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New and Emerging Technologies and Trends

Exploring Renewable Energy Dynamics in Power Grids Through Synchrophasor Technology

ग्रिड-इंडिया GRID-INDIA

Presented By

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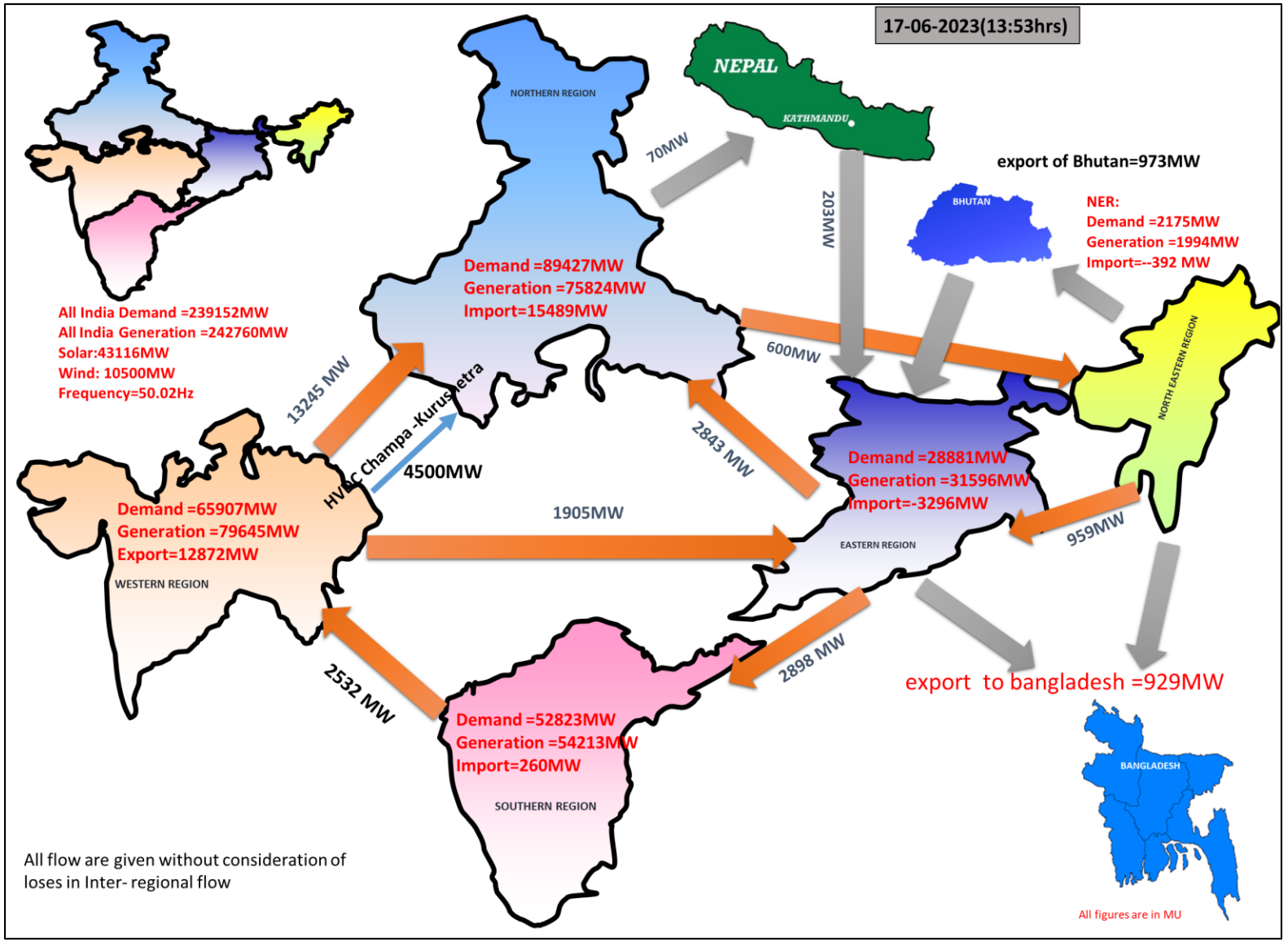
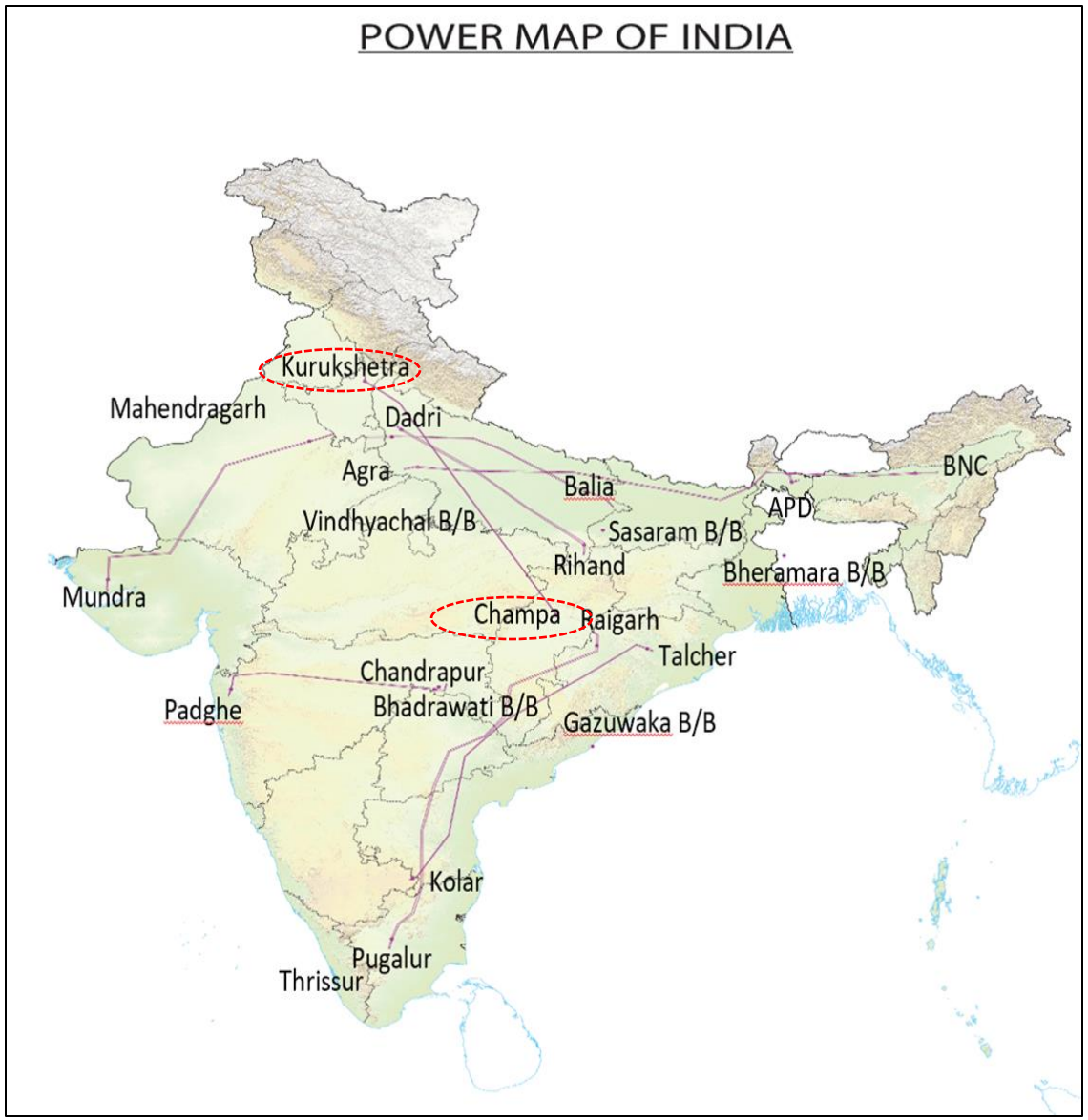
Grid Event in Northern Region on 17 June 2024
Antecedent Conditions



