ATC Technical Seminar

David Bones – ATC Chairman

Brisbane – 21/11/2019

cigre

For power system expertise

Agenda

Welcome	(9:00 – 9:10)
Key Note Presentation - Solar Enablement Initiative	(9:10 – 9:40)
• Presentation from Olav Krause from University of Queensland	
Australian Panel Presentations A1, B1, and C1	(9:40 – 10:25)
Coffee break	**(10:25 - 10:50)**
Australian Panel Presentations B4, A2, B2, and C2	(10:50 – 11:55)
System resilience - Stephen Jay and Leonie Bule	(11:55- 12:25)
AGM and Dinner update – Terry Killen	(12:25 – 12:30)
Lunch break	**(12:30 – 1:15)**
Australian Panel Presentations A3, B3, C3, D1 and B5	(1:15 – 2:30)
Coffee break	**(2:30 - 2:55)**
Australian Panel Presentations C4, C5, C6, and D2	(2:00 - 3:00)
Wrap-up and Thankyou	**(3:55 – 4:00)**

cigre
For power system expertise

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Connecting the Dots

Distribution System State Estimation

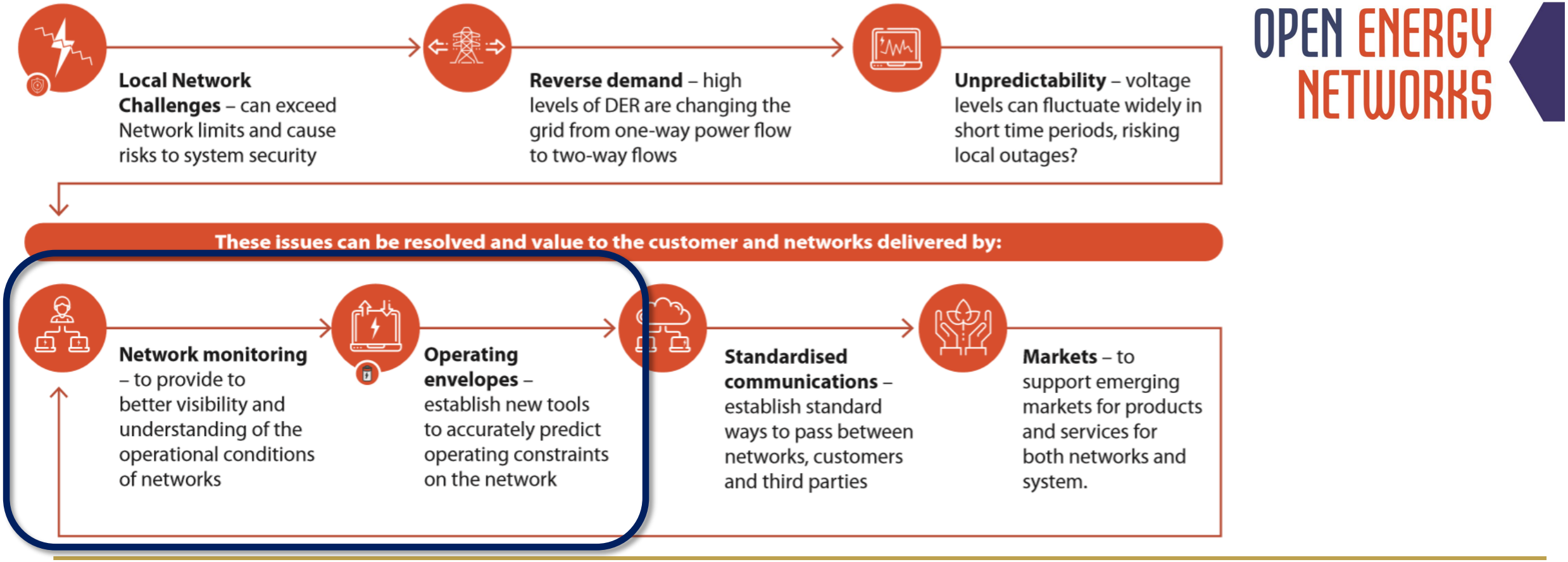
-

Solar Enablement Initiative

Olav Krause

Cigre AGM 2019, Brisbane

Monitoring crucial to address network challenges



Does monitoring always mean 'measuring'?

- There's a sea of data available today
  - Network: electrical models, asset registers, GIS, DMS
  - Load characteristics: types, count, capacity, energy consumption/production
  - Measurements: in-house SCADA, metering service providers, new energy service providers, customer measurements
  - Forecasts: load extrapolation, load forecasts based on weather forecasts

- There is plenty to work with, but the data is of different
  - type;
  - availability;
  - quality; and
  - usefulness.

What's needed: A data integration platform that integrates different types and allows managing different qualities

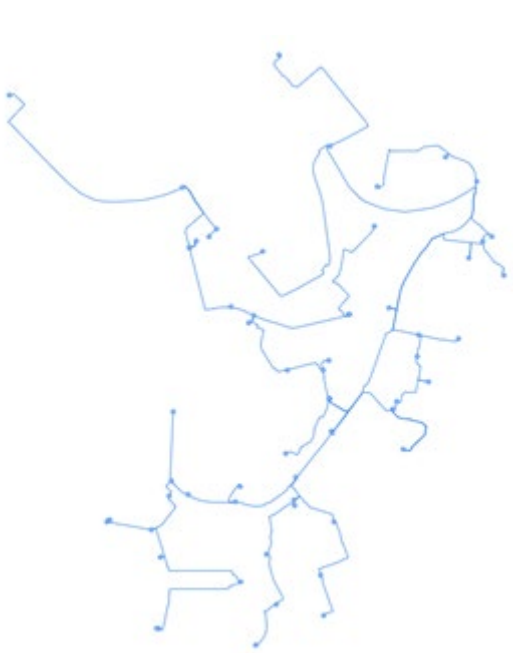
SEI at a glance

Project objective: Demonstrate that majority of Australian DNSPs have access to enough data to achieve full network visibility on MV level

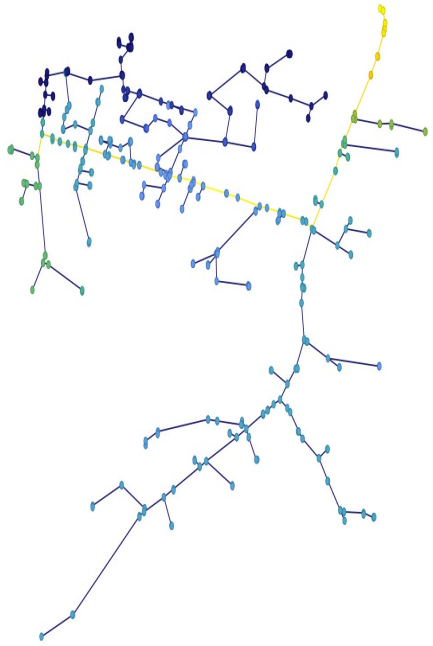
Project Partners

Partner DNSPs with different measurements

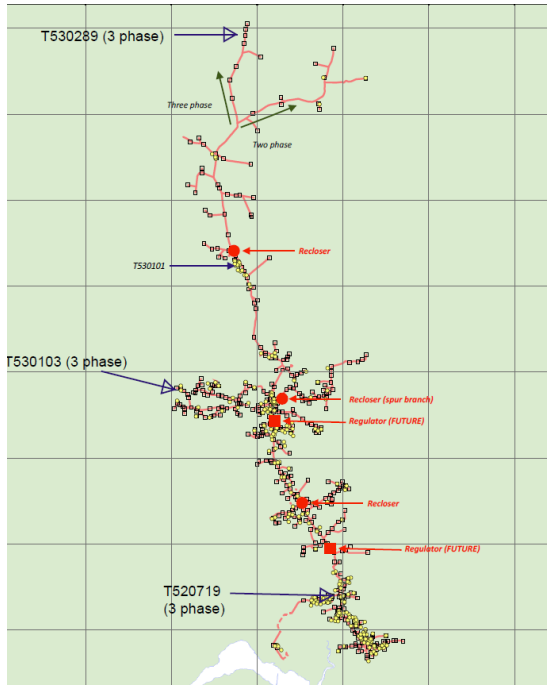
- Maintained almost ‘clear’ measurement scenarios
- Participating DNSPs run on their dominant measurement source
- Measurement schemes aren’t exclusive, but can be combined
- Achieved full visibility on all seven nominated feeders



DTX monitors



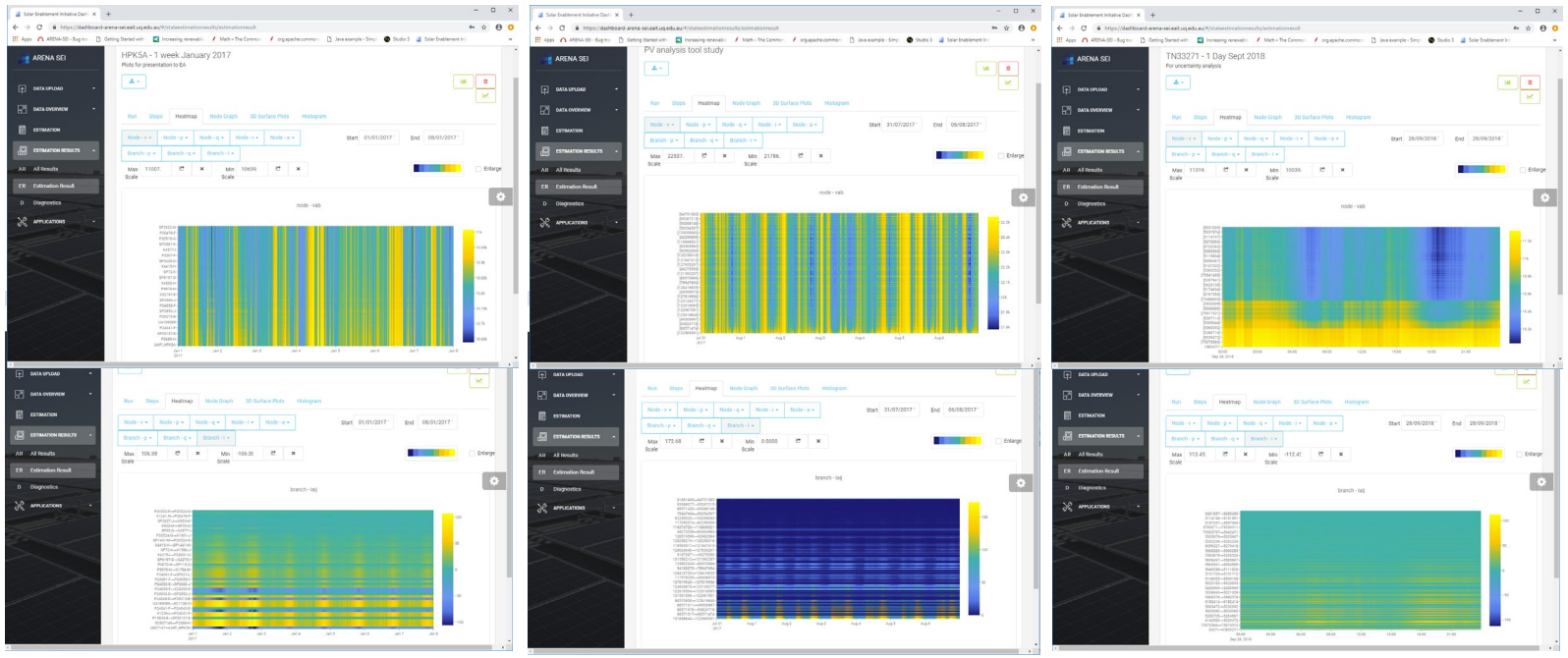
Smart Meter



SCADA

Partner DNSPs with different measurements

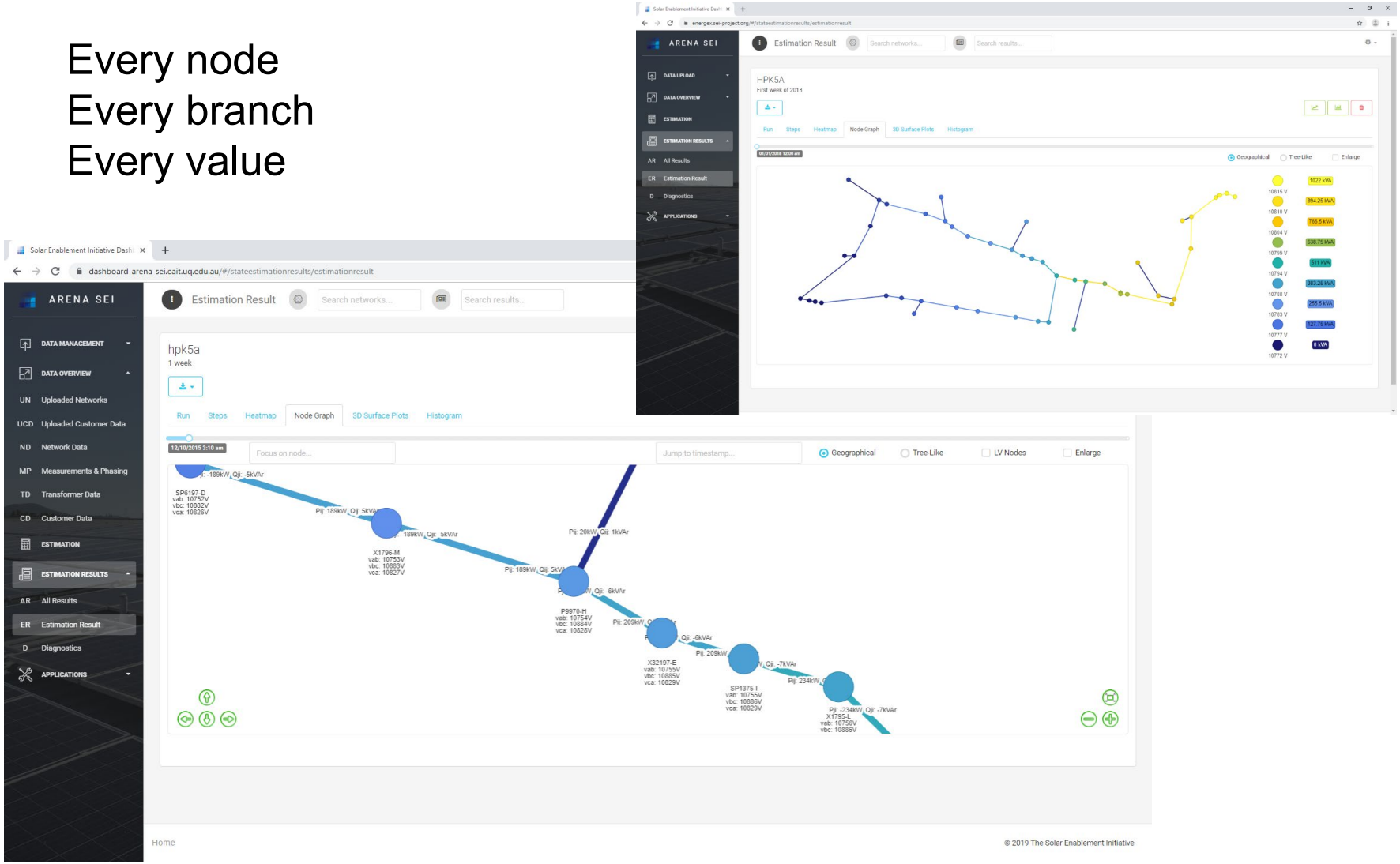
- Maintained almost ‘clear’ measurement scenarios
- Participating DNSPs run on their dominant measurement source
- Measurement schemes aren’t exclusive, but can be combined
- Achieved full visibility on all seven nominated feeders



DTX monitors | Smart Meter | SCADA

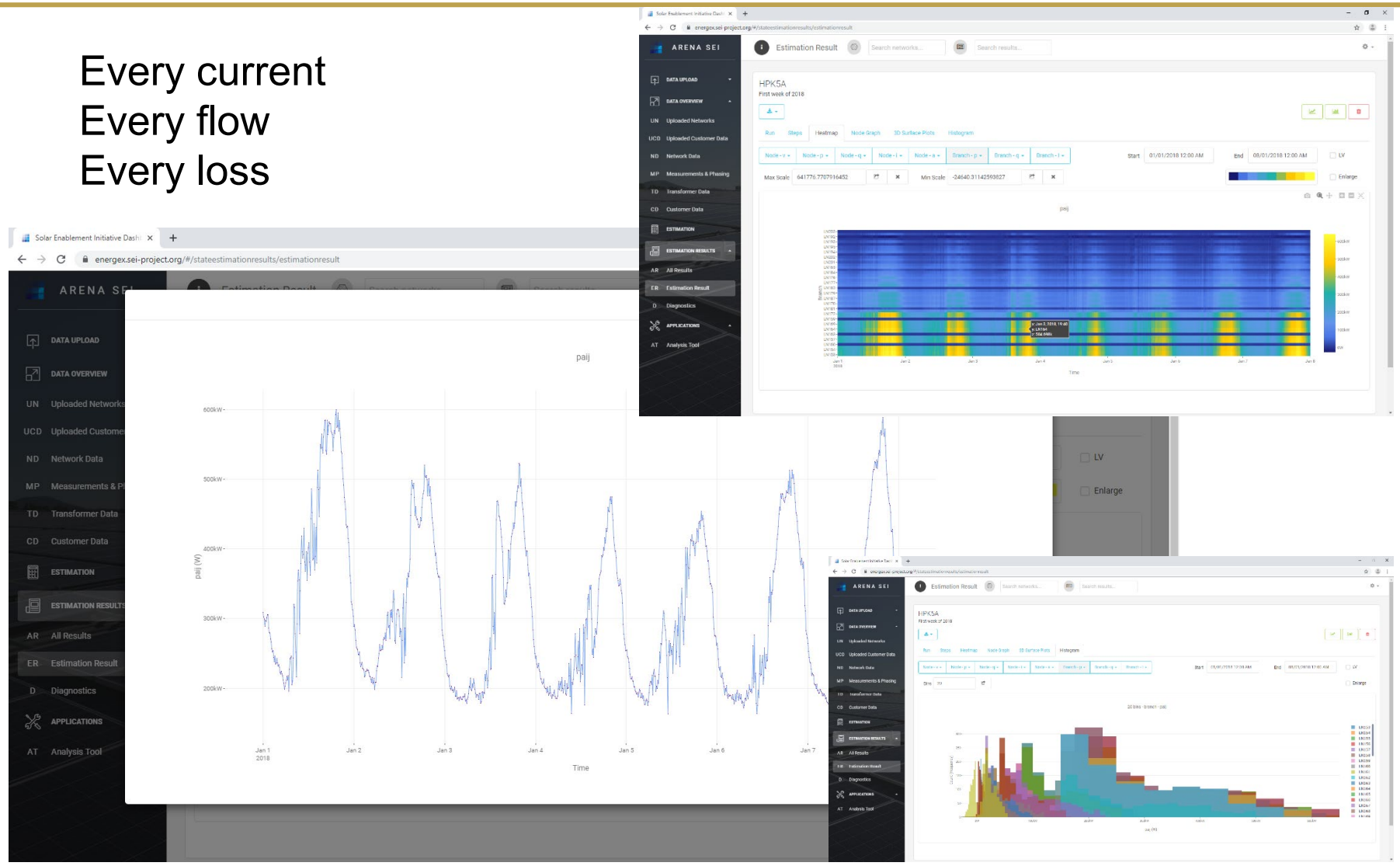
Full Network Visibility

Every node
Every branch
Every value



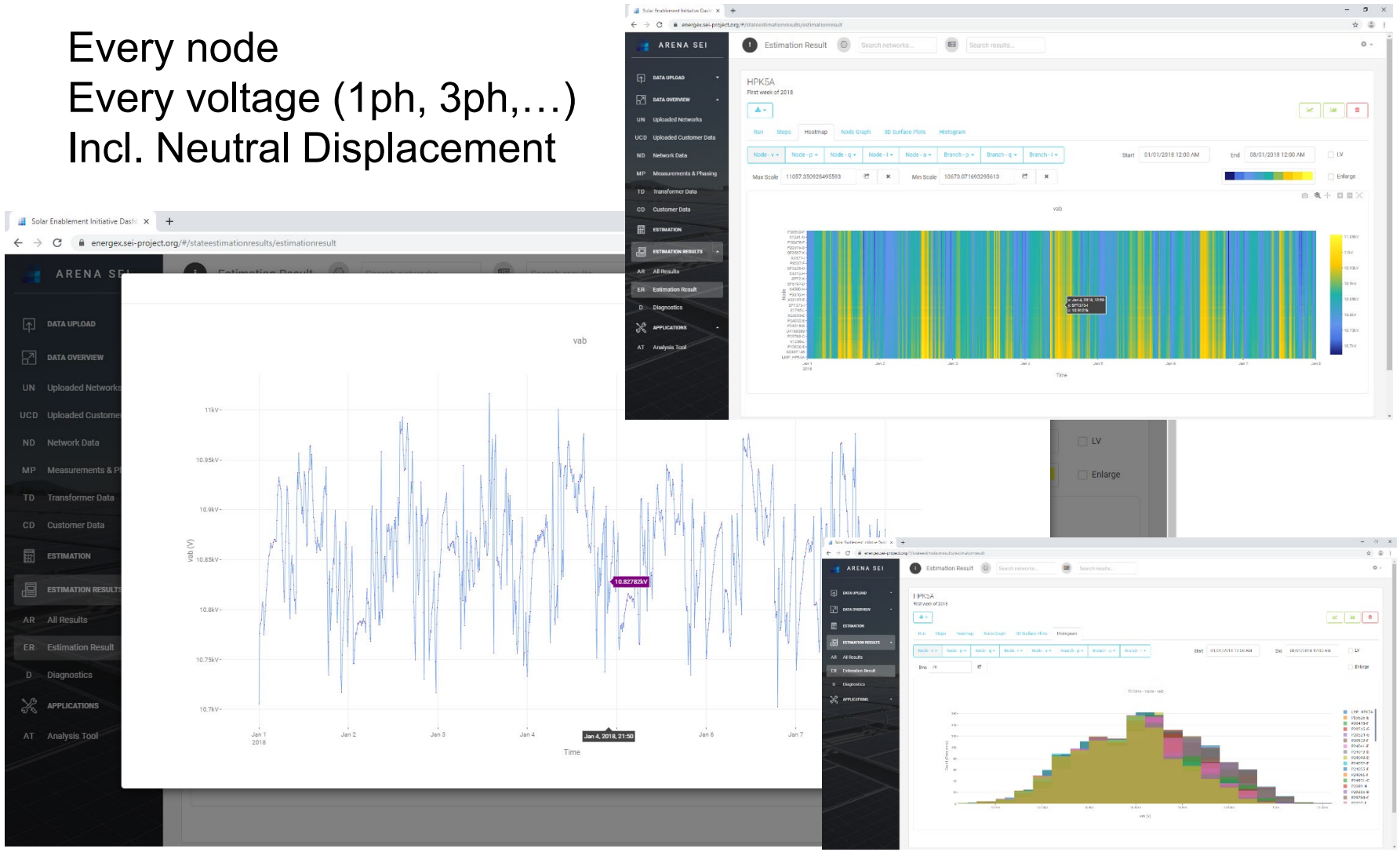
Asset Performance Data

Every current
Every flow
Every loss



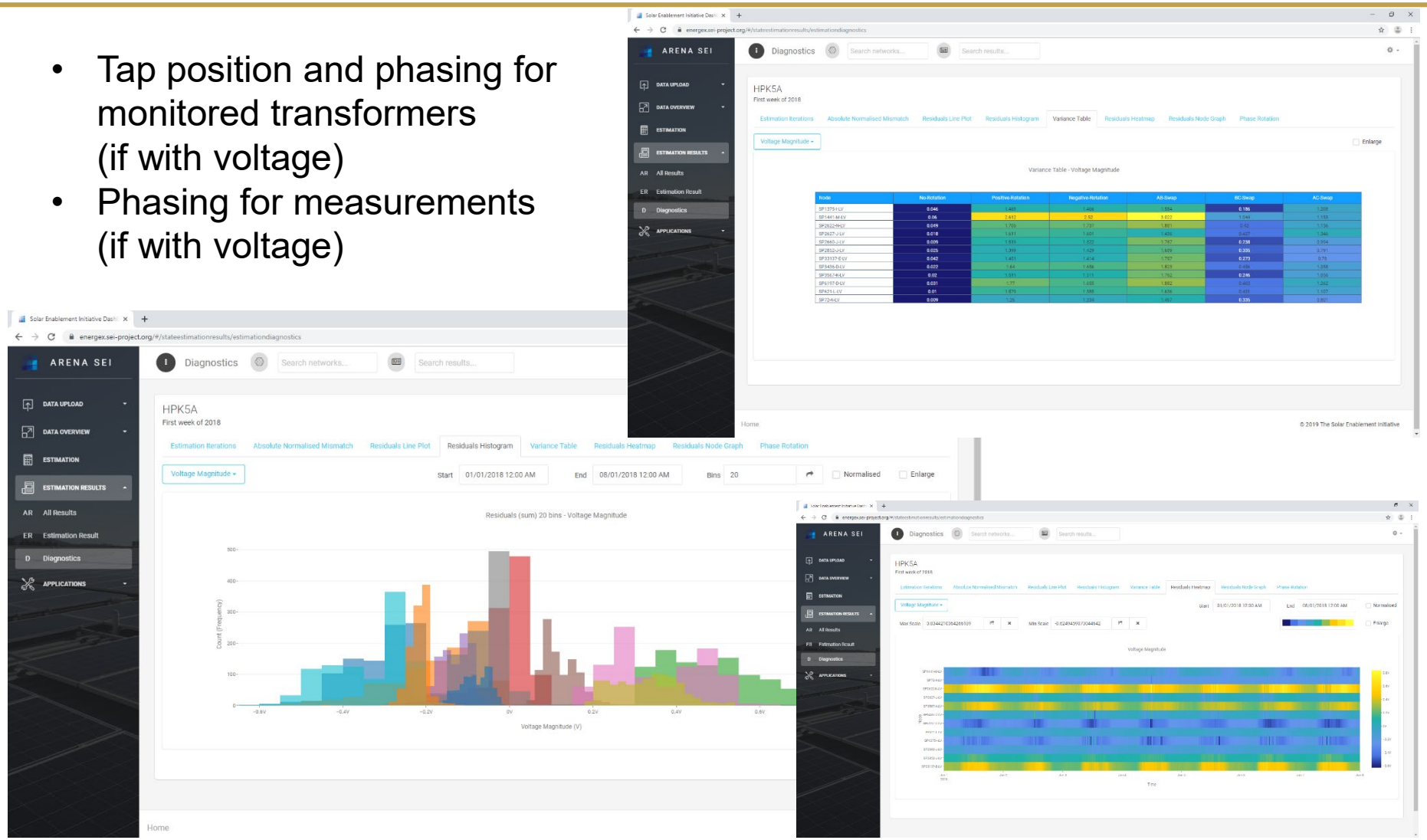
Voltage Compliance Data

Every node
Every voltage (1ph, 3ph,…)
Incl. Neutral Displacement

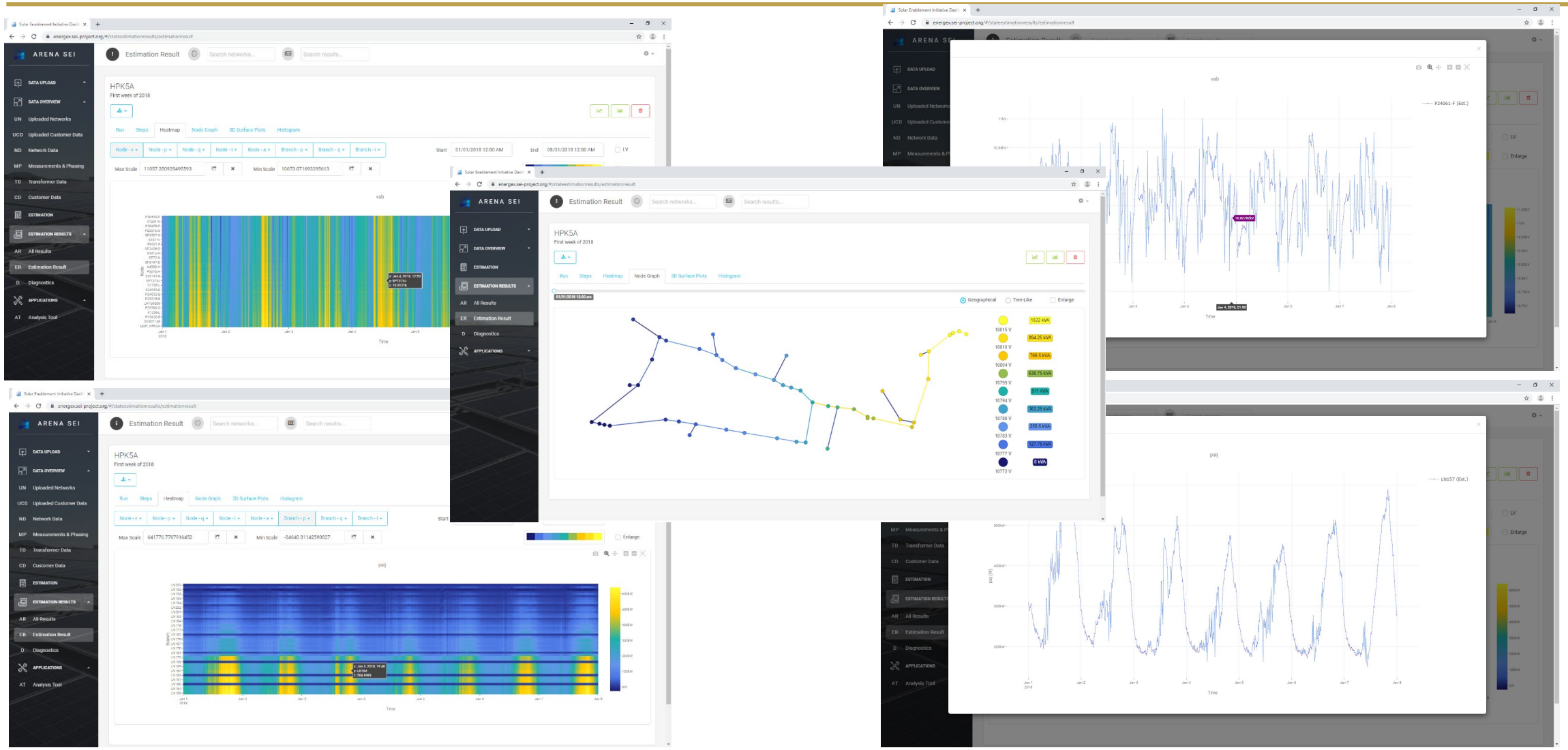


Identifying Model Errors (e.g. Tap Positions & Phasing)

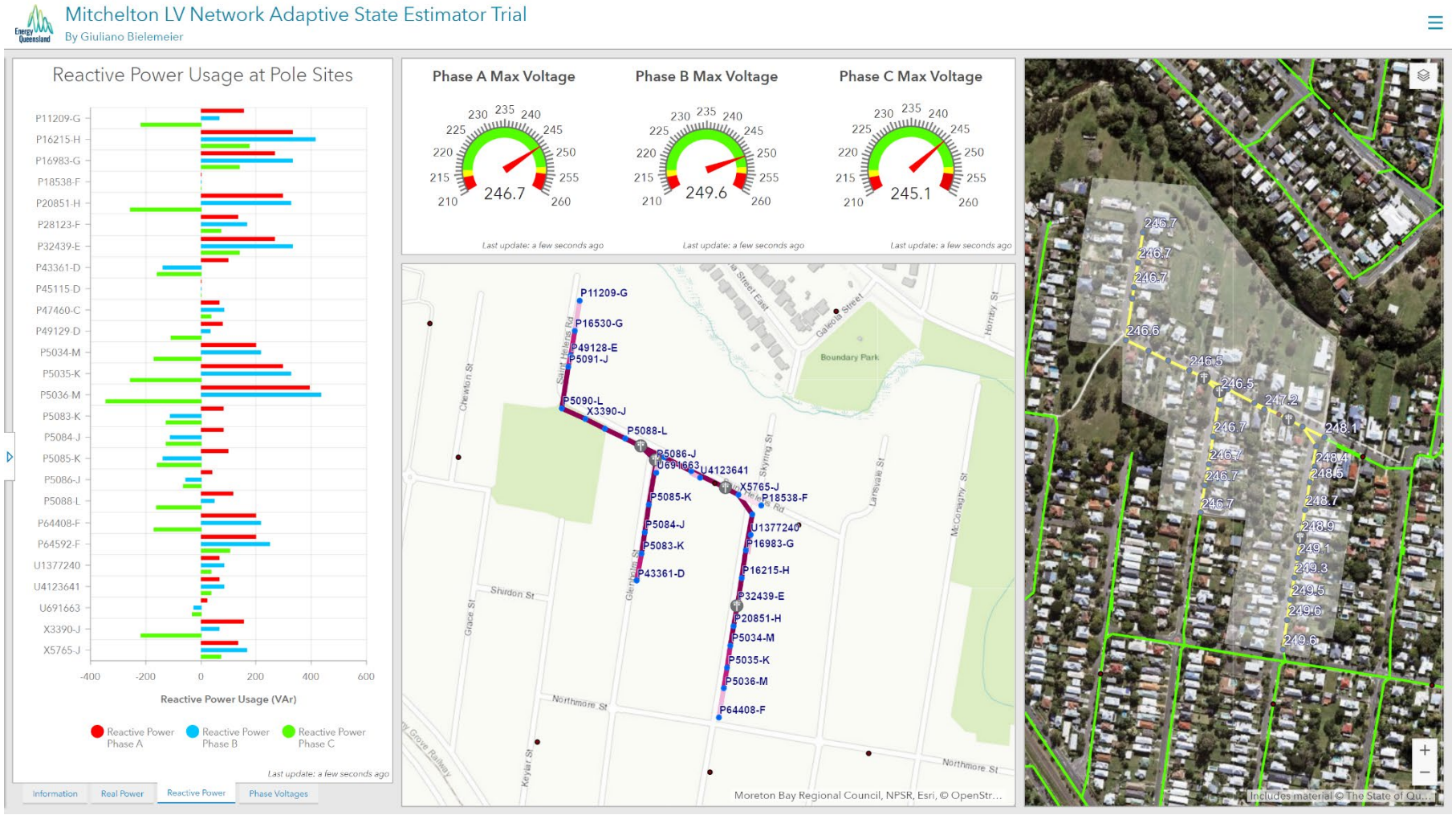
- Tap position and phasing for monitored transformers (if with voltage)
- Phasing for measurements (if with voltage)



Complete stand-alone system



To be integrated - LV State Estimation



Using Premise Level Data

- Voltage estimate precision when using third-party sourced premise level data in conjunction with transformer measurements

Table A.1: *Transformer Only - Heat Map*

Compared to Measured Value (Error Red = 5V, Yellow = 1V, Green = 0V)

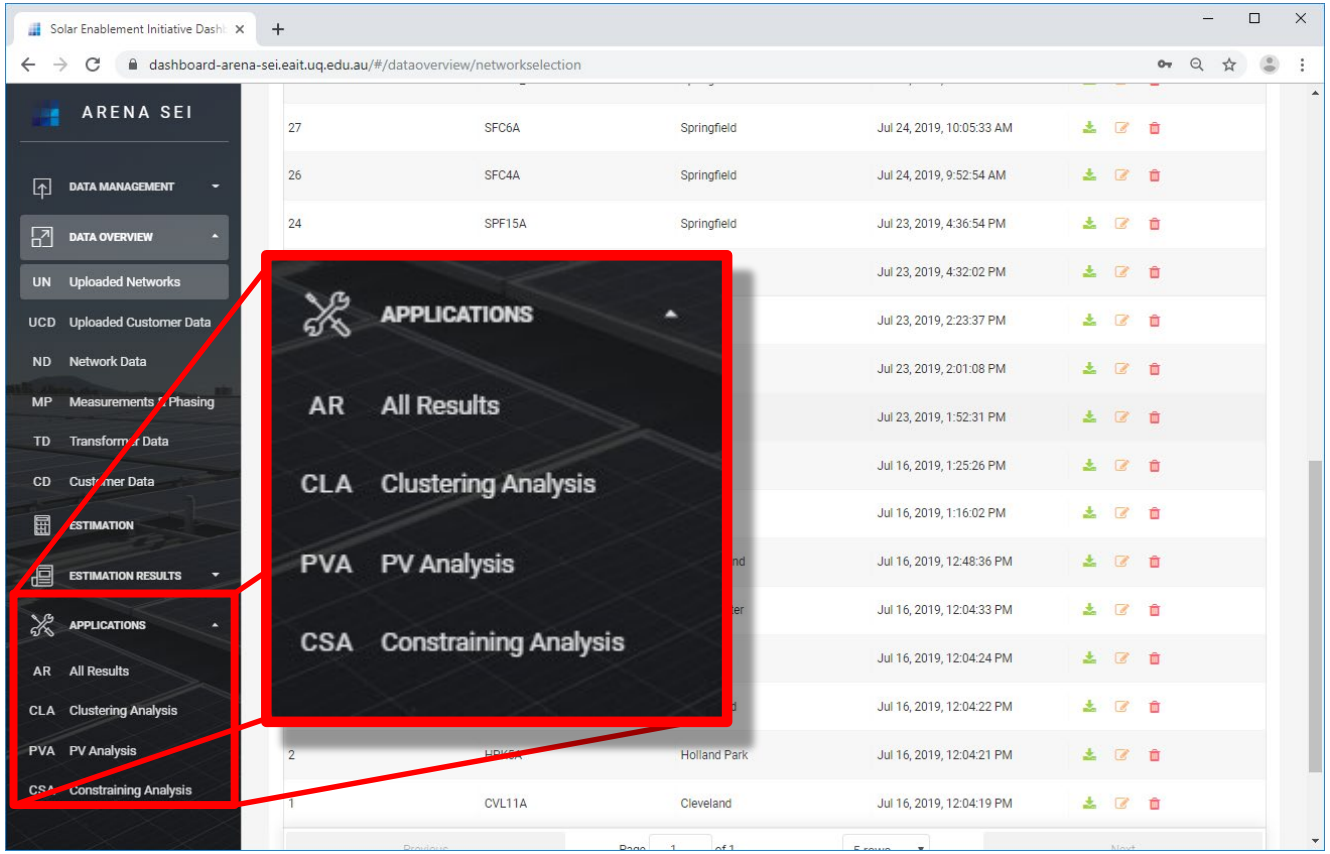
% Customers Monitored	Number of Customers Monitored	Meter Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	P1A	P1B	P1C	P2A	P2B	P2C	P3A	P3B	P3C	P4A	P4B	P4C	Unmonitored
0%	0	1.02	0.55	2.36	1.52	1.86	1.28	2.00	4.32	3.11	2.43	4.94	0.88	2.43	0.68	0.28	5.41	2.81	3.57	2.05	1.86	3.06	6.22	5.55	3.66	1.74	0.05	2.68	0.05	0.55	6.29	1.16	6.25	5.16	1.20	3.69	2.33	5.02	5.95	1.69	4.47	2.69	0.73	2.03	2.88	1.14	1.87	2.68
1%	1	0.61	0.66	2.22	1.35	1.61	1.26	2.11	4.16	3.03	2.62	4.36	0.82	2.54	0.89	0.26	5.36	2.56	3.41	1.55	1.78	2.49	5.97	5.50	3.61	1.57	0.06	2.19	0.06	0.66	6.23	1.06	6.20	4.60	1.12	3.56	2.44	4.45	5.90	1.57	4.26	2.52	0.83	1.62	2.68	1.25	1.43	2.59
2%	2	0.63	0.34	2.45	1.61	1.50	1.27	1.46	4.07	3.17	2.30	4.49	0.95	1.83	0.57	0.27	5.28	2.45	3.32	1.58	1.92	2.61	5.98	5.39	3.53	1.83	0.05	2.27	0.05	0.31	6.12	1.24	6.07	4.72	1.08	3.37	1.79	4.57	5.80	1.77	4.27	2.44	0.55	1.68	2.59	0.96	1.48	2.57
3%	3	0.56	0.64	0.75	0.16	1.58	1.34	1.94	4.05	2.23	2.69	4.34	1.00	2.34	1.03	0.34	5.56	2.53	3.30	1.50	0.98	2.47	5.55	5.77	3.81	0.04	0.03	2.16	0.03	0.61	6.53	0.03	6.50	4.57	1.03	3.38	2.27	4.42	6.14	0.32	3.89	2.42	0.76	1.59	2.58	1.22	1.38	2.47
4%	4	0.56	0.61	0.81	0.14	1.57	1.33	1.91	4.05	2.29	2.65	4.33	1.00	2.31	0.99	0.33	5.52	2.51	3.30	1.50	1.04	2.46	5.53	5.71	3.77	0.09	0.02	2.16	0.02	0.59	6.45	0.09	6.42	4.57	1.03	3.37	2.25	4.42	6.09	0.38	3.89	2.41	0.74	1.59	2.58	1.20	1.38	2.52
5%	5	0.41	0.55	0.82	0.13	0.59	1.31	1.95	3.56	2.30	2.38	4.32	1.07	2.38	0.67	0.31	5.25	1.60	2.81	1.37	1.05	2.45	5.43	5.35	3.50	0.10	0.01	2.12	0.01	0.52	6.07	0.10	6.01	4.56	0.81	2.95	2.29	4.40	5.76	0.39	3.81	1.91	0.58	1.56	1.98	0.99	1.35	2.37
6%	6	0.39	0.55	0.84	0.12	0.53	0.95	1.96	3.47	2.36	2.41	4.23	1.04	2.38	0.71	0.00	4.95	1.55	2.72	1.36	1.11	2.36	5.26	5.07	3.20	0.10	0.08	2.09	0.08	0.52	5.79	0.14	5.74	4.47	0.91	2.72	2.29	4.32	5.48	0.42	3.64	1.89	0.60	1.56	1.95	1.01	1.34	2.33
7%	7	0.36	0.05	0.92	0.05	0.56	0.96	0.56	3.40	2.44	2.43	4.61	1.09	0.95	0.80	0.01	4.95	1.57	2.65	1.33	1.19	2.73	5.27	5.07	3.20	0.18	0.10	2.21	0.10	0.03	5.79	0.22	5.74	4.81	0.89	2.44	0.95	4.69	5.47	0.50	3.66	1.84	0.44	1.57	1.91	0.91	1.33	2.29
9%	8	0.28	0.10	0.89	0.08	0.03	0.91	0.48	1.73	2.42	2.44	3.85	1.14	0.88	0.85	0.05	4.39	0.91	1.04	1.21	1.17	1.99	4.92	4.34	2.64	0.14	0.02	1.63	0.02	0.13	5.01	0.20	4.92	4.08	0.42	0.31	0.87	3.95	4.82	0.47	3.37	0.79	0.37	1.23	0.94	0.88	1.02	1.84
10%	9	0.26	0.03	0.54	0.31	0.01	0.95	0.56	1.72	1.27	2.58	3.86	1.22	0.96	1.04	0.01	4.51	0.93	1.03	1.19	0.08	1.99	4.86	4.41	2.76	0.06	0.08	1.62	0.08	0.06	5.07	0.32	4.96	4.08	0.38	0.30	0.94	3.95	4.91	0.05	3.25	0.77	0.42	1.21	0.92	0.96	1.00	1.81
11%	10	0.46	0.43	0.66	0.20	0.25	0.98	0.56	1.71	1.34	1.22	3.61	1.54	1.03	0.42	0.03	4.52	0.70	1.02	1.40	0.15	1.79	4.71	4.42	2.77	0.06	0.13	1.56	0.13	0.45	5.08	0.23	4.98	3.89	0.35	0.45	0.95	3.75	4.92	0.16	3.13	0.73	0.24	1.32	0.87	0.11	1.16	1.74
12%	11	0.19	0.41	0.64	0.22	0.19	0.92	0.73	1.46	1.34	1.15	0.99	1.51	1.18	0.54	0.03	4.40	0.75	0.77	1.09	0.15	0.65	4.04	4.28	2.65	0.03	0.00	0.30	0.00	0.43	4.93	0.23	4.82	1.54	0.32	0.33	1.12	1.32	4.79	0.15	2.55	0.64	0.23	0.69	0.83	0.11	0.60	1.37
13%	12	0.16	0.27	0.67	0.20	0.16	0.90	0.79	1.48	1.41	1.33	0.98	1.32	1.22	0.37	0.06	4.41	0.79	0.79	1.06	0.22	0.67	4.11	4.30	2.66	0.05	0.04	0.26	0.04	0.30	4.95	0.17	4.84	1.52	0.39	0.36	1.17	1.30	4.80	0.19	2.62	0.68	0.05	0.64	0.87	0.30	0.56	1.38
14%	13	0.11	0.33	0.70	0.17	0.15	0.90	0.33	1.48	1.42	1.41	1.07	1.29	0.33	0.26	0.05	4.44	0.79	0.78	1.00	0.23	0.75	4.08	4.34	2.69	0.08	0.05	0.14	0.05	0.35	5.00	0.15	4.89	1.42	0.38	0.38	0.71	1.22	4.84	0.22	2.60	0.67	0.01	0.56	0.86	0.35	0.48	1.36
15%	14	0.10	0.35	0.68	0.19	0.13	0.91	0.29	1.47	1.41	1.53	1.08	1.31	0.30	0.09	0.05	4.42	0.79	0.77	1.01	0.22	0.74	4.09	4.32	2.67	0.06	0.05	0.17	0.05	0.38	4.97	0.17	4.87	1.43	0.38	0.37	0.68	1.23	4.82	0.20	2.61	0.66	0.01	0.59	0.85	0.38	0.50	1.39
16%	15	0.10	0.35	0.68	0.19	0.13	0.92	0.29	1.48	1.41	1.53	1.08	1.31	0.30	0.09	0.03	4.44	0.79	0.78	1.01	0.22	0.74	4.09	4.34	2.69	0.06	0.05	0.17	0.05	0.38	4.99	0.17	4.88	1.43	0.38	0.37	0.67	1.23	4.84	0.20	2.61	0.67	0.01	0.59	0.85	0.38	0.51	1.44
17%	16	0.07	0.40	0.82	0.09	0.68	0.29	0.28	1.05	1.57	1.52	1.03	1.33	0.28	0.12	0.67	2.45	0.21	0.36	0.97	0.38	0.78	3.31	2.12	0.76	0.14	0.11	0.20	0.11	0.43	2.70	0.04	2.54	1.39	0.47	1.18	0.66	1.18	2.74	0.37	1.90	0.38	0.07	0.66	0.49	0.32	0.55	0.92
18%	17	0.08	0.40	0.81	0.10	0.72	0.29	0.26	0.97	1.57	1.52	1.00	1.33	0.27	0.12	0.66	2.44	0.16	0.29	0.97	0.38	0.81	3.30	2.11	0.75	0.14	0.11	0.17	0.11	0.43	2.69	0.03	2.52	1.36	0.43	1.37	0.65	1.16	2.73	0.36	1.90	0.31	0.06	0.64	0.43	0.33	0.54	0.93
19%	18	0.30	0.40	0.81	0.10	0.76	0.28	0.26	0.97	1.57	1.54	0.98	1.33	0.26	0.15	0.67	2.44	0.11	0.30	0.54	0.37	0.84	3.14	2.11	0.75	0.13	0.09	0.07	0.09	0.42	2.69	0.03	2.53	1.33	0.43	1.32	0.64	1.12	2.73	0.36	1.76	0.30	0.06	0.49	0.41	0.33	0.35	0.91
20%	19	0.31	0.41	0.60	0.33	0.76	0.30	0.25	0.97	1.87	1.53	0.98	1.39	0.26	0.13	0.65	2.49	0.11	0.29	0.54	0.77	0.85	3.08	2.17	0.80	0.10	0.13	0.06	0.13	0.43	2.75	0.12	2.58	1.32	0.42	1.30	0.63	1.12	2.78	0.17	1.69	0.29	0.09	0.49	0.40	0.31	0.35	0.94
21%	20	0.29	0.41	0.60	0.33	0.76	0.30	0.21	0.97	1.88	1.54	1.34	1.39	0.26	0.15	0.65	2.49	0.10	0.29	0.56	0.77	0.35	3.17	2.17	0.80	0.10	0.12	0.26	0.12	0.43	2.75	0.12	2.58	1.74	0.42	1.31	0.59	1.57	2.78	0.17	1.77	0.29	0.08	0.57	0.39	0.32	0.41	0.98
22%	21	0.48	0.43	0.48	0.45	0.75	0.24	0.18	0.97	1.87	1.50	1.18	1.42	0.23	0.11	0.72	2.32	0.11	0.29	0.38	0.77	0.53	0.69	1.84	0.62	0.20	0.34	0.11	0.34	0.46	2.34	0.17	2.19	1.56	0.42	1.20	0.57	1.39	2.53	0.09	0.15	0.28	0.12	0.50	0.38	0.28	0.31	0.76
23%	22	0.46	0.44	0.56	0.39	0.83	0.11	0.18	0.88	1.88	1.51	1.18	1.43	0.23	0.13	0.85	1.78	0.04	0.20	0.40	0.78	0.52	0.57	0.97	0.08	0.15	0.35	0.14	0.35	0.46	1.49	0.14	1.33	1.57	0.44	1.46	0.57	1.40	1.84	0.14	0.06	0.23	0.12	0.52	0.33	0.28	0.33	0.61
24%	23	0.46	0.44	0.56	0.40	0.83	0.11	0.18	0.88	1.88	1.51	1.17	1.43	0.23	0.13	0.85	1.76	0.04	0.20	0.40	0.78	0.52	0.57	0.95	0.06	0.15	0.35	0.14	0.35	0.46	1.48	0.13	1.31	1.57	0.44	1.47	0.57	1.40	1.82	0.15	0.07	0.23	0.12	0.52	0.33	0.28	0.33	0.60
26%	24	0.46	0.44	0.59	0.36	0.83	0.11	0.18	0.88	1.90	1.50	1.17	1.43	0.23	0.12	0.84	1.75	0.04	0.20	0.40	0.80	0.52	0.57	0.94	0.05	0.13	0.35	0.14	0.35	0.47	1.46	0.10	1.29	1.57	0.44	1.46	0.56	1.40	1.81	0.18	0.07	0.23	0.13	0.52	0.33	0.27	0.33	0.62
27%	25	0.47	0.44	0.60	0.36	0.83	0.12	0.18	0.88	1.91	1.51	1.17	1.42	0.23	0.12	0.83	1.75	0.04	0.20	0.39	0.81	0.53	0.58	0.94	0.05	0.13	0.28	0.12	0.30	0.46	1.46	0.09	1.29	1.56	0.43	1.46	0.56	1.39	1.81	0.18	0.08	0.23	0.12	0.49	0.33	0.28	0.31	0.63
28%	26	0.46	0.44	0.60	0.36	0.82	0.12	0.18	0.86	1.91	1.51	1.19	1.42	0.23	0.12	0.84	1.75	0.05	0.18	0.40	0.81	0.53	0.53	0.94	0.05	0.13	0.29	0.06	0.30	0.46	1.46	0.09	1.29	1.55	0.44	1.41	0.56	1.39	1.81	0.18	0.04	0.23	0.11	0.45	0.34	0.28	0.28	0.64
29%	27	0.46	0.44	0.60	0.36	0.82	0.12	0.18	0.86	1.91	1.51	1.19	1.42	0.23	0.12	0.84	1.75	0.05	0.18	0.40	0.81	0.53	0.53	0.94	0.05	0.13	0.29	0.06	0.30	0.46	1.46	0.09	1.29	1.55	0.44	1.41	0.56	1.39	1.81	0.18	0.04	0.23	0.11	0.45	0.34	0.28	0.28	0.67
30%	28	0.43	0.43	0.60	0.36	0.81	0.13	0.18	0.86	1.91	1.51	1.21	1.40	0.24	0.12	0.83	1.75	0.05	0.18	0.42	0.81	0.51	0.46	0.94	0.05	0.13	0.23	0.05	0.19	0.46	1.46	0.09	1.29	1.57	0.43	1.42	0.57	1.41	1.81	0.19	0.02	0.23	0.11	0.45	0.34	0.29	0.28	0.69
31%	29	0.43	0.33	0.60	0.36	0.82	0.13	0.24	0.89	1.91	1.56	1.21	1.38	0.28	0.16	0.83	1.75	0.04	0.21	0.42	0.81	0.51	0.46	0.94	0.05	0.13	0.22	0.03	0.19	0.35	1.46	0.09	1.29	1.57	0.43	1.45	0.63	1.41	1.81	0.19	0.01	0.24	0.04	0.45	0.34	0.35	0.28	0.71
32%	30	0.42	0.33	0.62	0.32	0.87	0.10	0.24	0.84	1.90	1.57	1.21	1.38	0.28	0.17	0.85	1.52	0.00	0.16	0.43	0.79	0.51	0.40	0.51	0.18	0.10	0.22	0.02	0.19	0.35	0.90	0.10	0.76	1.57	0.42	1.58	0.63	1.41	1.48	0.19	0.03	0.21	0.04	0.46	0.32	0.35	0.29	0.61
33%	31	0.42	0.33	0.63	0.31	0.86	0.10	0.24	0.84	1.90	1.56	1.21	1.38	0.28	0.17	0.86	1.50	0.00	0.16	0.43	0.80	0.51	0.41	0.51	0.20	0.08	0.22	0.03	0.18	0.36	0.90	0.12	0.78	1.57	0.42	1.57	0.63	1.41	1.47	0.19	0.04	0.21	0.05	0.45	0.31	0.34	0.28	0.65
34%	32	0.42	0.33	0.63	0.28	0.88	0.10	0.24	0.82	1.89	1.56	1.21	1.38	0.28	0.17	0.85	1.43	0.01	0.14	0.43	0.79	0.51	0.39	0.34	0.27	0.06	0.21	0.03	0.18	0.36	0.68	0.13	0.45	1.57	0.41	1.63	0.63	1.41	1.35	0.19	0.04	0.20	0.05	0.45	0.30	0.34	0.29	0.63
35%	33	0.42	0.33	0.63	0.28	0.86	0.10	0.25	0.79	1.89	1.56	0.81	1.38	0.28	0.17	0.85	1.42	0.00	0.11	0.42	0.79	0.95	0.33	0.34	0.28	0.06	0.20	0.21	0.16	0.35	0.68	0.13	0.45	1.09	0.41	1.76	0.64	0.97	1.35	0.19	0.09	0.20	0.04	0.38	0.31	0.35	0.23	0.53
36%	34	0.42	0.33	0.63	0.28	0.89	0.12	0.25	0.76	1.89	1.56	0.81	1.38	0.27	0.16	0.84	1.43	0.02	0.08	0.42	0.78	0.95	0.32	0.35	0.27	0.06	0.19	0.22	0.15	0.36	0.68	0.13	0.46	1.09	0.37	1.79	0.63	0.97	1.35	0.18	0.10	0.16	0.04	0.37	0.27	0.35	0.22	0.53

Leveraging SEI - Post Estimation Applications

Level 3:
Full network abstraction

Level 2:
Network simulation as a proxy for real network

Level 1:
Estimation Result interpretation



Summary and next steps

- All three DNSPs had enough data to perform Distribution State Estimation
- The SEI system is available for MV and, soon, also LV networks
- The SEI system is a parallelised stand-alone system that can be deployed
  - offline, for ex-post assessment purposes
  - real-time for operational purposes
- The SEI system allows to implement post-estimation applications that help extract more value from the generated state estimates, and to automate current manual, repetitive processes.

