RP2002
ETWW: RESIDENTIAL ELECTRICITY DEMAND FORECASTING FOR MICROGRID SYSTEM DESIGN

Research Question

Are microgrid systems currently a cost-effective energy supply option?

Motivations and Methodology

In 2014, Australian households were responsible for 11.2% of Australia's total net energy demand and solar photovoltaic (PV) only generated 3.14% of this energy (ABS, “Energy Account, Australia, 2014-15,” 2015). Emissions from households can be reduced by increasing the uptake of on-site generation. Although, a high uptake of solar photovoltaic generation can have negative impacts on the distribution network. Due to falling battery costs (for example, Tesla systems can cost $11,650 installed). Battery systems can negate many of the negative issues if controlled properly. As a result, to support solar systems and reduce losses battery systems are likely to become a major component of our future electricity network.

When precincts contain localised intelligently controlled solar generation, battery storage and loads they are commonly referred to as a microgrid. One barrier slowing the emergence of microgrid precincts is the difficulty in quantifying the economic relationship between solar and battery capacity, electricity load demand, network performance, network capacity, network losses, control strategies and emissions reductions. Our research addresses this by developing a tool capable of simulating the many technical aspects of microgrid systems to develop a detailed business case.

In our research, we first develop a Machine Learning electricity demand model that uses demographic information, appliance ownership and weather conditions to simulate half-hourly energy demand for individual homes. Next, we develop a Mixed integer microgrid design tool capable of simulating the decisions made by dynamic charge controllers, and optimising system capacities. We apply these first two steps to the Lochiel Park precinct case study.

Next, we develop a Digsilent Powerfactory model for Lochiel Park and evaluate aspects such as voltage rise issues and network losses.

Finally, we test our model to develop a business case for a microgrid system in Lochiel Park. We compare all losses, device requirements and imported energy. We complete this analysis for both utility and distributed storage scenarios and to reduce grid emissions by 75%.

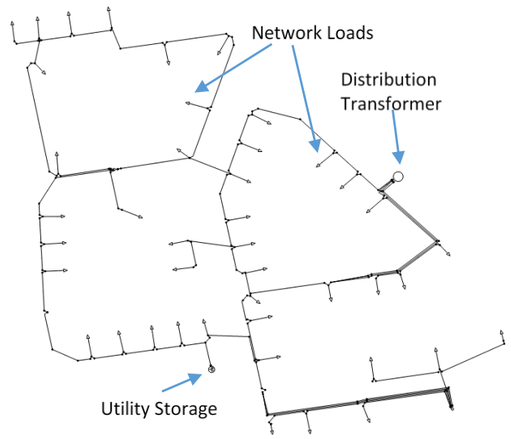

Figure 1: Powerfactory Microgrid Model.

Table 1: Cost comparison for Utility storage vs Distributed storage for Lochiel Park

Devices Names and Ratings	Cost per Unit	AC-Utility storage #	AC-Utility storage Device Cost	AC- Distr. Storage #	AC- Distr. Storage Device Cost
AC Cable (4x150mm2 AL XPLE)	$51,470	2.67	137,425	2.67	$137,425
Transformer (200 kVA, Polemount)	$10,644	1	10,644	1	$10,644
PowerPack Inverter and controller (250kW)	$69,800	1	69,800	1	$69,800
PowerPack 2 Battery (210kWh)	$123,800	4	495,200	0	-
Photovoltaic Arrays (5kW)	$5,008	84	$420,672	84	$420,672
Solar Inverter (5kw)	$2,080	84	$174,720	84	$174,720
Tesla Powerwall 2 AC Battery (13.5 kWh)	$11,650	$0	-	80	$932,000
Total Household Device Cost		$595,392		$1,527,392	
Total Utility Device Cost		$713,068.90		$217,868.90	
10 year NPV Retail Cost of Imported Energy		$253,572		$260,499	
10 year NPV Retail Cost of Converter Losses		$122,765		$100,824	
Total Cost		**$1,684,798**		**$2,106,584**	

High Values
Medium Values
Low Values

Results

Table 1 shows the cost comparison results. The lowest cost option was the microgrid system with utility storage. The major contributor to cost in the microgrid is the battery system. In the utility battery scenario, the battery system functions as a shared resource requiring a smaller battery capacity to meet the same 75% emissions reduction. In our model we allow solar capacity to be optimised, in all cases the maximum allowed capacity of 5 kW is installed.

To compare this to a non-microgrid system, we calculate the (non-microgrid) ten-year net present value cost of imported energy for Lochiel Park to be $1,406,900. This shows that for the utility microgrid scenario, while also achieving a 75% emissions reduction, the households would pay a similar NPV cost. Also, many of the same infrastructure is required, such as the cables and network transformer.

Conclusions

To summarise, we show that utility battery storage is the lowest cost solution and that this solution has an equivalent cost to installing no microgrid.

Anticipated impacts

A clear business case for residential microgrid systems and equivalent costs to existing state of affairs should encourage investment in microgrid systems and emissions reduction to be achieved.

Microgrid systems have the potential to reduce emissions and increase reliability.

Further information

Please email Steven Percy for more information. Steven is looking post-doctorate position in this topic area (PhD submission will be in Dec).

Contact

Steven Percy

University of Melbourne/CSIRO

Percy@student.unimelb.edu.au