Musselroe Wind Farm

Provision of FCAS

September 2021

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This project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program.

Abbreviations

AEMO	Australian Energy Market Operator
AGC	Automatic Generation Control (AEMO)
AP	Active Power
ARENA	Australian Renewable Energy Agency
CapBank	Capacitor Bank
COGATI	Coordination of Generation and Transmission Investment
CPP	Consolidated Power Projects Australia Pty Ltd
DI	Dispatch Interval (5 minutes)
ECM	Energy Conversion Model Guidelines (AEMO)
EMS	Energy Management System (AEMO)
FCAS	Frequency Control Ancillary Services
FDS	Functional Design Specification
FSM	Frequency Sensitive Mode (a PPC frequency control mode)
LVRT	Low Voltage Fault Ride Through
MASS	Market Ancillary Services Specification
MLF	Marginal Loss Factor
MRWF	Musselroe Wind Farm
NEMDE	NEM Dispatch Engine
OEM	Original Equipment Manufacturer
PPC	Turbine Power Plant Controller
PSS/E	Power System Simulation for Engineering (Software)
RoCoF	Rate of Change of Frequency
RRCS	Remote Runback Control Scheme
RTAC	Real-Time Automation Controller
SCADA	Supervisory Control and Data Acquisition
SCR	Short Circuit Ratio
TNSP	Transmission Network Service Providers
VCS	Voltage Control Scheme
UIGF	Unconstrained Intermittent Forecast Generation (either from AWEFS or Self-forecasting
WNH / WNR	Woolnorth Wind Farm Holdings / Woolnorth Renewables
WTG	Individual Wind Turbine Generators on site

Executive Summary

Woolnorth Wind Farm Holdings Pty Ltd (trading as Woolnorth Renewables – WNR), owns and operates the Musselroe Wind Farm (MRWF) in Northwest Tasmania. Given the plants capability and challenging operating conditions in Tasmania, WNR and project partners have been working since 2018 to configure, enable and operate MRWF in as many Frequency Control Ancillary Service markets as possible.

After completing several software updates and configuration changes and 21 separate tests, MRWF was able to successfully test and prove compatibility with the NEM requirements for FCAS provision. These tests, complete with linear ramping between dispatch targets and primary frequency response, clearly demonstrate that inverter based intermittent generation can be configured and operate within the general parameters required by AEMO with the context of the NEM.

There have been many challenges encountered by the project team to achieve this outcome:

- Frequency control capability (whilst remaining within site limits) was not able to be activated at the wind turbine level as originally desired, however it was able to be achieved at the Power Plant Controller (PPC) level.
- Fast FCAS (6 second response) was not able to be reliably achieved due to challenges associated with weak grids and the requirement for an extended PPC freeze whilst under fault ride through conditions.
- Voltage management equipment installed on site limited the full range of FCAS capability that could be demonstrated.
- Many iterations and changes to the control system were required to ensure conformance with basic AEMO requirements.

