MAY1603

Evaluation of Distributed Generation within a Municipal Electrical Infrastructure

may1603.sd.ece.iastate.edu

Our Team

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Client: City of Bloomfield

Advisors: Dr. Kimber & Dr. Wang

Introduction

Problem Statement

- Goal of energy independence by 2030
- Deliverables for this semester
    - Map the infrastructure
    - Simulate existing system
    - Run initial test of injected Distributed Generation (DG)

Outline

- Project Plan
  - Functional & Non-functional Requirements
  - Collecting Data
- Design
  - Mapping system
  - Modeling the system
  - Simulate DG injection
- Results
- Plan for next semester

System Specifications

Data Collection

- Site visit
  - Linesmen
  - Advisors
- Map
- Transformers
- Generators
- Load

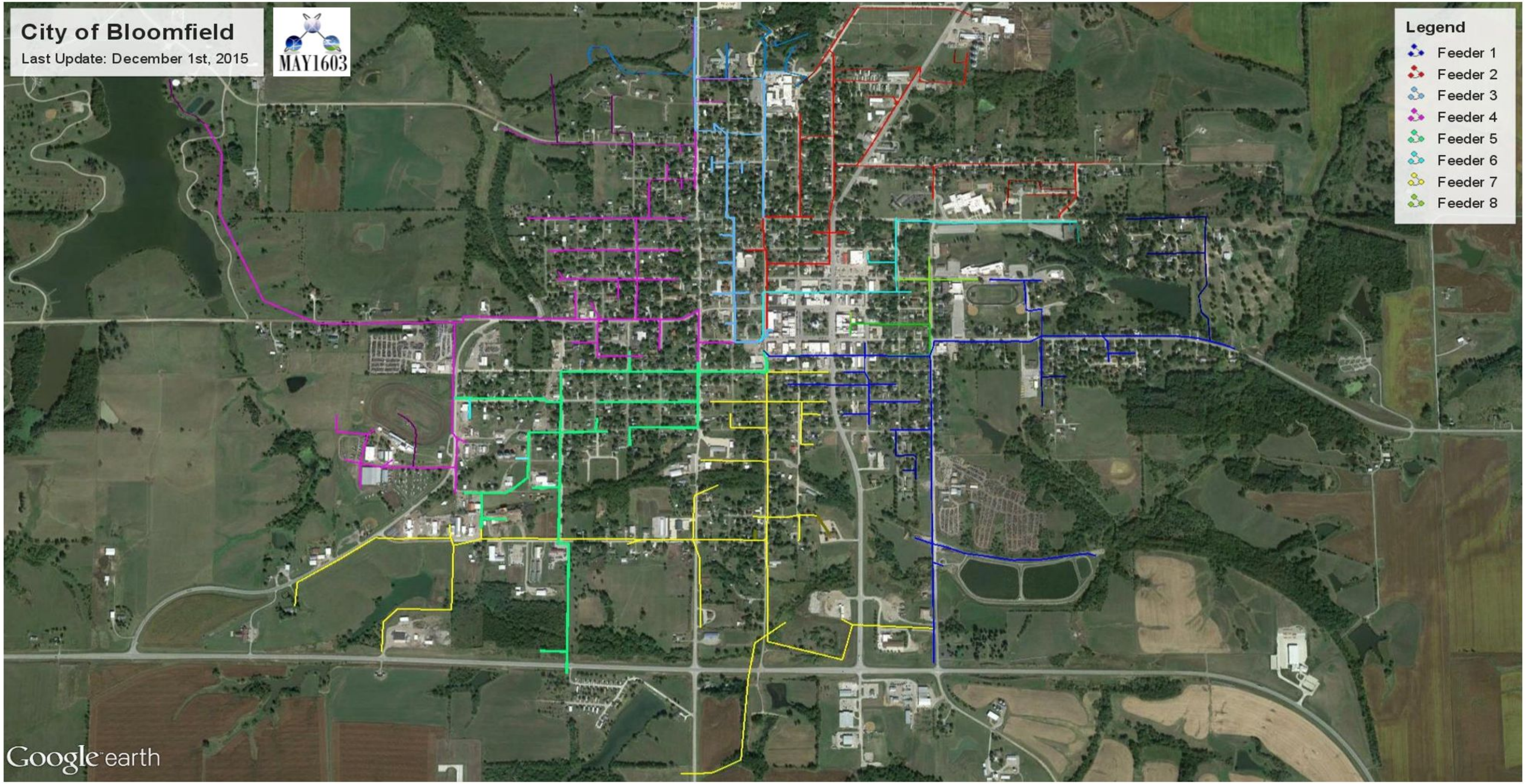
