Validation of IBR equivalent plant level PSCAD model using Synchrophasor measurements

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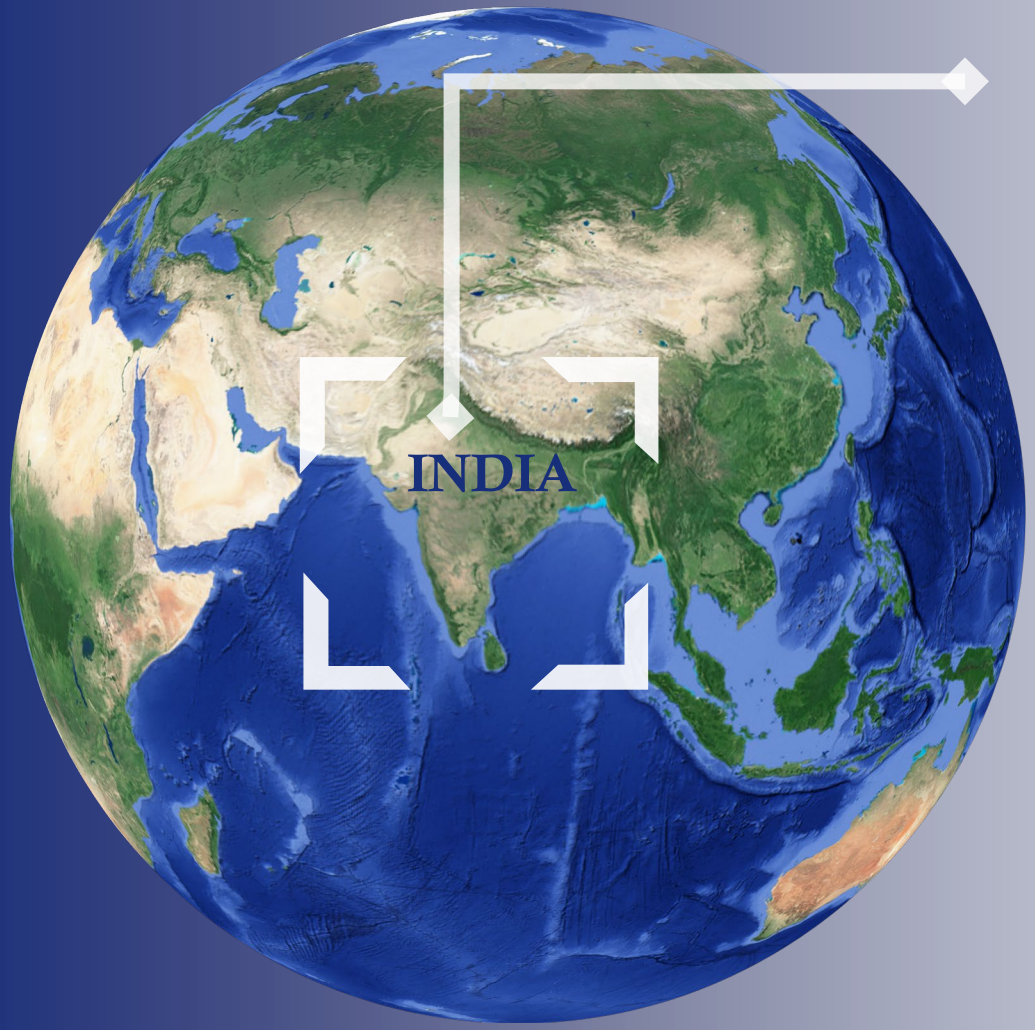
Contents

- Indian Grid
- Additional Transmission system for Renewables
- Western Regional Grid of India
- Renewables Integration Process
- Verification of models
- Validation of PSCAD simulation Model
- Conclusion

