Generator Performance Standards (GPS) review

Power and Water round two consultation workshop
26 June 2019

PowerWater

Workshop objective

- what PWC are now proposing for the GPS and why
- case studies and technical examples that illustrate the key concepts and address feedback.

1. Are the requirements of the proposed code amendments understood?
2. Having regard to the framework governing the Utilities Commission's approval of the code amendments, are any other viable options that Power and Water hasn't yet considered?

Agenda

1. Introduction
2. GPS review context
3. NEM comparison and evolving NEM lessons
4. Q&A on GPS review context

- Lunch -

5. Power and Water's approach
6. Reactive power
7. Requirement for C-FCAS capability
8. Requirement for capacity forecasting
9. Approach to other issues
10. Wrap up

GPS review context

Jodi Triggs & Peter Billing

PowerWater

What are the GPS?

What and why?

- Technical standards to ensure quality of supply for all system participants
- Keep the lights on and protect equipment connected to the system

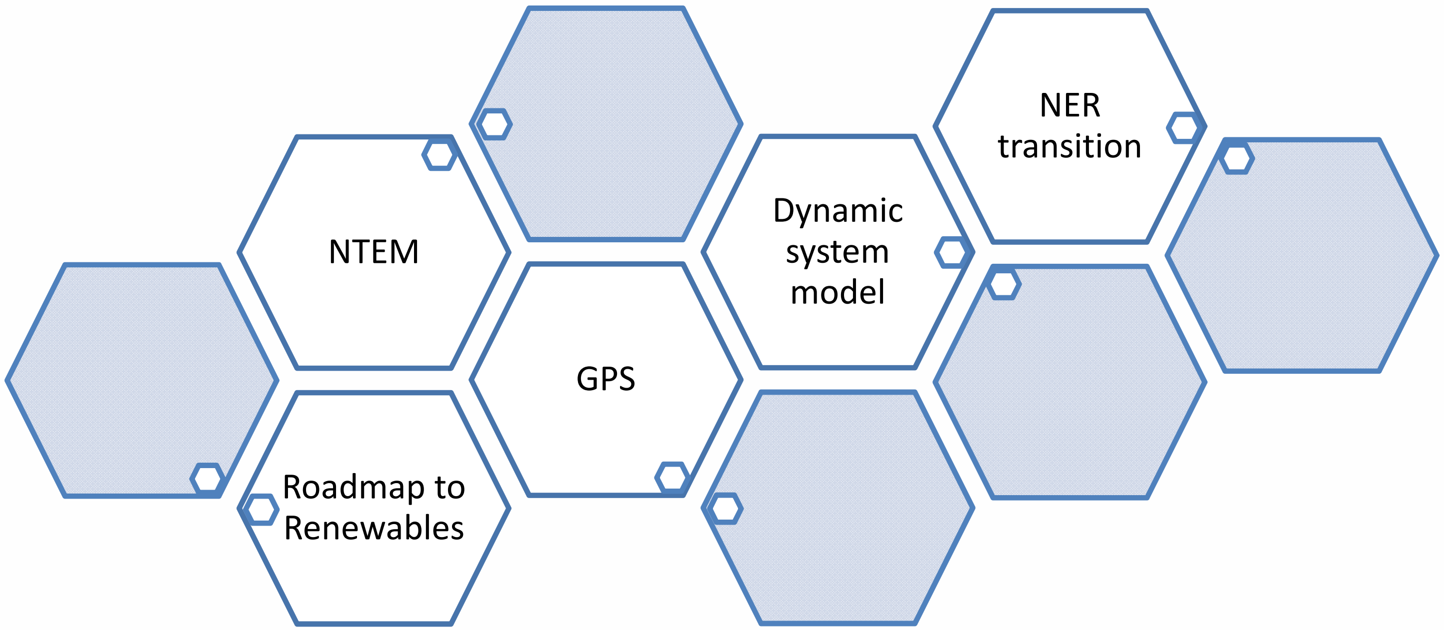
How?

- Generator connection and performance requirements

Why is this review so important?

- System is already fragile
- Large amounts of new variable asynchronous generation will exacerbate existing system security challenges

How do they fit in?



GPS and NTEM workstreams

	Purpose	NT Region Application	Regulatory Instrument
GPS Workstream	Capability requirements for connection	All	NTC until full NT NER Chapter 5 adoption
NTEM Workstream	Energy and Ancillary services market design and operation	DKIS only	SCTC (NT equivalent function NER Chapter 3)
System Security	Maintaining power system security at most efficient cost	All	SCTC (NT equivalent function NER Chapter 4) In the DKIS the AS price will be informed by NTEM workstream. Other regions – BAU.

DKIS = Darwin-Katherine Interconnected System
NTC = Network Technical Code
SCTC = System Control Technical Code
SCED – Security constrained economic dispatch

NT key differences to the NEM

Scale

The Territory systems are small so there is higher risk and less room to change if the frameworks aren't right.

No ancillary service market

There is currently no market for power system security services (ancillary services) in the Darwin to Katherine Interconnected System (DKIS). There will be no ancillary services market in the foreseeable future in the Alice Springs or Tennant Creek systems.

No interconnection to other geographically diverse markets

Limited renewable technology diversity

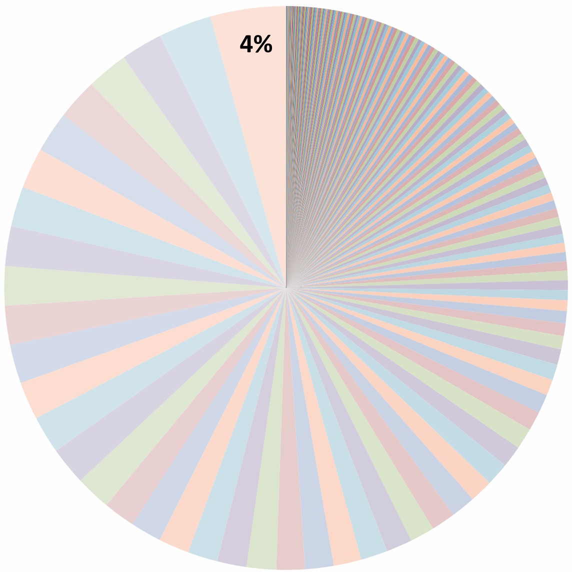
The current pipeline of renewable (RE) technology is PV so there is limited diversity in energy source.

Limited energy storage solutions

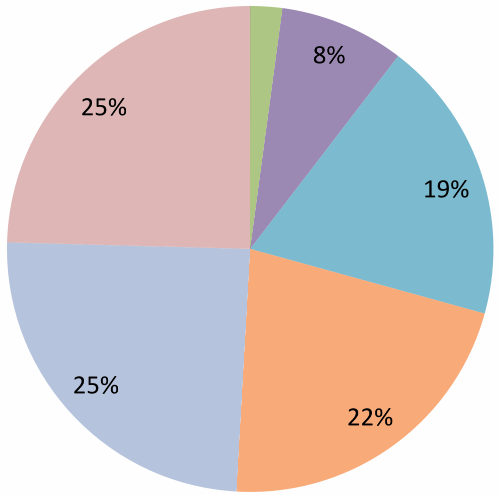
Current costs and physical practicalities including scale and terrain does not lend itself to long term energy storage technologies in the short to medium term.

NTEM vs NEM scale

NEM load sharing by generator

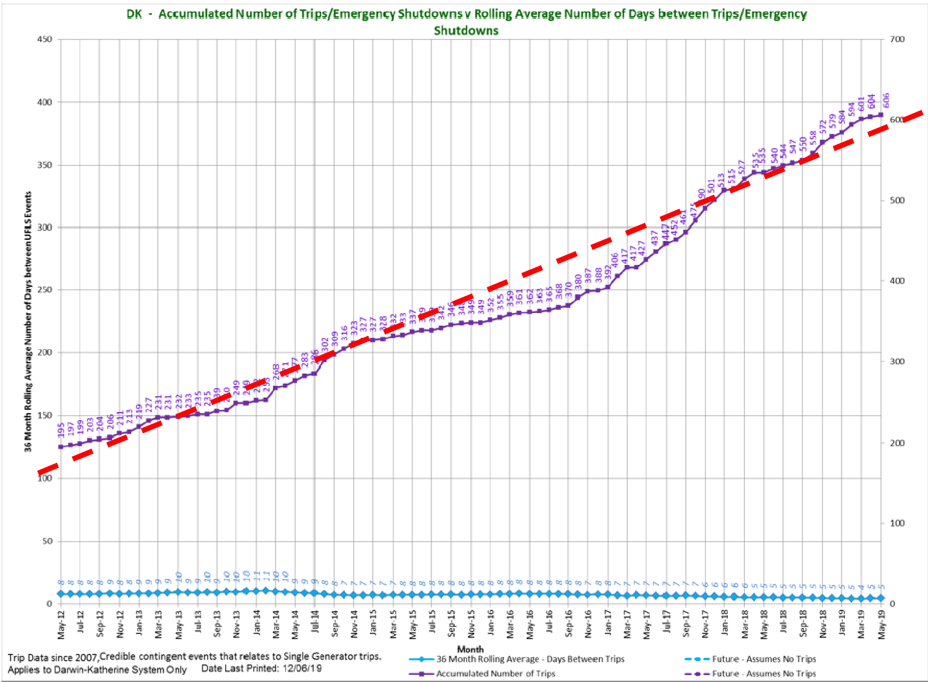


NT load sharing by generator



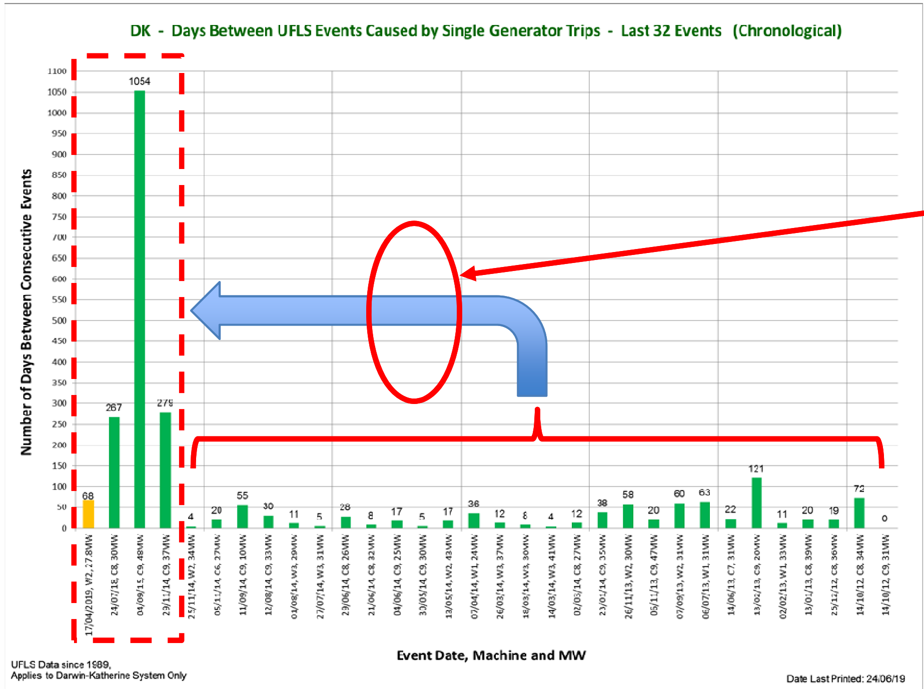
…. 1 generator tripping is significant for us

Fragility … generator trips are an ongoing credible contingency



….the underlying single generator trip frequency is largely unchanged at 5 – 10 days apart…..

