Project EnergyConnect System Integration

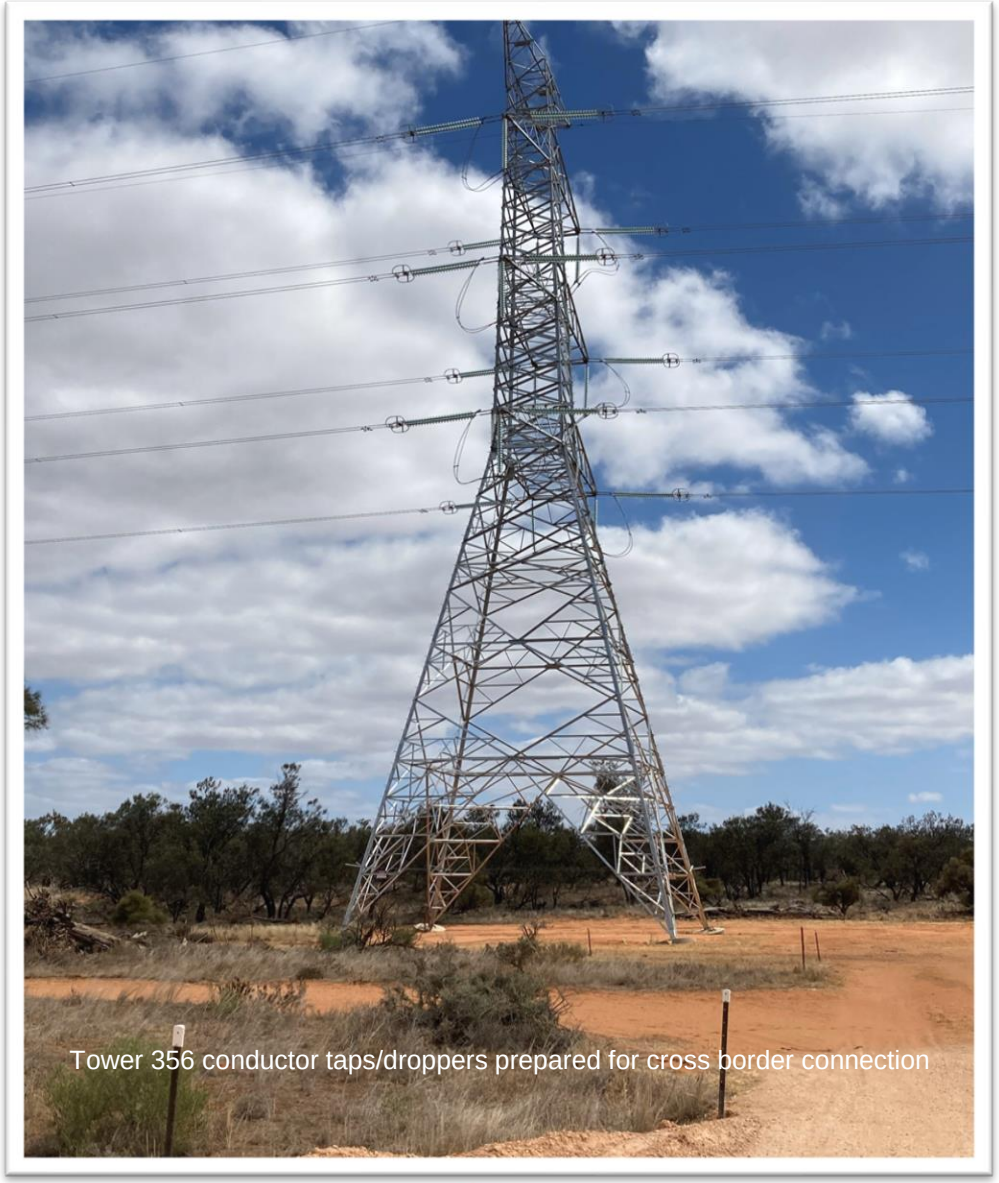
Industry Update

18 April 2024

ElectraNet | Transgrid AEMO AusNet ProjectEnergyConnect.com.au

Purpose

- Project EnergyConnect (PEC) industry update
- Focus on System Integration activities
- Slide pack published on the Project EnergyConnect website
- Future updates – provided through PEC website, as well as existing industry forums as appropriate



Tower 356 conductor taps/droppers prepared for cross border connection

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Outline for today's briefing

- High level status summary
- PEC key dates
- Inter-network testing
- Managing connection interest
- Indistinct event limits
- Overview of PEC-2 system integration activities
- Reference slides

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High level status summary

Hugo Klingenberg - ElectraNet

Status summary

- Capacity across PEC will be released according to an agreed inter-network test program
- Inter-network tests can only start once the following pre-requisites have been met:

Pre-requisites	PEC-1 status
AEMO market systems are ready	Ready
All network infrastructure is 'AEMO asset ready'	Expected Q3 2024
Relevant Special Protection Schemes have been reviewed / commissioned	On track
Limits advice has been provided by TNSPs and developed into constraint equations by AEMO	Ready

- Key milestones met:
  - ☐ Final inter-network test plan for PEC-1 - Published
  - ☐ PEC-2 indicative limits – refer reference slides in this presentation
  - ☐ Connection applications to PEC can now be accepted
- Key future milestones:
  - ☐ Updated PEC-2 limits / constraints for SA, NSW & VIC – Q3 2025
  - ☐ PEC-2 ready for inter-network testing – Q2 2026

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PEC key dates

Transgrid

PEC revised project schedule

- Construction continues to progress on the 700 km NSW section of PEC.
- The first stage of the project (150 MW) previously scheduled to be in service for the June quarter of this year is now scheduled to be in service in the September quarter of this year, at which time inter-network testing will commence.
- The second stage of the project will be completed and in service by the June quarter of 2026. Inter-network testing will then commence for release of up to 800 MW, subject to availability of suitable test conditions & successful test outcomes.
- Target dates for inter-network testing to start:
  - PEC-1: Q3 2024 (for modelling purpose 1 Sep 2024)
  - PEC-2: Q2 2026 (for modelling purpose 1 May 2026)

