GLOBAL PST CONSORTIUM

The 9th International Conference, Integration of Renewable & Distributed Energy Resources

(IRED2022)

Frequency control of the National Electricity Market: Challenges and Opportunities

Theme: The Global Power System Transformation Consortium (G-PST)

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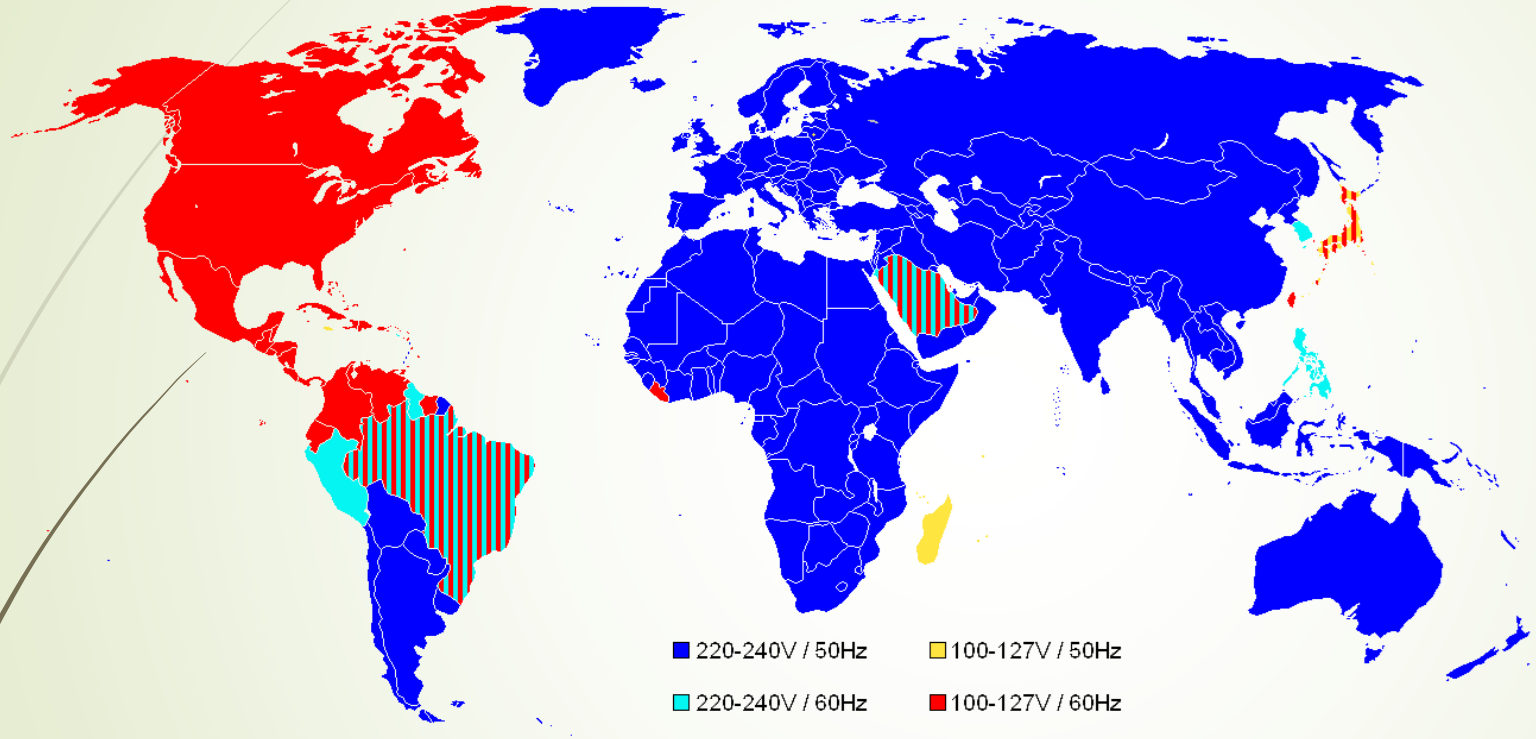
Introduction

Problem Statement

Challenges and Issues

Opportunities and Suggestion

The Big Picture of PS Frequency

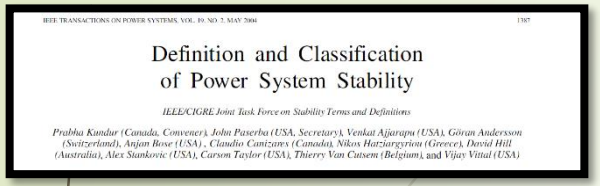


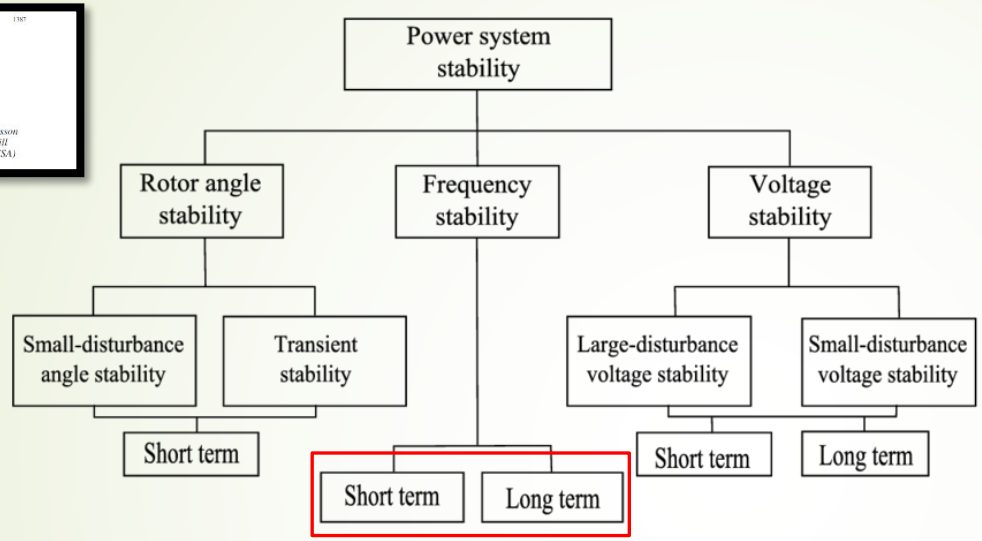
- The world's first AC power system in England, 1881
- The world's first DC power system in NY(USA), 1882
- The war of currents, 1888
- 1888-Second World's War: 16.66Hz and 133.33Hz
- Afterwards: 50Hz or/and 60Hz
- Future: Hz??