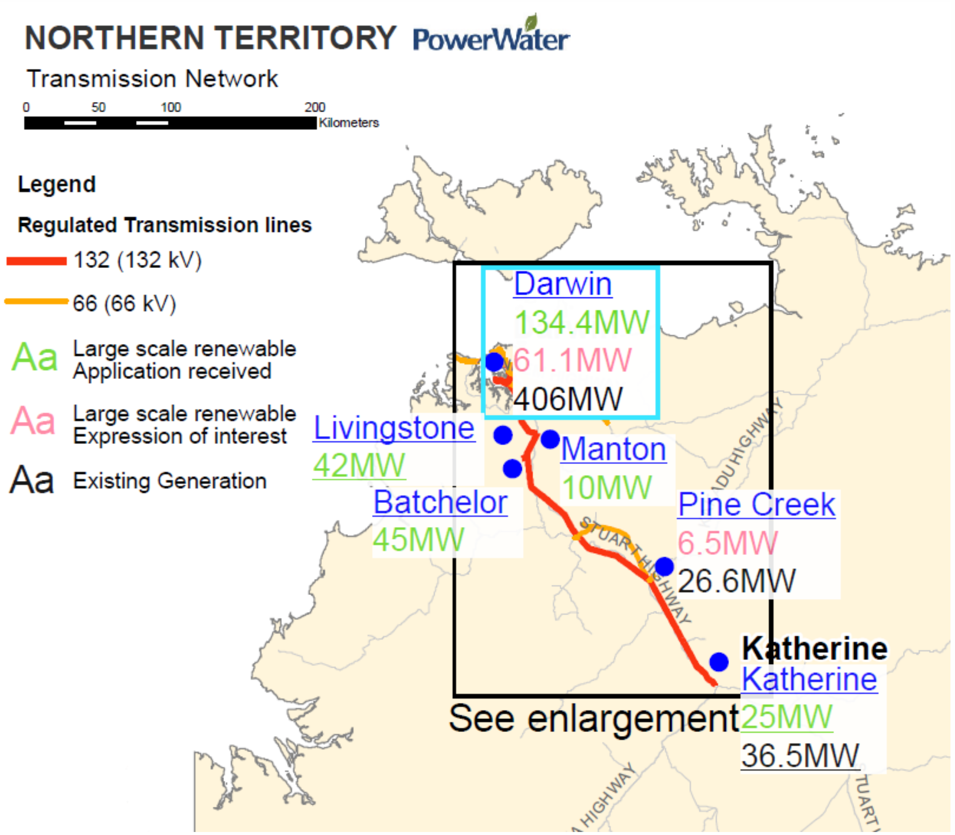
…changes to ancillary services policy reduced customer load shedding…for now



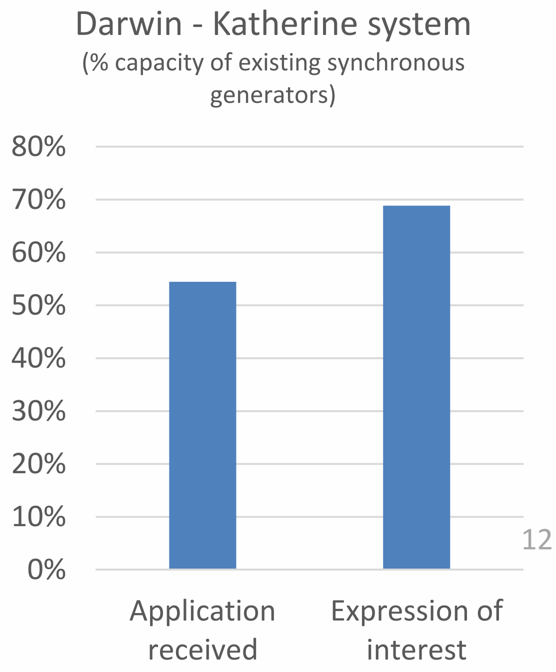
Changes to Spinning Reserve and Minimum Inertia Policy in 2014 reduced the frequency of load shedding events

