Meeting Date: 21 August 2024

AUTOMATIC UNDER-FREQUENCY LOAD SHEDDING (AUFLS) UPDATE ON WORK TO MOVE TO A FOUR-BLOCK SCHEME

SECURITY AND RELIABILITY COUNCIL

The Authority's compliance team will provide SRC members with an update on progress transitioning to a four-block scheme for AUFLS, also known as extended reserves. The compliance teams' presentation is included in Diligent for member pre-reading, together with an additional set of slides, giving further background to AUFLS, and the basis for changes to the regime. The background slides will not be presented at the meeting

Monitoring Automatic Under Frequency Load Shedding (AUFLS) readiness

Update to SRC 21 August 2024

ELECTRICITY AUTHORITY
TE MANA HIKO

Introduction

Authority's Compliance Committee requested SRC be updated

- **presentation is to inform**
- **individual participants are not identified as any Code breaches are confidential under the Enforcement Regulations**
- **the system operator's assessment for the 2021 and 2022 calendar years was that the system was secure at all times**
- **the 2023 assessment is due at the end of October 2024**

note: images sourced from various system operator reports

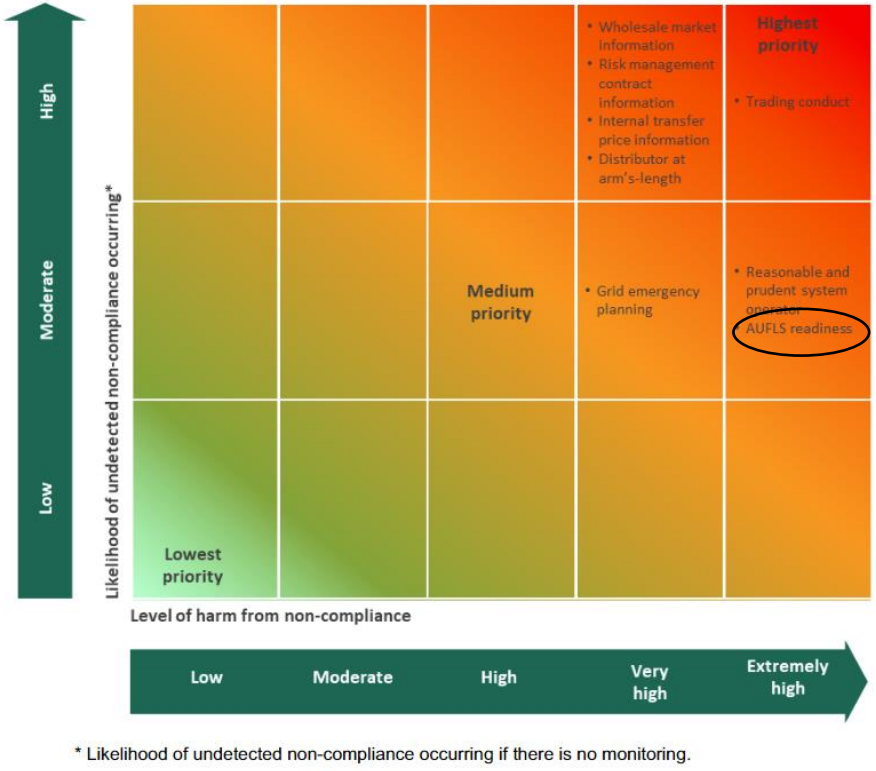
Compliance monitoring framework

- **published December 2022**
- **risked based assessment of the Code**

AUFLS readiness was identified

- extremely high level of harm from non-compliance
- moderate likelihood of undetected non-compliance

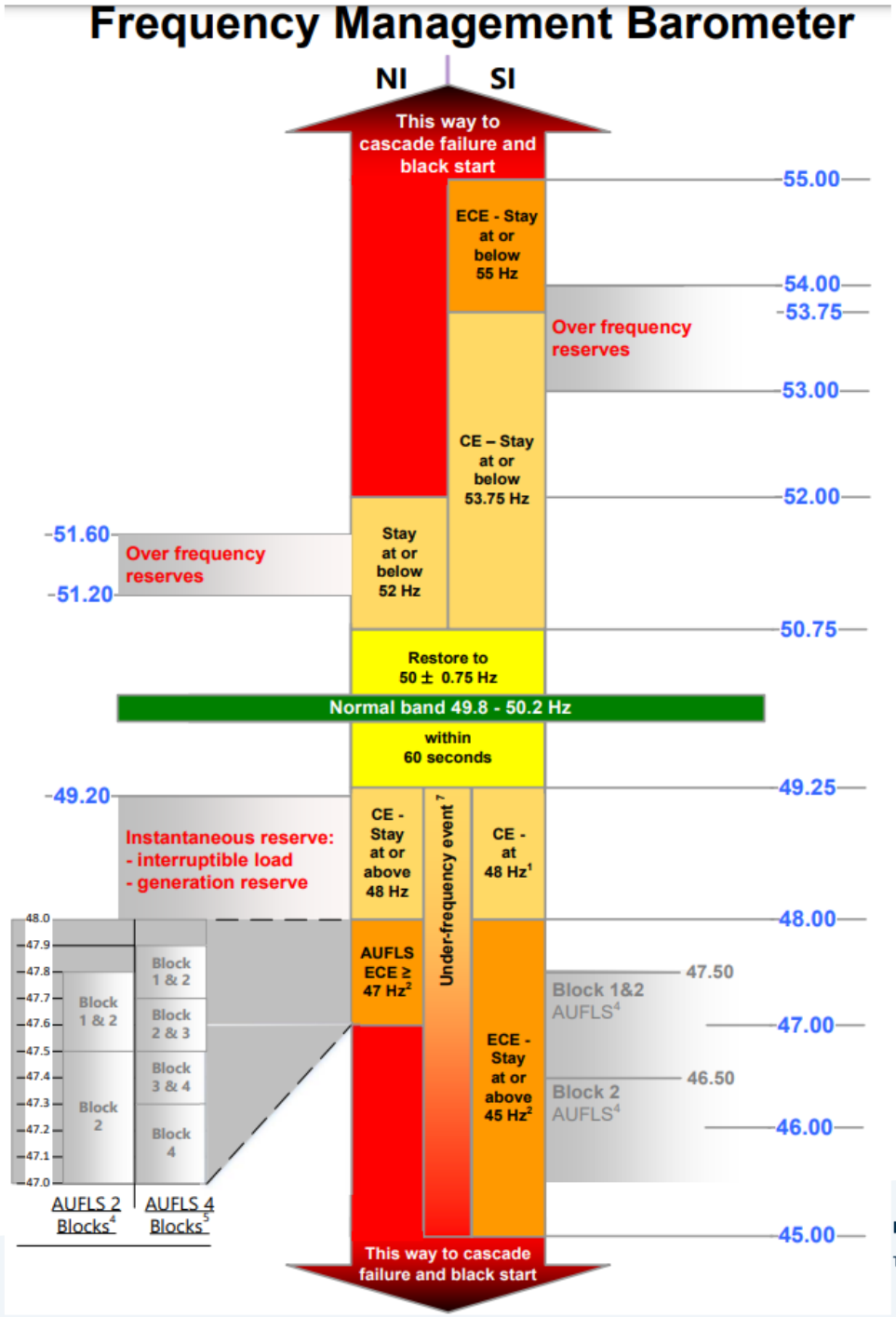
Figure 6 – Initial short list of high-priority areas for compliance monitoring



