotes).
New South Wales	Energy Savings Scheme (ESS)	**Reverse-cycle air conditioners:** We assume a rebate of $450 is generated for installing one RCAC (average of rebates estimate on the ESS website), or $675 for installing two RCACs (assuming a capacity equivalent to 1.5 times the single unit). **Heat pump hot water systems:** We assume a rebate of $535 applies when upgrading a resistive electric hot water system to a heat pump, or $250 when upgrading a gas hot water system (average of rebates estimated on the ESS website).
New South Wales	Peak Demand Reduction Scheme (PDRS)	**Residential batteries:** We assume 22 peak reduction certificates (PRCs) are generated per kWh battery capacity, for batteries that are subscribed to a Virtual Power Plant (VPP) (based on the BESS2 activity).[7] We assume an approximate value of $2.06/PRC.
Victoria	Victorian Energy Upgrades Scheme (VEU)	**Reverse-cycle air conditioners:** We assume installing an RCAC generates Victorian Energy Efficiency Certificate (VEECs) in accordance with the VEU registry calculator for activities 6(i), 6(iii), 6(ix), 6(v), 6(vii) and/or 6(xi). *For example, upgrading a gas ducted heater to three RCACs generates 32 VEECs.* **Heat pump hot water systems:** We assume installing a heat pump hot water system generates VEECs in accordance with the VEU registry calculator for activities 1D(18) or 3C. *For example, upgrading a gas continuous flow water heater to an iStore 270L heat pump generates eight VEECs.* **Induction cooktops:** We assume installing an induction cooktop generates VEECs in accordance with the VEU registry calculator for activity 46. *For example, installing a 60cm Bellini induction cooktop generates two VEECs.* A VEEC price of $82.50 is assumed (assuming customers see a value 25% below the rate seen by the installer), and the maximum discount is capped at the likely rebate amounts suggested on the VEU website for each upgrade ($840 for space heating; $630 for hot water; and $140 for cooking).
South Australia	Retailer Energy Productivity Scheme (REPS)	**Reverse-cycle air conditioners:** We assume installing an RCAC generates normalised REPS gigajoules in accordance with the specification HC2A. *For example, replacing a gas room heater with 2 RCAC generates 43.4 normalised REPS gigajoules.* **Heat pump hot water systems:** We assume installing a heat pump hot water system generates normalised REPS gigajoules in accordance with the specification WH1. *For example, replacing a gas continuous flow water heater with a heat pump generates 113 normalised REPS gigajoules* We assume an approximate value of $13.43 per REPS gigajoule.
Western Australia	WA Residential Battery Scheme	**Residential batteries:** We assume that batteries of 10kWh or larger are eligible for a rebate of $130/kWh in Synergy regions (e.g. Perth), or $380/kWh in Horizon Power regions (e.g. Geraldton), if they are subscribed to a Virtual Power Plant (VPP).[7]

[7] While these rebates are available to the model, they do not impact the results in the main report, as we have not modelled specific scenarios where batteries are subscribed to a VPP.

Detailed modelling results

Table 6 contains detailed modelling results including annual energy consumption, annual energy costs, upfront costs and paybacks associated with household energy upgrades, for a typical dual-fuel or inefficient electric home that installs efficient electric appliances, 8kW rooftop solar and a 10kWh battery.

Table 7 contains similar details, but for a 5-star thermally efficient dual-fuel or inefficient electric home that installs electric appliances, 8kW rooftop solar, and engages in pre-heating or pre-cooling.

Upfront costs for appliance upgrades reflect the comparative costs of efficient electric appliances versus like-for-like gas or inefficient electric replacements. In other words, they reflect an end-of-life appliance upgrade scenario.

Table 6: Detailed modelling results for typical dual-fuel or inefficient electric homes upgrading to efficient electric appliances, rooftop solar and a battery

