Effective Fault-ride through and Smart Load-shedding schemes for Secure Renewable Grid Integration

Nirmal Nair (he/him)

Associate Dean Postgraduate Research (ADPGR), Faculty of Engineering

Power Systems Group (PSG)

Department of Electrical, Computer, and Software Engineering

The University of Auckland

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Nirmal Nair

Association for this talk:

- **Technical Chair CIGRE New Zealand**
- **Convener, CIGRE WG:B5.78** *(New Network P&C Requirements for Renewable Energy Integration)*
- ***CIGRE GREEN Book Editor: IEC 61850 Principles and Applications to Electric Power Systems***
- Research Leader, Architecture of the Future Low-Carbon, Resilient, Electrical Power System
- Research Leader, QuakeCore- New Zealand Centre for Earthquake Resilience
- Principal Investigator, Te Pūnaha Matatini- New Zealand Centre of Research Excellence for complex systems

Research background interests:

- **Power System Protection (IEC 61850, SPS, WAPS, Cyber-physical)**
- Electricity Markets (Ancillary Services, Transactions-based pricing)
- **Smart Grids (Substation Automation, Smart metering, Protection and Control)**
- Integration of Renewable (Wind, Solar) and DG into Power Systems
- **Blackouts (Dynamic voltage instability, Bifurcation, Cascade propagation)**
- Recent Focus areas
  - **Energy and Sustainability**
  - **Low-carbon Strategies for New Zealand (Zero-carbon by 2050)**
  - **Innovation (Distributed Ledger), Policy (Resilience) & Outreach (Media)**
  - **Hosting conferences, meetings and Forum in Auckland, New Zealand**

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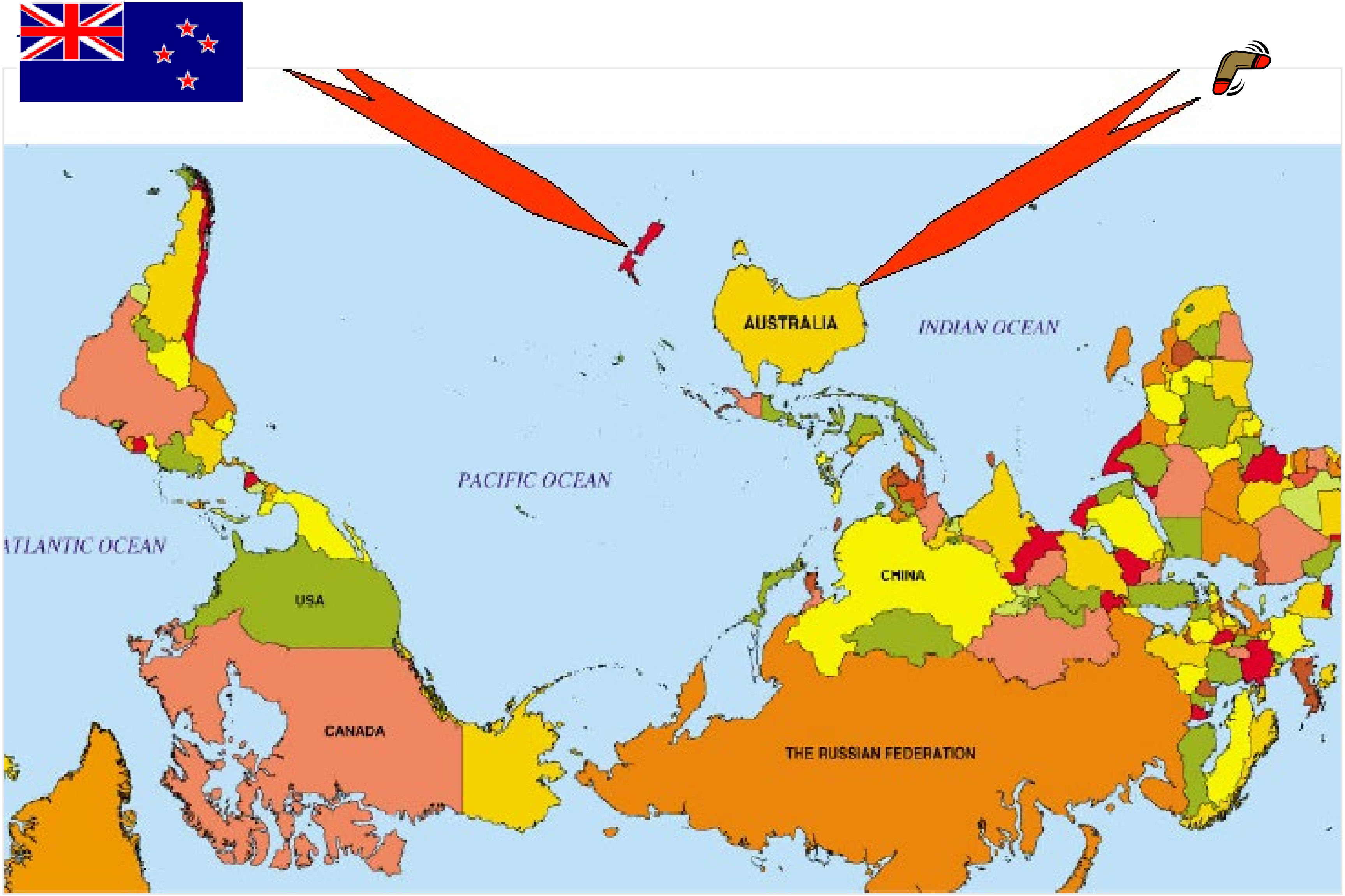
New Zealand- Top Above!

Home Base for Nirmal Nair:

Auckland,
New Zealand



OPERATION, PROTECTION & CONTROL DURING NATURAL HAZARDS ON POWER SYSTEMS WITH HIGH PENETRATION OF RENEWABLE ENERGY

Nirmal Nair

2018 Purple Mountain Forum

International Forum on Smart Grid Protection and Control

August 18-19, Nanjing, China

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ICED 2022

The 10th China International Conference on Electricity Distribution

Changsha, China September 7–8, 2022

Emergent Digital Substations: Principles, Applications and Standards

Name: Nirmal Nair

Company: University of Auckland

Country: New Zealand

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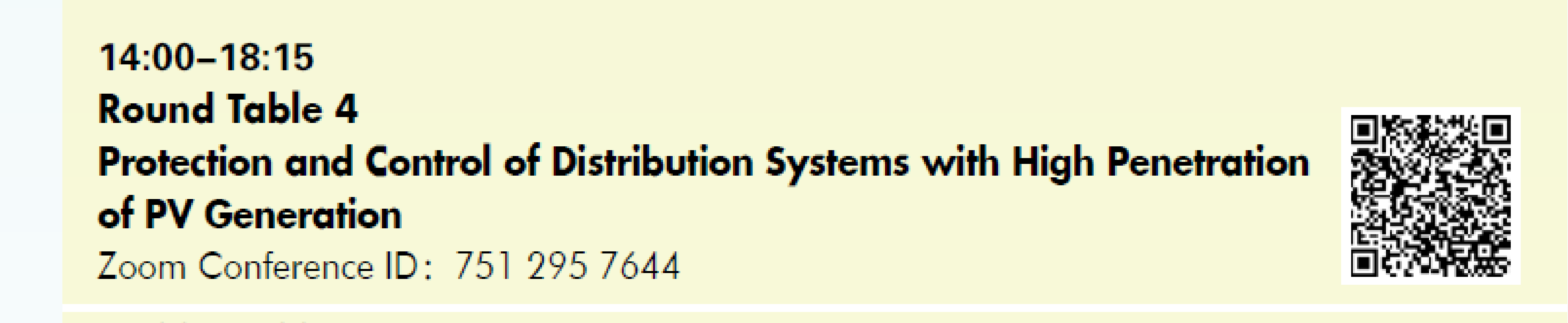
Round Table Session 4: Protection and Control of Distribution Systems with High Penetration of PV Generation
September 8, Thursday, 14:00-18:15 (Beijing Time)



14:00–18:15

Round Table 4

Protection and Control of Distribution Systems with High Penetration of PV Generation

Zoom Conference ID： 751 295 7644

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DEPARTMENT OF ELECTRICAL, COMPUTER, AND SOFTWARE ENGINEERING

IEEE PES
Power & Energy Society®

Keynote on Emergent Digital Substations: Principles, Applications and Standards

15.40-16:15 (India Standard Time)
December 17. 2022

Nirmal Nair

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- Low-carbon Goal

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Blackout Analysis of Protection Performance

Australia, Turkey, India

Protection Challenges

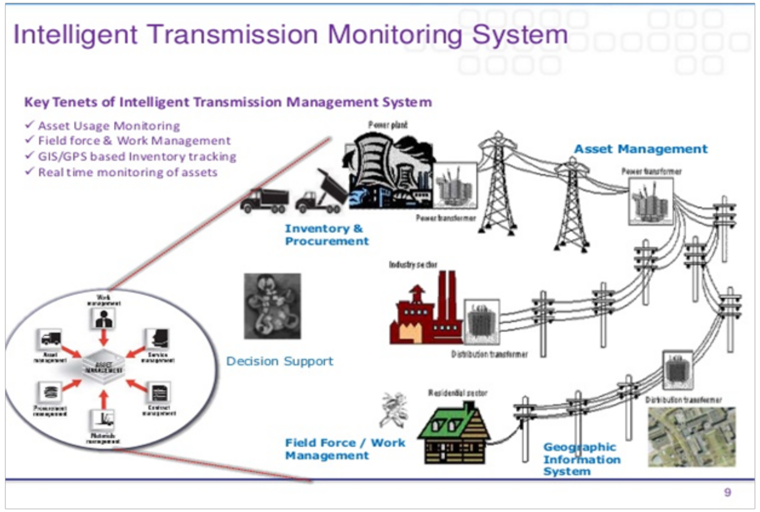
Ongoing work

- NZ South Island
- CIGRE Working Group and Special Report

Disclosure: *Pictures for this Forum presentation taken from various publically available sources*

Changing Impact Landscape for Electricity Infrastructure

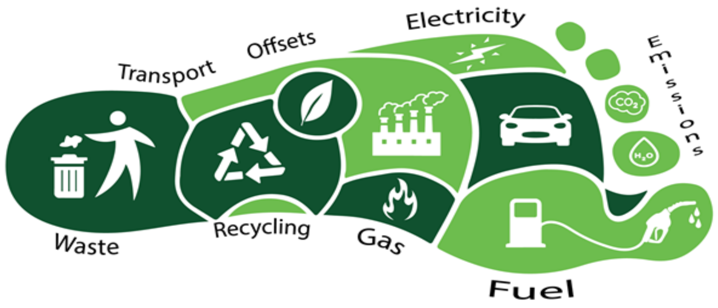
- Asset Management optimisation as life cycle of major components nearing replacement periods (**5 to 7 decades**)
- Market dynamics with multiple objectives
- Development of **FACT Devices especially HVDC**
- Reduction of carbon foot print renewables forms of generation
- Protection: **Changing architecture** (Transmission/Distribution) & **newer Grid dynamics** (low-inertia & fault level; voltage & frequency ride-through)

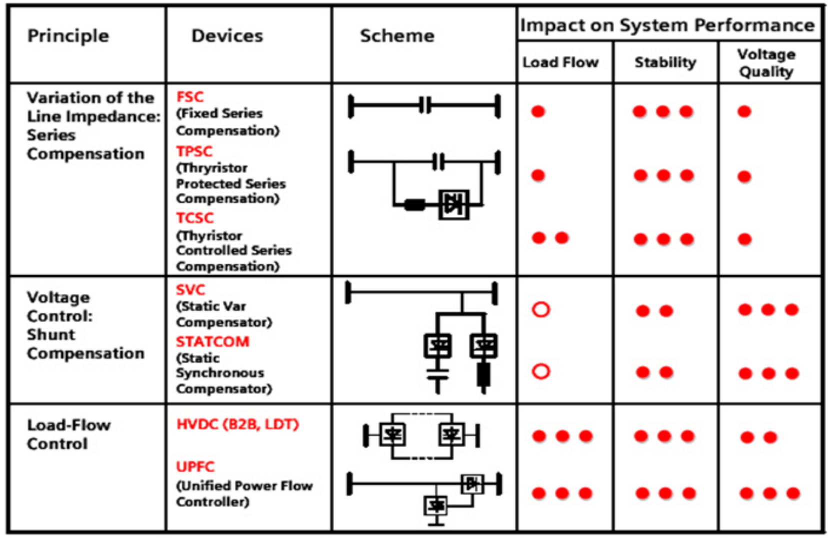


Intelligent Transmission Monitoring System

Key Tenets of Intelligent Transmission Management System

- ✓ Asset Usage Monitoring
- ✓ Field force & Work Management
- ✓ GIS/GPS based Inventory tracking
- ✓ Real time monitoring of assets





Principle	Devices	Scheme	Impact on System Performance		
			Load Flow	Stability	Voltage Quality
Variation of the Line Impedance: Series Compensation	FSC (Fixed Series Compensation)		●	●●●	●
	TPSC (Thryristor Protected Series Compensation)		●	●●●	●
	TCSC (Thyristor Controlled Series Compensation)		●●	●●●	●
Voltage Control: Shunt Compensation	SVC (Static Var Compensator)		○	●●	●●●
	STATCOM (Static Synchronous Compensator)		○	●●	●●●
Load-Flow Control	HVDC (B2B, LDT)		●●●	●●●	●●
	UPFC (Unified Power Flow Controller)		●●●	●●●	●●●

Influence: *

○	low or no
●	small
●●	medium
●●●	strong

* Based on Studies & practical Experience

Transition to a low carbon network

Large **hydro** power plants already in place. Possibilities left for small, mini, micro and pico hydro power plants. Also, **growth in Pumped Hydro schemes driven by perceived need for long-term seasonal storage for renewable dominated networks**

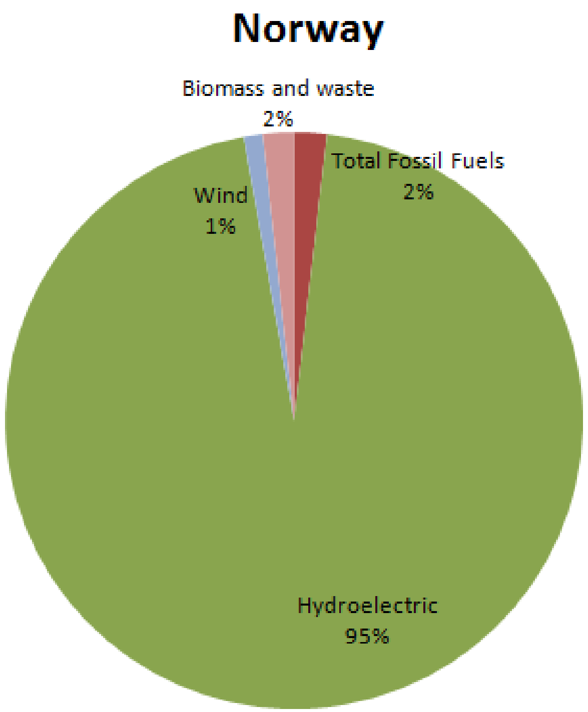
Development of large capacity **wind** turbines (currently Vestas V164 – 9 MW) and large windfarms (**On-shore and Off-shore**)

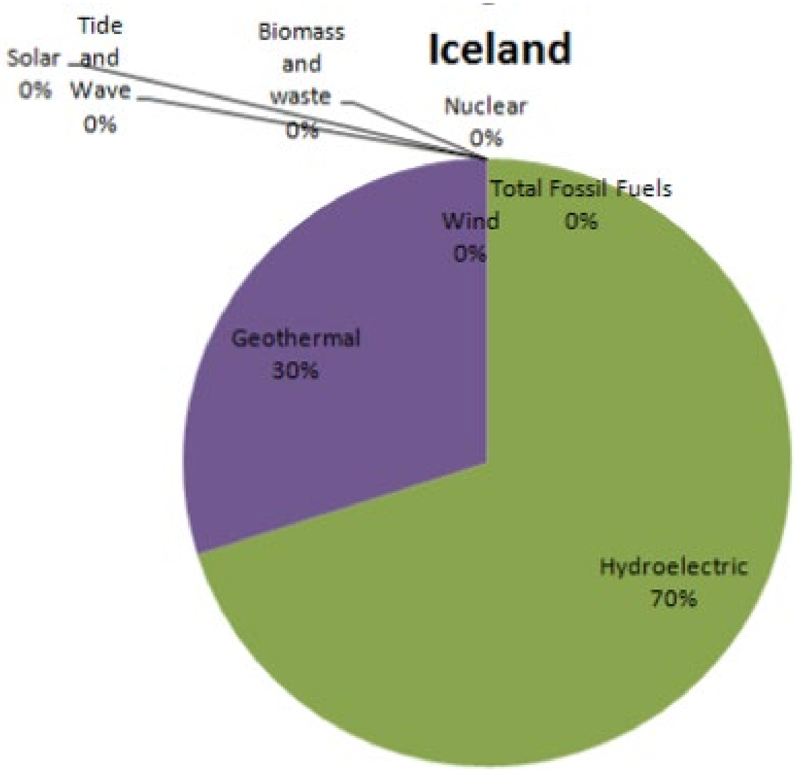
Development of large **PV** plants .

