Attachment 5

Potential System Impact Study

Executive Summary:

In Order 18-075, the Public Utility Commission of Oregon approved PacifiCorp's initial transportation electrification pilot programs, as modified by a stipulation supported by parties in Docket UM 1810. The stipulation includes the following provision:

> PacifiCorp will develop and conduct an initial pilot study of potential system impacts of residential electric vehicle adoption in a selected portion of the Company's Oregon service territory. Before beginning the study, PacifiCorp will share its proposed pilot study objectives, timeline and expected cost with the Stipulating Parties.[2]

In September 2018, the company shared its proposed pilot study objectives, timeline, and expected cost with UM 1810 parties and incorporated feedback received into the design of this study. Through this study, the company sought to understand the potential system impacts of residential electric vehicle adoption on the primary distribution system. The study accounts for variations in the company's Oregon service territory such as seasonality, geography, demographics, and electric vehicle adoption through 2025. The system impacts studied are equipment thermal loading, voltage range, and imbalance.

This study utilized a state-level vehicle adoption forecast provided by the Oregon Department of Transportation (ODOT), which considers the market share of new electric vehicles growing to 10% by 2025. The study analyzed sensitivities of 20% and 40% higher than the state- level adoption forecast (i.e., 12% and 14% market share by 2025, respectively) with random and clustered electric vehicle adoption. Each scenario was also studied with an additional 30% penetration of private solar generation to understand potential interactions between high levels of electric vehicle and private generation adoption. It is also assumed that customers installing electric vehicle charging will contact PacifiCorp regarding load additions.

The results of this study predict that in some locations, normal load growth will cause isolated system component overloading issues, which will be compounded by additional electric vehicle load. However, PacifiCorp's traditional distribution planning study process is designed to predict overload conditions that require system changes to mitigate. Barring a large increase in the installation of electric vehicle chargers in a short time period, this process will account for and prepare the system for the installation of residential electric vehicle charging.

Most overload conditions created by the installation of residential electric vehicle charging are capable of being mitigated by balancing the feeder load across all three phases. At some single-phase locations, the solution to mitigate the overload condition will require the evaluation and modification of the feeder configuration and protection scheme. The addition of private solar generation equal to 30% of the existing load is not projected to significantly impact the conductor overload conditions present due to residential electric vehicle adoption.

[2] Order 18-075 modified this requirement to include all parties, not only those that supported the stipulation.

Study Scope:

The study assessed three distribution substation transformers and their associated distribution circuits where the substation is categorized as primarily serving urban, suburban, or rural areas. The study starts with the expected loading in 2025 and then is adjusted with the additional increase from the electric vehicle loading sensitivities. The substation distribution transformers and associated distribution circuits are:

- Portland (urban)
  - Vernon substation, T3747
  - 5P394 (96% residential), 5P395 (97% residential)
- Bend (suburban)
  - Shevlin Park substation, T365701
  - 5D238 (91% residential), 5D241 (91% residential), 5D243 (79% residential)
- Klamath Falls (rural)
  - Texum substation, T338712
  - 5L112 (76% residential), 5L113 (12% residential), 5L116 (79% residential)

Methodology:

The study was performed using measured feeder loads and estimated load growth rates through 2025 as a baseline to evaluate the impacts of the ODOT projection of plausible electric vehicle increase to a 10% market share. To study potential impacts of higher levels of residential electric vehicle adoption, sensitivities representing electric vehicle market share of 12% and 14% by 2025 were analyzed. After adjusting the baseline to reflect the impacts of potential new electric vehicle adoption, power flow analysis was performed using time series analysis and peak feeder loading to evaluate the impacts of increased adoption on existing equipment, devices, and voltage delivery. The time series analysis included four one-week periods: the weeks of summer peak load, winter peak load, spring minimum daytime load, and fall minimum daytime load.

Electric vehicle penetration was studied using two different scenarios. The first scenario assumed that the electric vehicle distribution was evenly spread across the entire feeder. The second scenario assumed clusters of electric vehicles in specific areas of the feeders. The randomly spread scenario was modeled as a general load increase equal to the increase in load due to the assumed number of electric vehicle chargers. The clustered scenario was modeled as blocks of load added to feeder taps with a sufficient number of existing customers capable of sustaining the increase of electric vehicle charging. Each clustered scenario was also studied with the addition of private solar generation equal to 30% of the peak load on each feeder.

The study assumed that residents with plug-in hybrid electric vehicles (PHEVs) would use Level 1 chargers with an average peak demand of 3.5 kilowatts (kW) and that residents with battery electric vehicles (BEVs) would use Level 2 chargers with an assumed average peak demand of 8 kW.

