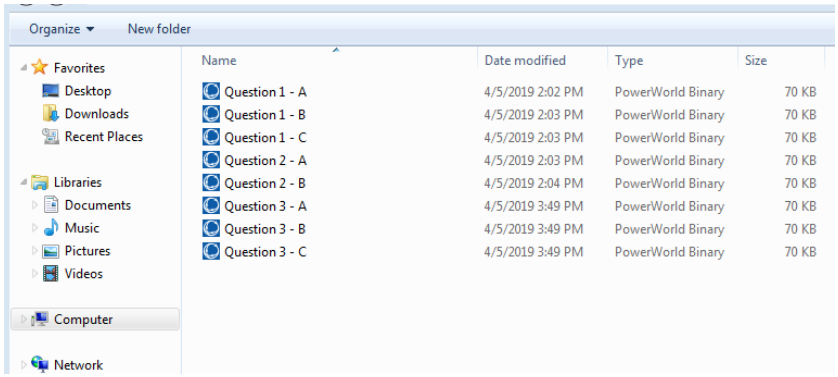
This Document is intended for Instructors only.

There are multiple correct ways to solve system issues listed in the questions below. The answers included below are just some optimal answers that Entergy has identified.

A set of fresh PowerWorld cases and oneline (.pwd) files have been provided with this lab.

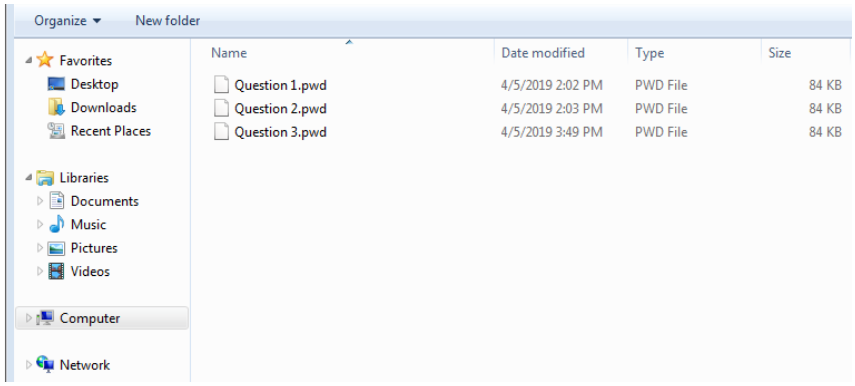
Opening a case:

- Open PowerWorld 20
- Click File
- Click Open Case
- Select the powerworld case respective to the question you want to answer
    - (alternatively you may double click the PowerWorld Binary file you wish to open for the folder)



The case will open, but the screen will still be blank

- Click File again
- Click Open Oneline
- Select the Oneline (.pwd) respective to the question you're answering



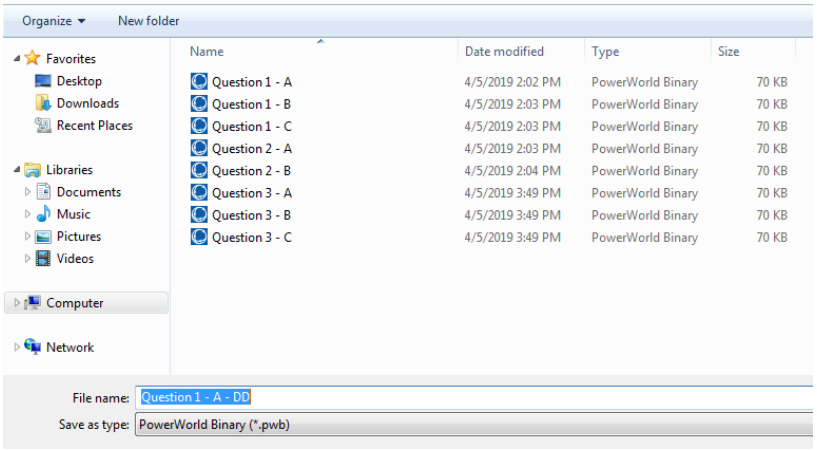
At this point you should see the Aggieland Power and Light system

