DIgSILENT Pacific

Power system engineering and software

Validation of solar power plant dynamic model
using commissioning test measurements

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DIgSILENT Pacific's NEM experience during 2017-19:

- Over 20 solar farms
- Located in VIC, NSW and QLD
- Designed 1,900 MW
- Commissioned 920 MW

Agenda

- NEM commissioning journey
- Model validation tests
- Model overlay examples
- Challenges during model validation process
- Reflections on model validation methodology
- Conclusions

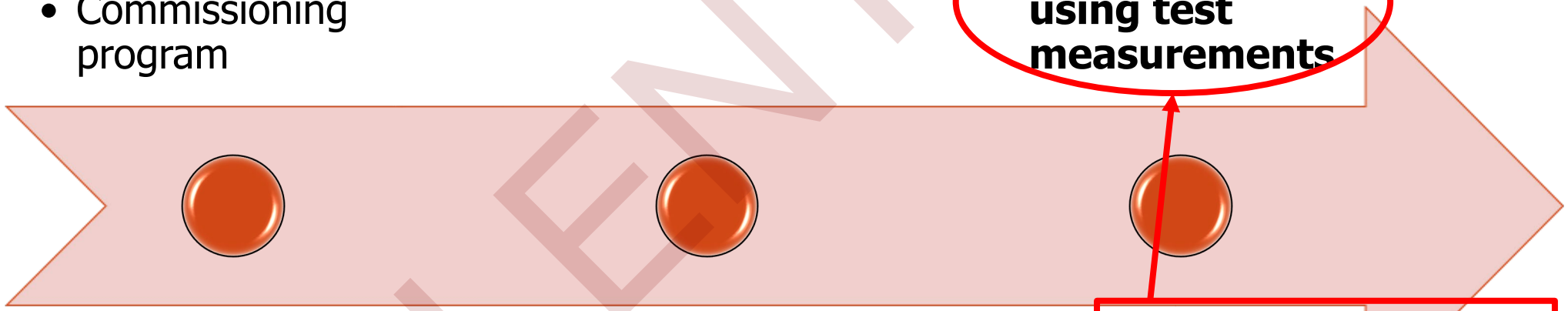
Commissioning journey in NEM

3 months before

- Model assessment
- Technical study
- Commissioning program

3 months after

- Compliance assessment results
- **Model validation using test measurements**