Definition: **An electric power system is a network of electrical components used to supply, transmit and use electric power.**

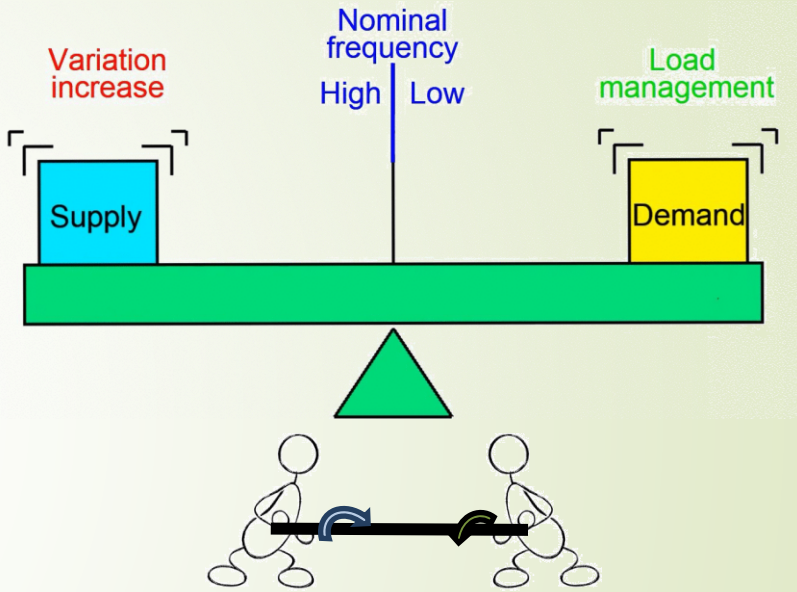
Source: Internet website, Copyright guaranteed, https://commons.wikimedia.org/

General Picture of Frequency Stability





"***Frequency stability*** ***refers to the ability*** **of a power system to maintain steady frequency following a severe system upset resulting in a significant imbalance between generation and load."**



$$M\frac{\mathrm{d}\Delta\omega}{\mathrm{d}t} = P_\mathrm{m} - P_\mathrm{e} - P_\mathrm{D} = P_\mathrm{acc}$$

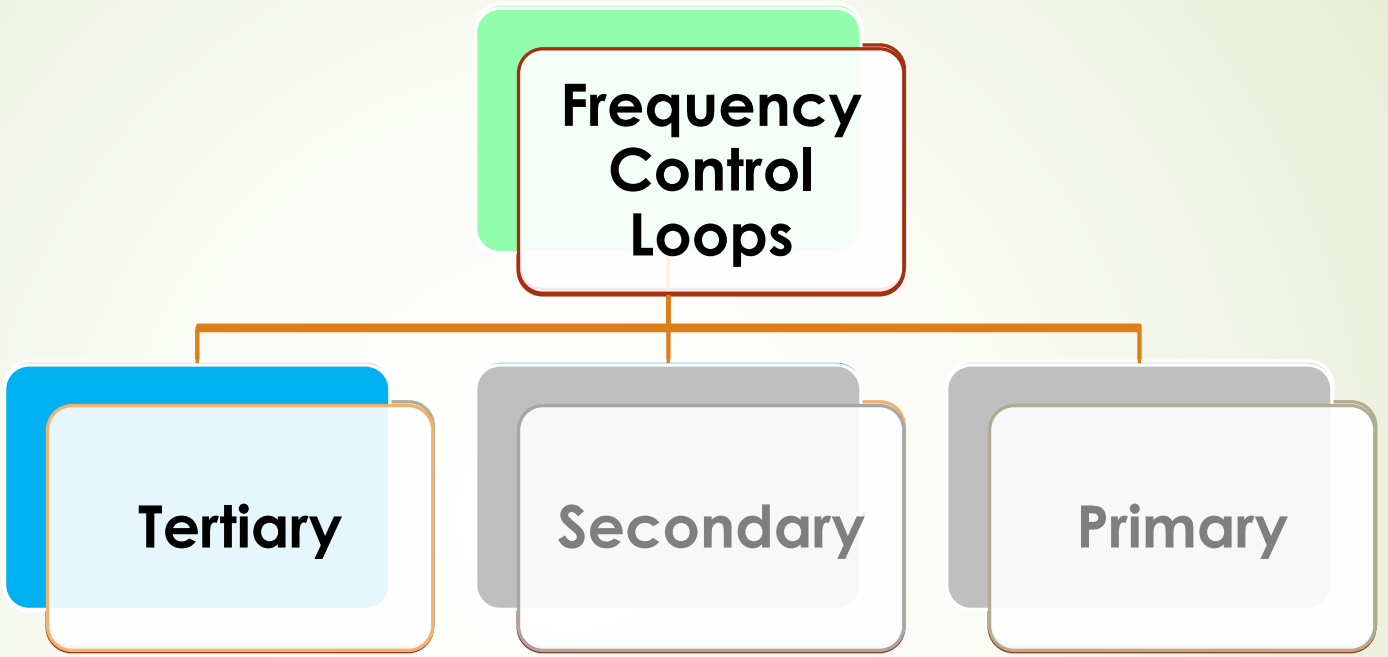
$$M = \frac{2HS_\mathrm{n}}{\omega_\mathrm{s}} = \frac{T_\mathrm{m}S_\mathrm{n}}{\omega_\mathrm{s}}, \quad P_\mathrm{D} = D\frac{\mathrm{d}\delta}{\mathrm{d}t}$$

Inertia (H): The greater the inertia, the less acceleration will be observed and the less will be the frequency deviation. Inertia is proportional to the total rotating mass.