Answering a question:

- Read the question thoroughly
- Attempt to develop a solution in your power world case
    - Use edit mode > Draw > Network to set up the scenario and create a solution
- Answer the question with two or three sentences, and include any calculation you may have done
- Provide a screen capture of the solution you designed in your power world case

After answering a question:

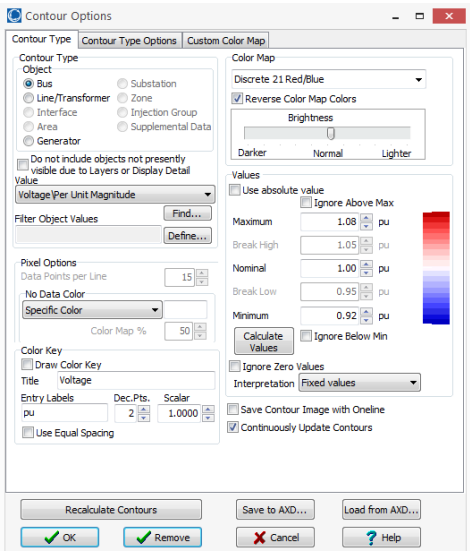
- Once you have completed answering a question (i.e. Question 1 – A)
- Save your case by clicking File
- Click Save Case As
- Save this answered case using your initials



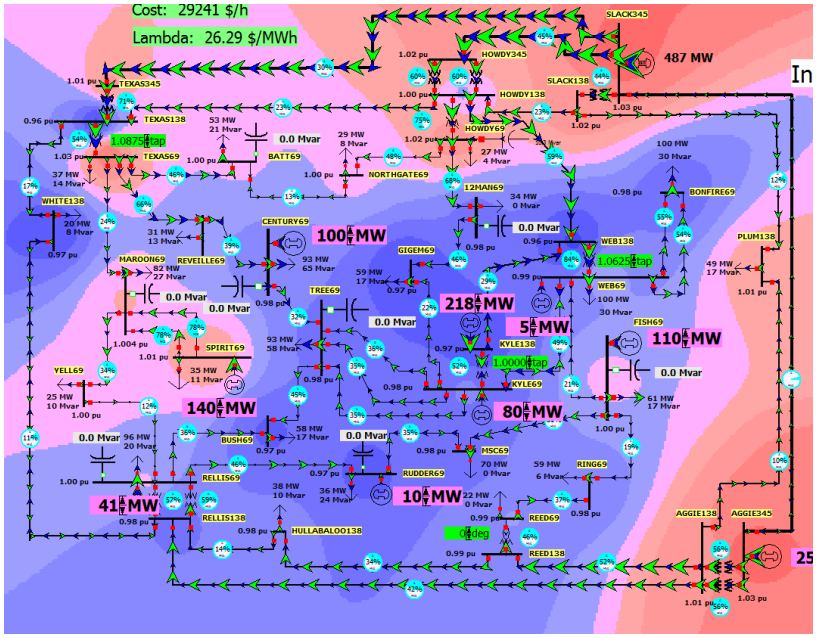
- open the next question (i.e. Question 1 – B) using the methods listed above

Contouring - A useful tool for power flow analysis is Contouring. This will allow you to see a heat map of the system. To enable Contouring:

- Open a case and oneline
- Right click on the system
- Select Contouring



- Click Ok



Low voltage areas will appear dark blue while high voltage areas will appear bright red.

Aggieland Power and Light is a utility that maintains a stable power system. This utility plans its transmission system in such a way that no overload or voltage issues will ever be seen in a base case scenario. A base case scenario is a snapshot of the system with no issues or outages. The Aggieland Power and Light planning standards are as follows:

- Voltage levels must not exceed 1.05 PU or fall below 0.95 at any time.
- In a base case situation the thermal loading of any line must not exceed 95%
- In the event of a N-1 situation (Line outage, Bus fault, Load trip etc…) the loading of any line in the system must not exceed 95%
- In the event of a G-1 situation (Planned or Unplanned Generation Outage) the loading of any line must not exceed 99%
- Capacitor banks may be utilized when running analysis on N-1 or G-1 events

Note: Any N-1 or G-1 events will explicitly be defined in the questions statements below. There is no need to explore alternative N-1 or G-1 events.