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Inter-network testing

Callan Masters - AEMO

PEC-1 Inter-network test plan

Summary of planned testing under NER 5.7.7:

- Three hold points with PEC-1 in service
- Tests include:
  - PST tapping test (at initial hold point)
  - South East – Tailem Bend or Robertstown – Tungkillo 275 kV switching
  - Buronga – Bundey 330 kV line switching
  - Murraylink interconnector reactive power step change or Buronga synchronous condenser voltage step change
  - Generic system damping assessment

Indicative timeline:

- Industry consultation – Complete
- Final inter-network test plan – Published
- Commence inter-network testing – Q3 2024
- Complete PEC-1 inter-network testing – Q4 2024
- HIC inter-network testing to commence following completion of PEC-1 inter-network testing

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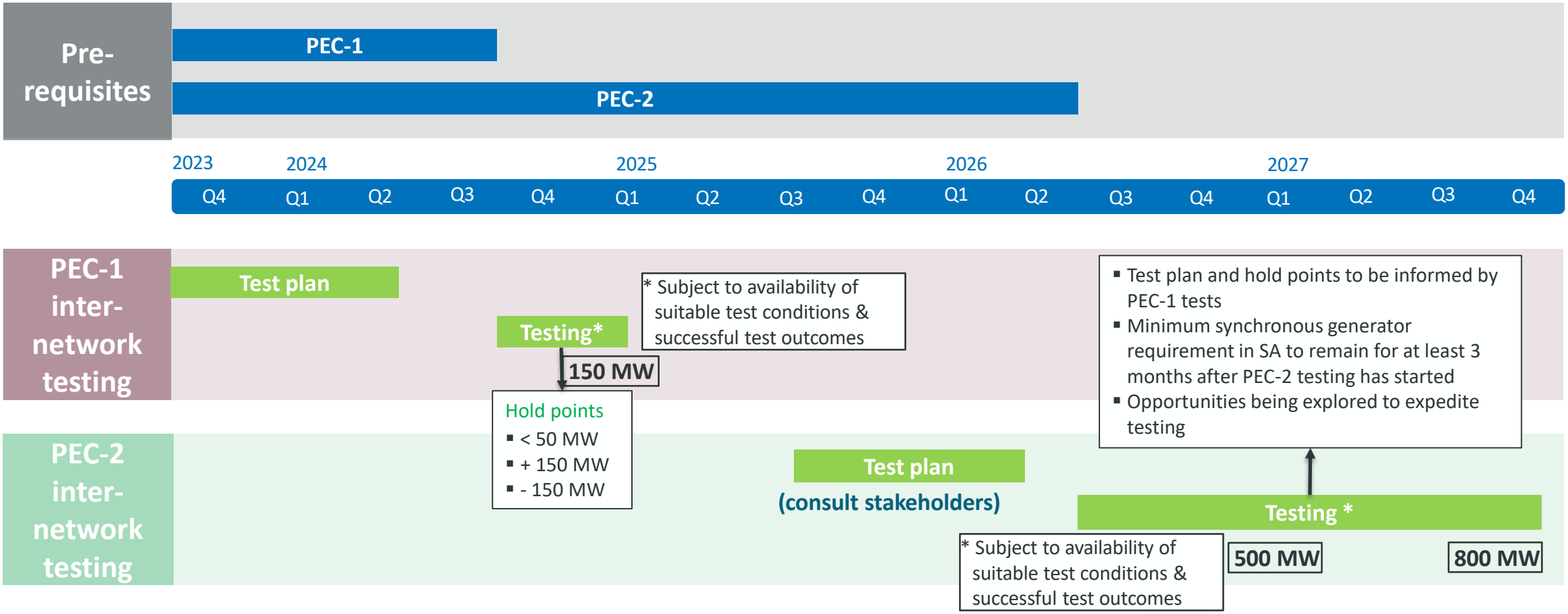
PEC capacity release – key dates

Estimated dates and hold points for inter-network testing



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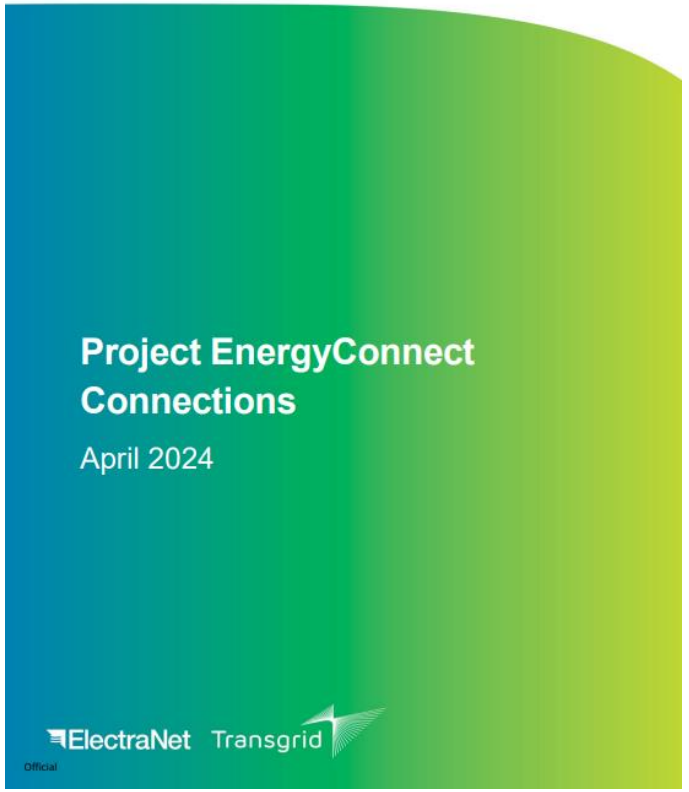
Managing connection interest