- **Severe heat wave conditions** in the Northern Region of India with temperatures ranging between **44-46 degrees Celsius**.
- Extremely high demand in Northern Region States of **89427 MW** with **13245 MW import from Western Region** and **2843 MW import from Eastern Region**.
- The power flows from the Western and Eastern Regions to the Northern Region were within the ATC limits.
- The voltages of major EHV nodes in the Northern Region were within the standards prescribed in the Indian Electricity Grid Code & CEA Grid Standards Regulations

Grid Event in Northern Region on 17 June 2024
Event Overview



1. Tripping of both Bipoles of **+/-800 kV HVDC Champa (WR) – Kurukshetra (NR) carrying 4,500 MW** from WR to NR

2. Sharp grid **voltage decline** and Northern Region **demand reduction by around 16.5 GW**.

   - Reduction in **NR RE generation of approx. 2870 MW.**
   - **12 conventional units tripped**, aggregating gen is **6775 MW,** majorly on over frequency.

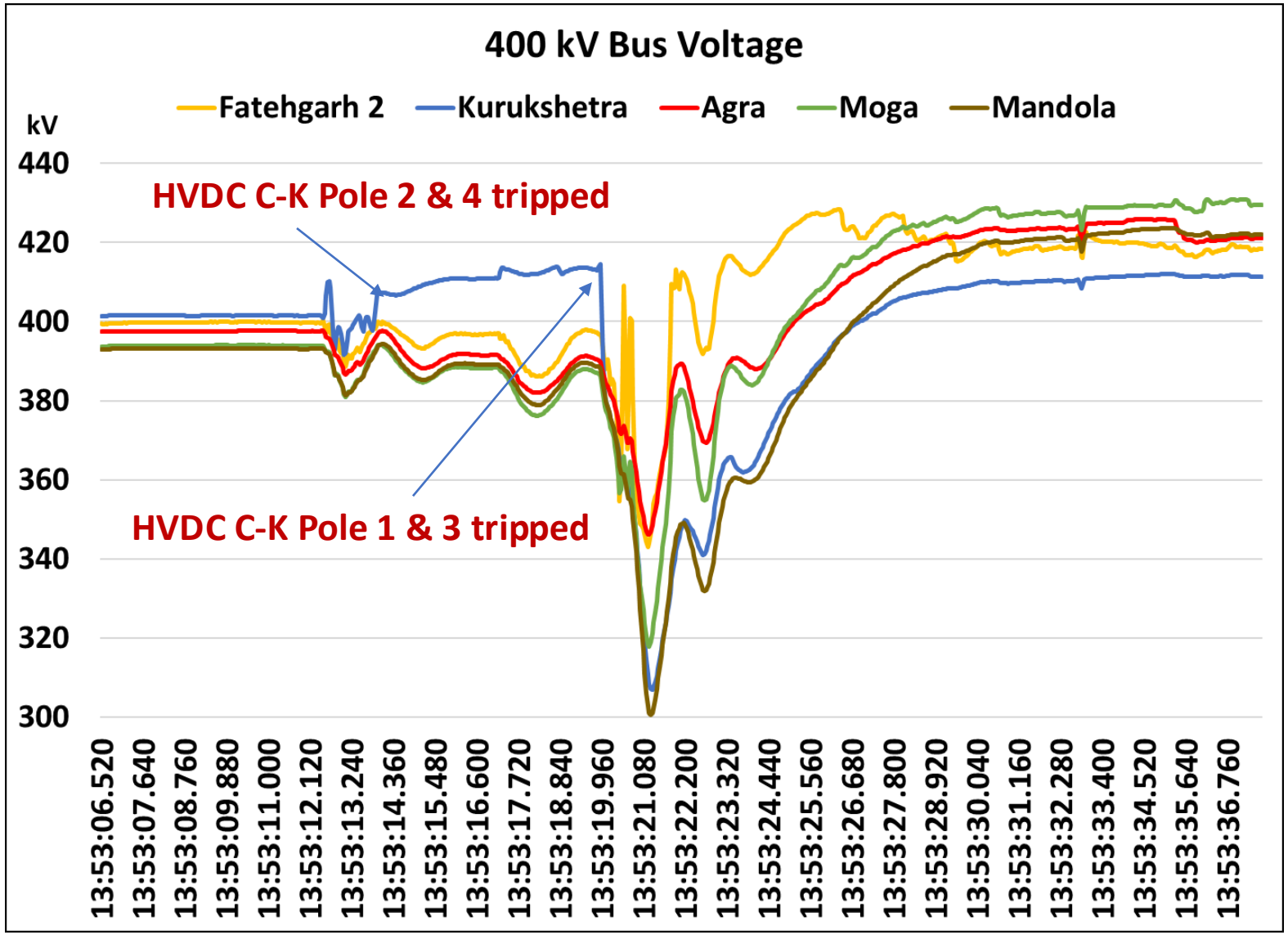
3. High voltage scenario due to offloading of transmission network.

   - A **total of 23 (nos) transmission lines** (765kV and 400kV) **tripped on OV**, causing a partial blackout at the 765/400kV Aligarh(PG) S/s.

4. Load that reduced during the **low voltage at 13:53 hrs** began to recover gradually, the grid experienced another **low voltage scenario at 14:05 hrs**.

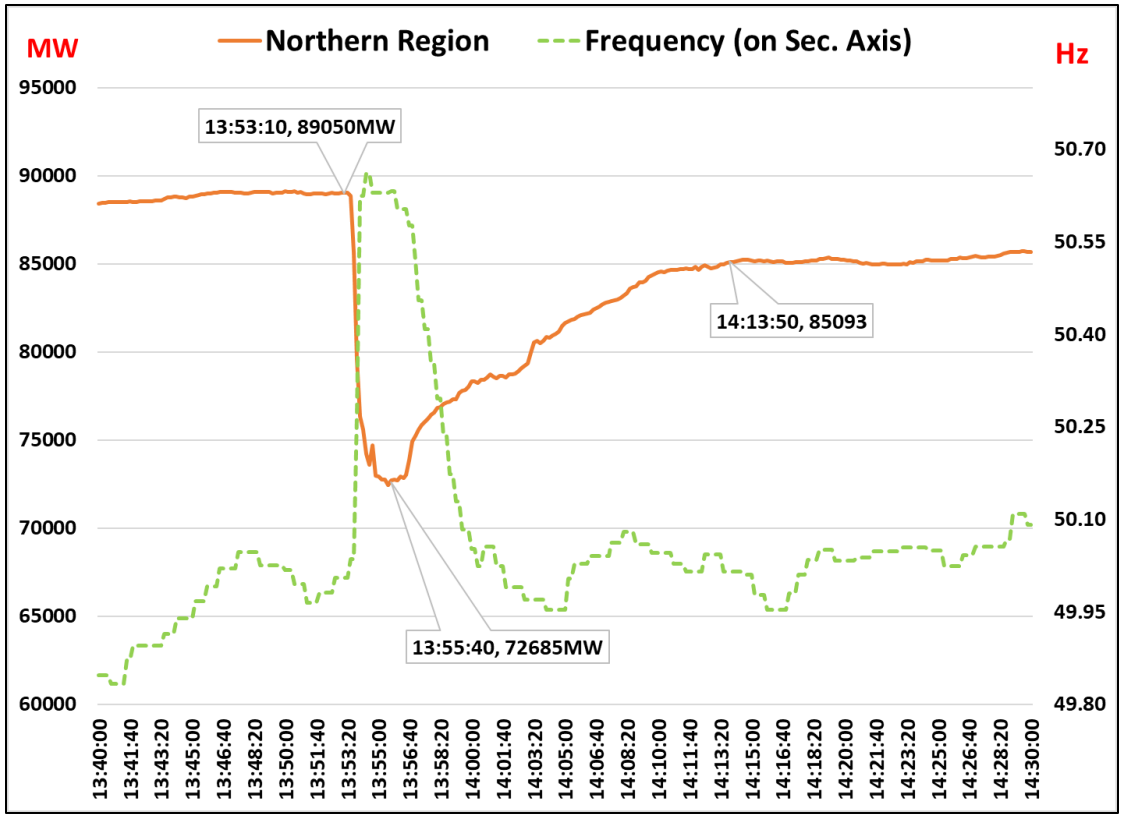
5. Frequency rise from **50.03 Hz to 50.68 Hz**, recovered back to 50.00 Hz within **~ 6 minutes**