Load Frequency Relief (D): The greater the load damping, the less contingency FCAS will be required and the less will be the frequency steady-state deviation. Load damping is proportional to the total rotating mass in demand-side.

Source: IEEE TF on Stability Terms and Dynamics

Frequency Control



Economic dispatching

It can remove deviations

Local controllers

Rescheduling reserve

It can not remove the frequency deviations

It needs communication channels

Time and cost consuming

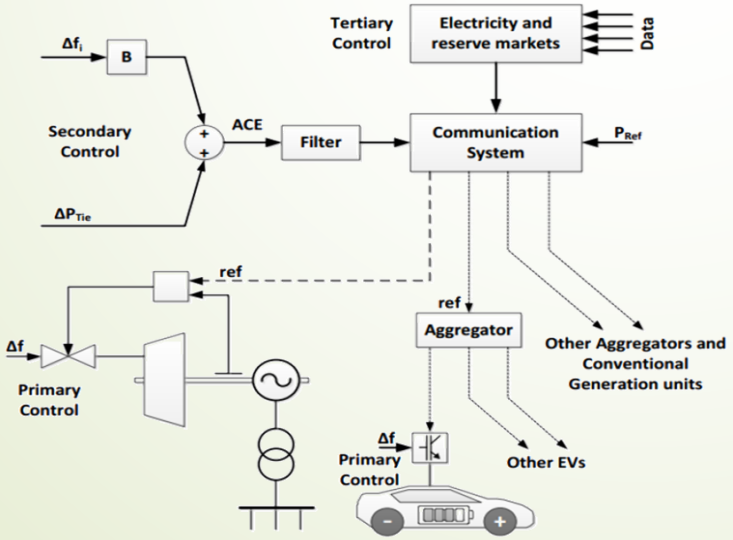
Source: Alhelou's presentations

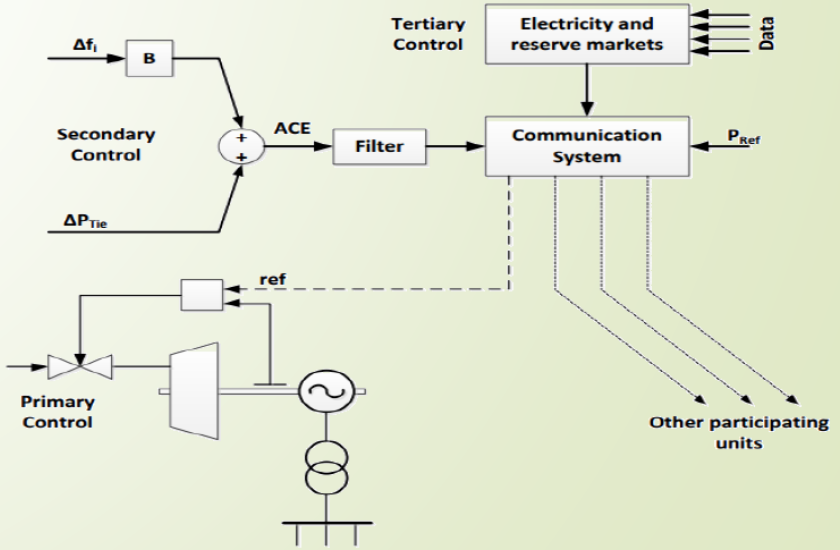
Frequency Control

Frequency control structure