…. reduced consequence but not frequency of events

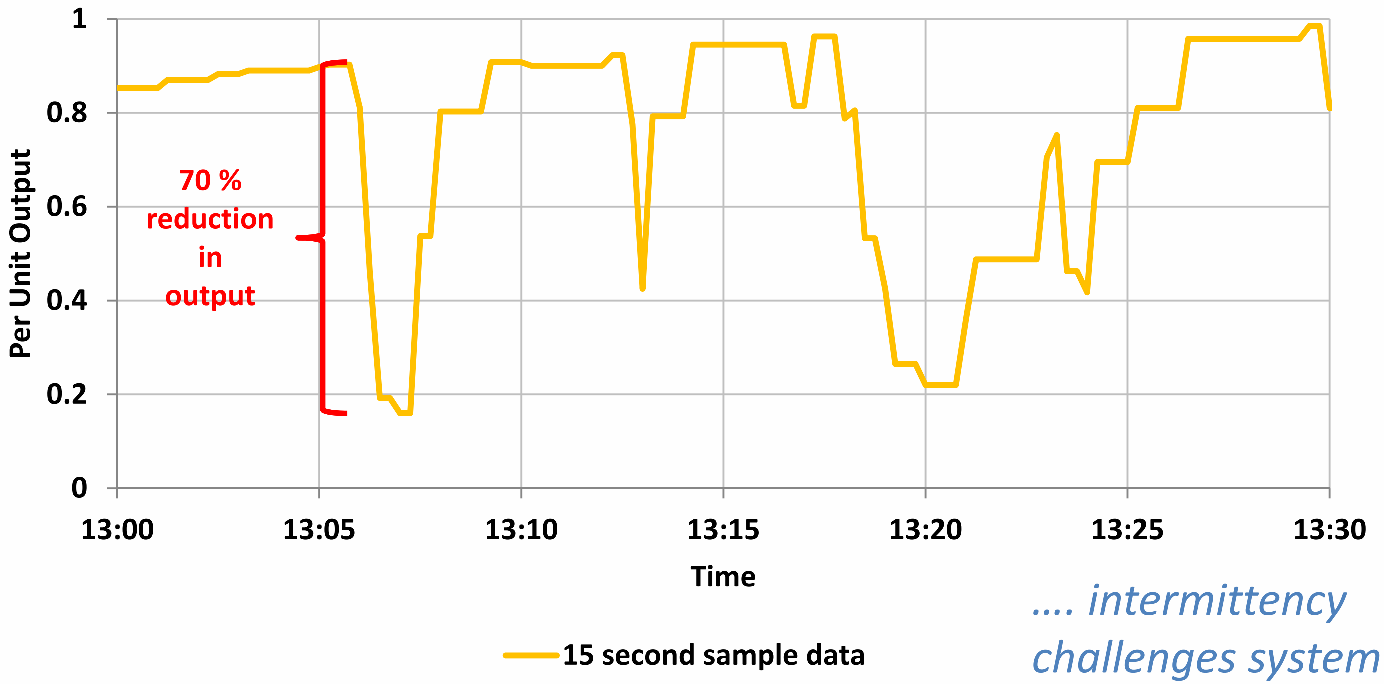
Need for change



.... scale & location both pose security challenges

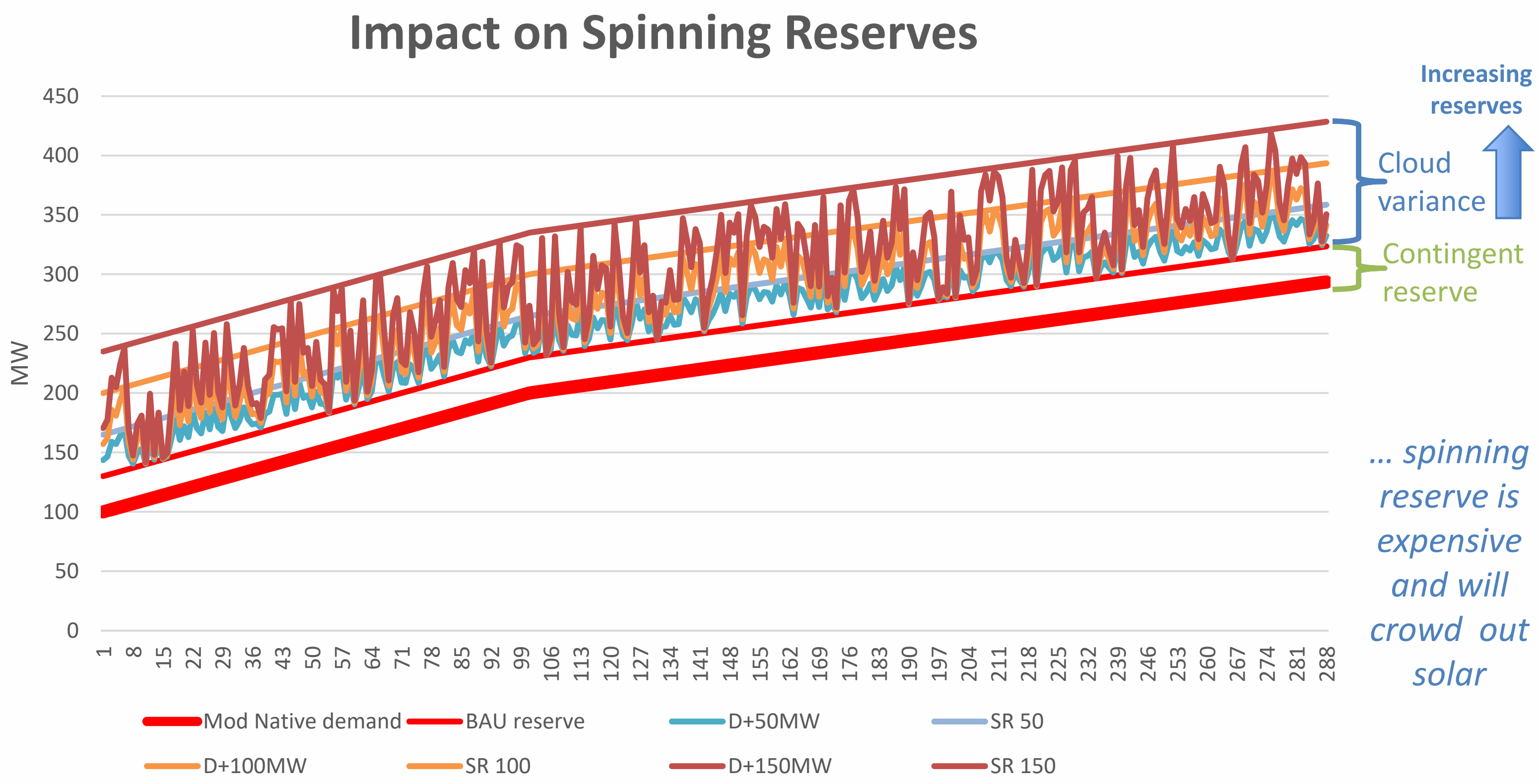


Non firm solar generation creates volatility in the supply / demand balance....



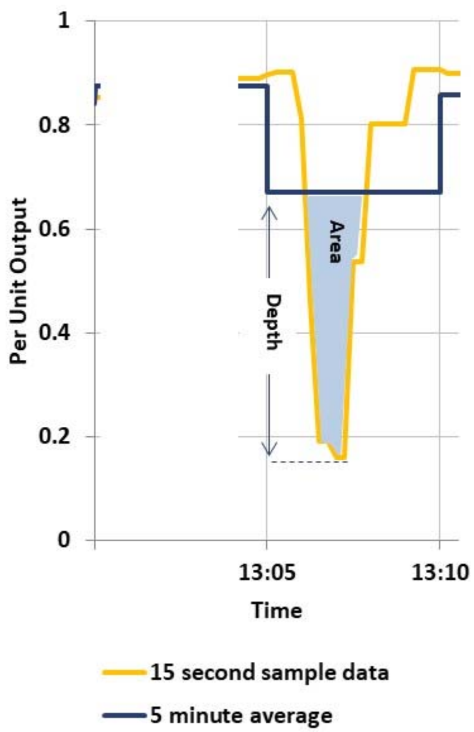
.... intermittency challenges system security

Illustrative impacts.....



... spinning reserve is expensive and will crowd out solar

Controllability



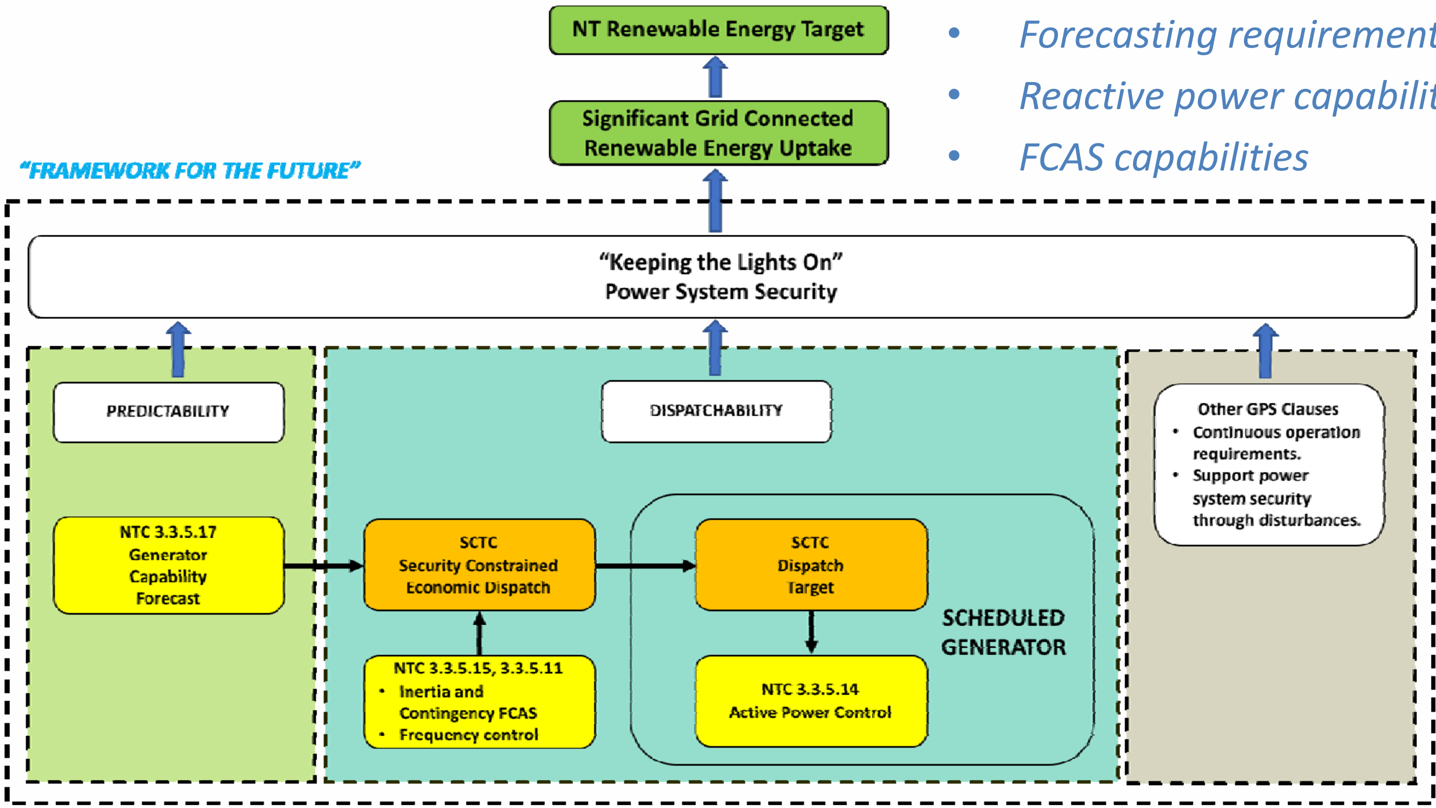
- DKIS has >50 MW of rooftop solar
  - Rooftop PV output varies in short periods of time (seconds to a few minutes)
  - Presents significant challenges for System Control to securely manage the system
  - Separate project addressing this issue
- This could substantially worsen as more solar farms are connected

…. hence our focus on solar farms providing capacity forecasts, firm offers, and firming their 5 minute production to reduce short term swings.

GPS "Framework for the Future"

What is changing?

- *Forecasting requirements*
- *Reactive power capabilities*
- *FCAS capabilities*



NEM comparison & lessons

David Swift

PowerWater

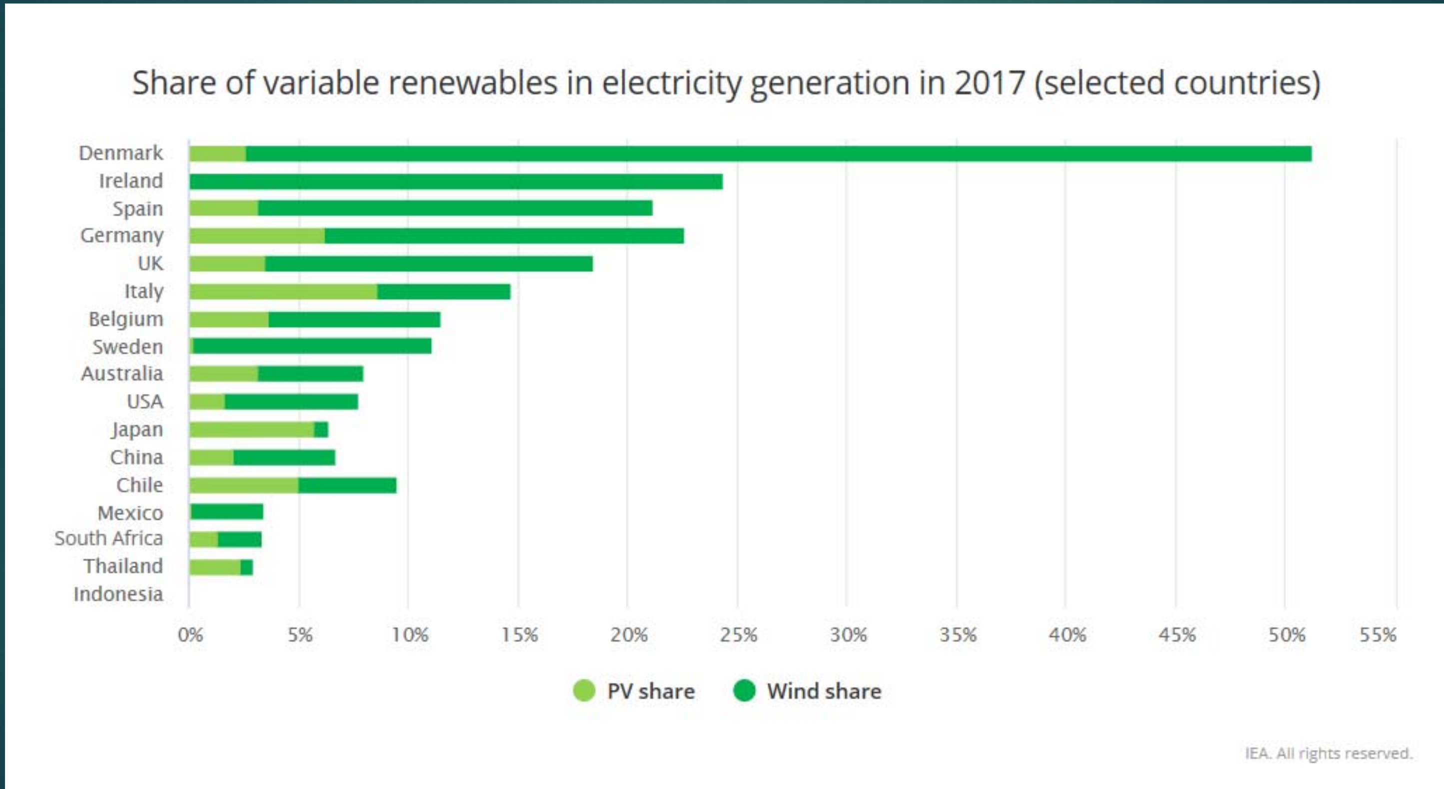
Lessons from the NEM

DAVID SWIFT

Scope

- Issues - the emerging asynchronous renewable energy integration issues affecting the NEM and international markets
- Tools/remedies - the existing and emerging tools and mechanisms for addressing these issues, including GPS
- Lessons - the lessons being considered about how the NEM may need to operate in future
- Insights for the NT - the comparative circumstances in the NT and implication of these circumstances for the tools and mechanisms that may be fit for purpose in the NT

