Lesson Learned

State Estimator Outages Requiring Tuning/Calibrating EMS Settings

Primary Interest Groups
Transmission Operators (TOPs)
Reliability Coordinators (RCs)
Transmission Owners (TOs) who operate a State Estimator (SE)

Problem Statement
Several registered entities have experienced short SE outages due to the software solutions not converging. The entities began troubleshooting techniques to locate and remove possible erroneous data point inputs into the energy management system (EMS) to help the SE to solve. After these techniques failed, each of the entities reached out to their EMS vendor for assistance.

Details
This lessons learned document is based on three very similar events that only differed in details. In all three events, the operators received an EMS alarm during off hours that the SE failed to converge. The operators notified the appropriate entities for assistance with monitoring as they began troubleshooting the SE outage. When the operators could not quickly identify the data point (internal or external) that was resulting in the nonconvergence, support personnel were contacted for additional troubleshooting and corrective actions. Following unproductive IT diagnostics and unsuccessful reboots of the SE, vendor support was solicited.

In all three cases, the vendor recommended a parameter or setting change that resulted in the SE converging. The cases did vary by which setting was adjusted (e.g., a voltage parameter or a setting that defines the minimum amount of busses that forms a topological island). The setting change was initially made in a testing environment to ensure that the setting change did not have negative impacts on the solution quality and to confirm that the SE would continue to solve with the new setting in place.

These events were analyzed through the Event Analysis Process (EAP), which discovered that the settings were part of the original SE design and installation in these cases. As part of the original design, the vendors were on-site to help the entity commission the SE. Settings and parameters were chosen and tested based upon the size and coverage of the entity's system. These settings and parameters are often uniquely programmed for the entity to meet the individual needs based upon the entity's configuration, topology, contingencies, and external model. In all three cases, the settings installed by the entity with the vendor's assistance worked well (for several years), prior to the SE nonconvergence events. Discussions with the vendor found that the settings were fine when the SE was originally installed, but the settings needed to be slightly tuned or calibrated based upon subsequent topology changes. Topology changes may include updates to the external model, varying generation paths due to the influx of renewables and the retirements of fossil fuel generators, new incoming ICCP data points, or any type of additional topology added to the model including sub-transmission data points, both internal and external.

Corrective Actions
The corrective actions for these three events all included a change to SE settings or parameters. These settings were further tested in both real-time and on historical cases to ensure that these new settings would result in good-quality solutions. While these changes mitigated the SE nonconvergence, the time to trouble-shoot and identify the needed changes resulted in the loss of some situational awareness throughout the events. During the SE outage, the entities relied on their RC for state estimation, including Real-Time Assessments from the Real Time Contingency Analysis.

Note: Because these outages happened during off-hours, there were no scheduled switching activities that may have aggravated the problem, but if switching had been underway, a prudent action would have been to halt any topology changes while the SE is not solving. If SE begins solving again before completion of SE issue troubleshooting, carefully track and control topology changes while troubleshooting.

This lessons learned document explores techniques to tune/calibrate SE settings and parameters before experiencing a SE outage so as to reduce these occurrences.

Lesson Learned
The loss of state estimating results in a partial loss of situational awareness. While the entity may rely on adjacent entities or the RC for assistance with monitoring, it is important to keep SE up and providing base case states for downstream applications like Real-Time Contingency Analysis.

While many SE trouble-shooting techniques are already known and disseminated across the industry, there are additional lessons learned that may help prevent these occurrences from happening. NERC has published a reference document: "Risks and Mitigations for Losing EMS Functions."

1. Periodic reviews of SE settings and parameters may be needed to ensure that the SE continues to converge and produce a quality solution. The frequency of these reviews will vary, but consider reviewing the settings and parameters following model changes, generation retirements, software upgrades, and any other significant changes made to the EMS system or the model.
2. If possible, run SE stress-tests in a test environment. This may include removing key data points (simulating an RTU outage) or inputting erroneous data on sub-transmission facilities. These tests may indicate which data points (or lack of data points) may lead to a SE nonconvergence.
3. Regarding (1) and (2) above, work with the EMS vendor or in-house expertise to review the settings to determine if the current design settings are still optimal. If needed, make adjustments in a test environment to see how setting/parameter changes impact the SE convergence and data-quality solution.
4. Continue to develop dedicated in-house expertise with real-time tools. In the three SE outage examples, the restoration time was delayed due to the need to engage with the vendor. More skilled in-house personnel who can troubleshoot and correct these issues (including the system

operators if applicable) can lead to shorter SE outage durations. This may include additional knowledge transfer from the vendor to the in-house personnel.

5. Working with the vendor, consider developing an inventory of key EMS settings that need to be tuned or calibrated. Collaborate as needed with other entities of similar size and topology using the same EMS platforms, or an independent third-party to review EMS settings. Consider the trade-off between convergence and quality solutions.
6. Work with vendors and other users to identify and develop key metrics (such as number of iterations to solve, mismatch size, residuals, abnormal voltages, abnormal measurements, Weighted Least Square (WLS) cost, etc.) that would proactively indicate when tuning would become beneficial.

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