Iowa State University
College of Engineering

Ames Microgrid Evaluation & Substation Consulting

sdmay25-02

Sean Carver, Bethany Danley, Thomas Edwards,
Nathan Kallal, Mina Khalil,
MacKenzie Woods

Team Members & Roles

Sean Carver - Substation Team
Mina Khalil - Substation Team
MacKenzie Woods - Substation Team

Bethany Danley - Distribution Team
Thomas Edwards - Distribution Team
Nathan Kallal - Distribution Team

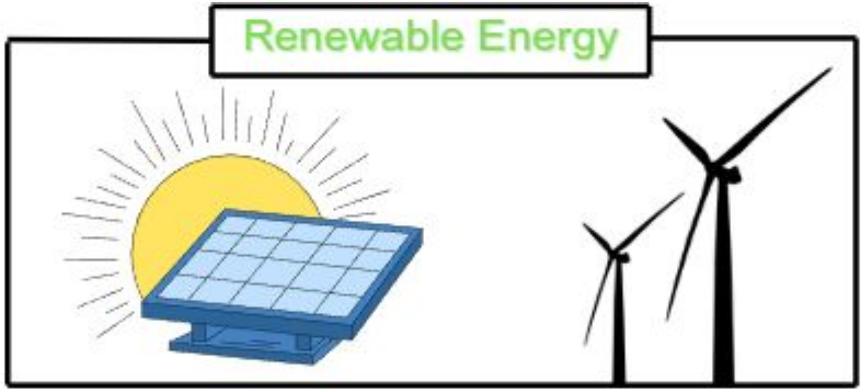
Project Overview

Client: Burns & McDonnell
Faculty Advisor: Zhaoyu Wang
User: ISU Utilities and Customers
Project Goals:

- Modernize ISU's substation and microgrid infrastructure
- Enable scalable transmission and distribution systems

Key Objectives:

- Deliver a safe, reliable substation design package
- Model a resilient microgrid with renewable energy integration and contingency support



Client Information

Burns & McDonnell:

- Engineering, Procurement, & Construction (EPC) firm with strong presence in power generation and transmission
- Our clients work in the Substation division under Transmission & Distribution

1898 & Co.:

- Consulting arm of Burns & McDonnell
- Our client represents the Distribution Consulting team

Problem Statement

Task:	• Model ISU's electric distribution microgrid and design a new substation
Objective:	• Deliver comprehensive models for both systems
Deliverables:	• Provide data-driven documentation supporting upgrade plans
Goal:	• Ensure reliable, scalable infrastructure for future campus growth

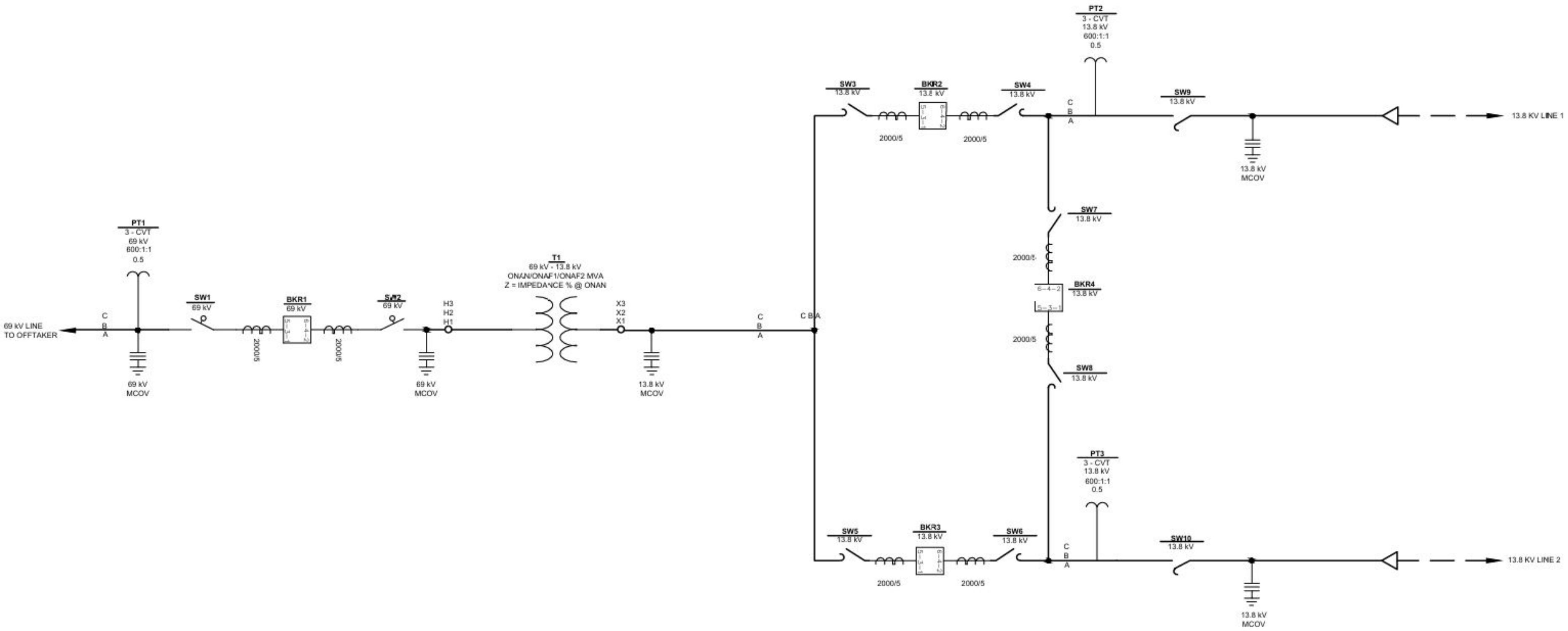
Transmission Team Goals

- Design a 69kV -13.8kV substation
- Ensure safe layout and grounding
- Deliver clear documentation and modeling

Construction One-Line (COL)

- Show equipment ratings, connections, grounding, and protection
- Guides contractors in installation and layout
- Ensures alignment with design standards and safety codes

