WECC

2023 WECC Annual Base Case Compilation and Data Check Report

WECC Staff

February 15, 2024

Executive Summary

WECC conducts the Annual Base Case Compilation and Data Check Program to provide high-quality base cases of the Western Interconnection electric system, as it exists and as is planned over the next 10 years, for WECC member and staff use. This report includes 10 base cases prepared in 2023. Seven stability simulations and the Steady-state and Dynamics Dashboard (SADD) were used to evaluate each case. The SADD is a list of potential data issues that the System Review Subcommittee (SRS) has identified as important to track in base cases. The stability simulations are used to find potential data issues and reliability risks. Five of the power flow cases were prepared for conducting operating studies and the other five modeled various planning cases out to 2034.

This report summarizes the results of the SADD and the disturbance simulations done by WECC staff, overseen by the SRS and the Reliability Assessment Committee (RAC). For the 2023 WECC Base Case Compilation and Data Check Report (2023 Report), disturbances were spread throughout the Western Interconnection in Northern California, Southern California, Colorado, and Idaho. Some of the disturbances have associated Remedial Action Scheme (RAS) action. All disturbances requiring RAS actions were simulated using in-run programs.

The primary objectives of the 2023 Report are to—

- Assess system model performance by simulating disturbances with a potentially high impact on the system; and
- Evaluate the quality of the steady-state data and dynamic transmission system model data that were used to develop WECC base cases.

For the 2023 Report, results of disturbance simulations were checked for undamped oscillations and other deviations from standard behavior. In the 2023 Report, several potential data anomalies found during the stability simulations are shown in Appendix B.

Recommendations

Data submitters should continue to make progress in decreasing the amount of SADD errors. NERC Case Quality Metrics that are checked in the SADD should be especially prioritized. Data submitters need to contact WECC staff for models that should be exempt from specific data checks.

Data submitters should review the dynamics error logs that WECC staff compiles for each case and in Appendix B for repeat issues and make corrections to prevent the errors from recurring.

Data submitters and WECC staff should strive to send data by the dates listed in the base case compilation schedule.

WECC staff should review the prioritized list of power flow model shortcomings and update the targets for 2024.

Table of Contents

Introduction

Each year, WECC performs a Base Case Compilation and Data Check (BCCDC) to create an ongoing assessment of the electric system model of the Western Interconnection in its existing state and for configurations extending 10 years into the future. Base case performance is gauged by transient simulations of high-impact disturbances and through many data check routines, both of which help WECC staff compiling the cases find anomalous data. If staff finds anomalies, they are logged for future investigation.

The 2023 BCCDC analyzes the base case model data quality by creating the Steady-state and Dynamics Dashboard (SADD) and running several disturbances on the cases used in the 2023 WECC Annual Base Case Compilation and Data Check Report (2023 Report). The SADD compares the data in the power flow and transient stability data to requirements in the Data Preparation Manual (DPM) and the NERC Case Quality Metrics. The log for each case is shown in Appendix A. The disturbances are run primarily in transient stability simulations but are occasionally evaluated in post-transient power flow simulations, as described in Appendix B. Appendix C explains the base case naming conventions.

The 2023 Report includes lessons learned during the 2023 BCCDC from approved WECC base cases showing system conditions between the winter of 2023 and the summer of 2034. The Results and Recommendations section presents conclusions about the results and recommendations for further action. The General Information section includes information about how WECC staff conducted the studies.

For the 2023 BCCDC, most base cases were compiled to represent system operation under high, but realistic, stress levels. Members of WECC's System Review Subcommittee (SRS) also requested two specialized base cases be built as part of the 2023 BCCDC. Specialized cases can represent the system under atypical conditions, such as severe weather, major equipment outages, or unusual generation patterns, or they can represent more typical system conditions that are not part of the nine recurring cases staff compiles annually. The second specialized case will be analyzed as part of the 2024 BCCDC. The nine recurring cases are five operating cases and four general 5- to 10-year cases.