Below are some important Aggie Land Power and Light estimations for line impedance, equipment cost, and substation distance. Know that these sets of data are fictitious, but will be useful for completing this lab.

Item Voltage Level	MVA	R/mile	X/mile	B/mile
69 kV Line	72	0.008019	0.01341	0.000576
69 kV Line	106	0.003777	0.014573	0.000293
138 kV Line	185	0.000634	0.003843	0.001032
345 kV Line	600	0.000095	0.000815	0.00828
138/69 kV Autotransformer	Limit - 211	0.00101	0.03925	/
345/138 kV Autotransformer	Limit - 220	0.00087	0.051	/

Transmission Item	Cost ($)
69 kV Substation	$ 4,200,000.00
138 kV Substation	$ 6,400,000.00
20 Mvar Capacitor Bank	$ 1,200,000.00
40 Mvar Capacitor Bank	$ 2,400,000.00
70 Mvar Capacitor Bank	$ 5,500,000.00
138/69 kV Autotransformer	$ 5,400,000.00
345/138 kV Autotransformer	$ 8,600,000.00
1 Mile of 69 kV Line (Rated at 72 MVA)	$ 750,000.00
1 Mile of 69 kV Line (Rated at 106 MVA)	$ 820,000.00
1 Mile of 138 kV Line (Rated at 185 MVA)	$ 1,200,000.00
1 Mile of 138 kV Line (Rated at 600 MVA)	$ 1,500,000.00

Substation	Distance (Miles)
Howdy - Northgate	7.2
Howdy - Web	10.1
Web - Kyle	5.6
Web - Bonfire	6.1
Slack - Howdy	14.8
Slack - Bonfire	7.9
Slack - Plum	18
Plum - Aggie	10.5
Plum - Bonfire	3.4
Texas -Batt	4
Texas - Reveille	4.2
Texas - Maroon	6.5
Texas - White	7
White - Rellis	13.1
White - Maroon	4
Reveille - Batt	6.9
Reveille - Century	1.2
Reveille - Maroon	5.3
Reveille - Spirit	6.8
Maroon - Spirit	1.5
Maroon - Century	6.2
Maroon - Yell	4.3
Yell - Rellis	5.2
Yell - Spirit	5.5
Century - Batt	7.2
Century - Tree	3.5
Century - Northgate	3.2

Entergy

1) Development Initiative

A) The Mayor of the city of Spirit wants to develop some vacant city property. He has asked the utility: "How much load can be added to the city without causing power issues if your system has no outages?"

- Find the base case load serving capability of the substations at Spirit. Assume a 0.9 Power Factor. 5

  i. The system can currently handle ~140MW (with 67.8MVar) of load in a non-contingent scenario.

- Identify which line in the system would become critically important serving this new load. Explain why. 5

  i. Texas – Maroon 69kV line will become the most critical on the system. If the city of spirit adds 135MW of load then the loss of Texas – Maroon 69 kV line would cause overloads on Yell –Maroon, Yell – Rellis, and Bush – Tree 69 Kv Lines.

B) The city has plans to build a hospital through this development initiative, and wants to know how big the hospital can be. The utility considers hospitals to be "critical load", and thus wants to plan for an event in which Spirit city's power plant is lost.

- Find the maximum amount of load that the city's substation can handle in an event where there is an outage at the Spirit power plant. Assume a 0.9 Power Factor. 10

  In a situation where the power plant goes down:

  i. ~ 5.5 MW (with 2.66MVar) with 95% loading on Texas – Maroon or…
  ii. ~11 MW (with 5.33Mvar) with 99% loading on Texas – Maroon

C) The mayor of Spirit decides that the city development project will add a total of 25 MW of load to the city. The mayor asks that all 25 MW of load be considered "critical load". Assuming a 0.9 power factor; study a 25 MW load addition at Spirit substation with the Spirit generation plant out of service.