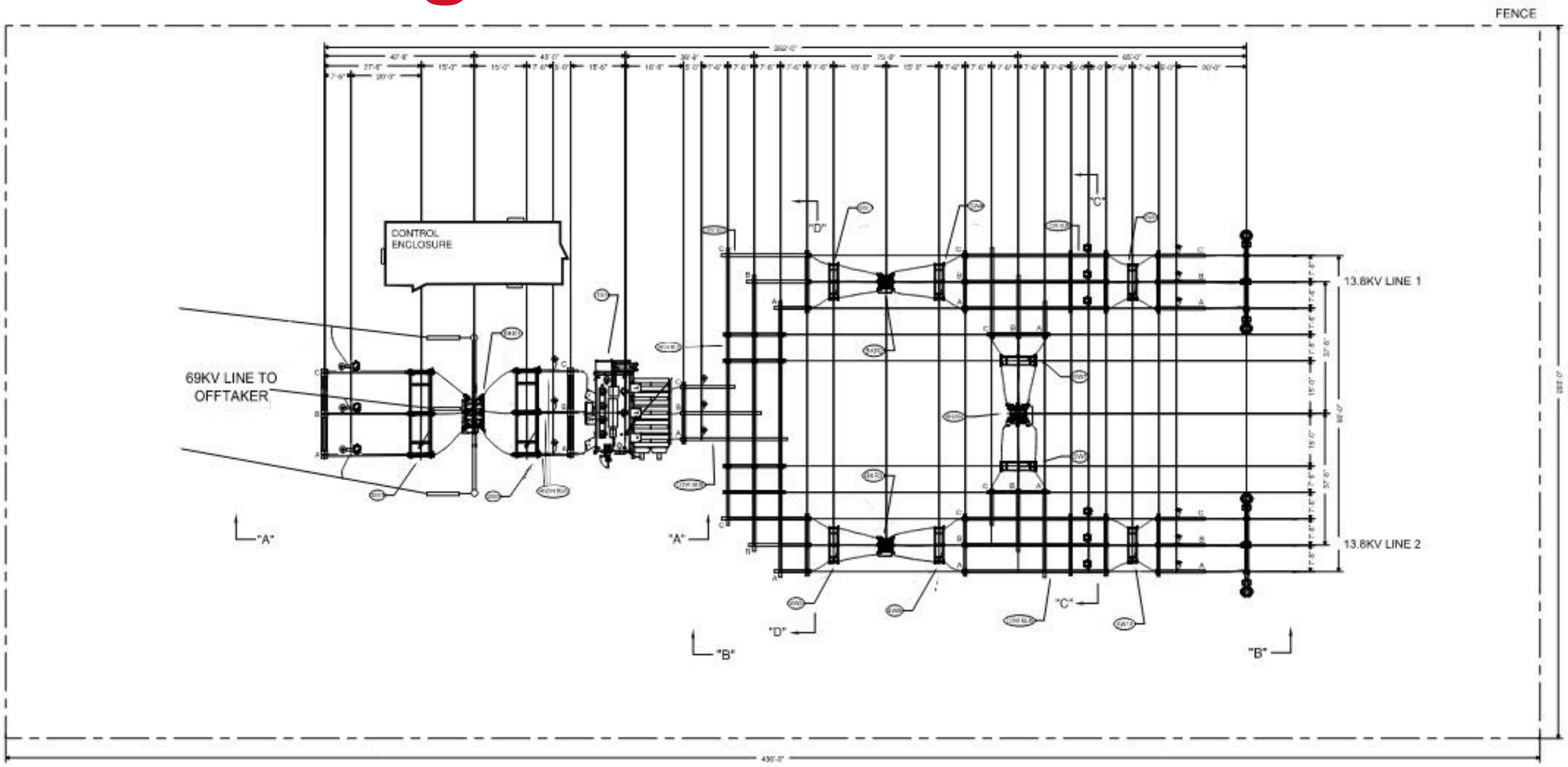
COL Drawing Revision 5



General Arrangement (GA)

- Displays physical layout of substation equipment
- Ensure safe spacing per IEEE & NEC standards
- Aids in maintenance access, crew safety, and future scalability
- Created using AutoCAD and Bluebeam for accurate scaling