The cases reviewed in this report are:

- 24LSP2Sa—2024 Light Spring 2 Specialized;
- 24HW3a—2024 Heavy Winter 3 Operating;
- 24LW1a—2024 Light Winter 1 Operating;
- 24HSP1a—2024 Heavy Spring 1 Operating;
- 29HW2a—2029 Heavy Winter 2 Typical 5-Year Case;
- 29HS2a—2029 Heavy Summer 2 Typical 5-Year Case;
- 24HS3b—2024 Heavy Summer 3 Operating;
- 24LS1a—2024 Light Summer 1 Operating;

- 34HW1b—2034 Heavy Winter 1 Typical 10-Year Case; and
- 34HS1a—2034 Heavy Summer 1 Typical 10-Year Case.

The specialized case was compiled to study the following:

- 24LSP2Sa—To represent anticipated operating conditions during light net load periods with high solar.

Disturbances Performed

Seven out of eight disturbances were run on each base case created in the 2023 BCCDC. Either the loss of two Palo Verde generating units or a bi-pole Pacific Direct Current Intertie (PDCI) outage was run on the case, depending on the direction of flow on the California Oregon Intertie (COI).

The 2023 Report included these disturbances:

1. 30-cycle insertion of Chief Joseph braking resistor ("ringdown");
2. Three-phase fault at Comanche and loss of the Daniels Park–Comanche 1 and 2 345-kV lines;
3. Three-phase fault at Colorado River and loss of Colorado River–Red Bluff 1 and 2 500-kV lines;
4. Three-phase fault at Hells Canyon and loss of Brownlee–Hells Canyon 230-kV line;
5. Three-phase fault at Midway and loss of Gates–Midway #1 and Diablo–Midway #2 500-kV lines;
6. Three-phase fault at Imperial Valley and loss of North Gila–Imperial Valley 500-kV lines;
7. Loss of two Palo Verde generating units; and
8. Bi-pole PDCI outage.

Results and Recommendations

SADD Totals

The SADD is a list of data issues regarded by the SRS as important to track in base cases. WECC staff creates two versions of the SADD for each base case. The first is sent out with the initial version of the case for data submitters to review and correct any issues in their data. Data submitters then submit changes for inclusion in the final, approved version of the case. WECC staff create the second version of the SADD based on the final version of each base case as a way for data submitters to track whether their updates are fixing data issues. The following figure reflects only the versions of the SADD created for the final version of each case. The cases are listed in chronological order by the date of the original data request. All cases were built as part of the 2023 WECC Base Case Compilation Schedule (BCCS).