1 Introduction

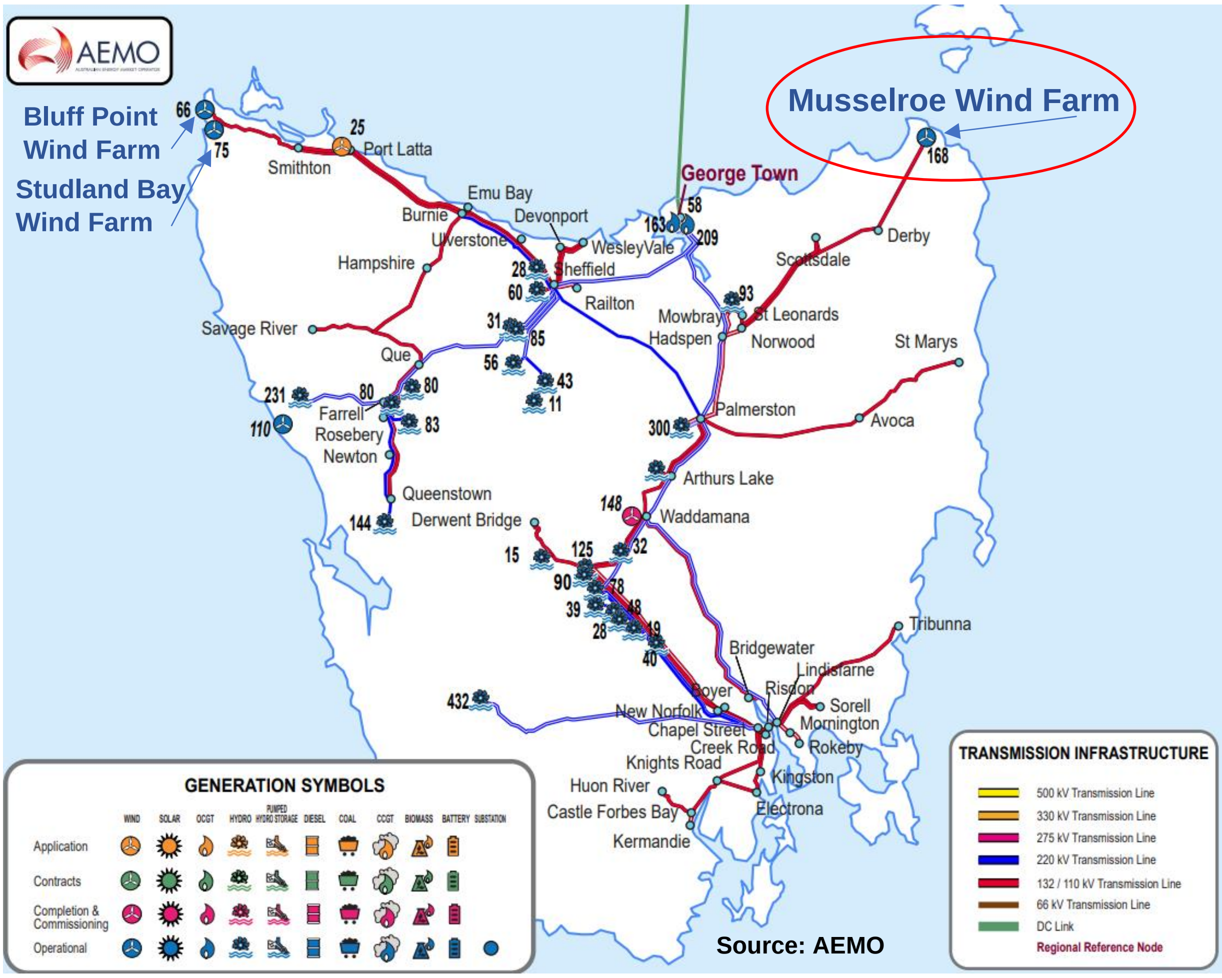
1.1 Background

Musselroe Wind Farm ("**MRWF**") located at Cape Portland in the North East of Tasmania comprises 56 V90 Vestas turbines with an installed capacity of 168 MW (Figure 1)

The facility is owned and operated by Woolnorth Wind Farm Holding Pty Ltd (trading as as Woolnorth Renewables ("**WNR**")), who also own and operate the Studland Bay (75 MW capacity) and Bluff Point (65 MW capacity) wind farms located in the North West of Tasmania.).

MRWF is connected to the Tasmanian network via a 48km 110 kV single circuit dedicated transmission line from the wind farm to the Tasmanian shared network at Derby. Derby is located approximately 120km from Georgetown the Regional Reference Node (RRN) for Tasmania.

Figure 1 NEM Network Connections – Tasmania Feb 2021



MRWF was commissioned in 2013 with significant network management equipment, due to its size, network connection arrangement and location. The Connection Point at the Derby

Substation has a very low fault level (360 MVA) resulting in Short Circuit Rato (SCR) range at the wind farm of between 1.8 - 2.1.

To meet the performance standards the reactive and generating plant comprises 4 x 4.0 MVar STATCOMs, 4 x 10.0 MVar Capacitor Banks and 2 x 14.0 MVA Synchronous Condensers, together with the 56 V90 3.0 MW double feed induction wind turbines.

The wind turbines are managed via a Vestas Power Plant Controller (PPC).

The plant within the generating system is connected to a 33kV collector network. This 33kV collector network is connected to a 110kV transmission line via 2 x 33/110kV 90MVA step-up transformers. Indicative locations for both revenue and operational metering are shown for reference as represented in Figure 2.

Figure 2 Overall Connection Schematic

MRWF also has a frequency response capability that was tested during the R2 validation tests in 2013 by injecting a series of artificial frequency events. The results showed that the frequency response capability can be substantial, however, actual enablement of Frequency Control Ancillary Services ("**FCAS**") capability was not a project deliverable at that stage.

1.2 Activity

In conjunction with ARENA, this project has been implemented to improve the understanding of the economic and commercial case for FCAS participation to support the business case for current and future participants seeking to participate in this market.

The critical outputs of the overall project include;

a) demonstrating the ability of an existing wind farm with Vestas turbines to deliver FCAS and undertake a series of tests in consultation with TasNetworks and AEMO;
b) summarise the commercial and economic assessment of wind farm participation in the FCAS market;
c) the requirements for interfacing with AEMO for the purposes of control, communications and wind forecasting;
d) the technical impact of enabling FCAS in an existing wind farm rather than a new build wind farm;
e) evaluating the installation of utility-scale battery storage as a means to provide FCAS; and
f) detailing MRWF's participation in the FCAS market.

