ELEN 460
Computer Laboratory Exercise No: 7
Economic Dispatch and Contingency Analysis on Small and Medium Sized Systems

Objective:

Gain experience and insights on the use of economic dispatch and contingency analysis by running studies on both a 37 bus system and a 2000 bus system. Observe the effects as the system load and generation is varied.

Background on 37 Bus APL System

As was the case with the previous lab, we'll be working with the 37 bus system modeling the fictional Aggieland Power and Light (APL) grid. However, this system has been slightly modified from before, mostly with some enhancements in transmission line and transformer limits to better improve its contingency analysis performance. The oneline for this system is shown in Figure 1.

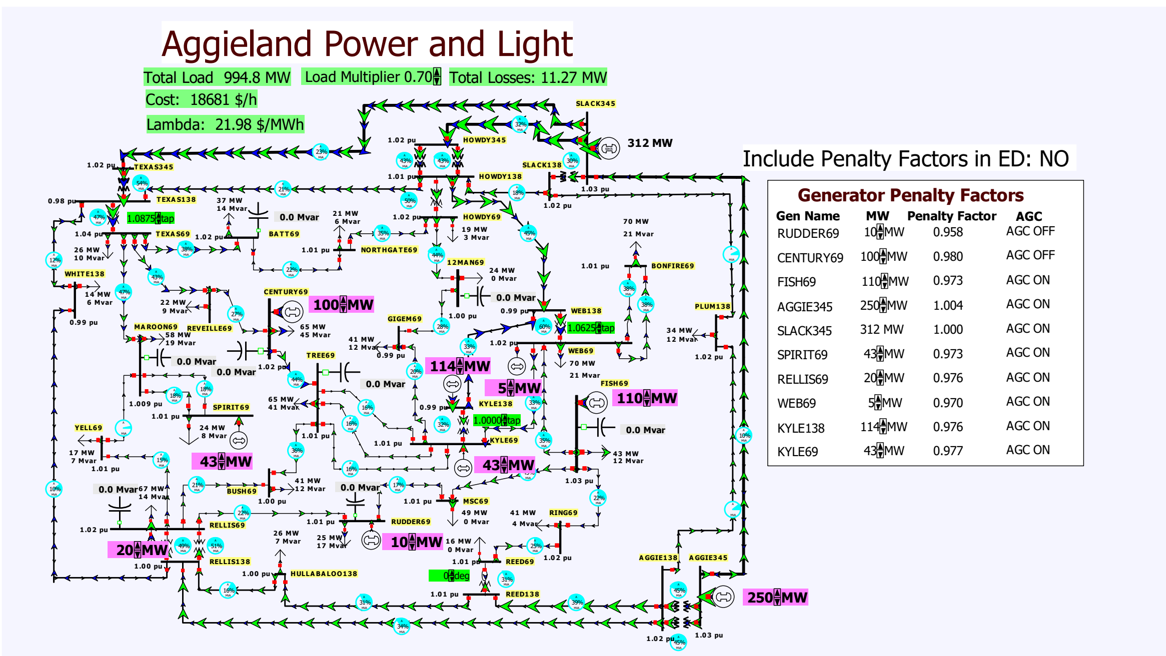

Figure 1: 37 Bus APL System

The system has also been setup to automatically do an economic dispatch (ED) of all the ten generators. Also, the oneline now provides a button towards the top to all you to easy scale the load in 5% increments of the APL all time system peak load. Initially we'll be starting at 70% of the peak load.

Procedure for 37 Bus System

1. Start PowerWorld Simulator. Open the Lab7_Bus37Start case. This power flow case represents an operating point of 70% of the system peak load. Initially the case is setup to do an economic dispatch, except without taking into account the generator penalty factors in the ED (this is equivalent to treating all the penalty factors as unity).

2. Record the initial system Total Load, Hourly Cost, Losses, and Lambda. Select **Tools**, **Play** to start the power flow simulation.

3 Click on the Load Multiplier up arrow (towards the top of the oneline) to increase the load by 5% (of the system peak) to 0.75. Again record the Total Load, Hourly Cost, Losses, and Lambda.