<u>Transformer Data:</u>

High V: 67kV
Low V: 4.16kV
kVA: 5000

System Map


N
TRANSMISSION AND DISTRIBUTION
INSPECTION SCHEDULE
YEAR
FEEDER
GASOLINE LISTI
JANUARY
FEBRUARY

System Map


City of Bloomfield
Last Update: December 1st, 2015
MAY1603
Legend
Feeder 1
Feeder 2
Feeder 3
Feeder 4
Feeder 5
Feeder 6
Feeder 7
Feeder 8
Google earth

System Requirements

Functional Requirements

10.05 PERMISSIBLE SECONDARY VOLTAGE VARIATION:

- “For 120-600 volt nominal service variations of no more than 5% above or below the standard voltage will occur.”

  All voltage regulation is handled by regulators at the sub-station. Try to maintain 125V as it leaves the sub.

10.06 PERMISSIBLE PRIMARY VOLTAGE VARIATION:

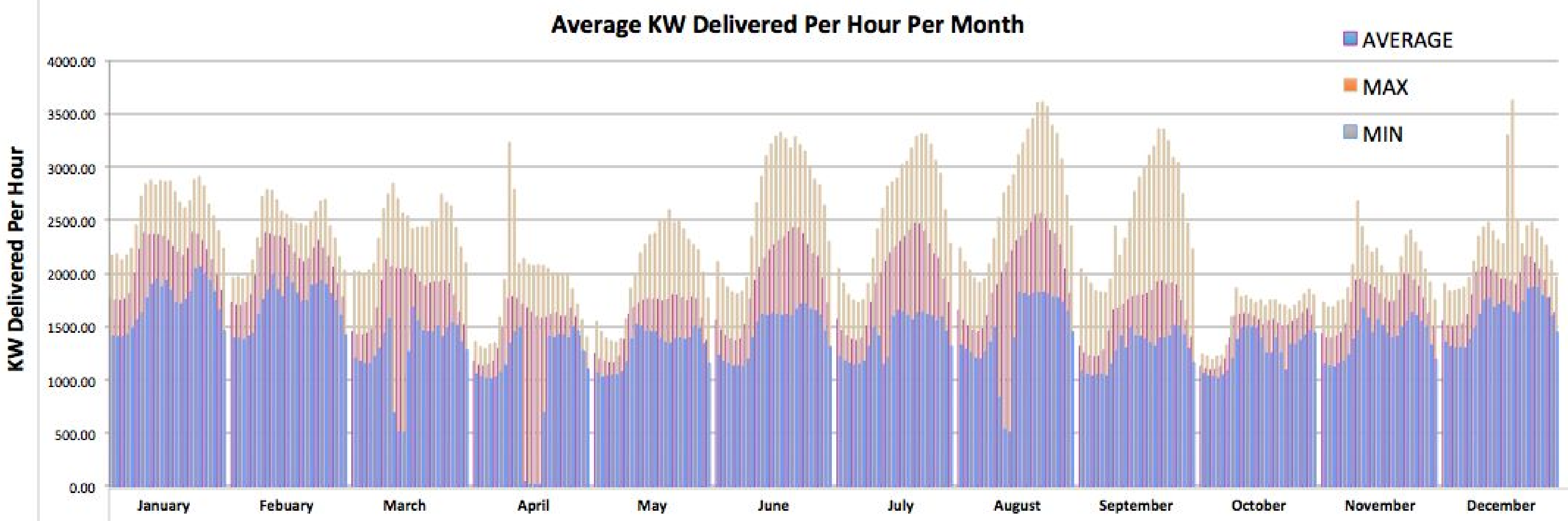
- “Variance of no more than 5% above or 2.5% below the standard nominal voltage”