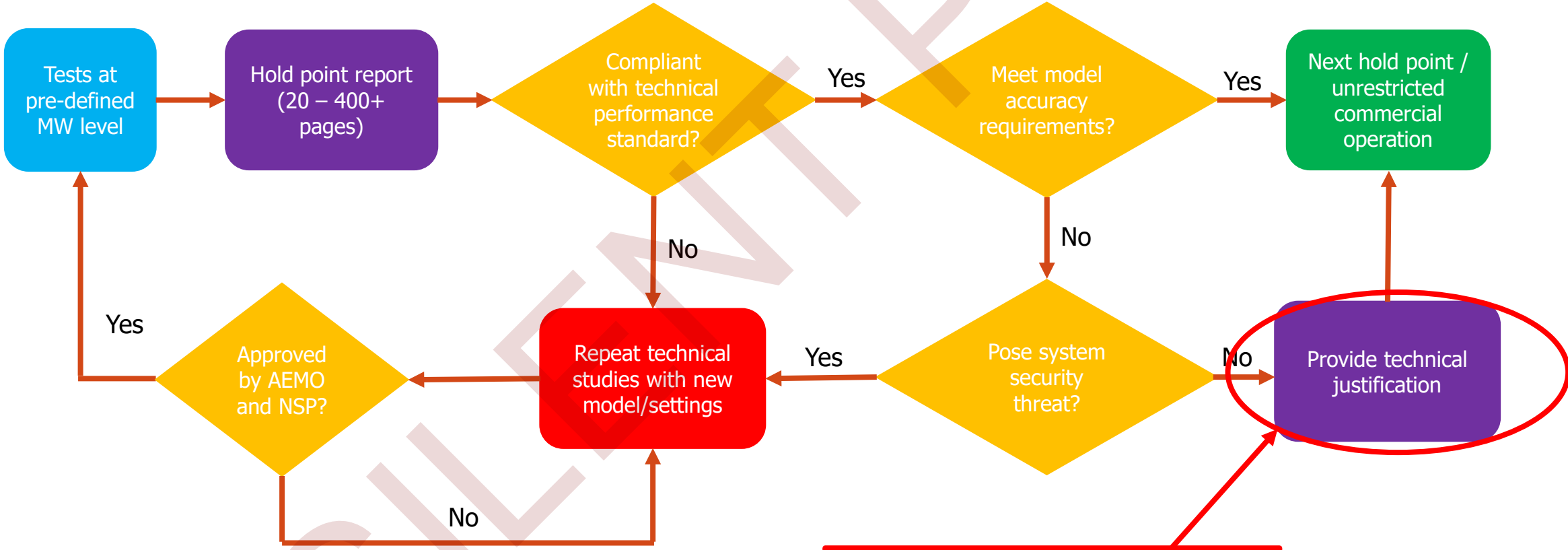


During commissioning

- Load profile
- Pre-test simulation
- **Hold point tests**

Require model overlay with measurement

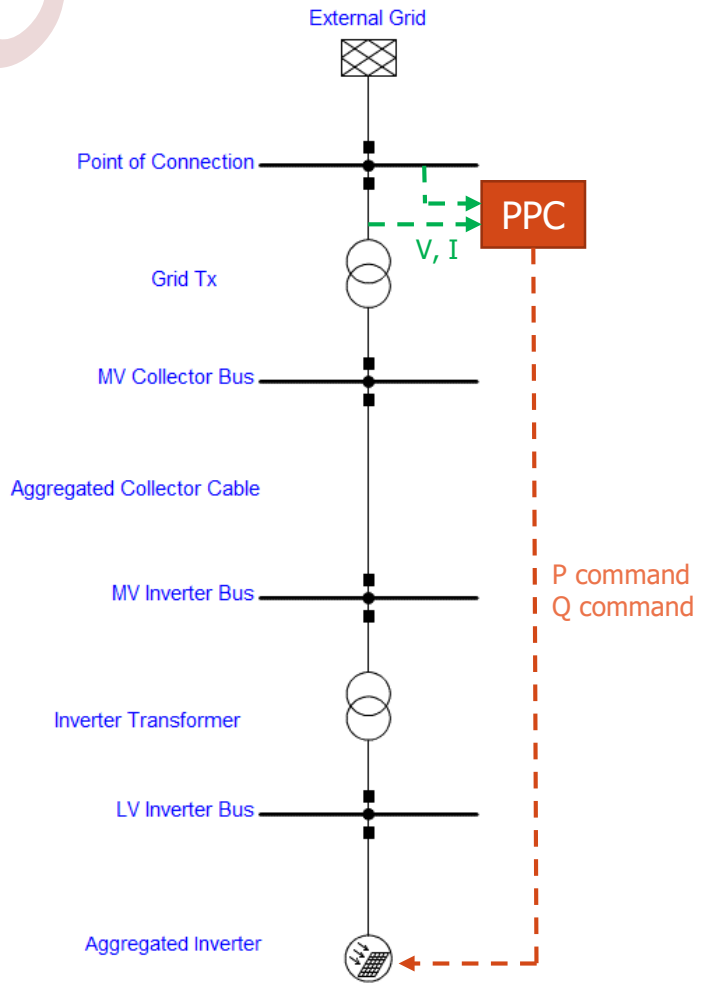
Hold point testing



Good justification can avoid repeat of tests

Solar power plant dynamic model validation

- Inverter and power plant controller (PPC) dynamic models to be validated
- Equivalent lumped collector network model is mainly used in the model validation
- Model validation test type:
  - Reactive power (or power factor) step test
  - Voltage step test
  - Active power ramping test
  - Frequency control test
  - External voltage disturbance test (e.g. capacitor switching test)
  - Reactive power capability assessment
- Fault-ride-through performance is difficult to be validated on site



