



Voltage Stability in High-Renewable Grids: Start with the Constraint, Not the Technology

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Why this issue matters

As Cambodia, Tajikistan and Uzbekistan integrate higher shares of variable renewable energy, voltage stability and reactive power management are becoming increasingly important operational issues.

Different parts of a power system can face very different constraints: high voltage at light load, low voltage at peak, weak-grid conditions, delayed voltage recovery after faults, or limits on power transfer.

Webinar No. 2 under *TA-10533 REG: Integration of Innovative Grid Control Technology to Scale Up Renewable Energy – 0001 Studies for Integrating High-Level Technologies in Controlling the Grid to Increase RE (58052-001, [link to the project](#))* that was held on 5 August focused on a practical principle: identify the binding constraint first, define the service the system needs, then select the technology — and verify that it can deliver the required response.

WEBINAR NO. 2 AT A GLANCE

5 August 2026 | Online | [Link to the recording](#)

Voltage, Reactive Power and FACTS for High-VRE Grids

The session brought together transmission system operators, ministries and industry representatives from around ten countries, with strong participation from Cambodia, Tajikistan and Uzbekistan.

It examined how voltage, reactive power and system strength can constrain secure operation, compared technologies for addressing those constraints, and reviewed lessons from recent international power-system events. The discussion also feeds into the country studies now being prepared under the technical assistance (TA) project.

ABOUT THE WEBINAR SERIES

Webinar No. 2 is one of six regional webinars planned under the project to support participating countries in assessing innovative grid-control technologies and digital solutions for secure large-scale renewable energy integration.

Start with the problem, not the technology



Capability is not contribution.

Declared capability is not the same as actual contribution. A datasheet shows the reactive range a device can deliver; secure operation depends on what it contributes when voltage moves, given the control modes and settings in use.

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One Transition, Three Different Grid Constraints

The three participating power systems are moving through the same broad transition towards higher renewable penetration, but the operational constraints presented during the webinar are different.

Uzbekistan

Long western transmission lines can produce excess reactive power and high voltage during light-load periods, while the Fergana area can face reactive shortages and low voltage at peak.

The direction identified is to automate reactor switching and provide dynamic absorption where the reactive surplus varies.

Tajikistan

The webinar highlighted summer undervoltage and delayed voltage recovery after faults on long irrigation feeders, significant industrial reactive demand, and an N-1-exposed north-south corridor.

In the conditions discussed, inertia was not identified as the binding issue. The discussion pointed instead to fast reactive reserve and to control modes embedded in connection rules.

Cambodia

Cambodia combines long corridors into one main load center, low-strength solar clusters, and growing rooftop solar that is largely invisible to the system operator — the closest match among the three systems to the Iberian conditions.

The direction identified is to assess system strength before the next cluster connects.

**Three systems, three requirements.
A single technology template will not fit all.**

Four Takeaways

1 Reactive needs are two-sided

A system may need to absorb reactive power during light-load conditions and supply it at peak. Fixed or switched shunts may therefore cover only part of the operating requirement.

2 Measure before procuring

P-V and Q-V studies under N-1 conditions can identify weak buses, assess remaining voltage margin and show where support is actually needed before major equipment is selected.

3 Coordinate the response

Reactive devices and voltage-control equipment need to operate as one coordinated hierarchy, ordered by response time, with tap changers and mechanical equipment acting last.

4 Use more than one indicator

Short-circuit ratio alone can become misleading where grid-forming assets provide voltage stiffness with limited fault current. Where system strength is low or converters cluster, additional screening and electromagnetic transient (EMT) studies using validated vendor models may be required.

From Evidence to Action

84

SECONDS

When Available Capacity Could Not Be Used

The webinar referenced the 28 April 2025 Iberian Peninsula event, drawing on the ENTSO-E Expert Panel final report, to illustrate the difference between having reactive capability and being able to use it when the system needs it. Earlier in the day, shunt reactors had been manually switched out as part of the response to inter-area oscillations. When voltage later rose rapidly, restoring reactive absorption depended on manual action during an event that unfolded in only 84 seconds.

Three lessons were highlighted.

Control mode and requirements matter

Solar plant operating in fixed power-factor mode did not respond dynamically to changing voltage, and there was no dynamic requirement or compliance check.

Activation speed matters

Reactive capacity that depends on manual switching may not be available quickly enough when system conditions change rapidly.

Settings and coordination matter

Protection margins, reactive-power targets and operational settings can determine how much of the available capability remains useful as an event develops.

Spain held the reactive capacity it needed; control mode, activation speed and protection settings prevented its use.

Available capacity only matters if it can be activated when it is needed.

What Can Start Now?

Which technology is required will differ from system to system. Before procurement, several readiness checks apply in all three grids: they determine whether existing capability can actually be used when voltage conditions change.

01

Check control modes

Confirm whether generators and inverter-based plant are operating in the voltage-control modes rather than fixed power factor.

02

Review protection settings

Review overvoltage, ride-through and related protection settings against the operating conditions the system may encounter.

03

Measure activation time

Time an actual reactor switching operation from operator decision to breaker response. Installed capacity is useful only if it can be called on quickly enough.

LOOKING AHEAD

Future sessions will continue to explore operational priorities identified through the Technical Assistance process. Flexibility, forecasting and reserves are among the themes currently under consideration as renewable penetration increases.

Stay tuned for upcoming webinars and newsletters.

CALL FOR INSIGHTS

Future issues may include short think pieces, technical notes or selected articles from participating institutions and experts.

Contributions may address innovative grid-control technologies, renewable energy integration, system stability, operational readiness, flexibility or regional coordination.

To propose a contribution or article for a future issue, please contact the project team.

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