GA Drawing Revision 5

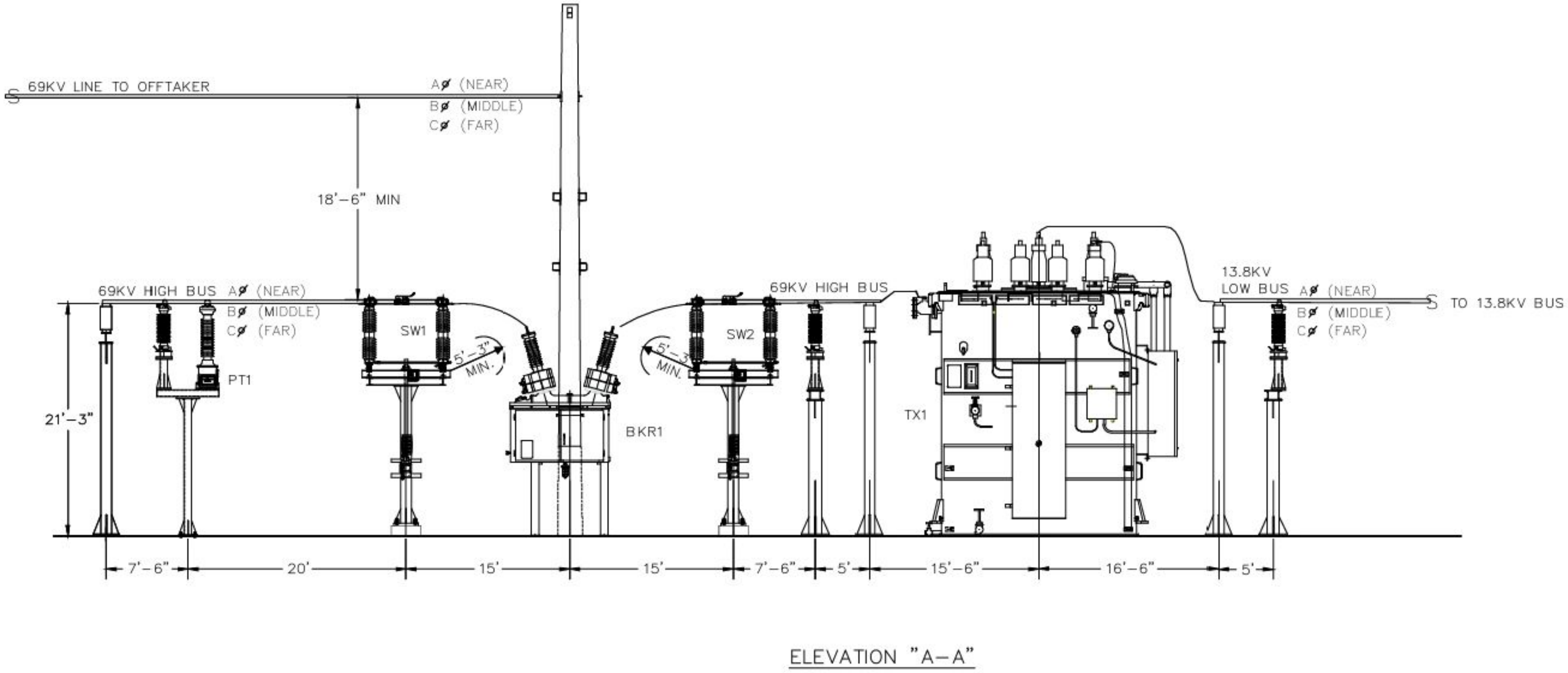


Elevations

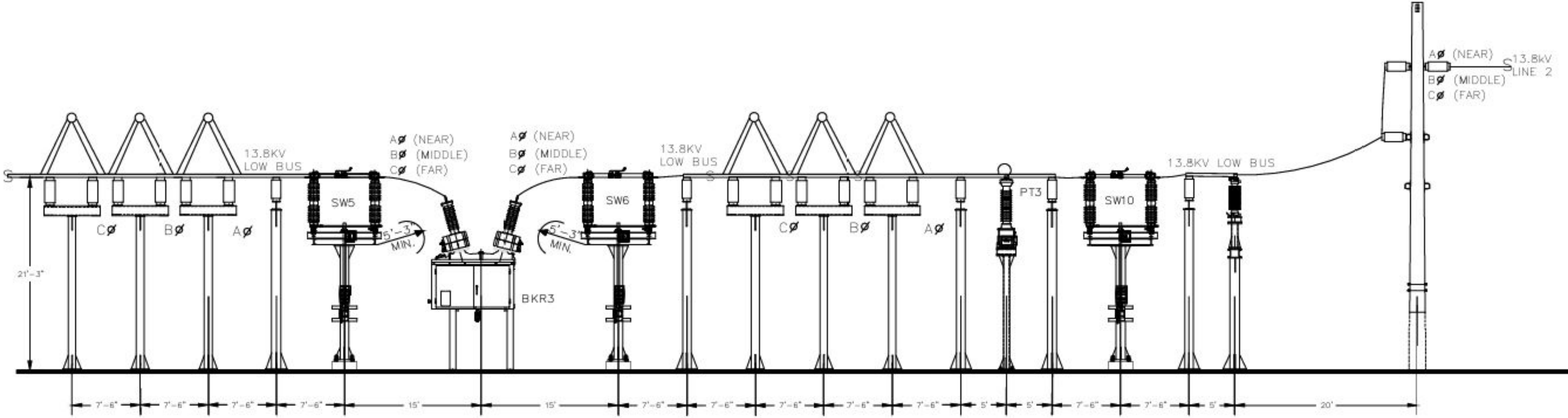
- Illustrates vertical dimensions of substation structures
- Defines height clearances for buses, breakers, disconnects, etc.
- Verifies compliance with clearance and safety standards (IEEE 605)
- Supports coordination with rigid bus design and GA drawing

https://www.gwelectric.com/products/switchgear/?creative=&keyword=switch%20gear%20company&matchtype=p&network=o&device=c&msclkid=e1928eb4224f18c27ba6e6ac165d521c&utm_source=bing&utm_medium=cpc&utm_campaign=Generic-Phrase&utm_term=switch%20gear%20company&utm_content=switchgear