To be continued…

Presented by Tri Tran - Convener

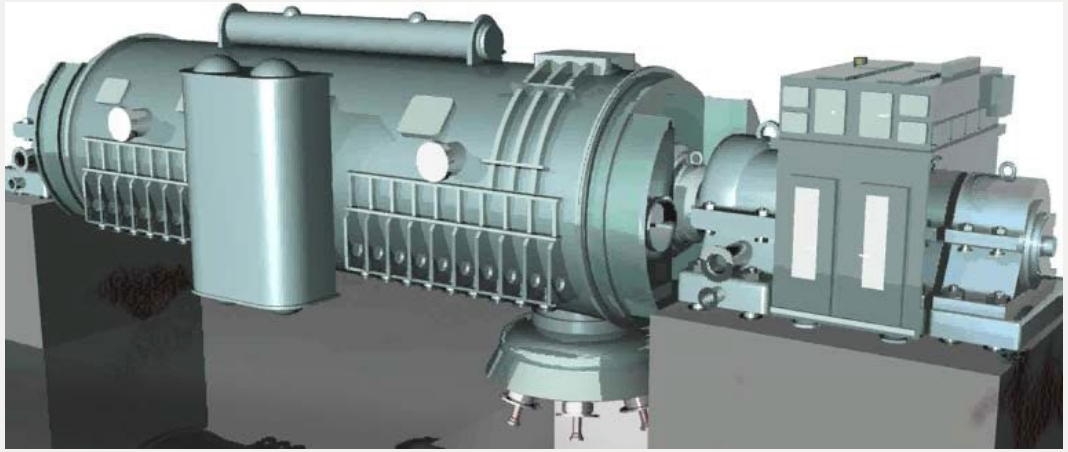
Brisbane 21/11/2019

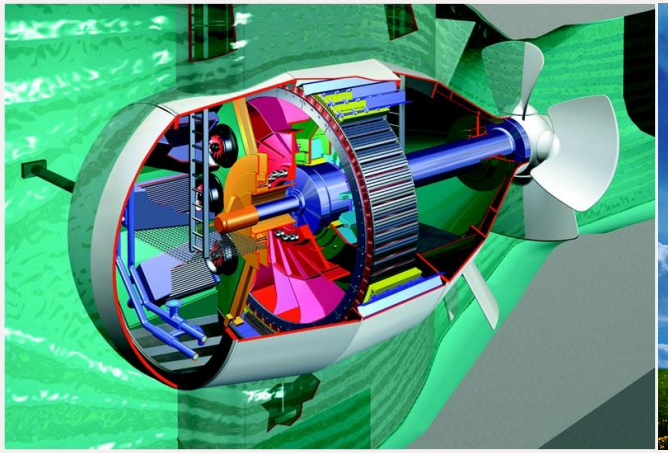
cigre
For power system expertise

SC A1 Overview

Study Committee Purpose

SC A1 focuses on the development of new technologies and the international exchange of information and knowledge in the field of rotating electrical machines, to add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing guidelines and recommendations.





cigre
For power system expertise

SC A1 Overview

Four Advisory Groups / Study Areas

- **Turbo generators:** condition assessment, maintenance, refurbishment, power upgrade, asset management and long term health assessment of such plant.
- **Hydro Generators:** condition assessment, maintenance, refurbishment, power upgrade, asset management and long term health assessment of such plant.
- **Non-conventional Rotating Machines**: focus on wind turbine generators and superconducting machines. In addition review of grid codes as impact on generators.
- **Large Motors and Drives:** focus on Motors >1kV and >500kW. Benefits of High Efficiency Motors, Variable Speed Drives (VSD) on motors and impact of flexible operation of motors.

SC A1 Overview

Key Areas of Interest

- Asset Management to extend the life of existing generators or to recommend their replacement
- Machine monitoring, diagnosis and prognosis to perform optimal maintenance
- Renewable generation which may be connected directly to the transmission and distribution or even directly to consumers setting up microgrids.
- Enhancements in the construction of large turbo and hydro generators
- High efficiency rotating electrical machines with new materials, improving cooling and insulation systems in generators and motors.
- Large motors and high efficiency motors
- Utilization of Polymer nano-composites as near-future HV electrical insulation in rotating machines

2019 SC A1 Activities

Colloquium, Tutorials & WG Meetings in India 22nd to 28th September.

WG Session presentations on progress - 23/09/19

- 4 WG (A1-29, A1-31, A1-37, A1-39) finished
- 3 WG (A1-33, A1-48, A1-50) at final stage
- 3 new WG (A1-63, A1-65, A1/C4-66) proposed with TOR approved

SC A1 Chairman Summary - 24/09/19

- Technical Council meeting and activities,
- Review of Cigre membership status,
- Women with Cigre, e-Cigre, KMS,
- Proposal for 2021 Colloquium in Japan and 2023 in Russia.

Four Tutorials were presented 25/09/19

- Magnetic Core Dimensioning Limits in Hydro-Generators
- Application of dielectric dissipation factor measurements on new stator coils and bars

cigre
For power system expertise

2019 SC A1 Activities

Colloquium, Tutorials & WG Meetings in India 22nd to 28th September.

- Guidance on the Requirements for High speed Balancing/over speed testing of turbine Generator Rotors following Maintenance or Repair
- Guide for Cleanliness and Proper storage of Generators and Components

SC A1 Colloquium 26/09/19 and 27/09/19 two main Preferential Subjects:

- PS 1 - High Renewable Penetrated Networks
- PS 2 - Operational Experience and New Developments
- 24 presentations on:
  - large turbo-generators and hydro-generators
  - machine insulation system, and, large motors.

Two technical tours

- 22/09/19 - Dadri PS where it has 500MW of coal-fire power plant, a Combined Cycle Gas based Power Plant, and an Integrated Solar Thermal Hybrid Plant, which utilise solar thermal energy to heat feed water and enhance efficiency of the thermal power plant.
- 28/09/19 - Agra 800kV 6000MW HVDC terminal station.

Relevance to Australia

Turbo and hydro generators

- Recently completed Technical Brochure 690 - Vibration and stability problems met in New, Old and Refurbished Hydro-generators, Root Causes and Consequences
- WG A1-29 Guide on New Generator - Grid Interaction Requirements. Highly relevant to prevention of wide spread state blackout similar to that in 2016 in South Australia.
- WG A1-31 State of Art of Stator Winding Supports in slot area and winding overhang of hydro generators & WG A1-37 Generator Stator windings support systems experience. Highly relevant to the old turbo and hydro generators.
- New Working Group proposed - Guide on Synchronous Condensers for System Inertia, Short Circuit withstand capability (fault levels) and MVAr support in power grids with high level of renewable energy generation.

Thank you

cigre
For power system expertise

Australia & New Zealand Report

Presented by Russell Wheatland
Convener AU B1

Brisbane November 2019

cigre
For power system expertise

Australia & New Zealand Report

- AU B1 has strengthened its links with NZ, now with 5 Kiwi members
- AU B1 now has 32 active members

cigre
For power system expertise

Australia & New Zealand Report

- **CIGRE is now actively engaging with MV assets**
  - ✓ Some AU B1 members engaged in MV only networks
  - ✓ Looking at developing a NZ B1 mirror panel just for MV networks
- **NGN member involvement**
- **AU B1 members have been active this past year**
  - ✓ MV cable accessory forum due to termination and joint failures in the field
  - ✓ Planning for a cable seminar to present several tutorials
  - ✓ Planning a Cable Failure database for AU/NZ utilities
- **HV and EHV cable systems are growing in popularity**
  - ✓ Expanding populations in capital cities of both countries
  - ✓ Redevelopment of city areas - to remove overhead infrastructure
  - ✓ The push for more renewable, distributed generation
  - ✓ Renewed pressure on aged infrastructure replacement
  - ✓ Increased use of GIS with cable entry options

cigre
For power system expertise

Australia & New Zealand Report

Transmission

- **Renewable Energy**
  - ✓ **Significant investment in Solar and Wind farms**
  - ✓ **In Victoria alone estimated 5GW by 2040**
    - Extensive upgrade of Western Transmission 220kV and 500kV networks
  - ✓ **Snowy 2.0 (Extension of the Snowy Mountains hydro scheme)**
    - Strengthens Snowy Mountains role as a “battery” for national electricity market
    - Central geographic location in between the major load centres (Sydney and Melbourne)
  - ✓ **Commissioning renewable generation continues relentlessly, all requiring some cable**
    - Developers demanding shorter implementation times - creating cost vs engineering discipline tension
- **Increased interest in undertaking PD measurements at both T & D Voltages**
- **NZ constructing and planning 110kV circuits to manage Auckland’s growth**

cigre
For power system expertise

Australia & New Zealand Report

Distribution

- **Renewable Energy**
  - ✓ **Distribution (domestic roof top generation)**
    - In Victoria, by 2030 potentially four times the currently installed capacity up to 2.6GW
    - Reverse power flows, Major change to demand profiles, Mini Grids
- **NZ Regulator sanctioned ‘step’ increase in capital expenditure**
  - ✓ To replace aged/condition expired equipment. Consequently, a building demand on local engineering profession.
- **NZ Govt. sponsoring research on effects of Lava flows on U/G infrastructure**
- **Focus on reducing System Outages**
  - Average Interruption Frequency Index (SAFI) and
  - System Average Interruption Duration Index (SAIDI)

cigre
For power system expertise

Australia & New Zealand Report

AU B1 Involvement with WGs and TFs

✓	WG B1.48 Trenchless Technologies		H. Kent
✓	JWG B1/B3:49 Standard design of a common, dry type plug-in interface for GIS		P. Robinson
✓	WG B1:50 Sheath Voltage Limiters and Bonding Systems		H. Kent
✓	WG B1.57 Update of service experience of HV underground and submarine cable systems		J. Lansley
✓	WG B1.54 Behaviour of Cable Systems under Large Disturbances	R. Joyce	R. Wheatland
✓	WG B1:58 Asset Management in MV Cables Networks		D.C. Lee
✓	WG B1.60 Maintenance of HV Cable Systems		J. Ferencz
✓	WG B1.61 Installation of HV Cable Systems		P. Robinson
✓	WG B1.67 Loading pattern on cables connected to windfarms		K. Prickett
✓	WG B1.68 Condition evaluation and lifetime strategy		R. Bradley
✓	WG B1.69 Recommendations for the insulation coordination on AC cable systems		T. Auditore
✓	WG B1.71 Guidelines for safety risk management in cable system		C. Noel
✓	WG B1.72 Cable ratings verification (2nd part)		D. Spackman
✓	TF B1.73 Recommendations for the use and the testing of optical fibres in land cable systems		G. Barnewall
✓	TF B1.74 Recommendations for a performance standard of insulated busbars		D. Platt

cigre
For power system expertise

Australia & New Zealand Report

International Activities

✓AORC B1 Meeting in Bali (Indonesia) March 2019

- Well chaired by Tanaka san
- Australia plays an active part in this AORC
- Agenda item with the AU NC
- Providing a link with fast growing regional countries
- Bali meeting coordinated with AORC Technical meeting
  - Managed to spend some time with Rob Stephen

Attended	6th	7th	8th	9th	10th	11th	12th	13th	14th
Australia	X	X	X	X	X	X	X	X	X
Bangladesh									
China PR	X	X	X		X	X	X	X	X
Hong Kong	X		X		X	X		X	X
India				X	X		X	X	X
Indonesia						X			X
Japan	X	X	X	X	X	X	X	X	X
Korea	X	X	X	X	X				
Macau									
Malaysia West	X		X		X	X	X		
Malaysia East									
New Zealand				X	X			X	
Singapore	X	X	X			X	X	X	(X)
Sri Lanka									
Thailand	X	X			X	X	X	X	X
Vietnam									

✓JiCable 19

- Several AU B1 members attended

cigre
For power system expertise

Thank You

cigre
For power system expertise

C1

Power system development and economics

Presented by Graeme Ancell- Convener

Brisbane – 20/11/2019

cigre

For power system expertise

SC C1 Overview

Study Committee Scope

The scope of Study Committee C1 is to study economics and system analysis methods for the development of power systems in order to support electricity system planners worldwide

Specific Activities of SC C1:

System planning

Asset management

Business management

Interconnections – horizontal, vertical

cigre
For power system expertise

2019 Chengdu Symposium
20-25 September 2019

PREFERENCE SUBJECTS

PS1 - Planning for a future sustainable grid

PS2 - Integrating distributed energy resources to build a sustainable future and integrating renewable

PS3 - Technology solutions for a future sustainable power system

PROVINCES:						AUTONOMOUS REGIONS:	CENTRAL GOVERNMENT–CONTROLLED MUNICIPALITIES:	SPECIAL AUTONOMOUS REGIONS:
AH Anhui	HI Hainan	SC Sichuan				GX Guangxi Zhuang	Beijing	Hong Kong
FJ Fujian	HL Heilongjiang	SD Shandong				NM Nei Mongol (Inner Mongolia)	Chongqing	Macau
GD Guangdong	HN Hunan	SN Shaanxi				NX Ningxia Hui	Shanghai	
GS Gansu	JL Jilin	SX Shanxi				XJ Xinjiang Uygur	Tianjin	
GZ Guizhou	JS Jiangsu	YN Yunnan				XZ Xizang (Tibet)		
HA Henan	JX Jiangxi	ZJ Zhejiang						
HB Hubei	LN Liaoning	*Province and autonomous region capitals are marked on the map*						
HE Hebei	QH Qinghai							

cigre
For power system expertise

Chengdu Symposium

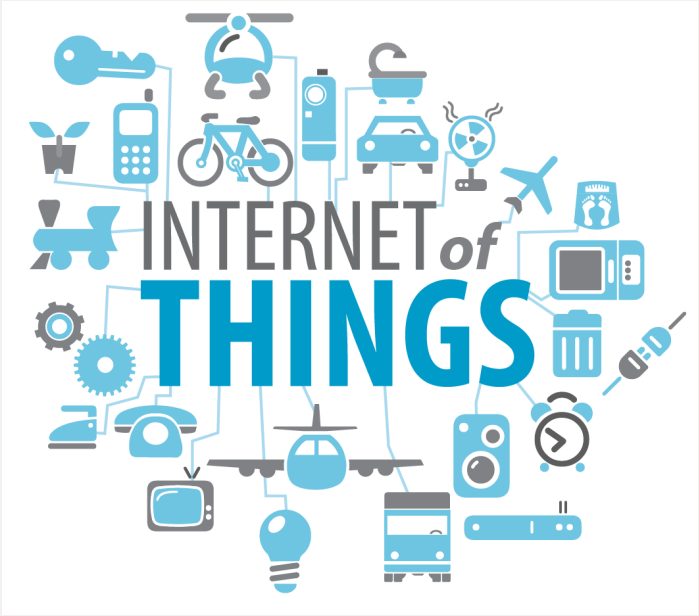
20-25 September 2019
Towards active, sustainable digital networks that are resilient and integrated from UHV to distribution

Keynote Speakers

"Technology and Applications of **IOT** in Electricity Power", Kunlun Gao, Global Energy Interconnection Research Institute

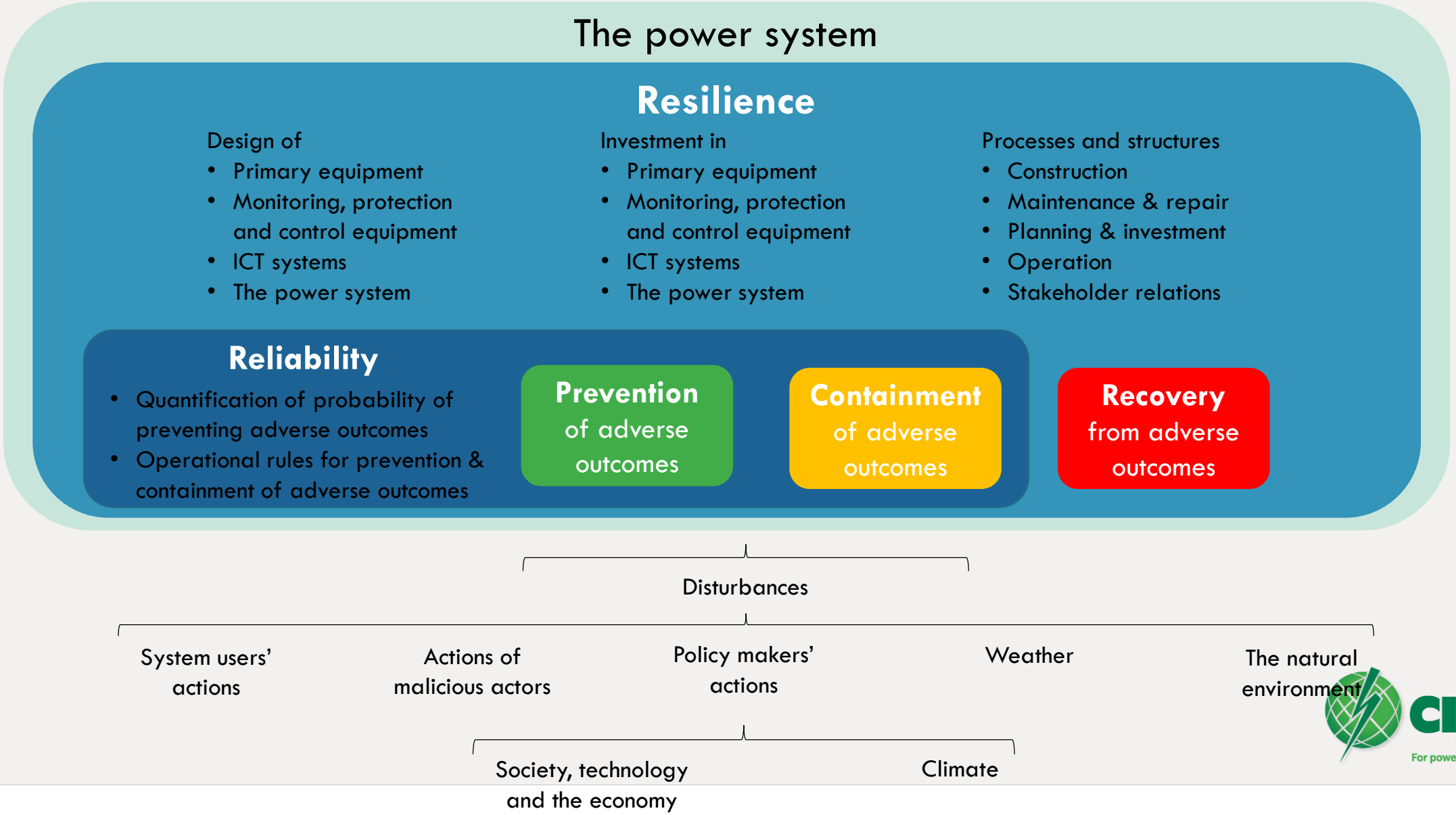
"Three Issues in the Application of **Electric Internet of Things** for Energy Transition", Junyong Liu, Professor of Sichuan University

"Potential Effects of **IoT** Devices on Electricity Demand Functions under Sector Coupling Scenarios", Konstantin Staschus, Chair of C1



cigre
For power system expertise

Reliability' and 'resilience'. A holistic view



Relevance to Australia

SC C1 has produced many Technical Brochures with very high relevance to the Australian electrical industry.

TB 775 Global electricity network - Feasibility study

TB 715 The future of reliability - Definition of reliability in light of new developments in various devices and services which offer customers and system operators new levels of flexibility

TB 701 Review of drivers for transmission investment decisions

TB 681 Planning criteria for future transmission networks in the presence of a greater variability of power exchange with distribution systems

TB 670 Establishing best practice approaches for developing credible electricity demand and energy forecasts for network planning

TB 666 Technical risks and solutions from periodic, large surpluses or deficits of available renewable generation

cigre
For power system expertise

2019 Deliverables

TBs published in 2019

TB 775 Global electricity network - Feasibility study

WGs nearing completion with a TB expected late 2019 or 2020

C1.34 ISO SERIES 55000 STANDARDS: IMPLEMENTATION AND INFORMATION GUIDELINES FOR UTILITIES

C1.38 Valuation as a comprehensive approach to asset management in view of emerging developments

Other WG of interest

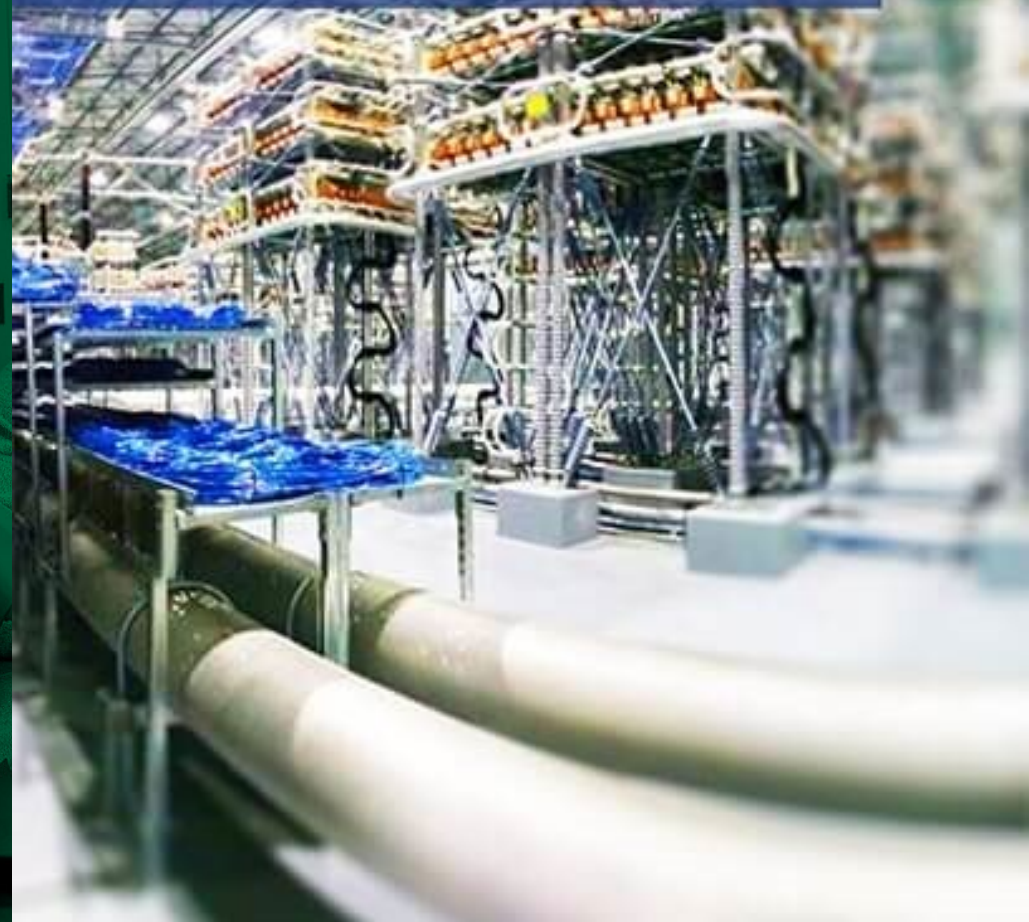
C1.44 Global Interconnected and sustainable electricity system Effects of storage, demand response and trading rules

C1.41 “Closing the Gap in Understanding between Stakeholders and Electrical Energy Specialists”

cigre
For power system expertise

B4

DC systems and power electronics



Presented by Les Brand - Convener

Brisbane – 21/11/2019

cigre

For power system expertise

Scope of SC B4

- The scope of SC B4 covers:
  - High Voltage Direct Current (HVDC) systems and power electronic equipment for AC systems (e.g. FACTS).
  - DC systems and equipment and Power Electronics for other applications such as distribution, and Power Quality improvement.
  - DC converters for energy storage.
- Overhead lines or cables, which may be used in DC systems are not included in the scope of SC B4.
- The members of SC B4 come from manufacturers, utilities, transmission system operators (TSOs), distribution system operators (DSOs), consultants and research institutes.
- SC B4 is expanding its activities to cover DC and power electronics applications in distribution systems.

Source: Siemens

HVDC

Source: GE

FACTS

Source: ABB

DC CONVERTERS

cigre
For power system expertise

Scope of SC B4 – Australian and New Zealand Context

- Considering the scope of SC B4 in the Australian and New Zealand context:
  - We have been an early adopter of both major HVDC technologies (LCC and VSC):
    - Inter-Island HVDC in NZ – one of the earliest HVDC schemes in service (1965)
    - Directlink HVDC in NSW – the second VSC commissioned in the world.
    - Murraylink HVDC in Victoria/SA – at the time, and until recently, the longest underground cable in the world.
    - Basslink in Victoria/Tasmania – at the time, the longest submarine cable in the world.
  - Australia has been using FACTS devices on our transmission and distribution networks for a very long time:
    - At last count – 65 SVCs/STATCOMs on transmission and distribution system across Australia and NZ.
    - In service since 1977.
  - Recent drive for the connection of inverter connected renewable energy sources (e.g. solar) and storage solutions (e.g. batteries).
    - Australia is starting to experience (and solve!) issues that the networks in other countries have yet to experience!

cigre
For power system expertise

SC B4 Technical Direction

- Main changes in technical direction observed within the last 10 years, from 2009 up to 2019 are as follows:

1. More application of VSC HVDC
2. More feasibility and development on HVDC grids
3. More PE applications in other areas with joint effort with other SCs
4. Application of DC technologies started to extend to distribution
5. Fewer LCC HVDC WGs
6. Fewer FACTS WGs

Source: Siemens

- Industry drivers include:
  - Offshore renewable energy sources and the creation of renewable energy hubs a long distance away from the load (HVDC grids)
  - Use of PE solutions in renewable energy generation and battery storage.
  - Distribution applications driven by a balance between centralised renewable energy generation and dispersed loads.

Source: www.tdworld.com

cigre
For power system expertise

SC B4 Activities

- Working Groups:
  - 14 SC B4 working groups plus 5 jointing working groups.
  - Many on relatively new topics including MVDC, cyber security and EMT modelling.
  - Some examples of working groups underway include:
    - B4.64 - Impact of AC System Characteristics on the Performance of HVDC schemes
    - B4.70 - Guide for Electromagnetic Transient Studies involving VSC converters
    - B4.78 - Cyber Asset Management for HVDC/FACTS Systems
    - C6/B4.37 - Medium Voltage DC distribution systems
    - B4/A3.80 - HVDC Circuit Breakers - Technical Requirements, Stresses and Testing Methods
    - B4.81 - Interaction between nearby VSC-HVDC converters, FACTs devices, HV power electronic devices and conventional AC equipment
    - B4 .82 - Guidelines for Use of Real-Code in EMT Models for HVDC, FACTS and Inverter based generators in Power Systems Analysis

SC B4 Activities

- Recently published Technical Brochures and Articles:
  - TB 766 - Network Modelling for Harmonic Studies.
  - TB 754 - AC side harmonics and appropriate harmonic limits for VSC HVDC.
  - Paper - AC Fault response options for VSC HVDC Converters.
- Green Books
  - Green book on FACTS – to be published prior to Paris 2020.
  - Green Book on Electricity Supply of the Future – Chapter on HVDC and FACTS – to be published prior to Paris 2020.
- Working Groups About to Start
  - Use of partially open-source software for HVDC systems.
  - Commissioning of FACTS.
  - AC fault response options for VSC HVDC converters (follow on from TF 77).
- HVDC Compendium
  - An online compendium of all in-service HVDC systems around the world.
  - Being updated and revised – due April 2020.
  - Available on e-cigre.

cigre
For power system expertise

2019 AU/NZ Contributions to SC B4

- One paper accepted for Paris 2020:
  - "Experience of integrating FACTS based modular power flow control equipment into the Australian transmission network" by P. Harrington.
- Significant contribution by Australian and New Zealand members to the Green Book on FACTS:
  - Babak Badrzadeh
  - Peeter Muttik
  - Rizah Memisevic
  - Andrew Van Eyk
- Contributing author to Green Book on Electricity Supply of the Future, HVDC chapter (Les Brand)
- Member, SC B4 AG-01 "Advisory Group" (Les Brand).
- VSC HVDC Common Terms Document
  - Develop a "*Common Terms and Description*" document for VSC HVDC technology (Les Brand).
- Participation on International Working Groups and Task Forces:
  - Task Force TF B4.77 – "*AC Fault response options for VSC HVDC Converters*" (Simon Bartlett).
  - JWG C6/B4.37 – "*Medium Voltage DC distribution systems*" (Les Brand and Georgios Konstantinou).
  - B4 .82 – "*Guidelines for Use of Real-Code in EMT Models for HVDC, FACTS and Inverter based generators in Power Systems Analysis*" (Nathan Crook).
  - B4.78 – "*Cyber Asset Management for HVDC/FACTS Systems*" (Mark Shilliday).
- Special Reporter for Paris 2020 technical session (Les Brand).

cigre
For power system expertise

2019 SC B4 Colloqium

- Johannesburg, South Africa.
  - Combined with the 9th CIGRE Southern Africa Regional Conference.
  - Working Groups – 28 and 29 September 2019.
  - B4 Study Committee Meeting – 30 September 2019.
  - Tutorials – 1 October 2019 – Two tutorials presented by SC B4:
    - FACTS Planning, Technology Selection and Specification
    - Technology Selection and Specification of HVDC
  - Colloquium – 2 October to 3 October 2019
    - Three parallel streams – two covering the Southern Africa Regional Conference and one for SC B4.
    - 28 Papers presented for SC B4 covering the following topics:
      - Network Stability
      - Renewable Energy
      - LVDC and MVDC distribution and microgrids, Distributed FACTS devices, Synthetic inertia, HVDC Insulation
      - HVDC Reliability, Refurbishment and upgrades of HVDC and FACTS installations
      - HVDC and FACTS Equipment and Technology
  - Australian member chaired the session on Renewable Energy.

cigre
For power system expertise

2019 AU B4 Panel Meeting and Membership List

- 2019 Panel Meeting held at Queenstown, New Zealand – 12 to 14 November 2019.
- 13 out of 19 members in attendance.
- Hosted by Transpower.
- One and half days of meeting in Queenstown plus half day site visit to Benmore HVDC converter station.
- New Convenor from 2020 – Mr John Wright-Smith of AMSC.

Name	Organisation	Name	Organisation
Les Brand (Convenor)	Amplitude Consultants	**Gerard Ledwich**	Queensland University of Technology
David Gibbs	Powerlink Queensland	**Angelo Iacono**	Siemens
Luke Roberts	TasNetworks	**Michael Dalzell**	Transpower, New Zealand
Peeter Muttik	GE	**Stuart Dodds**	APA Group
Andrew van Eyk	ElectraNet	**Ranjith Perera**	Entura
John Wright-Smith	American Superconductor	**Yau Chow**	Western Power
Richard Xu	TransGrid	**Georgios Konstantinou**	University of NSW
Greg Mather	Basslink Pty Ltd	**Mark Shilliday**	AEMO
Colin Wood	ABB	**Stephen Bex**	Jacobs
Nalin Pahalawaththa	GHD		

cigre
For power system expertise

GLOBAL TRENDS IN HVDC

cigre
For power system expertise

Global Trends in HVDC

- So…what's new?
- A few of my thoughts:
  - Increased application of Voltage Source Converter (VSC) projects…
  - ….but Line Commutated Converter (LCC) projects are not dead yet…just BIGGER
  - "Hybrid" HVDC Links
  - Earth return? What about "deep well" electrodes?
  - Global interconnections – the new buzz…

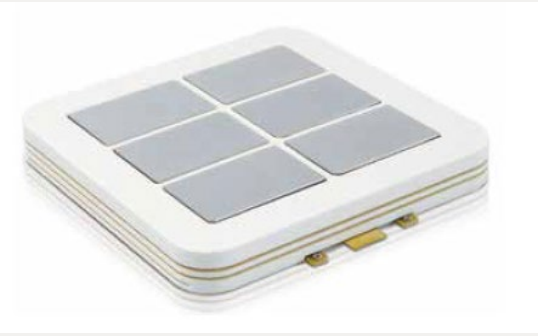
Source: Siemens

Source: CSPG "Ongoing HVDC Project Introduction"

cigre
For power system expertise

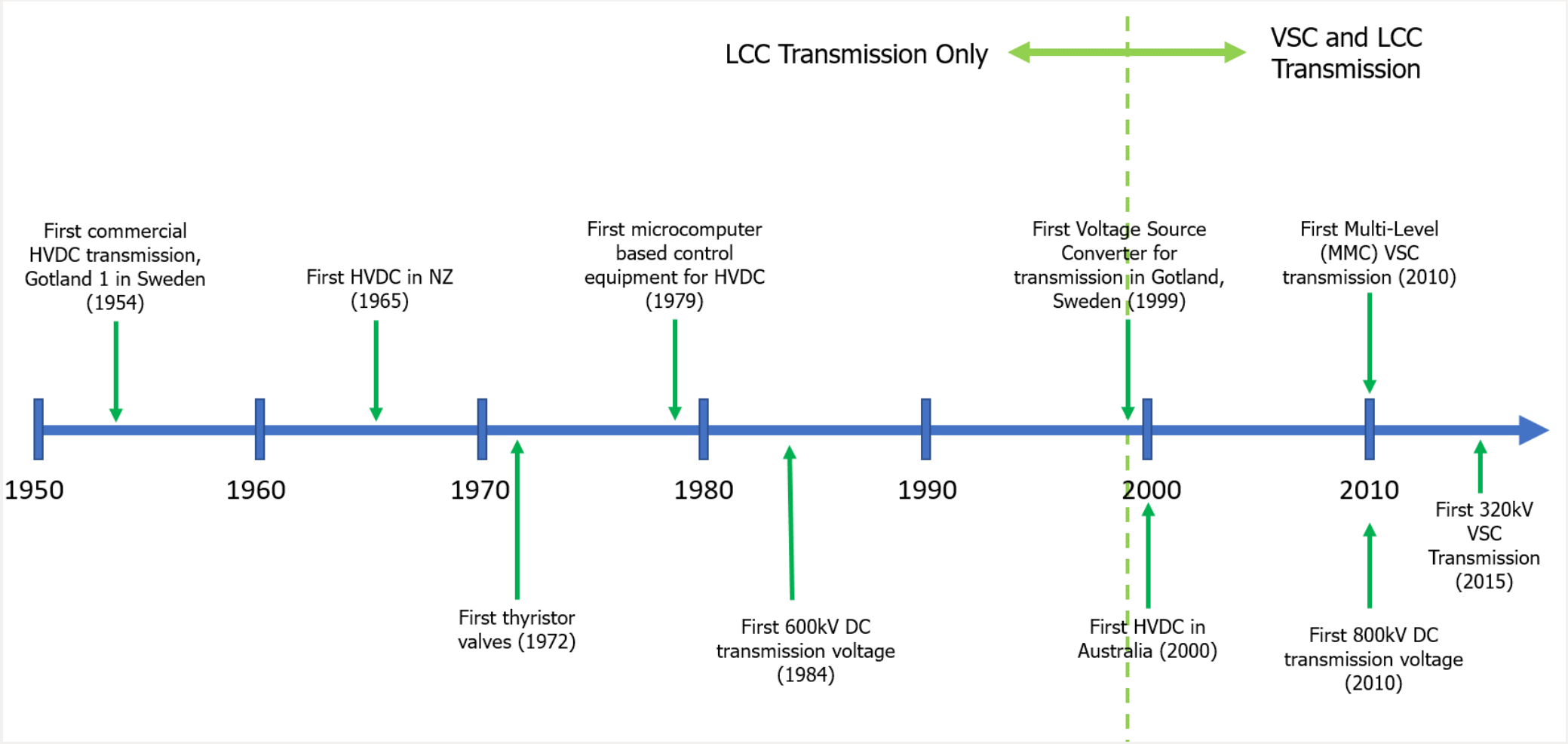
HVDC Technologies

- Line Commutated Converters (LCC)
  - ✓ Often referred to as “conventional” HVDC or “classic” HVDC.
  - ✓ Utilises thyristor valves to commutate the current.
  - ✓ Been around since the mid-1950s.
  - ✓ Thyristors in use in LCC converter stations since 1972 (prior to that mercury arc valves were used).
- Voltage Source Converters (VSC)
  - ✓ Conversion through the use of Insulated Gate Bipolar Transistors (IGBTs)
  - ✓ Self commutating - the IGBTs are switched on and off under the direction of a control system to develop an AC and DC voltage waveform.
  - ✓ HV VSC technology was first introduced commercially in 1997.

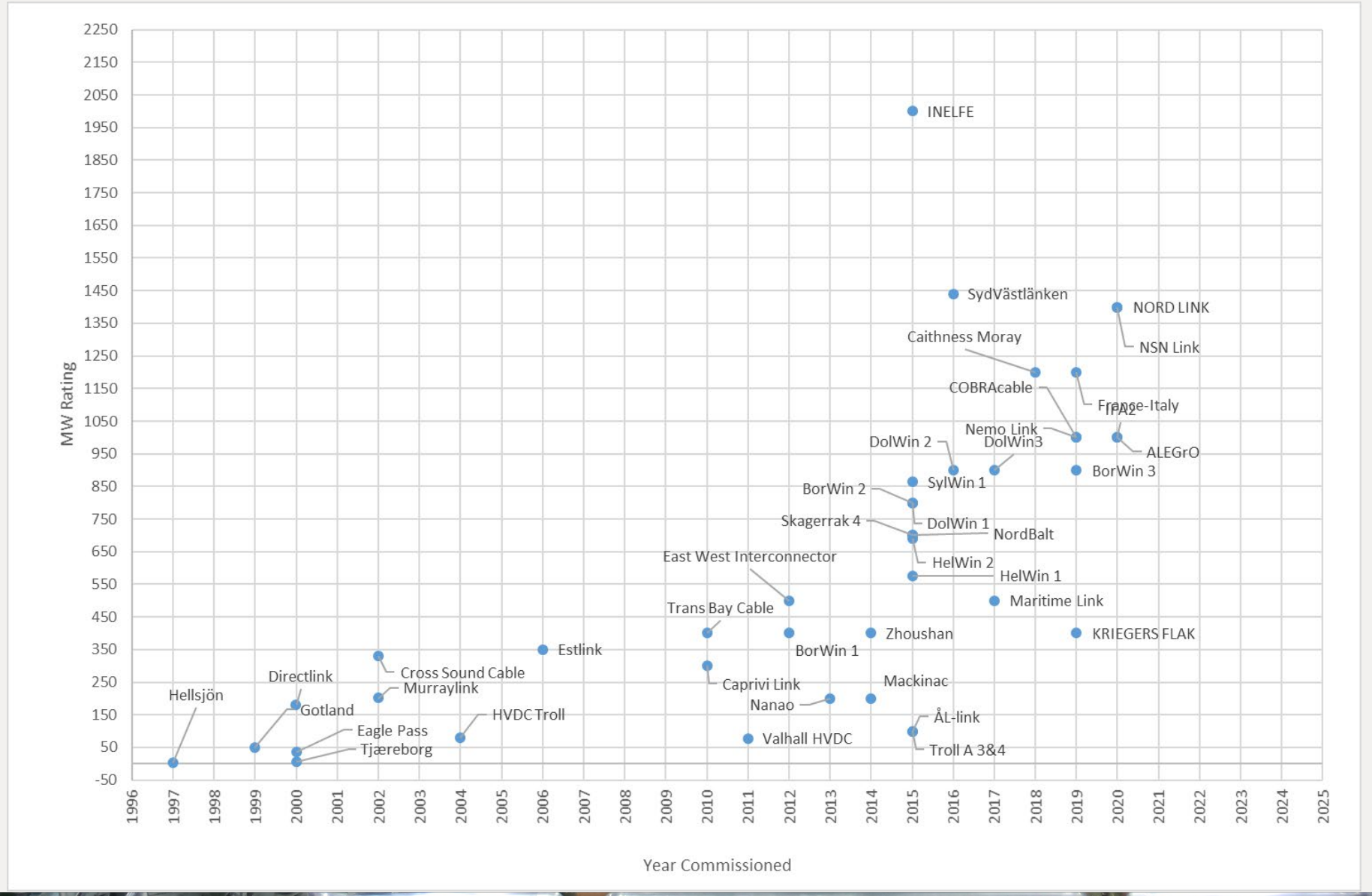


cigre
For power system expertise

History and Development of HVDC



Evolution of VSC HVDC Technology



cigre
For power system expertise

Drivers for Preference of VSC Technology

- To name a few:
  - Low power applications e.g. smaller islands, remote sites.
  - Offshore loads, some distance from shore – e.g. oil platforms.
  - Offshore generation – e.g. offshore wind – e.g. Germany off shore wind farms – up to 800MW.
  - Interconnection into / between weak networks.
  - Small footprint applications – into cities and heavily populated areas – e.g. trans bay cable.

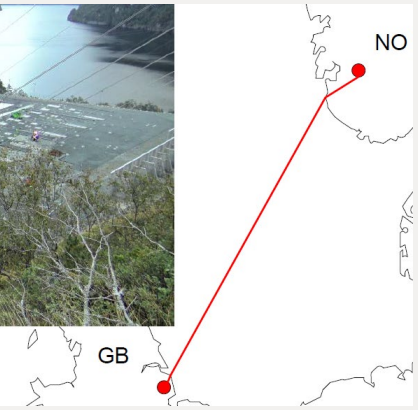
Source: ABB

Source: Siemens

cigre
For power system expertise

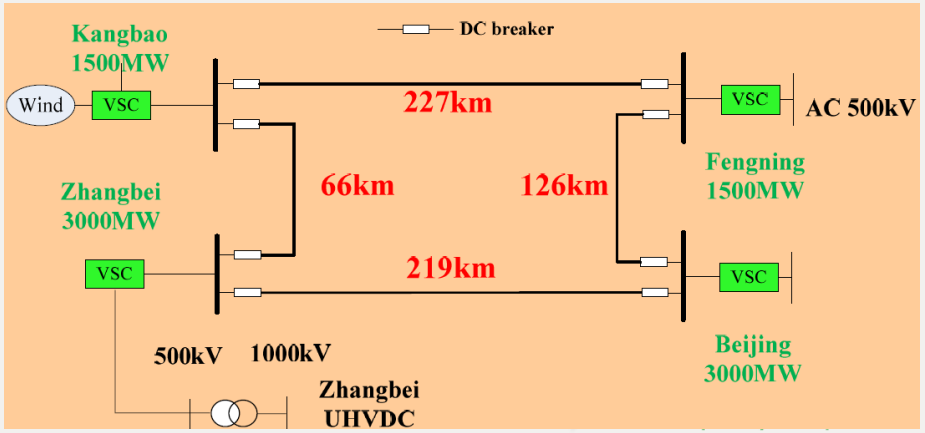
Big VSC Projects Coming Up

- North Sea Link
  - 1,400MW ±515kV
  - VSC “Rigid” Bipole
  - 720km HVDC submarine cables
  - To be commissioned 2021
- China VSC Projects
  - 5GW VSC Station – Guangdong
    - To be commissioned 2020
  - Zhangbei 4 Terminal VSC Link
    - To be commissioned 2019-2021
    - Up to 3GW converters



Source: Stattnett

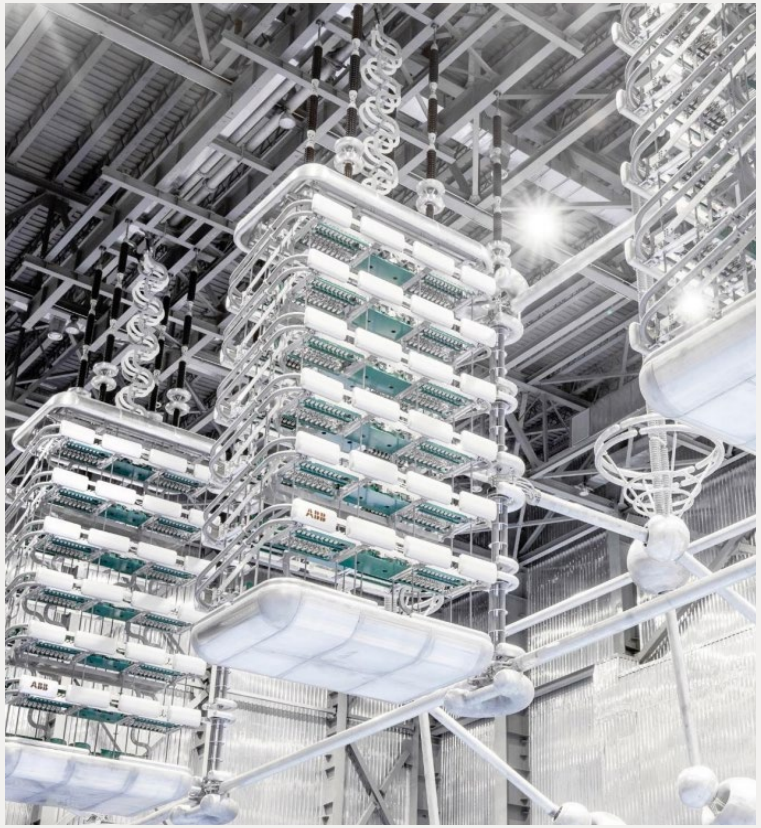
Source: China Southern Power Grid



Source: Global Energy Interconnection Research Institute China

New BIG LCC Links

- Line Commutated Converter (LCC) technology still used for large power – long distance applications.
- Changji-Guquan UHVDC link (China)
  - 12 GW
  - ±1,100kV
  - 3,000km overhead DC line
  - First power transmission – 2019

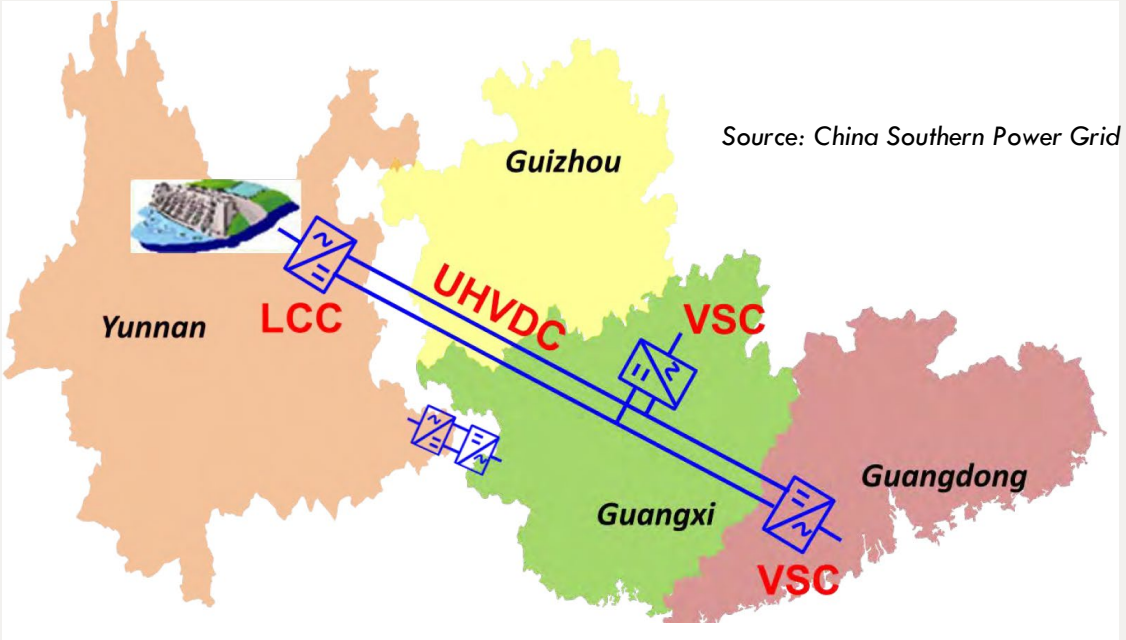


Source: ABB

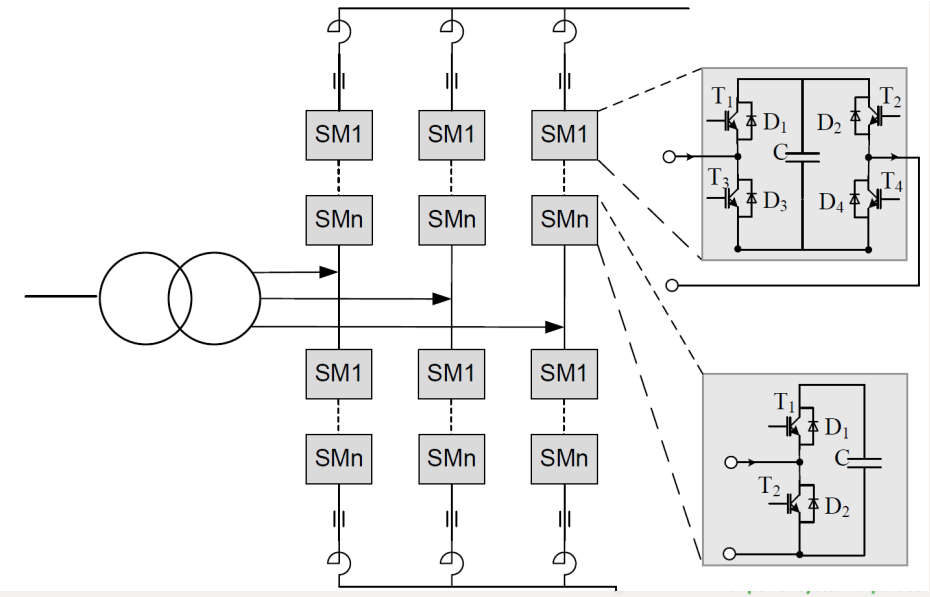
cigre
For power system expertise

“Hybrid” HVDC Links

- WDD Hybrid UHVDC Project
- Combination of LCC and VSC.
  - Rectifier – LCC – 8GW
  - Inverter 1 – VSC – 3GW
  - Inverter 2 – VSC – 5GW
- DC Voltage = ±800kV
- Why “Hybrid”?
  - Improve stability of multi-infeed system at inverter
  - No commutation failures at inverter
- Combination of half-bridge and full-bridge sub-modules:
  - Manages DC faults on overhead lines
  - Minimise costs – full-bridge = more IGBTs than half-bridge
  - Approx. 70% full-bridge.



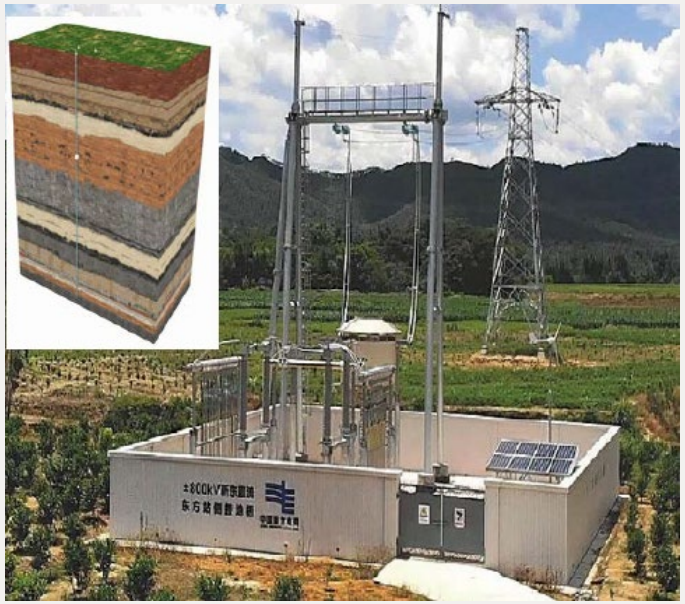
Source: China Southern Power Grid

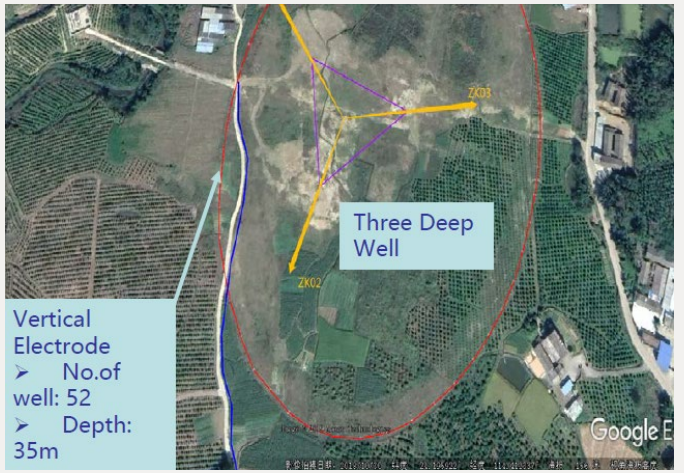


Source: China Southern Power Grid

Deep Well Electrodes

- “Conventional” earth electrodes can have impacts on the environment surrounding the electrode or other utilities and infrastructure in the vicinity.
- Project by China Southern Power Grid
  - The world's first 1000m deep-well grounding electrode project.
  - Mitigates the impact of HVDC earthing currents to the surrounding environment and other utilities.
  - Can reduce nearly two-third of the construction area of conventional earth electrode.





