DIgSILENT Pacific

Power system engineering and software

Two hot topics

System strength and the 5.3.9 process

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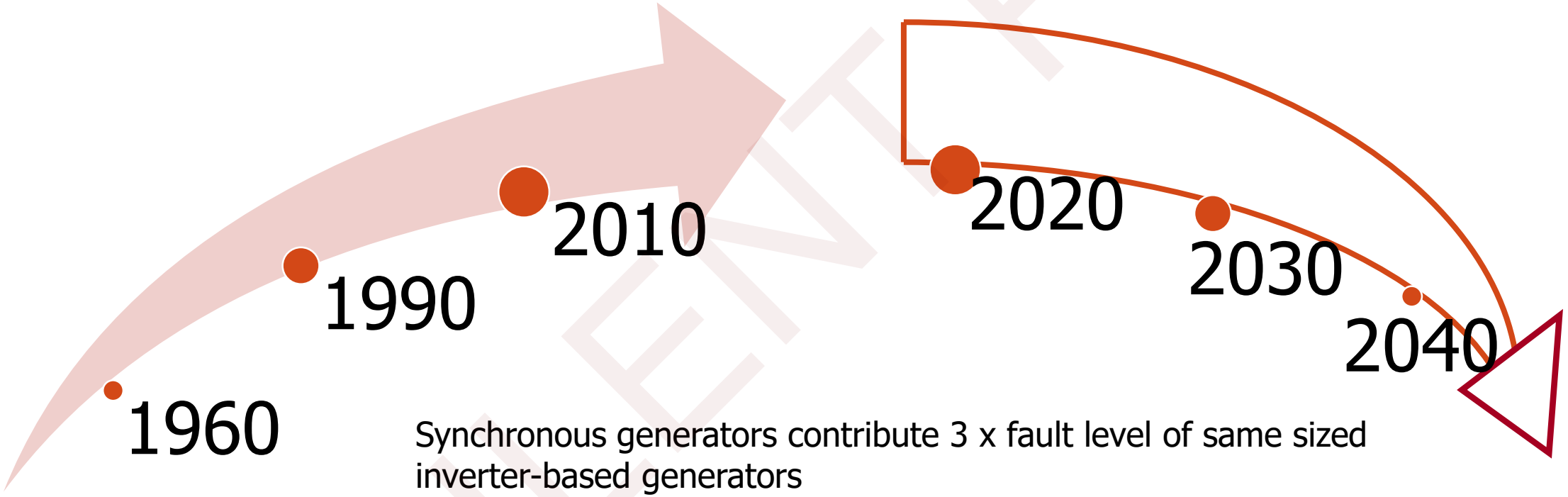
System strength – 3 messages

- System strength is influenced by fault level, and affects voltage stability
- It has become a major roadblock to orderly transition of generation to low carbon technologies
- The Rules around this need an urgent re-think

