HIGH PHOTOVOLTAIC PENETRATION AND THE IMPACT ON DISTRIBUTION SYSTEMS

Team Dec1520
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Industry Client Alliant Energy

Problem Statement -

Utilities are seeing a rise in private generation, known as distributive generation. Distributive generation, or DG, is most commonly seen as solar generation at the home level. These secondary markets are causing a new dynamic in the traditional power generation model. Our goal is to help alleviate the stresses that arise when certain conditions are met. Namely peak generation during periods of low demand each day. From this analysis we will help Alliant Energy devise an optimal and cost effective solution that will benefit both Alliant and their customers' that desire to become Net Zero.

Background -

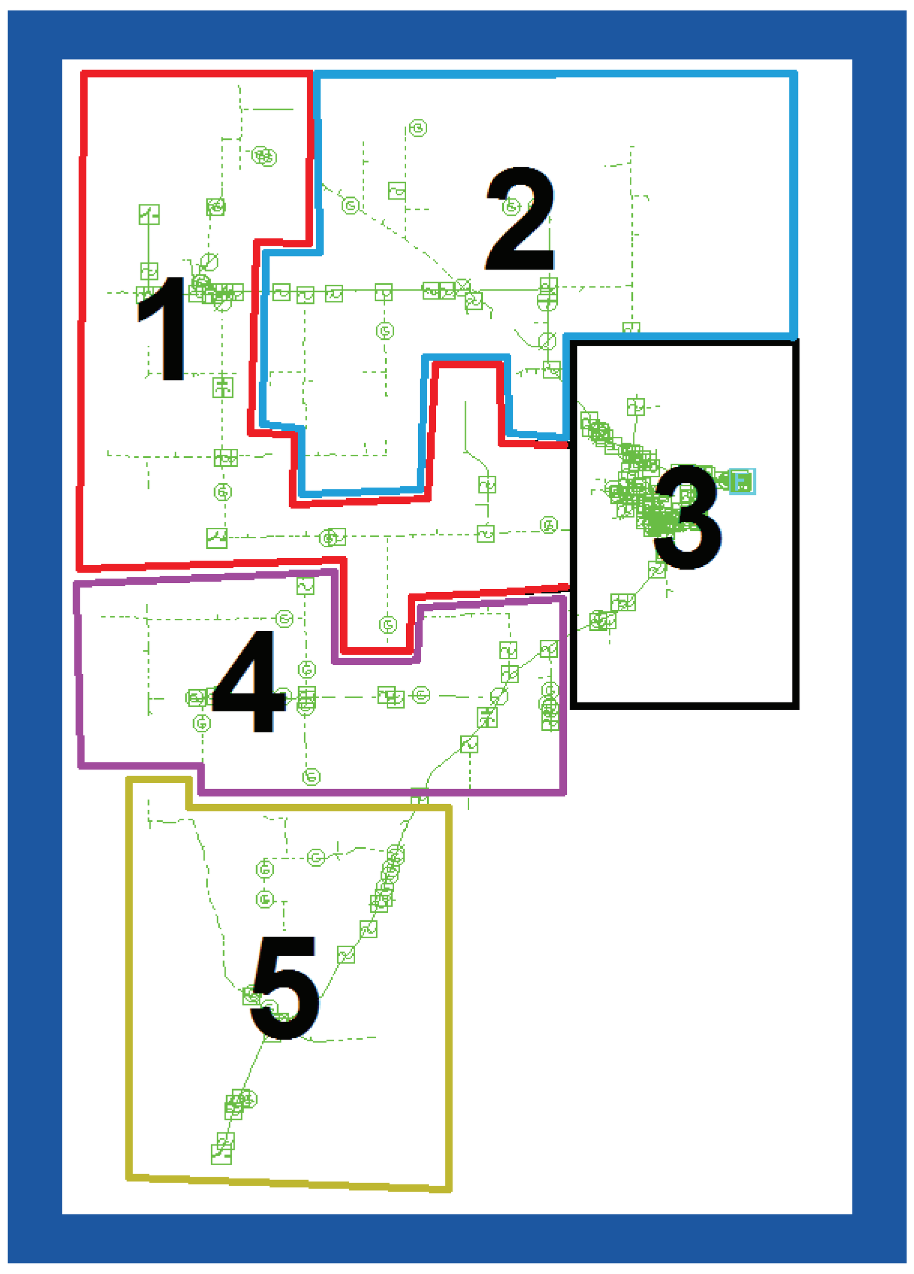
Photovoltaic, or PV, cells are a cost effective manner to reduce energy costs and carbon emissions. Consequently this has resulted in an increase of installation of PVs on residential homes and farms. To dissipate excess power generated when demand is low, the PV inverters are connected to the distribution grid. This defines a concept called Distributive Generation, or DG. DG can result from multiple sources including: wind turbines, gas generators, and geothermal generators. However, a vast majority of the DG comes from PV cells.