Parameters

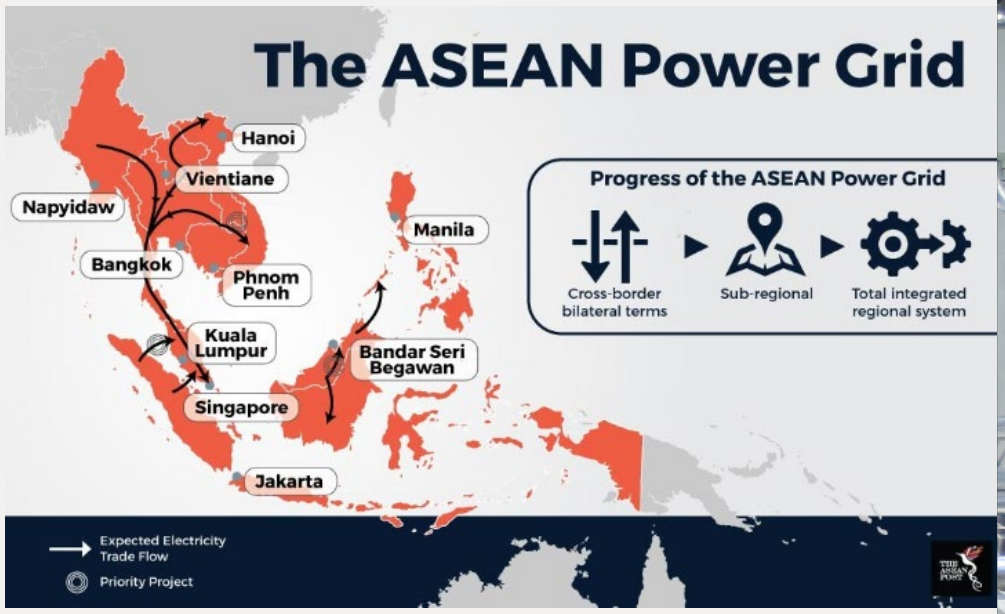
- Number of electrode: 3;
- Separation distance: 100m;
- Depth of single well: 1000m;
- End hole caliber: 406mm;
- Diameter of protection casing: 340mm;
- Upper end under ground: 150m;
- Diameter of feeder bar: 73mm;

Source: Presentation by China South Power Grid, CIGRE B4 Colloquium, Johannesburg 2019

cigre For power system expertise

Global Interconnections

- Focus of CIGRE on global interconnectors.
- Utilising power sources in one country (e.g. renewable energy sources) to provide supply to neighbouring countries.
- Potential to take advantage of time zone differences in terms of generating capacity (e.g. daylight hours) and peak loads.
- Allow countries with minimal renewable resources (e.g. land constraints for solar) to be able to achieve renewable energy targets.
- HVDC will have a significant role in the development of such global interconnections.
- CIGRE plan to host a workshop during 2020 supported by a number of SCs, including B4.
- Some examples:
  - ASEAN Power Grid
  - North East Asia (NEA) Power System Interconnection



Source: ASEAN Centre for Energy (ACE)

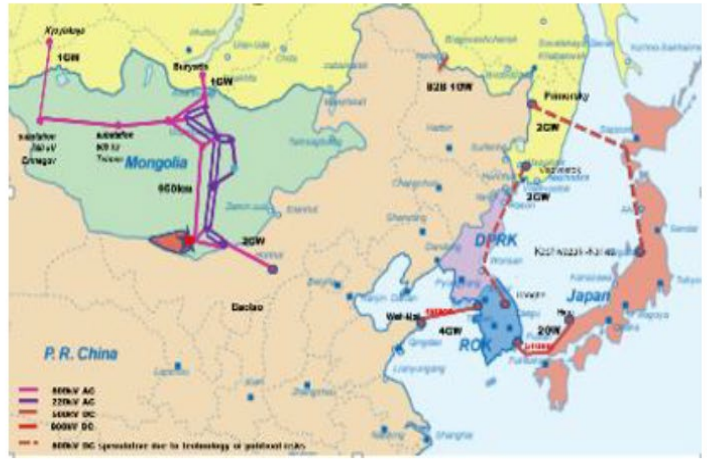
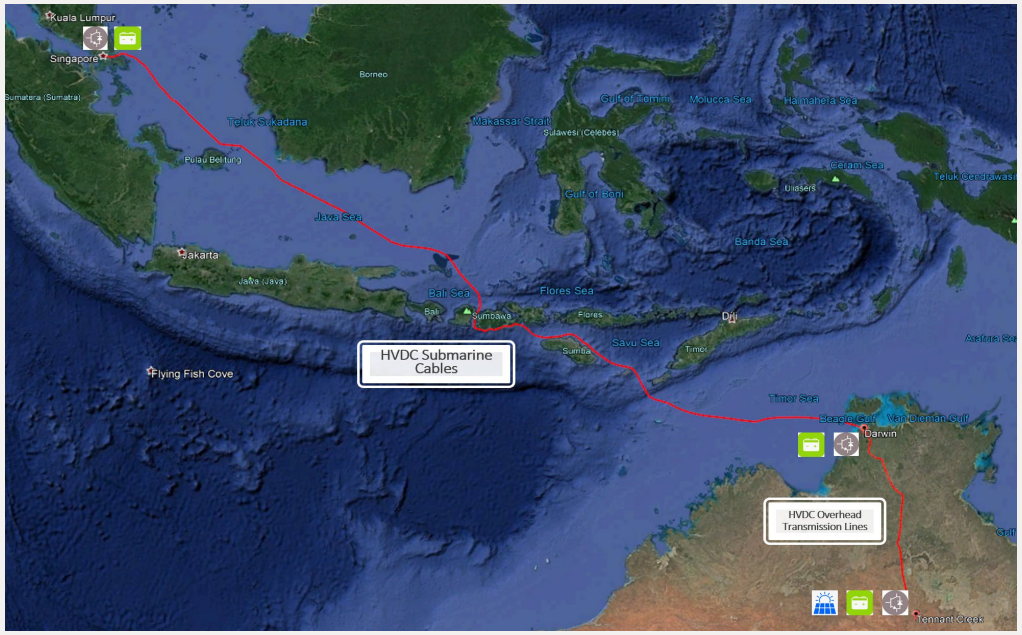


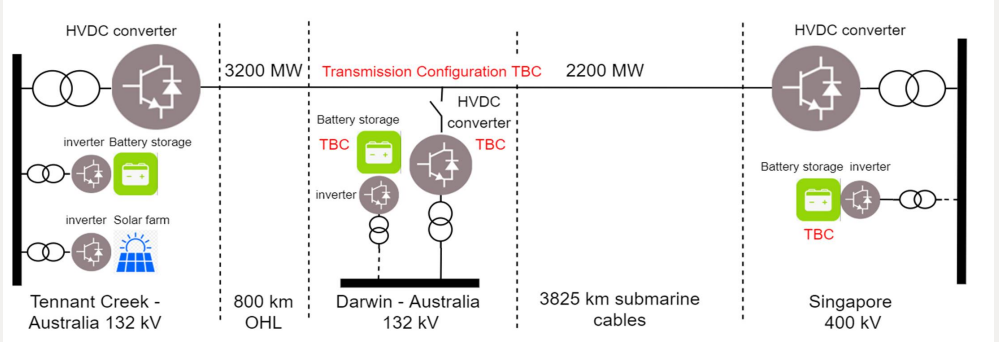
Figure 4: 5GW Renewable exportation from Mongolia by 2026

Source: EDF Electricité de France

Global Interconnections – Australian Example

- Australia-Singapore Power Link
  - A 10 GW capacity solar farm with battery storage near Tennant Creek, Northern Territory, Australia.
  - A 3,200 MW HVDC overhead transmission line system from Tennant Creek to Darwin.
  - A connection to the Darwin grid and local loads, via an HVDC converter terminal “tap”
  - A 2,200 MW HVDC subsea cable system with connection to Singapore’s transmission grid.
  - The project will be capable of producing up to 20% of Singapore’s annual electricity demand.
  - VSC technology, multi-terminal.





cigre
For power system expertise

Thank You For Your Time!

cigre
For power system expertise

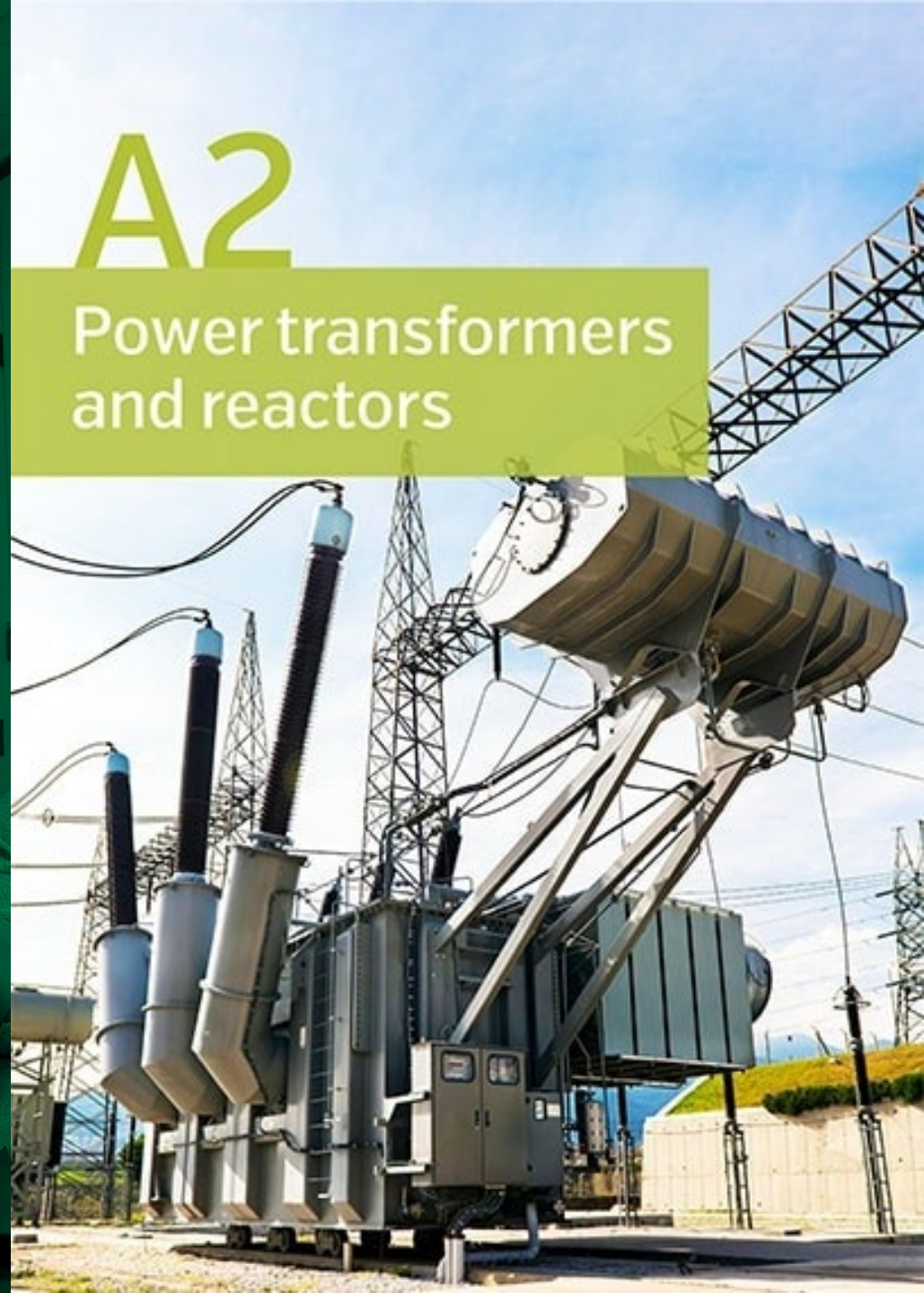
Prepared by Ross Willoughby – Convener

Presented by Lagath Ganepola

Brisbane – 21/11/2019

cigre

For power system expertise



SC A2 Overview

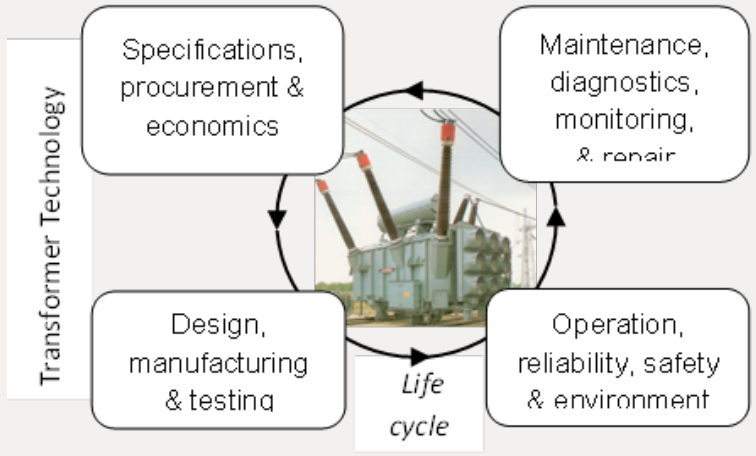
Study Committee Scope

- All kinds of power transformers, including HVDC transformers converter and phase-shifting transformers;
- All kinds of reactors, including shunt reactors, series reactors, and HVDC smoothing reactors;
- All transformer components, including bushings, tapchangers, and other transformer accessories.

Specific Activities of SC A2 :

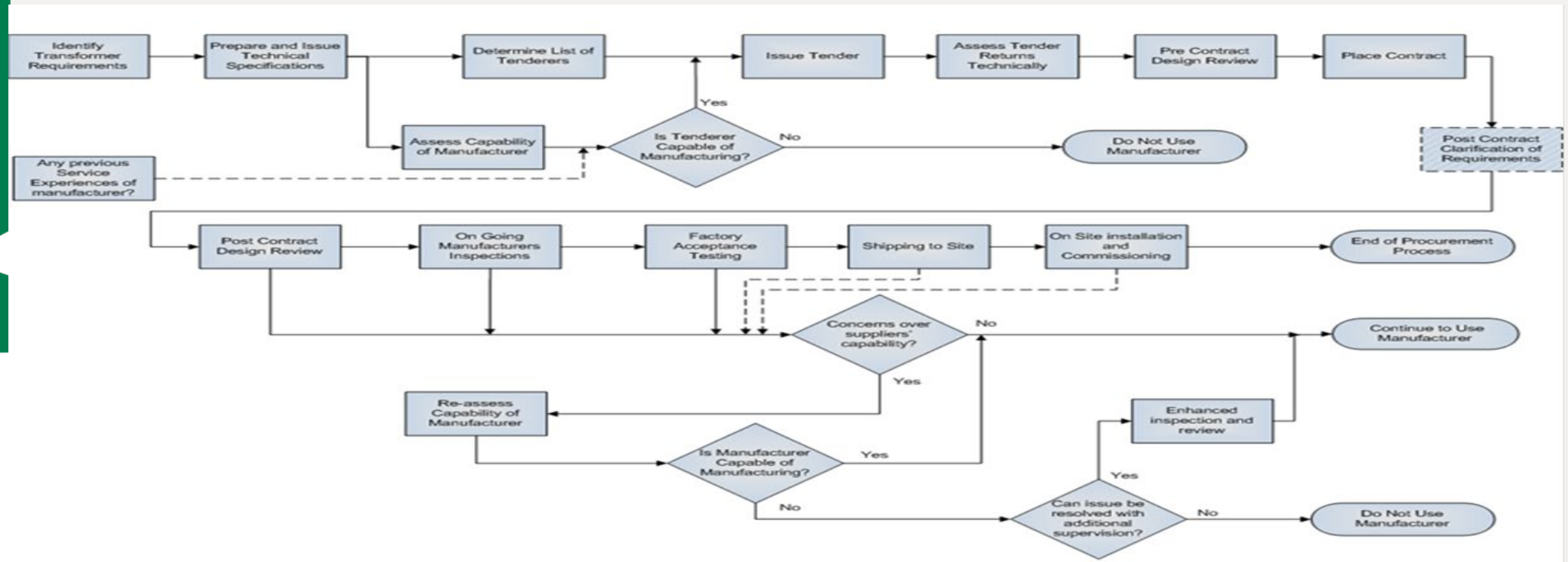
Covers the life cycle of a transformer in 4 key domains:

- Specification, procurement and economics
- Design, manufacturing and testing
- Operation, reliability, safety and environmental impact
- Maintenance, diagnostics, monitoring and repair



SC A2 Green Book in development

- **SC A2 has formed new Advisory Group - Green Book on Transformer Procurement**
  - The work would amalgamate and develop the existing material used in the trilogy TBs 528-529-530 for procurement process
  - Add the new work of TB 673 Transportation and WG A2.58 Installation, Pre-commissioning & Trial Operation



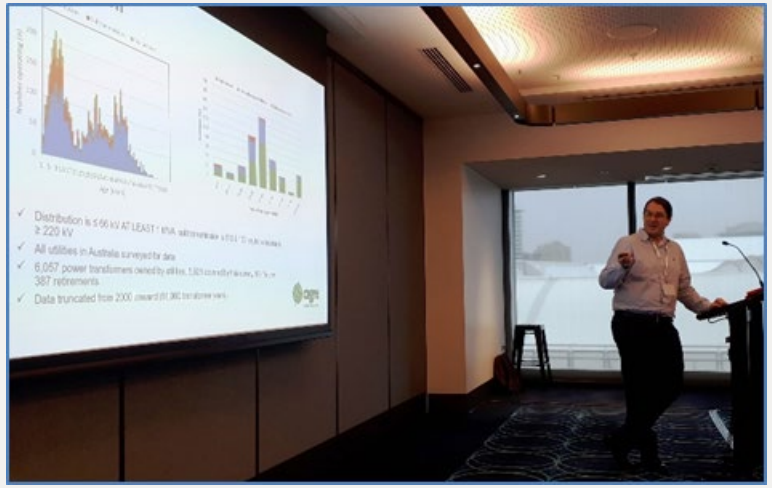
cigre
For power system expertise

2019 AU A2 Activities

Cigre Event – 1 Day Workshop

"Transformers – with a Focus on Tapchangers – an interactive workshop" was held on 3 April

- 11 speakers (3 from transformer OEM, 1 test equipment vendor, 4 from OLTC OEM or service, 1 Aust. university, and 3 int'l experts on OLTC, testing and corrosive sulphur)
- 69 delegates
- Expert Panel
- High relevance to Aust on tapchanger failure. Risks and avoidance



cigre
For power system expertise

Relevance to Australia

- SC A2 has produced a long series of Technical Brochures with very high relevance to the Australian electrical industry.
- TB 445 Guide for transformer maintenance has one of the highest hits on the e-cigre site for TB downloads
- 735 Post-mortem Analysis
- 673 Guide on transformer transportation
- 655 Technology and utilization of oil-immersed shunt reactors
- 642 Transformer reliability survey
- 630 Guide on Transformer intelligent condition monitoring
- 625 Copper sulphide long term mitigation and risk assessment
- 537 Guide for transformer fire safety practices
- 528/529/530 Guides to assess the capability of a transformer manufacturer, design review for power transformers, and preparation of specifications for power transformers

There are some major changes coming from IEEE, IEC and CIGRE guides and standards on the interpretation of DGA.

Active Australian participation in A2 WGs – either as regular members, corresponding members or conveners

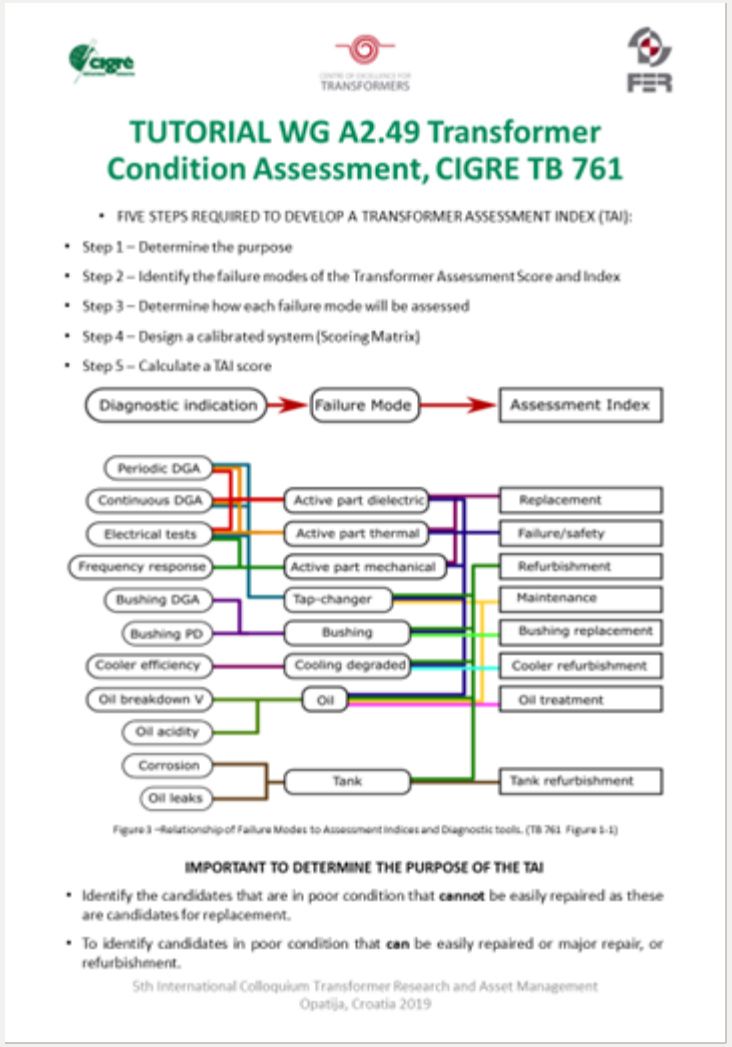
NGN interest and involvement too

cigre
For power system expertise

2019 Deliverables

Technical Brochures

- TB 755 – Transformer Bushing Reliability
- TB 761 – Condition Assessment of Power Transformers
- TB 771 – Advances in DGA Interpretation
- TB 783 – DGA Monitoring Systems
- TB 779 – Field Experience with Transformer Solid Insulation Markers



cigre
For power system expertise

ATC Meeting, 2019
AUB2 Overhead Lines Report

Convenor: John McCormack

November 2019

cigre
For power system expertise

AUB2 2019 Activities

Strategy:

- ✓ Engage with broader industry (eg DNSP, Research Establishments, Asset Management Council)
- ✓ Seek opportunities to interact with OHL Asset Manager/Owner representatives (eg invitations at next panel meeting
- ✓ Encourage NGN participation

Panel Meeting – Sydney, 10-12th September 2019

- Technical Tour: OH/UG line re-route for new airport; Noise mitigation of 330kV line.
- New WG's – UAV's, MV/LV conductor, OHL assets & fire, Condition Monitoring at Remote sites (JWG B2/D2)
- Key presentations:
  - Ice Loading on OHL (Snowy 2.0 project)
  - NCI insulator failures
  - Design/construction of new line connections in far north of South Australia
  - Tower replacement in NSW; Line re-routing for West Gate Bridge, Melbourne
  - Lightning Performance of OHL
- 28 panel members; 34 attendees including 14 invited guests

Next Panel Meeting – Queensland, Sept/Oct 2020

Technical Seminar - Sydney, 10-12th September 2019

- Electrical clearance criteria for OHL structure geometry design
- Conductor vibration effects and mitigation
- Live Work safe systems of work evaluation
- Covered Conductor to mitigate bushfire risk

cigre
For power system expertise

SCB2 WG & Publications - 2019

WG	Title	Status	Publication	AUB2 Rep
JWG13 C3/B1/B2	Environmental issues of high voltage transmission lines for rural and urban areas	Complete	With Publishers	Tim de Grauw
B2.23	Geotechnical and structural design of foundations for HV & UHV Lines	Final draft due 2019		Graeme Paterson
B2.24	Qualification of HV and UHV OHL Line Supports under static and dynamic loads	TB issued for review		Elias Elkhoury, Robert Lake, Henry Hawes Asif Bhangor (reviewer)
B2.40	Calculations of the electrical distances between live parts and obstacles for OHL	Final draft due 2019		Robert Lake (convenor) John McCormack
WG45	WG B2.45 Bushfire characteristics and potential impacts on OHL Performance	Complete	TB 745 (issued 2019)	Francis Lirios (WG) Michael Lee (WG) Peter Dulhunty (WG)
WG50	WG B2.50 Safe handling of fittings and conductors	TB issued for review		Peter Dulhunty (convenor)
WG55	WG B2.55 Conductors for the Uprating of Existing Overhead Lines	Complete	TB 763 (issued 2019)	Glenn Ford
WG56	WG B2.56 Ground Potential Rise at AC OHL Structures during Faults	Complete	TB 694 (issued 2019)	Charles Crew
WG57	Survey of operational Composite Insulator Experience and Application Guide for Composite Insulators	target complete?		Steve Redhead

SCB2 WG & Publications – 2019 (cont)

WG	Title	Status	Publication	AUB2 Rep
WG58	Vibration Modelling of HTLS conductors - Self damping characterization	target complete 2018/19		Jack Roughan
WG59	Forecasting Dynamic Line Ratings	target complete 2018/19		Michael Lee
WG60	Affordable Overhead Transmission Lines for Sub-Saharan Countries	target complete?		Michael Lee
WG61	Transmission Line Structures with Fibre Reinforced Polymer (FRP) Composites	Final draft reviewed		Francis Lirios
WG62	Design of Compact HVDC Overhead Lines	Final draft reviewed		Asif Bhangor
WG63	Compact AC Transmission Lines	Final draft reviewed		not represented
WG64	Inspection & Testing of Equipment and Training for Live-Line Work on OHL	Active		Alexandra Price (WG) Simon Leitch / John Mc
WG65	Detection, Prevention and Repair of Sub-surface Corrosion in OHL Supports, Anchors and Foundations	Active		Elias Elkhoury
WG66	Safe handling and installation guide for high temperature low sag conductors	Active		Michael Wilson, Transpower

SCB2 WG & Publications – 2019 (cont)

WG	Title	Status	Publication	AUB2 Rep
WG67	Assessment and testing of wood and alternative material type poles	Active		Nathan Spencer (convenor), Glen Ford, Peter Dulhunty (WG)
WG68	Sustainability of Conductor & Fittings	Active		Andrew Taylor
WG69	Coatings for Power Networks	Active		Francis Lirios
WG 70	Aerial Warning Markers	Active		Jack Roughan, Sara Sun
WG 71	Inter-phase spacers	Active		Indhran Pillay (tbc)
WG 72	Condition Monitoring of OHL In Uninhabited Areas	Active		Robert Lake, Stephen Brooks
WG 73	The role of OHL electrical assets with respect to the initiation and prevention of bushfires	Active		Peter Dulhunty (convenor) David Mate, Grant Bailey, Francis Lirios,
WG 74	UAV for maintenance of OH distribution lines	Active		Francis Lirios, Ergon (tbc)
WG 75	Guide for application of insulated conductors on overhead MV & LV distribution lines	Active		Linden Bronleigh

SCB2 Proposed WG – 2019 (cont)

	Proposed WG	Status	TAG	AUB2 Rep
	Lightning Performance of OHL	CAG review	TAG 04 Electrical	
	Audible Noise of OHL	CAG review	TAG 04 Electrical	Jitesh Raniga
	Foundations for Difficult Soils	CAG review	TAG 05 Structures	Frank Yao Graeme Paterson
	HTLS for new lines	CAG review	TAG 05 Structures	
	Ice on OHL	CAG review	TAG 05/06 Structure/Mechanical	Brett McKillop
	Risk of OHL	CAG review	TAG 07 Asset Mgt	Asif Bhangor (proposed convenor)
	Construction methodology	Under Development	TAG 05 Structures	
	Asset Management Principles	Under Development	TAG 07 Asset Mgt	Francis Lirios (proposed convenor)
	Performance of elastomer fittings - life expectancy	Under Development	TAG 06 Mechanical	
	Damping for long spans	Under Development	TAG 06 Mechanical	
	Inspection & repair of OHL structures	Under Development	TAG 05 Structures	
	Live Work: Review of Safe Systems	proposed	TAG 07 Asset Mgt	

ATC Seminar 2019

Presented by Greg Hesse - Convener

Brisbane – 21 November 2019

cigre

For power system expertise

SC C2 Scope

- **Technical, human resource and institutional**

aspects and conditions for

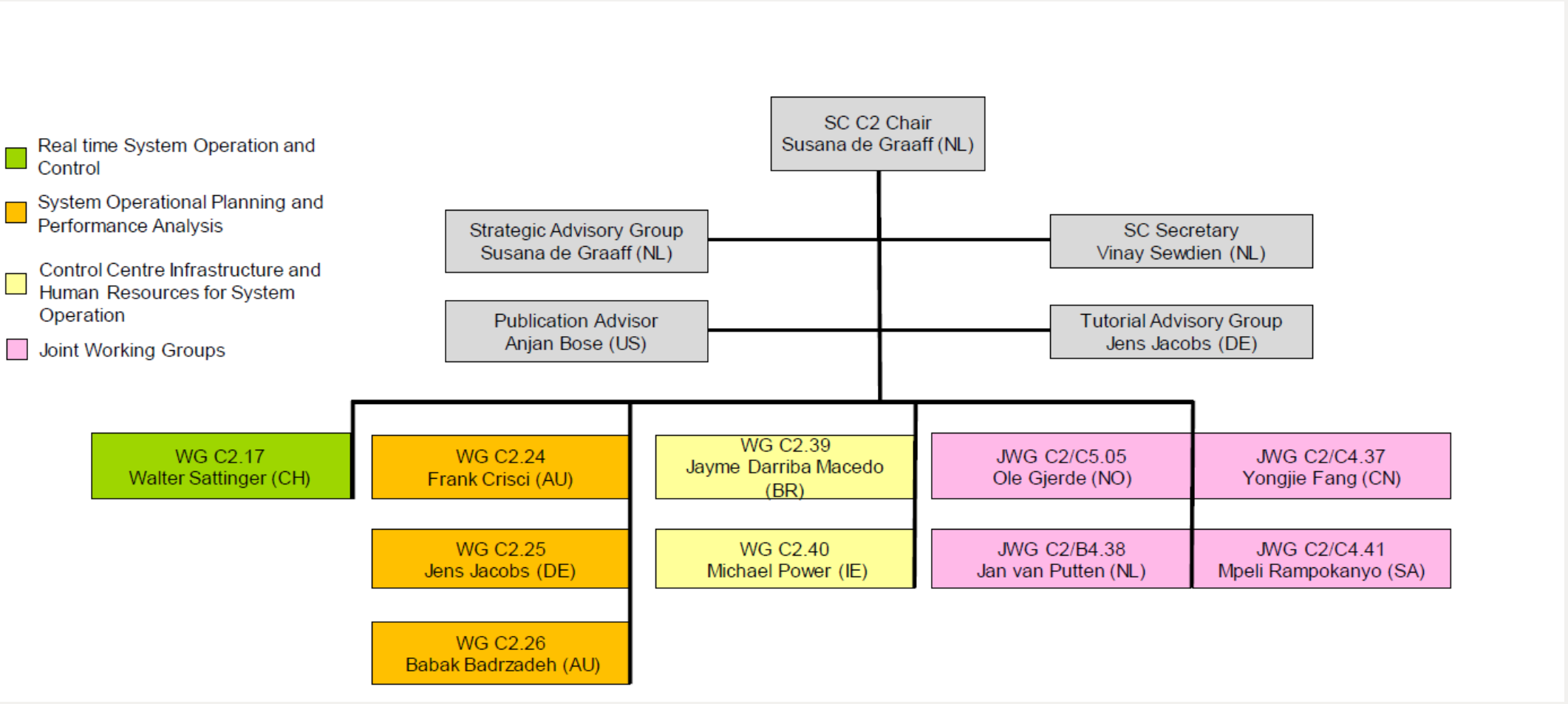
- **Secure and economic operation of power systems**

while protecting against

- **System disintegration, equipment damage and human injuries**

cigre
For power system expertise

Structure of C2



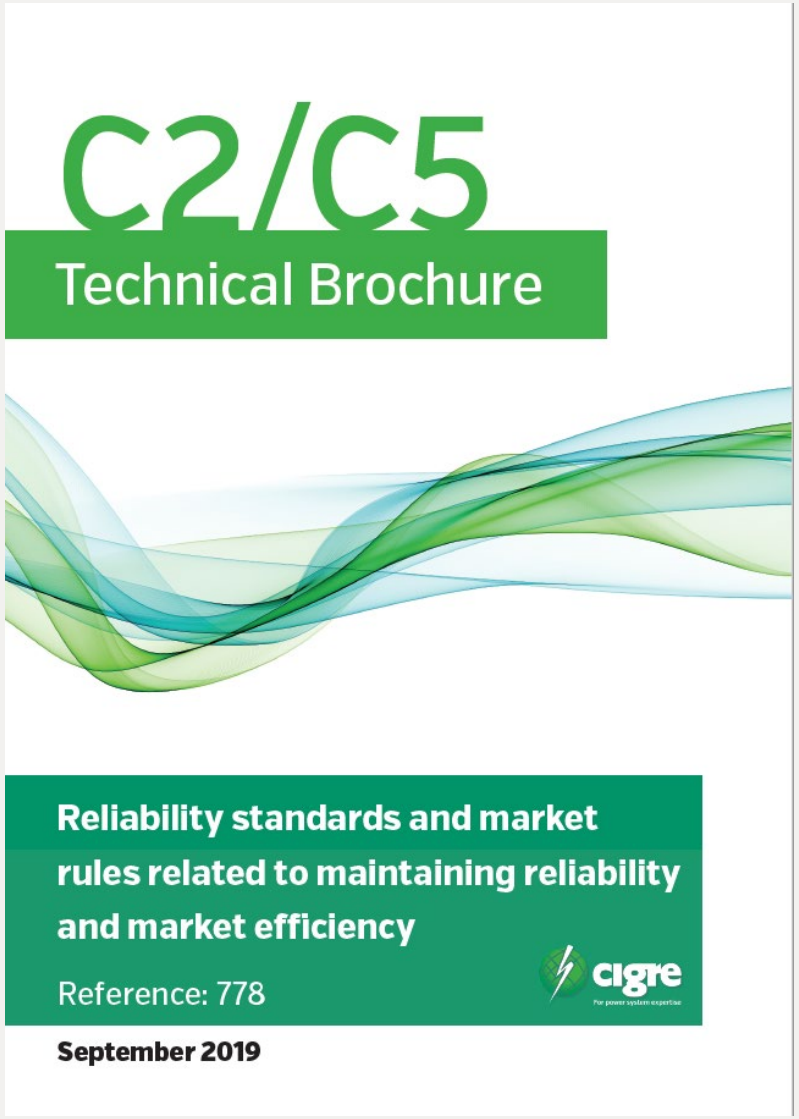
2019 Activities
Publications

TB742 - *A proposed framework for coordinated power system stability control* (Joint with SC C4)

TB778 - *Reliability standards and market rules related to maintaining reliability and market efficiency* (Joint with SC C5)

CSE13 - *Icelandic operational experience of synchrophasor-based fast frequency response and islanding defence*

CSE14 - *System operation and control, power system restoration – World practices & future trends*



cigre
For power system expertise

Aalborg Symposium – “Going Offshore”

SC C2 hosted four paper sessions

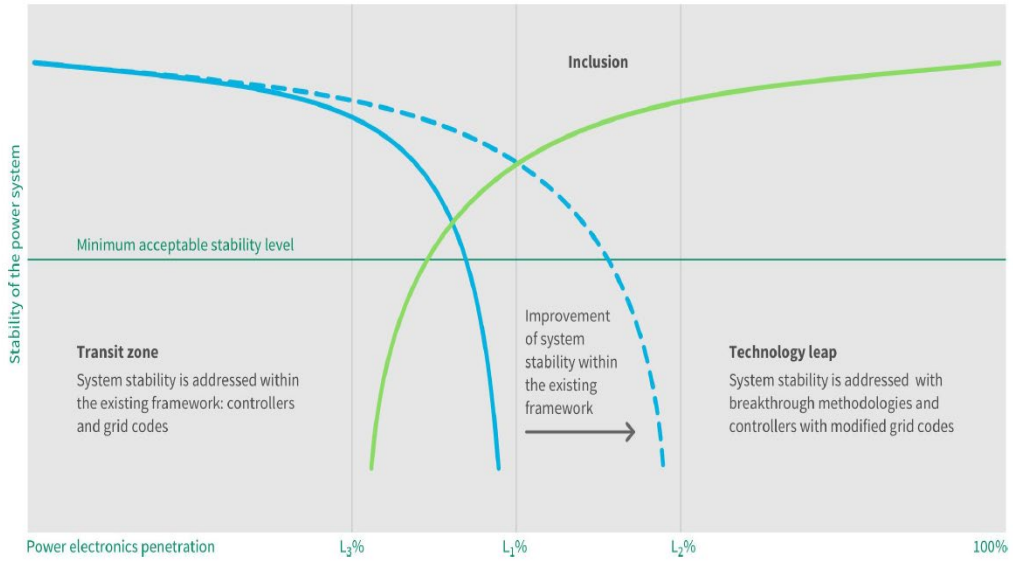
- Assessment and study tools for system operation
- Operation of hybrid and low inertia power systems
- Support from VSC HVDC for system operation
- Frequency support from power electronic interfaced devices

cigre
For power system expertise

Aalborg Symposium – key insight

MIGRATE

OVERARCHING GOAL



MIGRATE

THE CONSORTIUM

cigre
For power system expertise

SC C2 – Relevance for Australia / Paris 2020

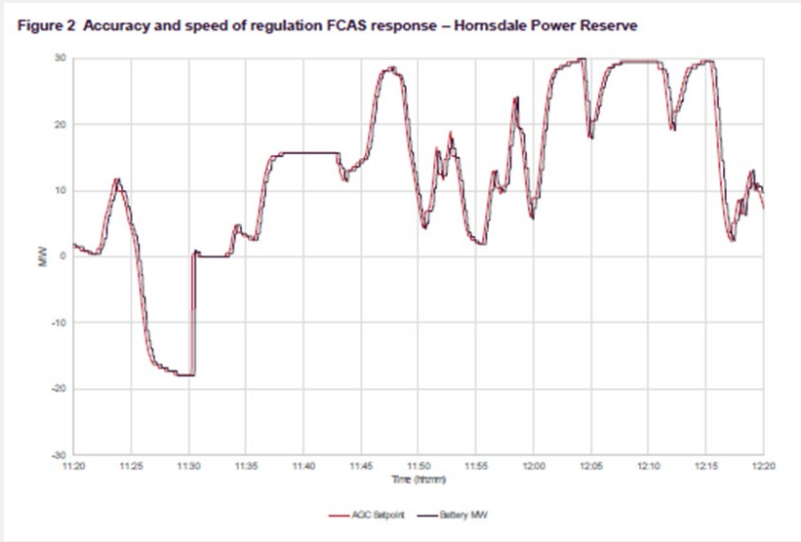
Secure operation of power systems with high penetration of PE devices

- **PS1 – Capabilities required for future power system operation**
- **PS2 – System operation interfaces: improving observability and controllability**

Harnessing new technologies and DER to improve power system operations

- **PS3 – System operation challenges with increasing use of distributed energy resources**

ATC Seminar 2019

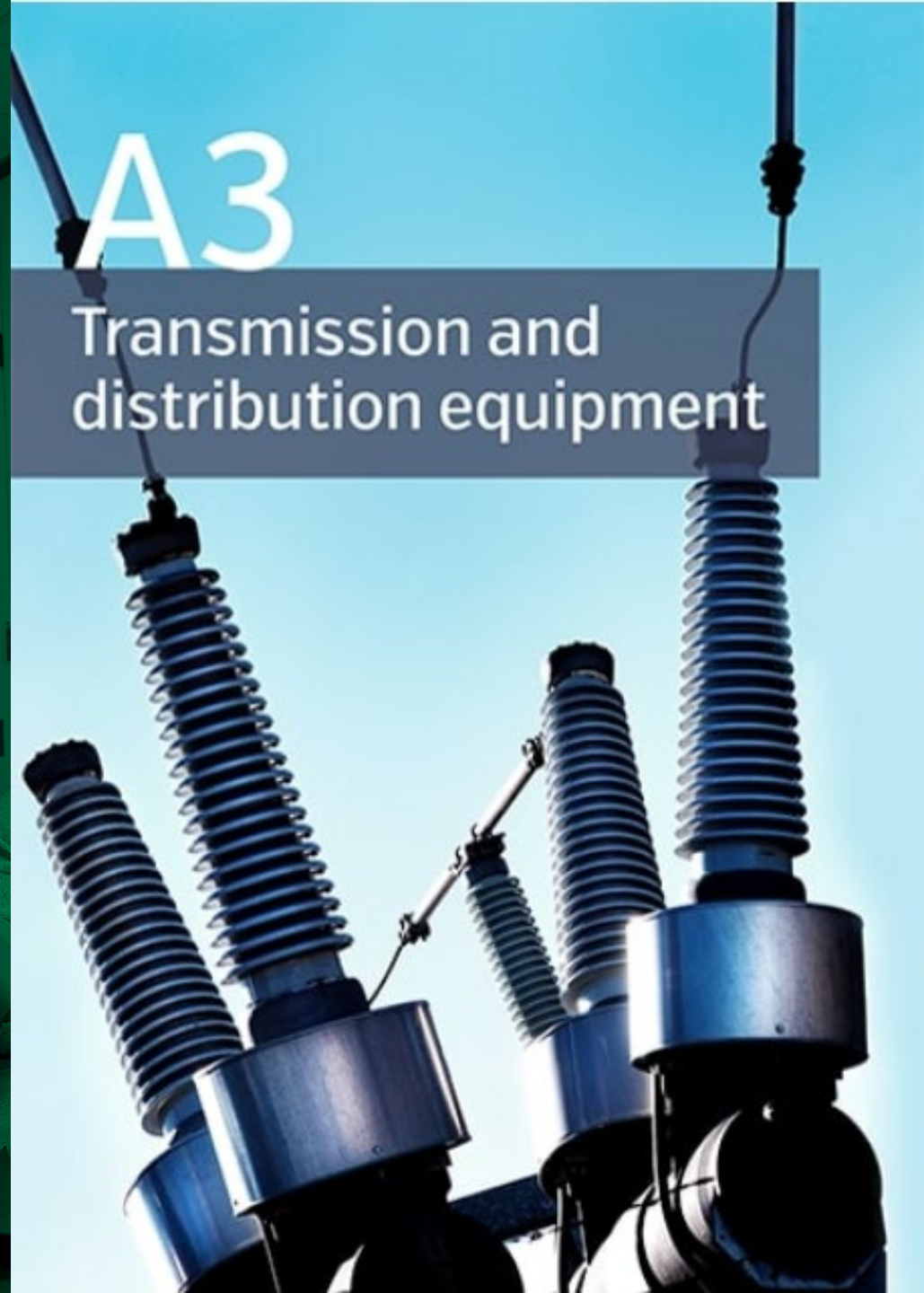


cigre
For power system expertise

Presented by Wayne Pepper - Convener

Brisbane – 21/11/2019

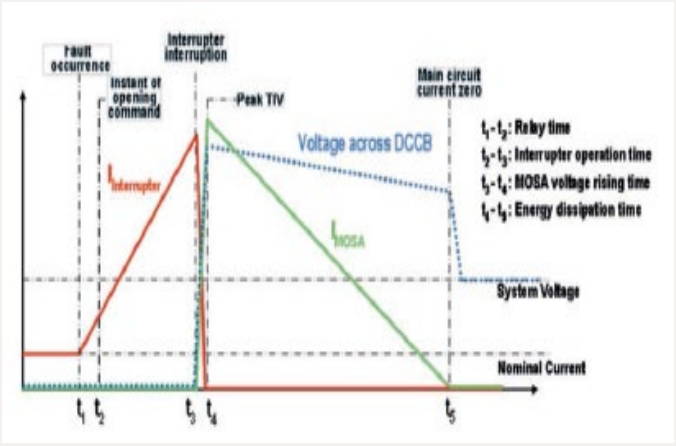
cigre
For power system expertise



SC A3 Overview

Scope

- Responsible for theory, design, construction and application of equipment components, equipment, and equipment systems applied to both AC and DC systems from distribution up to highest transmission voltage levels.
- Equipment covered includes:-
  - Switching equipment (CB's, disconnectors, earthing switches, distribution equipment)
  - Fault current limiters
  - Surge arresters,
  - Capacitors (series & shunt)
  - Busbars
  - Bushings
  - Insulators
  - Instrument transformers (CT's, VT's, CVT's, NC-IT's etc)

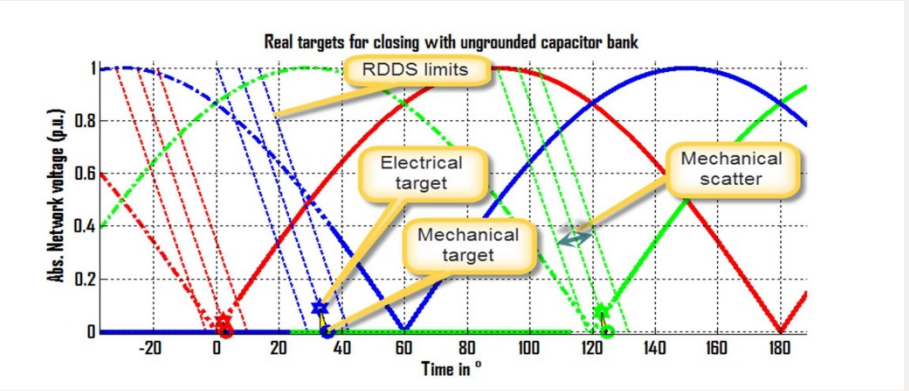


cigre
For power system expertise

SC A3 Overview

Areas of Interest

- Innovative technologies (e.g UHV equipment and DC Circuit Breakers)
- Requirements for equipment in changing network conditions
- Incorporation of intelligence in HV equipment (e.g Controlled Switching)
- Monitoring and diagnostics of transmission and distribution equipment
- New and improved testing techniques
- Reliability assessment, end-of-life assessment of ageing equipment
- Mitigation methods for overstressing and overloads

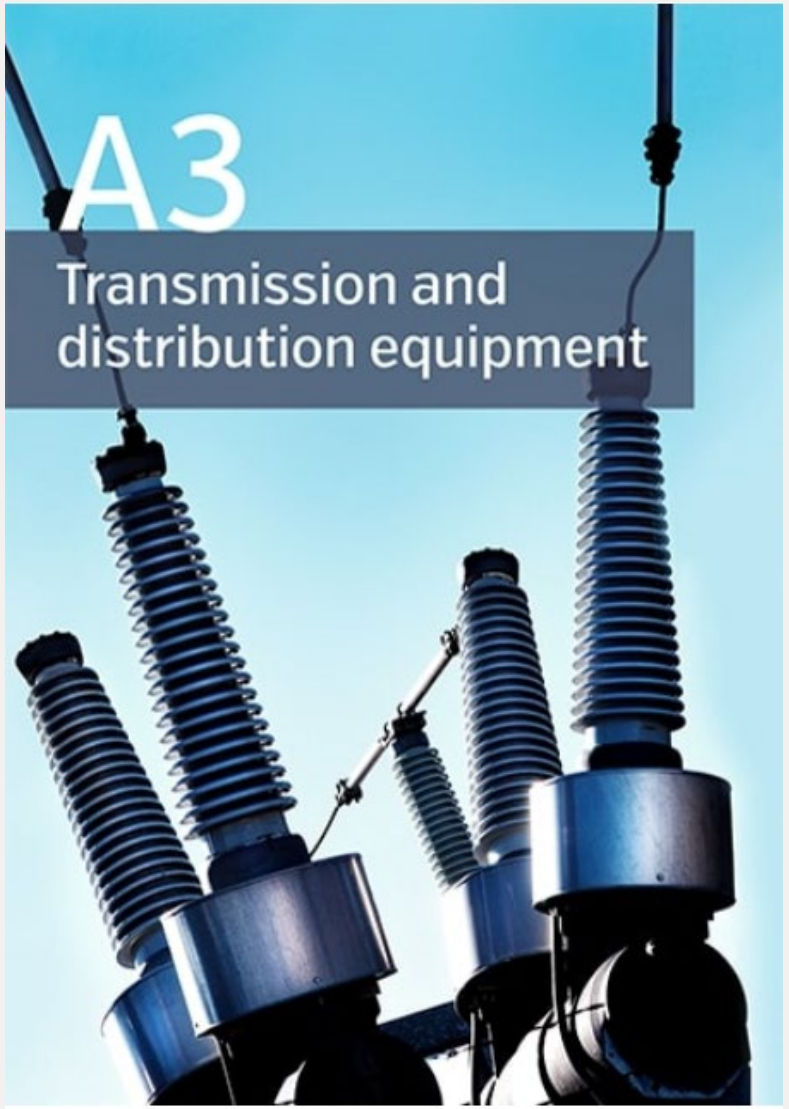


cigre
For power system expertise

2019 International Activities

SC A3

- In September 2019, A3 SC meeting was in Bucharest, Romania, with Condition Monitoring, Diagnosis and Maintenance (CMDM) conference. The CMDM conference is a biennial conference organised by CIGRE Romania.
- 3 days of technical papers and 6 Tutorials from 3 SC's.
- 2 WG's completed their activities, with 3 new WG's commencing in 2019. Currently 8 WG's active.
- Proposal for a Utility Advisory board to commence with members from utilities to meet twice yearly. Aim is to meet needs of Utilities with proposals for new WG's and Preferential subjects.



cigre
For power system expertise

2019 Deliverables

Technical Brochures

- TB 757 – Guideline and best practices for the commissioning and operation of controlled switching projects.

Green Book

- A3 Green Book – “Switching Equipment” published in August 2018 – 489 copies sold @ Sept – 2019.
  - A3 AU contribution to chapter on “Lifetime Management of Equipment”
- 2nd edition being planned with additional content
- Contributing to a chapter in future C1 Green Book on “Asset Management”

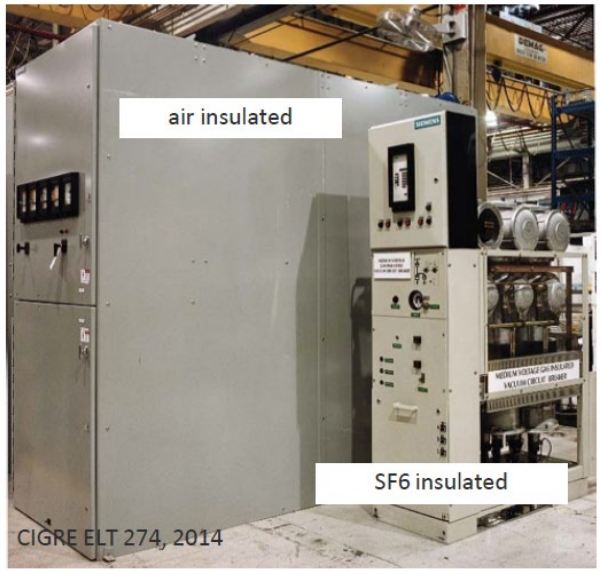
cigre
For power system expertise

Big Issue - SF6

- Greenhouse gas GWP SF6 1kg = 22,500kg CO2
- Legislation to phase out SF6 use in Europe and many other countries.
- Several companies developing SF6 alternatives. No direct replacement for SF6. Change to CB designs required to use alternative gases and operate at higher pressures.
- Trials of equipment with SF6 alternatives occurring around world in a variety of equipment have been occurring since 2012.
- No penalties in Australia for SF6 equipment leaks.
- Leak repair cost ~$25,000.

Paris 2018

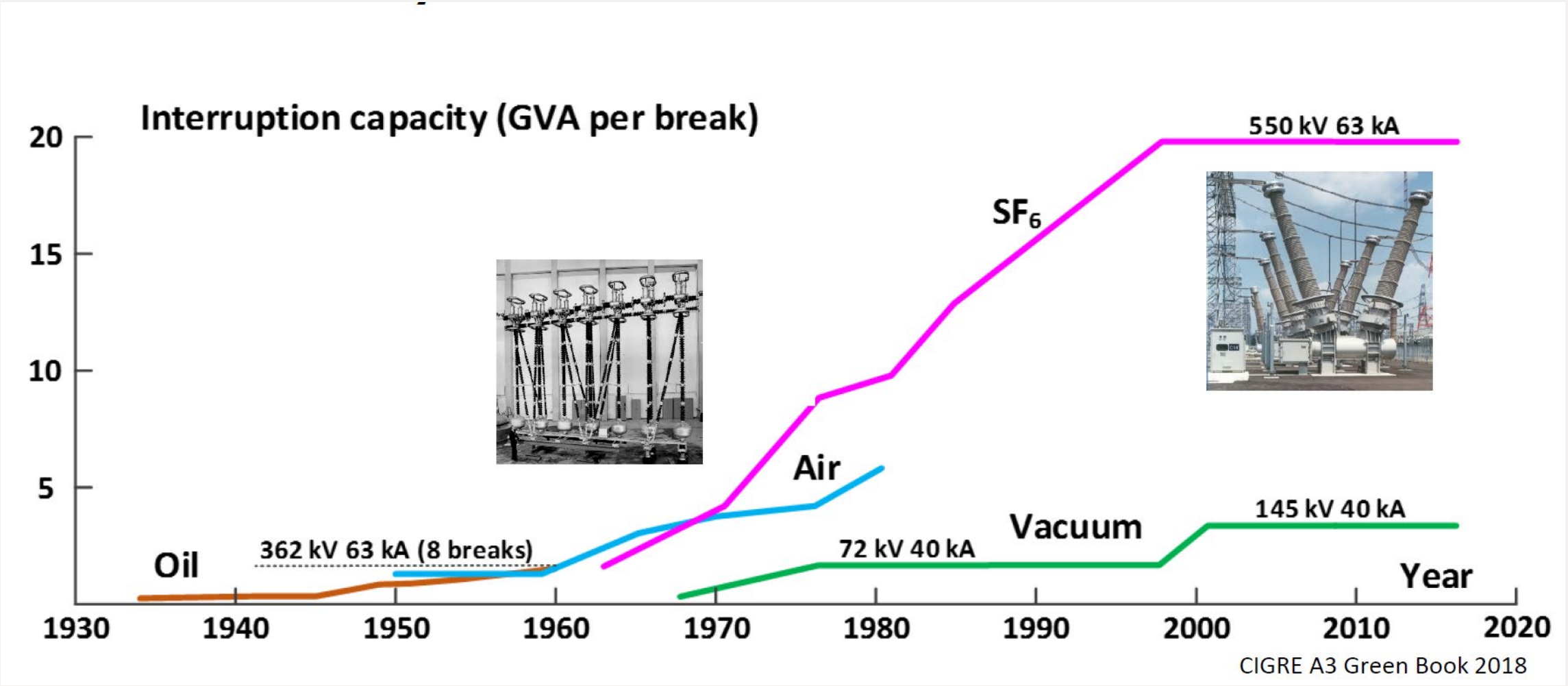
- 5 papers in A3
  - WG A3.41 Impact on switching with alternative gases
- 3 papers in B3
  - WG B3.45 Application in GIS
- 3 papers in D1
  - WG D1.67 Dielectric Performance



36 kV switchgear panel

cigre
For power system expertise

Circuit Breaker SF6 Success story

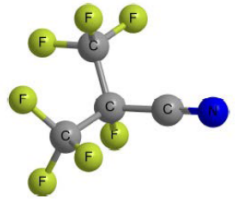


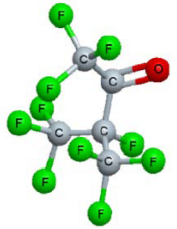
SF6 alternatives @ CIGRE 2018

Pure gas	GWP	P_{min} (MPa)	T_{min} (deg)
SF_6	23500	0.43 .. 0.6	-41 .. -31
CO_2	1	0.6 .. 1	-48
Vacuum (Clean Air™)	0	<<	-60

g³™ (fluoronitrile)	GWP	P_{min} (MPa)	T_{min} (deg)
HV: CO_2+O_2? + 4-6% C4-PFN	327 .. 690	0.67 .. 0.8	-25 .. -10
MV: N_2 + 20-40% C4-PFN	1300 .. 1800	0.13	-25 .. - 20

AirPlus™ (fluoroketone)	GWP	P_{min} (MPa)	T_{min} (deg)
HV: CO_2+ O_2 + 6-12% C5-PFK	1	0.7	-5 .. +5
MV: Air + 7-13% C5-PFK	0.6	0.13	-25 .. -15





Recent developments and interruption performance with SF6 alternative gases, Electra 291, 2017

2019 AU/NZ Activities

2019 AP-A3 Meeting in Perth in October

- 6 attendees
- Discussion points:-
  - Local and International CIGRE matters since last meeting – 2019 SC A3 matters, WG activities and surveys
  - Utility reports – New equipment, ageing equipment risk assessments, equipment failure presentations, procurement issues, SF_6 management and equipment leak issues
  - Asset management topics including Lifecycle cost evaluations; Application of RCM and FMEA for substation equipment; Risk based asset management of substation equipment
- AU A3 providing information to A3 WG surveys on 2014-17 equipment reliability survey & Lifecycle management of T&D switchgear.
- AU A3 member on new WG on Instrument Transformer Failure analysis
- 2 x AU A3 members on WG for Lifecycle management of T&D switchgear

Thank You
Any Questions?

Wayne Pepper

Senior Engineer – Transmission Switchgear

Ausgrid (NSW)

21 November 2019

cigre
For power system expertise

B3

Substations and electrical installations

Presented by Crina Costan - Convener

Brisbane – 21/11/2019

cigre

For power system expertise

SC B3 Overview

Our Mission

- SC B3 aims to facilitate and promote the progress of engineering and exchange of information and knowledge in the field of substations and electrical installations. SC B3 acts to add value to this information and knowledge by means of synthesizing state-of-the-art practices, developing recommendations and providing best practice.

Scope SC B3

- The activities cover the design, construction, maintenance and ongoing management of substations and the electrical installation in power stations excluding generators.
- SC B3 serves a wide range of target groups in the Electric Power Industry whose needs include the technical, economic, environmental and social aspects in varying degrees.
- Major objectives include increased reliability and availability, cost effective engineering solutions, managed environmental impact, effective asset management and the adoption of appropriate technological advances in equipment and systems to achieve these objectives.

2019 Chengdu Symposium

cigre
For power system expertise

Chengdu Event Summary

Symposium and Annual Meeting SC B3

- 6 Study Committees - B3, B5, C1, C3, C6, D2 (Led by B3 and C6);
- 193 abstracts submitted;
- 72 presented papers from 19 countries;
- 336 registered delegates;
- 15 oral sessions;
- 8 tutorials;
- Various workgroup meetings;
- 3 SC annual meetings (B3, C1 and C6); and
- Launch of the Chinese Translated Substation Green Book.

Thanks to our Hosts:

- State Grid Sichuan Electric Power Company;
- Sichuan University; and
- Sichuan Energy Internet Research Institute of Tsinghua University.

and the Sponsors:

- CIGRE;
- CIGRE Chinese National Committee; and
- Chinese Society for Electrical Engineering.

cigré SUSTAINABLE ELECTRICITY FOR ALL

B3 – Highlights / Awards

- **Launch of the Substations Green Book – Chinese Version:**
  - Dr. Jianbin Fan (CN), Terry Krieg (AU)

    and Koji Kowakita (JP).

- **SCB3 Annual Awards:**

- **Mark Osborne (GB):**
  - WG member: B3.11, B3.26, B3.36; Editor: TB740;
  - Substation Greenbook leader of part I - "Future developments";
  - B3 AA1 Area Advisor (2007 - present);
  - SAG member (2007 - present);
  - Special reporter Paris Session (2014 - present).

- **John Nixon (US):**
  - WG member: B3.21, B3.23, B3.31, B3.32, B3.38, B3.46, B3.53 (2006 - present);
  - WG secretary: B3.31, B3.46;
  - Substation Greenbook leader of part B "Air Insulated Substations", chapter 12 "Specification and selection of main components for Air Insulated Substations";
  - Workshop chair at 2018 CIGRE Paris Session.

cigré SUSTAINABLE ELECTRICITY FOR ALL

B3 Current and Future Meetings and Events

AP. B3 Substation Conference – Hunter Valley Nov-Dec 2019

Chairing IEEE Power and Energy Society in Victoria

Contribution to IEEE standards

Future B3 meetings:

- 2019 Symposium in Chengdu, China - with C6; and also B5, C1, C3, and D2
- 2021 Symposium in Bucharest, Romania – with A2
- 2023 – New Delhi, India or Cairns, Australia?

