Introduction to FAN

3 February 2026

2026 Annual FAN Workshop (3-4 February 2026)

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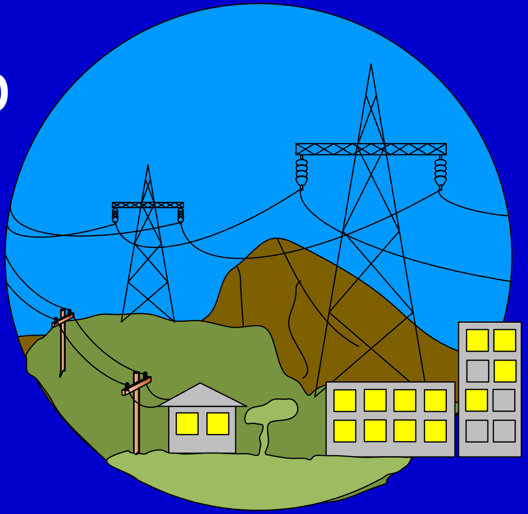
Future Architecture of the Network
TE WHATUNGA HIKO

WELCOME to the FAN Workshop

Exploring the Future Architecture of the Electrical Power System



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Outline

1. Motivation for DC
2. Changing Electrical Landscape
3. Vision for the Future Electrical Network
4. Future Architecture of the Network (FAN)
5. The Government's Strategic Science Investment Fund
6. International work on DC systems

Motivation for DC

Sustainability

Decarbonisation

Integration of Distributed Energy Resources (DER)

Renewable Energy Sources (RES)

Power electronic equipment

Energy Storage

Reliability

Affordable

Illustration by Microsoft CoPilot

Why FAN, why now?

- Rapid growth of inverter-dominated resources
- Limitations of incremental AC solutions
- Need for coordinated national architecture thinking

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Changing Electrical Landscape

Industrial loads and large-scale generation

- Photovoltaic (PV) generation
- Wind generation
- Transportation (cars, trucks, buses, light rail, trains and aircraft)

- Pumps and fans for industrial processes
- Irrigation pumps
- Process heat
- Electroplating
- Electrolysis

Changing Electrical Landscape
Household and commercial

- Chargers and power supplies for equipment
- Lighting equipment
- Entertainment equipment (TV, Stereos, etc)
- Computer equipment
- Heat-pump/air-conditioners
- Domestic Photovoltaic (PV) systems
- Electric Vehicles
- New generation of:
  - Fridges and freezers
  - Washing machines and clothes dryers
  - Hot-water heaters

