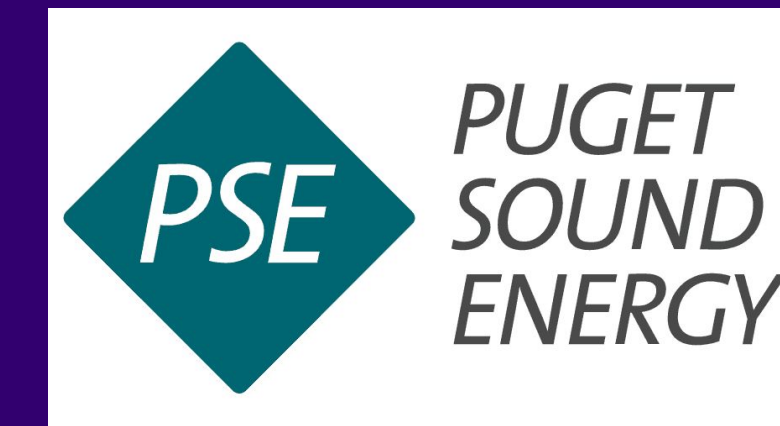


TRANSMISSION HOSTING CAPACITY MAPPING FOR PUGET SOUND ENERGY

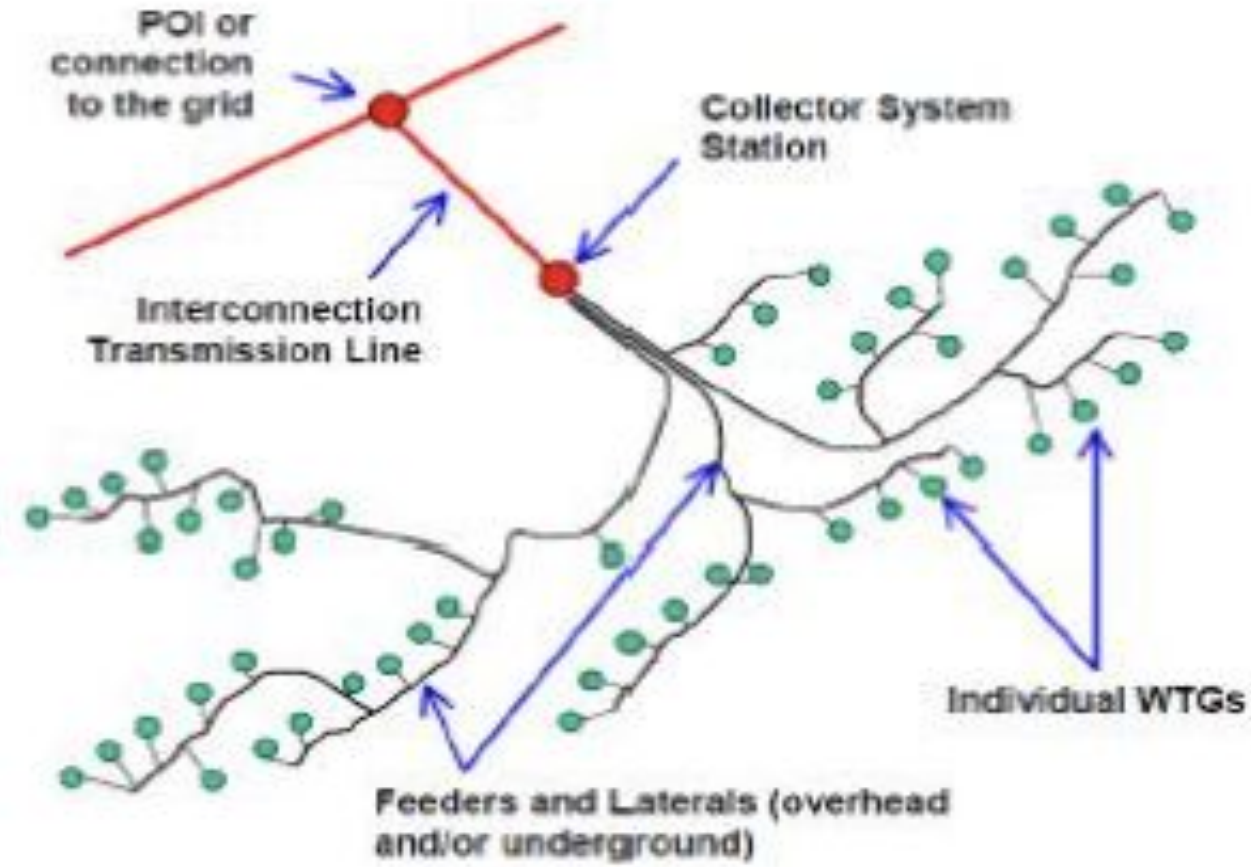


STUDENTS: Sam Ayars, Eric Hans Freitag, Menelik Hailu, Vedant Modak, Steven Zhou-Wright

