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

PROJECT PLAN

May19-24

MISO
Dr. James McCalley
Shannon Foley – *Lead Project Manager, Co-Project Trainer*
Zaran Claes – *Lead of Communications, Co-Project Trainer*
David Ticknor – *Lead of Automation Design, Asst. Power Systems Economic Analyst*
Matthew Huebsch – *Lead of Organization and Reporting, Asst. PLEXOS Modeler*
Ian Rostkowski – *Lead Power Systems Economic Analyst, Co-PLEXOS Modeler*
Shelby Pickering – *Lead Data Analyst, Co-PLEXOS Modeler*

zclaes@iastate.edu
http://sdmay19-24.sd.ece.iastate.edu/

Revised: September 28, 2018
Version 1

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MISO: Midcontinent Independent System Operator

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

NERC: North American Electric Reliability Corporation.

1 Introductory Material

1.1 Acknowledgement

Special thanks to:

MISO Team: *James O., Armando F., and Brandon H.*

Iowa State Faculty: *Dr. McCalley, Dr. Zambreno*

1.2 Problem Statement

Renewable energy generation is currently the fastest growing source of energy in the US, especially in the Midwest. 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 Operating Environment

(Unsure what to put here as we are just doing software-based analysis and not creating something physical)

1.4 Intended Users and Intended 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 / simplifications / specific limitations, so this will be filled in as we continue on in the development)

1.6 Expected End Product and Other Deliverables

For each new renewable level studied, an effective load carrying capability 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 Proposed Approach and Statement of Work

2.1 Objective of the Task

There are several end goals that we are trying to achieve with this project. The main objective is to analyze the effect of the increase of renewable energy resources, such as wind and solar, into the MISO system on the loss of load expectation (LOLE) target. We will do this for different levels of renewable penetration so we can get a solid understanding of how it will affect the LOLE.

One sub-goal that will go along with this project is learning new software such as PLEXOS, kaleidoscope, and management software. Additionally, at the conclusion of the study, we will try to write and publish an official paper summarizing our findings. This is something both us as a team and MISO would like to see done, this way we learn how to write a document summarizing a study as well as be able to use this for future hiring.

2.2 Functional Requirements

QUESTION FOR ZAMBRENO: Since we are being given data and are utilizing different software to evaluate the data for different cases, our group is wondering what our functional requirements might consist of? Is this where we list requirements that MISO wants us to get out of this study?

2.3 Constraints Considerations

- Learn project management – MISO is asking us to pick some management software to use for this project. This is an opportunity for us to learn something new and have that in our pocket for future jobs/projects.

- Learn how to write a paper summarizing our study – MISO would like to see a professional paper at the end of this project to explain our study (what we did, how we did it, and the results).
- North Electric Reliability Council (NERC) - we are required to do this study for resource adequacy analysis per NERC
- Ethical issues should not come into play here.

2.4 Previous Work and Literature

MISO and Dr. McCalley gave us several documents showing examples of similar studied previously done as well as general literature about the topic for us to read, review, and use as reference. Although the previous studies may have been similar, they are not in any way the same. This is why MISO is having us do this project, because it is a very real study that they need done for their system. Listed below are the documents that were provided.

- 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*

2.5 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 cite 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.

2.6 Technology Considerations

There are many types of software that exists to analyze the data that we are trying to look at. PLEXOS is the best choice because it is one of the few programs that is free to students and has a GUI. PLEXOS is used in the industry to make decisions about the power grid. Learning PLEXOS is a useful skill for after college. A draw-back to PLEXOS is that the software can be difficult to learn, but a big benefit is that it comes with a detailed guide on how to use it.

2.7 Safety Considerations

This project is going to be completed only using the computer. No physical items will be built. Our project builds a computer model and analyzes it to gain data. There are inherent risks to working on the computer and they are not to be taken lightly. A simple internet search reveals that computer related injuries are growing globally. Risks include but are not limited to: posture related injuries from prolonged sitting, hand strain from typing, eye strain from looking at a close screen for long periods of time, and shoulder pain from improper keyboard height. Preventative measures will include: regular breaks to stand and walk around, looking away from the computer, and proper seating. If any of these injuries occur during the project, we will have the affected party contact a doctor for further information.