Indian Grid.. One of the World's Largest



1 National synchronous grid

3 Electricity consumption

4 Wind generation

5 Renewable Energy generation

6 Hydro generation

9 Pumped storage capacity

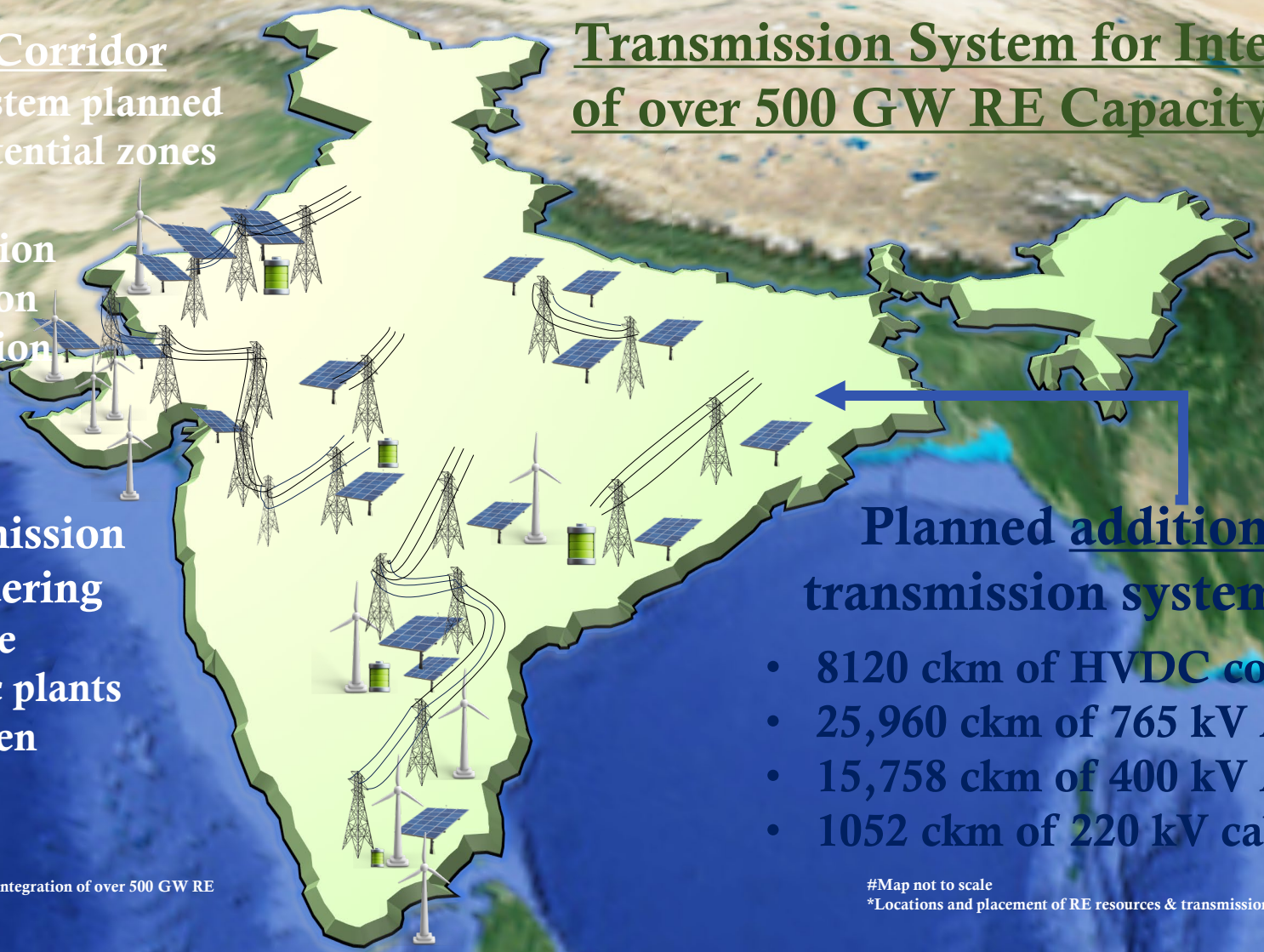
Source: IEA Key World Energy Statistics 2020 & IHA 2020 Hydro Status Report (2018 data, 2019 provisional data).

Transmission System for Integration of over 500 GW RE Capacity ~ 2030

Green Energy Corridor

Transmission system planned for major RE potential zones in

- Northern Region
- Western Region
- Southern Region



Planned transmission schemes considering

- Energy storage
- Hydro electric plants
- Green hydrogen production

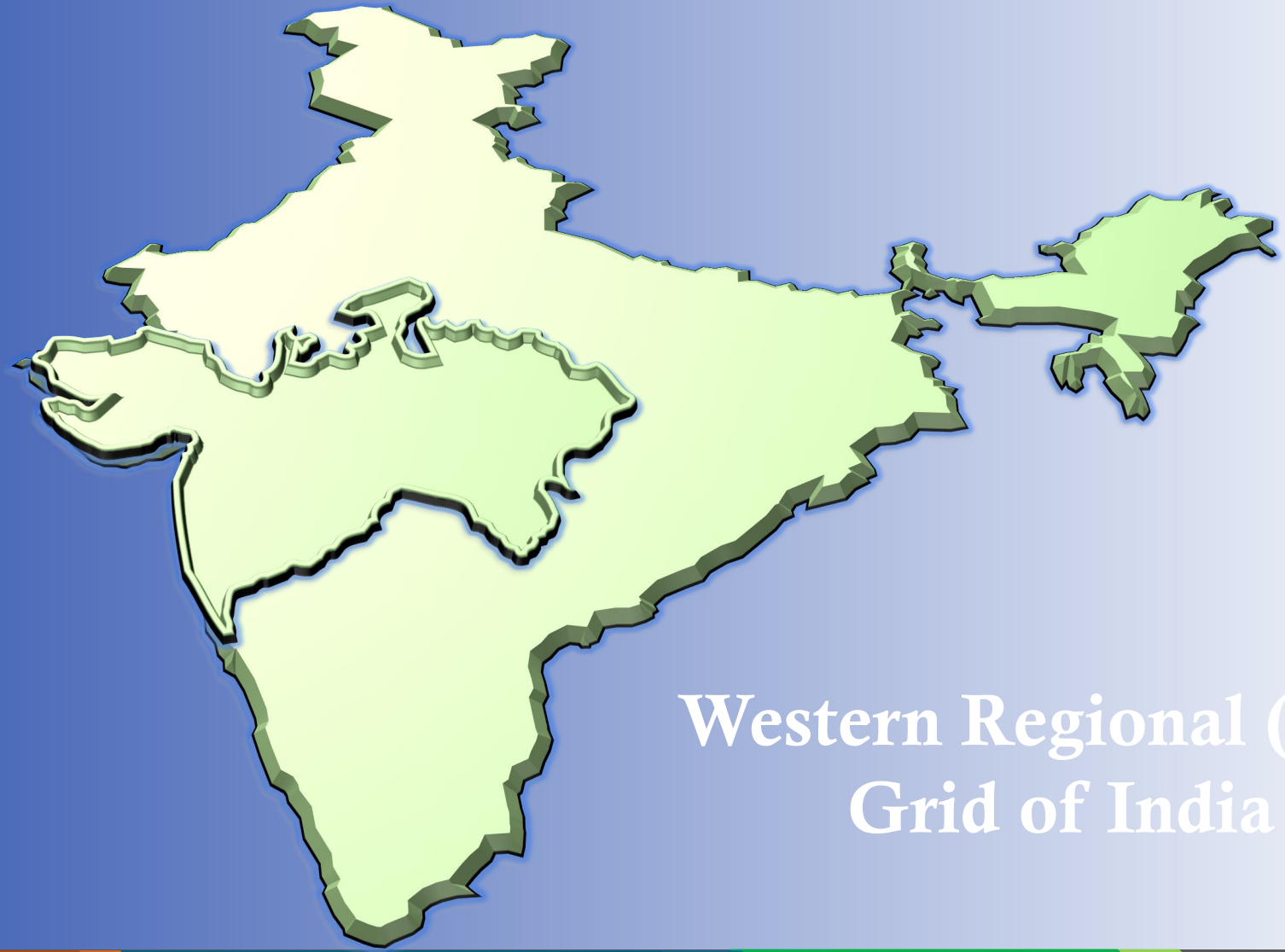
Planned additional transmission systems of