Elevation “A-A” Drawing Revision 6

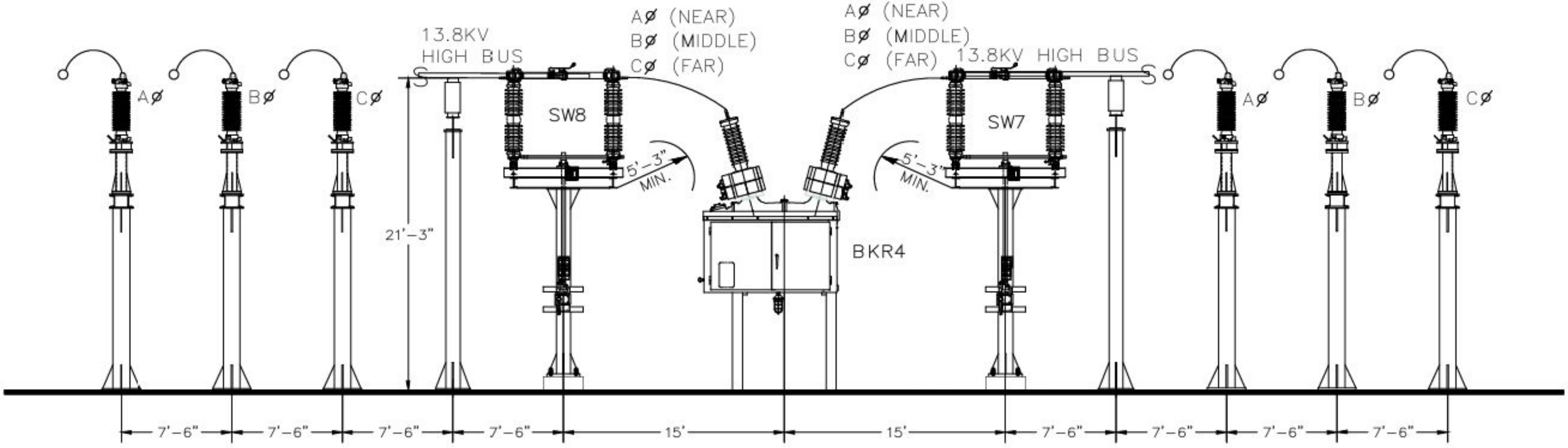


Elevation “B-B” Drawing Revision 5



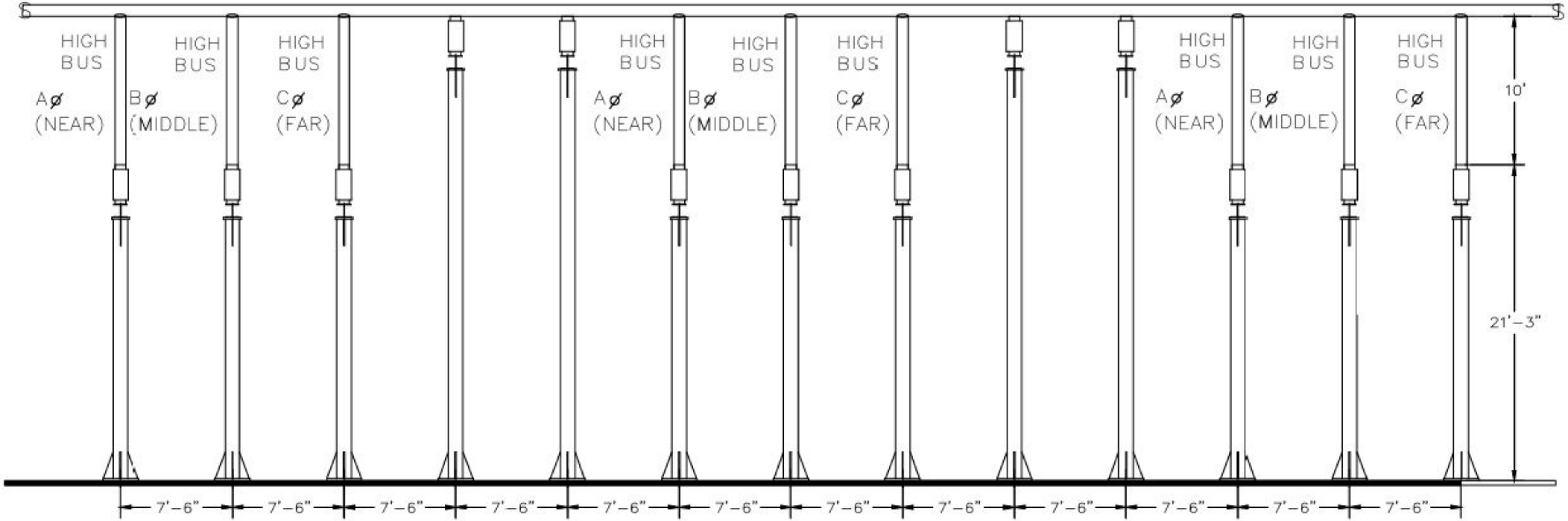
ELEVATION "B-B"

Elevation “C-C” Drawing Revision 4



ELEVATION "C-C"

Elevation "D-D" Drawing Revision 4



ELEVATION "D-D"

Clearance Checks

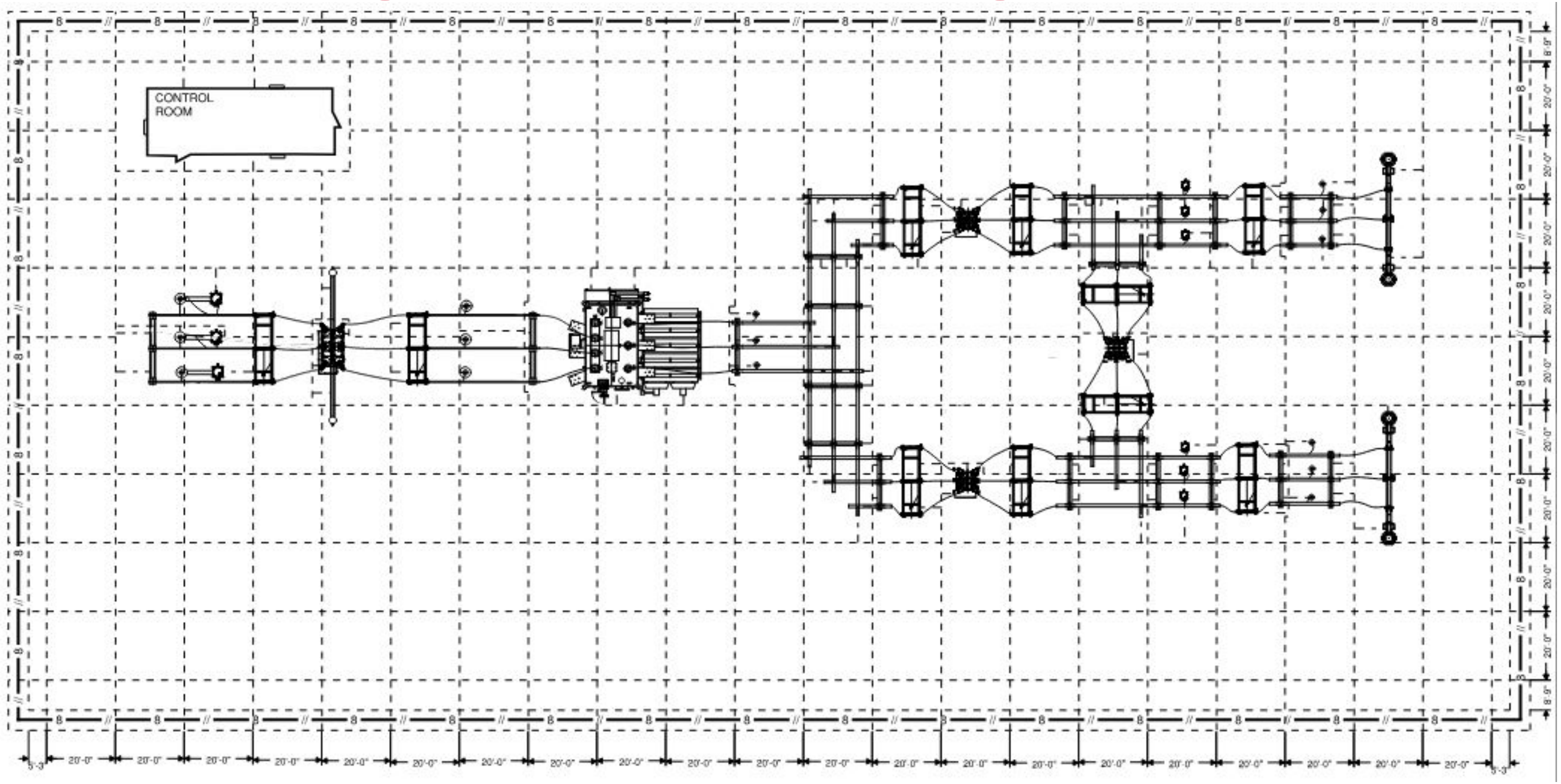
- Verified equipment spacing against IEEE 605 and NESC (IEEE C2-2023) standards
- Ensured safe working distances and arc flash protection zones
- Addressed horizontal & vertical clearances for maintenance and operation

