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

Short form: Future Architecture of the Network (or FAN)

Asset Management Forum
Neville Watson
18 November 2021

Future Architecture of the Network
TE WHATUNGA HIKO

Outline

- Introduction
- Motivation
- Future Architecture of the Network Project

Introduction

1. Which technologies are coming?
2. What are the opportunities and barriers?
3. Which technical areas to invest in?
4. What are the opportunities for:
   - research,
   - industry/academia collaboration, and
   - Government/industry investment
5. Strategic roadmaps for technology and innovation?

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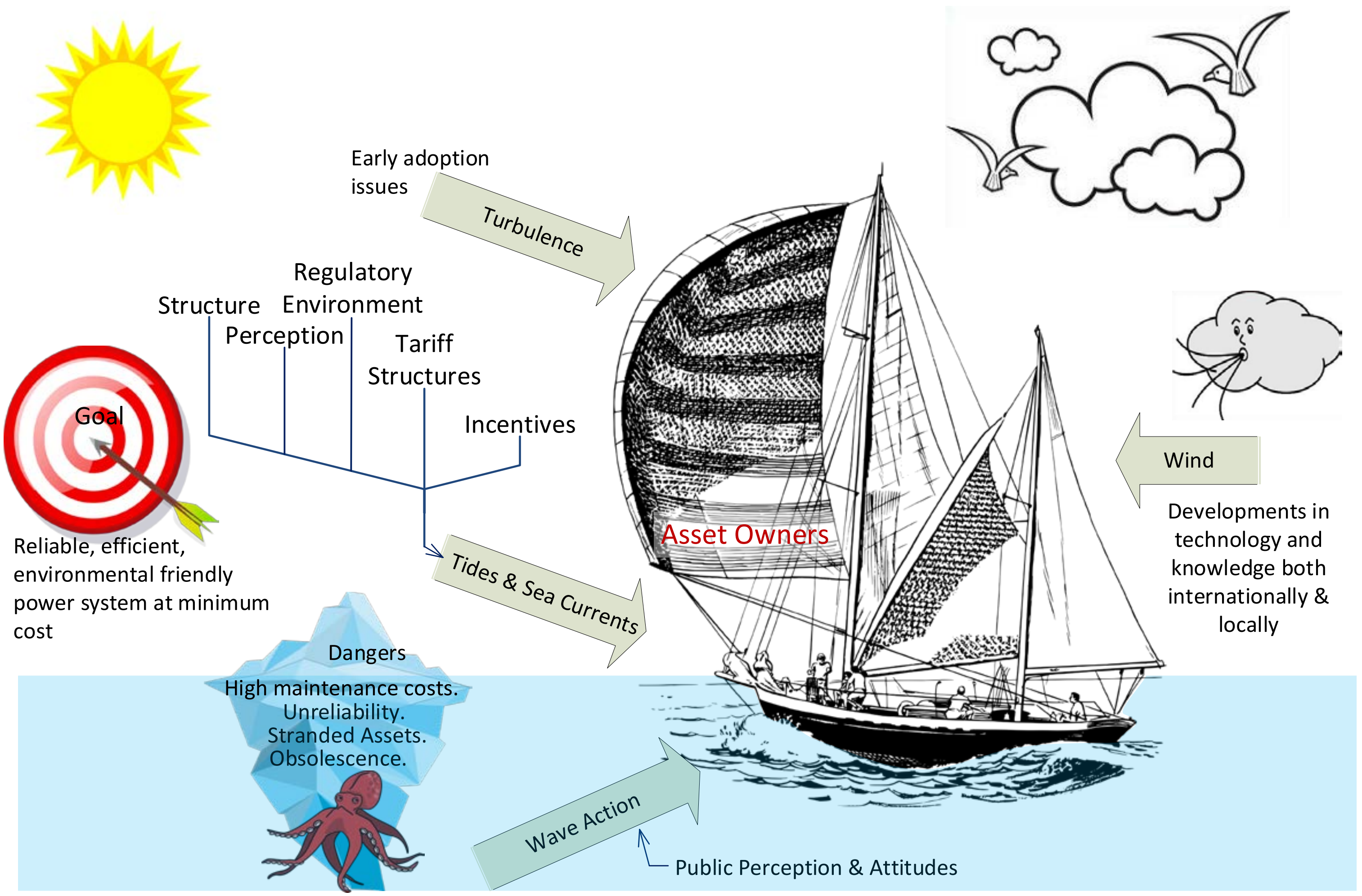

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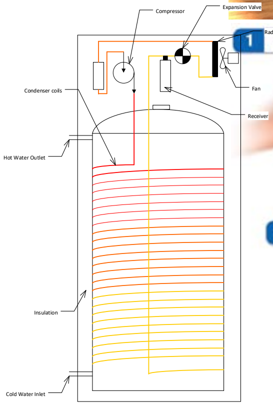
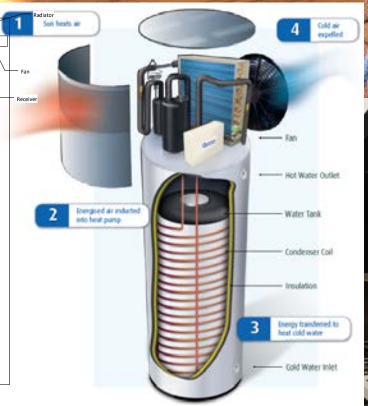
Household Equipment





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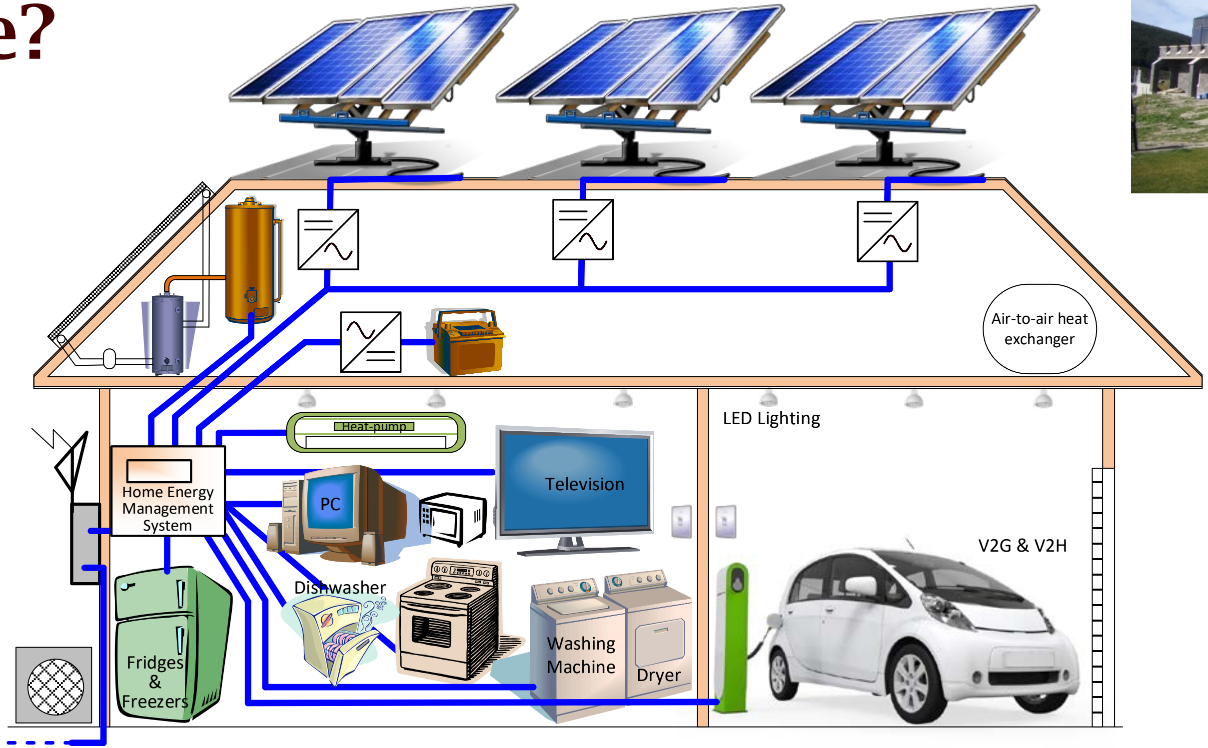
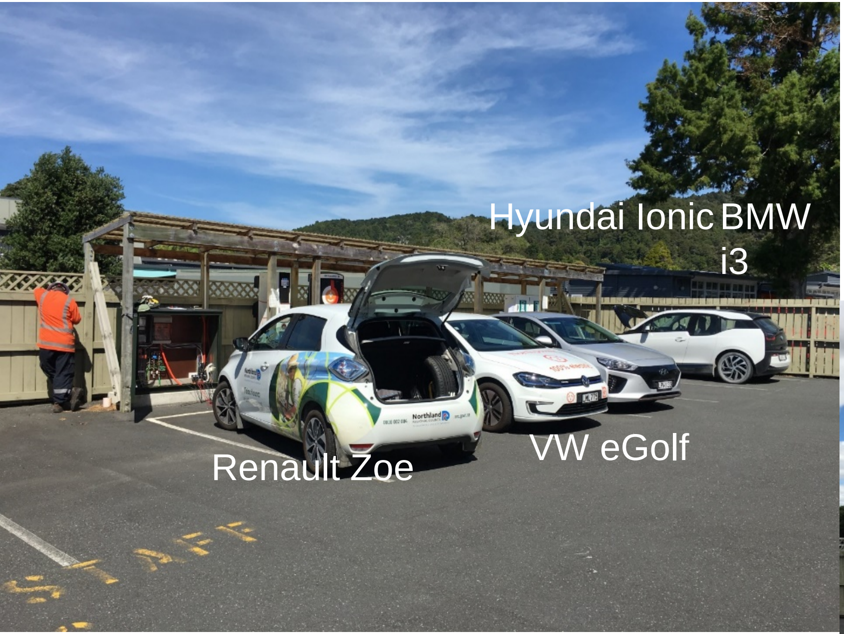
Home?