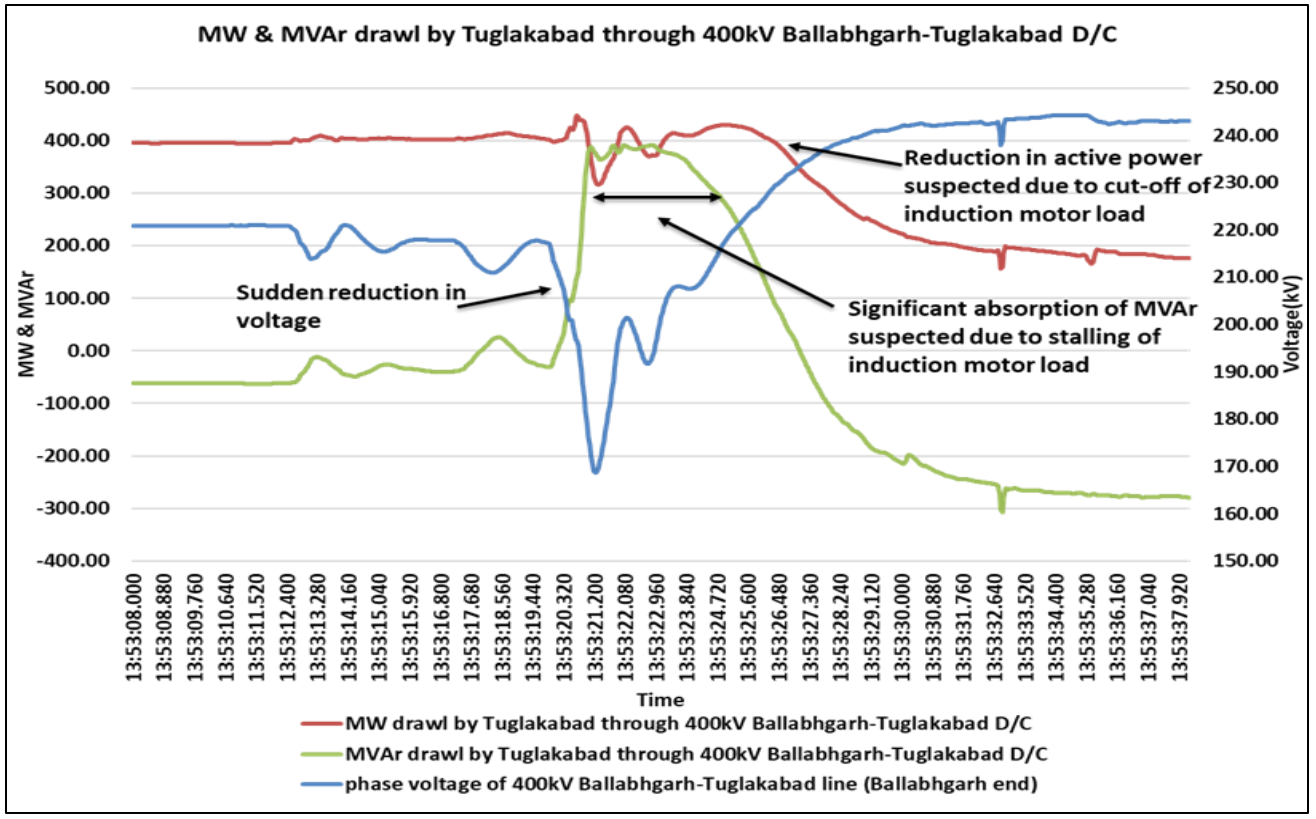
Voltage Drop After Outage of HVDC Pole 1 & 3



Substation Name	Voltage recorded at 13:53:21 hrs (as per PMU data)
Mandola	302 kV
Ballabhgarh	313 kV
Nallagarh	335 kV
Moga	320 kV
Mahendargarh	330 kV
Ratangarh	323 kV
Lucknow	380 kV
Barellly	360 kV
Rishikesh	327 kV
Koldam	328 kV
Wagoora	389 kV