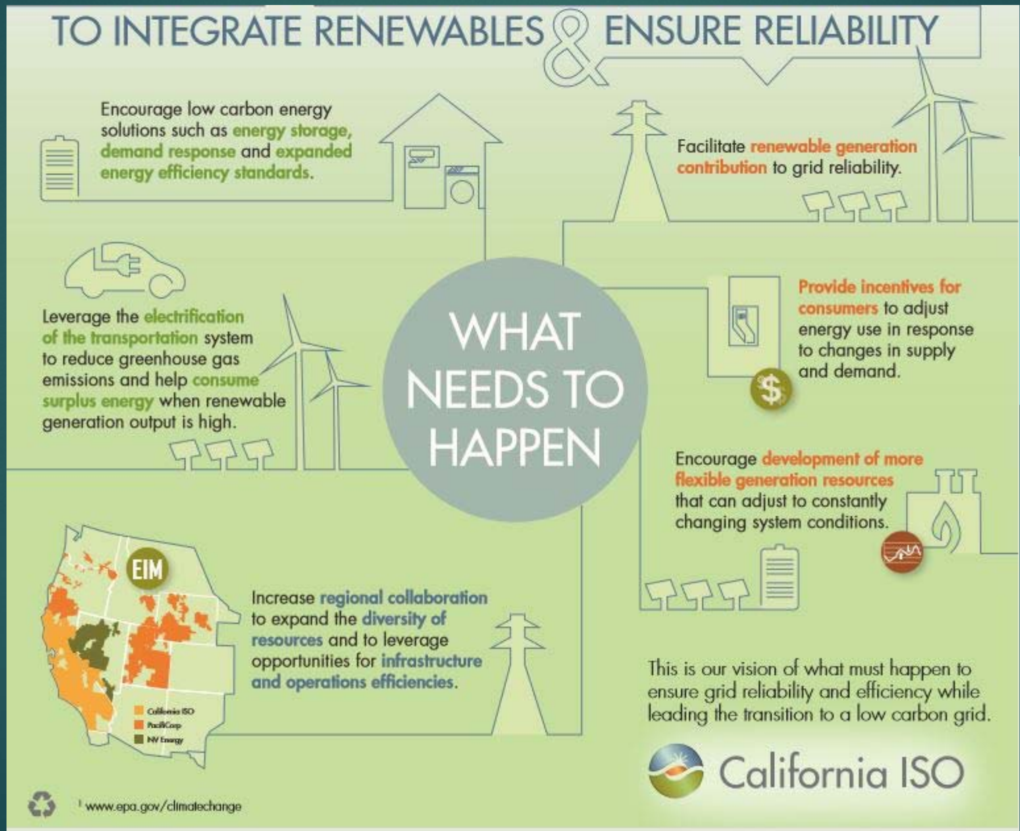
IEA Classifications



Experience with high levels of variable renewable energy (VRE)

- While a number of jurisdictions have committed to high renewable energy targets, there is little experience at high levels of VRE
- Denmark is currently close to 50% VRE. VRE in Denmark is predominately wind generation and Denmark is closely interconnected to Germany and Scandinavia
- Ireland is only at 25% but has a very active program to ensure the integration of renewables while maintaining security.
- Supply in California currently includes approximately 20% VRE
- The NEM is well down the list but growing fast – expected to reach 15% soon. South Australia taken by itself is similar to Denmark

California ISO actions



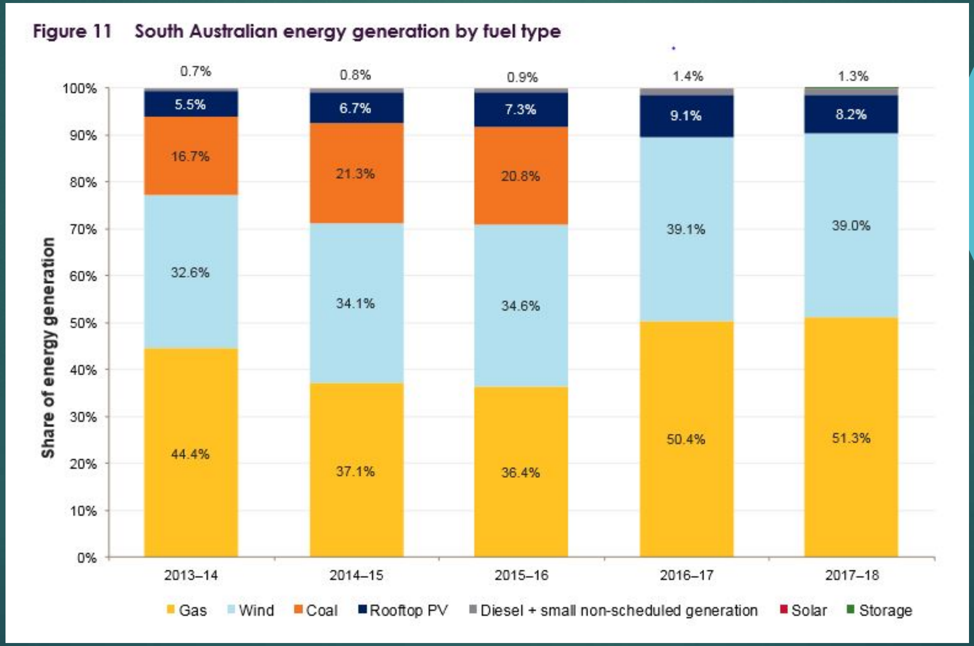
Some International markets taking action to integrate renewables

- California
- Northeast USA (PJM)
- Europe (European standard market design)
- United Kingdom (National Grid)
- Ireland
- Texas (ERCOT)
- Hawai

Experience with utility scale variable renewable resources in SA

- SA has the highest proportion of VRE in the NEM
- At June 2018, SA had 1809 MW of wind generation providing 39% of generation in the region (despite constraints). A further 245 MWs is coming online
- SA has had the highest generator performance standards in the NEM since 2006
- AEMO regularly has to intervene and force on additional synchronous (gas fired) generation to maintain system strength. This also often requires curtailment of renewable generation or increased exports
- Syncons will be commissioned in 2020 to improve system strength and increase inertia
- The interconnectors are critically important to SA with nominal capacity of 650/500 MWs on Heywood and 220 MW on Murraylink.
- SA has 130 MW of battery storage online and 210 MW of fast start (reciprocating) generation coming online

Generation mix in SA



Solar PV in SA

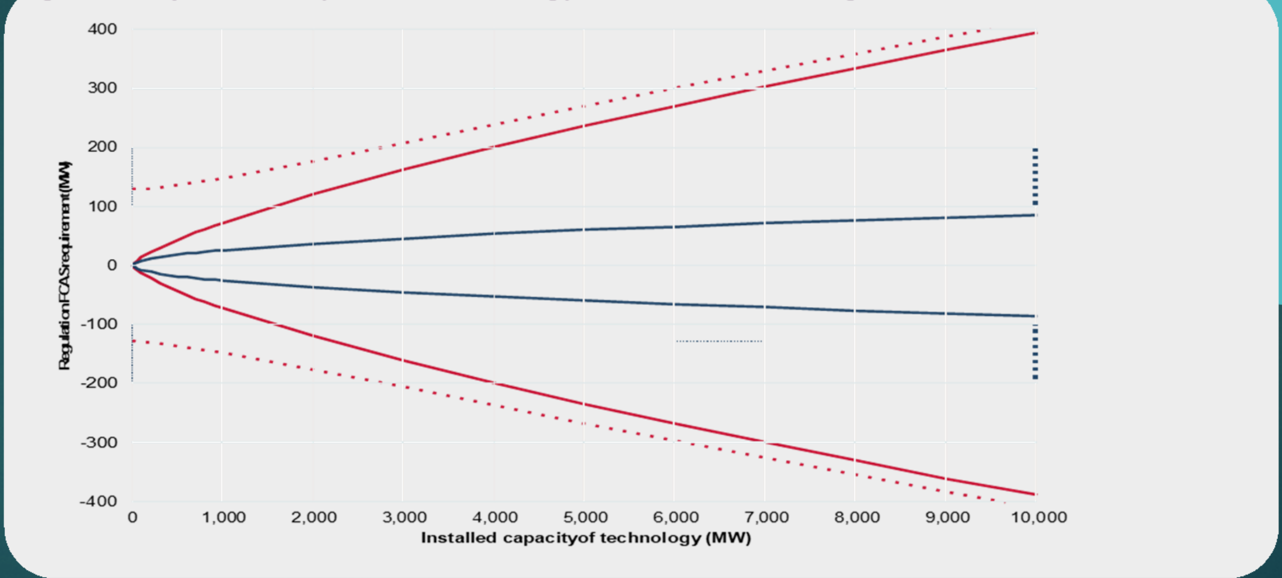
In 2017/18 in South Australia:

- The greater proportion of renewable energy is wind generation
- There is only 135 MW of utility scale solar (recently commissioned) and a further 205 MWs is coming online
- SA has a relatively high penetration of rooftop solar with over 800 MWs installed
  - Rooftop PV has moved the time of peak grid demand to 7.30 pm Adelaide time
  - Rooftop PV also reduced the minimum operational demand, with a minimum demand of 645.6 MW recorded at 1:30 pm in 2017-18. Periods of negative demand are forecast by 2023-24.
- In total, solar PV is currently providing 8.7% of underlying demand in SA

Projected requirements for frequency control in the NEM

- Variability of solar compared to wind drives greater need for more frequency control resources

Figure 32 Projected FCAS requirements for increasing penetration of solar and wind generation



Integrated system plan

- AEMO produced the first Integrated System Plan (ISP) for the NEM in 2018
- Provided an outlook for the development of the power system and grid as ageing coal fired generators are expected to retire and be replaced by renewable generation – wind and solar
- ISP showed that the solution to integrate higher levels of VRE in the system was:
  - Utilise existing conventional generation
  - Increase interconnection
  - Take advantage of diversity
  - Invest in storage – particularly pumped hydro storage

Maintaining a secure power system

- Delivering and maintaining a secure power system requires ongoing attention to a number of areas including:
  - Generator connection requirements
  - Network development
  - Compliance by all parties
  - Ancillary services and network control services
  - Dispatch, monitoring and operational management
- System security and reliability cannot be efficiently maintained in real time without having the right mix of resources and capabilities available

Connection standards and issues in the NEM

- National standards are now tighter and parties seeking to connect in a number of sub-regions, including Western Victoria, Southern NSW and Queensland, now face challenges especially in regard to:
  - System strength
  - Power quality
  - Emerging network constraints
  - Falling marginal loss factors
- Allowing early generators to connect with lower performance has caused barriers to later connections

Ancillary services

- The future of ancillary services – or I prefer to call them system services – is under review in the NEM
- The current arrangements are complex.
  - Frequency control is delivered by 8 co-optimized spot markets for regulating and contingent services.
  - Supplemented by a range of non-market ancillary services
- However the current arrangements are incomplete:
  - Frequency control is poor and the NEM has residual issues with system strength and, under certain conditions, voltage control
  - Causer pays only applies to regulating FCAS and is under review

Developments in the NEM

- There are many reviews currently underway in the NEM, including a full work program on security and reliability related matters.
- These include:
  - Lowering the generator registration thresholds
  - Short term forecasting by semi-scheduled generators
  - Frequency frameworks review
  - Enhancing use of demand side management
  - Virtual power plant trials
  - ....
- ESB is undertaking a broader review of the post 2025 market

Lessons for NT

- The NT system is quickly moving to the leading edge of world experience with high levels of VRE.
- That VRE is likely to be dominated by solar PV, which is the most variable.
- NT systems are islands (unable to draw on external support) and there is no known potential for pumped hydro storage. These are important in many international examples with high VRE.
- Efficiently maintaining security and reliability requires end-to-end attention – from the generator performance standards through to the market arrangements.
  - Need to balance use of regulation and standards with financial incentives
  - Recognise that the scale of the NT systems make it difficult to justify the cost and complexity of the systems operated by AEMO and other leading International operators

Lessons for NT – The positives

- **Gas** - Gas plant provides relatively flexible plant
- Renewable energy costs continue to fall
- Battery storage costs also falling
- Worldwide and national attention to developing the technical solutions required
- Internet of things provides the opportunity to efficiently coordinate the use of distributed energy resources

Proposed arrangements

- Generator performance standards deserve close consideration and are foundational to delivering an efficient and secure system
- Given the mix of plant expected, efficiently managing volatility in every timeframe will be important
- Different approaches are possible, but to minimize the overall costs to consumers, the arrangements need to:
  - Allocate risks where they can be best managed and provide the right incentives to minimize overall costs
  - Minimise the need for responsive plant
  - Ensure the resources are available to provide the necessary services
  - Efficiently dispatch resources
- Arrangements need to be put in place early to avoid high barriers to entry to further generation

GPS review context & challenges

Q&A

PowerWater


Our approach to this GPS review
Jodi Triggs
PowerWater
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Our approach

Legislative requirements	What governs code changes?						
Evidence	System context	Technology context					
Inputs	System Control role	Policy direction	Scenarios	Stakeholder feedback	Vendor discussions	Verifier review	NEM experience

Legislative requirements

Utilities Commission Act

Commission must have regard to the need:

a) to promote competitive and fair market conduct

b) to prevent misuse of monopoly or market power

c) to facilitate entry into relevant markets;

d) to promote economic efficiency

e) to ensure consumers benefit from competition and efficiency

f) to protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries

… PWC doesn't have unfettered discretion in how it designs the code amendments. We must satisfy the UC.

a) technology agnostic to not create market power or raise costs for subsequent renewable generators

b) grandfathering shouldn't create market power

c) long term "no regrets" view that establishes "Framework for the Future" energy market

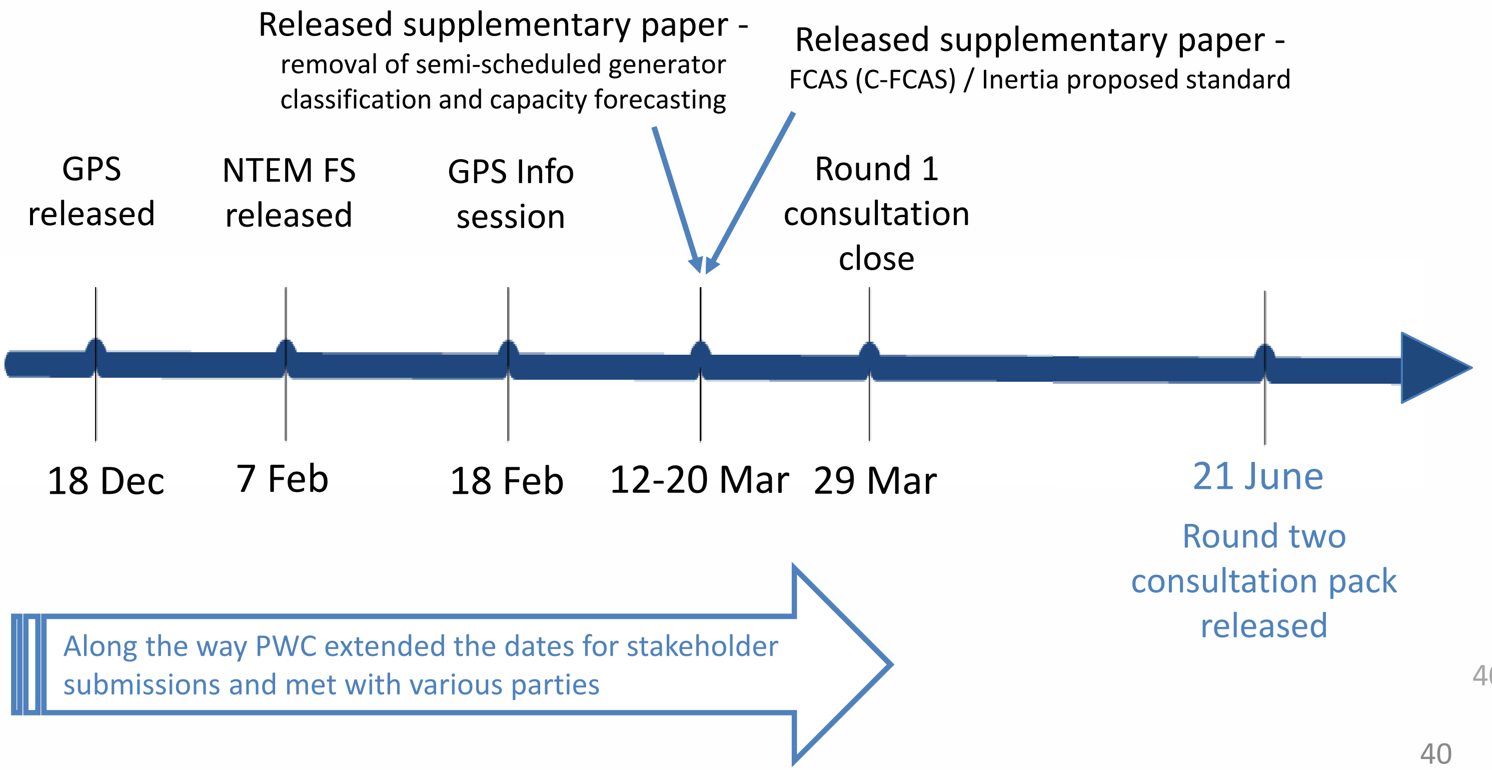
d) support efficiency through:

- lowest total cost of reliably providing energy whilst facilitating the connection of asynchronous energy
- assessing cost trade-offs between GPS, ancillary services and network investment
- placing risk with those best able to manage it

e) facilitate renewable generation entry in a manner that minimises the total cost

f) keep the lights on while facilitating increased connection of asynchronous renewable energy and storage technologies.