John Hele - Transgrid

Managing connection interest

- There is a staged approach to progressing connections to PEC. A connections framework outlining pre-requisites for each connection project phase relative to PEC milestones is available on Project EnergyConnect website.
- A connections update was published on the PEC website in April 2024 when the Connection Application pre-requisites were met.
- Participants can request PEC modelling data via the AEMO data request page
- Connections to certain sections of PEC network infrastructure in NSW will be subject to South-West REZ access arrangements (for details see: https://www.energyco.nsw.gov.au/sw-rez)
- The key Connection Assessment Transition Framework consists of the following milestones:
  - ☐ Connection enquiry pre-requisites (Complete)
  - ☐ Connection application pre-requisites (Complete)
  - ☐ 5.3.4A/B approval pre-requisites
  - ☐ Registration and commissioning pre-requisites



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Draft connection assessment transition framework

Milestones	Connection Enquiry pre-requisites	Connection Application pre-requisites	5.3.4A/B approval pre-requisites	Registration and Commissioning pre-requisites
Status	**Achieved in March 2023**	**Achieved in March 2024**	**In Progress**	
PEC milestone	• PEC formally achieves Considered status	• PEC detailed design complete (design data available including functional requirements of South Australia Intertrip Remedial Action Scheme (SAIT RAS))	• Detailed design of SAIT RAS finalised and complete	• SAITRAS commissioned and in service (including impact assessment on Heywood Interconnector) • PEC internetwork testing completed, and 500 MW transfer capacity released across PEC
PEC model maturity	• PEC planning models (PSS/E) available via AEMO data request • PEC PowerFactory model available	• Standard or Detailed (S/D) data for Buronga and Dinawan synchronous condensers (syncons) available	• PEC R1 dynamic models (PSS/E and PSCAD) available (including Buronga and Dinawan syncons)	• PEC R2 dynamic models (PSS/E and PSCAD) available (including Buronga and Dinawan syncons)
PEC limit advice, Special Protection Schemes (SPS) and other considerations	• Preliminary PEC Limit advice available	• Preliminary PEC limit advice available • Preliminary limit advice available for nearby key transmission lines • For connections to the NSW end of PEC, updated NSW SPS details (including preliminary impact on existing SPS in NSW) • SAIT RAS functional requirements available	• AEMO PEC constraint equations available. AEMO constraint equations available for nearby key transmission lines • For connections to the NSW end of PEC, updated NSW SPS details (including impact on existing SPS in NSW) • SAIT RAS impact assessment and coordination of any new control schemes by newly proposed connecting plant completed	• AEMO constraint equations for PEC and nearby key transmission lines available and active • SAIT RAS, NSW SPS details and limit advice updated based on connecting plant impacts

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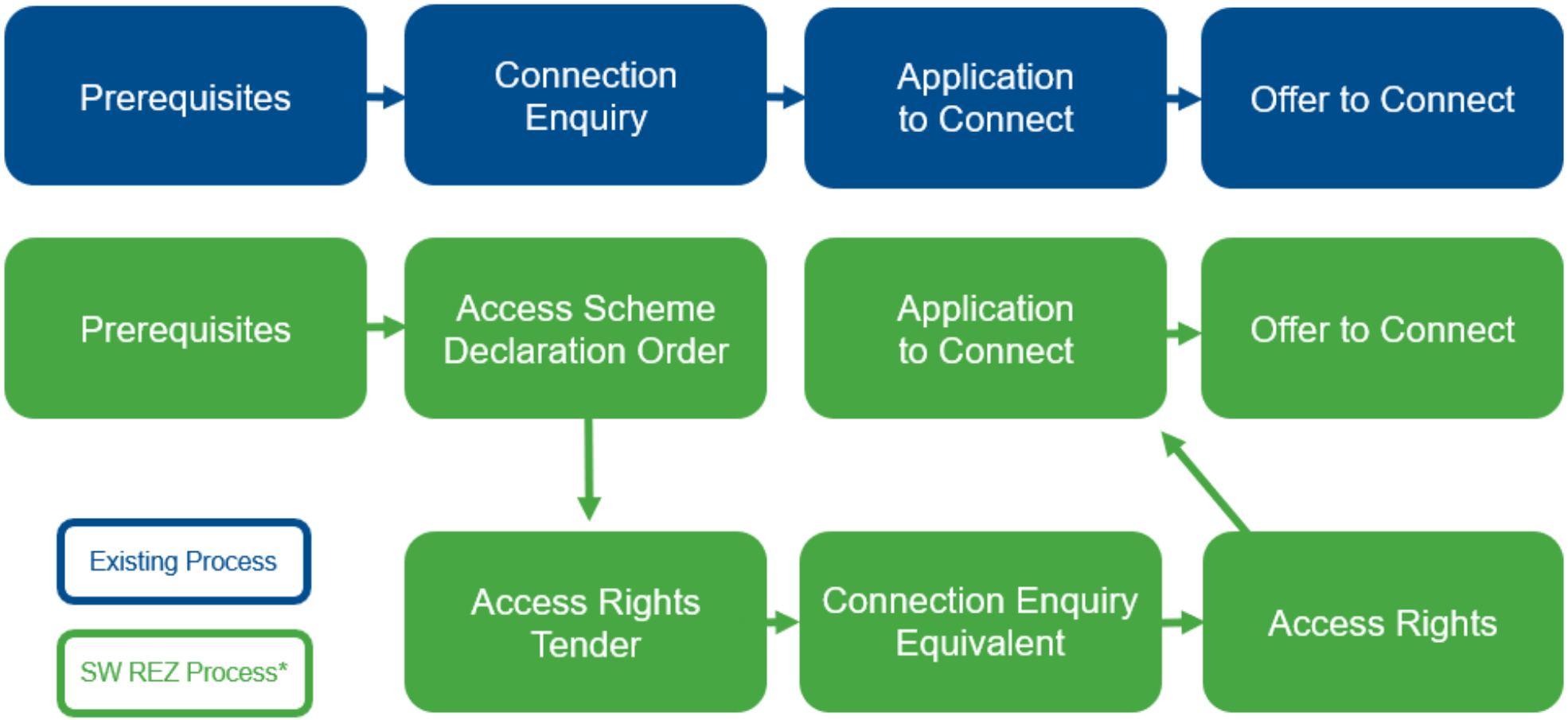
Proposed connection process after South West REZ Declaration