Low fault level = weak grid = low system strength

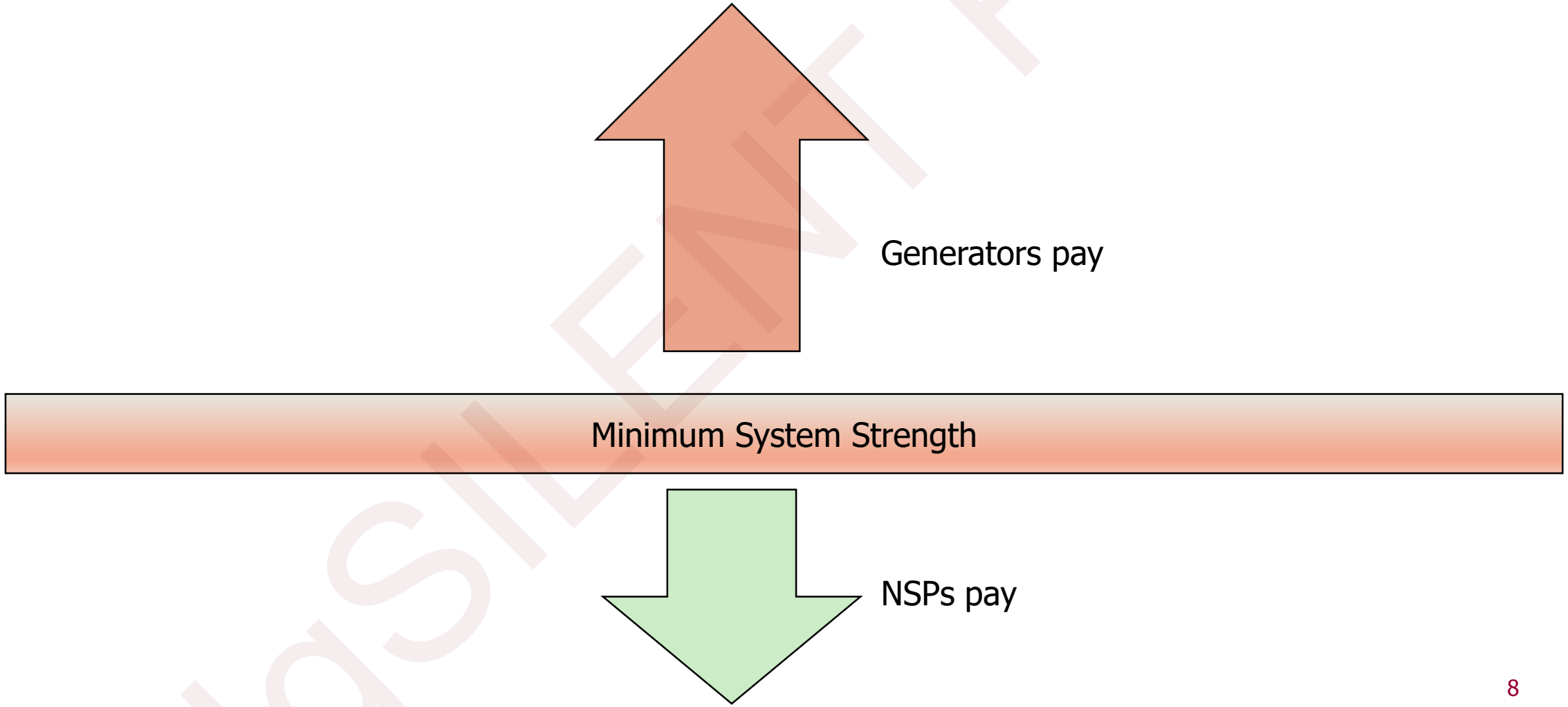


Synchronous generators contribute 3 x fault level of same sized inverter-based generators

Fault level also varies by

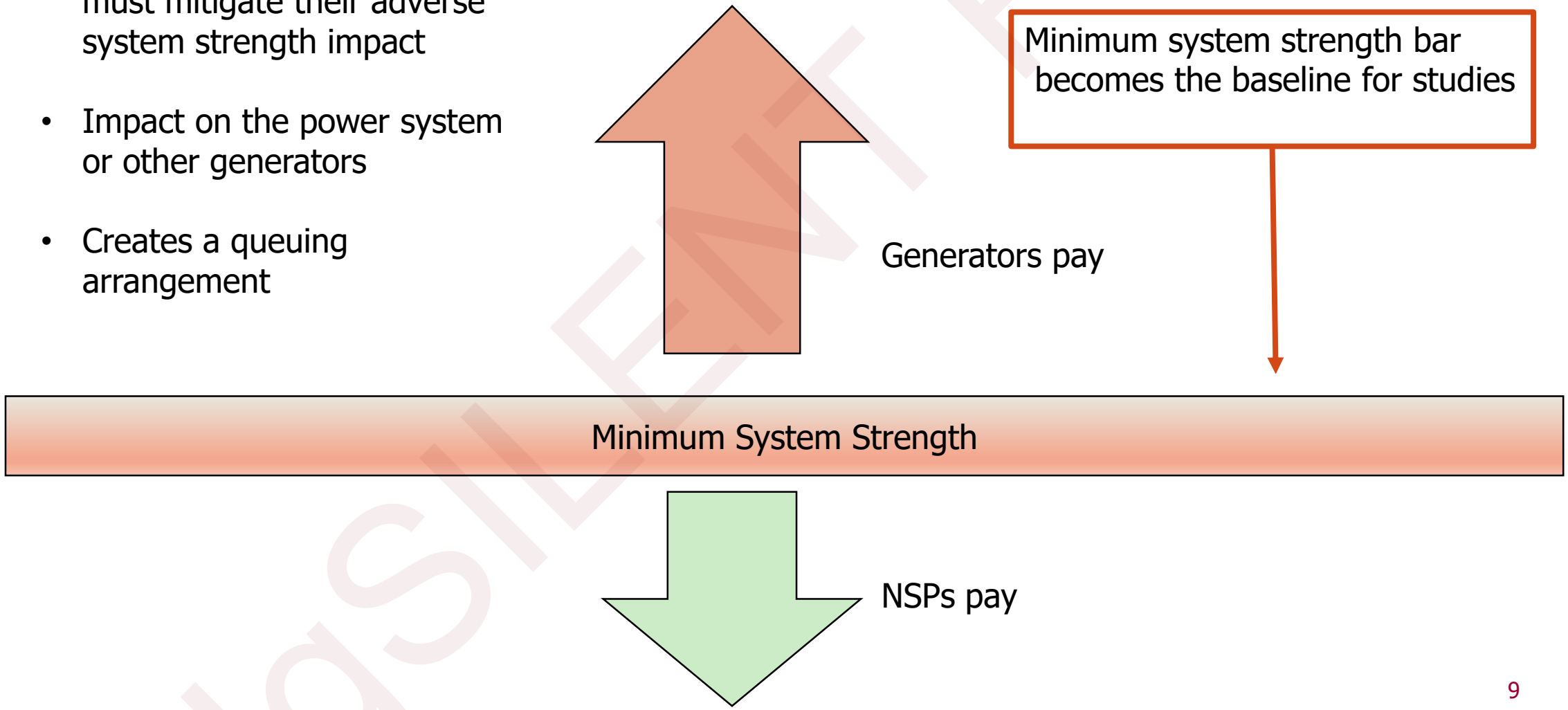
- Location
- Synchronous generation dispatch
- Network outages