Consultation process to date



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What we heard and did

Key issues

- Reactive power
- Removing semi scheduled generator classification
- C-FCAS capability
- Forecasting requirements
- Grandfathering

Explain

Test

Amend

Role of technical verifier

Verify capacity forecasting:

- technical feasibility of the forecasting requirement
- reasonableness of modelling approach, data and assumptions
- battery provision assumptions both technical and costing

Verifying technical feasibility and incremental cost to:

- achieve C-FCAS capability
- provide steady state and dynamic reactive power capability

Test

This further consultation

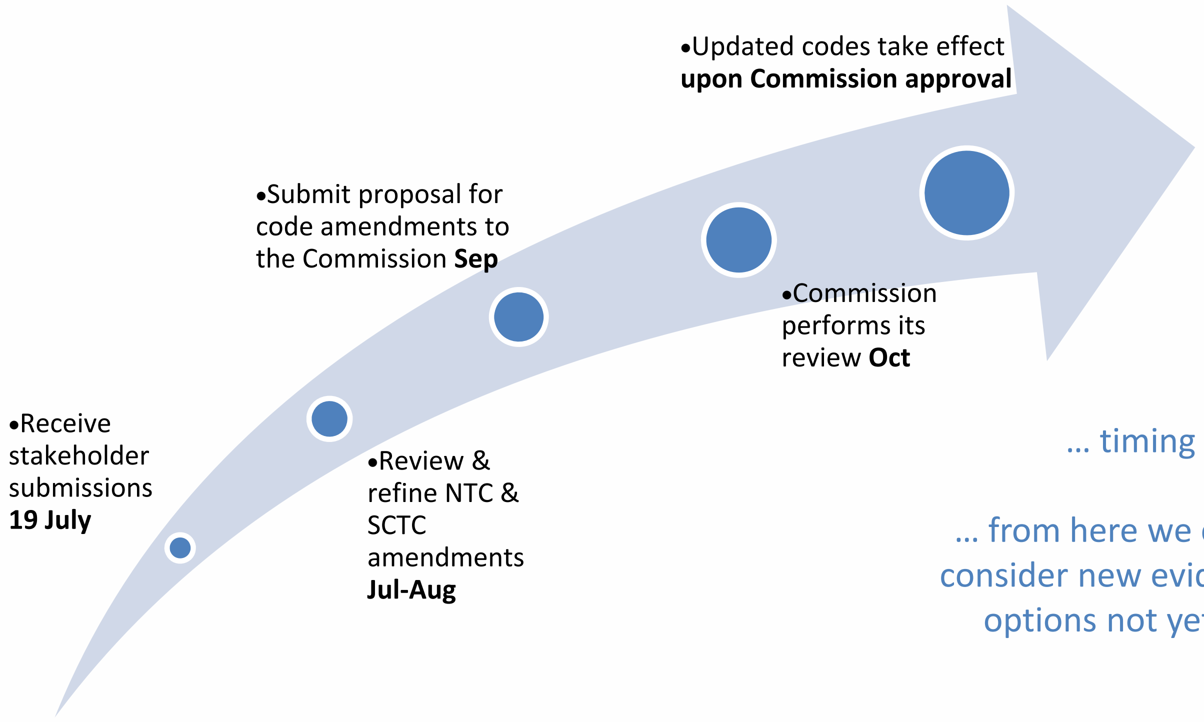
We have listened and refined

We now need to get these to the UC for timely approval

For this further consultation we want to test:

1. Are the requirements of the proposed code amendments understood?
2. Having regard to the framework governing the Utilities Commission’s approval of the code amendments, are any other viable options that Power and Water hasn’t yet considered?

Timeline to implementation



… timing is tight

… from here we can only really consider new evidence on viable options not yet considered

Reactive power & dynamic reactive capability

Sean Egan

PowerWater

Feedback

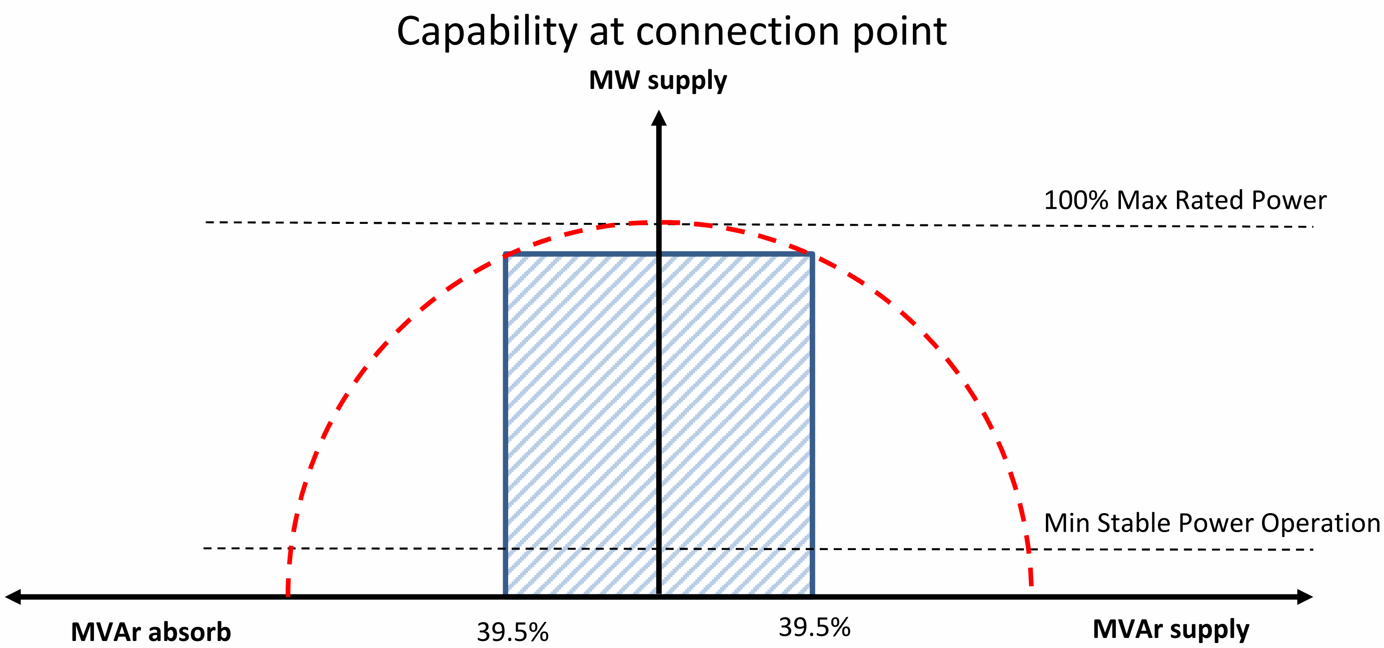
- Too onerous:
  - Additional costs oversizing equipment
  - More than the NEM requires

Feedback was reviewed, requirements have been tested and amended accordingly

The revised standards maintain the existing balance of reactive support between generators and networks

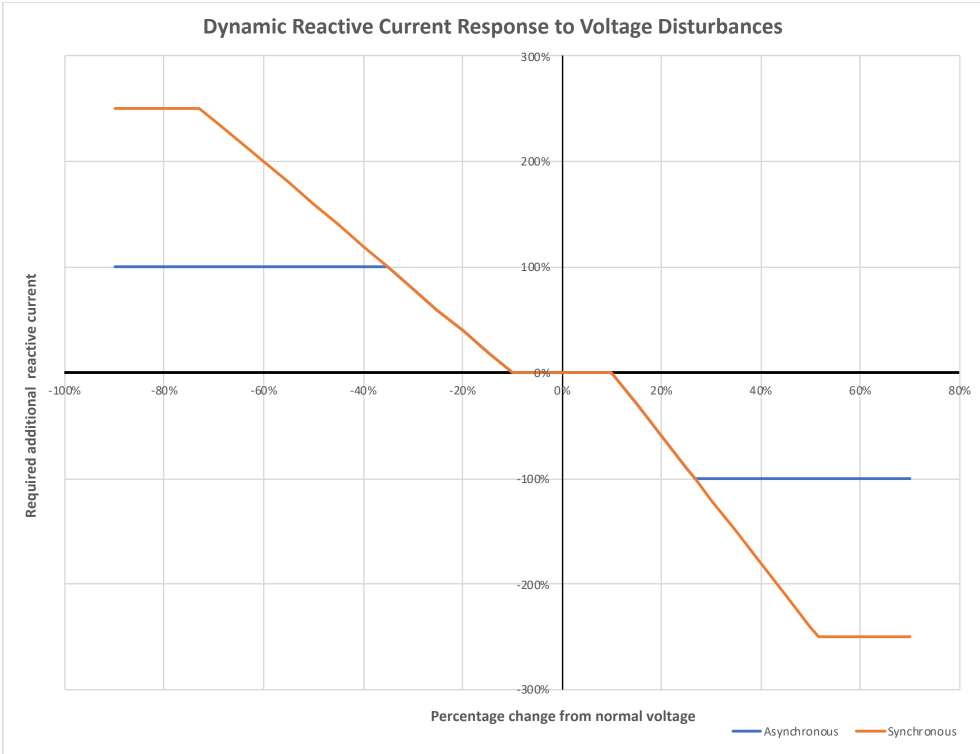
Revised steady state requirement

We have adopted the NER requirements



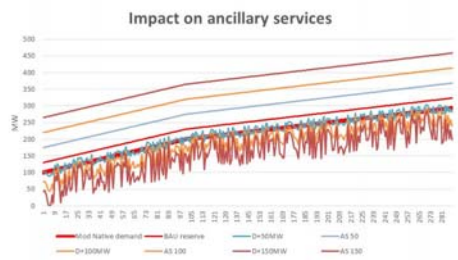
Revised dynamic requirement

- Dynamic reactive capability also adjusted:
  - Asynchronous capped at 100% fault contribution
- System strength addressed via system integration studies and long term via NER adoption.