- 8120 ckm of HVDC corridors
- 25,960 ckm of 765 kV AC lines
- 15,758 ckm of 400 kV AC lines
- 1052 ckm of 220 kV cables

Source: CEA, Transmission System for Integration of over 500 GW RE Capacity by 2030

#Map not to scale

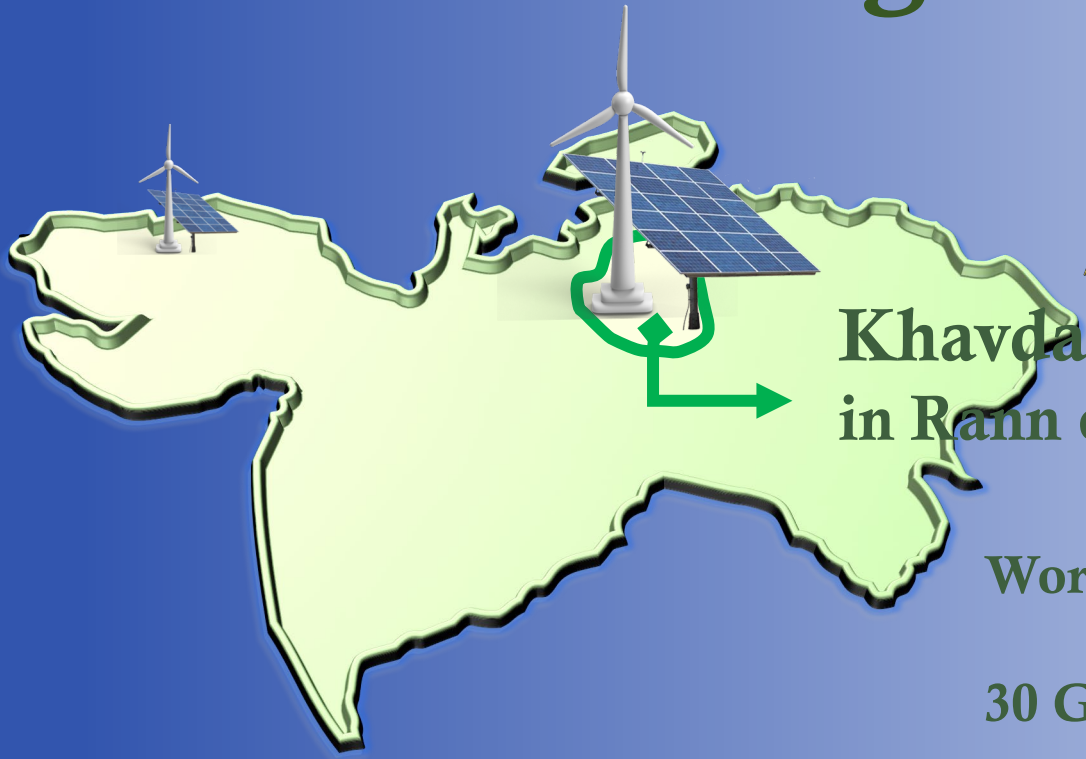
*Locations and placement of RE resources & transmission lines are only for illustration



Western Regional (WR) Grid of India

#Map not to scale

Western Region and World's largest RE park



- 50% of All India 765 kV lines are in WR

- WR is Vital highway for energy transmission to other Regional grids of India

World's largest RE park in Gujarat state, India

- Support Bidirectional flows during peak demand and RE generation

30 GW of Clean energy ~ peak demand in next 5 years

Area of 726 square kilometers

- Installed capacity: 141 GW

Comparable to Size of Singapore

#Map not to scale
*Locations and placement of RE resources & transmission lines are only for illustration
-https://ornatesolar.com/news

Grid Integration Process-RE Generator

CTU
Apply for Connectivity

National Single Window System

Metering Scheme Approval from RLDC

Contact RLDC for approval of metering scheme of Generating Station

Connection Agreement with CTU

After submission & verification of model data

Payment of Registration Fees

Payment of one time registration fees and submission of documents as per procedure

RLDC Registration

First Time Charging(FTC)

FTC code shall be issued after receiving all documents & ensuring telemetry as per procedure