Other Future events:

- IEC Conference on UHV AC/DC Trends – Hakodate, Japan April 23-26, 2019
- Conference on Condition Monitoring – Bucharest, Romania Sept 7-13, 2019

B3 Deliverables

B3 has 26 active WG's, 3 recent Technical Brochures, with the Substation Green Book now published and available for sale or download:

- ✓ TB 723 "SF_6 Measurement Guide" WG 40
- ✓ TB 734 "Management of Risk in Substations " WG 38
- ✓ TB 740 "Contemporary Design of Low Cost Substations in Developing Countries" WG 43

cigre
For power system expertise

AP.B3 Substations 2019 Conference

1. Building substations for a sustainable green grid:

- Evolution of design, operations and maintenance skills with the connection of renewables to existing infrastructure
- Environmental, safety and fire protection changes with the connection of renewables to existing infrastructure
- Integration of renewables and storage technologies to existing substations – challenges and opportunities

2. Challenges and opportunities of substation digitalisation:

- Transition from traditional substation design to digitalised substation
- Substation digitalisation contribution to increased substation resilience
- Digital information storage platforms and usage

3. Managing ageing substation assets in an era of digital substations:

- Integration of new technologies (hardware and software) into existing substations
- Making economic and risk-based decisions supporting asset management
- Experience with life extension methods in substations

AP.B3 Substations 2019 Conference

DAY 1 – Thursday, 7 November 2019	Presenter	Company	
Conference Registration			0745 - 0830
Welcome & Introduction to Conference. **Welcome from Bess Clark, General Manager Project Marinus, TasNetworks** **Welcome from Steve Davy, Chief Executive Officer, Hydro Tasmania**			0830 - 0845 0845 - 0850 0850 - 0855
Introduction to Guest Speaker			0855 - 0900
Key Note Address: Hon. Guy Barnett - Minister for Primary Industries & Water, Minister for Resources, Minister for Energy			0900 - 0920
Futuristic Networks: Grid Collection Substations	Anurag Gupta	GHD	0920 - 0940
Integrating Synchronous Condensers into Renewable Generator and Grid Substations	Peter Berry	CPP	0940 - 1000
Connecting Renewable Generation Sources – Now a Network Issue	George Bergholcs	ElectraNet	1000 - 1020
Questions and Answers			1020 – 1030
Morning Tea			1030 - 1050
DERMS – The Future of DER Operation in Microgrids	Lee Ucich Perry Tonking	Horizon Power	1050 - 1110
Introduction to Seminars of Day 2			1110 - 1115
- Low Cost Substation Design Solutions (for Developing Countries)	Perry Tonking	CIGRE	
- Current Interruption in Atmospheric Air"	David Peelo	IEEE	
- Substation Earthing System Design Optimisation Through the Application of Quantified Risk Analysis (QRA)	Steve Palmer	Safearth	
- Workshop – High Power, Grid Forming Inverters enabling tomorrow's high renewables NEM	Stephen Sproul	ABB	
The possibilities of hydrogen technologies in direct network support applications	Mark Jackson	Mark G Jackson Consulting	1115 - 1135
Integration of a Large BESS to a Brownfield Substation	Dorin Costan	ElectraNet	1135 - 1155
Isolation techniques and guarding against the risks of back feeding	Faraz Mirzaagha	DNV GL	1155 - 1215
Questions and Answers			1215 - 1230
Lunch			1230 - 1300
Panel Discussion: Challenges Associated with the Connection of Renewables to Existing Substations	John Szmalko	Jacobs Engineering	1300 - 1400
Paradigm Shift in Power Transformer Asset Management by "Digitizing" & "Digitalizing" Temperature Measurements	Bhaba Das, Naser Hashemnia	ABB	1400 - 1420
Managing technical and non-technical challenges in the transition to a digitalised substation	Lara Kruk	Jacobs Engineering	1420 - 1440
Experiences with TransGrid's Journey to Substation Digitisation	Mark Jones	TransGrid	1440 - 1500
Earthing Systems and Substation Digitisation-issues, investigations and solutions	Stephen Palmer	Safearth	1500 - 1520
Modernising Substation Delivery through the use of BIM	John Fallow	Beca (NZ)	1520 - 1535
Questions and Answers			1535 - 1540
Afternoon Tea			1540 - 1550
Performance and Operational Experiences of High Voltage GIS with clean air insulation and digital features	Chris Gonzalez	Siemens	1550 - 1610
Point on Wave Switching of Power Transformers	Alan Crombie	UGL	1610 - 1630
End of Life Strategies for Substation Gantry Steelwork and Foundations	Evan Lamplough	TransGrid	1630 - 1650
Developments in the use of non-SF_6 gases and gas mixtures for a more sustainable grid	Terry Krieg	Power Network Consulting	1650 - 1710
Questions and Answers			1710 - 1720
Close of Day 1			
Cocktail Reception & Networking Function – Trade display area, Wrest Point Casino			1730 - 2030

cigre
For power system expertise

AP.B3 Substations 2019 Conference

ARENA Australian Government Australian Renewable Energy Agency

MARINUS LINK

TasNetworks Delivering your power

MEDIA RELEASE – TASNETWORKS SUPPORTS CIGRE SUBSTATION 2019 CONFERENCE

BY PROJECT MARINUS
NOVEMBER 7TH, 2019

From Bess Clark, General Manager Project Marinus – TasNetworks

TasNetworks is very pleased to support the CIGRE Substations 2019 conference held at the iconic Wrest Point Casino in Hobart on November 7-8. CIGRE and its members around Australia, New Zealand, and the world, undertake important work in considering the technical and economic aspects of the end to end power system.

The conference gathers together experts in the industry to discuss solutions to address some of the challenges facing the rapidly transforming power system including the influx of variable renewable generation.

Bess Clark, General Manager of Project Marinus at TasNetworks, opened the conference, and spoke about the important relationship TasNetworks has with CIGRE.

Ms Clark demonstrated the evolution of the power system in Tasmania over the decades by looking at the Emu Bay Substation in Burnie, featured in a Advocate News clipping from 1939.

cigre For power system expertise

AP.B3 New WG Members

WG B3.52 Neutral Grounding Method Selection and Fault Handling for Substations in the Distribution Grid

Bill Carman as Correspondent Member

WG.B3.53 (new): Guidelines for fire risk assessment and mitigation in substations

Michael Verrier, Terry Lee as Members and Derek Perkins as Correspondent Member

WG.B3.54 Earthing System Testing Methods

Stephen Palmer WG Convener

WG B3.55 Design guidelines for substations connecting battery energy storage solutions (BESS)

Crina Costan: as Correspondent Member

WG B3.56 Application of 3D Technologies in Substation Engineering Works

Todd Margitich: Member

WG.B3.46: Guidelines for Safe Work Methods in Substations

Perry Tonking as Correspondent Member and Kerry Williams as Member

AP.B3 Panel Members

	Name	Company
1.	Alan Crombie	UGL
2.	Alan Goodridge	Peracon
3.	Andy McMahon	Transpower
4.	Andreas Laubi	Jacobs
5.	George Bergholcs	ElectraNet
6.	Colin Crisafulli	Endeavour
7.	Doug Ray	Vector
8.	Mark Hibbert	Aurecon
9.	Michael Verrier	TasNetworks
10.	Ping S Wang	GE Grid
11.	Simon Hickey	Energy Queensland
12.	Stephen Palmer	Safearth
13.	Peregrine Tonking	Horizon Power
14.	Terry Krieg	Powernetwork Consulting
15.	Chris Gonzalez	Siemens
16.	Wu Hang	Aecom
17.	Jeremy Kearney	Entura
18.	Mark Pritchard	SA Power Networks
19.	Evan Lamplough	Transgrid
20.	Dasgupta Raj	NT Water & Power
21.	Malcolm Busby	WSP
22.	Anurag Gupta	GHD
23.	Mark Burns	Office of Technical Regulator
24.	Marco Surace	Western Power
25.	John Szmalko	Jacobs
26.	Joseph Pinheiro	Powerlink
27.	Hao Tian	ABB
28.	Chris Grinter	AusNet
29.	Crina-Miana Costan	TS Consulting
30.	Robert Scott	NGN - TasNetworks

ATC

cigre
For power system expertise

C3 System Environmental Performance

Presented by James Hart - Convener

Brisbane – 21/11/2019

cigre

For power system expertise

SC C3 Scope

Responsible for the identification and assessment of the various impacts on the natural environment arising in electric power systems and the recommendation of appropriate monitoring, management and control measures.

Impacts addressed will include greenhouse gases, air and water pollution, electromagnetic fields, noise, visual, land use and flora and fauna impacts.

cigre
For power system expertise

2019 International Activities

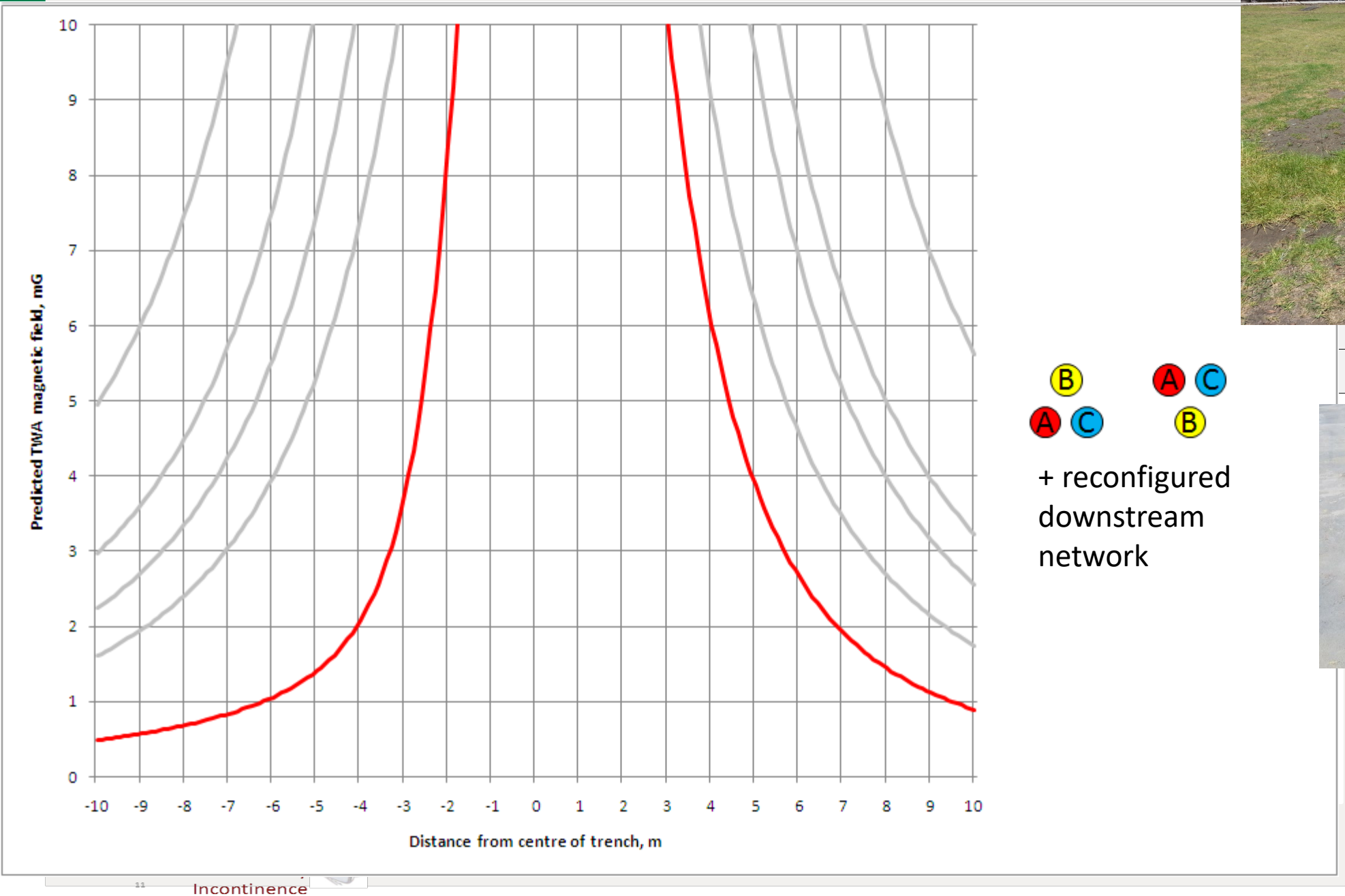
Symposium - Going offshore - Challenges of the future power grid

Active Working Groups

- RG C3.01 EMF and Health
- WG C3.09 Corridor management (Renewed)
- WG C3.12 Methodologies for GHG inventory and reporting for T&D utilities
- WG C3.14 Impact of environmental liability on transmission and distribution activities
- WG C3.15 Best environmental and socio-economic practices for improving public acceptance of high voltage substations
- WG C3.16 Interactions between electric infrastructure and wildlife
- WG C3.17 Interaction between wildlife and emerging RES and submarine cables
- WG C3.18 Eco-friendly approaches in Transmission and Distribution
- WG C3.19 Responsible management of the EMF Issue
- WG C3.20 Sustainable development goals in the electric power sector
- WG C3.21 Including stakeholders in the investment planning process (Renewed TOR of former JWGC1/C3.31)
- WG C3.22 Vegetation management in substations
- WG C3.23 Eco-design methods for TSO/DSO under environmental transition

cigre
For power system expertise

EMF



B A C

A C B

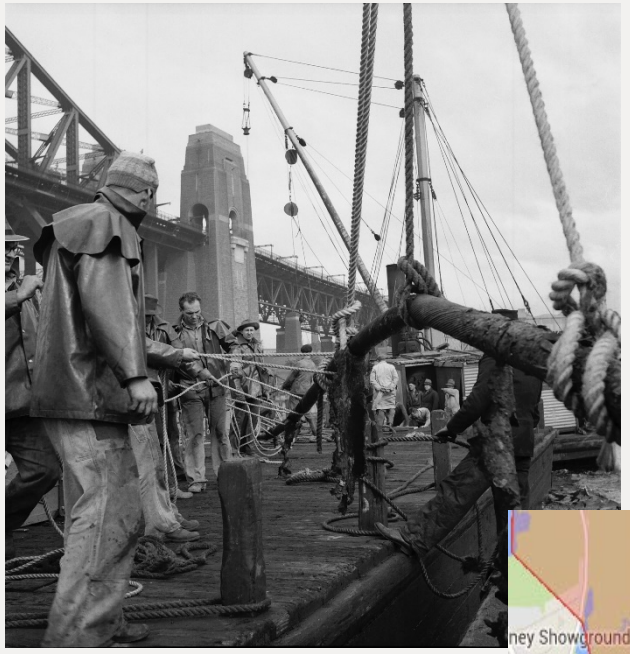
+ reconfigured downstream network

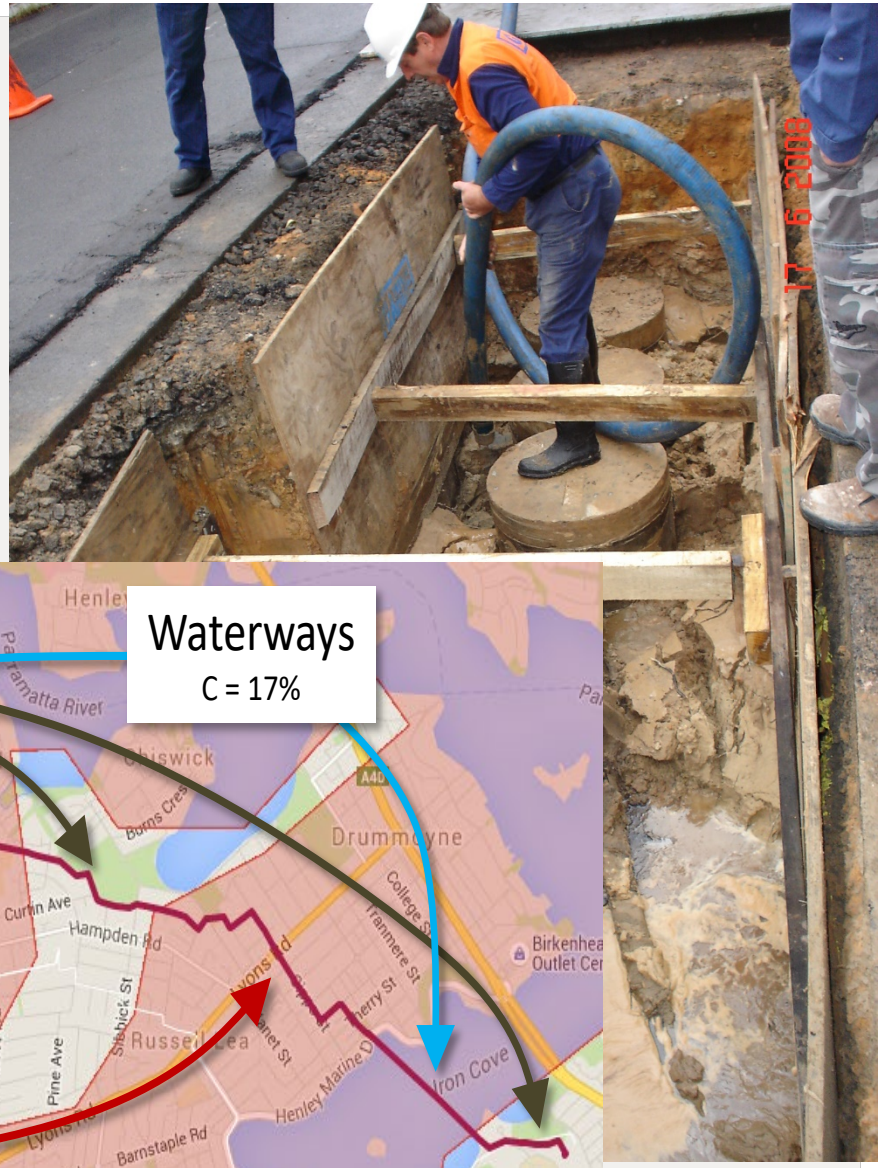
Incontinence

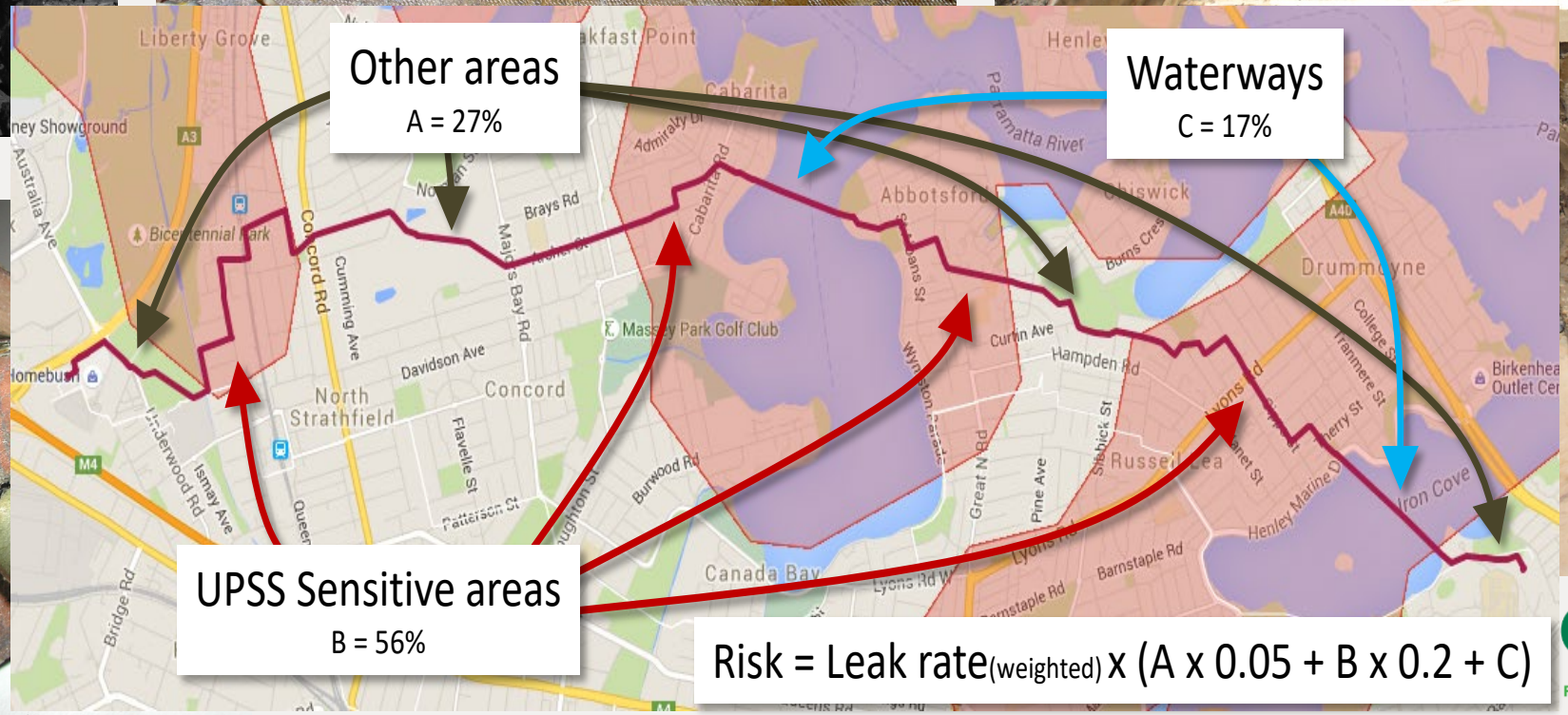
cigre
For power system expertise

Oil filled cables

cigre
For power system expertise







Other areas
A = 27%

Waterways
C = 17%

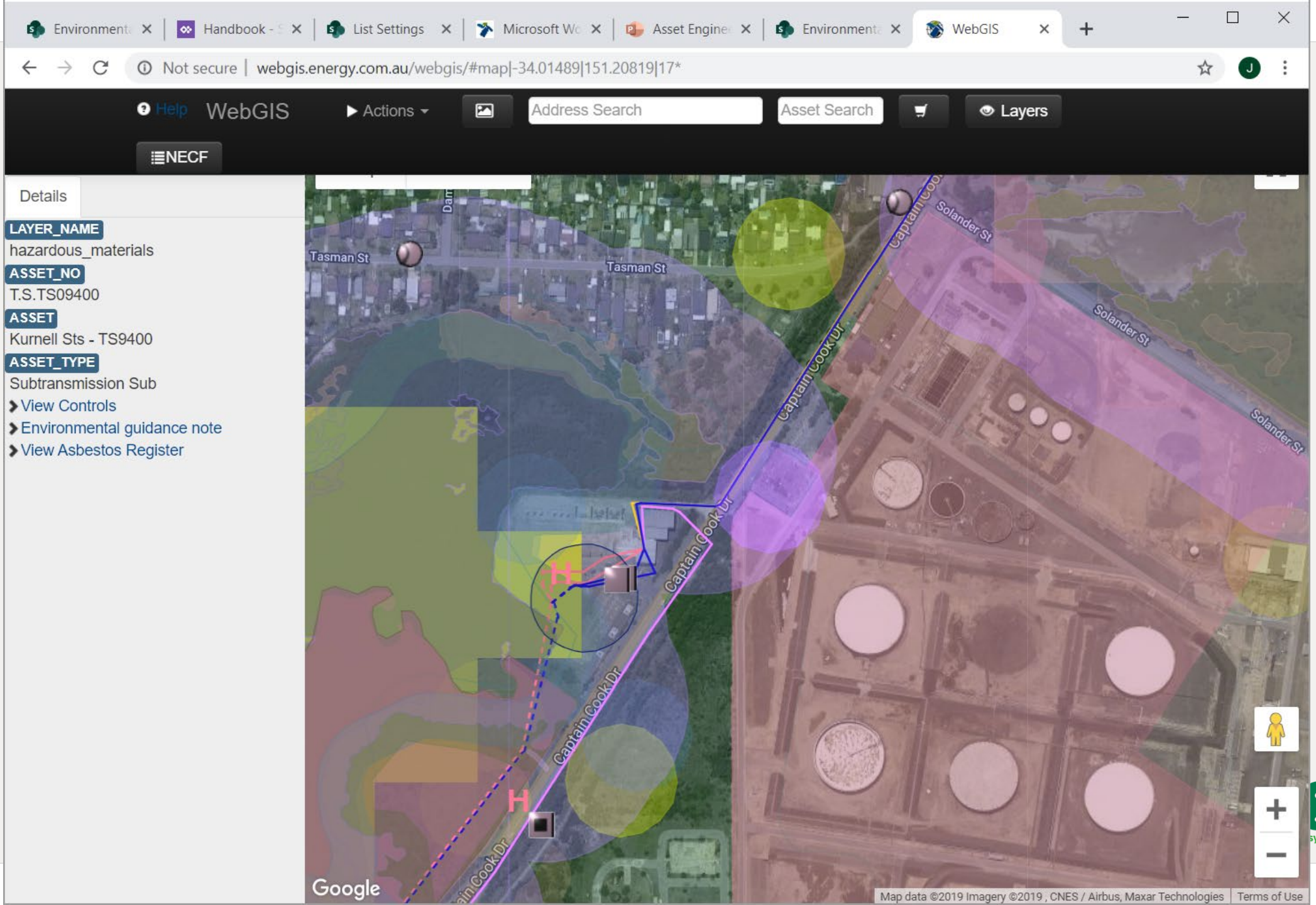
UPSS Sensitive areas
B = 56%

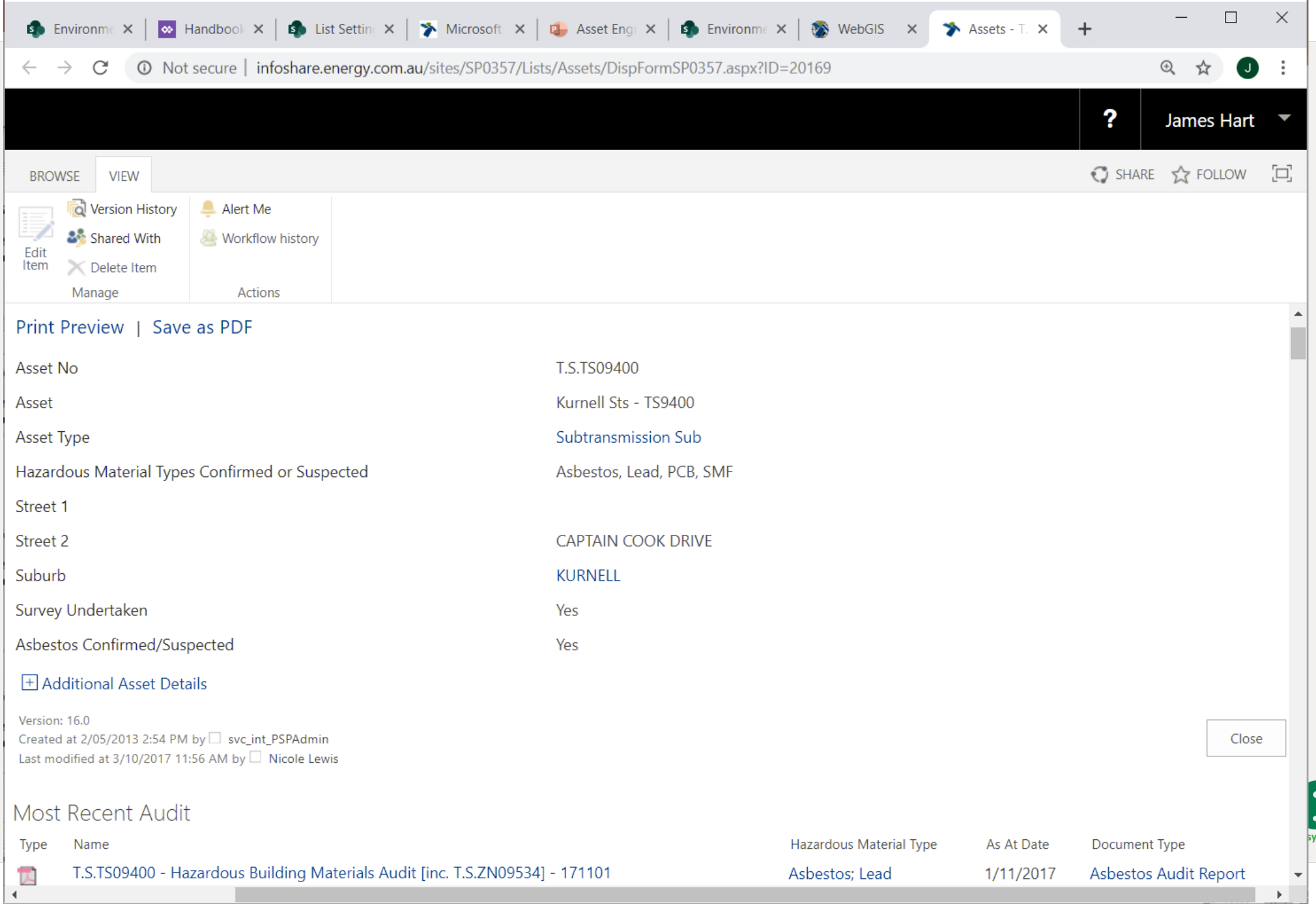
Risk = Leak rate(weighted) x (A x 0.05 + B x 0.2 + C)

cigre
For power system expertise

Environmental planning tools

cigre
For power system expertise


WebGIS
Not secure | webgis.energy.com.au/webgis/#map|-34.01489|151.20819|17*
Help
WebGIS
Actions
Address Search
Asset Search
Layers
NECF
Details
LAYER_NAME
hazardous_materials
ASSET_NO
T.S.TS09400
ASSET
Kurnell Sts - TS9400
ASSET_TYPE
Subtransmission Sub
View Controls
Environmental guidance note
View Asbestos Register
Tasman St
Captain Cook Dr
Solander St
Google
Map data ©2019 Imagery ©2019 , CNES / Airbus, Maxar Technologies
Terms of Use


Environme
Handbook
List Setting
Microsoft
Asset Engi
Environme
WebGIS
Assets - T.
Not secure | infoshare.energy.com.au/sites/SP0357/Lists/Assets/DispFormSP0357.aspx?ID=20169
James Hart
BROWSE
VIEW
SHARE
FOLLOW
Version History
Shared With
Delete Item
Edit Item
Manage
Alert Me
Workflow history
Actions
Print Preview | Save as PDF
Asset No
T.S.TS09400
Asset
Kurnell Sts - TS9400
Asset Type
Subtransmission Sub
Hazardous Material Types Confirmed or Suspected
Asbestos, Lead, PCB, SMF
Street 1
Street 2
CAPTAIN COOK DRIVE
Suburb
KURNELL
Survey Undertaken
Yes
Asbestos Confirmed/Suspected
Yes
Additional Asset Details
Version: 16.0
Created at 2/05/2013 2:54 PM by svc_int_PSPAdmin
Last modified at 3/10/2017 11:56 AM by Nicole Lewis
Close
Most Recent Audit
Type
Name
Hazardous Material Type
As At Date
Document Type
T.S.TS09400 - Hazardous Building Materials Audit [inc. T.S.ZN09534] - 171101
Asbestos; Lead
1/11/2017
Asbestos Audit Report

PRM
PROGRESSIVE RISK MANAGEMENT

Photolog

Site:	Zone Substation Kurnell - ZN9400 & Kurnell Zone Substation (New	**Project Details:**	P033634.001 / C0002

Photo 7: Yard, ground floor, external, 33 kV feeders, residue to cables - Positive Asbestos Debris

Photo 8: Yard, ground floor, external, 33 kV feeders, residue to cables - Positive Asbestos Debris

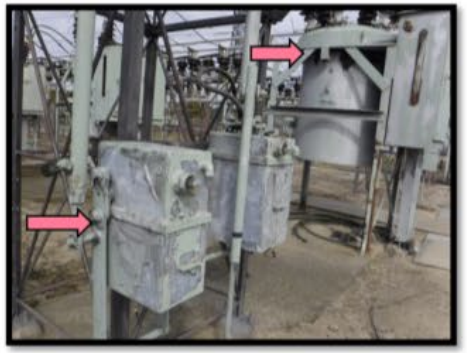


Photo 9: Yard, ground floor, external, circuit breakers and earthing switches, green paint - Lead based Paint

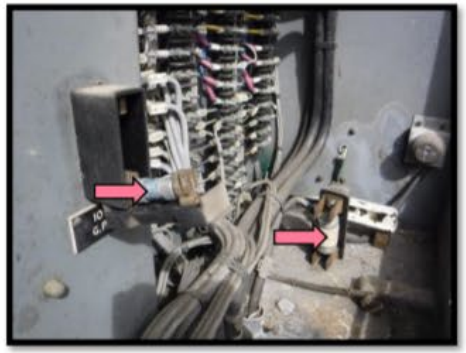
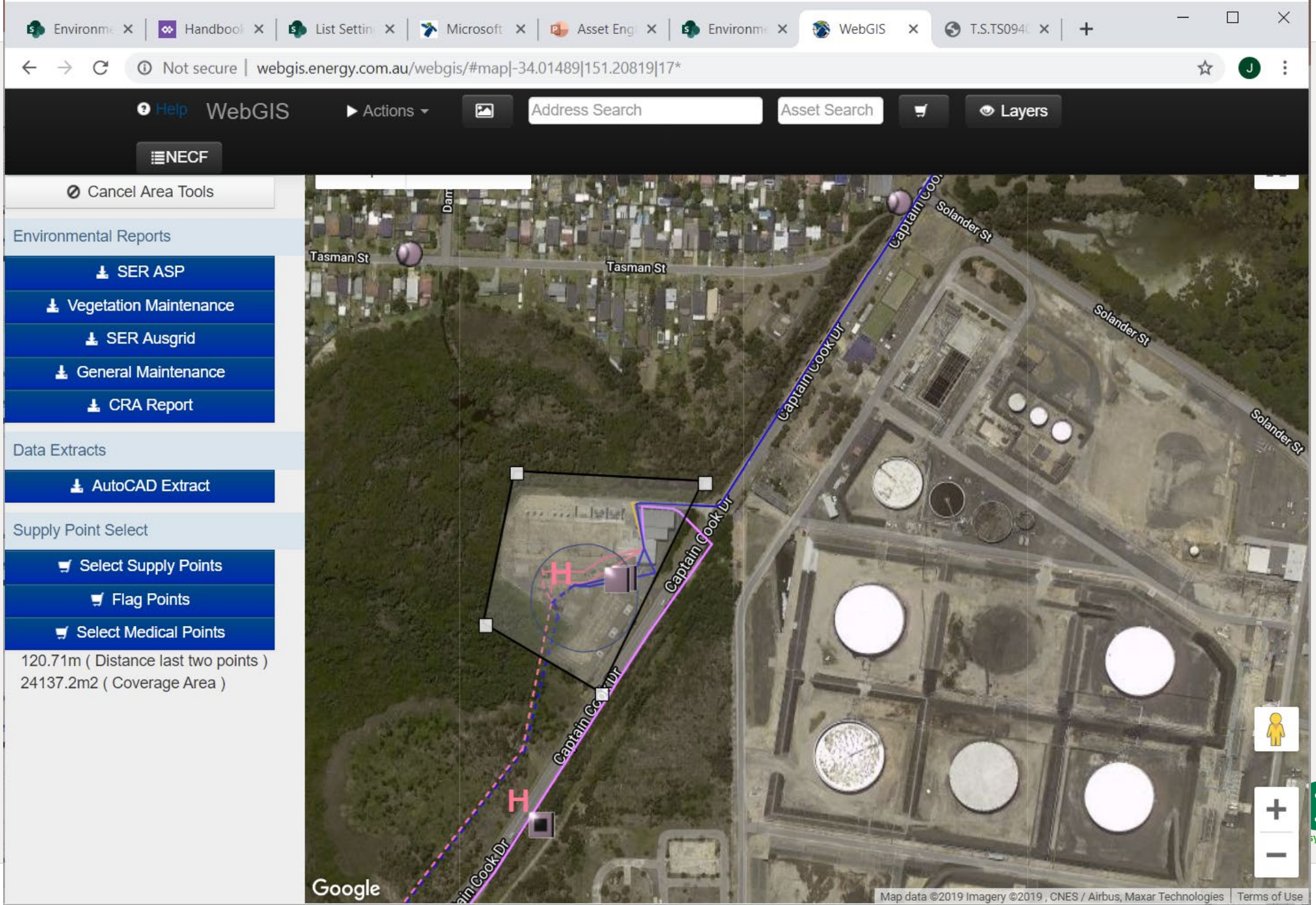


Photo 10: Yard, ground floor, external, throughout - Suspected Positive LV HRC Fuses

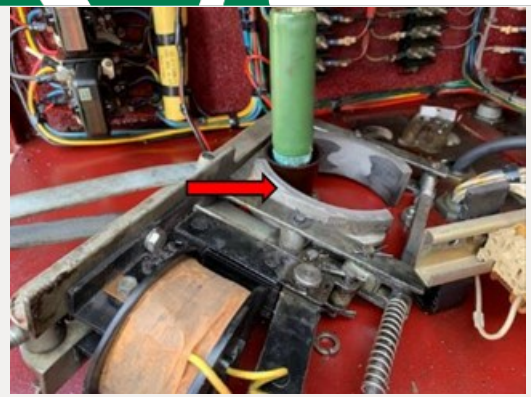

WebGIS
Not secure | webgis.energy.com.au/webgis/#map|-34.01489|151.20819|17*
Help
WebGIS
Actions
Address Search
Asset Search
Layers
NECF
Cancel Area Tools
Environmental Reports
SER ASP
Vegetation Maintenance
SER Ausgrid
General Maintenance
CRA Report
Data Extracts
AutoCAD Extract
Supply Point Select
Select Supply Points
Flag Points
Select Medical Points
120.71m (Distance last two points)
24137.2m2 (Coverage Area)
Tasman St
Solander St
Captain Cook Dr
Google
Map data ©2019 Imagery ©2019 , CNES / Airbus, Maxar Technologies
Terms of Use

Restricted Area - NSW National Park Estate	Towra Point Nature Reserve	1	1. Works in ecological sensitive areas require a specialist assessment and / or approval unless all of the following controls are implemented:
			• All workers to be made aware of ecological sensitive areas and the need to avoid impacts.
			• No works in undisturbed areas (including storing equipment, parking vehicles or accessing the site).
			• No disturbance of bush rock, tree hollows, wetlands, mangroves, nests, aquatic or other sensitive habitats.
			• Retain ground cover vegetation, excluding regularly mown or slashed areas.
			• Keep vehicle and plant movements to existing roadways or access tracks.
			• No importing mulch from other sites.
			• No disturbance of native vegetation unless all of the following apply:
			  ◦ works are for the purpose of vegetation maintenance.
			  ◦ works are undertaken in accordance with ISSC 3, NS179 Vegetation Management and Ausgrid's Tree Safety Management Plan.
			  ◦ clearing is to the minimum extent necessary to maintain existing and regularly maintained clearances (ie no new clearance envelopes).
			• Inspect the worksite for animal occupation prior to starting work.
			• Where animals are present (eg birds, possums, snakes, bats) wait for the animal to relocate.
			• Where animals (including eggs and nests) need to be physically relocated contact a local wildlife rescue organisation or NPWS.
			• When undertaking inspection, maintenance and emergency works in national park estate, comply with the OEH Protocol and Consent. Conditions include:
			  ◦ Provide at least 4 days' notice for inspection works (unless the inspections are undertaken by foot or passenger vehicle and do not require the use of equipment).
			  ◦ Provide at least 2 weeks' notice and a conservation risk assessment for maintenance works.
			  ◦ Provide notice as soon as practicable after any emergency works have been undertaken.

Restricted Area - RMS Classified Road	REGIONAL	1	The area defined by this report contains RMS Classified Roads. 1. Consents, approvals and ROLs (where required) must be in place prior to works commencing. Comply with associated conditions. 2. Ensure that affected residences / businesses are consulted in accordance with NS 174C (Section 1-6).

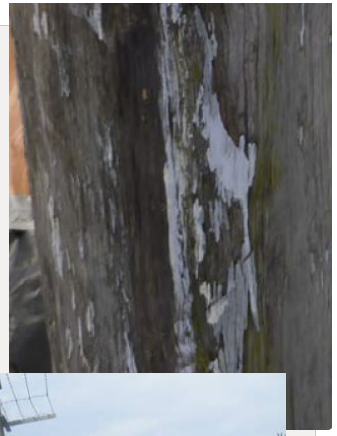
Asbestos

cigre
For power system expertise



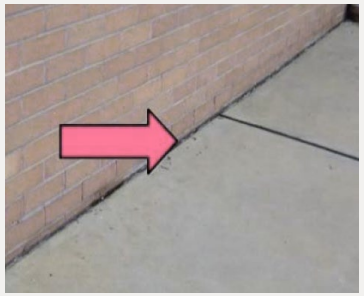
Reinhausen tap changer

Meters



John valves

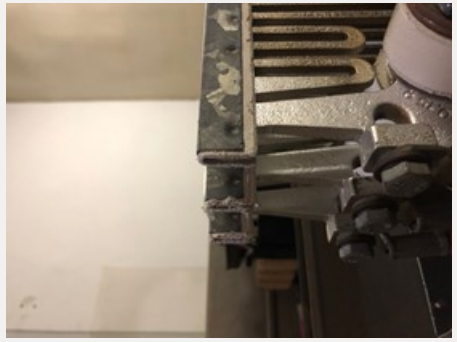
Relays



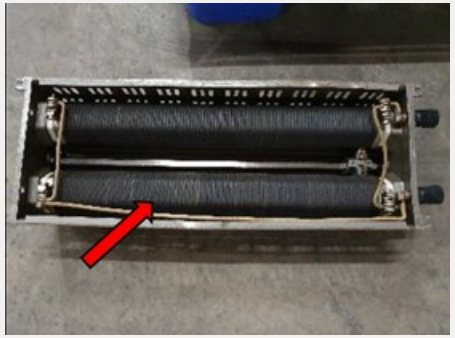
Water proofing membranes

Paint

Recycled spoil



Ripple filter resistor



Berco resistor

Westinghouse relay

cigre
For power system expertise

D1 Materials and Emerging Test Techniques

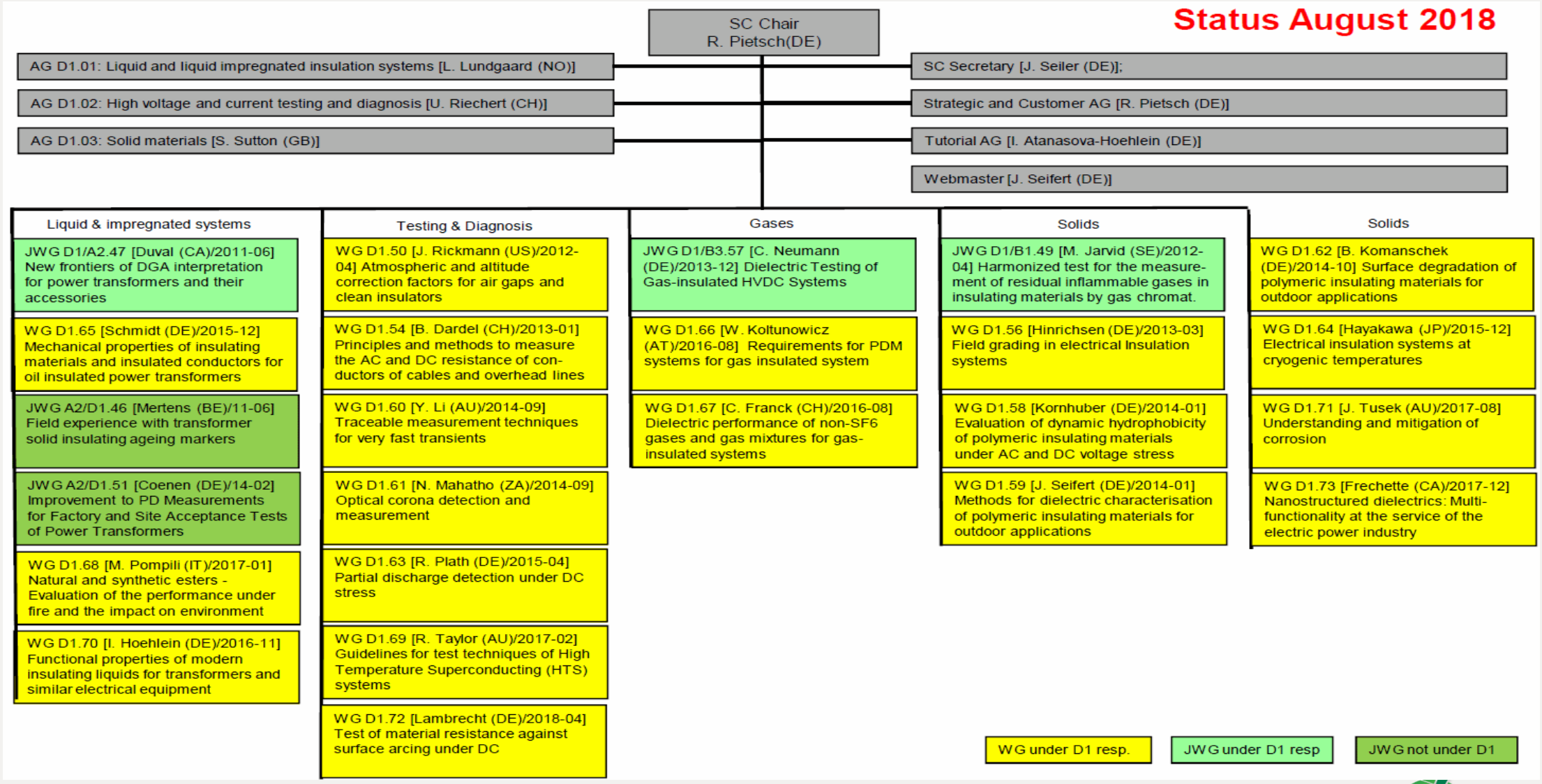
Presented by Joe Tusek - Convener

Brisbane – 21/11/2019

cigre

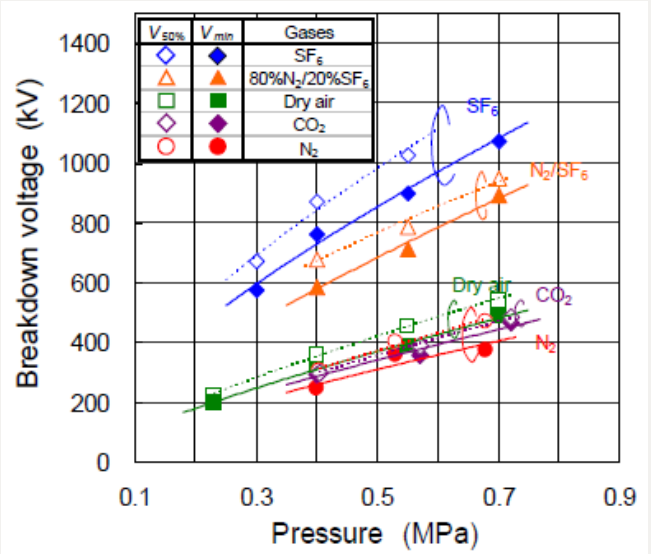
For power system expertise

Status August 2018



cigre
For power system expertise

Recent Areas Interest in D1



SF6 Alternatives

The industry is slowly moving to an SF6 free future.

TB 730 from WG D1.51 produced a brochure outlining the potential to use natural-origin gases (dry air, N2, CO2) and N2/SF6 gas mixtures as are placement for SF6.

Organisations need to start thinking about gas handling, as it is likely that there will be a number of gases in use.

Note : Vacuum breakers at 145kV are now a catalogue item.

TB 738 - Ageing Of Liquid Impregnated Cellulose

For power Transformers, documents new understanding of ageing mechanisms in paper-oil insulation including thermally upgraded papers.

Identifies that the different types of degradation have different temperature dependant degradation rates.

Paper's mechanical strength is considered the key determinant for condition assessment, ability to withstand shear-stress is key.

The TB also discussing the benefit of various life extension options, such as moisture and oxygen removal. Also, various drying options including low frequency heating.

cigre
For power system expertise

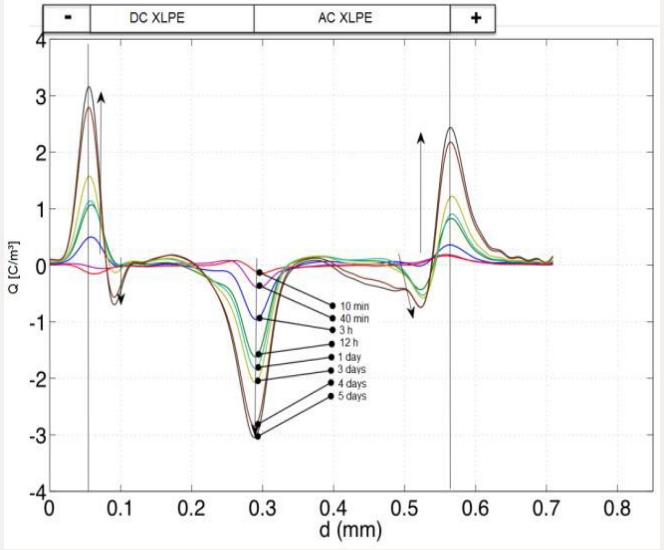
Recent Areas Interest in D1

TB 751 - Electrical properties of insulating materials under VLF voltage

The TB outlines the results of investigations into the properties of materials under VLF, considering the frequency range from 0.01-1.0 Hz.

The various ways in which VLF is produced and the impact of the different waveshapes is considered. As is the breakdown of insulation under VLF and generation of space charge.

An important consideration is the electric field distribution within accessories under VLF conditions.



TB 765 - Understanding and mitigating corrosion

The TB outlines the science and factors associated with corrosion and its prevention.

Its aim is to provide a common understanding and language for corrosion within the Cigre community.

This brochure is the what and how of corrosion and will be followed up by a new Working Group that will look at specific instances and remediations of corrosion within electrotechnical arena.

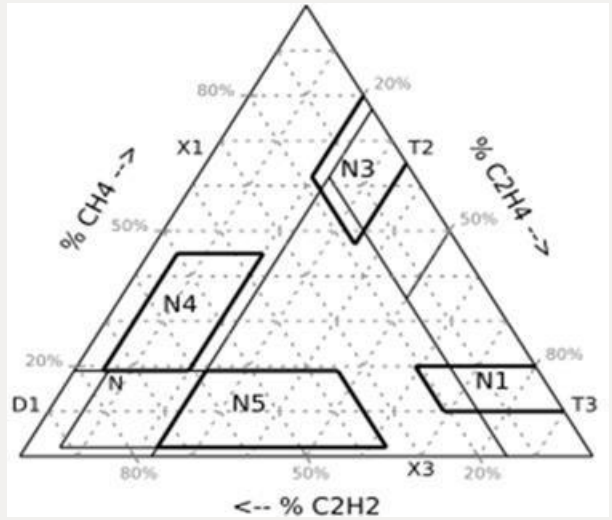
cigre
For power system expertise

Recent Areas Interest in D1

TB 771 - DGA interpretation advances

is the output of JWG D1/A2.47, is the long-awaited brochure that contains a comprehensive description of Michel Duval's various analytical tools for interpreting insulating oil Dissolved Gas Analysis results.

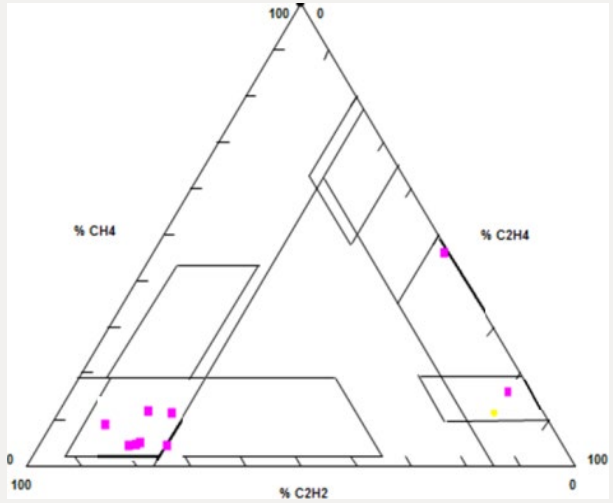
The brochure covers the triangle and pentagon analytical methods and contains numerous case studies which demonstrate their use.



TB 779 - Field experience with transformer solid insulation ageing markers

This brochure demonstrates the applicability of Methanol as another indicator for degree of polymersation of paper.

It compares the characteristics of Furans and Methanol for paper degradation, showing where each gives the greatest sensitivity.



cigre
For power system expertise

2020 Paris Session

PS 1 : Testing, Monitoring And Diagnostics

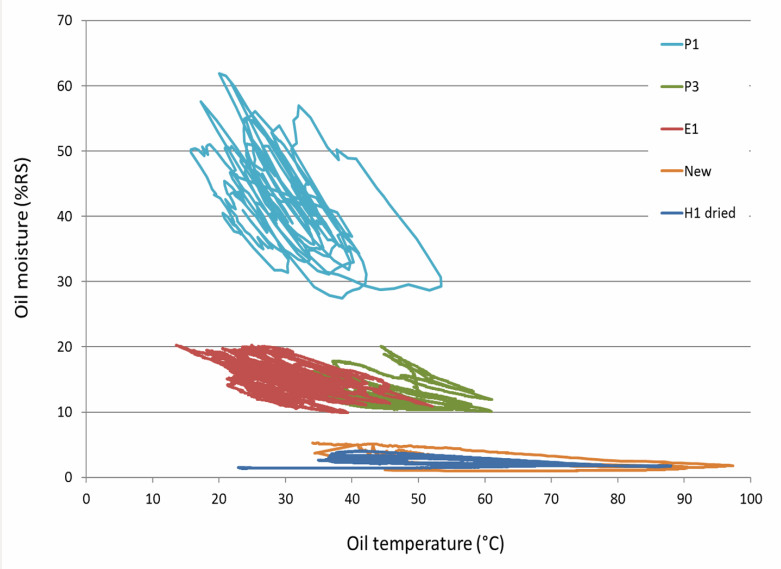
- Experience and insight from monitoring systems.
- Reliability of test equipment and systems for testing, monitoring, and diagnostics.
- Data handling, analytics, and advanced condition assessment.

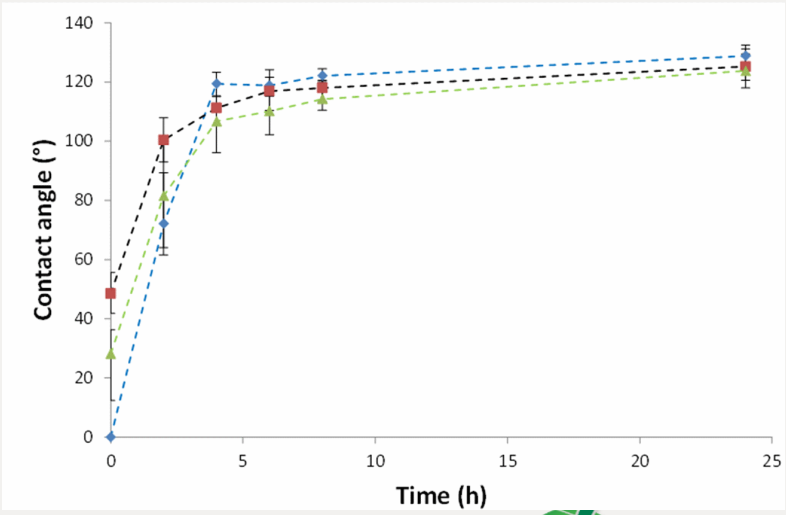
PS 2 : Functional Properties And Degradation Of Insulation Materials

- New stresses, e.g. power electronics, load cycling, higher temperatures, and compact applications.
- Materials with lower environmental footprint, during production, operation, and disposal.
- Characterisation methods for validating functional properties.

PS 3 : Insulation Systems Of Advanced Components

- Materials under high stresses, e.g. field stress, flux, electric current, and frequency.
- Experience and requirements for new test procedures and standards.
- Development of new materials, e.g. 3D printing; lamination; casting; and additive or subtractive manufacturing.





cigre
For power system expertise

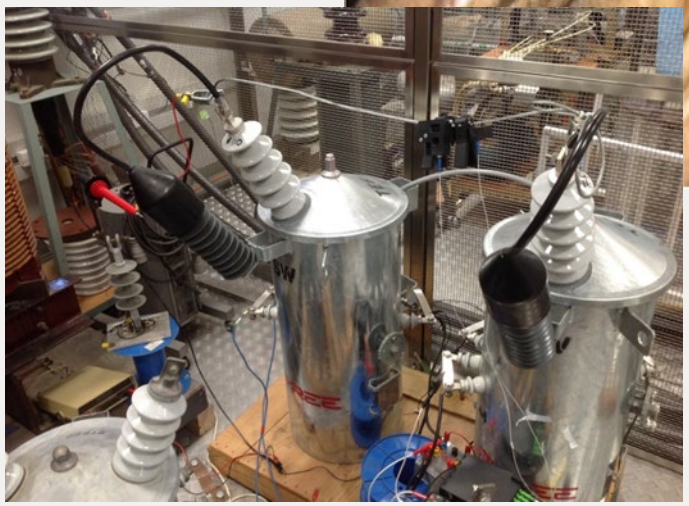
2019 AP D1 Activities

Highlights

- **Meeting held 22 October 2019 in Newcastle**
  - SWER line arching fault monitoring
  - Transformer Frequency Response Analysis
  - Synchronous condenser installation in SA network
  - Technical details of transformer tank design that greatly increase risk of water ingress.
  - Cable testing of very long HV cables.