* SW REZ process applies only for projects seeking connection to SW REZ 'access rights network'

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Indistinct event limits

Callan Masters - AEMO

Revocation of the existing SA protected event

- As discussed in the previous industry update, the Reliability Panel published its final determination on AEMO's request on 14 September 2023.
- The SA protected event was revoked on 30 March 2024 in advance of the expected synchronisation and testing of PEC Stage 1.
- Constraints associated with destructive wind conditions are now according to the Power System Security Guidelines (Operational Procedure 3715).
- AEMO is finalising studies to confirm the limits to apply post PEC-1 during destructive wind conditions.
- Updates to limits will be covered in AEMO's annual General Power System Risk Review and AEMO's published interconnector capabilities document.

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Overview of PEC-2 system integration activities

Hugo Klingenberg - ElectraNet

Overview of PEC-2 system integration activities

- Market integration activities:
  - Rule change proposal pending with AEMC
- Develop range of system limits
- Review of existing special protection schemes
- Developing the South Australian Interconnector Trip Remedial Action Scheme (SAIT RAS) to prevent SA being separated from the NEM for the non-credible loss of either PEC or the Heywood interconnector
- Exploring opportunities to expedite PEC-2 inter-network testing
- Connection applications that impact on the PEC corridor will have to be carefully considered taking the above integration activities into account

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Thank You!

System Integration Steering Committee:

Hugo Klingenberg, ElectraNet

Kasia Kulbacka, Transgrid

Luke Robinson, AEMO

Nicola Falcon, AEMO Victorian Planning

Andrew Linnie, AusNet Services

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Reference Slides

Governance of System Integration activities

- System Integration Steering Committee (SISC) has responsibility for system integration activities, including stakeholder engagement as required
- The SISC is overseen by an Executive SISC comprising relevant ElectraNet, AEMO, Transgrid, AEMO Victorian Planning and AusNet Services Executives and Project Directors

Key objectives of PEC System Integration Steering Committee

- Collaboration across AEMO, ElectraNet, Transgrid, AEMO Victorian Planning and AusNet Services to coordinate timely PEC integration into the National Electricity Market (NEM)
- Provide governance and reporting in accordance with National Electricity Rules (NER) frameworks and meet all requirements of clause 5.7.7 of the NER
- Achieve combined transfer limit across both the Heywood and PEC interconnectors of 1,300 MW import into South Australia and 1,450 MW export. The project is designed to achieve these transfer levels with consideration of non-credible loss of either interconnector

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- PEC is a geographically diverse second Alternating Current (AC) interconnector that will significantly increase the transfer capability between South Australia and the rest of the National Electricity Market
- This will increase access to other regions and increase competition in the wholesale electricity market putting downward pressure on electricity prices

Interconnector	Nominal Limit (MW)	Nominal Combined Limit (MW)	Combined Transfer Limit[1]
Heywood Interconnector (HIC)	+/-[2] 650	+/- 1450	+ 1300 - 1450
Project EnergyConnect (PEC)	+/- 800		

1. Combined transfer limit dependent on transient system stability and sufficient loads and generators in the SAIT RAS
2. + import into SA
   - export from SA
3. Current transfer limit is SA-VIC: 550 MW, VIC-SA: 600 MW
4. Transmission augmentation information: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/transmission-augmentation-information

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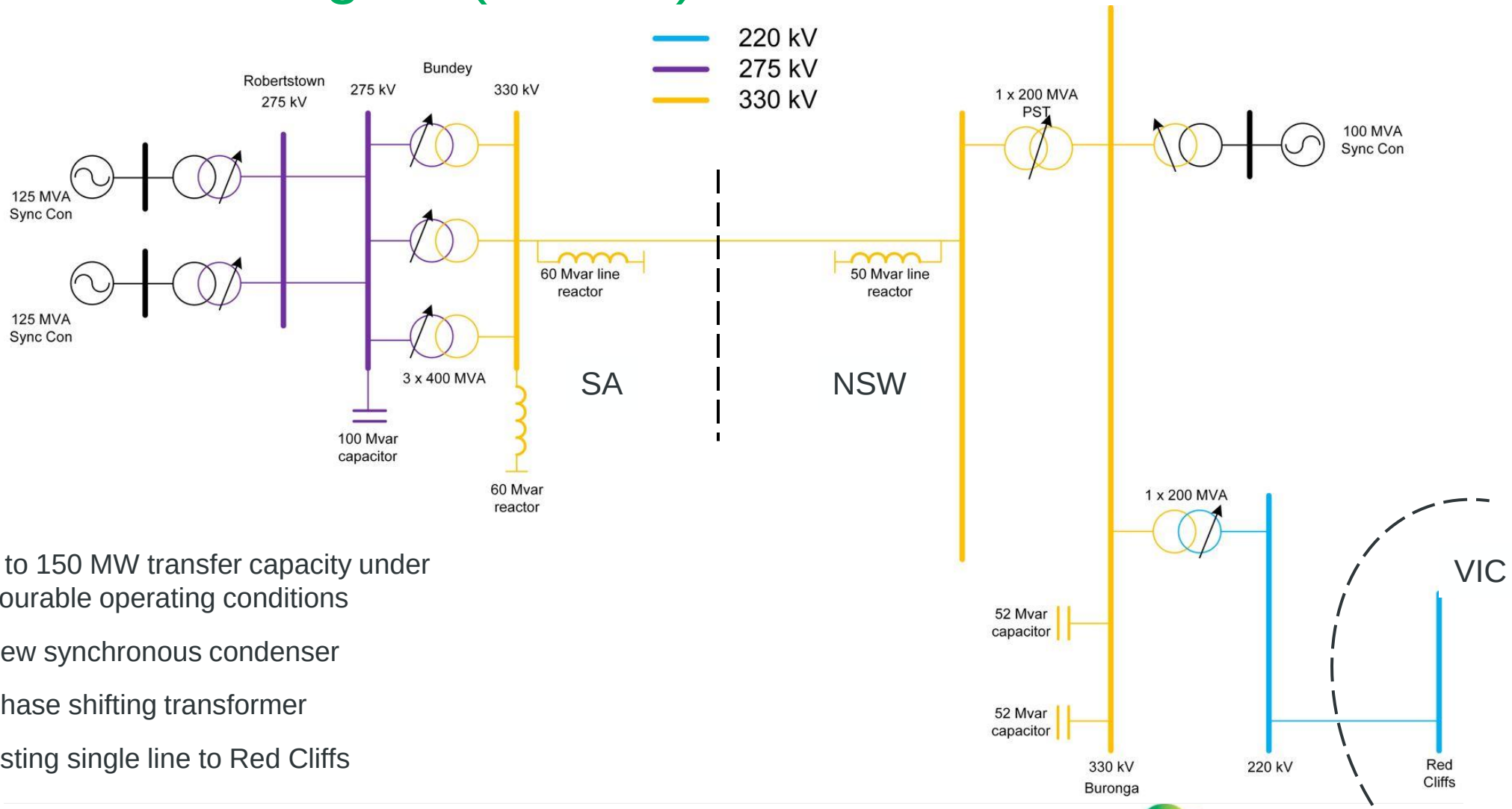
Scope - PEC stage 1 (PEC-1)