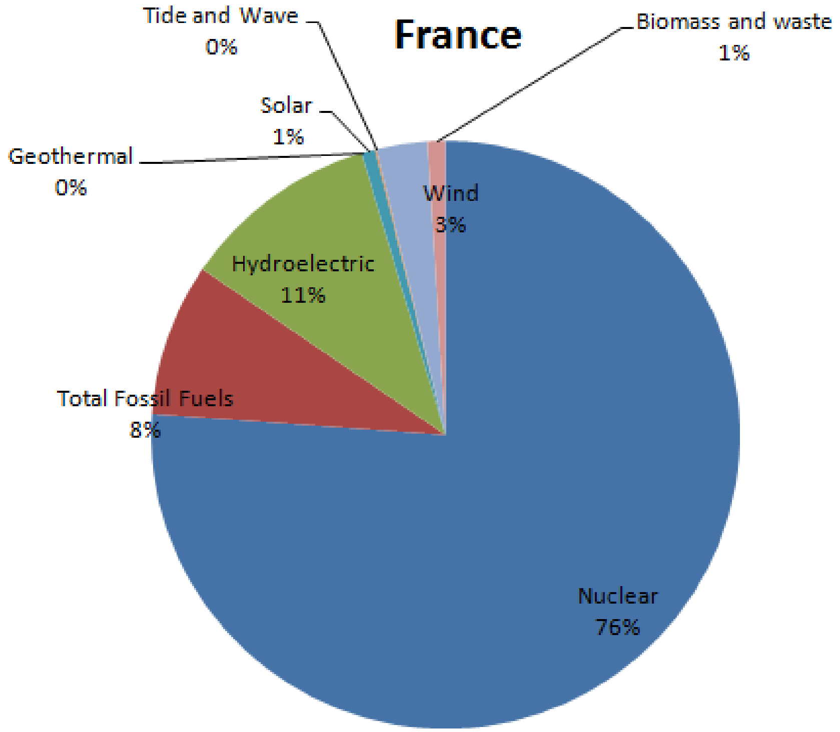
Increasing penetration of EVs (serve both as load and storage)

Transition to Low-carbon Electricity network: Exemplars

- 100% currently possible with Hydro or Nuclear Dominated systems:

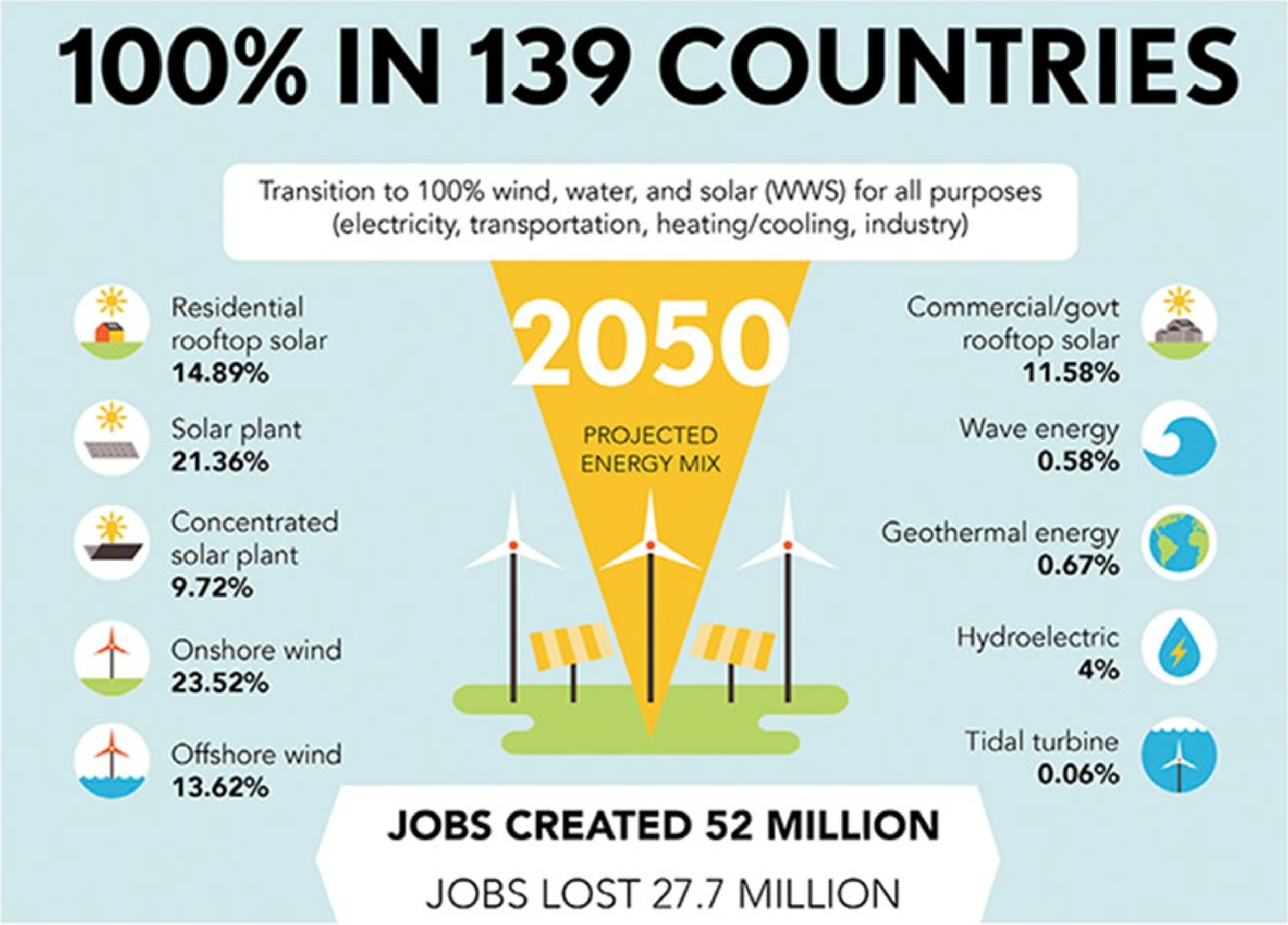






P. Verma, N. Patel, **N.-K.C. Nair,** A, C. Brent "Improving the energy efficiency of the New Zealand economy: A policy comparison with other renewable-rich countries, Energy Policy, Volume 122, 2018,pp 506-517, ISSN 0301-4215,

Transition to Low carbon Network: Pledge



100% IN 139 COUNTRIES

Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

2050

PROJECTED ENERGY MIX

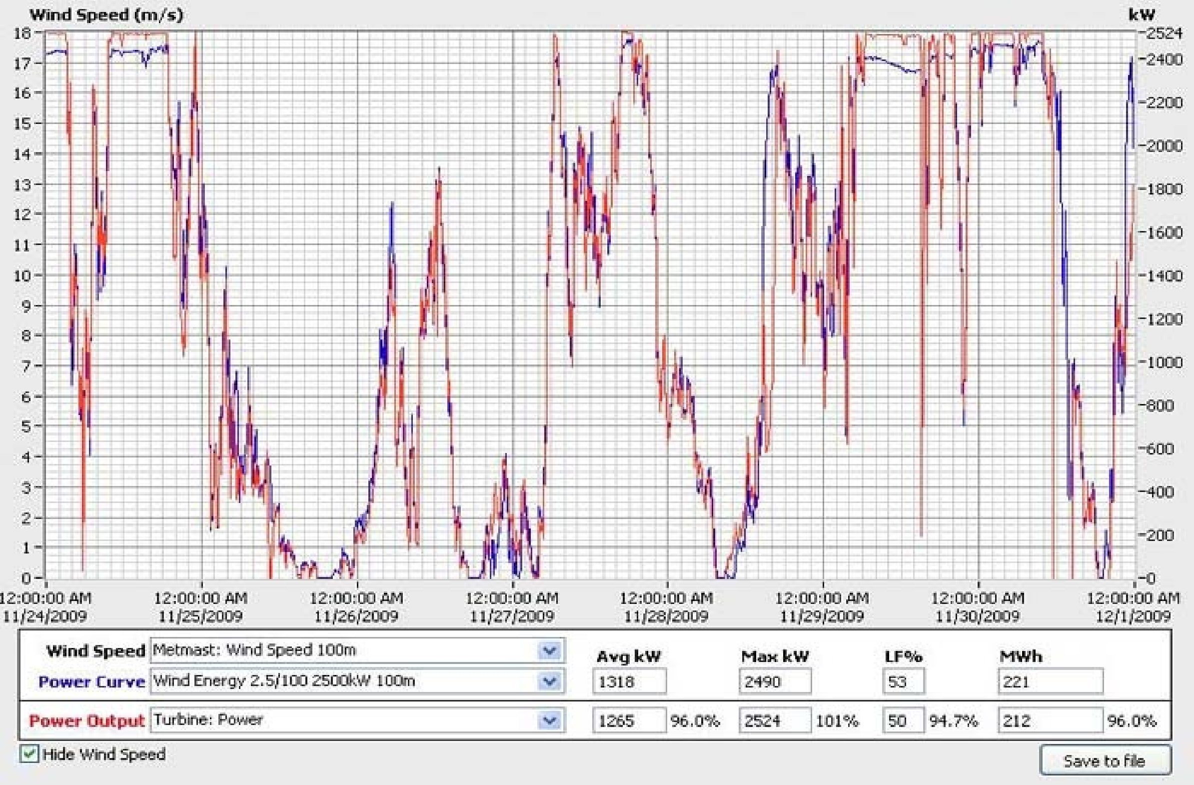
Residential rooftop solar	**14.89%**
Solar plant	**21.36%**
Concentrated solar plant	**9.72%**
Onshore wind	**23.52%**
Offshore wind	**13.62%**
Commercial/govt rooftop solar	**11.58%**
Wave energy	**0.58%**
Geothermal energy	**0.67%**
Hydroelectric	**4%**
Tidal turbine	**0.06%**

JOBS CREATED 52 MILLION

JOBS LOST 27.7 MILLION

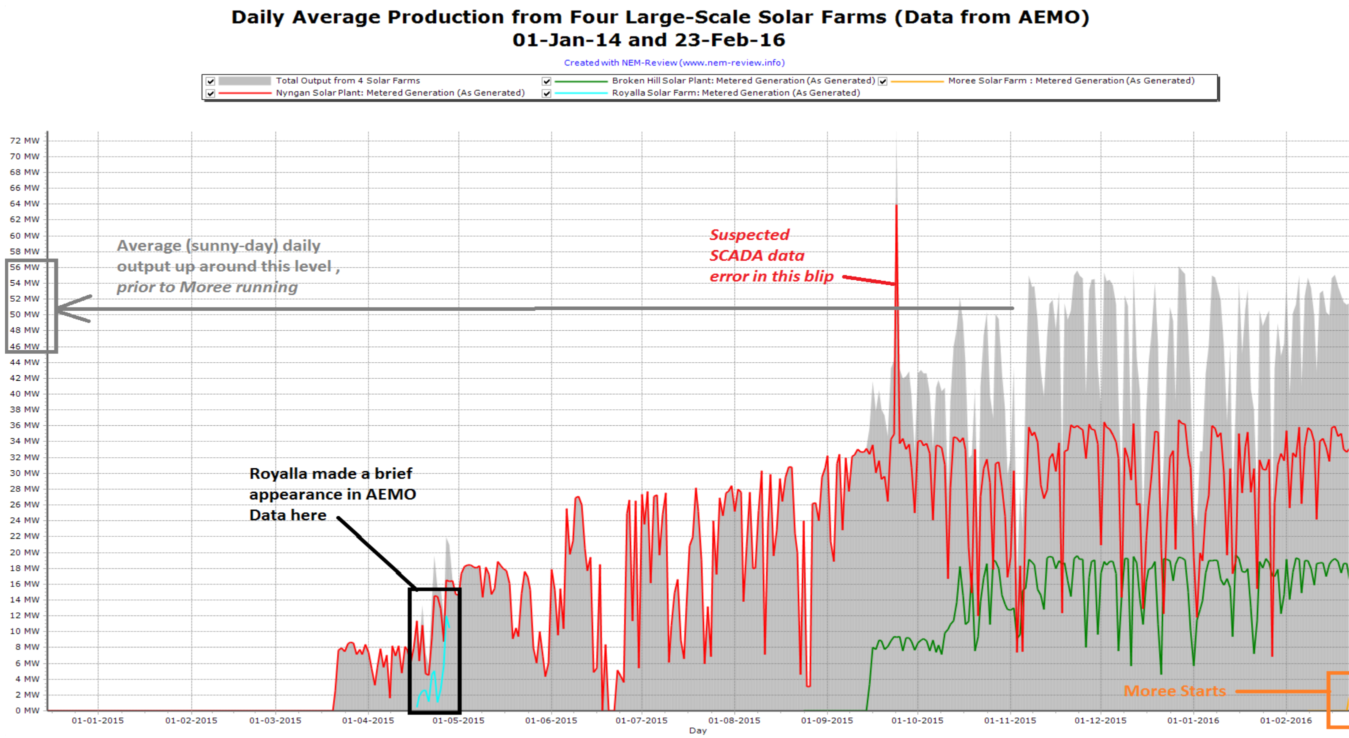
Technical issues that need addressing

- Non-dispatchability and lack of intermittency
- Overcapacity needs in terms of backup for reliability
- Bidirectional power flows challenging protection philosophy
- Low inertia (Frequency deviations)



		Avg kW		Max kW		LF%		MWh	
Wind Speed	Metmast: Wind Speed 100m								
Power Curve	Wind Energy 2.5/100 2500kW 100m	1318		2490		53		221	
Power Output	Turbine: Power	1265	96.0%	2524	101%	50	94.7%	212	96.0%

☑ Hide Wind Speed



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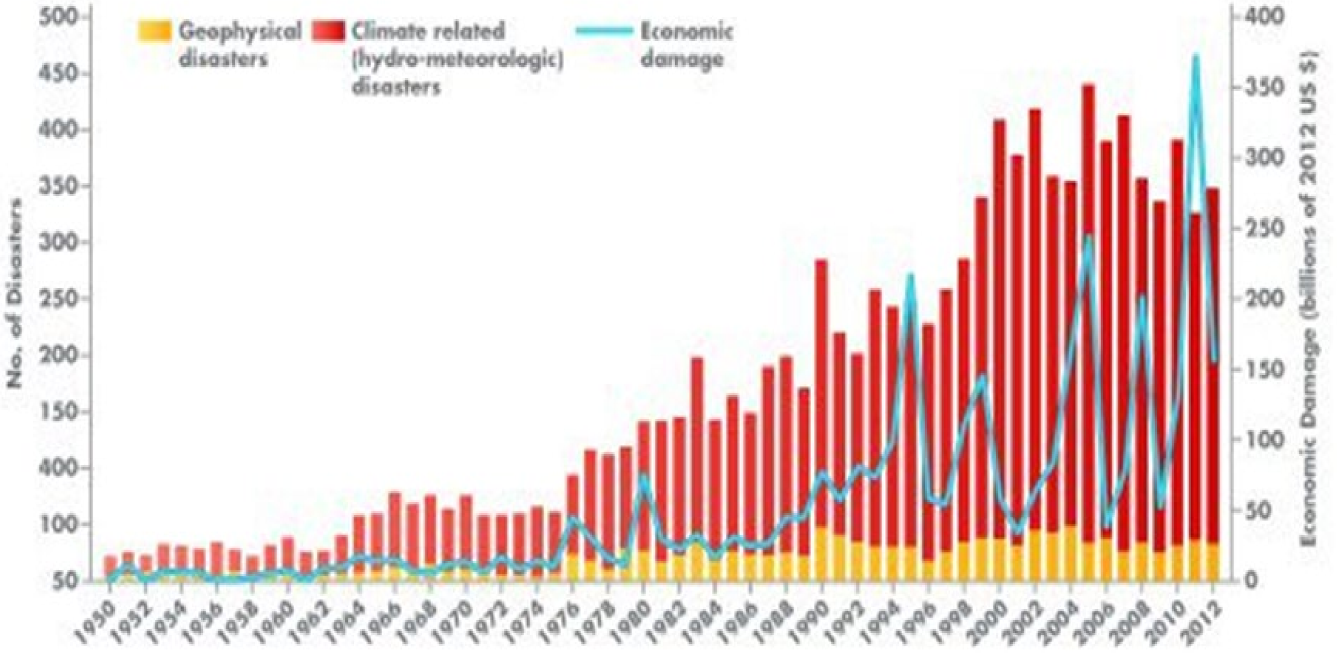
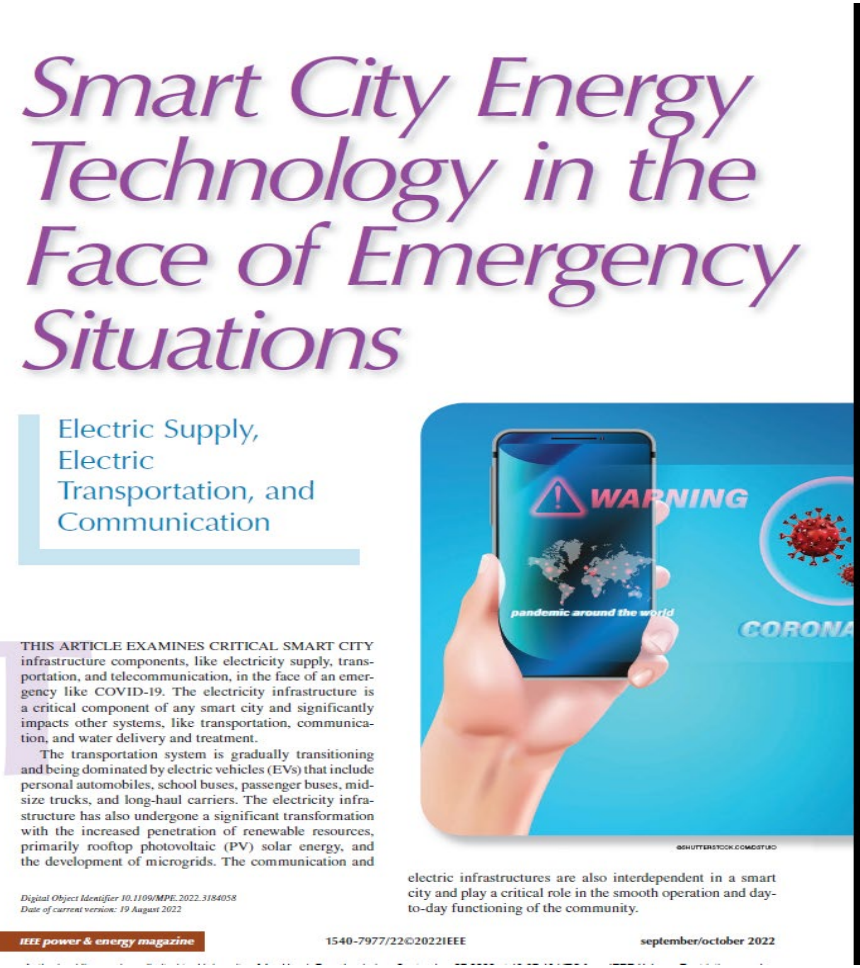
Natural Hazards

But Wait!!!!! This is also happening

- Increase in climate-related seasonal events and its severity (Hurricanes, Tornadoes)
- Large-scale Natural Events (Earthquakes, Volcanoes, Solar Storms)
- Today number of humans living in high-density cities are more than in towns/villages



New Emergent Emergency Situations for Power Systems



Smart City Energy Technology in the Face of Emergency Situations

Electric Supply, Electric Transportation, and Communication

THIS ARTICLE EXAMINES CRITICAL SMART CITY infrastructure components, like electricity supply, transportation, and telecommunication, in the face of an emergency like COVID-19. The electricity infrastructure is a critical component of any smart city and significantly impacts other systems, like transportation, communication, and water delivery and treatment.