2.8 Task Approach

Describe any possible methods and/or solutions for approaching the project at hand. You may want to include diagrams such as flowcharts to, block diagrams, or other types to visualize these concepts.

2.9 Possible Risks And Risk Management

We have to gain access to PLEXOS by submitting various forms and information. Doing any of the parts of the project that require the use of PLEXOS will be stalled by this waiting process. Once we have access however, the only thing that could possibly slow our work down would be classwork. Tests, homework, and final projects may tie up the hands of some team members during certain weeks, causing the whole project to slow down slightly.

It's also possible that once we start working with data, we'll enter a wrong number here and there. These errors are hard to check for in excel files, but we'll be working with a software called kaleidoscope to map out the data, which will let us run sanity checks.

2.10 Project Proposed Milestones and Evaluation Criteria

After we retrieve all the data we'll be using, we need to come up with the necessary changes to the data for each level of penetration. This will involve deciding the amount of each type of generation needed at each point in the MISO bubble. As a team we'll come up with a viable data set, and then run it by the policy studies team to make sure everything checks out. We hope to have this done sometime this semester, preferably near the middle.

After the last task is completed, we want to have data for ELCC under different penetration levels for renewables. We want data for 10%, 30%, 50%, and 100% levels of penetration. We hope to have all this data collected by the end of this semester.

2.11 Project Tracking Procedures

Our team will meet via web-ex with the policy studies team and Dr. McCalley on a weekly or bi-weekly basis to catch everyone up on what we've been doing, and what kind of progress MISO hopes to see from us in the next coming weeks.

We'll also be using some sort of project management tool to divide up/keep track of the work that people will be doing. We'll be following a tentative schedule provided to us by the MISO team to make sure that we're staying up to date with our work and staying on schedule.

2.12 Expected Results and Validation

By the end of the study, we hope to discover what changes will have to be made to the grid, and what the cost will be if we intend to add more generation from renewable sources. Under each level of penetration, we should hope to have a grid design with the increased renewables, a calculation for ELCC, and an associated monetary cost.

2.13 Test Plan

For each case we will be studying, we will be using PLEXOS and kaleidoscope in order to analyze/test the different cases.

Different cases include:

- Different penetration levels of renewables (wind and solar), e.g. 10%, 20%, etc.
- Different mixes of wind and solar, e.g. 50/50 mix, 30/80 mix, 80/30 mix, etc.
- Different siting locations

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

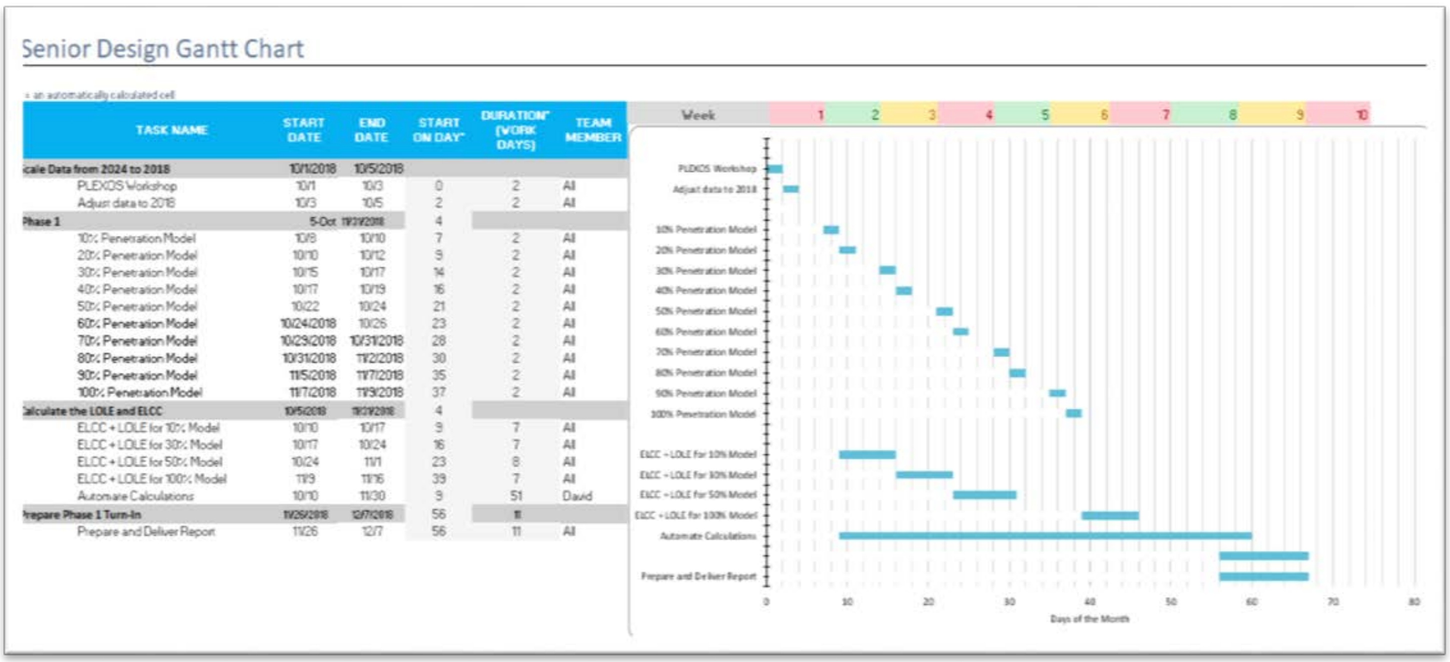
– Start with a Gantt chart showing the tasks and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Completely compatible with Agile development cycle if that's your thing