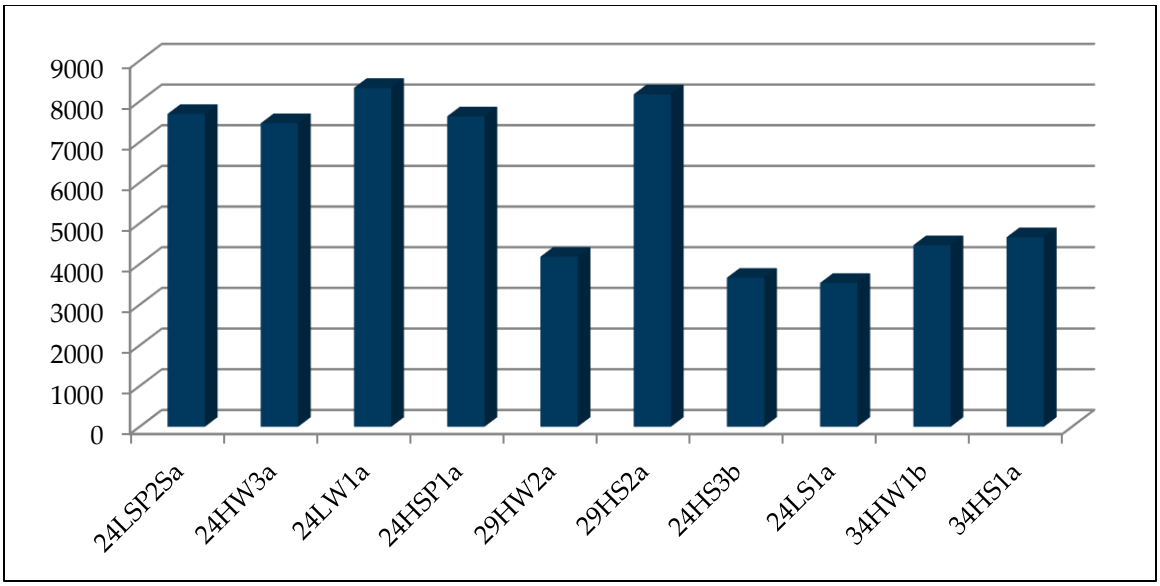

Figure 1: 2023 BCCDC SADD Totals

Recommendation

SADD totals in the 2023 BCCDC are significantly lower than 2022 BCCDC totals, continuing a year-by-year trend. SADD totals in the 2022 BCCDC averaged 11,291 compared to 5,981 in the 2023 BCCDC. Additionally, the case with the most SADD errors in the 2023 BCCDC, the 24LW1a, had fewer errors than all but one of the cases in the 2022 BCCDC which was a specialized case specifically aimed at reducing SADD totals. The progress data submitters made in the 2023 BCCDC is commendable, and data submitters should continue to prioritize minimizing SADD errors for the 2024 BCCDC as well as ensuring that data fixes propagate throughout case builds. This will ensure that WECC staff need only apply data fixes once. Furthermore, WECC staff prepares logs of manual adjustments made to both steady-state and dynamics data and the reason the adjustment was made. Data submitters should review the logs included with each case to ensure they do not revert data back to less-feasible values without intention.

Scorecard Metrics

WECC's Board of Directors issued a directive as part of WECC's 2023 Corporate Scorecard to prioritize and reduce shortcomings in power flow models by 15%. Following a similar initiative in 2022, WECC Staff proposed the following prioritized list of power flow model shortcomings for 2023:

1. Address unreasonable and severe generator saturation factors.
2. Address unreasonable generator inertia constants.
3. Match generator MVA in power flow and dynamics.
4. Reduce the amount of netted generation for units above 10 MVA, or 20 MVA for collector-based generation.

5. Address generator reactive power limits compared with maximum active power to have a reasonable power factor.

WECC and data submitters achieved a 56% reduction of the prioritized errors, as summarized in the following table.

Table 1: Prioritized Power Flow Shortcomings

Updated Priorities	2023 Heavy Summer Tabulation	2024 Heavy Summer Tabulation
Unreasonable/severe saturation factors	818	496
Unreasonable inertia constants	426	174
Mismatched dynamic and power flow MVA base	854	17
Number of netted generators above 10 MVA, or 20 MVA for collector-based systems	132	182
Unreasonable power factor for reactive power limits compared to maximum active power	494	322
TOTAL	2724	1191
GOAL (2024 heavy summer tabulation)	2315	Achieved (56% reduction)

Recommendation

WECC staff should update the prioritized list for the 2024 BCCDC to reflect the large reduction in errors achieved in the 2023 BCCDC. The NERC Case Quality Metrics should inform the new priorities, as well as common errors WECC staff observes when compiling the base cases.

NERC Case Quality Metrics

NERC annually publishes a report detailing base case error counts for certain metrics that NERC considers important. The report's recommendations are directed to each interconnection's MOD-032 designee, which is WECC for the Western Interconnection. As of the 2023 BCCDC, most NERC case quality metrics have been incorporated directly into the SADD for data submitters to review; however, data submitters should still familiarize themselves with the case quality metrics for those that are not captured in the SADD. Some of the main metrics driving error counts in the Western Interconnection include generators at their reactive power limits, generator terminal voltages outside typical bands, natural gas generator ambient temperature power limits, not recommended generator models, non-

zero generator speed damping parameters, and the amount of netted generation in cases. The following figure shows the NERC Case Quality Metrics totals for the 2023 BCCDC.