Item e) and f) are still in the process of being finalised and will be completed with Milestone 3 of this project.

As part of this project, Milestone 1 and 2A have already been completed.

1.3 Milestone 2B Deliverables

Milestone 2B (FCAS test and implement reporting and optimisation systems) requires completion of the following items:

1. WNH undertaking a series of tests, in consultation with TasNetworks and AEMO;
2. WNH reviewing and reporting on the test results;
3. Completion of the FCAS tests;
4. WNH calculating the optimal MRWF position in the energy and FCAS markets and describing how this is bid into AEMO's physical dispatch process;
5. WNH designing and developing the relevant ICT/SCADA system to manage the interface of the wind forecasting system;
6. FCAS bids with AEMO's dispatch and wind forecasting system; and
7. WNH applying to AEMO for classification of MRWF generating units as ancillary services generating units under clause 2.26 of the Rules.

If technical or regulatory barriers were identified that restricted the ability of Musselroe Wind Farm to comply with the Market Ancillary Services Specification ('MASS') thus precluding classification under clause 2.2.6 of the Rules, WNH shall use its best endeavours to provide feedback facilitating a review of the MASS.

In conjunction with this 2B report, the *Knowledge Sharing Report* also required a presentation and report to cover the following items:

- A public presentation to demonstrate how MRWF provides FCAS:
    - Details of the technical requirements
    - Techniques to enable FCAS
    - Turbines capability and how others could enable FCAS
    - AGC signal integration
    - Frequency response outcomes

1.4 Milestone 2B Status

As at the time of writing (31 March 2021), the following items have been completed or are awaiting final outcomes.

Milestone 2B Status	Status	Comment	Next Step
1 Conduct Tests	✓	21 in total	-
2 Review and report on Tests	✓	All tests analysed	-
3 Completion of the FCAS tests	🕒	Final FCAS tests to be completed after Registration	Will occur after Registration
4 Calculation of Optimal MRWF position	✓	Completed (see Section 4)	-
5 ICT / SCADA designed/implemented	✓	Completed (see Section 3)	-
6 FCAS bid capability with AEMO	✓	Completed (see Section 4)	
7 FCAS bidding registered with AEMO	🕒	In progress	AEMO Registration submitted

The final modifications to the control system were made in March 2021 and finalised in May 2021. The final series of 4 tests (a raise and lower test at both high and low generation levels, each lasting 10 minutes) was conducted and successfully achieved, providing the final dataset AEMO required to complete the draft registration that had already been submitted.

The completion of the FCAS test would be expected within 2 weeks of AEMO registration.

2 Milestone Activities

2.1 Summary of Tests Conducted

21 separate testing and performance evaluation events have been required over the life of the project to date to verify the specifications of the plant to date. Each test group has identified the requirement for further refinements to control system logic. The final tests completed in May 2021 successfully completed the test.

Table 1: FCAS Test Groups and Outcomes

Test Group	Test Observations	Test Outcomes
March 2020	MRWF not adhering to SDC targets and was drifting from its curtailed level	Refinements to the AP control system logic were required.
October 2020	Tests from high generation levels produced voltage movements	Further refinement of control system logic for capacitor bank (CapBank) switching was required.
December 2020	Tests produced CapBank limits that restricted maximum FCAS supply	The availability of CapBanks is identified as the primary limitation on the provision of FCAS (this issue had been masked by the previous AP management issues)
February 2021	Tests confirm CapBank limitations above 130MW will restrict FCAS provision	Final test envelope for FCAS provision established
March 2021	Performance Tests	Test series halted due to UIGF interactions
May 2021	Final Tests	Final tests conducted and completed successfully

2.2 Significant Activities since Milestone 2A Report (November 2019)

Key activities for this project that have been completed since the end of November 2019 include:

a) Continuing revision of the existing design and control system specifications to enable frequency control in the PPC.
b) Continuing virtual engagement with OEM’s, network specialists and regulatory bodies during the COVID19 period, including limitations on site visits and travel restrictions to Tasmania.