- **Participating in WG's**

D1.48	Properties of insulating materials under VLF voltages
D1.59	Methods for dielectric characterisation of polymeric insulating materials for outdoor applications
D1.60	Traceable measurement techniques for very fast transients
D1.50	Atmospheric and altitude correction factors for air gaps and clean insulators
D1.69	Guidelines for test techniques of High Temperature Superconducting (HTS) systems



cigre
For power system expertise

2019 AU/NZ D1 Activities

D1 Papers accepted for Paris Session

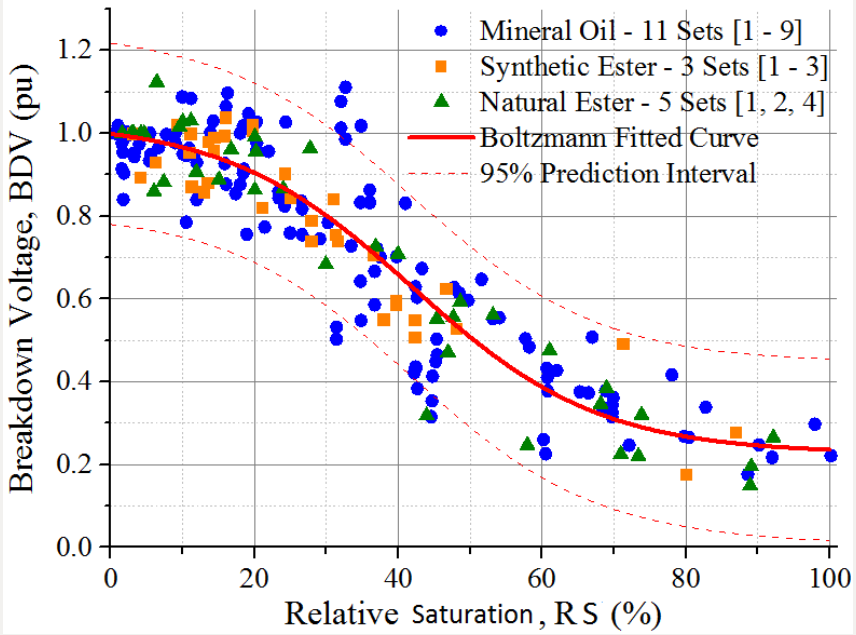
- ✓ D1-519 Extended Frequency Range Testing of HV Cables - J. Tusek
- ✓ D1-500 A measurement system for insulator puncture test with the fast-rise impulse voltage – Dr Y. Li
- ✓ D1-511 Characterization of pressboard mechanical properties for understanding the dynamic behaviour of transformer winding clamping pressure – Prof T. Saha.

cigre
For power system expertise

2019 Deliverables

Technical Brochures

- TB 783 – D1/A2.47 - DGA Monitoring Systems - 2019
- TB 779 – Field Experience With Transformer Solid Insulation Ageing Markers - 2019
- TB 771 - Advances In DGA Interpretation - 2019
- TB 765 - Understanding And Mitigating Corrosion - 2019
- TB 741 - Moisture measurement and assessment in transformer insulation - Evaluation of chemical methods and moisture capacitive sensors - 2018
- TB 738 - Ageing of liquid impregnated cellulose for power transformers- 2018
- TB 730 - Dry air, N2, CO2, and N2/SF6 mixtures for gas-insulated systems - 2018
- TB 706 - Guidelines for the use of statistics and statistical tools on life data - 2017
- TB 705 - Guidelines for altitude correction of pollution performance of insulators - 2017
- TB 703 - Insulation degradation under fast, repetitive voltage pulses - 2017
- TB 691 - Pollution test of naturally and artificially contaminated insulators - 2017
- TB 676 - Partial discharges in transformers – 2017



cigre
For power system expertise

Presented by Peter Bishop - Convener

Brisbane – 21/11/2019

cigre

For power system expertise

B5

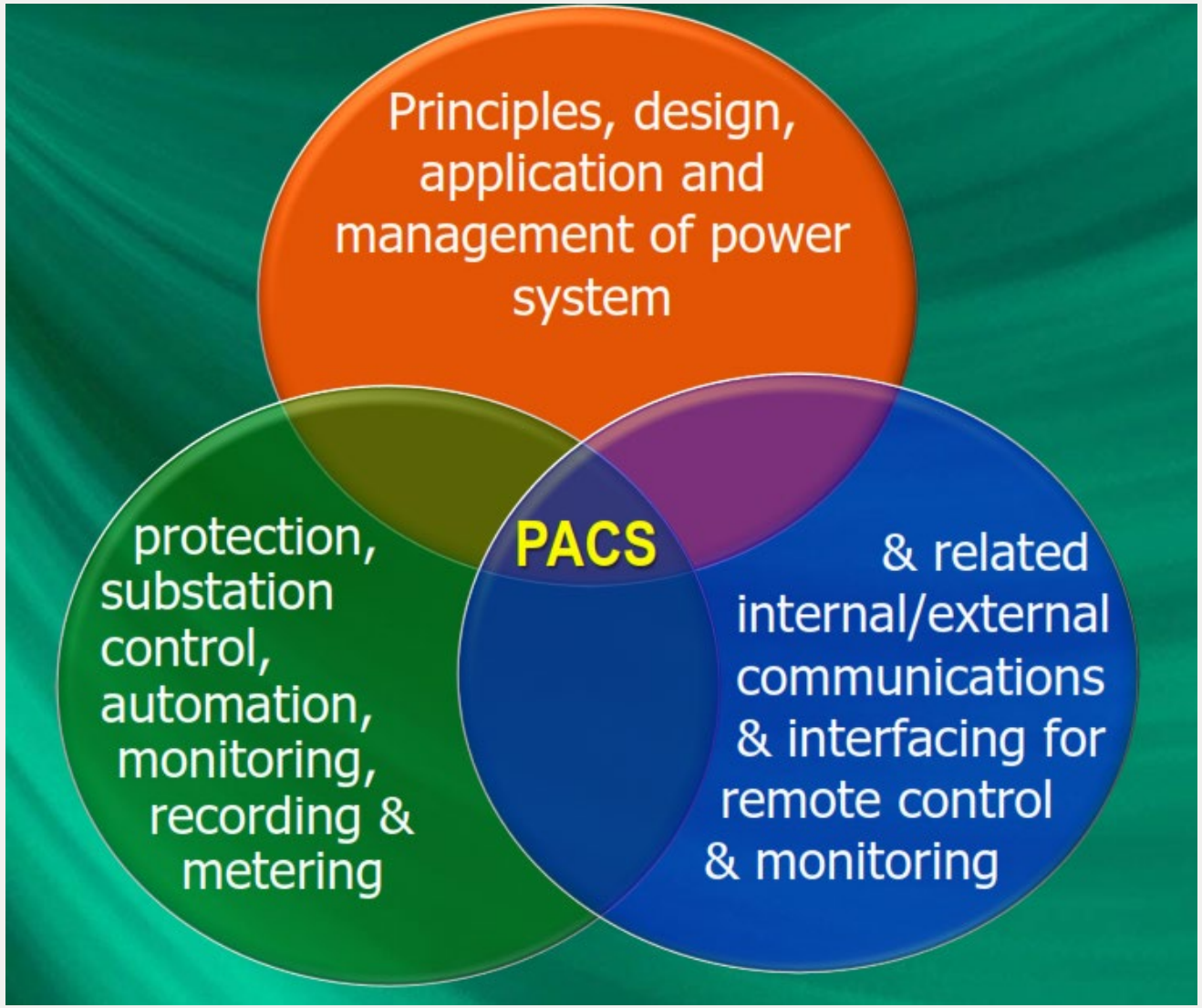
Protection and automation

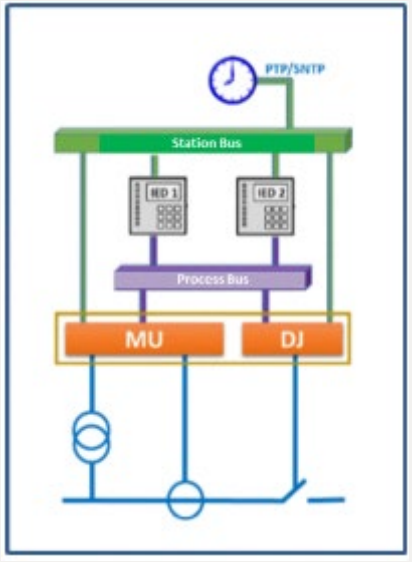
Contents

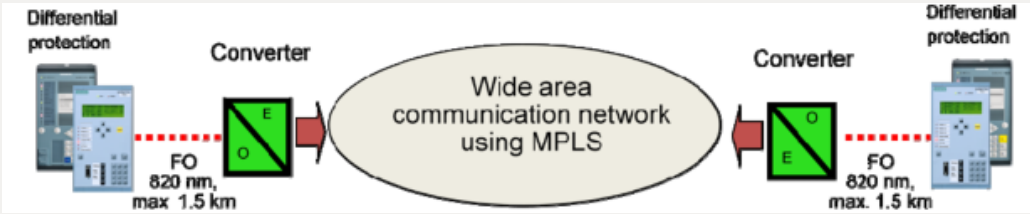
- Scope of Study Committee B5 – Protection & Automation
- Key B5 Future Focus Areas
- Study Committee B5 Meeting - Topics of Relevance
- Australia/NZ Activities
  - March SEAPAC Protection Conference in Sydney
  - Task Force/Working Group Contributions
  - Panel Meeting & Website Interaction
- 2019 Deliverables involving SC B5

cigre
For power system expertise

Scope of Study Committee B5 – Protection & Automation





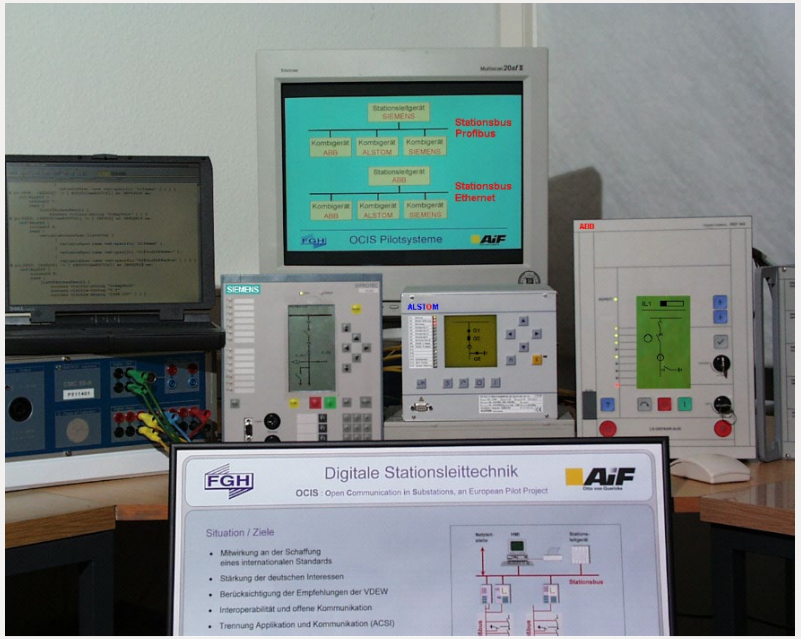


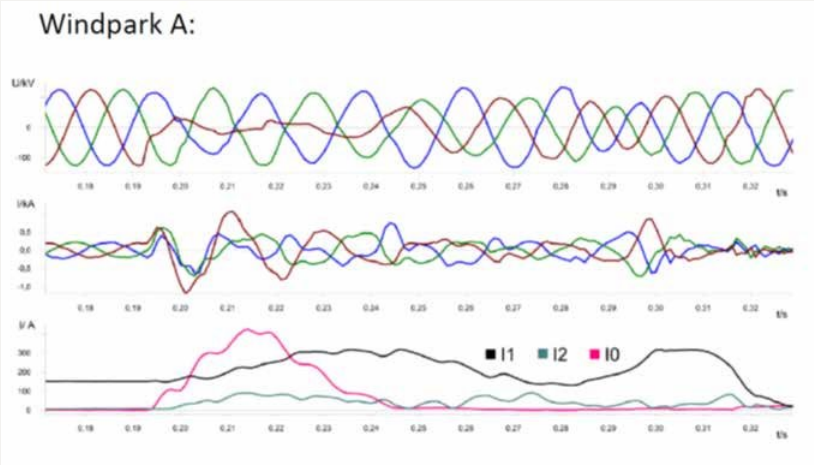
cigre
For power system expertise

PACS = Protection, Automation & Control Systems

Key B5 Future Focus Areas

- Greater inclusion of distribution protection and end to end system co-ordination
- Future Preferential Subjects and Working Groups on:
    - Interoperability for devices of different manufacturers (new applications & technology)
    - Fast transient based protection (renewables)
    - Managing the Protection Impact of Low-Inertia and Low Fault Level Networks (renewables)
    - Protection communication requirements for inter-substation and wide area applications
    - Modelling of protection systems for power system planning

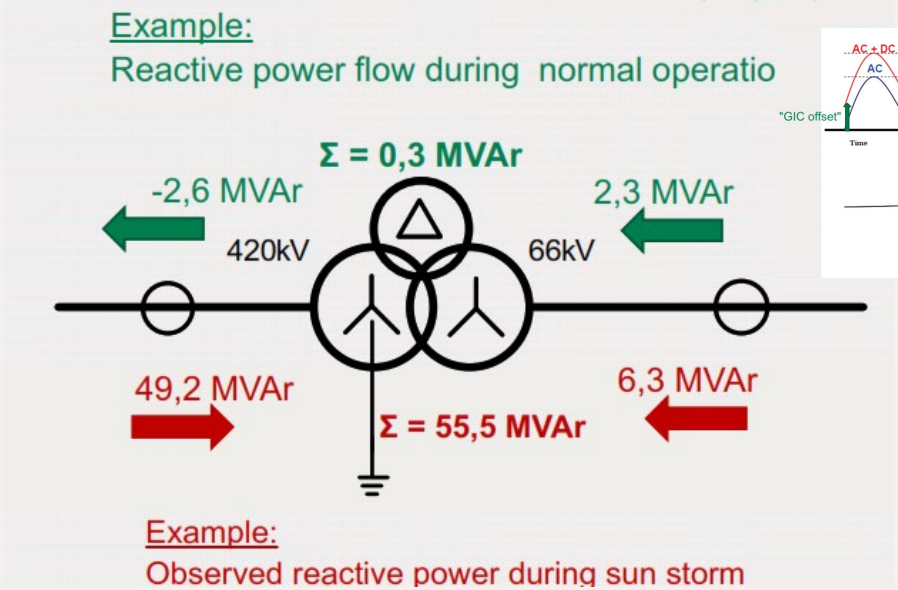


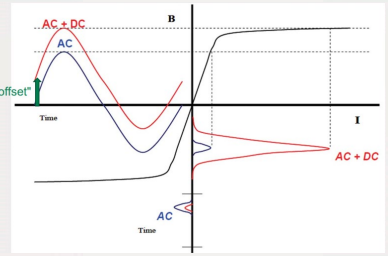


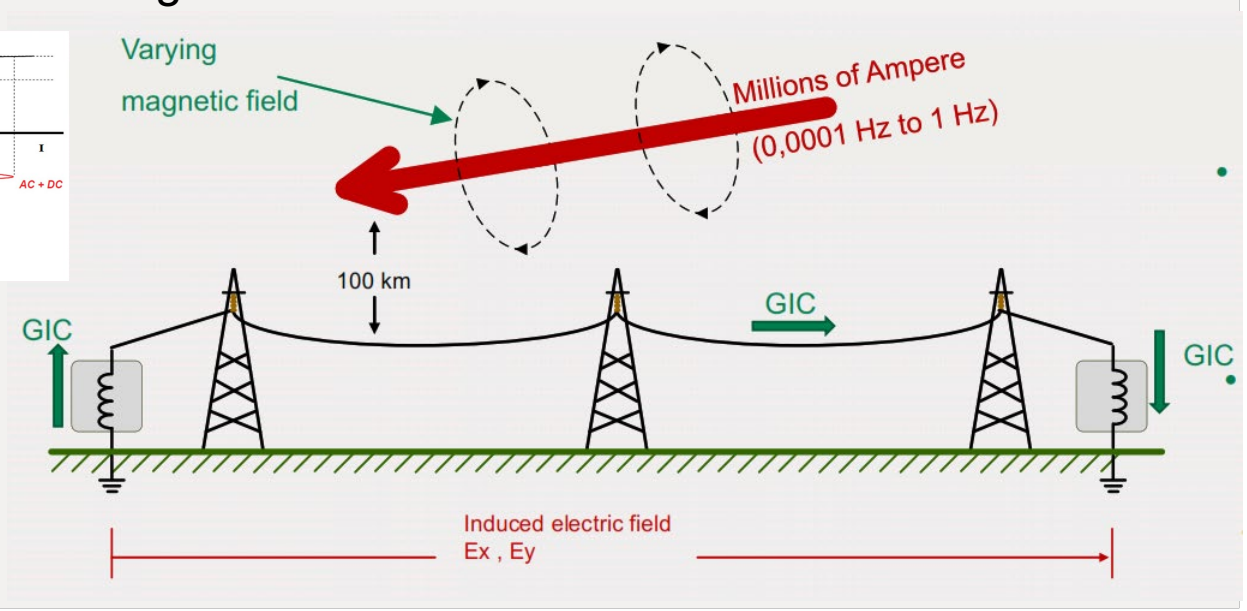
cigre
For power system expertise

Study Committee B5 2019 Norway Meeting – Solar Storm Tutorial

- Geomagnetic Storms Tutorial - Impact on Power Systems
- Many counties affected – including Norway and NZ
- Large dc currents can flow
- 2018 Norway transformer saturation and protection trip
- Due for very large storm – bigger & wider area impact
- Recommend study vulnerability – model, measure & mitigate

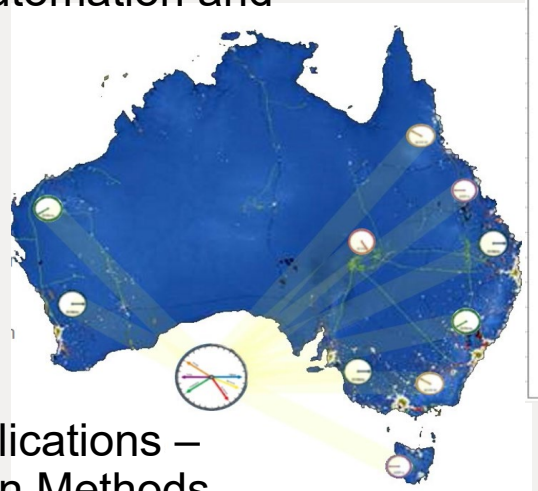


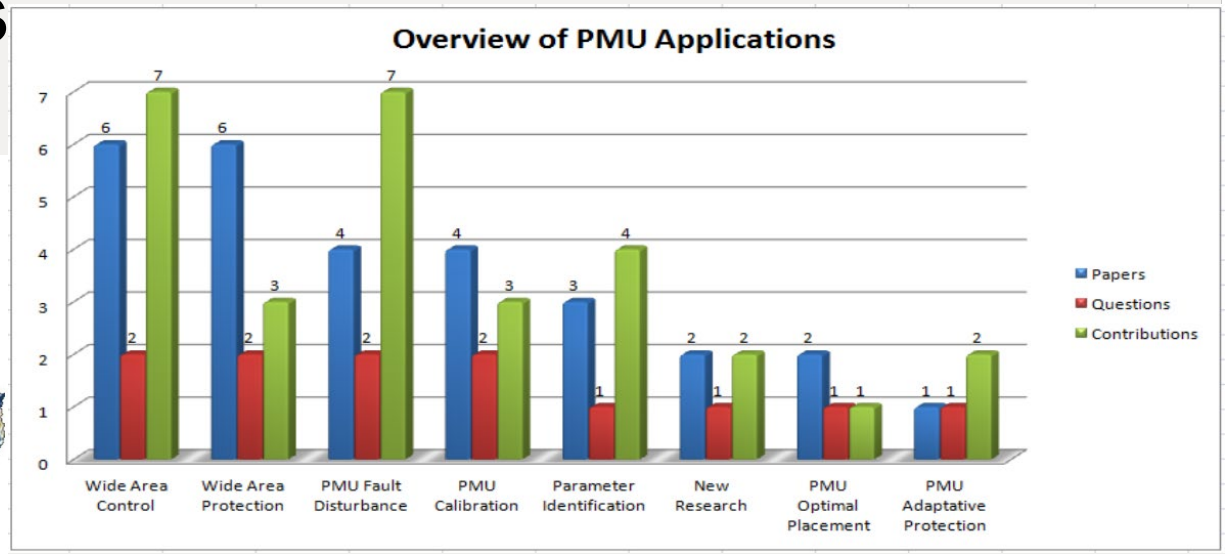




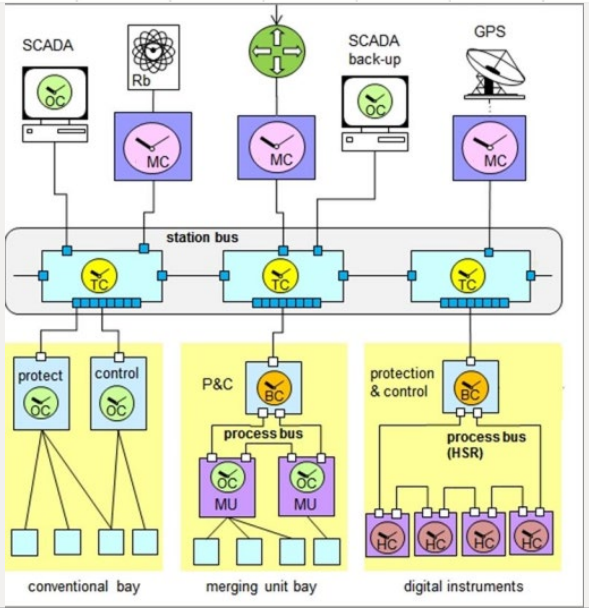
Study Committee B5 2019 Norway Meeting – Preferential Subject Aspects

- PS1: Leveraging Phasor Measurement data for better Protection, Automation and Control Systems
  - Range of applications maturing
  - Including for Distributed Energy Resources





- PS2: Time in Protection Applications – Time sources and distribution Methods
  - Time is now critical for protection and digital subs
  - Alternative Sources
  - LAN connected



- PS3: Future technologies for inter-substation communication and Migrating Digital Teleprotection Channels to Packet-Based Networks

cigre
For power system expertise

Australia/NZ Activities - SEAPAC Conference in Sydney – 19 & 20 March 2019

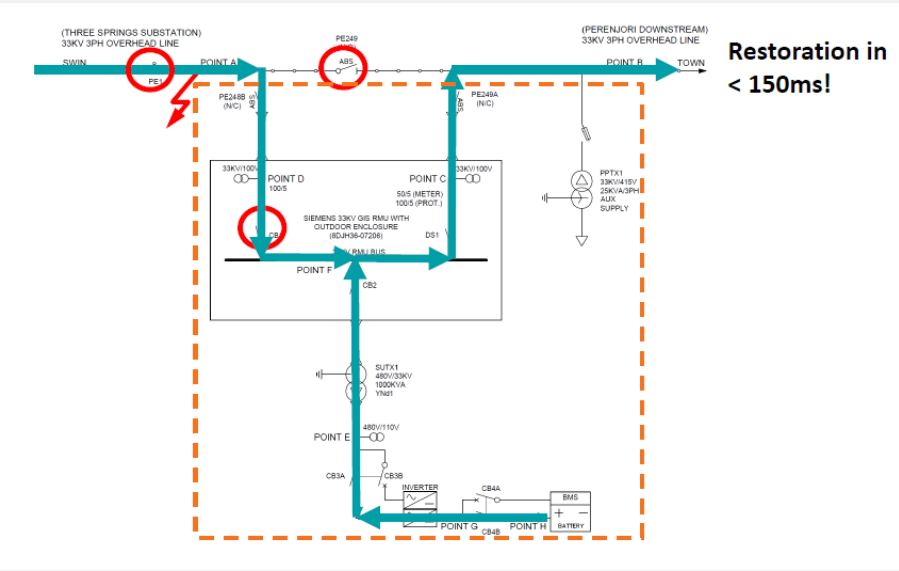
- 139 Delegates
- 12 Exhibitors
- 35 Presentations
- Diverse Range of Topics
- Keynote speech from TransGrid on changing Grid and challenges ahead

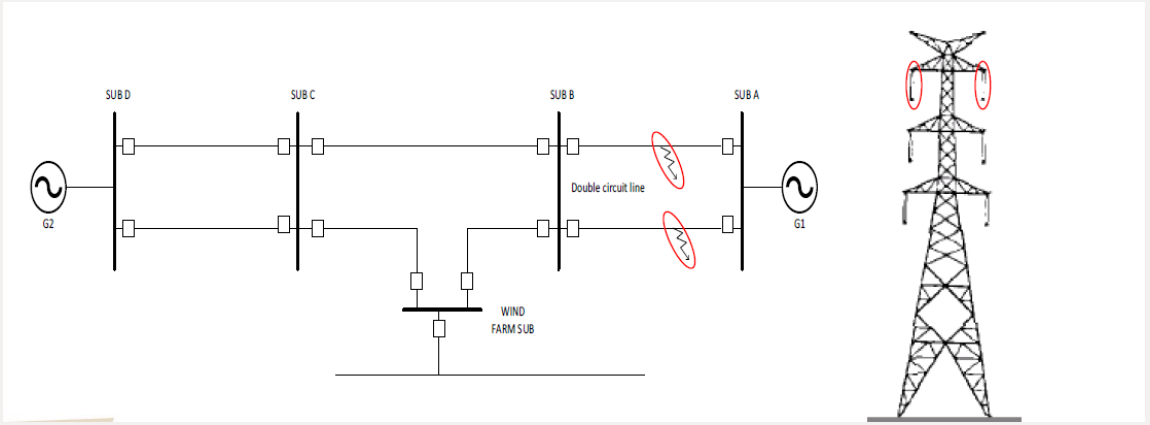
SEAPAC = South East Asia Protection & Automation Conference

cigre
For power system expertise

Australia/NZ Activities - SEAPAC Conference in Sydney – Presentation Highlights

- **BESS Battery experience** – Improve remote towns supply reliability with battery during faults
- **Frequency change - affect on Protection**
- **Renewables Protection** - Islanding Experience
- Using Wavelength Division Multiplexing for **High Speed Protection Signal Scheme** Applications
- Using **SCADA for automated reactive power control**
- Large Scale Australian **PMU Application** Project



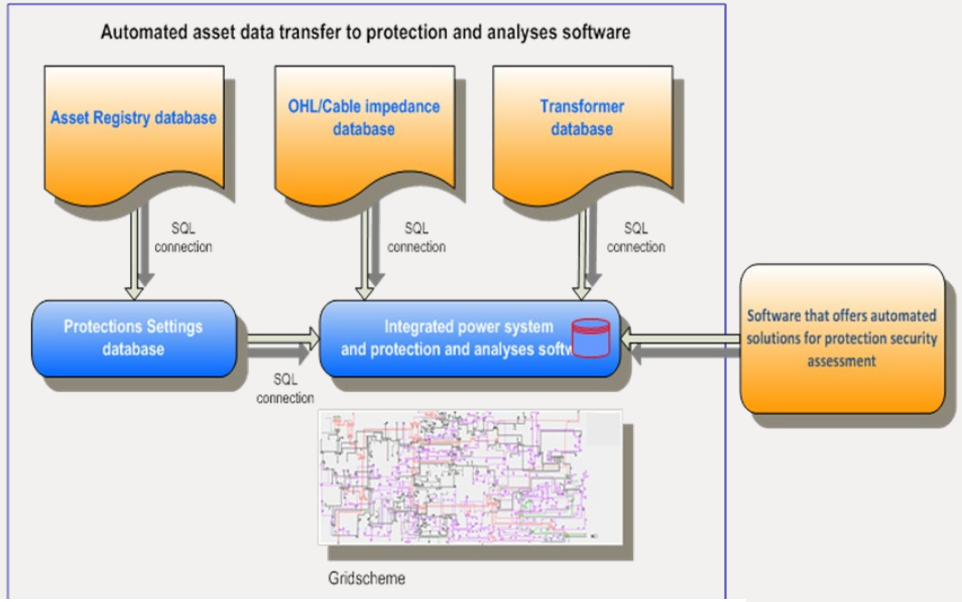


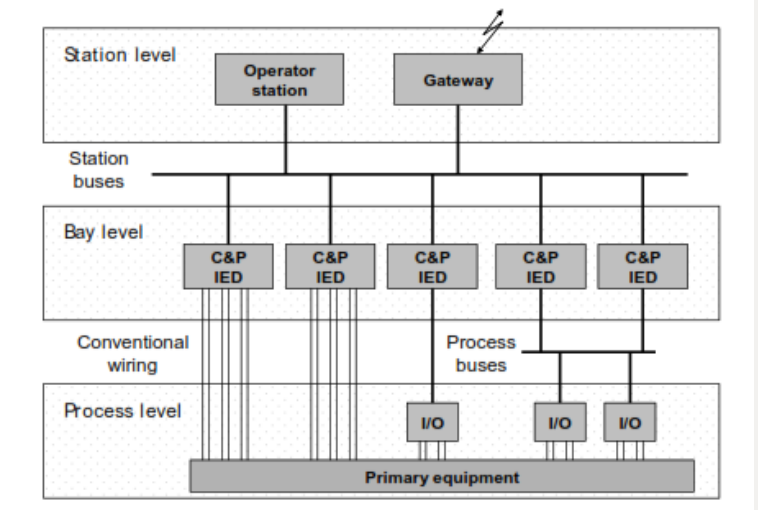
ATC Seminar 2019

cigre
For power system expertise

Australia/NZ Activities - Working Group & Task Force Involvement

- Australian B5 panel representatives **contribute** to **14 Working Groups** and **one Green Book** Task Force
- Working Groups include:
  - B5.47 - **Network Protection Performance Audits**
  - B5.57 - **New challenges for frequency protection**
  - B5.58 - **Faster protection and network automation systems**
- Australia B5 panel convenor is also SC B5 **IEC61850 Green Book** Convenor
  - Very relevant for future digital substations
  - Standard for communication between devices for schemes etc
  - Compact Study to cover principles and practice for wide audience
  - To include Primary System Applications

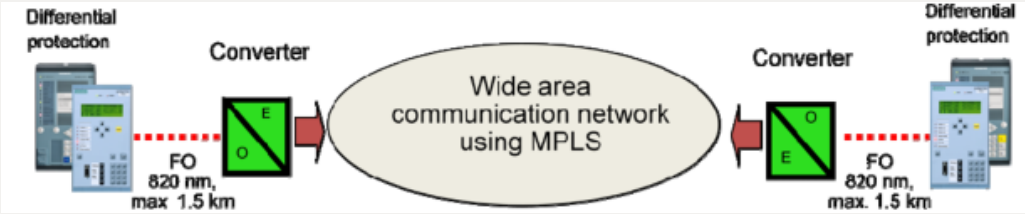




cigre
For power system expertise

Australia/NZ Activities - Panel Meeting and Website Panel Interactions

- Snowy Hydro hosted Panel Meeting
- Local Presentations on Protection Issues and website interaction
  - Alternative protection approaches to prevent bushfire from power system fault
  - Protection testing before migration to packet based communication network
- Seven Australian/NZ Contributions developed for Norway SC B5 Meeting

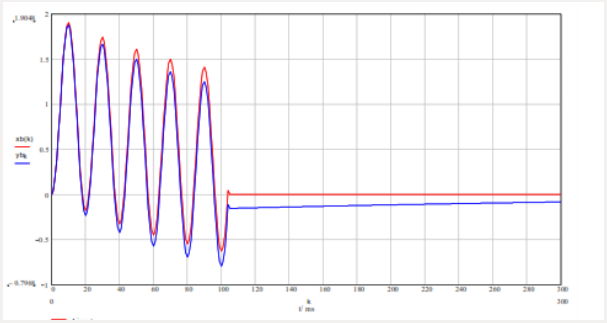


cigre For power system expertise

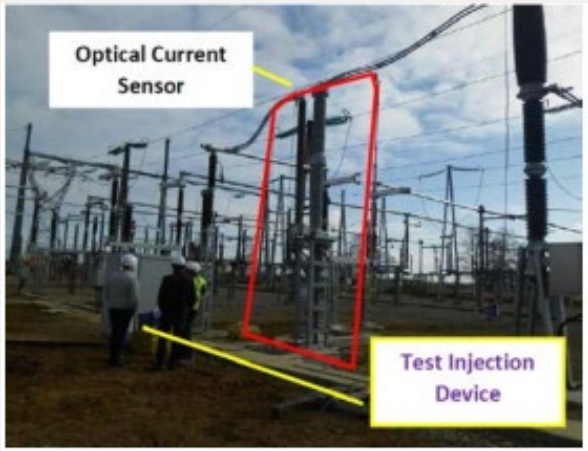
2019 Deliverables

Technical Brochures

- WG B5.24 – TB 768 **- Protection Requirements on Transient Response of Digital Acquisition Chain**



- WG B5.53 – TB 760 - **Test Strategy for Protection, Automation and Control (PAC) Functions in a full digital substation based on IEC 61850 Applications**



cigre
For power system expertise

Presented by Andrew Halley

Convener (2016)

Brisbane – 21/11/2019

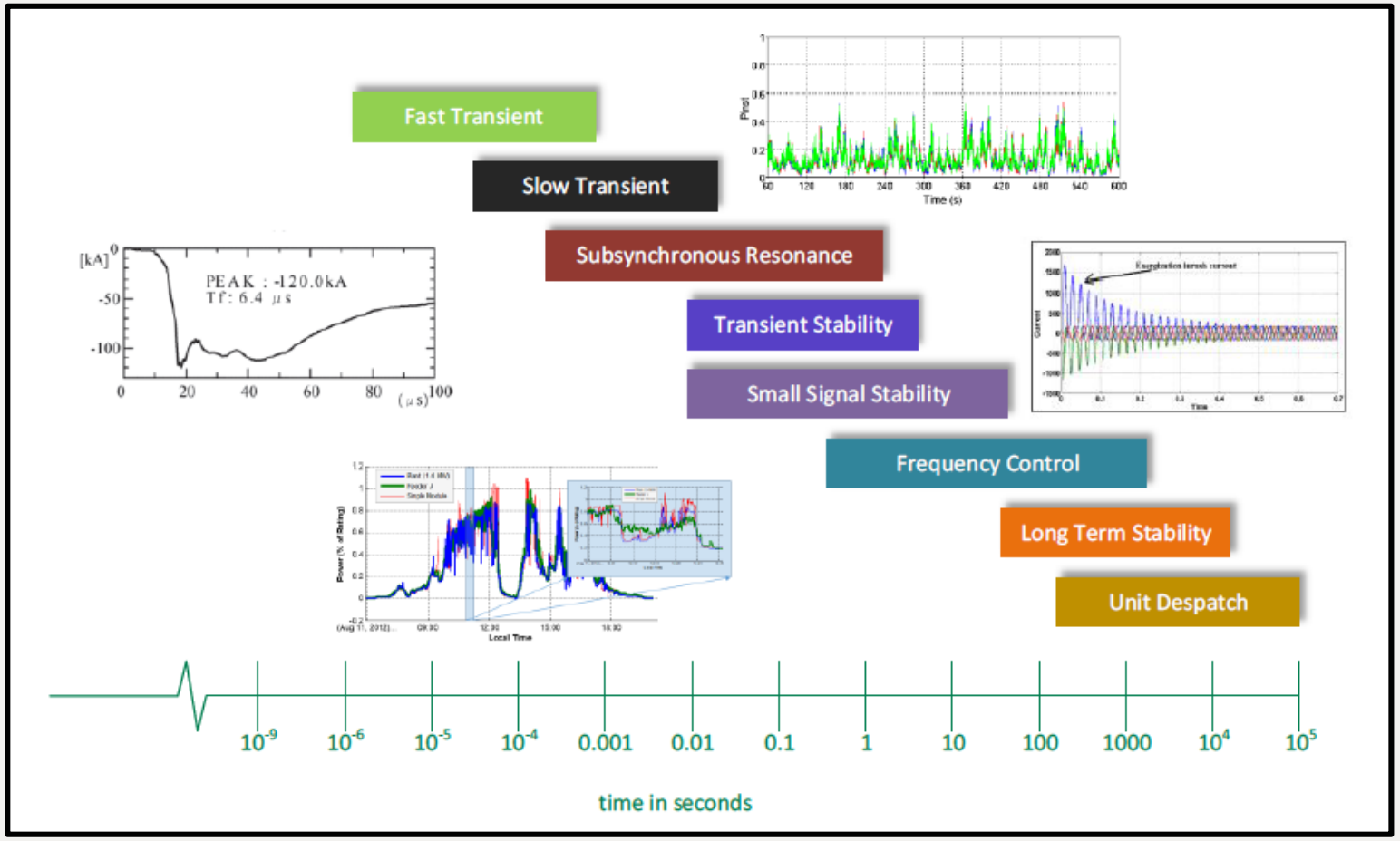
cigre

For power system expertise

C4

Power system technical performance

SC C4 - Scope



- Power quality (PQ)
- Electromagnetic Compatibility and Interference (EMC/EMI)
- Insulation Co-ordination (IC)
- Lightning (L)
- Power Systems Dynamics and Numerical Analysis (PSDNA)

cigre
For power system expertise

What's going on in C4? LOTS!

Working Groups – the CIGRE engine room

- Thirty five (35) active working groups in progress.
- Approximately one-third are PSDNA related (related to the changing generation mix and associated issues).
- Andrew's picks (highest relevance for Australia, my future reading list):
  - JWG C4.40/CIRED Revisions to IEC Technical Reports 61000-3-6, 61000-3-7, 61000-3-13, and 61000-3-14.
  - WG C4.47 Power system resilience.
  - WG C4.56 Electromagnetic transient simulation models for large-scale system impact studies in power systems having a high penetration of inverter connected generation.
  - JWG A1/C4.66 Guide on the assessment, specification and design of synchronous condensers for power systems with predominance of low or zero inertia generators.
  - JWG B5/C4.61 Impact of Low Inertia Network on Protection and Control

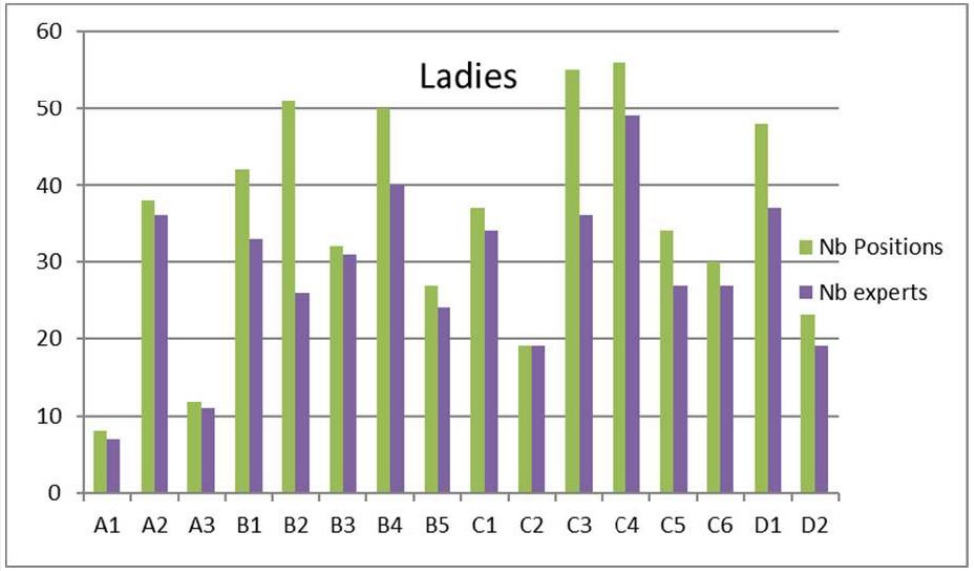
Power quality, 5

EMC/EMI, 5

Insulation co-ordination, 7

Lightning, 7

Power Systems Dynamics and Numerical Analysis, 11



cigre
For power system expertise

Publications since last ATC

Five Technical Brochures (TB) have been published since November 2018.

TB 742:	A proposed framework for coordinated power system stability control, WG C2/C4.37.
TB 745:	Issues related to spark discharges, WG C4.25.
TB 766:	Network modelling for harmonic studies, WG C4/B4.38.
TB 780:	Understanding of geomagnetic storm environment for high voltage power grids, WG C4.32.
TB 781:	Impact of soil-parameter frequency dependence on the response of grounding electrodes and on the lightning performance of electrical systems, WG C4.33

Consult the AU C4 Annual Report for a summary of Australian contributors to past and present working groups!

cigre
For power system expertise

Publications since last ATC

CIGRE Science and Engineering Journal (CSE) and Electra

CSE Journal Feature Article:

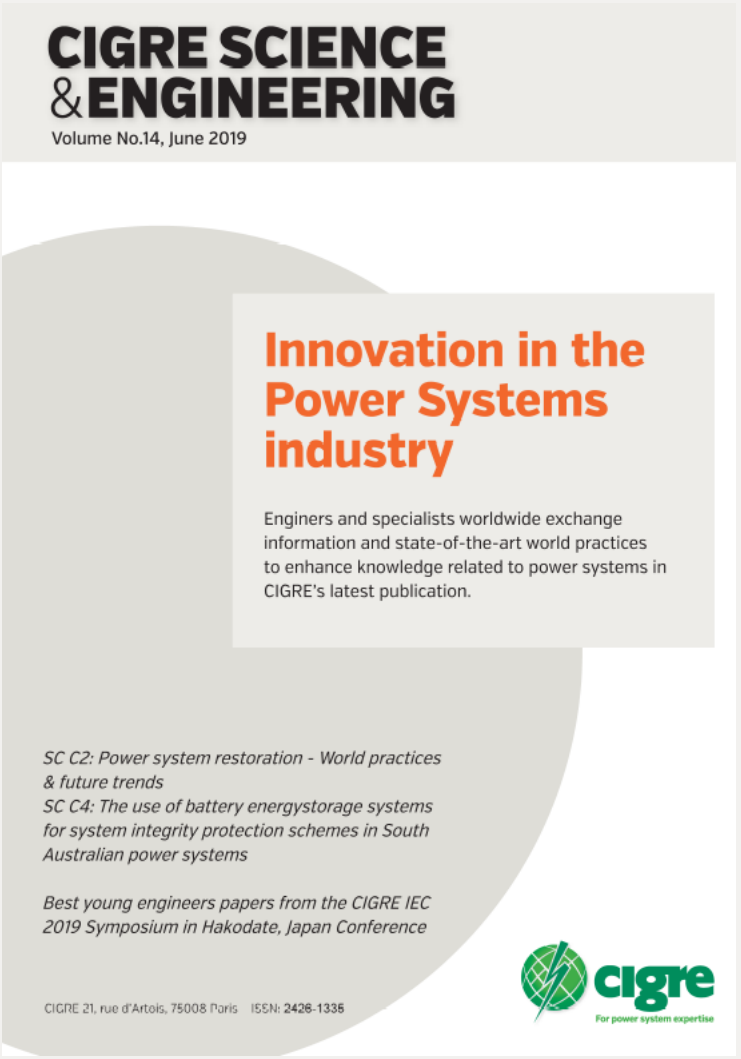
"***The use of battery energy storage systems for system integrity protection schemes in the South Australian power system***"

Document reference: CSE-014, June 2019

Reference paper by WG C4.47:

"***Defining power system resilience***",

Document reference: Electra RP-306-1.



cigre
For power system expertise

Publications since last ATC

Three C4 Webinars

"**Benchmarking of Power Quality Performance in Transmission Systems**", by Davor Vujatovic, Convener of WG C4.27. January 16, 2019. (64 attendees)

"**Modelling of inverter-based generation for power system dynamic studies**", by Koji Yamashita, Co-Covener of CIGRE JWG C4/C6.35/CIRED. Apr 4, 2019. (112 attendees)

"**A proposed framework for coordinated power system stability control**", by Yongjie Fang, convener of JWG C2/C4.37. Sep 5, 2019. (No data available)

Anholt Wind Farm (400 MW)
Offshore 220/33 kV substation
Danish Symposium 2019
(not related to webinars in any way but is a great graphic!)

cigre
For power system expertise

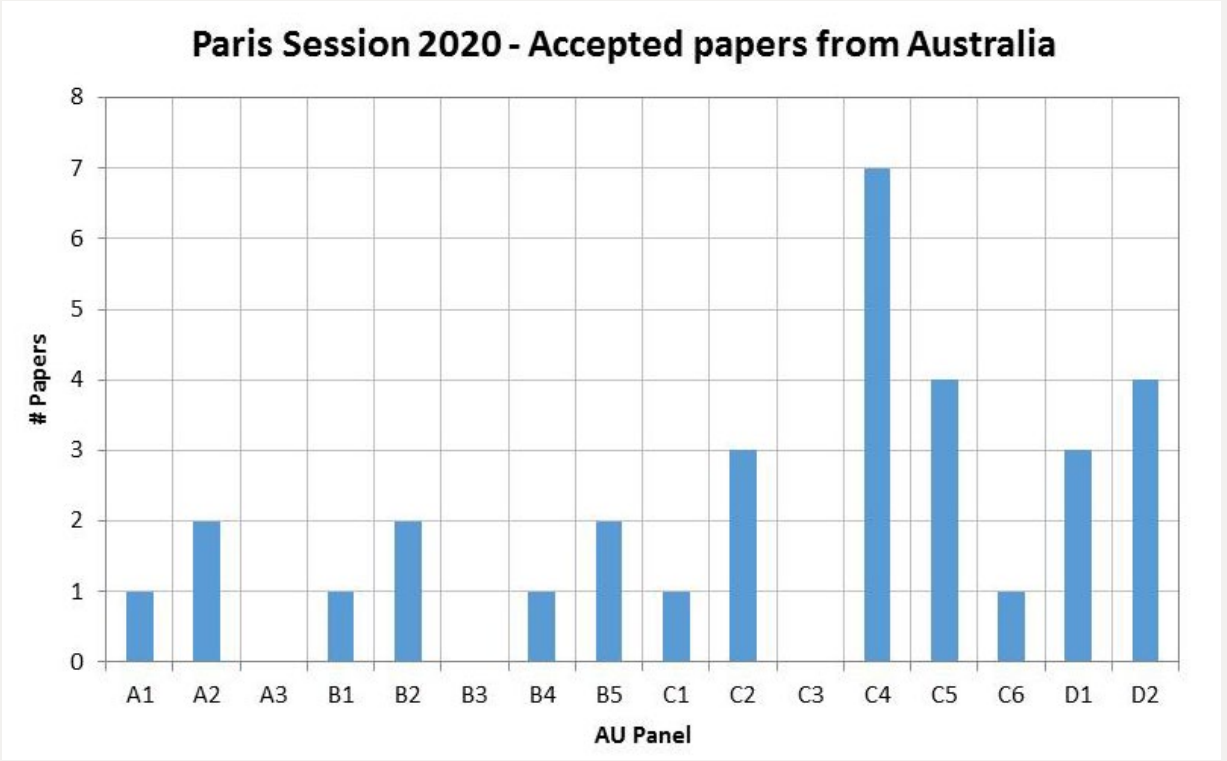
2020 Paris Session

Preferential subjects and AU-C4 accepted papers (7)

PS 1: Improving power system technical performance through the use of advanced methods, models and tools.

PS 2: Modelling of the future grid based on lessons learned from system events.

PS3: Methods, models and techniques for evaluating lightning, power quality and insulation coordination to enhance the performance of the evolving grid.



2020 Paris Session

Preferential subjects and AU-C4 accepted papers

Lead author	Paper #	Title
Neil Browne	520	Trends in power quality disturbance compatibility in Australia.
Nalin Pahalawatta	515	Power system analysis tools for supporting renewable generation connections.
Winodh Jayewardene	514	Holistic approach to modelling and tuning of a wind farm in conjunction with a synchronous condenser in a low system strength grid.
Greg Hesse	491	Monitoring and modelling of geomagnetically induced currents across the Australian National Electricity Market (NEM).
Babak Badrzadeh	499	Synchronous condenser solutions to replace synchronous generators for providing system strength in a large-scale power system – the South Australian experience.
Babak Badrzadeh	495	A large-scale electromagnetic transient model validation based on measured system disturbances.
Tony Morton	502	Generator fault current injection: Are system operators asking for the right thing?

cigre
For power system expertise

2020 Paris Session

Friday Workshop

May be offered in May/June 2020 in Australia as a practice run for Paris – Stay tuned…

"System strength – Concepts and associated technical issues for networks having a high penetration of power electronic interfaced generating systems"

- Explanation of what is meant by 'system strength' and its relationship with system inertia.
- Description of local vs system-wide system strength issues.
- Descriptions about how a 'lack of system strength' can manifest as an issue for the power system.
- Tools and techniques for analysing low system strength conditions (including screening methods and detailed simulation studies).
- Practical examples of assessing and managing local system strength issues including examples of both control system tuning and installation of auxiliary equipment (including synchronous condensers) as mitigation measures.
- Management of system strength in a real time operational environment.
- Current and prospective system strength solutions.

Coordinators, Andrew Halley and Babak Badrzadeh

cigre
For power system expertise

2019 AU C4 Panel Meeting

Thursday 22 and Friday 23 August – Energy Queensland, Brisbane

- Closed panel meeting held on the Thursday with 24 attendees (including several EQ guests).
- Opening address and welcome from Peter Price, Executive General Manager of Strategy, Asset, Performance and Security)

- Open technical seminar was held on Friday, approx. 30 attendees

Terry Killen:	Update on CIGRE Australia activities.
Garry Melik:	EMF issues associated with air core reactors.
Vic Gosbell:	Harmonic compliance assessment - why is it such a difficult issue!
Andrew Halley:	Management of system strength and inertia in Tasmania.
Alex Baitch:	Issues with ferroresonance.
Michael Negnevitsky:	Enhancing flexibility, reliability, and resilience of isolated power systems via low-load and variable speed diesel integration.

Energy Queensland (Peter Kilby, Alan Louis):

- Managing the 230V transition and PQ performance.
- PQ challenges with distribution supply to remote areas having high penetrations of renewable generation.

Thanks EQ.
Thanks to all presenters.

Was a great two days!

cigre
For power system expertise

Thanks for listening.

Any questions

Andrew Halley,

AU C4 Convenor

Anholt Wind Farm (400 MW)

Technical Tour @ 2019 Danish Symposium

cigre
For power system expertise

AUC5 report to ATC 2019

Presented by Greg Thorpe

Brisbane, 21 November 2019

cigre

For power system expertise

C5 Scope

- C5 is one of 16 study committees within the overall organisation reporting to an international chairman who in turn reports to an international Technical Council comprising all study committees
- Australia is one of a number of countries with sufficient membership scale to have a local Technical Council
- To assess the operation of electricity markets and regulation and where appropriate to discuss potential amendments (my words)
- The brief is broad
- In line with CIGRE strategic directions our remit is extending into distribution networks
- Our work clearly overlaps with other study committees especially within the C family and must be ever vigilant to work together.

cigre
For power system expertise

Summary

- Self assessment
  - **Doing OK**
    - 4 Paris 2020 papers
    - Leading 1 WG
    - Member 3 WGs
    - Coordinating Paris 2020 market disturbance workshop (with C2)
    - Montreal (C5 annual meeting, Symposium, CIGRE Canada)
  - **Can do better**
    - Additional working groups
    - Additional members
      - Sector diversity
      - Geographic diversity
      - Gender diversity
  - **Proposed actions**
    - Recruitment
    - Additional WG leads
- Annual meeting – 2019 Sydney (hosted by Deloitte)
- Annual meeting – 2020 Hobart (to be hosted by Tas Networks)

cigre
For power system expertise

2020 Paris Papers

- Four C5 papers proposed and accepted from Australia
  - **Value of battery behaviour to customers**
  - **Impact of price signals on Demand Management and Distributed Energy Resources**
  - **System strength, inertia and network loss factors. A proponent perspective**
  - **Emerging Ancillary Service changes in the NEM**
- All topical. Australia at the leading and sometimes ‘bleeding edge’ so lots to contribute

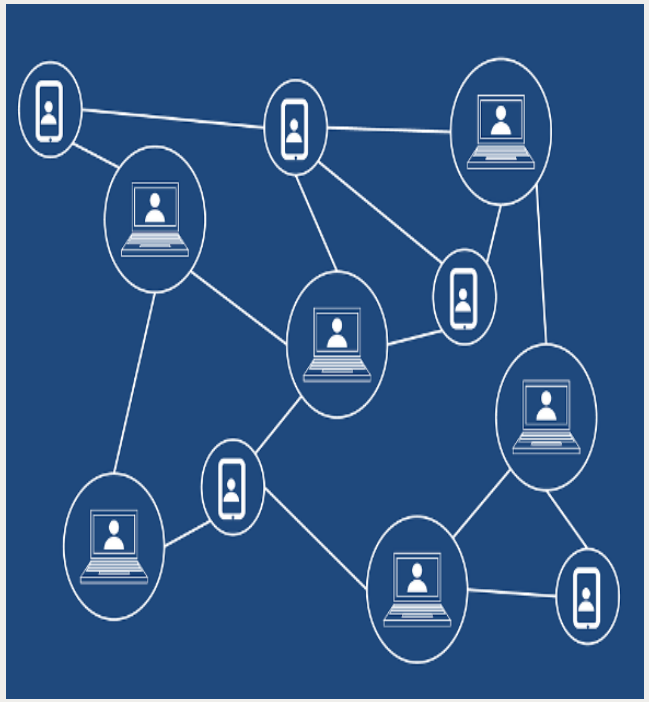
cigre
For power system expertise

C5 Working Groups with Australian participation

cigre
For power system expertise

Working Group C5-31 on Block Chain applications
Convenor David Bowker (Australia)

- Very pleasing participation from a range of countries.
- Responses highlight diverse stage of development in different countries but a strong interest in the topic
- Working Group has received numerous papers and presentations including a very valuable input from AEMO
  - (including an audio presentation to the recent Montreal meeting at a very uncivilised time in Australia)



cigre
For power system expertise

Working Group C5-27 International review of market arrangements for sources of operating flexibility

- Convenor: Gerard Doorman (Norway)
- Australian contributors Gregor Verbic (Syd Uni), Greg Thorpe
- Addressing the question about what to do about international responses to manage increasing short term volatility, often from non-scheduled resources.
- What are the market (pricing) impacts and what market (pricing) options are available.

cigre
For power system expertise

Working Group C5 28: Dispatch Price Formation

- Convenor Adam Keech (PJM)
- Australian contributor Greg Thorpe
- Very topical and relevant consideration of international practices for setting dispatch and (where different) Spot or Balancing Price
- In market design services and behaviours can be either mandated (e.g voltage performance, network constraint management) or commercially incentivised energy and some ancillary (essential services)
- Existing standards and pricing have not kept pace with system conditions – especially in the NEM.
- C5 28 is comparing and contrasting different approaches around the world.
- A number of challenges have emerged – for example how (if) to recognise the effect of day ahead and intra-day markets that operate in some markets

cigre
For power system expertise

Other C5 working groups

- C5–24 Market based value of Smart Grid (finalising this quarter)
- C5-25 Work is complete but planning a webinar in November
- C5-26 Auction and other mechanisms for DR Services (TB near complete)
- Joint C5-C6.29 Local energy communities (just starting)
- C5-31 Cost impacts of flexible DR (just starting)
- C5-32 Carbon Pricing in Electricity Markets

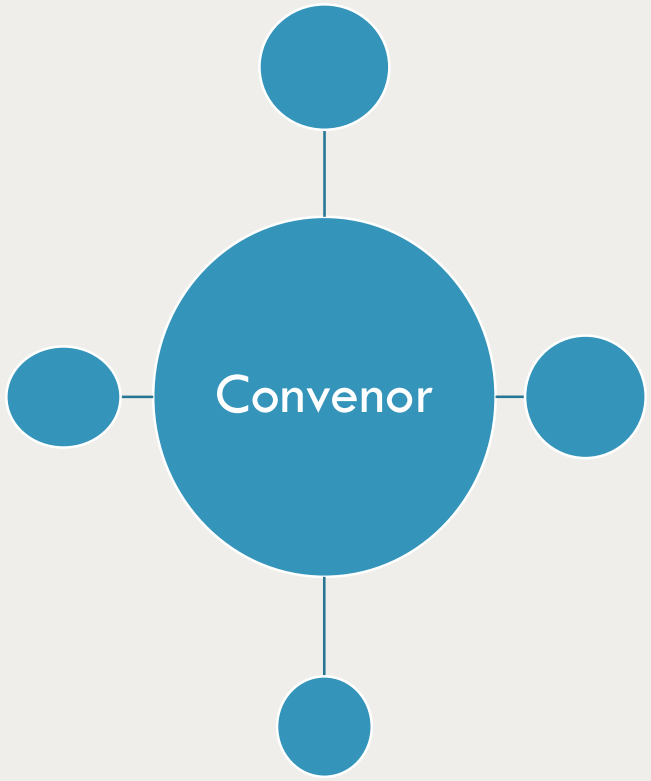
cigre
For power system expertise

Paris 2020 Market/System disturbance workshop preparation

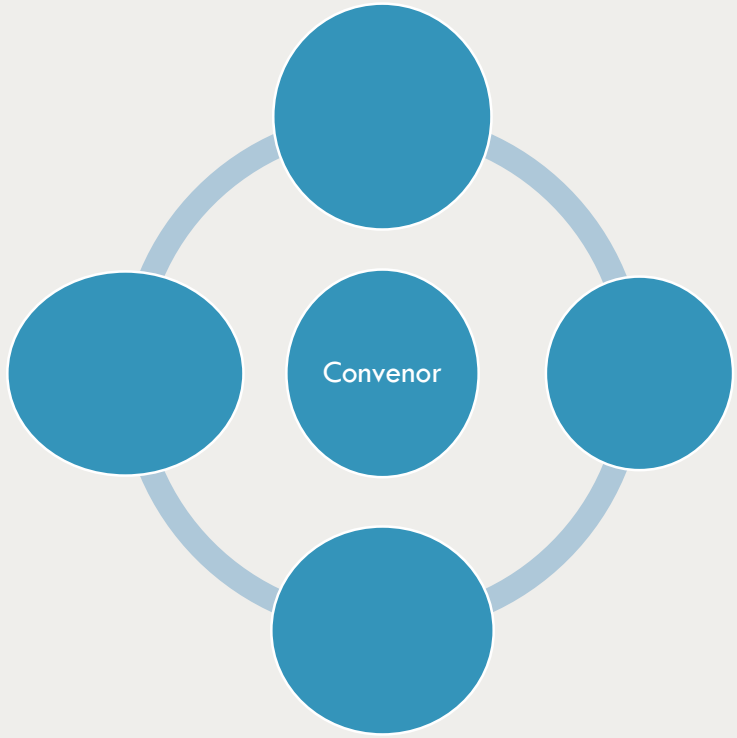
- A joint C2/C5 activity – generally a well attended event in Paris
- Greg Thorpe is coordinating C5 input internationally
- ‘Spoilt’ for choice, across C2 and C5 related issues we have events in:
  - Australia
  - Argentina
  - US (PJM)
  - Germany
  - Indonesia
  - UK
  - Japan
- Work is stepping up to organise the workshop

cigre
For power system expertise

Resourcing



- No surprise, but at present future actions rely heavily on the convenor.
- At this point acknowledge the great work also done by secretary (Victor Francisco)
- Core group of paper authors appreciated but - aim to broaden the base.
- Wishful thinking??