System strength in the Rules

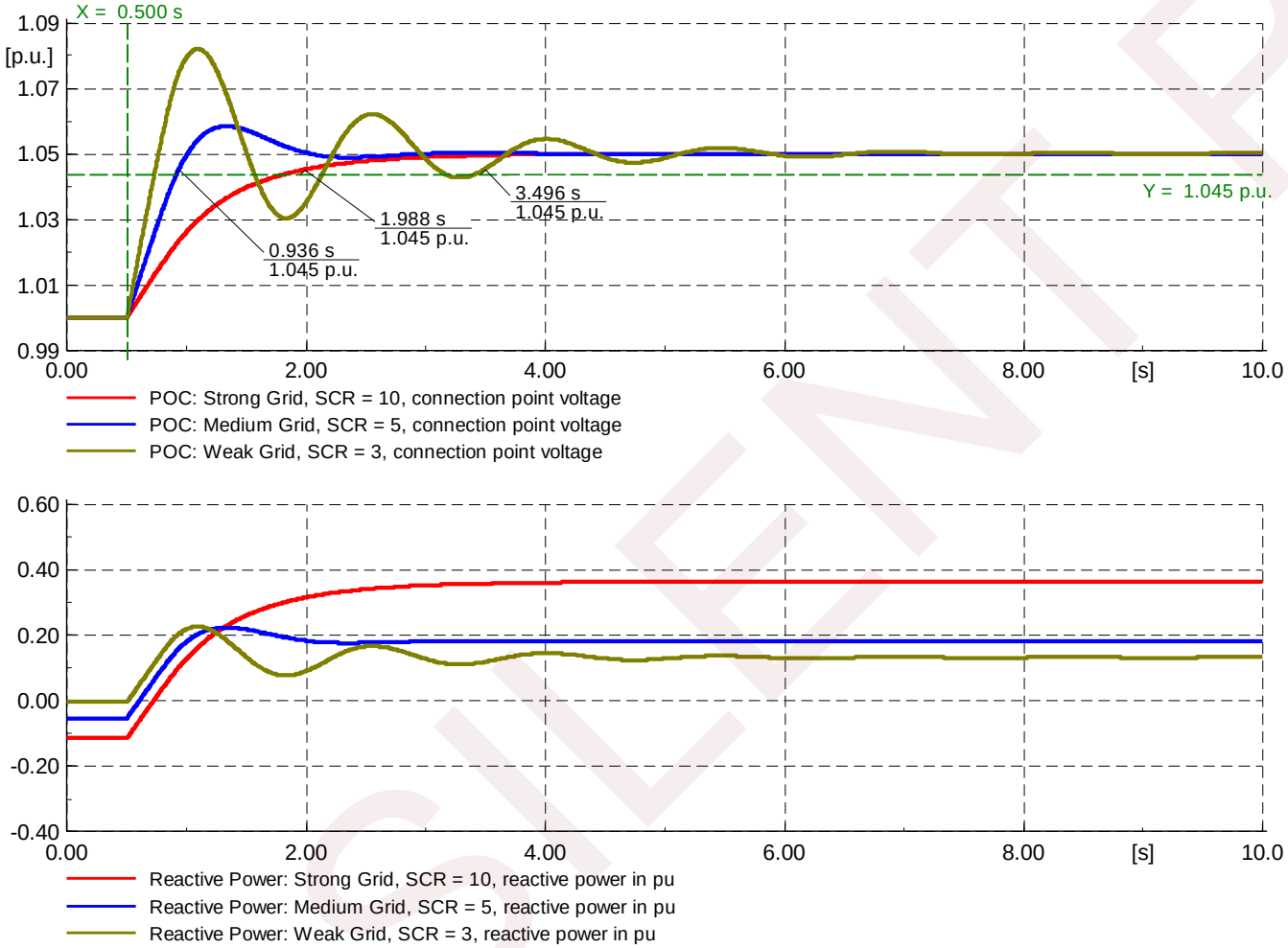


System strength in the Rules

- New or altered generators must mitigate their adverse system strength impact
- Impact on the power system or other generators
- Creates a queuing arrangement



Why is this a big deal? Its all about stability!