c) Additional modification of ICT/ SCADA interfaces and SCADA Control Logic requirements in conjunction with Vestas and CPP.
d) Numerous documents and manuals were studied and workshops held with Vestas, to understand the frequency control capability of the PPC. This included AP management of plant limits and network setpoints.
e) AEMC and AEMO implemented the Frequency Operating Standard limits for Tasmania that effectively limited MRWF to 153MW at the dispatch point, effective 1 Jan 2020.
f) AEMC and AEMO implemented primary frequency response requirements that required test plans, inclusion and consideration within the test outcomes.
g) Site tests were conducted in March, October, and December of 2020 to test the PPC AP and dispatch controller functionality.
h) Site tests conducted in February, March and May 2021 further refined the technical envelope within which FCAS could be provided at MRWF:
    i. A maximum enablement limit of 129MW was required to prevent changes to the voltage management scheme of the site (which in turn would trigger GPS compliance issues), and
    ii. A minimum enablement level of 50MW was required to prevent the pausing of turbines (and switching to alternate control modes)
i) SCADA Control Logic changes to the PPC and RTAC were implemented by October 2020 that allowed for effective management of overall site limits, AEMO dispatch targets and frequency control enablement.
    i. Testing was successful given that:
        i. A change in AEMO dispatch cap whilst frequency control is enabled;
        ii. Linear ramping for the revised AEMO dispatch cap;
        iii. Frequency decreases resulting in a positive active power response;
        iv. Frequency increases resulting in an active power decrease;
        v. Release of AEMO dispatch cap, plant returns to the RRCS limit (which was artificially low for test purposes), noting that the plant continued to respond to frequency changes (particularly high frequency).
    ii. Additional improvements to the loop control functionality were identified and required testing prior to undertaking the FCAS registration testing in May 2021.
j) Initial market registration documents have been submitted to AEMO.

The final test, conducted in May 2021, shows the expected and correct response from MRWF in the test series 21a → 21d. For each stepped response of 500mHz, the response from the unit was exactly as expected. This is shown in Figure 3 over the page.

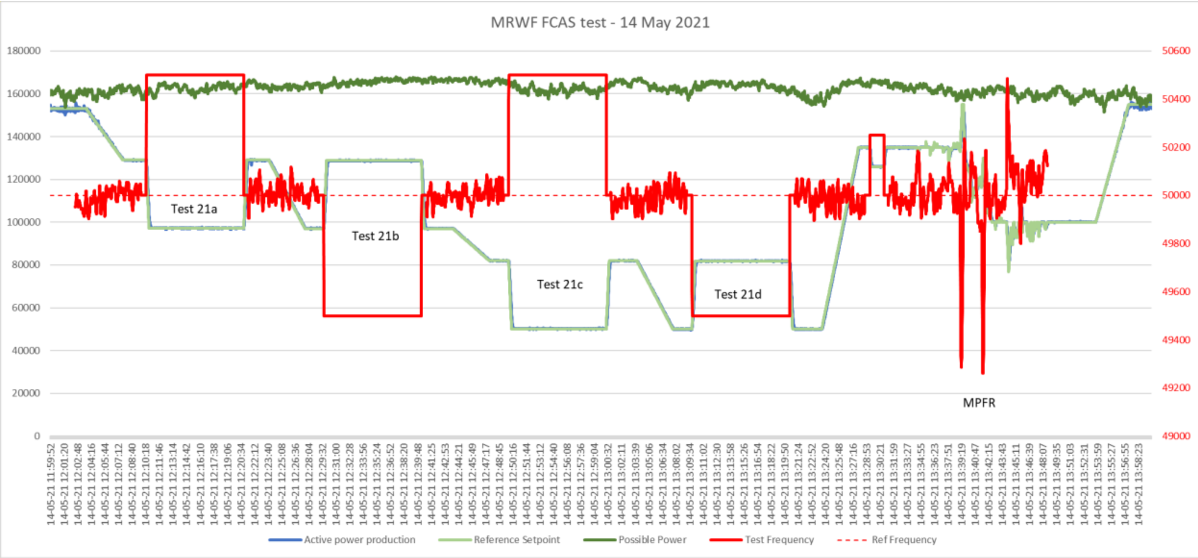


Figure 3: Final FCAS Test - May 2021

Towards the later stages of the test window, even tighter frequency deadband settings were enabled and the site was allowed to respond to frequency as required. At the same time, Basslink was changing direction resulting in a large frequency swing in Tasmania. MRWF responded correctly and helped correct Tasmanian frequency.

2.3 Summary of Test Outcomes

The following key learnings and outcomes through this phase of the project have been developed:

- Voltage management is (and will remain) vital to wind farm performance and outcomes:
    - MRWF will not be able to achieve Fast FCAS because of Fault Ride Through (FRT) limitations noted in previous reports;
    - MRWF will not be able to achieve FCAS above 130MW due to CapBank availability issues that cannot be changed easily without further voltage assessments and modelling
    - MRWF will not be configured to provide FCAS below 50MW due to WTG mode switching (pausing of the turbines) which would render active power management for frequency control extremely difficult.