Increasing Issues -

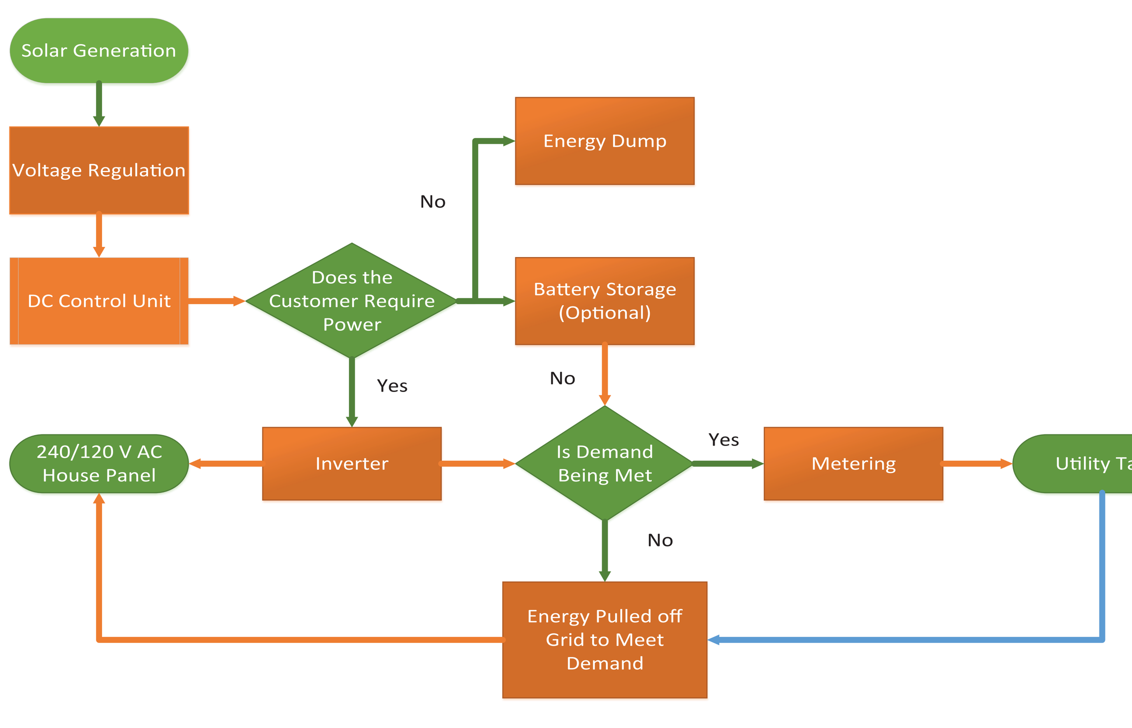
Initially DG was not an issue to utilities, in fact it was seen as beneficial since it allowed generation to provide less power to the distribution level. However, with the rapid increase in DG on many feeders, the utilities are finding themselves dealing with a new problem. This problem is caused when PV generation is at its peak, while demand is low and can cause stress on the utilities aging infrastructure. These stresses result in damage and decreased life expectancy in the equipment and thus potential power outages and loss of capital.

