

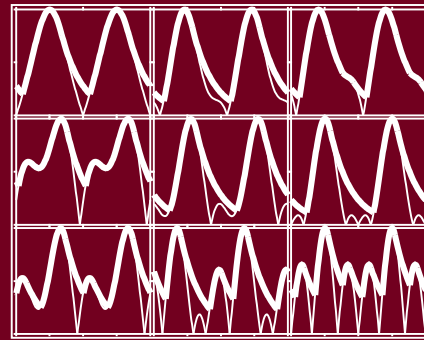
Workstream 1 Update

Software Tools for the Architecture of the Hybrid AC-DC Grid

Josh Schipper

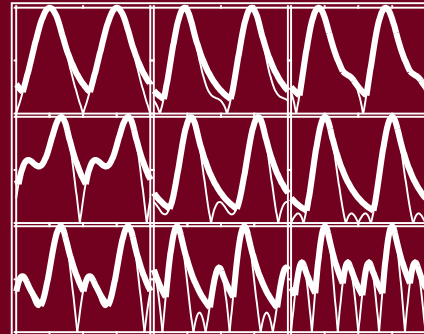
josh.schipper@epecentre.ac.nz

12/02/2024



FAN2024

Christchurch, New Zealand
12/13th February

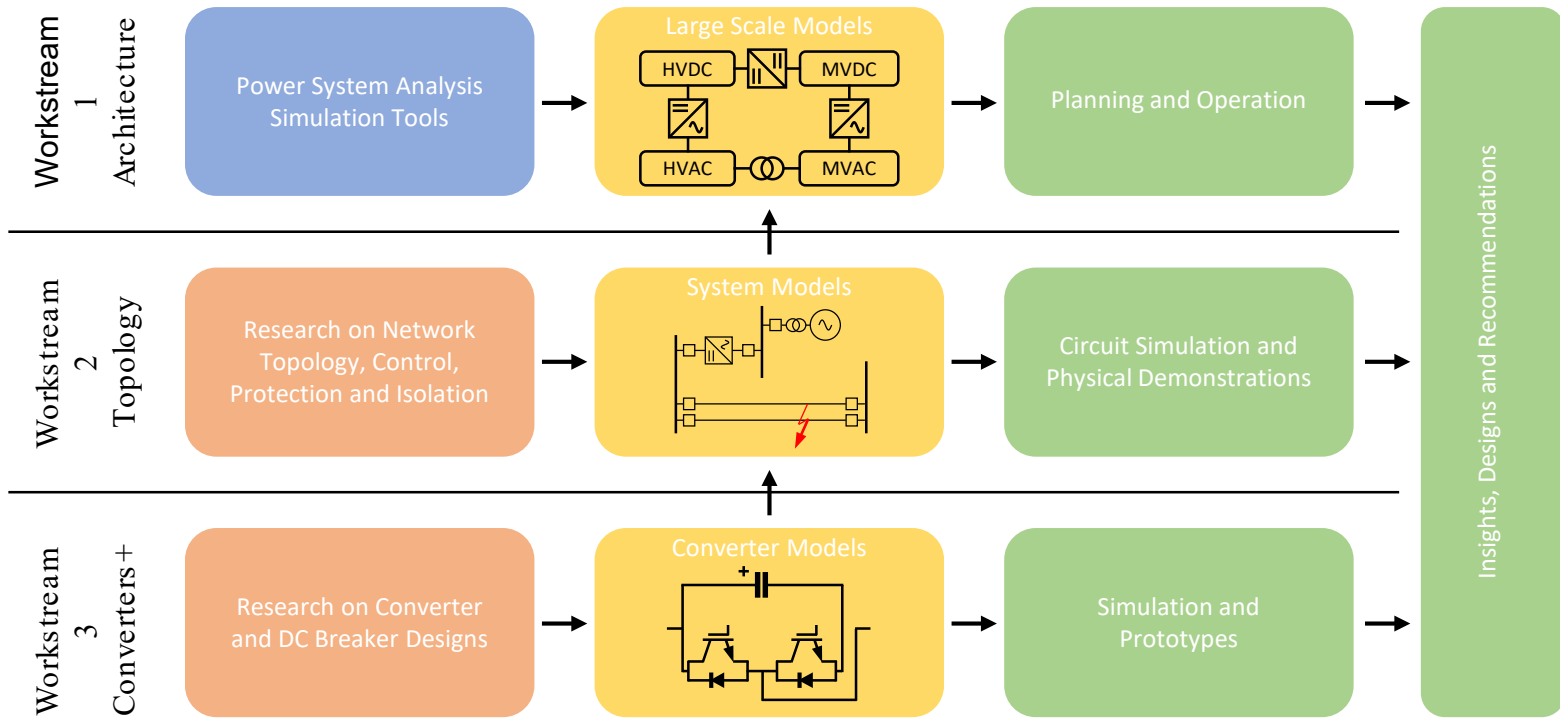


Outline

1. Workstream 1 Objectives
2. Timeline
3. Progress to Date
4. Architecture



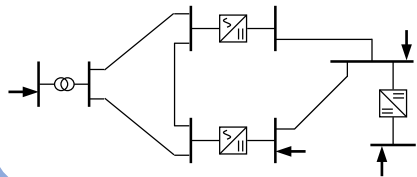
Outline of Objectives



Objectives of Workstream 1

Tools

POWER-FLOW ANALYSIS



Capabilities



- To simulate hybrid AC-DC network topologies with detailed switching and dynamic average models of converter technologies
- Capable of simultaneous simulation of both:
 - Transmission and Sub-transmission networks
 - Sub-transmission and distribution networks
 - AC and DC networks

FAN Outcomes

- Feasibility study to optimize DC integration



Basis for Future Industry Tool

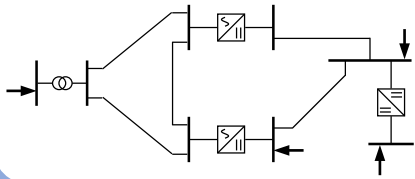
- For Planning
- For Contingency Analysis/
Security Assessment