Source: ELECTRIC TARIFF Filed with the I.U.B

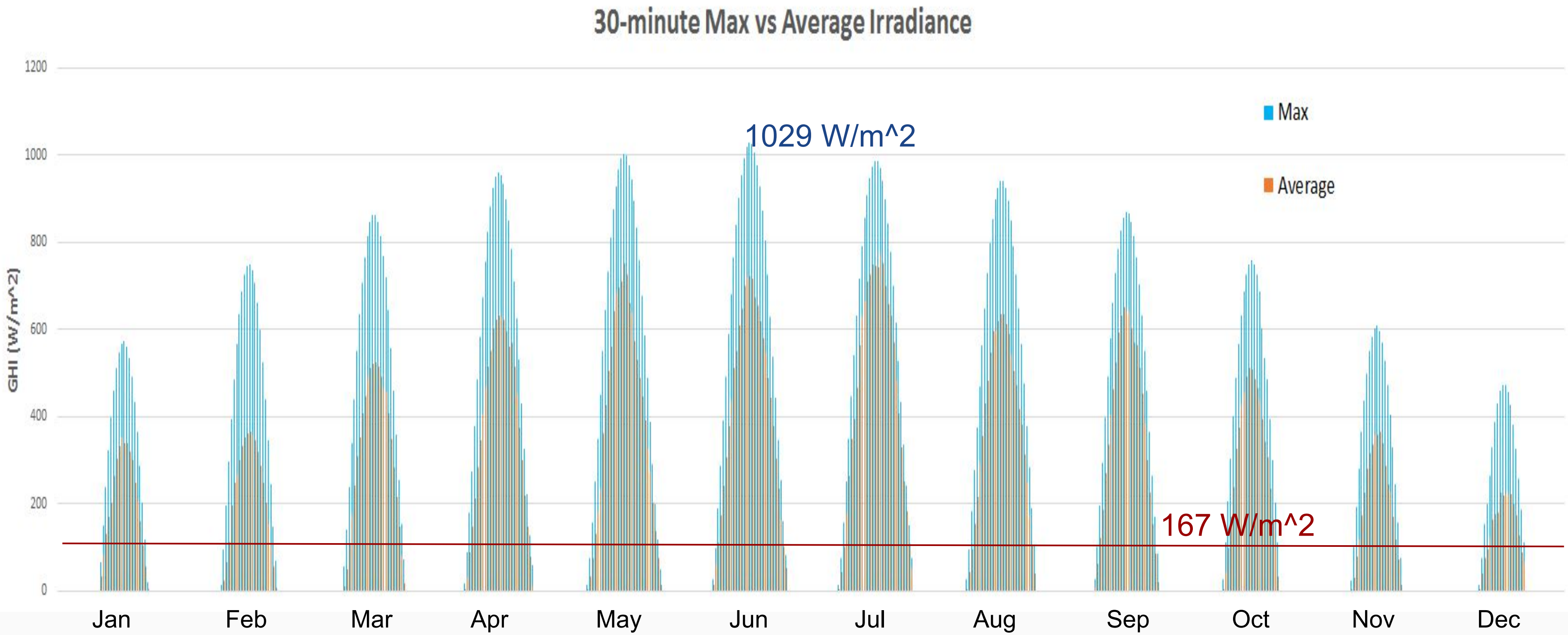
Nonfunctional Requirements

- What Type of DG System?
- Contract Stipulations with Current Power Provider
- System Sizing and Feasible Scalability
- Possible Locations
- Financial Implications

Sizing and Scalability



Irradiance



30-minute Max vs Average Irradiance
1200
1000
800
600
400
200
0
GHI (W/m^2)
Max
Average
1029 W/m^2
167 W/m^2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Potential DG Locations