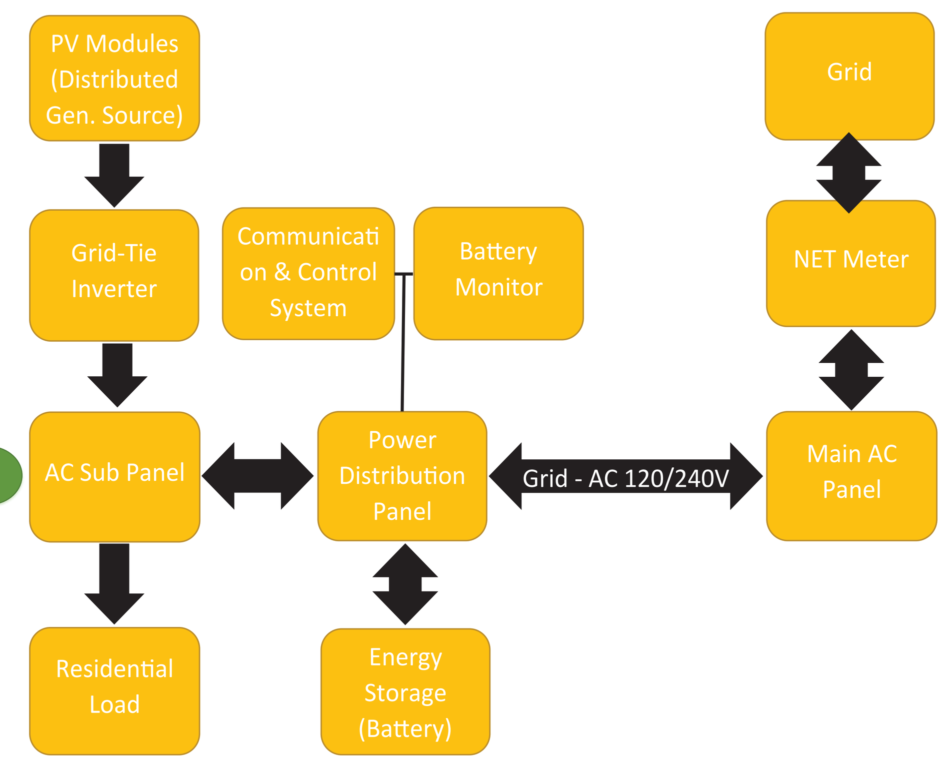
Distribution Layout -

- Washington, Iowa
- Main Feeder: 13.2 kV
- Approximate Customers
- General Customers: 567
- PV Customers: 56
- Zoned for easy addition of additional PV Generation expansion



Design/Development Process -

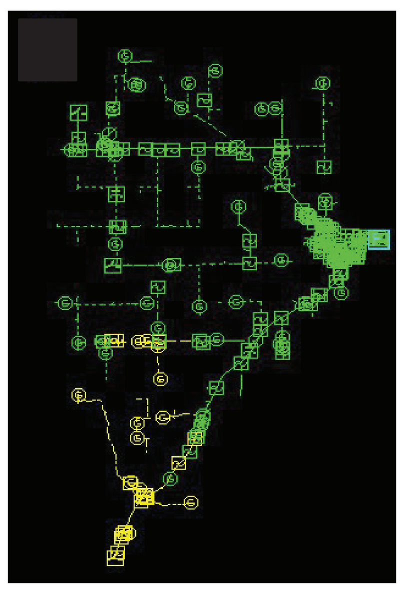
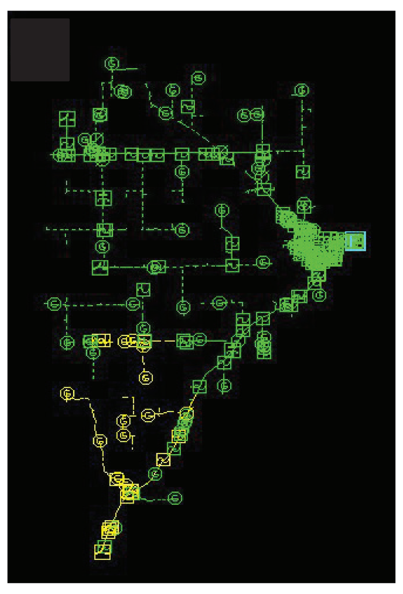