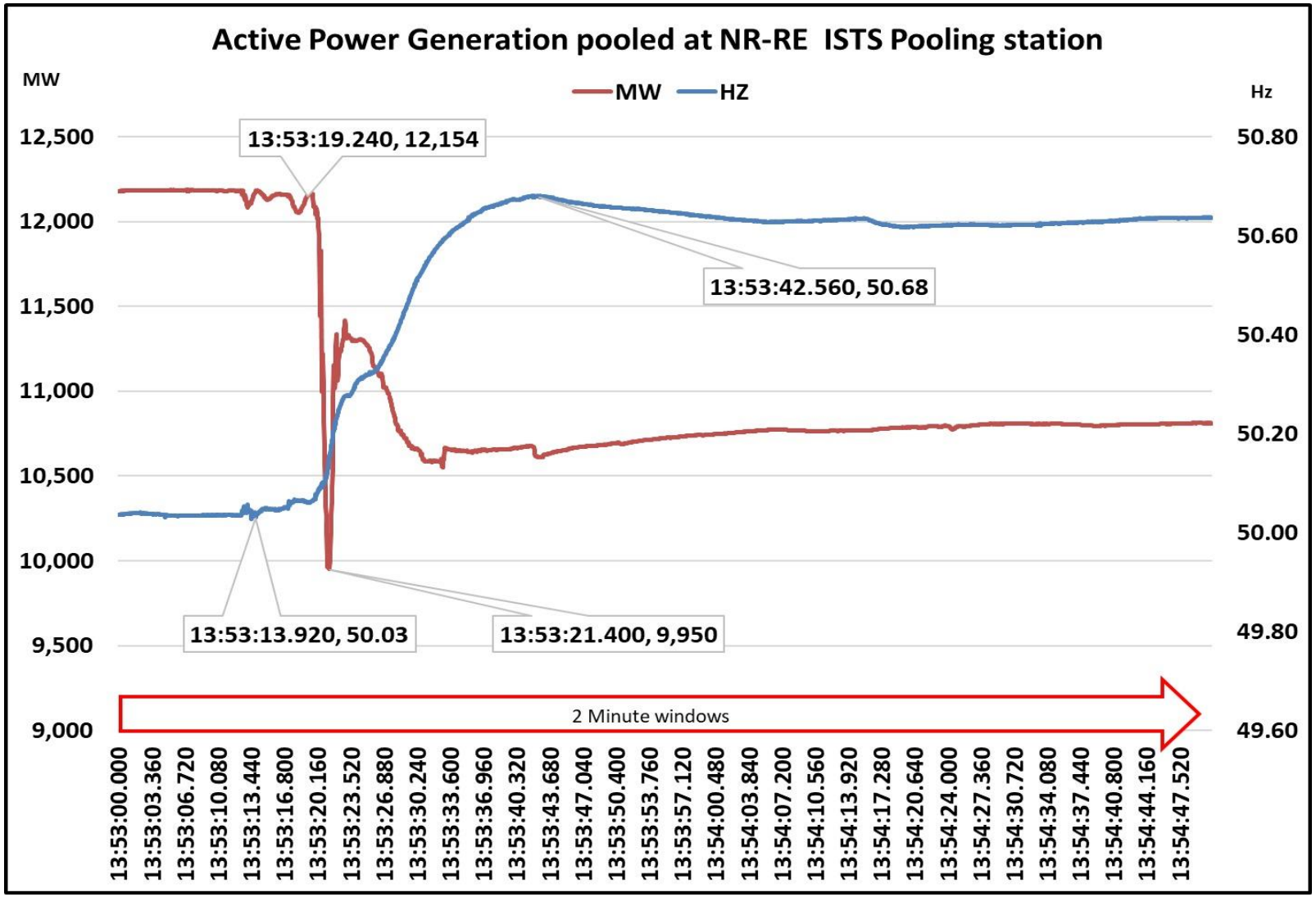
Demand Drop Observed during Disturbance





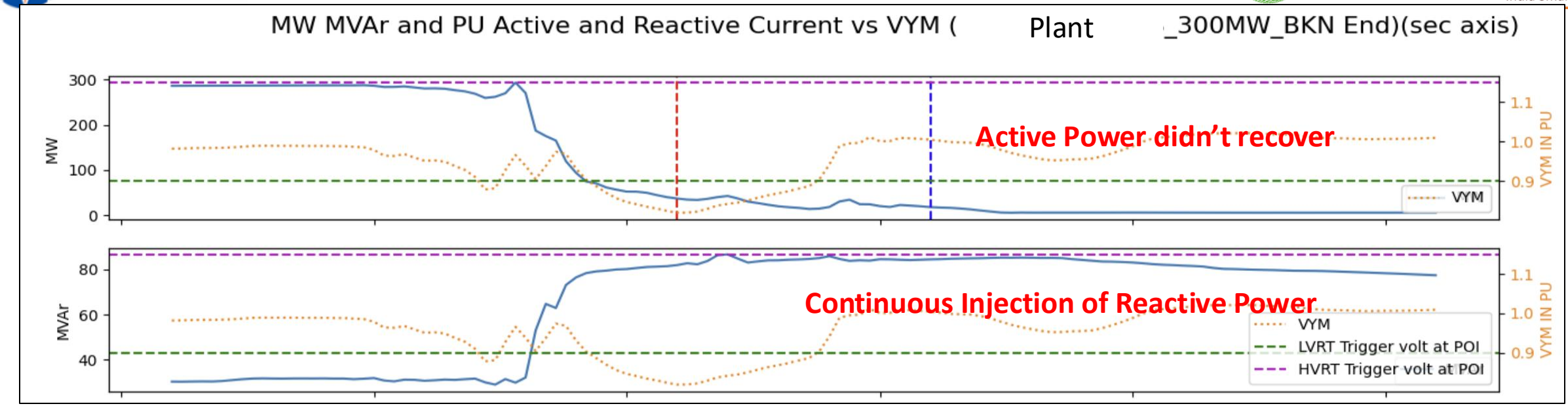
STATE		PUNJAB	HARYANA	UTTAR PRADESH	RAJASTHAN	DELHI	UTTRAKHAND	HIMACHAL PRADESH	JAMMU & KASHMIR	NORTHERN REGION
Pre-Event Demand (MW)		15320	13138	28939	17636	7513	2237	1743	2520	89410
LOAD LOSS	(MW)	3780	4384	2481	3150	2388	350	240	370	16518
Percentage of Demand Loss		25%	33%	9%	18%	32%	16%	14%	15%	18%

