Impact of High Photovoltaic Penetration on Distribution Systems

What is Photovoltaic?

- Photovoltaic(PV) is known as solar cells that can convert light to electricity
- The current efficiency of most commercial solar panels is around 21.5%
- Residents can install residential solar PV for supporting their own demand of electricity
- When the demand of residents is fulfilled, the rest of electricity can be sold to local utility company
- Solar PV is now one of the most popular and important renewable sources

Why is this Project Important?

Solar Photovoltaic generation is gaining popularity across the nation, including Iowa. Because of its volatility nature, when generation exceeds certain limits, it introduces undesirable stability issues such as transients, high voltage levels, and reverse power flow.

To predict and analyze new trends associated with high solar photovoltaic penetration in distribution feeders is now necessary. Our team is collaborating with Alliant Energy to develop a preventive plan to tackle these instability issue as more photovoltaic generation is added to their Washington distribution feeder.

Plan of Action

- Learn to use OpenDSS to simulate distribution system based on IEEE Test Feeders
- Learn to install Solar PV into simulation systems
- Study and explore the real distribution system of Washington, IA from Alliant Energy
- Create test system based on the real world system and modify
- Test systems with different settings under different condition
- Conclude system performances, stability and results
- Summary suggestions about solar PV installation

Design Requirement

- A working simulation model of a real world feeder with high PV penetration
- Comparison between impact of residential PV and community solar PV
- Find most suitable places to install solar PV and test performance
- Create a guideline to give suggestions about stability of feeder with solar PV under different situation

Required Software:

- OpenDSS

Design Procedure

Stage I: Learn Key Concepts and OpenDSS

OpenDSS/IEEE/4 and 34 Bus Systems	Solar Integration and Manipulation	System Optimization and Lower Cost Concept Study

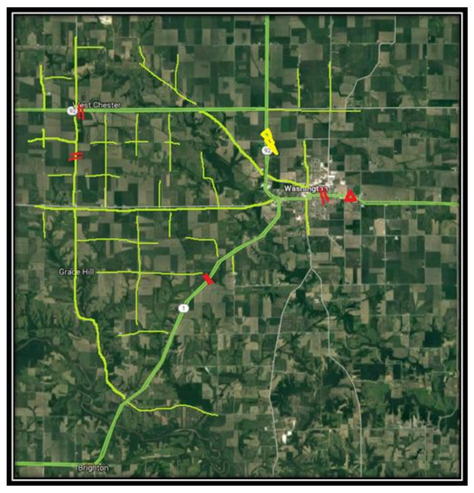
Stage II: Alliant Energy System Study

Real World Load Shapes Analysis	Research the topography of Washington Distribution System	Match OpenDSS simulation solutions with Client's Data

Stage III: Manipulate Alliant Energy System for Research

Create a Complete Test System Based on Current Alliant Energy System	Add Solar PV System to Test System	Evaluate the Test System under Different Scenarios	Discuss different solution approaches with Alliant energy

Design System

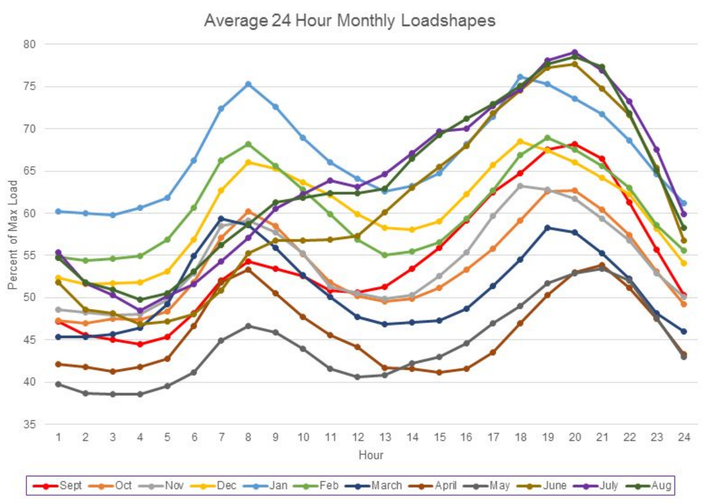


- Test system is divided in North, South, and Residential Regions
- In each region, 5 different locations are picked for research
- The solar PV power range is from 5kVA to 50 kVA
- Locations (named by node numbers):

North Region	South Region	Residential Region
240837.1.2.3	240503.1.2.3	255695.1.2.3
229659.1.2.3	240448.1.2.3	254620.1.2.3
229597.2	229017.1.2.3	240629.1
240716.2	240444.2	240696.1.2.3
240569.2	229443.3	240767.1.2.3

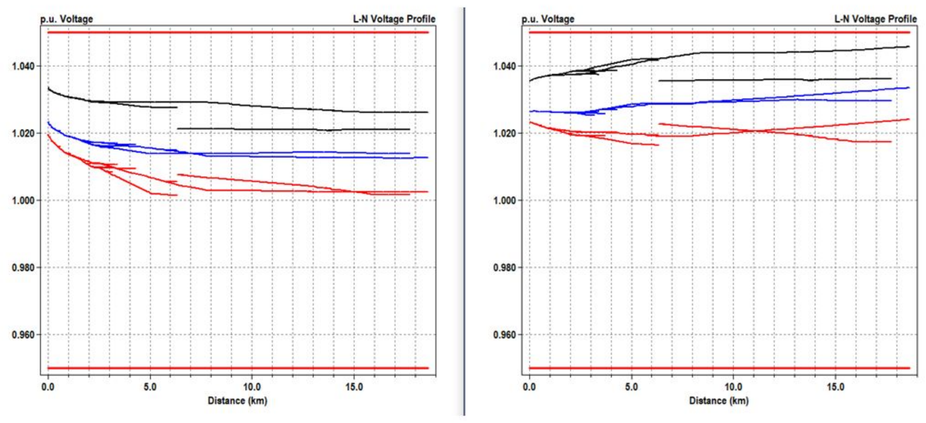
Average 24 Hour Monthly Loadshapes

- July has the peak value of load
- May is the low load value
- January is the highest duck curve load shape



Results

- With installing 15 solar PV into the system, the per unit voltage profile has significantly changed
- Left figure is the original profile, and the right figure is the per unit voltage profile with solar PVs



Members:
Logan Heinen
Zhengyu Wang
Difeng Liu
Redouane Zaou

DEC16-14

Email: dec1614@iastate.edu
http://dec1614.sd.ece.iastate.edu/

Client: *Alliant Energy*

Advisor: *Dr. Venkataramana Ajjarapu*