Preamble

Attention: Ben Hiron, Sebastien Henry

Dear Sirs,

Please find below my personal considerations on the proposed rule changes. Whilst I was one of the authors of the submission, this communication highlights my personal position on the issue and hopefully communicates the main points clearly without loss of clarity associated with requirements of the rule drafting proposal.

It should be clear that I support the proposed rule change.

Importance of Power system frequency control

The importance of maintaining good control over the power system frequency cannot be over emphasized. It is equivalent to the brake and accelerator of a vehicle which is used to control its speed. Without good control over frequency, loss of power supply will become more common leading to consequent social and economic impacts. In recent years, the system has experienced several events which could have been avoided or made less serious if the control of system frequency and consequent power flows across interconnectors was better. Specifically:

- The blackout of SA in 2016 was in part caused by lack of frequency response of synchronous generation in SA (specifically TIPS) which were not enabled for frequency regulation at the time.
- South Australia Separation Event, 1 December 2016 was caused by power swings over the Heywood interconnector – which could have been reduced by appropriate control of frequency in South Australia
- The Queensland and SA separation event of August 2018, lack of frequency control resulted in load shedding in NSW and VIC, and reestablishing the system after the event took much longer than similar events in the past due to poor frequency regulation.

Recently the UK experienced a large load shedding event due to the tripping of two large generators. This resulted in widespread disruption to the Metro transit system even though the decline in frequency was relatively minor and took a relatively long time (~ 26 seconds) to reach load shedding thresholds. Similarly to Australia the UK is also experiencing poor frequency control , possibly also due to poor market design.

During the recent RMIT workshop (25th October 2019) there was some discussion as to how much frequency control is appropriate. In my view this is a misleading question to pose. The control that is required depends on the incident that is being guarded against which cannot be predicted ahead of time. You might as well ask how hard should a driver push the brake pedal when a pedestrian steps out in front of a car – as hard as is needed. There is no economic advantage limiting control, and likely significant cost if the control is artificially constrained.

Dysfunction of current design of FCAS markets

Through the causer pays methodology the current design of the FCAS markets penalizes generators which respond to local changes in system frequency because it will cause them to deviate from their power reference setpoint. Accordingly there is an incentive for generation to “not respond to system frequency”. This is further reinforced by a market which places a higher value on energy output than it does on system frequency control, which consequently means more and more generation is exiting or ignoring its FCAS assurances in favour of providing MW over control of MW. The only generation that is left to respond are units which have legacy controls, or have controls defined in their generator performance standards. These generators do not necessarily receive any payments for responding to frequency deviations.

This was highlighted in the 2018 Queensland separation event in which the only reason Queensland did not suffer a state wide blackout was because some solar farms and some existing traditional plant responded to the high frequency condition despite the fact that the FCAS lower price was very low at the time (~ 5 – 15 cents/MWh). For several minutes after the islanding of Queensland the frequency reference for the NEM dispatch engine was set to Sydney West, so perversely several generators in Queensland were dispatched up in power (to respond to the low system frequency in NSW) despite a statewide frequency exceeding 50.6 Hz. Under the causer pays methodology, generation which did not follow the upwards trending signal from NEMDE would be penalized.

It is clear the that the current FCAS market is not delivering what it was intended to deliver and accordingly should be reformed.

Economic costs of poor frequency control

The prime motivation for the proposed rule change is to improve power system resilience, the benefits of which cannot be easily quantified in economic terms because it requires a comparison of the likelihood of hypothetical events. Needless to say the avoidance of a system black event will likely prevent billions of dollars of costs, and likely loss of life.

The cost of the poor regulation of frequency is easier to estimate but can only be done using rough approximations. Compared to a perfectly controlled system frequency, a power system which is constantly varying in speed will experience greater losses. This is similar to the fact that driving a car at slow and then fast speeds will consume more petrol than driving a car continuously at the average speed. The losses experienced at high speed are greater than the losses saved at low speed. As the car speeds up and slows down, at net loss over the cycle occurs due to friction and other effects.

	MW	
Typical size of Power system =	26000	
Assume cubic frictional losses with frequency		
26000 x (50.1/50)^3	26156	156.31
26000 x (49.9/50)^3	25844	155.69
Difference =	312	1

The difference of the difference in nominal power of 26000 MW is therefore 1 MW.
The frequency slow cycles from high to low to high approximately every 40 s
therefore there is an effective system loss of 1 MW every 40 s due to poor frequency regulation.

per annum this is 60/40*60*24*365	788,400.00	MWh
At typical cost of $80 /MWh =	**$ 63,072,000.00**	per annum

Whilst this is a rough calculation using rule of thumb approximations, it indicates the order of magnitude of the day in day out costs borne by the market due only to the poor regulation of power system frequency. It does not include the hidden costs of wear and tear on the power system equipment, or the huge costs that would occur if a blackout is experienced which is caused or exacerbated by poor frequency control.

Conclusion

Since this issue was brought to the attention of the industry nearly three years ago, in my opinion the AEMC for whatever reason have been unable to act on the urgency of this issue. The control of system frequency is slowly deteriorating with time. Eventually an event will occur which will result in significant disruption to the power supply. The costs are likely to be very high for such an event.

This rule change will reverse the damage that has been done and place the market on a sounder technical and economic footing.

