ATSE EXPLAINER

Power to the people

Smarter energy use through demand side management explained

Australian Academy of Technological Sciences & Engineering

APRIL 2025

Key messages

Power to the people

Smarter energy use through demand side management explained

Demand side management can play a major role in helping to reduce bills, improve electricity system reliability, improve utilisation of expensive network infrastructure and better manage both periods of minimum and peak demand.

Empowering consumers to shift their demand from periods of high demand to times of low demand can improve energy grid stability and bring down energy costs for all Australians.

Giving consumers the choice to control their demand is only going to become more important. Increased adoption of electric appliances and vehicles will increase grid demand at the same time as more variable renewable energy sources come online.

We have the technologies and capability to dramatically improve the way we use energy. If properly implemented, these changes would increase consumer choice, help to reduce the cost of energy, and support the transition to a high-renewables grid.

WHAT IS DEMAND SIDE MANAGEMENT?

Demand Side Management (DSM) is the process of incentivising and enabling customers to reduce their energy use or change their energy consumption patterns from times of high energy demand to times when demand is lower. Managing power use from residential, commercial and industrial customers helps to balance the demand and supply of energy, reducing the overall cost of maintaining the electricity grid.

WHY IS DEMAND SIDE MANAGEMENT IMPORTANT?

Over the next 20 years, Australia's energy system will undergo a major transition to a net zero energy system, underpinning our future net zero emissions economy. This transition will include moving from internal combustion cars to electric vehicles, electrifying household appliances such as ovens and heaters, and replacing coal and gas in industry. This will all lead to large increases in the demand for electricity. The increase in electricity demand will occur at a time when a larger proportion of electricity will be generated from variable energy supplies, such as wind and solar, as the nation moves to more renewable energy generation.

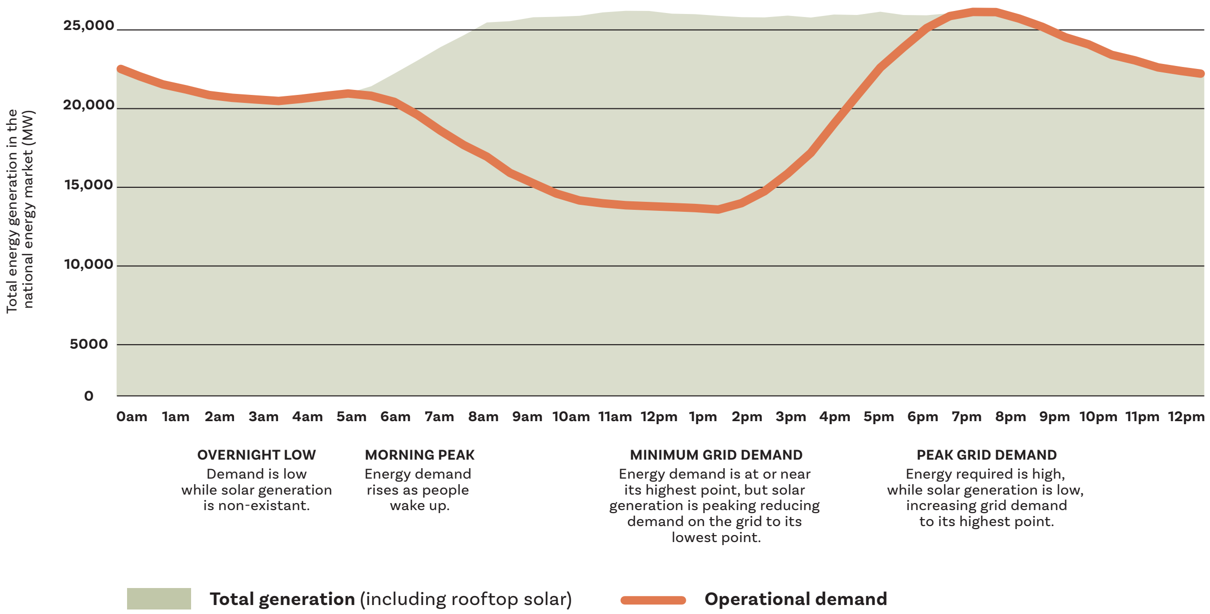
DSM is an under-utilised enabler of Australia's net zero transition. DSM can play a major role in helping to reduce bills, improve electricity system reliability, improve utilisation of expensive network infrastructure and better manage both periods of minimum demand and peak demand. Fully implemented, DSM could reduce Australian household power bills by up to 24%[1] - equivalent to annual savings of $331 for an average family[2]. Fully embracing DSM gives consumers more control over how they use energy and provides opportunities for consumers to make significant savings on their energy bills.