Measurement for commissioning tests

HV and MV terminals of main transformer

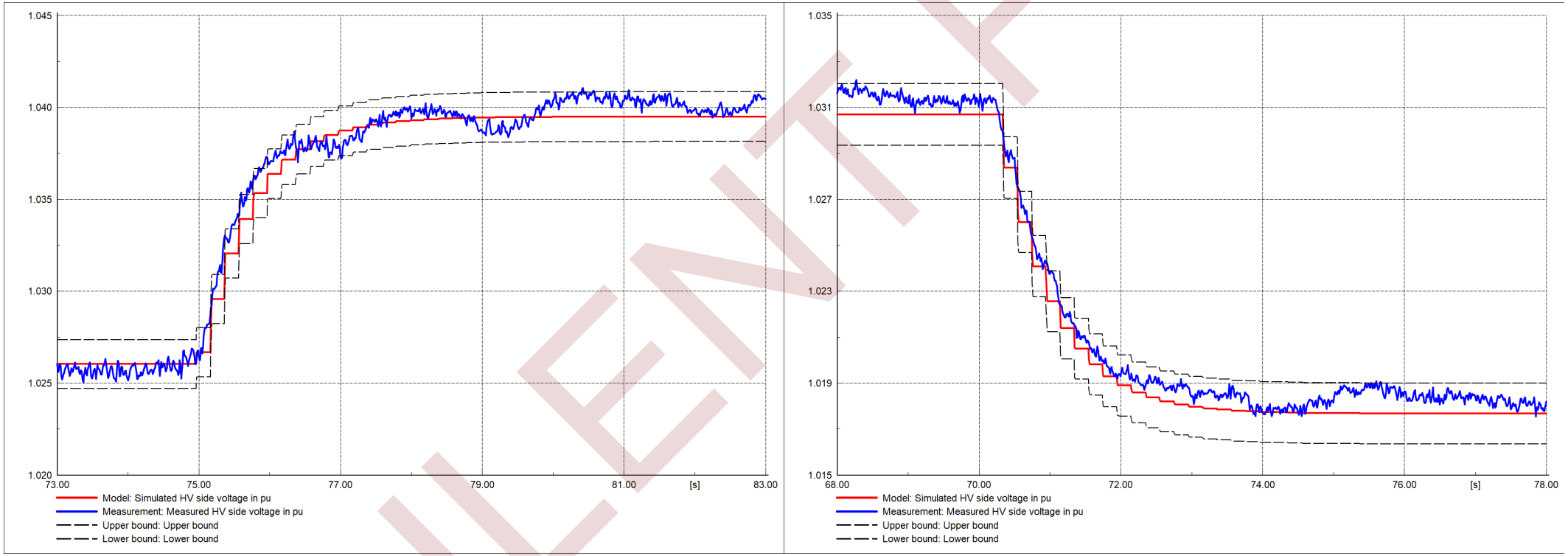
Inverter LV terminal electrically CLOSEST to MV collector bus

Inverter LV terminal electrically FURTHEST to MV collector bus

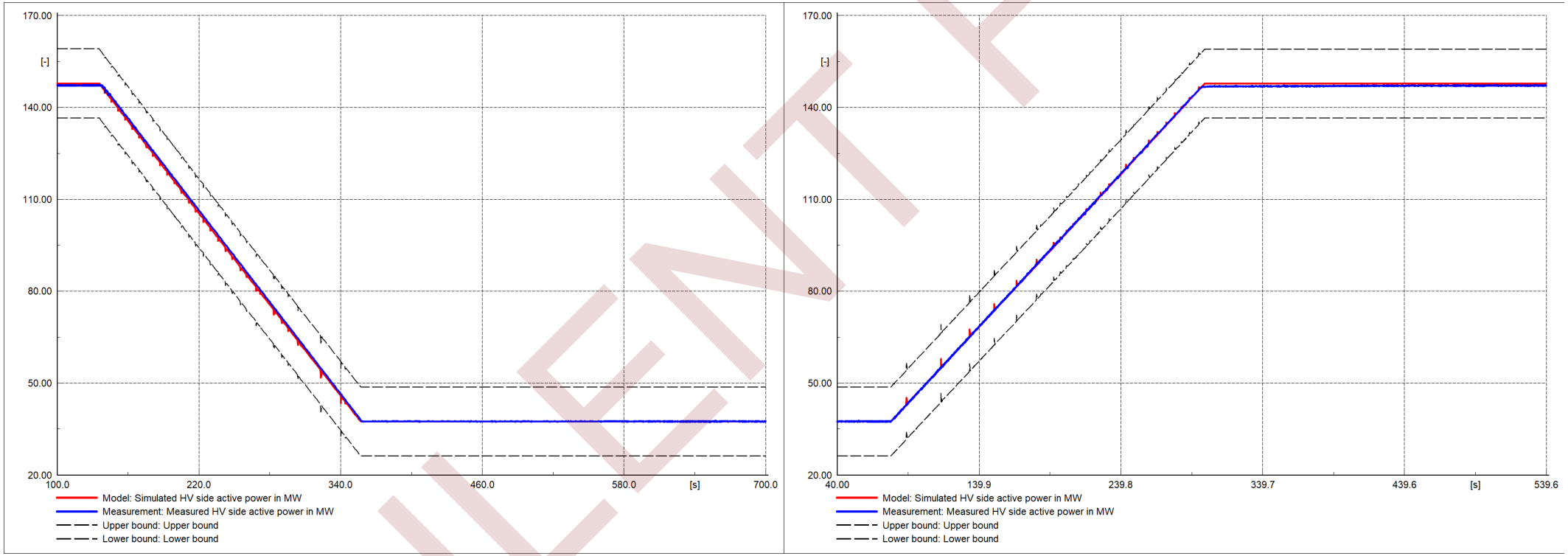
Meter requirements:

- Time synchronised with other meters
- High speed monitoring (sampling rate >10kHz)
- Calibrated
- Independent of the control system

