Power System Reliability in the Midwest for High Wind/Solar Levels

DESIGN DOCUMENT

May19-24

MISO

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Revised: October 12, 2018

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List of Definitions

MISO: Midcontinent Independent System Operator

Renewable Energy: Energy produced by renewables sources such as wind and solar.

NERC: North American Electric Reliability Corporation.

ELCC: effective load carrying capability

LOLE: loss of load expectation

Net Load: The difference between the gross load and renewable generation

DG: Distributed generation

UPV: Utility scale solar Photovoltaic

Capacity Factor: Ratio of actual energy production in a year divided over the total energy production in a year

Capacity Credit: Ratio of average energy production during peak net load conditions over the installed capacity

Balancing authority (BA): Combination of buses

1 Introduction

1.1 Acknowledgement

Special thanks to:

<u>MISO Team:</u> *James O., Armando F., and Brandon H.*

<u>Iowa State Faculty:</u> *Dr. McCalley, Dr. Zambreno*

1.2 Problem and Project Statement

Renewable energy generation is currently the fastest growing source of energy in the US. Coupled with the retirement of older generation plants, there are many unanswered questions relating to the impact of these changes on the US power grid.

The North American Electric Reliability Corporation requires studies done by the electric grid operators such as MISO to do analysis on resource adequacy, otherwise known as the balance in energy generation and demand. The goal of this project is to do this analysis for increasing renewable levels in the energy grid. We will be primarily using software for our mathematical analysis. We will also be developing models to accurately reflect this increase in renewable generation to run this analysis on.

1.3 Operational Environment

At the end of our senior design project, we will give to MISO important data that can be used to help utilities make decisions based on what is best for both themselves and the entire Eastern Interconnection. We will also create a simple software to automate the ELCC calculation and save the company countless hours of guess and check work.

1.4 Intended Users and Uses

The data gathered here will be reported directly to MISO. The results will be encompassed into the already extensive analysis done within MISO's Renewable Integration Impact Assessment (RIIA). The data finalized by MISO within RIIA is made public, and accessible by anyone seeking the information. This can include anyone from the public, to MISO Stakeholders with which this study directly impacts.

1.5 Assumptions and Limitations

This project will be done with many assumptions. The most important being the assumption of a future with 50/50 solar/wind renewable energy. After we complete this task, we will assume 75/25 solar wind respectively. MISO energy has already done a study for 25/75 solar/wind respectively, and we are filling in the other potentials that could happen in the future.

Our largest limitation is time. Because of the nature of the project, an unlimited amount of time could be used to study the effects of an infinite number of futures that could happen. Because we don't have unlimited time, we must think clearly about what are the several extreme scenarios for futures that will give us the best idea of what could happen. If we study high level, low level and medium level renewables, then we will have the ability to assume the values between those extremes.

(This project will be done with many assumptions / simplifications / specific limitations, so this will be filled in as we continue on in the development)

2.6 Expected End Product and Deliverables

For each new renewable level studied, an effective load carrying capability (ELCC) of wind and solar will be produced, along with documentation of our assumptions and description of how the new renewables were sited.

Weekly reports with detailed group development.

All codes and scripts will also be delivered to MISO.

One final report encompassing our findings and conclusions, along with a presentation to be given on our findings.

(WIP, section will continue to expand as we add more processes into our development)

2. Specifications and Analysis

2.1 Proposed Design

Renewable energy is the fastest growing type of energy in the United States right now. Our project must answer questions that will highlight where problems will arise in the future due to added renewables. We must plan our design around "one event in ten years", or in other words, only losing load one day in ten years due to lack of generation. Our solution is to create a model in a software called PLEXOS. This model contains generation and load data of the Eastern Interconnection. PLEXOS will allow us to run studies on the data such as Effective Load Carrying Capability (ELCC) of wind and solar energy. We are going to use data to site where new wind and solar plants would best be placed. When we add in the new generation, we will run the model and adjust our generations accordingly.