Best Regards

B. J. Miller

Ancillary Services and Markets

Bruce Miller, Principal Consultant, Advisian

25th October 2019

www.**advisian**.com

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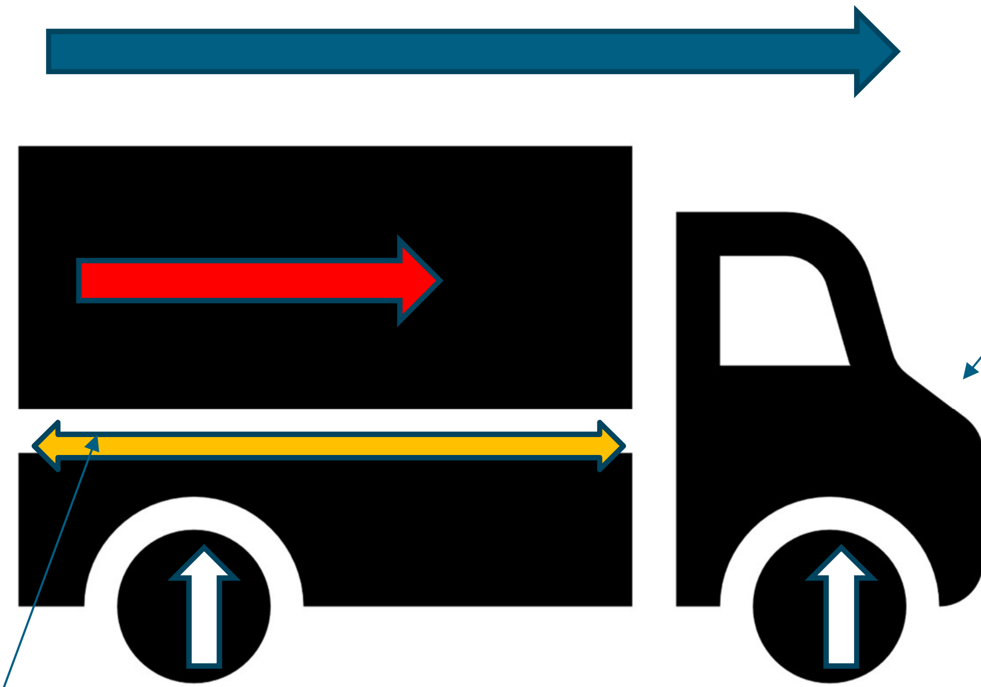
Risk – Reward Ratio for Engineers

Description of two recent market *“bugs”*

- **Provision of network support services**

- **Frequency control**

Ancillary Services Truck Analogy



Engine~ Generator

Speed ~ Frequency

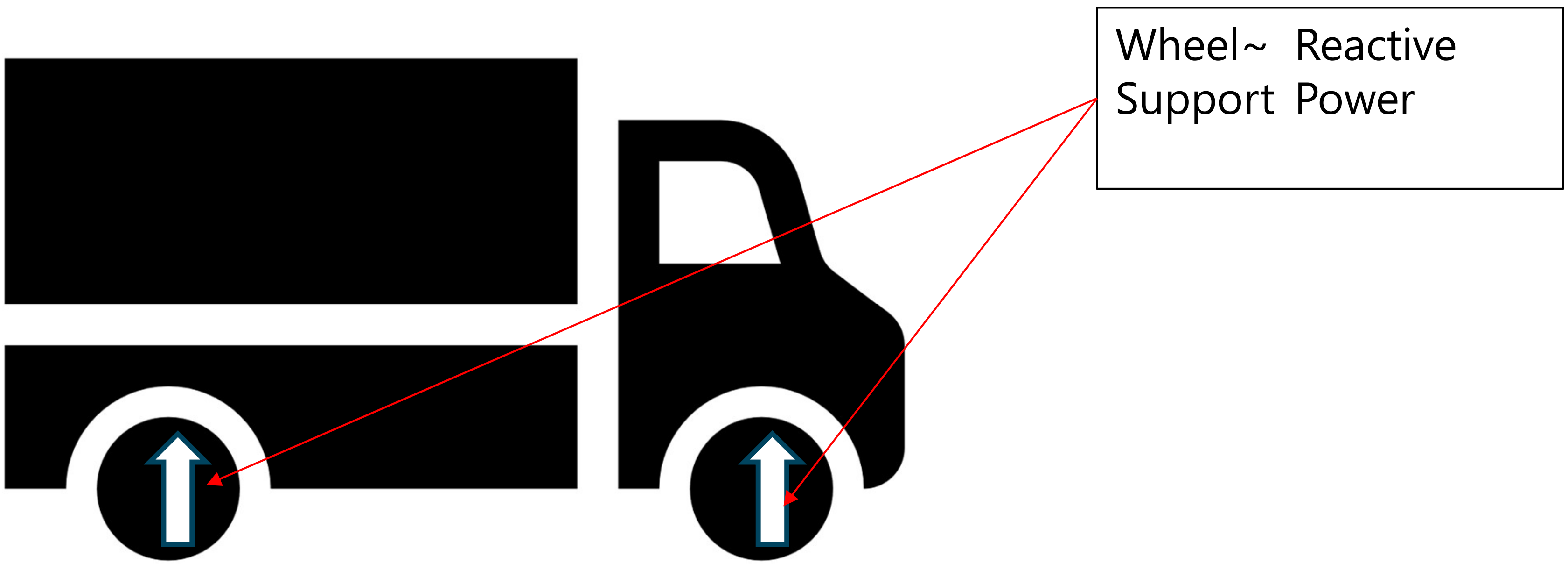
Momentum~Inertia

Wheel~ Reactive Support Power

Brake and accelerator pedal ⟷ Governor

System Strength

Ancillary Services – System Support services



Ancillary Services Truck Analogy

Wheel~ Support

Reactive Power

Paid for by the regulator

Gold plated ?

Failed RITT?

Paid for by Generator/Developer

Ancillary Services Truck Analogy

Wheel ~ Support | Reactive Power

Paid for by Generator/Developer

Existing and proposed system support

Figure 1 – Western Victoria transmission network as at November 2018

Karadoc

Gannawarra (Battery)

Murra Warra

Bulgana

Ballarat (Battery)

Plus (NSW)

Buronga Sync con (Finley)