Trail Run

Declaration of Commercial Operation

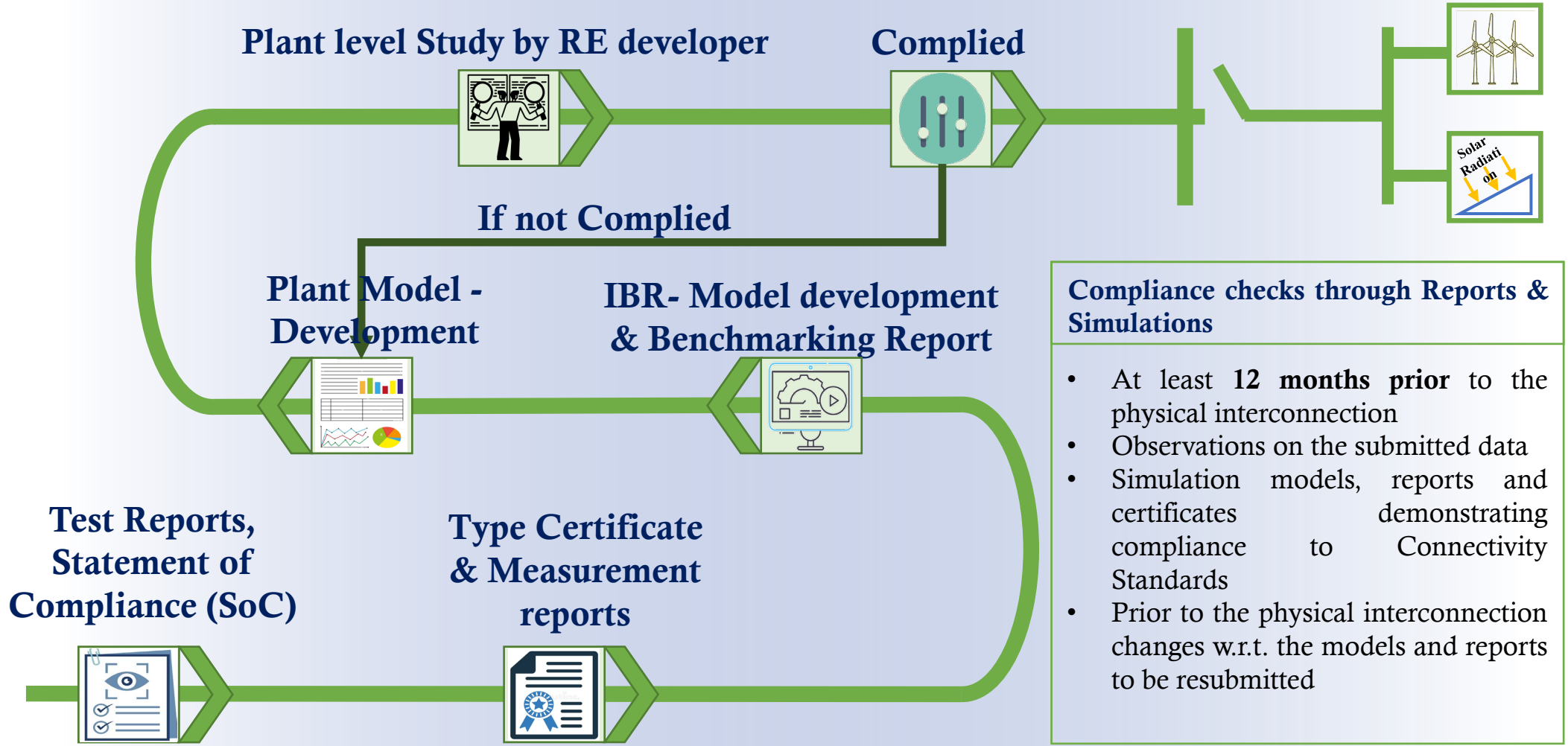
COD can be declared by plant after receiving trail run certificate by RLDC

Scheduling of RE Generator

Commissioning (COD)

CTU: Central Transmission Utility
RLDC: Regional Load Despatch Centre

Verification of Model Data-Pre Commissioning

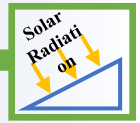


Compliance checks through Reports & Simulations

- At least **12 months prior** to the physical interconnection
- Observations on the submitted data
- Simulation models, reports and certificates demonstrating compliance to Connectivity Standards
- Prior to the physical interconnection changes w.r.t. the models and reports to be resubmitted

Verification of Model Data-Post Commissioning

Installation of any additional equipment & changes in controller settings



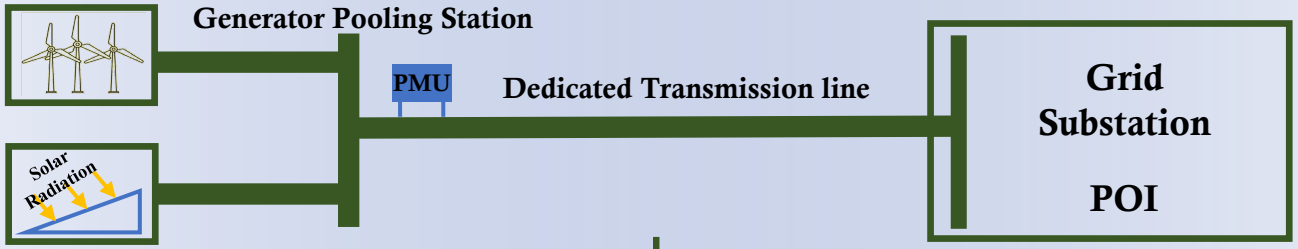
Updated implemented controller and protection settings

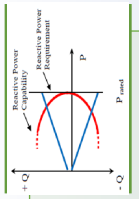
Detailed equivalent models

Compliance checks through Reports & Simulations

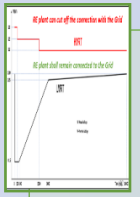
- Within 03 months of commissioning, detailed and equivalent models to be submitted
- Updated implemented controller and protection settings (both IBR and Power Plant Controller) shall also be submitted
- Changes in the plant due to installation of additional equipment, changes in controller settings- updated models to be submitted

Compliance Checks on Models

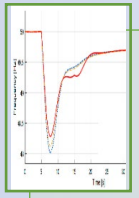




Reactive Capability assessment



Voltage Ride Through Requirement (Low/High)

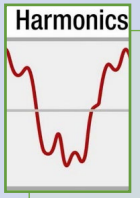


Frequency Response

Active and Reactive Power - Set Point Control

Design Requirement – Weather, Temperature Extremes etc.

