Australia's National
Science Agency

Air-conditioning demand response resource assessment

Summary Report

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Background

For just 3% of the year, demand for electricity in the National Electricity Market (NEM) increases by 20%. This is equivalent to the generation capacity of the two largest coal fired power stations in Australia combined (1). Across almost all of Australia, these periods of highest demand are associated with hot days (Figure 1) and with resulting high demand for air-conditioning.

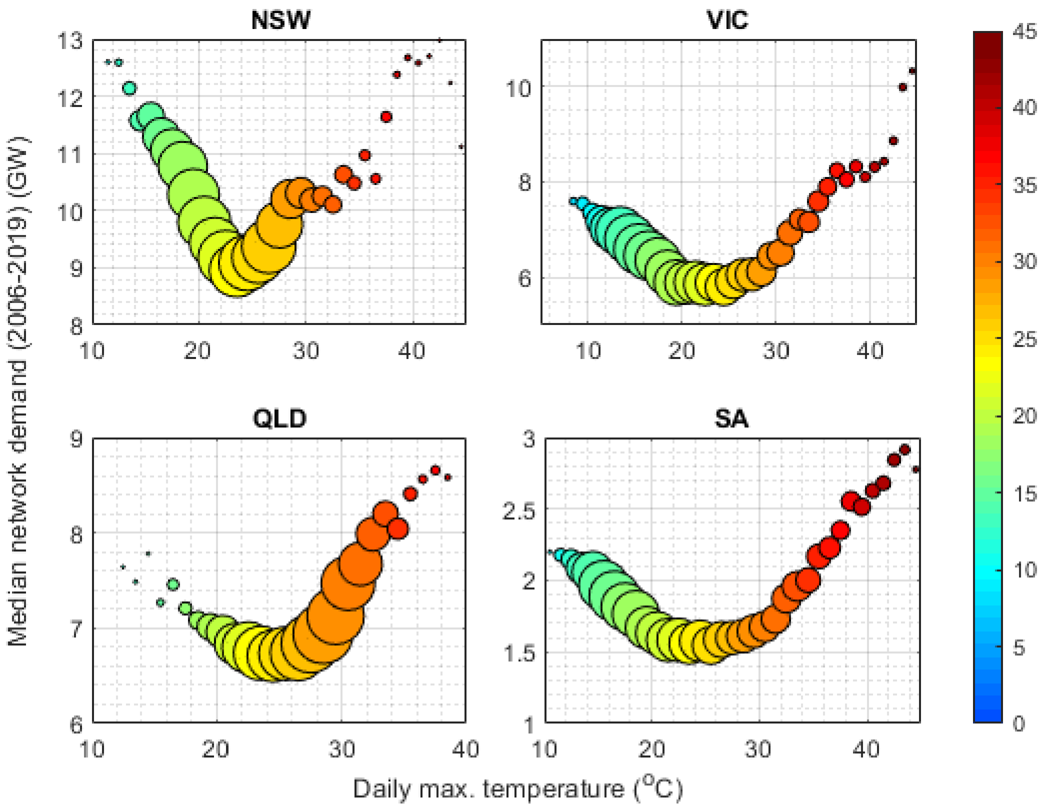

Figure 1 Median network demand as a function of temperature by NEM state (marker size indicates time duration).

Voluntarily reducing the amount of air-conditioning being used in buildings can prevent extreme peak demand, while still maintaining the comfort conditions inside buildings within acceptable tolerances. Activating this voluntary air-conditioning demand response (DR) takes advantage of the cool thermal energy stored in the building fabric. The amount and duration of DR available can be further enhanced by the addition of supplementary thermal storage capacity.

Air-conditioning DR provides a mechanism for improving the reliability of the electricity grid and reducing the cost of building new electricity infrastructure. Compared with other capital-intensive strategies for managing peak demand (such as new generation capacity and on-site battery installations), air-conditioning DR can be a low-cost option because it takes advantage of existing air-conditioning equipment and associated control infrastructure.

Air-conditioning DR can cover a range of time scales and market services including i) Frequency Control Ancillary Services (FCAS), ii) wholesale energy market, iii) network support and, iv) emergency load shedding. While fast response FCAS is an attractive future target for investigation, this study focuses on assessing the potential of slow (i.e. ≥30 minute) DR corresponding to functions ii), iii) and iv) above.

Research Question

The aims of this study were to;

i) Estimate the magnitude of short-term electricity demand response that could be achieved from air-conditioning across Australia's commercial and residential building stock.
ii) Evaluate the location and timing of the DR potential, particularly to identify DR potential that is coincident with peak demand on a given network substation.

A review of the open literature failed to identify existing studies that have addressed these two questions. However, several related studies from other jurisdictions (mostly the United States) are reviewed in the full report (2). The demand response resource estimates developed here are expected to be useful for informing broad energy and electricity network policy development, and for planning future demand response initiatives.