Simulations & Results -

Model Name	Voltage (kV)	Total Solar (KW)	Solar PF (%)	Base Load (KW)	Solar PV/ Load Demand	Total Demand Required (KW)	Solar PV/Total Demand Required	Description	Amount of grid overvoltage (%) [With Base Load]	Description of Error
Base Case	13.2	868.45	100.00%	1250	0.69476	1250	0.69476	Base Case	5.84%	High V on generators near Grace Hill
First Iteration	13.2	968.45	100.00%	1250	0.77476	1415	0.684416961	Added one 20 KW of Solar, 1PH, 100% PF to each zone where DG is minimal	7.46%	High V on generators near Grace Hill. High V on south end of feeder
Second Iteration	13.2	1068.45	100.00%	1250	0.85476	1390	0.768669065	Added one 20 KW of Solar, 1PH, 100% PF to each zone to space out evenly vs previous iterations		
Third Iteration	13.2	1168.45	100.00%	1250	0.93476	1640	0.712469512	Added one 20 KW of Solar, 1PH, 100% PF to each zone to space out evenly vs previous iterations	18.60%	High V throughout the south end of the Feeder
Fourth Iteration	13.2	1268.45	100.00%	1250	1.01476	1845	0.687506775	Added one 20 KW of Solar, 1PH, 100% PF to each zone to space out evenly vs previous iterations	21.47%	High V throughout the south end of the Feeder



Initial conditions for simulations:
- Voltage regulators are off.
- Capacitor banks are off.
- All DG is run on signle phase.

Results indicate that high voltage issues contiually appear in the southern portion of the feeder.

All results simulated via SYNERGI: Power Distribution Analysis and Optimization.

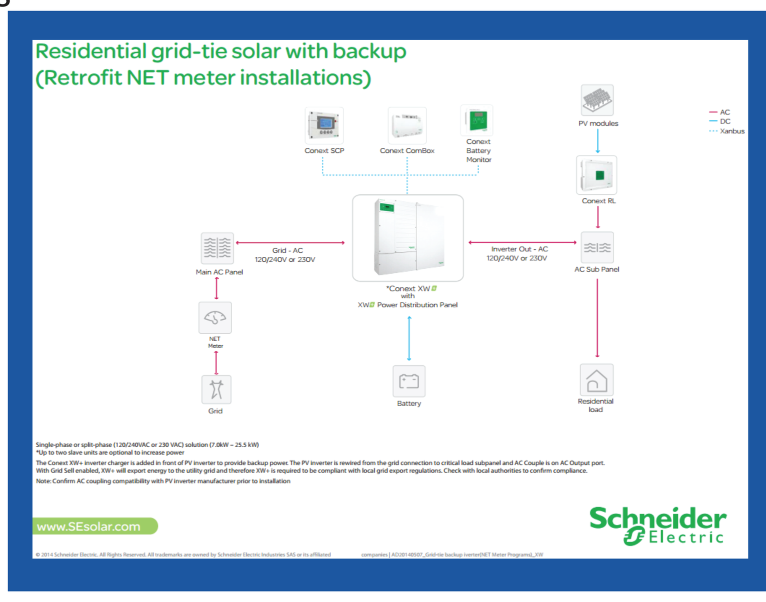
Solution -

The residential level would be the optimal solution for all parties. Our recommendation would be to use a grid-tie inverter with or withouth backup power. Schneider Electric has the proper inverter needed to operate in the harsh conditions that present themselves in the Midwest.
The approximate cost would run about \$3,200 and can operate a single or three phase load from 4.5 to 6.8 kW with in normal temperateures from 25 to 40 degrees Celsius.

Estimated Average Consumption in kWhrs

Type	Power Consumption	Number
LED TV	0.1	2
Lights/Room	0.1	4
Washer	2.3 (each run)	1
Dryer	2.3 (each run)	1
Dishwasher	2.8 (each run)	1
Fridge	1.6/day	1

Using these estimates the average house uses 2.2 kWhrs/day, with a maximum of 13.2 kWhrs/day. So the customer and utility should allot for the following battery design approximations:



- Should be at least 3-4 kWhrs
- 12 V with 40 Ahr capacity
- To reach the max we need would be 10 batteries (lead acid)
- 9 batteries in series gives us 120 V @ 40 Ahr
- This equates to 4.8 kWhrs

Works Cited -

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