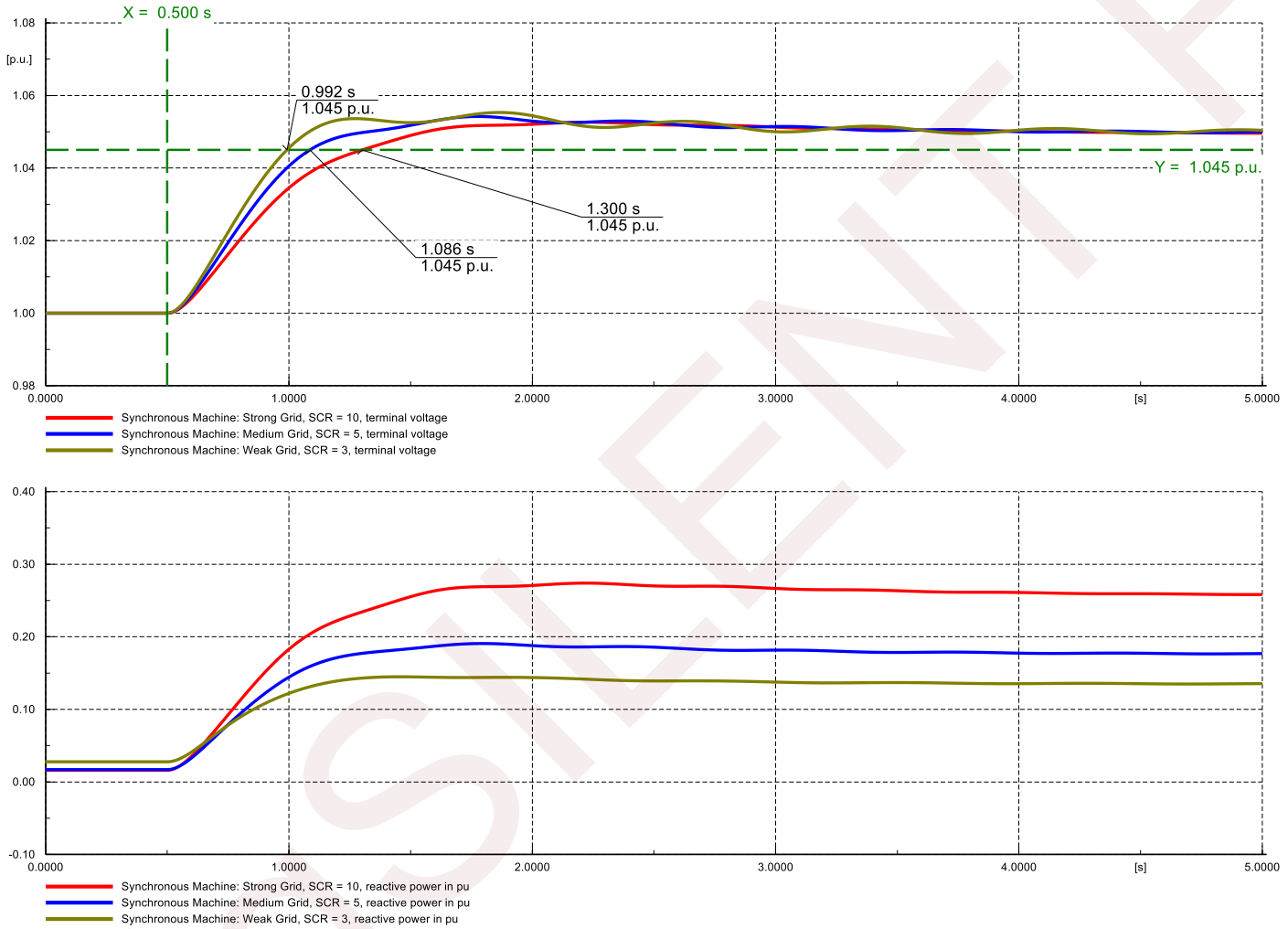


Slower response
as fault level
Increases

Less stable as
fault level decreases

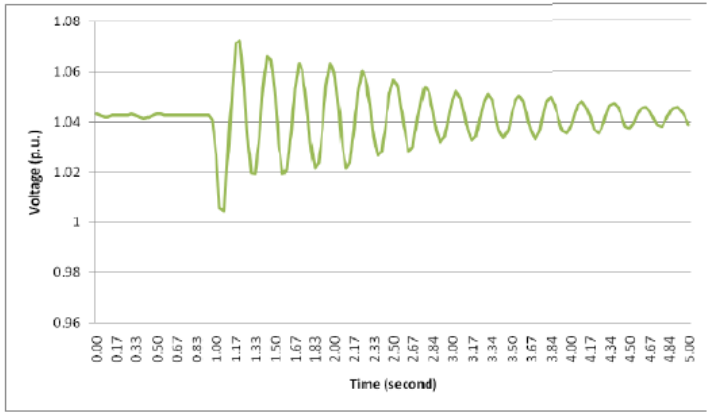
Less reactive power
power required
as fault level decreases
for same voltage change

Synchronous generators are not immune

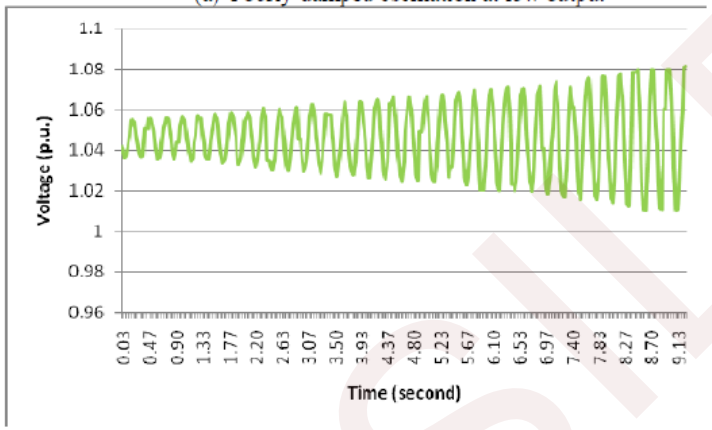


Damping is lower as fault level reduces

Oscillations observed (from USA – similar here)



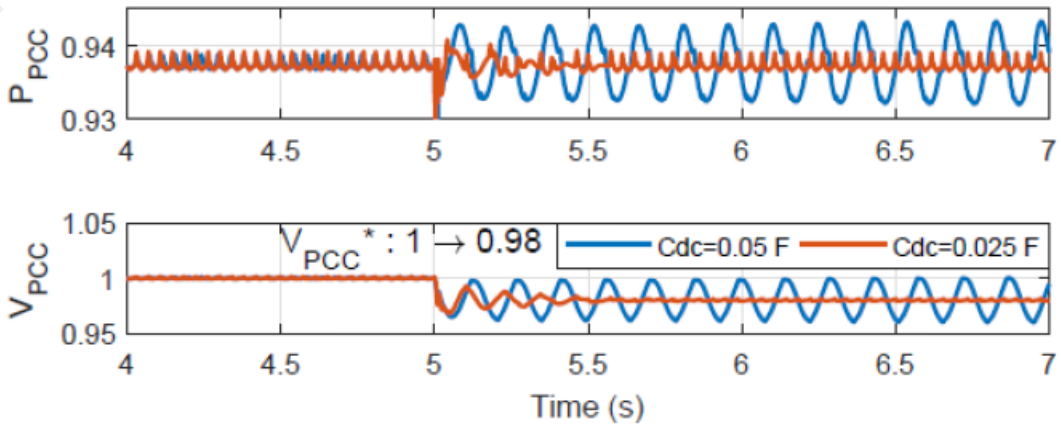
(a) Poorly-damped oscillation at low output



(b) Un-damped oscillations at high output

4 Hz oscillation on a wind farm

7 Hz oscillation on a solar farm



Source: Lingling Fan SETO Modelling conference 2019, USF

What does this mean for technical design?

