Modelling for the Electricity Distribution Network

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EXTENDED ABSTRACT ONLY

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Abstract: Global awareness for cleaner and renewable energy is transforming the electricity sector at many levels. New technologies are being increasingly integrated into the electricity grid at high, medium and low voltage levels, new taxes on carbon emissions are being introduced and individuals can now produce electricity, mainly through rooftop photovoltaic (PV) systems. While leading to improvements, these changes also introduce challenges, and a question that often rises is 'how can we manage this constantly evolving grid?'

The Queensland Government and Ergon Energy, one of the two Queensland distribution companies, have partnered with some Australian and German universities on a project to answer this question in a holistic manner. The project investigates the impact the integration of renewables and other new technologies has on the physical structure of the grid, and how this evolving system can be managed in a sustainable and economical manner. To aid understanding of what the future might bring, a software platform has been developed that integrates two modelling techniques: agent-based modelling (ABM) to capture the characteristics of the different system units accurately and dynamically, and particle swarm optimization (PSO) to find the most economical mix of network extension and integration of distributed generation over long periods of time.

Using data from Ergon Energy, two types of networks (3 phase, and Single Wired Earth Return or SWER) have been modelled; three-phase networks are usually used in dense networks such as urban areas, while SWER networks are widely used in rural Queensland. Simulations can be performed on these networks to identify the required upgrades, following a three-step process: a) what is already in place and how it performs under current and future loads, b) what can be done to manage it and plan the future grid and c) how these upgrades/new installations will perform over time.

The number of small-scale distributed generators, e.g. PV and battery, is now sufficient (and expected to increase) to impact the operation of the grid, which in turn needs to be considered by the distribution network manager when planning for upgrades and/or installations to stay within regulatory limits. Different scenarios can be simulated, with different levels of distributed generation, in-place as well as expected, so that a large number of options can be assessed (Step a). Once the location, sizing and timing of assets upgrade and/or installation are found using optimisation techniques (Step b), it is possible to assess the adequacy of their daily performance using agent-based modelling (Step c).

One distinguishing feature of this software is that it is possible to analyse a whole area at once, while still having a tailored solution for each of the sub-areas. To illustrate this, using the impact of battery and PV can have on the two types of networks mentioned above, three design conditions can be identified (amongst others):

- Urban conditions
  - Feeders that have a low take-up of solar generators, may benefit from adding solar panels
  - Feeders that need voltage support at specific times, may be assisted by installing batteries
- Rural conditions - SWER network
  - Feeders that need voltage support as well as peak lopping may benefit from both battery and solar panel installations.

This small example demonstrates that no single solution can be applied across all three areas, and there is a need to be selective in which one is applied to each branch of the network. This is currently the function of the engineer who can define various scenarios against a configuration, test them and iterate towards an appropriate solution. Future work will focus on increasing the level of automation in identifying areas where particular solutions are applicable.

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