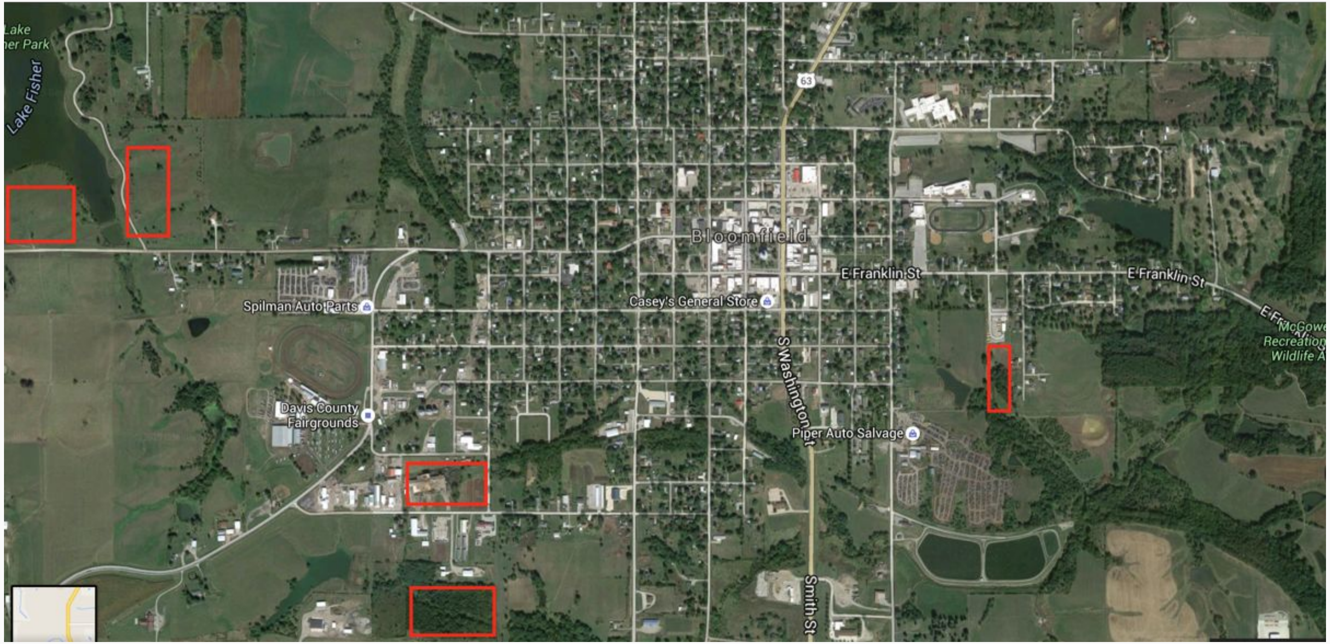
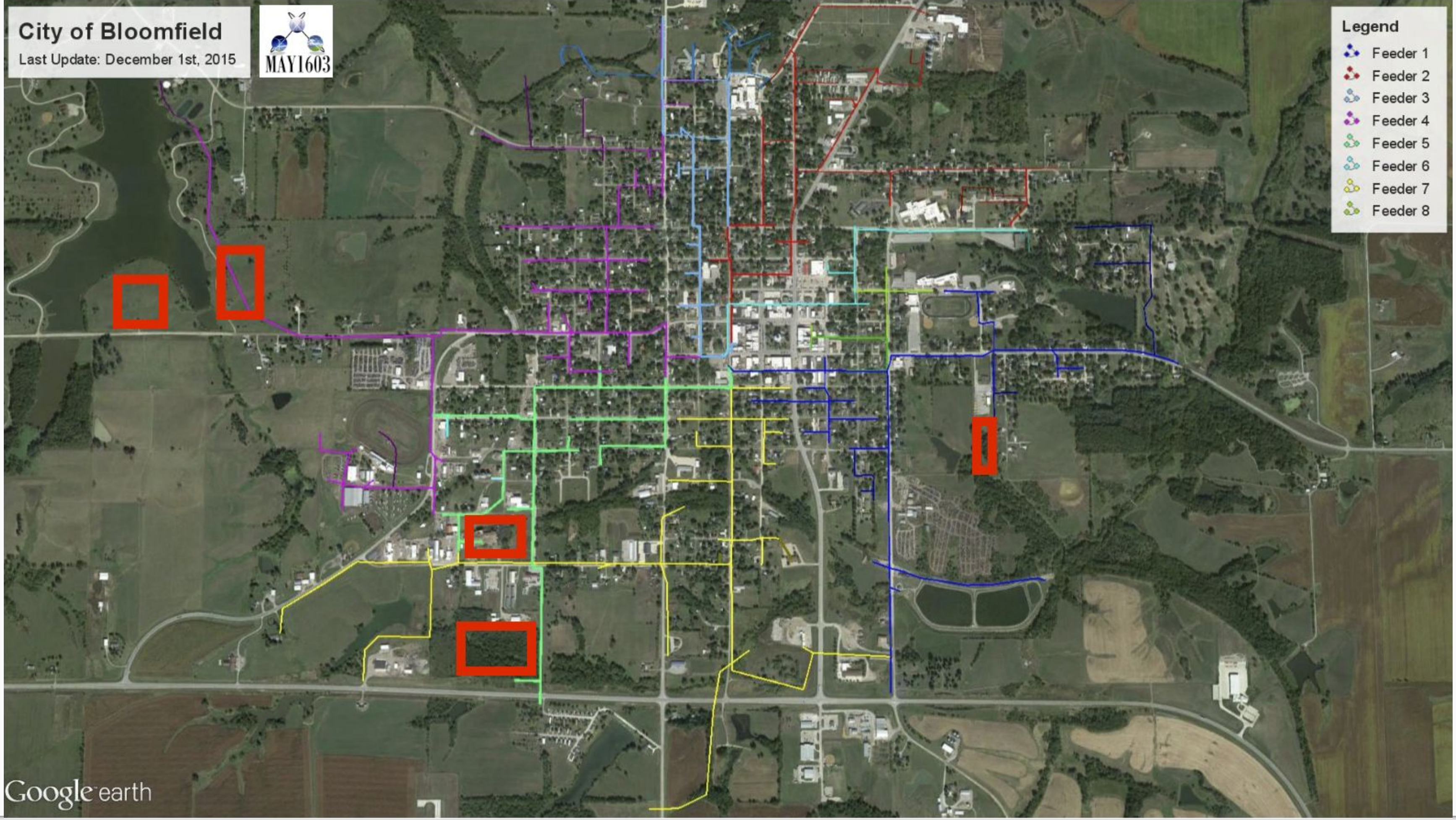