Smarter
New structure

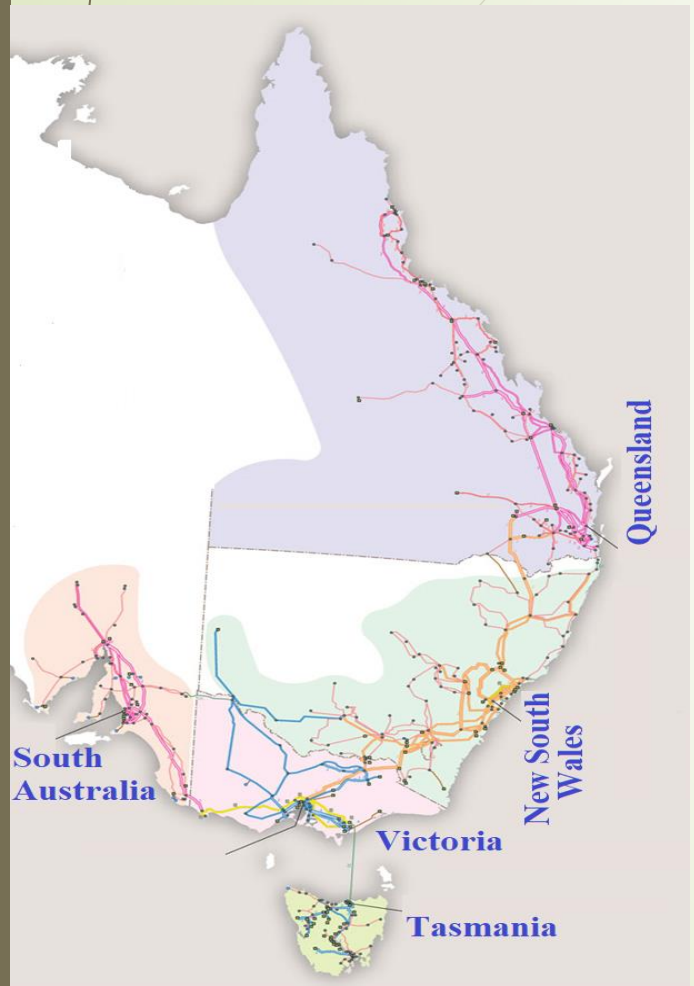
Conventional

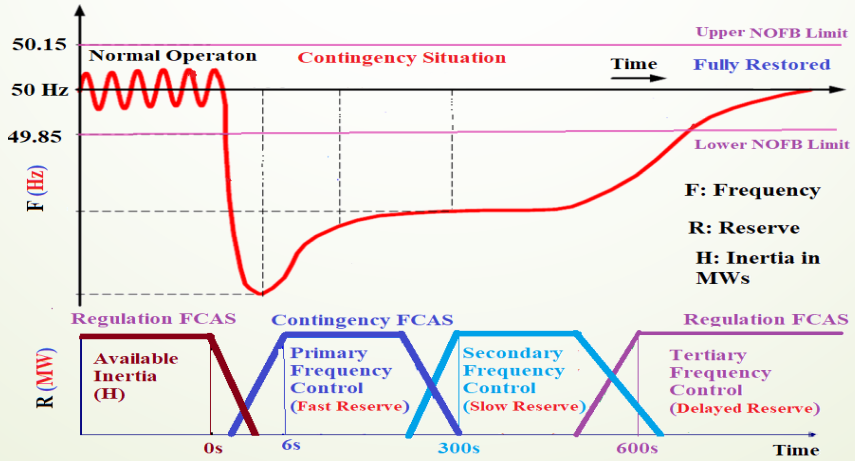




Source: Alhelou's presentation

NEM Frequency Control: Reality vs Assumptions



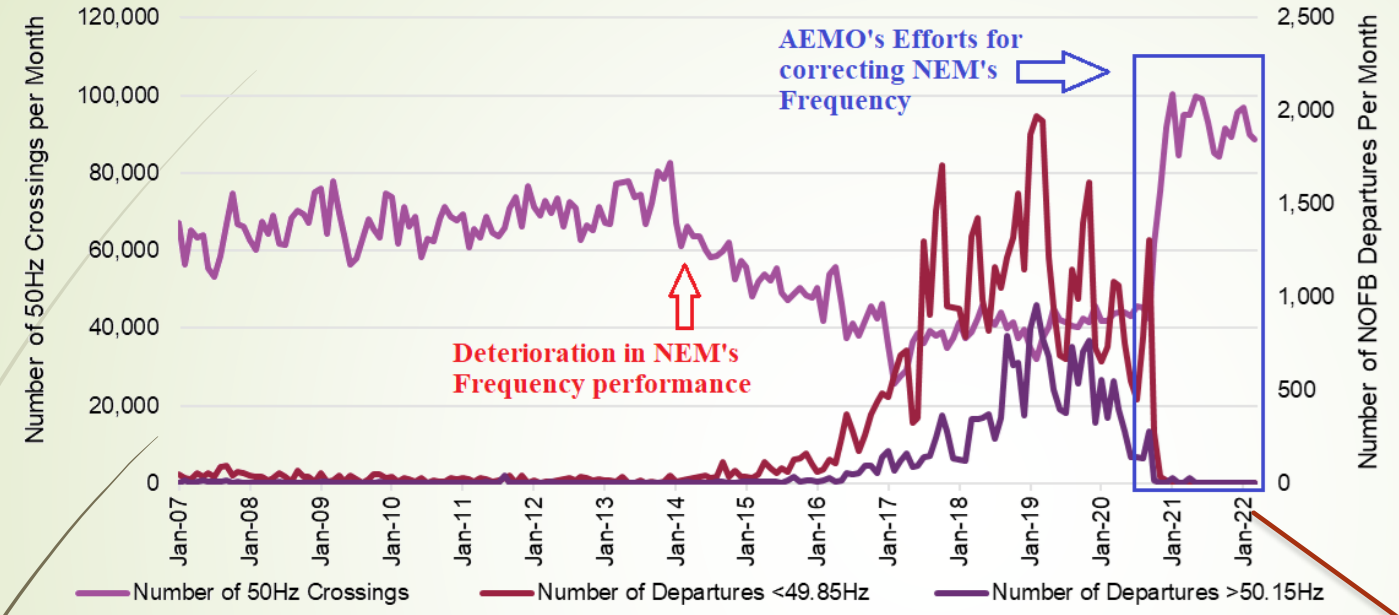


- 5 Power Regions
- Geographical Constraints
- Weak Interconnectivity
- Hybrid HVDC/AC Interconnectivity
- high Uncertainties and Variability
- Fast Dynamics

- One Single Balancing Area
- Market Issue
- Ignoring boundaries
- Low variability
- Slow SCADA System

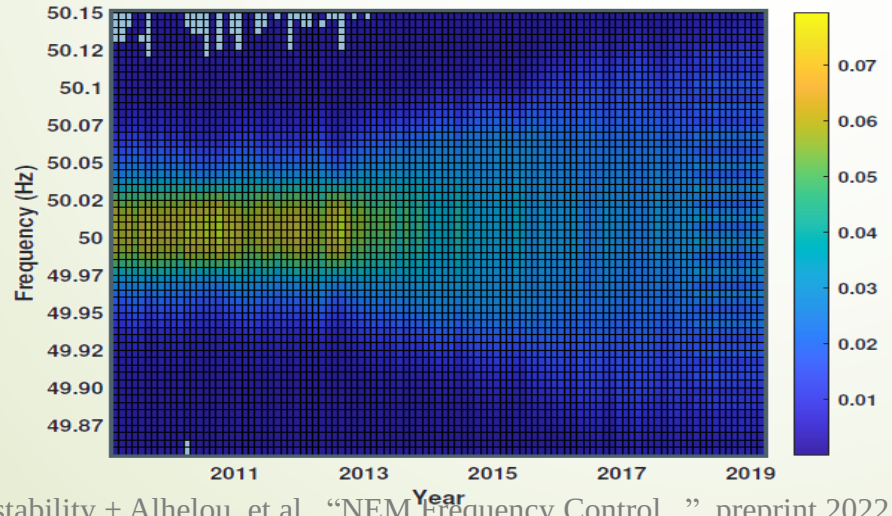
Source: AEMO Website+ Alhelou et al, "NEM Frequency Control: Challenges and Opportunities" Preprint

