GVEA Carbon Reduction Study Final Report

Alaska Center for Energy and Power, University of Alaska Fairbanks

Author: Christian Seekins

August 7, 2020

Introduction

Alaska imposes some of the most difficult challenges in the world for energy systems, such as extreme cold weather or traversing some of the most diverse terrain in the world. Addressing these challenges not only proves our human capabilities, but our willingness to do everything in our power to enjoy and experience one of the most beautiful regions in North America.

I, Christian Seekins, am a senior studying electrical/computer engineering with minors in applied business and mathematics. During the internship, I have been a member of the Alaska Center Energy (ACEP) and Power Carbon Reduction Study Team.

Purpose

CO2 reduction is garnering the largest attention it has seen in decades. The need and want to reduce carbon emissions, promote green energy and keep our power production stable has never been as important as it is now. ACEP is participating in these efforts alongside power producer Golden Valley Electric Association (GVEA). ACEP's Carbon Reduction Study, requested by GVEA, is studying various approaches, costs, and resources needed to reduce their company's rate of CO2 emissions by 26% in only 10 years.

Throughout the internship I researched, analyzed and modeled a diverse number of technologies that can potentially be utilized to reach the 10-year goal of CO2 reduction. I will primarily be looking into residential battery storage technology, along with electric vehicle (EV) storage technology that can be coupled with vehicle-to-grid technology. I am working with economist Dr. Steve Colt and electrical engineering faculty member Dr. Mohammad Kapourchali, providing feedback on technologies that will impact both the grid, and CO2 output altogether.

Methodology

Experiencing and observing the challenges in Alaska that utilities/energy projects face is truly a full learning adventure. As a part of the ACEP Carbon Reduction Study Team, I have observed the very limited ability to attack environmental impacts with energy providers such as a lack of data, and general challenges that come with the real-world operation of a utility including system reliability and rate control, including the programs used to solve these real-world problems.

When the team determined the appropriate route for our study, Professor Kapourchali and I began learning a new program that would allow us to simulate and run models for our team.

Matpower, a free, open-source matlab m-file ready package is the program we decided on. Matpower is designed for solving steady state power system simulation and optimization problems such as powerflow and optimal powerflow. GVEA's transmission lines (Figure 1), a vast Alaska network, presents the team with the general area we are analyzing. Additional documentation in the form of a one-line diagram was shared with the team as a classified, proprietary piece of information. Using a basic Matpower provided "template", I began analyzing GVEA's one-line transmission diagram provided by GVEA. The first step when analyzing the values on the diagram is to convert the values into per-unit values. We convert to per unit in order to generalize the data values into a single unit for ease of calculations. Once I had the values in pu form, I entered the available data into the matpower system sheet for each set of systems such as generator, branch, and bus data from GVEA. After entering the information into Matpower, we ran a powerflow function simulation, an autoset function that uses powerflow equations to determine the optimal voltages that our generators need to run at without overloading our system. Professor Mohammad and I needed to confirm that the data and program were functioning correctly before moving onto the next step of scenario simulating. Once we confirmed the simulation was running correctly we proceeded to run a series of scenarios through Matpower on GVEAs virtual grid. These scenarios ranged from adding additional power, loads, and variabilities to the system in order to view the effects that these additions would have on the system. We would like to run extra simulations with more precise data such as load data in the future in order to give an even more accurate analysis of the systems.