Inverter-based fridge and freezer

Inverter-based whiteware

Future Scenario - Hybrid AC/DC System

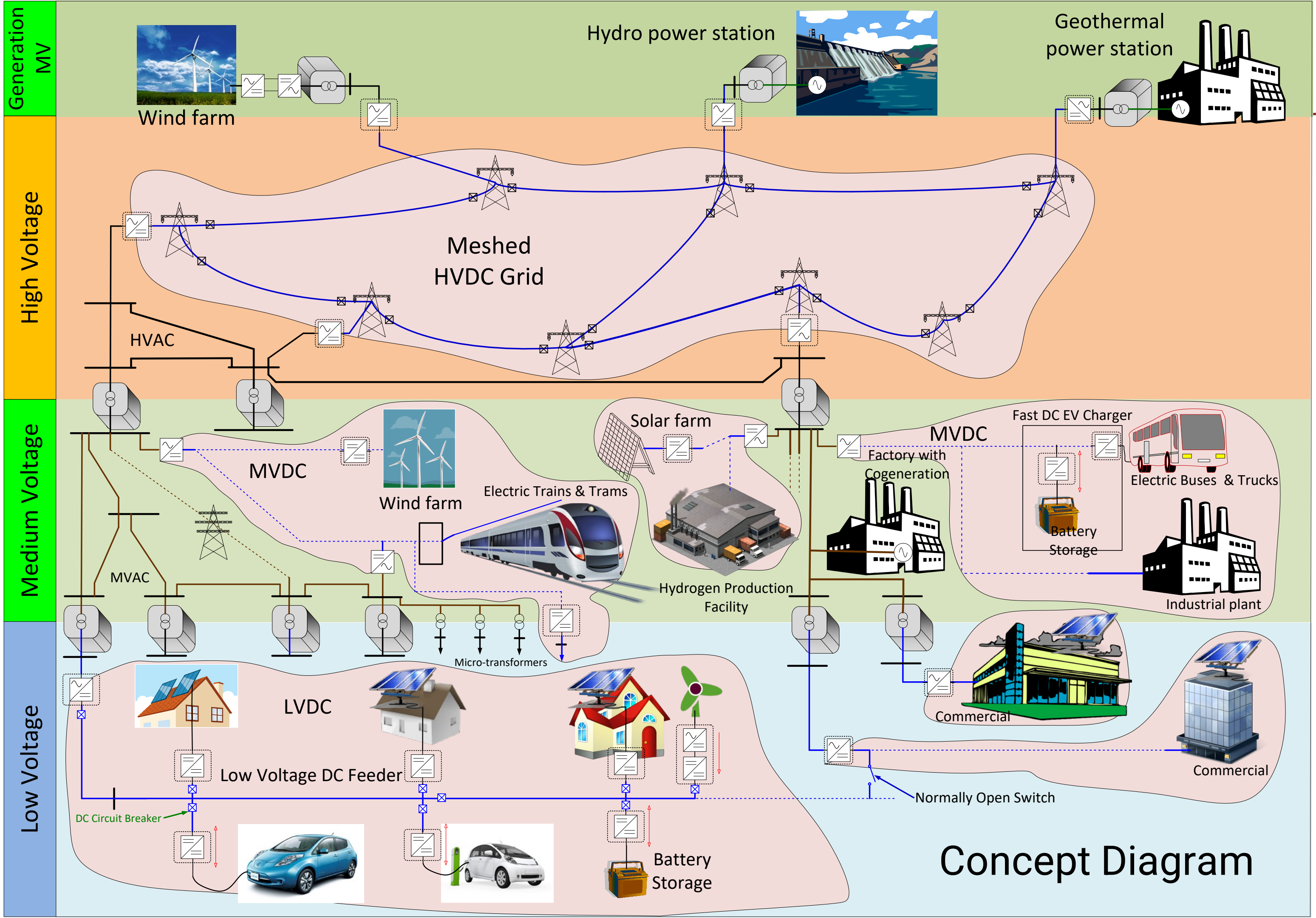
The question is no longer whether DC transmission, distribution, and DC systems will play a role in future power systems, but where they should be used, how they should be implemented, and how rapidly they should be deployed.

Vision for the Future Electrical Network

Future Architecture of the Network (FAN)

Why a Hybrid AC/DC Power System?

- Gives the best of both worlds. Easy integration of new technologies and easy translation of system voltage.
- Lower losses (conversion and transmission).
- Direct integration of DC-based generation and loads.
- Why not end-to-end DC? There is an optimum voltage for a given distance and power to be conveyed.
    1. The AC transformer is a mature technology with a high reliability and efficiency (Up to 99.7% for large power transformers)
    2. DC/DC converters are available for lower voltage levels, but unlikely to be available at 400 kV in the MW range in the foreseeable future.
    3. A lot of money already invested in AC transformers