Alternatives to our model could be to use a different software. However, if we were to decide this, we would have to re-learn and re-create the new model from scratch. The model is already built, so we believe that this will be the best to stick with what is already there.

2.2 Design Analysis

As of this writing, we have worked on analyzing data. This has allowed us to create relative heat maps of areas well-suited for our future siting of future renewable generation plants. We have just started creating criteria for these siting locations, and will be using this for ranking locations to place new generation locations. As of this writing we have just started on the data analysis, and in the future will need to analyze models created after this step.

Analysis so far has shown us how renewables behave with respect to the time of day/year. We can see through this analysis how renewables act at times of peak load. This will give us insight when planning for the future to the kind of problems that may show up on the grid with higher levels of renewables, and how we can go about solving those problems.

Since the grid we're running tests on is a simplified model, we can't count on our final outcome to be a precise prediction for the future. However, because of the simplicity of the model, we can quickly and easily make predictions for multiple futures.

3 Testing and Implementation

3.1 Interface Specifications

This project is dependent on a few pieces of software to organize, and analyze the data gathered during testing of our renewable models. These include Microsoft Excel, PLEXOS, and eventually Python. Excel is used for data aggregation and mapping. Excel is a well-known and common platform, making it very valuable for data sharing and calculation. PLEXOS will be used for analyzing our created models. This is very important to validate our siting assumptions. Finally, Python will be utilized towards the end of our phases. Python will be used to automate the data processing for PLEXOS input and output.

3.2 Hardware and software

Testing our model is very important to check the reliability of the study as a whole. To do this, we will graph as much of the data as we can to perform "sanity checks". Heat maps and a software called Kaleidoscope will be used to check that our data is in the correct locations.

3.3 Functional Testing

We will run our models through PLEXOS, which will analyze the given data, and produce data from an economically-optimized and functional system. If any contradictions in our input data show up, or if the system we created is infeasible, PLEXOS will catch that. We can also use Kaleidoscope to perform the previously mentioned sanity checks on the data to make sure our system is behaving correctly.

3.4 Non-Functional Testing

Once we're sure that our model is running correctly, we'll want to look at the data that is being produced and analyze it. This would involve making sure that the generation produced matches the load that MISO must carry under each level of renewable penetration. We would use the output data to calculate the ELCC, and if the ELCC is too small, we would enter new data and then re-calculate.

Quick note here, the ELCC (expected load carrying capability) is typically quite a bit higher than the actual load. A system could still be feasible with a low ELCC, just not necessarily reliable.

3.5 Process

As you can see in the figure below, testing will begin with the processes of performing various calculations, such as capacity factor and capacity credit per site, using excel. Additionally, we will be using excel to create heat maps to help us better visualize what is going on with the wind and solar data. In terms of siting, there is no real way to test the sites we choose. We do have certain criteria, such as generation requirements, we will have to consider when we site the renewables. The next round of testing will come when we receive the PLEXOS software. We will begin putting in different sets of data and calculating the LOLE, trying to get it as close to a one day in ten-year event as possible. After this, we will then write some program in python to calculate the ELCC.