Ramping Capability

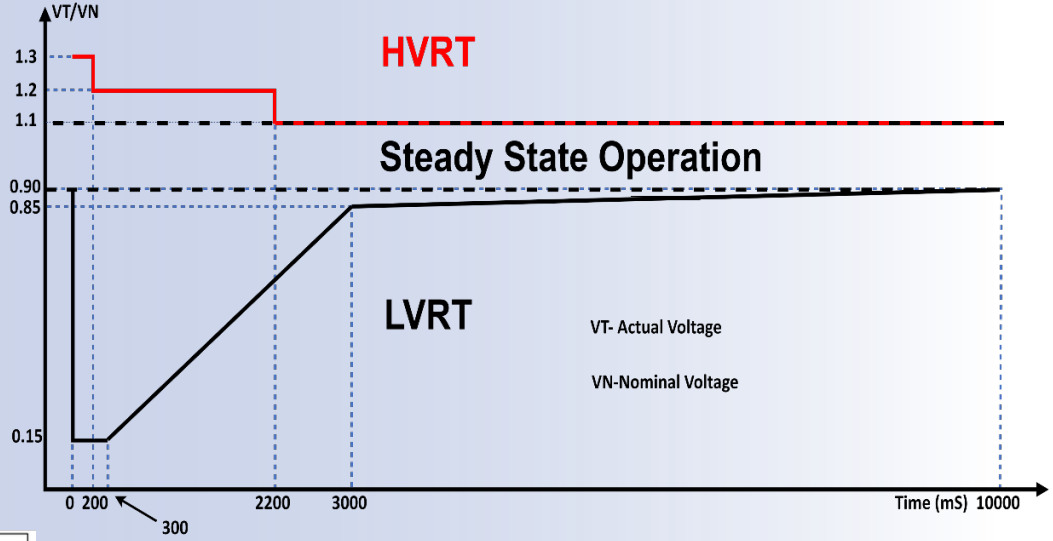


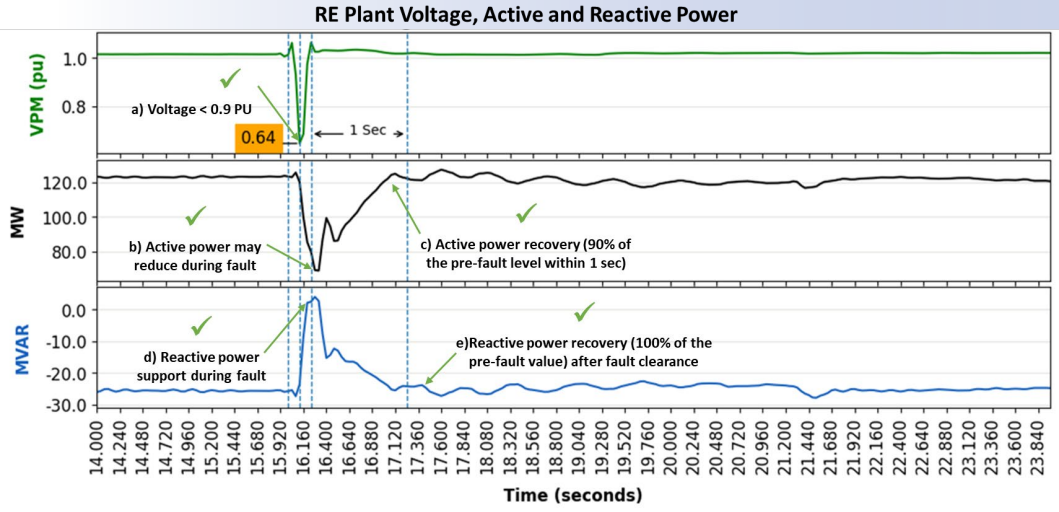
Power Quality Requirements

Compliance Check-Fault Ride Through (FRT)

Low Voltage Ride Through (LVRT): Shall remain connected to the grid when voltage dips, supply reactive power, active power may reduce for specified time period

High Voltage Ride Through (HVRT): Shall remain connected to the grid when voltage swells for specified time & support to grid.