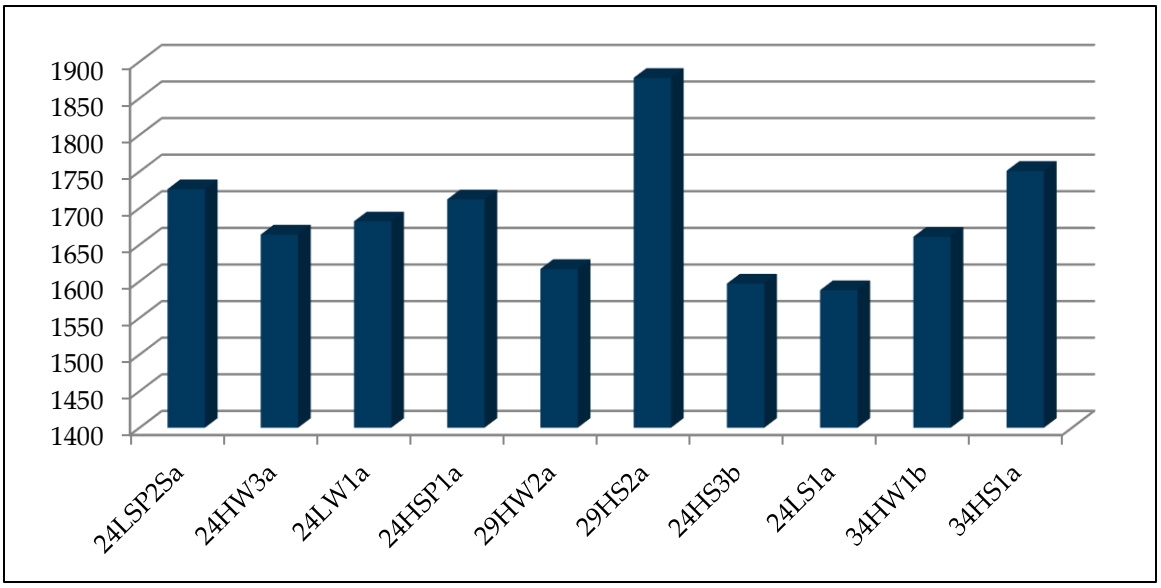

Figure 2: 2023 BCCDC NERC Case Quality Metrics

Recommendation

Staff and data submitters should work together to prioritize reducing NERC case quality metric counts. These case quality metrics should continue to feed into the prioritized list of power flow model shortcomings described in the Scorecard Metrics section. If a data submitter verifies that a value is being flagged as incorrect by the SADD or case quality metrics, but is actually accurate, they should communicate that to staff for inclusion in exemption lists.

Late Data

WECC staff maintains a log of late data received for each case in a given year's BCCDC. Late data can make it difficult to assemble a case on time due to complications that arise when attempting to integrate new data into a partially compiled case that staff has already started working on. Starting with the 2023 BCCDC, the late data log now includes cases that WECC published late, as well as a column to discuss observed data quality issues that WECC staff observed. Overall, the 2023 BCCDC suffered from large amounts of late data and generally exhibited more tardiness than the 2022 BCCDC. Turnover and training involving both data submitters and WECC staff contributed largely to the delays. Some entities did not submit anything for certain case submissions as they transitioned new people into the role of data submitter. Additionally, WECC staff sent several cases out for review late which further exacerbated the issue.

The late data log also tracks mismatched area interchanges and entities whose RAS files loaded into operating cases with issues. Compared to the 2022 BCCDC, interchange data and RAS errors were

corrected more quickly in the 2023 BCCDC. However, WECC staff is preparing a proposal to streamline the RAS collection process which should be monitored during the 2024 BCCDC.