- Up to 150 MW transfer capacity under favourable operating conditions
- 1 new synchronous condenser
- 1 phase shifting transformer
- Existing single line to Red Cliffs

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Key changes – PEC-1

PEC-1 results in effectively a bigger Heywood Interconnector (HIC)

Vast majority of existing constraints are expected to remain in place

- HIC trip will intertrip PEC-1
- PEC-1 150 MW – in both directions (with slight reduction at very high Murraylink flows)
- Combined transfer limits for PEC-1 and HIC - SA-VIC: 700 MW, VIC-SA: 750 MW*

Impact on existing Special Protection Schemes (SPSs):

- All Special Protection Schemes (SPSs) potentially impacted by the PEC-1 integration have been reviewed – One change: Trip parallel 132 kV circuit for either Tailem Bend to South East or Tungkillo to Tailem Bend 275 kV line trips
- Murraylink Very Fast Run Back (VFRB) scheme will be upgraded shortly after the second Buronga – Red Cliffs 220 kV circuit is commissioned

*Additional HIC capacity release is subject to effective management of interconnector drift and consideration of impact of mainland contingencies on SA interconnector flows.

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Expected impact of constraint changes – PEC-1

PEC-1 constraint / limit changes

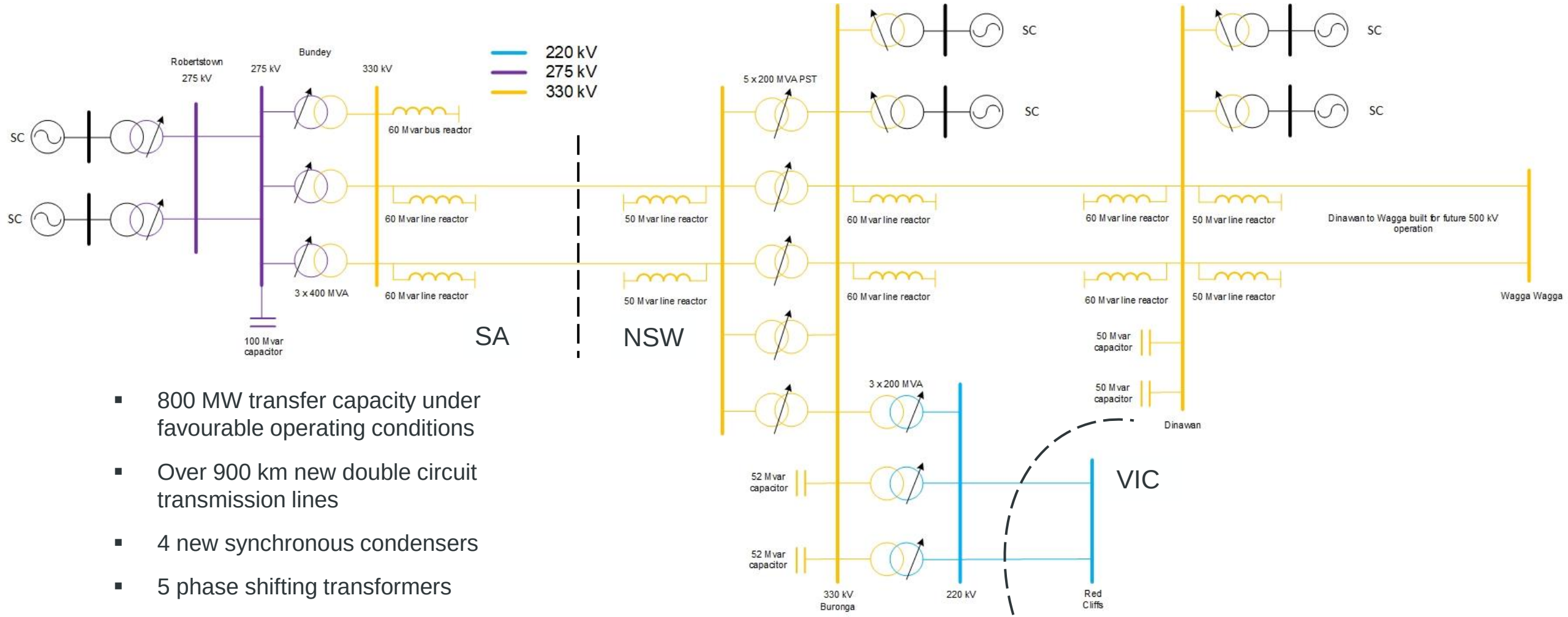
New constraints

- Overload on Buronga PST for trips of Murraylink

Revised limits

- Existing Line X5 (Balranald – Darlington Point) voltage stability limit which is expected to be relieved marginally
- Existing thermal limits in NW Vic and SW NSW to include PEC term
- System strength limits under outages in NW Vic likely to change
- Further revision to limit factors when second Buronga – Red Cliffs 220 kV circuit is commissioned