Scenario		Annual gas consumption	Annual grid electricity consumption	Net annual energy bill	Upfront costs		Payback (years)	
					Before rebates	After rebates	Before rebates	After rebates
Sydney	**Typical dual-fuel home**	17,346MJ	4,139kWh	$2,782	-	-	-	-
	Upgrade to efficient electric appliances	- *(-17,346MJ)*	5,537kWh *(+1,398kWh)*	$2,301 *(-$481)*	$3,330	$2,257	6.9	4.7
	Add 8kW rooftop solar	-	2,600kWh *(-2,936kWh)*	$900 *(-$1,402)*	$8,756	$6,128	6.2	4.4
	Add 10kWh battery							
	self-consumption only	-	36kWh *(-2,565kWh)*	$167 *(-$733)*	$10,000	$6,700	13.4	9
	enable imports & exports		36kWh *(-2,565kWh)*	$195 *(-$705)*	$10,000	$6,700	13.5	9
	add better tariffs	-	“	$64 *(-$836)*	$10,000	$6,700	11.5	7.7
	projected 2030s costs	-	“	“	$5,000	-	5.7	-
Melbourne	**Typical dual-fuel home**	60,814MJ	3,705kWh	$3,731	-	-	-	-
	Upgrade to efficient electric appliances	- *(-60,814MJ)*	7,048kWh *(+3,342kWh)*	$2,319 *(-$1,412)*	$4,216	$357	3	0.3
	Add 8kW rooftop solar	-	3,612kWh *(-3,435kWh)*	$1,209 *(-$1,110)*	$9,346	$7,101	8.4	6.4
	Add 10kWh battery	-						
	self-consumption only	-	1,403kWh *(-2,210kWh)*	$669 *(-$540)*	$10,000	$6,700	17.9	12
	enable imports & exports		1,424kWh *(-2,189kWh)*	$625 *(-$584)*	$10,000	$6,700	17.1	11.4
	add better tariffs	-	“	$452 *(-$757)*	$10,000	$6,700	13.2	8.8
	projected 2030s costs	-	“	“	$5,000	-	6.6	-
Brisbane	**Typical inefficient electric home**	-	7,383kWh	$2,909	-	-	-	-
	Upgrade to efficient electric appliances	-	5,358kWh *(-2,025kWh)*	$2,242 *(-$667)*	$2,106	$1,508	3.2	2.3
	Add 8kW rooftop solar	-	2,396kWh *(-2,962kWh)*	$975 *(-$1,267)*	$9,356	$6,728	7.4	5.3
	Add 10kWh battery	-						
	self-consumption only	-	- *(-2,396kWh)*	$290 *(-$685)*	$10,000	$6,700	14.5	9.7

	Scenario	Annual gas consumption	Annual grid electricity consumption	Net annual energy bill	Upfront costs: Before rebates	Upfront costs: After rebates	Payback (years): Before rebates	Payback (years): After rebates
	enable imports & exports		- *(-2,396kWh)*	$305 *(-$669)*	$10,000	$6,700	14.6	9.8
	add better tariffs	-	"	$127 *(-$848)*	$10,000	$6,700	11.6	7.8
	projected 2030s costs	-	"	"	$5,000	-	5.8	-
Perth	**Typical dual-fuel home**	16,832MJ	4,309kWh	$2,605	-	-	-	-
	Upgrade to efficient electric appliances	- *(-16,832MJ)*	5,671kWh *(+1,361kWh)*	$2,162 *(-$443)*	$3,080	$2,482	7	5.6
	Add 8kW rooftop solar	-	2,449kWh *(-3,221kWh)*	$935 *(-$1,227)*	$8,593	$5,965	7	4.9
	Add 10kWh battery	-						
	self-consumption only	-	8kWh *(-2,441kWh)*	$197 *(-$739)*	$10,000	$6,700	13.1	8.8
	enable imports & exports		8kWh *(-2,441kWh)*	$157 *(-$778)*	$10,000	$6,700	12.1	8.1
	add better tariffs	-	"	$101 *(-$834)*	$10,000	$6,700	11.4	7.6
	projected 2030s costs	-	"	"	$5,000	-	5.7	-
Adelaide	**Typical dual-fuel home**	19,213MJ	4,444kWh	$3,660	-	-	-	-
	Upgrade to efficient electric appliances	- *(-19,213MJ)*	5,966kWh *(+1,523kWh)*	$2,949 *(-$712)*	$3,080	$381	4.3	0.5
	Add 8kW rooftop solar	-	2,518kWh *(-3,449kWh)*	$1,253 *(-$1,696)*	$8,851	$6,223	5.2	3.7
	Add 10kWh battery	-						
	self-consumption only	-	84kWh *(-2,434kWh)*	$266 *(-$986)*	$10,000	$6,700	9.6	6.4
	enable imports & exports		86kWh *(-2,431kWh)*	$270 *(-$983)*	$10,000	$6,700	9.6	6.4
	add better tariffs	-	"	$132 *(-$1,120)*	$10,000	$6,700	8.4	5.7
	projected 2030s costs	-	"	"	$5,000	-	4.2	-
Hobart	**Typical inefficient electric home**	-	9,507kWh	$2,989	-	-	-	-
	Upgrade to efficient electric appliances	-	5,049kWh *(-4,458kWh)*	$1,789 *(-$1,200)*	$4,683	$4,045	3.9	3.4
	Add 8kW rooftop solar	-	2,561kWh *(-2,488kWh)*	$576 *(-$1,214)*	$10,733	$8,488	8.8	7
	Add 10kWh battery	-						
	self-consumption only	-	383kWh *(-2,178kWh)*	$217 *(-$359)*	$10,000	$6,700	34.8	23.3
	enable imports & exports		394kWh *(-2,168kWh)*	$239 *(-$337)*	$10,000	$6,700	36.3	24.3
	add better tariffs	-	"	$203 *(-$372)*	$10,000	$6,700	32.1	21.5
	projected 2030s costs	-	"	"	$5,000	-	16	-
Canberra	**Typical dual-fuel home**	46,471MJ	4,401kWh	$3,864	-	-	-	-
	Upgrade to efficient electric appliances	- *(-46,471MJ)*	6,982kWh *(+2,581kWh)*	$2,294 *(-$1,570)*	$3,989	$3,391	2.5	2.2
	Add 8kW rooftop solar	-	3,909kWh *(-3,073kWh)*	$956 *(-$1,337)*	$8,791	$6,163	6.6	4.6
	Add 10kWh battery	-						
	self-consumption only	-	1,126kWh *(-2,784kWh)*	$416 *(-$541)*	$10,000	$6,700	18.5	12.4
	enable imports & exports		1,126kWh *(-2,784kWh)*	$396 *(-$561)*	$10,000	$6,700	18.6	12.5
	add better tariffs	-	"	$317 *(-$640)*	$10,000	$6,700	16.2	10.9
	projected 2030s costs	-	"	"	$5,000	-	8.1	-