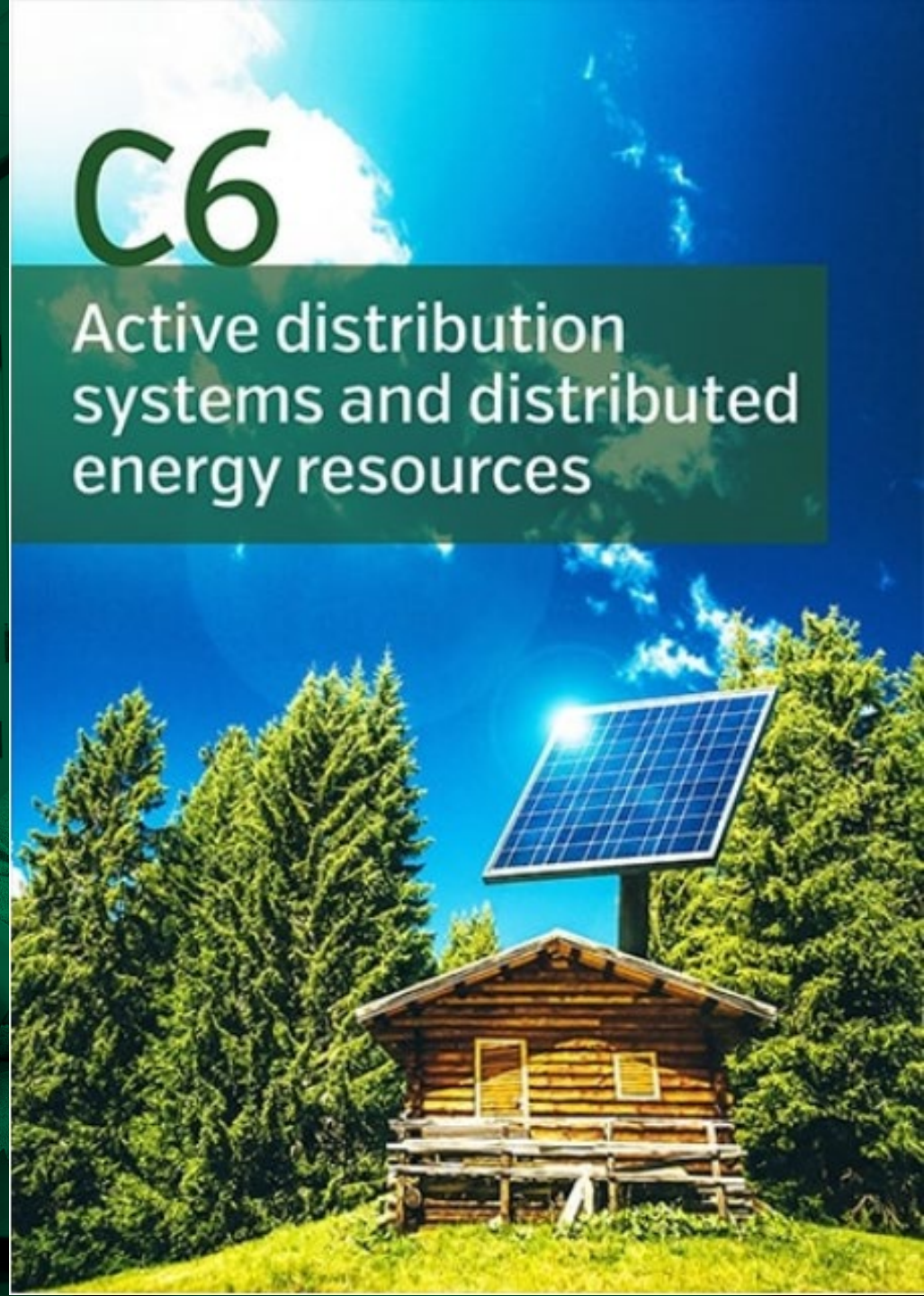


cigre
For power system expertise

Presented by Ray Brown - Convener

Brisbane – 21/11/2019

cigre
For power system expertise



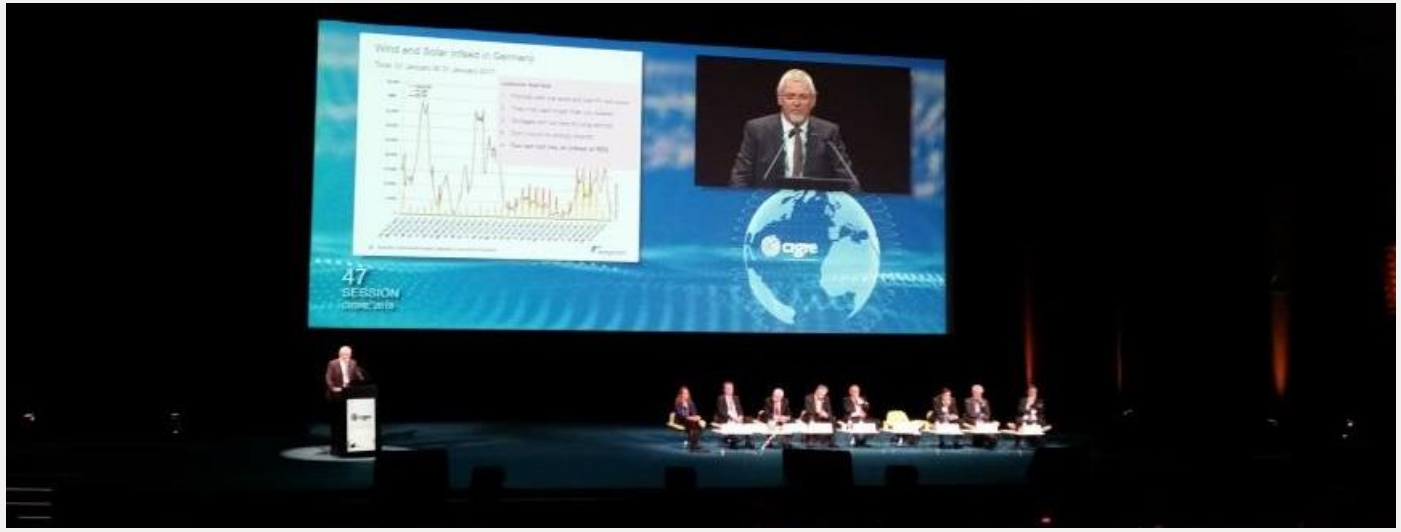
SC C6 Overview

Principal Areas of Interest

- Assessment of the technical impacts which a more widespread adoption of DER could impose on the whole energy system and of enabling technologies and innovative solutions for DER integration in active distribution networks

Main Areas of Attention

- Enabling technologies
- Innovative solutions for DER
- Storage technologies
- New approaches to configure distribution systems
- Consumer integration & empowerment
- Smart cities
- Rural electrification



cigre
For power system expertise

2019 International Activities

Symposium Chengdu - September 2019

- C6 and B3 Lead Study Committees
- 87 papers from 19 countries in 15 sessions
- More than 300 registrations

cigre
For power system expertise

2019 AU/NZ Activities

Australia Panel C6 Meeting - Melbourne - 19 August 2019

cigre
For power system expertise

2019 AU/NZ Activities

CIDER 19

ASIA PACIFIC CONFERENCE ON INTEGRATION OF DISTRIBUTED ENERGY RESOURCES

Pullman, Melbourne on the Park, 192 Wellington Parade, Melbourne, Vic, Australia

cigre Australia

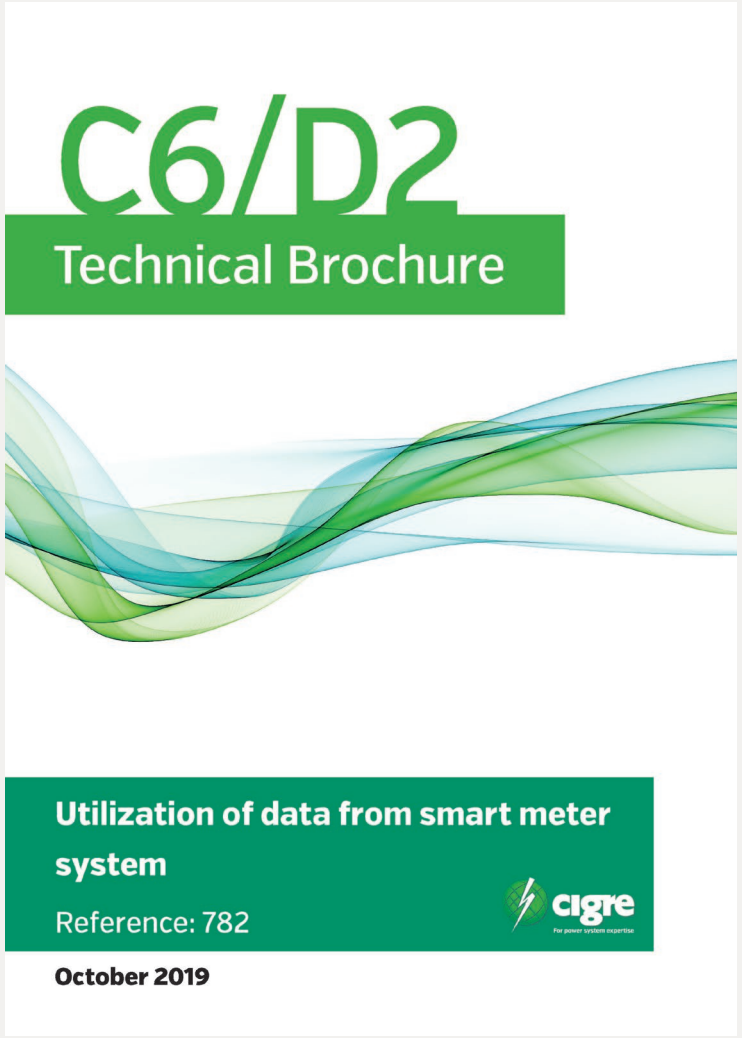
CIDER 2019 - Conference on Integration of Distributed Energy Resources Melbourne - 20 & 21 August 2019

- Previously held Brisbane 2015 and Sydney 2017
- 2 keynote speakers
- 26 presentations
- NGN Session
- Stand-up networking dinner
- Very positive feedback from delegates

2019 Deliverables

Technical Brochures

- TB 782 - Utilization of Data from Smart Meter System (JWG C6/D2)



cigre
For power system expertise

Upcoming Activities - 2020 Paris

Preferential Subjects

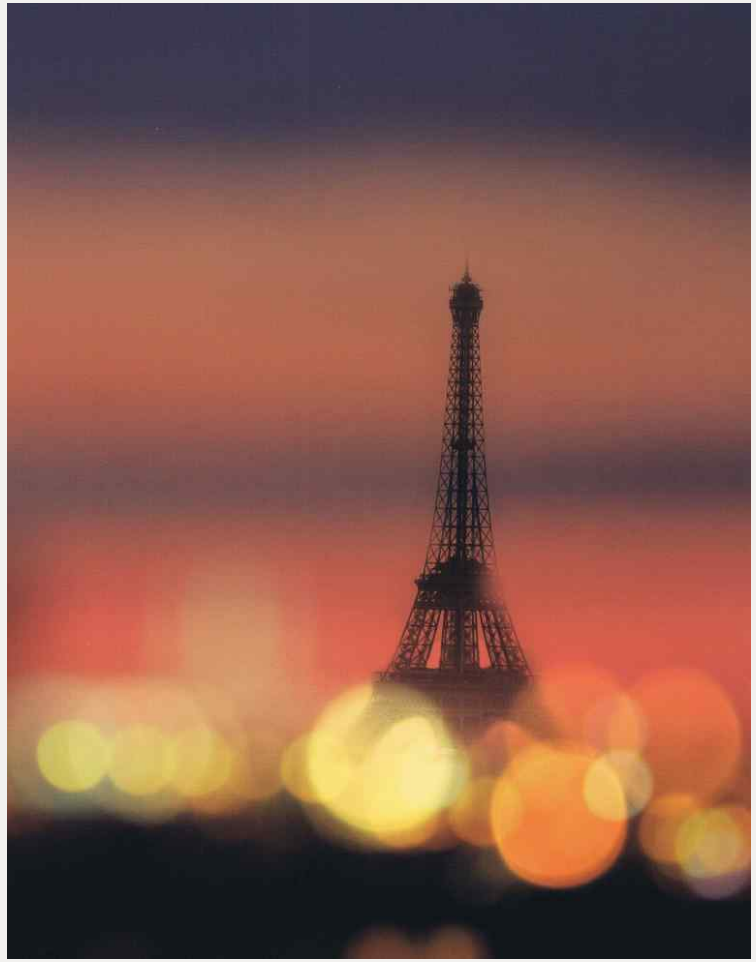
SC C6

PS1 : Advanced distribution system design incorporating DER

PS2 : Enabling technologies and solutions for distribution systems

Co-chaired by both C2 and C6

PS 3: System Operation Challenges with Increasing Distributed Energy Resources



cigre
For power system expertise

Upcoming Activities

cigre Japan

CIGRE – AORC Technical Meeting 2020

Kanazawa – Japan, 14-17 April 2020

cigre

Symposium 2021 in Kyoto, Japan

SC C6, C1, C2, C5, D2

10 -16 October, 2021

cigre For power system expertise

Upcoming Activities

CIGRE Cairns Symposium 4-7 September 2023

Themes and Issues

Community Energy Storage

- Existing trial at Mandurah
- Further installations to go ahead
- Good community feedback, over-subscribed
- Assist with local network issues
- Positive business case

cigre
For power system expertise

Themes and Issues

Innovative Methods of Supply

Western Power

- 50% of the network only supplies 3% of the customers / load

Installation of 57 stand-alone power systems

- Lower cost
- Increased reliability
- Improved community satisfaction
- Re-training of line workers
- Issue with regulations preventing "shrinking" of the grid
- Need to move quickly as the locations where this is most promising are also where the network most needs re-building

Themes and Issues

Integration of Small-scale DER in Australia

- **Many previous concerns have not eventuated**
  - Power Quality
  - Number tap-changes at zone substation transformers
  - Unintentional islanding
- **Voltage in LV networks remain an issue**
- **Increased range of tools to deal with voltage issues**
  - LV STATCOMs
  - Voltage-regulating distribution transformers (VRDT)
  - Dynamic voltage management system
  - Power Quality response modes of inverters - P(U), Q(U)
- **Standardisation of inverter settings**
- **Tension between anti-islanding protection and system performance**
  - ROCOF
  - Underfrequency

Presented by Victor Tan - Convener

Brisbane – 21/11/2019

cigre

For power system expertise

D2

INFORMATION SYSTEMS & TELECOMMUNICATION

SC D2 Overview

Purpose

- Promote the interchange of technical knowledge, information and experience between all countries in the fields of power industry telecommunications, information and telecontrol systems. APD2 also provides a forum for information sharing and representation of local issues affecting its members.

Study Areas

- **Information Systems:** EPU-specific IS areas, asset management, customer relationship, smart meter systems, situational awareness
- **Cyber security:** Security policy and standards**,** securing EPU assets, technical security controls, risks and mitigation
- **Telecommunication:** Design, planning and operation of networks, optimising current technologies, emerging technologies, high availability, networks supporting time-sensitive and other EPU applications

2019 D2 Colloquium Helsinki

Helsinki, Finland; 11 – 14 June 2019

Around 150 participants

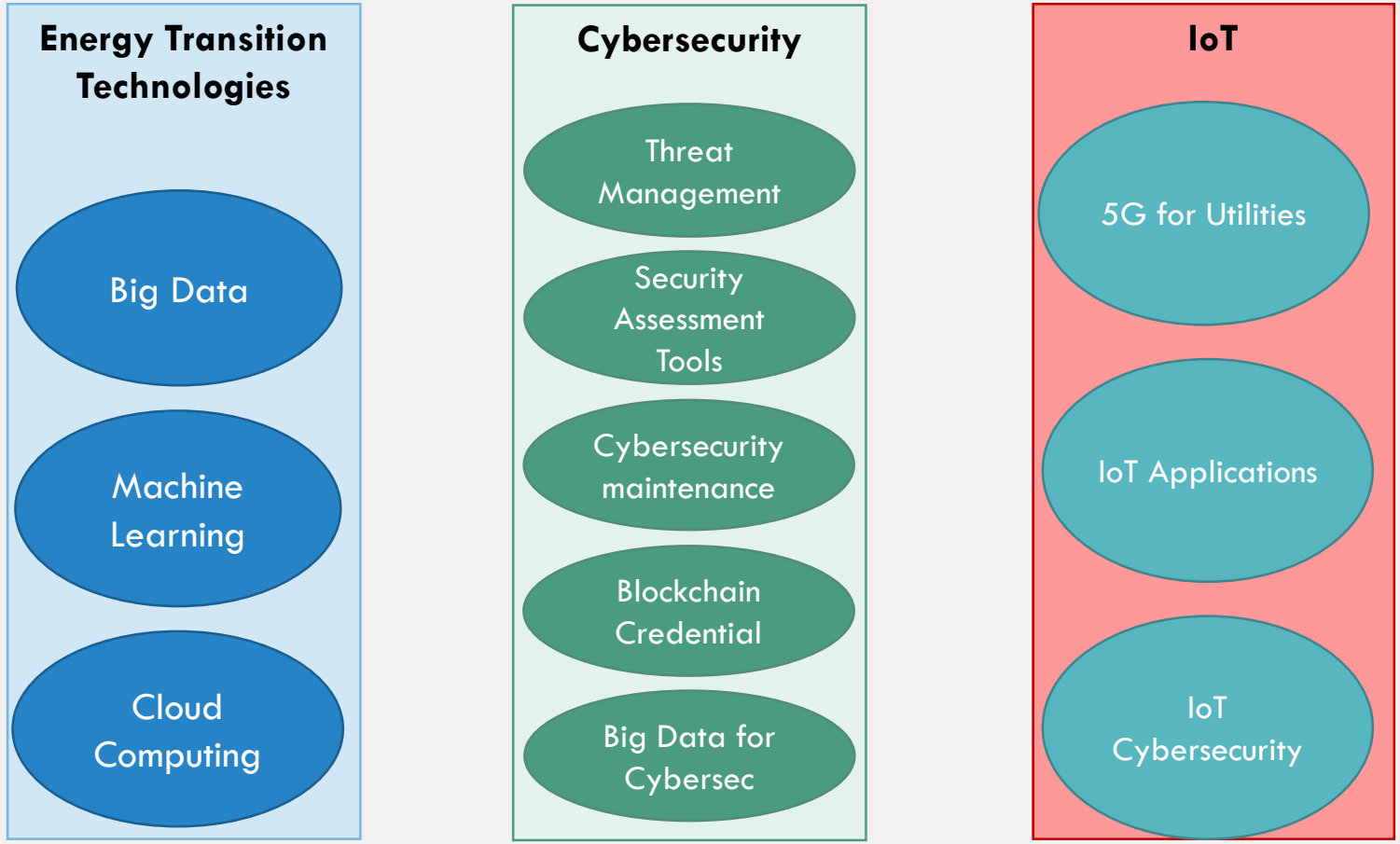
Areas of focus:

- Big data and machine learning
- Cyber security
- IoT

cigre
For power system expertise

2019 D2 Colloquium Helsinki

- **42 Papers in the Helsinki Colloquium in the following areas:**



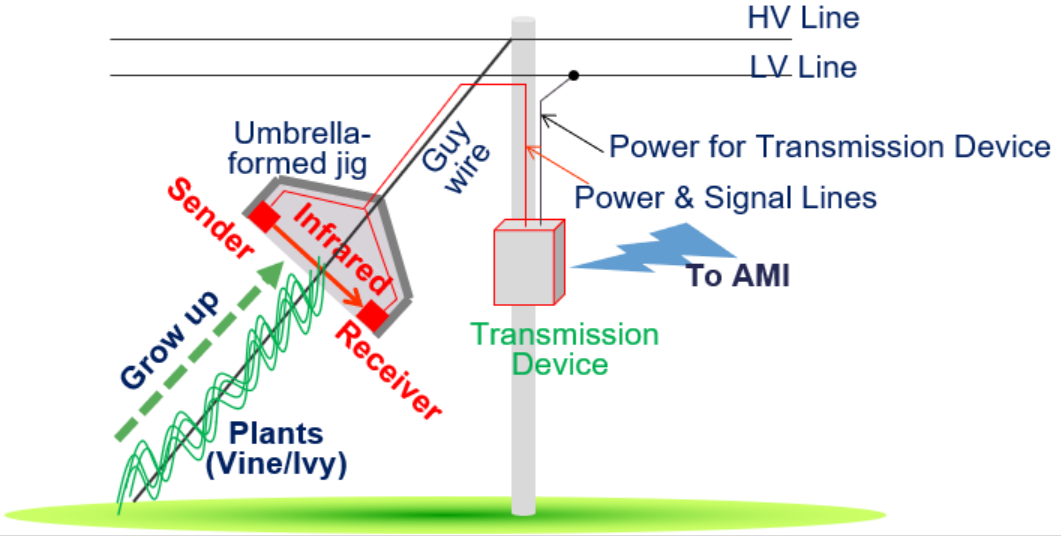
cigre
For power system expertise

2019 D2 Colloquium Helsinki

DETECTION OF CLIMBING PLANTS

8

- We attached an infrared sensor to the existing Umbrella-formed jig and connected to the transmission device



✓We confirmed that we could remotely monitor the growth status of plants

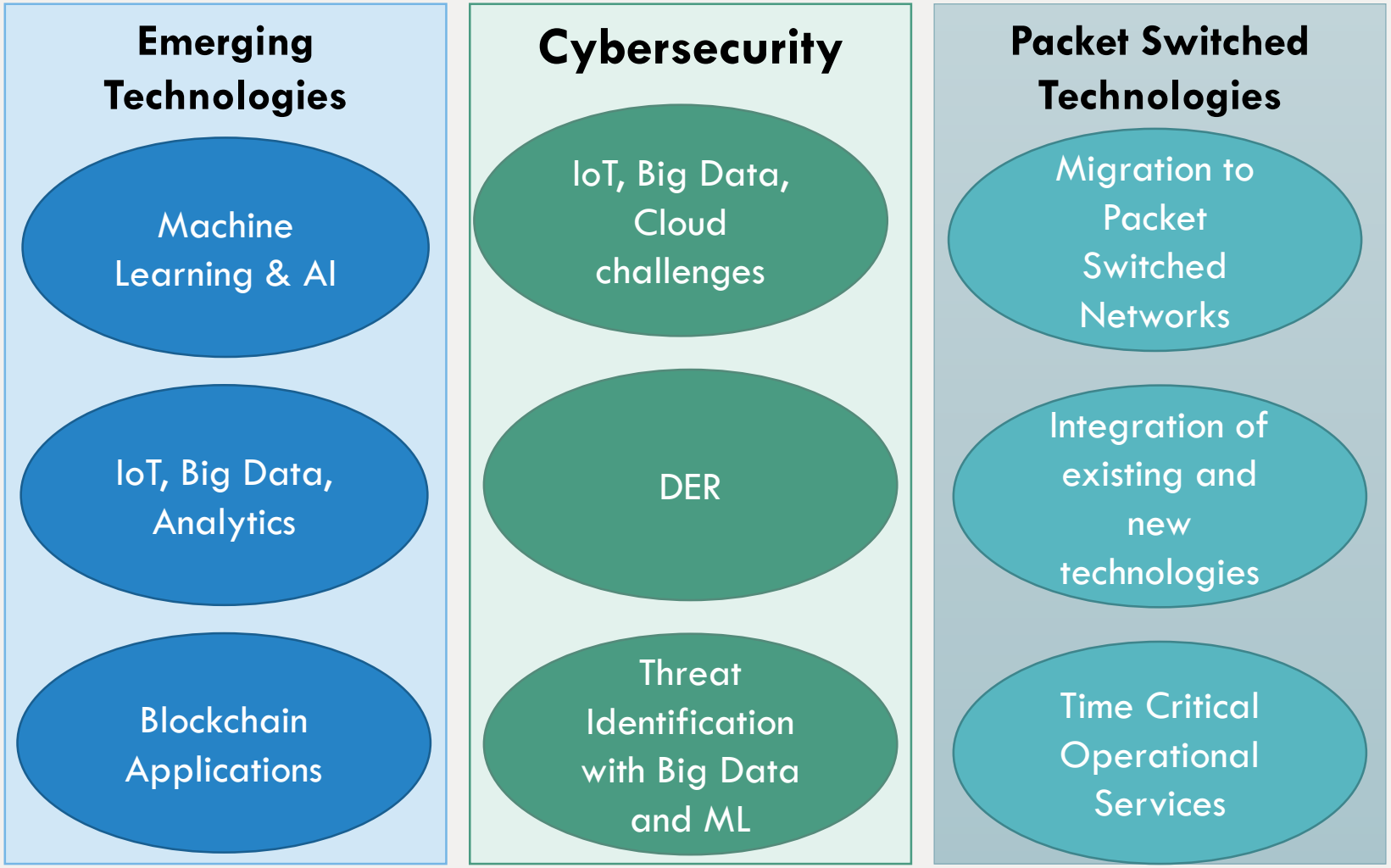
cigre SC D2 cigre Finland

Source: T. Kiuchi, T. Okabe, TEPCO Japan, D2 Colloquium 2019

cigre For power system expertise

2020 Paris Session (D2) – Areas of Focus

57 Paper abstracts approved



cigre
For power system expertise

Active Working Groups

WG	Title	Convenor	2019		2020		2021		2022	
			S1	S2	S1	S2	S1	S2	S1	S2
JWG C6/D2.32	Utilization of data from smart meter system	Y. MATSUURA (JP)								
WG D2.43	Enabling Software Defined Networking for EPU telecom applications	V. TAN (AU)								
WG D2.44	Usage of public or private wireless communication infrastructures for monitoring and maintenance of grid assets and facilities	P. MULVEY (IE)								
WG D2.45	Impact of governance regulations and constraints on EPU sensitive data distribution and location of data storage	H. KLIMA (AT)								
WG D2.46	Cybersecurity future threats and impact on EPU organizations and operations	D.K. HOLSTEIN (US)								
JWG B5/D2.67	Time in Communication Networks, Protection and Control Applications – Time Sources and Distribution Methods	R. DE VRIES (NL)								
JWG D2/C6.47	Advanced consumer side energy resource management systems	A.A. NEBERA (RU)								
JWG D2/C2.48	Enhanced information and data exchange to enable future transmission and distribution interoperability	G. TAYLOR (GB)								
JWG B2/D2.72	Condition Monitoring and Remote Sensing of Overhead Lines	A. KULKARNI (GB)								

Active Working Groups – Global D2 Contributors Distribution

Active Working Groups – AU D2 Contribution

Victor Tan (VTAN)

Greg Helps (Enet)

Louise Watts (SAPN)

WG	Title	Convenor	2019		2020		2021		2022	
		Victor Tan (VTAN)					S1	S2	S1	S2
JWG C6/D2.32	Utilization of data from smart meter system	Y. MATSUURA (JP)								
WG D2.43	Enabling Software Defined Networking for EPU telecom applications	V. TAN (AU)								
WG D2.44	Usage of public or private wireless communication infrastructures for monitoring and maintenance of grid assets and facilities	P. MU… (IE)								
WG D2.45	Impact of governance regulations and constraints on EPU sensitive data distribution and location of data storage	H. KLIMA (AT)								
WG D2.46	Cybersecurity future threats and impact on EPU organizations and operations	D.K. HOLSTEIN (US)								
JWG B5/D2.67	Time in Communication Networks, Protection and Control Applications – Time Sources and Distribution Methods	R. DE VRIES (NL)								
JWG D2/C6.47	Advanced consumer side energy resource management systems	A.A. NEBERA (RU)								
JWG D2/C2.48	Enhanced information and data exchange to enable future transmission and distribution interoperability	G. TAYLOR (GB)								
JWG B2/D2.72	Condition Monitoring and Remote Sensing of Overhead Lines	A. KULKARNI (GB)								

Andrew Bain

Manoj Kumar (Commtel)

Benjamin Haines (Ausgrid)

Victor Tan (VTAN)

cigre For power system expertise

Publications

Technical Brochures an Publications

- Technical Brochure published since August 2018
  - TB 762 “Remote Service Security Requirement Objectives”
  - TB 746 “Design, Deployment, and Maintenance of Optical Cables associated to Overhead HV Transmission Lines”

- Technical Brochure published in 2019
  - TB 782 “Utilization of Data from Smart Meter System”

2019 Australia D2 Activities

Australia D2 Panel Meeting held in TasNetworks, Hobart : 24 – 26 July 2019.

- 24 attendees
- 4 guest speakers from TasNetworks, Keysight, CommTel and Nozomi

cigre
For power system expertise

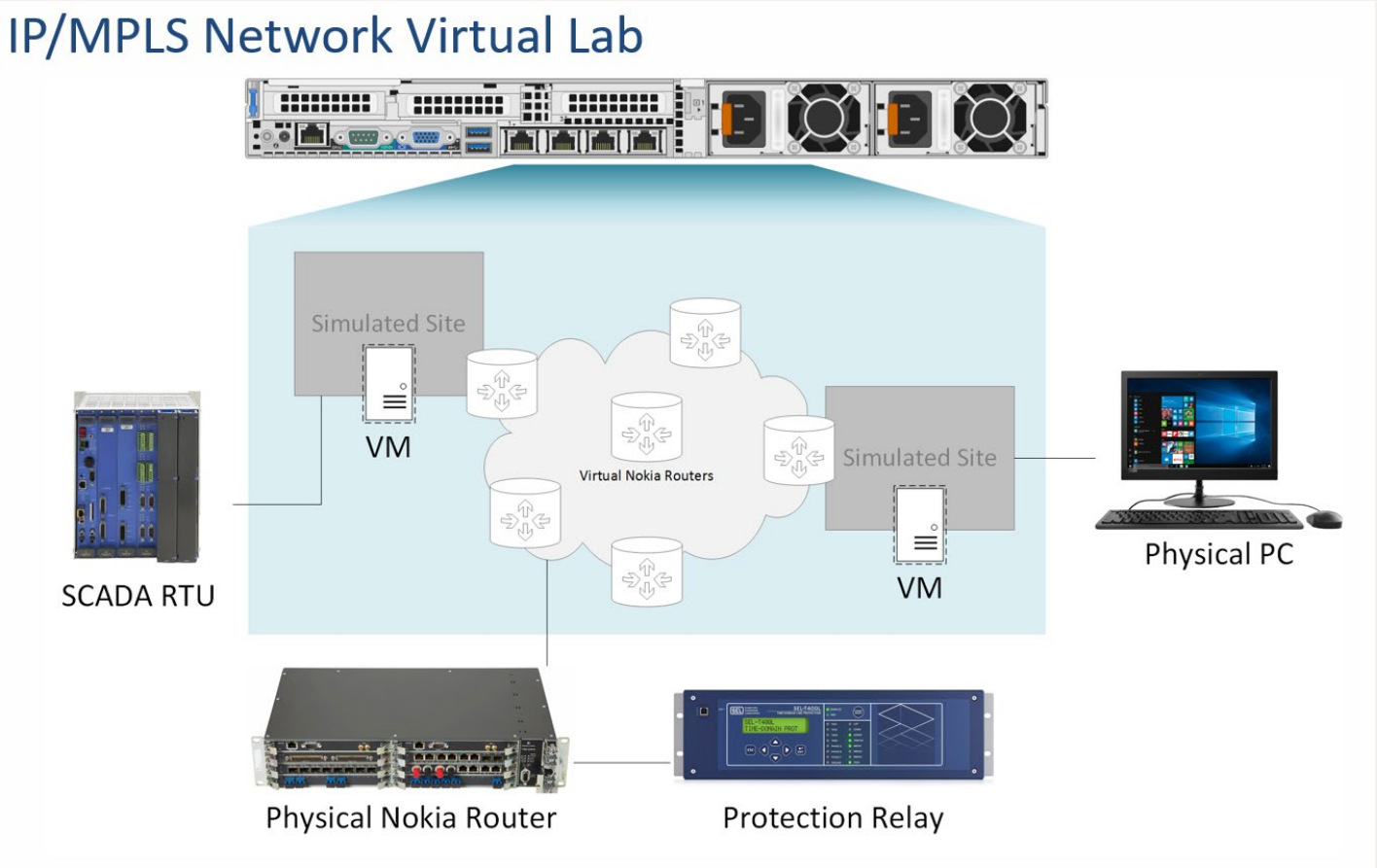
2019 Australia D2 Activities

- Some of the presentation and discussion topics:
  - ✓ **Cybersecurity**
  - ✓ **Dealing with legacy infrastructure and equipment obsolescence**
  - ✓ **IoT, 4G, 5G**
  - ✓ **MPLS**
  - ✓ **Fire planning issues for Telecommunications equipment/site**
  - ✓ **Strategy Development**
  - ✓ **Impact of restructure on Telecommunication operations**
  - ✓ **. . .and many many more**

cigre
For power system expertise

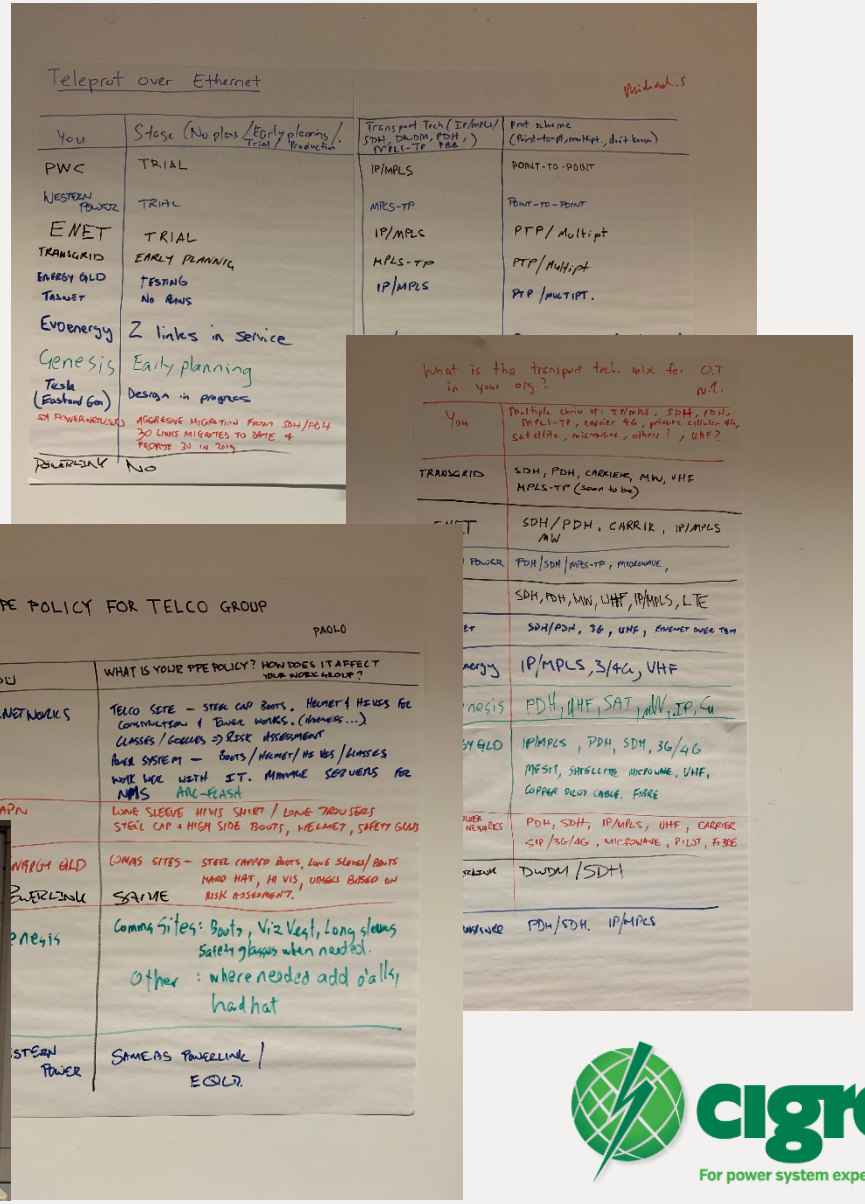
2019 Australia D2 Activities

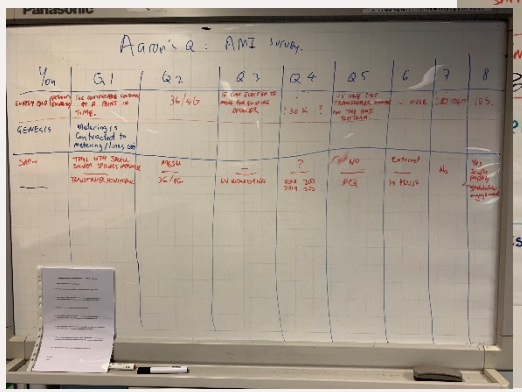
- Example presentation – Power Utility Telecommunications Lab



2019 Australia D2 Activities

- Panel member survey on the following topics:
  - ✓ **Battery technology**
  - ✓ **Teleprotection over Ethernet**
  - ✓ **Telecommunications Technology Mix in OT**
  - ✓ **Use of AI/Machine Learning in Cybersecurity**
  - ✓ **Use of radio and cellular services in distribution networks**
  - ✓ **PPE (personal protective equipment) policy**
  - ✓ **AMI planning and implementation**





cigre
For power system expertise

2019 Australia D2 Activities

- Site visit on the last day to a Telecommunication site

cigre
For power system expertise

Looking Forward

2020:

- July – Australia D2 Panel meeting (venue TBD)
- August – Paris Session

2021:

- July – Australia D2 Panel meeting (venue TBD)
- Oct – Kyoto - Symposium (C6, C2, C2, C5, D2) ACtive Distribution Network Planning, Operation and Contorl

CIGRE ANC
2019 FORUM
Brisbane, Australia

Socializing Research Findings with Energy Stakeholders

Energy – Communication Resilience Group

Presented by Leonie Bule

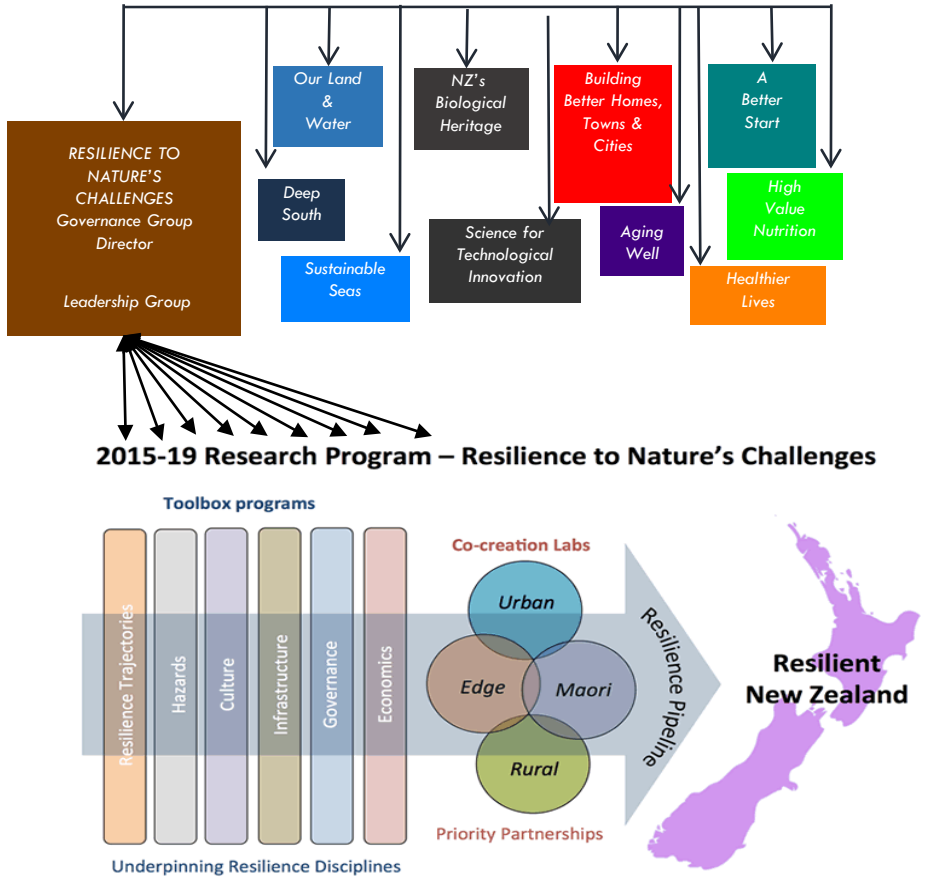
Work done by Resilience to nature's challenges UoA group:
Dr. N-C. K Nair, S. Shirzadi, D. Maina, E. Rehman, F. Latif, S. Al-Sachit

Ministry for business, innovation and employment national science challenges

RNC 1 Goals

Infrastructure

- Networks and Components
- Network Interdependencies
- Performance Measures and Impacts



Contractual research funding relationship
between
MBIE (contractor)
and
The research provider (research institutions)
through
GNS Science – RNC host (hosts the RNC director)

Sub-contractual research funding relationships

GNS (contractor) & lead research institutions;
↓↑
Lead research institutions & Program members (research institutions)
↓↑
Program members (research institutions) & researchers

Power system resilience

Asset Resilience

2010-2011 Canterbury Earthquake Sequence Impact on 11KV Underground Cables

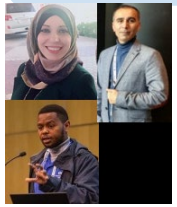
UG Cable Network

Ebad Ur-Rehman

System Resilience

NZ Electricity Distribution Network Resilience Assessment and Restoration Models following Major Natural Disturbance

Electricity



Samad Shirzadi
Duncan Maina
Safa Al-Sachit

Communication

Farrukh Latif

Milestones

- Hazard Mapping to Infrastructure Impact
- Communication Assessment during AF for WestCoast
- Assessing Micro-grid (Islanded Grid) restoration for WestPower
- Policies, Guidelines and Engagement

Power system resilience

Analysing 12 cited definitions of resilience in the context of power system

		Resilience Factors	Times repeated
Factors	1	ability of recovery and restoration	10
	2	ability to withstand	9
	3	ability to adapt	6
	4	ability to anticipate the risks	4
	5	ability to minimize the impacts	3
	6	ability to absorb	2
	7	ability to handle uncertainties	1
	8	ability to isolate	1