4. Repeat Step 3, going up until the Load Multiplier is 1.0.

5. Reset the Load Multiplier to 0.7. You can either click it down using the down arrow, or simply reopen the case.

6. Next we will repeat this process, except including the generator penalty factors in the ED. To enable this option, right click on the "Include Penalty Factors in ED" field, select the **Area Information Dialog**. Then go to the **Options** page and check the **Include Loss Penalty Factors in ED** option. To save this change and close the dialog, click the **OK** on the button (this dialog is shown in Figure 2).

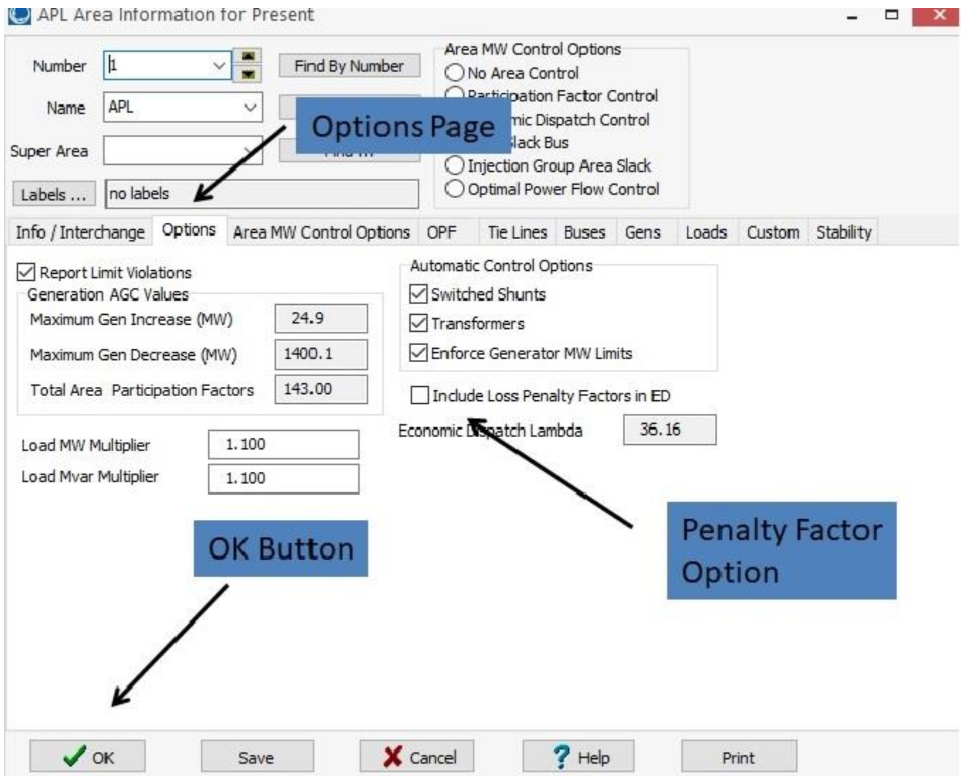

Figure 2: Area Options for Enabling Penalty Factors

7. Repeat steps 3 and 4, again going from 0.7 to 1.0 for the Load Multiplier. In your report you will be comparing these values.

8. Reset the Load Multiplier back to 0.7, but keep the option to Include Loss Penalty Factors in ED (if you reload the case you'll need to redo step 6). Next we'll be considering the N-1 reliability of the system using contingency analysis. The case has already been setup to include 56 single line or transformer outage contingencies. To view the Contingency Analysis Form select **Tools, Contingency Analysis**. Initially we'll perform a contingency analysis with the Load Multiplier at 0.7. To do this select the **Start Run** button, shown in the bottom right of this form. At this load level there should be no violations. The violation limits are set to 100% for the flows, and 0.95 per unit for low voltages, and 1.1 per unit for high voltages.

9 Close the Contingency Analysis form (this part is quite important), click the Load Multiplier Up arrow two times to go up by 0.1 to 0.8. Reopen the Contingency Analysis form, and rerun contingency analysis. Now there should be some voltage violations. Like in the last experiment this case has all the capacitors initially set open. Use your engineering judgement to close in some capacitors to fix all the contingency voltage violations. Rerun contingency analysis to verify. You may need to iterate a few times to fix all the problems, closing the contingency analysis form between runs. Record the final set of capacitors that you closed for your report.