[1] S. Iyer, W. G. Dunford and M. Ordonez, "DC distribution systems for homes," 2015 IEEE Power & Energy Society General Meeting, Denver, CO, 2015, pp. 1-5, doi: 10.1109/PESGM.2015.7286585.




Electric Vehicles



Measuring the EV Charger characteristics

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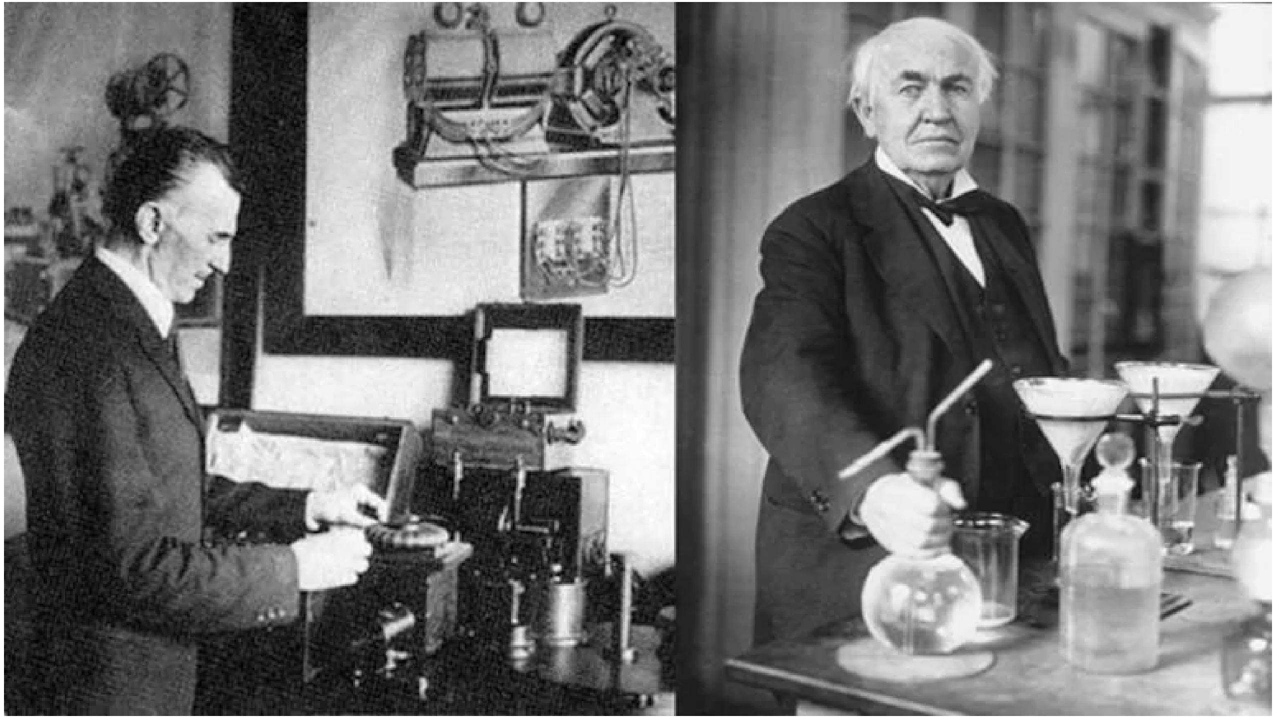
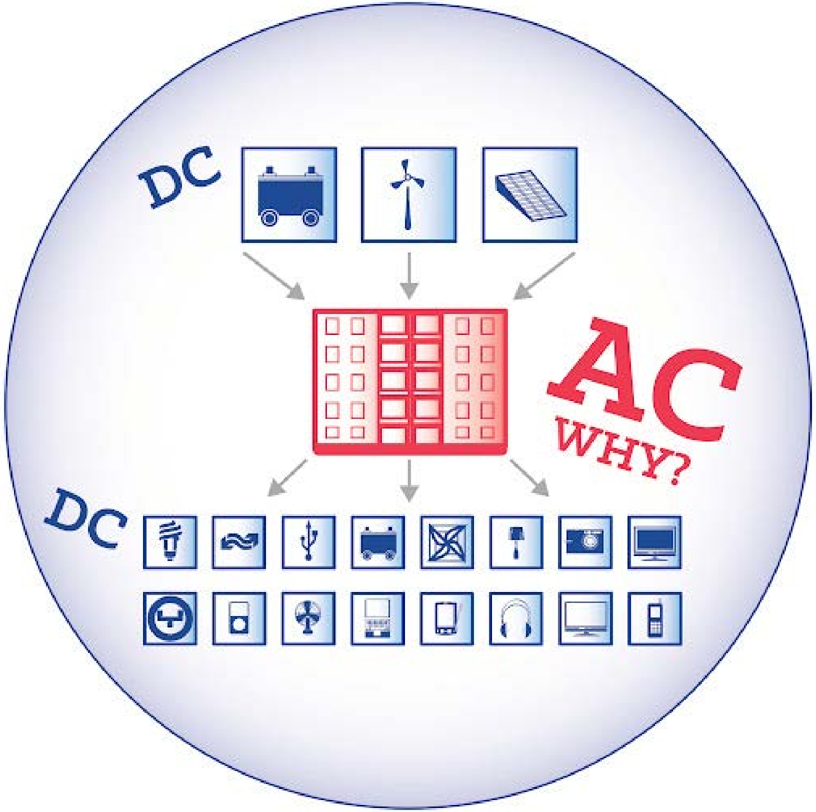
Motivation - AC versus DC



Battle of the Currents, part II?

