New Simulation Methods to More Effectively Integrate High Levels of Renewable Energy Resources

DESIGN DOCUMENT

Team Number 21
MISO
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Executive Summary

Development Standards & Practices Used

We will be using the PEP 8 style guide for all python code.

Summary of Requirements

Phase 1:

• Develop a working method to effectively, efficiently, and accurately compress the 8760 -hour data profile

• Validate the developed method and demonstrate its effectiveness from a statistical perspective

Phase 2

• Simulate in actual production cost database using industry applications and real-world system data

• Automate the profile reduction process for use in industry applications

Applicable Courses from Iowa State University Curriculum

EE 458

New Skills/Knowledge acquired that was not taught in courses

Experience in coding with the Python Language

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List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Acknowledgement

We would like to thank James Okullo, Armando Figueroa-Acevedo, Yifan Li, David Severson, and Ryan Hay from the MISO team for their experience and insights.

We would also like to thank Dr. James McCalley for his helpful suggestions during our discussions.

1.2 Problem and Project Statement

MISO runs thousands of production cost simulations (year-long hour-by-hour simulations of the electric and economic performance of the MISO grid) every planning study cycle to investigate a host of topics including the efficacy of proposed transmission upgrades, the impact of federal policy, and the complexity of integrating large amounts of renewables to the system. These simulations, which model the entire Eastern Interconnect of the US power system, take large amounts of processing time due to high model dimension with a large number of load and generation profiles. The projected high growth of renewable penetration in the MISO footprint, and the resulting increase in modeling data, will only exasperate the situation.

To more efficiently and effectively integrate more renewable energy onto the grid, new modeling techniques are needed. The goal of this study is to, therefore, research and implement various methods to appropriately reduce the fidelity of the data profiles while maintaining an adequate amount of the key production cost information. The study will validate the methods' reliability and quantify the effects that profile approximation has on simulation runtime and results. It is expected that the properly designed profile reduction method would make the normal 8760 hours production cost simulation more efficient. The increased efficiency has the potential to enable us to explore more ways to improve our current planning study processes by introducing cutting edge research in academia and industry.

The project provides an excellent opportunity to engage with industry personnel employed by a uniquely positioned organization for the Midwestern US grid operation and planning.

1.3 Operational Environment

The final product of this project will be used by MISO engineers and modelers to assist in running simulations

1.4 Requirements

Our first and foremost requirement for this project is that the final approximated data will produce simulation results similar to un-approximated data in a faster time frame.

1.5 INTENDED USERS AND USES

Our intended user is a transmission engineer or modeler who plans to run production cost modeling simulations and needs the simulation to produce results faster without losing too much accuracy.

1.6 ASSUMPTIONS AND LIMITATIONS

Assumptions	Limitations
*No assumptions have been made yet. *	*No limitations have been found yet. *

1.7 EXPECTED END PRODUCT AND DELIVERABLES

Phase 1: (Fall 2019 – Spring 2020)

- Develop a working method to effectively, efficiently, and accurately compress the 8760 -hour data profile
- Validate the developed method and demonstrate its effectiveness from a statistical perspective

Phase 2: (Spring 2020)

- Simulate in actual production cost database using industry applications and real-world system data
- Automate the profile reduction process for use in industry applications

Phase 3: (Summer 2020)

- Beyond the ISU capstone project, MISO will independently validate the proposed methods.

Deliverables:

- Bi-weekly updates on the study status
- Phase 1 Report (end of Fall Semester)
- Conference paper (end of Spring Semester)

2 SPECIFICATIONS AND ANALYSIS

2.1 PROPOSED DESIGN

So far, the proposed plan to develop the code is as follows: each team member researches their own design. We each develop a basic python code in order to find representative days for the 8760 profile. Once done, we will convene and determine the best method proposed. We will then research this singular design further. Finally, code will be developed to automate this chosen method.

2.2 Design Analysis

So far, we have discussed many different attributes of the 8760 profile that we can base our code around. We are just beginning to develop Python code to test these different attribute theories.

2.3 Development Process

We currently use a lightweight model built on developing multiple approximation prototypes, testing them all at once, and comparing the results between each other and previous successful tests.

2.4 Design Plan

Our first step is to develop a tool for calculating different aspects of the data we determine to be relevant to our testing. Next, we will write software to determine representative data points based on these aspects. Finally, we will input this representative approximation into the PCM simulation software and compare the output with previous test results. Our process will be to refine which aspects are chosen to create the approximations and our final product will incorporate all these different steps.

3. Statement of Work

3.1 Previous Work and Literature

- **Background Information:** Literature we've reviewed was lectures and notes about Production Cost Modelling
- **Previous Work:** MISO has done previous work into this topic by looking at approximating hourly data by looking at the generation or load value of a profile at that time. Our work will expand on this work by trying approximated daily, weekly, and monthly data with many different aspects of the data being considered.

3.2 Technology Considerations

For the approximation tool we considered writing it in either R or Python. The two languages are very similar and offer about equal amounts of relevant functions in the form of libraries. Ultimately, we chose to write our tool in Python as more MISO employees are familiar in Python and would benefit from the ability to more easily read the code.

3.3 Task Decomposition

List of Tasks

1. Research and brainstorm to determine different aspects of the load/generation data that could be used to find approximations of profiles
2. Write a function that takes in a load/generation profile, computes relevant aspects of the data based on the time interval being considered, and outputs the data in a table.
3. Write a function that takes in a table of data with each column being a different aspect and a number of clusters, compute a number of representative clusters, and output this data in a form fit for input to our PCM tool.