10 As a last step for this case, increase the Load Multiplier to 1.0. Then manually redispatch the generation to minimize the total system losses, ignoring the economic dispatch and contingency considerations. Note, a necessary condition for an unconstrained minimum would be to have all the penalty factors equal to unity, but you will not be able to achieve this because of the generator MW limits. Record the initial losses and your minimum losses. Again, don't spend too much time on this step and don't need to achieve an optimal solution for full credit. In your report provide the change in losses and comment on whether you think this would be a good operating condition.

Background on the 2000 Bus TSGC System

This is the same Texas Synthetic Grid Company (TSGC) 2000 bus system you used in Lab 6, except all the lines are now in-service and the load has been modified. You will be doing economic dispatch and contingency analysis studies on this system. However, rather than operating the entire system, you'll be focusing on the North Central area of the system, which is shown highlighted in yellow in Figure 3. Also, rather than running all 3800 single element contingencies (which would take a bit of time), the contingency set has been reduced to just 77 single line and transformer outages associated with the 500 kV system in the North Central Texas area.

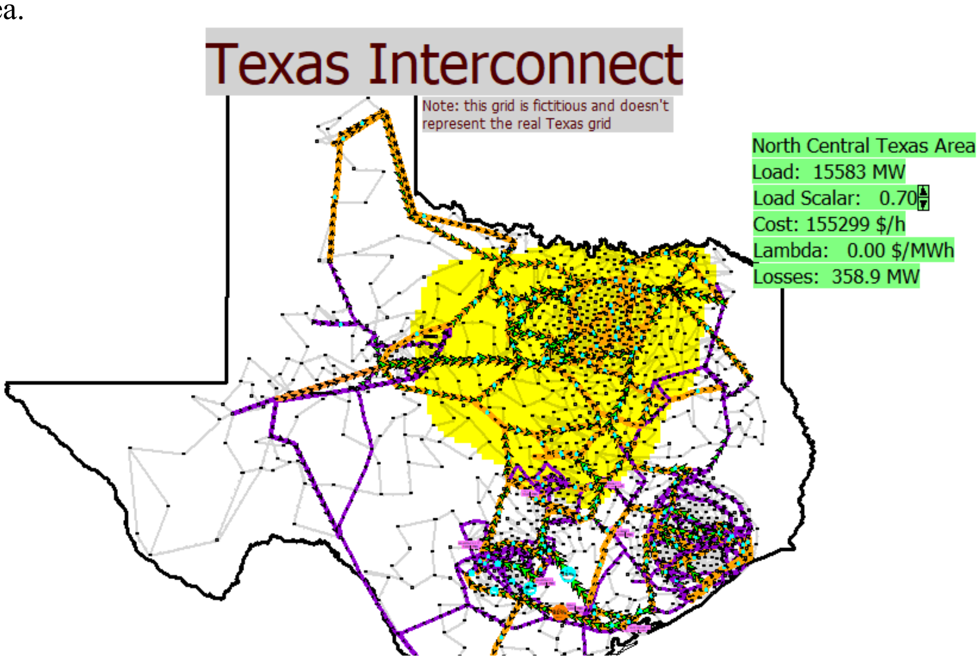

Figure 3: 2000 Bus TSGC System, With North Central Texas Area Highlighted in Yellow

Procedure for TSGC System

1. Open up Lab7_Texas_Start. This is the TSGC power flow with the 500 kV lines shown in orange and the 230 kV lines in violet.
2. For the North Central Texas area record from the oneline the initial Load, Hourly Cost, Losses, and Lambda. Select **Tools**, **Play** to start the power flow simulation. The North Central region is setup on economic dispatch including the loss penalties.
3. Click on the Load Multiplier up arrow (towards the top of the oneline) to increase the load in the North Central area by 5% (of the area's peak) to 0.75; the load in the other portions of the system will remain constant. Again record the Load, Hourly Cost, Losses, and Lambda.
4. Repeat step 3, again going from 0.7 to 1.0 for the Load Multiplier. In your report you will be comparing these values.
5. With the Load Multiplier at 1.0, run contingency analysis (this will take a few seconds since it is solving 77 power flow solutions). You should see two contingencies with violations. Record the contingencies and their associated line violations. Close contingency analysis.
6. Try redispatching the generation to fix both of these contingencies. For convenience the oneline has "Views" defined that show you the contingency location. To zoom to a specific view, right-click on a blank part of the oneline to display the local menu, select **Go To View** and pick the desired view (which are named for the contingencies). To fix each contingency, open the 500 kV line associated with the contingency and change the generation until you've fixed the line violation. Save a screenshot of the solution. Then place the line back in service and attempt to solve the other contingency, again saving a screenshot of your solution. With this case the contingencies are far enough apart that changes to solve one contingency should not have much impact on the other. An example view is shown in Figure 4. Rerun contingency analysis to verify that you have solved both violations.