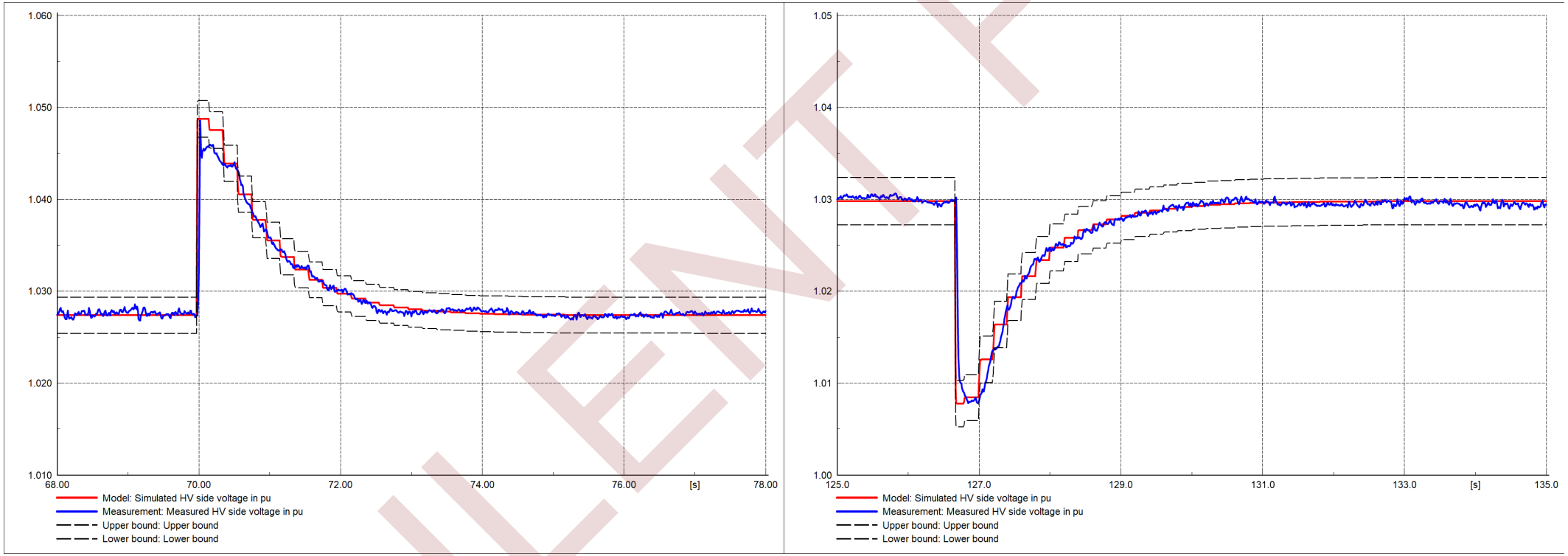
Model overlay example 1 - Voltage step tests



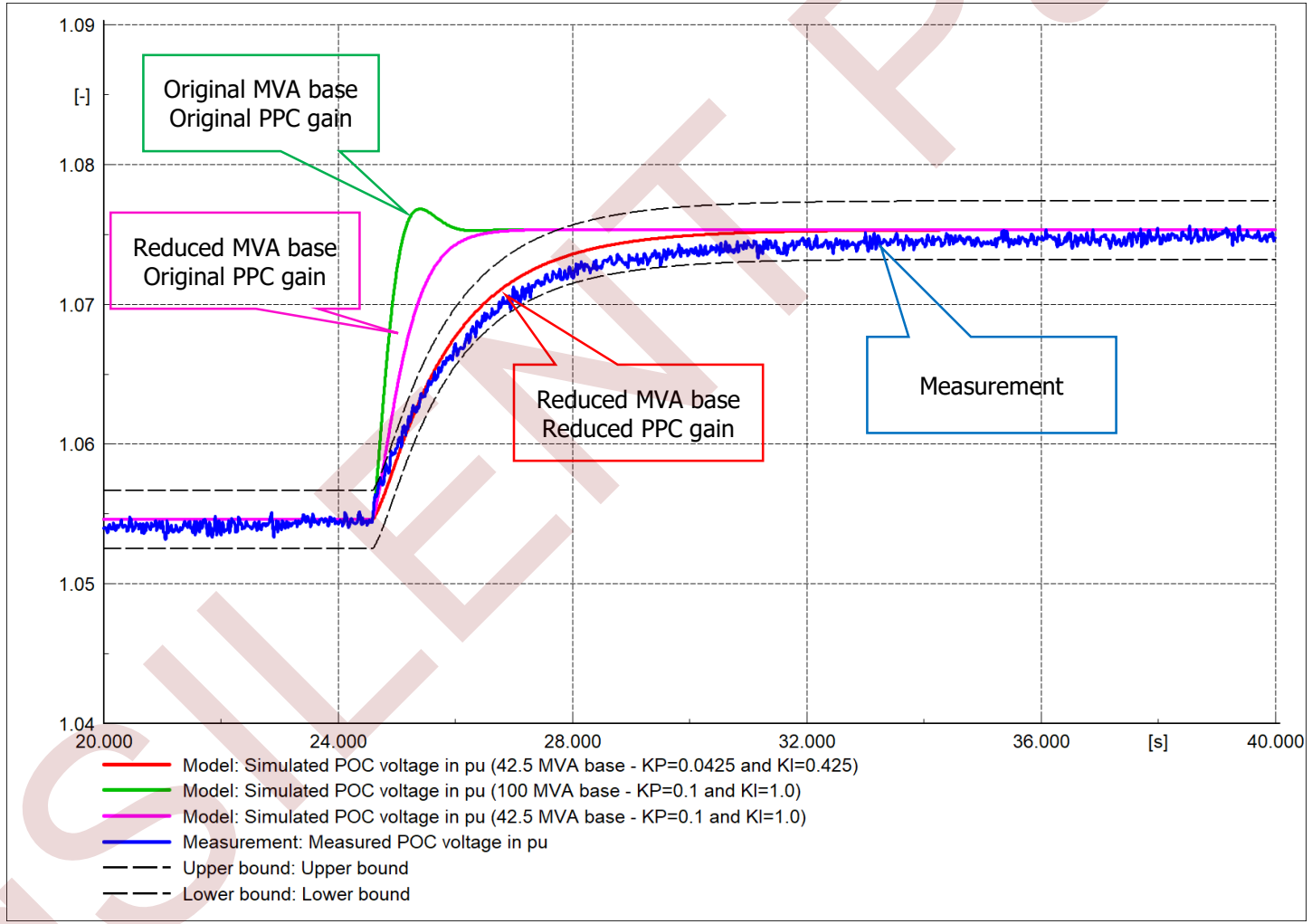
Model overlay example 2 – Active power ramp tests