IEEE SA STANDARDS ASSOCIATION

Grounding Plan

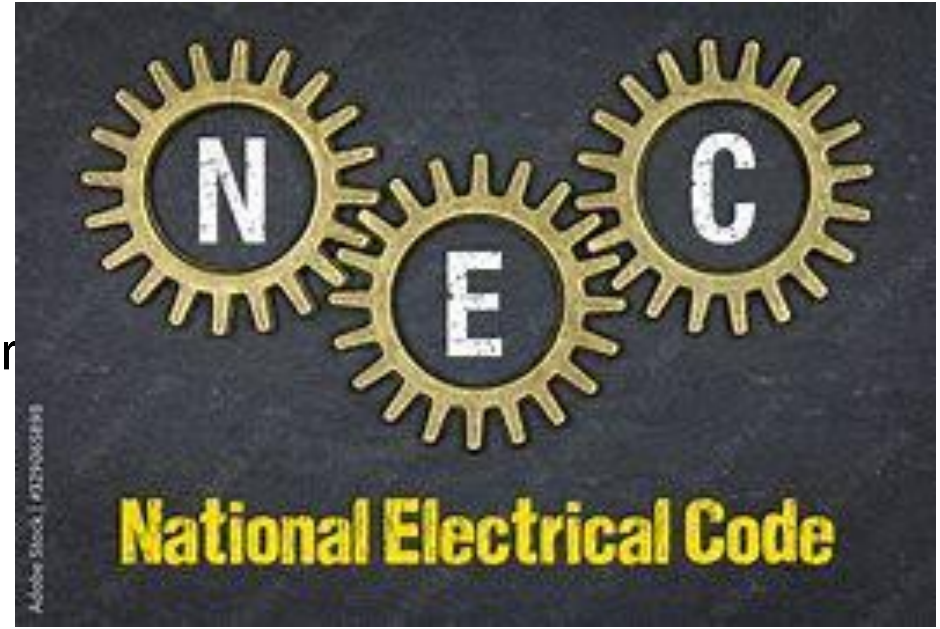
- Design in compliance with IEEE 80-2013 and IEEE 142-2007
- Ensured touch and step potential safety under fault conditions
- Ground grid layout supports equipment protection and personnel safety
- Verified through scaled drawings and calculations in Bluebeam

Grounding Plan Drawing Revision 2



Cable and Conduits

- Identified routing paths between major equipment: transformers, breakers, relays, and control building
- Considered separation of power and control cables for safety and signal integrity
- Sized and specified conduits based on NEC guidelines



[NEC National Electrical Code Stock Photo | Adobe Stock]

Low-Level Bill of Materials (LLBOM)

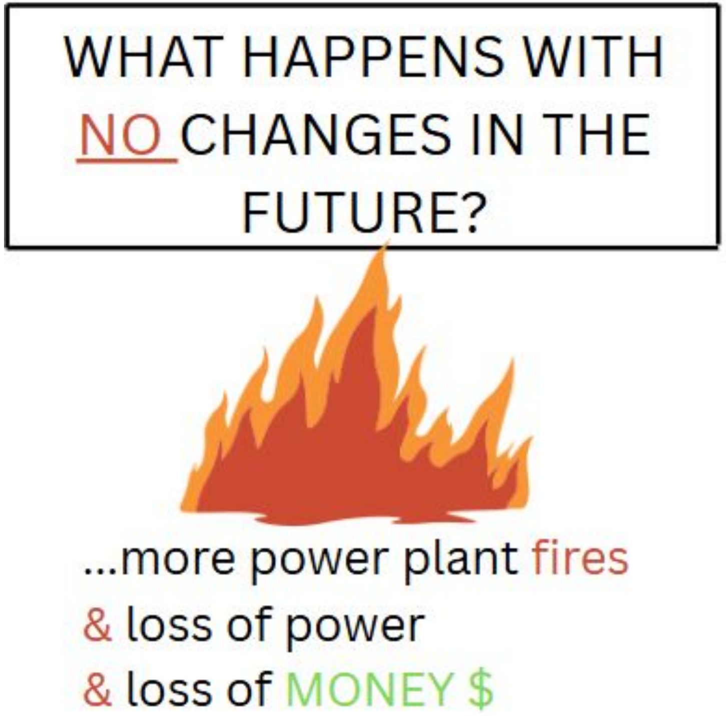
- Created detailed component list for both substation and distribution systems
- Included key equipment: transformers, circuit breakers, relays, grounding material, control panels, and cables
- Documented quantities
- Ensured compatibility with design layout and system ratings