4. Determine the aspects that are important in analyzing the data.
5. Run the PCM simulation with the approximated data and compare it to un-approximated data. Searching for similarities and differences that could refine the next approximation.
6. Develop UI for this tool that incorporates all the different steps of this process and gives the user options for how they want to approximate data

3.4 Possible Risks and Risk Management

The only major area that could hinder progress is our developing knowledge of Python and PCM software like Plexos.

3.5 Project Proposed Milestones and Evaluation Criteria

- Complete function to compute aspects of data profiles
  - Evaluated by reviewing code and possibly hand computing test samples
- Complete function that clusters data
  - Evaluated by reviewing code and trying simple, one-dimensional sample clusters
- Run multiple PCM simulations with different approximated data sets
  - Evaluated by comparing to results of un-approximated data set
- Complete UI
  - Evaluated by reviewing code and handing it off to MISO engineers to try and figure out.

3.6 Project Tracking Procedures

We currently have an excel sheet of all tasks to complete and who is most responsible for completing them

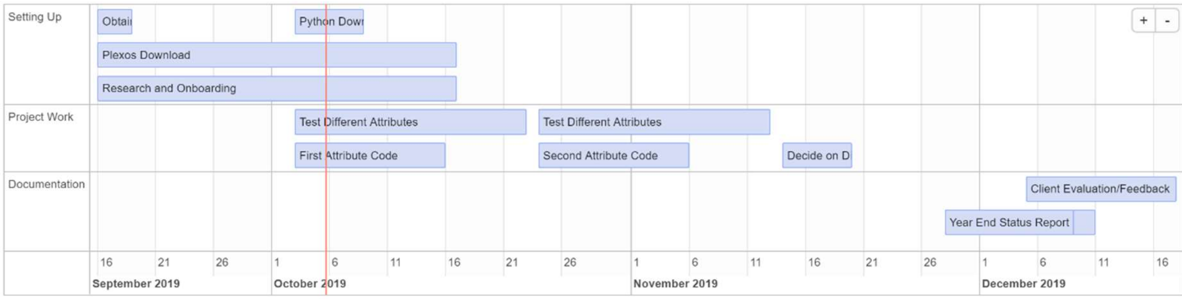
3.7 Expected Results and Validation

Our desired outcome is that our tool will approximate data quickly and this data will produce simulation results equivalent to the original data in less time.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

Rough bird-view schedule for the project below:



4.2 Feasibility Assessment

This project will be a test of many different aspects of data to find the best approximation of that data. This project will result in a tool that can approximate any data sets based on the most successful aspects but will allow the user to develop and test their own aspects.

4.3 Personnel Effort Requirements

Task	Time Requirement (group hours)	Reasoning
Task 1	10	An ongoing process that will take time to look at all the different angles of the data.
Task 2	30	Heavily dependent on developing group comprehension of Python and data manipulation.
Task 3	30	Heavily dependent on group comprehension of Python and clustering algorithms.
Task 4	100	Dependent on how many simulations we decide to perform and the simulation runtime.
Task 5	40	Dependent on ability and comprehension of programming GUIs in Python.

4.4 Other Resource Requirements

The only other resources needed are workstations (Python IDE) to develop code, copies or licenses of the PCM software Plexos, and virtual machines to run the PCM simulation tools.

4.5 Financial Requirements

No financial requirements are necessary.

5 Testing and Implementation

Testing will be needed for runtime and accuracy of the production cost model estimate. This will require running the Plexos program with the original data and then a second time with our modified inputs.

We will be looking at total runtime and the percent difference between the estimate's output and the normal output. Our runtime will be significantly shorter than the normal method, testing will show us if the time saved is satisfactory enough for MISO.

We will input many different test cases into the program to see how it reacts to the different data profiles.

There will also be testing for usability and universal understanding of the code.

Once testing has begun, this section will be updated to reflect our findings.

5.1 Interface Specifications

We will not be developing any interfacing techniques in this project. Our tool will interpret data profiles and output approximations in the same format.

5.2 Hardware and software

Software used in the test will include Python and a Python compiling software to be determined later, Plexos, and Excel. The code will be written in Python as this a widely used language and will be the easiest for MISO employees to learn. Moreover, Python is industry standard, and has a lot of accessible documentation online. Plexos will be used to run the production cost models with the new inputted data from our Python code. Excel is used for all data inputs. Each software is essential for our successful implementation of this new method.

5.3 Functional Testing

Functional testing will include but is not limited to: total computation time and accuracy of final estimate. The goal for the computation time is one business day (less than 8 hours with the goal being around 2 hours total). The final estimate needs to be accurate enough to provide the user with a reliable forecast before they run the non-estimated model.

5.4 Non-Functional Testing

We will also test for readability and usability. The code will be used by many different MISO employees and will need to be commented, clear, and concise. Once the code is developed, we will shorten it to the best of our ability.

5.5 Process

No processes yet as testing has not commenced yet. Will report back once the first wave of code testing has been completed.

5.6 Results

No results yet as testing has not commenced yet. Will report back once the first wave of code testing has been completed.

6. Closing Material

6.1 Conclusion

The work we have done so far includes but is not limited to: started the process to acquire Plexos, developed a list of attributes to test in the upcoming weeks, completed the onboarding process to fully understand the task at hand, and developed a plan for the rest of this semester as well as team roles and tasks for each member. Also, completed filling out license forms in the process of acquiring Plexos.The best way to complete our goals on time will be to stick to the schedule, adapt as needed, and seek advice from MISO and our advisor.

6.2 References

References will be made once all code production and testing has been finished.

6.3 Appendices

In future document versions, we will post the python files used as well as flowcharts that describe the process used in the code. Plexos files won't be useful because only a select few have the Plexos software.