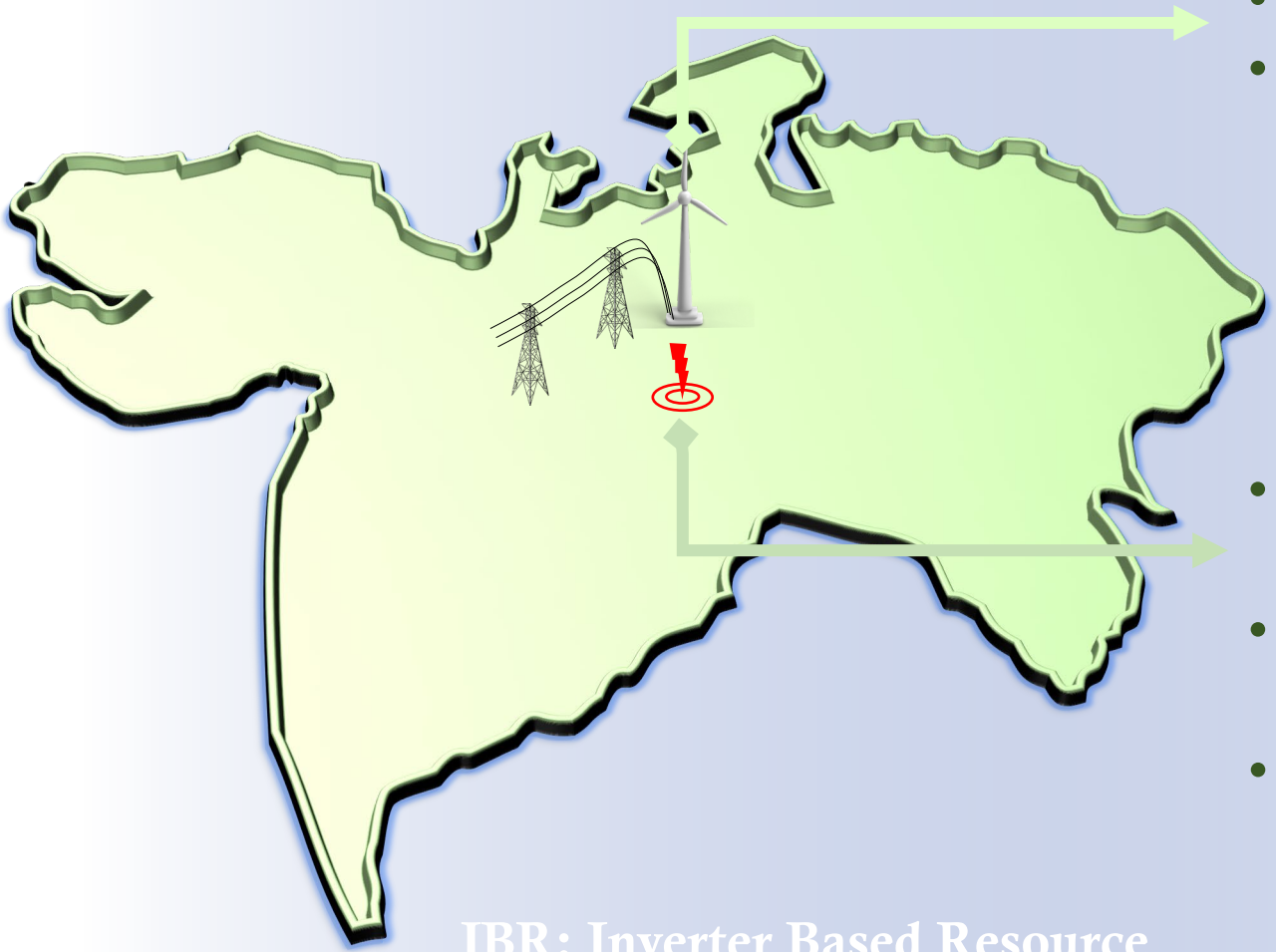




During fault ride through priority is

1. Reactive power
2. Active power
3. Revival just after fault to pre fault conditions in specified time

Validation of IBR Plant



- 324.4 MW of Wind Plant
- Interconnected with grid via single 220 kV transmission line

- Event at nearby sub-station (L-G fault)
- Voltage ~0.86 PU at Wind Plant
- Validation of submitted PSCAD simulation model