	Scenario	Annual gas consumption	Annual grid electricity consumption	Net annual energy bill	Upfront costs		Payback (years)	
					Before rebates	After rebates	Before rebates	After rebates
Darwin	**Typical inefficient electric home**	-	10,823kWh	$3,473	-	-	-	-
	Upgrade to efficient electric appliances	-	9,433kWh *(-1,390kWh)*	$3,060 *(-$413)*	$2,756	$2,237	6.7	5.4
	Add 8kW rooftop solar	-	4,271kWh *(-5,162kWh)*	$954 *(-$2,105)*	$13,897	$10,973	6.6	5.2
	Add 10kWh battery	-						
	self-consumption only	-	990kWh *(-3,281kWh)*	$367 *(-$588)*	$10,000	$6,700	18	12.1
	enable imports & exports		990kWh *(-3,281kWh)*	$361 *(-$593)*	$10,000	$6,700	18	12.1
	add better tariffs	-	"	$361 *(-$593)*	$10,000	$6,700	18	12.1
	projected 2030s costs	-	"	"	$5,000	-	9	-

Note: Numbers in brackets indicate change relative to previous scenario in table. Battery sub-scenarios align to Figure 16 of main report (with 'current case' in the main report representing the most economical case between self-consumption only, and enabling imports & exports). Rebates were not modelled for 'projected 2030s costs' batteries scenario.

Table 7: Detailed modelling results for 5-star dual-fuel or inefficient electric homes upgrading to efficient electric appliances, rooftop solar and enabling pre-heating/pre-cooling.

	Scenario	Annual gas consumption	Annual grid electricity consumption	Net annual energy bill	Upfront costs		Payback (years)	
					Before rebates	After rebates	Before rebates	After rebates
Sydney	**5-star dual-fuel home**	13,928 MJ	3,585 kWh	$2,466	-	-	-	-
	Upgrade to efficient electric appliances	- *(-13,928 MJ)*	4,755 kWh *(+1,169 kWh)*	$2,019 *(-$447)*	$1,665	$1,128	3.7	2.5
	Add 8 kW rooftop solar	-	2,221 kWh *(-2,533 kWh)*	$746 *(-$1,273)*	$8,756	$6,128	6.9	4.8
	Enable pre-heating & pre-cooling	-	2,075 kWh *(-146 kWh)*	$722 *(-$24)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$180	-	6.2	-
	High cost		"	"	$298	-	10.2	-
Melbourne	**5-star dual-fuel home**	63,011 MJ	6,566 kWh	$2,756	-	-	-	-
	Upgrade to efficient electric appliances	- *(-63,011 MJ)*	10,494 kWh *(+3,928 kWh)*	$1,823 *(-$933)*	$2,108	$179	2.3	0.2
	Add 8 kW rooftop solar	-	5,097 kWh *(-5,397 kWh)*	$887 *(-$936)*	$9,346	$7,101	10	7.6
	Enable pre-heating & pre-cooling	-	2,140 kWh *(-2,957 kWh)*	$807 *(-$81)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$192	-	2.2	-
	High cost		"	"	$447	-	5.1	-
Brisbane	**5-star inefficient electric home**	-	6,303 kWh	$2,552	-	-	-	-
	Upgrade to efficient electric appliances	-	4,589 kWh *(-1,714 kWh)*	$1,987 *(-$565)*	$1,053	$754	1.9	1.3
	Add 8 kW rooftop solar	-	2,087 kWh *(-2,501 kWh)*	$852 *(-$1,135)*	$9,356	$6,728	8.2	5.9

