115/34.5kV Solar Power Plant & Substation Design Project

Design Document

Team Number: 18
Client: Black & Veatch
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Executive Summary

Development Standards & Practices Used

We will use our knowledge in power systems as well as programs such as ETAP, Bluebeam, and AutoCAD to design a 115/34.5 kVA substation and solar field. We will use IEEE standards, as well some OSHA standards to ensure we construct a safe environment for everyone involved.

Summary of Requirements

List all requirements as bullet points in brief.

* Equipment sizing calculations (breakers, transformers, etc) – Excel files
* Solar layout drawings – Bluebeam/CAD/PDF editor
* Solar panel string sizing design – Excel files
* Electrical layout drawings (substation equipment) – Bluebeam/CAD/PDF editor
* Grounding analysis and ground-grid developed with IEEE-80 – Excel files
* Bus calculations for substation – Excel files
* Possibility of additional calculations (DC battery bank, lightning protection, etc.) – Excel files
* Creation of solar/substation design-optimizing tool – TBD
*Simulation of designed substation – SIMULATION SOFTWARE – STUDENT LICENSE [ETAP/SKM/ASPEN]
* Coordination Study / AC Arc Flash Study / Protection Element Analysis – SIMULATION SOFTWARE – STUDENT LICENSE [ETAP/SKM/ASPEN]
* Load Flow Scenario Wizard / Configuration Manager – SIMULATION SOFTWARE – STUDENT LICENSE [ETAP/SKM/ASPEN]

Applicable Courses from Iowa State University Curriculum

List all Iowa State University courses whose contents were applicable to your project.

EE322 Semiconductor Devices

EE303 Power System

EE455 Distribution System

EE456 Power System 1

EE457 Power System 2

New Skills/Knowledge acquired that was not taught in courses

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum in order to complete this project.

CAD – Computer-Aided-Design

ETAP – Electrical Transient Analysis Program

Solar and Substation Design

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team members

1.1.1 Baylor Clark

1.1.2 Eduardo Jimenez-Tzompaxtle

1.1.3 Eli Schaffer

1.1.4 Liam Gossman

1.1.5 Chicheng Tang

1.1.6 Siti Mohd Radzi

1.2 Required Skill Sets for Your Project

Technical Wise

CAD - Solar layout drawings

IEEE-80 - Grounding analysis and ground-grid calculations

Excel - Equipment sizing calculations, additional calculations (DC battery bank, lightning protection,etc), solar panel string sizing design. Grounding analysis and ground-grid calculations

ETAP/SKM/ASPEN- Solar Substation Simulation, Load flow scenario, Protection Element Analysis,

ETAP (Electric Transient Analysis Program) - Simulation software

Bluebeam - Electrical Layout drawings

1.3 Skill Sets covered by the Team

(for each skill, state which team member(s) cover it)

Everyone- Grounding and ground-grid circuit calculations/analysis

Baylor Clark: I have experience with project management and team communication through internships the past two summers. I also have experience working on projects with a couple of the other members in the group from previous classes.

Elymus Schaffer: I bring my extrovert personality to help me invoke thought provoking questions and discussions for our team. I have also worked for companies throughout semesters while also keeping my grades up and communicating effectively with my employer. I have knowledge in creating a Bill of Materials and being able to help schedule who does what, when.

Eduardo Jimenez-Tzompaxtle: I have experience working with a group and communicating with people. I have taken some classes in transmission and power

Chicheng Tang: I have experience collaborating with team members to complete the work. And I have taken a class about distribution and transmission systems.

Liam Gossman: I have experience with substation design and general operations through my internships at MidAmerican Energy. I also have experience with distribution systems design, as well as effective communications skills necessary for collaboration between different design departments.

Siti Mohd Radzi: I have numerous experiences working in a team, from various work environment, from working for technical projects, student organization, volunteering programme, and fundraising, I believe I would be able to contribute to create a healthy work environment within the team, by ensuring the expectation and performance of the team is consistent and good.

1.4 Project Management Style Adopted by the team

Majority vote in group decisions in order to keep everyone in the loop and make sure that nobody has more power than anyone else. People voice their opinions and concerns freely to avoid

1.5 Initial Project Management Roles

- Baylor: Team Organizer
- Bell: Recorder and Testing
- Liam: Client Correspondent
- Chicheng: Research and Testing Leader
- Eduardo: Submission, Research and Testing Leader
- Eli: Team Lead

2 Introduction

2.1 Problem Statement

Our team is attempting to to design and simulate a 60 MW solar farm as well as the substation that connects it to the grid. We will design the solar farm during the first semester and the substation the second semester.

2.2 Requirements and constraints

In this project, we are required to design the solar power plant and the substation plant by using AutoCAD, ETAP, and Bluebeam. We also have requirements to calculate voltage drops, grounding currents, and design specifications. We are not required to have a replica of our designed substation and solar farm, but we are required to have all of the documentation that goes along with the design work. Here are a few deliverables we need to provide as well:

- Equipment sizing calculations (breakers, transformers, etc) using Excel files
- Solar layout drawings provided with Bluebeam/CAD/PDF editor
- Solar panel string sizing design done with Excel files
- Electrical layout drawings (substation equipment) printed using Bluebeam/CAD/PDF editor

- Grounding analysis and ground-grid developed with IEEE-80 also can be conducted using Excel files
- Bus calculations for substation design with Excel files
- Additional calculations of DC battery bank and lightning protection calculated using Excel files
- Creation of solar/substation design-optimizing tool can be done with ACAD/ETAP/new program
- Simulation of designed substation connection with a simulation software known as ETAP using the student license
- Coordination Study, AC Arc Flash Study, and Protection Element Analysis also using ETAP
- Load Flow Scenario Wizard and Configuration Manager done using ACAD/ETAP.

2.3 Engineering standards

Solar Power Plant Design Standards

IEEE 1562:2007 Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems

IEEE 2778-2020 Grounding System Design for Ground-Mount Photovoltaic (PV) Solar Power Plant

Substation Standards

NEC 2020- (National Electrical Code)

2.4 Intended users and uses

There are two groups that could potentially benefit from the results of our project. The first interest group is our sponsor company, Black & Veatch. After completion of the project, they are able to take our design and compare it to other senior design groups and also traditional designs done at the company. The other group that could benefit from our project if it were to be implemented in the real world would be the public using the energy produced by our solar power plant. This would help out the local community and power grid by adding another 60 MW of power to be consumed.

Black & Veatch are a group that are interested in the design and implementation of solar power plants and substations. Renewable energy advocacy groups would also be interested in the design and creation of a solar power plant. Black & Veatch could take the design of our project and implement our design if the situation makes sense and is applicable to a specific location.

3 Next section