* Likelihood of undetected non-compliance occurring if there is no monitoring.

AUFLS

- **designed to maintain system frequency above 47Hz for North Island and above 45Hz for the South Island**
- **last line of defence to prevent cascade failure**
- **32% of demand is always armed to automatically disconnect**
- **provided at different trigger frequencies over either**
  - two 16% blocks of demand or
  - four blocks of demand - two blocks of 10% and two blocks of 6% (new scheme)
- **last AUFLS events 2011, 2013, 2017**



Risks covered by AUFLS

system operator assesses credible event risks

North Island – the largest contingency

- HVDC bipole trip up to 1,200MW DC North

South Island – the two largest contingencies

- HVDC bipole trip up to 850MW DC South, or
- Manapouri 220kV bus trip up to 384MW

AUFLS provision

North Island

Connected asset owners

- distributors (15)
- direct connect consumers (7)

~ 500 relays and 2,800 feeders

(98 relays are provided by the grid owner and will not be provided under 4 block scheme)

South Island

The grid owner

supported by

- distributors
- NZAS at Tiwai

~ 300 relays and 300 feeders

Code obligations

North Island connected asset owners

South Island the grid owner

- establish and maintain AUFLS at all times in the block sizes and armed at the required trip settings
- periodically test, confirm settings and provide results to the system operator
- provide ½ hourly profile information to the system operator
- may apply to the system operator for an equivalence arrangement
- provide post event high resolution recording
- North Island to transition to 4 blocks by 30 June 2025

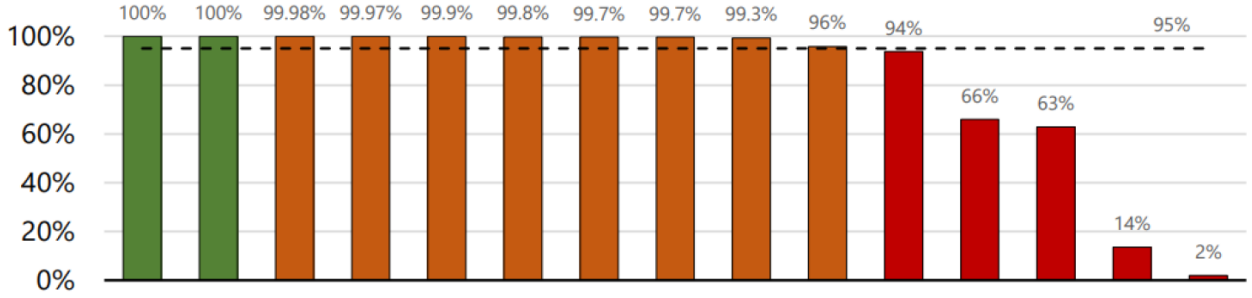
system operator

- maintain frequency within specified bounds
- schedule instantaneous reserves
- may grant equivalence arrangements
- may rely on the information provided
- provide a report to the Authority with its assessment as to whether the system was secure in the previous calendar year

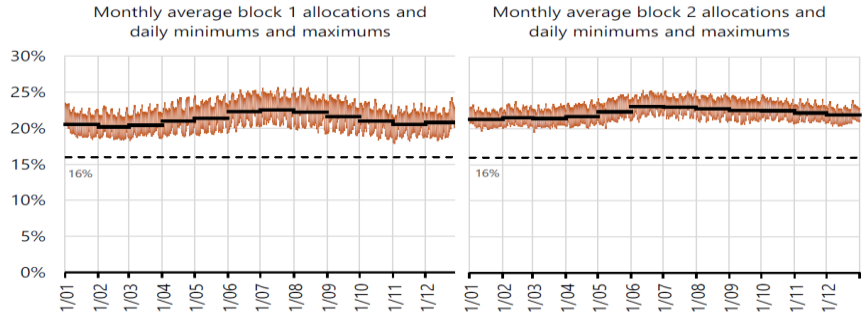
System operator's AUFLS 2022 annual assessment

- ½ hour profile information from connected asset owners and the grid owner
- assess individual provider compliance
- assess aggregate island AUFLS provision
- undertake security assessments
- undertake over-provision assessments
- report to the Authority
- North Island direct connect consumers excluded for 2022

North Island 2022 individual distributor compliance % of time compliant



North Island 2022 aggregate performance



Note: the reported block 1 and 2 sizes are calculated based on the aggregate demand of North Island AUFLS providers only for the compliance period.