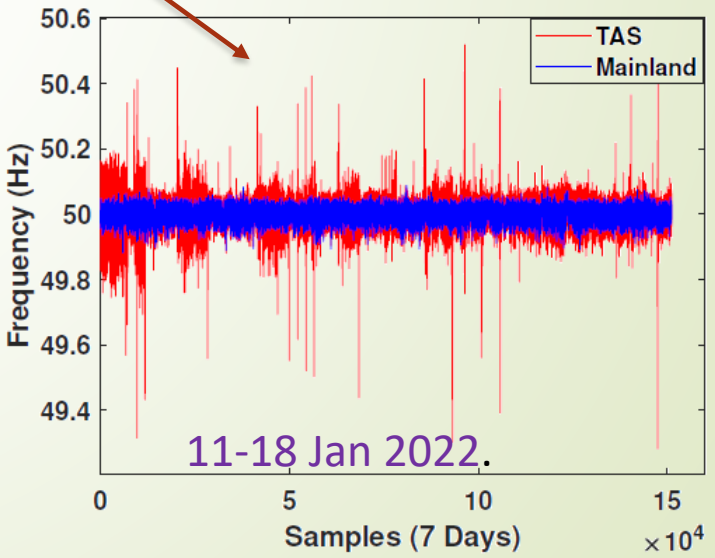
NEM Frequency Control: Performance Metrics/Standards



Metrics or Standard issues?

AEMO's effective efforts



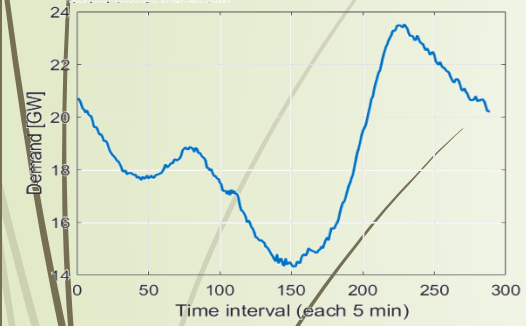


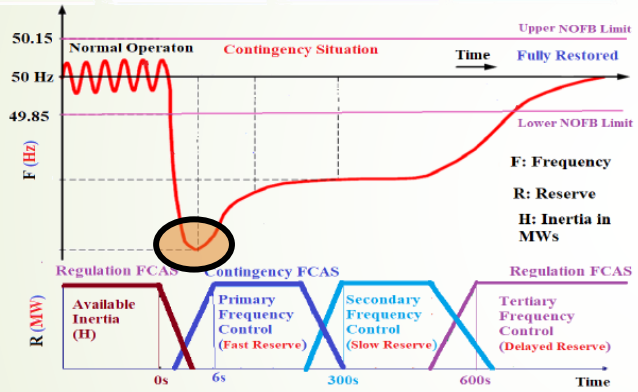
Source: AEMO's report on frequency stability + Alhelou, et al., "NEM Frequency Control ..", preprint 2022

Frequency Security Assessment

Figure 7 Scenario input assumptions

DEMAND	Slow Change		Progressive Change		Step Change		Hydrogen Superpower	
Electrification	2030	2050	2030	2050	2030	2050	2030	2050
- Road transport that is EV (%)	2	36	5	84	12	99	18	94
- Residential EVs still relying on convenience charging (%)	82	58	75	44	70	31	66	22
- Industrial Electrification (TWh)	-24	-21	4	92	27	54	37	64
- Residential Electrification (TWh)	0	0	0.2	15	4	13	2	4
- Energy efficiency savings (TWh)	8	19	14	40	22	55	22	56

