Impact of High Photo-Voltaic Penetration on Distribution Systems

PROJECT PLAN

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1 Introduction

1.1 PROJECT STATEMENT

The amount of solar generation is increasing rapidly in Iowa and the current systems are having problems (over-voltage, opposite direction power flow, possibility of islanding, etc.) keeping up with all the additions. In this project, we are trying to assess the impact of high penetration solar power generation on distribution feeders and its effects on the power quality delivered to the consumer.

1.2 PURPOSE

The purpose of this project is to use computer modeling systems to analyze the impacts of solar generation in the utility's distribution systems. This will be beneficial to the society because we will be able to find the adverse effects of high penetration solar generation before the implementation of the generation so the customers never see the problems. Also, this project will allow for more solar power on distribution systems while limiting the problems seen.

1.3 GOALS

We have several goals that we would like to achieve. Our goals are shown below.

- Run simulations on an Alliant owned distribution feeder to calculate the allowable PV generation that the feeder can handle before operating outside regulated parameters.
- Compare community PV generation and residential PV generation
- Find solutions that will prevent future problems relating to solar PV generation on the Alliant Energy systems

2 Deliverables

The deliverables necessary in this project are listed below.

- Voltage profiles and other necessary plots from simulations
- Comparison of residential and community solar PV generation
- Results of simulation with solar PV in certain areas
- Possible solutions for modifications to distribution system
- Cost Estimations

3 Design

We are using OpenDSS which is a program used to analyze distribution systems. It can return many different points of information: graphs, time series, voltage profiles, the magnitude and phase of voltages and currents at any given bus, and more. We will be running the files provided for us and then collecting different

3.1 PREVIOUS WORK/LITERATURE

We have been using the OpenDSS user manual that can be found at http://smartgrid.epri.com/SimulationTool.aspx. It is an open source program.

We are also using the book Distribution System Modeling and Analysis to help us better understand how the data we get from the computer is computed by hand so that we know whether our data makes sense.

Kersting, William H. Distribution System Modeling and Analysis. Boca Raton: Taylor & Francis, 2012. Print.

3.2 PROPOSED SYSTEM BLOCK DIAGRAM

Everything we do will be done with the OpenDSS software. Our project goals will be to first get a better understanding of OpenDSS by running different IEEE test cases, getting data, and analyzing that data. Once we understand everything that is being output by the simulation, then we will move into modifying the simulations.

When modifying the simulations, we will be adding community and residential solar to see how that addition will affect the stability of the distribution system we are testing.

After we are experienced with all the test systems, we will be provided a system from Alliant Energy that we will test in multiple different scenarios to see how solar will impact their current distribution system, and see if any changes need to be made to make sure that the system can handle the solar penetration.

3.3 ASSESSMENT OF PROPOSED METHODS

We do not currently have the flexibility of other options. We must stick to our plan as we need to report specific information to our adviser each week.

3.4 VALIDATION

In the short term, our results will be confirmed in our weekly meetings with our professor and graduate assistant. We will go through and discuss everything that we did the past week.

In the long run, we will be providing possible solutions to Alliant, and giving them the technical data that we calculated. We will want to review this with our professor before we send it off to make sure he agrees with the data.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

- Analyze IEEE distribution systems.
    - Load profiles
    - Voltage magnitudes and angles
    - Voltage violations at busses
- Add Solar PV to the distribution models
    - Compare the load profiles to those from the base case
    - Compare the power flows to the base case
- Analyze the Alliant Energy bus system provided
    - Load profiles
    - Compare those when solar is added
- Determine what modifications need to be made to the current Alliant system for it to be feasible to add solar

4.2 NON-FUNCTIONAL

- Can the current Alliant system support high solar penetration as it exists now?
- How much would modifications cost to the current system?

5 Challenges

The organization and representation of simulation data presents the need for outside code to acquire, format, and display data from OpenDSS in another program such as Excel or Matlab. Learning how to write code to communicate between the programs is useful for when we must export large amounts of data to be combined and organized to present to our adviser.