FIG. Locations provided by Chris Ball



Locations Overlaid Atop Existing Power Grid

Software

System Modeling

- OpenDss
  - Power distribution systems simulation tool
  - Supports all frequency domains
  - Intended to support DG integration
  - Can be modified to meet future needs i.e DG protection

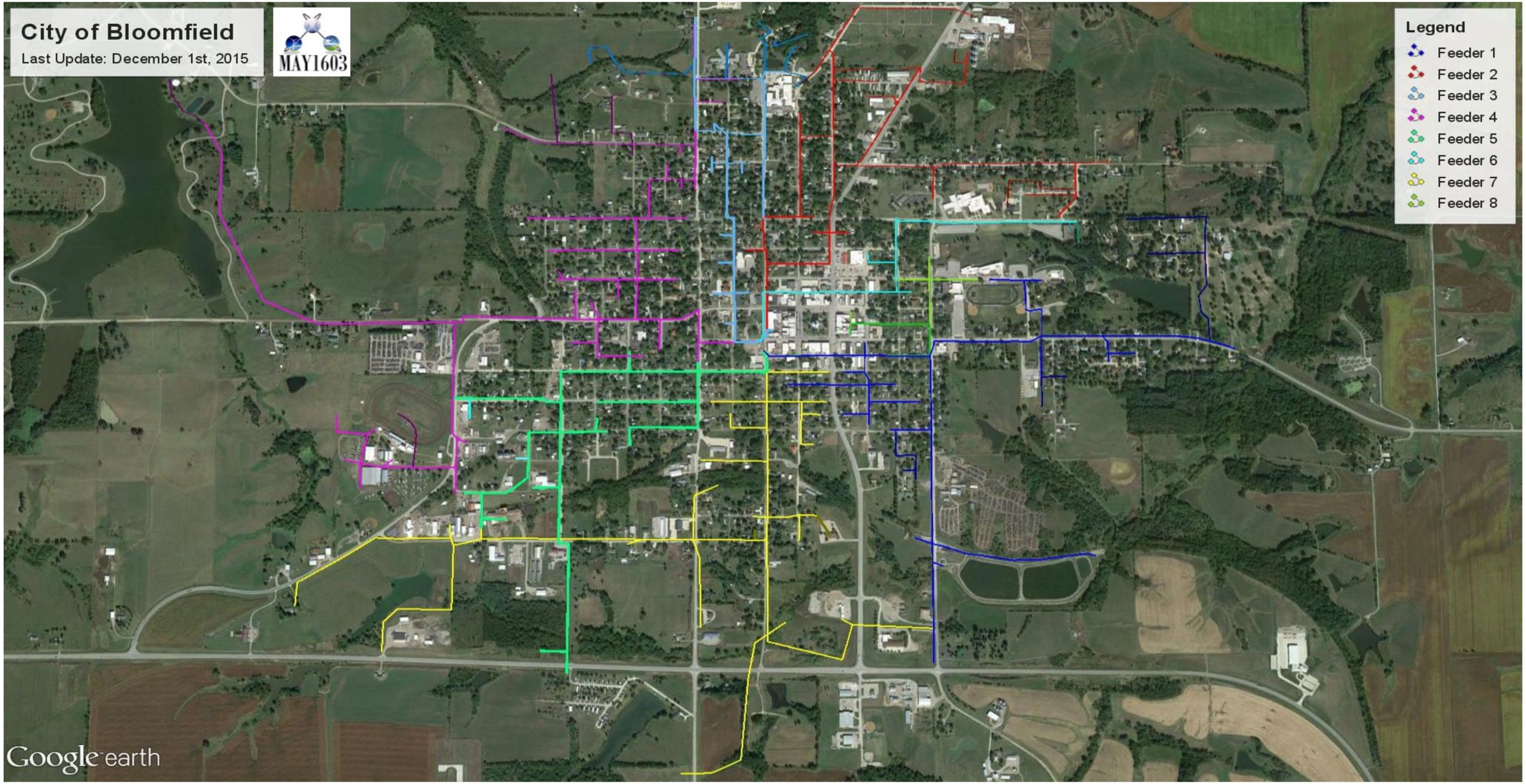
Testing

- Solar injection Expectations
    - Voltage rise on the feeders resulting in power loss reduction
    - $P = VI \qquad V=IZ$

      $P = I^2 Z$

      Impedance stays constant, current drops, power drops

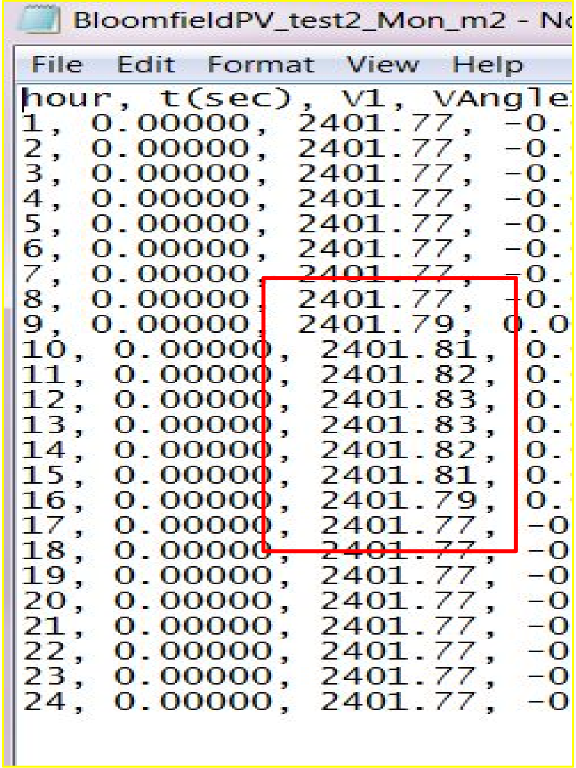
Existing System Infrastructure



Initial Simulation Results

- Acceptable voltage drop on feeders
- PV generator raises voltage
    - Data from January 2014
    - One feeder tested
    - Slight voltage rise between 8.00 am and 3.00 pm
    - Easily regulated at substation level
    - Not enough to stress the feeder

OpenDss Output


BloomfieldPV_test2_Mon_m2 - N

File Edit Format View Help

hour	t(sec)	V1	VAngle
1	0.00000	2401.77	-0.
2	0.00000	2401.77	-0.
3	0.00000	2401.77	-0.
4	0.00000	2401.77	-0.
5	0.00000	2401.77	-0.
6	0.00000	2401.77	-0.
7	0.00000	2401.77	-0.
8	0.00000	2401.77	-0.
9	0.00000	2401.79	0.0
10	0.00000	2401.81	0.
11	0.00000	2401.82	0.
12	0.00000	2401.83	0.
13	0.00000	2401.83	0.
14	0.00000	2401.82	0.
15	0.00000	2401.81	0.
16	0.00000	2401.79	0.
17	0.00000	2401.77	-0
18	0.00000	2401.77	-0
19	0.00000	2401.77	-0
20	0.00000	2401.77	-0
21	0.00000	2401.77	-0
22	0.00000	2401.77	-0
23	0.00000	2401.77	-0
24	0.00000	2401.77	-0