IBR: Inverter Based Resource

#Map not to scale
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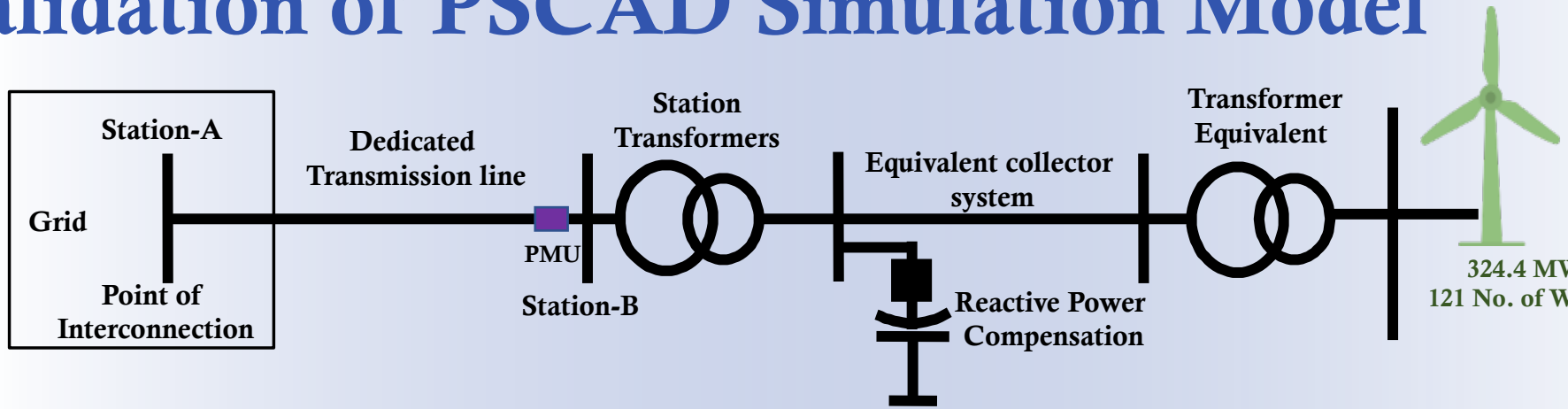
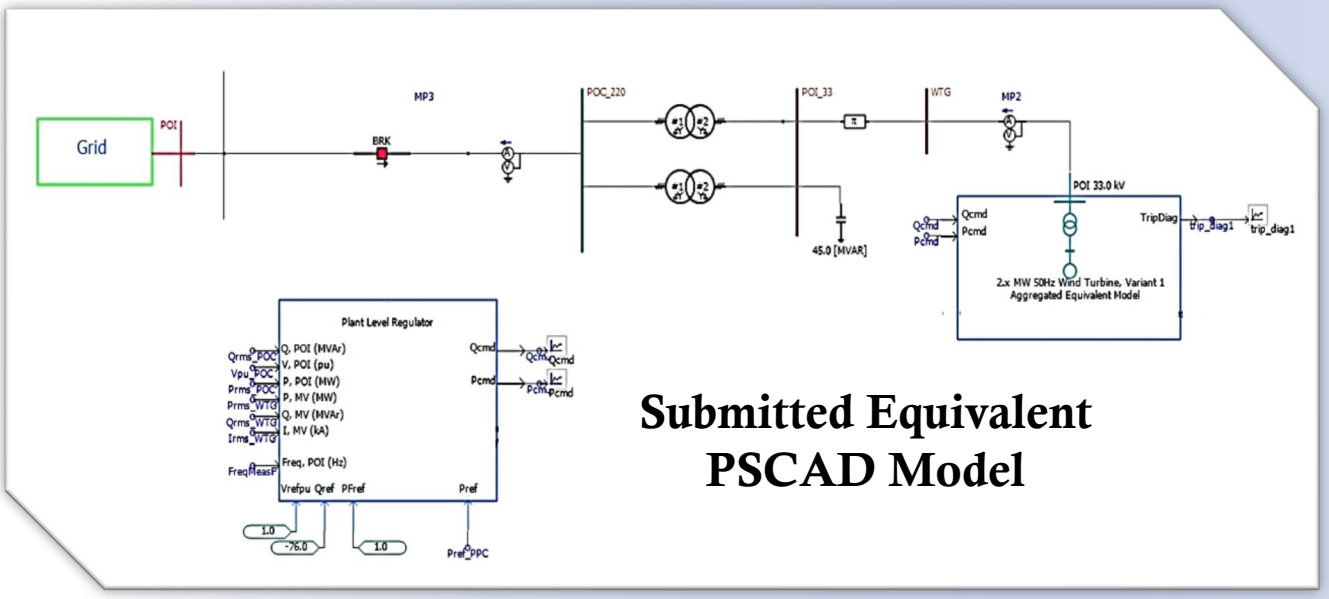
Validation of PSCAD Simulation Model