No one in our group had used the OpenDSS software before starting this senior design project. This puts the group in the position to have to learn the software at a swift pace to perform the assignments that are given to us by our adviser on a weekly basis.

6 Timeline

6.1 FIRST SEMESTER

Assign different roles to group members and learn how to operate OpenDSS software.

Write out hand calculation for the IEEE 4-bus system and run OpenDSS simulation and compare results.

Simulate 34-bus system in OpenDSS and provide plots of the voltage profile at certain busses in the system. We also need to change the load to a different value to show the effects on the system.

Analyze voltage profiles and distinguish why the voltage at certain points in the system is out of bounds and how to fix that issue.

Research voltage regulators, capacitors, reactors and find out cost of installation at certain points in the distribution system.

Research adding community and residential solar PV into the system to see the effects it has on the entire system.

Simulate Solar PV at 5 various locations in the 34 Bus test system under 20% thru 100% of a load profile to see where there are voltage violations and how the Solar PV affects the system.

Record the number of tap changes and bus violations after Solar PV has been added and choose 10 new locations for concentrated Solar PV.

End of Semester – Finalize simulation of IEEE test system and figure out if we will use a new distribution system for the project or if we will continue to use Alliant Energy system. Give presentation of our work thus far on the project.

6.2 SECOND SEMESTER

Begin our work by researching the various types of Solar PV, residential and community, and how they would fit in with the Alliant Energy distribution system.

Perform cost analysis on the various outcomes of Solar PV penetration at predetermined locations in the test system to see if there is a need for adding voltage regulators or capacitor banks in the system to keep voltage violations at a minimum.

Finish project and submit our work to Alliant Energy after it is approved by our adviser. Give final presentation of our project during dead week.

7 Conclusions

Work with OpenDSS software to simulate different scenarios on the IEEE test systems as well as the Alliant Energy system.

Figure out what the best solution would be with regards to installing voltage regulators at certain points in the system.

Analyze data from both systems to figure out what solution would work the best with regards to the compensating any issues with solar PV penetration in the system.