The assumed registered electric vehicle penetration was based on statewide penetration of electric vehicles and adjusted by individual feeder population. The assumed registered electric vehicle penetration is shown below.

Substation	Feeder	12%		14%	
		BEV	PHEV	BEV	PHEV
Portland- Vernon- Urban	5P394	79	41	95	50
	5P395	53	28	64	34
Bend- Shevlin Park- Suburban	5D238	48	37	58	42
	5D241	52	40	63	45
	5D243	28	21	34	25
Klamath Falls- Texum- Rural	5L112	1	2	2	3
	5L113	0	0	0	0
	5L116	1	3	2	4

Results

Urban:

Summary: The urban Vernon feeders are projected to experience overloaded conductors in all scenarios during normal load growth, random electric vehicle adoption ramping up to 12% market share, clustered electric vehicle adoption at 12% market share, and clustered electric vehicle adoption at 14% market share by 2025.

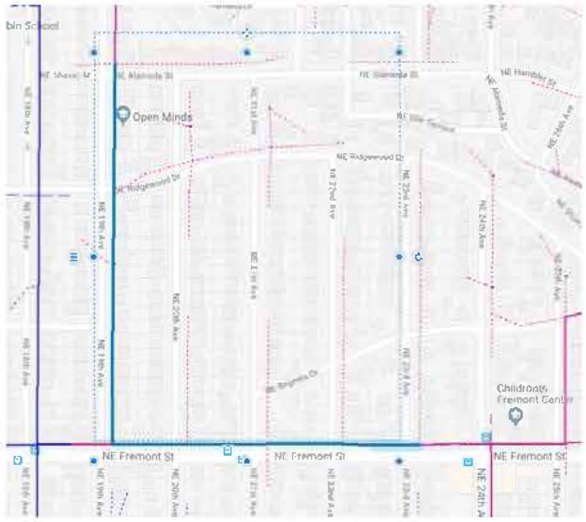
Normal Load Growth: The urban Vernon feeders are projected to experience normal load growth of up to 2.0% over the period ending in 2025. This normal growth rate is modeled to cause conductor overload of up to 118.5% on feeder 5P395 during summer loading conditions at multiple locations. There are no modeled overload conditions due to normal load growth during winter, spring, or fall loading conditions.

12% Electric Vehicle Market Share: The addition of electric vehicle charging to this feeder is modeled to increase this overload to 124.7% by 2025. Random electric vehicle adoption is modeled to overload one section of conductor on 5P395 to 100.5% during summer loading conditions. Clustered electric vehicle adoption in this scenario is modeled to overload one section of conductor on 5P395. All sections of overloaded conductor can be brought into tolerances with targeted phase balancing to move the load to under-loaded phases.

Random electric vehicle adoption in this scenario is modeled to overload the conductor between facility points 01101001.0236009 and 01101001.0236001 on feeder 5P395 to 100.5% during summer loading conditions.

Clustered electric vehicle adoption in this scenario is modeled to overload the section of #2/0 copper on feeder 5P395 beginning at facility point 01101001.0237203 and extending to facility point 01101001.0237003 to 111.3% during winter loading conditions. The addition of private solar generation is expected to decrease the overload to 109.1% in the case of 12% electric vehicle registration and 118.6% in the case of 14% electric vehicle registration. This section of conductor is shown in Figure 1.

Figure 1. Potentially Overloaded Conductor, FP 01101001.0237203 to 01101001.0237003



14% Electric Vehicle Market Share: Clustered electric vehicle adoption ramping up to 14% market share by 2025 is modeled to overload four additional sections of conductors on 5P394 and 5P395.

- The span of 336 ACSR conductor on feeder 5P395 beginning at 0101001.0236009 to 01101001.0236001 is modeled to be overloaded to 108.2% during winter loading conditions. The addition of private solar generation may reduce this overload to 106.4%. This span of conductor is shown in Figure 2.
- The section of 336 AAC conductor on feeder 5P395 beginning at facility point 01101001.0237305 to 01101001.0237202 is modeled to be overloaded to 107.1% during winter loading conditions. The addition of private solar generation may reduce this overload to 105.2%. This section of conductor is shown in Figure 3.
- The 5P394 feeder getaway of 1000 kcm aluminum is modeled to be overloaded to 102.6% during winter loading conditions. The addition of private solar generation may reduce this overload to 101%.
- The section of 4/0 copper conductor on feeder 5P394 beginning at 01101001.0236309 to 01101001.0236310 is modeled to be overloaded to 107.2% during winter loading conditions. The addition of private solar generation may reduce this overload to 105.4%. This section of conductor is shown in Figure 4.