South Island 2022

Provision of 16% of SI demand less Tiwai

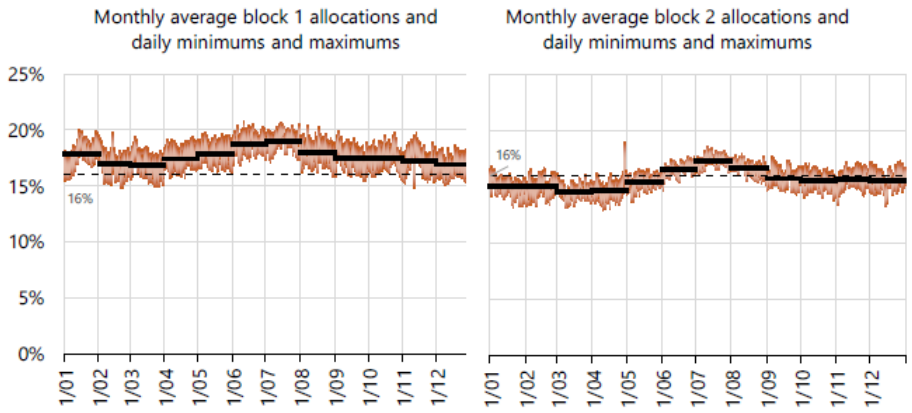


Figure 4-1: South Island AUFLS provision showing daily minimum and maximum, and monthly average AUFLS provision

Provision of 16% of SI demand less Tiwai

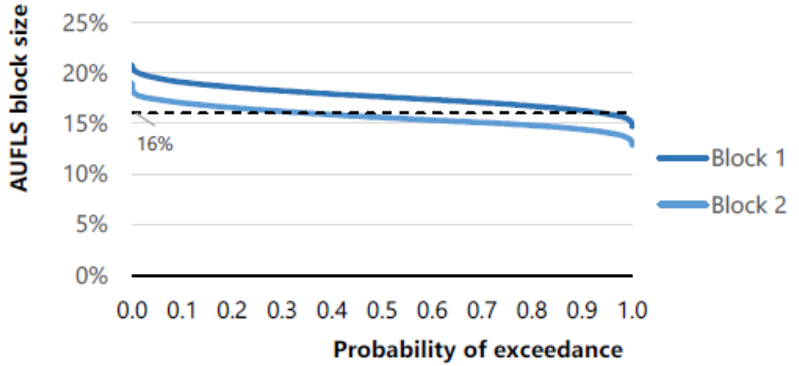


Figure 4-2: South Island AUFLS: duration curves demonstrating the level of compliance with the Code

Tiwai AUFLS

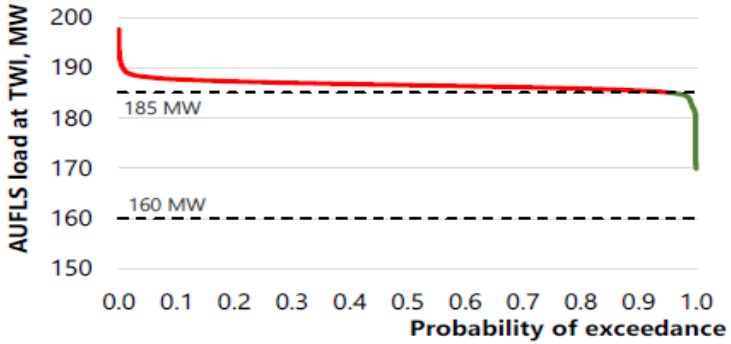
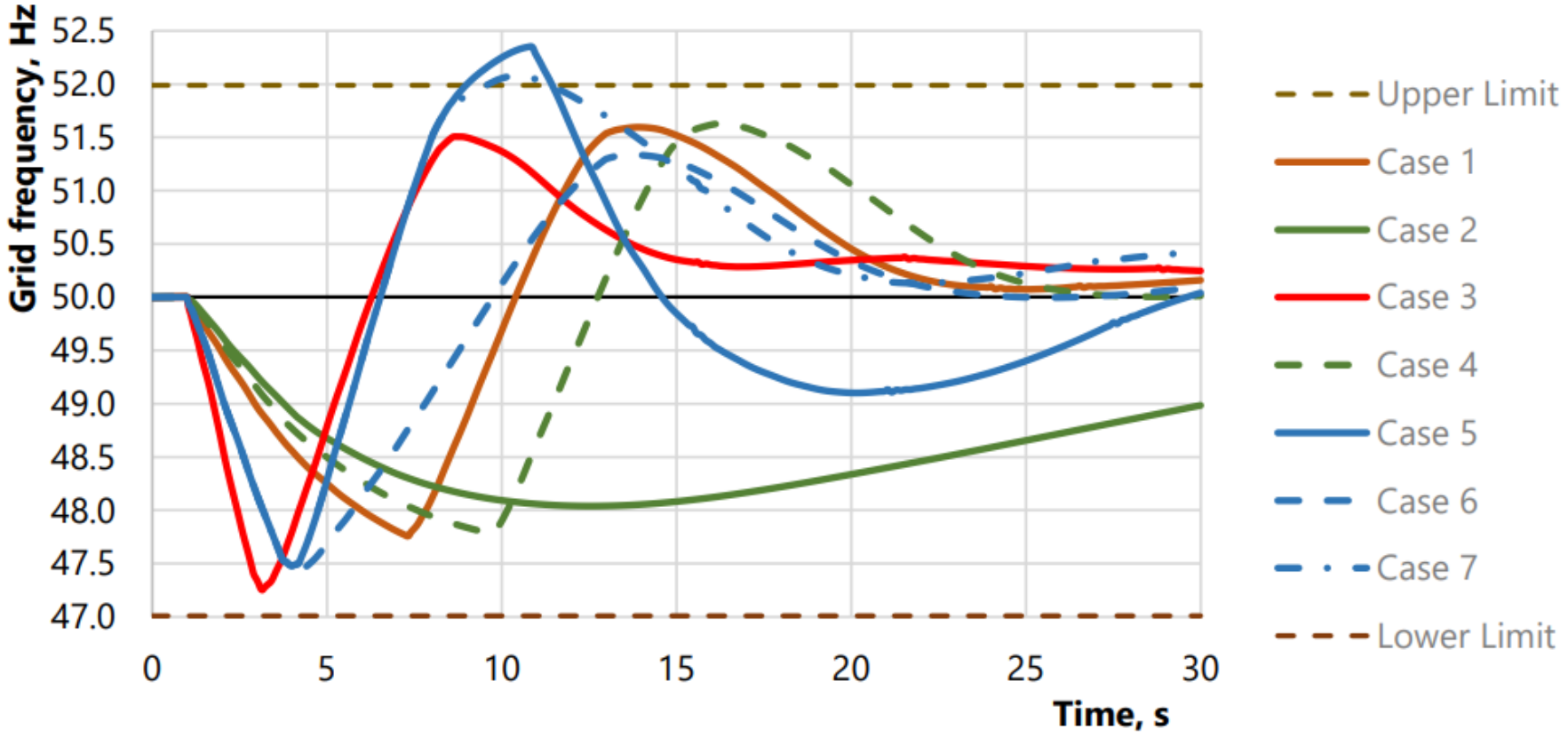


