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

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

Workstream 2 – Proposed Summer Project

Project 2

Plug-and-Play DC Infrastructure for Future Electrified Cities

Workstreams: WS2 + WS3

Background and Motivation

A central WS2 research question is how to configure DC bus architecture within LV and MV networks so that diverse devices, EV chargers, solar systems, battery storage, and smart loads can connect with minimal configuration while maintaining safe and stable operation. WS3 (Converters and Enabling Technologies) complements this by evaluating the converter interfaces that enable such connectivity.

FAN WS2 has already demonstrated a lab-scale multi-terminal DC (MTDC) bus system at the University of Auckland [1] and published design and simulation results for radial MTDC topologies with zonal protection [2]. The next step is understanding how the 'plug-and-play' connection of future DC devices affects system stability, protection coordination, and interoperability, which this project will explore in an NZ urban context.

With EV uptake and rooftop solar growing rapidly in New Zealand cities, the practical pathway to low-loss DC infrastructure depends on resolving interoperability, fault management, and control coordination challenges. This project builds directly on WS2 hardware and modelling outputs to date.

Key FAN References

[1] S.A. Khan, A. Ukil, N.-K.C. Nair, "Design and Simulation of Radial Multi-Terminal DC System with Zonal DC Protection," APPEEC 2025.

[2] A.N. Cuppen et al., "Multilayer Networks Framework Concept applied to Hybrid MV AC/DC Network Topologies," IEEE eGRID 2022.

Research Aim

To investigate plug-and-play DC infrastructure concepts for future electrified cities and evaluate how modular DC connection approaches can support safe, interoperable, and resilient urban energy networks.

Research Objectives

The student will:

- Review existing FAN WS2 and WS3 findings on DC bus architectures and converter topologies.
- Analyse plug-and-play connection scenarios and their impact on protection, stability, and power quality.
- Identify key interoperability and control challenges for modular DC urban infrastructure.
- Develop conceptual recommendations for future NZ DC network standards or design guidelines.

Methodology

Focused literature review of WS2/WS3 outputs and international DC infrastructure developments; technical assessment of connection scenarios using available FAN simulation tools (MATLAB/Simulink, OPAL-RT where appropriate); synthesis of findings into a conceptual design framework.

Expected Outcomes

- Review of FAN-relevant plug-and-play DC concepts and challenges.
- Scenario analysis of DC connection impacts on protection and stability.
- Conceptual framework for future NZ urban DC infrastructure.
- Technical report and presentation.

Potential Supervisor(s):

- Nirmal Nair
- Krishna Kumar
- Yuan Liu
- Tobias Massier

Based in: The University of Auckland