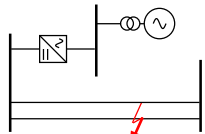
Objectives of Workstream 1

Tools

POWER-FLOW ANALYSIS



SHORT-CIRCUIT ANALYSIS



Static Assessment

Capabilities

- Capable of simultaneous simulation of both:
 - Transmission and Sub-transmission networks
 - Sub-transmission and distribution networks
 - AC and DC networks

FAN Outcomes

- Collaborate with Workstream 2 to understand the impact of protection requirements on circuit topology

Basis for Future Industry Tool

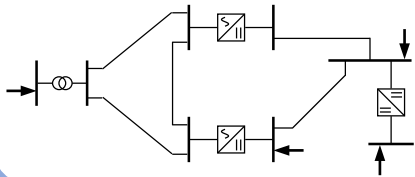
- To address protection coordination
- Design of protection system and associated settings



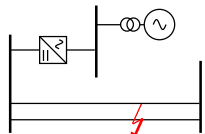
Objectives of Workstream 1

Tools

POWER-FLOW ANALYSIS

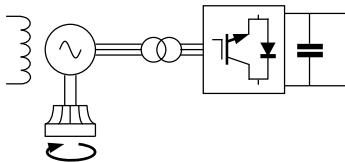


SHORT-CIRCUIT ANALYSIS



Static Assessment

DYNAMIC ANALYSIS



Basis for Future Industry Tool

- A planning and operational tool for assessing network stability

FAN Outcomes

- Determine the system security requirements on network architecture.
- Assess the impacts of converter control design on whole networks.

