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

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

Workstream 2

Project 1

Topic: Interaction of Distributed Energy Resources with Future Hybrid AC/DC Grids

Workstreams: WS1 + WS2

Background and Motivation

The Future Architecture of the Network (FAN) programme is investigating how New Zealand's electricity grid can transition from conventional AC infrastructure to hybrid AC/DC systems that better support decarbonization and electrification. WS1 focuses on network architecture and WS2 on circuit topology, with a shared goal of understanding how distributed energy resources (DERs), rooftop solar, batteries, EV chargers, and flexible loads interact with emerging hybrid AC/DC networks.

Recent WS2 research has demonstrated that converter-dominated hybrid systems exhibit fundamentally different fault behaviour from traditional AC networks [1], and that grid-forming inverter validation across distribution, transmission and integrated T–D networks raise important new stability questions [2]. As the FAN programme approaches its 2027 target of defining an optimum DC circuit topology, summer projects investigating DER interaction dynamics provide valuable supporting evidence.

This project extends that foundation by asking how increasing penetration of DERs affects future hybrid AC/DC grid operation, and what topology and control choices best support resilient, low-carbon electricity systems in a New Zealand context.

Key FAN References

[1] Sruthi Babu (2025) – Protection Challenges and Schemes in Hybrid AC–DC Distribution Systems (MESTU Project).

[2] Y. Liu et al., "A Review of Grid-Forming Inverter Validation across Distribution, Transmission, and T–D Integrated Networks," APPEEC 2025.

Research Aim

To investigate how distributed energy resources interact with future hybrid AC/DC electricity networks and identify topology and control strategies that best support resilient, flexible operation.

Research Objectives

The student will:

- Review hybrid AC/DC network architectures and current FAN WS2 topology findings.
- Analyse how DERs (solar PV, BESS, EVs) affect power flow, voltage stability, and protection in converter-dominated networks.
- Identify technical challenges for protection coordination and fault isolation in mixed AC/DC systems.
- Propose and evaluate (through simulation or literature synthesis) topology or control options that improve DER integration.

Methodology

The project will combine a focused literature review of WS2-relevant publications, technical analysis of DER interaction scenarios, and simplified simulation (MATLAB/Simulink/HIL) to evaluate system behaviour under different topology options.

Expected Outcomes

- Concise literature synthesis linked to FAN WS2 topology questions.
- Analysis of key DER interaction challenges for hybrid AC/DC systems.
- Recommendations for future FAN research directions.
- Technical report and presentation.

Potential Supervisor(s):

- Nirmal Nair
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