Scope - PEC stage 2 (PEC-2)



- 800 MW transfer capacity under favourable operating conditions
- Over 900 km new double circuit transmission lines
- 4 new synchronous condensers
- 5 phase shifting transformers

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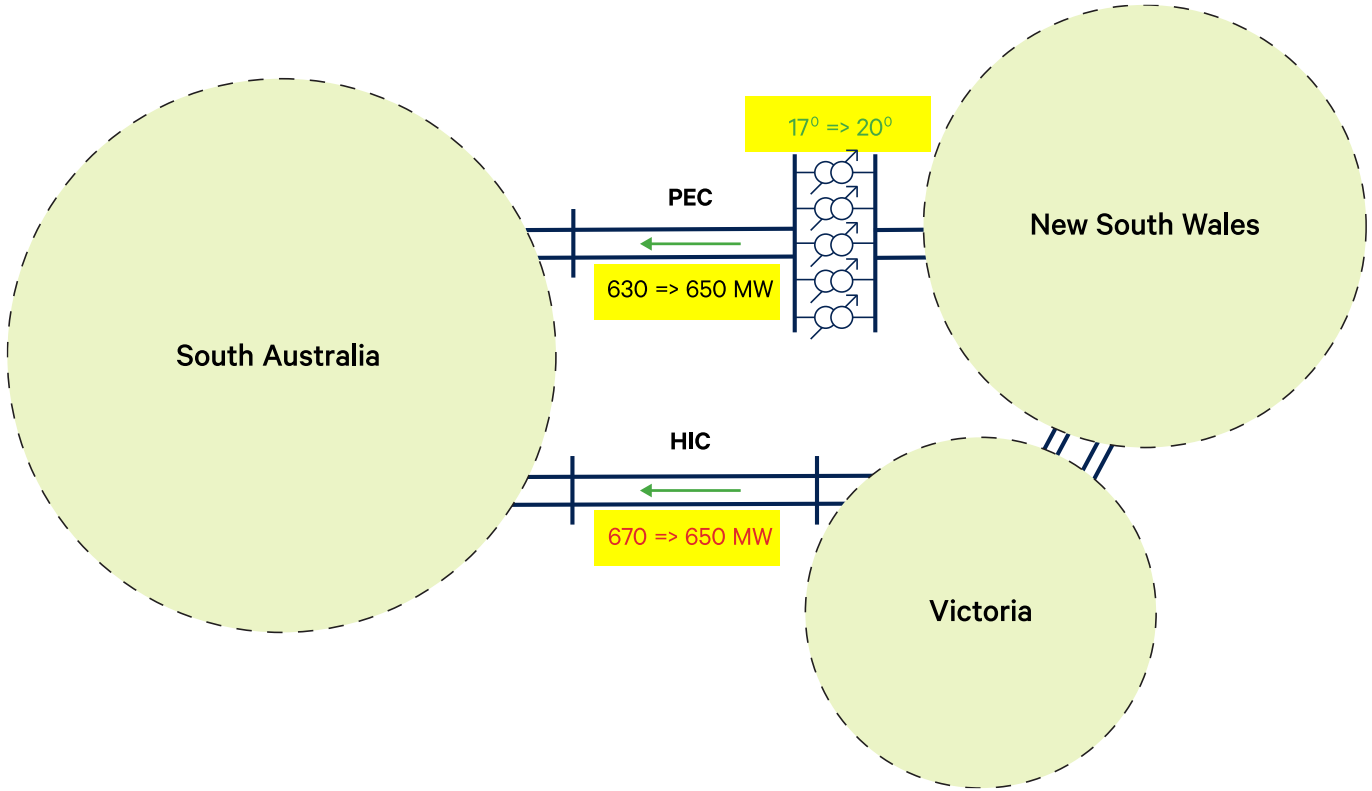
Phase Shifting Transformers (PSTs): Expected operation

- PST allows optimisation of power flow sharing on PEC and Heywood (HIC) Interconnectors
- PST tap setting (angle) will be an input to the AEMO NEM Dispatch Engine
- Taps can be manually or automatically changed to divert flows between HIC and PEC when one of them gets closer to limits
- At times of high transfer, each PST tap change is expected to vary PEC flow by about 10 MW with PEC-1, and about 20 MW with PEC-2

Example	PST tap angle (degrees)	HIC (MW)	PEC (MW)	Combined transfer (MW)
SA import	17	670	630	1300
	≈1 tap ↓			
	20	650	650	1300
	40	510	780	1290
	0	780	520	1300
SA export	-25	730	710	1450
	≈1 tap ↓			
	-28	710	730	1450
	-40	640	810	1450
	0	890	530	1420