The above points have provided the technical envelope for MRWF FCAS provision within voltage management limitations. These limitations were not expected when the project was commenced. This then allows for the evaluation of the provision of FCAS and economic assessment in the next stage of the project, as well as the registration of the services with AEMO.

3 ICT and SCADA Changes

As indicated in the previous section, many changes have been required to the existing systems that were in place at project commencement in order to achieve project outcomes.

3.1 Control System Changes

Perhaps the most important series of key developments from this entire project has been the additional control system changes that were required despite some existing frequency control capability in the plant from its commissioning days.

- Significant changes were required on the control system logic within the active power control loops.
- Voltage control at the connection and dispatch points remains a very challenging aspect to this and any renewable provider of FCAS.
- Frequency control was not possible at the wind turbine level despite this being the best location for frequency control to be managed:
    - It could not be physically enabled, even locally standing in the bottom of the wind turbine
    - The vendor did not know how to enable the feature in the V90 remotely
- Initially, PPC Frequency Control worked in test and lower mode, but not in full (raise and lower) 'real world' conditions with AEMO setpoints and site runback limits
- Control system priority for the site limits (runback limits) had to be elevated in the control system

3.2 Enablement of FCAS Contingency Services

A number of control system interface changes were required to be developed and implemented before successful testing could be achieved in the following systems:

a. On the Vestas VOB Control System interface, to enable the correct management of all FCAS related parameters and settings
b. On the Citect RTAC Control System Interface, to manage and understand the active power control limits and site settings
c. Linear ramping of the site from one dispatch interval to the next was also implemented at the same time

3.3 FCAS Regulation Enablement

FCAS Regulation services are effectively a new active power signal to the generating unit every 8 seconds (in the case of Tasmania), although this feature is yet to be finally tested (it cant be done until FCAS registration is completed).

Therefore, the following additional SCADA elements were added to enable FCAS Regulation (many of these are now standard with AEMO's Energy Conversion Model (ECM) template):

d. Additional SCADA
   i. Possible Power
   ii. Local Limit
   iii. AEMO AGC feedback
   iv. AGC Upper Limit
   v. AGC Lower Limit
   vi. AGC Ramp Up
   vii. AGC Ramp Down
   viii. AGC Status; and
   ix. Frequency Control Enablement state.

It should be noted there has been no end-to-end AGC tests at this stage because AEMO do not test without configuration of their AGC system, and they do not configure their AGC system with new assets until the Market Registration is completed, which is still in progress.

A functional test (where it receives AEMO test signals and tests and verification that values change etc) was completed in February 2019, which was successful.

3.4 Final Setup

All of these site control system changes were made to enable five key scenarios to take place, as described below:

1. Respond to low and high frequency events while a Runback limit is in place
2. Follow an AEMO dispatch target with a frequency event (and within site limits)
3. Follow an AGC target limit, no frequency event
4. Follow an AGC target limit, with a frequency event whilst staying within all plant limits
5. Follow an AEMO semi-dispatch target from AEMO – no frequency event, using a linear ramp from dispatch interval to dispatch interval

3.5 FCAS Information Systems

All the FCAS enablement levels are managed through AEMO data that is made available by a private AEMO infoserver that was set up very early on in the project: FCAS optimisation is not able to be achieved without private AEMO data being available.

At present, all the bidding is managed through the AEMO Bidding Interface. The below figure shows a manual rebid conducted on 4 March 2021 to manage high FCAS prices at MRWF.

Effective from date 04/03/2021 **Duid** MUSSELR1 **Service** Energy **Action** Copy this... Create new...

Trading date Thu 04/03/2021 Submitted on Thu 04/03/2021 14:33:01

Daily Energy (MWh) **MR Scaling Factor**

FS Min Load 0 **T1** 0 **T2** 0 **T3** 0 **T4** 0

Reason 1430 A ACTUAL HIGH R6 RRP [$4,142.62] - SL

Price Bands

PB 1	PB 2	PB 3	PB 4	PB 5	PB 6	PB 7	PB 8	PB 9	PB 10
-902.40	-250.00	-120.00	-95.00	-30.00	-5.00	50.00	150.00	500.00	13536.00