ability of recovery and restoration

black start

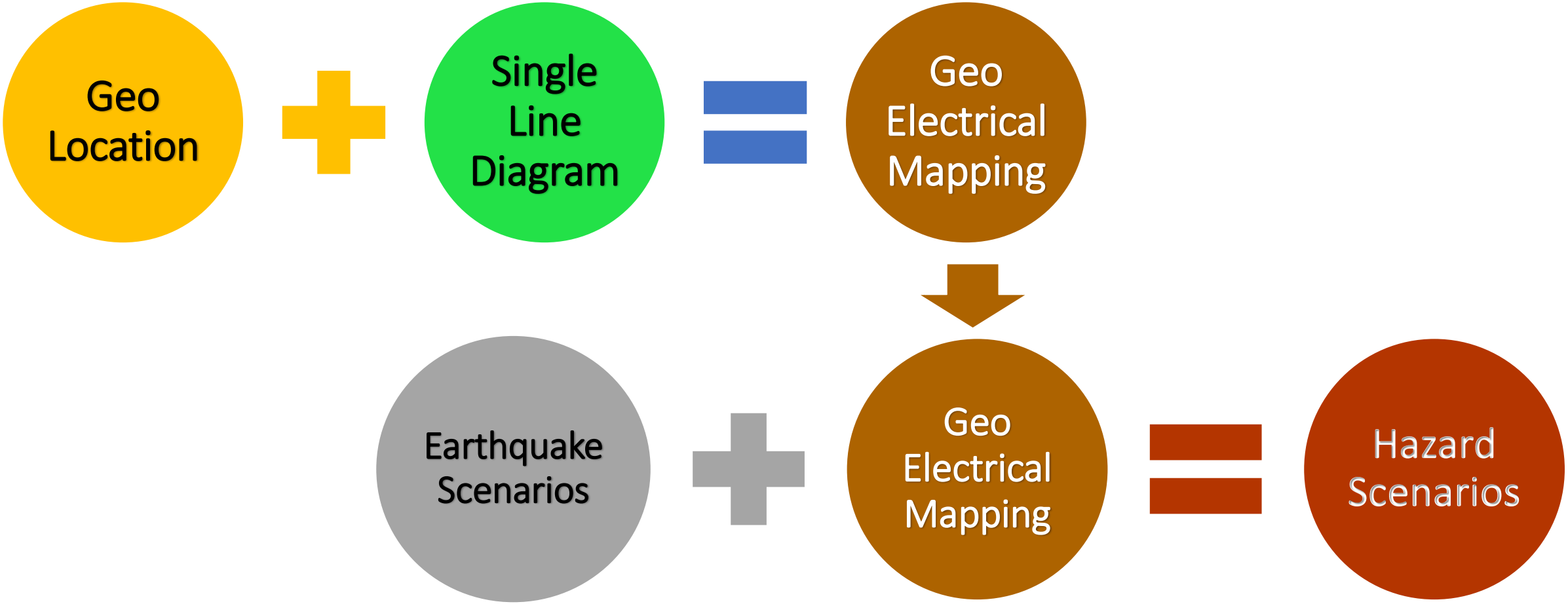
ability to adapt

transition to islanding mode

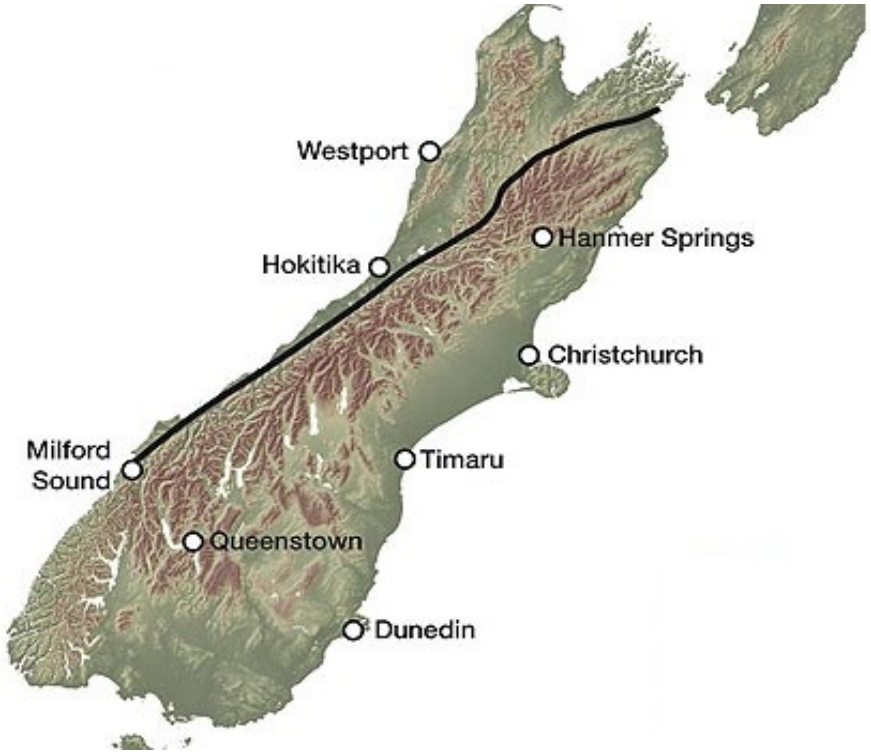
islanded grid control

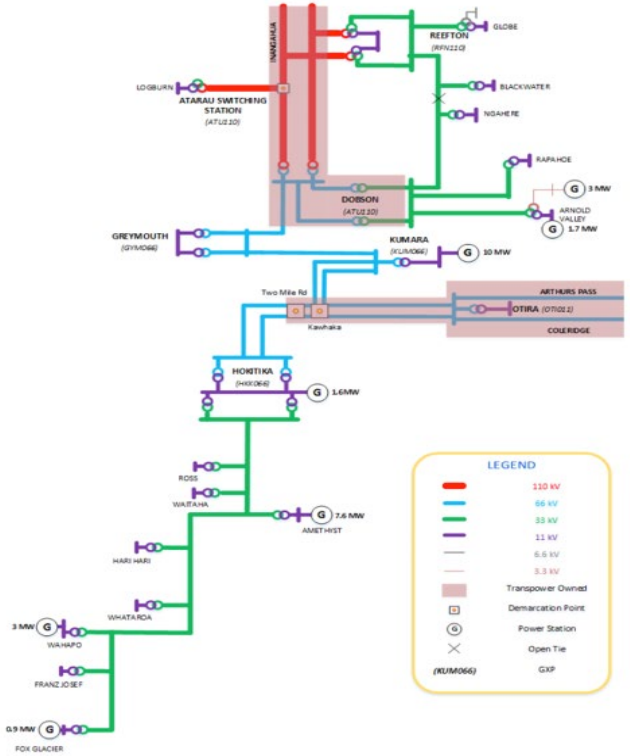
protection

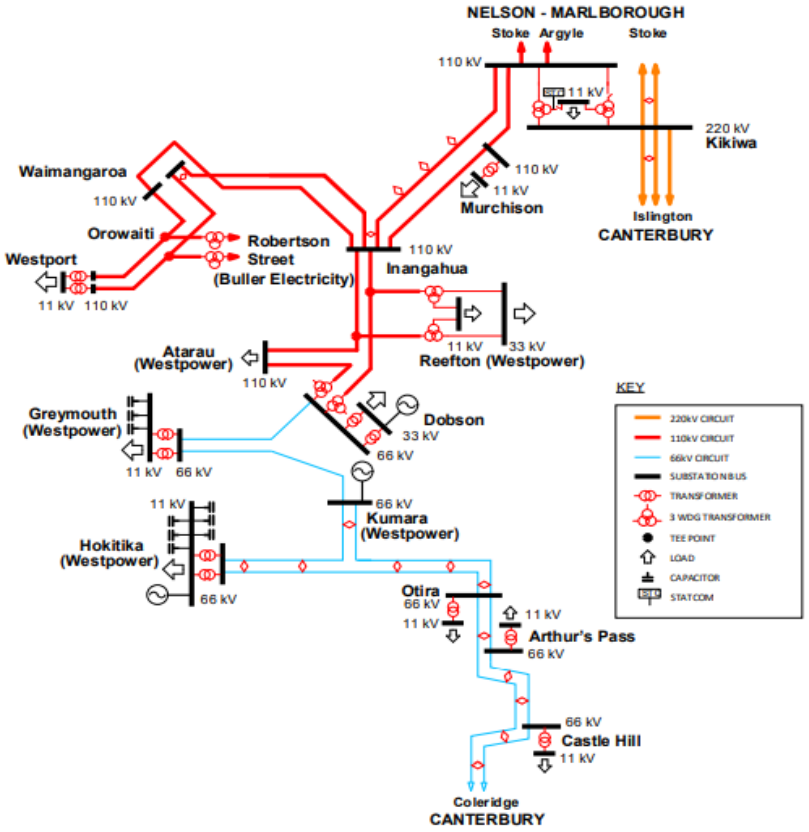
Hazard Mapping



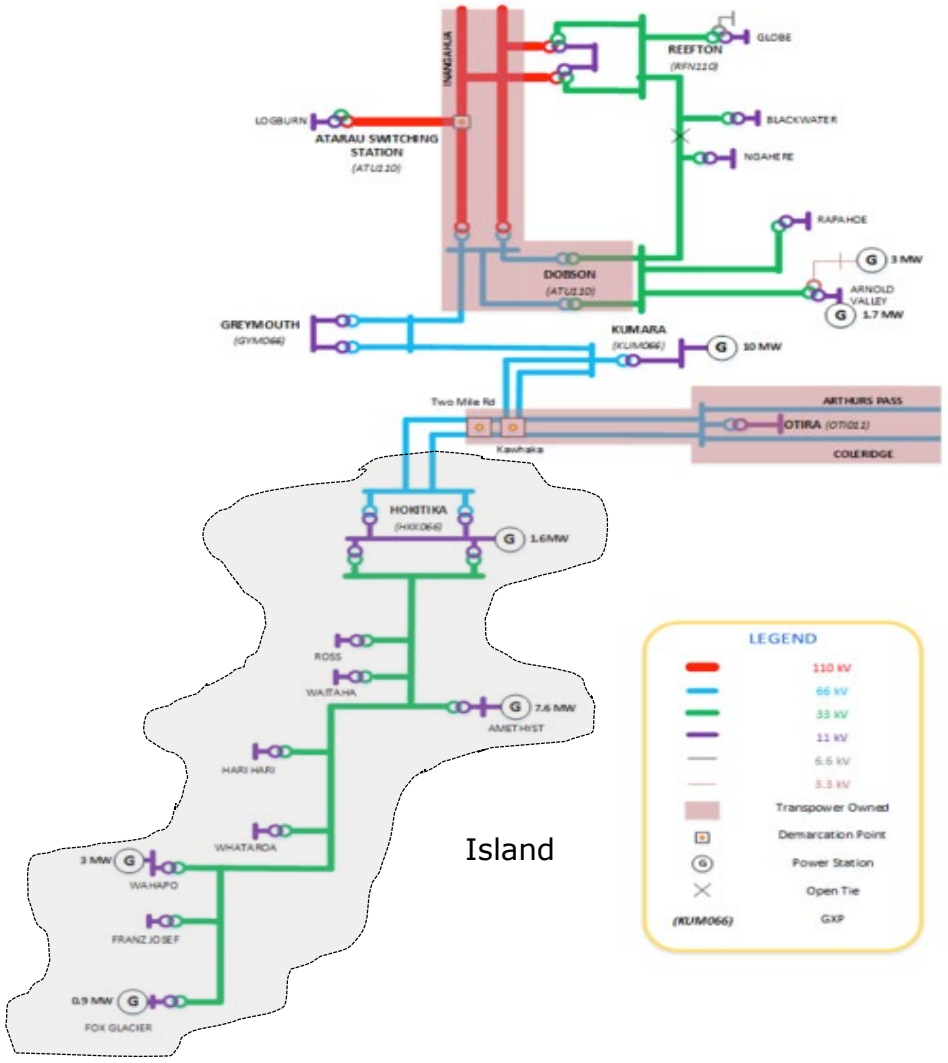
Geo Electrical Mapping

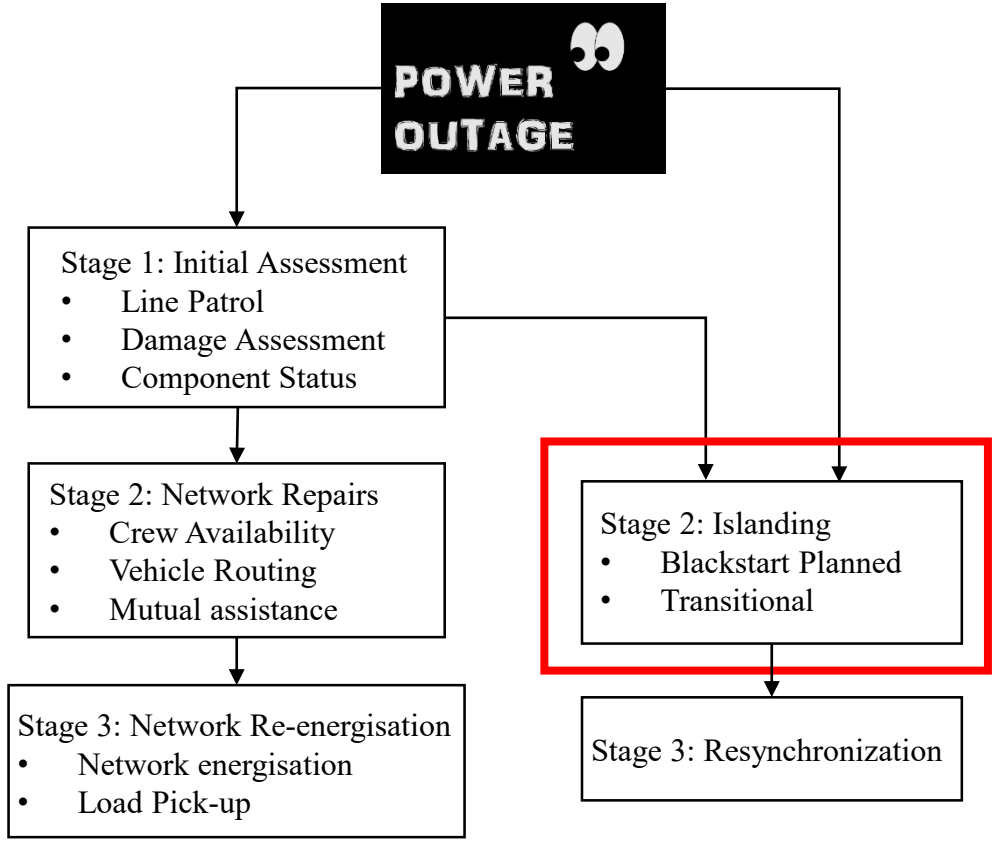




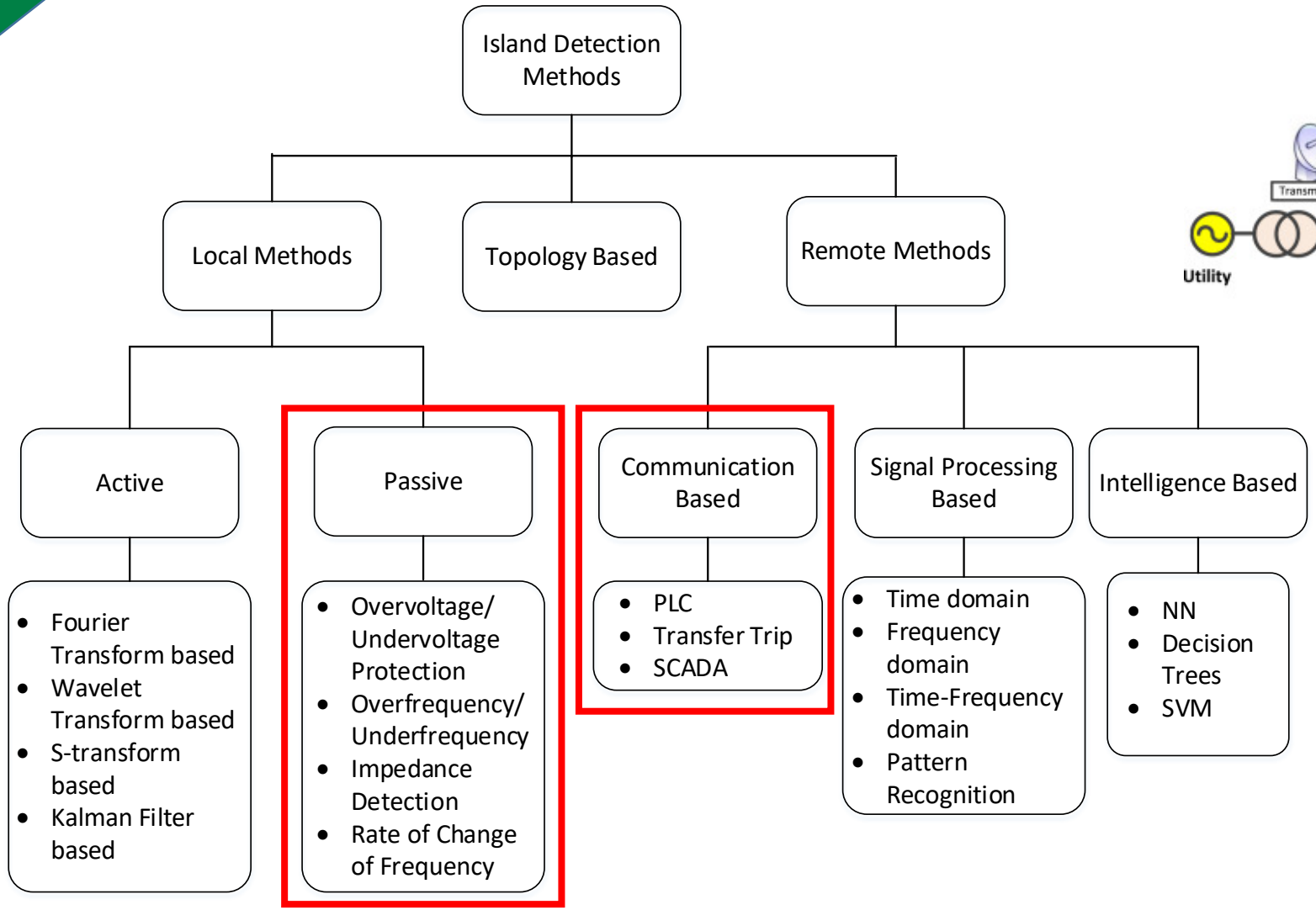


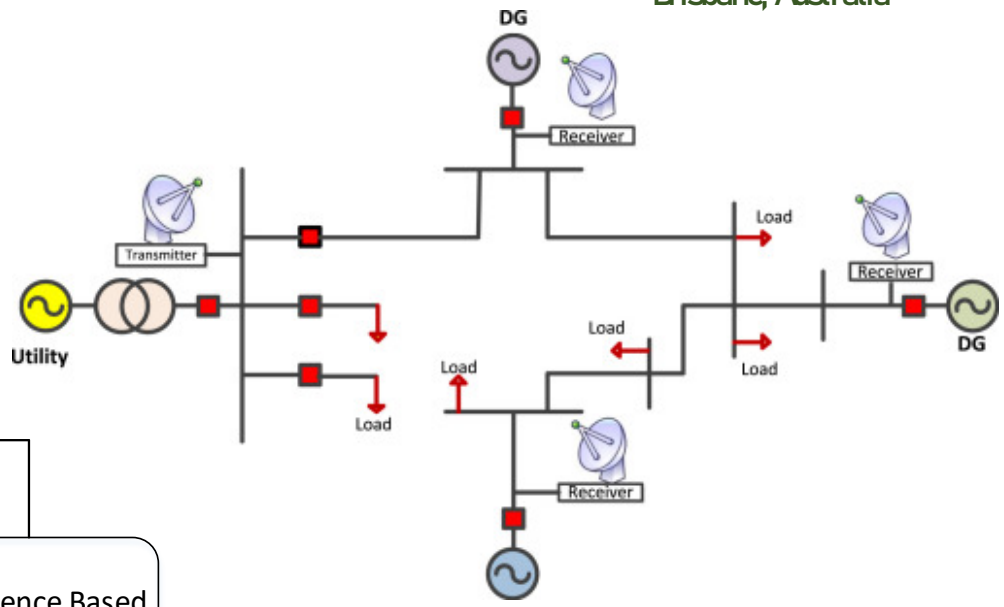
Restoration Model



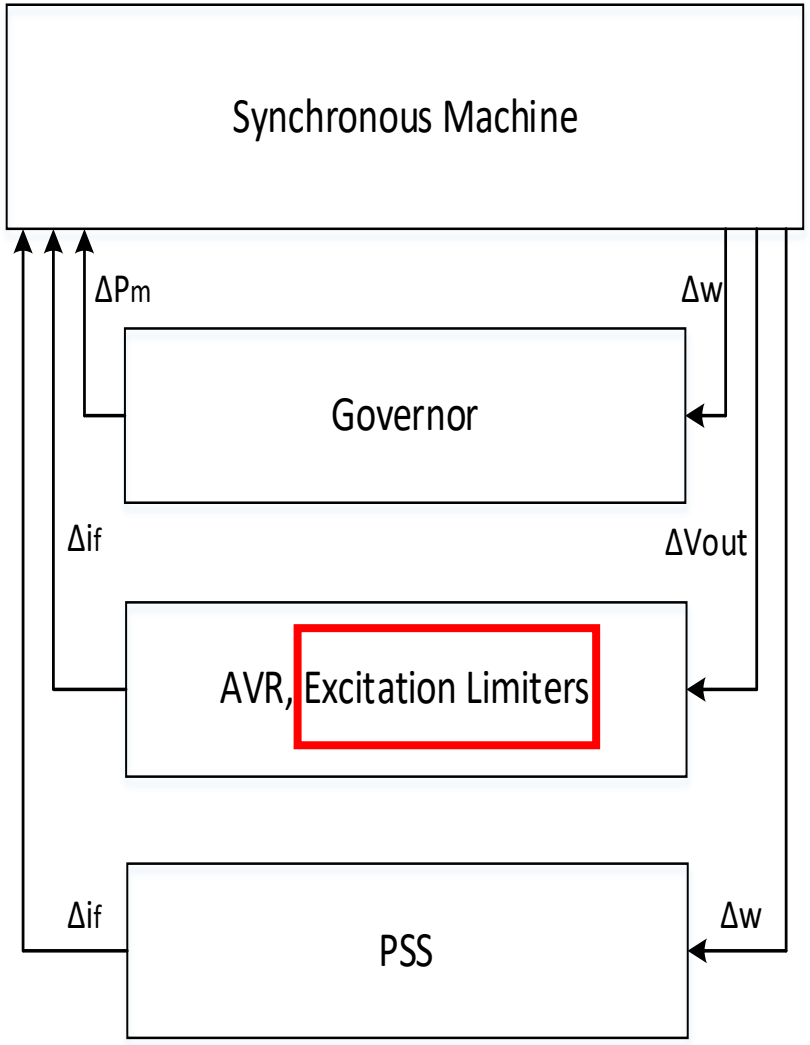


Island Detection

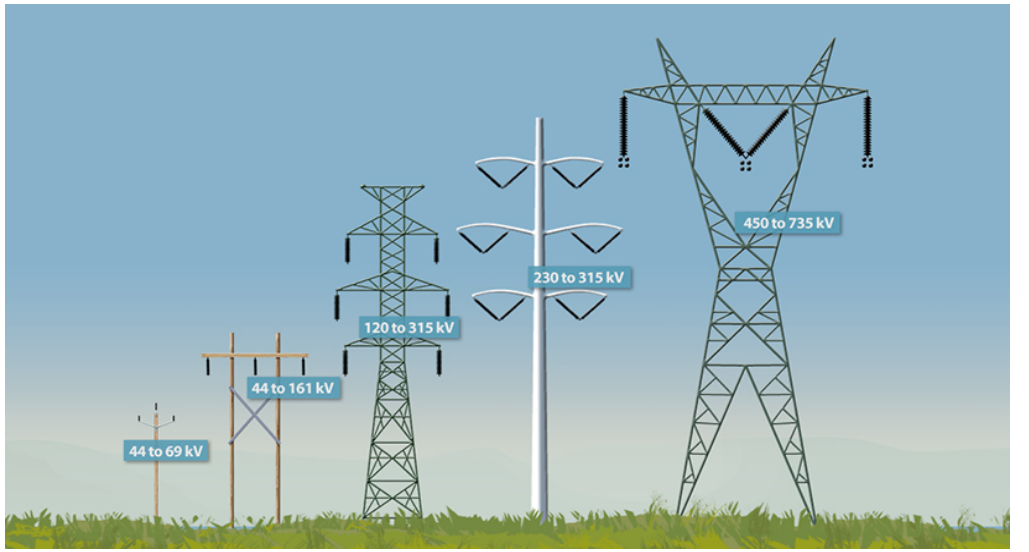




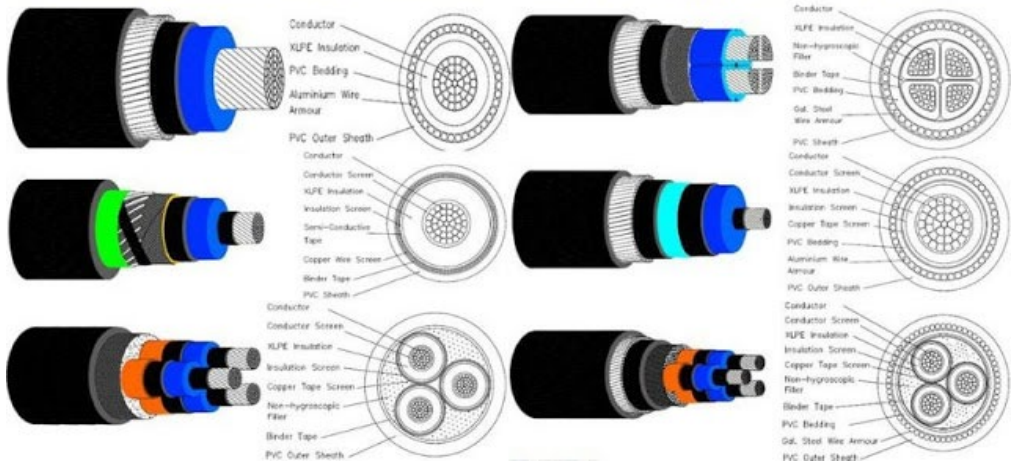
Generator Modelling



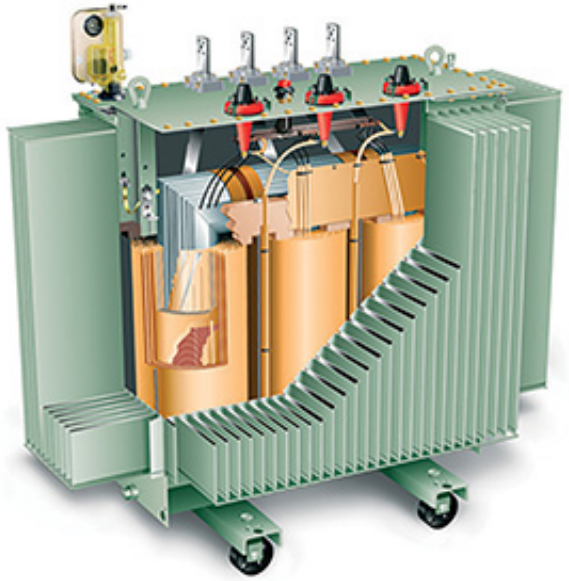
Transmission Line Modelling

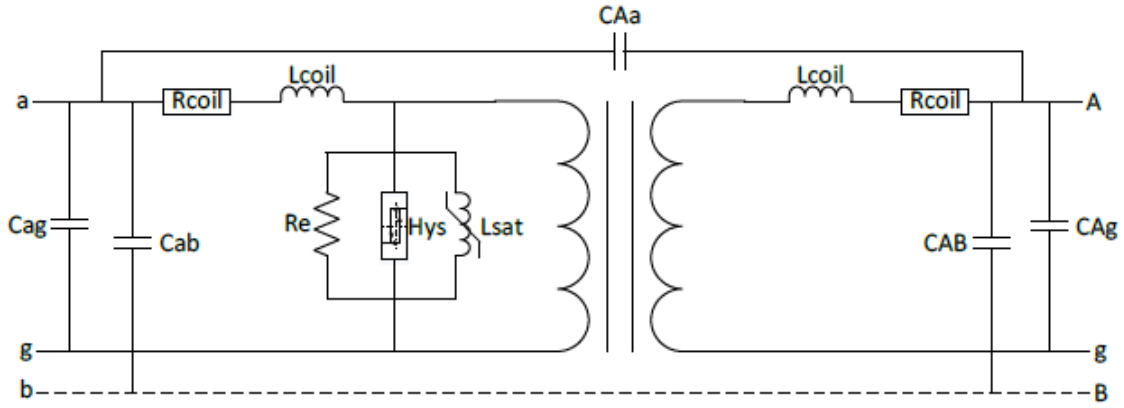


General Cable Construction 1kV ~ 35 kV, Copper / Al Conductor



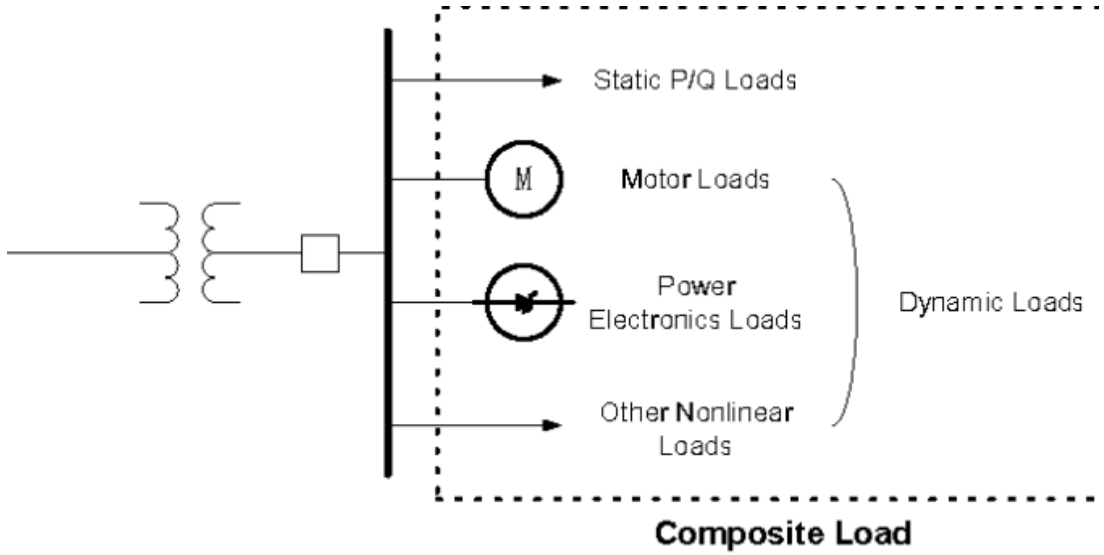
Transformer Modelling





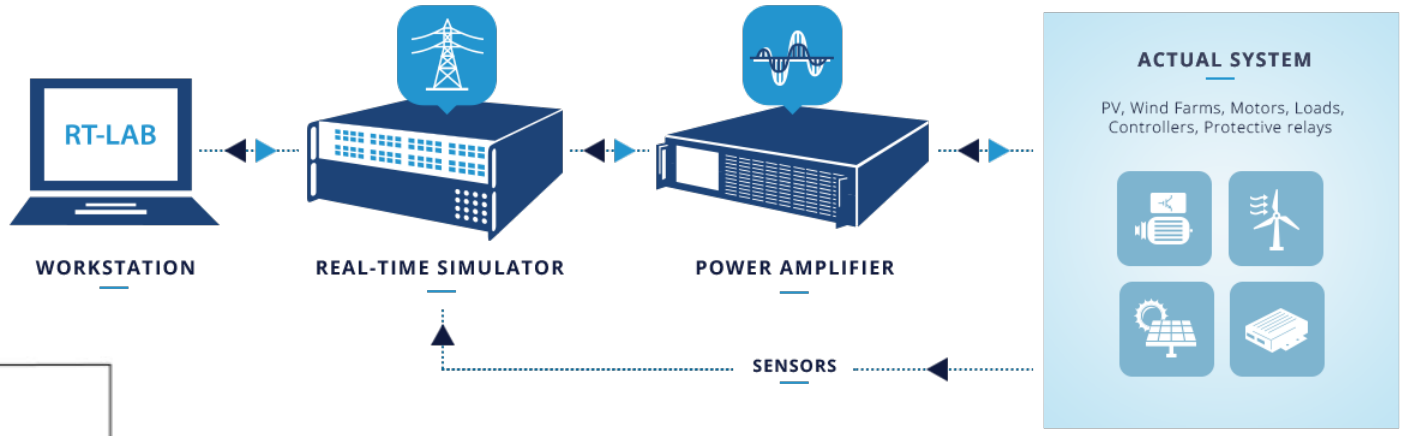
Load Modelling

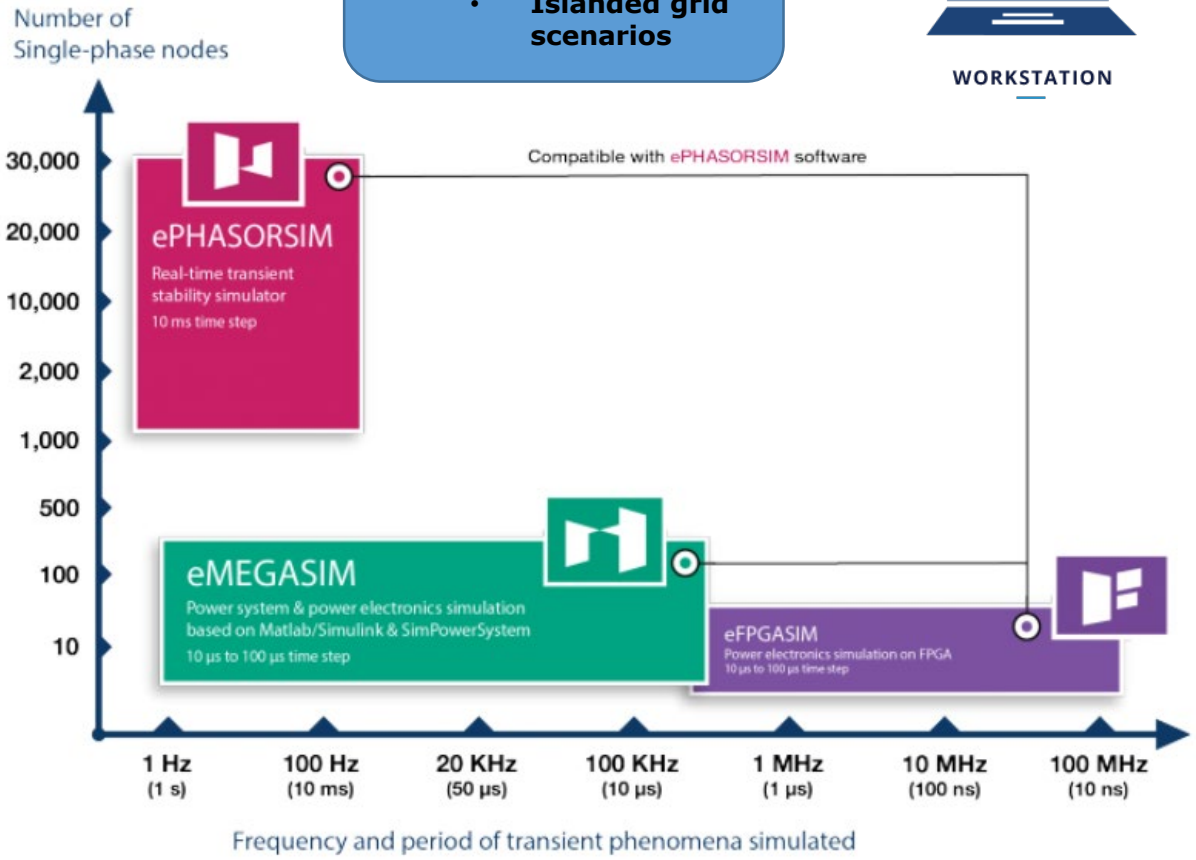
- Load Models:
  - Constant Impedance Load Model
  - Constant Current Load Model
  - Constant Power Load Model
  - Exponential Load Model
  - Polynomial Load Model



Real Time Simulation

Network Info:
- **Grid topology**
- **Parameters**
- **Islanded grid scenarios**





EMT simulations in real time.

MATLAB SIMULINK®

RT-LAB

NZ Electricity Distribution Network Resilience Assessment and Restoration Models following Major Natural Disturbance

NETWORK COMPONENT MODELLING FOR BLACKSTART PLANNED ISLANDING

Authors:

Duncan Kaniaru Maina
Nirmal-Kumar C Nair

Affiliations:

Duncan Kaniaru Maina, B.Sc. (First class) at University of Nairobi, Kenya and, Master of Electrical Power System Engineering with Distinction at University of Manchester, UK. He is currently pursuing his PhD in Power Systems Group at the University of Auckland.

Nirmal-Kumar Nair, B.E. (M.S. University, Baroda, India), M.E. (IISc., Bangalore, India),

HOW DO YOU ASSESS AND QUANTIFY RESILIENCE FOR DISTRIBUTION NETWORKS?

Authors:

Nirmal-Kumar C Nair, Dr.
Duncan Kaniaru Maina
Leo Yang Liu, Dr

Affiliations:

1. Nirmal-Kumar Nair, B.E. (M.S. University, Baroda, India), M.E. (IISc., Bangalore, India), Ph.D. (Texas A&M University, College Station, USA), is currently an Associate Professor in the Electrical and Computer Engineering Department, The University of Auckland, New Zealand.
2. Duncan Kaniaru Maina, B.Sc. (First class) at University of Nairobi, Kenya and, Master of Electrical Power System Engineering with Distinction at University of Manchester, UK. He is currently pursuing his PhD in Power system engineering group at the University of Auckland.
3. Leo Yang Li, B.E. degree (with first class Hons.) and PhD in Electrical Engineering from the University of Auckland in 2012 and 2016 respectively. He is currently a research fellow at the Department of Civil and Environmental Engineering, University of Auckland.

Fault Detection in Transmission Lines — A Novel Voltage-Based Scheme for Differential Protection

Safa Kareem Al-Sachit
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
slas931@aucklanduni.ac.nz

Mohammad Javad Sanjari
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
msan310@aucklanduni.ac.nz

Nirmal-Kumar C Nair
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
n.nair@auckland.ac.nz

***Abstract*—Current-based protection schemes such as distance, overcurrent, and differential relays are usually used to protect transmission lines (TL) in power systems where the high fault current plays a key role in detecting faults. The continuous development in the power network and emerging new technologies have made the power grid more complicated and soon will start to affect the reliability of the existing protection schemes. Issues like current transformer saturation, the effect of the mutual coupling impedance of the TL and emerging new power electronic-based technologies have become major challenges in power systems from a protection perspective. To avoid all the current-based problems this paper proposes a new voltage-based relay principle for TL protection to indicate fault occurrences in transmission networks. The proposed scheme is tested under all fault events to show that it is highly accurate when it comes to rapid trip activation during any of the tested cases.**

Keywords: Differential relay, negative sequence voltage, relay modeling, symmetrical components, transmission line protection, unbalanced fault.

scheme depends on measuring the impedance of the protected TL to identify the faulted zone. However, [2] recognized that distance relays have some obstacles regarding the phase shift between voltage and current, fault resistance and third zone maloperation [3]. The CT saturation effect appears prominently in the transmission network using distance protection schemes; hence it results in excessive tripping delay time [4-6]. The high fault current in some cases prevents CTs from sending the actual current value to the relay, and the relay will receive only a relatively low current at the secondary side during severe faults. However, distance protection is recommended for distribution networks due to it having a directional element that increases its ability to deal with meshed networks. The high cost of this scheme might be an obstacle since it requires both voltage and current transformers. However, it is only suitable for a small range of considerations and the correct settings may be more difficult to determine compared to the OCR [1].

Differential relays have also gained a wide recognition because it is a protection scheme rated as highly sensitive,

2018 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)

Power system resilience through microgrids: A comprehensive review

Samad Shirzadi, Nirmal-Kumar C. Nair
Electrical and Computer Engineering Department
The University of Auckland
Auckland, New Zealand
shirzadi1983@gmail.com, n.nair@auckland.ac.nz

***Abstract*—This paper reviews the role of microgrids in power system resilience improvement. Different definitions of system resilience that are addressed in different works are analyzed and summarized. Framework and metrics in power system resilience improvement and assessment are discussed and reviewed. Finally different microgrid based solutions for system resilience improvements are categorized and discussed.**

Keywords—microgrid, power system resilience, reconfiguration, operation, control, protection, hybrid microgrids

resilience. Third section explains the power system framework, resilience metrics and hazard event characterization. Fourth section covers the role of microgrids in power system resilience improvement and sixth section provides a conclusion.

Earthquakes

Darfield earthquake

- 04 September 2010 at 4:36 AM
- Magnitude: 7.1 MW, Depth: 10 Km
- Location: 40 Km west of Christchurch near Darfield

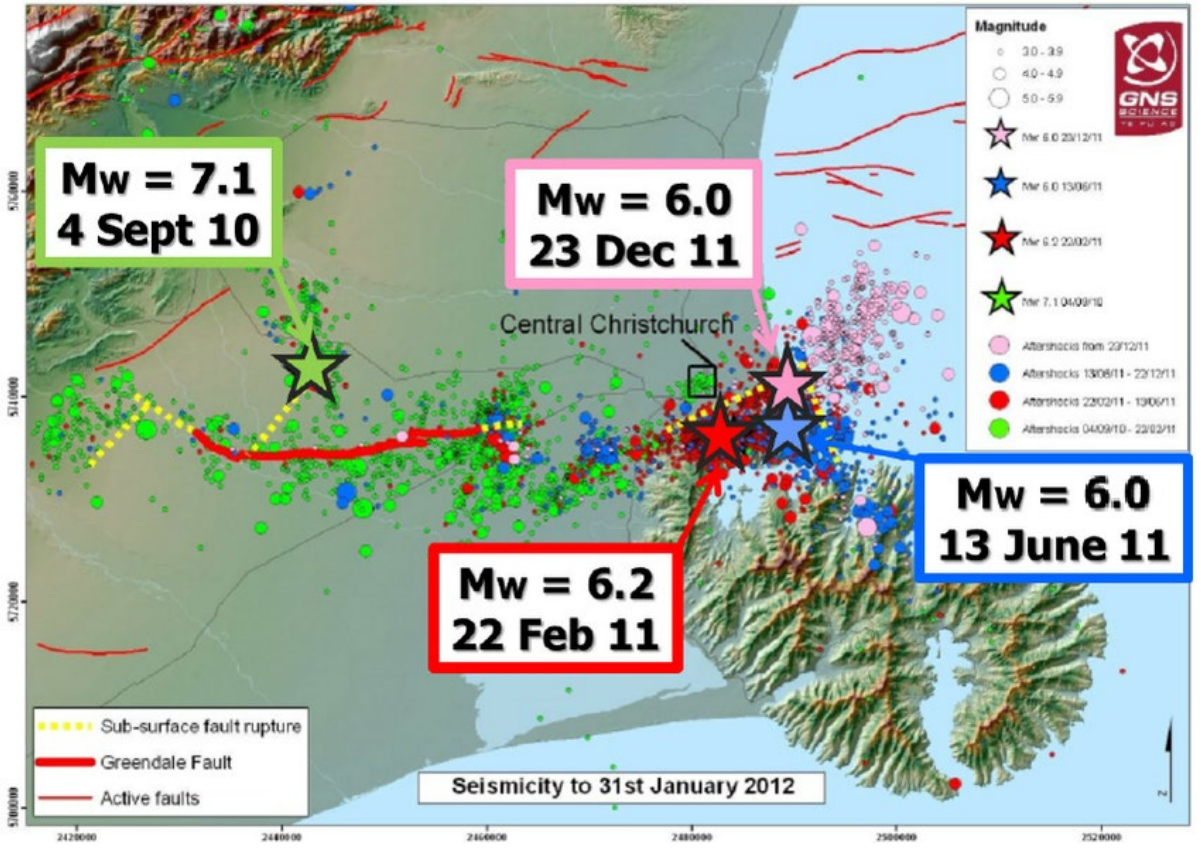
Christchurch earthquake

- 22 February 2011 at 12:51 PM
- Magnitude: 6.2 MW, Depth: 5 Km
- Location: 10 Km south-east of Christchurch near Lyttelton

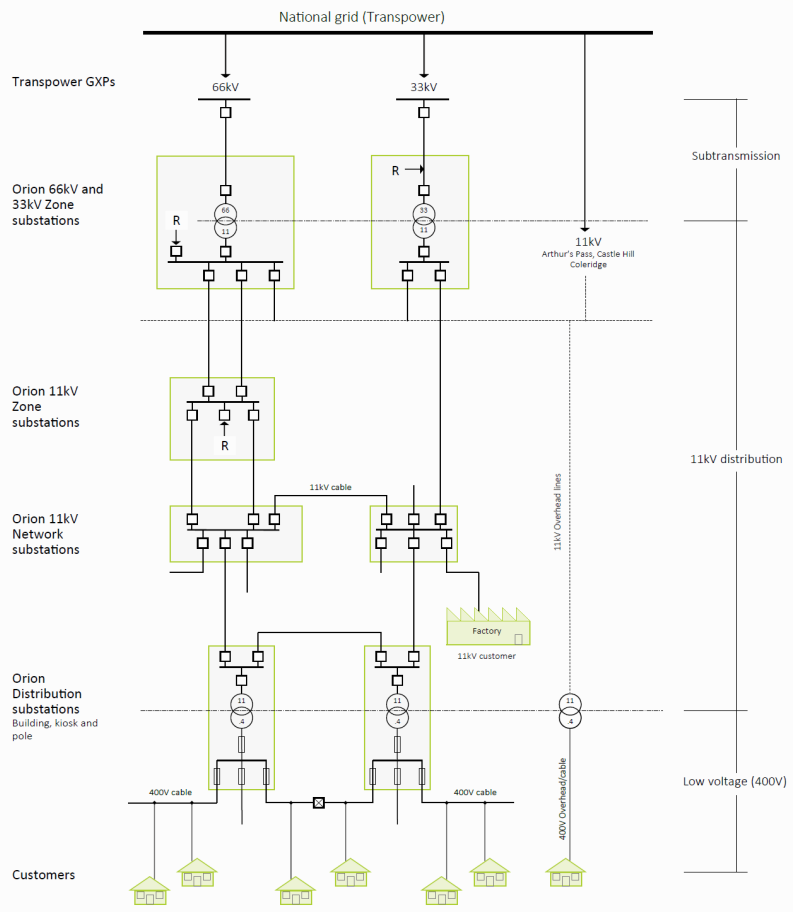
Numerous aftershock occurred later, several with magnitude greater than 5 MW

Impact of an Earthquake

1. Liquefaction
2. Land Slide
3. Ground Deformation
4. Tectonic Uplift



Orion Cable Network–Case Study



Category	Description	31 March 2017
Total network	Lines and cables (km)	15,623
	Zone substations	51
	Distribution substations	11,361
Overhead lines (km)	66kV	246
	33kV	279
	11kV	3,209
	400V	1,804
	Street lighting	917
Underground cables (km)	66kV	89
	33kV	37
	11kV	2,602
	400V	2,974
	Street lighting	2,434
	Communication	1,031
	Total cables	9,168
Zone substations	66kV	27
	33kV	19
	11kV	5
Distribution substations	Building	468
	Ground mounted	4,724
	Pole mounted	6,397
Embedded generation	Greater than 1MW	10 Customer-owned sites
Major business customers	Loads between 0.3MW and 11MW	325

Rationale

Impact	Darfield Earthquake	Christchurch Earthquake
Date & Time	04 Sep 2010 4:36AM	22 Feb 2010 12:51PM
Magnitude & Depth	7.1 Mw, 10 KM	6.2 Mw, 5 KM
Location	40 KM west	10 KM south-east
Damage (%)	1-3	7-10
Restoration Time (90%)	1 Day	10 Day
Direct Cost	$4 Million	Over $40 Million
Customer Minutes Lost	88 Million	630 Million

Hazard	Overhead Asset	Underground Asset
Liquefaction	Minor/Moderate	Major
Lateral Spreading	Minor/Moderate	Major
Ground Deformation	Minor	Major
Tectonic Uplift	Minor	Major

Types of 11 KV Underground Cables

Metal Core

- Copper
- Aluminum

Insulation Material

- Paper-Insulated Lead Covered Armored (PILCA)
- Cross-Linked Polyethylene (XPLE)
- High-Density Polyethylene PILCA (PILCA HDPE)

Damage to 11KV underground cables

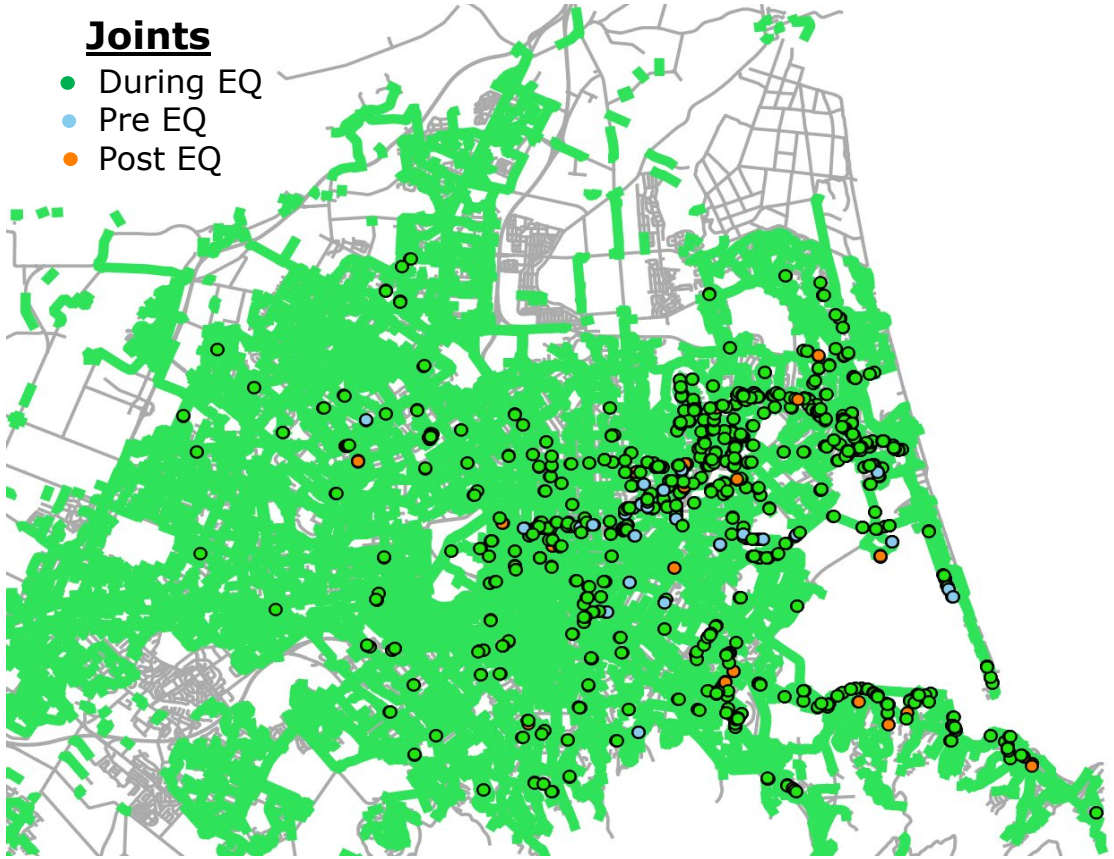
- Bending
- Stretching
- Insulation damage
- Being pulled-off equipment
- Joints breaking

Digitising Data

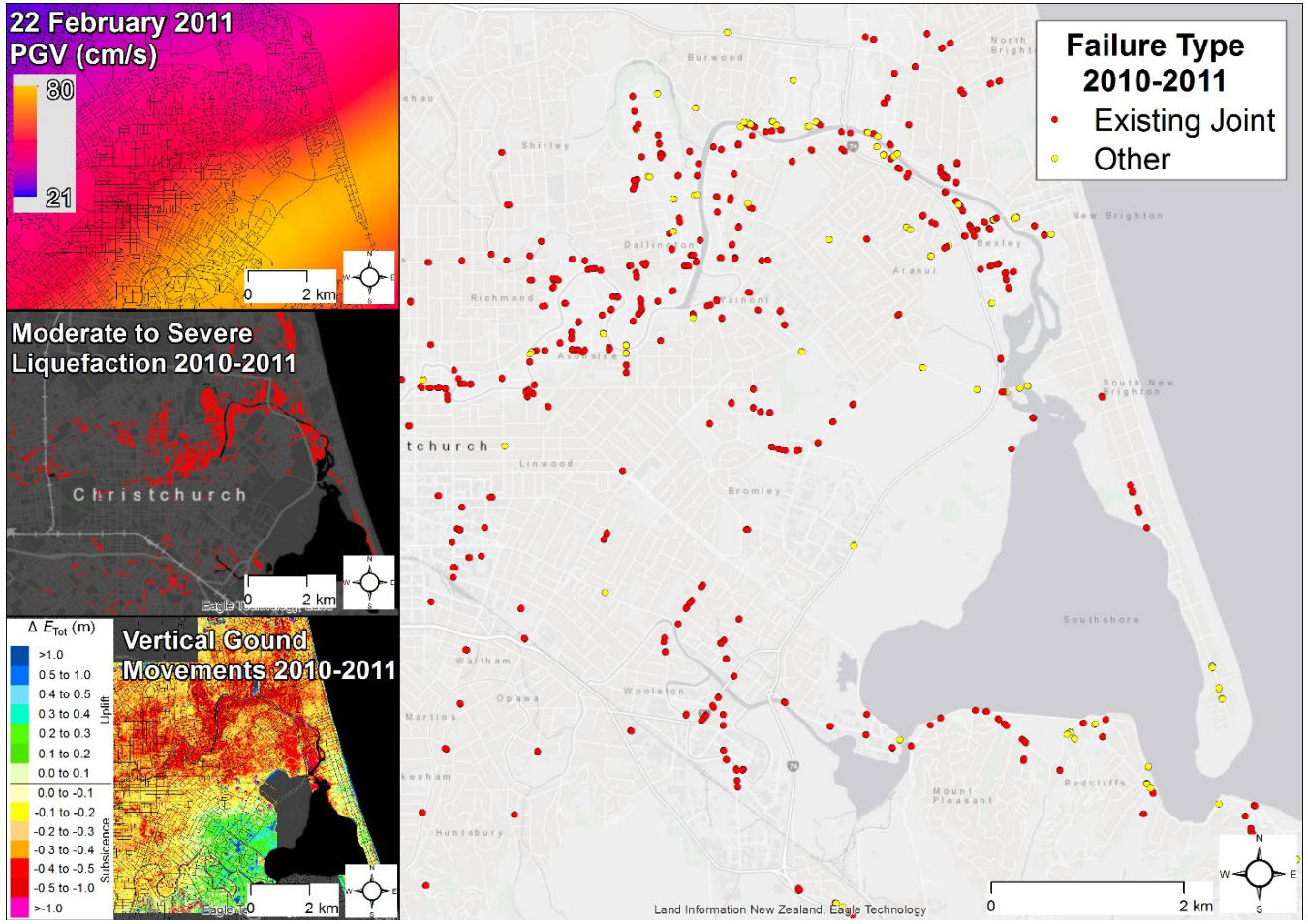
Post-Earthquake database development - Compilation of a detailed geospatial database of component and network repairs.

Data dictionary construction, information will include:

1. **Job date and time**
2. **Job location** (based on address and/or other location information)
3. **Infrastructure type** – e.g. buried cable type/material, substation etc.
4. **Failure cause** – e.g. earthquake-induced transient and-or permanent ground deformation
5. **Failure mode** – detailed description of component/material failure – use photographs taken by repair crews
6. **Repair** – detailed description of repair action/components and materials used - use photographs taken by repair crews
7. **Other information** – e.g. details on pre/post-repair lines testing (other?)



Digitizing the Damage Points on 11KV Underground Cable



Failure Type	Total
Cable Faults	156
Existing Joints	1,050
Bridge Movement	29
Grand Total	**1,234**

CIGRE ANC
2019 FORUM

Blackbird, Brisbane

Socializing Research Findings with Energy Stakeholders

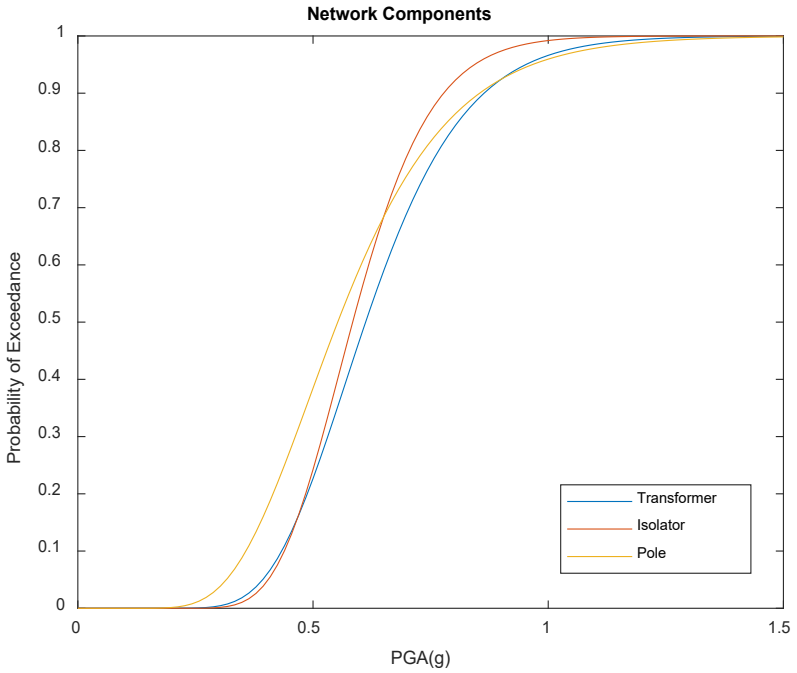
Energy – Communication Resilience Group

THANK YOU

RNC contact UoA:
Dr. Nirmal Nair

Hazard Mapping

Component Fragility Curves **OR** **Component Fragility Assumption**



More Scenarios

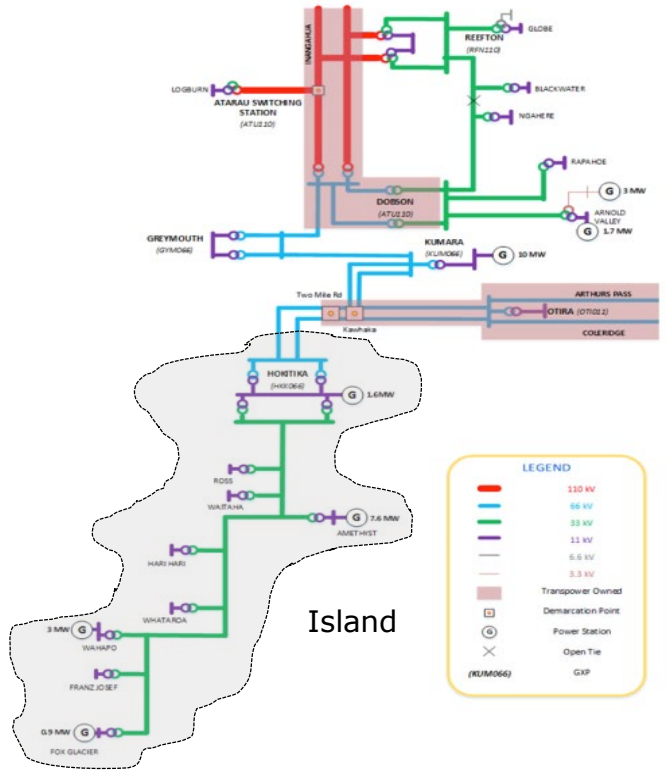
Hazard Mapping

Component Fragility Assumption

PGA

MMI

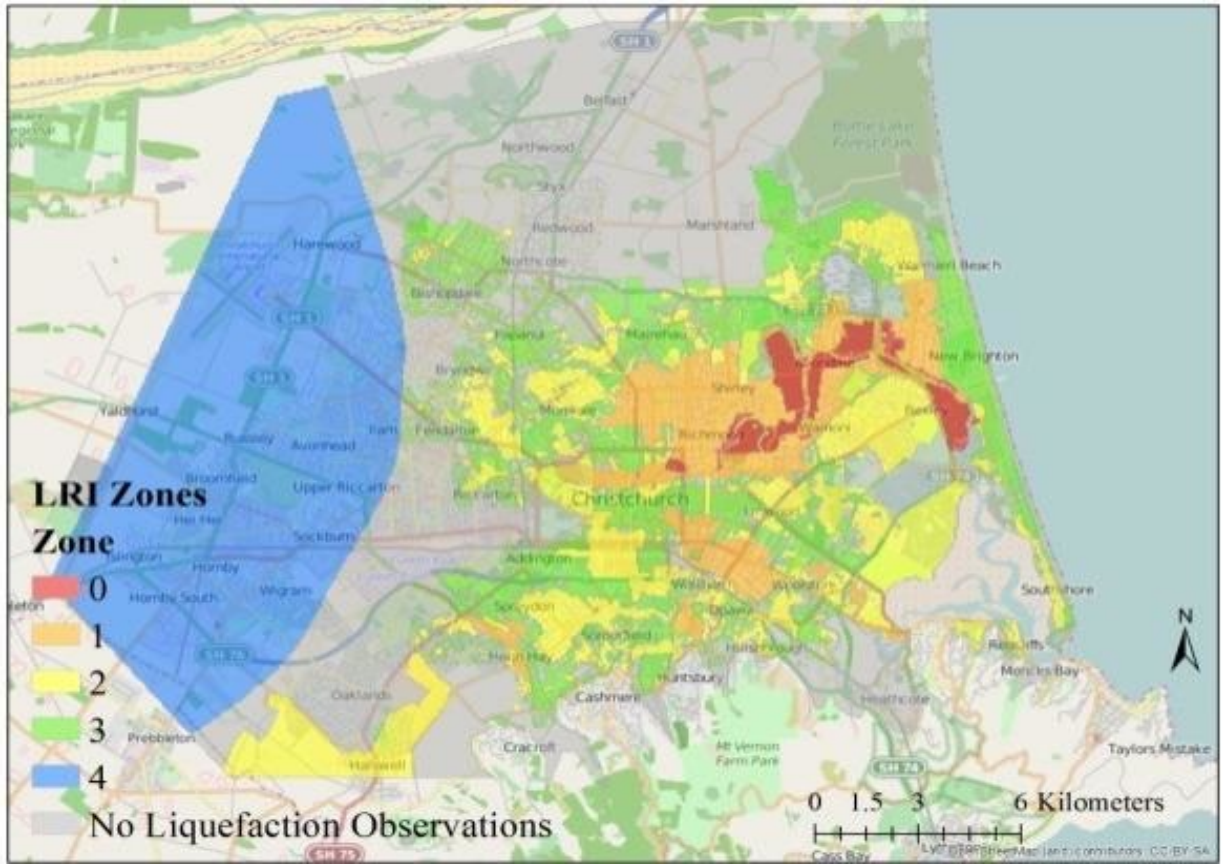
MMI _1
MMI _2
MMI _3
.
.
.
MMI _10



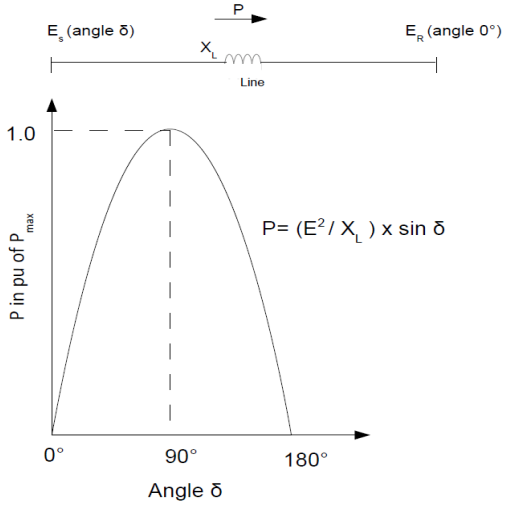
MMI _8 Scenario
Whole Grid as an Island

Intensity Measures (IM)

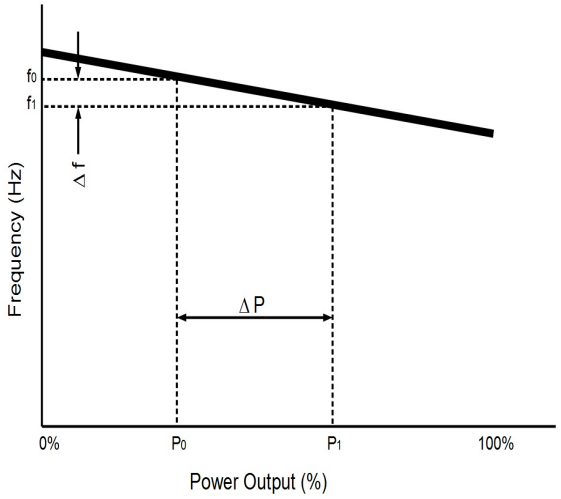
1. Peak Ground Acceleration (PGA)
   (Relates to inertia forces)
2. Peak Ground Velocity (PGV)
   (Relates to Ground Strain)
   - Vertical Ground Deformation ($PGDf_V$)
     (Relates to differential vertical settlement)
   - Horizontal Ground Deformation ($PGDf_H$)
     (Relates to lateral spread)



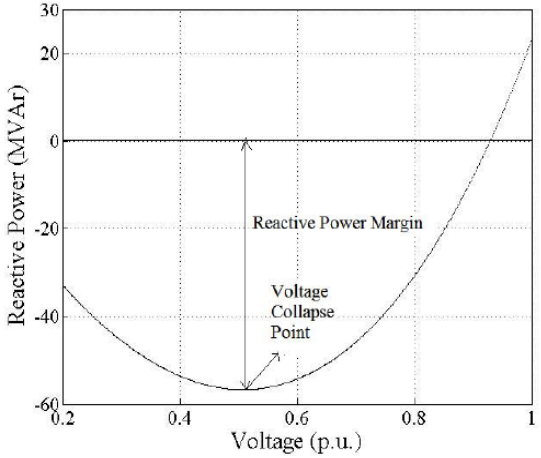
Islanded Grid Control



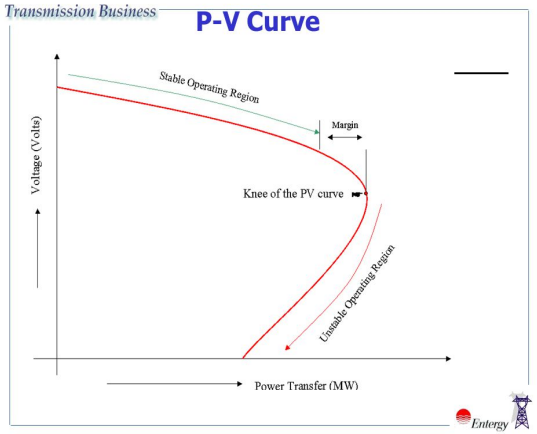
Angle stability



P–F balance



V–Q balance



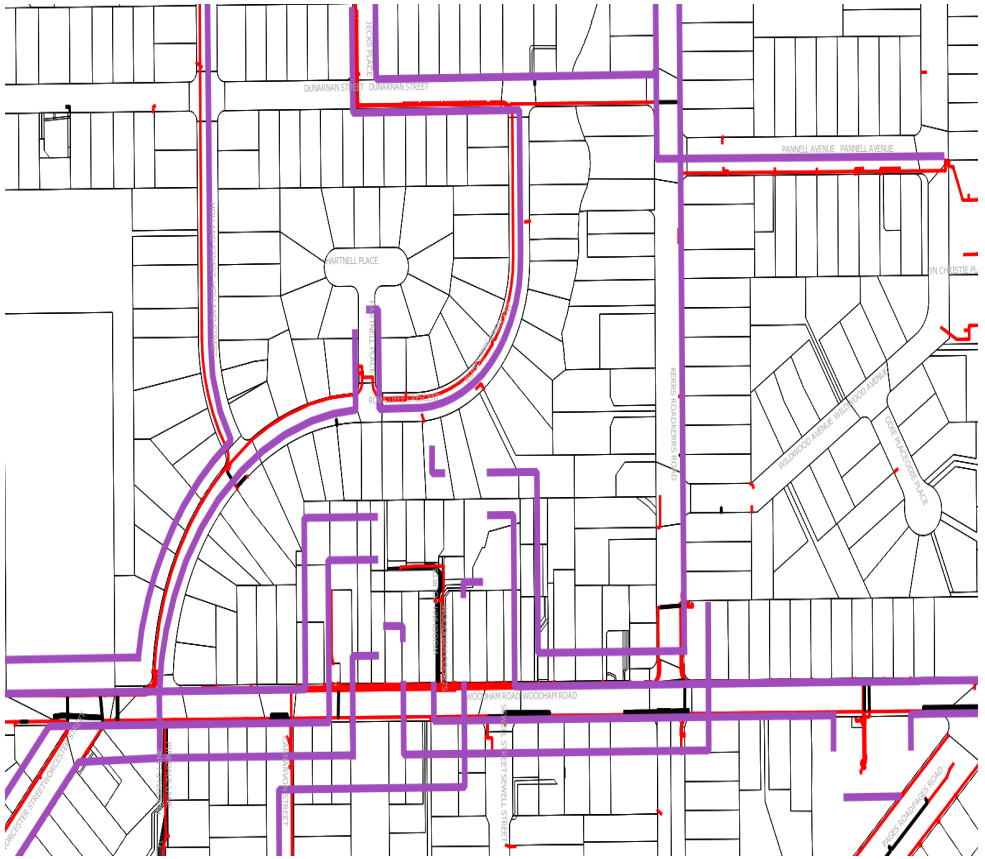
V-P Balance

Cables Geo-Spatial Location

Post-Earthquake database development - Compilation of a detailed geospatial location of underground cables and network repairs.