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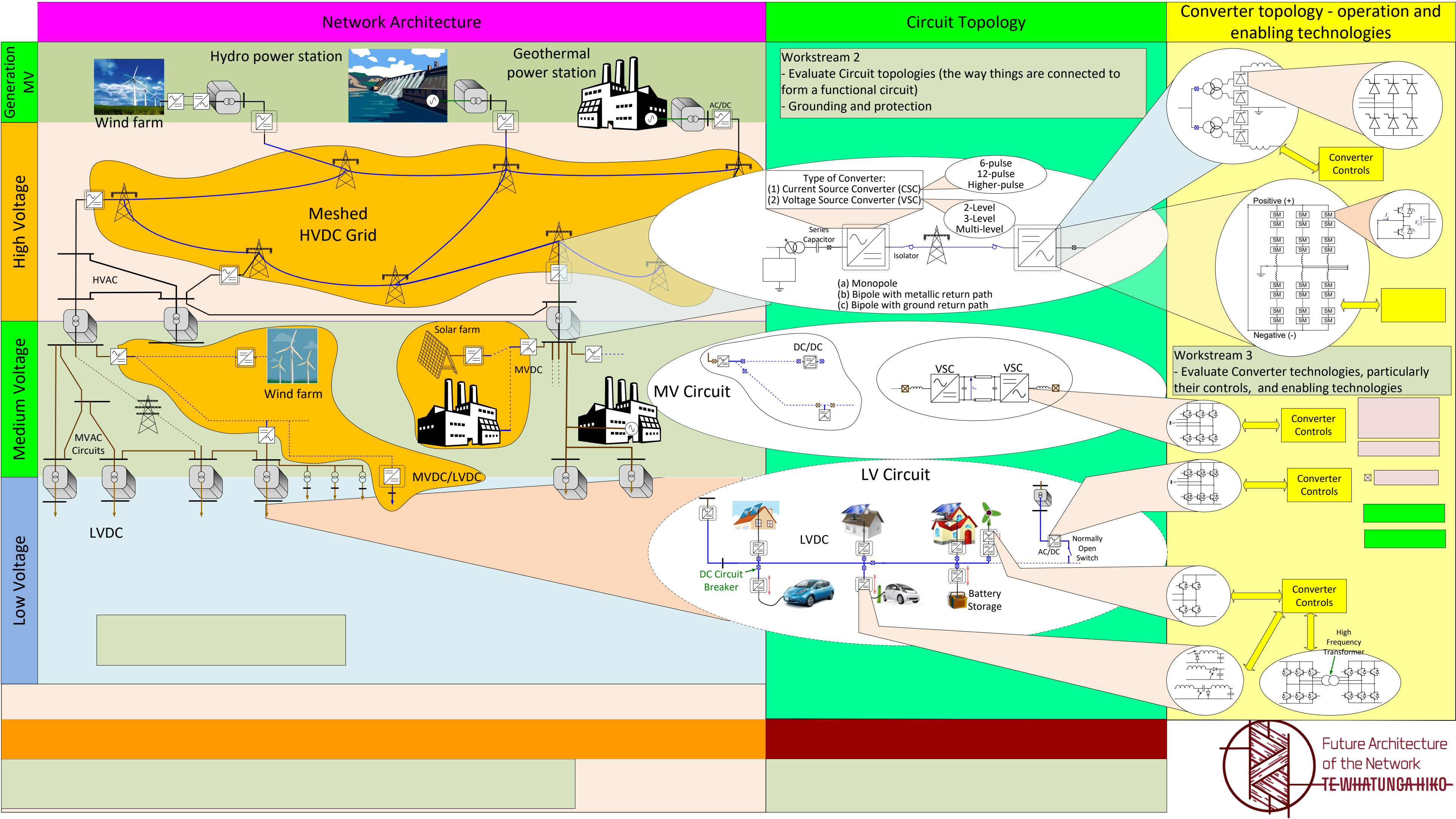
Concept Diagram