Band Availability

Period	Max Avail	PASA Avail	Fxd Load	R.Up	R.Down	Avail 1	Avail 2	Avail 3	Avail 4	Avail 5	Avail 6	Avail 7	Avail 8	Avail 9	Avail 10	MR Cap	PeriodId
04:30	168	168		168	168	0	168	0	0	0	0	0	0	0	0		1
05:00	168	168		168	168	0	168	0	0	0	0	0	0	0	0		2
05:30	168	168		168	168	0	168	0	0	0	0	0	0	0	0		3
06:00	168	168		168	168	0	168	0	0	0	0	0	0	0	0		4
06:30	168	168		168	168	0	168	0	0	0	0	0	0	0	0		5
07:00	168	168		168	168	0	168	0	0	0	0	0	0	0	0		6
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15:30	168	168		168	168	0	168	0	0	0	0	0	0	0	0		23
16:00	168	168		168	168	0	168	0	0	0	0	0	0	0	0		24
[illegible]	168	168		[illegible]	168	[illegible]	168	[illegible]	0	0	[illegible]	0	[illegible]	0	[illegible]		25

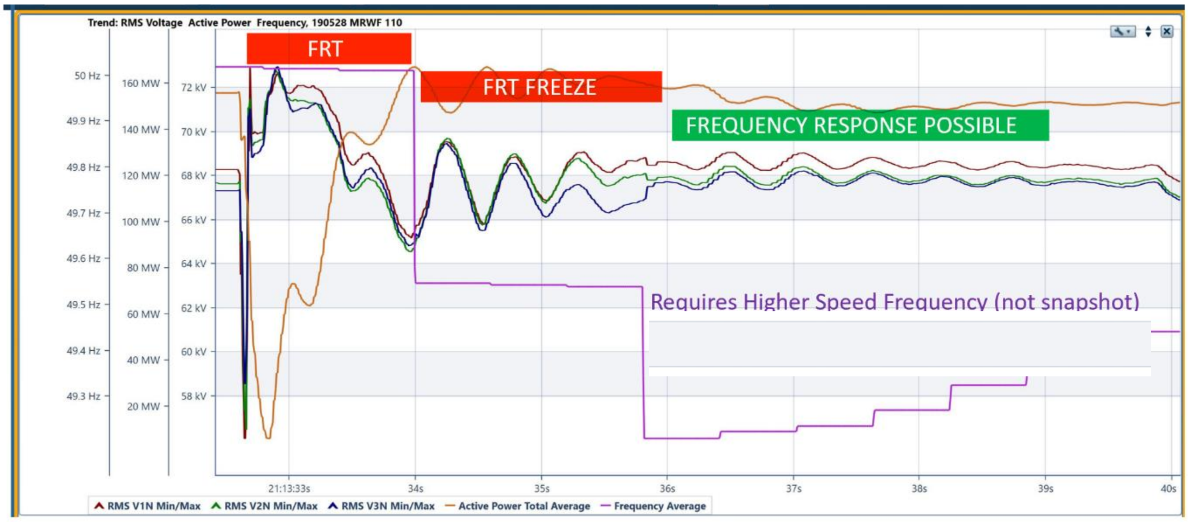
4 Key implications for other participants

The following key issues and challenges need to be well understood by others attempting projects with this level of complexity.

a) Modifications to control systems take time and must be signed off by the relevant authorities. Importantly this includes intermediary and counterparty implications due to the complex interaction of all generating systems and market interfaces.
b) The importance of linear trajectories for ramp up and down is essential for management of dispatch and power system security. All participants should make sure their control system is in line with the market systems.
c) Existing Functional Design Specifications, agreed Generator Performance Standards, Site Data Sheets and modelling may require detailed reviews and updating.
d) Enhancement of internal knowledge and capability, where plant operation and market outcomes become more intertwined, will result in less reliance on the vendor, especially in a changing market environment.
e) Market forecasting and Dispatch offers should be aligned with the real time generation activities, coupled to the control systems and a constant monitoring and alerting system implemented.
    i. Private AEMO data is essential for FCAS optimisation.
    ii. Given the nature and complexity of energy, FCAS cost and FCAS revenue co-optimisation, auto-bidding optimisation (as opposed to pure bid submission solutions) are highly desirable and likely to be mandatory for any participant.
f) Participants entering this form of financial optimisation need to have a higher degree of revenue and cost management understanding to ensure optimal outcomes: it is far more complex than simply maximising energy generation.
g) Connection arrangements in weak grids remains problematic (and typical for the NEM):
    i. LVRT remains a primary issue for all inverter-based equipment that must be managed at all times in conjunction with frequency control. This means that within weak networks it is not possible to look at AP or frequency control in isolation – the voltage control strategy must be also be carefully maintained and monitored. Most PPC's are designed to suspend any AP control during voltage disturbances. Due to filtering of the voltage signal in the PPC and inherent latency, a blocking/freeze function is required to prevent excited active power oscillations post a fault event. This potentially limits enablement of 6 second contingency frequency services at MRWF and all wind and solar sites across the NEM. Interestingly, within the Irish grid, they do exclude fast frequency response from wind and solar sites given the increased meshed nature of their grid.
    ii. The PPC blocking/freeze functions cannot be changed without careful assessment. The network in Tasmania possess unique challenges in meeting grid stability requirements that the wider NEM are yet to experience. As the wind farm is large relative to the size of the Tasmanian power system, inertia, RoCoF settings and voltage regulation require careful consideration. Accurate modelling, especially in weak grids is required to ensure the performance of the generating plant meets all its performance standards under all operating conditions. Manufacturers and equipment suppliers are reluctant to provide detailed modelling information on their plant and associated control due to intellectual property concerns making it difficult for owners of the generating plant to optimise their assets. In the case of MRWF, even where extensive