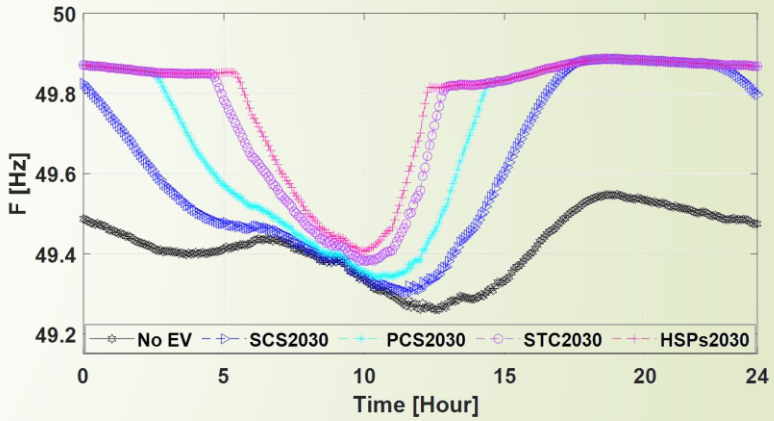




Considering eMobility Contribution

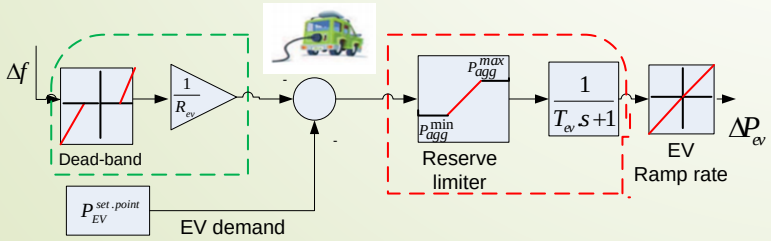
ISP's Scenarios

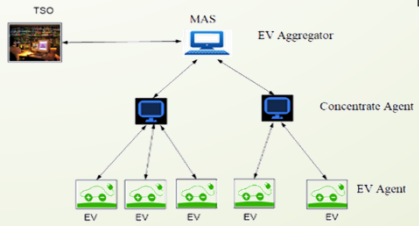
Demand-side opportunities

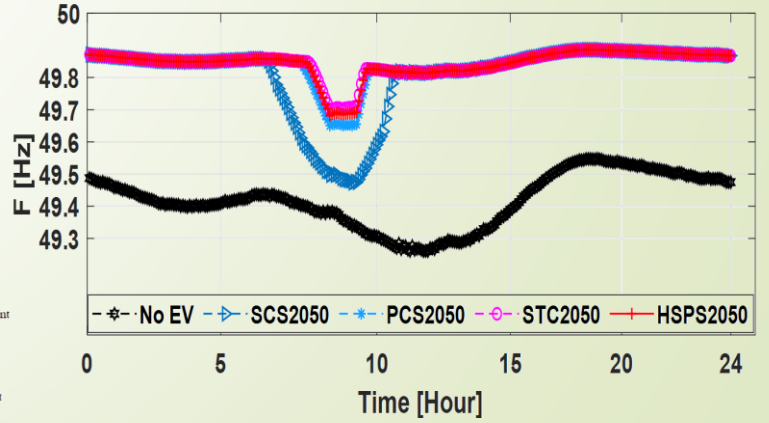


Kogan Creek Power Station

Credible Event=699.32MW





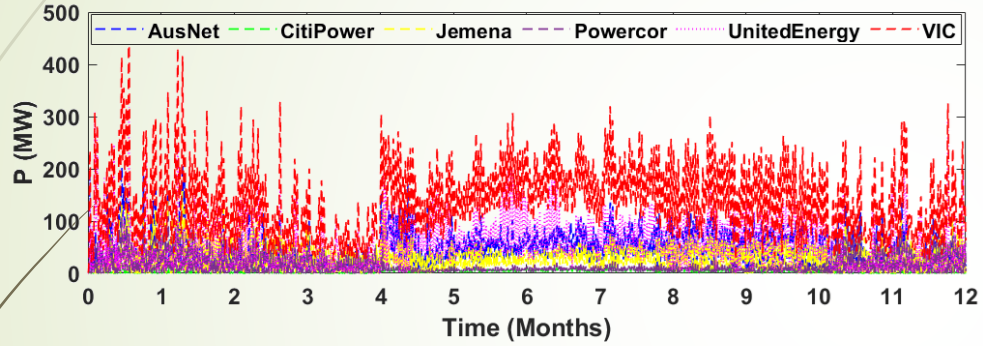


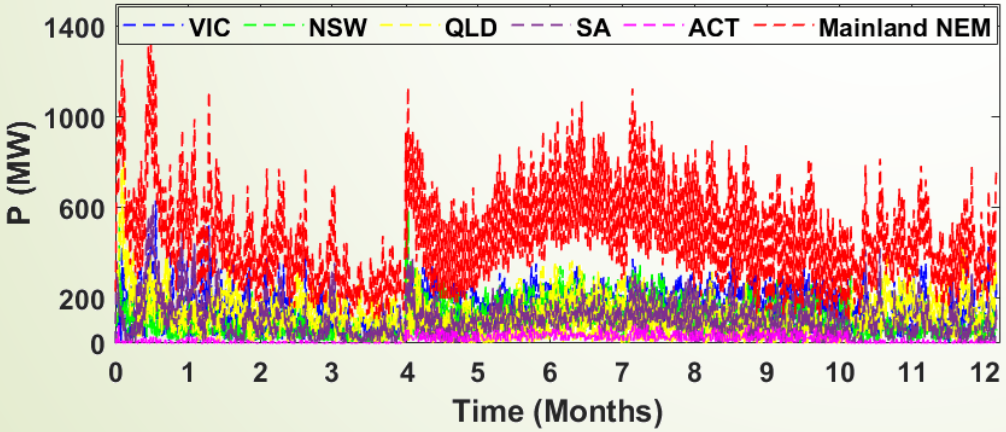
Enhanced Regulation FCAS Control

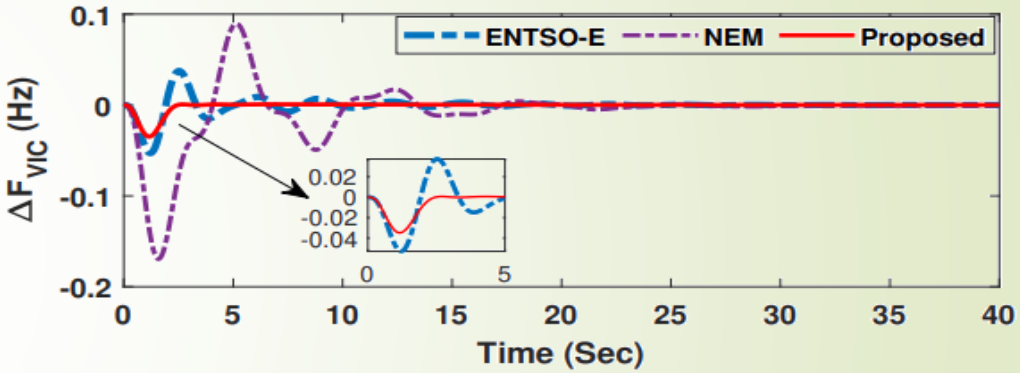
An Affordable Sophisticated Frequency Control for Australian National Electricity Market System Considering Industry and Infrastructure Challenges

Hassan Haes Alhelou, *Senior Member, IEEE*, Behrooz Bahrani, *Senior Member, IEEE*,and Jin Ma, *Senior Member, IEEE*

- **Novel Frequency Control approach**
- **Improving the activation of FCAS**
- **Enhancing Frequency Stability**







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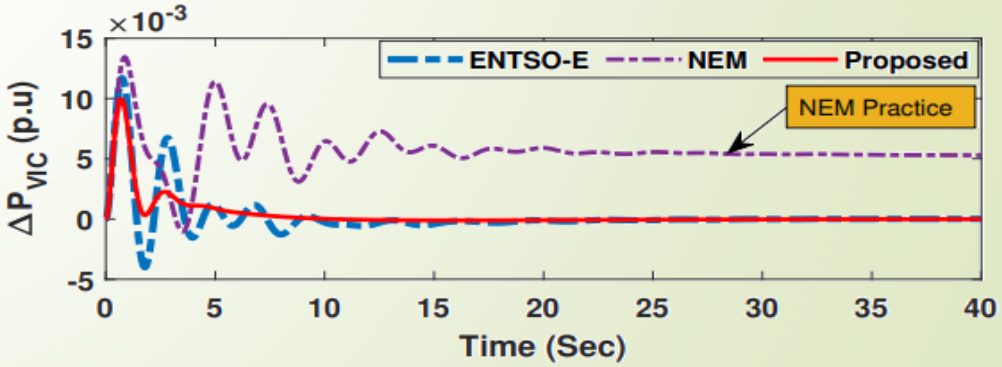

(b)

Source: Alhelou et al, "An Affordable Sophisticated Frequency Control for Australian National Electricity Market System Considering Industry and Infrastructure Challenges" Preprint 2022

Remarks & Recommendations

1. Enhanced and Reliable Services are crucial for Energy Transition
2. Demand-side is a promising source, Yet highly challenging and complex.
3. Understanding the boundaries between market and technical sides
4. Assessing the reliability and affordability of PE-based FCAS sources

The Global Power System Transformation (G-PST)

GLOBAL PST CONSORTIUM

- Identifying Challenges
- Providing unique Solution
- Developing New Approaches

↓

- Enabling Energy Transition
- Securing and Stabilizing Frequency
- Discovering possible alternatives for FCAS sources

↓

- Collaborate with us!!