DSM is typically the cheapest way to balance demand with supply at a grid level. DSM can reduce peak electricity demand (for example during the hottest or coldest days of the year). It not only reduces the risk of blackouts, but it also minimises the need for expensive transmission and distribution network upgrades that might only be needed for a few hours each year. During minimum demand periods, DSM can help to increase load on the electricity system, making it more stable. Unlocking DSM's full potential can therefore play a vital role in reducing power bills and cost of living pressures.

1. Behi et al., 'Cost-Benefit Analysis of a Virtual Power Plant Including Solar PV, Flow Battery, Heat Pump, and Demand Management: A Western Australian Case Study'.
2. Canstar Blue, 'What Is the Average Electricity Bill?'

PEAK AND MINIMUM DEMAND

Illustration of energy demand within the National Energy Market on 29 October 2023.
Data provided by the Australian Energy Market Operator.



Demand from the grid usually follows a predictable daily pattern. Electricity use usually peaks in the middle of the day, as commercial and industrial businesses run at full capacity and, in summer, air conditioning is most needed. Despite electricity consumption being at its highest, the influx of electricity from rooftop solar generation in the middle of the day also leads to a peak in the supply of electricity. This means that the middle of the day can be the point when demand on large generators supplying the grid is the lowest – known as minimum demand. When minimum demand drops too low, grid stability can be compromised. Like when you ride a bicycle, the grid needs a minimum momentum to maintain stability[3].

Peak demand on the grid usually happens in the late afternoon to early evening, around 6 to 8 PM, when solar generation declines. This peak is driven by high residential energy usage as people return home from work, turn on lights, use kitchen appliances, and increase heating or cooling of residential properties. Larger peaks require additional generation and storage, increasing the cost of electricity, while transmission networks need to have the capacity to meet the peak demand to avoid system overload and blackouts.

A combination of high peak and low minimum demand could lead to an expensive and unstable electricity grid. Supporting customers to shift energy usage throughout the day from times of peak demand to times of minimum demand reduces this gap, increasing grid efficiency and reliability and bringing down power prices for consumers.

3. For more information on grid stability, please see ATSE's Powering the net zero transition: Electricity security explained.

EMERGING ENERGY TRENDS AFFECTING ENERGY DEMAND

Transition from gas to electricity

A net zero future will require a reduction in the amount of natural gas used in both residential properties and industrial applications. In homes, natural gas often fuels some of the most energy intensive appliances – hot water heaters, cooktops and home heating – while 74% of natural gas used by industry is for industrial heat generation[4]. Commercially available electric alternatives for industrial heating up to 400°C are already available with the technology for heating up to 1000°C developed and ready for commercialisation (e.g. electric boilers and furnaces)[5]. At home, electric appliances offer improved energy efficiency compared to gas appliances, resulting in lower costs and reduced greenhouse gas emissions. Additionally, modern electric appliances, such as heat pumps and induction cooktops, can draw power from home solar panels and battery storage systems and be managed with digital control systems, reducing the customers' reliance on the grid and hence their power bills. However, the large-scale shifts to electric appliances needed to reach net zero emissions will increase demand for electricity, and, if not managed, could put pressure on the grid at times of peak demand. Conversely, the use of electric appliances during periods of minimum demand can help smooth out energy demand making the grid more stable and reliable.