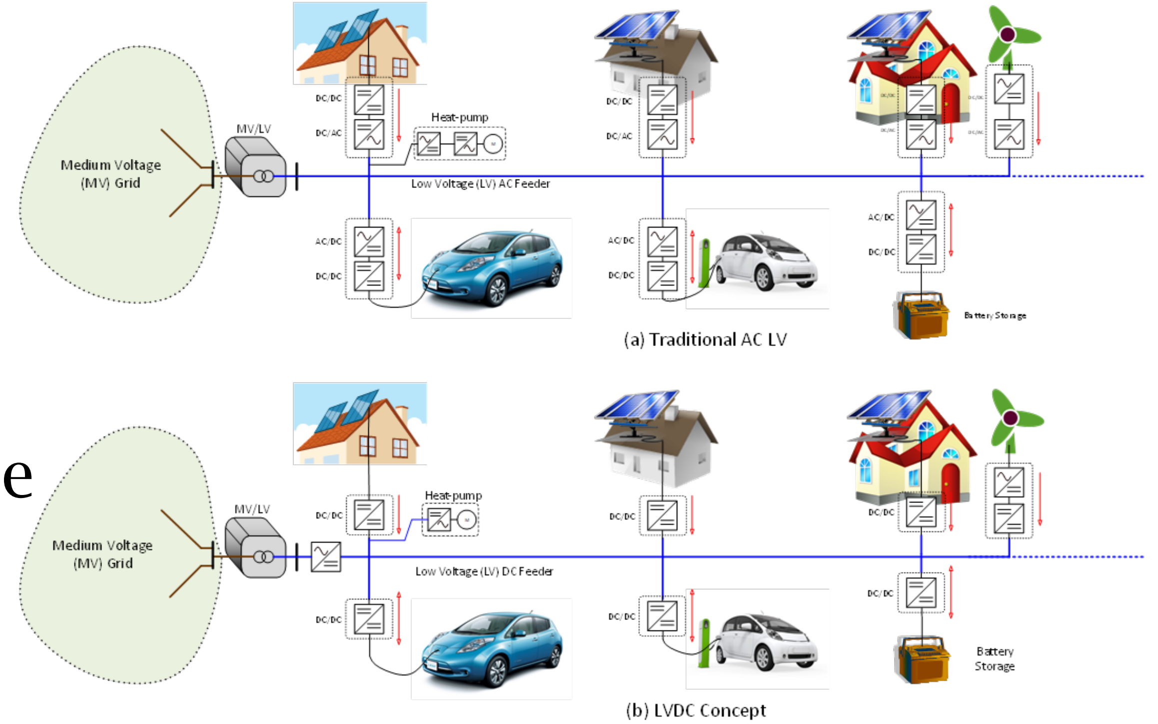
Motivation

The question is not whether DC conveyance and DC systems will have a role in the system moving forward, but where should it be used, how is it to be implemented and how fast should it be deployed.



Motivation

- Ease of connectivity of converter interfaced technologies
- Minimise losses; electricity conveyance and conversion



The era of DC begins– Pursuit of best AC/DC hybrid mix

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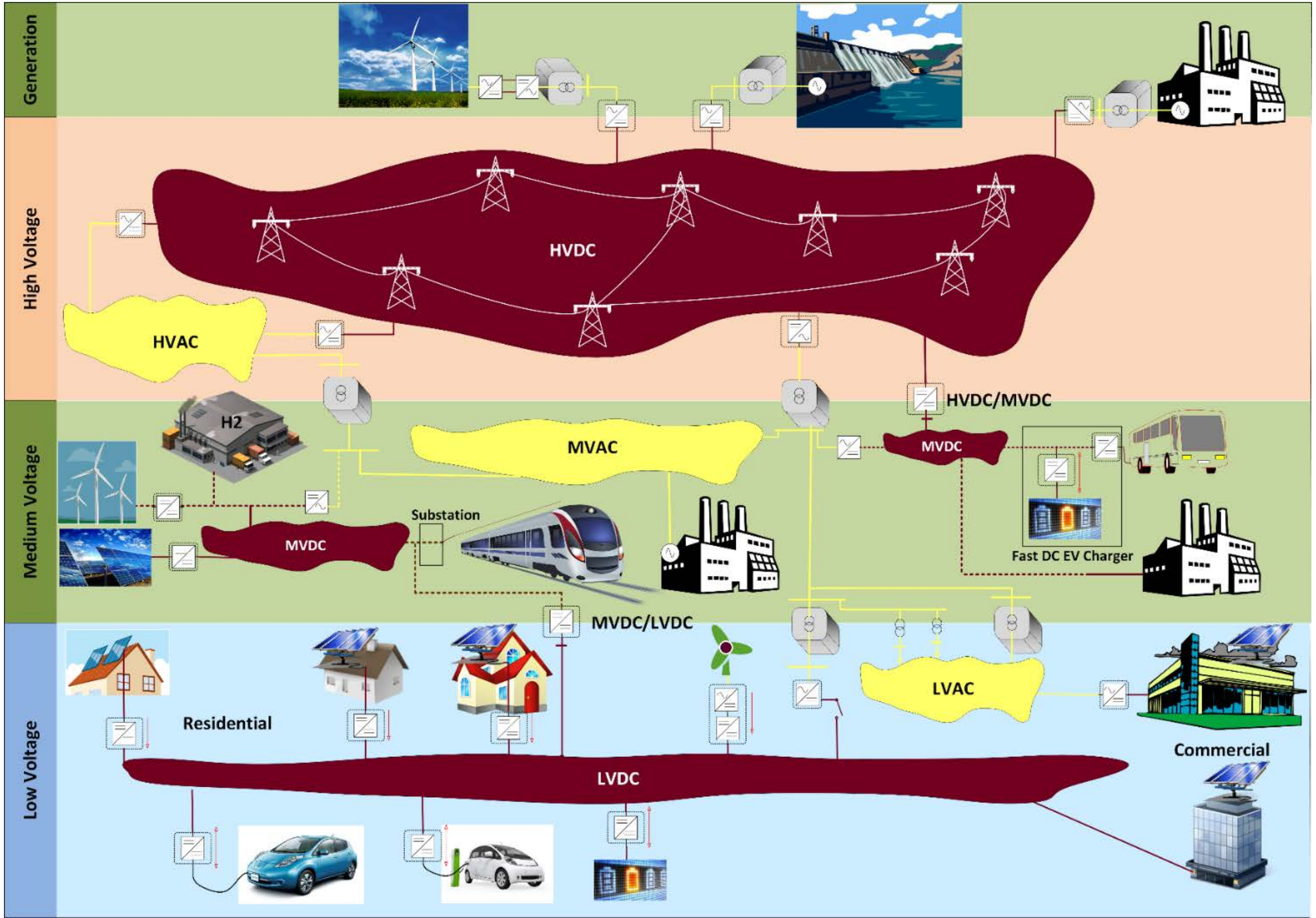
Hybrid AC-DC Concept