Recommendation

WECC staff and data submitters should emphasize the importance of timely data submissions when budgeting time for work-related tasks. Data submitters, especially those newer to the role, should attend System Review Subcommittee meetings where education and outreach on base case building processes is a core tenet of the SRS. If someone expects their data will be late, they should begin communicating with WECC staff or the affected data submitter as soon as possible. Additionally, data submitters should coordinate area interchange values and tie-line statuses prior to submitting data to WECC.

Inertia

One finding from the 2021-21 WECC Study program was for SRS to track the amount of inertia in base cases. Figure 3 shows the inertia in GVA-seconds for each case in the 2022 BCCDC in chronological order of the time the case is intended to model. Figure 4 shows the system frequency response to a loss of two Palo Verde generators at a 500 kV bus in California using the heavy summer operating case. The worst-case frequency response observed is still well above the underfrequency load shedding limit of 59.7 Hz.

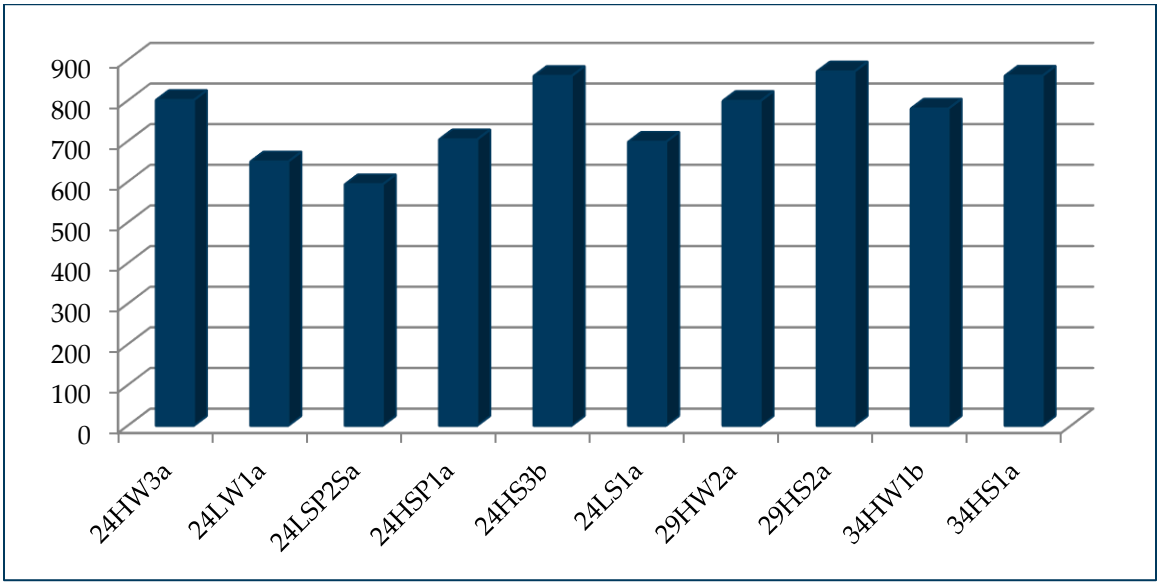

Figure 3: 2023 BCCDC Inertia Totals

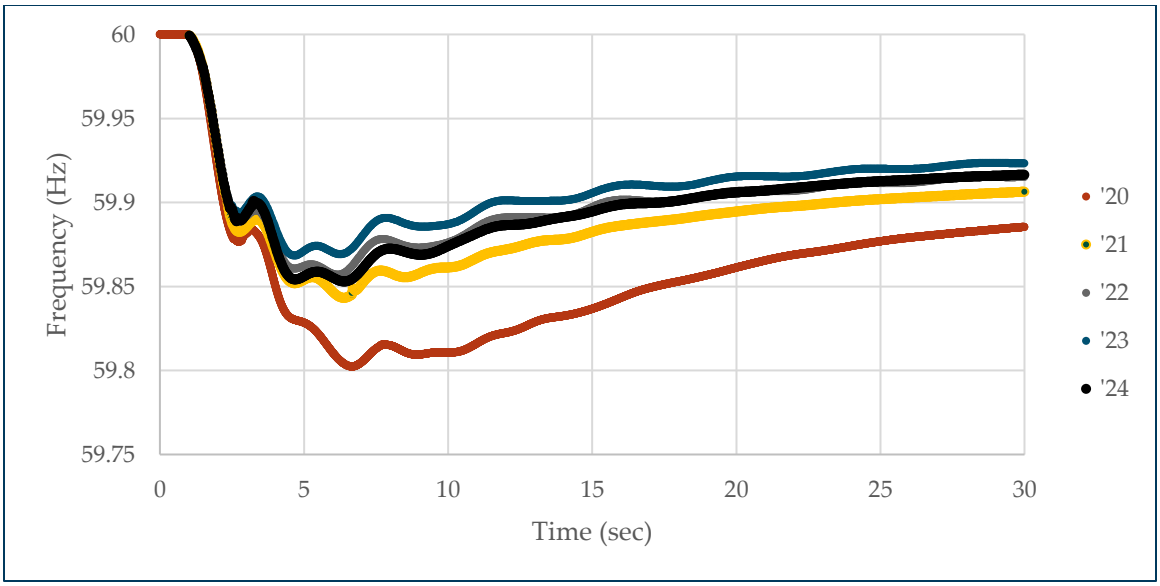

Figure 4: 2023 BCCDC Inertia Totals

Recommendation

WECC staff should continue to track the amount of inertia in cases and monitor the headroom of the underfrequency load shedding limit for possible risks to the BPS.

Inverter-based Resources

As the resource mix continues to change in the Western Interconnection, tracking amounts of distributed generation (DG) as well as inverter-based resources like wind and solar will be essential to ensure those components are being modeled in reasonable amounts in base cases. **Error! Reference source not found.** shows the amount of DG, solar, and wind in gigawatts that is online in each case in the 2022 BCCDC, arranged from nearest to furthest in the future. As expected, the amount of solar and DG online in the cases trends upward the further into the future that the cases model. Wind, on the other hand, seems constant. Note that the 24LW1a and 24LS1a model light load conditions from 3:00 to 5:00 a.m. and 4:00 to 6:00 a.m., respectively, so low amounts of solar should be expected.