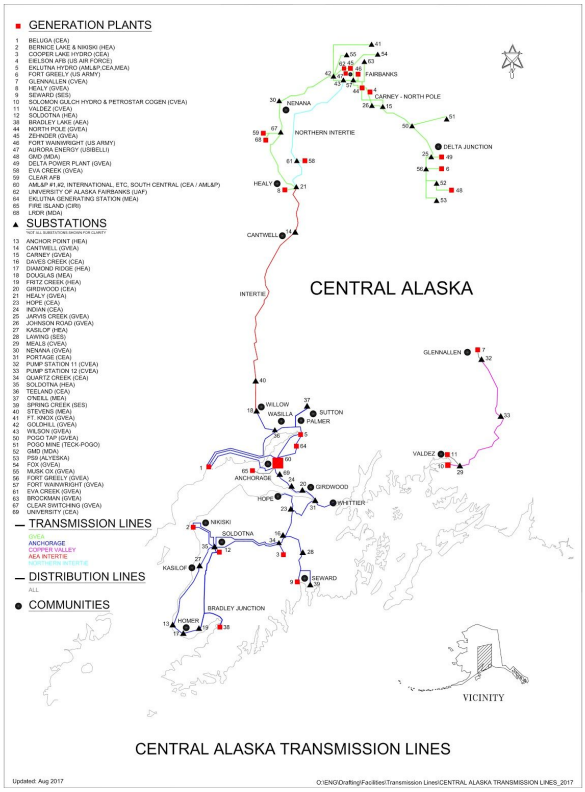

Figure 1: Central Alaska Transmission Lines

Results and Discussion

When I first joined the team, they were in the mist of setting up a public workshop to pitch the overall plan to reduce carbon output from GVEA. This workshop, which I attended in order to learn more about the project, gained a great deal of input from community members who participated. Between the community input and consistent meetings with GVEA, the team was able to put together a structured plan and analysis of what needs to be done.

Initially I was tasked with researching and comparing DER and EV products from various companies. These included products from Tesla, LG, and Sonnen. Comparing and researching these products was an important part of the initial study, in order for the team to implement recommendations to GVEA for a particular product use and distribution. Involving current and new technologies that enable less fossil fuel energy to be consumed or beneficially distributed throughout the energy provider's service area is an important part of tackling the carbon reduction goal.

Post my product research assignment, the team moved in a different direction with the project. The team was unable to obtain a particular set of data that was going to enable us to do modeling for GVEA. Feedback from the community and ongoing research also contributed to the change in direction. As of mid June, key members of the team focused on their specific tasks

after the change in direction and left a void in assignments for me. During this time of project uncertainty, I set personal tasks for myself, studying and practicing programs that could benefit the team once revised objectives were formed. Programming languages I worked with, learned, and practiced include Coursera's Introduction to Matlab, Intermediate Matlab, Datacamp's Introduction to Python, and Intermediate Python Programming. Additional programs I studied include Simulink via Matlab's website and Matlab documentation.

Near the beginning of July, the team gained an understanding of what direction to move into, and which modeling programs we were going to use. Along with Professor Mohammad, we chose to use Matpower, an open source modeling program coupled with Matlab. At this point I begin dual weekly meetings with Professor Mohammad so that he could teach me about powerflow for grid systems, leading into the use of Matpower. Professor Mohammad was incredibly helpful, taking his time during the week to meet and instruct me on complex modeling. The learning continued until the mid July, when I grasped the basics of Matpower. At this point I was able to help Professor Mohammad with grid modeling. An example of the type of modeling we were practicing can be viewed in Figure 2. In the future, we would like to run extra simulations with more precise data such as load data in the future in order to give an even more accurate analysis of the systems.