How would you plan for the project to be completed in two semesters? Represent with appropriate charts and tables or other means.

Make sure to include at least a couple paragraphs discussing the timeline and why it is being proposed. Include details that distinguish between design details for present project version and later stages of project.



Senior Design Gantt Chart

= an automatically calculated cell

TASK NAME	START DATE	END DATE	START ON DAY*	DURATION* (WORK DAYS)	TEAM MEMBER
cale Data from 2024 to 2018	10/1/2018	10/5/2018			
PLEXOS Workshop	10/1	10/3	0	2	All
Adjust data to 2018	10/3	10/5	2	2	All
Phase 1	5-Oct	[illegible]	4		
10% Penetration Model	10/8	10/10	7	2	All
20% Penetration Model	10/10	10/12	9	2	All
30% Penetration Model	10/15	10/17	14	2	All
40% Penetration Model	10/17	10/19	16	2	All
50% Penetration Model	10/22	10/24	21	2	All
60% Penetration Model	10/24/2018	10/26	23	2	All
70% Penetration Model	10/29/2018	10/31/2018	28	2	All
80% Penetration Model	10/31/2018	11/2/2018	30	2	All
90% Penetration Model	11/5/2018	11/7/2018	35	2	All
100% Penetration Model	11/7/2018	11/9/2018	37	2	All
Calculate the LOLE and ELCC	10/5/2018	[illegible]	4		
ELCC + LOLE for 10% Model	10/10	10/17	9	7	All
ELCC + LOLE for 30% Model	10/17	10/24	16	7	All
ELCC + LOLE for 50% Model	10/24	11/1	23	8	All
ELCC + LOLE for 100% Model	11/9	11/16	39	7	All
Automate Calculations	10/10	11/30	9	51	David
repare Phase 1 Turn-In	[illegible]	12/7/2018	56	11	
Prepare and Deliver Report	11/26	12/7	56	11	All

Fig 1.

Due to the nature of this project, the team will be repeating the same task of citing generations sources, constructing the grid in PLEXOS, and then analyzing the data. This will be done 10 times throughout Phase 1 of the project for varying renewable penetration levels. Assuming the Team Receives access to the required data and programs by October 1st, the proposed plan above gives the group 1 week to become accustomed to the program and adjust given data for a 2024 power grid to what would be considered correct for a modern 2018 grid.

Afterwards, the group only has 7 weeks to work on the project (assuming no work will be done the week of Thanksgiving Break, Dead-Week, and Finals Week). This gives the group 3.5 days for each grid. This plan is ambitious in that it gives 3 days to start and finish a single grid project and it assumes no work on weekends. The reasoning for this is to set goals for the team to complete the individual grids quickly and to allow some leeway if one grid project takes a bit longer than another.