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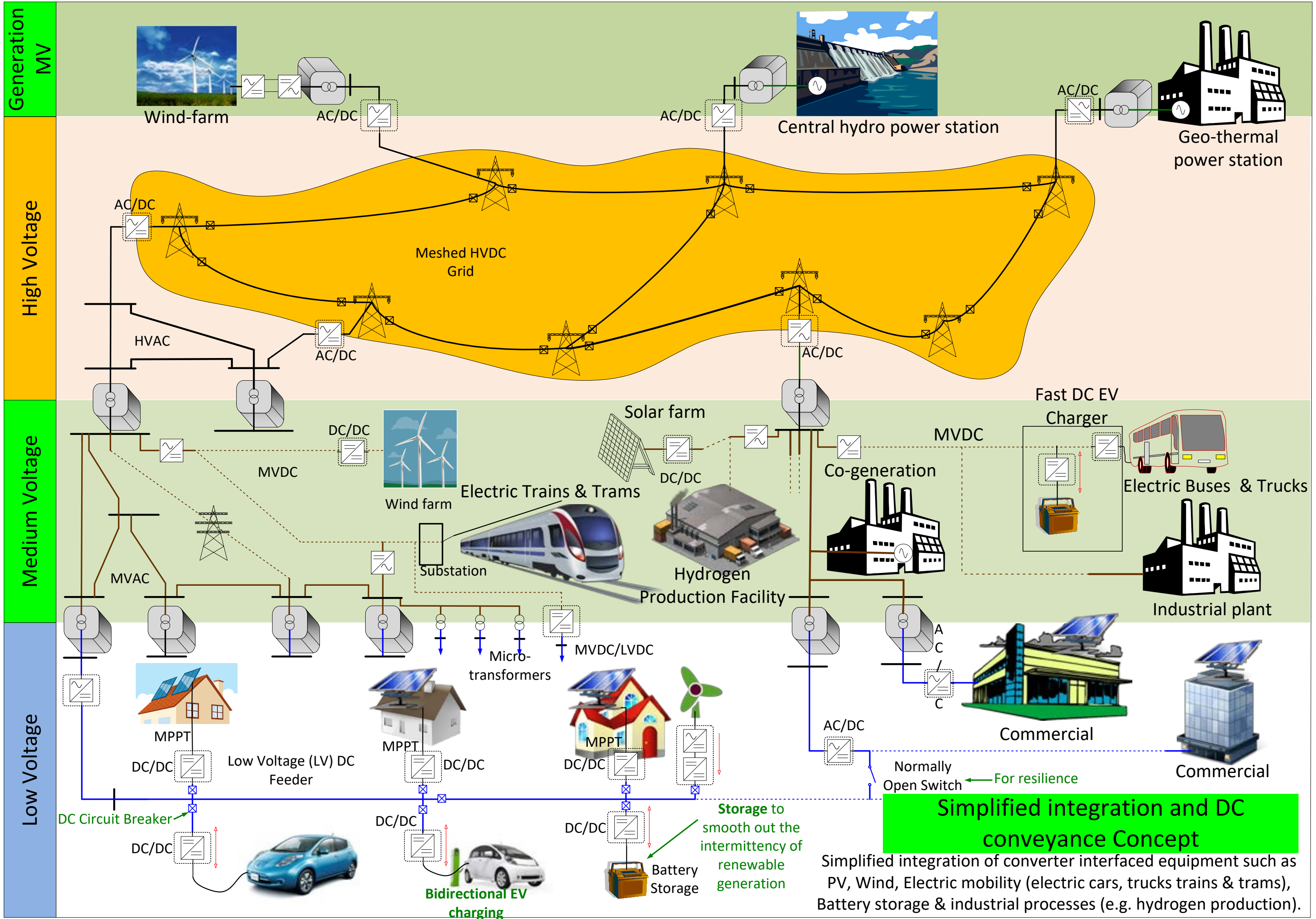

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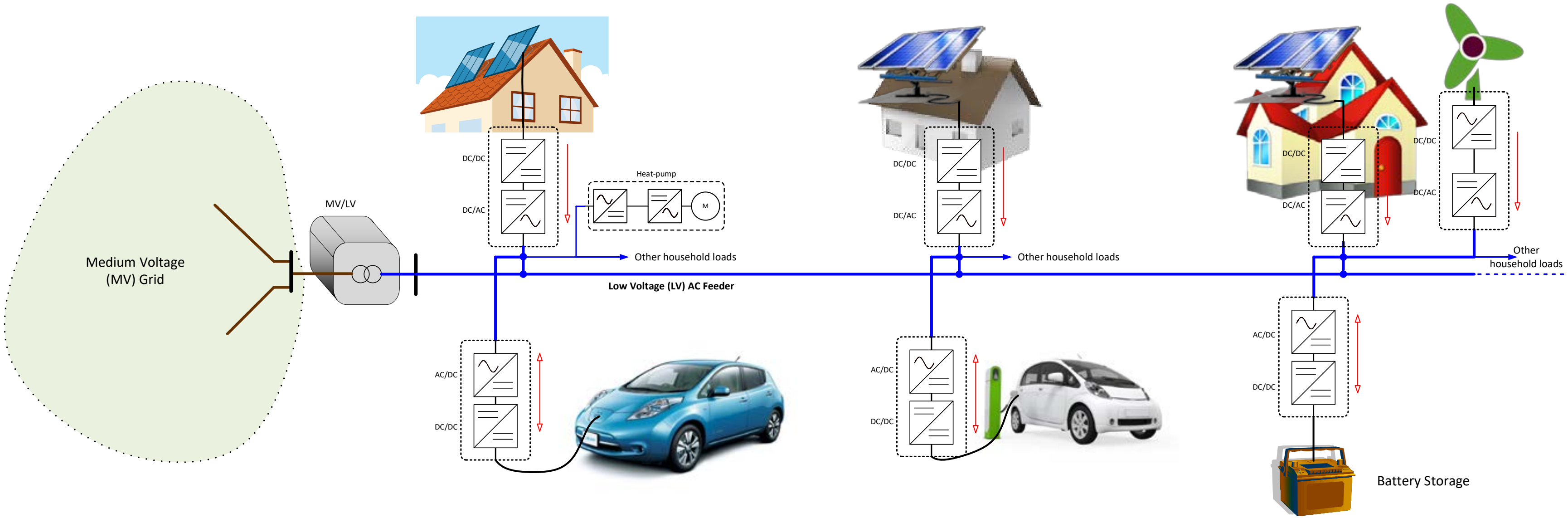
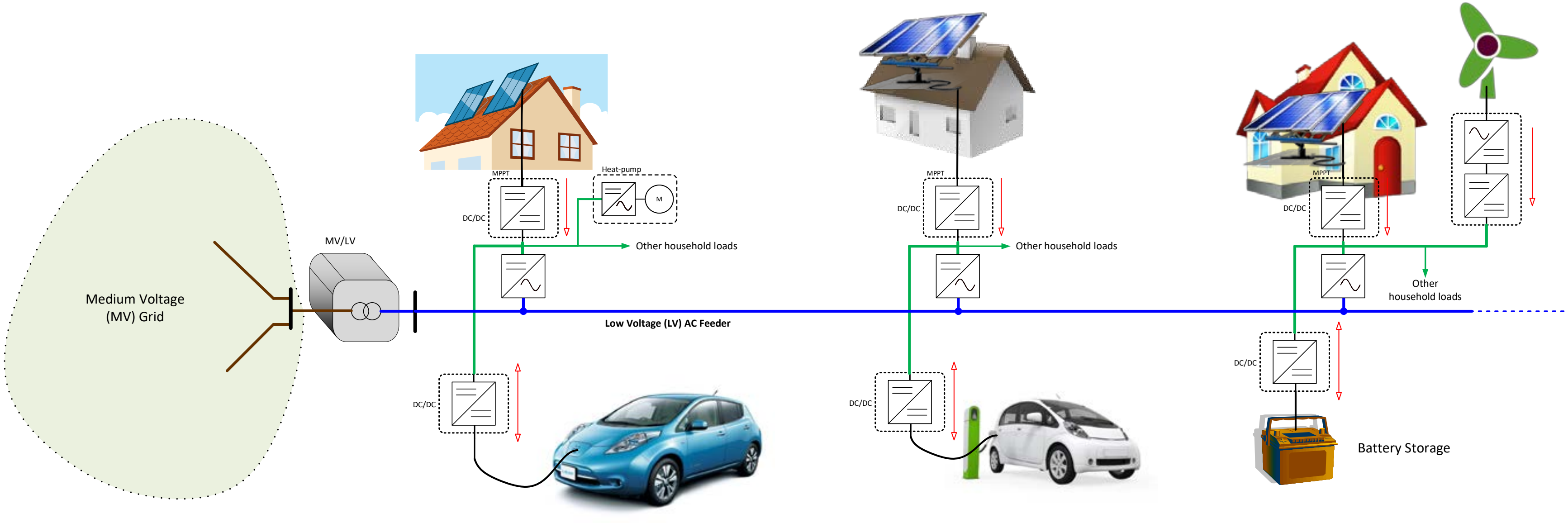
Existing Low Voltage (LV) System