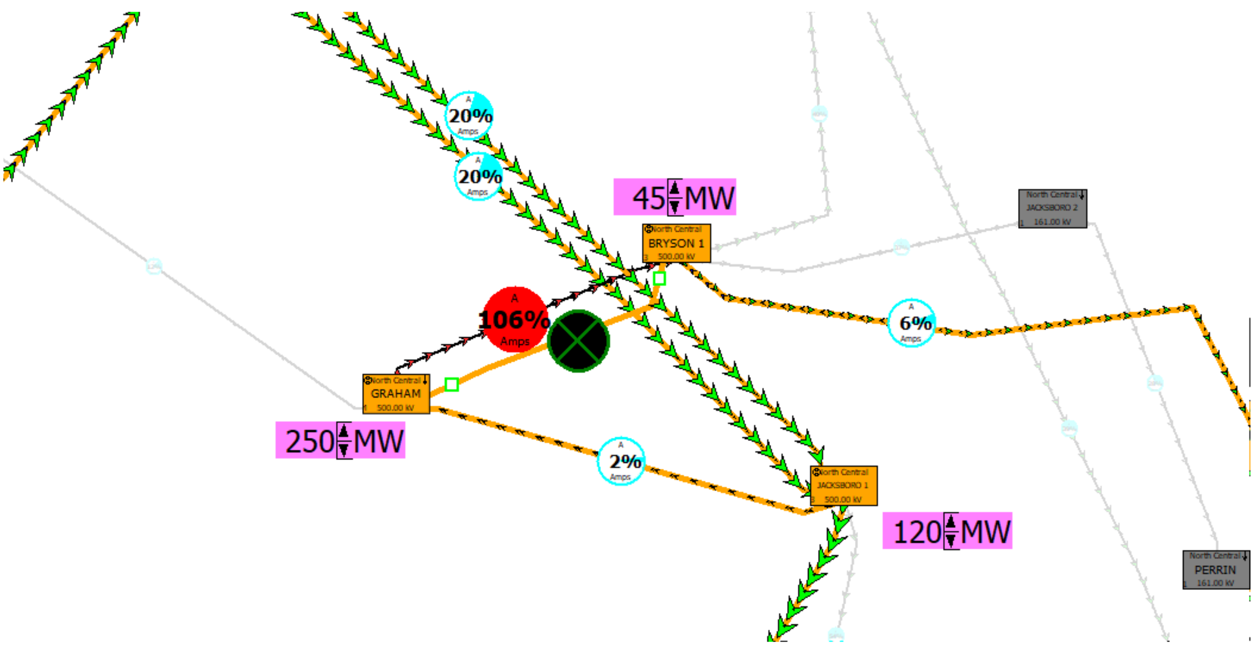

Figure 4: GRAHAM-BRYSON 500 kV Line Contingency

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Report:

For both the 37 bus and 2000 bus systems, provide a summary of the procedures you followed and the results you have obtained. For the 37 bus system for steps 3 to 7 in your report provide a graph of Total Cost (on the y-axis) versus Total Load (on the x-axis) for the two ED options of without and with the penalty factors (i.e., your graph will have two curves). Do the same for the marginal cost. Which option would you say is best? Be sure to include your results from the last two steps in your report as well.

For the 2000 bus system in your report provide a graph of the Total Cost (on the y-axis) versus Total Load (on the x-axis). Do the same for losses and marginal cost. Provide your recommendations for fixing the contingency violations.