LLBOM Drawing Revision 0

Bill of Materials (BOM)						
Stock Number	Description	Unit of Measure	Quantity	Unit Price	Total Price	Refrences
1	69 kV Surge Arrester	Unit	6	$ 2,000.00	$ 12,000.00	Link
2	13.8 kV Surge Arrester	Unit	9	$ 1,000.00	$ 9,000.00	Link
3	69 kV Capacitive Voltage Transfomer (PT)	Unit	3	$ 6,000.00	$ 18,000.00	Link
4	13.8 kV Capacitive Voltage Transfomer (PT)	Unit	6	$ 5,500.00	$ 33,000.00	Link
5	69 kV - 13.8 kV Transfromer (T)	Unit	1	$ 100,000.00	$ 100,000.00	Link
6	69 kV Disconnect Swtich (SW)	Unit	2	$ 10,000.00	$ 20,000.00	Link
7	2000/5 Current Transfomer (CT)	Unit	24	$ 500.00	$ 12,000.00	Link
8	69 kV Circuit Breaker (BKR)	Unit	1	$ 50,000.00	$ 50,000.00	Link
9	13.8 kV Disconnet Switch (SW)	Unit	8	$ 20,000.00	$ 160,000.00	Link
10	13.8 kV Circuit Breaker (BKR)	Unit	3	$ 20,000.00	$ 60,000.00	Link
11	Motor Operators for 69 kV Swtiches	Unit	2	$ 5,000.00	$ 10,000.00	Link
12	69 kV Insulator	Unit	6	$ 300.00	$ 1,800.00	Link
13	13.8 kV Insulator	Unit	57	$ 100.00	$ 5,700.00	Link
14	69 kV Tubular Bus	FT	80	$ 50.00	$ 4,000.00	Link
15	13.8 kV Tubular Bus	FT	645	$ 50.00	$ 32,250.00	Link
16	69 kV Strain Bus	FT	94	$ 50.00	$ 4,700.00	Link
17	13.8 kV Strain Bus	FT	615	$ 50.00	$ 30,750.00	Link
Total					**$ 563,200.00**	

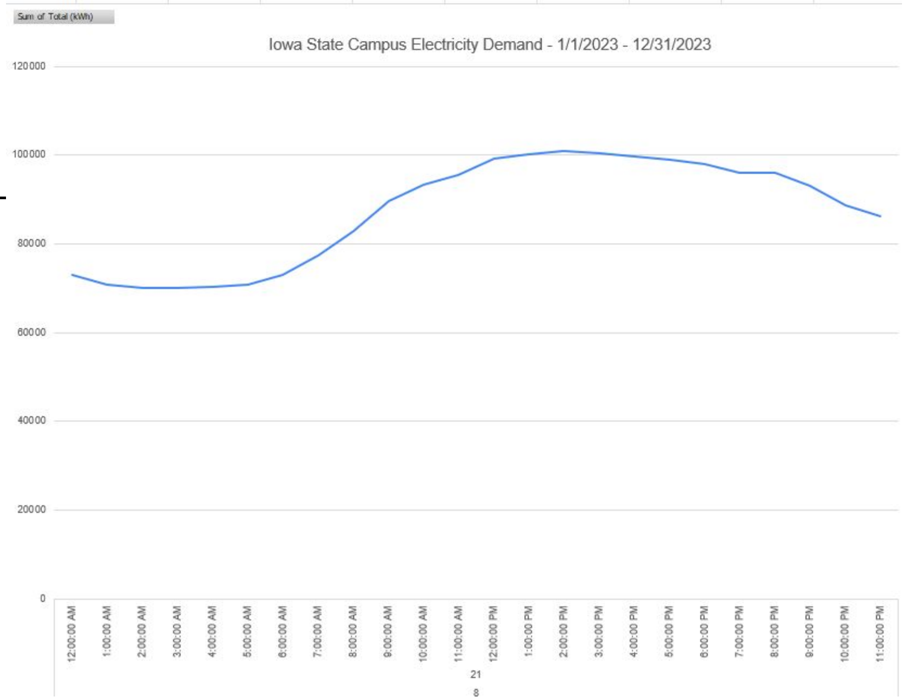
Distribution Team Goals

- Support Load Growth
- Ensure Reliable Power Delivery
- Integrate Distributed Energy Resources (DERs)
  - Solar Panels, Small Wind Turbines, Battery Storage
- Improve System Resilience
- Enhance Efficiency