Model overlay example 3 – Capacitor switching tests

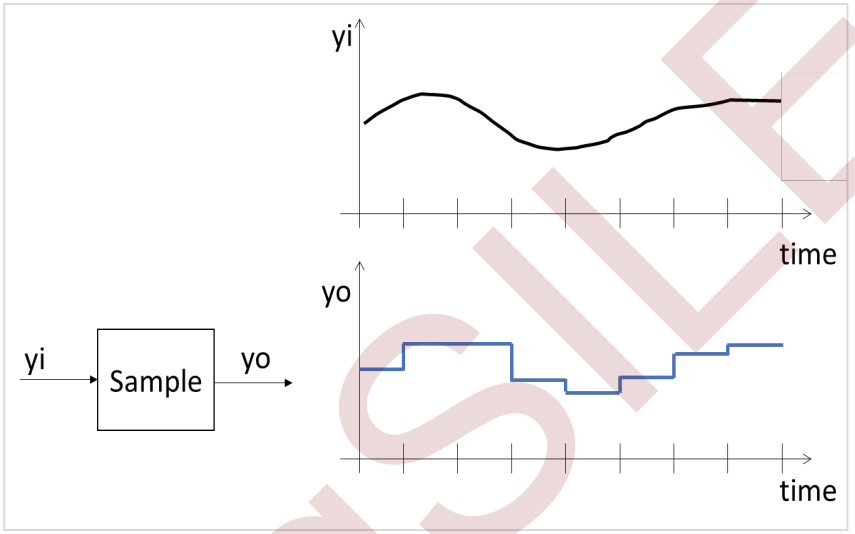


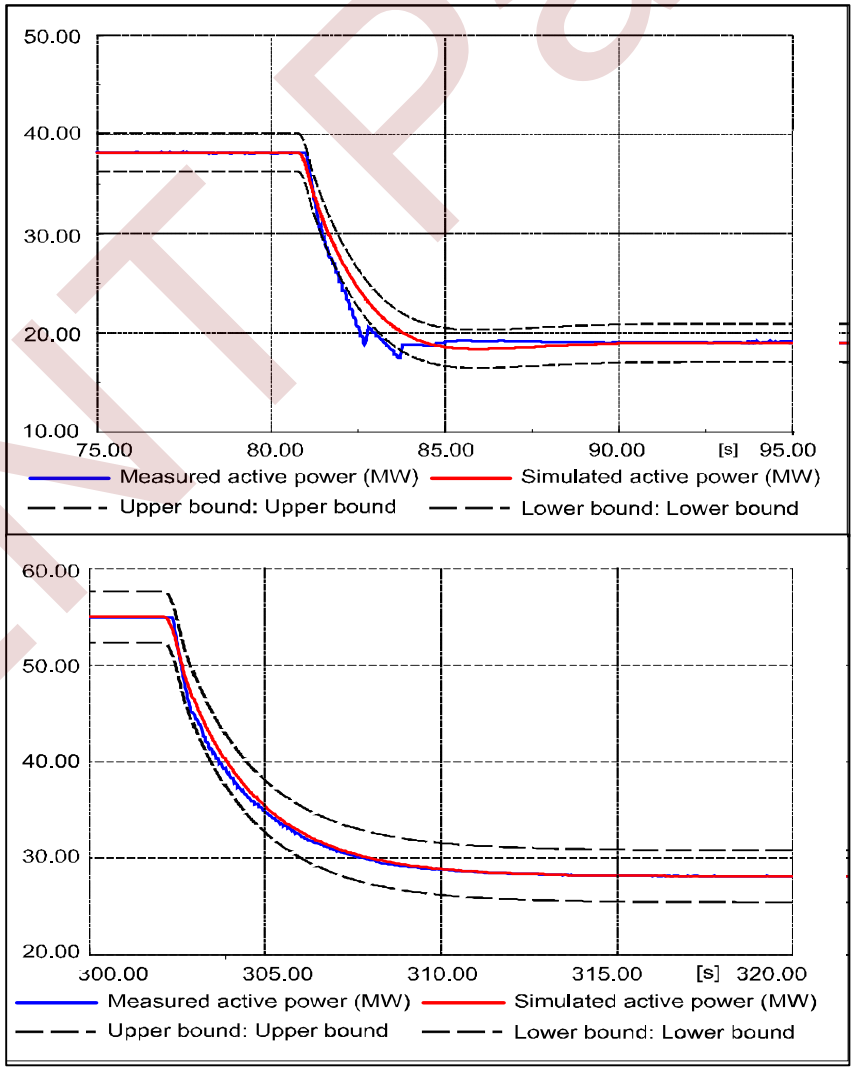
Challenge 1 – Reduced number of inverters



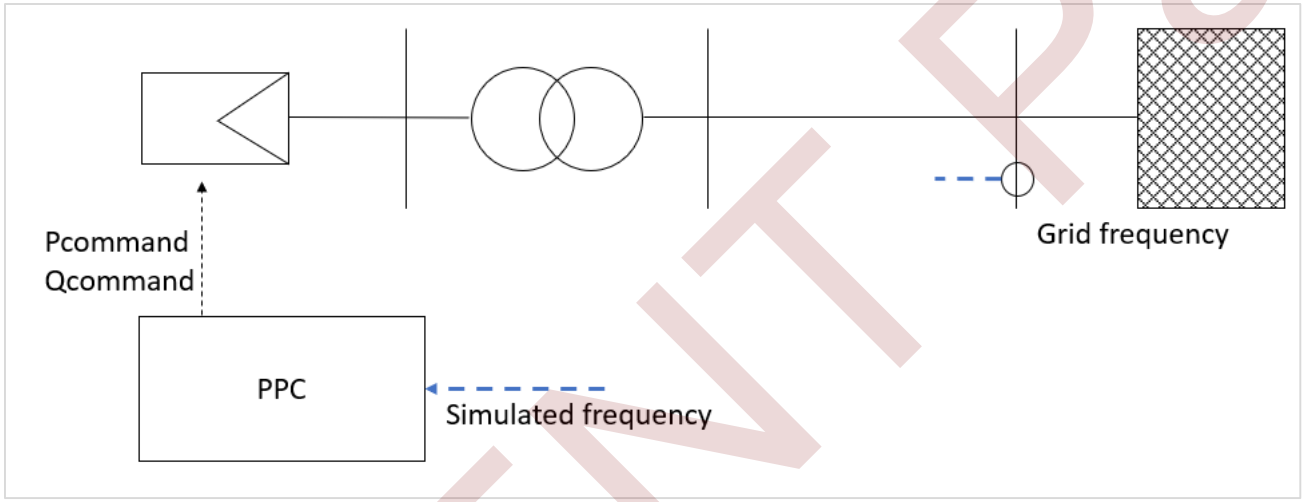
Challenge 2 – Low sampling rate of PPC meter

- PPC cycle time ≈ 100ms
- Default sampling rate of PPC meter = 200ms (or 1s)
- Model alignment becomes an issue when sampling rate ≥ 200ms
- Nyquist sampling theorem, i.e. <50ms sampling rate