The transportation system is gradually transitioning and being dominated by electric vehicles (EVs) that include personal automobiles, school buses, passenger buses, midsize trucks, and long-haul carriers. The electricity infrastructure has also undergone a significant transformation with the increased penetration of renewable resources, primarily rooftop photovoltaic (PV) solar energy, and the development of microgrids. The communication and electric infrastructures are also interdependent in a smart city and play a critical role in the smooth operation and day-to-day functioning of the community.

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By Vijay Vittal, Nirmal Nair, and Farnoosh Rahmatian

Emergency situations, such as the COVID-19 pandemic, impact the normal functioning of the human population around the world. The pandemic had a significant influence on both large urban areas and rural communities. COVID-19 has altered the daily normal routines and functioning of industry, commerce, transportation, cities, towns, villages, and individuals. Given these profound changes, this article specifically examines the impact and management of a pandemic like COVID-19 on smart cities from the viewpoint of the electric supply, transportation dominated by EVs, and communication systems.

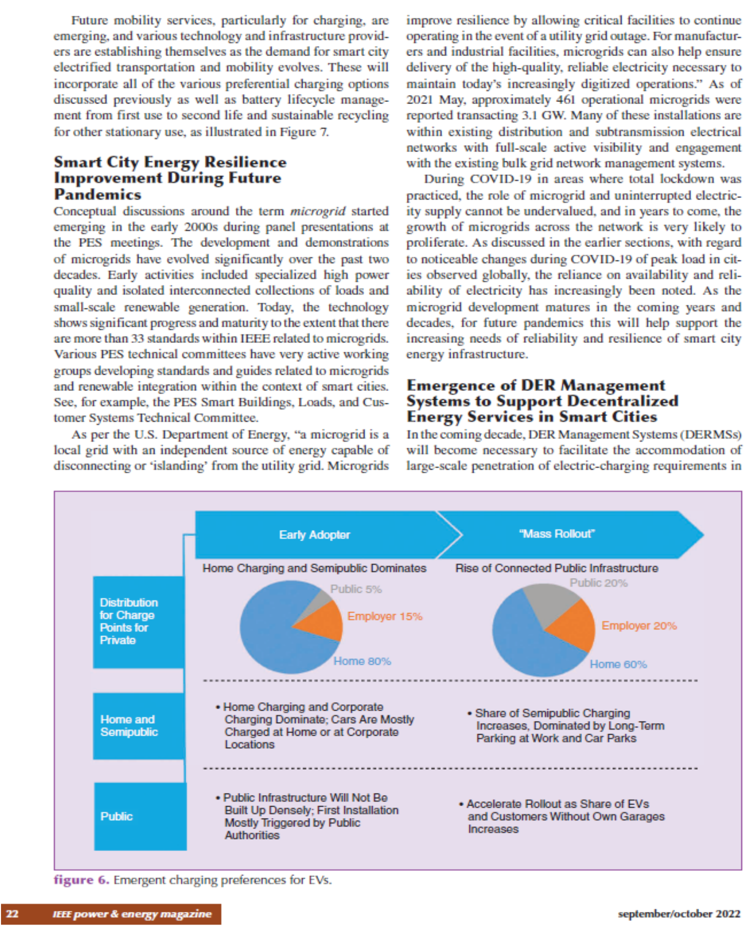
In examining the impact of COVID-19 on these critical smart city infrastructure components, significant information is derived from a report developed by the IEEE Power & Energy Society's (PES's) Industry Technical Support Leadership Committee based on an international survey of electric utilities and organizations and two subsequent PES webinars based on this report. The survey included responses from electric utilities and organizations in Europe, Asia, Oceania, South America, and North America. The subsequent report detailed the impact of COVID-19 on 1) health, business, and technical aspects of the electric utility industry, 2) mitigation measures and practices, and 3) conclusions.

The impact on electric utility operation included topics related to resource availability, the criticality of electric infrastructure and its reliability and resilience, supply chain disruptions, energy consumption and peak demand, modifications of consumption patterns, market reliability and generation mix, and mid- to long-term impacts. Mitigation measures and effort included practices related to control centers, field operations, customer operations and office staff, resilience and supply chain measures, alleviation of technical issues, and practices adopted to cope with the circumstances. With this background, this article will examine three specific aspects of smart city infrastructure systems: 1) electric supply, 2) electric transportation, and 3) communication in the face of an emergency like COVID-19.

Smart City Electric Infrastructure

Smart city infrastructure systems are highly dependent on a reliable and resilient electric supply infrastructure. Additionally, the traditional electric supply setup, which included the concept of central plant generation in combination with the transmission and distribution systems, is rapidly evolving into a system with significant rooftop PV generation, coupled with battery energy storage, community solar systems, and microgrids. In many parts of the world where solar energy is abundant, residential customers and commercial and industrial entities have installed renewable resources that supply a significant part of their load and, during certain times of the year and certain days of the week, sell electric energy back to the utility.

During the pandemic, the commercial and industrial load dropped significantly because of closures. However, the residential load during the week resembled a weekend load or was even heavier, with a large percentage of the population in various parts of the world working from home. Figure 1(a) shows the average daily total load across peak hours for various European countries from 2 March to 3 April 2020. The results show



Future mobility services, particularly for charging, are emerging, and various technology and infrastructure providers are establishing themselves as the demand for smart city electrified transportation and mobility evolves. These will incorporate all of the various preferential charging options discussed previously as well as battery lifecycle management from first use to second life and sustainable recycling for other stationary use, as illustrated in Figure 7.

Smart City Energy Resilience Improvement During Future Pandemics

Conceptual discussions around the term *microgrid* started emerging in the early 2000s during panel presentations at the PES meetings. The development and demonstrations of microgrids have evolved significantly over the past two decades. Early activities included specialized high power quality and isolated interconnected collections of loads and small-scale renewable generation. Today, the technology shows significant progress and maturity to the extent that there are more than 33 standards within IEEE related to microgrids. Various PES technical committees have very active working groups developing standards and guides related to microgrids and renewable integration within the context of smart cities. See, for example, the PES Smart Buildings, Loads, and Customer Systems Technical Committee.

As per the U.S. Department of Energy, "a microgrid is a local grid with an independent source of energy capable of disconnecting or 'islanding' from the utility grid. Microgrids improve resilience by allowing critical facilities to continue operating in the event of a utility grid outage. For manufacturers and industrial facilities, microgrids can also help ensure delivery of the high-quality, reliable electricity necessary to maintain today's increasingly digitized operations." As of 2021 May, approximately 461 operational microgrids were reported transacting 3.1 GW. Many of these installations are within existing distribution and subtransmission electrical networks with full-scale active visibility and engagement with the existing bulk grid network management systems.

During COVID-19 in areas where total lockdown was practiced, the role of microgrid and uninterrupted electricity supply cannot be undervalued, and in years to come, the growth of microgrids across the network is very likely to proliferate. As discussed in the earlier sections, with regard to noticeable changes during COVID-19 of peak load in cities observed globally, the reliance on availability and reliability of electricity has increasingly been noted. As the microgrid development matures in the coming years and decades, for future pandemics this will help support the increasing needs of reliability and resilience of smart city energy infrastructure.

Emergence of DER Management Systems to Support Decentralized Energy Services in Smart Cities

In the coming decade, DER Management Systems (DERMSs) will become necessary to facilitate the accommodation of large-scale penetration of electric-charging requirements in

- Home Charging and Corporate Charging Dominate; Cars Are Mostly Charged at Home or at Corporate Locations
- Share of Semipublic Charging Increases, Dominated by Long-Term Parking at Work and Car Parks
- Public Infrastructure Will Not Be Built Up Densely; First Installation Mostly Triggered by Public Authorities
- Accelerate Rollout as Share of EVs and Customers Without Own Garages Increases

figure 6. Emergent charging preferences for EVs.

V. Vittal, **N. Nair** and F. Rahmatian, "Smart City Energy Technology in the Face of Emergency Situations: Electric Supply, Electric Transportation, and Communication," in *IEEE Power and Energy Magazine*, vol. 20, no. 5, pp. 16-25, Sept.-Oct. 2022, doi: 10.1109/MPE.2022.3184058.

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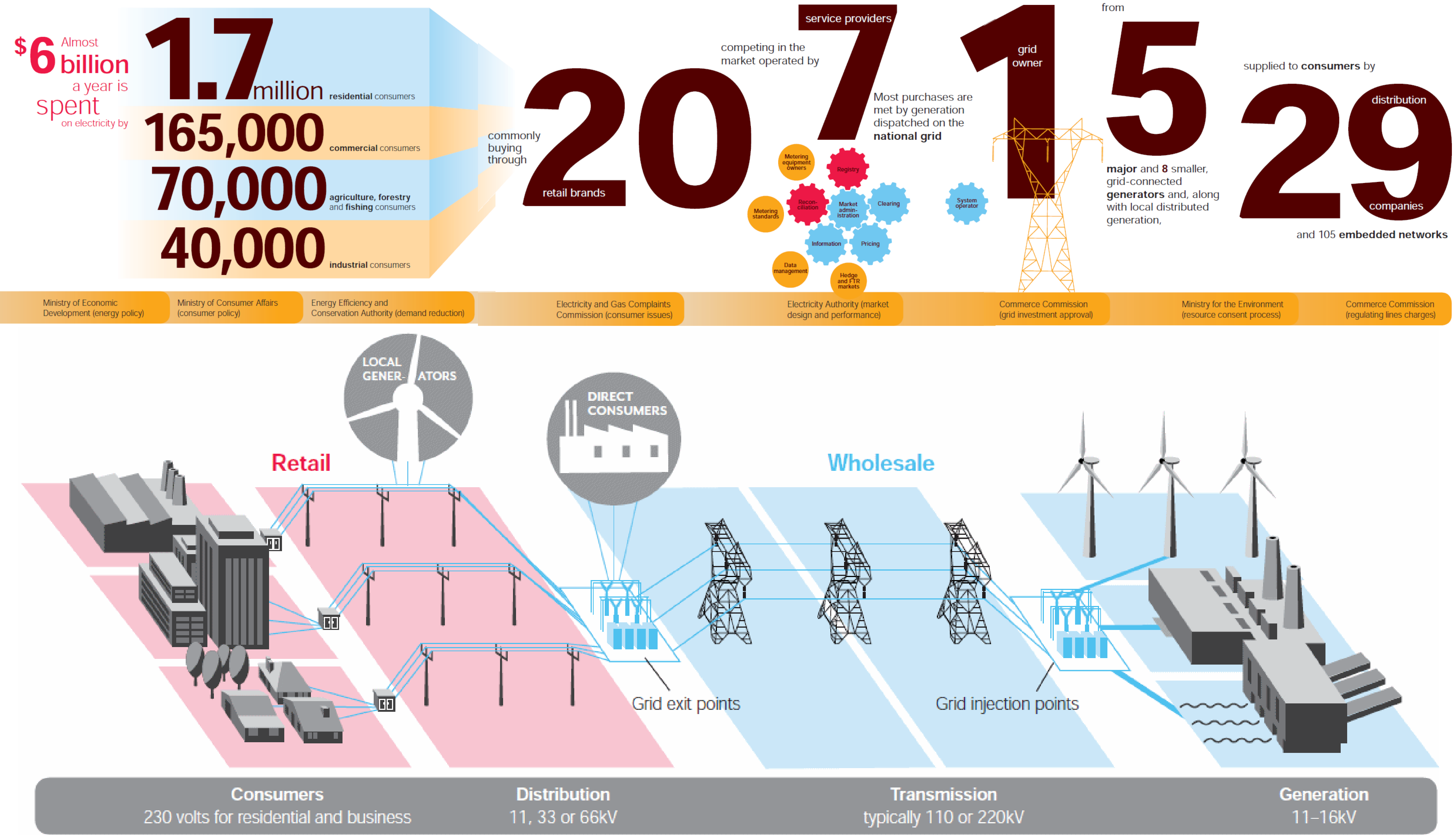


Almost **$6 billion** a year is spent on electricity by

1.7 million residential consumers

165,000 commercial consumers

70,000 agriculture, forestry and fishing consumers

40,000 industrial consumers

commonly buying through **20** retail brands

competing in the market operated by **7** service providers

Most purchases are met by generation dispatched on the **national grid**

1 grid owner

from **5** major and **8** smaller, grid-connected **generators** and, along with local distributed generation,

supplied to **consumers** by **29** distribution companies

and 105 **embedded networks**

Ministry of Economic Development (energy policy)

Ministry of Consumer Affairs (consumer policy)

Energy Efficiency and Conservation Authority (demand reduction)

Electricity and Gas Complaints Commission (consumer issues)

Electricity Authority (market design and performance)

Commerce Commission (grid investment approval)

Ministry for the Environment (resource consent process)

Commerce Commission (regulating lines charges)

Consumers
230 volts for residential and business

Distribution
11, 33 or 66kV

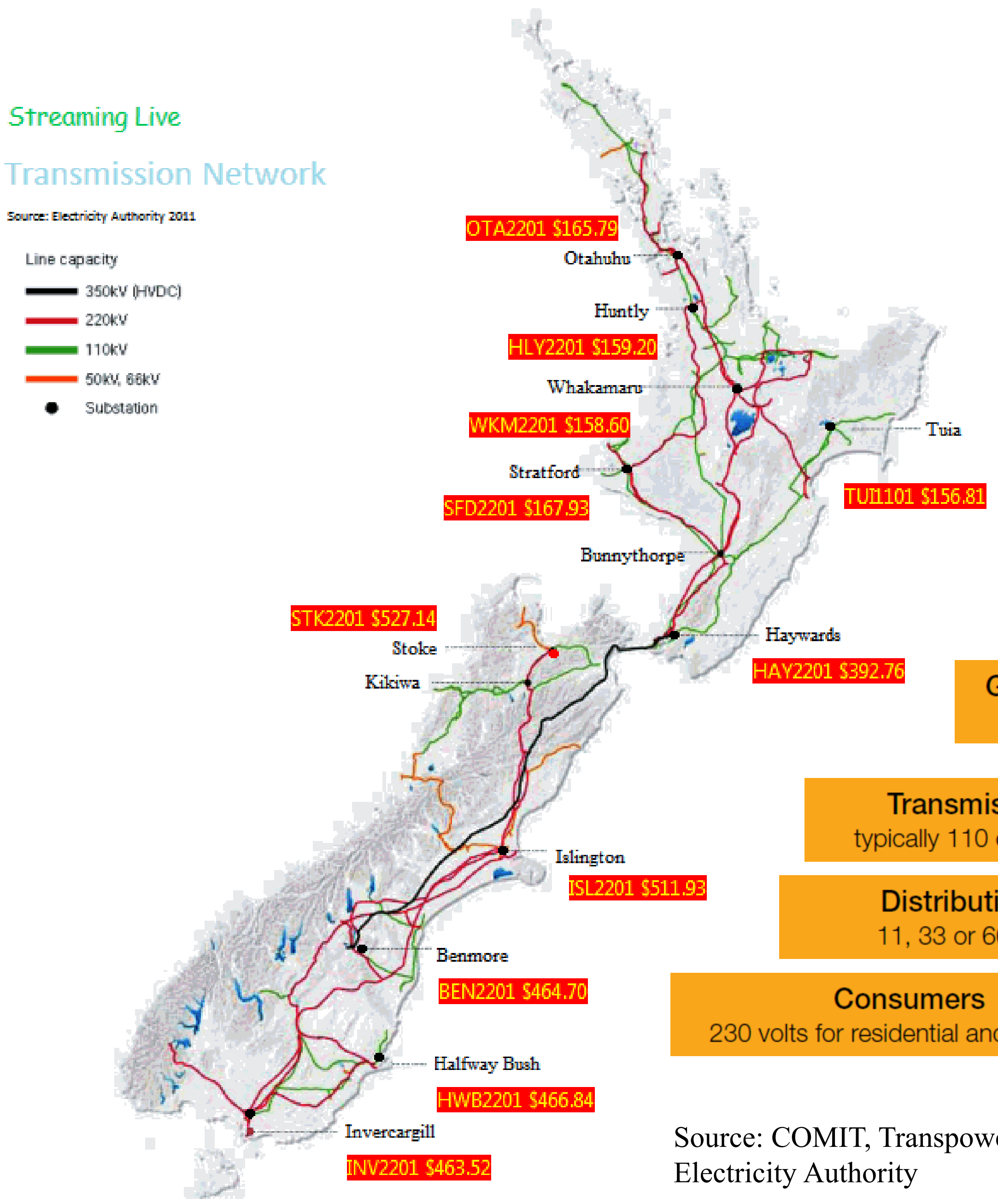
Transmission
typically 110 or 220kV

Generation
11–16kV

Ref: EA (2011)

New Zealand Electricity Market (NZEM)

- $6 billion spent, $2.1 billion wholesale transactions in 2011
- 5 Gencos, 28 Disco 20+ retail brands
- Security Constrained Economic Dispatch (SCED)
- Scheduling, Pricing and Dispatch (SPD) model
- Locational Marginal Prices



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Source: COMIT, Transpower, Electricity Authority

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New Zealand North Island (NZNI) Power System Network