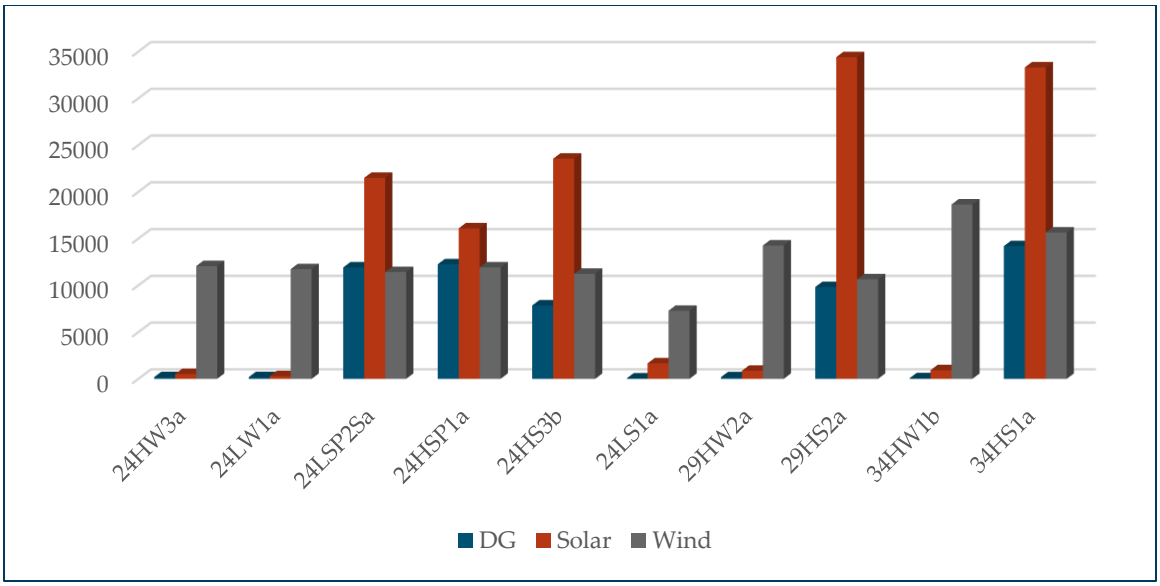

Figure 5: 2023 BCCDC IBR Totals

Recommendation

WECC staff should continue to track the amount of DG, solar, and wind online in cases. Data submitters should also check the amount in their areas makes sense with the specific case time and goals before submitting data to prevent the need to make large adjustments to load or generation after staff has begun compiling a case.

2022 Report Review

This section will examine the recommendations from the 2022 Report and progress made toward those recommendations. The first recommendation was to continue to reduce SADD errors. Overall, WECC staff and data submitters made excellent progress towards reducing the total amount of SADD errors with the highest total from the 2023 BCCDC being lower than all but one total from the 2022 BCCDC.

The 2022 Report also recommended that data submitters work to specifically reduce the amount of blank turbine types. The 2022 BCCDC averaged 355 blank turbine types while the 2023 BCCDC averaged 153, so a significant improvement was achieved.

The third recommendation from the 2022 Report was to prioritize reducing the count of NERC Case Quality Metrics errors. WECC staff achieved this by investigating generators being flagged for unreasonable saturation factors and inertia constants with validated generator test reports.

The fourth recommendation from the 2022 Report was to reduce the amount of late data. This recommendation was not achieved; rather, the amount of late data in the 2023 BCCDC increased, both on the part of WECC staff and data submitters. Both should continue to make this a priority in the 2024 BCCDC.

The fifth recommendation from the 2022 Report was for data submitters to reduce the amount of repeated dynamic errors seen throughout case builds. This recommendation was not achieved. WECC staff should continue to explore solutions for repeated model issues.

The sixth recommendation from the 2022 Report was to track the amount of inertia in the heavy summer cases. This recommendation was followed in the 2023 Report, and WECC staff should continue to track inertia.

The seventh recommendation from the 2023 Report was to track the capacity of inverter-based resources in each case. This recommendation was followed in the 2023 Report, and WECC staff should continue to track the amount of inverter-based resources.

General Information

For the 2023 Report, disturbances were run on 10 power flow base cases. Stability simulations were run on all cases in the 2023 BCCDC.

1. The power flow, stability, and post-transient simulations for the 2023 BCCDC were conducted on a PC using the Microsoft Windows 10 operating system and Version 22.0.5 of the General Electric (GE) Positive Sequence Load Flow (PSLF) software program.
2. All 2023 Report disturbance simulations were run with the governor response represented in the power flow (base load flag) and dynamic data (governor models) provided.
3. For the 2023 Report disturbance simulations, Phase 2 of the composite load model, which includes single-phase motor stalling, was used. Models were generated using either the climate zone representation or the load-specific representation.
4. For all the 2023 cases, DG was included in the load data, and DG dynamics data was modeled with the DER_A model in the composite load model.

As part of the 2023 base case development, data-check routines, along with stability studies, were run to find potential data errors.

Objectives

The following section addresses each objective developed in the 2023 BCCDC Scope of Work. The objective is stated, followed by the findings and actions related to it.

Base Case Development

The first objective is the development of steady-state and dynamic base case models.

Actions and Findings

The 10 power flow base cases and stability data files were created for the 10-year data bank. The 10 cases include five operating cases, one specialized case, and four typical planning cases. The cases are available to WECC members on wecc.org.

Model Performance Assessment

The second objective is to annually assess the performance of the transmission system model based on selective disturbances run using the cases.