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Chief Investigator
Monash University

Hassan Haes Alhelou
Chief Investigator
Monash University

Jin Ma
Chief Investigator
The University of Sydney

GLOBAL PST CONSORTIUM

MONASH University

Thank You!!

GHD

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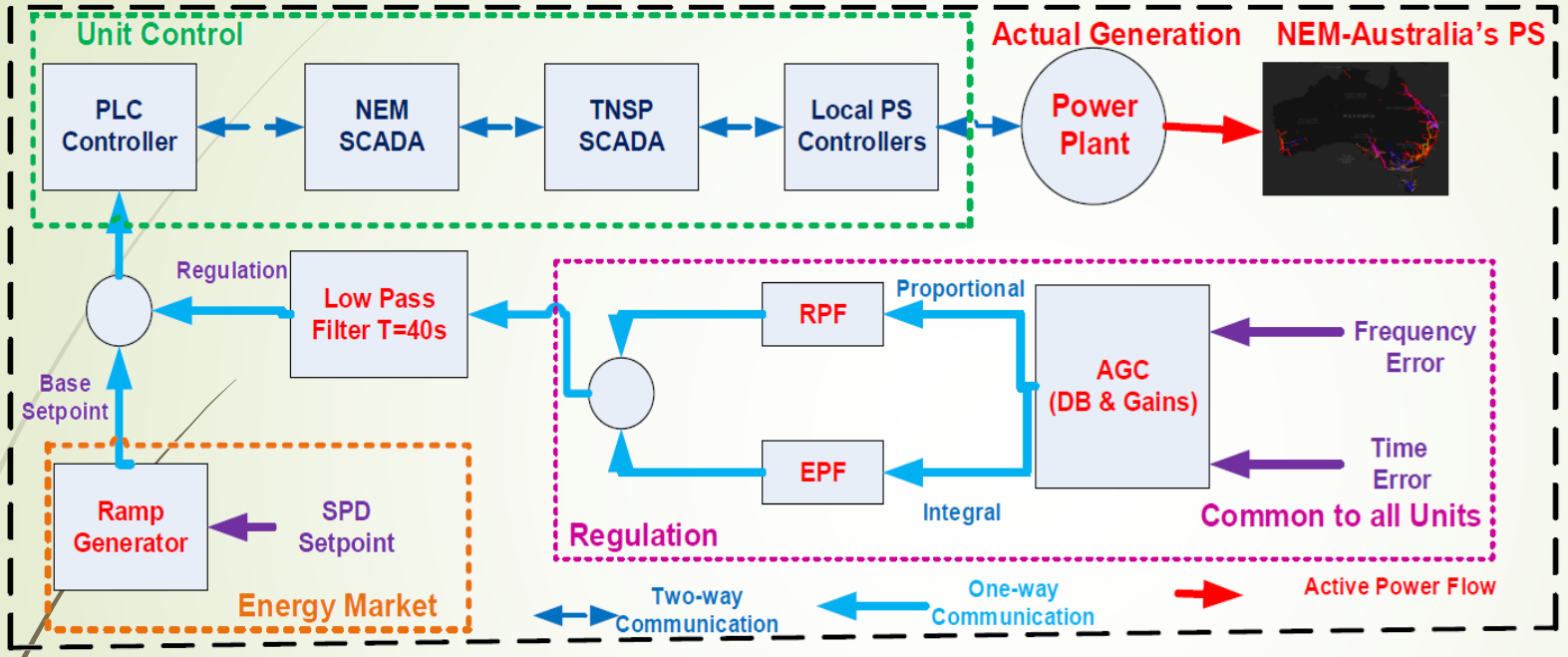
CSIRO