Electric vehicle growth

Electric vehicles (EVs) offer substantial environmental benefits by decreasing reliance on fossil fuels and lowering overall transportation emissions. AEMO projections show that under a "Step Change" scenario, 97% of vehicles on the road could be EVs by 2050. Charging these EVs can put additional strain on the energy grid, particularly if charging occurs during periods of peak demand (e.g. evenings). Current data suggests that most EV owners charge vehicles during non-peak periods (the middle of the day or overnight)[6], but as the number of EVs increases, so will the impact on peak demand. Commercial fleets of EVs also risk adding to this demand if large numbers of vehicles are charged simultaneously (for example, fleets of delivery vehicles being charged at the end of the day). Managing this demand through time-of-charging incentives and utilising the batteries of electric vehicles garaged at home for energy storage will help ensure that peak demand - and thus infrastructure requirements and power prices - is kept as low as possible.

Increasing amount of variable generation

The increasing amount of variable generation in the electricity grid coming from renewable energy sources offers significant opportunities for reducing greenhouse gas emissions and promoting sustainable energy use. Currently, one-third of detached homes in the National Electricity Market (NEM) have solar panels, and this could rise to 79% by 2050[7]. At a grid level, renewable energy capacity is expected to rise from 21 GW currently to 127 GW by 2050 – a six-fold increase.[8] However, renewable energy resources do not produce power continuously and the integration of this volume of variable generation poses substantial challenges that will need to be carefully managed. Options for managing this include financial incentives, home energy storage, community battery projects and virtual power plants.

4. DISR, 'How Australian Gas Is Used Today'.
5. Roelofsen et al., 'How Electrification Can Help Industrial Companies Cut Costs'.
6. Philip, Lim, and Whitehead, 'Driving and Charging an EV in Australia: A Real-World Analysis'.
7. Australian Energy Market Operator, '2024 Integrated System Plan'.
8. Australian Energy Market Operator.

TECHNOLOGICAL AND POLICY SOLUTIONS

Energy Pricing

Reducing the cost of electricity during minimum demand and raising it in peak demand can incentivise customers to use electricity during non-peak periods. Currently, energy providers mainly offer fixed rate tariffs – where customers are charged a flat rate regardless of their time of use. This form of tariff is simple to understand and is generally preferred by most customers[9] but provides no incentive to shift energy use to off-peak periods when electricity is cheaper, and demand is lower.

Alternatives like time-of-use pricing set different rates for electricity based on the time of day, with higher prices during peak demand periods and lower prices during off-peak times. It can also be used to increase the amount paid to consumers for putting energy back in the grid during times of peak demand, and to incentivise the efficient use of consumers' electrical appliances. Demand charges, on the other hand, impose fees based on the highest level of power a customer uses during peak periods. These measures encourage consumers to shift their energy-intensive activities to times when demand is lower, and electricity is cheaper. Provided a customer can shift their energy use, this can result in significant savings, while also promoting a more balanced and efficient energy system.

However, not all customers have the ability or have access to the technological support to shift their energy use effectively. For example, lower socio-economic households may not be able to afford to install solar, battery or digital control systems, while hospitals or individuals with medical needs may have little say in when they use energy intensive - but lifesaving – equipment. Consumers may also be unaware of how they can adjust their energy use to take advantage of variable tariffs. For households unable to adjust their energy consumption, compulsory time-of-use or demand charge tariff structures may significantly increase the cost of energy, resulting in the burden of these charges being felt by those least able to pay. If variable tariffs are introduced, they therefore need to include measures to support vulnerable customers, as well as education and support to assist all customers to benefit from the new tariff structures.

Digital control systems to manage connected devices

Digital control systems (often known as Home Energy Management Systems or Building Management Systems) manage connected devices to give customers full control over their energy use and provide immediate energy usage information. Digital control systems make it easier for consumers to manage their energy consumption efficiently by enabling automated control and optimisation of energy consumption across various devices and appliances. This can include programming appliances and energy resources (like rooftop solar or batteries) to be automatically turned on or off at certain times. Additionally, these systems enhance fault detection, allowing for quicker identification and resolution of issues, which can prevent energy waste and reduce costs. Digital control systems are most effective when they can connect to and control a range of appliances and energy resources (i.e. interoperability), allowing consumers to have the greatest control over their energy use.