Figure 2. Potentially Overloaded Conductor, FP 01101001.0236009 to 01101001.0236001

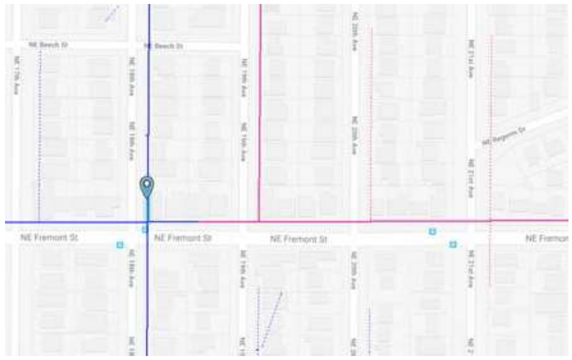
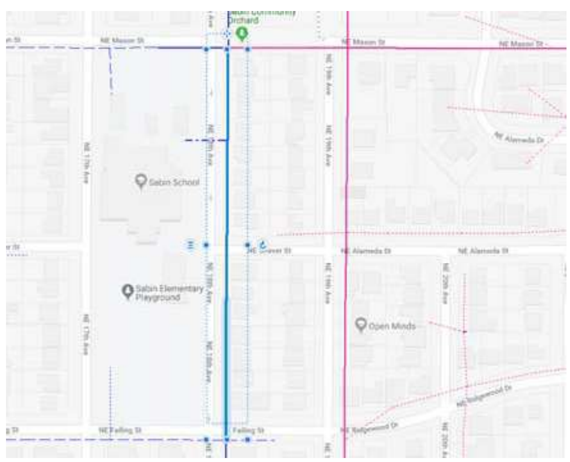


Figure 3. Potentially Overloaded Conductor, FP 01101001.0237305 to 01101001.023720

Figure 4. Potentially Overloaded Conductor, FP 01101001.0236309 to 01101001.0236310



<u>Suburban:</u>

Summary: The suburban Shevlin Park feeders are projected to experience overloaded fuse conditions during normal load growth, clustered electric vehicle adoption ramping up to 12% market share, random electric vehicle adoption ramping up to 14% market share, and clustered electric vehicle adoption at 14% market share. Overloaded elbow conditions are also projected on feeder 5D241 during clustered electric vehicle adoption of 14% market share.

Normal Load Growth: The suburban Shevlin Park substation is expected to experience normal load growth of up to 5.0% on feeder 5D243 while experiencing lower growth rates of 0.5% on feeders 5D238 and 5D241 over the period ending in 2025. The normal load growth on 5D243 is not expected to lead to overloading issues by 2025. This normal load growth is expected to lower the peak load voltage to 94.8%, which is outside of ANSI Range A. Normal load growth is modeled to cause overloading up to 128.7% at three fuse locations on 5D238 and 5D241 during summer and winter loading conditions.

12% Electric Vehicle Market Share: The random and clustered electric vehicle charging scenarios were shown to cause single-phase overloading at various additional fuse and elbow locations on feeders on 5D238 and 5D241. Extreme clustered electric vehicle charging on feeder 5D238 was shown to increase load up to 150% of the rated capacity of some devices during winter loading conditions. 5D243 was not shown to have any overload issues that are the result of electric vehicle charging.

When random electric vehicle is modeled, it is shown to cause the single-phase overload of the 200A elbows to 100.3% at facility point 01418012.0063782 during summer loading conditions. This is modeled to increase to 102.1% with the random electric vehicle adoption of 14% of registered vehicles. This location is shown in Fig 5.

Clustered electric vehicle adoption in this scenario is modeled to cause the single-phase overload at three fuse locations.

- The 100T fuse at 01417011.0252800 on feeder 5D238 is expected to be overloaded to 118% during winter loading conditions and 130.5% with the clustered electric vehicle adoption of 14% of registered vehicles. This overload is modeled to be 109.3% during summer loading conditions with electric vehicle adoption if 12% of registered vehicles and 120.1% with electric vehicle adoption of 14% of registered vehicles. The addition of private solar generation may reduce the overload by 1.1% for each scenario. This fuse feeds a three-phase tap and the overload condition can be mitigated by balancing the load beyond the fuse. This fuse location is shown in Figure 6.

- The 80E fuse at facility point 01417011.0247281 on feeder 5D238 is modeled to be overloaded to 134.4% during winter loading conditions. The addition of private solar generation may reduce the overload by 1.4% for this scenario. This fuse feeds a single-phase tap that would not benefit from load balancing. An evaluation of the fuse coordination and normal open point beyond this fuse would need to be performed to determine the ideal solution to this overload condition. This location is shown in Figure 7.