Capabilities

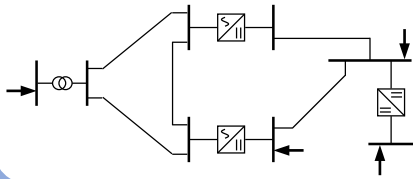
- Capable of simultaneous simulation of both:
 - Transmission and Sub-transmission networks
 - Sub-transmission and distribution networks
 - AC and DC networks
- Achieving this capability will require a large amount of smarts and computational resources to have a fast methodology.



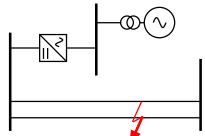
Objectives of Workstream 1

Tools

POWER-FLOW ANALYSIS

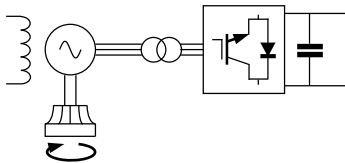


SHORT-CIRCUIT ANALYSIS



Static Assessment

DYNAMIC ANALYSIS



Models for Verification

NEW ZEALAND POWER SYSTEM

EMI | ELECTRICITY AUTHORITY
TE MANA HIKO

TRANPOWER

Cigre - DC GRID BENCHMARK
MODELS FOR SYSTEM STUDIES

cigre

B4
DC systems and power electronics

DC grid benchmark models for system studies
Reference B4

Case Study 2

Case Study 1

Case Studies
Presentation
Dr Veerabrahmam
Bathini

Models for Impact

NEW ZEALAND POWER SYSTEM
+ HVDC NETWORK MODEL
FUTURE WORK

FAN Outcomes



Timeline

Tools

POWER-FLOW ANALYSIS + STEADY STATE

SHORT-CIRCUIT ANALYSIS – STATIC ASSESSMENT

DYNAMIC ANALYSIS

PRESENT



Principal Investigators and Research Engineers

Radnya Mukhedkar

Neville Watson

Nirmal Nair

Veerabrahmam Bathini

Josh Schipper

Postgraduate Students

Choidorj Adiyabazar