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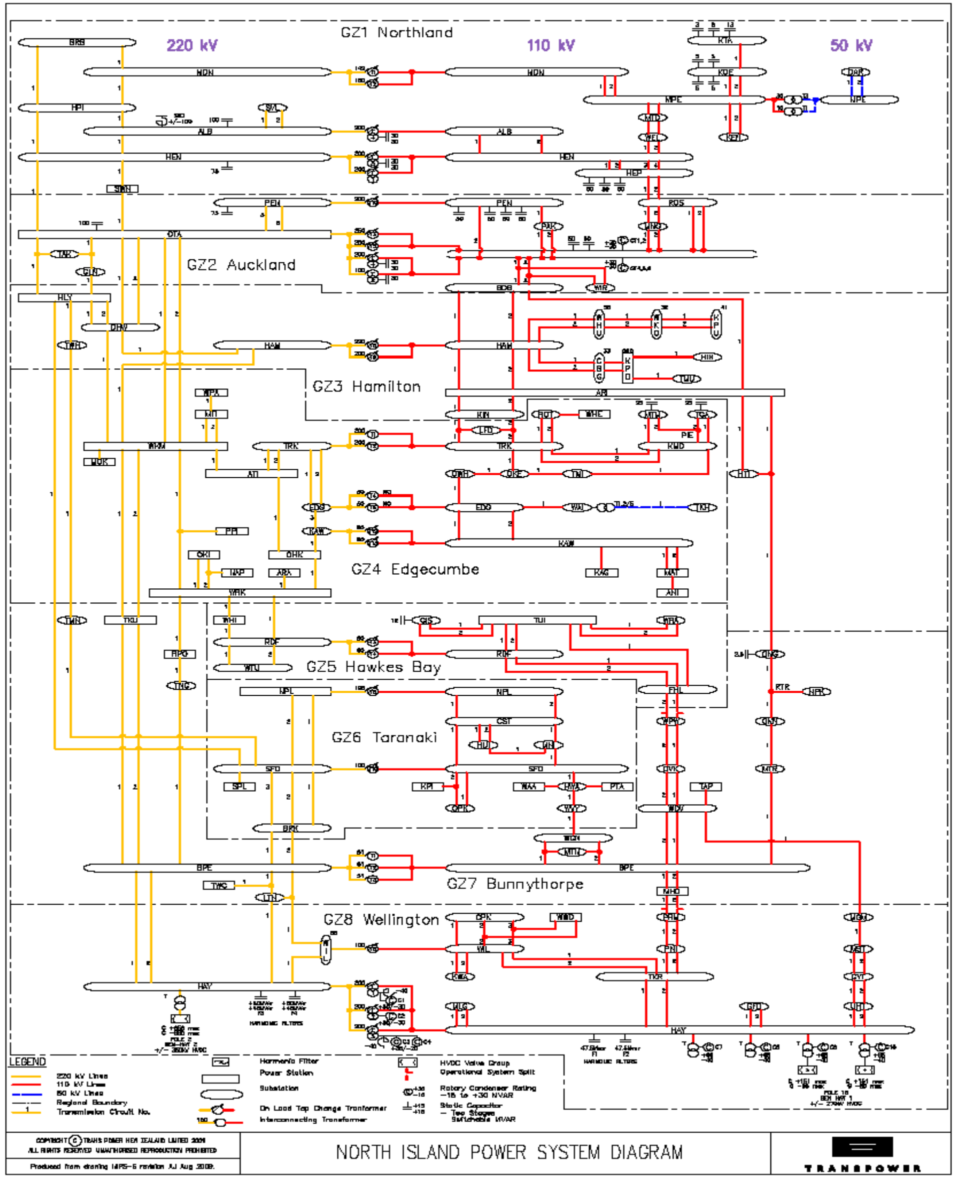
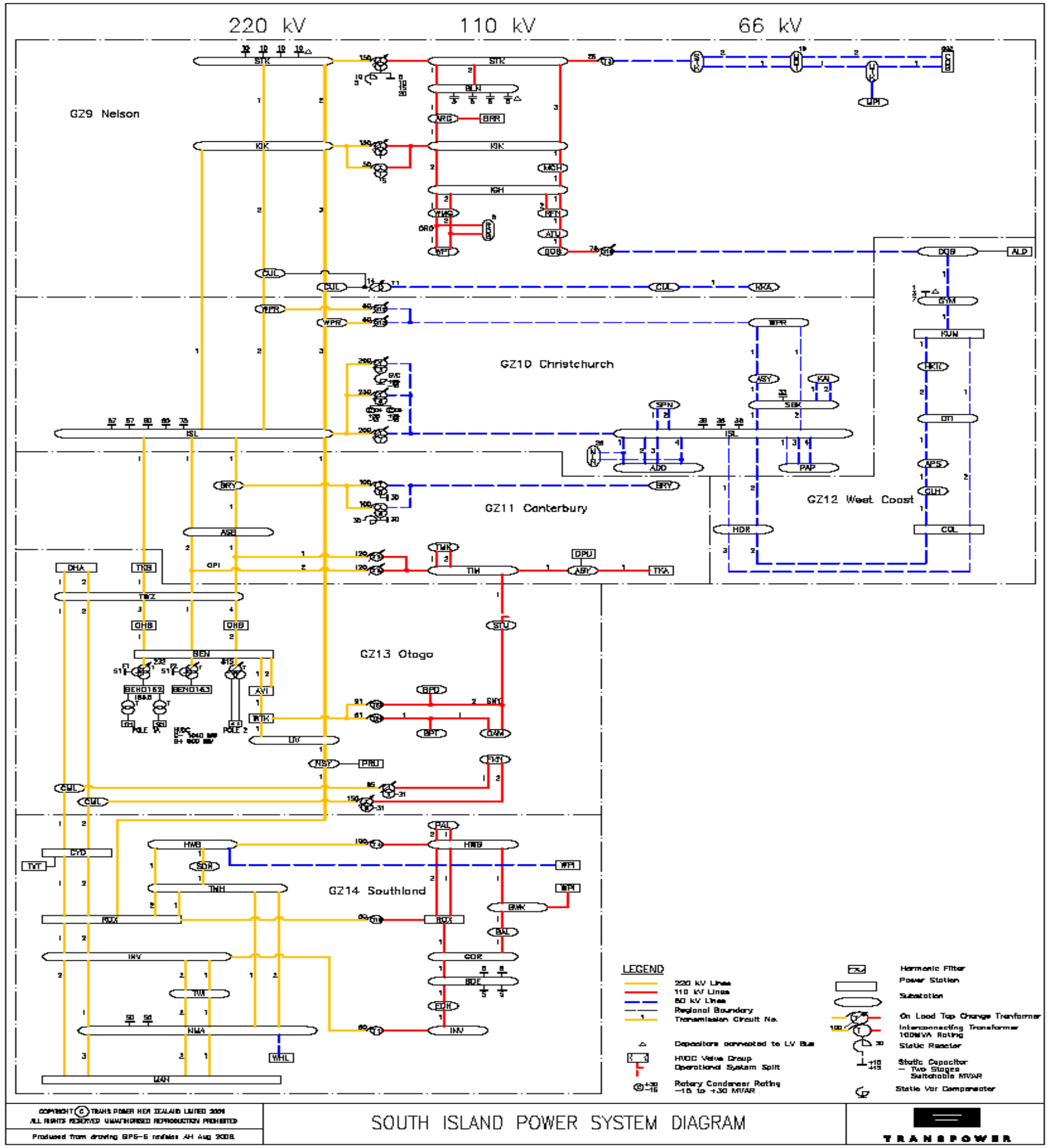
Developing Ride-through criterion through power system protection studies: New Zealand Case Study

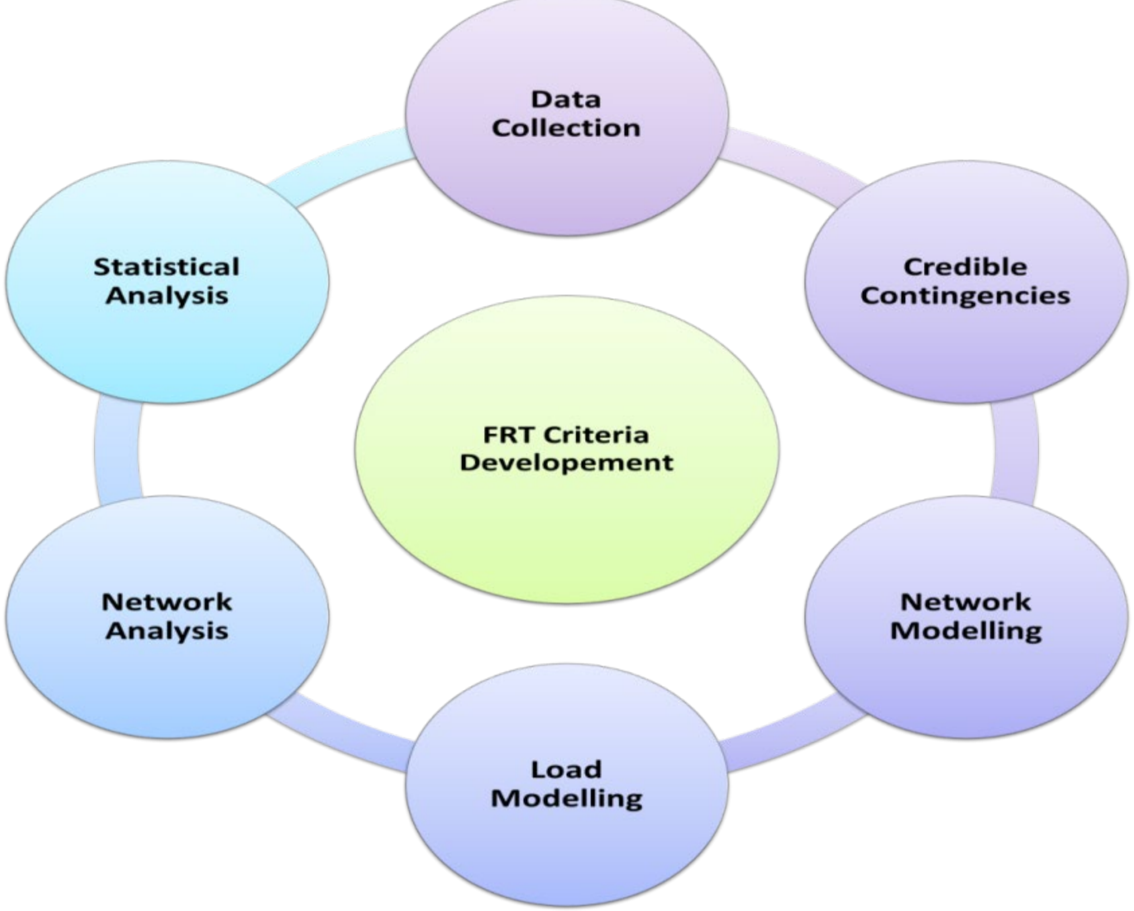


New Zealand South Island (NZSI) Power System Network



Produced from drawing SPS-5 revision AH Aug 2008

Developing NZ FRT Grid codes



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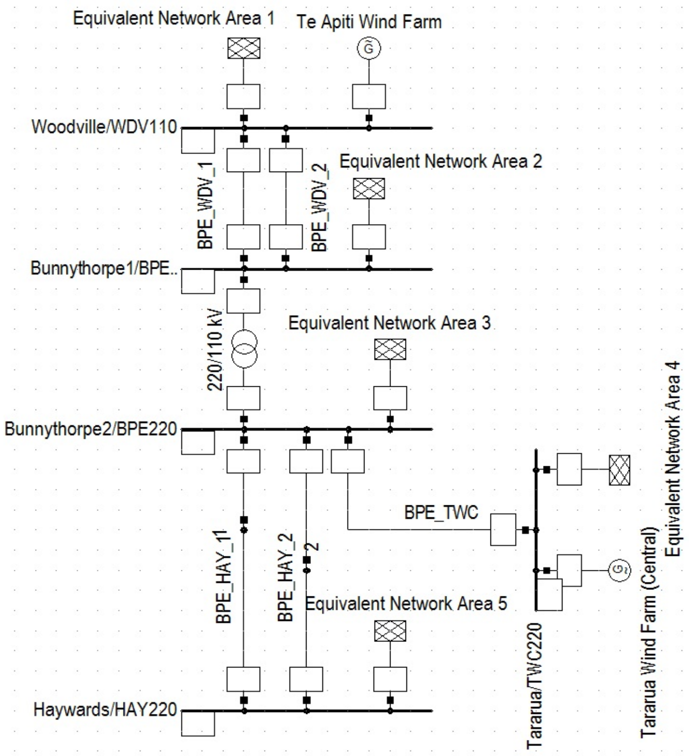
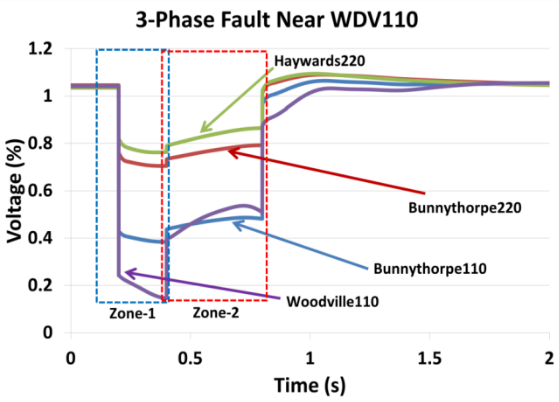
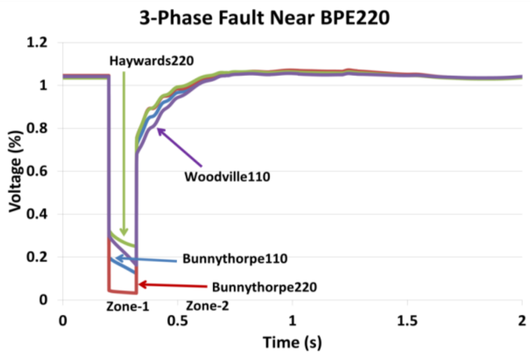
Developing NZ FRT Grid codes







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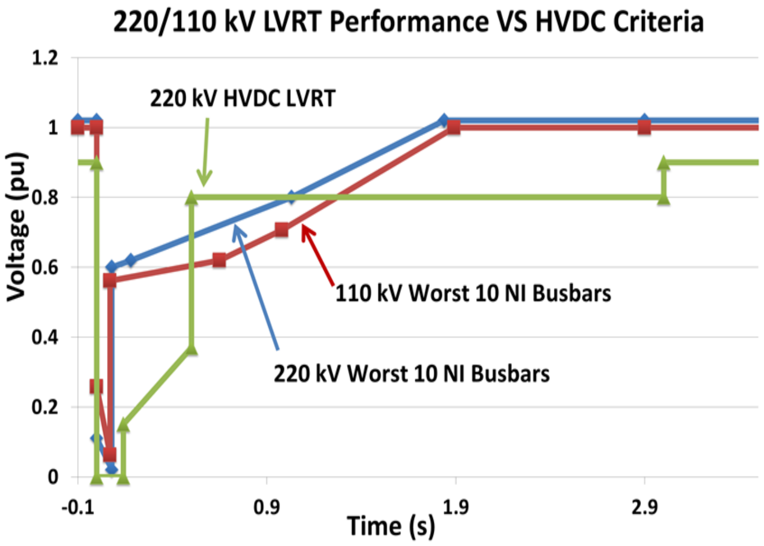
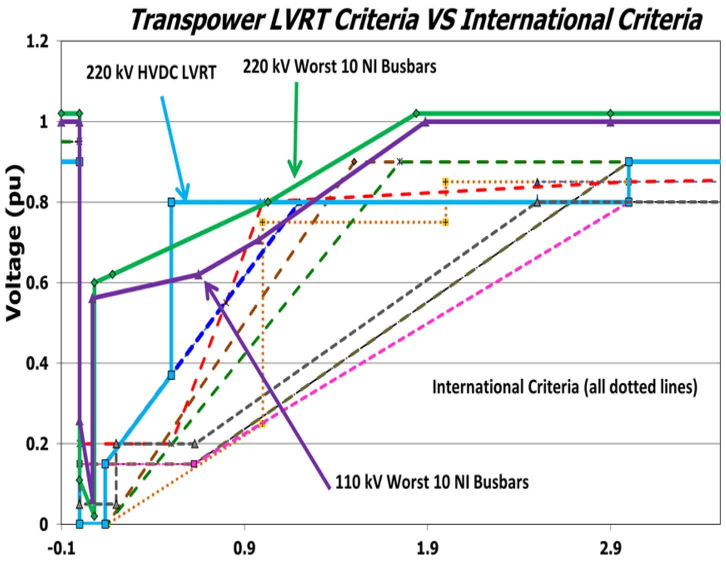
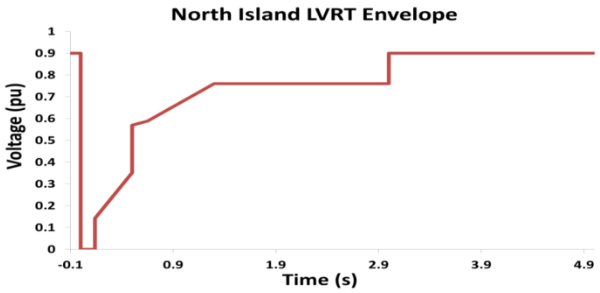
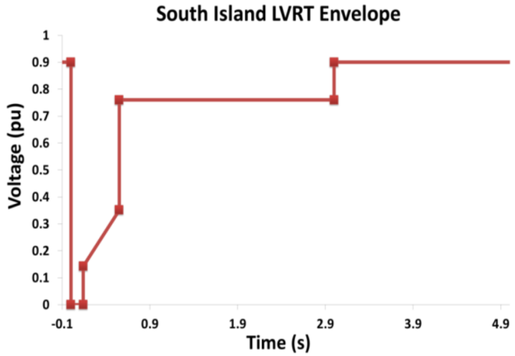




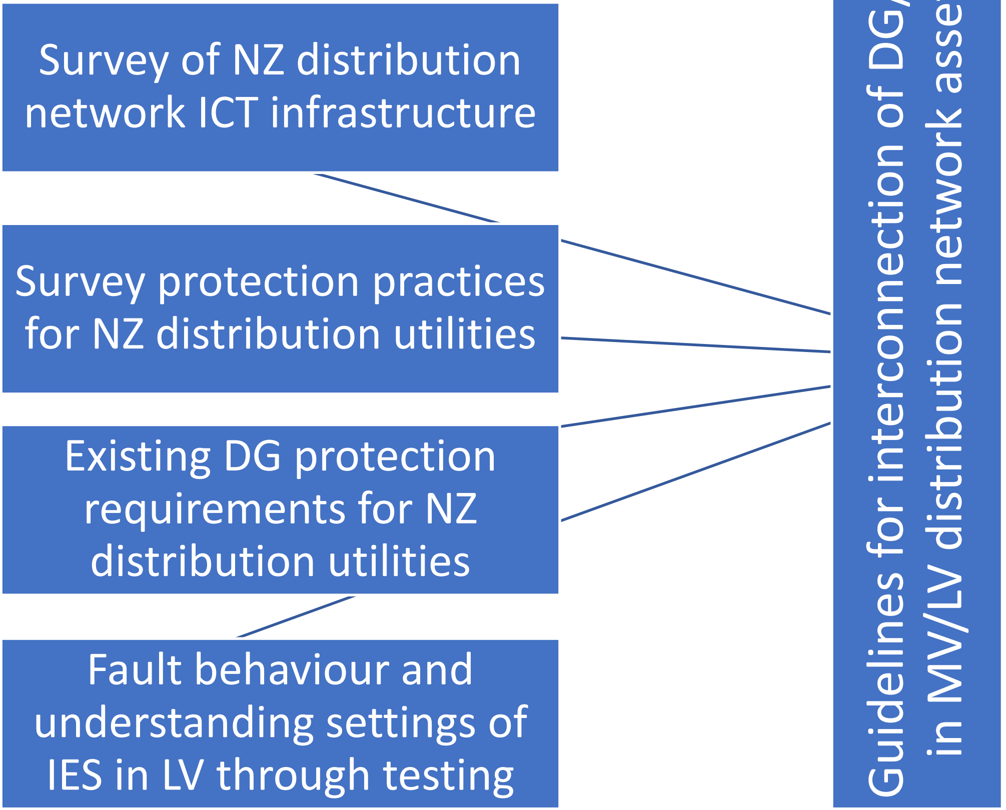




Nair, N. K., & Qureshi, W. A. (2014). Fault Ride-Through Criteria Development. In J. Hossain, & A. Mahmud (Eds.), *Renewable Energy Integration: Challenges and Solutions*. Singapore: Springer.