The cost savings from more efficient energy use can make digital control systems cost effective for owner-occupiers. In rental properties, such control systems are usually installed and maintained by the property owner, rather than the tenant who is using the electricity. As such, landlords typically bear the upfront costs of installing these systems and integrating them with existing appliances or local electricity generation and storage – while customers reap the benefits of lower energy costs. This misalignment of costs and benefits often discourages property owners from making these investments, despite energy-efficient properties generally producing higher rents and increased occupancy[10]. Financial incentives from governments or funding agreements between owners and tenants can help balance this misalignment.

9. Stenner et al., 'Australian Consumers' Likely Response to Cost-Reflective Electricity Pricing Copyright and Disclaimer'.
10. Gabriel et al., 'The Environmental Sustainability of Australia's Private Rental Housing Stock'.

Improved interoperability standards for devices

Interoperability of appliances and consumer energy resources allows consumers to coordinate their energy use (generally with digital control systems or inbuilt settings). Interoperability is dependent on manufacturers creating technology that allows appliances and energy resources to talk to each other. Mandating high standards for devices in the energy sector can help to create a cohesive system where energy resources can communicate and coordinate their functions. For example, an EV charger could be programmed to charge only when solar panels are producing excess energy, optimising energy use and reducing costs.

Standardisation, however, could limit the development of new technologies, as developers may be penalised for creating new technologies that adopt new systems that may not be backwards compatible. Regulators must be careful to balance these priorities as standards are developed and updated.

Infrastructure and incentives for grid friendly EV charging

As the number of EVs that need to be charged increases, so will the need for financial and technological options to minimise the impact on the grid. Ideally, EVs should be charged during the midday solar generation peak, or between midnight and sunrise, when grid demand is at its lowest. AGL, for example, offers a discount for EV charging between midnight and 6am in New South Wales. Incentives to charge vehicles during low demand periods can help encourage those who can adjust their vehicle charging times to do so. However, while cars are parked at home 80% of the time[11], many vehicles are often away from home during the middle of the day (during minimum demand), making it challenging to take advantage of this charging window.

Additionally, many apartment buildings do not have dedicated EV chargers, making it difficult for residents to charge their vehicles overnight – another preferred charging period. Those apartment buildings that do have charging options are often limited in the number of charging stations that can draw from the grid simultaneously by the building's connection capacity. Expanding public charging infrastructure, especially in workplace parking areas and residential complexes could help to address these issues. Apartment complexes can also use control systems to allow more vehicles to be plugged in to charge simultaneously, with control units swapping which vehicle chargers are active to ensure larger numbers of vehicles can be charged without overloading existing infrastructure.

Household energy storage

Household energy storage is becoming an increasingly important aspect of modern energy management, allowing consumers to shift supply from the grid to a battery at times when prices and grid demand are lower (especially when integrated with a digital control system). Battery storage is gaining popularity, evidenced by the installation of 57,000 battery units in 2023 alone[12] and household energy storage is expected to increase from a total of 1 GW today to 34 GW by 2050[13]. Alternatively, heat (one of the largest reasons for energy use) itself can be stored. By heating or cooling a building or its hot water during non-peak periods, less energy is required to maintain that temperature during peak periods.

Battery storage systems allow users to store electricity during periods of high household generation/low grid prices and either use this electricity themselves later or sell it back to the grid during times of high demand/high prices. This can be particularly beneficial for consumers when combined with demand-driven pricing, such as time-of-use pricing. However, the high upfront costs for batteries can make battery storage less economically attractive to consumers over a typical 10-year warranty period, depending on usage patterns and fee structures. High upfront costs also characterise the technologies that enable consumers to make the most of their battery storage systems – including modern electric appliances, solar generation and electric vehicles. This financial hurdle slows the transition to more efficient energy use patterns and reduces the overall effectiveness of DSM strategies, as fewer consumers can afford to participate.

Rebates and subsidies are often used to reduce the upfront cost, which makes these technologies more affordable, but they rarely eliminate the total upfront cost – leaving the poorest households unable to access them. For those for whom subsidies are unable to sufficiently reduce the financial barrier, programs that spread the cost of these technologies over time through monthly payments added to utility bills, or income contingent loans, can make the cost more manageable.