Requirement for Capacity Forecasting
Dr Karel Nolles
PowerWater

Forecasts… it’s about information…



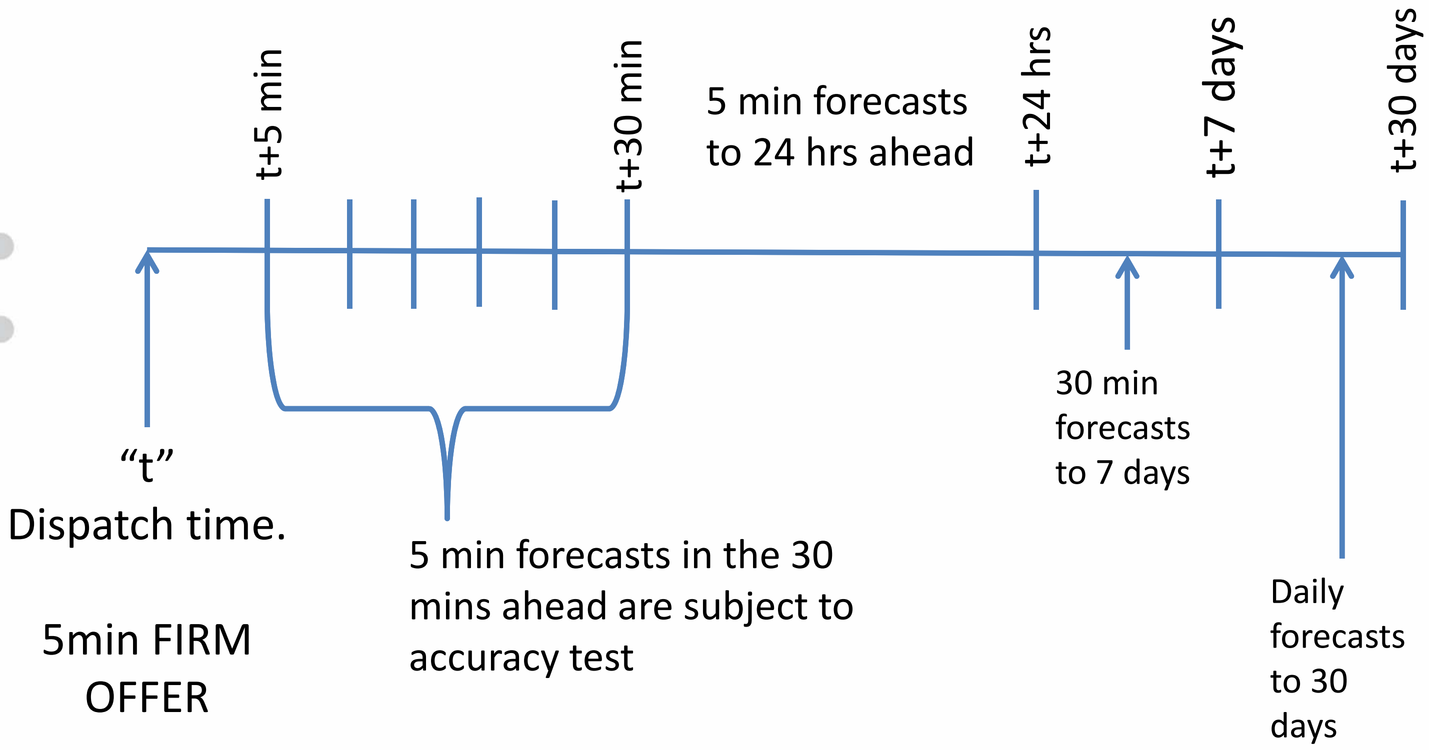
- System control needs to balance supply and demand to manage system stability
- Where we don’t have information, we will need to act conservatively. The better our information, the more we can use generators to their full potential.
- The NT is rapidly moving into uncharted territory with high levels of intermittent asynchronous generation in a small grid
- We will be observing closely how things perform in practice.
  - Specifics will probably change in the future
  - Lots of new systems

… all about getting renewable generators the maximum actual export into a secure system

How dispatch currently works…

When	What	Why
Day Before (before “gate close” of 12pm)	Generators send us price / offer sheets	Could be one sheet for every 30 minutes, but generally is one for the day.
Just after 12pm	1. System Control prepares demand forecast 2. Runs pre-dispatch engine (New version currently in beta)	This generates a possible economic merit order for the next day, from 4am onwards. • Provided to generators and to system controllers
4:00am – new day starts	Controllers use the merit order to start dispatching plant	The dispatch output is currently used as a guide, but will become more fixed in future.
30-60 minutes ahead	Controllers are observing demand, generator/system performance and making dispatch decisions	If a new turbine needs to be started, this must be decided in the time between 60 mins and 30 mins

Forecasting timeline

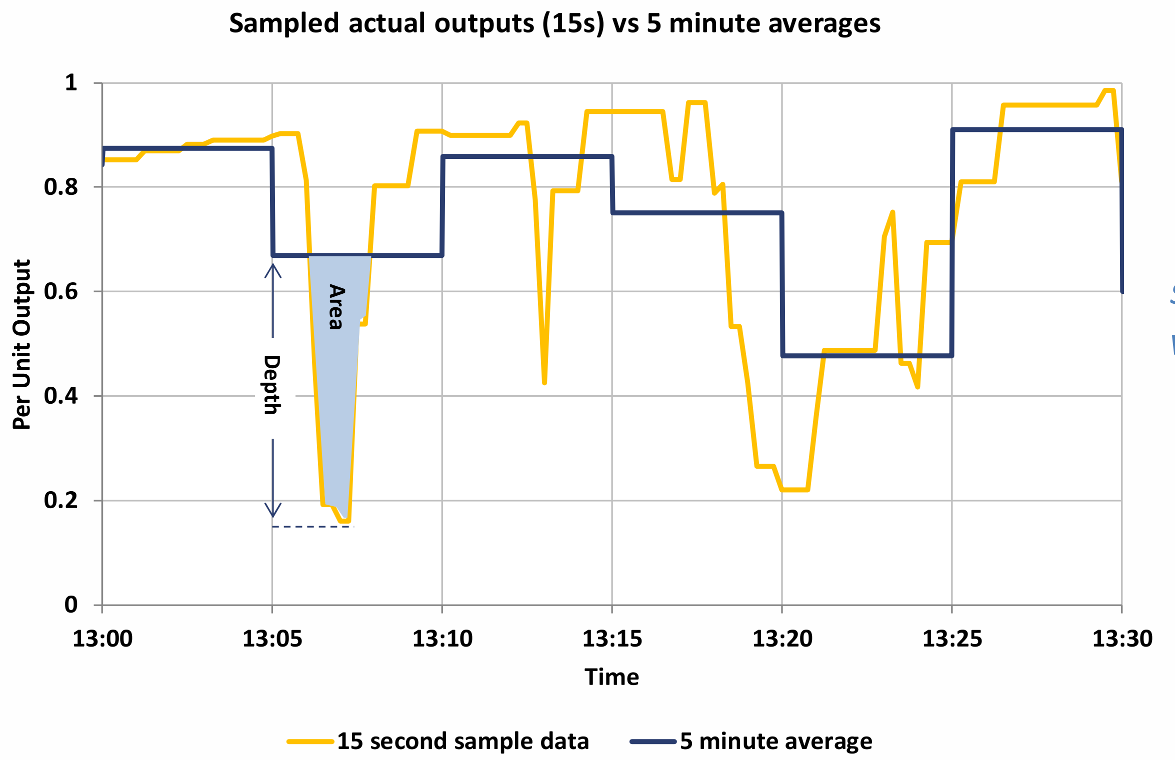


An example of 5 min rolling capacity forecasts

Dispatch Time (t)	Firm offer	t+5	t+10	t+15	t+20	t+25	t+30	t+35
11:05	8.8 MW	8.7 MW	8.8 MW	8.7 MW	8.6 MW	8.7 MW	8.7 MW	25 MW
11:10	8.8 MW							…
11:15	8.8 MW							…
11:20	8.8 MW							…
11:25	8.8 MW							…
11:30	8.8 MW							…
11:35	8.9 MW	8.8 MW	8.9 MW	8.2 MW	8.6 MW	8.6 MW	8.6 MW	8.5 MW

11:05 t+30 used for dispatch at 11:35

Capacity vs energy forecasts



… we cannot securely dispatch without 5 minute certainty

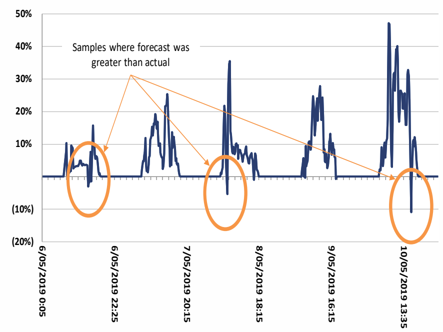
What capacity forecasting involves

- A projection of technical capability
  - For a solar farm, the insolation forecast
- Knowledge of the specific performance of the plant
  - Planned maintenance, outages, historical performance
- Risk management / trading strategy
  - Including how to use any available storage or other commercial arrangements

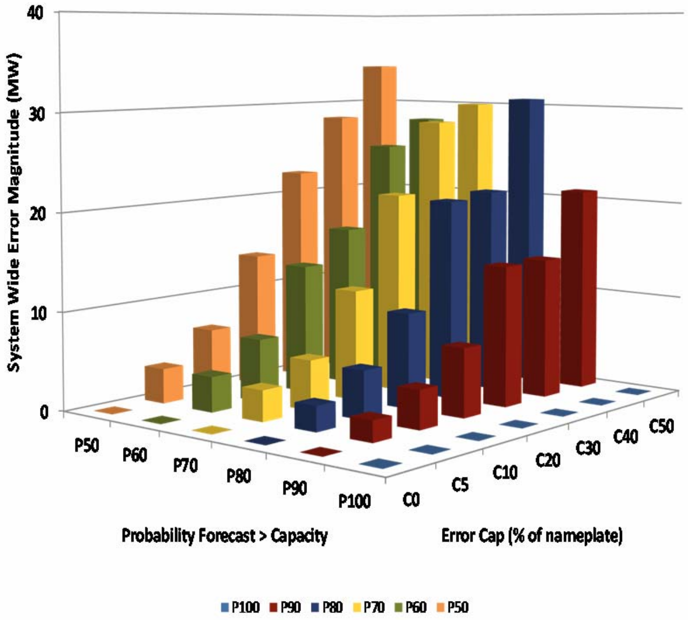
… this is information the generator is best placed to know

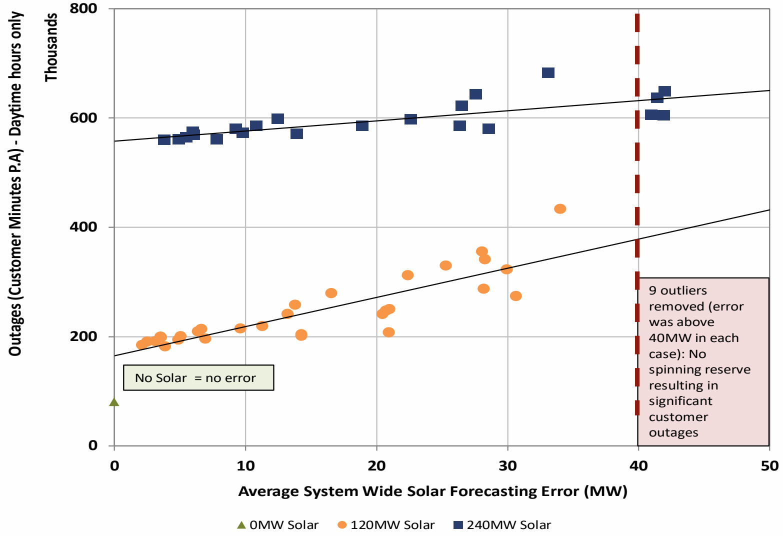
Why we think this is feasible

- Solar forecasts become inaccurate the further out one goes, but appear to have good accuracy on the 30 min ahead timeframe
  - Examined solar forecast data from two providers
- 30 mins is the practical minimum we need for turbine plant
- Firming across the 5 min can be achieved using a relatively small battery, over-panelling, or in other ways
- Individual operators clearly should have good knowledge of the performance of their own plant



Forecast accuracy is important





How is forecasting accuracy measured?