- NER technical standards favour super-fast responses…….
  - But response depends on fault level
  - A fast response for the 'typical' fault level at a connection point may be unstable if fault level reduces for a network outage
- Over time, synchronous plant may retire, reducing the fault level
  - Over time the response of voltage control systems speeds up
- As you add more inverter-based plant to the same area, stability declines on existing plant, and new plant are at risk
  - Last minute system strength impacts
  - Parallel processing leading to over designed synchronous condensers

Impacts of low system strength

- 3 generators in Queensland currently constrained by system strength (more than 12 months)
- New connections in North Queensland stalled
- 5 generators in Victoria/NSW currently constrained by system strength – down to ½ capacity since September 2019
- 5 NSW/Vic generators in commissioning stalled – constrained at current hold point level
- Many more generators near completion unable to register and connect in West Murray area
- CEC reports $6.28 billion in investments threatened
- Investors are rattled: CEC reports 28 projects were approved in 2019 ($4.5 billion) down from 51 projects in 2018 ($10.7 billion)
  - Recent DIgSILENT analysis identified system strength as key barriers to new entry (other barriers being MLFs and congestion)

What needs to happen next?

- Technical solution involves coordinated retuning of control settings of existing plant (first step)

- This would minimise the cost of
  - Mitigating existing system strength problems
  - Connecting new generation
  - Non-compliances of existing generation

- Recent Rule changes hinder the process of changing control settings
  - Especially changes to clause 5.3.9 (next topic)

- Connection Applicants and their consultants need access to the wide area EMT models
  - Can’t propose settings to fix what you can’t model.

Other Rule factors

- System strength Rules create a queuing process
  - Leads to inefficient outcomes, expensive solutions – not consistent with NEO
  - Sequential connections assessment – significantly delays connection

- Some aspects of the technical standards need work, especially S5.2.5.13
  - Faster response is not better

- Need a better way of
  - Grouping connections
  - Optimising controls
  - Optimising network development
    - RIT-T process is too slow for renewables

- System strength impact assessment guidelines needs work
  - Process for identifying a system strength shortfall needs to be reviewed – clearly didn't work for Victoria's West Murray region
  - North Queensland as a problem too – that is hindering investment – but doesn't identify a shortfall
  - Preliminary impact assessment does not work

5.3.9 Process – changes to generating systems

5.3.9 Three messages

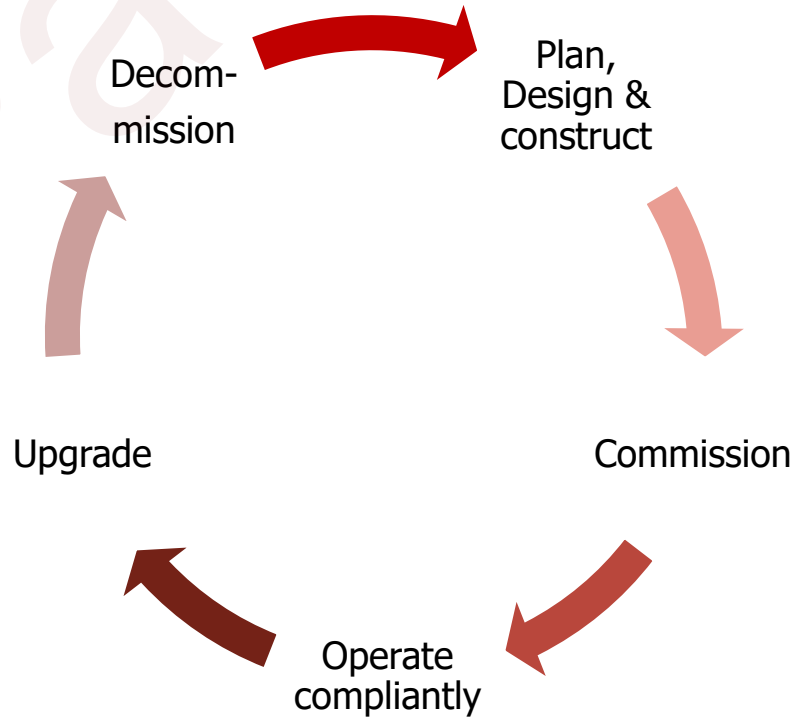
- Recent changes to the 5.3.9 process, and associated policies, have added layers of complexity, time and cost

- The changes also increase the technical risks to the operation of the NEM
  - Potentially detrimental to power system security and cost of supply to customers

- Streamlining is required, including changes to the Rules

Changes to generating systems

- Clause 5.3.9 of the NER applies to a Generator wishing to alter a connected generating plant
- Applies where
  - there are alterations to a connected plant
  - plant not yet connected, but generator performance standards previously accepted
- And will
  - affect performance of the generating system relative to any technical requirements of S5.2.5, S5.2.6, S5.2.7, S5.2.8 or
  - have an adverse system strength impact (in AEMO's opinion) or
  - Adversely affect network capability, power system security, quality or reliability of supply, inter-regional power transfer capability or use of network by another Network User
- Present day technical requirements apply
  - Affected performance standards depends on what is altered.