Transmission Hosting Capacity Map Motivation

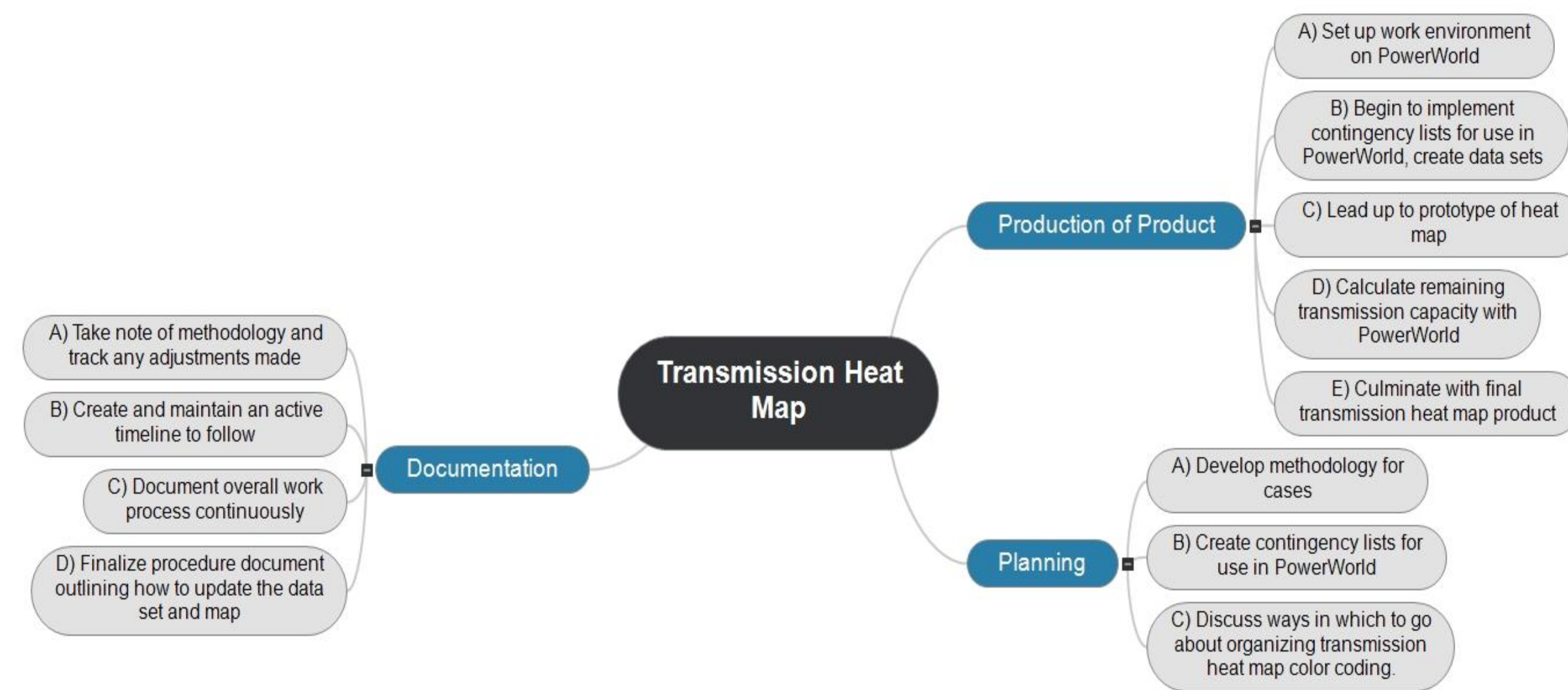
- PSE is looking to fully transition into fully renewable and clean energy resources, and in order to do that there will be an increased load/demand due to electrification.
- We are tasked with determining PSE's transmission system hosting capacity for the interconnection of generation and energy storage resources at transmission level voltages of either 115 kV or 230 kV.
- Transmission hosting capacity is defined as the level of generation that a transmission system can accommodate without causing thermal overloads or voltage violations.
- Creating a map outlining the various major substations and transmission lines of interest with their available capacities would help indicate areas that can accommodate new generation resources. There are five geographic zones we are dealing with: North King County, South King County, Pierce County, Thurston County, and Kitsap County.

