RP2002

ELECTRICITY DEMAND FORECASTING WITH BATTERY SYSTEMS

Research Question

How can Australian residential precincts move to a low carbon scenario through the uptake of solar and battery systems? What are the optimal capacity requirements to minimise energy bills and reduce the reliance on grid infrastructure?

Methodology

The research uses newly available Australian datasets to develop a machine learning demand model, using an adaptive boost regression tree algorithm. This model is capable of simulating the hourly load demand of a home based on a small set of input features including: household demographics, appliance ownership and weather conditions. Aggregating the simulated demand can be used to evaluate the carbon impact of a precinct, this has been completed for Lochiel Park in Adelaide.

A linear programing optimisation model has been formulated to simulate the impact of residential solar and battery systems on the demand profiles. The model is used to determine the carbon emissions saved by installing residential solar and battery systems. In addition, optimal capacities and lifetime energy costs are determined.

Results

Figure 1 shows the measured and simulated hourly demand for 53 homes in Lochiel Park for the peak demand week. It can be seen how the model predicts this yearly peak event very well.

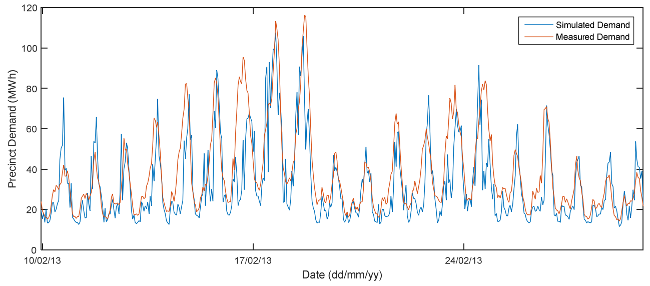

Figure 1: Consider including a table to help explain your research.

Table 1 shows the costs of energy for different residential battery capacities. It can be seen that high demand homes gain the biggest cost saving from installing battery systems, and the biggest saving is observed at small battery capacities. For a low demand home, minimal cost is saved by installing a battery larger than 2.4 kWh and for a high demand home minimal saving is observed by installing a battery larger than 3.6kWh.

Table 1: Energy cost (25 years NPV) and grid reliance for different battery capacities.

	Battery Capacity (kWh)	0	1.2	2.4	3.6	4.8	6	7
Low Demand	**Grid Import ($)**	8425	7206	6808	6703	6658	6633	6620
	Solar Export ($)	7094	6779	6661	6630	6616	6609	6605
	Grid Difference ($)	1331	427	147	73	42	24	15
	Grid Reliance (%)	56	21	8	4	3	2	1
Med Demand	**Grid Import ($)**	11083	9639	8637	7995	7569	7310	7163
	Solar Export ($)	6720	6379	6119	5947	5831	5759	5717
	Grid Difference ($)	4363	3260	2518	2048	1738	1551	1446
	Grid Reliance (%)	61	43	30	21	15	11	9
High Demand	**Grid Import ($)**	13150	11585	10300	9306	8646	8241	8017
	Solar Export ($)	6097	5750	5431	5172	4996	4887	4825
	Grid Difference ($)	7053	5835	4869	4134	3650	3354	3192
	Grid Reliance (%)	55	44	34	25	20	16	14

Table 2 gives an upper limit on battery cost to make batteries economically equivalent for the home owner to install. This means if batteries cost more than this value, the home owner will not pay off the battery in the lifetime of the system. If it costs less than this value money is saved by installing the battery. It can be seen that this limit is dependent on demand and capacity and small battery capacities have a higher upper limit; meaning they are better to install. In addition, high demand homes have a bigger cost saving from installing battery systems, as a result should be targeted for uptake while costs are high. This data can be used to select the optimal battery capacity given the cost of the battery system.

Table 2: Upper limit on NPV battery costs, (green is good).

	Battery Capacity	1.2	2.4	3.6	4.8	6	7	
$0.06 Solar Export Rate	**Low Demand**	753	493	349	269	218	188	$/kWh
	Med Demand	919	769	643	547	469	417	$/kWh
	High Demand	1015	910	811	709	617	552	$/kWh
Zero Solar Export Rate	**Low Demand**	847	555	394	302	245	212	$/kWh
	Med Demand	1140	1047	951	840	733	658	$/kWh
	High Demand	1266	1139	1017	890	774	693	$/kWh

From Table 2, it can be seen that a zero solar export rate increases the value proposition for battery systems. Results in this research also showed that small batteries get utilised more meaning their lifetime is shorter, this causes a trade-off between battery capacity, cost and degradation.

Conclusions

This work provides tools that can evaluate the carbon impact of new or existing residential precincts when considering solar and battery systems. The research captures all costs and provides as a method to evaluate the value proposition of distributed solar and battery systems in residential precincts.

Anticipated impacts

- Evaluate the carbon impact of residential precincts with solar and battery systems.
- Give a clear value proposition for distributed solar and battery systems in residential precincts.
- Provide recommendation o the optimal capacity for residential homes based off demand characteristics.
- Advice the customer types that will gain a higher cost saving from installing battery systems, allowing them to be targeted first while battery costs are high.
- Advice battery manufactures on the warranty lifetime for battery systems. Relate the energy demand profile to the expected lifetime of the battery.
- Relate emissions reductions to cost of solar and battery infrastructure.
- Provide an upper limit on battery costs and motivate manufacturers to reduce battery costs.

Solar and Battery systems can reduce emissions and lower energy costs for the home owner.

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