11. James, 'End of the Road? Why It Might Be Time to Ditch Your Car'.
12. Barnes, 'How to Buy the Best Solar Battery Storage'.
13. Australian Energy Market Operator, '2024 Integrated System Plan'.

Virtual power plants

Virtual power plants (VPPs) are systems that coordinate the generation and consumption of energy from multiple sources that are widely distributed - like large numbers of rooftop solar and battery systems. VPPs can optimise energy use, enhance grid stability, and provide additional capacity during peak demand. This decentralised approach can reduce the need for large-scale power plants, can help manage consumer energy resources more effectively and enables greater consumer participation in the energy market.

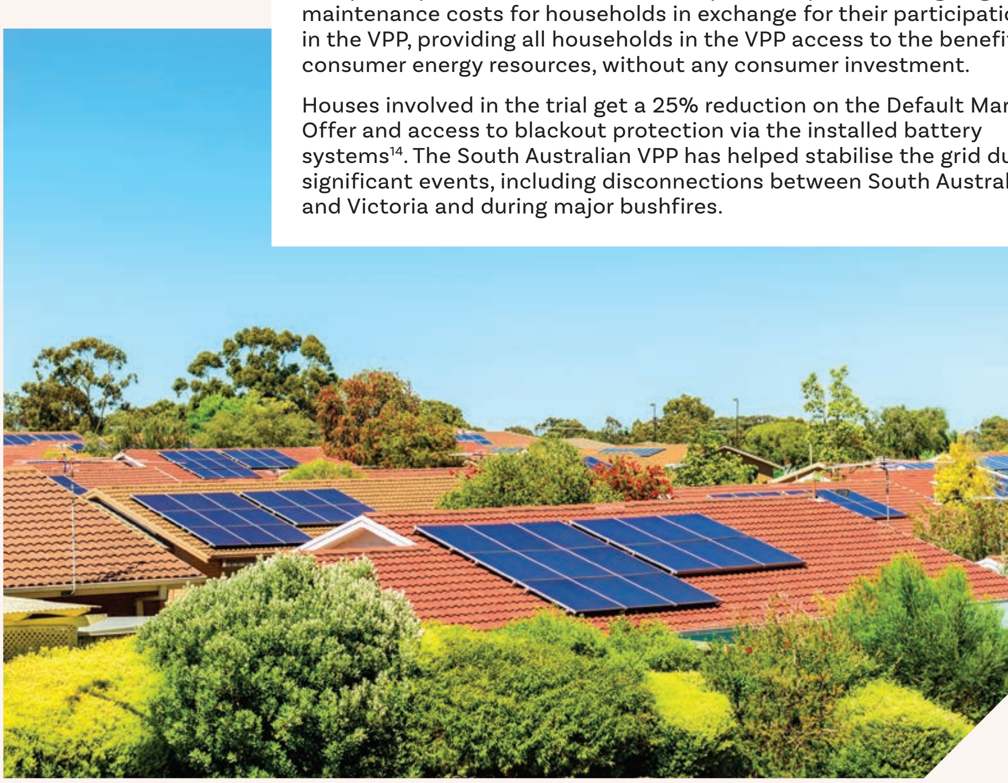
As they use the customer's own energy generation and storage, VPPs require the buy-in of consumers, who may feel uncomfortable about their energy provider turning on and off the consumer's own energy resources – especially where the customer has invested a lot of money to receive the benefits of those resources. At a larger scale, VPPs could include community battery storage systems, allowing for a distributed network of smaller batteries, rather than single, large-scale, battery systems.

CASE STUDY

The South Australian Government, Tesla and retailer Energy Locals, have collaborated to establish a VPP open to public and community housing residents in South Australia, with over 5,500 Housing SA homes already connected.

To help manage concerns about energy resource ownership, the scheme has funded the installation of rooftop solar and battery systems for trial participants. This eliminated the upfront capital and ongoing maintenance costs for households in exchange for their participation in the VPP, providing all households in the VPP access to the benefits of consumer energy resources, without any consumer investment.