Illustration of System Interconnection



Example Collector System

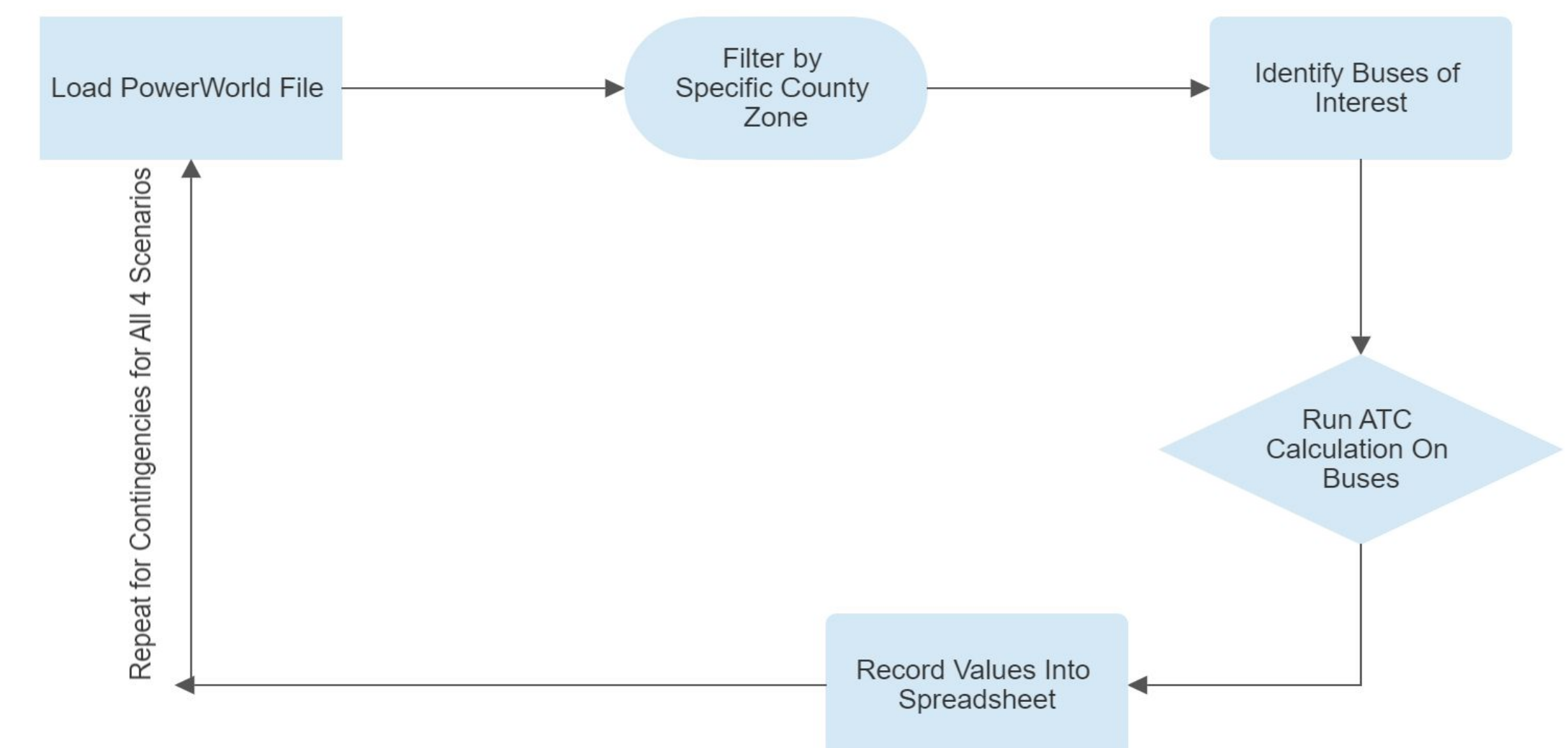
Work Breakdown Structure



Utilization of PowerWorld

- PowerWorld is an interactive power system simulation package designed to simulate power system operation at a large scale.
- We will be dealing with a base case, an N-1 contingency, and an N-1-1 contingency. The base case deals with a system having no significant outages, operating normally. The contingencies deal with cases where there is an outage of an important component, such as a transformer or transmission line between substations. N-1 refers to a single outage while N-1-1 refers to two outages occurring one after the other. Each case will be done for four different time period scenarios, for one year in the future in either the summer or winter, and for five years ahead in either season.
- We used the Available Transfer Capacity (ATC) function to determine the capacity at the major buses of interest.