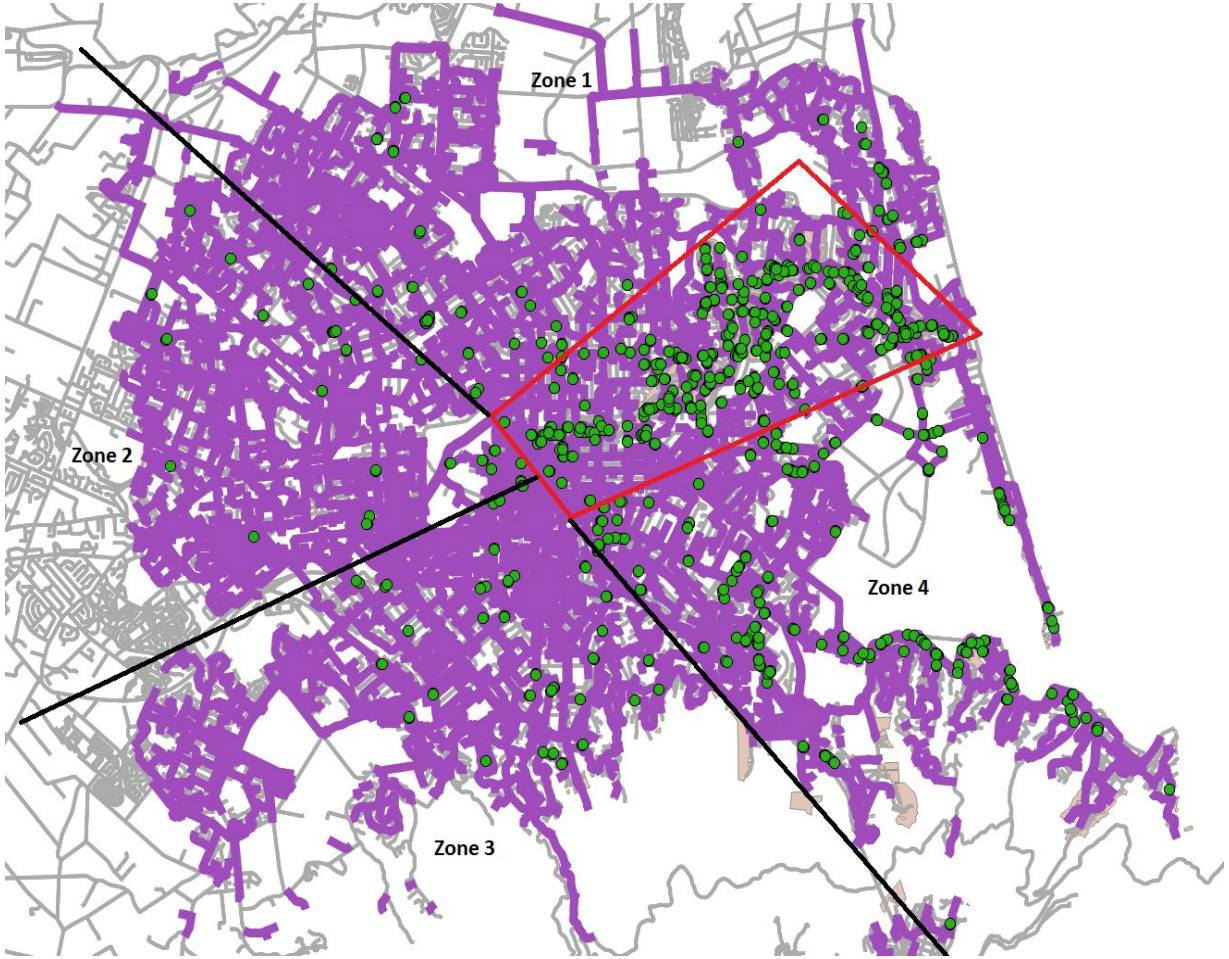
Data dictionary construction, information will include:

1. **Cable Phase** – Number of cores of cable
2. **Cable Size** – diameter of cable
3. **Copper – Alu** – Conductor material of UG cable e.g. copper or aluminium
4. **Belted / SCR** – classification of cable construction
5. **Cable card** – repair job number
6. **Cable cons** – type of insulating material
7. **Installed Ye** – Year installed
8. **Installed Mo** – Month installed



Future Work

- Develop fragility curves to determine the damage caused by the earthquake.
- Determine the health of the asset.
- Study on the LV network effected during the 2010-2011 Canterbury earthquake



HOW DO YOU ASSESS AND QUANTIFY RESILIENCE FOR DISTRIBUTION NETWORKS?

Authors:

Nirmal-Kumar C Nair, Dr.
Duncan Kaniaru Maina
Leo Yang Liu, Dr

Affiliations:

1. Nirmal-Kumar Nair, B.E. (M.S. University, Baroda, India), M.E. (IISc., Bangalore, India), Ph.D. (Texas A&M University, College Station, USA), is currently an Associate Professor in the Electrical and Computer Engineering Department, The University of Auckland, New Zealand.
2. Duncan Kaniaru Maina, B.Sc. (First class) at University of Nairobi, Kenya and, Master of Electrical Power System Engineering with Distinction at University of Manchester, UK. He is currently pursuing his PhD in Power system engineering group at the University of Auckland.
3. Leo Yang Li, B.E. degree (with first class Hons.) and PhD in Electrical Engineering from the University of Auckland in 2012 and 2016 respectively. He is currently a research fellow at the Department of Civil and Environmental Engineering, University of Auckland.

2018 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)

Power system resilience through microgrids: A comprehensive review

Samad Shirzadi, Nirmal-Kumar C. Nair
Electrical and Computer Engineering Department
The University of Auckland
Auckland, New Zealand
shirzadi1983@gmail.com, n.nair@auckland.ac.nz

***Abstract*—This paper reviews the role of microgrids in power system resilience improvement. Different definitions of system resilience that are addressed in different works are analyzed and summarized. Framework and metrics in power system resilience improvement and assessment are discussed and reviewed. Finally different microgrid based solutions for system resilience improvements are categorized and discussed.**

***Keywords*—microgrid, power system resilience, reconfiguration, operation, control, protection, hybrid microgrids**

resilience. Third section explains the power system framework, resilience metrics and hazard event characterization. Fourth section covers the role of microgrids in power system resilience improvement and sixth section provides a conclusion.

Islanded Grid Protection

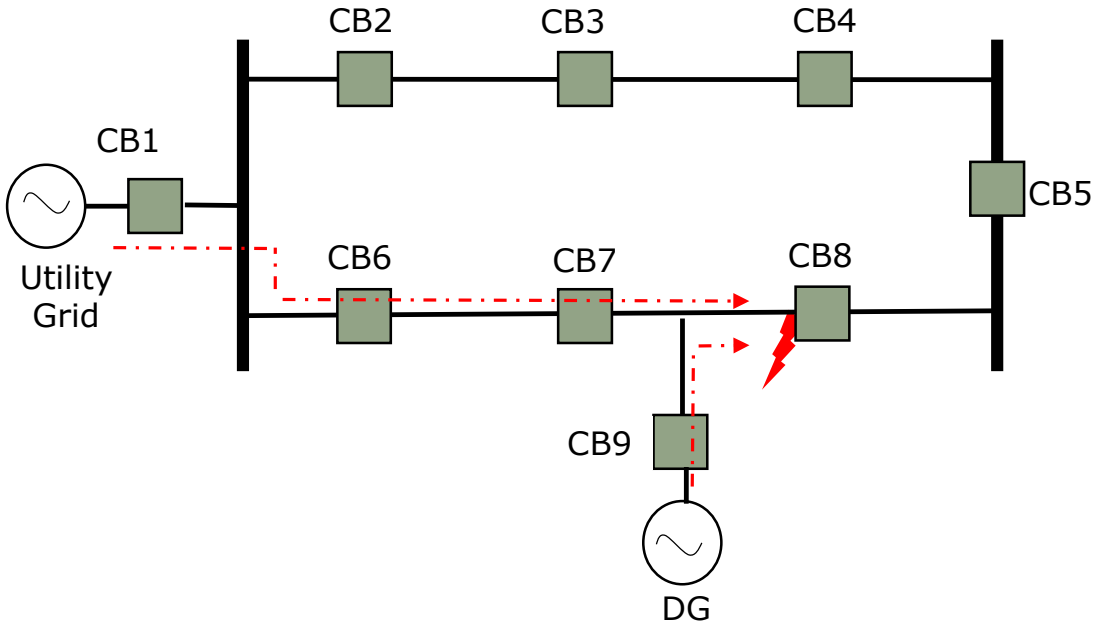
- Bidirectional Power flow
- Two operational mode
- Change in LV network topology
- Increasing fault current level in grid connected mode
- Low short circuit level in islanded mode

Islanded Grid Protection

Blinding of Protection

Devices upstream will not be able to see Faults due to :

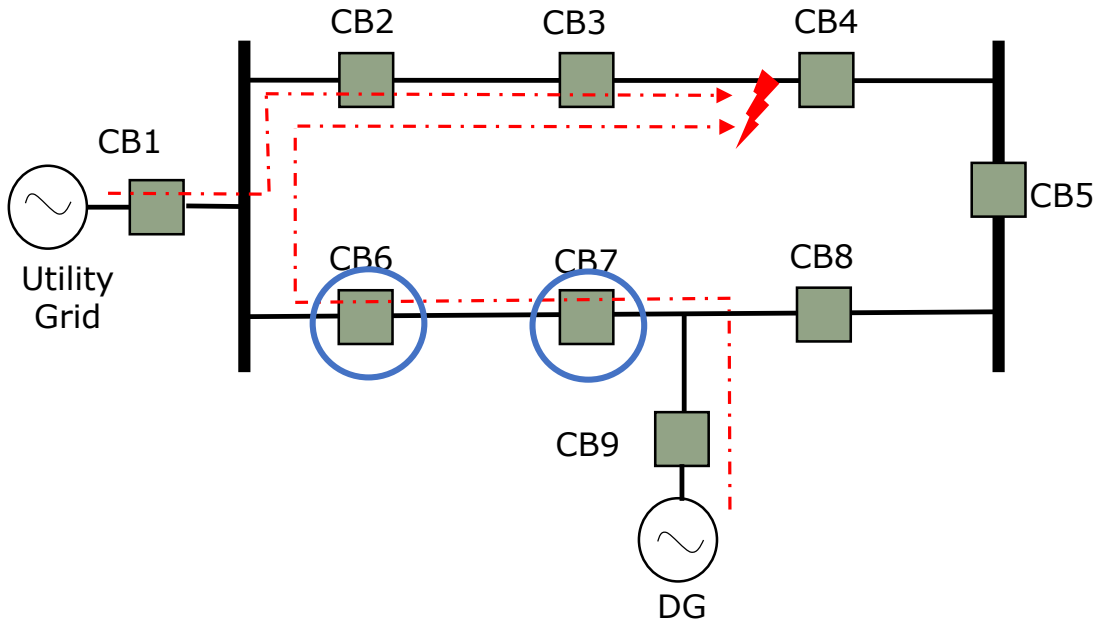
- High fault current near distribution generators
- Long distance between the upstream relays and fault points
- Low tripping speed



Islanded Grid Protection

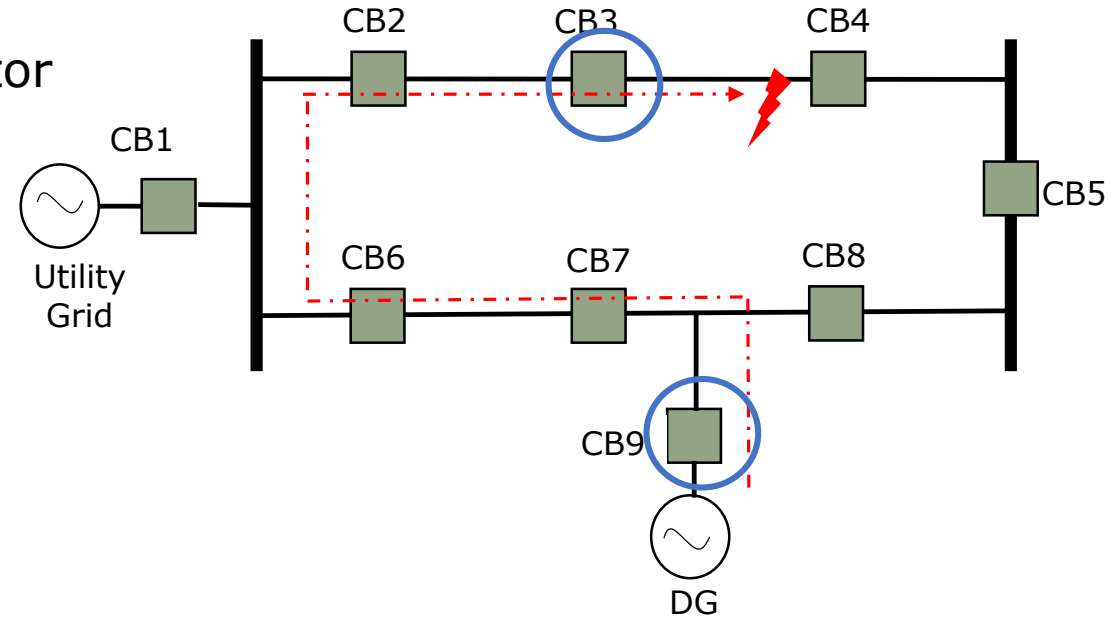
False Tripping or Sympathetic Tripping

Due to distribution generators contribution
A number of possibilities for tripping on parallel feeders will take place

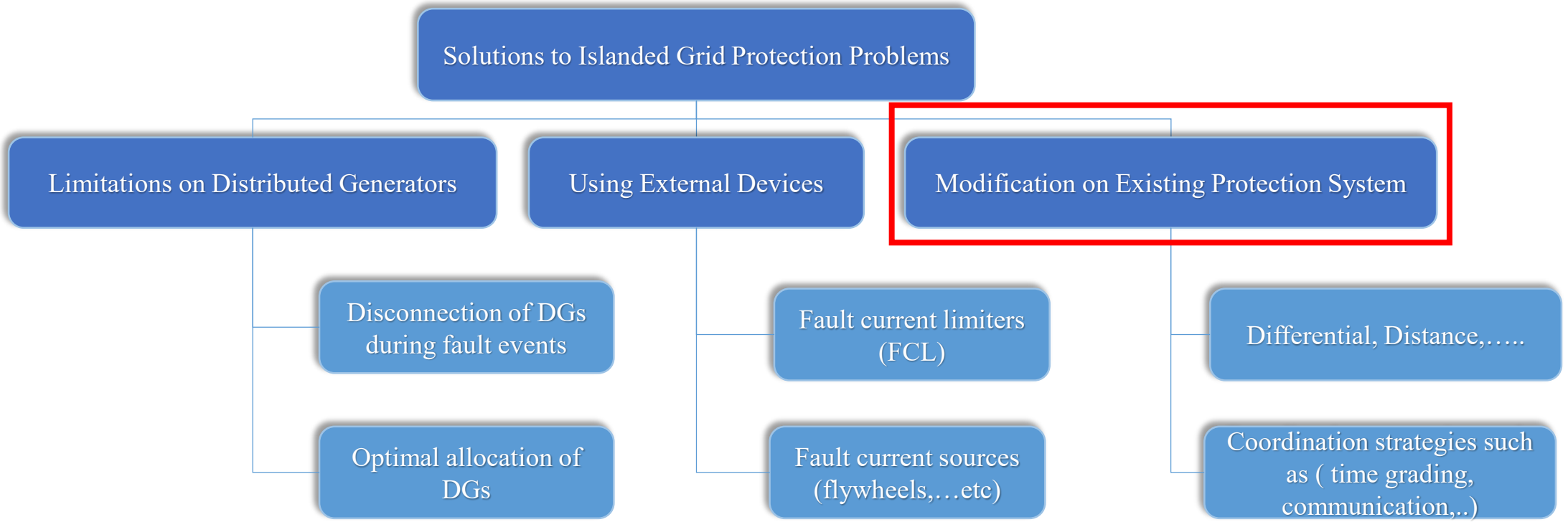


Islanded Grid Protection

- Islanding Problems
  - Low fault current
  - Delay of tripping
  - Disconnection of the distribution generator



Islanded Grid Protection



Proposed Protection Schemes

Fault Detection in Transmission Lines — A Novel Voltage-Based Scheme for Differential Protection

Safa Kareem Al-Sachit
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
slas931@aucklanduni.ac.nz

Mohammad Javad Sanjari
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
msan310@aucklanduni.ac.nz

Nirmal-Kumar C Nair
Electrical and Computer Engineering, University of Auckland
Auckland, New Zealand
n.nair@auckland.ac.nz

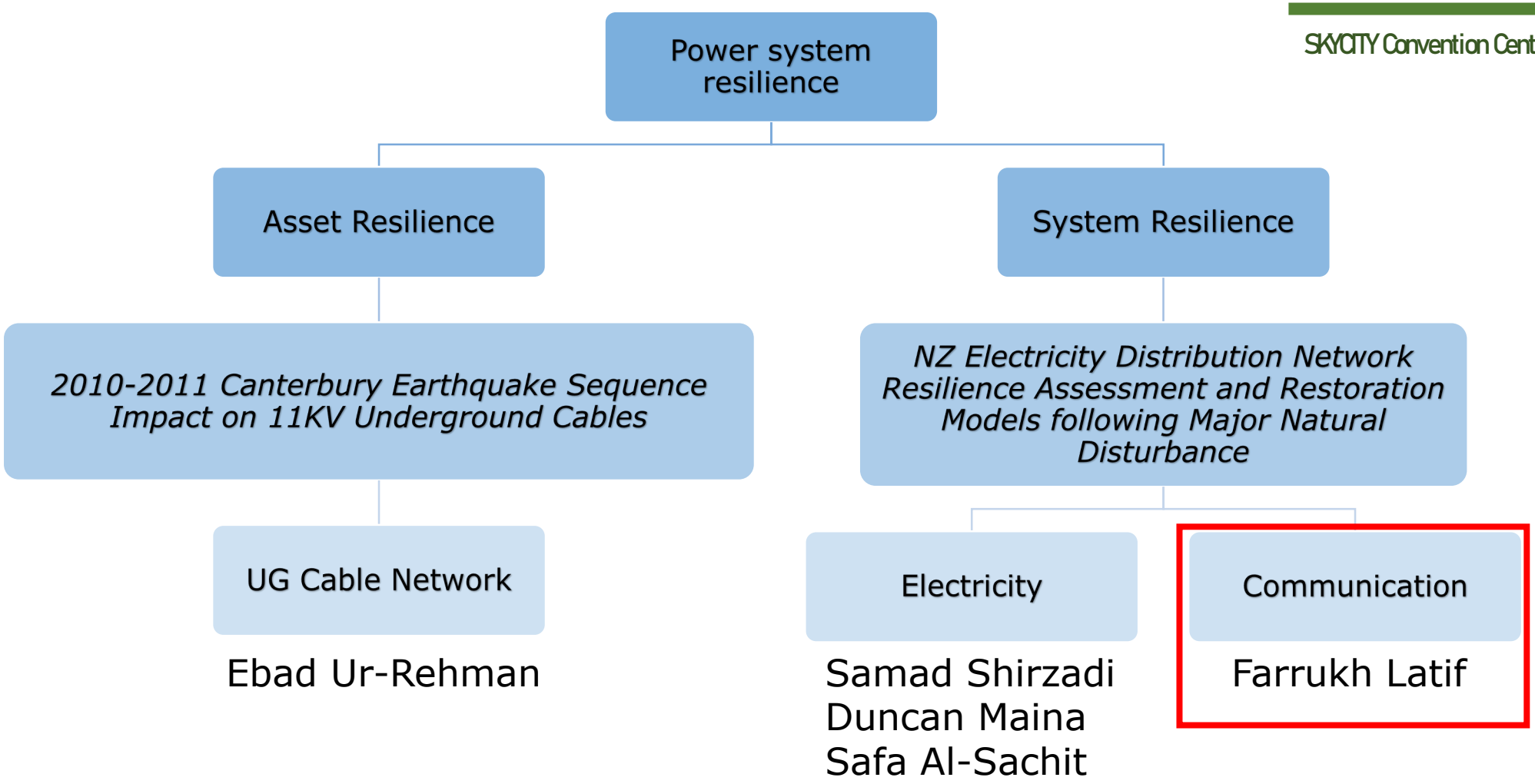
***Abstract*—Current-based protection schemes such as distance, overcurrent, and differential relays are usually used to protect transmission lines (TL) in power systems where the high fault current plays a key role in detecting faults. The continuous development in the power network and emerging new technologies have made the power grid more complicated and soon will start to affect the reliability of the existing protection schemes. Issues like current transformer saturation, the effect of the mutual coupling impedance of the TL and emerging new power electronic-based technologies have become major challenges in power systems from a protection perspective. To avoid all the current-based problems this paper proposes a new voltage-based relay principle for TL protection to indicate fault occurrences in transmission networks. The proposed scheme is tested under all fault events to show that it is highly accurate when it comes to rapid trip activation during any of the tested cases.**

Keywords: Differential relay, negative sequence voltage, relay modeling, symmetrical components, transmission line protection, unbalanced fault.

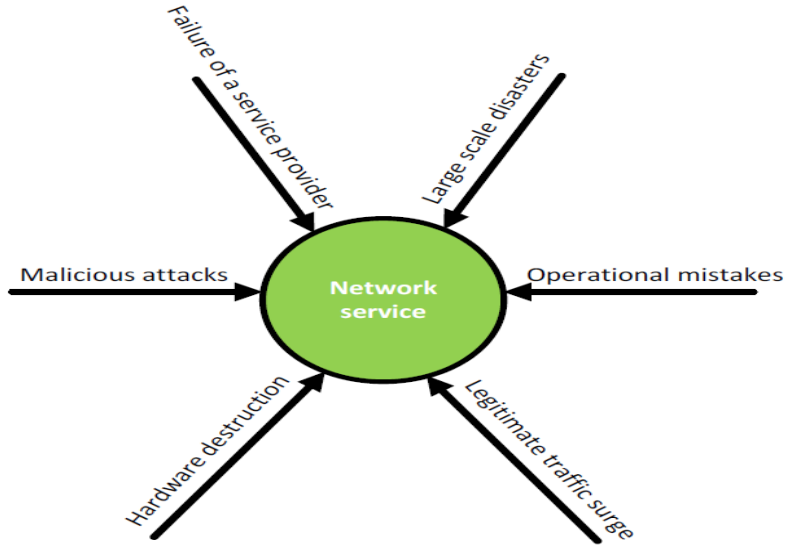
I. INTRODUCTION

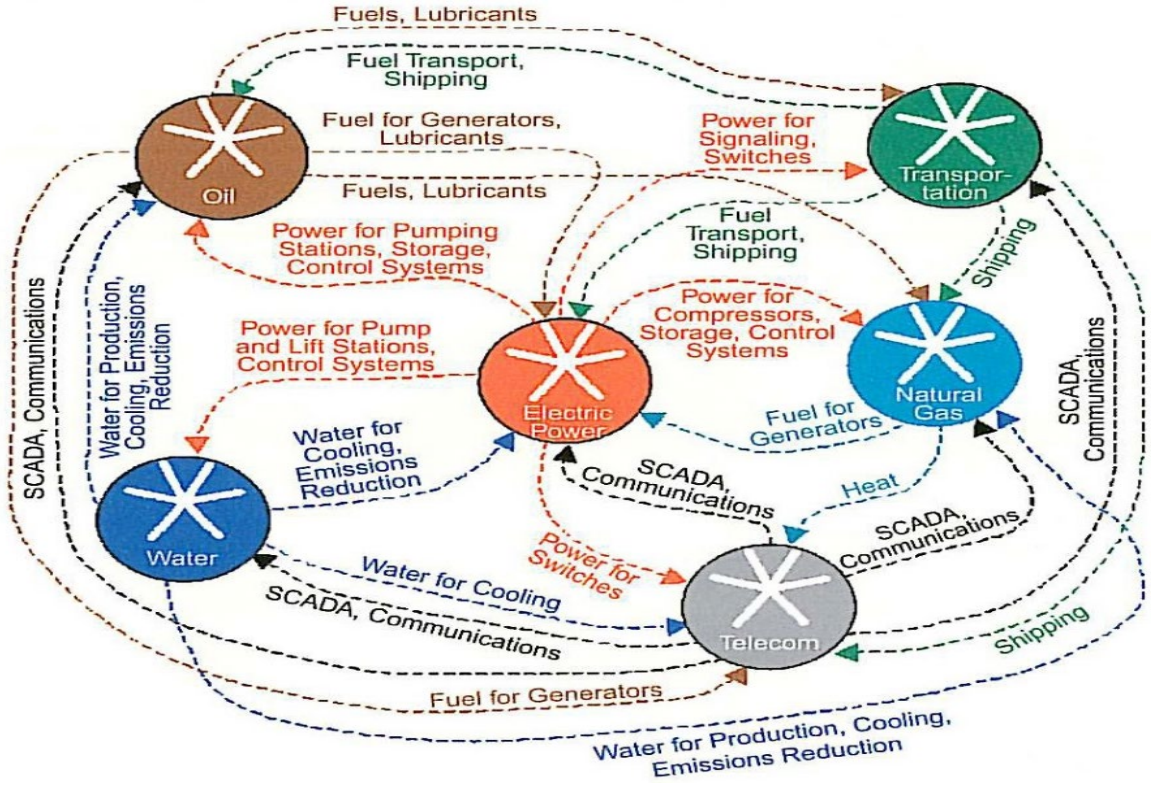
Transmission lines are subject to many events that might cause small or bulk damage to them and to the other parts of the system. Events which might affect TL include current transformer (CT) saturation issue, zero current mutual coupling, fault current limitations of power electronic based devices (PED), and grid code obligations. As a result, a sensitive, reliable and fast protection scheme is required to reduce expected damage. Many protection strategies have been suggested for TL in high, medium and low voltage parts of the network. These protection schemes such as overcurrent scheme depends on measuring the impedance of the protected TL to identify the faulted zone. However, [2] recognized that distance relays have some obstacles regarding the phase shift between voltage and current, fault resistance and third zone maloperation [3]. The CT saturation effect appears prominently in the transmission network using distance protection schemes; hence it results in excessive tripping delay time [4-6]. The high fault current in some cases prevents CTs from sending the actual current value to the relay, and the relay will receive only a relatively low current at the secondary side during severe faults. However, distance protection is recommended for distribution networks due to it having a directional element that increases its ability to deal with meshed networks. The high cost of this scheme might be an obstacle since it requires both voltage and current transformers. However, it is only suitable for a small range of considerations and the correct settings may be more difficult to determine compared to the OCR [1].

Differential relays have also gained a wide recognition because it is a protection scheme rated as highly sensitive, selective, fast and insensitive to the bi-directional flow of current when compared to the distance and overcurrent schemes [1], [7]. The differential relay operational concept is based on calculating currents from the connected CTs across the protected section according to Kirchhoff's law. Differential relays face some issues due to the fault location discrimination besides the effect of CT saturation and CT mismatch on the relay operation [8]. Communication failures because of limited bandwidth channels over long distances also play a major role in reducing the effectiveness of this scheme. However, compared to distance relays it can be


Power system resilience
Asset Resilience
System Resilience
2010-2011 Canterbury Earthquake Sequence Impact on 11KV Underground Cables
NZ Electricity Distribution Network Resilience Assessment and Restoration Models following Major Natural Disturbance
UG Cable Network
Electricity
Communication
Ebad Ur-Rehman
Samad Shirzadi
Duncan Maina
Safa Al-Sachit
Farrukh Latif

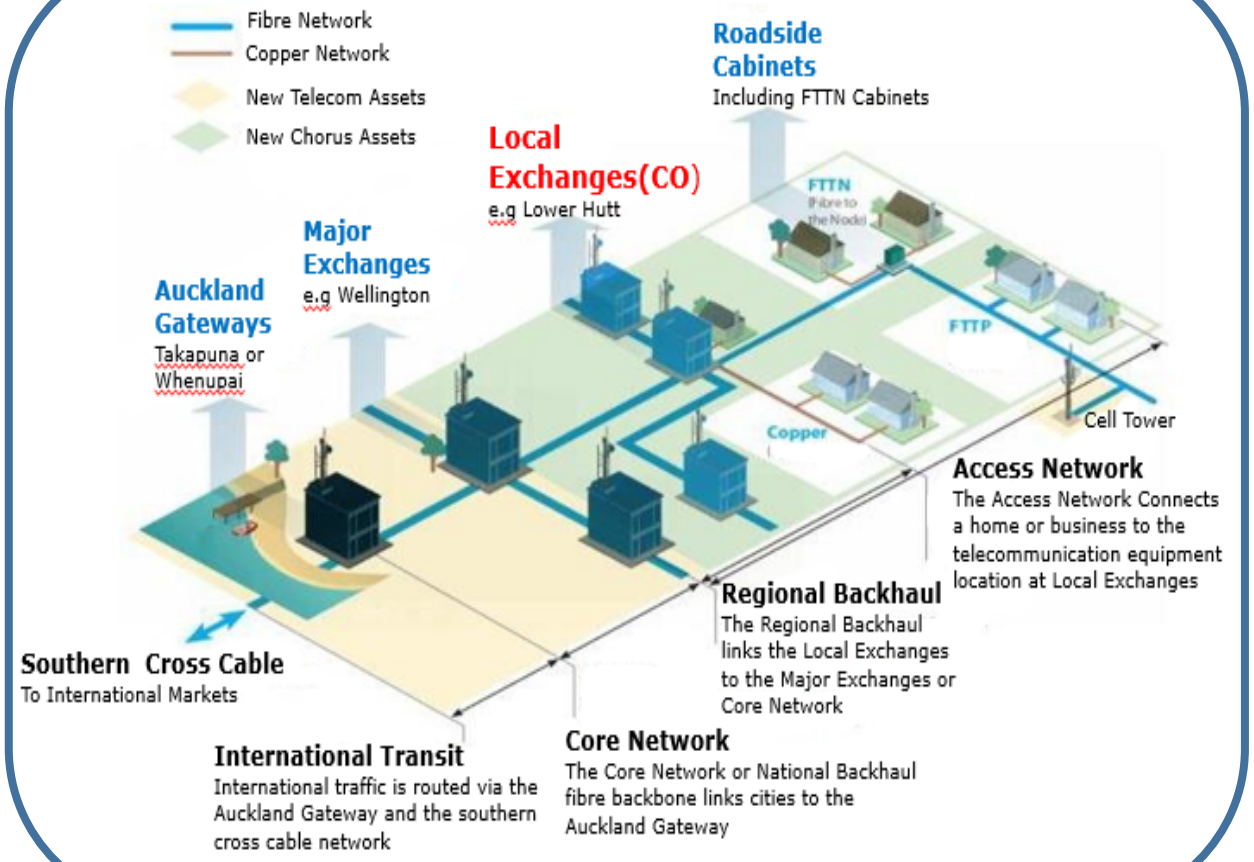
WHY? "The Rational"

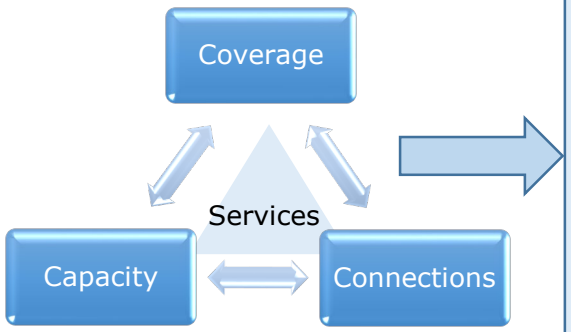




Broadband and Voice Network (Courtesy of Chorus)

NZ Communication Infrastructure and Services

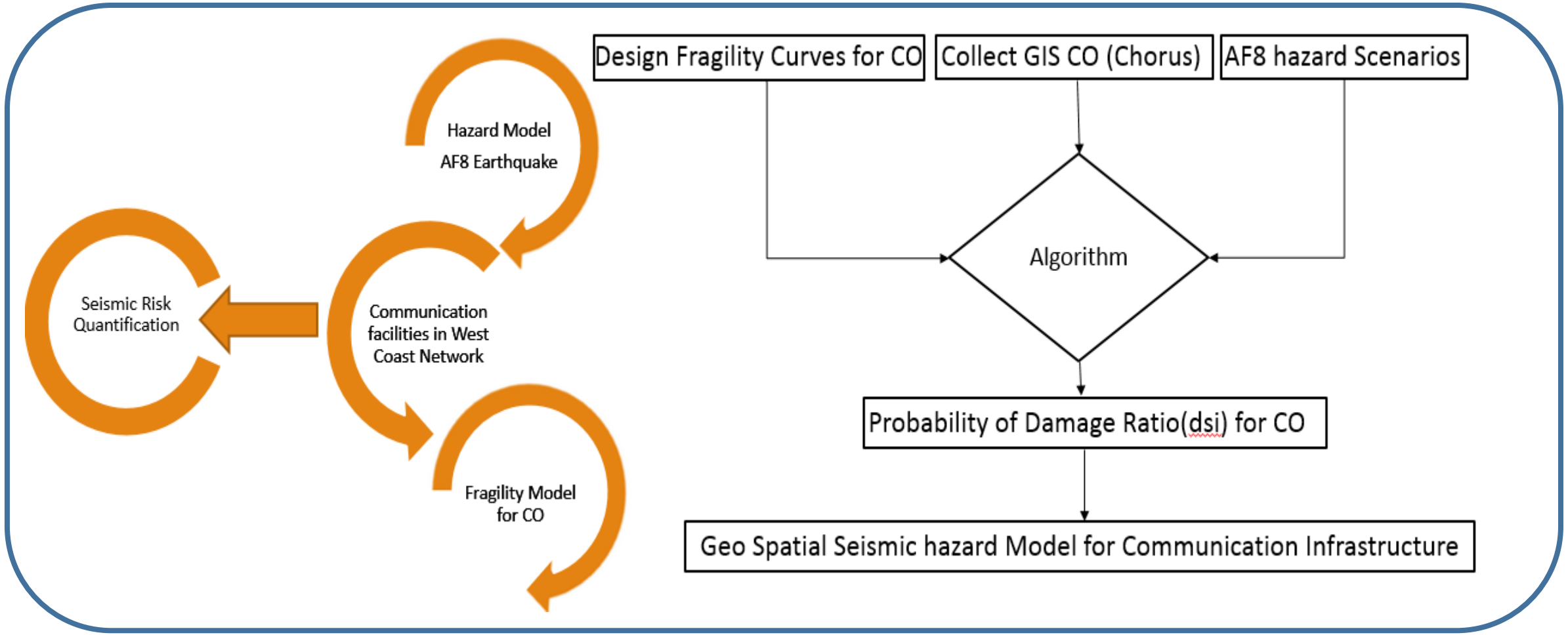




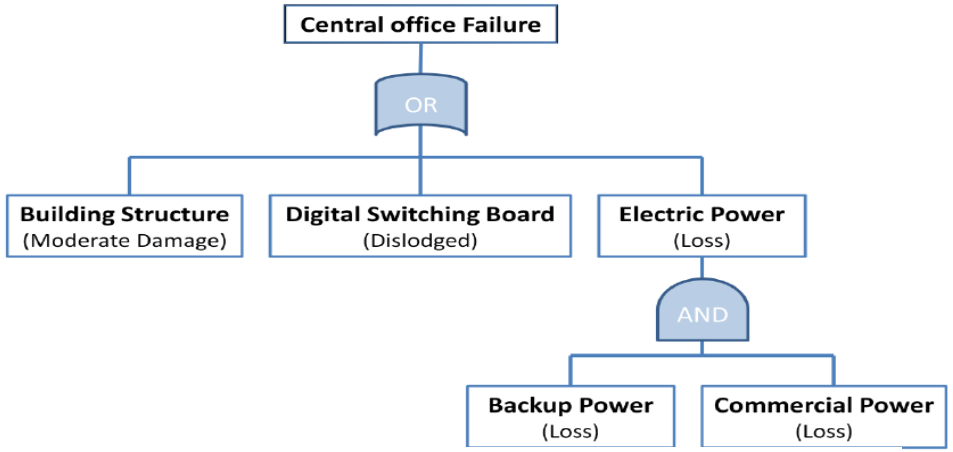
- Voice
- Internet
- Cloud/Datacentres
- Enterprise Services
- Emergency Response Services
- Mission Critical Services
- Defence Services
- IOT
- VR
- AI
- TV/On Demand Content

Broadband and Voice Network (Courtesy of Chorus)

Approach and Method for Seismic Hazard Mapping

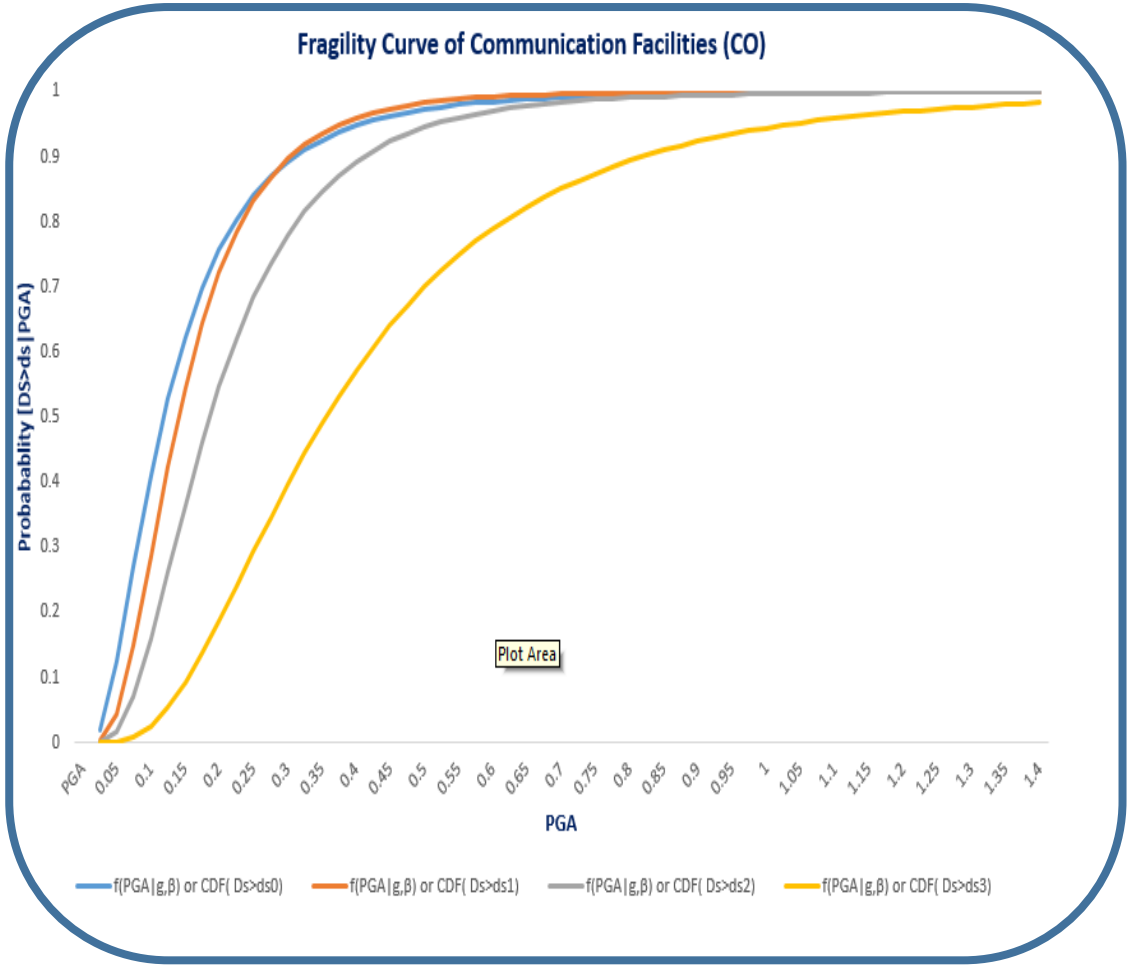


Approach and Method for Seismic Risk Quantification

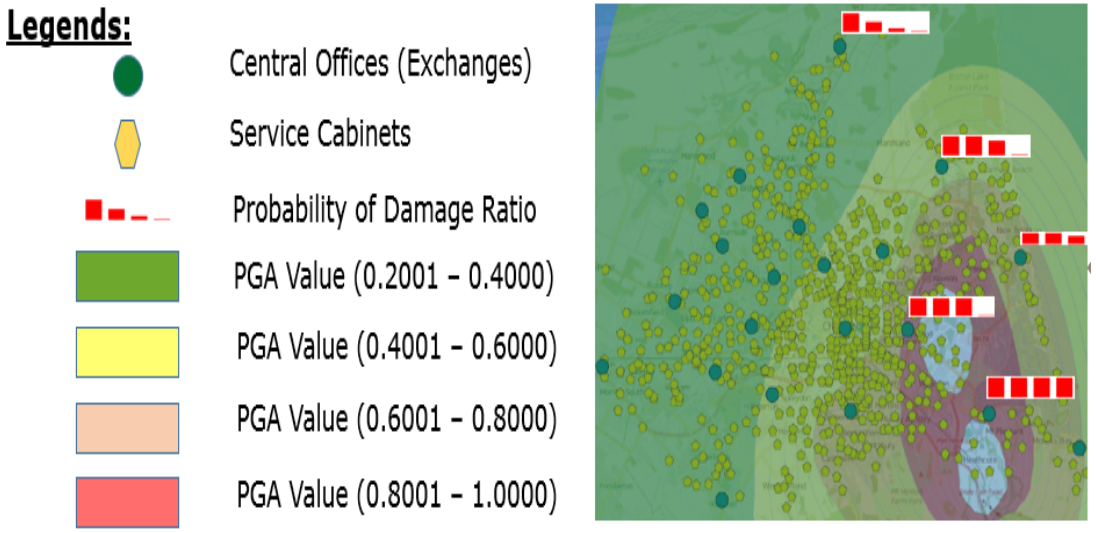


$$P(E_{CO}) = P\left(E_{Structure} \cup E_{Switching\_Board} \cup (E_{Backup} \cap E_{Commercial})\right)$$

Damage State	Description	
ds0	minor	None
ds1	moderate	Power outage for few hours or days
ds2	extensive	Few electronic boards are dislodged and need replacement
ds3	Complete	Complete Blackout



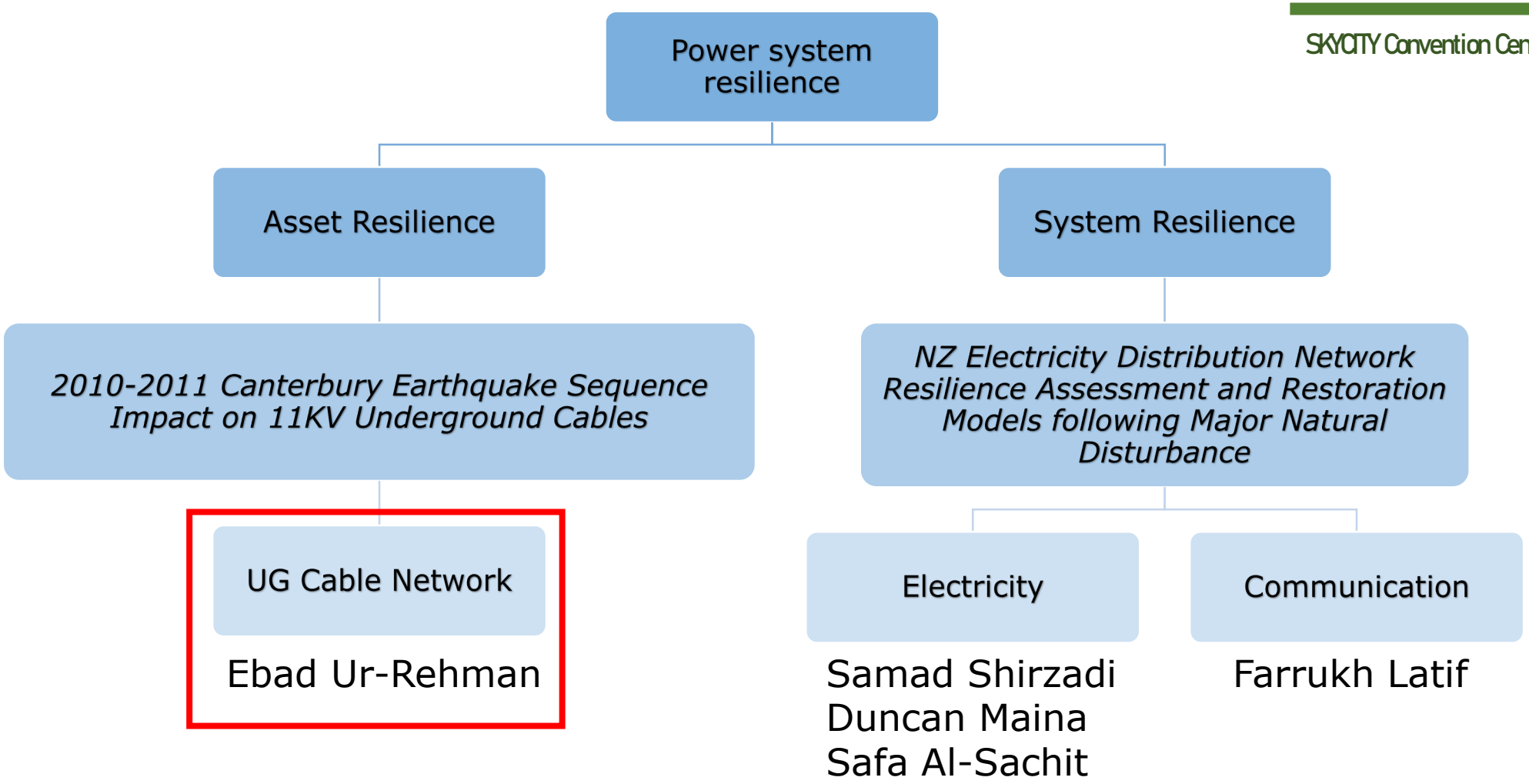
Expected Results and Future Work



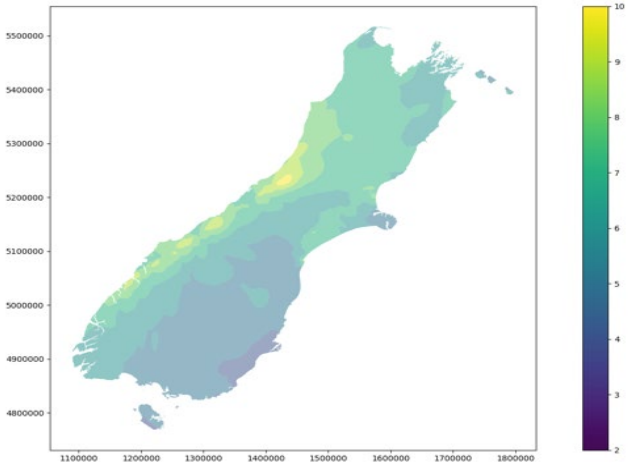
1-Develop a seismic hazard model (using GIS tool) to quantify the risk to spatially distributed critical communication infrastructure and Validate Against AF8 West Coast Scenarios.

2-Develop a framework for Measuring Resilience in communication infrastructure for seismic hazards.

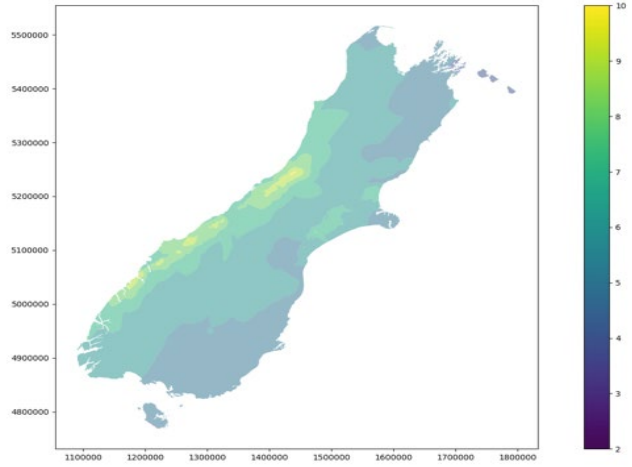
3- Guidelines for Future Resilient Communication Network Architecture


Power system resilience
Asset Resilience
System Resilience
2010-2011 Canterbury Earthquake Sequence Impact on 11KV Underground Cables
NZ Electricity Distribution Network Resilience Assessment and Restoration Models following Major Natural Disturbance
UG Cable Network
Ebad Ur-Rehman
Electricity
Samad Shirzadi
Duncan Maina
Safa Al-Sachit
Communication
Farrukh Latif

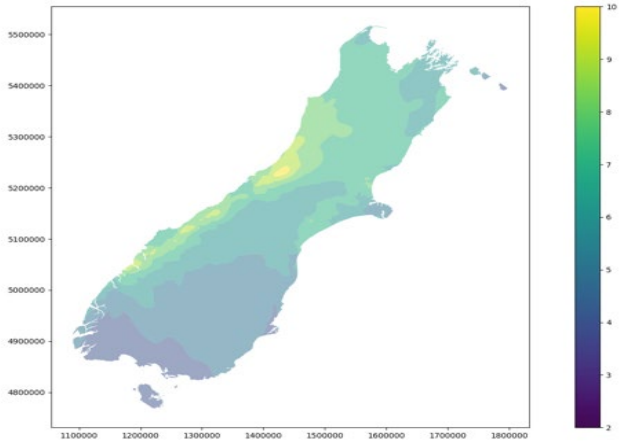
Hazard Mapping



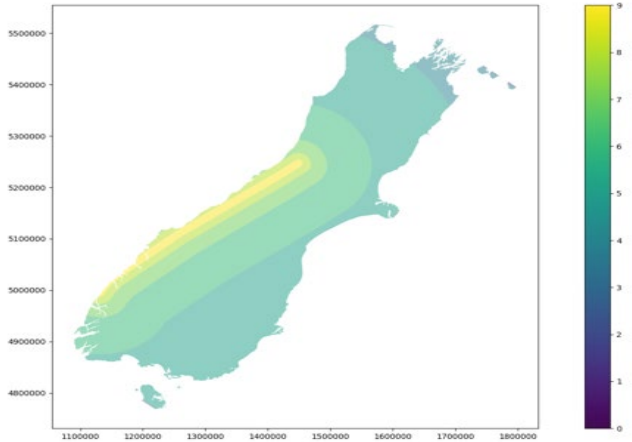
Central Hypocenter



Northern Hypocenter

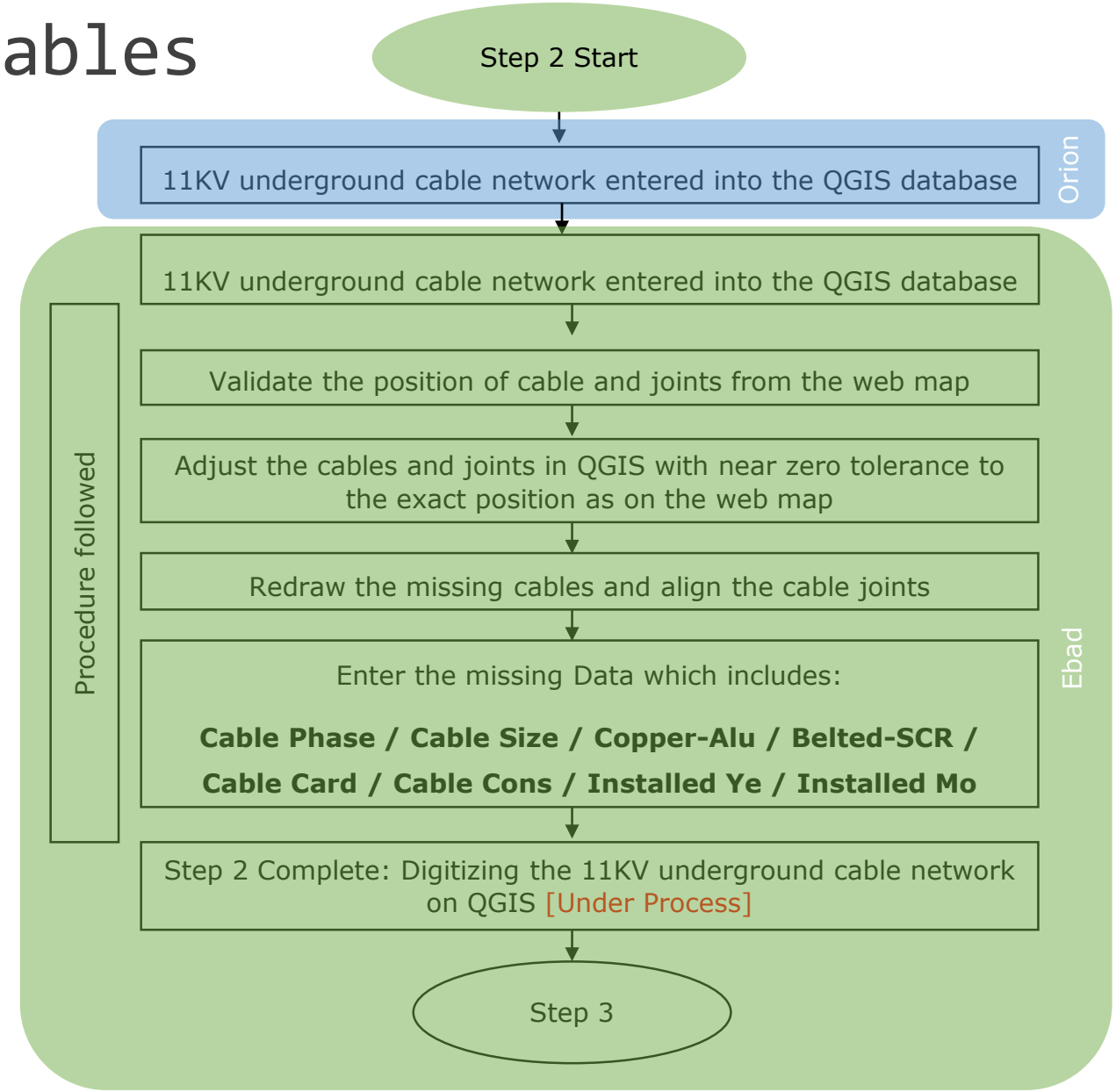


Southern Hypocenter



Empirical Southern Hypocenter

Step 2: Digitising Cables



Step 1:Digitising Repair Joints