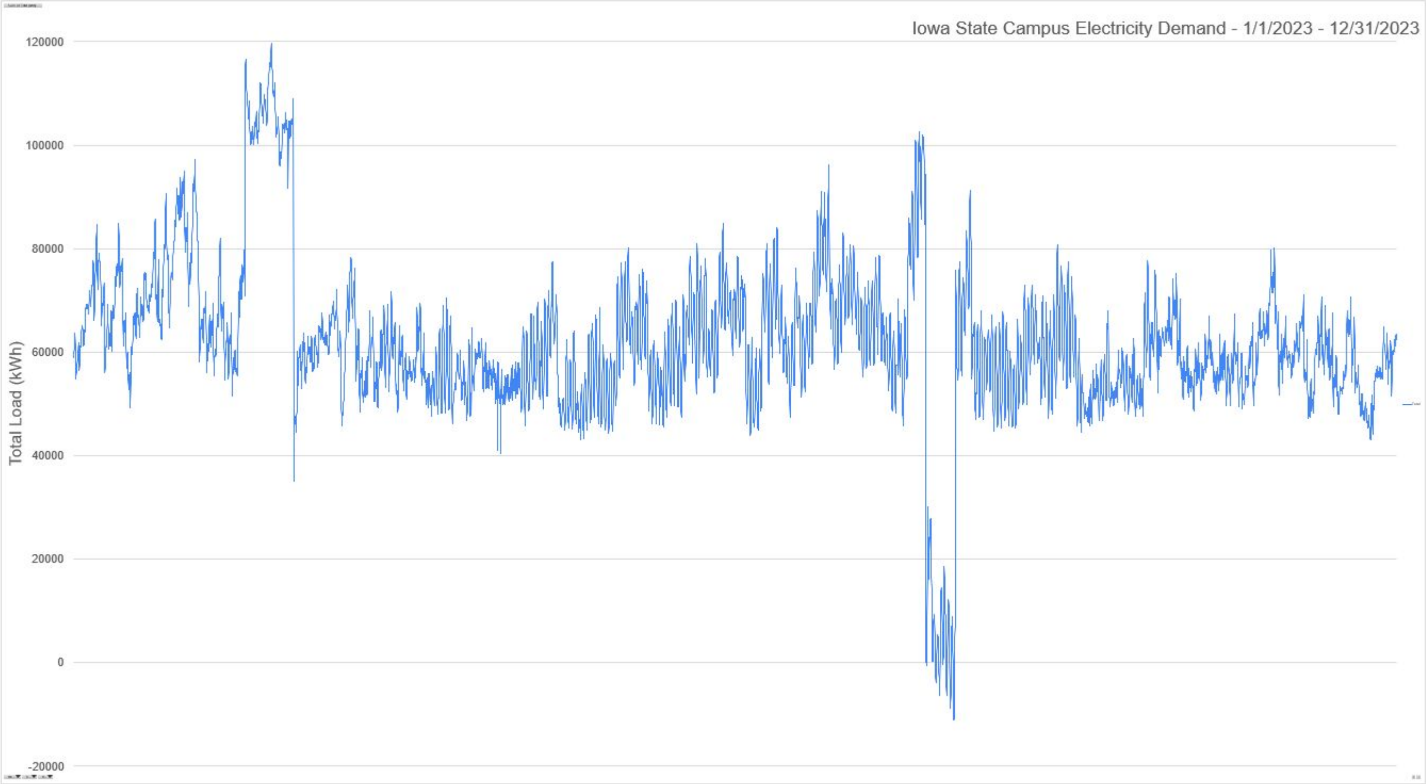


Campus Load Profile Goals

- Data provided by the City of Ames
- Converted from Yearly Load – Daily BTU → Daily kWh
- Image shown : Yearly load
- Next slide: put in just a daily load to show the load shape for a typical day



Campus Load Profile



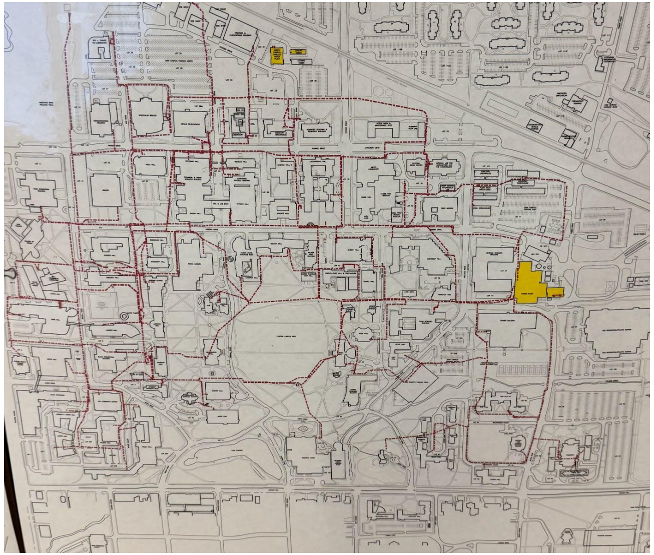
Distribution Planning Source

Power Sources:
- Generated at Power Plant or purchased

Underground Distribution System:
- Medium voltage cables run through steel conduits and concrete duct banks

Substations:
- Includes transformers and/or switchgear

Voltage Distribution:
- Electricity supplied: 13,800V or 4,160V
- Over 500 building transformers to manage voltage
  - Reduce voltage to 480V, 208V, and/or 120V