Converter interface for Each home



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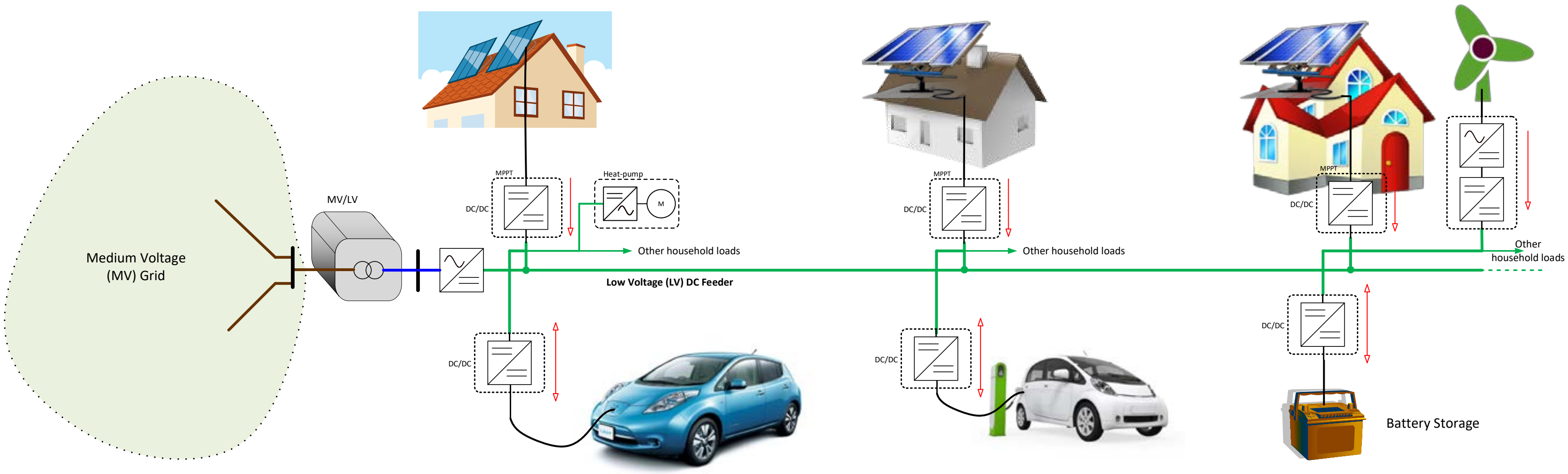
Complete LVDC System



[1] IEC, LVDC: electricity for the 21st century, Technical Report, 5 Sept. 2017

Future Architecture of the Network Project

A 7 year Advanced Energy Technology Platform (AETP)

MBIE-funded programme (SSIF-Strategic Science Investment Fund)

AETP enables research into technology at the frontier of innovation, with the potential to advance and disrupt global energy markets. These technologies will have the potential to radically shift the global energy landscape and develop market opportunities for New Zealand.

Awarded October 2020

Future Architecture of the Network (FAN) Objective

1. To develop knowledge and understanding of the extent of DC technology and circuit penetration within the AC network that is **optimum** for the future.
2. Address a suitable **transition pathway** for the New Zealand context.
3. Significant focus on ***knowledge*** and ***capability development***.

Impact horizon of 2050 and beyond

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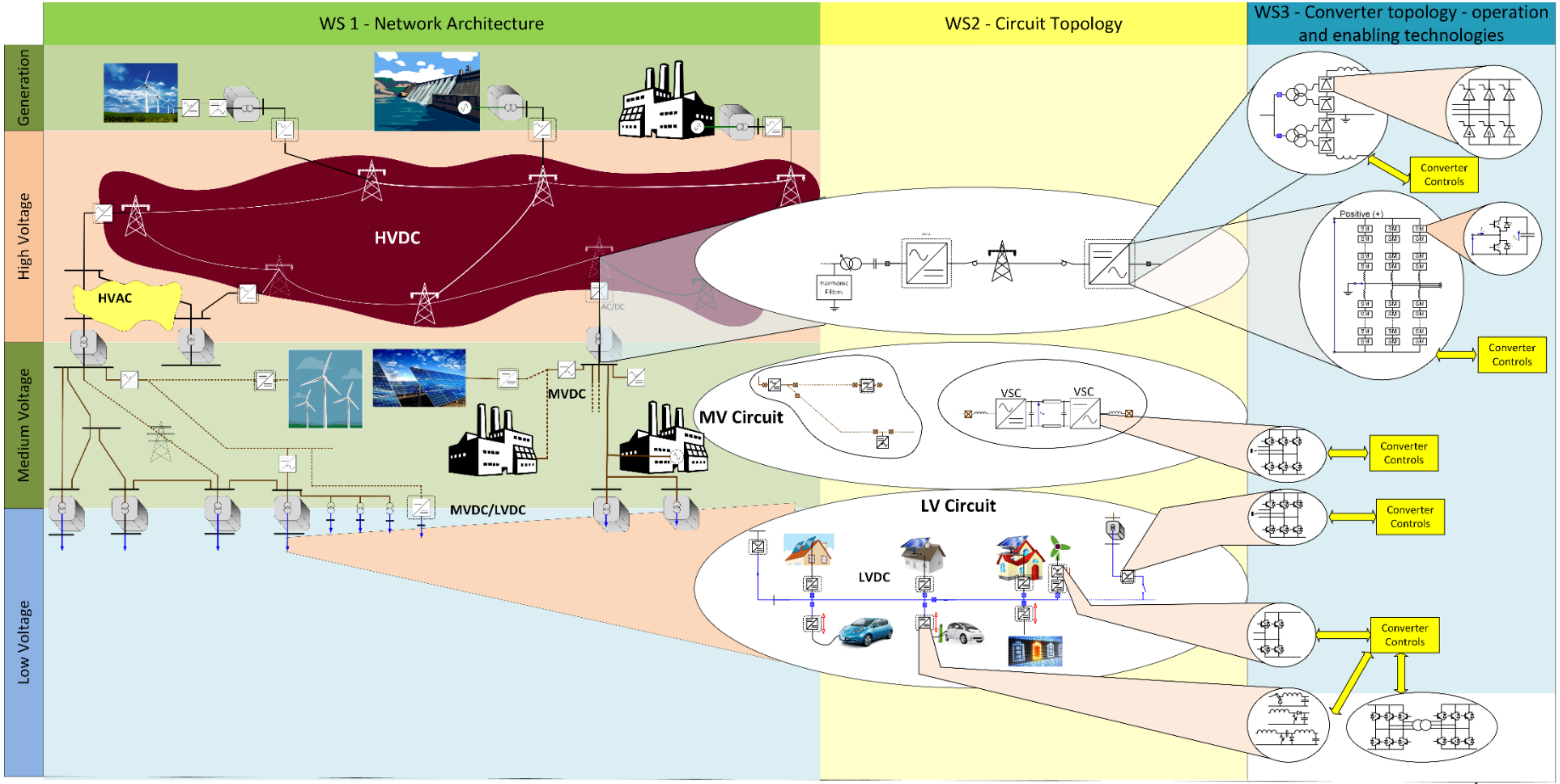
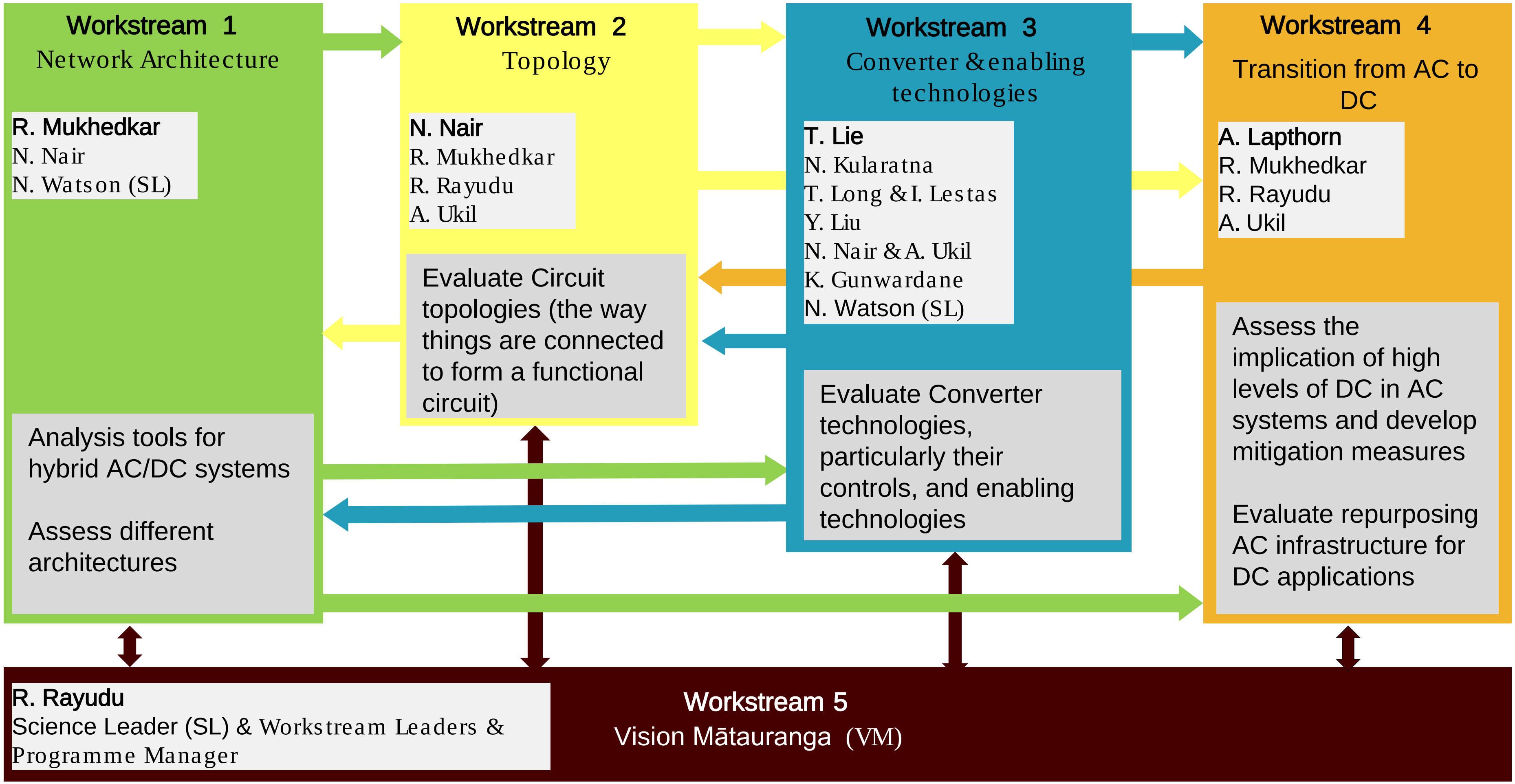
Research Challenges