Figure 4-3: AUFLS demand at Tiwai against the thresholds stated in equivalence arrangement 2708

Annual assessment – real worst-case and stress test cases

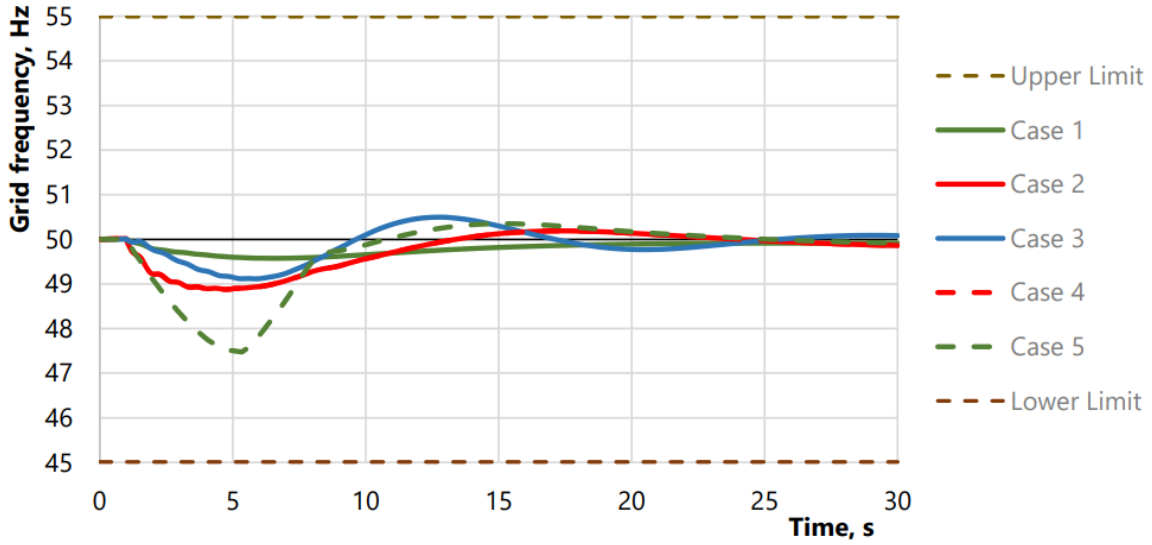
North Island 2022



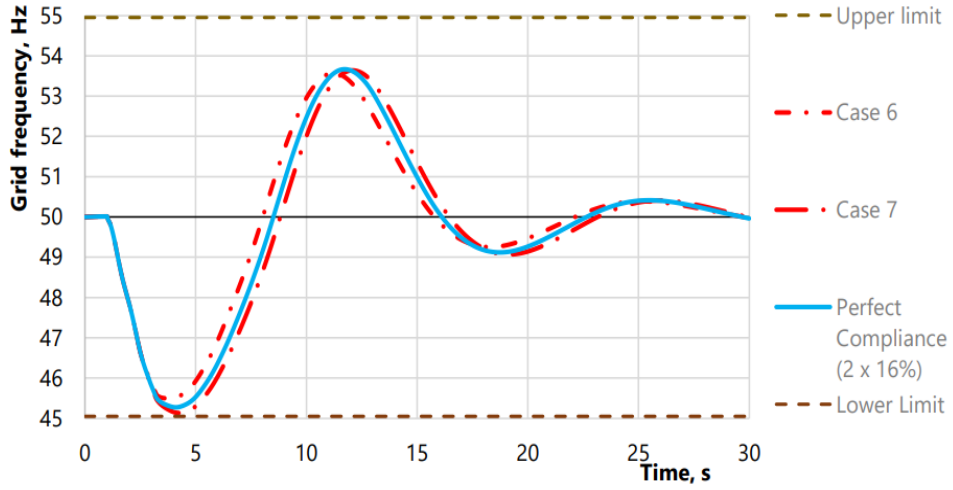
Annual assessment – real worst-case and stress test cases

South Island - 2022

Manapouri bus trip



HVDC south transfer bipole trip



Note: "perfect compliance" means AUFLS is armed as two blocks of exactly 16%

Annual assessment conclusion for 2021 and 2022

- **the power system was secure at all times**
- **collectively (ie across an entire island) AUFLS were sufficient despite individual non-compliances**
- **risk of over-frequency response – mitigated by over frequency arming of particular generating units**