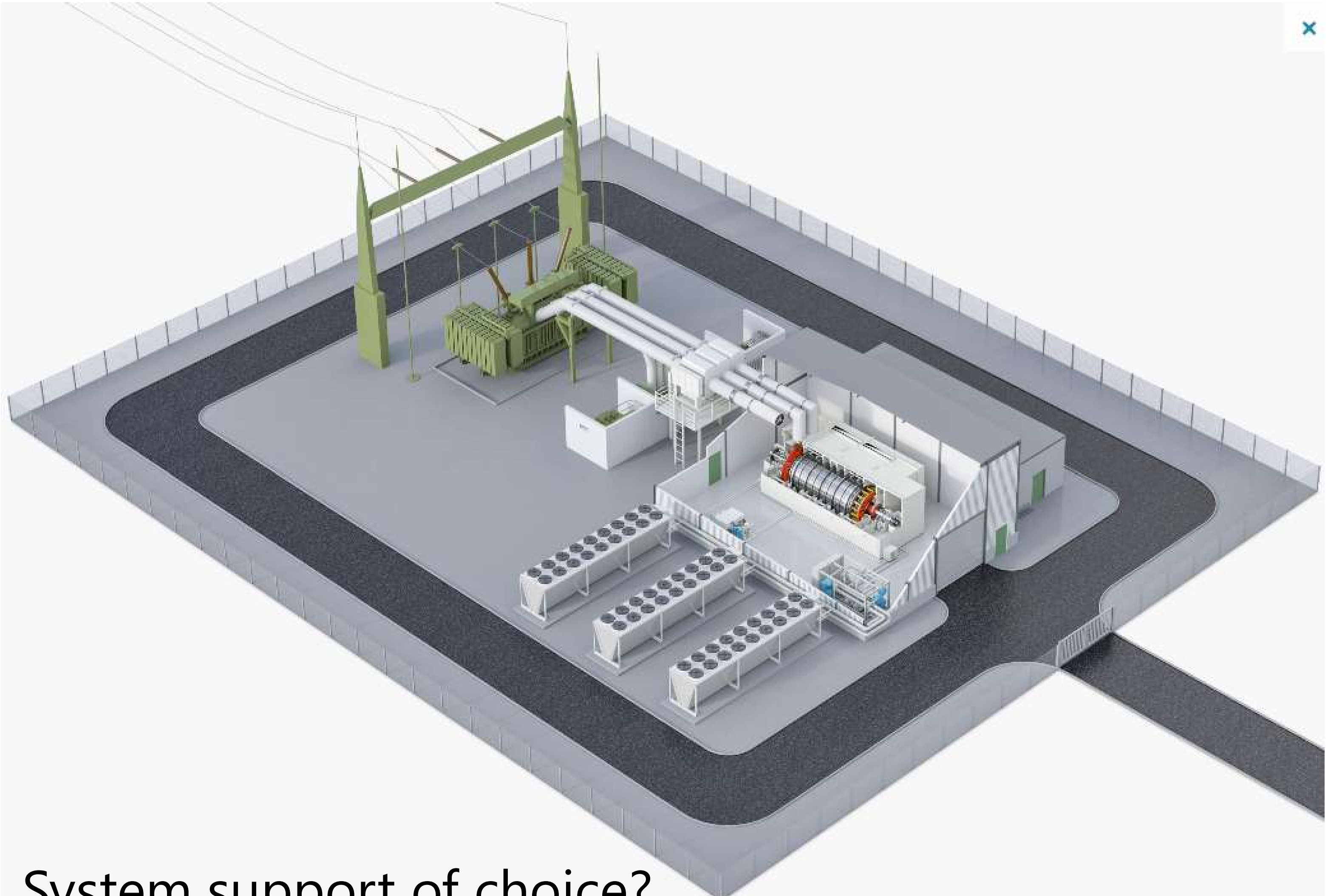
Silverton Broken Hill

SVCs at

Kerang

Horsham

Synchronous Condenser



System support of choice?

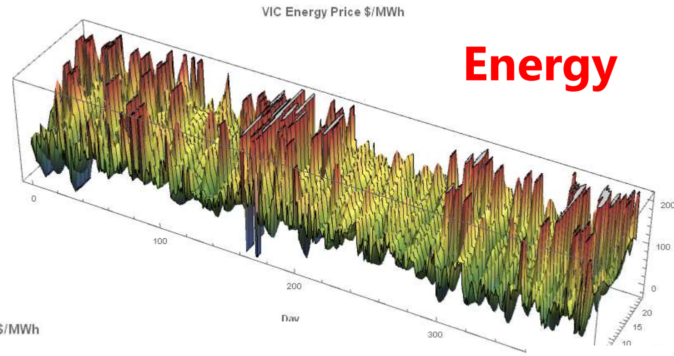
Existing and proposed system support

Most of this support is unnecessary
Counterproductive and costly

At best it is economically
Inefficient

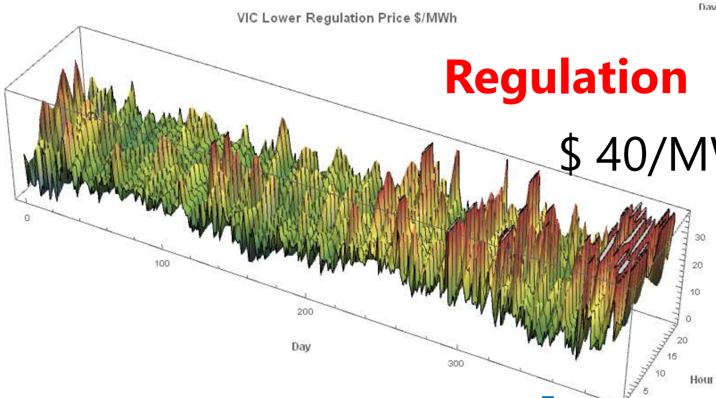
At worst - …………..