1. Interaction between AC and DC systems
2. Loss of grid inertia due to converter penetration
3. Undesirable interaction between converters
4. Protection, reliability and safety
5. Effective adoption of DC –> transition path

Project Structure





Workstream 1
Network Architecture
R. Mukhedkar
N. Nair
N. Watson (SL)
Analysis tools for hybrid AC/DC systems
Assess different architectures
Workstream 2
Topology
N. Nair
R. Mukhedkar
R. Rayudu
A. Ukil
Evaluate Circuit topologies (the way things are connected to form a functional circuit)
Workstream 3
Converter & enabling technologies
T. Lie
N. Kularatna
T. Long & I. Lestas
Y. Liu
N. Nair & A. Ukil
K. Gunwardane
N. Watson (SL)
Evaluate Converter technologies, particularly their controls, and enabling technologies
Workstream 4
Transition from AC to DC
A. Lapthorn
R. Mukhedkar
R. Rayudu
A. Ukil
Assess the implication of high levels of DC in AC systems and develop mitigation measures
Evaluate repurposing AC infrastructure for DC applications
R. Rayudu
Science Leader (SL) & Workstream Leaders & Programme Manager
Workstream 5
Vision Mātauranga (VM)

Objectives

– WS1 Network architecture

To develop methodologies and prototype tools that enable:

- power-flow analysis
- transient and fault analysis
- dynamic analysis

for large scale hybrid AC/DC transmission and distribution systems

Objectives

– WS2 Topology

To develop topologies and methodologies that enable:

- new ways of fault detection, location and isolation ensuring safety and minimising outage
- curtail DC egress into AC networks
- ways to ensure continued stable operation post fault isolation

for large scale hybrid AC/DC transmission and distribution systems

Objectives

– WS3 Converter topology, operation and enabling technologies

To enable proliferation of DC grids within AC grids by addressing technologies and control mechanisms for different power electronic converter configuration:

- AC-DC converters; interfacing AC and DC networks that essentially convert AC power into DC power and vice versa.
- DC-DC converters that enable change in DC voltage levels.
- Converters utilised in ancillary circuits such as DC breakers for circuit isolation

Objectives
– WS4 Transition from AC to DC

To delivers research suggesting a transition path from the present electricity system to the network of the future:

- Assess network infrastructure that can be repurposed for use under DC stress.
- Determine capability, modifications and mitigation measures to enable continued use of AC equipment such as transformers.

Through modelling and testing

Objectives
– WS5 Vision Mātauranga (VM)

The living VM strategy is build on four main pillars:

- Build and develop VM capability across the key researchers of the programme and across the workstreams
- Co-development of projects or products which will bring direct impact and benefit for our Māori partners.
- Build the capability of Māori individuals or groups (iwi, hapū, businesses, etc) to support the increase of number of Māori researchers or businesses in this field.
- Dissemination and outreach to empower more Māori students in STEM related fields, and especially working in the electricity industry.

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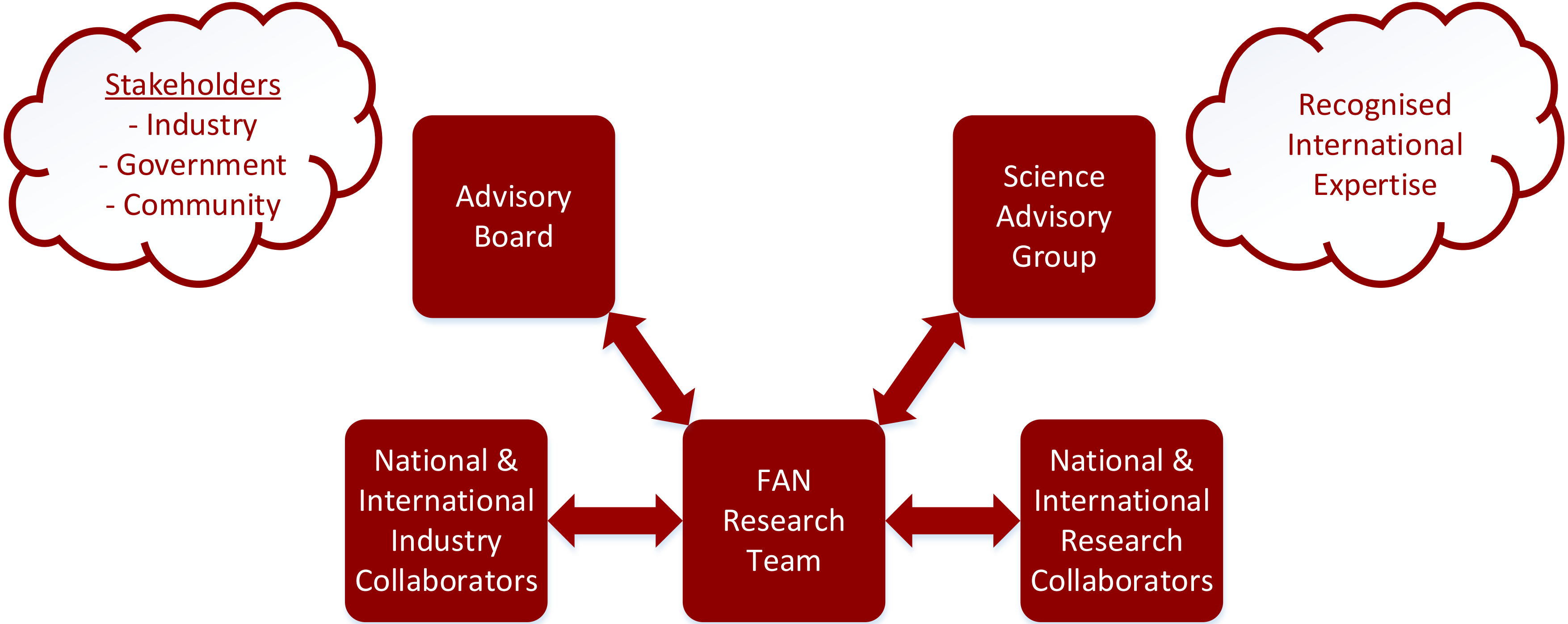
FAN Research Collaborations