Equivalence arrangements

North Island

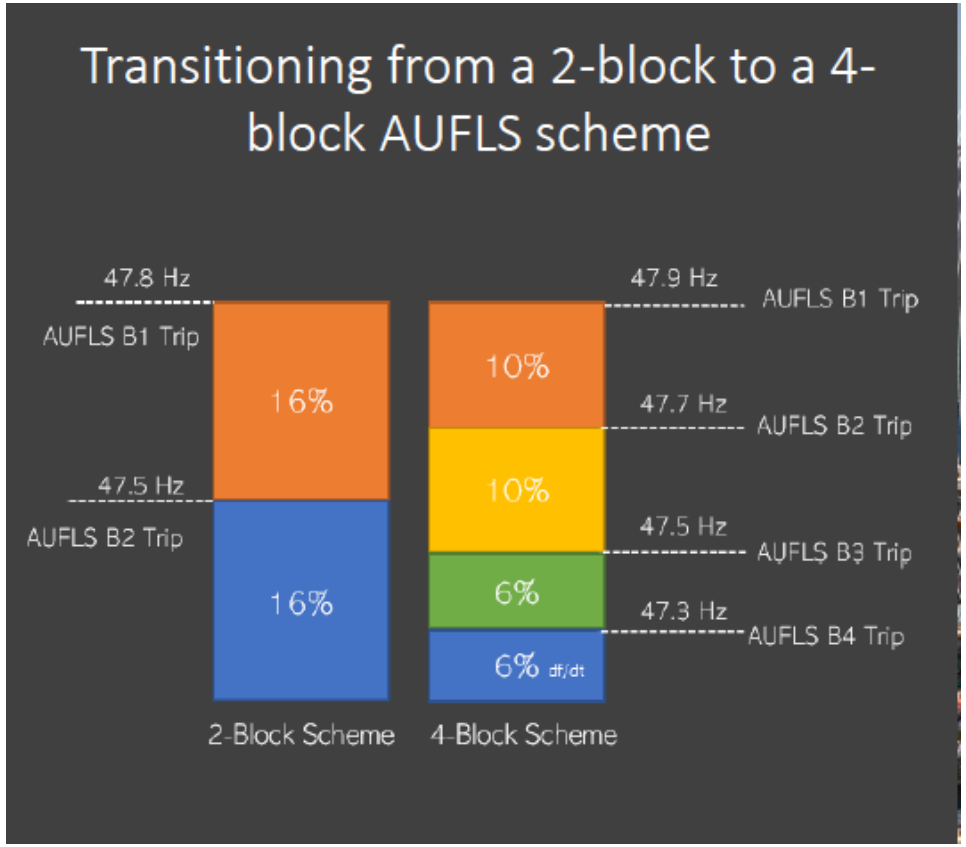
- **exemptions for direct connect consumers expired 30 June 2022**
- **equivalence arrangements approved North Island direct connect consumers - at various stages of implementation**

South Island

- **Tiwai GXP – a single block of between 160MW to 185MW to be shed at 46.7Hz within 0.4 seconds with a secondary setting of 47.5Hz within 15 seconds**
- **application to increase from 185MW to 195MW (for 2022 the 185MW was exceeded 95% of the time)**

North Island 4-block scheme

- **2011 event identified shortcomings of 2-block scheme – over provision of AUFLS**
- **System operator's technical studies recommended changes to improve reliability**
- **recommended option was 'large early'**
  - 2 blocks of 10% and 2 blocks of 6%
  - a rate of change of frequency in block 4 with early activation if frequency fall is faster than -1.2Hz/s
  - maximum operating time reduced from 400ms to 300ms
- **greater resiliency due to faster acting design anticipating increasing renewable energy with reduced system inertia**



North Island 4-block transition project

Technical Advisory Service project

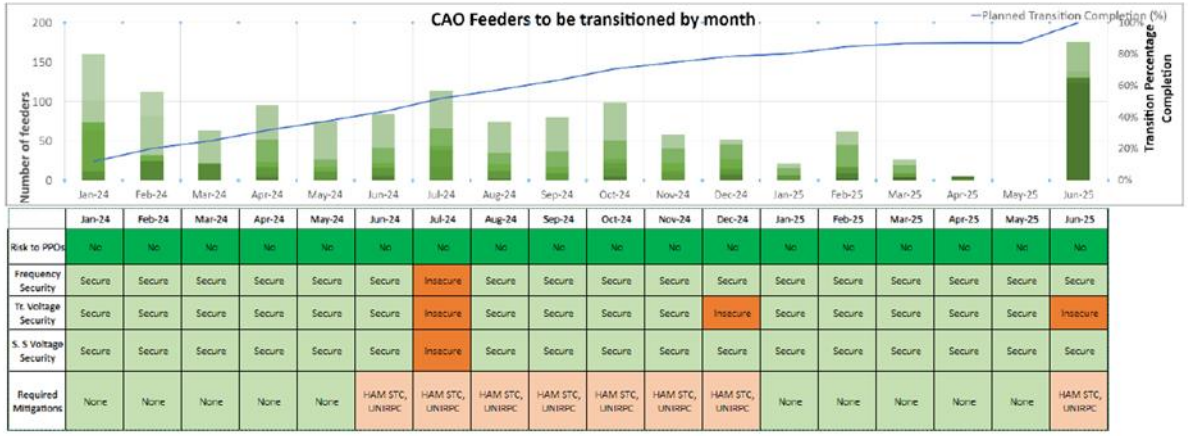
Monthly process

Providers supply:

- update on feeders transitioned
- any change request for month ahead

System operator:

- performs security studies for the month ahead
- informs provider if change is accepted or declined
- reports findings to the Authority