Network Architecture
Circuit Topology
Converter topology - operation and enabling technologies
Generation MV
High Voltage
Medium Voltage
Low Voltage
Hydro power station
Geothermal power station
Wind farm
AC/DC
Meshed HVDC Grid
HVAC
Solar farm
Wind farm
MVDC
MVAC Circuits
MVDC/LVDC
LVDC
Workstream 2
- Evaluate Circuit topologies (the way things are connected to form a functional circuit)
- Grounding and protection
Type of Converter:
(1) Current Source Converter (CSC)
(2) Voltage Source Converter (VSC)
6-pulse
12-pulse
Higher-pulse
2-Level
3-Level
Multi-level
Series Capacitor
Isolator
(a) Monopole
(b) Bipole with metallic return path
(c) Bipole with ground return path
DC/DC
MV Circuit
VSC
VSC
LV Circuit
LVDC
DC Circuit Breaker
Normally Open Switch
AC/DC
Battery Storage
Converter Controls
Positive (+)
Negative (-)
SM
Workstream 3
- Evaluate Converter technologies, particularly their controls, and enabling technologies
Converter Controls
Converter Controls
Converter Controls
High Frequency Transformer
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The Government's Strategic Science Investment Fund

Advanced Energy Technology Platform

Architecture of The Future Low-carbon, Resilient, Electrical Power System

Part of the government's ***Strategic Science Investment Fund*** (SSIF) on ***Advanced Energy Technology Platform*** (AETP). Time horizon 2050.

The SSIF *Advanced Energy Technology platform* to **support and develop world-leading research capability in niche areas of advanced energy science.**

It enables New Zealand to contribute to, and benefit from, opportunities in international technology markets and deliver on the Government's advanced energy technology investment goals.

About FAN

www.fan.ac.nz

Full Research programme name:

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

Short-form name of the programme:

Future Architecture of the Network (FAN)