network models were developed, they require updating and to date are inadequate and still not detailed enough for frequency control assessment, resulting in additional delays and complexities for the project.

Figure 4 Conceptual change to the LVRT Freeze function



- iii. Extensive interaction with the TNSP and AEMO has been required to ensure compliance standards are maintained, coordination of testing occurs, and control system changes are well understood. As the energy transition continues more detailed studies will be required especially as potential displacement of traditional hydro generating assets in Tasmania impacts system inertia and voltage regulation.

h) Commercial considerations:
- i. NEM Registration requirements including Intermediary arrangements;
- ii. Potential for Power Purchase Agreement changes;
- iii. Operation and Maintenance agreements
- iv. Market interfaces and access

i) Regulatory considerations:
- i. Changes to the Frequency Operating Standard for Tasmania
- ii. Mandatory Primary Frequency Control rule changes that are now being implemented by AEMO; and
- iii. Consultation on the MASS, MLF and COGATI.

j) Forecasting, Dispatch and Operational considerations
- i. Operational forecasting and dispatch were disconnected from the real time SCADA, impacting:
  - dispatch conformance;
  - FCAS enablement; and
  - commercial outcomes
- ii. SCADA updates and gaining access to the market data/portals were required.

Further information will be shared on this area in a series of Knowledge Sharing activities in conjunction with the project Knowledge Sharing Partner, Greenview Strategic Consulting.

Appendix 1: AEMO’s FCAS Set up

a) FCAS Trapezium

An FCAS offer for each FCAS service consists of the following key attributes[1]:

- Ten price bands, each with a band price ($/MWh) and band availability (MW) with prices defined by trading day and MW quantities defined for each trading interval of each trading day
- The following technical limits apply to each service:
    - Enablement Min (MW)
    - Low Breakpoint (MW)
    - High Breakpoint (MW)
    - Enablement Max (MW)
    - Max Availability (MW)

  with all these aspects combining to provide a technical envelope (the ‘FCAS Trapezium’ - red) that will be co-optimised with the energy target for the DUID (in the case of scheduled or semi-scheduled units).

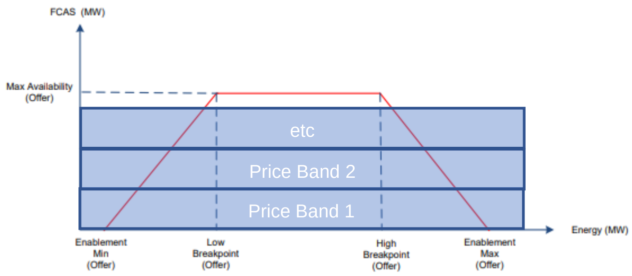
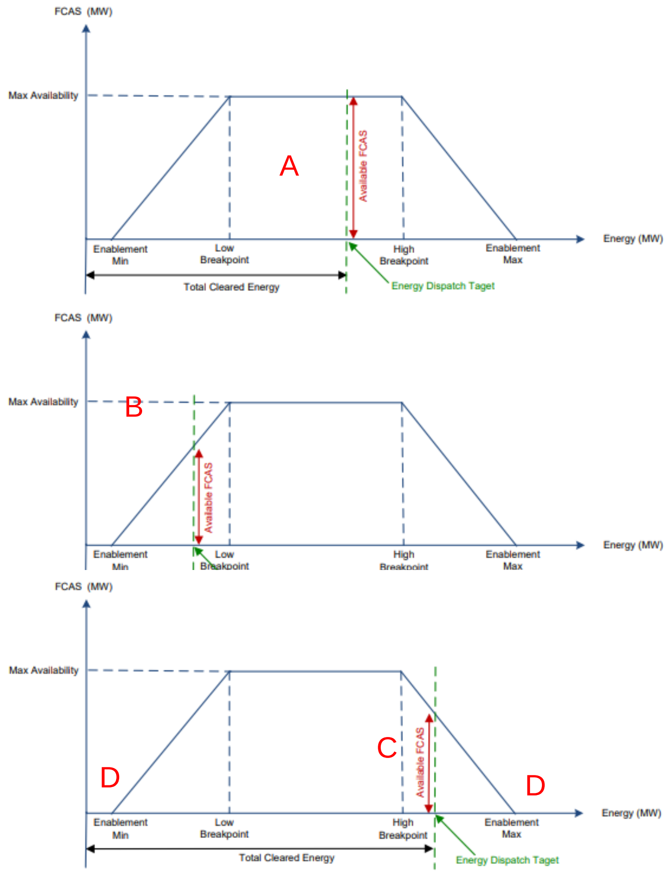