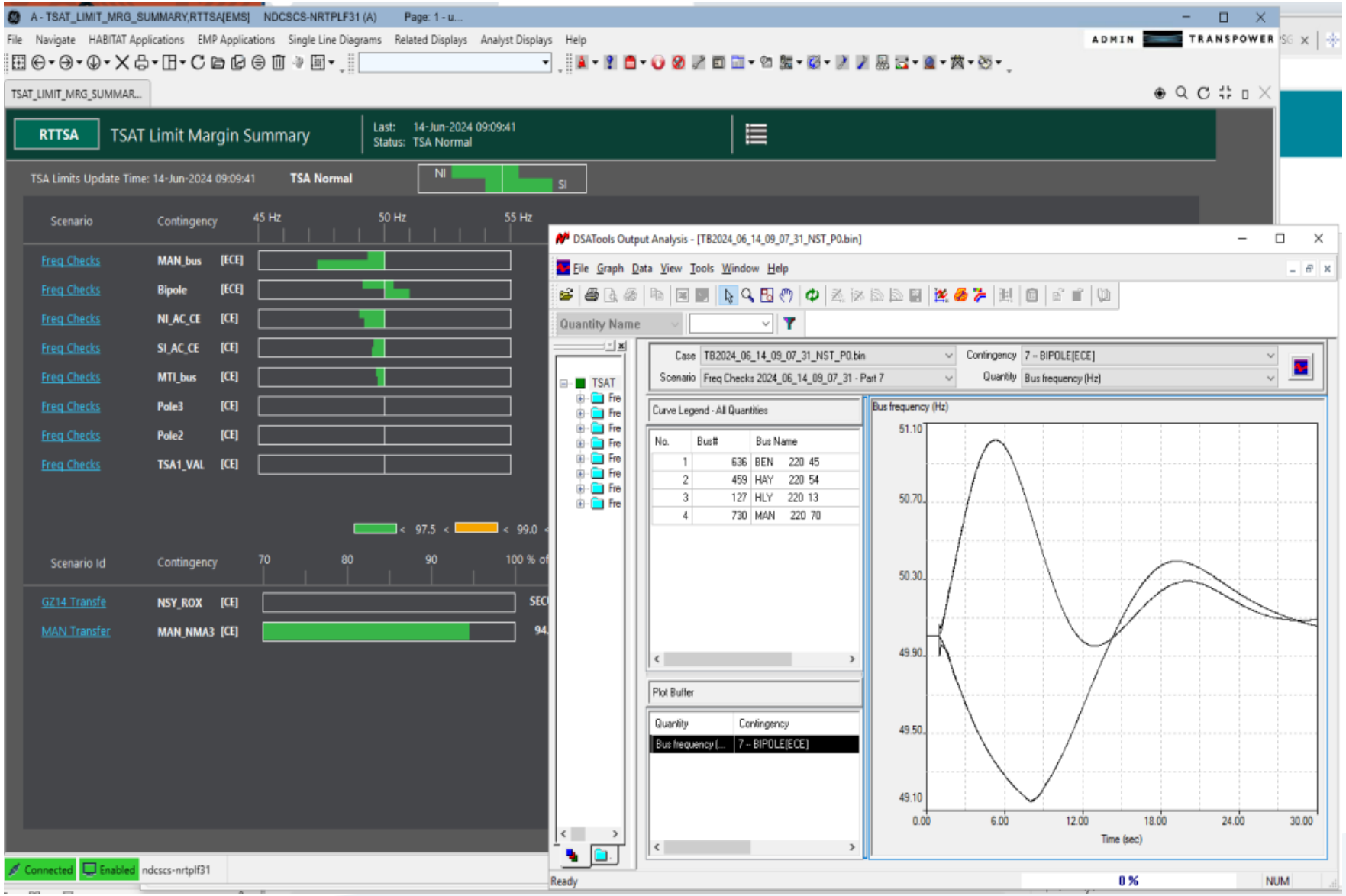


	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25
Risk to PPOs	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Frequency Security	Secure	Secure	Secure	Secure	Secure	Secure	Insecure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure
Tr. Voltage Security	Secure	Secure	Secure	Secure	Secure	Secure	Insecure	Secure	Secure	Secure	Secure	Insecure	Secure	Secure	Secure	Secure	Secure	Insecure
S. S Voltage Security	Secure	Secure	Secure	Secure	Secure	Secure	Insecure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure	Secure
Required Mitigations	None	None	None	None	None	HAM STC, UNRPC	HAM STC, UNRPC	HAM STC, UNRPC	HAM STC, UNRPC	HAM STC, UNRPC	HAM STC, UNRPC	HAM STC, UNRPC	None	None	None	None	None	HAM STC, UNRPC

Security assessments in real time

- **Reserve Management Tool (RMT) and Transient Stability Analysis Tool (TSAT)**
- **RMT calculates the reserve requirement to cover:**
  - the largest Contingent Event to ensure frequency remains above 48Hz. AUFLS not used
  - the largest Extended Contingent Event (ECE) where the frequency can fall below 48Hz but remain above 47Hz in the North Island and 45Hz in the South Island
- **reserves are procured taking into account AUFLS contribution for ECE risks. For ECE risks both AUFLS and reserves are relied on**
- **system operator assumes approximately 90% of the 32% AUFLS load responds**
- **TSAT verifies system frequency response for both CE and ECE risks with a solve every 5-8 minutes using a snapshot of the current power system (actual HVDC transfer, system load, generation, network information via SCADA and interruptible load)**
- **if insufficient to mitigate the binding ECE risk a process is triggered to re-dispatch the system to reduce the size of the ECE risk, procure additional instantaneous reserves and/or arm more over frequency reserve**

TSAT control room screen



Routine testing

Test operation

- 4 years for analogue and non-self monitored digital AUFLS systems
- 10 years for self monitored digital AUFLS systems
  - provide verified set of trip settings and time delays to the system operator within 3 months of testing
  - system operator receiving test results due to the transition otherwise sporadic
  - system operator considering how best to store test results that would facilitate reporting

Compliance activity

non-compliances

- **from annual assessments**
- **from transition project**

monitoring progress towards compliance

regular updates to the Compliance Committee

Questions ?