FIG. Feeder 1 simulated using 2 MW PV generator

Model Uncertainties

- Limited Data
- Assumptions
  - Balance load
  - Uniformly distributed
  - Spot loads

Summary

Plan for Next Semester

Solar PV Generation

- Cost Analysis
- Optimal Locations
- System/Upgrade Recommendations

May investigate the following:

- Energy Efficient Programs
- Install Direct Load Control
- Diesel Power Plant
- Wind Generation
- Micro-Turbines
- Battery Energy Storage
- Biodigester Generation
- Geothermal Energy

Questions?

Sources

Chiong, L. N. *Network losses with penetration of photovoltaic (PV) as distribution generation (DG) resource.* Universiti Teknologi Malaysia, June 2012.

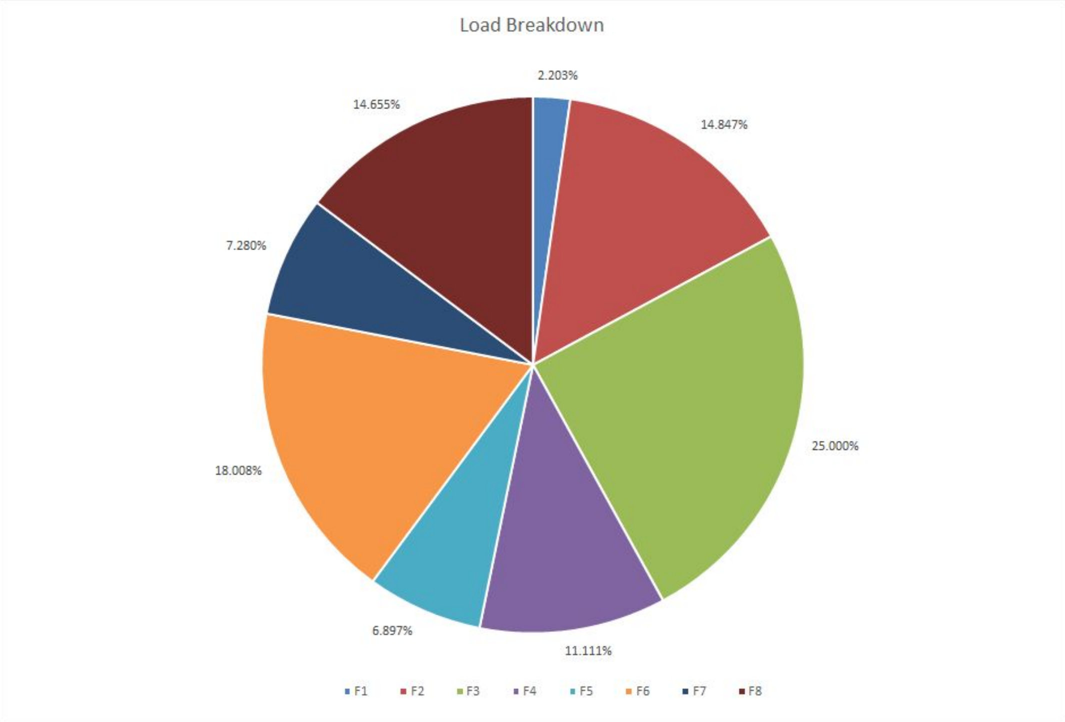
Electrical Load Estimation – Part Two. (n.d.). Retrieved December 9, 2015, from http://www.electrical-knowhow.com/2012/11/electrical-load-estimation-part-two.html

The NSRDB Data Viewer. National Renewable Energy Laboratory, n.d. Web. 08 Dec. 2015. <https://mapsbeta.nrel.gov/nsrdb-viewer/>.