Houses involved in the trial get a 25% reduction on the Default Market Offer and access to blackout protection via the installed battery systems[14]. The South Australian VPP has helped stabilise the grid during significant events, including disconnections between South Australia and Victoria and during major bushfires.



14. Department for Energy and Mining, 'South Australia's Virtual Power Plant'.

EMERGING TECHNOLOGIES

EVs with vehicle-to-grid and or vehicle-to-home capabilities

EV batteries offer a substantial capacity for energy storage and grid management, costing around the same price per kWh as a household battery, while also providing transportation. A typical EV battery holds around 60 kWh of energy – three times the daily usage of an average household and six times that of a typical household battery. This substantial energy storage could be used to help manage household energy use, storing energy during minimum demand periods and using it during peak demand periods. On average, a trip in an EV uses about 10 kWh, and most trips start with more than 50% battery charge[15], meaning there is usually substantial spare energy that can be fed back into the grid or a home.

Vehicle batteries can therefore provide an alternative to home battery systems – with greater capacity and the bonus of also providing transport – helping consumers manage their electricity supply and demand. Consumers with vehicle-to-grid capabilities could also profit by charging their EVs during periods of low demand (and low costs) and returning energy to the grid during peak demand (and high costs), effectively earning money through this process. The positive impacts of this on the grid is dependent on vehicles being connected for extended periods[16]. However, the idea of allowing power companies to control their vehicle battery may be off-putting to some drivers, meaning limits on the amount of power taken from vehicles are likely to be needed. Vehicle manufacturers may also want to continue to restrict the use of a vehicle's battery for non-driving use to maintain battery performance and limit potential warranty issues.

The use of EV batteries to return energy to the home or grid requires bidirectional charging capability within the vehicle itself, which currently only a few EV models possess. It also requires a bidirectional charger, which are more expensive that unidirectional chargers. Prices for bidirectional chargers should come down as a result of the economies of scale associated with increased adoption but are still likely to have higher upfront costs unless rebates or other incentives are introduced. Development in this area is ongoing, but regulatory frameworks for vehicle-to-grid transfers are largely still emerging. For example, bidirectional chargers are only permitted to connect to the grid in South Australia through SA Power Networks. Developing the regulatory frameworks for bidirectional charging will be required to take advantage of the substantial storage capacity provided by EVs.

15. Philip, La Nauze, and Lim, 'Australia's Electric Vehicle Numbers Doubled Last Year. What's the Impact of Charging Them on a Power Grid under Strain?'
16. Jones et al., 'Modelling V2G: A Study on the Economic and Technical Value Proposition for V2G'.

GLOSSARY

Building Management Systems (BMS)
BMS's automate control of energy usage of a building through a single interface. Systems can monitor and adjust building energy use by adjusting connected appliances including lighting, air conditioning. Also known as Building Automation Systems (BAS) or Building Management and Control Systems (BMCS), amongst other names, depending on the exact configuration and use.

Consumer Energy Resources (CER)
Refers to small-scale energy generation or storage devices that allow consumers to vary how they use energy. Examples include rooftop solar systems and in-home battery devices.

Distributed Energy Resources (DER)
Sometimes used interchangeably with CER, DER refers to small scale energy and storage devices included in CER but also includes larger community-based assets such as community solar or battery projects.

Demand Side Management
The process of managing consumer demand (from residential, commercial and industrial customers) to help balance the demand and supply of energy.

Electrification
The process of replacing other energy sources (typically natural gas) with electricity. For example, replacing a gas stove top with an electric induction stovetop.

Home Energy Management Systems
Typically, an internet enabled system for monitoring and controlling power use within households. Systems can help to manage domestic energy generation and storage as well as energy consumption through major household appliances.

Minimum Demand
The lowest level of energy demanded from the grid over a period of time. Also known as Minimum Operational Demand.

Peak Demand
The highest level of energy demanded from the grid over a period of time. Also known as Peak Operational Demand.