Other relevant changes to Rules : system strength

- System strength:
  - NSP must undertake a system strength impact assessment for each proposed alteration to a generating system to which clause 5.3.9 applies (5.3.4B)

- If the assessment indicates an *adverse system strength impact*, either:
  - NSP undertakes works at generator's cost or
  - Generator proposes a remediation scheme or
  - Both (5.3.4B (e) and (f))

Changes to negotiation framework for technical rules

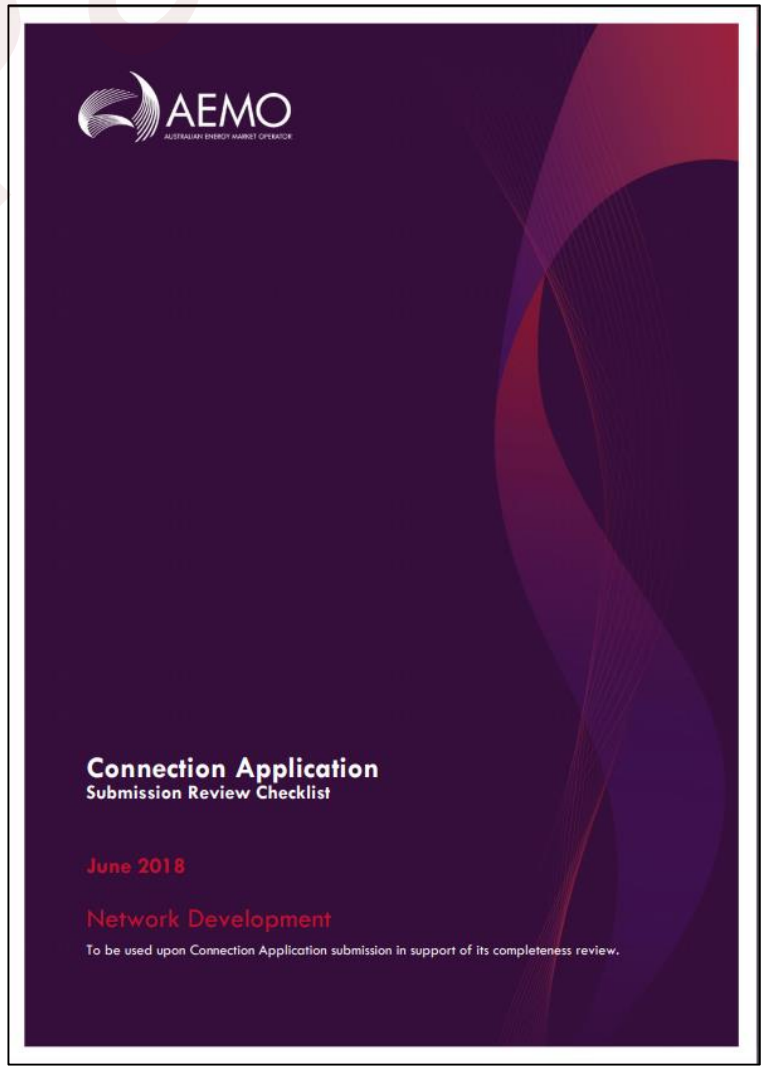
- Negotiated access standards (5.3.4A(b1))
  - As close as practicable to automatic access standard
  - Having regard for
    - Need to protect plant from damage
    - Power system conditions at the connection location
    - Commercial and technical feasibility
  - Automatic standards have increased (especially voltage ride through, response to disturbances, voltage/reactive control systems)
    - Compliance assessment is much more time consuming and onerous than earlier technical standards
  - Minimum negotiated standard permitted is (5.3.4A(1A)):
    - no less onerous than the performance standard that corresponds to the technical requirement that is affected by the alteration to the generating system

Additional requirements for connection

- Modelling:
  - PSCAD models required – NEW
  - PSS/e models may need to be updated (additional model validation requirements)
  - PSS/e Model acceptance tests
  - Benchmarking of PSS/e and PSCAD models - NEW
  - Functional block diagrams and source code
  - Model validation (R2) report (NEW for PSCAD)
  - Releasable user guide (NEW for PSCAD)
  - Power system datasheets

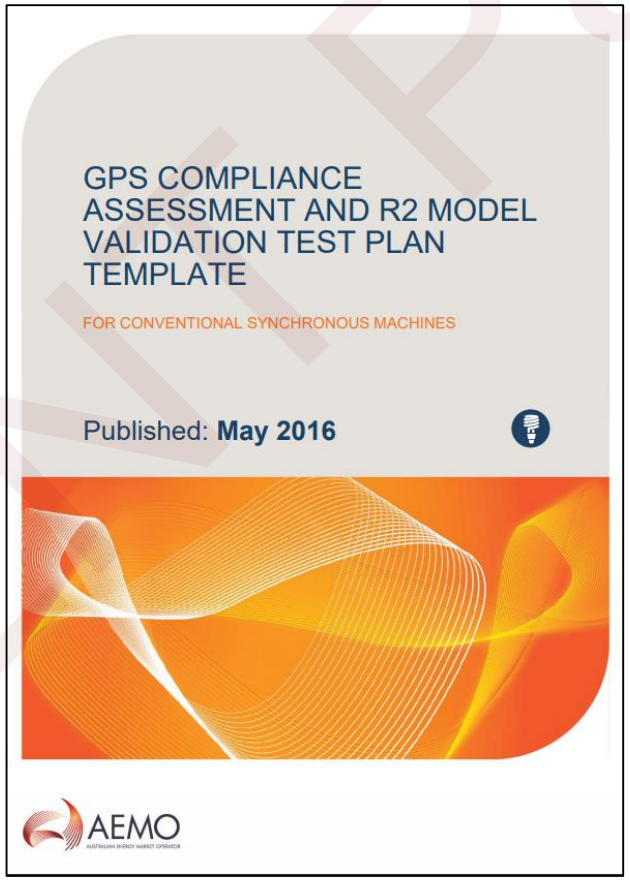
- Performance standards:
  - GPS into latest format
  - Connection studies (NEW technical standards)
  - Voltage control strategy document (NEW)
  - Single line diagrams (various)
  - Protection and control scheme details
  - Generating system capability curve