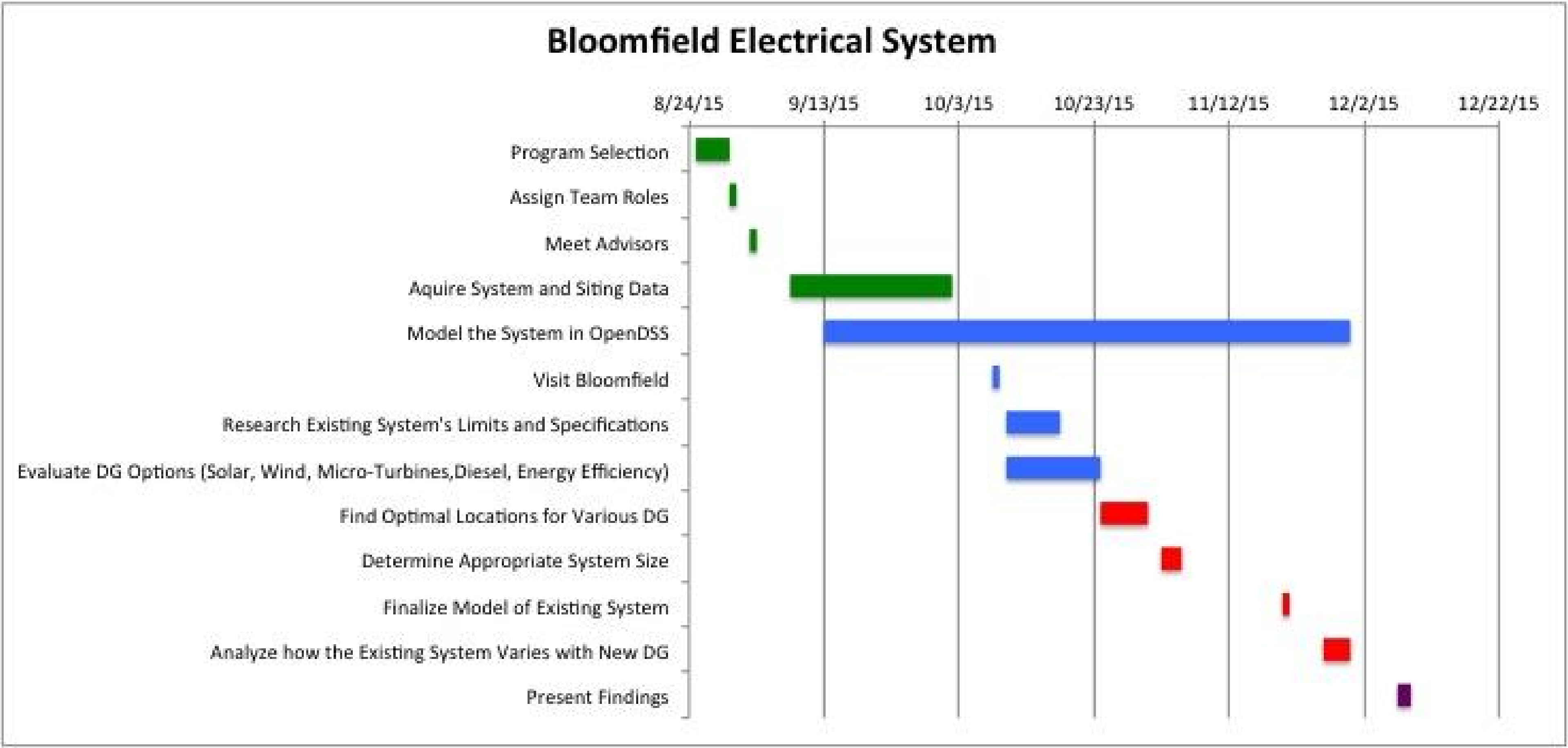
Maher, James P. *GENERAL RULES AND REGULATIONS FOR ELECTRIC SERVICE STANDARDS*. Iowa Utilities Board, 2007. Web. 1 Dec. 2015.

Appendix

Load Breakdown



Timeline



Bloomfield Electrical System
8/24/15
9/13/15
10/3/15
10/23/15
11/12/15
12/2/15
12/22/15
Program Selection
Assign Team Roles
Meet Advisors
Aquire System and Siting Data
Model the System in OpenDSS
Visit Bloomfield
Research Existing System's Limits and Specifications
Evaluate DG Options (Solar, Wind, Micro-Turbines,Diesel, Energy Efficiency)
Find Optimal Locations for Various DG
Determine Appropriate System Size
Finalize Model of Existing System
Analyze how the Existing System Varies with New DG
Present Findings