North Island study cases

Table 3-3: Details of cases to study the frequency response, following an ECE

Case	Case Description (Date and Time)	NIPS Load (MW)	Total AUFLS		HVDC Transfer (MW)	Binding Risk	OFA (Units)
			MW	% NI Load			
1	Maximum NI AUFLS demand in MW (17/06/22 18:00)	4,677	1,863	39.8	495	HLY G5	All, except KAG
2	Maximum NI AUFLS as a percentage of NI demand (31/07/22 18:00)	4,208	1,706	40.6	390	HLY G5	All, except KAG
3	Maximum HVDC Northward Transfer (19/09/2022 18:00)	4,089	1,483	36.3	955	HLY G5	All
4	Modified Case 2, with HVDC transfer increased to trip AUFLS Block 1 only	4,208	1,706	40.6	440	HLY G5	All, except KAG
5	Modified Case 2, with HVDC transfer increased to trip AUFLS Block 1 and 2	4,208	1,706	40.6	840	HLY G5	All, except KAG
6	Modified case 5, with AUFLS modelled as in the real-time tools	4,208	1,246	29.6	840	HLY G5	All, except KAG
7	Modified case 5, with AUFLS modelled as in the real-time tools and all generators available for OFA being armed	4,208	1,706	40.6	840	HLY G5	All

Note(s):

- the following NI generators are available for OFA: THI G1 and G2, KAG G1, NAP G1 and MOK G10;
- in modified cases, the modified parameters are underlined;
- % NI Load excluded AUFLS armed by direct consumers.

South Island study cases

Table 4-1: Details of cases to study the frequency response, following an ECE

Case	Case Description (Date and Time)	Contin-gency	SIPS Load (MW)	Tiwai AUFLS (MW)	AUFLS (% SIPS less Tiwai Load)		HVDC Transfer (MW)
					Block 1	Block 2	
1	Minimum SI AUFLS demand in MW (09/10/22 15:00)	MAN bus trip	1,556	0	16.5	15.0	-215
2	Maximum HVDC South Transfer (13/07/22 01:00)	MAN bus trip	1,569	180	19.3	17.9	680
3	Min AUFLS when TWI is providing AUFLS (21/02/22 02:30)	MAN bus trip	1,241	180	14.9	13.9	0
4	Modified case 2 with min AUFLS when TWI is providing AUFLS	MAN bus trip	1,569	180	14.9	13.9	680
5	Modified case 1, with MAN bus adjusted to max	MAN bus trip	1,556	0	16.5	15.0	-215
6	Modified case 2 with HVDC bipole as contingency	HVDC bipole trip	1,569	180	19.3	17.9	680
7	Modified case 2 with min AUFLS when TWI is providing AUFLS	HVDC bipole trip	1,569	180	14.9	13.9	680

Notes:

- the following SI generators are available for OFA: AVI G1-G4, BEN G1-G6, CYD G1-G4, MAN G1-G7;
- a negative HVDC transfer indicates Northward transfer;
- in the modified cases 4-7, the modified parameters are underlined.

Automatic Under Frequency Load Shedding (AUFLS) 4-block transition

Project background and development summary

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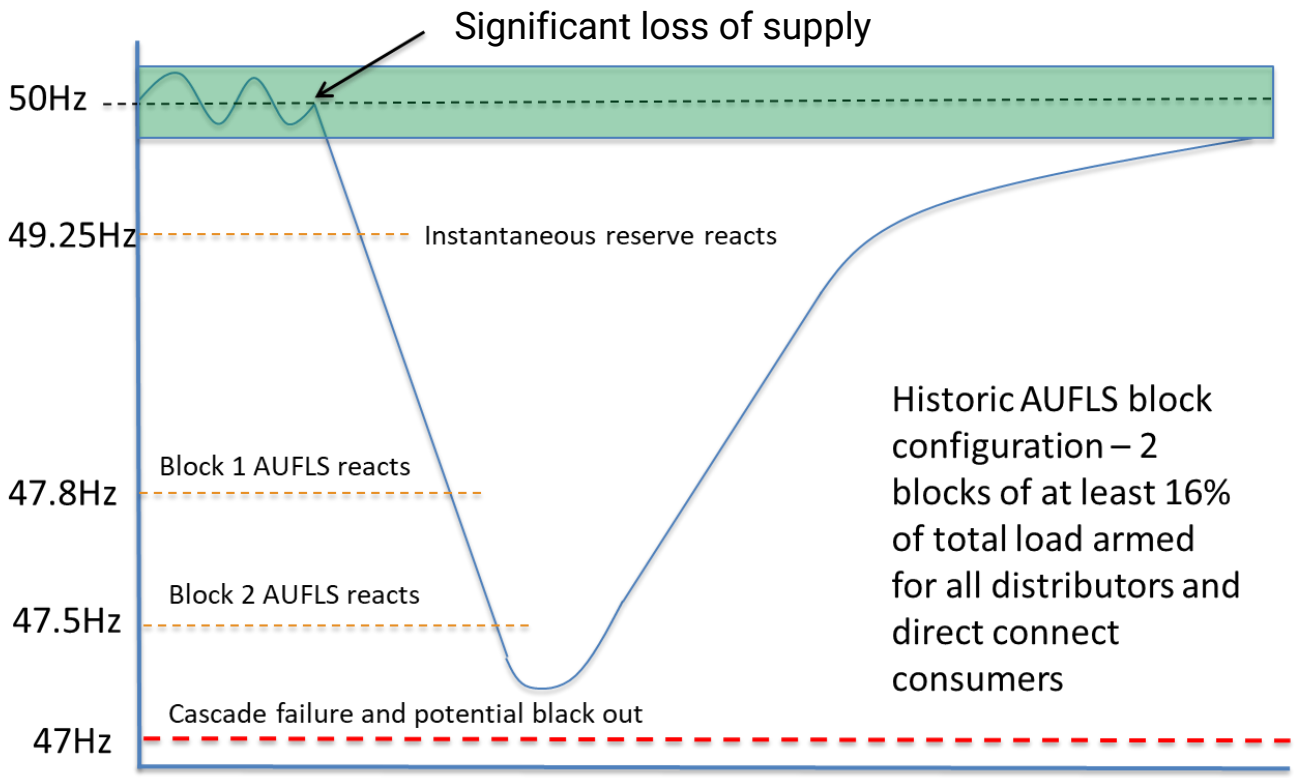
Content