Certain penetration levels also require an ELCC and LOLE calculation to be made with them. After the data has been created by PLEXOS, this plan gives the group 1 week to make these calculations after the required data has been created. The Automation Design Lead, David Ticknor, will also be working to automate these calculations. The hope is that the calculations will be automated as soon as possible, but if it takes longer than expected, then the group may have to make due. The major goal is to at least have automation in place before Phase 2 of the project come the spring semester.

Provided this schedule can be held to a reasonable degree, the individual grids and their associated calculations will be created and automated before Dead-Week and the team will then have a reasonable amount of time to prepare a final report on the findings of the project without interfering with preparation or finals.

3.2 Feasibility Assessment

In order to increase chances of a high-quality final product, the project has been split up into two sections: Phase 1 and Phase 2, each of which will have a specified turn-in at the end.

The purpose of Phase 1 is to allow group members a chance to familiarize themselves with the vocabulary that is intrinsic of this type of project as well as the various software programs that need to be utilized. The final turn-in for Phase 1 will be a collection of 10 grids, starting with 10% renewable penetration and increasing by 10% with each subsequent attempt up to 100%. This will take about a month. With base assumptions in mind, the ELCC for the given combination of wind and solar will also be calculated for the 10%, 30%, 50% ad 100% grids. For Phase 1, the mix of wind and solar in the grid will always be 50/50. During Phase 1, the group will also attempt to automate the ELCC and LOLE calculations. The calculation of the ELCC values and automation of their calculations should also take about a month.

By Phase 2, the group will hopefully have a deeper understanding of how to utilize the program, how to optimize renewable sources being added to the grid, and have automated programs to assist with needed calculations. With these assets, the group will repeat the same grid construction process used in Phase 1 for penetration levels of 10%, 20%, 30%, 40%, 50% and 100%., However, the 50/50 split between wind and solar will be removed. Instead, it will be up to the group to determine what mixture of renewables will better service the grid at each increment and determine the correct siting and capacity additions needed to make the grid serviceable at each increment. Just like in Phase 1, the ELCC and

LOLE will be calculated. Additionally, Phase 2 will require group members to calculate the cost implication of changing the ELCC.

The final turn in will be a finalized report containing the data gathered from Phases 1 and 2, as well as the group's conclusions regarding the siting and capacity additions made and which configuration of siting and penetration level is currently best.

Major challenges that will be encountered in this project stem from the fact that some group members do not have the industry experience that the other group members do. Therefore, a portion of time needs to be carved out to allow the less experienced group members to acquaint themselves with some of the given software and common vocabulary used in this project. To remedy this, the first 4 weeks of the project will be split up into 2 learning periods where the group will focus on the vocabulary and important topics associated with the project and the second term will focus on working with the required software.

3.3 Personnel Effort Requirements

The hope for this project is that all group members will be able to work on the main project to some degree. Some group members have positions that require them to handle things for the group that do not directly relate to working with PLEXOS or calculating ELCC or LOLE values, while others do. As a result, the latter mentioned group members may put more effort towards the main project and constructing the varying penetration level grids than those who are expected to lead other group members or work on needed side-projects such as automation.

With this in mid, each group member is still required to put their best effort towards their given tasks and to assist the rest of the group in ensuring the project is completed in an efficient and timely manner. If a group member is unable to complete their work, or productivity begins to slow down, group members may have to take over rolls for others or put in more time when needed to stay on course. This will hopefully be a last resort measure, as the purpose for splitting up work among the group members and assigning lead roles that correlate to each individual's interests and strengths is to avoid unnecessary drops in productivity.

3.4 Other Resource Requirements

Required resources include:

-PLEXOS software for modeling and running calculations on grid configurations

-Associated data for PLEXOS including siting and generation data for a 2024 model that will be scaled back to represent 2018 data.

-Open source NREL data regarding weather patterns for predicating solar and wind generation

-CyBox collaboration platform for working on documentation

-R-Studio & Kaleidescope for creating locational maps of the Eastern Interconnection

3.5 Financial Requirements

There are no financial necessities for this project. All assets used are either open-source programs or were given to the group at no expense.

4 Closure Materials

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

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.

– Any additional information that would be helpful to the evaluation of the project plan or should be a part of the project record shall be included in the form of appendices

– Examples of project documentation that might be included are property plat layouts or microprocessor specification sheets germane to the proposed project.