FCAS and Energy Prices - Victoria



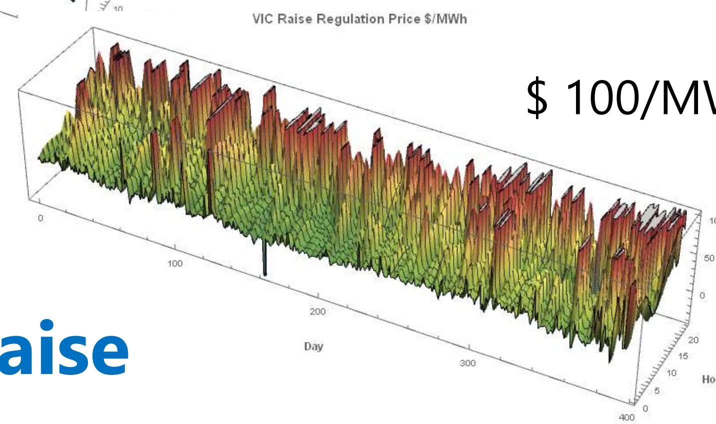
Energy

$ 300/MWh



Regulation

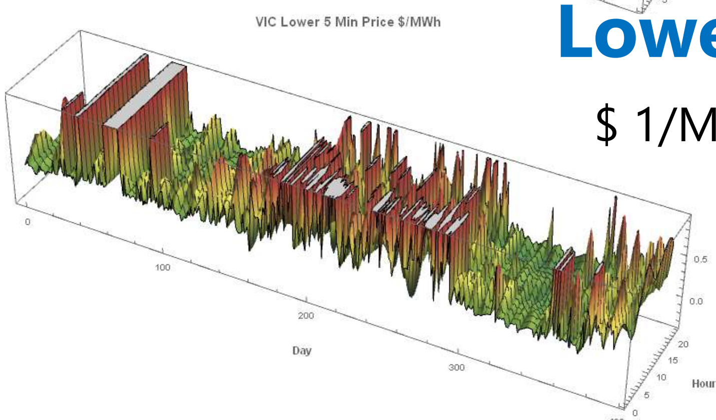
$ 40/MWh



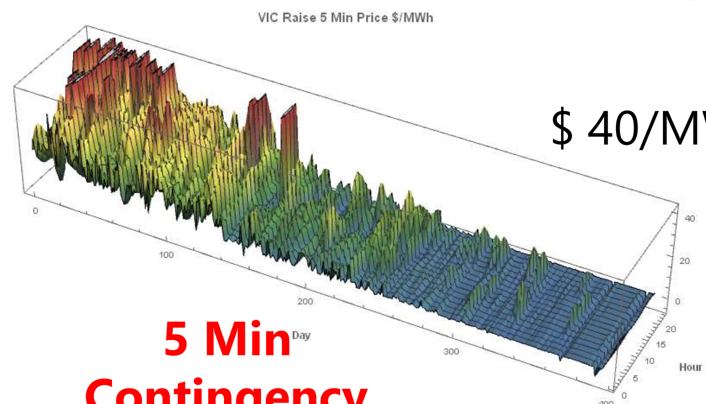
$ 100/MWh

Lower

Raise



$ 1/MWh



$ 40/MWh

5 Min Contingency

How many markets are there?

5 x Energy markets

Plus

5 x Raise Regulation

plus 5 x Lower regulation

Plus

3 x 5 x Lower Contingency

3 x 5 x Raise Contingency

= 45 Markets

Price	QLD	NSW	SA	VIC	TAS
Energy	$-41.82	$101.50	$91.66	$105.03	$104.38
Raise Reg	$17.79	$17.79	$17.79	$17.79	$17.79
Lower Reg	$45.73	$8.50	$8.50	$8.50	$8.50
Raise 6 sec	$10.00	$10.00	$10.00	$10.00	$10.00
Raise 60 sec	$5.89	$5.89	$5.89	$5.89	$2.75
Raise 5 min	$2.78	$2.78	$2.78	$2.78	$2.78
Lower 6 sec	$74.99	$0.00	$0.00	$0.00	$0.00
Lower 60 sec	$28.99	$0.03	$0.03	$0.03	$0.03
Lower 5 min	$37.30	$0.07	$0.07	$0.07	$0.07

How many markets are there?