Figure 5: Basic FCAS Trapezium

In Figure 5, power generation is shown on the horizontal axis (as energy), and the frequency response capability is shown on the vertical axis (as FCAS).

The maximum FCAS that can be enabled is restricted by the FCAS offer trapezium for that service, as described by the following:

- if a unit is dispatched in the energy market between its Low Breakpoint and High Breakpoint, the maximum available FCAS that can be enabled equals its Max Availability, as shown by the vertical red at point A.
- If a unit is dispatched in the energy market between its Enablement Min and Low Breakpoint, the available FCAS is bound by the left-hand-side lower trapezium slope, as shown by Point B.
- If a unit is dispatched in the energy market between its High Breakpoint and Enablement Max, the available FCAS is bound by the right-hand-side upper trapezium slope, shown as Point C.
- If a unit is operating below its Enablement Min or above its Enablement Max, the available FCAS is zero (Point D).



1 FCAS Model in NEMDE (aemo.com.au)

NEMDE will use the most restrictive of FCAS Enablement Max and the UIGF (or AWEFS availability) for all FCAS services provided by semi-scheduled units. If the UIGF is more restrictive than the Enablement Max, NEMDE scales the offer trapezium by making the UIGF the effective maximum enablement limit and adjusting the trapezium upper break point to maintain the trapezium angles (shown as α in Figure 6). If the offer enablement maximum limit is more restrictive than the UIGF, this scaling has no impact BUT will be the most restrictive limit if FCAS is enabled.

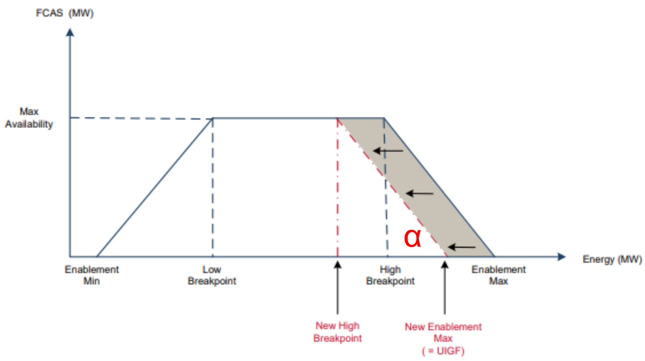


Figure 6: FCAS Trapezium scaled for UIGF

b) Pre-conditions for FCAS Enablement

After FCAS trapezium scaling as described above, a semi-scheduled generating unit is considered for enablement for a particular FCAS in NEMDE if the following conditions are satisfied:

- The maximum availability offered for the service is greater than zero:
  - FCAS Max Availability > 0
- At least one of the offer price bands has a capacity greater than zero for the service:
  - PB 1 → 10 > 0
- The energy availability is greater than or equal to the FCAS trapezium enablement minimum of the service:
  - Energy Max Availability ≥ FCAS Enablement Min
- The FCAS trapezium enablement maximum of the service is greater than or equal to zero:
  - FCAS Enablement Max ≥ 0
- The unit is initially operating between the FCAS trapezium enablement minimum and maximum of the service:
  - FCAS Enablement Min ≤ Initial MW ≤ FCAS Enablement Max
  - One consequence of this pre-condition is that units operating at an energy level less than the Enablement Min or more than the Enablement Max of an FCAS trapezium cannot be enabled for that FCAS. This phenomenon is referred to as “stranded outside the FCAS trapezium”.
- In addition to the above conditions, for Dispatch and the first interval of Pre-dispatch and 5-minute Pre-dispatch, regulating FCAS is enabled only if the following condition is met:
  - AGC Status = “On”

c) FCAS and Energy Co-optimisation

All of these elements come together to understand how MRWF could be enabled for FCAS at particular times and under particular conditions, thereby becoming a factor in the overall co-optimisation of the energy and FCAS costs (which currently exist even without FCAS revenue enablement).