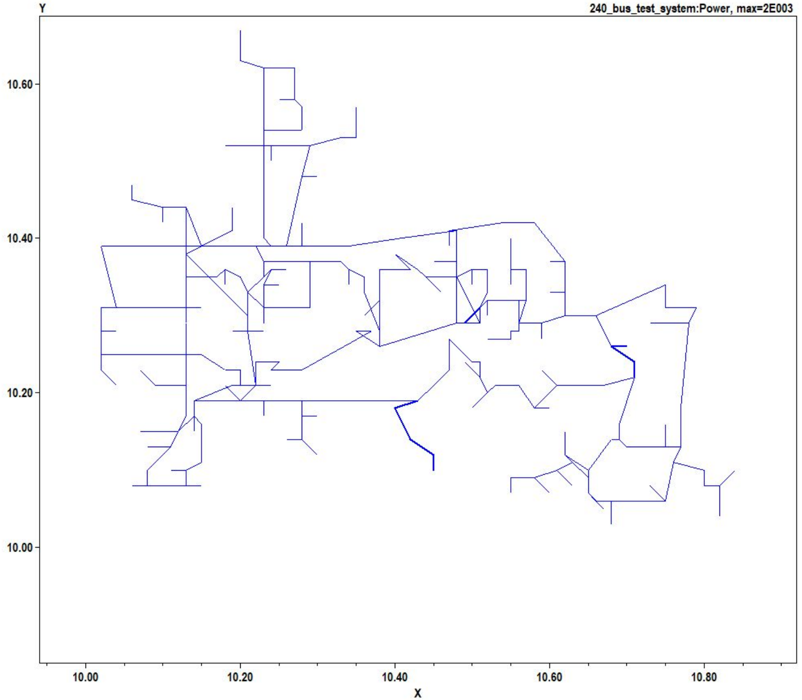
Conversion to OpenDSS

Plotting Load Points

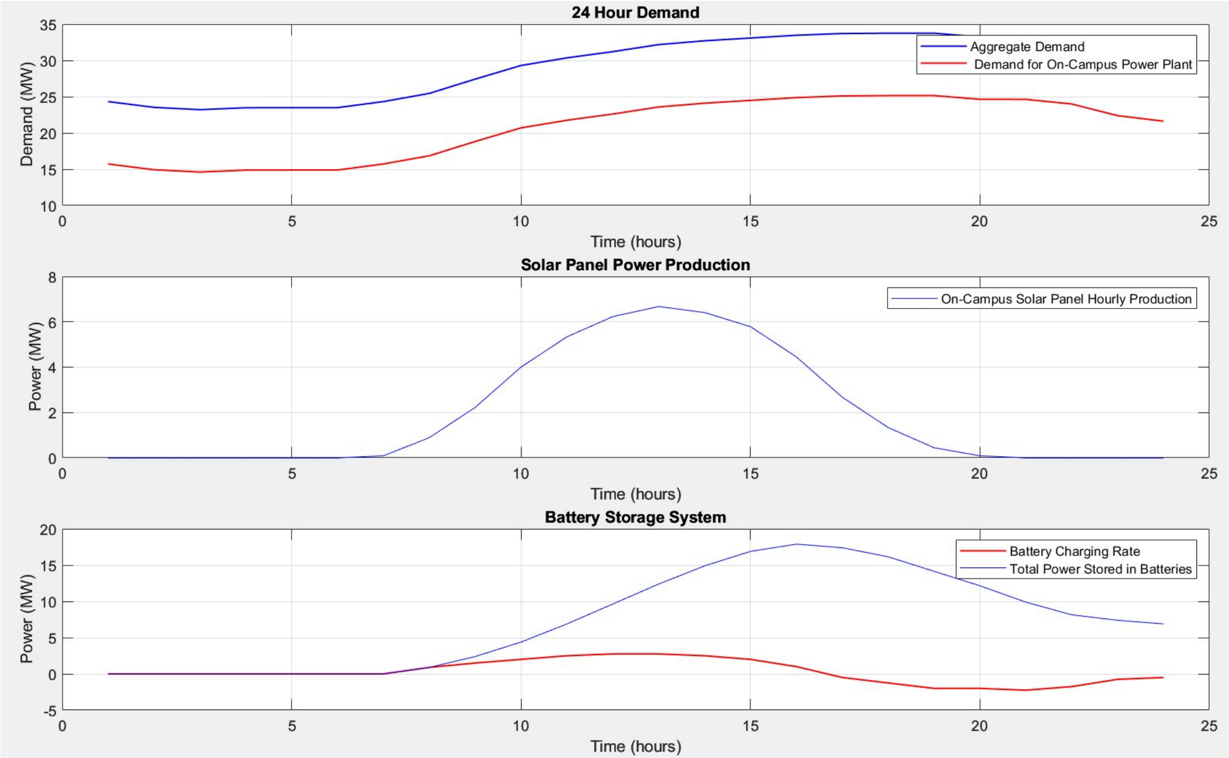
- Google Earth used to determine relative locations
- Map location mirrors the loads found in the ISU Power Plant

Underground Distribution System

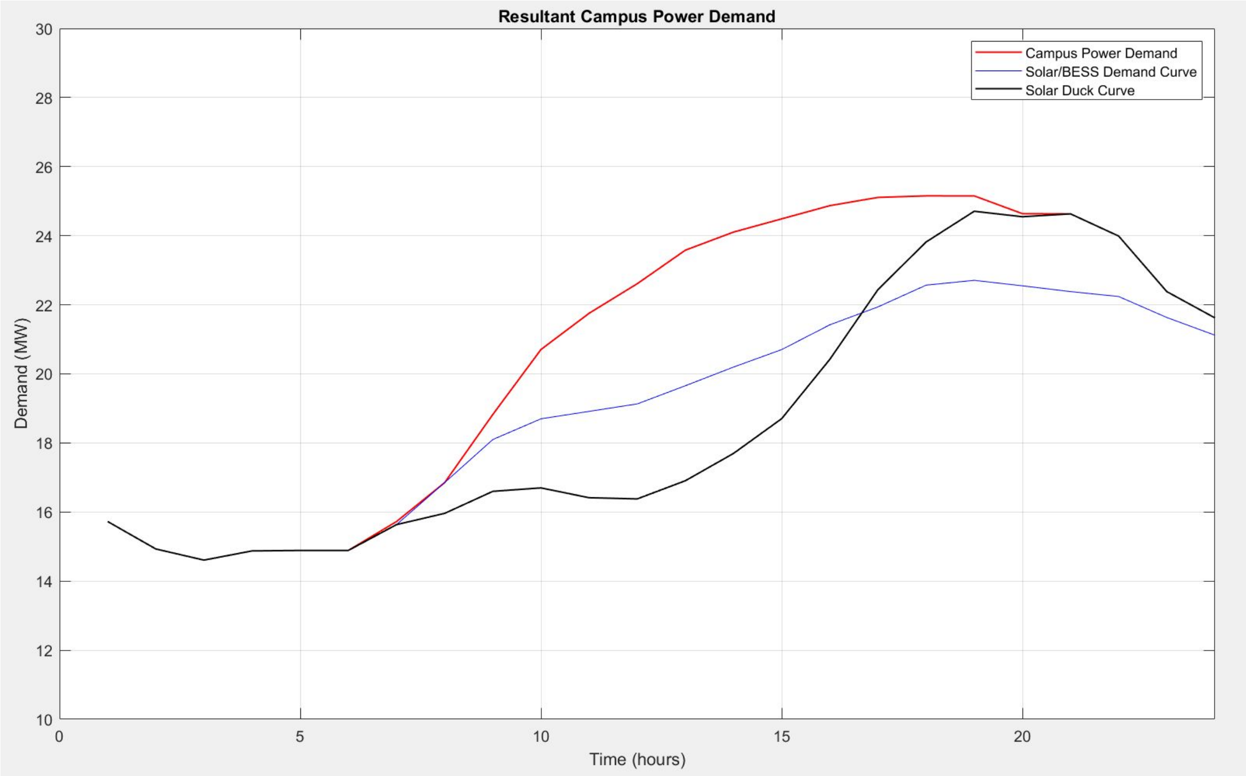
- Instructor-provided impedances for underground cables used (R + jX /mile values)



Average Campus Load



Average Campus Load



Conclusion

- Developed comprehensive models for ISU’s substation and microgrid
- Ensured designs support safety, reliability, and scalability
- Integrated renewable energy and battery storage to enhance campus resilience
- Aligned design with IEEE standards and client needs
- Delivered documentation and models to support future implementation

Questions?

BURNS & McDONNELL

CREATE AMAZING.