45 Markets

4 Components

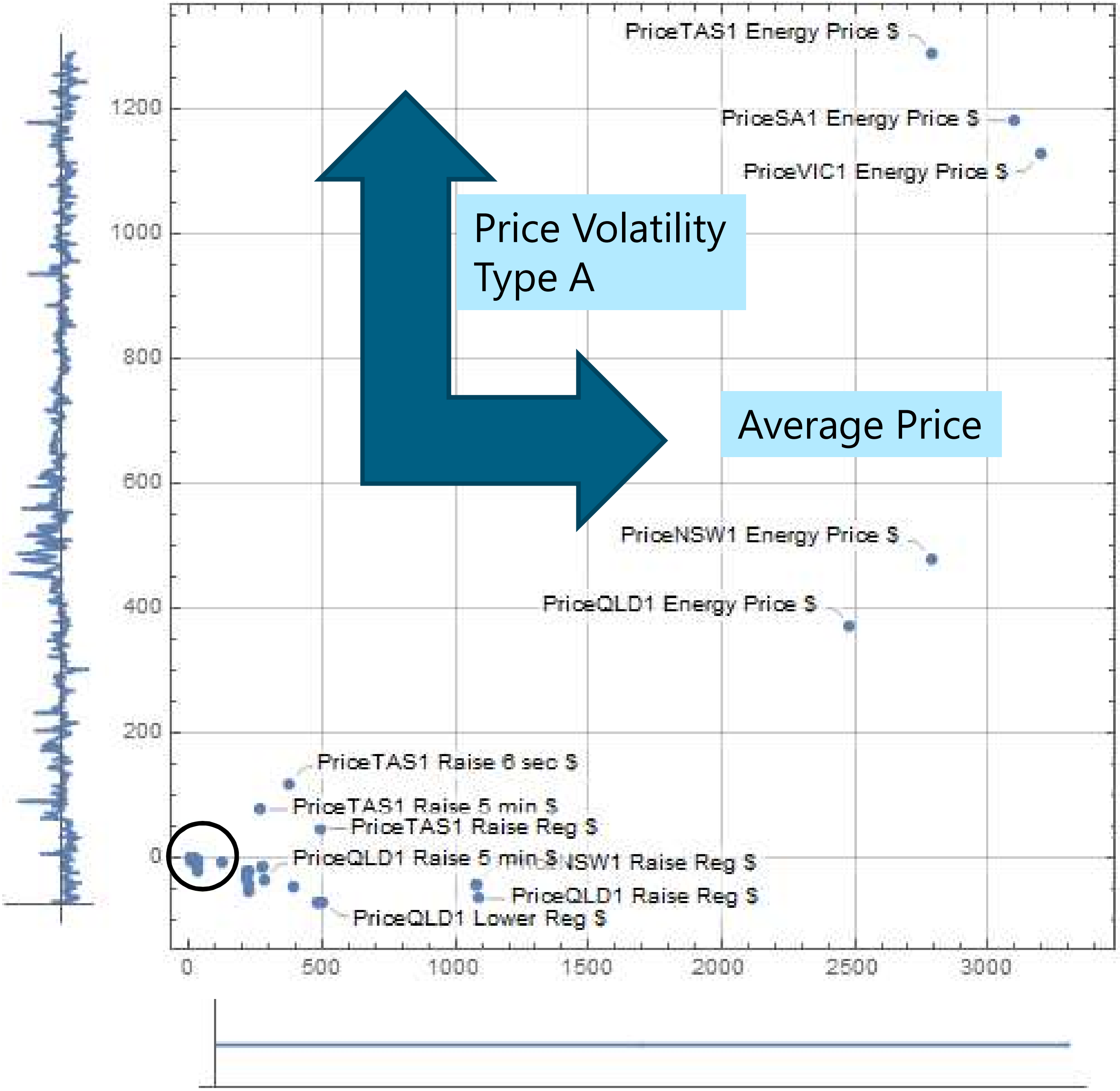
1 Average

2 Volatility A

3 Volatility B

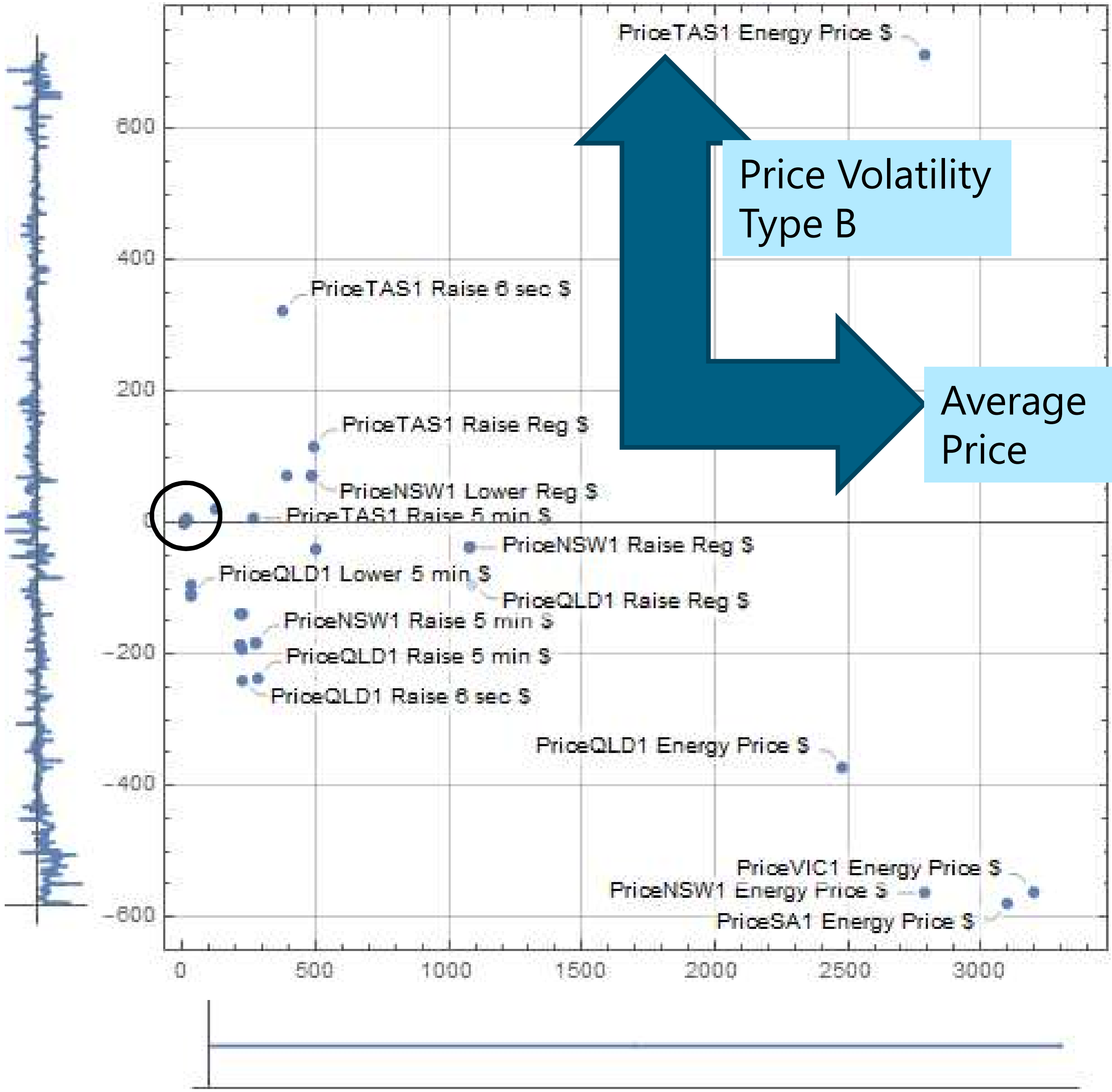
4 Volatility C

ICA Graphs



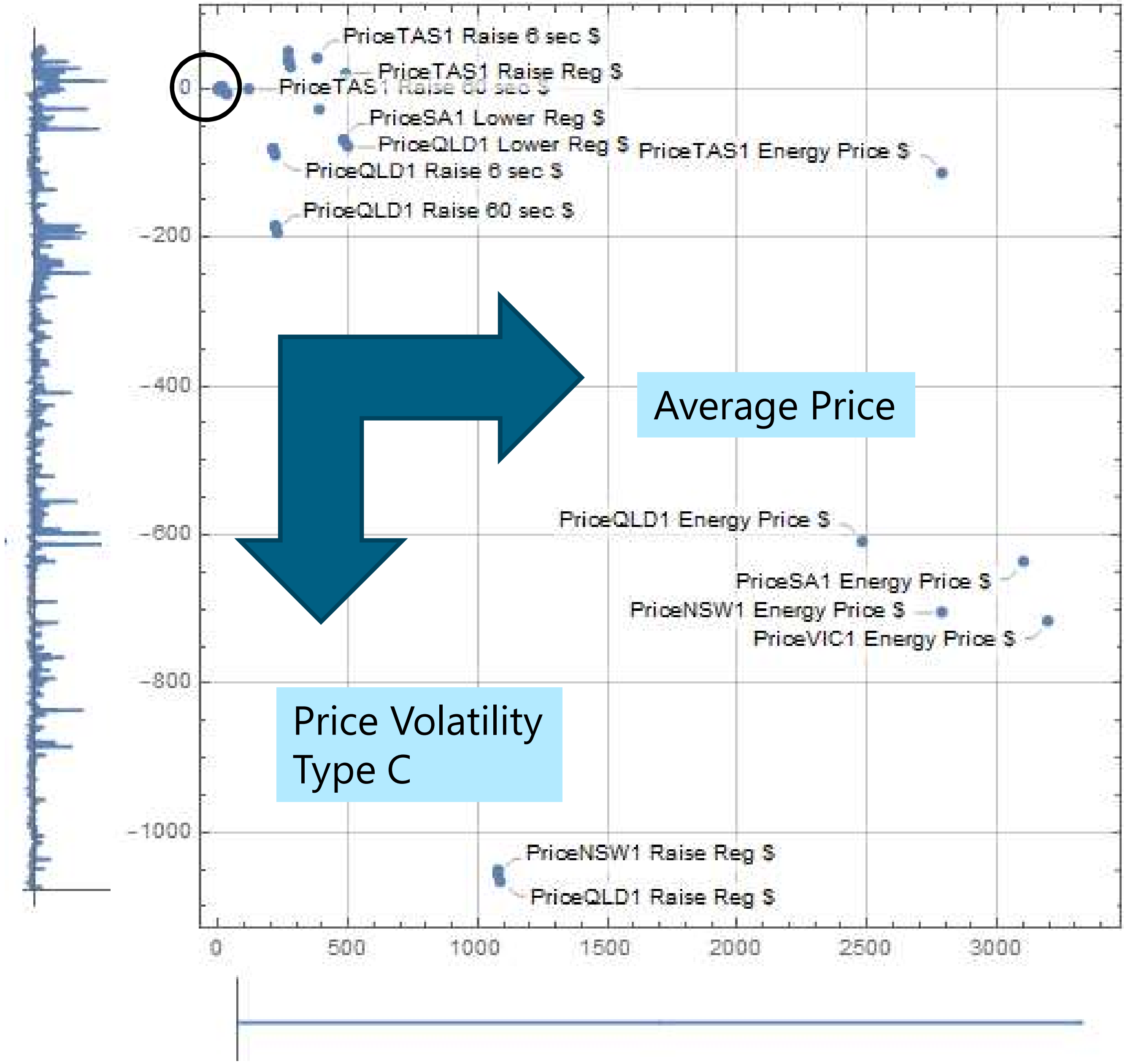
PriceTAS1 Energy Price $
PriceSA1 Energy Price $
PriceVIC1 Energy Price $
Price Volatility Type A
Average Price
PriceNSW1 Energy Price $
PriceQLD1 Energy Price $
PriceTAS1 Raise 6 sec $
PriceTAS1 Raise 5 min $
PriceTAS1 Raise Reg $
PriceQLD1 Raise 5 min $
NSW1 Raise Reg $
PriceQLD1 Raise Reg $
PriceQLD1 Lower Reg $
1200
1000
800
600
400
200
0
500
1000
1500
2000
2500
3000

ICA Graphs



PriceTAS1 Energy Price $
Price Volatility Type B
Average Price
PriceTAS1 Raise 6 sec $
PriceTAS1 Raise Reg $
PriceNSW1 Lower Reg $
PriceTAS1 Raise 5 min $
PriceNSW1 Raise Reg $
PriceQLD1 Lower 5 min $
PriceQLD1 Raise Reg $
PriceNSW1 Raise 5 min $
PriceQLD1 Raise 5 min $
PriceQLD1 Raise 6 sec $
PriceQLD1 Energy Price $
PriceVIC1 Energy Price $
PriceNSW1 Energy Price $
PriceSA1 Energy Price $
600
400
200
0
-200
-400
-600
0
500
1000
1500
2000
2500
3000

ICA Graphs



PriceTAS1 Raise 6 sec $
PriceTAS1 Raise Reg $
PriceTAS1 Raise 60 sec $
PriceSA1 Lower Reg $
PriceQLD1 Lower Reg $
PriceTAS1 Energy Price $
PriceQLD1 Raise 6 sec $
PriceQLD1 Raise 60 sec $
Average Price
PriceQLD1 Energy Price $
PriceSA1 Energy Price $
PriceNSW1 Energy Price $
PriceVIC1 Energy Price $
Price Volatility
Type C
PriceNSW1 Raise Reg $
PriceQLD1 Raise Reg $
0
-200
-400
-600
-800
-1000
500
1000
1500
2000
2500
3000

