ECEN 460 Spring 2025
Computer Laboratory Exercise 4
Power System Upgrades Analysis

Objective:

Gain experience and insights on working with larger power system cases by focusing a study on one zone of a 2000 bus system case. Observe the effects of updating the case load, generators, transmission lines, transformers, and shunt capacitors on the system bus voltages and transmission line flows.

Background:

This lab uses the Texas Synthetic Grid Company system again (Case file: TSGC_Lab04.pwb, oneline file TSGC_Lab04.pwd). In this scenarios you are a planning engineer for a smaller utility company that covers just one zone, “Aggieland”, which is zone number 7, of the full (synthetic) Texas interconnect. You want to focus your analysis on this zone, but it is interconnected with other zones, so you need to use the full Texas case for your analysis. Each bus has a zone number associated with it, so you can use that to identify what part of the system is included in the Aggieland zone. For this lab, you will be focusing mainly on the tables of data in the model explorer feature of PowerWorld Simulator. Your task is to check the status of the case and then implement the upgrade changes that are planned for next year. You will then assess the impact of those changes. Make sure to follow the directions in this lab procedure carefully and record all results for your report.

Part A Procedure:

1. When you open up the case, notice that the oneline diagram has a color contour that shows the zone number of each bus. The Aggieland zone is medium-blue, on the center-east of the grid, as circled in Fig. 1. Zoom up on that zone and save a screenshot of the oneline diagram for your report.

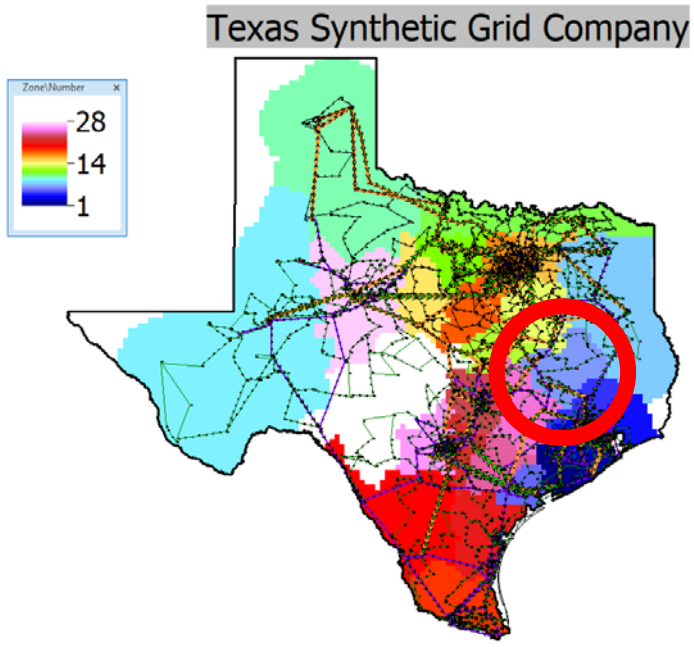

Fig. 1, Zones in the Texas Synthetic Grid Company, with the Aggieland zone circled.

2. Open the log window by going to Tools -> Log. Then click Tools -> Solve Power Flow and confirm from the log that the power flow was solved successfully. Save a picture of this for your report.
3. Open up the model explorer by going to Case Information -> Model Explorer. The left side of the model explorer screen gives a variety of object types that could be in the system. When you select one, the right side of the screen shows a table of objects in the system and their important parameters.
4. Open the table of buses. Scroll over to the rightmost column, which should give the zone number of each bus. Sort by zone number by clicking on the column header. Then find out how many buses are in this zone and record that for your report. Do the same thing for loads and generators.
5. Set a filter on the case to only show data for your zone. You can do this from Case Information -> Area/Zone filters. Then find your zone and make only it visible. Now go back to the Bus and Load tables and observe that the number of elements has decreased to only the ones in your zone. If you want to view the whole case again, you can always change the filtering.
6. With the filter in place, go to the generator table. Answer the following questions about the generators for this report. How many total generating units are there? What is the total capacity (sum of the max MW) of all units? How many are online, that is, status=closed, in this planning case? How much power, in terms of MW, are they actually generating in this case? Compare the MW of the generation fleet to the total maximum and comment on how that might affect operations.
7. Go to the Zones table (under aggregations). Make a table for your report of Mvar for the Aggieland zone. How much is the load Mvar? Generation Mvar? shunt capacitors? losses? import or export to other zones? Make sure that real and reactive power balance are satisfied.
8. Using the model explorer, find the maximum and minimum bus per-unit voltage magnitude in the case, and the highest-loaded branch as a percentage of its limit. Ideally, voltages should be in the range 0.95 to 1.05, and branches should be well under their limit.