Project Steps undertaken to address safety and protection associated with penetration of DG/IES to NZ homes and distribution networks

Developing Grid connection criteria for Inverter- interfaced energy resources: New Zealand Case Study



Survey of NZ distribution network ICT infrastructure

Survey protection practices for NZ distribution utilities

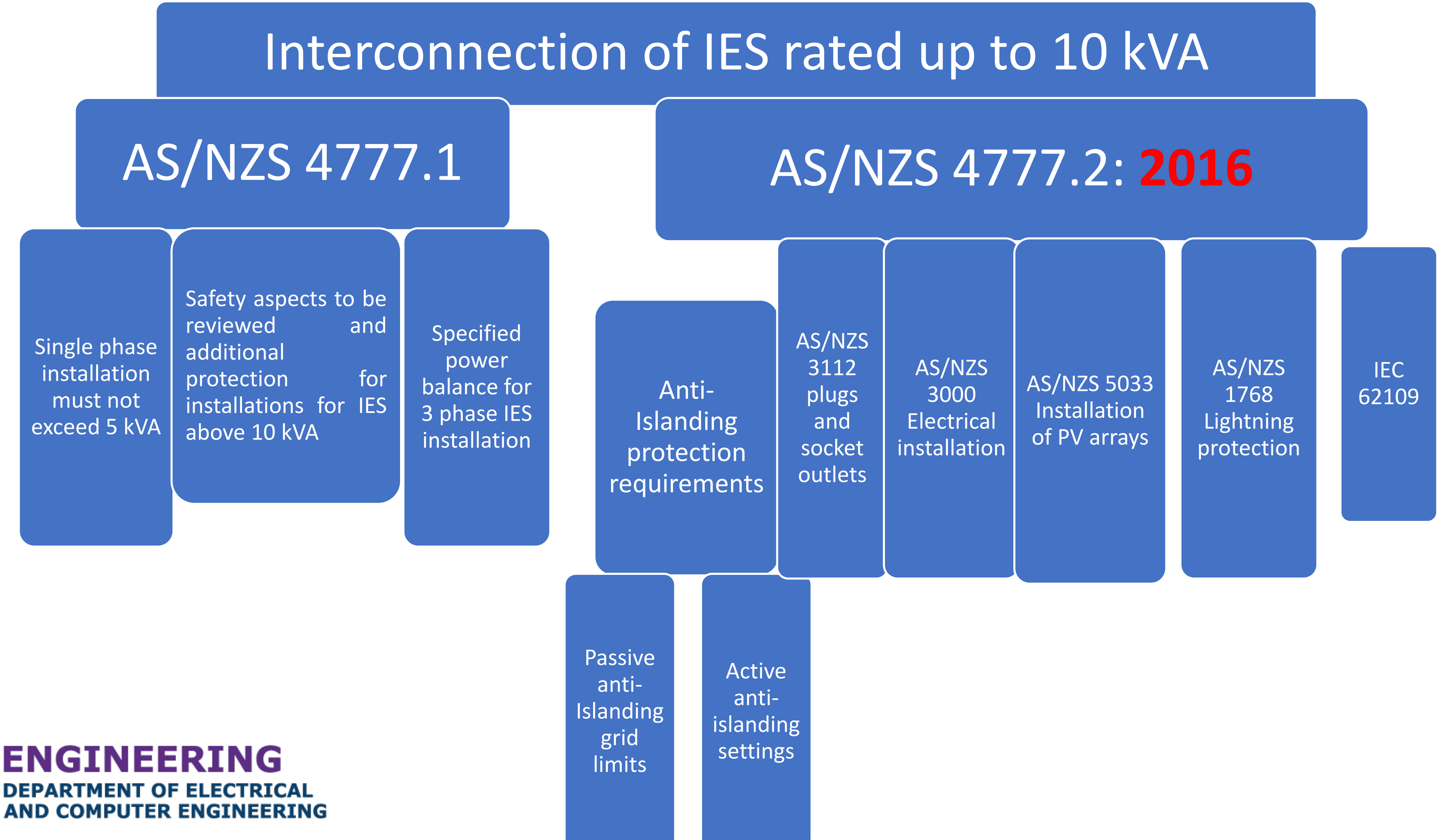
Existing DG protection requirements for NZ distribution utilities

Fault behaviour and understanding settings of IES in LV through testing

Guidelines for interconnection of DG/IES in MV/LV distribution network assets

1. Top Energy
2. Northpower
3. Vector
4. Counties Power
5. WEL Networks
6. Powerco
7. Waipa Networks
8. The Lines Company
9. Unison Networks
10. Horizon Energy Distribution
11. Eastland Network
12. Centralines
13. Scanpower
14. Electra
15. Wellington Electricity
16. Nelson Electricity
17. Marlborough Lines
18. Network Tasman
19. Buller Electricity
20. Mainpower New Zealand
21. Westpower
22. Orion New Zealand
23. Electricity Ashburton
24. Alpine Energy
25. Network Waitaki
26. Aurora Energy
27. OtagoNet Joint Venture
28. The Power Company
29. Electricity Invercargill

New Zealand Guidelines for interconnection of IES to LV distribution network



Interconnection of IES rated up to 10 kVA

- AS/NZS 4777.1
  - Single phase installation must not exceed 5 kVA
  - Safety aspects to be reviewed and additional protection for installations for IES above 10 kVA
  - Specified power balance for 3 phase IES installation
- AS/NZS 4777.2: **2016**
  - Anti-Islanding protection requirements
    - Passive anti-Islanding grid limits
    - Active anti-islanding settings
  - AS/NZS 3112 plugs and socket outlets
  - AS/NZS 3000 Electrical installation
  - AS/NZS 5033 Installation of PV arrays
  - AS/NZS 1768 Lightning protection
  - IEC 62109

Presentation Outline

Overview: Global Emerging Agendas

- Existing/New Asset class
- Low-carbon Goal

Contingencies

- Natural Hazards (High Impact Low Probability)
- Blackouts (Voltage Collapse, system splits)

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Blackout Analysis of Protection Performance

Australia, Turkey, India

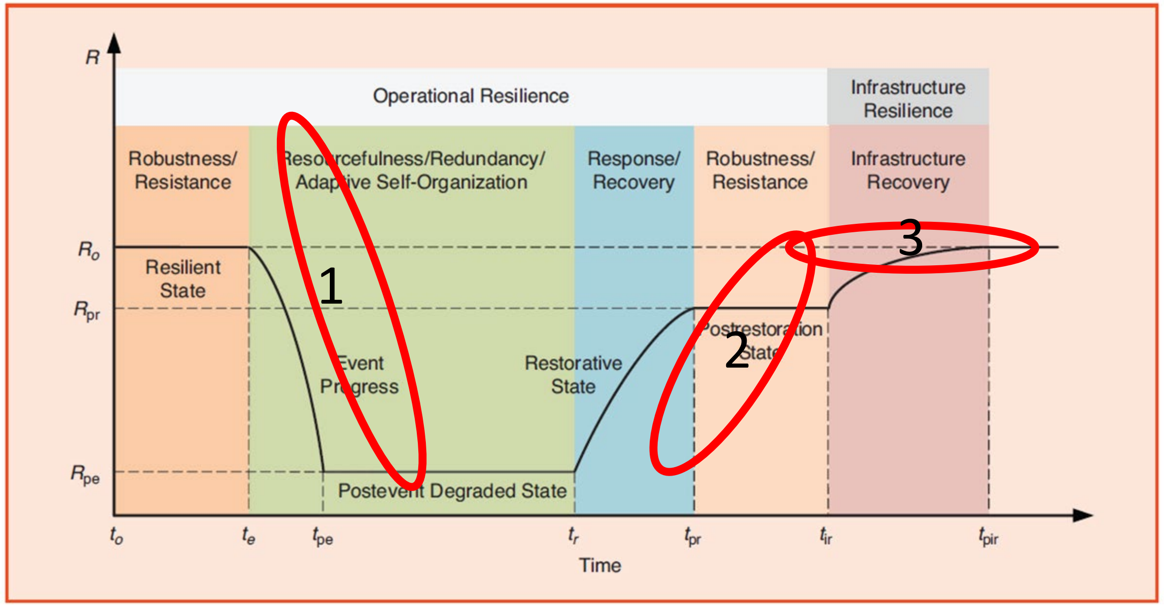
Protection Challenges

Ongoing work

- NZ South Island
- CIGRE Working Group and Special Report

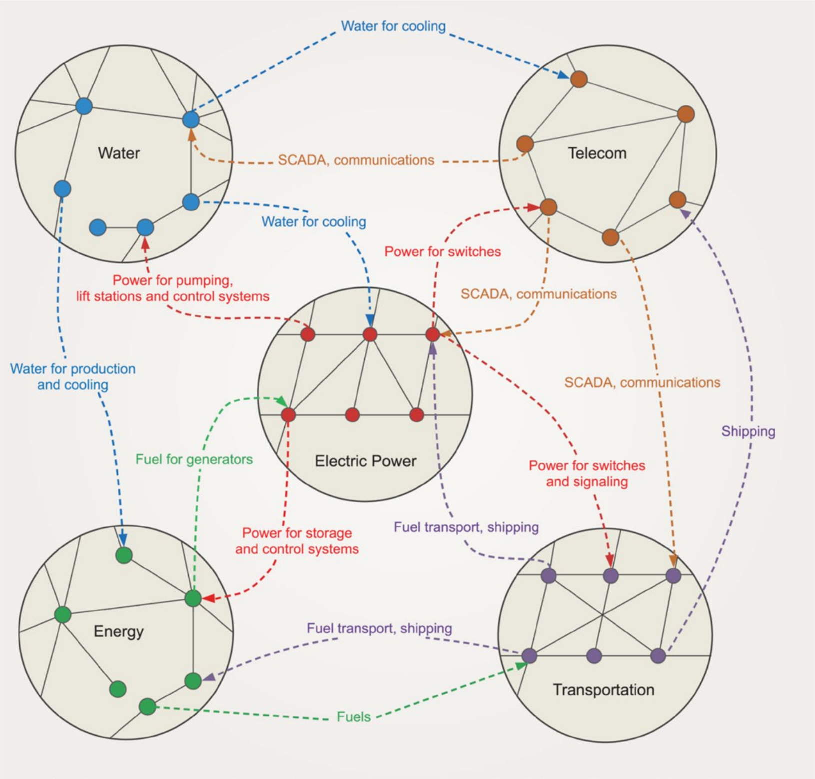
Disclosure: *Pictures for this Forum presentation taken from various publically available sources*

Operating States in disaster related conditions



System operation, control and protection during:

1. Event Progress
2. Restorative State
3. Post-Restorative State

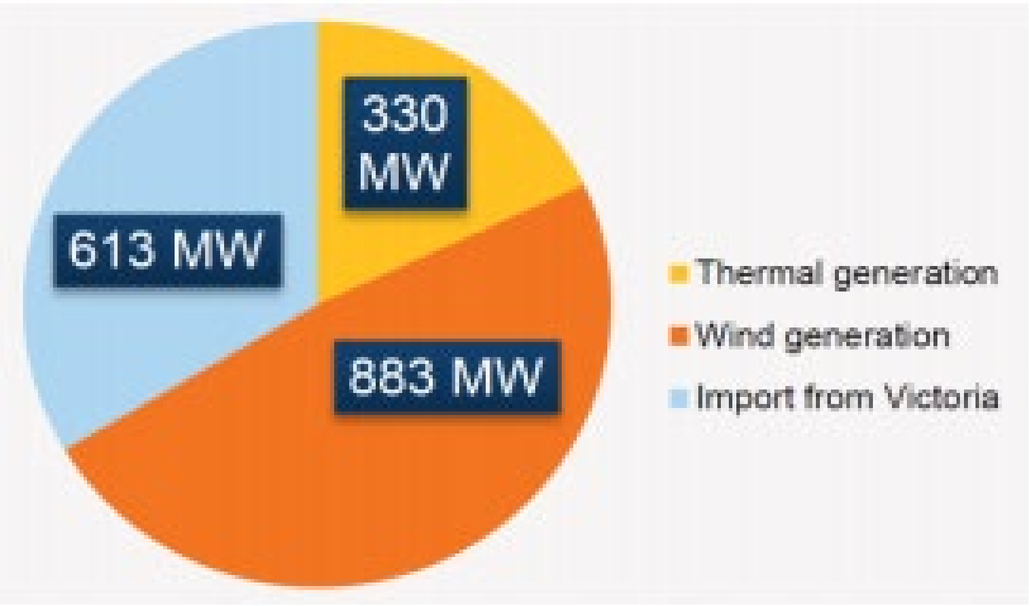


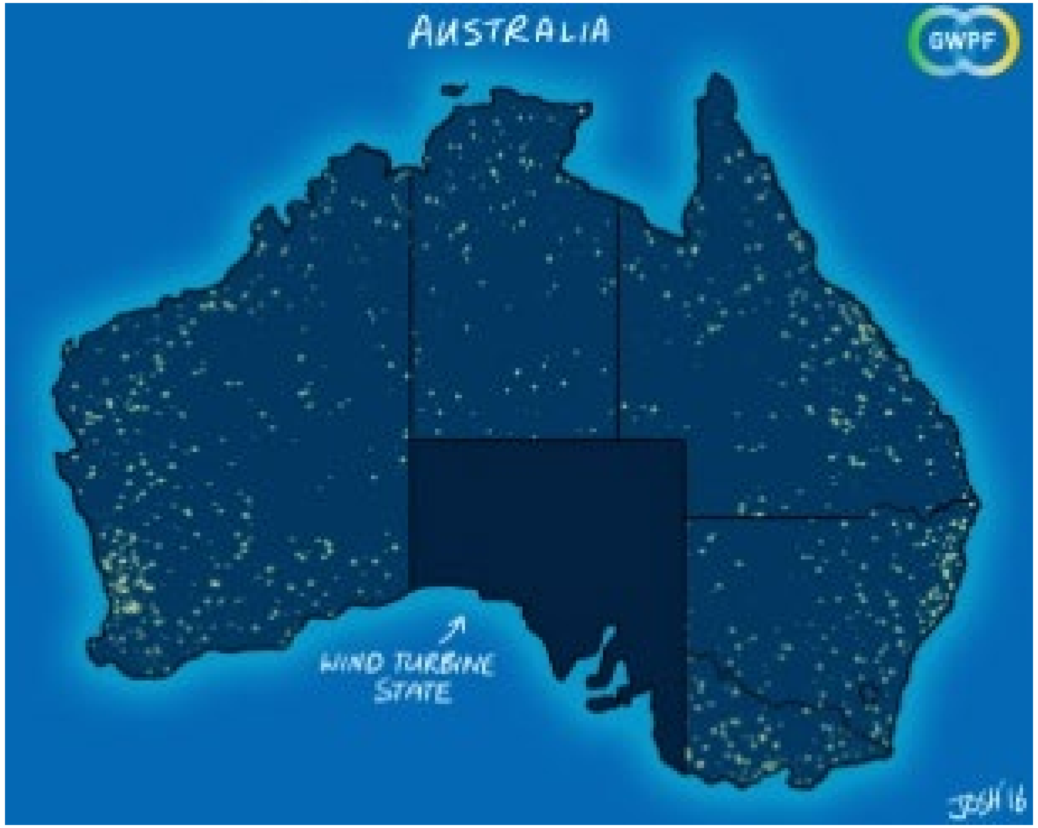
How does control, operation and protection philosophies change during abnormal states? Best understood by **case studies**.