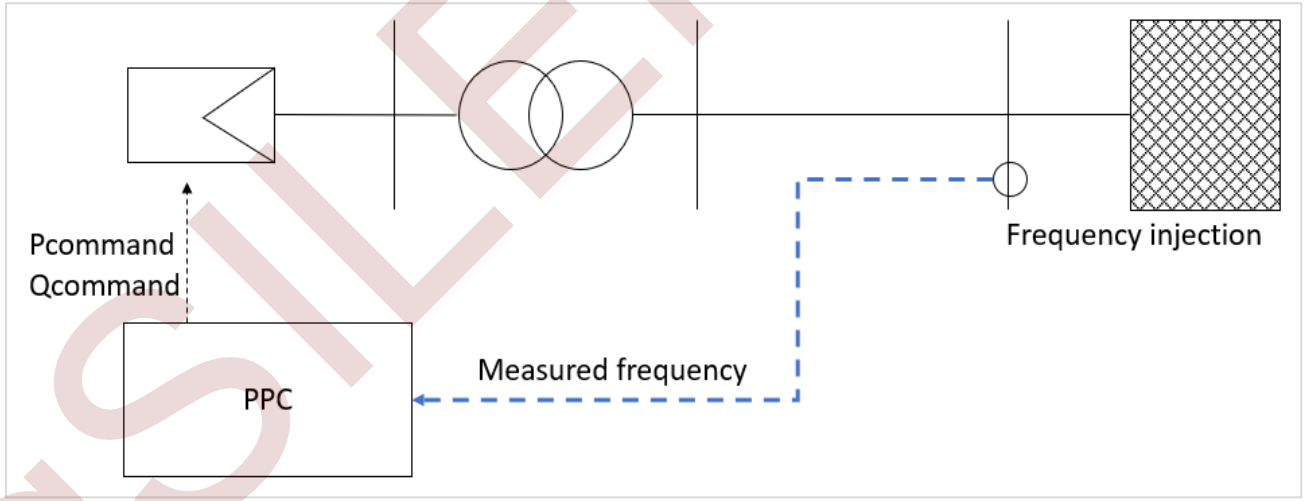




Challenge 3 – Different frequency step application

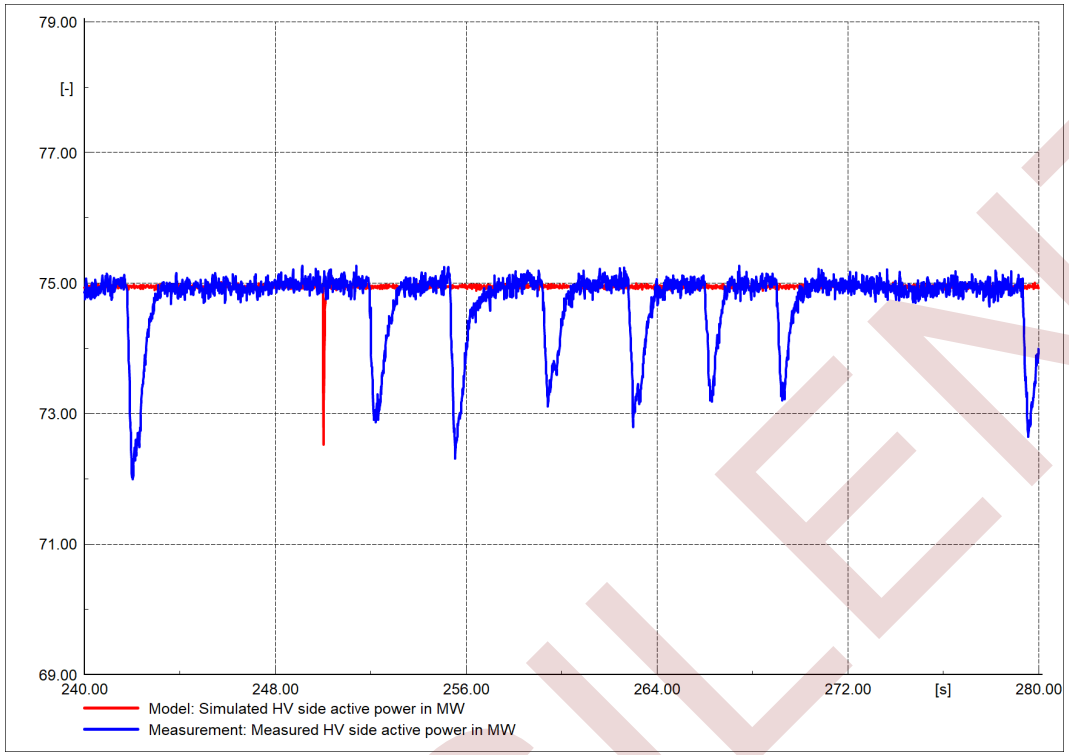


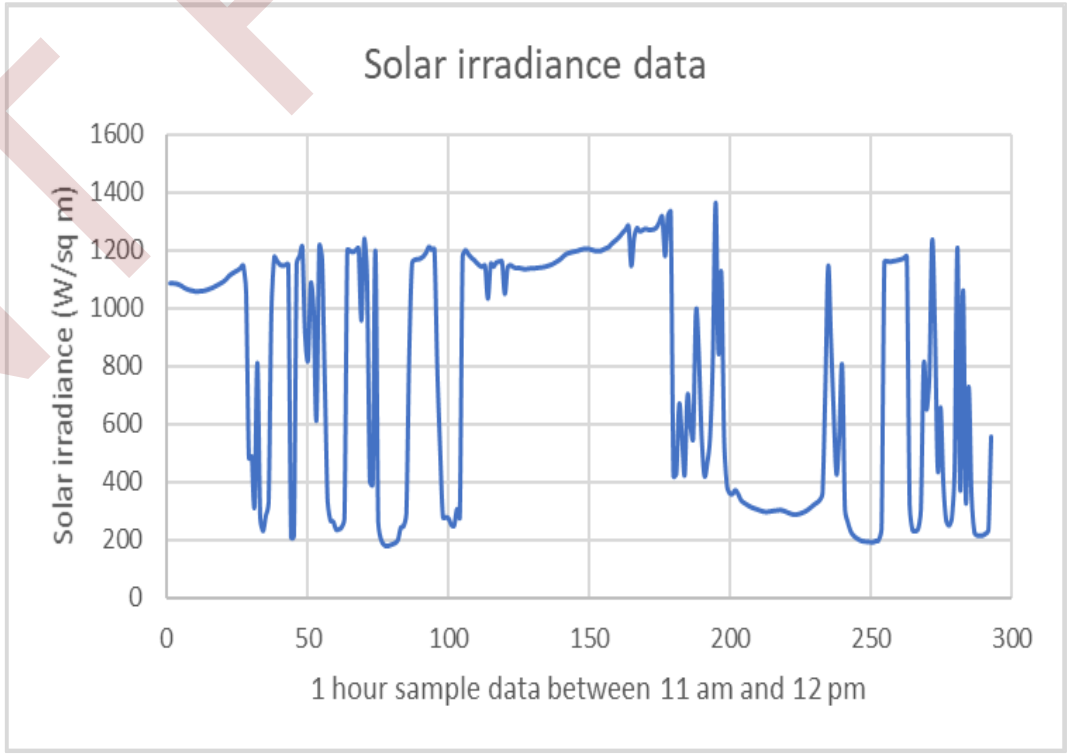
On site setup



Model simulation setup

Challenge 4 – Variation in solar irradiance





Reflections on model validation methodology

- Existing generating system model validation requirements used in NEM are mainly developed based on synchronous machine commissioning test experience

- Differences between synchronous machine and inverter technologies:

Synchronous machine	Inverter
Each generating system is unique	Inverter system design is standardised and modular
PID control can be measured on-site	Inverter control algorithms are “blackbox”
Generating system responses are relatively slower	Generating system responses can be very fast

Reflections on model validation methodology

In light of differences between synchronous machine and inverter technologies, reconsideration of the model validation objectives and methodology is needed:

1. For the same inverter type, is it better to perform type testing at the OEM factory with site-specific settings downloaded to the inverters?