- What is AUFLS?
- System considerations
- Reset project activities and timeline

AUFLS overview



AUFLS provision is an obligation on all distributors and direct connect consumers in the North Island, and an obligation on Transpower as Grid Owner in the South Island

A brief history of time

- AUFLS relays first installed in North Island in 1965 along with the HVDC link (2 x 20% blocks)
- In 2000 the scheme was amended following HVDC link upgrade to 2 x 16% blocks and tighter trip frequencies. Also extended to include the South Island
- In 2010 the system operator released a technical report putting the case for change to a 4 – block scheme
- In 2013 the Authority initiated the EPER project to implement an economically efficient selection of load alongside the 2 to 4-block transition
- In 2019, after issues implementing the economic selection aspect of the scheme, the Authority decided to reset the transition project and focus on the technical transition to a 4-block scheme and set aside the economic selection

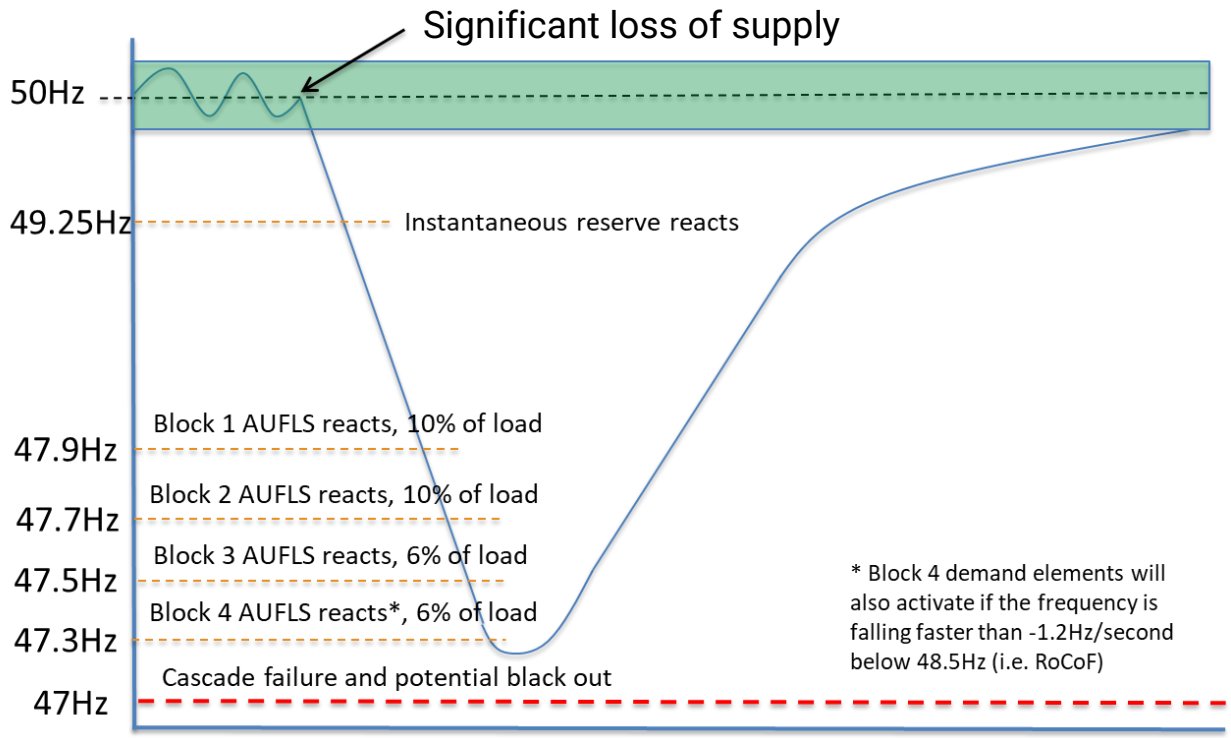
Drivers for change to a 4-block scheme

- The high rate of fall of system frequency during large events could result in the second AUFLS block tripping too late to prevent system black out
- Coarse 2-block design may result in more load tripping than necessary – more granularity is needed
- If the over response of AUFLS is significant, there is a potential risk of system frequency going high enough to trip generation for safety reasons. This would then send frequency back down towards cascade failure

4-block scheme design considerations

- Improve flexibility and resilience of the AUFLS scheme
- Improve monitoring – introduce regular reporting and review of armed load
- Ensure AUFLS has sufficient flexibility to manage future changes in the electricity supply mix (renewables, demand response etc)
- Remove the need for exemptions (level the playing field)
- Ensure “high value” loads are not included in AUFLS (hospitals, CBDs..)
- Design should not preclude future policy developments with respect to AUFLS provision

New AUFLS scheme settings



- More granular load blocks
- Technically achievable
- More responsive to faster grid frequency drops

Progress to date

- Revised Code amendment published December 2021
- Tool development and transition planning started by the system operator early 2022
- Baseline reporting of AUFLS status started 2023
- System operator received transition plans from distributors June 2023
- Transition activity started January 2024, due to complete June 2025