Christian Yap

PhD Student #3

PhD Student #4

Summer Students

Saranya Ramani

Review of Power System Analysis

Ammar Ariffin

Dynamic Phasors

Huey Ann Yap

Holomorphic Embedded Load-flow Method

Finn Drabsch

HVDC Model and Literature Review Database

William Beauchamp

Acceleration Techniques for Fixed Point Power-flow

Ryan Murray

Newton-Krylov Methods for Power-flow

Ryan King

Optimisation Methods for AC-DC Power-flow

(Anna) Yuanyuan Qin NZ Power System Model and Tool User Interface – Case Study 1

Daniel Duan Verify Tool with Cigre Benchmark AC-DC Models – Case Study 2

(Max) Nghia Vang Sparse Matrix Methods for Linear Equations

Chris Huynh Preconditioners, GMRES, and Linear Equations

People

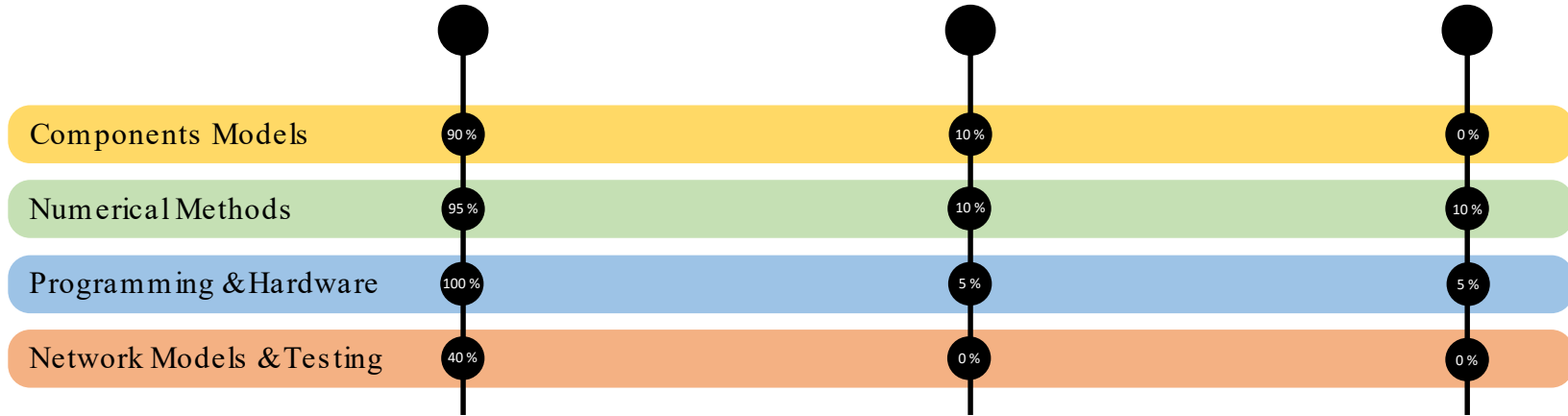


Progress to Date

POWERFLOW
ANALYSIS TOOL

SHORT-CIRCUIT
ANALYSIS TOOL

DYNAMIC
ANALYSIS TOOL

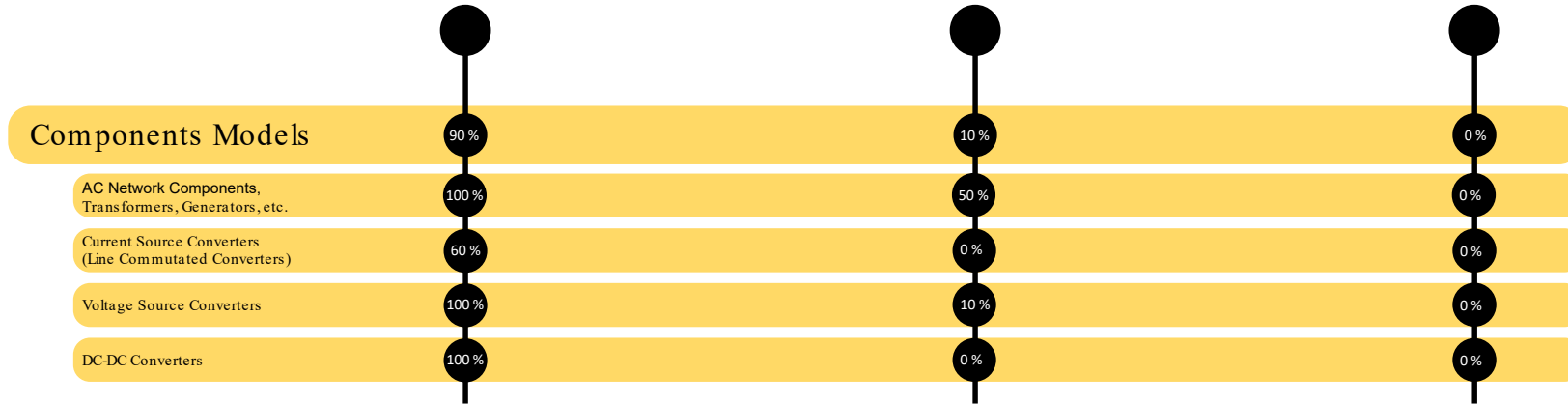


Progress to Date – Component Models

POWER-FLOW
ANALYSIS TOOL

SHORT-CIRCUIT
ANALYSIS TOOL

DYNAMIC
ANALYSIS TOOL

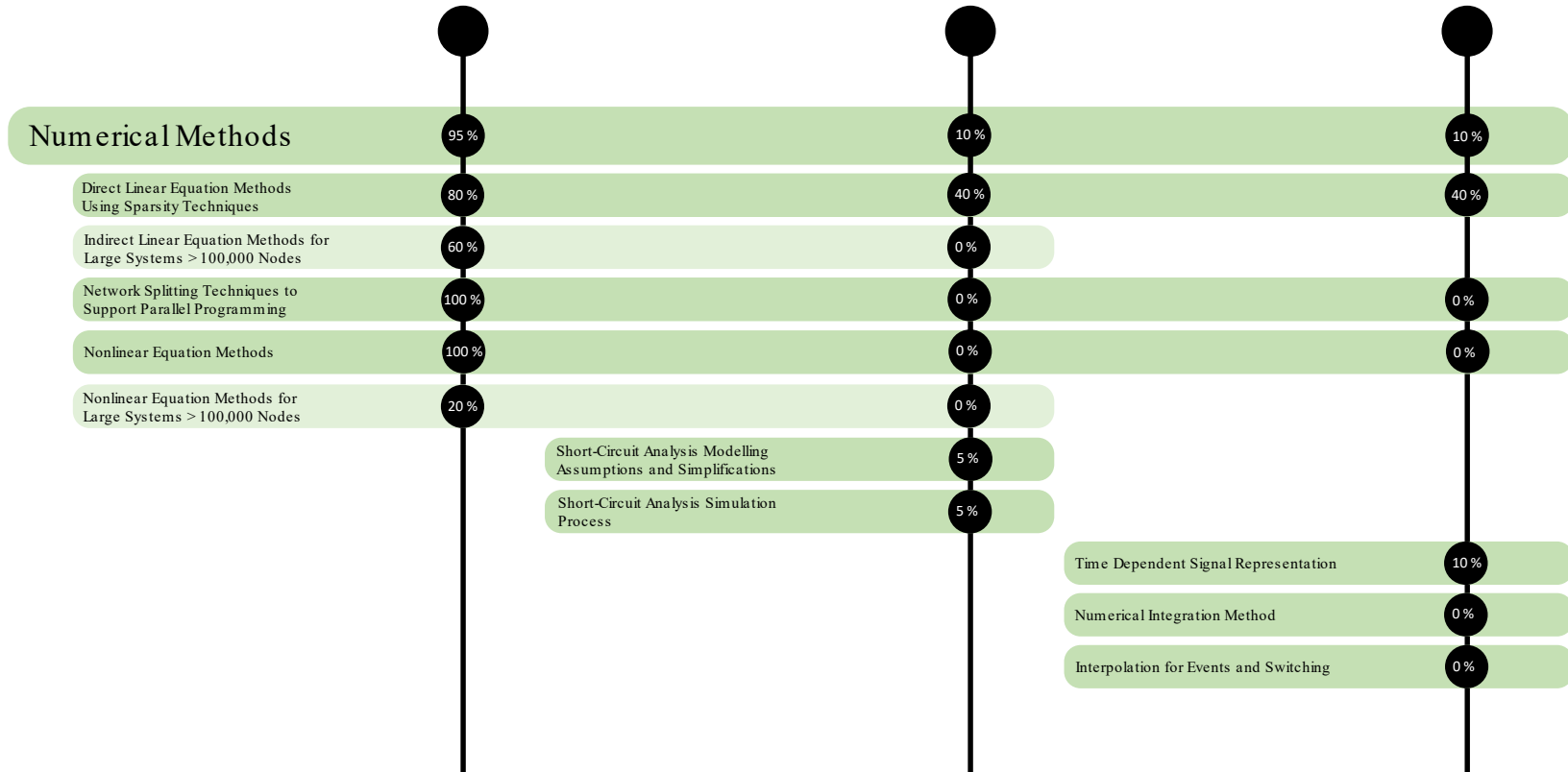


Progress to Date – Numerical Methods

POWERFLOW ANALYSIS TOOL

SHORT-CIRCUIT ANALYSIS TOOL

DYNAMIC ANALYSIS TOOL



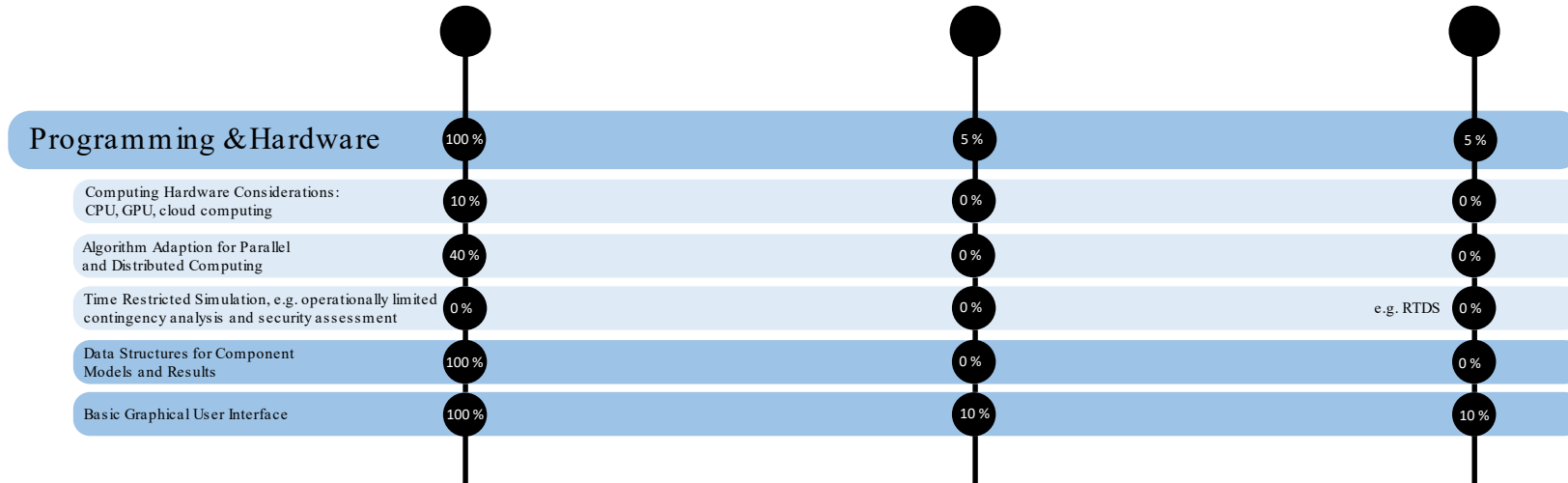
Lighter shaded boxes are not critical to tool requirements.