	Enable pre-heating & pre-cooling	-	1,957 kWh *(-130 kWh)*	$834 *(-$18)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$180	-	8.4	-
	High cost		"	"	$298	-	14	-
Perth	**5-star dual-fuel home**	12,699 MJ	3,586 kWh	$2,194	-	-	-	-
	Upgrade to efficient electric appliances	- *(-12,699 MJ)*	4,671 kWh *(+1,085 kWh)*	$1,847 *(-$347)*	$1,540	$1,241	4.4	3.6
	Add 8 kW rooftop solar	-	2,038 kWh *(-2,633 kWh)*	$763 *(-$1,084)*	$8,593	$5,965	7.9	5.5
	Enable pre-heating & pre-cooling	-	1,905 kWh *(-133 kWh)*	$734 *(-$29)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$180	-	5.3	-
	High cost		"	"	$298	-	8.7	-
Adelaide	**5-star dual-fuel home**	14,429 MJ	3,590 kWh	$3,097	-	-	-	-
	Upgrade to efficient electric appliances	- *(-14,429 MJ)*	4,793 kWh *(+1,203 kWh)*	$2,439 *(-$657)*	$1,540	$191	2.3	0.3
	Add 8 kW rooftop solar	-	2,057 kWh *(-2,736 kWh)*	$1,010 *(-$1,429)*	$8,851	$6,223	6.2	4.4
	Enable pre-heating & pre-cooling	-	1,907 kWh *(-149 kWh)*	$968 *(-$42)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$180	-	3.7	-
	High cost		"	"	$298	-	6.2	-
Hobart	**5-star inefficient electric home**	-	7,108 kWh	$2,347	-	-	-	-
	Upgrade to efficient electric appliances	-	4,441 kWh *(-2,666 kWh)*	$1,627 *(-$720)*	$2,342	$2,023	3.3	2.8
	Add 8 kW rooftop solar	-	2,190 kWh *(-2,252 kWh)*	$452 *(-$1,175)*	$10,733	$8,488	9.1	7.2
	Enable pre-heating & pre-cooling	-	2,039 kWh *(-151 kWh)*	$445 *(-$7)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$180	-	44.9	-
	High cost		"	"	$298	-	74.3	-
Canberra	**5-star dual-fuel home**	29,441 MJ	4,029 kWh	$3,067	-	-	-	-
	Upgrade to efficient electric appliances	- *(-29,441 MJ)*	5,841 kWh *(+1,812 kWh)*	$1,979 *(-$1,088)*	$1,995	$1,695	1.8	1.6
	Add 8 kW rooftop solar	-	3,140 kWh *(-2,700 kWh)*	$716 *(-$1,263)*	$8,791	$6,163	7	4.9
	Enable pre-heating & pre-cooling	-	2,724 kWh *(-416 kWh)*	$686 *(-$30)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$192	-	5.9	-
	High cost		"	"	$447	-	13.7	-
Darwin	**5-star inefficient electric home**	-	8,779 kWh	$2,854	-	-	-	-
	Upgrade to efficient electric appliances	-	7,388 kWh *(-1,390 kWh)*	$2,441 *(-$413)*	$1,378	$1,119	3.3	2.7
	Add 8 kW rooftop solar	-	3,257 kWh *(-4,131 kWh)*	$567 *(-$1,873)*	$13,897	$10,973	7.4	5.9
	Enable pre-heating & pre-cooling	-	2,134 kWh *(-1,123 kWh)*	$732 *(+$165)*				
	No cost		"	"	$0	-	0	-
	Medium cost		"	"	$168	-	No payback	-
	High cost		"	"	$149	-	No payback	-

Note: Numbers in brackets indicate change relative to previous scenario in table. Pre-heating/pre-cooling sub-scenarios align to 'Pre-heating and cooling' section in main report. No rebates exist for enabling pre-heating and pre-cooling.

Glossary

AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BoM	Bureau of Meteorology
CoP	Coefficient of Performance
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DWGM	Declared Wholesale Gas Market
ESS	Energy Savings Scheme
kW	Kilowatt
kWh	Kilowatt-hour
MJ	Megajoule
NatHERS	Nationwide House Energy Rating Scheme
PDRS	Peak Demand Reduction Scheme
PRC	Peak Reduction Certificate
RBS	Residential Baseline Study
RCAC	Reverse-Cycle Air Conditioner
REPS	Retailer Energy Productivity Scheme
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificate
VEEC	Victorian Energy Efficiency Certificate
VEU	Victorian Energy Upgrades
VPP	Virtual Power Plant

About IEEFA

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

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