- The 100T fuse at 01417012.0317502 on feeder 5D241 is modeled to be overloaded during summer loading conditions to 106.3% in this scenario. The addition of private solar generation is expected to decrease this overload by 1.8%. This fuse feeds a single-phase tap that would not benefit from load balancing. An evaluation of the fuse coordination and normal open point beyond this fuse would need to be performed to determine the ideal solution to this overload condition. This fuse location is shown in Figure 8.

Figure 5. Potentially Overloaded Elbow, FP 01418012.0063782

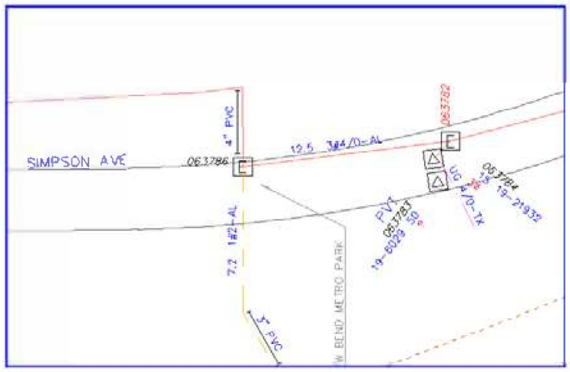


Figure 6. Potentially Overloaded Fuse, FP 01417011.0252800

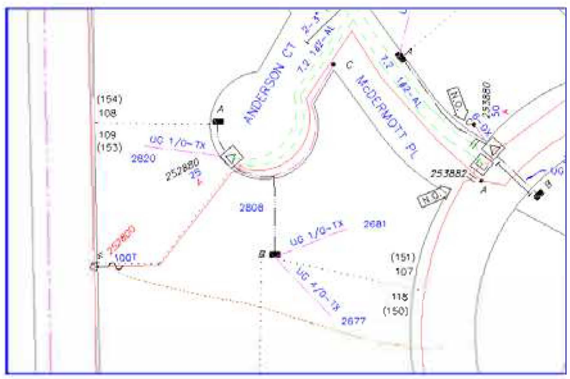


Figure 7. Potentially Overloaded Fuse, FP 01417011.0247281

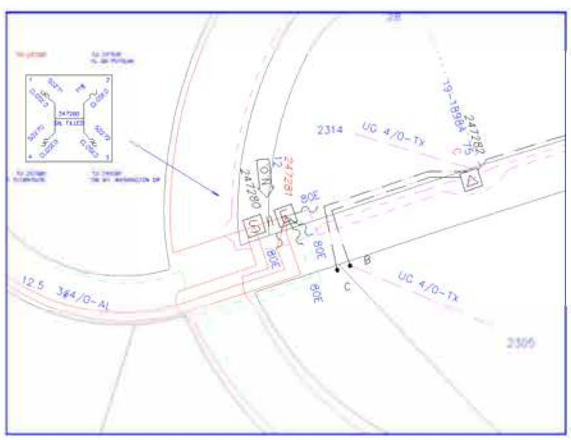
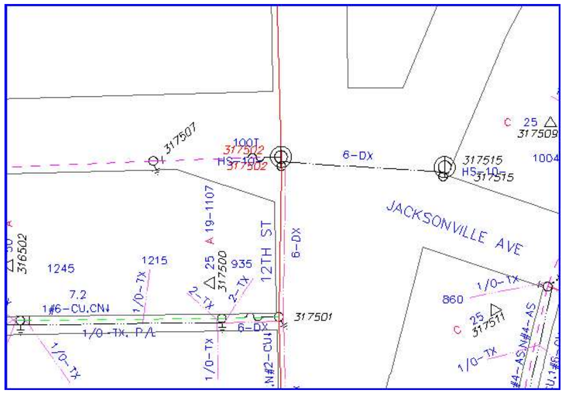


Figure 8. Potentially Overloaded Fuse, FP 01417012.0317502



14% Electric Vehicle Adoption: Clustered electric vehicle adoption ramping up to 14% market share is modeled to cause an overload condition of up to 102.1% on 200 A elbows between facility points 01418012.0063782 and 01418011.0019782 during summer loading conditions on B phase. This overload condition would be able to be corrected by balancing the load beyond the elbows. The addition of private solar generation may reduce this overload condition to less than 100%. This section of line is shown in Figure 9.

Figure 9. Potentially Overloaded Elbows, FP 01418012.0063782 to 01418011.0019782

Rural:

The rural Texum substation load examined in this study does not expect any load growth over the period ending in 2025. The assumption of between seven and 11 residential electric vehicle chargers connected to these feeders is not expected to cause any loading or voltage issues by 2025.