Progress to Date – Programming & Hardware

POWERFLOW ANALYSIS TOOL

SHORT-CIRCUIT ANALYSIS TOOL

DYNAMIC ANALYSIS TOOL

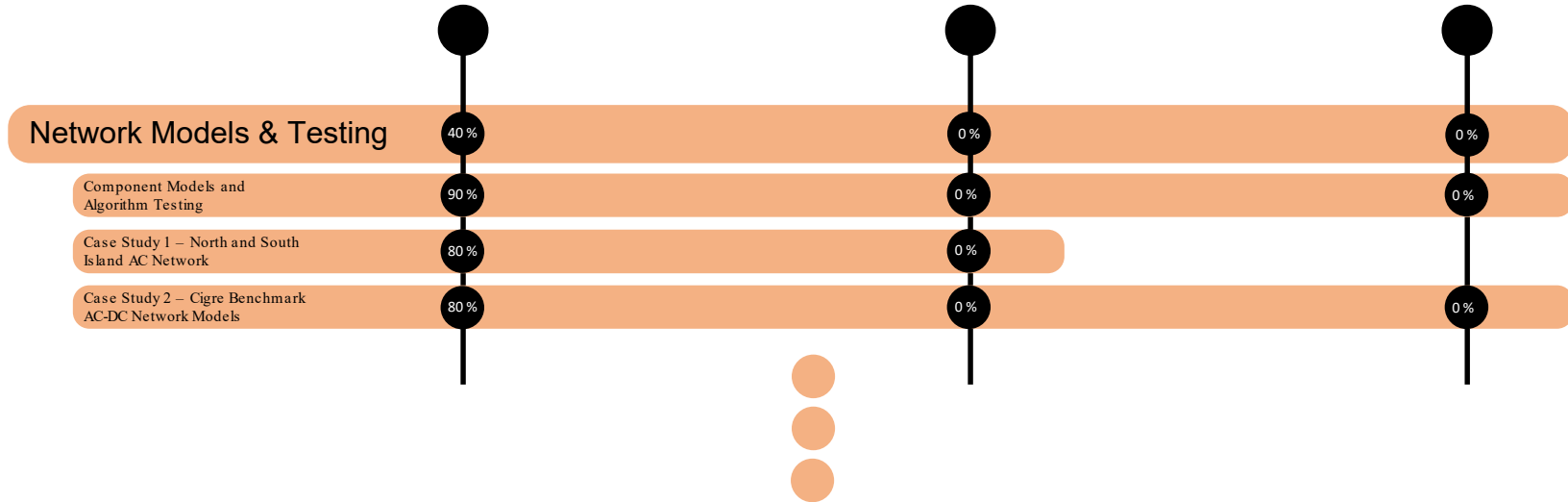


Progress to Date – Network Models & Testing

POWER-FLOW
ANALYSIS TOOL

SHORT-CIRCUIT
ANALYSIS TOOL

DYNAMIC
ANALYSIS TOOL



Architecture – Questions that need Answering

1. What are the benefits of an HVDC grid running the length of New Zealand?
2. Is there a place for Medium Voltage DC (MVDC)? Then what about HV to MV DC converters?

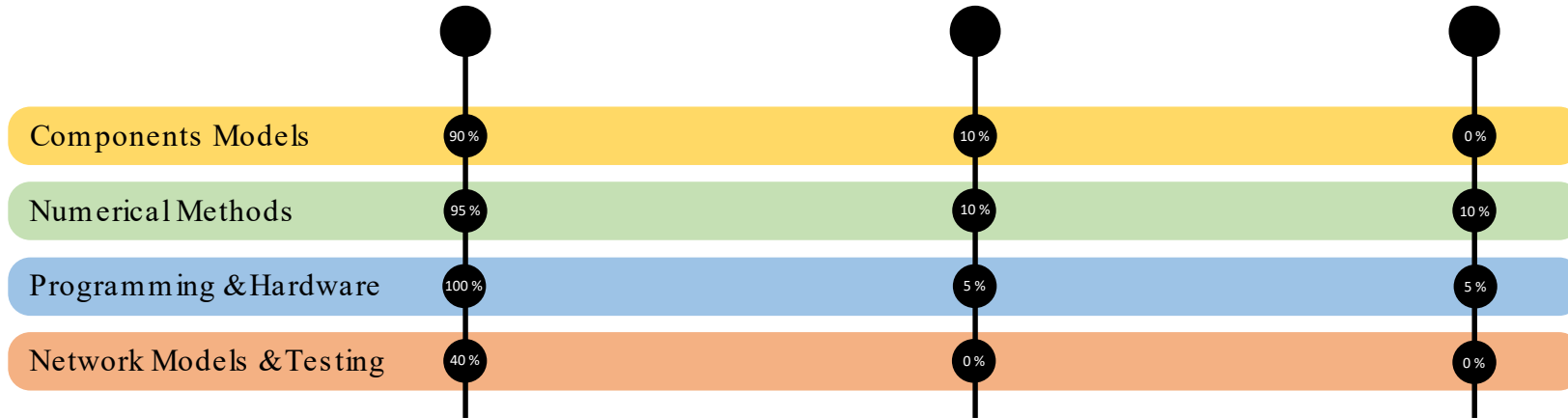


Progress to Date - Summary

POWERFLOW
ANALYSIS TOOL

SHORT-CIRCUIT
ANALYSIS TOOL

DYNAMIC
ANALYSIS TOOL



FAN Research Partners

New Zealand



Overseas – University of Cambridge, Aalborg University