Case Study: Australia 2016 blackout

Pre-Event Status:

- Demand – 1826 MW (850,000 electricity consumers)
- Wind Generation – 883 MW (near 50%)
- Tie Line Power – 613 MW
- Gas Generation – 330 MW
- Solar Power – 50 MW
- Coal Power – Retired early during the year (undergoing decommissioning)

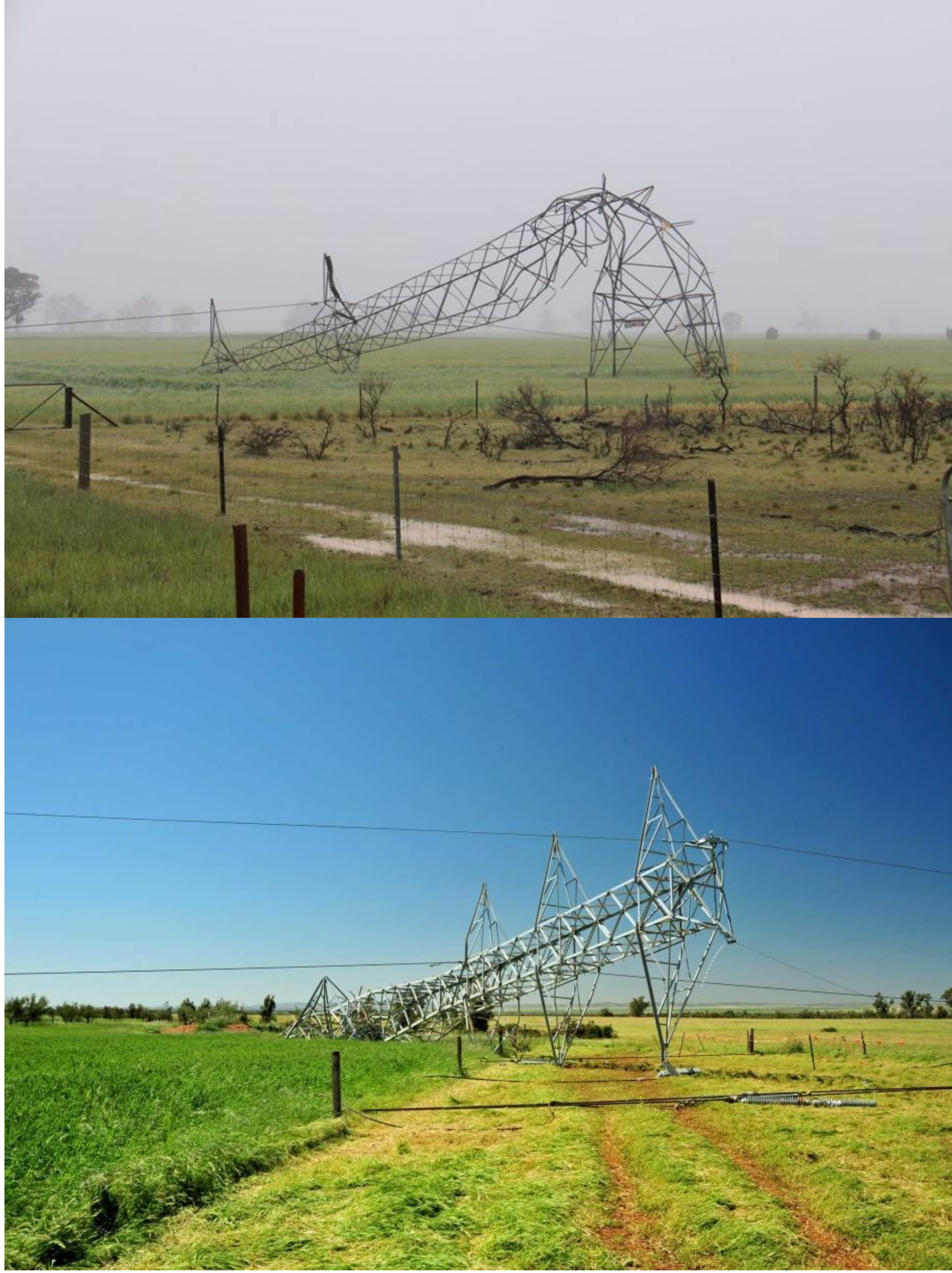




Case Study: Australia 2016 blackout

Event Progression:

- Major Storm (190 – 260 Km/hr).
- Multiple lightning strikes.
- Tornadoes.
- 22 damaged transmission pylons.
- Damage of 3 out of 4 tie-line interconnections
- 5 major faults within 2 minutes
- Low voltages stressed the windfarm ride through capabilities leading to disconnection of some windfarms with about 456 MW.



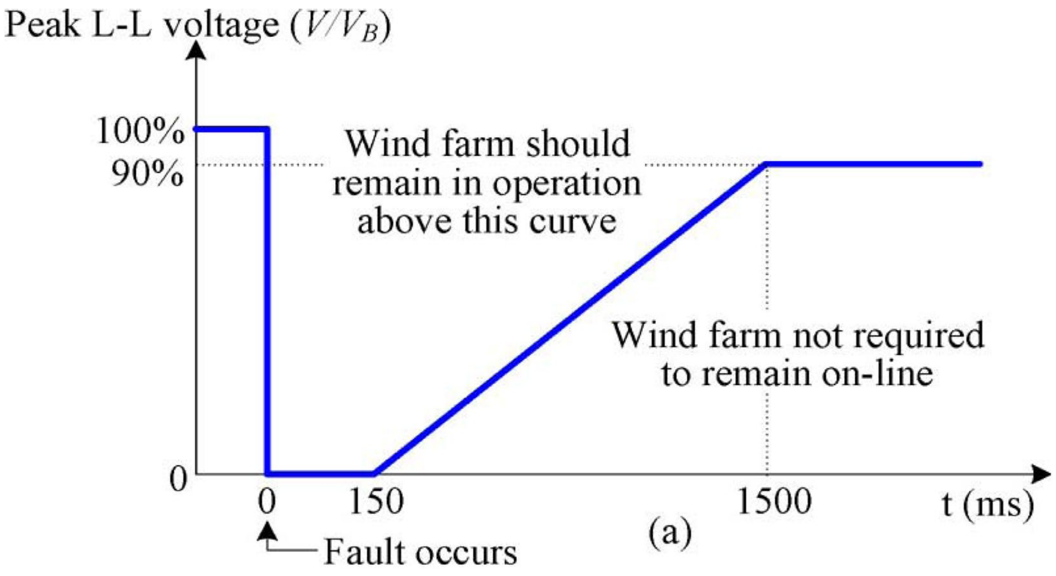
Case Study: Australia 2016 blackout

Progression of the event:

- Low voltages stressed the windfarm ride through capabilities leading to disconnection of some windfarms with about 456 MW.
- Demand much greater than supply.
- **UFLS reaction time** slower than the frequency drop time.
- System collapse.

System during restoration :

- Restoration begins…….
- Unsuccessful switching sequences when cranking of large generating units using small generating units. **Trip on transformer protection** from inrush current during this energisation process.
- Planned Islanded mode around Port Lincoln area failed due to inability to control frequency.



THE UNIVERSITY OF AUCKLAND
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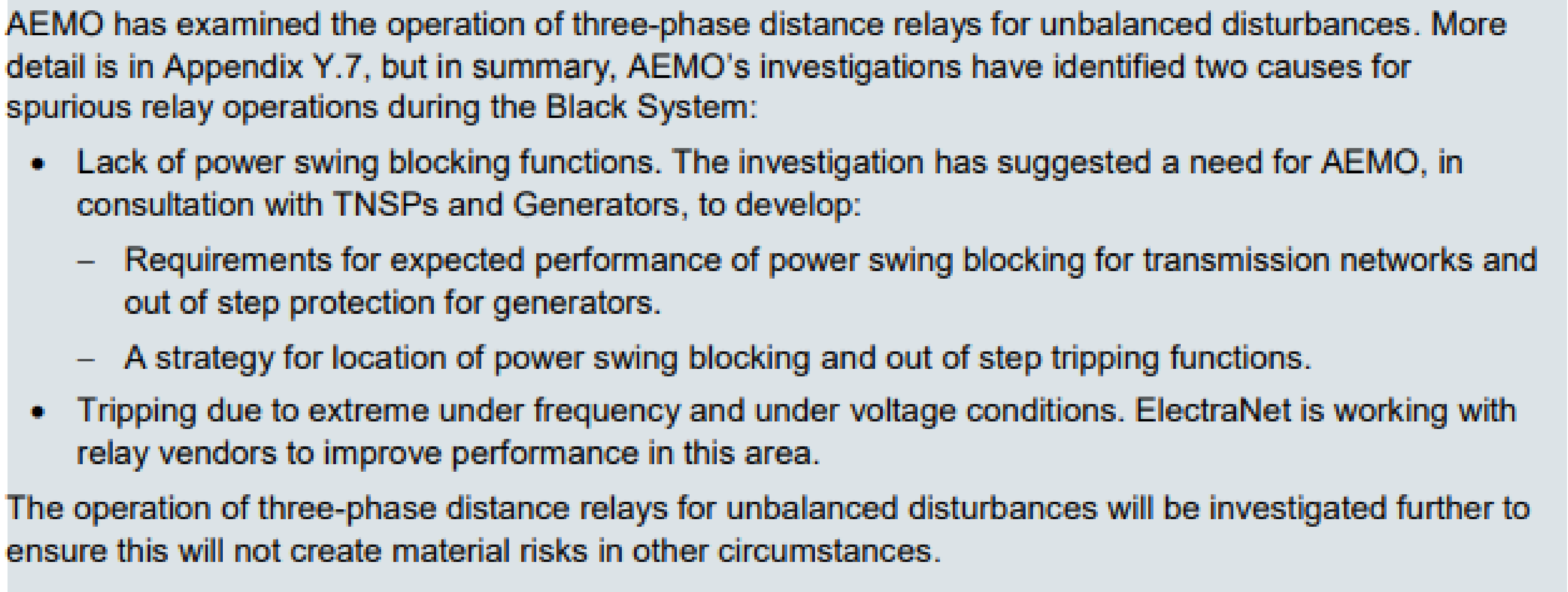
NEW ZEALAND

ENGINEERING
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Case Study: Australia 2016 blackout

Event Learnings:

- Protection performance under extreme contingencies to be conducted



AEMO has examined the operation of three-phase distance relays for unbalanced disturbances. More detail is in Appendix Y.7, but in summary, AEMO's investigations have identified two causes for spurious relay operations during the Black System:

- Lack of power swing blocking functions. The investigation has suggested a need for AEMO, in consultation with TNSPs and Generators, to develop:
  - Requirements for expected performance of power swing blocking for transmission networks and out of step protection for generators.
  - A strategy for location of power swing blocking and out of step tripping functions.
- Tripping due to extreme under frequency and under voltage conditions. ElectraNet is working with relay vendors to improve performance in this area.

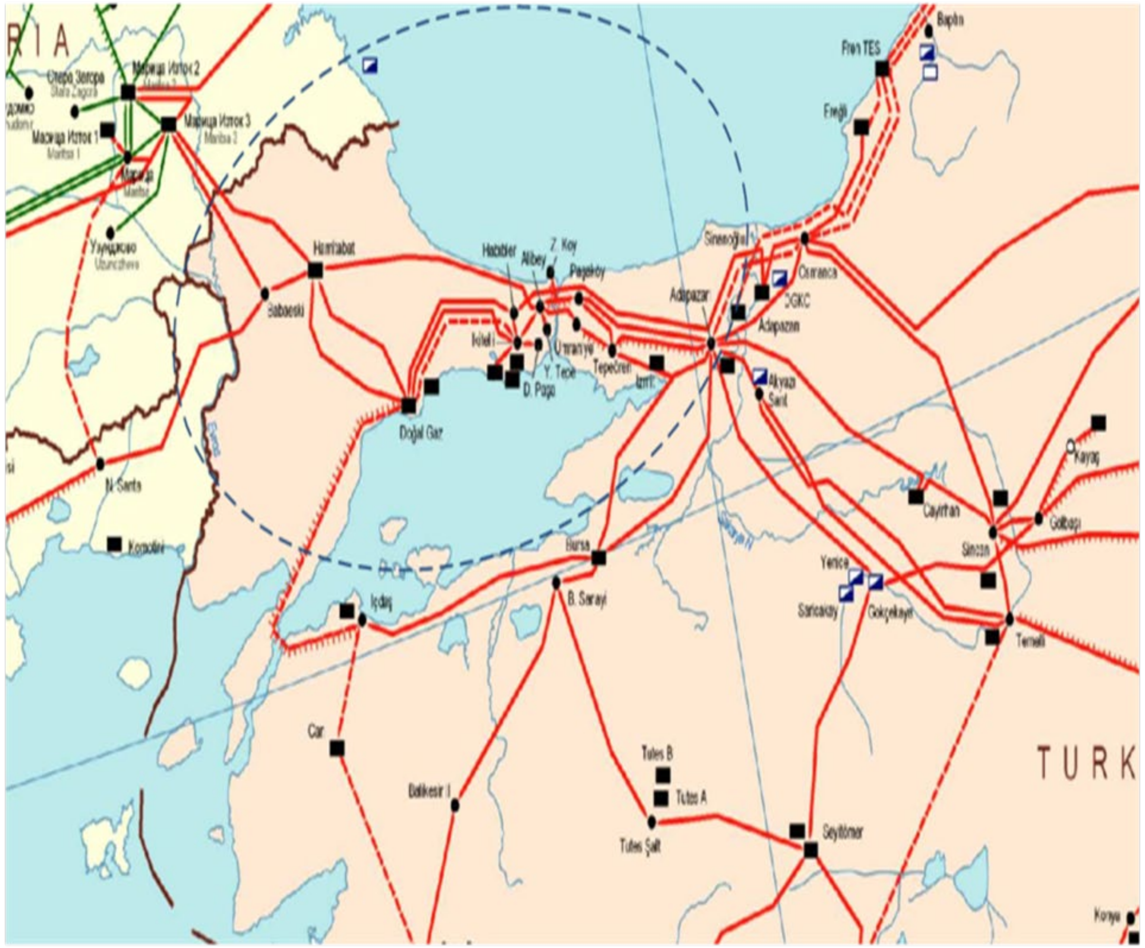
The operation of three-phase distance relays for unbalanced disturbances will be investigated further to ensure this will not create material risks in other circumstances.

- Review of windfarm ride through settings.

- Need to investigate role of non-hydro based renewables in restoration.

Case Study: Turkey 2015 Blackout

- Caused by overloads majorly caused by maintenance of lines and outage of all series capacity that usually increase capacity.
- Restoration began as per established policy….
- At **95% restoration**, SPS operating on the tie lines between Bulgaria and Turkey operated tripping the two 400 KV lines interconnecting the two lines.
- The SPS was deactivated after which the system was fully restored.
- Coordination between the **SPS and UFLS** needed to be reviewed as in this case the SPS operated before the UFLS.



Case Study: India 2012 Blackout

- Caused by line overloads (unscheduled tie line exports and imports) that led to cascading effect and tripping of other lines leading to a blackout.
- Restoration began as per established policy….
- Failure of blackstart generators due to operation **of reverse protection scheme** operated on one generation unit in a power plant that switched to household.
- Loss of communication thus loss of visibility thus delay in restoration.

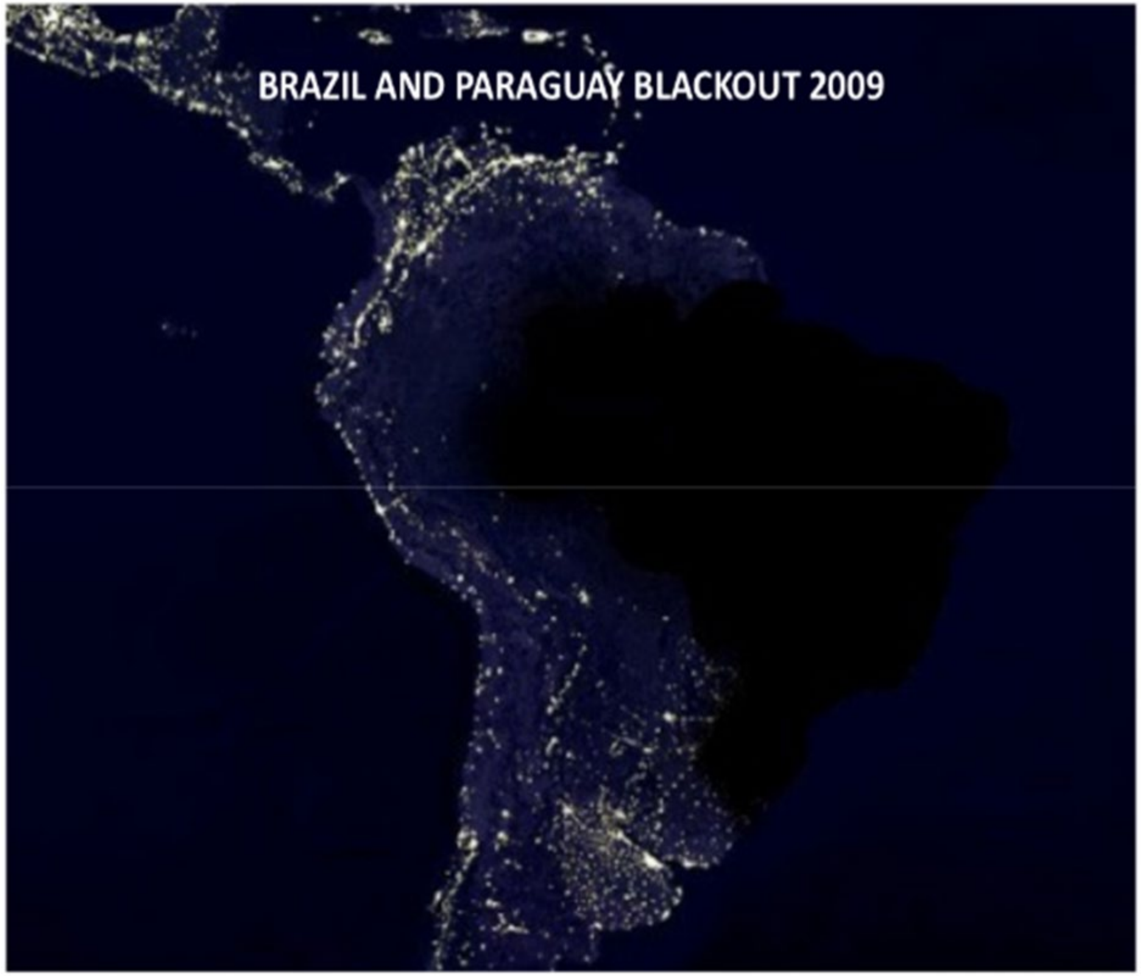
Lights Out

States and territories affected by blackouts Tuesday (in red)

Source: Government of India
The Wall Street Journal

Case Study: Brazil/Paraguay 2009 Blackout

- Bad weather led to automatic disconnection of 765 KV lines isolating the Itapu power plant.
- There was successful reclosers but this led to injection of very high current with harmonics and **DC components in the neutral of a shunt reactor** on the line disconnecting the line
- Restoration begins………..
- Incorrect amount of overvoltages, **excessive load pickup** and load rejection.
- **Incorrect resynchronisation** strategies.
- Failure of planned blackstart generators to perform as required.