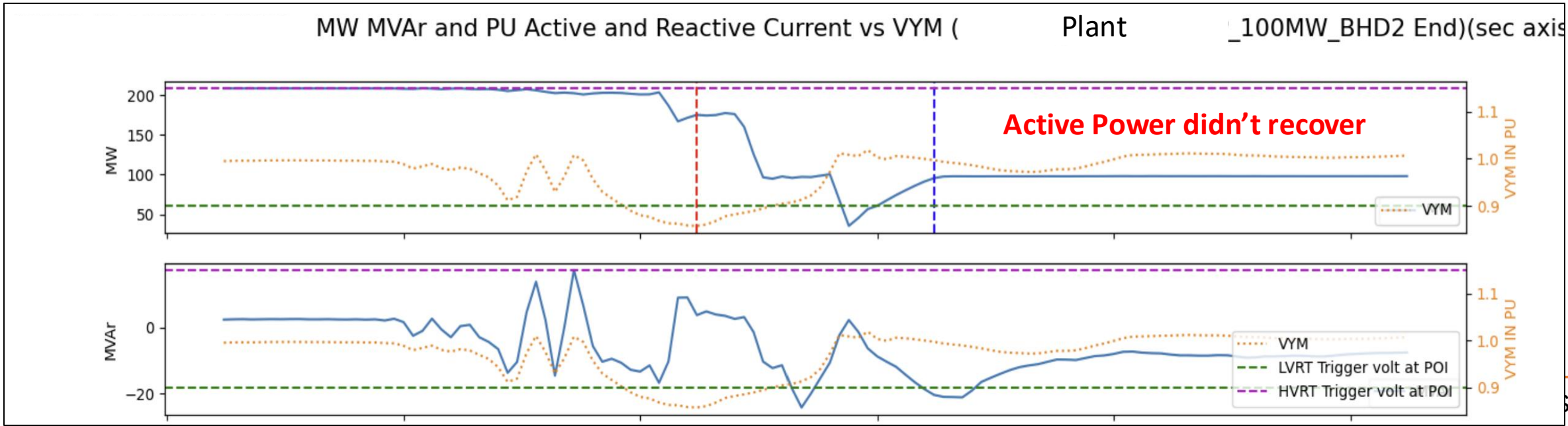
Impact Analysis : Rajasthan RE Generation



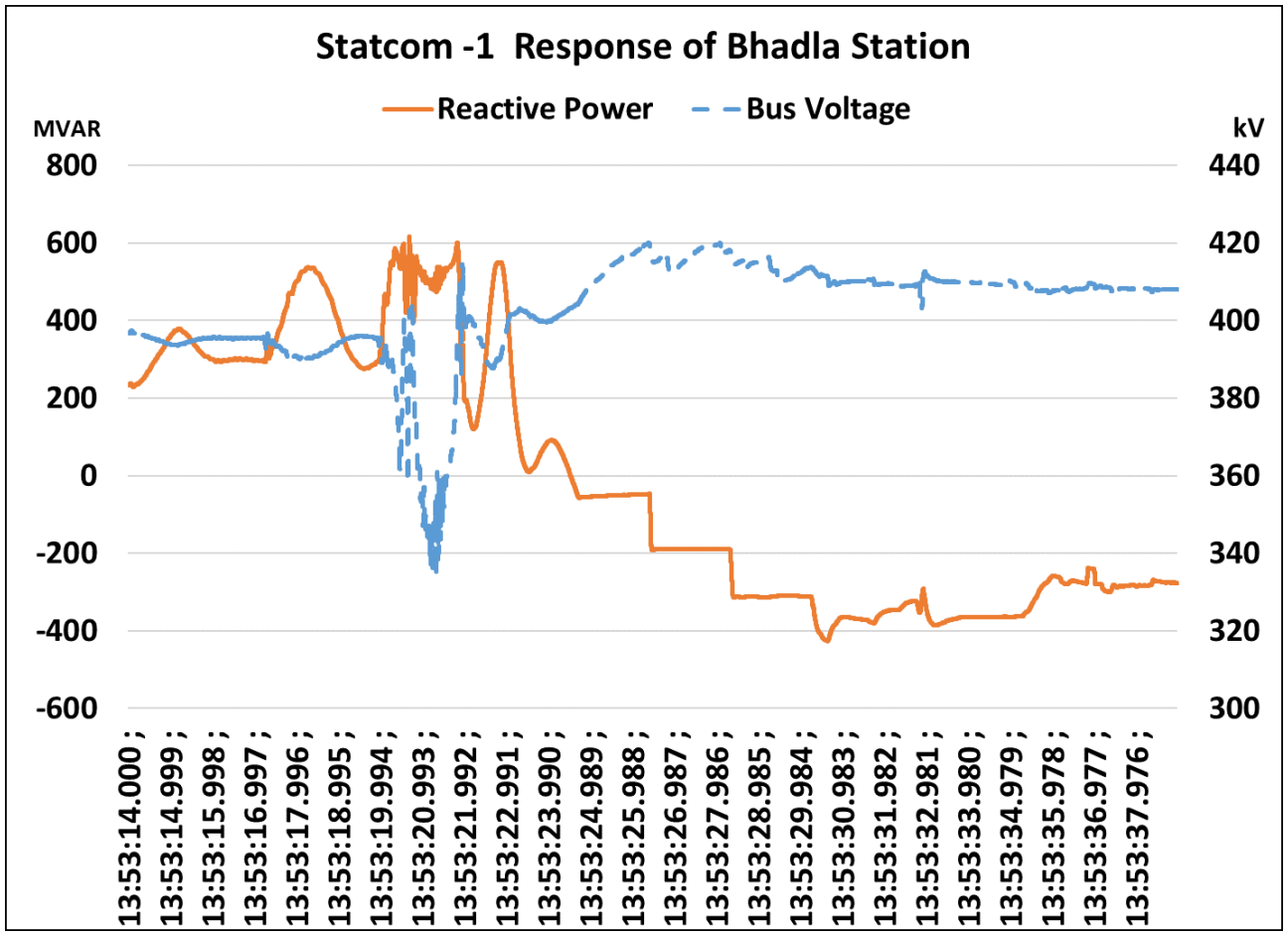
- The voltage drop RE generation in Rajasthan.
  - **~2800 MW of RE generation** (as per SCADA data) was reduced, with around **1500 MW** recovering within 4 minutes.
- As per PMU data, **2200 MW** solar generation reduction was observed out of which **1350 MW** recovered within **one second**.
- **29** out of **65 RE plants** are **non-compliant** w.r.t recovery of active power, unable to recover to 90% of the pre-fault level within 1 second of the restoration of voltage.
- Reactive Power Response from RE plants are also **opposite**.