Methodology & Data Sources

The technically feasible demand response potential estimates obtained in this study were based on top-down disaggregation from half-hourly electricity zone substation data, and from commercial and residential building stock data, sourced from the NEAR data platform (https://near.csiro.au/).

The model covers approximately 2000 substations across 14 Distribution Network Service Provider (DNSP) regions from the period 2013 – 2017.

The temperature dependent (cooling) electrical demand was first estimated from total sub-station demand. Next a statistical model was fit to decompose the temperature dependent component into separate components corresponding to commercial and residential buildings. The model for disaggregating substation load into airconditioning electricity demand was validated against detailed residential monitoring data. Finally, models of available DR fraction (as a function of the outside temperature and time of day) were applied, based on a DR strategy that implements a 2°C thermostat set-point adjustment to the air-conditioned zones. The demand response capacity was estimated for each substation and half-hour interval. Further details can be found in (2).

Key Results

Figure 2 shows boxplots of the total current demand on the NEM as a function of hour of the day. The base case peak demand[1] is shown by the solid black line and the peak demand that would be achieved under full implementation of commercial and residential air-conditioning DR is shown by the blue dashed line. The NEM-wide peak demand occurs between 4pm and 5pm and equates to 20.8GW.

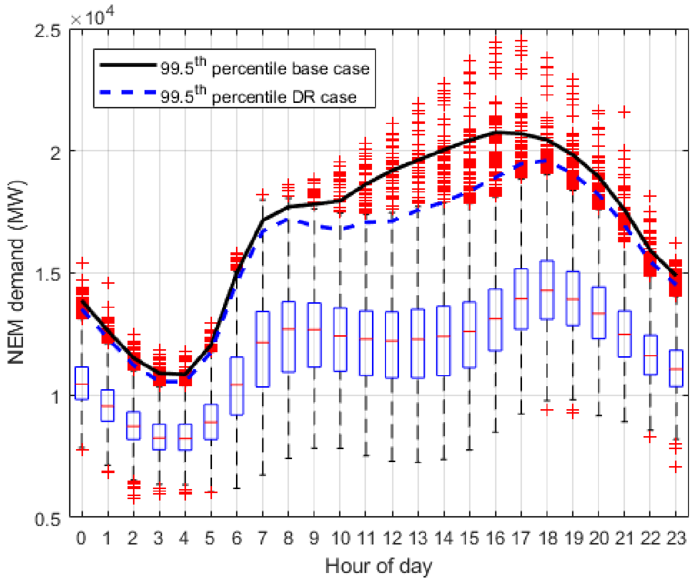

Figure 2 Total demand on the NEM as a function of hour of the day.

Local differences (by network service provider areas and/or by substation) can be observed in the percentage of network peak demand that can reduced by air-conditioning DR.

Implementing air-conditioning DR across all commercial and residential buildings in the NEM, is estimated to reduce NEM peak demand by 1.2GW (~5.8%) and shift it forward in time by approximately 2 hours.

Implementing air-conditioning DR across i) commercial and, ii) residential buildings, in different network substations across the NEM, achieves a median DR potential of between i) 1.1% and 4.0% and, ii) 5.0% and 15.3%, respectively, of peak total substation demand.

The demand reduction potential from commercial and residential buildings, in each network service provider area, is detailed in Table 1. An exemplar heat map, of commercial building DR potential in Greater Brisbane substations is illustrated in Figure 3.

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[1] Defined here as the 99.5th percentile of demand.

Table 1: Summary of estimated median demand response potential from commercial and residential building airconditioning at peak demand times, by network service area. Data period 2013-2017 inclusive.

Network service area	Total floor area (res, com, ind) x10^{6}m^2	Peak demand	Peak network demand (MW)	Peak demand reduction potential from commercial buildings (MW)	Peak demand reduction potential from residential buildings (MW)
ActewAGL (Evoenergy)	31,13,1	Heating dominated	466	10	49
TasNetworks	27,23,2		424	0	0
Ausgrid	366,83,21	Cooling dominated	4173	55	429
AusNet	165,37,11		1290	24	198
CitiPower	38,23,1		878	23	44
Energex	360,80,22		3795	48	425
Endeavour	220,55,18		2452	28	281
Ergon	131,41,10		1451	17	109
Jemena	66,18,8		678	10	64
Powercor	164,48,17		1413	36	210
SA Power	168,98,7		2117	85	263
United Energy	162,44,13		1525	23	150
Western Power	238,60,23		3254	55	351
Essential	190,50,18	Cooling & heating	2106	27	205