Actions and Findings

1. A no-disturbance simulation was done on each case. Data for machines with significant oscillatory behavior were revised. The results for the cases compiled during 2023 for the WECC 10-year power flow and stability data bank showed no significant oscillatory behavior after changes were made.
2. After additions and changes to the master dynamics file, a 35-second simulation of a "ringdown" (30-cycle insertion of Chief Joseph braking resistor) case was done.
3. One standard disturbance was run on each case to tune the dynamic and power flow data. Tripping of two Palo Verde units was simulated as the standard disturbance on cases with north-to-south flows on the COI. For cases with south-to-north flows, loss of the PDCI was simulated. If the standard disturbance results were not stable, changes were made to the base case to correct data problems or flows outside of known operating limits. If the results were still unacceptable, they were included in the Annual Base Case Compilation and Data Check Log.
4. Seven disturbances were run on each case, the results of the stability studies were checked for system data or modeling problems. Any issues found are in Appendix B. WECC urges data submitters to review Appendix B and submit corrections to models shown as being unstable when stressed by these disturbances.
5. Each power flow base case was checked relative to known transfer capabilities and nomograms. Transfers in each of the power flow cases for the 2023 BCCDC were within the estimated transfer capability and nomogram limits at the time they were compiled.

Disturbance Summary

The Disturbance Summary table shows the stability studies that were conducted and associated their RAS.

Table 2: Disturbance Summary

Fault Location	Elements Removed	Remedial/Relay Action
COMMANCHE 345-kV SUBSTATION	**Time (cycles) Switching** 60 Three-Phase Comanche 345-kV fault 64 Clear the fault after four cycles and open the Comanche–Daniel Park 345-kV Lines 1 and 2 Study terminated at 35 seconds	None
COLORADO RIVER 500-kV SUBSTATION	**Time (cycles) Switching** 60 Three-Phase Colorado River 500-kV fault 64 Clear the fault after four cycles and open the Colorado River–Red Bluff 500-kV lines 1 and 2 Study terminated at 35 seconds	None
HELLS CANYON 230-kV SUBSTATION	**Time (cycles) Switching** 60 Three-Phase Hells Canyon 230-kV fault 65 Clear the fault after five cycles and open the Hells Canyon–Brownlee 230-kV Line Study terminated at 35 seconds	Hells Canyon Generator Tripping
MIDWAY 500-kV SUBSTATION	**Time (cycles) Switching** 60 Three-Phase Midway 500-kV fault 64 Clear the fault after four cycles and open the Midway–Vincent 500-kV sections 1 and 2 and Midway–Diablo 500-kV line 2 Study terminated at 35 seconds	None
IMPERIAL VALLEY 500-kV SUBSTATION	**Time (cycles) Switching** 60 Three-Phase Imperial Valley 500-kV fault 64 Clear the fault after four cycles and open the Imperial Valley–North Gila 500-kV line Study terminated at 35 seconds	None

Fault Location	Elements Removed	Remedial/Relay Action
DOUBLE PALO VERDE UNIT OUTAGE	**Time (cycles) Switching** 60 Trip 2 Palo Verde Generators Study terminated at 35 seconds	Trip load associated with the loss of 2 Palo Verde units
CHIEF JOSEPH RESISTOR INSERTION	**Time (cycles) Switching** 60 Insert Chief Joseph Braking Resistor 90 Clear the Chief Joseph Braking Resistor Study terminated at 35 seconds	None
BI-POLE PACIFIC DC INTERTIE OUTAGE	**Time (cycles) Switching** 60 Open two DC Lines from Sylmar to Celilo Study terminated at 35 seconds	None

More details on the results of power flow cases and disturbance simulations are in the appendices. Appendix A includes summary information from the SADD for each power flow case. Appendix B shows anomalies found while running the standard list of disturbances, which is contained in this report. Appendix C explains the base case naming conventions used in this document.

Approving Committee, Entity, or Person	Approval Date
SRS	

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