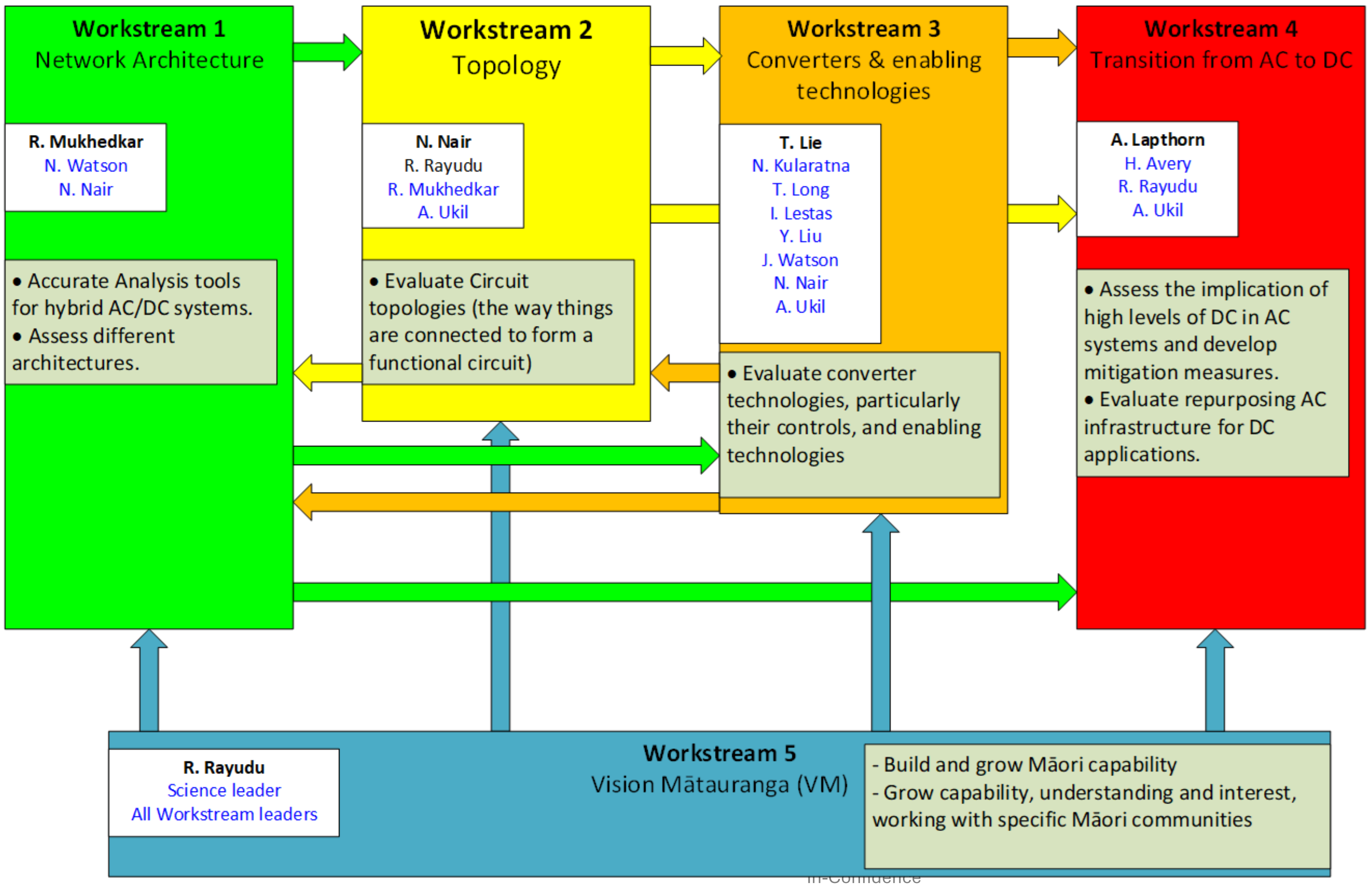
or *Te Whatunga Hiko*

7-year project (started in the latter part of 2020)

Science Leader: Professor Neville Watson (University of Canterbury)