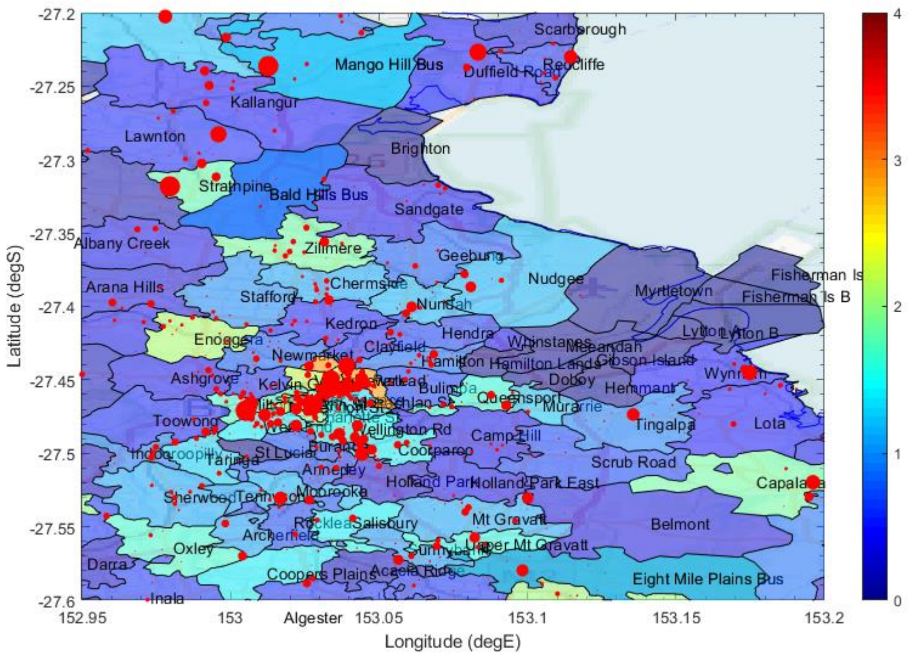

Figure 3 Demand response available from commercial building HVAC in Greater Brisbane, as a mean percentage of sub-station load during peak times (area shading). Dots indicate concentrations of commercial buildings.

Visualisation tool

An online *HVAC Demand Response Atlas* visualisation tool has been developed to facilitate better access to the results (3). The tool enables users to view total sub-station load and commercial and residential HVAC demand response estimates by month of the year, time-of-day and temperature band. Users can also download the underlying dataset via the tool.

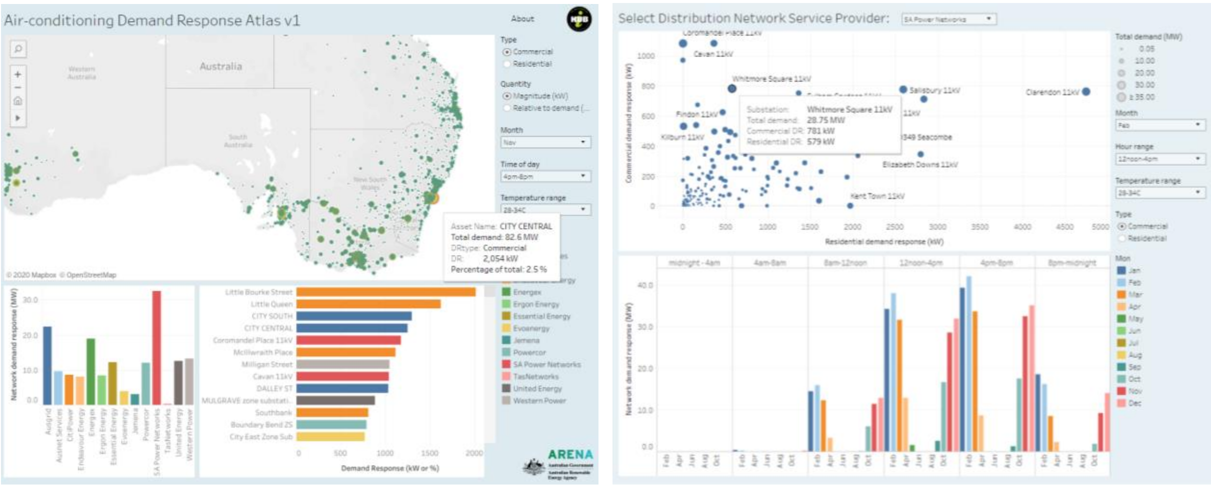

Figure 4 Screenshots from the online demand response visualisation tool.

Invitation for feedback

We would appreciate feedback in any form, for example written or via online tele-conference, to help us further refine the method and develop the resource. Contact details can be found at the end of this report.

References

1. **Australian Energy Market Operator.** Aggregated price and demand data. [Online] 1 15 2020. https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/aggregated-data.

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3. —. Air-conditioning demand response atlas v1. [Online] 2020. https://public.tableau.com/views/DemandResponseAtlasV1_1/Overview?:display_count=y&:origin=viz_share_link.

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