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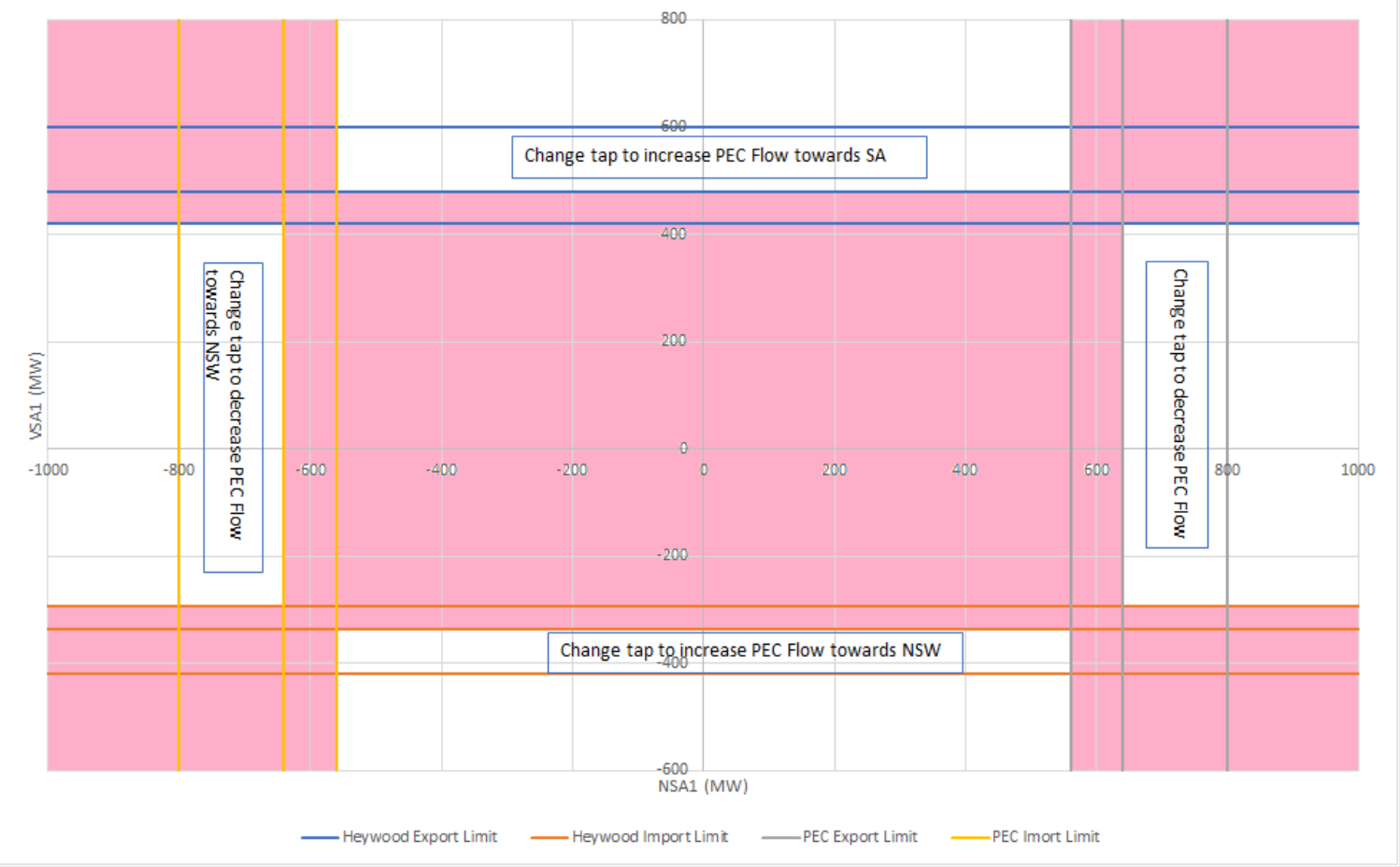
Phase Shifting Transformers (PSTs): Control strategy overview



- System normal conditions: PSTs operated in Auto mode to enable efficient power flow sharing on HIC and PEC interconnectors.
- Auto mode: PST tap changer will operate when one interconnector is above 80% of its nominal capacity, while the other is below 70% of its nominal capacity (**white** areas in the figure)
- The tap changer will not operate when the interconnectors are not approaching constraints or are equally constrained (**pink** areas in the figure).
- Non-Auto control mode will be activated under abnormal or high-risk system conditions. Under Non-Auto mode, the PSTs will be manually controlled by Transgrid under AEMO's instruction.

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PEC Market Integration
Directions Paper Consultation Completed

Consultation Activity	Date	Status
Directions Paper published	1 November 2023	Completed
PEC-MI Information Session #1	Tuesday 14 November 2023	Completed
Submissions closed	Friday 1 December 2023	Completed
Final Report published	Friday 9 February 2024	Completed
AEMO's Rule Change Proposal submitted	Friday 9 February 2024	Completed
PEC-MI Information Session #2	Thursday 14 February 2024	Completed

More information: NEMReform@aemo.com.au

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Final approach for market integration - settlement

Integrate PEC Stage 2 into AEMO systems

- Use the interconnector dispatch integration model
- Revise existing automated Negative Residue Management constraints
  - Limit the application of interconnector clamping, to when aggregate loop IRSR is negative. This would limit the extent interconnector clamping is a driver of dispatch outcomes.
- Reallocate negative IRSR when settlement, in aggregate, is in surplus across the three interconnectors for each trading interval.
- Negative IRSRs reallocated are payable by the importing TNSP
- Include PEC in the SRA
- Post implementation, continue to monitor value of units available for SRA

More information: AEMO Project Market Connect – Market Integration Project

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Anticipated constraints for PEC-2

New constraints

- Combined system normal limit of 1,300 MW import into SA and 1,450 MW export from SA across PEC and Heywood – hard design limit with Buronga PST at (+/-40 degrees)
- ElectraNet will develop new voltage, transient and thermal limit equations based on PEC-2 network configuration for both system normal and N-1 network operating conditions

Constraints being revised

- Line X5 (Balranald – Darlington Point) voltage stability limit – expected increase of 15 MW depending on PEC-1 and reactive plant status
- Thermal limits in NW Vic and SW NSW to include PEC term
- System strength limits to be assessed with PEC-2 and HIC operating in parallel
- System oscillatory (damping) limits will be assessed with PEC-2 and HIC operating in parallel

Anticipated conditions where above combined transfers may not be fully achievable

- Network element outages – refer next slides
- Regional generation dispatch or availability of generation sources
- Impact of local demand close to the PEC & HIC corridors

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Expected impact of prior outages following PEC-2 (1/3)