FCAS Markets

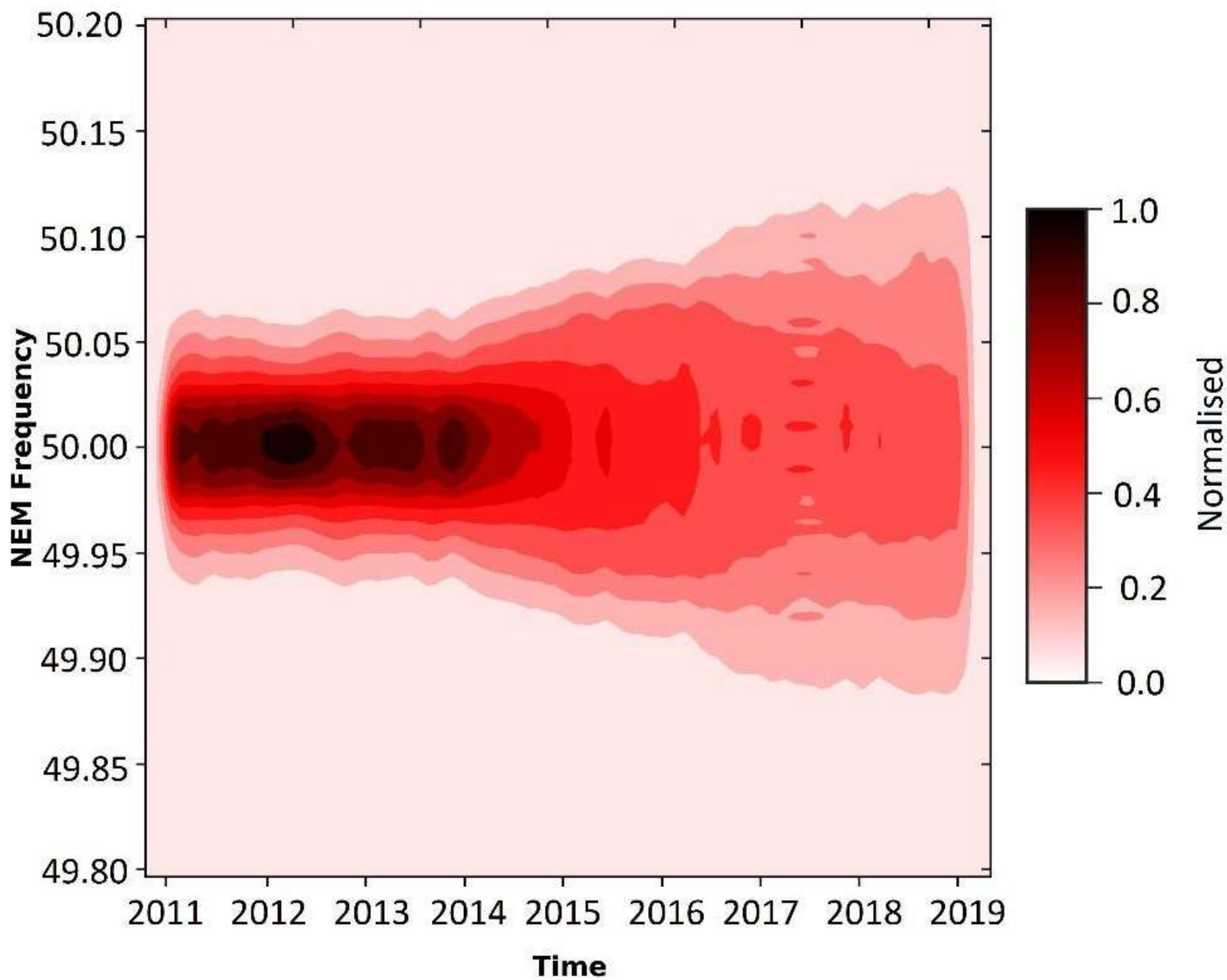
The preceding analysis indicates that

- At least for merchant markets (i.e. not PPA)
  - there are limited opportunities in the FCAS markets
  - you might as well concentrate on the energy markets

  - Leave frequency control to someone else

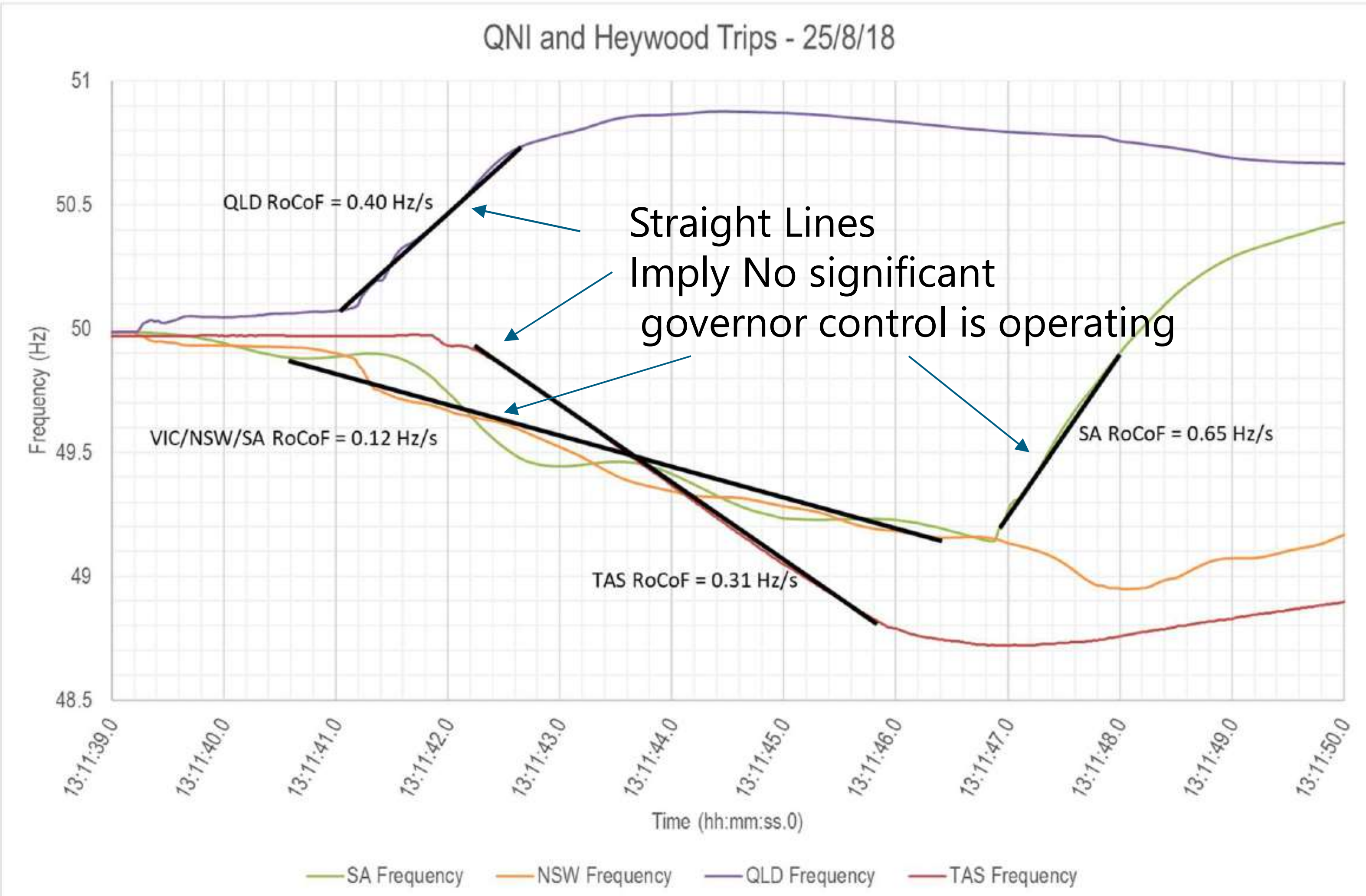
- The next slides show what the outcome of that strategy is

