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A characterisation of air conditioning consumption in Australia's eastern capitals

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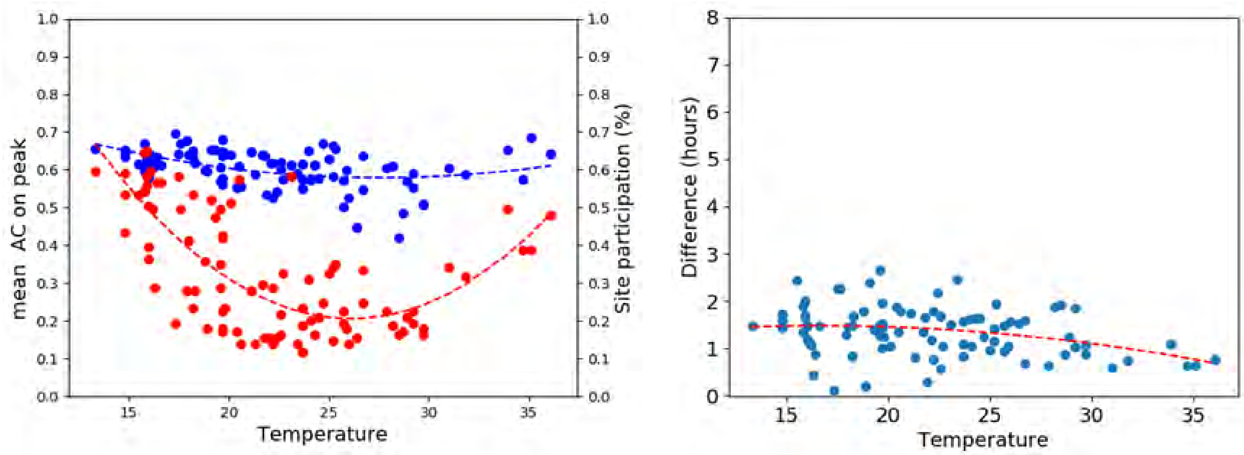
Effective air conditioning (A/C) DR has the potential to reduce the cost of electricity in the NEM significantly. Accurately characterising A/C consumption in Australia is a necessary step in the process of determining the potential of A/C DR. A report written by consultancy CME in 2012 [1] estimated that the savings per MW avoided through an effective demand response (DR) program is between $1.7 million and $6.2 million, with a National Electricity Market (NEM) central estimate of $5.3 million. These savings come from avoided expenditure on generation, transmission and distribution infrastructure to meet peak demand. Also, according to the Australian Energy Market Operator (AEMO), for all regions aside from Tasmania, the maximum operational demand currently occurs, and is expected to continue occurring, in summer, driven by cooling load [2].

Work already conducted in this area includes [3], where an extensive data set including household consumption and air conditioner ownership for residents in Mexico between 2009 and 2012 is used to characterise empirically the relationship between temperature, income, and residential air conditioning. This relationship is then used to forecast future electricity consumption. In [4], the relationship between household consumption and factors such as income, appliance usage, occupants, and building type is examined. The study uses 30-min net metering data and relies upon survey responses to determine whether there is an A/C unit in the house. In [5], the developments in network peak demand, at a national, network distribution, and local distribution feeder level to show recent trends in peak demand are examined. The paper also analyses half-hourly consumption data from Ausgrid's smart meters, combined with local weather data, to develop an algorithm which can recognize air-conditioner use and can identify consumption patterns and peak load. This estimate is then compared to system peaks to determine residential air conditioning's impact on overall demand. The expert system can predict air conditioner existence with a 93% accuracy.

This paper presents a characterisation of A/C consumption for Australia's eastern capitals; Sydney, Melbourne, Brisbane and Adelaide. The analysis uses high resolution (5-min) A/C consumption data from Solar Analytics. The data sets in the papers mentioned combine household consumption data and survey responses to determine appliance (A/C unit mainly) usage. Having a data set with actual A/C consumption allows for a more detailed analysis than currently exists in the literature. The analysis presented in this paper accurately characterises A/C consumption and the potential reduction in peak demand that can be achieved through A/C curtailment.

Initial analysis of the Solar Analytics data set looked at the relationship between A/C consumption and peak household demand. Select results of the initial analysis are given below. In Figure 1 a), the left sided y-axis is the ratio of A/C consumption (kWh) on household consumption (kWh) for the hour of peak consumption. The right sided y-axis is the site participation (households that used A/C on that day) percentage. These metrics are plotted against temperature. The data used for this plot is for Adelaide during Spring 2018. The scatter plot shows that the ratio of A/C consumption on peak household consumption is relatively consistent for all temperatures, but that the number of households that participates increases with temperatures below and above 25 degrees. Using the same data set as used in Figure 1 a), Figure 1 b) plots the difference in hours between peak A/C consumption and peak household consumption versus temperature, the scatter plot shows how well correlated peak A/C consumption is with peak household consumption.

The remainder of the work further expands on the correlation between A/C consumption and peak consumption, examines hourly A/C consumption according to temperature, season and location, and derives a method for predicting A/C consumption using forecast temperature.



a) b)

Figure 1 a) Temperature versus LHS: Ratio of A/C consumption (kWh) on household consumption (kWh) for the hour of peak consumption. RHS: Site participation percentage. b) Difference in hours between peak A/C consumption and peak household consumption versus temperature

References

[1] CME Consulting, 2012, 'Reducing electricity costs through Demand Response in the National Electricity Market', https://www.aph.gov.au.

[2] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Demand-Forecasts/Electricity-Forecasting-Insights/2017-Electricity-Forecasting-Insights/Summary-Forecasts/Maximum-and-minimum-demand

[3] Davis, I., and Gertler, P., 2015, 'Contribution of air conditioning adoption to future energy use under global warming', *National Academy of Sciences*, 112, p5962-5967.

[4] Fan, H., MacGill, I., and Sproul, A., 2015, 'Statistical analysis of driving factors of residential energy demand in the greater Sydney region, Australia', *Energy and Buildings*, 105, p9-25.

[5] Smith, R., Meng, K., Dong, Z., and Simpson, R., 2013, 'Demand response: a strategy to address residential air-conditioning peak load in Australia', *Journal of Modern Power Systems and Clean Energy*, 1, p223-230.