Research technology and solutions at the frontier of innovation to radically shift the global energy landscape through collaboration

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FAN Research Partners

New Zealand

UC
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

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FAN Research Team

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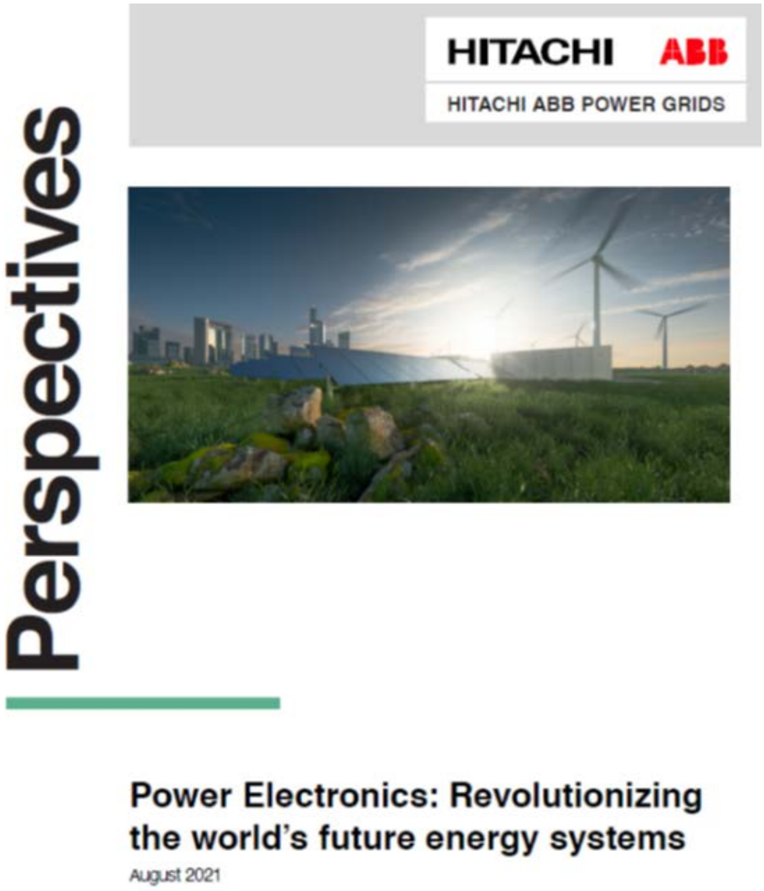
Other’s Perspective

Frede Blaabjerg
Professor of Power Electronics and Drives
Aalborg University
Simon Round
Corporate Executive Engineer
Power Electronics and Digital
Hitachi ABB Power Grids


HITACHI ABB
HITACHI ABB POWER GRIDS
Perspectives
Power Electronics: Revolutionizing the world’s future energy systems
August 2021

