The electric power grid has been very well established for over a century. However, as the power demand increases, the efficiency, reliability, and safety of the grid become even more valuable. The simple power grid needs to be ‘smarter’ to handle the increase in demand in the most cost-effective manner. This need led to the inception of a smart grid, where the installation of automated equipment, smart meters, and distribution management system, gives complete control over the grid. The Pullman Smart Grid Demonstration project, headed by Avista Utilities, is conducted to quantify the smart grid’s benefits. The newly installed equipment coupled with the distribution automation system has the ability to have constant control over the grid and also the potential to decrease demand during peak hours. This research explores one aspect of the smart grid in distribution automation called Integrated Volt-Var Control (IVVC) scheme. Voltage regulation over a distribution feeder serves the purpose of achieving a flat voltage profile and maintaining the permissible voltage (plus or minus 3% of 120V) at the end-use customer. Var control allows power factor correction in real time. By maintaining near unity power factor, the system’s operating current is minimized; thus reducing the size of operating devices such as cable, transformer, alternator, etc. The benefits of IVVC include reduction of losses, maintenance costs, operating costs, and voltage variation, and increase in the power delivery capacity of existing equipment. Results of the smart grid control show demand savings of 2-3%, validating the need for a smart grid.

**Motivation**

- Need for a self-healing grid to improve power system efficiency, reliability, and security
- Instantaneous balance of supply and demand to meet the increasing energy consumption
- Meet the requirements of the I-937 “Green” Initiative bill that requires utilities to supply 15% of the energy from renewable sources by 2020.

**Objective**

- To quantify the benefits of the Integrated Volt-Var Control (IVVC) Scheme
- To accurately model the loads on a distribution feeder
- To find the optimal locations for installation of regulators and capacitor banks on a feeder to achieve greater savings

**Pullman Smart Grid Project**

- 13 Feeders
- 20 switched and fixed capacitor banks
- 45 automated line switches and reclosers
- Wireless and fiber communication
- 13,384 smart meters

**Integrated Volt-Var Control Scheme**

**Factors Affecting IVVC**

**Load models:** Static load models are categorized into constant impedance (Z), constant current (I), and constant power (P) loads. Mathematically, these are represented as:

\[ P = V^2 / Z \]

**Line voltages:** As can be seen from the load model above, higher voltages result in higher power consumption. Thus it is imperative to keep the voltage as low possible while still meeting the allowable +/- 5% voltage variations.

**Capacitor switching:** Since capacitors provide reactive power to the system, switched capacitors can be used to achieve near unity power factor. However, because capacitors also act as voltage booster, switching capacitors unnecessarily could significantly increase the demand (Figure 4).

**Proposed Methodology**

**Results**

- **Demand Savings Comparison with Capacitor Switching**
  - (Top) Actual energy consumption and IVVC absolute savings in kWV plotted against time.
  - (Middle) Demand savings (kWV) comparison with and without IVVC control.
  - (Bottom) Percentage savings for different levels of EOL voltages.

**Summary**

This poster discussed the potential benefits of implementing the IVVC scheme on a distribution feeder. Studies showed that depending on the type of feeder, there was 2-3% demand savings and loss factor is not a significant benefit.

**Future Work**

- Utilize data from SEL 2431 to identify load parameters
- Analyze smart meter data to set the end of line voltage
- Find the optimal installation location for new smart grid equipment

**Acknowledgments**

1. Avista Utilities, Spokane, WA.
3. KP Schneider, FK Tuner, JC Fuller, and R. Singh, Evaluation of conservation voltage reduction (CVR) on a national level, Pacific Northwest National Laboratory, July 2010