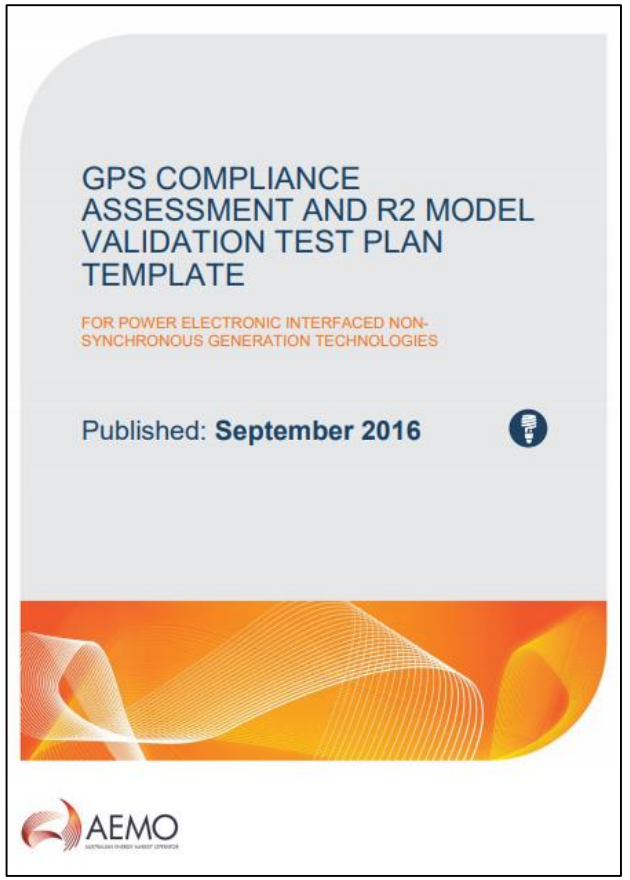
- System Strength Impact assessment
  - Preliminary/ Final impact assessment
  - Remediation scheme



Additional requirements for commissioning

- AEMO has published templates for commissioning of synchronous and asynchronous plant
  - Greater emphasis on overlays of measurement with PSS/e models
  - Hold points can be much slower/more onerous (NSP dependent)





Problem areas: 5.3.9 process is a deterrent to updating settings and controls (1)

- During commissioning is most likely time to find GPS compliance problems
  - 5.3.9 process is unworkable for minor tweaks of controls and GPS
    - Time consuming, risky and costly
  - Often performance is not as good, but impact on security/power quality is not significant -
    - Conflicts with minimum negotiated access requirement
  - E.g. firmware upgrade to correct some performance flaw leads to additional requirement reduction in active and reactive capability with temperature
  - **Rules need some allowance for adjustments to GPS below existing**

Problem areas: 5.3.9 process is a deterrent to updating settings and controls (2)

- **Control system optimisation across multiple generators can increase hosting capability of network**
  - **5.3.9 process cost and risk for generators deters changes**
- **Slower controls can improve performance**, but S5.2.5.13 is written as if faster is always better
  - **conflicts with minimum negotiated access requirement**
- Potential **need for periodic review of all power system stabiliser settings** across NEM as fault level drops and inertia drops (frequency rate of change increases)

Problem area: 5.3.9 process makes upgrades very expensive and risky (1)

- Minimum negotiation requirement refer to no less onerous than the [existing] performance standard
  - New technical rules have additional requirements
  - **Previous standard may be silent**, but actual performance of plant less than current minimum standard
    - E.g. multiple ride through – not dealt with explicitly in previous rules
      - **Risk is undeniable: AER is prosecuting wind farms for not riding through multiple faults in 2016 SA blackout**
    - Accessing actual multiple ride through capability is difficult for old plant – requires mechanical design to be assessed