- Identify the lowest cost (non-capacitor bank) solution for the city of Spirit. Explain your proposed solution and any system adjustments. 10

  i. Build a new 69 kV line between Reveille and Maroon substation

- How much would this transmission project cost?

    i. This project will cost $3,975,000.00 (5.3 miles at $750,000 a mile)

2) Hurricane Preparation

A) Century power plant has been in a maintenance outage for 6 months, and the utility is beginning to worry about an approaching hurricane. The utility has identified the 69 kV line between Century and Tree substation to be at a high risk of outage from the potential heavy winds from the hurricane.

- Determine how much load would need to be shed in order to bring all thermal overloads within the utility's reliability criteria the event of the loss of the Century – Tree 69 kV line during a continued maintenance outage of the Century power plant. 10

    - The student will first need to find that the load at Century is operating at a power factor of 0.8196, and will then shed load until the worst overload is below 99%. The load shed amount is ~30 MW

B) After identifying this as a reliability issue, what transmission upgrades should the utility invest in to prevent this issue in the future?

- What is an optimal long term solution, why? 10

  A long term solution would include building a line from Northgate to Century.

- What would be the price of this proposed project? 5

  3.2 miles of 69 kV line will cost $2,400,000.00

3) Industrial Customer

A) Company A is planning to build a chemical refinery plant in the city of Bonfire. The company has expressed concern to the utility that it desires a more reliable transmission feed to the local substation. This company has reported that the expected load for their new facility will be 20 MW and will operate at a 0.85 power factor.

15

- Estimate the lowest cost project that would mitigate any base case issues by adding another 69kV feed into Bonfire. Note: there is no room in the Web 69 kV substation for another transmission line.

    i. The lowest cost project would be to build a line from Plum to Bonfire. This project would include:
        1. 138 kV substation at Bonfire
        2. One 138/69 kV Autotransformer
        3. 3.4 miles of 138 kV transmission line Bonfire – Plum

        The total cost of this project will be $15,880,000.00

B) After learning about the cost associated with upgrading the reliability of substation at Bonfire, company A determined internally that the existing transmission system would provide sufficient reliability to their new facility. However, within the utility there have been talks about replacing the Web 138/69 autotransformer. Study the effects that an autotransformer replacement project would have on the company A's potential load by simulating an outage of the Web autotransformer. **Add the prospective customer's load to Bonfire 69kV substation, and take the 138/69 kV autotransformer out of service at Web substation** in anticipation of an autotransformer replacement project

- Can a redispatch of system generation mitigate any issues seen? Explain.

10

    i. In order to bring the overloads seen on the Kyle – Web 69 kV line and the Kyle 138/69 Autotransformer to acceptable system levels (95% loading on any line) redispatch:

        1. Kyle 138 kV Generation down to ~130 MW
        2. Kyle 69 kV Generator down to ~20 MW
        3. Web69 kV Generator Up to ~60 MW
        4. Rellis 138 kV Generator Up to ~60 MW
        5. Spirit 69kV Generator Down to ~80 MW
        6. Rudder 69kV Generator Up to ~40 MW

        NOTE: Redispatch can very

- Can the utility serve the new customer at Bonfire without any transmission upgrades? 10

    i. No, the loss of Web 138/69 kV auto drives overloads, and low voltage issues. A redispatch of local generation will mitigate the overloads; however the new load at Bonfire will create low voltage issue that will require a transmission upgrade.

- Explain what (if any) cost effective system upgrades will be needed to serve Company A's load. 10

    i. After redispatching local generation; to mitigate the low voltage issue seen at Bonfire: either add a new line to Bonfire, or add cap bank at Bonfire. **The most cost efficient solution will be to turn on the 30 MVar capbank at Fish 69 kV substation, and add a 40 Mvar Capbank at Bonfire.**