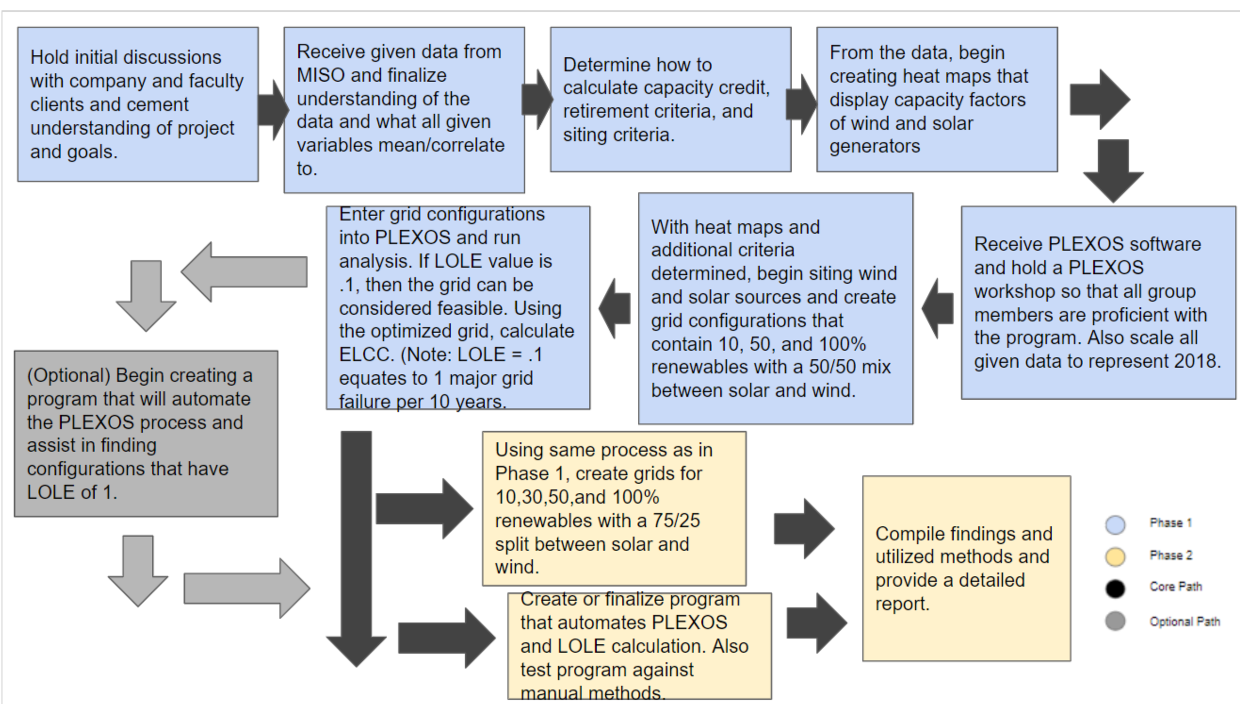

Figure 2: Flow diagram of process

3.6 Results

(Section will be filled out as testing starts)

Results so far: capacity factor and capacity credit calculations, capacity factor heat maps

Failures: First round of capacity credit failed as we took the wrong time frame into respect.

Successes: Yearly average capacity factors were correct and well received by MISO

We have learned how to better utilize excel.

We have not gotten to modeling quite yet, as we still need the PLEXOS software to do so. However, our created heat maps are, in a way, a form of modeling that we have done so far.

Implementation issues and challenges: not yet applicable?

4 Closing Material

4.1 Conclusion

With renewable resources being the fastest growing energy resource in the US, and many older generation units retiring, there is an uncertainty on what the grid of the future will look and behave like. In recent years the conversation on understanding these changes has been rapidly changing and beginning to dive into the specificities of topics.

Our project aims to be a part of that conversation, by expanding the knowledge on resource adequacy of our energy grid for varying levels of Renewable integration.

This will be done by closely working with MISO and advisors at Iowa state. We will be developing and carrying out a model building process. These models will be the estimated future grid of the Midwest, including new levels of Renewable mixes. With these we will be able to directly study the impact the changes have by utilizing PLEXOS to understand the LOLE and ELCC of the additional renewables. This project plan lays out the steps we intend to follow to help grow the understanding of future changes on our energy grid.

4.2 References

- Capacity Value of Wind Power, *IEEE Transactions on Power Systems*
- Maintaining Reliability in the Modern Power System, *U.S. Department of Energy*
- Planning Year 2017-2018 Wind Capacity Credit, *MISO*
- Potential Capacity Contribution of Renewables at Higher Penetration Levels on MISO System, *Brandon Heath and Armando L. Figueroa-Acevedo from MISO*

4.3 Appendices

We may have items for this section as the semester progresses.