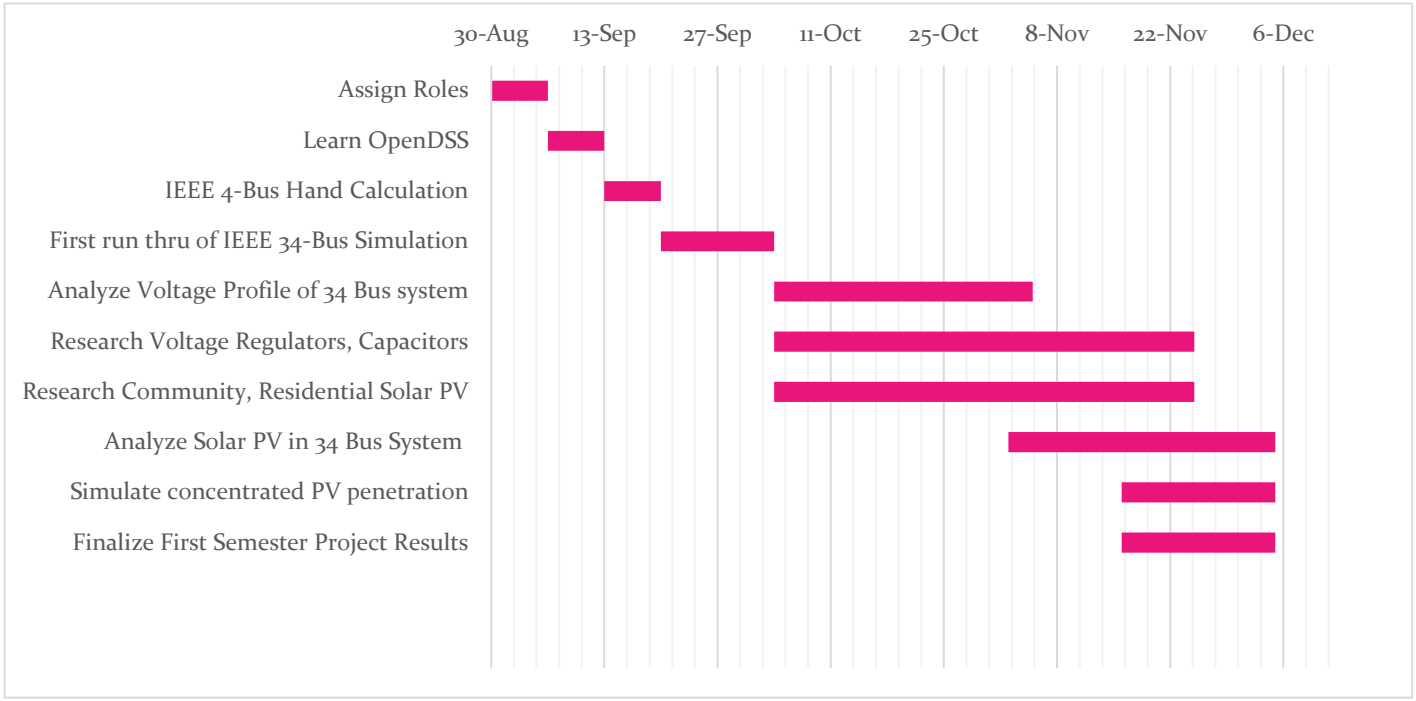
8 References

"EPRI | Simulation Tool – OpenDSS." *EPRI | Simulation Tool – OpenDSS*, Electric Power Research Institute, Inc., 1 Jan. 2011, smartgrid.epri.com/SimulationTool.aspx.

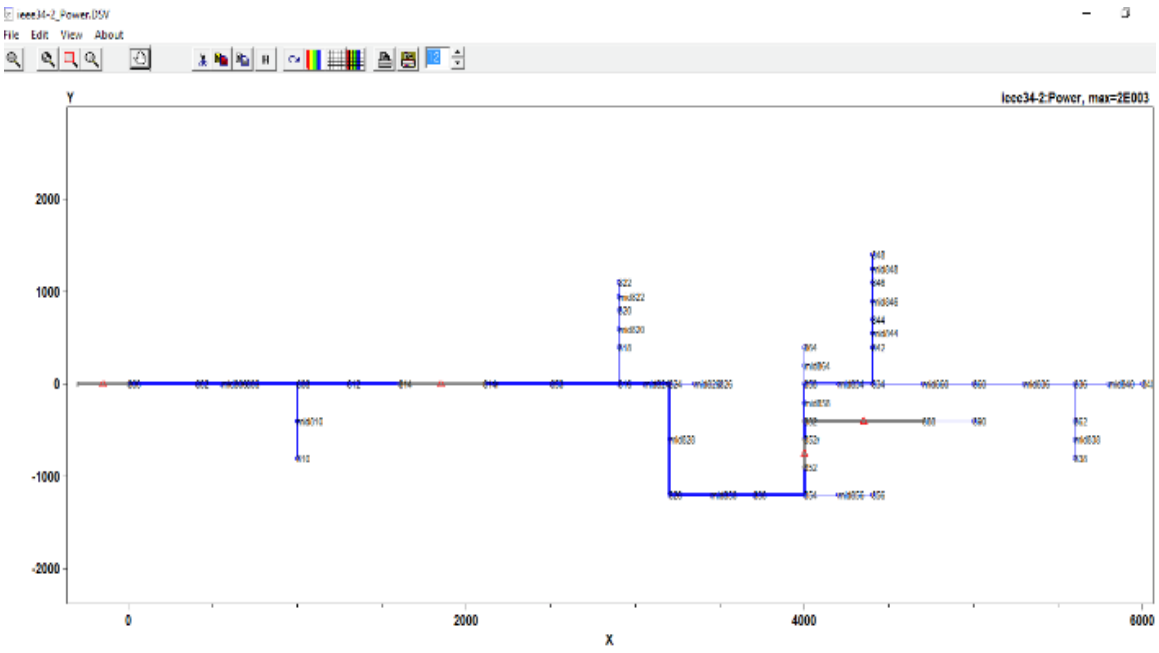
Kersting, William H. Distribution System Modeling and Analysis. Boca Raton: Taylor & Francis, 2012. Print.