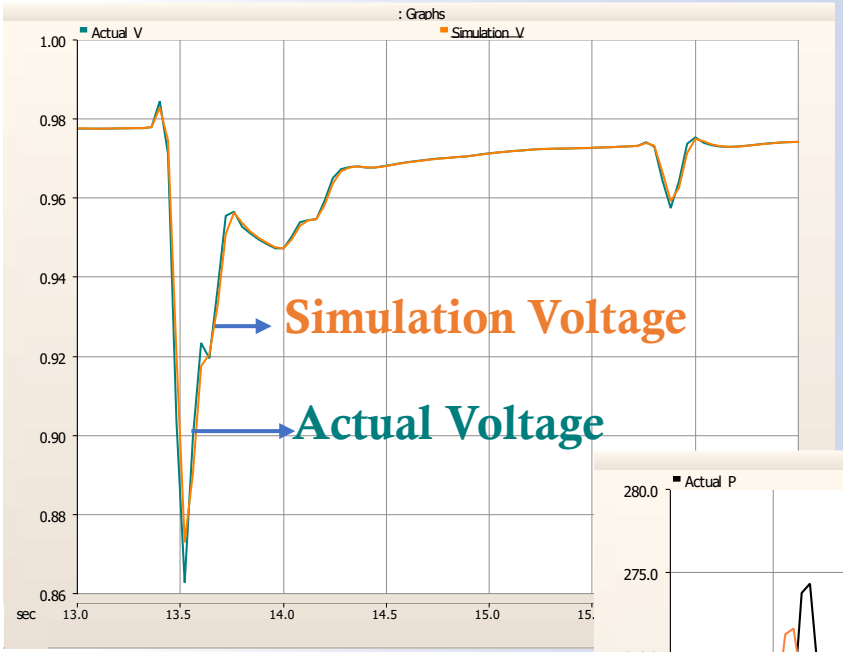


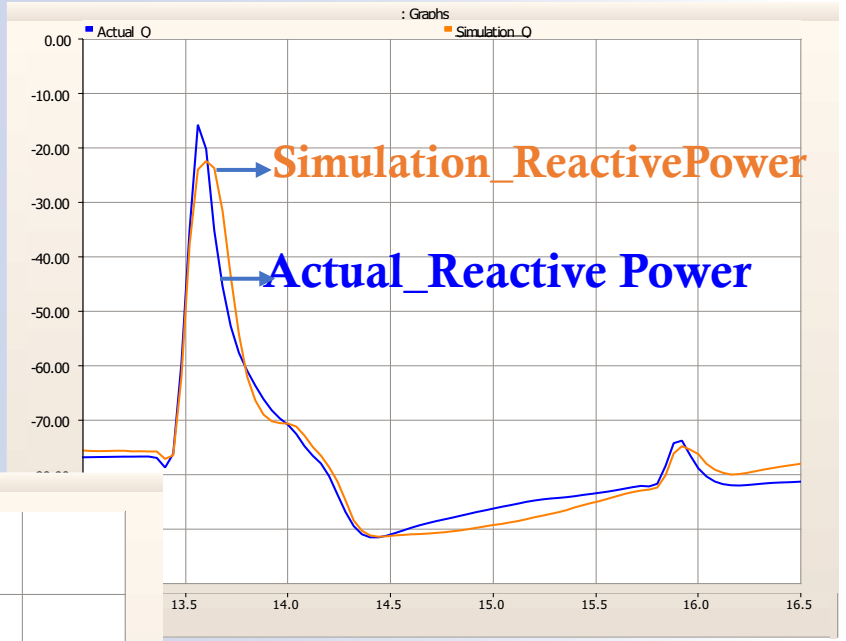
Submitted Equivalent PSCAD Model

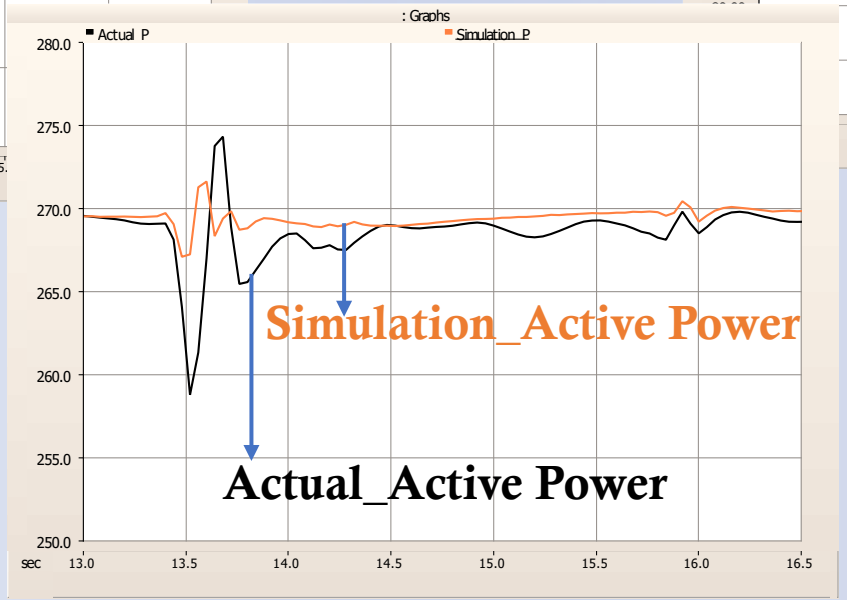
Event at nearby sub-station

- Voltage: 0.86 PU at 220 kV Station-B
- 220 kV station-B represented as grid with three phase voltage source
- Input to voltage source-PMU data at station-B.
- Initial conditions: P_SET-270 MW, Plant operated in constant Q-mode (76 MVAR absorption) & capacitor bank kept ON

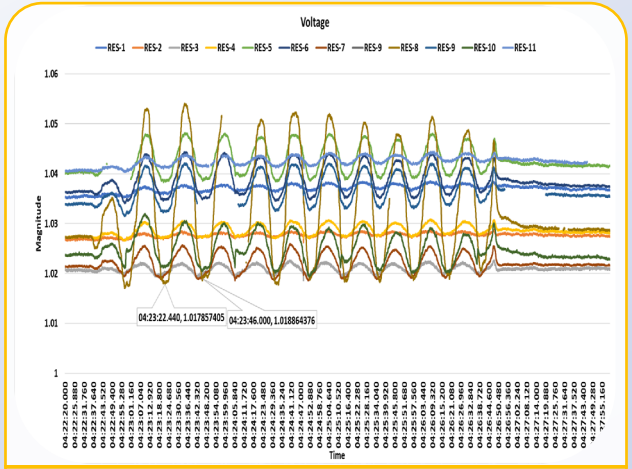
Simulation Results





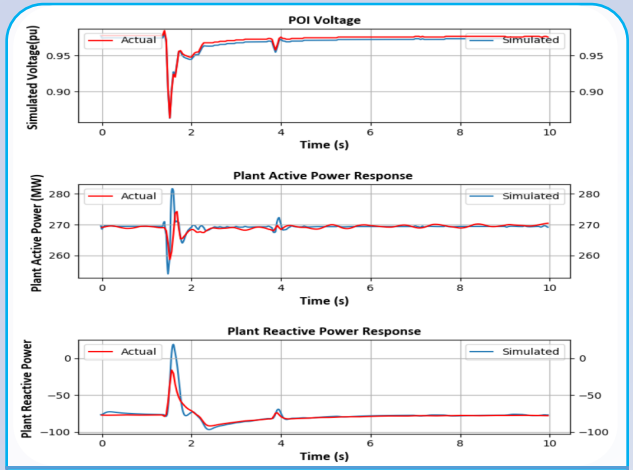


PMU Data for IBR Performance



Oscillations Analysis

FRT Performance



Model Validation

- **Observations**
  - **Lack of Inverter level data**
  - **Multiple RE plants sharing the same evacuating line**
  - **RE power from wind farms and solar farms is evacuated through same evacuating lines**
  - **Lack of high-resolution data-Reporting rate: 40ms**

Conclusions

Submitted model represents the actual performance of the plant with slight variations

1

Conducting plant-level testing is not feasible. Instead, validation of plant performance using PMU data or event log data during events is preferable.

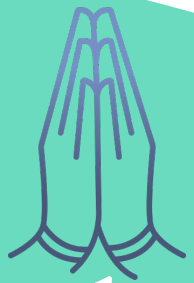
2

Validating actual performance supports the tuning of parameters to improve plant performance

3

Difference in actual and simulation responses are due to reactive power support from the plant and individual IBR to terminal voltage vary

4



Thank You

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