- Across a rolling 24 hour period
- Compares the forecasts received for t+5 through to t+30 to the actual firm offer provided at t+0
- 90% of intervals, forecasts to be > actual
- In the other 10%, not out by more than 5% of nameplate or 1MW (whichever is less)

Verifier's views

Is this technically achievable?

"Forecasting requirements proposed by PWC have been assessed by Entura for their implications on solar PV generators. Entura supports the view that mature technical solutions are available to meet these requirements. Likely cost (or revenue) implications for generators is estimated in the order of about $320-480/kWac of PV installed or 20-30% of the cost of the solar PV plant, plus a similar ratio of ongoing operations and maintenance cost."

Test

Where can firming be provided?

- Seeking to set a technical standard, not mandate particular approaches
- For example, rather than an on-site battery a farm could have a central battery facility (or a turbine operator) provide these services
  - However the requirement remains on the entity with the connection agreement
    - You cannot contract out of responsibility
  - Such arrangements would in practice probably involve network augmentations. This can only be assessed when specific proposals are put forward.

If the forecasts are "wrong"? ("wrongness type 1")

- Accuracy Error on t=5 to 30 forecasts
  - When compared to actual capacity, the forecasts did not meet the 90% of the time / 5% leeway on capacity accuracy
  - Measured on a rolling 24 hours
  - This would likely lead to derating of future 5 to 30 forecasts
  - This would remain in place until we were confident the accuracy standard is being met.

If the forecasts are "wrong" ? ("wrongness type 2")

- Error on firm offer
  - made firm offer at t=0, but when called upon, failed to dispatch
  - This would likely lead to immediate curtailment and some discussions to explain what happened and why and how we can have confidence it won't happen next time.

“semi-scheduled”

- Becomes somewhat an issue of terminology
  - Follow a constraint signal, or provide forecasts….
- Remains available for small (approx < 2 MW) and in the code

Engagement questions

Capacity forecasting requirements | engagement questions
1. Do you understand the difference between an energy and a capacity forecast?
2. Do you believe that providing a dispatchable offer at 30 minutes ahead and a firm offer at dispatch time would make your project non-commercial? Where do you believe the costs of securely managing commercial scale asynchronous generation uncertainty should be borne?
3. Does the forecasting obligation as drafted in the proposed code, provide sufficient clarity on the obligation? If not, please provide suggested amendments.
4. Do you understand the factors that differentiate the feasibility of classifying a generator as semi-scheduled from those present in the NEM and WEM?

Requirement for C-FCAS capability

Sean Egan

Overview

- Requirements
  - Capability via GPS
  - Operational requirements not modified (remain under I-NTEM)
- Feedback
  - Too onerous to provide C-FCAS at all times (based on original operational information)
  - Requirements were confusing

What is the issue?

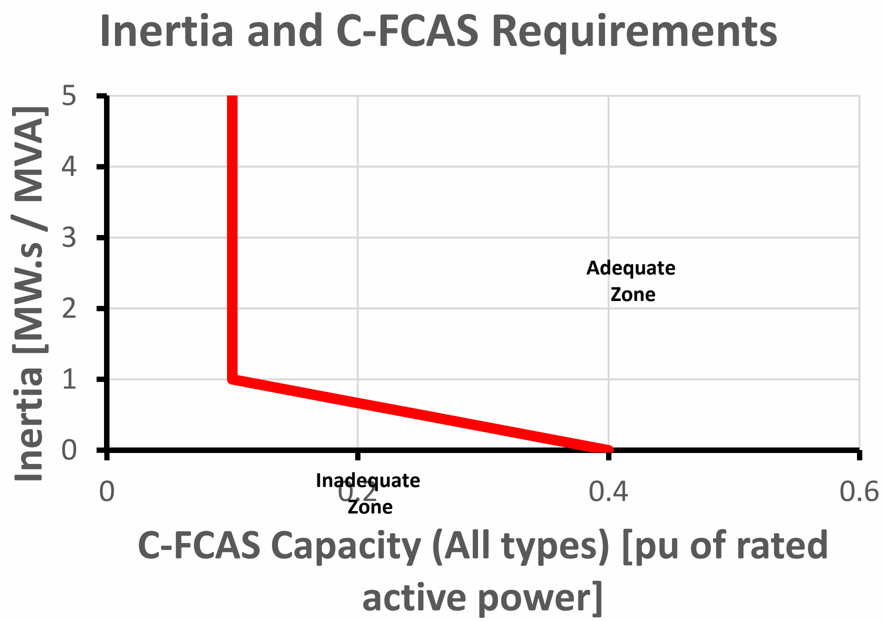
- Frequency control is core to supply
- Without this capability in the GPS:
  - Capability will not be replaced by entrant generators
  - Significant operational constraints on new entrant generators

Terminology

Capability	• Can do
Enablement	• Switched on
Provision	• On with room to do
Delivery	• Has done

The obligation

Generator performance standards capability



The requirement recognises the fast frequency response capability of inverters to trade off with inertia

Actual operation

Dispatch principles are unchanged from existing I-NTEM:

- All units operate with C-FCAS capability enabled
- Non T-Gen generators provide C-FCAS only:
  - If it is in their benefit (higher dispatch)
  - As a last resort

Enablement facilitates higher utilisation of renewables.

Scenarios for provision

- C-FCAS raise provision
  - Islanding of 132kV
  - Forecasting differences
  - Reduced T-Gen share of dispatch/ contingency event

- C-FCAS lower provision
  - UFLS stabilisation
  - Lightning/Contingency

Verifier’s views

“This definition is consistent with Entura’s view of the capability of typical inverter based solar PV plant. System Control could only call on raise capacity from systems with no storage if they were known to already be curtailed. A requirement for ‘enablement’ of automatic frequency control is expected to add no significant additional cost to a typical inverter solution in the market now.”

Test

Conclusion

- Capability immaterial cost to achieve
- Based on the operational principles under I-NTEM it provides:
  - Greater dispatch for entrant generators
  - Safety net for consumers

The requirement provides a cost effective safety net for consumers and facilitates higher utilisation of renewables.

Engagement questions

Requiring ability to provide C-FCAS | engagement questions
1. Do you understand the terminology used to describe the capability, enablement, provision and delivery of C-FCAS? 2. Do you believe the droop characteristic will introduce additional cost to your project? How material is this? 3. Do you believe all generators should contribute to providing a C-FCAS/Inertia safety net for customers? 4. Would you be interested in providing and delivering C-FCAS services if a market/competitive mechanism were introduced?


Our approach to other issues
Jodi Triggs
PowerWater
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Updated GPS grandfathering

Existing	• Existing generators will (to the extent they are able without requiring modification, alteration or enhancement) need to comply with the automatic access standards and their performance updated in their connection agreement
Modifications	• Generators that modify any part of their generating system will need to comply with the relevant NT NER requirements
In flight projects	• Generators not physically connected prior to 1 April 2019 will need to comply with the proposed GPS

What we heard and did

Other issues

Actioned:

- Other code change feedback
- Suggested clause changes actioned now

Explain

Noted:

- Suggested clause changes
- Policy matters

Amend

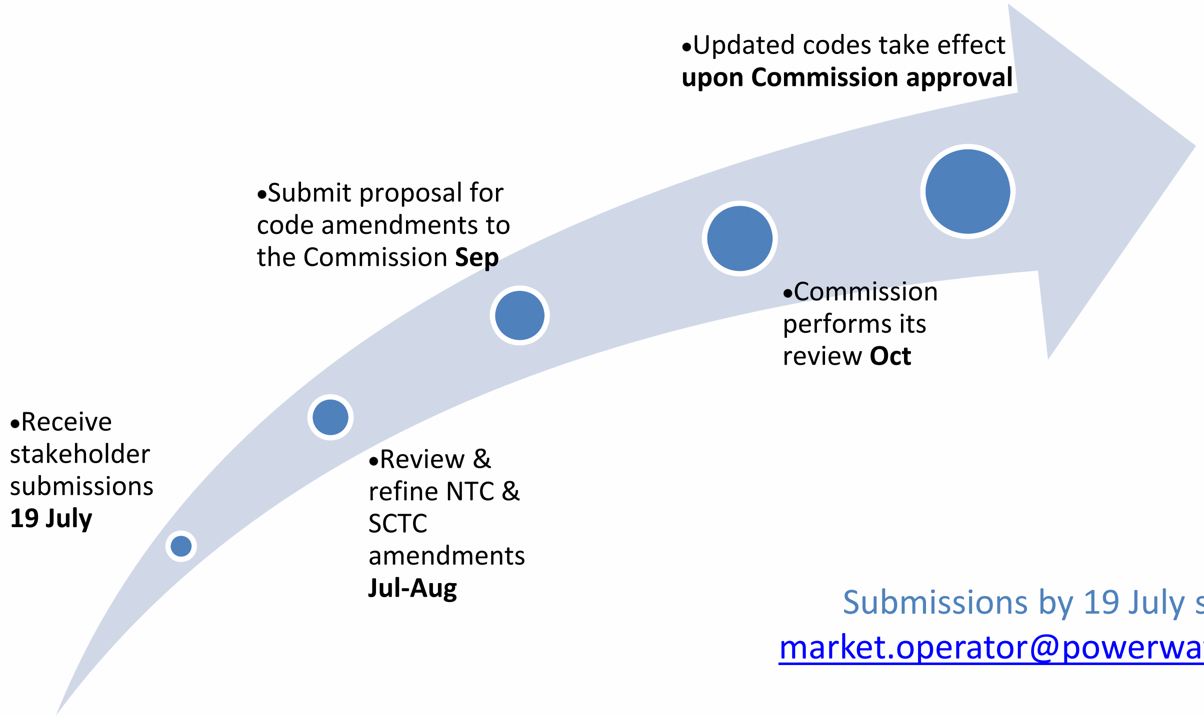
Wrap-up

Rob McMillan

PowerWater

- Agree outcomes
- Recap questions taken on notice
- Recap the consultation timelines

Timeline to implementation



Submissions by 19 July sent to
market.operator@powerwater.com.au