Process Workflow Chart for Manual ATC Calculation



PowerWorld and Python Script Automation

- Our initial ATC calculations were done manually by simulating them one by one for each of the relevant substations. The results were then copied into a Google Sheets spreadsheet. To automate this process, we have written a Python script that will be able to perform the ATC calculations.
- We will be making use of PowerWorld's capability to have integration with Python to implement all of this.
- This script will act as validation also. To validate our python script, we will compare its output with the output we generated manually for the base case scenarios. For the ATC portion of our dataset, we have run all scenarios under base case, N-1 contingencies, and N-1-1 contingencies.

Requirements and Results: Transmission Map

- The main requirements of our final transmission map consist of having a descriptive and concise color code for different ranges of power transfer, have different layers for the contingencies and weather/time period scenarios, and include wind power potential, solar power potential, and other layers relating to the acquisition and usage of land for power generation as time allows or sponsor demands.
- We have developed a Python script that will simulate, via PowerWorld, base and contingency case scenarios for the regions in which PSE operates.
- Through the use of Google Earth, we have developed a heat capacity map with all of PSE's major buses in each region and color coded for different MW ranges that will help future power developers in making better decisions on potential areas/regions to develop future power systems.

Hosting Capacity Map for Distribution System

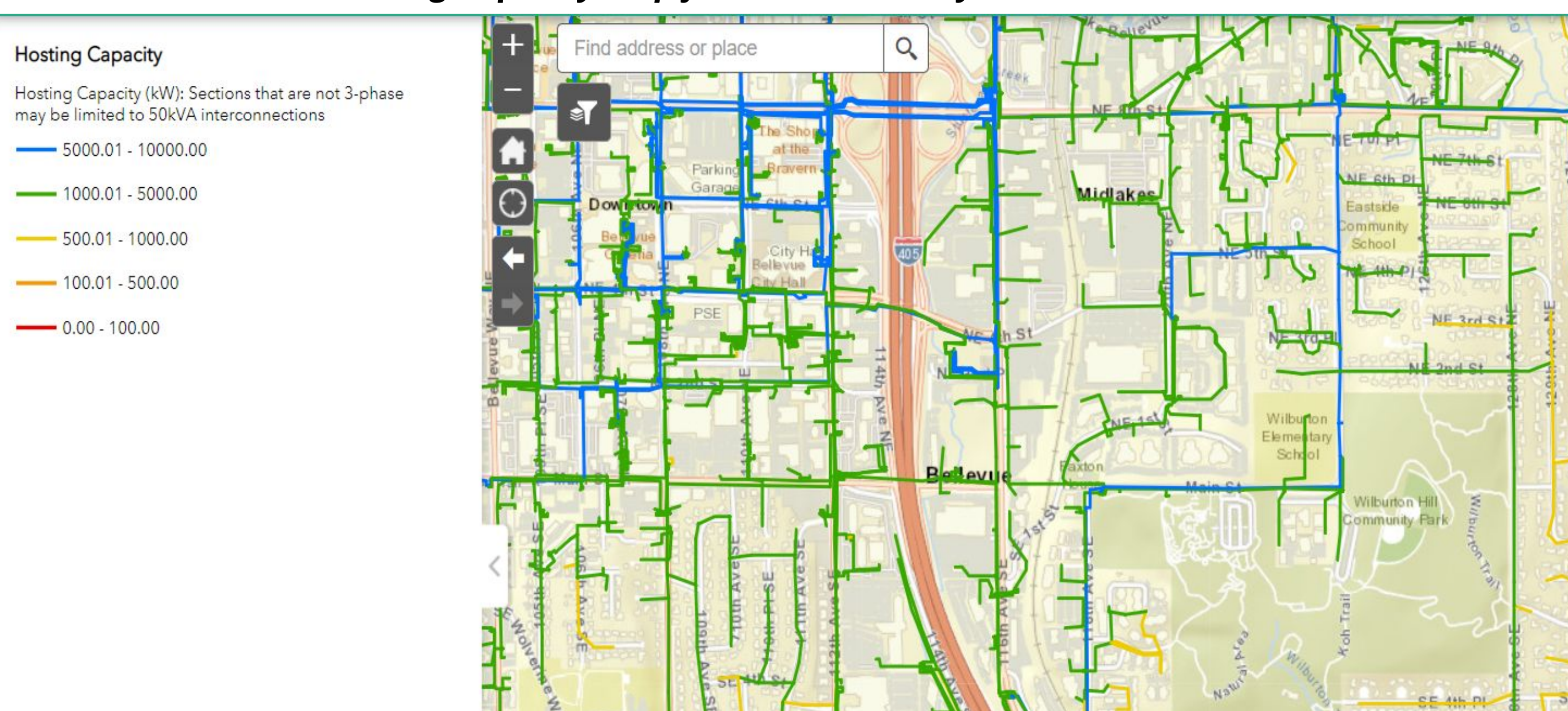
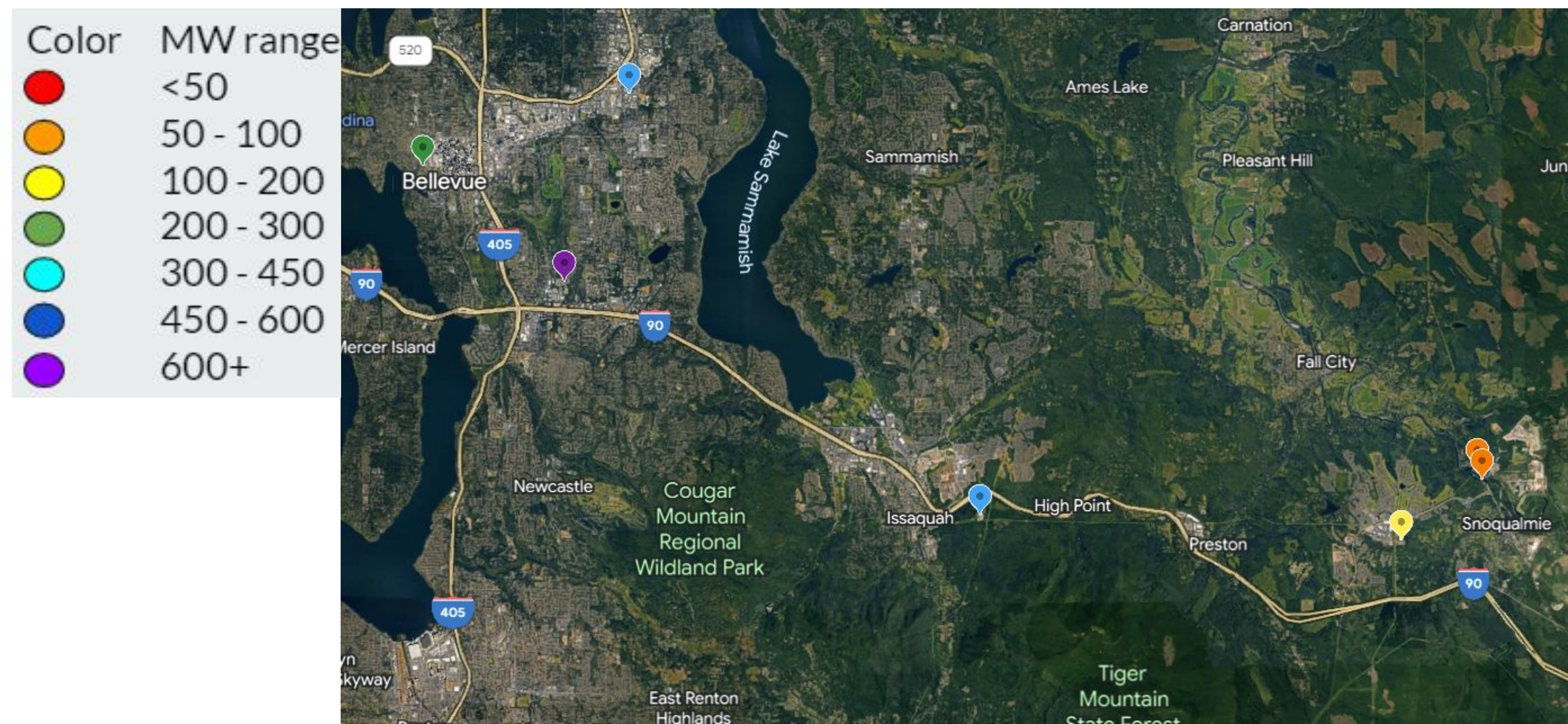


Image of Final Transmission Hosting Capacity Map, With Color Code



Future Work For PSE/Conclusion

- PSE will utilize the documentation we provide them with on how update the transmission map to be able to continue with their further work.
- Much of the future work done will consist of PSE using the transmission map to be able to accurately determine areas in the system that have available capacity to accommodate new generation resources.
- Independent power producers will collaborate with PSE to interconnect their specific power to PSE's points of interconnection in their transmission system. The transmission map will greatly facilitate much of that.

Acknowledgements

- We could not have accomplished any of this without the help of our industry mentors Benjamin Walborn, Robby Anderst and Eleanor Ewry at Puget Sound Energy. Their expertise in power systems from an industry perspective was extremely helpful.
- We would also like to thank our faculty mentor Professor Daniel Kirschen for his presence in overseeing our progress.