Singhal, Ankit, and Venkataramana Ajjarapu. "Impact Assessment and Sensitivity Analysis of Distribution Systems with DG." *2015 North American Power Symposium (NAPS)*, 23 Nov. 2015, *IEEE*, doi:10.1109/naps.2015.7335218.

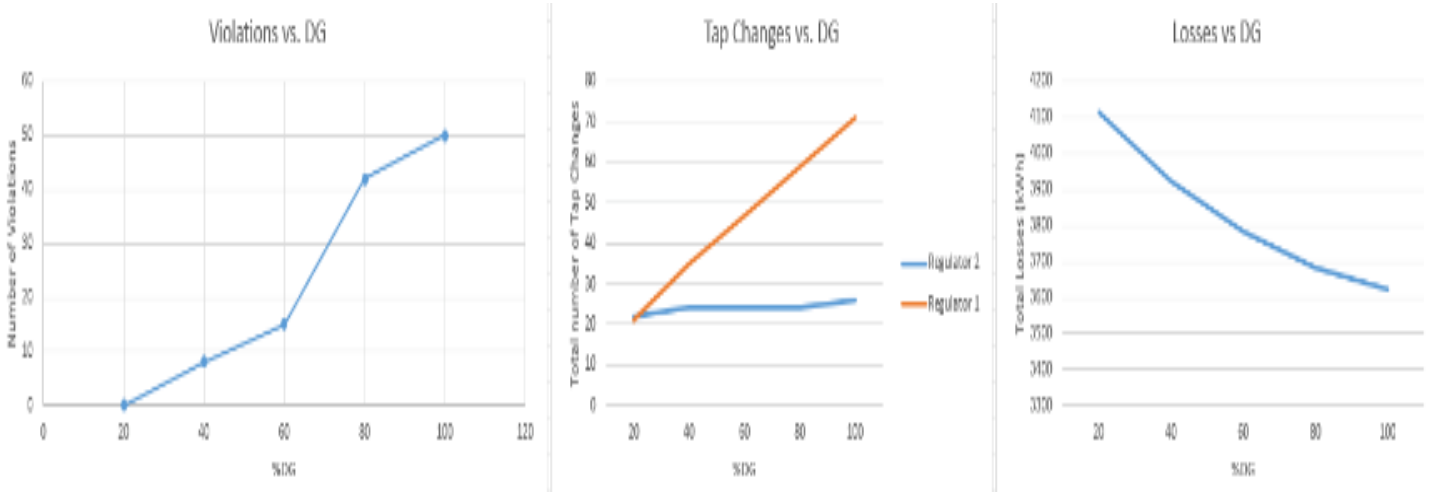
9 Appendices



First Semester Gantt Chart



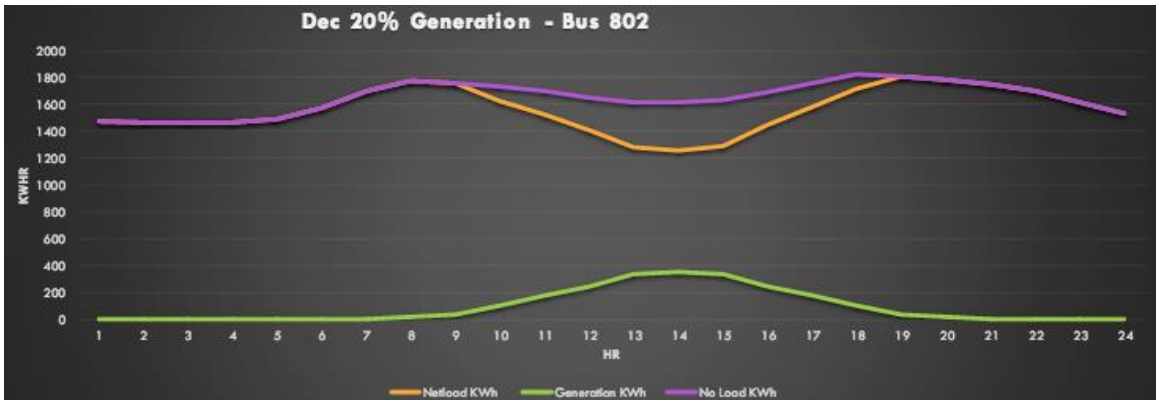
34 Bus system

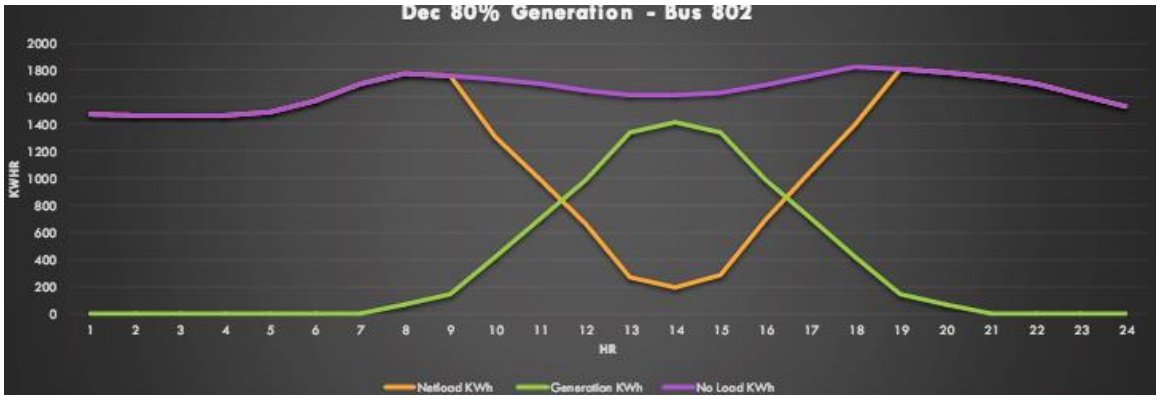


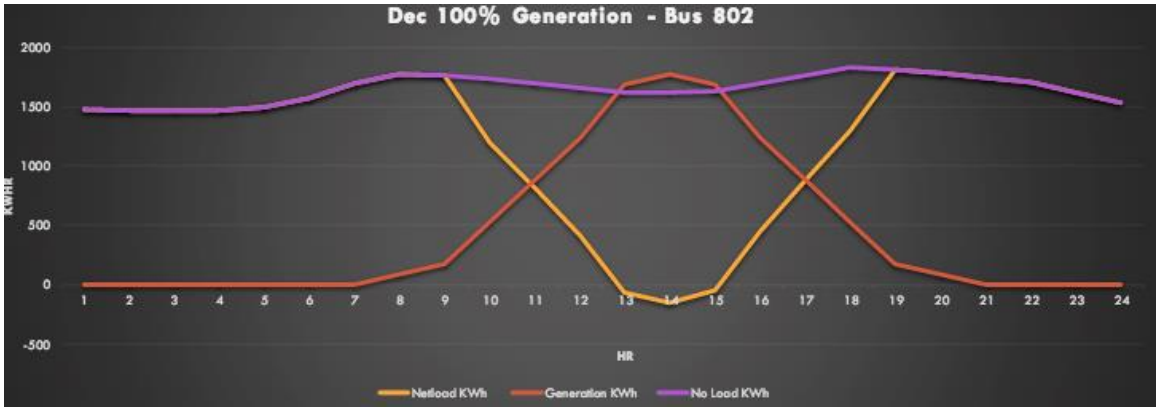
Violations and Tap Changes data for comparison between months

Exceptions	Total Reg1 Changes	Total Reg2 Changes	"Load Losses kWh"	Month	Bus
15	21	20	4336.215347	June	802
29	23	24	4124.216482	June	808
42	53	26	3719.381905	June	814
42	61	24	3729.570168	June	816
42	61	24	3732.125987	June	850
44	59	38	3483.985236	June	854
42	59	24	3683.910927	June	mid824
42	59	26	3641.48868	June	mid828
44	63	68	3215.67679	June	mid834
44	63	68	3217.72118	June	mid836

Data for June after Solar PV addition







Analysis with solar PV added to the system at different loads