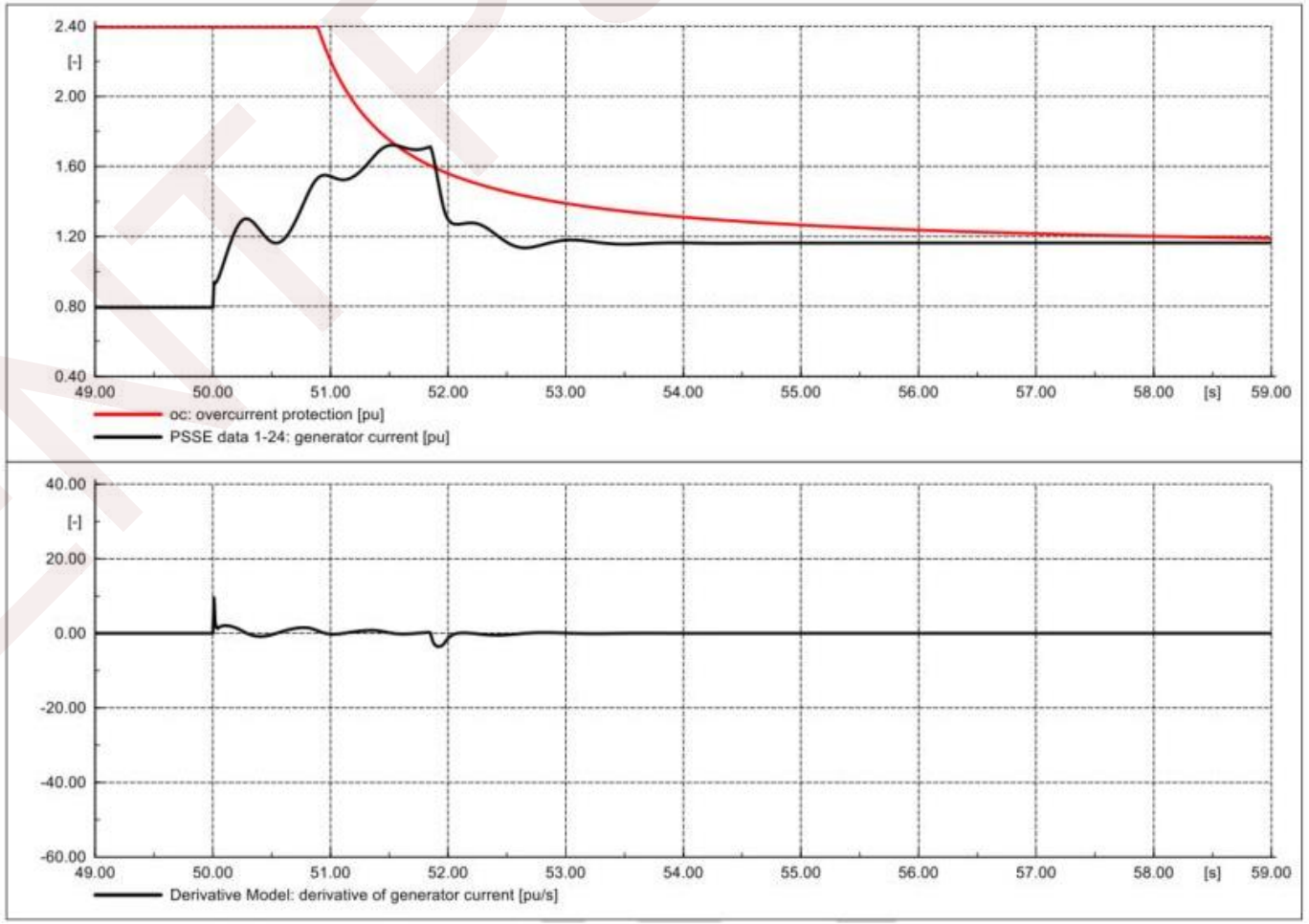
"On 6 August 2019 the AER commenced proceedings against four wind farm operators (AGL, Neoen, Pacific Hydro and Tilt Renewables) concerning the Black System Event in South Australia on 28 September 2016….
The AER is alleging that certain wind turbine generators ceased supplying power in response to voltage disturbances that occurred on 28 September 2016. By not maintaining continuous uninterrupted operation to ride-through low voltage disturbances, as required by their Generator Performance Standards, we allege the generating units at the wind farms contravened the National Electricity Rules. …The AER is seeking declarations, orders for a compliance program, pecuniary penalties and costs."

Source AER

Problem area: 5.3.9 process makes upgrades very expensive and risky (2)

- **Interpretation of rules has changed since GPSs were first written**, where performance requirement was in previous GPS.

- E.g. S5.2.5.4: previous requirement for continuous uninterrupted operation in range 0.8 pu to 1.1 pu for 10 seconds was **NOT** interpreted previously to mean generator had to operate at 0.8 pu for 10 seconds.



Problem area: 5.3.9 process makes upgrades very expensive and risky (3)

- Generating systems not previously exposed to system strength requirements are exposed when changes are made.
  - High risk for asynchronous generators (solutions tend to be very expensive)
    - **High deterrent for upgrades**
  - Unable to assess without NSP modelling.
  - Process highly lacking in transparency.

Areas where Rules changes are required

- **Need a process for coordinated changes to settings/controls on generators and NSP devices**
- to improve system strength, improve hosting capacity, improve p.s. security

- Should not:
  - Require costs to be borne by individual generators – **benefit is to whole NEM and consumers**
  - Impose additional performance obligations on generators
  - Expose generators to system strength risks
- Should
  - Streamline additional documentation requirements
  - Allow slower control actions, where this improves overall system performance or hosting capacity of power system
  - Require TNSP (or AEMO?) to coordinate settings (on SVCs too)
  - Require TNSP to be transparent about modelling assumptions and results (as this may affect generators' performance standards/compliance)
  - Remove setpoint change response time from GPS (S5.2.5.13)

In line with this:

- **Need Rule change to require review PSS settings through out NEM periodically** as fault level and frequency behaviour of the power system changes over time

Change minimum negotiated requirement

- Where existing GPS is silent on a technical requirement that is included in the new technical standards
  - **Minimum negotiated requirement should reflect the actual plant capability**

- Where existing plant cannot meet its GPS (eg non-compliance found during commissioning/ operation)
  - **Needs to be a pragmatic approach that allows for a lower standard to be accepted, where its impact is not materially detrimental** to:
    - Power system security
    - Power quality
    - System strength
  - Clause 4.14 (p) allows for amendment of GPS by agreement of parties
    - Can be applied when no alteration to plant is required

Summary

- Looked at:
  - Why system strength has become a major bottleneck for the NEM
  - The implications for generators and controls design and coordination

  - How the 5.3.9 process has changed over the past few years
  - Why both issues have become expensive and risky for generators

- Shown that system strength and some of the current Rules are
  - Putting investment in the NEM at risk

- Shown the 5.3.9 process is detrimental to:
  - Cost of electricity to consumers

- Touched on changes to the Rules are that needed to address these deficiencies

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