Hitachi ABB Power Grids

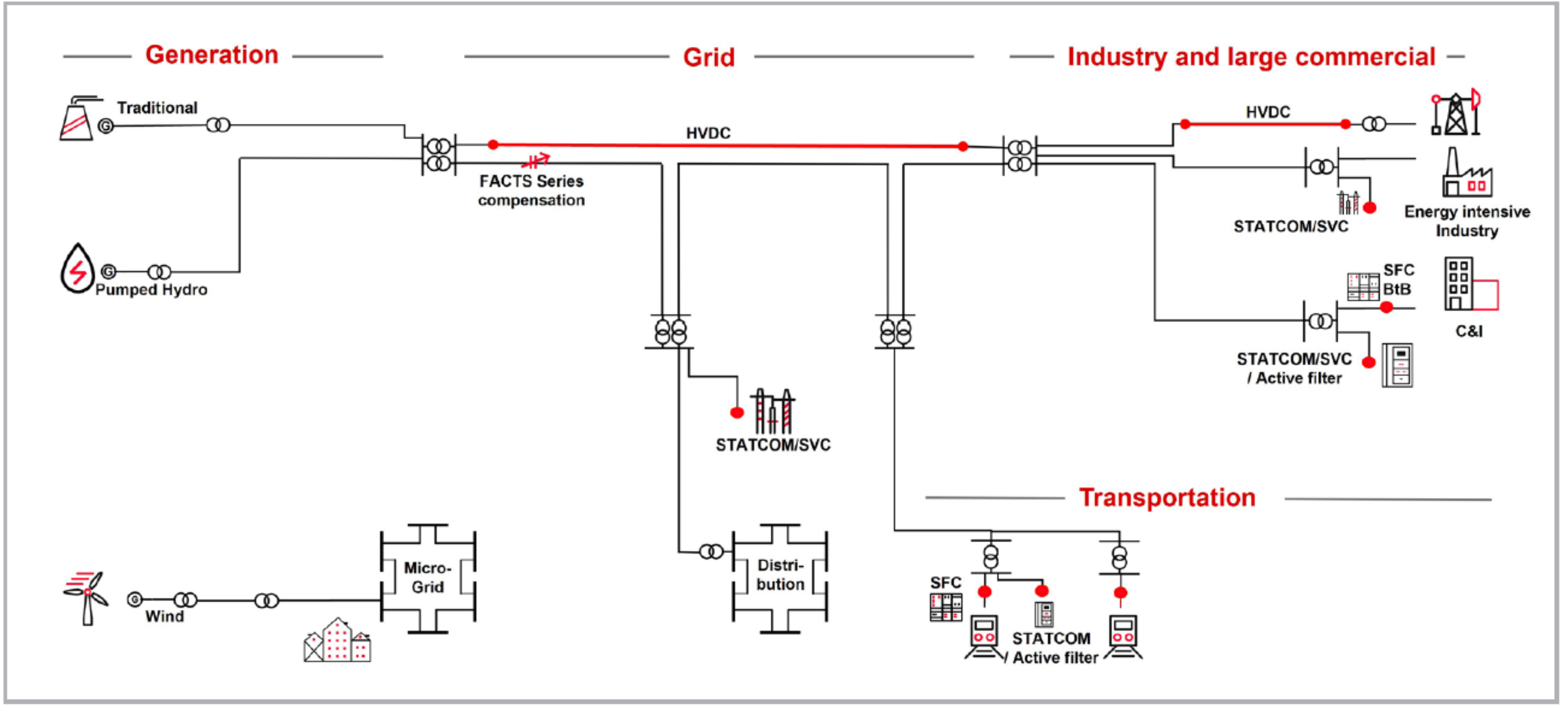


Fig. Power Electronics solutions in the grid – where we have come from

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Hitachi ABB Power Grids

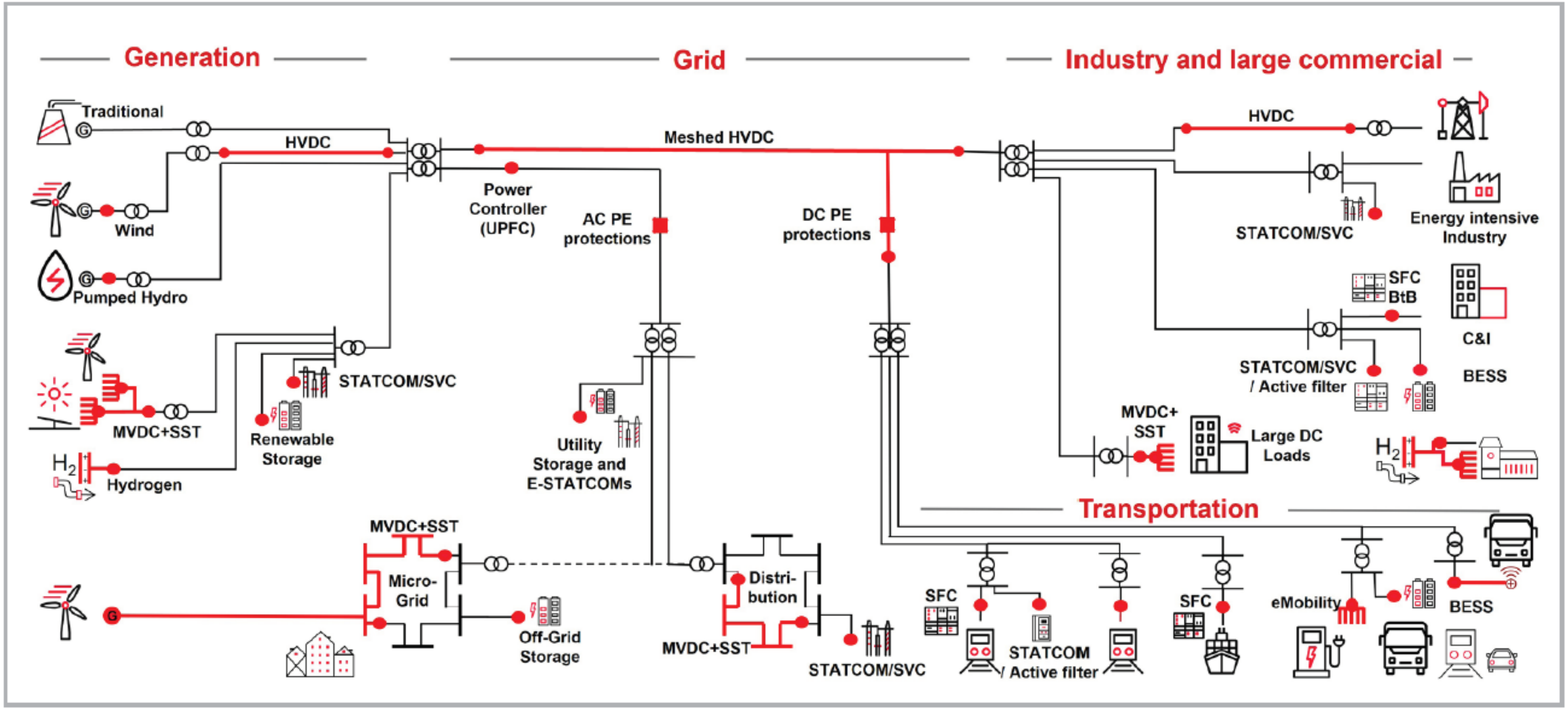

Fig. Power Electronics solutions in the grid – future evolution

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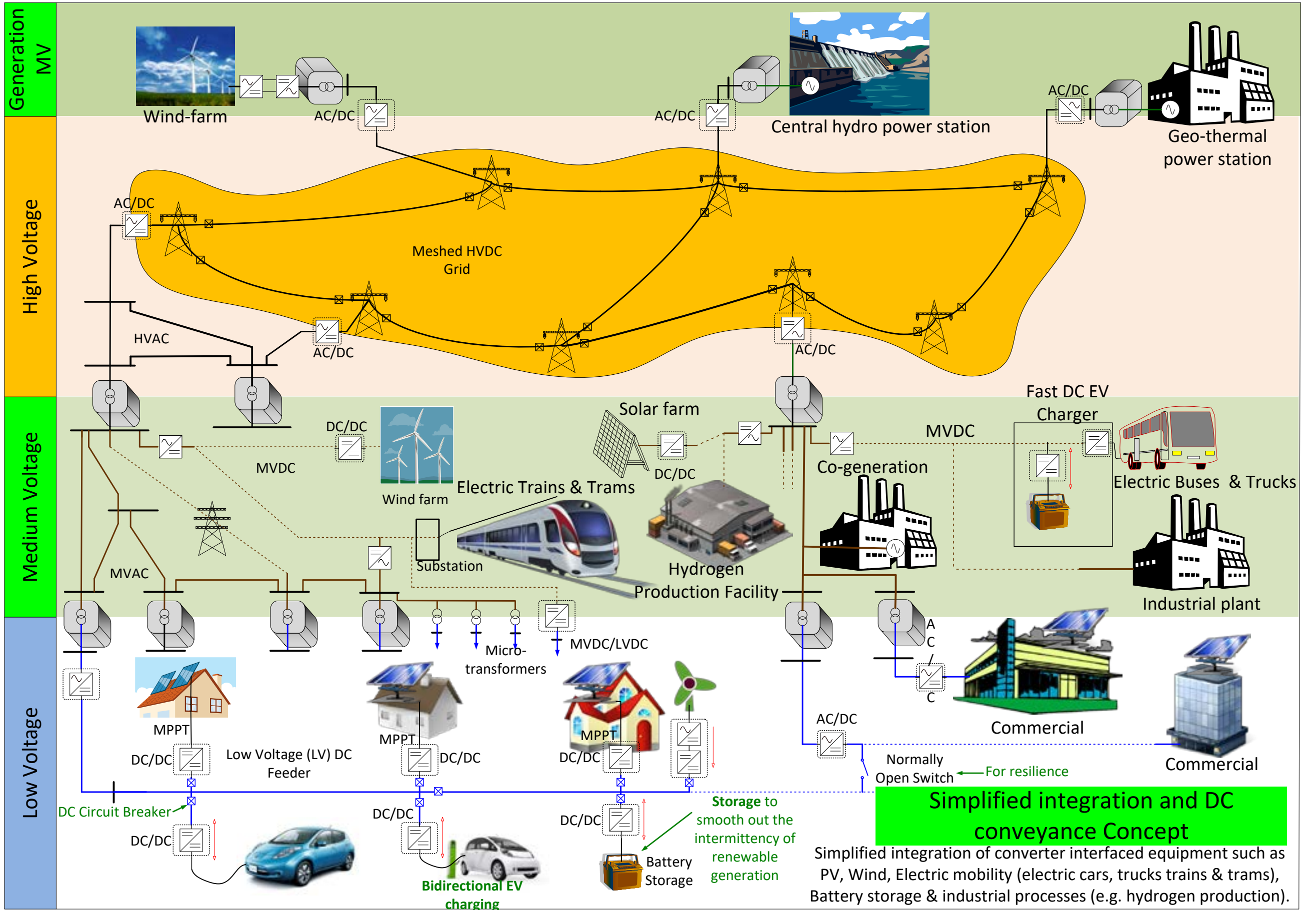
Very similar to:



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New Energy and Industrial Technology Development Organization (NEDO)

第 4. 2. 2 図　直流利活用の 2050 年のイメージ例

Future DC power utilization and technology.

Courtesy: Dr. Keiichi Hirose, NEDO (Japan).
https:// www.nedo.go.jp/english/in dex.html

Long Term Benefits

Develop knowledge to enable adoption and implementation of a hybrid AC/DC network:

- Modelling tools, technology, design concepts and templates
- Contribution to standards and procedures
- Energy transition pathway for NZ
- Develop NZ based engineering and research capability, collaboratively with national and international academic and industrial expertise
    - Up to 7 post-doctoral fellows
    - Around 18 post graduates
    - Over 50 summer projects

Impact horizon of 2050 and beyond

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The Road Ahead

Impact horizon of 2050 and beyond

www.fan.ac.nz
Contact: futurearchitecturenetwork@canterbury.ac.nz

Two related Government projects

- Solar Tsunamis: NZ$15 million for a five-year research project to develop space-weather prediction and risk mitigation measures for New Zealand's energy infrastructure.

- Risk to electrical infrastructure from Volcanic ash (Resilience to Nature’s Challenges)

Thank you

Questions?

Website: www.fan.ac.nz
futurearchitecturenetwork@canterbury.ac.nz

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