Part B Procedure:

9. The case you have been looking at so far is for this year. Now your task is to modify the case to reflect upgrades for the next year. Save a new copy of the case and change the name to reflect next year's case.
10. There is an Excel spreadsheet file included with the case, titled, "Next Year Aggieland Load". It came from the engineers who have been working to forecast customer load from next year, and provides an updated list of each bus's load for your zone. Most loads have gone up, but some have gone down. This file can be viewed in Excel, and loaded into PowerWorld. With the file open in Excel, copy the whole table including the headers. In the new case, find the load table and paste the data in. Notice that the loads have changed.
11. With the log open, solve the power flow for the case.
12. What? Solution failed! What's the problem? To investigate, open up the table under Solution Details -> Mismatches. This shows where the solver had trouble getting power balance to work, which led to the failed solution. Which bus had the largest mismatch in the power flow? That's where the problem likely is. Look at the loads and see if you can identify which load value is probably bad data. Correct that load to 12.7 MW, 3.0 Mvar.
13. Looks like somebody accidentally put the bus number three times instead of the MW and Mvar, causing voltage collapse! Being able to identify the source of an issue is a key skill to develop in power engineering. Now try solving again. You may need to fix the Excel file, reopen the original case, and then import the correct load in order to get a good solution. Check that the log shows a good solution and that the mismatches are all low.

14. How are the voltages and line flows with the new loading? How has the import/export with other zones been affected? Record the max and min voltages.
15. Next, a 182 Mvar capacitor bank is scheduled to be installed next year on bus 8095. Go to the switched shunts table and enter edit mode. Click records -> insert and create the new switched shunt.
16. Solve the case again and see how the voltages have been affected.

Part C Procedure

17. Finally, there is a new substation being installed in your zone next year to service a brand new 120 MW wind plant. This will be a 230 kV substation with two new transmission lines connecting it to the system. You can model the substation as a single bus, giving it the number 18000, with a generator attached. Assume the generator has a capacity of 120 MW and $\pm$60 Mvar, and is regulating its terminal to 1.03 per-unit voltage. The two transmission lines are the same conductor and tower design: resistance is 0.115 Ω/mile, the inductance is 1.5 mH per mile, the capacitance is 18.6 nF per mile, and the per-phase ampacity is 950 A. The first line is 11 miles long to bus 8139, and the second one is 32 miles long to bus 8159. Create the bus, generating unit, and two transmission lines and add them to the zone. For starters put the lines in with (R=0, X=0.1, B=0, MVA limit = 0). Then do calculations to find the correct per-unit, total values. What values did you put for these lines? What other modeling information did you need to fill in? Make sure to record exactly what you did in this step.
18. Solve the power flow with the new substation in place. Comment on the impact to system loading, voltages, interchange, and generation.
19. Open up a bus view for your new bus (Onelines -> Bus View) and save a snapshot of the busview for this case.

Report:

Start the report with a short paragraph abstract explaining what you did in this lab at a high level and what your overall observations were. Then go through the steps of the report and include each of the figures or data requested and answer any questions that are asked.