Secondary Power Flow with Static VAR Compensators
Sponsor: Avista Utilities
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Background
The client, Avista utilities, tasked the team with investigating the effects of adding static VAR compensators (SVCs) at the feeder level of the distribution system. In a distribution system, multiple meters (houses) connect to the secondary side of a particular transformer. When a meter’s voltage falls below NERC standards, it has to be compensated at the high side of the transformer by adding more power to the system. Avista asked the team to find a way to reduce this voltage loss by using SVCs. In addition to minimizing voltage loss, the client required the team to explore software with better low voltage modeling capabilities, such as GridLAB-D.

Configurations
Using GridLAB-D, the team modeled two different types of connections to the transformer; an open-wire model and a triplex model which can be seen in the figures below.

<table>
<thead>
<tr>
<th>Configuration 1</th>
<th>Configuration 2</th>
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<tbody>
<tr>
<td>Open-wire model</td>
<td>Triplex model</td>
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Broader Impacts
This project could present many societal, economical, and environmental impacts if applied in the real world. The first and most obvious beneficiary would be the customers of Avista. A well-regulated power system would minimize occurrences of light flickering, outlet malfunctions, and brown/blackouts, leading to a more content customer base. The economical impact of this project would be through the savings in power consumption, and with the new SVC technology. Currently there are no SVCs that are designed to be used at the feeder level. This means that using this technology would create a new product in the industry of power electronics. This technology would also be beneficial to the environment by reducing the generation requirements. Improved voltage regulation would help decrease losses, and lead to a more efficient power grid. This benefits the environment by requiring less power to be generated through the use of coal and other fossil fuels.

Results

<table>
<thead>
<tr>
<th>SVC Placement vs Voltage at House 6</th>
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<tr>
<td>Voltage at house 6 improved the most when the SVC was placed at house 6 versus no SVCs or placing the SVC at house 1</td>
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<th>SVC Quantity vs Voltage at Transformer Secondary</th>
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<td>The voltage on the overall system was most improved with an SVC on each of the houses (meter)</td>
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<th>VAR Consumption of System</th>
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<td>The system becomes more efficient when SVCs are added because of the reduced reactive power consumed</td>
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Methodology
This was the design process used by Intarsia:

Conclusions
The following conclusions were drawn from the project:
- SVCs at every meter provide best voltage compensation
- Efficiency is improved by using SVCs in the system
- SVCs should be placed at midpoint of meters with lowest voltages for more economically feasible design
- GridLAB-D is adequate in modeling feeder level power systems, but there is no formal model for the SVC

Future Work
Static VAR Compensators on the feeder level are not a product that exist now, and therefore limitations in data and time prevented a full analysis of the system. Things that could be done for future work are:
- Test larger SVCs if production makes them viable
- Perform analyses with a more detailed SVC model as more data about the product becomes available
- Test more parameters on GridLAB-D since not all capabilities were tested
- Develop ZIP loads for a more specific model
- Run a cost analysis of the optimal SVC configurations to see if they are financially feasible
- Test model with data that has more variance between meter voltages

Team Intarsia
We would like to acknowledge Carlos Limon from Avista for our data, Mike Diedesch for mentoring us, and PNNL for GridLAB-D support.