2. Can conventional RMS model accurately represent sophisticated power electronic inverter and controls?

3. Is it still reasonable to expect plant measurement to align very closely with simulated response?

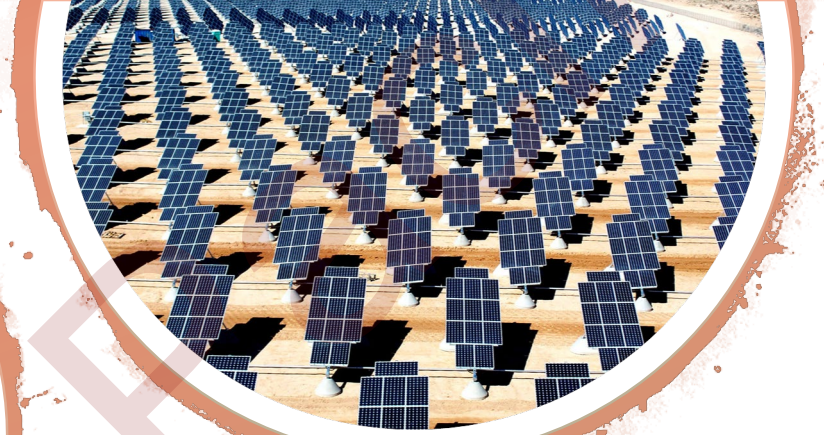
4. How will the commissioning tests and model validation process be affected by supporting plants within the solar power plants (e.g. synchronous condenser, battery storage)?

Conclusions

- Solar power plant commissioning is relatively a new experience in NEM (and probably elsewhere in the world)
  - Different grid operators have different requirements and methodologies
  - More and more requirements in time
  - Cause delay in commissioning timeframe and increase in cost

- Model validation process is valuable as it enables better understanding of the solar power plant performance and capability
  - This is the main reason for sharing this commissioning experience

- In order to streamline the model validation process, it is good practice to ensure that:
  - Model parameters are consistent to the actual plant configuration
  - Detailed test log is kept
  - Measurement equipment is calibrated



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