Architecture of the Future Low-Carbon, Resilient, Electrical Power System

Future Architecture of the Network (FAN) – Te Whatunga Hiko

Workstream 1 –Summer Project

Project title: Review of Energy Storage Requirements for hybrid AC/DC Grids

Relevant Workstream(s): WS 1

This project is offered to help in the ongoing research in the Future Architecture of Network (FAN) programme, where the benefit, design and analysis of DC electricity grids are explored. The FAN project is a 7-year, New Zealand wide research program led by the University of Canterbury. The project is broken into five workstream, where this summer student project is a part of Workstream 1, which is the development of fast and accurate numerical analysis tools to simulate large-scale hybrid AC/DC grids, such as for Power-Flow Analysis, Fault Analysis, Harmonic Analysis, Transient Stability, and Electromagnetic Transients. Also, WS1 proposes a future architecture of the hybrid AC/DC, which will be the focus of this project.

Project Description:

The security of power systems to disturbances or contingencies is influenced by the availability and placement of reserves. The speed in achieving required power output and duration of sustained power output are important factors in characterising reserve. Therefore, this project is to review reserve requirements for hybrid AC/DC grids. An assessment of existing sources of energy storage in hybrid AC/DC power systems, and areas where energy storage is required for reserve has to be identified. The review has to cover the following topics:

- Compare disturbances and contingencies between AC and DC grids. For example, what could result in lower than nominal voltage in DC grids, how do these differ from AC grids, and which of these disturbances requires reserves.
- What is the impact of low voltage on a DC grid, particularly the components connected to it? How does the impact vary based on voltage level and duration?
- Identify how far a contingency can impact the grid it occurs on and to the neighbouring grids.
- Identifying all sources of energy storage in power systems and characterise them by their controllability and size. This includes electrical and magnetic fields in transmission lines, transformers, converters, reactors and capacitors, etc. Also, synchronous and asynchronous inertia. Stored energy for generation, and explicit energy storage components, such as Battery Energy Storage Systems (BESS).
- Where may some additional energy be required in hybrid AC /DC grids to ensure security through disturbances and for N-1 contingencies.

This review is a thought experiment to be applied to High Voltage, Medium Voltage, and Low Voltage hybrid AC/DC grids. The New Zealand power system can be used as an AC example, but some amount of imagination is required to extend the concepts to DC grids.

The successful applicant will gain a greater understanding of power system security. Concepts and understanding can be tested using MATLAB Simulink. The main outcome of this project is a report presenting the review.

Helpful Resources:

Reserve requirements in New Zealand, https://ir.canterbury.ac.nz/items/4b9de28c-3b5c-4488-8bec-f1ab38841006

New Zealand Ancillary Services, https://www.transpower.co.nz/system-operator/information-industry/electricity-market-operation/ancillary-services/about

Hopefully more resources to come.

Specific requirements:

- BE(Hons) - Electrical and Electronic Engineering (EEE) student- Third (second Pro) or Fourth (Third Pro) year.
- Good knowledge of power system grids and power electronics
- Experience with programming languages, e.g. MATLAB and Simulink
- Some familiarity with power system simulation tools like PowerFactory DIgSILENT and PSCAD/EMTDC will be helpful.
- Excellent academic track record
- High proficiency in written and spoken English
- Enthusiastic applicants (any nationality) that want to make a positive impact in the world and can work in a collaborative environment

Potential Supervisor(s): Josh Schipper, Veerabrahmam Bathini, Neville Watson

Based in: University of Canterbury, EPECentre