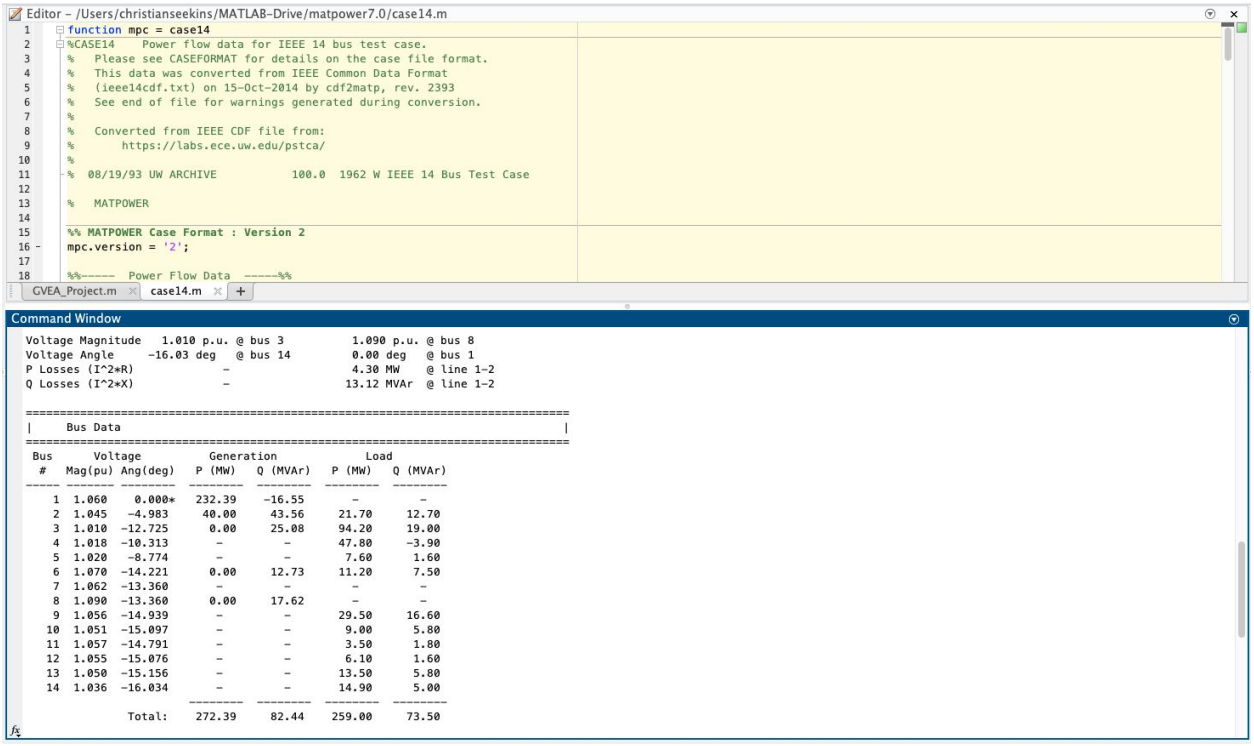

Figure 2: Matpower powerflow result example, case 14

Conclusion/Difficulties

Most engineers, mathematicians, and data analyzers know how important data collection is in order to make an informed decision through methods such as modeling or charting. Unfortunately, the Carbon Reduction Study Team experienced resistance to data requests. This came as a surprise to me as this was my first time working on a project on behalf of a third party. As I am new to field work, I was expecting data to be readily available and easy to obtain. Throughout the project I have learned valuable lessons for the future such as the need to get an agreement on data sharing before beginning a project. Ultimately we were unable to get specific data requested and thus were unable to complete specific modeling for our study. The team transitioned our efforts towards general grid modeling as well as open source economic data that other members collected and analyzed. An additional lesson learned during the project was how to cope during a pandemic. Working as an intern during a global pandemic has been an extreme learning process, adapting to the work environment and change in project pace has been an experience that will greatly benefit me as an engineer in the future.

References

Zimmerman, R; Murillo-Sanchez C. (2019). Matpower User Manual Version 7.0. Power Systems Engineering Research Center.

Zimmerman, R & Murillo-Sanchez C. (2019). Matpower Optimal Scheduling Tool Most (v1.0.2). Power Systems Engineering Research Center.

Hashemi, S., Arias, N. B., Bach Andersen, P., Christensen, B., & Traholt, C. (2018). Frequency Regulation Provision Using Cross-Brand Bidirectional V2G-Enabled Electric Vehicles. In Proceedings of 2018 6th IEEE International Conference on Smart Energy Grid Engineering, SEGE 2018 (pp. 249-254). [8499485] IEEE. https://doi.org/10.1109/SEGE.2018.8499485.

Ferreira, C. (2018). Green Mountain Power Resilient Home Innovation Pilot Update. Vermont Public Utility Commission.

Acknowledgments

I would like to express my thanks to a number of individuals that made this summer a marvelous experience. I would first like to thank the Alaska Center of Energy and Power for providing me the opportunity to work in the field as an intern with the ability to learn and contribute my education in a real world environment. Specifically I would like to thank Heike Merkel and Patty Eagan from ACEP, and Eric Goddard from the UAF Bristol Bay campus for all

their hard work helping, assisting, and pushing the internships forward, making sure that each individual intern had the finest experience as possible. For the team I was so graciously able to work with over the summer, the ACEP Carbon Reduction Study Team. I would like to thank all the members of that team, along with an extended thank you to Golden Valley Electric Association that we are working on behalf. Finally, I would like to personally thank the two members of the team that I personally worked with that shaped this summer into a true learning experience that will greatly benefit me as a professional, an engineer, and a person -- Steve Colt and Mohammad Kapourchali. Professor Kapourchali took personal time to explain engineering systems, diagrams, and scenarios throughout the summer. I learned a great deal from him and am extremely grateful for his time, effort, and knowledge. Thank you to all who made the summer internship possible including our funders, the Office of Naval Research, and the University of Alaska Fairbanks.