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New Functionalities, Services, Integration IT Standards for Substations

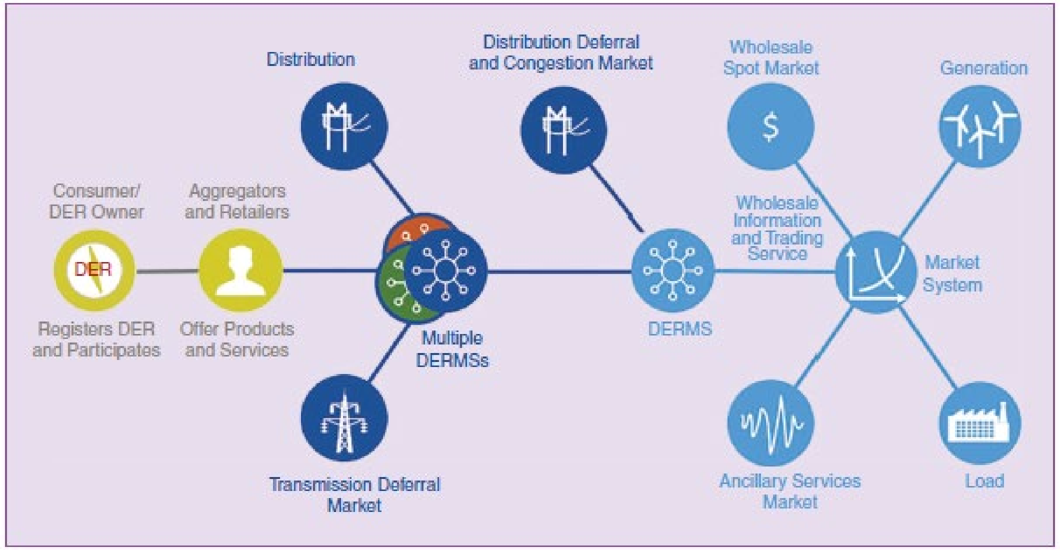


figure 8. The interaction of DERMSs to facilitate smart cities, microgrid, and electric-charging services.

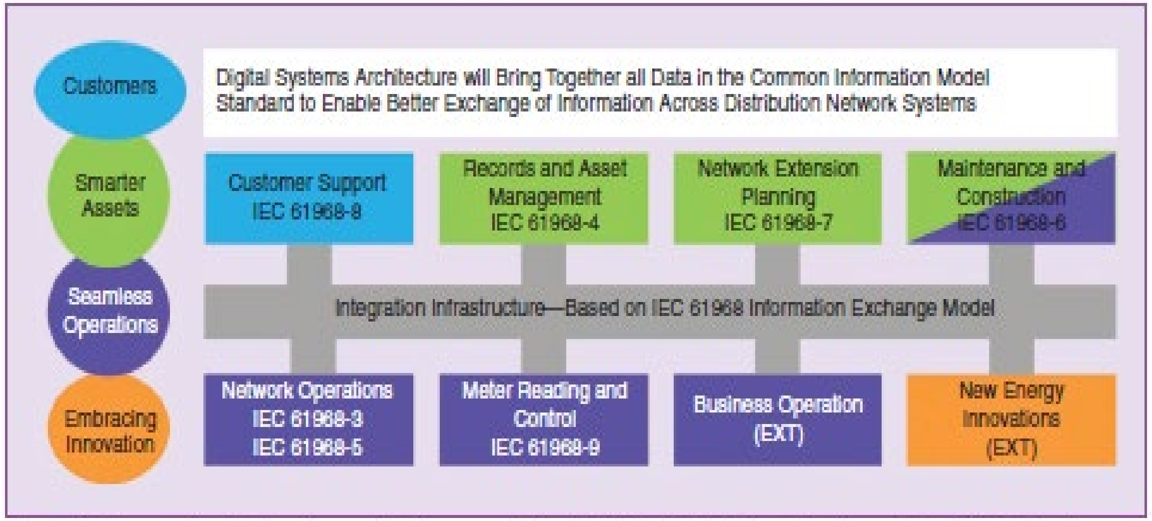
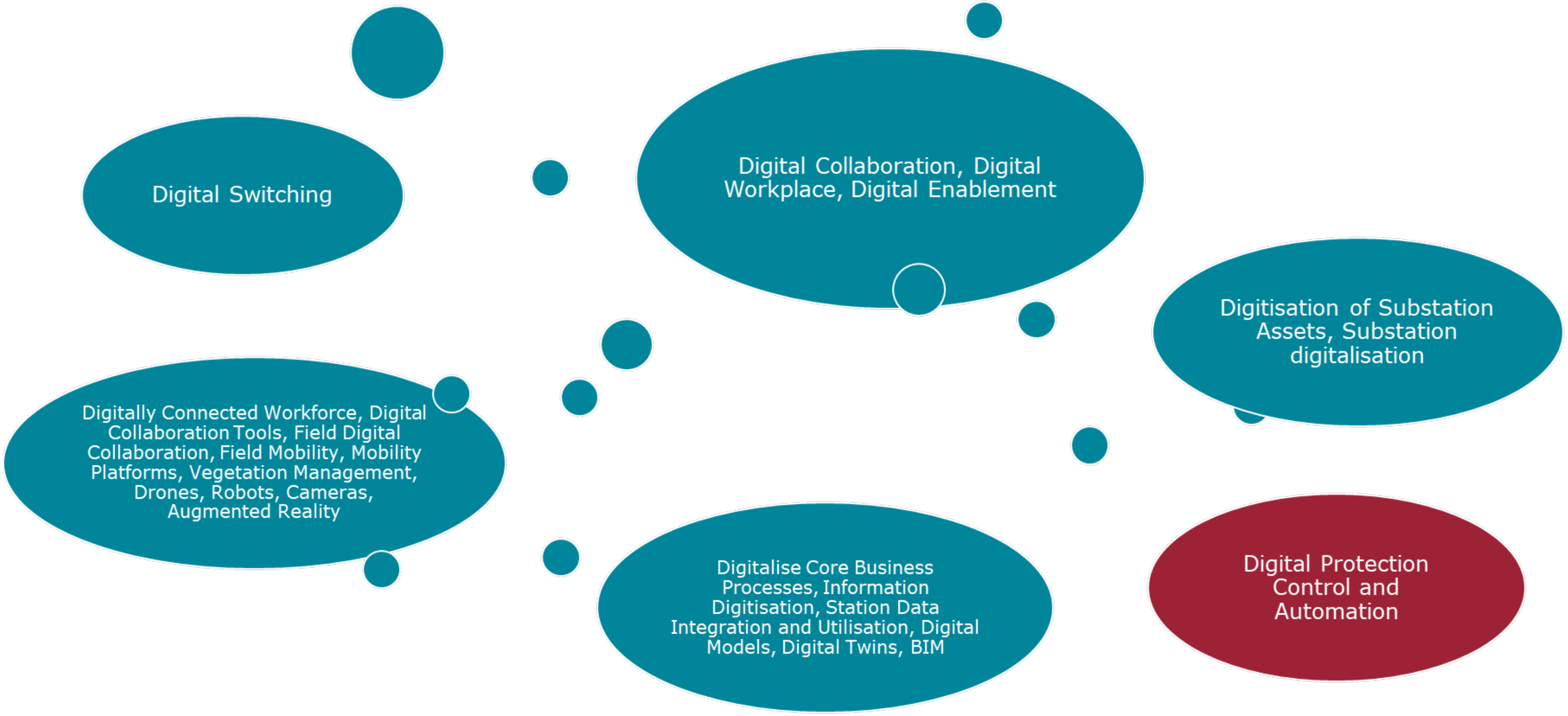


figure 9. An emerging standards-compliant framework for electricity distribution network operators. EXT: external.

V. Vittal, **N. Nair** and F. Rahmatian, "Smart City Energy Technology in the Face of Emergency Situations: Electric Supply, Electric Transportation, and Communication," in *IEEE Power and Energy Magazine*, vol. 20, no. 5, pp. 16-25, Sept.-Oct. 2022, doi: 10.1109/MPE.2022.3184058.

- A digital substation is a small part of **Substation Digitalisation**
- Focus on Digital PAC



Digital Switching

Digital Collaboration, Digital Workplace, Digital Enablement

Digitisation of Substation Assets, Substation digitalisation

Digitally Connected Workforce, Digital Collaboration Tools, Field Digital Collaboration, Field Mobility, Mobility Platforms, Vegetation Management, Drones, Robots, Cameras, Augmented Reality

Digitalise Core Business Processes, Information Digitisation, Station Data Integration and Utilisation, Digital Models, Digital Twins, BIM

Digital Protection Control and Automation

Emergent Digital Substations: Principles, Applications and Standards

- With the emergence of **highly distributed**, **decentralized** and **digitalized nature of networks**, particularly distribution systems, there is a need to establish **first-order principles** that will help guide developing **guides and standards** to help implement various applications and services that are being conceived globally.

- Recently, this presenter has co-edited a Book "*IEC 61850 Principles and Applications to Electric Power Systems*" that was released during cigre PARIS 2022

- This presentation will identify those principles and then extend it to propose for **Digital Substations** and ideas of what emergent applications are likely to be supported during this transitions and **potential risks and challenges**.

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B5

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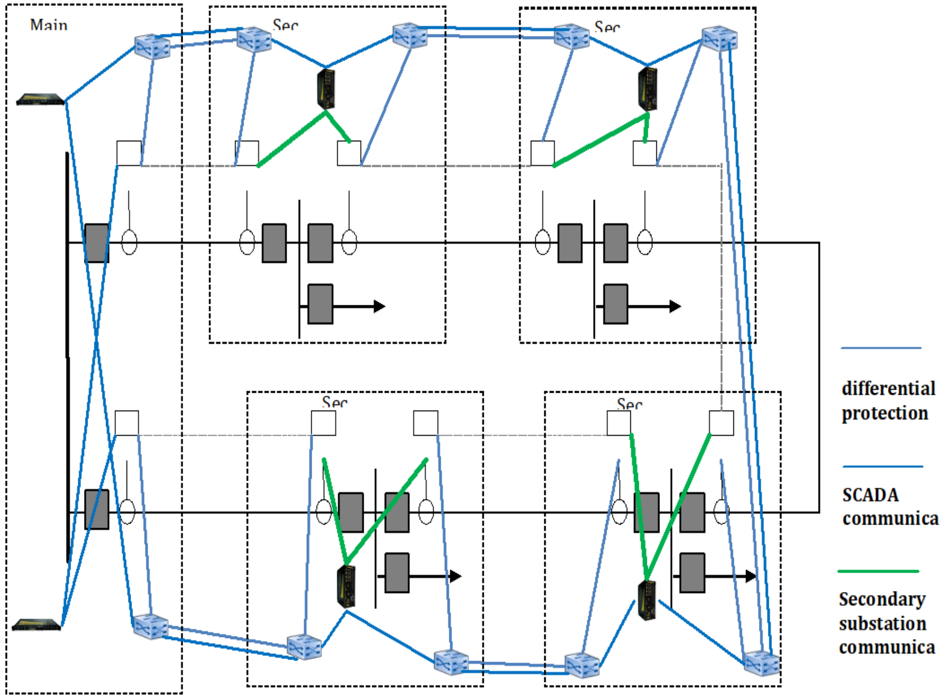
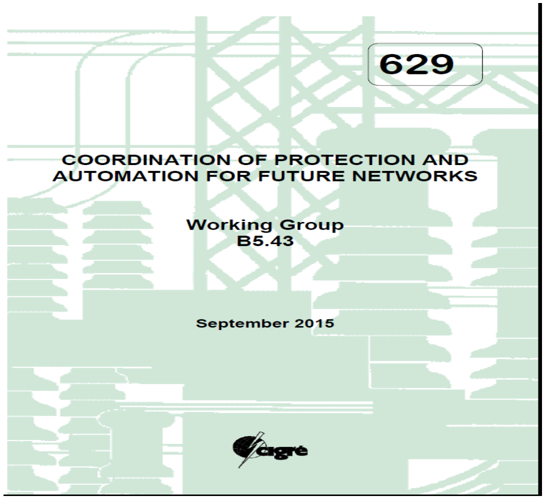
NEW ZEALAND

More T&D substations to be built

- With the emergence of **highly distributed**, **decentralized** and **digitalized nature of networks**, particularly distribution systems, there is a need to establish **first-order principles** that will help guide developing **guides and standards** to help implement various applications and services that are being conceived globally.
- More substations would be built and increasingly in the Distribution network
- Highly decentralized and distributed renewable generation like Solar farms, roof-top solar will be integrated to the MV and LV network
- Distribution network will likely require to be more meshed like transmission
- **CIGRE TB 629** and **CIGRE TB 810** are good sources to understand the emerging T&D networks and its PAC needs

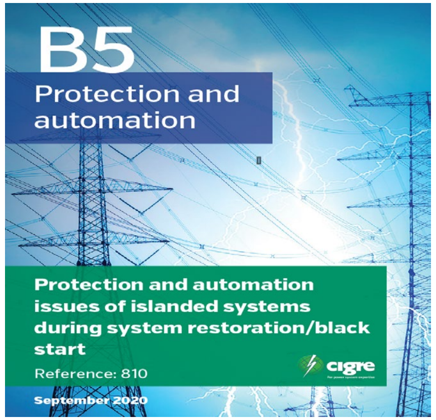



629

COORDINATION OF PROTECTION AND AUTOMATION FOR FUTURE NETWORKS

Working Group B5.43

September 2015


B5

Protection and automation

Protection and automation issues of islanded systems during system restoration/black start

Reference: 810

September 2020

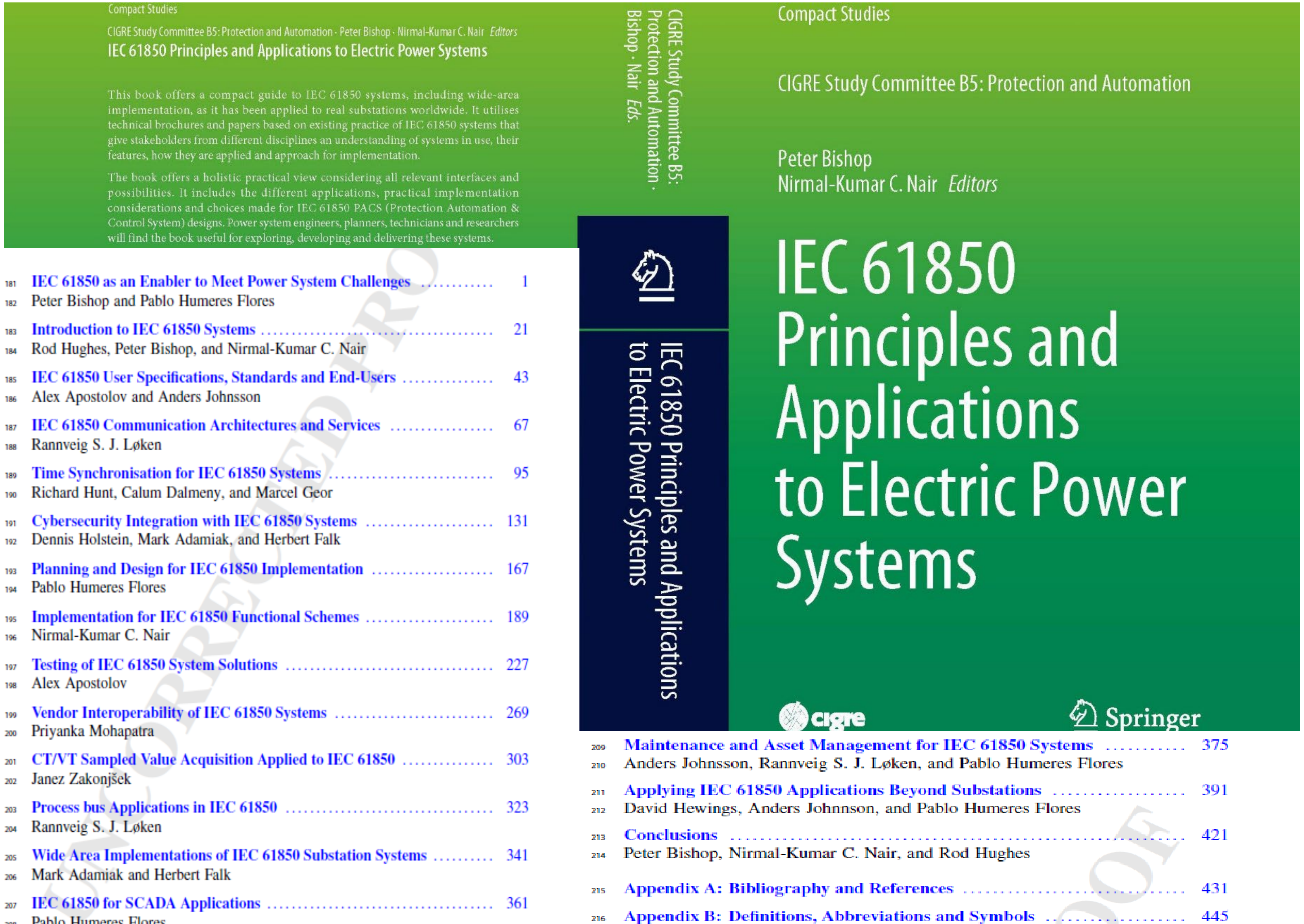
After Two Decade of IEC 61850

- Recently published CIGRE B5 Green Book

- It reflects on the confidence and maturity level of various trials and tribulations which this PACS technology undertook successfully over the last 2 decades.

- Maturity level of this in other **non-traditional substation** spaces like traction, hydro plant control, wind-farm management etc. are well established now

- It is definitely-time within the next 5 years to roll-out "digital" substation deployments leveraging the data and functional intelligence gathered through this PACS experience.



Compact Studies

CIGRE Study Committee B5: Protection and Automation · Peter Bishop · Nirmal-Kumar C. Nair *Editors*

IEC 61850 Principles and Applications to Electric Power Systems

This book offers a compact guide to IEC 61850 systems, including wide-area implementation, as it has been applied to real substations worldwide. It utilises technical brochures and papers based on existing practice of IEC 61850 systems that give stakeholders from different disciplines an understanding of systems in use, their features, how they are applied and approach for implementation.