Split Incentives
Spilt incentives occur when the person who is required to invest in energy upgrade (e.g. a landlord) is not the same person who benefits from those upgrades (e.g. a tenant) creating a situation where it is disadvantageous to make such an investment.

Vehicle-to-grid capability
A system in which a plug-in electric or hybrid vehicle can sell energy stored in its battery back into the grid in order to manage grid demand.

Vehicle-to-home capability
A system in which a plug-in electric or hybrid vehicle can utilise its battery storage as a backup power source for a home during power outages, without connecting to the grid.

REFERENCES

Australian Energy Market Operator. ‘2024 Integrated System Plan’, 2024. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp.

Barnes, Chris. ‘How to Buy the Best Solar Battery Storage’. Choice. Accessed 27 May 2024. https://www.choice.com.au/home-improvement/energy-saving/solar/buying-guides/battery-storage-buying-guide.

Behi, Behnaz, Ali Baniasadi, Ali Arefi, Arian Gorjy, Philip Jennings, and Almantas Pivrikas. ‘Cost-Benefit Analysis of a Virtual Power Plant Including Solar PV, Flow Battery, Heat Pump, and Demand Management: A Western Australian Case Study’. Energies 13, no. 10 (1 May 2020). https://doi.org/10.3390/en13102614.

Canstar Blue. ‘What Is the Average Electricity Bill?’, 2 April 2024. https://www.canstarblue.com.au/electricity/average-electricity-bills/.

Department for Energy and Mining. ‘South Australia’s Virtual Power Plant’. Accessed 23 August 2024. https://www.energymining.sa.gov.au/consumers/solar-and-batteries/south-australias-virtual-power-plant.

DISR. ‘How Australian Gas Is Used Today’, 9 May 2024. https://www.industry.gov.au/publications/future-gas-strategy/how-australian-gas-used-today.

Gabriel, Michelle, Phillipa Watson, Rachel Ong, Gavin Wood, and Maryann Wulff. ‘The Environmental Sustainability of Australia’s Private Rental Housing Stock’. Australian Housing and Urban Research Institute, December 2010. https://www.ahuri.edu.au/research/final-reports/159.

James, Anthony. ‘End of the Road? Why It Might Be Time to Ditch Your Car’. The Conversation, 15 February 2017. https://theconversation.com/end-of-the-road-why-it-might-be-time-to-ditch-your-car-72097.

Jones, Laura, Kat Lucas-Healey, Bjorn Sturmberg, and Johannes Hendriks. ‘Modelling V2G: A Study on the Economic and Technical Value Proposition for V2G’, n.d. https://arena.gov.au/knowledge-bank/modelling-v2g-simulation-a-study-of-the-economic-and-technical-value-proposition/.

Philip, Thara, Kai Li Lim, and Jake Whitehead. ‘Driving and Charging an EV in Australia: A Real-World Analysis’. Australasian Transport Research Forum, 2022. http://www.atrf.info.

Philip, Thara, Andrea La Nauze, and Kai Li Lim. ‘Australia’s Electric Vehicle Numbers Doubled Last Year. What’s the Impact of Charging Them on a Power Grid under Strain?’ The Conversation, 21 March 2023. https://theconversation.com/australias-electric-vehicle-numbers-doubled-last-year-whats-the-impact-of-charging-them-on-a-power-grid-under-strain-201478.

Roelofsen, Occo, Ken Somers, Eveline Speelman, and Maaike Witteveen. ‘How Electrification Can Help Industrial Companies Cut Costs’. McKinsey & Company, n.d. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry.

Stenner, Karen, Elisha Frederiks, Elizabeth V Hobman, and Sarah Meikle. ‘Australian Consumers’ Likely Response to Cost-Reflective Electricity Pricing Copyright and Disclaimer’, 2015. https://doi.org/https://doi.org/10.4225/08/584af1df6317e.

Australian Academy of Technological Sciences & Engineering
1975-2025

We acknowledge Traditional Owners of Country across Australia and recognise their continuing connection to land, water and community.
We pay respect to Aboriginal and Torres Strait Islander culture, and Elders past and present.

atse.org.au

241028