FCAS Markets



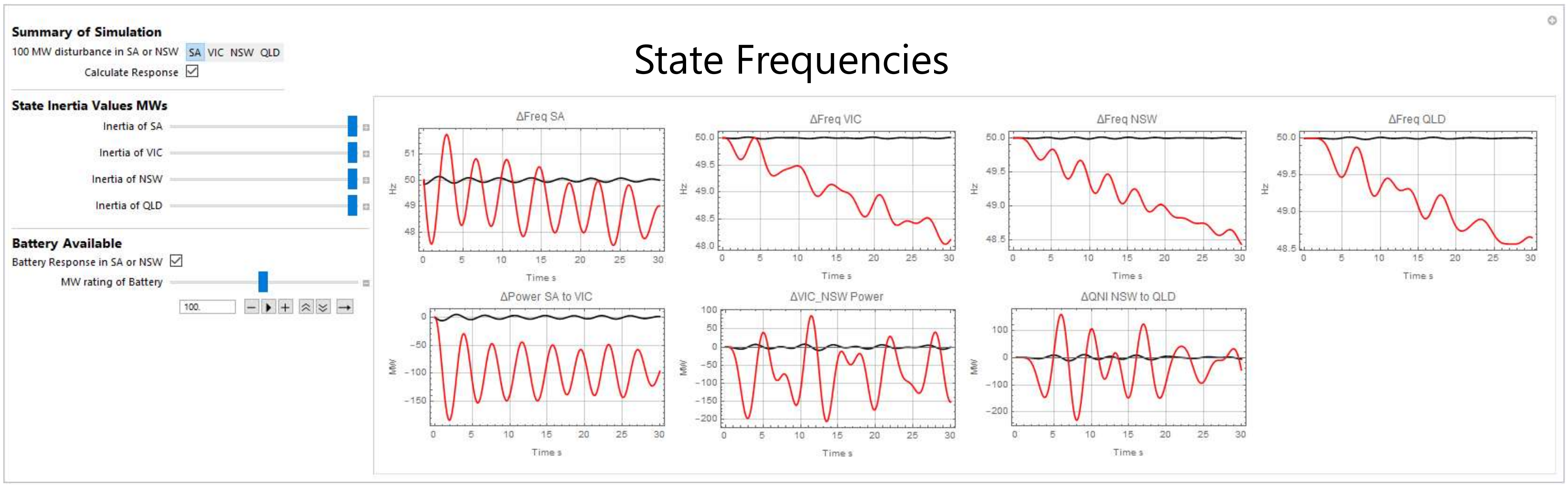
FCAS Markets

Figure 13 Regional Frequencies and RoCoF during the event



Alternative Directions

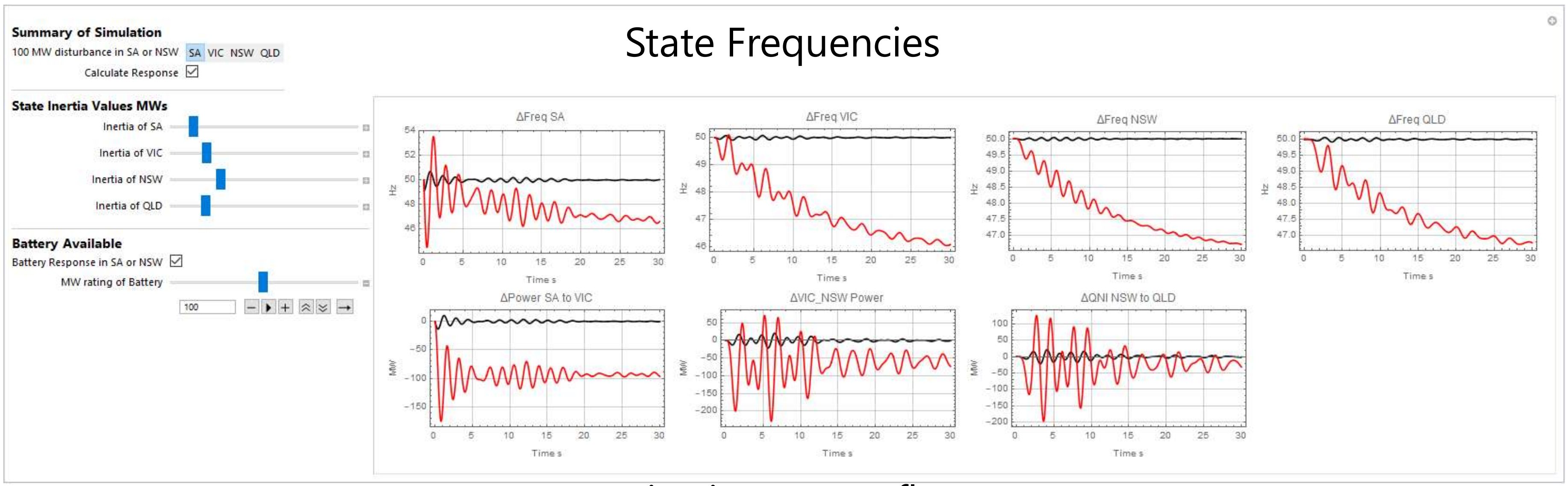
100 MW Disturbance in SA
100 MW Step up Inverter response in SA at t = 40 ms



Tie Line Power flows

Heavy Inertia

100 MW Disturbance in SA
100 MW Step up Inverter response in SA at t = 40 ms



Tie Line Power flows

Light Inertia

Summary

System support requires planning and engineering – not ad-hoc solutions imposed on individual developers

The FCAS markets are not providing the necessary signals to keep the system frequency under control.

The entire system is at risk

The technology is available to fix these issues

why aren’t we rolling it out and using it correctly?

Advisian

WorleyParsons Group