Contact: **futurearchitecturenetwork@canterbury.ac.nz**

How FAN is Structured: Workstreams



International work on DC systems

1. Affiliate Organisations
2. Exchanges
3. Papers

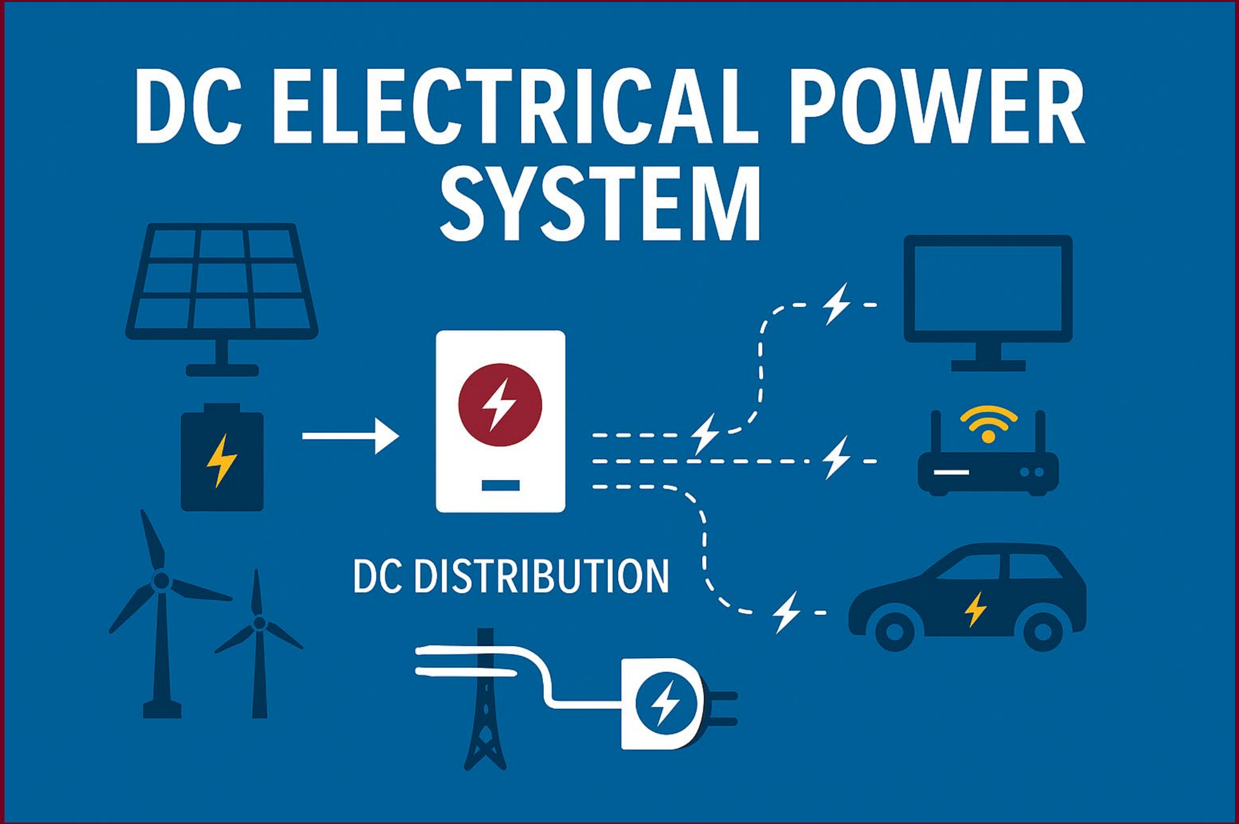


Illustration by Microsoft CoPilot

Affiliate Organisations

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Institution	Contact name	Date of consideration at RLT
TU Dresden	Jan Meyer	18/01/2024
Aalborg University	Frede Blaabjerg	21/12/2023
University of Cambridge	Ioannis Lestas	21/12/2023
University of New South Wales (UNSW)	Georgios Konstantinou	13/02/2024
TUMCREATE	Tobias Massier	13/02/2024
RWTH Aachen Flexible Electrical Networks	Prof De Doncker	19/09/2024
Indian Institute of Science	Gurunath Gurrala	19/12/2024
Taltech	Andrii Chubb	25/09/2025
Purdue University	Kevin Kircher	22/01/2026

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Exchanges and visits made by FAN team (during reporting year 2024/2025)

1. ***Chamara Dassanayake*** (PhD) undertook a 5-week visit to Secheron to work on detector subsystem design for DC circuit breaker (plus visited Fraunhofer IISB)
2. ***Veerabrahmam Bathini*** (postdoc) seconded to industry for 3 months (Orion)
3. ***Josh Schipper*** (postdoc) seconded to Siemens Energy in Germany for 6 months
4. ***Dilshani Maheepala*** (PhD) visited UNSW for 2 weeks in May 2025.
5. ***Nalindi Herath*** (PhD) visited TU Graz in Austria for 2 months to continue research on PhD
6. ***Tipene Merritt*** (VM Lead) visited Purdue Uni, Indiana and Vermont.
7. ***Jeremy Watson*** (Researcher) spent a week at University of Aberdeen, and also visited Universities of Cambridge, Manchester, Leicester and Imperial College, London
8. ***Andre Cuppen*** (PhD) visited Europe in April/May 2025, visiting TU/Eindhoven and KU Leuven

Technische Universität (TU) Dresden

- AC2DC project

[concepts and their feasibility for operating DC distribution networks for LV and MV]

There have been exchanges of researchers.
Also meet online every 6 weeks for a technical exchange.

Joint outputs to date:

[1] Josh Schipper, Radnya Mukhedkar, Neville Watson, Veerabrahmam Bathini and Jan Meyer, Generalised harmonic domain analysis for transformer core hysteresis modelling, Electric Power Systems Research, Volume 249, December 2025, 111987, ISSN 0378-7796, https://doi.org/10.1016/j.epsr.2025.111987.

[2] Paper on measurement of DC home being worked on.