The book offers a holistic practical view considering all relevant interfaces and possibilities. It includes the different applications, practical implementation considerations and choices made for IEC 61850 PACS (Protection Automation & Control System) designs. Power system engineers, planners, technicians and researchers will find the book useful for exploring, developing and delivering these systems.

CIGRE Study Committee B5: Protection and Automation · Bishop · Nair *Eds.*

IEC 61850 Principles and Applications to Electric Power Systems

Compact Studies

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Peter Bishop
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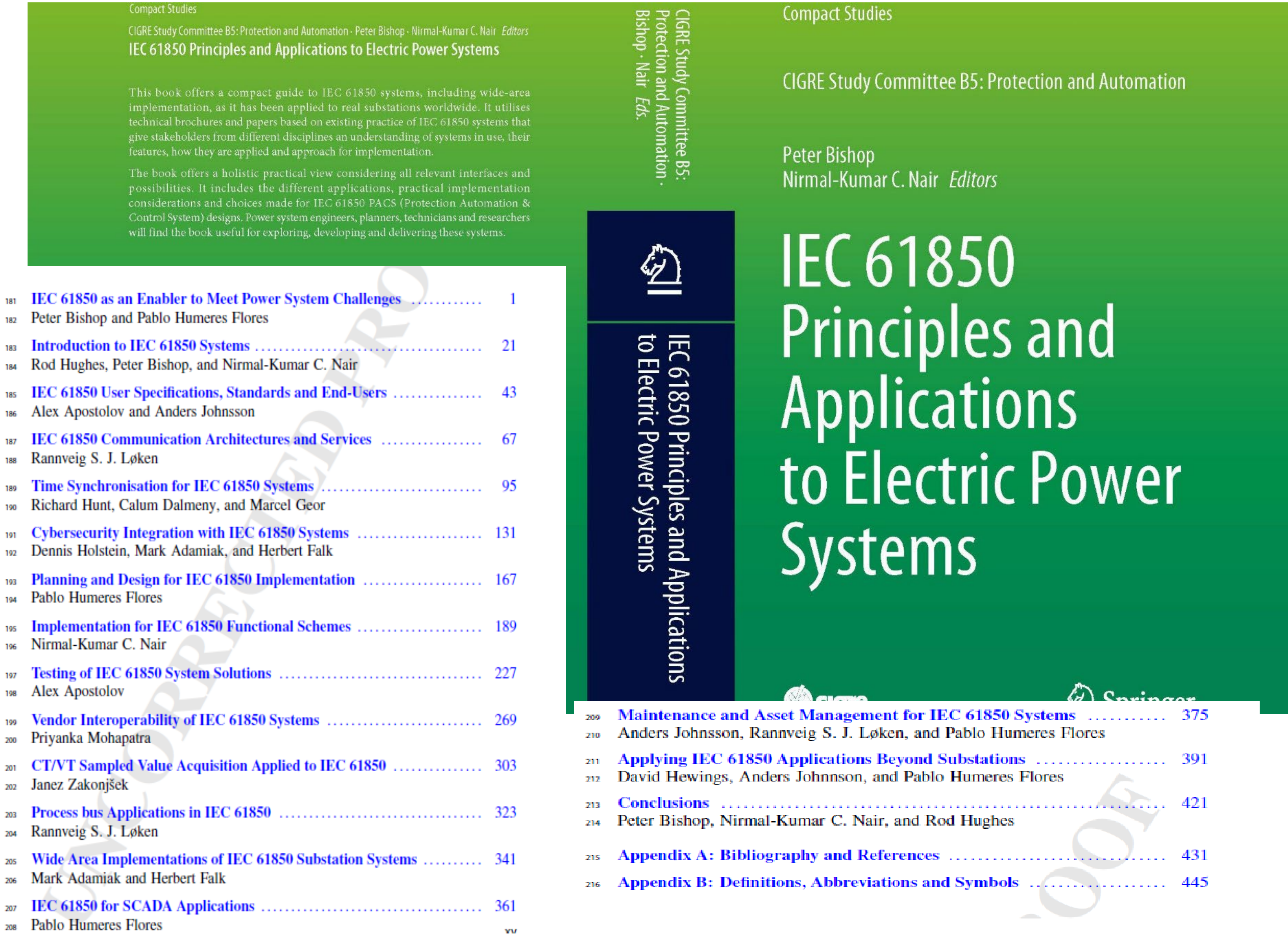
IEC 61850 Principles and Applications to Electric Power Systems

cigre

Springer

IEC 61850 as Digital Substation Enabler

- The Chapter on Applying IEC 61580 beyond substation have details around examples of this technology being adopted and reaching maturity levels in railways traction, hydro generation plants and wind-farm standard PACS design.
- Several emerging applications like HVDC, Electric Vehicle, Batteries etc. still in R&D but reaching maturity through standardization has also been identified.



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IEC 61850 Principles and Applications to Electric Power Systems

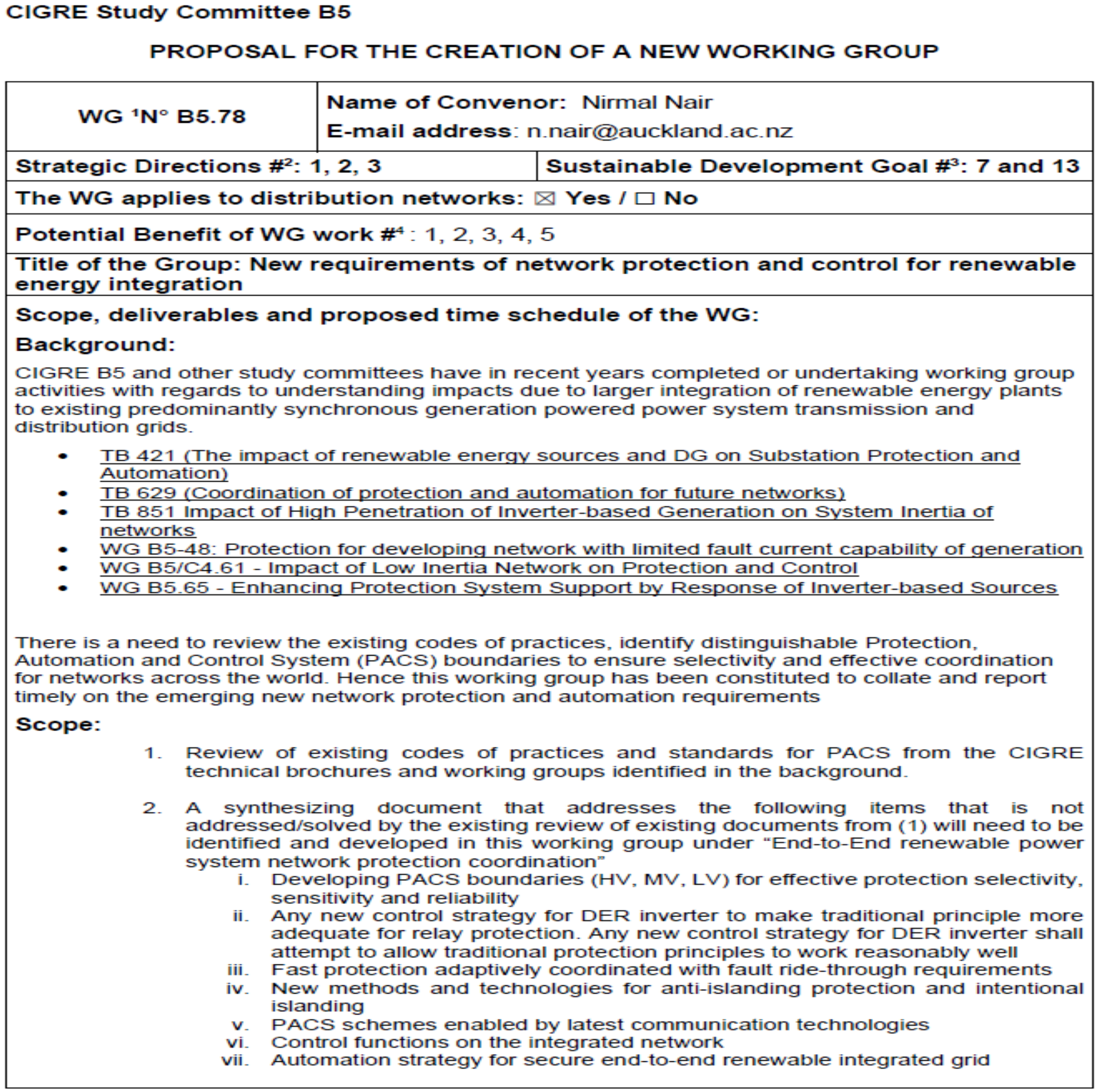
Identifying New PACS Requirements for Multi-energy resource integration

- Out of 10’s of Trillion of energy infrastructure investment annually 10% is typically associated with Renewable energy

- World is undergoing “deeper-electrification” across its economy.

- Electricity (‘Electron’) as the dominant energy vector for next 3 decades has now been baked into every nations’ policy. (end-to-end renewable energy grid)

- We need to identify how to help accelerate this from where PACs is currently, through to the transition phase (accelerating) and the end-state of 100% renewable system.



CIGRE Study Committee B5

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG [1]N° B5.78	**Name of Convenor:** Nirmal Nair **E-mail address**: n.nair@auckland.ac.nz
Strategic Directions #[2]: 1, 2, 3	**Sustainable Development Goal #[3]: 7 and 13**

The WG applies to distribution networks: ☒ Yes / ☐ No

Potential Benefit of WG work #[4] : 1, 2, 3, 4, 5

Title of the Group: New requirements of network protection and control for renewable energy integration

Scope, deliverables and proposed time schedule of the WG:

Background:

CIGRE B5 and other study committees have in recent years completed or undertaking working group activities with regards to understanding impacts due to larger integration of renewable energy plants to existing predominantly synchronous generation powered power system transmission and distribution grids.

- TB 421 (The impact of renewable energy sources and DG on Substation Protection and Automation)
- TB 629 (Coordination of protection and automation for future networks)
- TB 851 Impact of High Penetration of Inverter-based Generation on System Inertia of networks
- WG B5-48: Protection for developing network with limited fault current capability of generation
- WG B5/C4.61 - Impact of Low Inertia Network on Protection and Control
- WG B5.65 - Enhancing Protection System Support by Response of Inverter-based Sources

There is a need to review the existing codes of practices, identify distinguishable Protection, Automation and Control System (PACS) boundaries to ensure selectivity and effective coordination for networks across the world. Hence this working group has been constituted to collate and report timely on the emerging new network protection and automation requirements

Scope:

1. Review of existing codes of practices and standards for PACS from the CIGRE technical brochures and working groups identified in the background.

2. A synthesizing document that addresses the following items that is not addressed/solved by the existing review of existing documents from (1) will need to be identified and developed in this working group under “End-to-End renewable power system network protection coordination”
   - i. Developing PACS boundaries (HV, MV, LV) for effective protection selectivity, sensitivity and reliability
   - ii. Any new control strategy for DER inverter to make traditional principle more adequate for relay protection. Any new control strategy for DER inverter shall attempt to allow traditional protection principles to work reasonably well
   - iii. Fast protection adaptively coordinated with fault ride-through requirements
   - iv. New methods and technologies for anti-islanding protection and intentional islanding
   - v. PACS schemes enabled by latest communication technologies
   - vi. Control functions on the integrated network
   - vii. Automation strategy for secure end-to-end renewable integrated grid

Summary

Gearing towards 100% renewables + Increase in natural disasters = Increased Investment in ‘Digital’ Substations

- Newer Substation projects will have larger digitalization enabled through wider digita network within and outside of the substation.

- Protective relaying philosophies (**sensitivity, selectivity, wide-area**): New IEDs

- Cyber-physical technologies needs integrated into **Protection & Automation** accommodating **privacy** and **wide-area** disruption mechanisms threats

AWARDS FINALIST: solarZero – power system stability

15 Aug 2023

SolarZero achieved a world first in late 2022 when it provided frequency response from 3200 household battery systems.

Each micro-computer in the firm's household solar and battery system observes frequency and instructs the battery to respond to any dip in frequency within milliseconds. Using machine learning, solarZero estimates the amount of reserve available from each battery for each half-hour trading period and combines those to provide an overall reserve offer to grid operator Transpower.

The company says it worked closely with Transpower to set up the initiative. Transpower created two new virtual power stations – one in the North Island and one in the South Island – representing the aggregation of solarZero's battery systems across the two islands.

World first

Using distributed residential battery systems to provide frequency response was a world first. Both the computer hardware and software were developed in Hamilton. Testing of the system was carried out on the grid simulator at Auckland University.

In parallel to the testing on the grid simulator, beta versions of the software were installed on a small subset of about 200 household systems around the country. Data from these systems provided information on real-world frequency variations.

The project involved multiple agencies and companies, with Transpower, the Electricity Authority, Auckland University, NZX, Panasonic New Zealand, and Torutek all playing significant roles

2023 IEEE PES Innovative Smart Grid Technologies - Asia (ISGT ASIA)

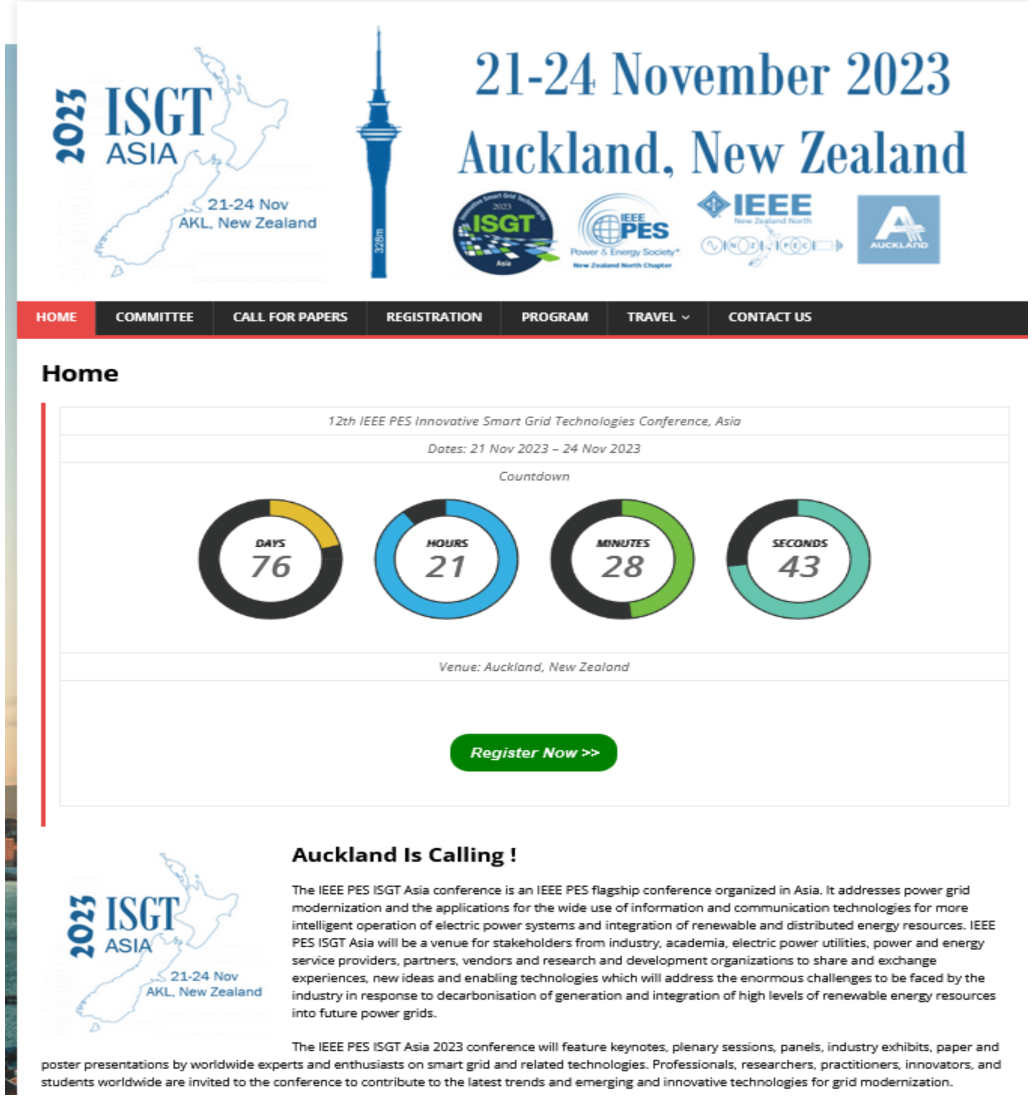
Date: Monday, November 20 – Friday, November 24 2023

Location: Auckland, New Zealand

Website: https://ieee-isgt-asia.org/

Contact: Nirmal Nair

Email: n.nair@auckland.ac.nz



12th IEEE PES Innovative Smart Grid Technologies Conference, Asia

Dates: 21 Nov 2023 – 24 Nov 2023

Countdown

Venue: Auckland, New Zealand

Auckland Is Calling !

The IEEE PES ISGT Asia conference is an IEEE PES flagship conference organized in Asia. It addresses power grid modernization and the applications for the wide use of information and communication technologies for more intelligent operation of electric power systems and integration of renewable and distributed energy resources. IEEE PES ISGT Asia will be a venue for stakeholders from industry, academia, electric power utilities, power and energy service providers, partners, vendors and research and development organizations to share and exchange experiences, new ideas and enabling technologies which will address the enormous challenges to be faced by the industry in response to decarbonisation of generation and integration of high levels of renewable energy resources into future power grids.

The IEEE PES ISGT Asia 2023 conference will feature keynotes, plenary sessions, panels, industry exhibits, paper and poster presentations by worldwide experts and enthusiasts on smart grid and related technologies. Professionals, researchers, practitioners, innovators, and students worldwide are invited to the conference to contribute to the latest trends and emerging and innovative technologies for grid modernization.


Thank You
Raibh Maith Agat
Chokrane
Juspaxar
Dankon
Maake
ASANTE
GRAZIE
Kiitos
DANK JE
Mamana
Ua Tsaug Rau Koj
Obrigado
DANK JE
Mochchakkeram
Raibh Maith Agat
Obrigado
Terma Kasih
Chokrane
Grazie
Asante
Obrigado
MATONDO
Welalin
Raibh Maith Agat
Dankon
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SPASIBO
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