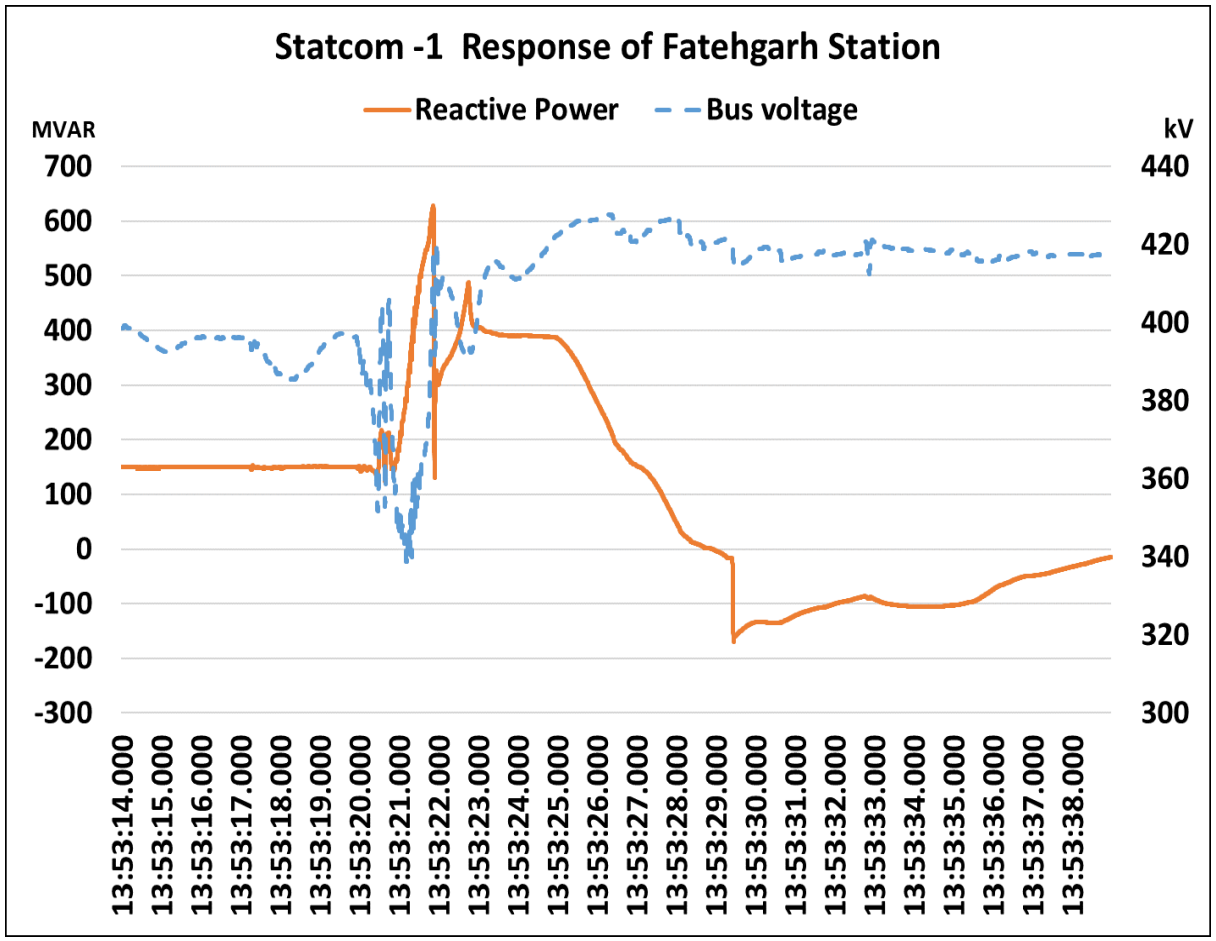
Unsatisfactory Response of RE plants (PMU Data)