Other Research Program

FEN project – Flexible Elekt

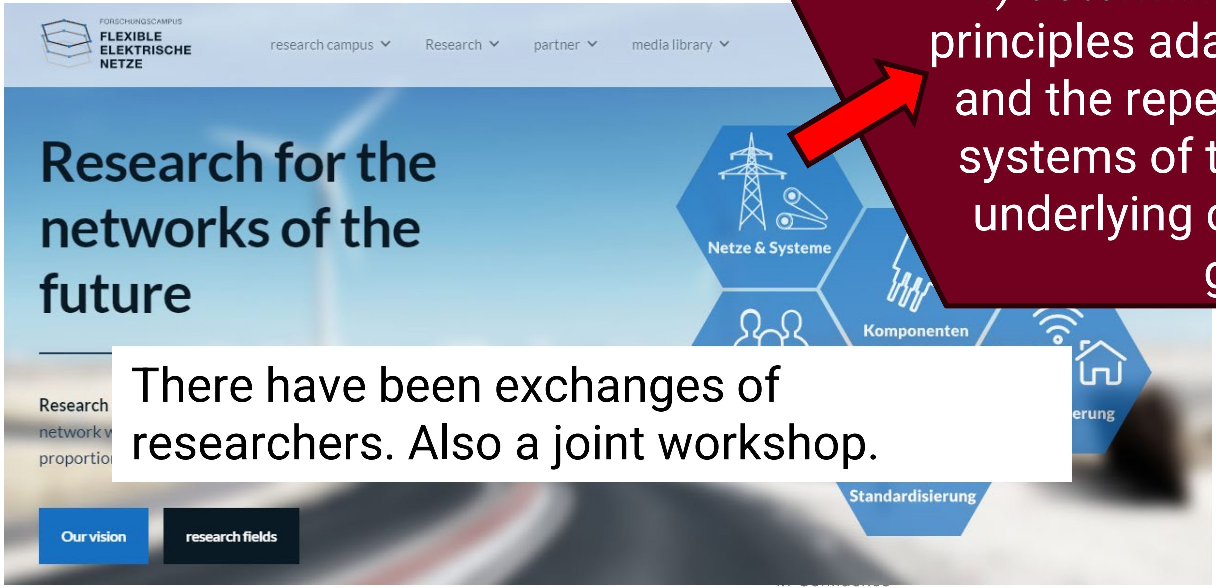
https://www.fenaachen.n

RWTH Aachen University

FEN researchers are engaged in:

i) researching procedures and methods for the planning and operation of pure DC or hybrid grids (DC and AC grids).

ii) determining the planning principles adapted for DC grids, and the repercussions on the systems of the overlying and underlying conventional AC grids.



There have been exchanges of researchers. Also a joint workshop.

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Collaboration with other SSIF/AETP programmes

Locally collaborating with two AETP programmes:
Aotearoa Green Hydrogen Technology, and
Electrifying Large-Scale Transport.

Publications

Thirty one (31) papers either published or are accepted for publication in the annual reporting period 2024/2025

1. These include top-tier IEEE journal papers, high-quality international conference presentations, and applied research contributions to CIGRE symposia.

2. Topics cover *solid-state DC circuit breakers*, *hybrid AC/DC systems*, *DC microgrids*, *supercapacitor-assisted converters*, *renewable energy integration, and fault detection methods*, showing both breadth and depth in power systems research.

3. Many works demonstrate novel methods, practical implementations, and system-level studies, reflecting a balance between *theoretical rigor* and *applied engineering*.

IEEE Transactions on Power Electronics Letters

- Special Section on *Highly Robust Power Electronics in the Era of DC Grid* *in* IEEE Transactions on Power Electronics Letters (TPEL).
- Open to Submission: 1 October 2024

Key questions

- Where does DC add the most value first?
- What are the biggest transition risks?
- Where should NZ lead internationally?

FAN Research Partners

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New Zealand

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UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

AUT
UNIVERSITY
NEW ZEALAND

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Overseas – University of Cambridge, Aalborg University

This work was supported by the Ministry of Business Innovation and Employment, New Zealand under the Strategic Science Investment Fund – Advanced Energy Technology Platform programme "Architecture of the Future Low-Carbon, Resilient, Electrical Power System" contract number UOCX2007

Thank you

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Questions?

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