The MW values quoted are based on limited studies and are indicative only

Prior Outage	Expected impact on transfer capability	Expected impact on generators (in addition to transfer capability, mainly system strength)	Comment
Any circuit along the Wagga-Buronga-Bundey-South East-Heywood-Moorabool corridor (PEC and HIC corridor)	An outage of one circuit on this corridor results in loss of the other circuit to be a credible contingency event. Combined transfers across PEC and HIC will be reduced to about 800 MW	SA: No system strength impact anticipated NSW: No pre-contingent disconnection of existing renewable generators in south west NSW VIC: No impact on Vic gens anticipated	
SA transmission line (not on the PEC and HIC corridor)	Minimal impact expected on PEC and HIC transfers. Existing voltage limits are present in the Mid North of SA for outages on the Robertstown to Davenport corridor	SA: Local impact only, effectively the same as current limits NSW & VIC: Minimal impact expected	
NW Victoria transmission line (not on PEC and HIC corridor)	Minimal impact on PEC	VIC: Some impact depending on location / anti-islanding schemes SA & NSW: Minimal impact expected	
Any one SVC in South Australia	Expected to be less than 50 MW reduction	SA: No system strength impact anticipated NSW: No pre-contingent disconnection of existing renewable generators in south west VIC: No impact on Vic gens anticipated	
Any one synchronous condenser at Davenport or Robertstown	Expected to be less than 50 MW reduction	SA: SA instantaneous IBR generation limit reduced from 2,500 to 2,200 MW NSW & VIC: Minimal impact expected	

Expected impact of prior outages following PEC-2 (2/3)

The MW values quoted are based on limited studies and are indicative only

Prior Outage	Expected impact on transfer capability	Expected impact on generators (in addition to transfer capability, mainly system strength)	Comment
Any one synchronous condenser at Buronga or Dinawan	About 50 MW reduction	SA: Minimal impact expected NSW: No pre-contingent disconnection of existing renewable generators in south west NSW VIC: No impact on Vic gens anticipated	
Buronga to Red Cliffs Line X1	Expected to be less than 50 MW reduction	Balranald renewable generation can remain in service; Broken Hill renewable generation can remain in service	Line OX1 trip scheme to be modified
Buronga to Balranald Line X3	Expected to be less than 50 MW reduction	Balranald 220 kV renewable generation to be disconnected as per existing arrangements; Broken Hill renewable generation can remain in service	Line X3 trip scheme to be modified
Balranald to Darlington Point Line X5	About 50 – 100 MW reduction	Balranald renewable generation can remain in service; Broken Hill renewable generation can remain in service	Line X5 trip scheme to be modified

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Expected impact of prior outages following PEC-2 (3/3)

The MW values quoted are based on limited studies and are indicative only

Prior Outage	Expected impact on transfer capability	Expected impact on generators (in addition to transfer capability, mainly system strength)	Comment
Darlington Point to Wagga Line 63	Expected to be less than 50 MW reduction	Darlington Point renewable generation to be disconnected as per existing arrangements; Balranald renewable generation can remain in service; Broken Hill renewable generation can remain in service; Line X5 to be opened as per existing arrangements	Line 63 trip scheme to be modified
Lower Tumut to Wagga Line O51; or Wagga to Jindera Line 62; or Jindera to Wodonga Line O60; or Dederang to Wodonga 330 kV Line	PEC 330 kV may need to be opened at Wagga depending on south west NSW load and generation; PEC transfers could be limited to less than 100 - 200 MW at these times	Renewable generation in Wagga – Darlington Point area to be disconnected; Balranald and Broken Hill renewable generation can remain in service	Humelink will resolve

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Anticipated construction outages

- Key outages expected to have a material market impact

Stage	Outage	Expected impact	Timing	Length
PEC-1	Buronga – Red Cliffs Line OX1	Approx 900 MW renewable generation curtailed	May 2024	23 hrs
PEC-2	OX1 (Buronga – Red Cliffs) and Red Cliffs 220 kV Busbar	Approx 900 MW renewable generation curtailed	Sep 2024	2 days
PEC-2	Wagga to Jindera Line 62 - Relocation onto temporary pole	Approx 1,900 MW renewable generation curtailed	Sep 2024	2 days
PEC-2	Wagga to Jindera Line 62 - Cutover into its new switchbays	Approx 1,900 MW renewable generation curtailed	Sep 2024	3 days
PEC-2	Darlington Point to Wagga Line 63, Wagga No.3 Transformer, Wagga B Bus No.2 section	Approx 1,300 MW of renewable generation curtailed	Sep 2024	5 days

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PEC-2 – Managing non-credible events

- Electricity transmission networks are designed and operated to withstand credible contingencies
- It would be prohibitively expensive to design and build a transmission system that can withstand non-credible contingencies without impacting on loads and/ or generators
- Instead, Emergency Control Schemes are used to keep the system connected and stable if non-credible contingencies happen
- The South Australian Interconnector Trip Remedial Action Scheme (SAIT RAS) is being developed to prevent SA being separated from the NEM
- Other RASs may be required to cater for non-credible events 'out of scope' for SAIT RAS, e.g.
  - Non-credible loss of the Buronga – Red Cliffs 220 kV lines
  - Non-credible loss of Moorabool - Sydenham 500 kV lines with significant generation connecting on that corridor
  - Non-credible loss of Buronga – Dinawan – Wagga 330 kV lines if significant generation connects on that corridor
- Number of impacted SPSs being reviewed
  - SA: 7 ; NSW: 7 ; VIC: 4

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SAIT RAS

Indicative concept design

Inputs Monitored

- Line End Open on PEC corridor into NSW, up to Wagga Wagga
- Line End Open on HIC corridor into Victoria, up to Moorabool
- Synchrophasor (PMU) measurements
- SA inertia
- Response resource availability

Central Control Unit

Monitors inputs shown and determines in real time the MW response required if one of the interconnectors was to trip or remedial action is required due to another non-credible event.

If remedial action is required automatically sends signals to deploy the required resources.

Resource Action

Very fast proportional response in SA - up to 600 MW

Potential actions:

- Trip load
- Trip generation
- Charge or discharge BESSs

Telecommunications requirements

- **Duplicated high-speed communications into Victoria and NSW**
- **Duplicated high-speed communications to resource response sites**

HIC – Heywood Interconnector **BESS** – Battery Energy Storage System

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