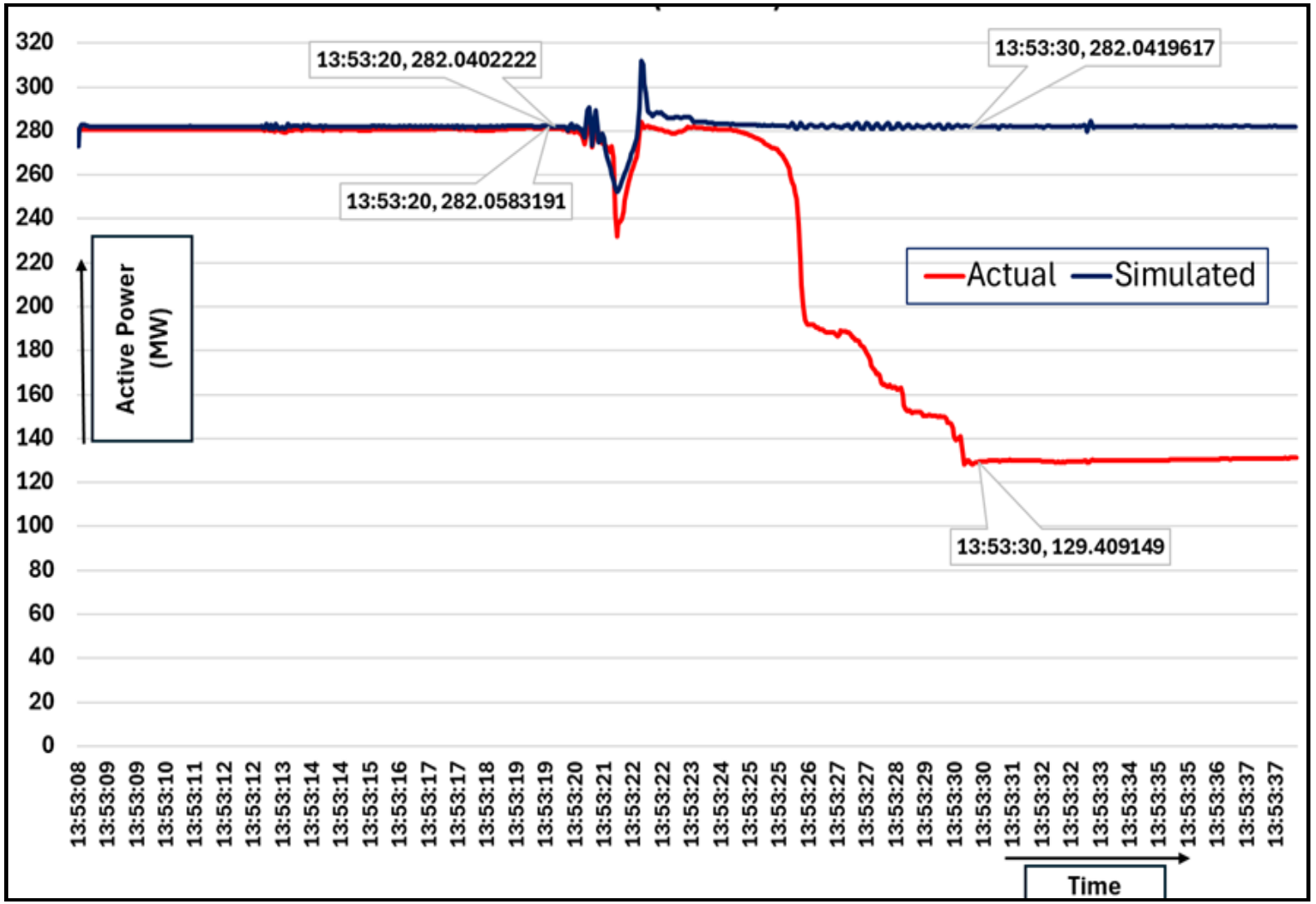
Reactive Power Response of STATCOM (PMU data)





Provided reactive power support during the sudden reduction of voltage and subsequent overvoltage conditions

SIMULATION STUDIES: Actual Vs. Simulation Performance Of Plants



(i) Initial Recovery:

During the voltage dip event, the plant initially responded as expected and successfully recovered its active power output in both the actual and simulation cases.

(i) Post-Recovery Active Power Reduction:

After 2–3 seconds, a reduction of approximately 152 MW in active power was observed in the actual response, bringing the output down to ~129 MW. This reduction occurred despite the voltage at the interconnection point being well below 1.1 pu, which suggests non-compliance with High Voltage Ride Through (HVRT) requirements.

Strengthening RE Integration for Grid Stability

Key Learnings from the Grid Event (June 17, 2024)

⚡ **Voltage Issue** – A sudden voltage drop **stalled induction motor loads**.
⚡ **2800 MW RE Tripped** – Rajasthan RE complex suffered major generation loss, worsening grid instability.
⚡ **Delayed Recovery** – Only **1500 MW** of RE restored within 4 minutes, exposing weak fault ride-through capability.
⚡ **Non-Compliance** – Several RE plants failed **CEA Low Voltage Ride Through (LVRT) regulations**.
⚡ **Reactive Power Deficiency** – RE plants did not provide **adequate reactive power support** during voltage dips.
⚡ **Mismatch in Response** – Expected vs. actual RE response **did not align**.

Way Forward: Strengthening RE Grid Performance

✅ **Mandate CEA Compliance** – Enforce **LVRT/HVRT standards** with regular audits.
✅ **Enhance Reactive Power Support** – Deploy **SYNCON/STATCOMs/SVGs** at RE hubs to prevent voltage dips.
✅ **Real-time Monitoring** – Deploy PMUs at key substations & distribution networks for real-time grid monitoring.
✅ **Hybrid RE+Storage** – Promote **battery & pumped hydro solutions** to stabilize RE fluctuations.

🔋 **Outcome: A More Resilient & Reliable Renewable Energy Grid**

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THANK YOU

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