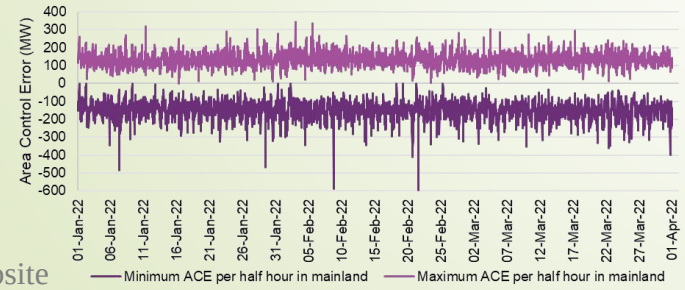
THE UNIVERSITY OF SYDNEY

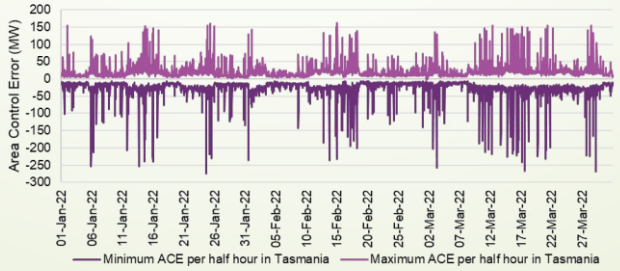
NEM Frequency Control: AGC System

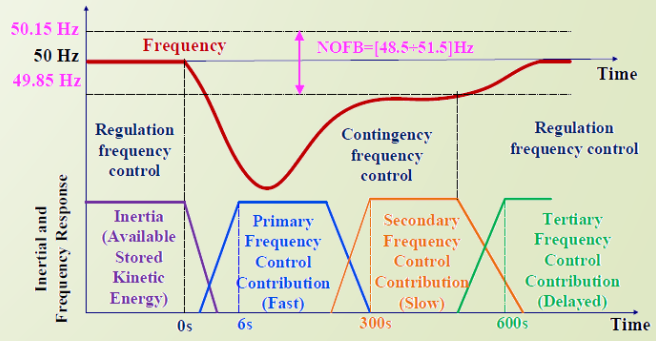


Current Approach

Possible advancements and improvement rooms

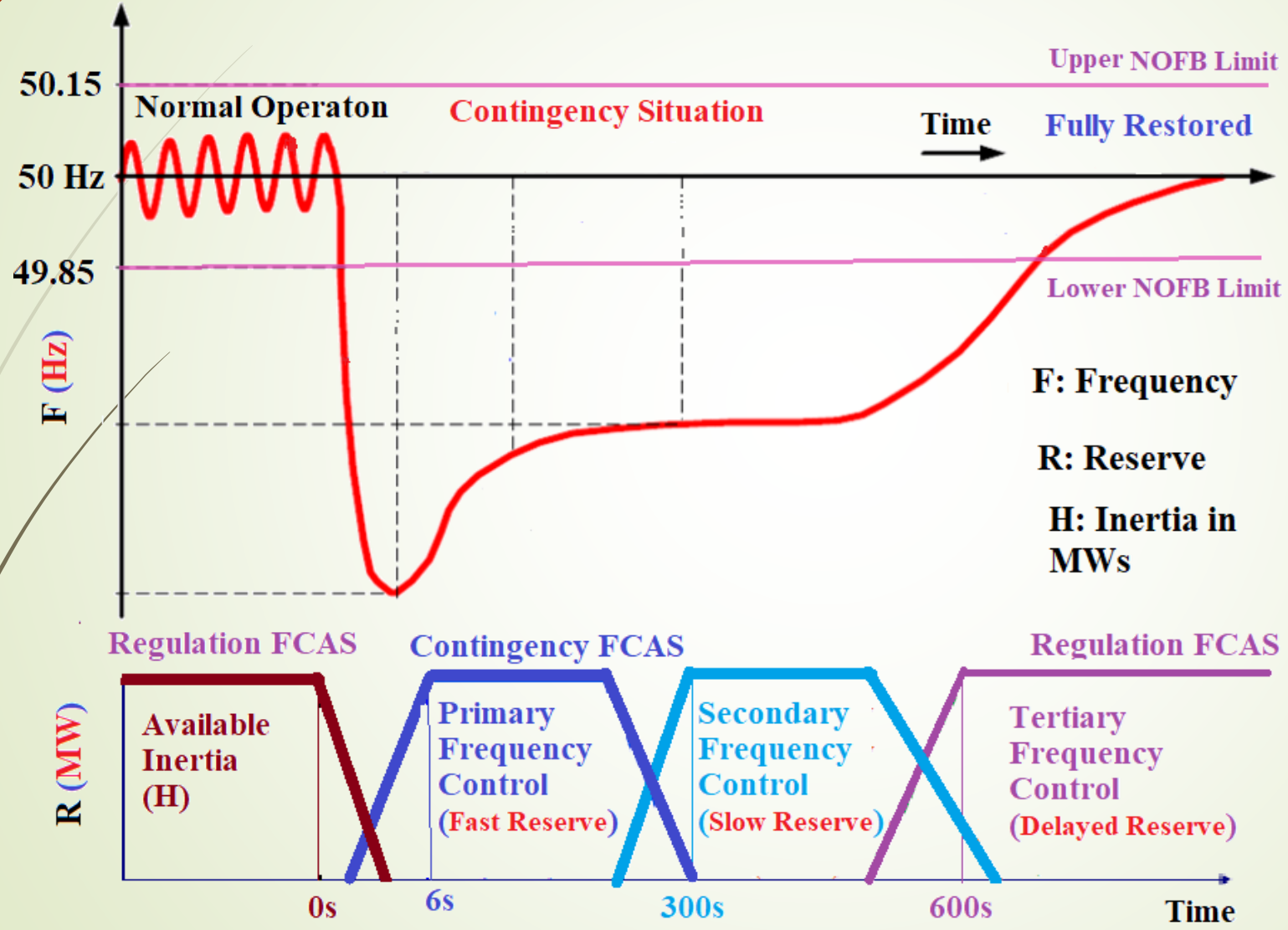


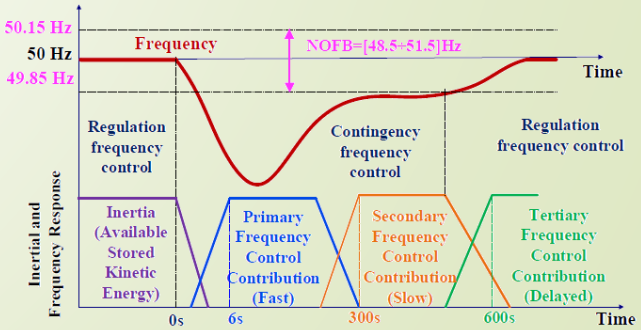




Source: Internet website

NEM Frequency Control: Current Approach





Source: AEMO Website+ Alhelou et al, "NEM Frequency Control: Challenges and Opportunities" Preprint

NEM/International System Frequency Issues

Frequency Regulation Issues: Current AGC System, High Variability and Uncertainties from GS and DS, Regulation FCAS Activation Issues.

Frequency Stability Issues: Fluctuating Inertia, Unknown Load Frequency Relief, Mixed Dynamics,

Frequency Security Issues: Separation events, High single credible event in some regions,

Frequency Market Issues: Allocation of FCAS, rule changes

Frequency Regulation Issues: Involving DER and demand-side, upgrading infrastructure and FCAS activation rules, regionalizing FCAS and services.

Frequency Stability Issues: Introducing inertia spot market for virtual inertia and inertia emulation, compensating shortfall of load frequency relief, seeking new stability rules.

Frequency Security Issues: regionalizing FCAS, adopting security issues-resilient control and preventive approaches.

Frequency Market Issues: More flexibility to operators