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1. PROBLEM STATEMENT

Due to an increased energy demand from a new factory, a 69kV/12kV transmission substation will need to be designed by Black & Veatch. Our senior design project team will be responsible for the complete design of the substation which includes physical design, protection and control design, and associated construction deliverables.

2. PROJECT SCOPE

The scope of this project has been predefined by our client, Black & Veatch, in a "Project Description" document. A summary of the different aspects to the scope can be found below. Black & Veatch has required a comprehensive design plan that incorporates physical design, protection and control design, and engineering management services. While the technical requirements of this project are highlighted, the ability to provide professional documentation and communication is just as imperative within the scope of this project.

2.1. PHYSICAL LAYOUT DESIGN

The team will be responsible for determining the layout of the components that we select to comprise the substation. The substation will be conscious and wary of use of space to avoid using excess space, while at the same time provided room for future expansions if the load requirements ever increased. The elevation cuts will be provided at a later date by the client, Black & Veatch.

2.2. STATION SERVICE TRANSFORMER & POWER SPECIFICATION

The team will be required to calculate and determine the associated specifications of the station service transformer and power. This will be based on the expected load from the industrial center's load. After selecting the transformer, sizing will be determined for other associated components of the substation.

2.3. WIRING DIAGRAMS & CABLE SIZINGS

Proper documentation of the design and wiring diagrams will be provided by the senior design team. Wiring diagrams will be needed for within and outside of the control house. Within the control house will focus on panel wiring. Outside the control house, we will need to properly connect all conductors. In addition, based on rated loads we will need to verify that the conductors are properly sized to handle power and current requirements.

2.4. STATION BATTERY & BATTERY CHARGER SPECIFICATION

A battery is needed prior to the development of the control house. The design team is expected to carry out the sizing of the batteries, battery chargers, and panels that will utilize this system. The team will need to consider how long to provide power via the battery to the service station based upon traditional service station outages.

2.5. GROUNDING GRID DESIGN

An integral part of substation design is the design and layout of the grounding grid, and the team is expected to complete this. We do not currently know which grounding software we will utilize. The client will provide us with a suggestion at a later date. The design of the grounding grid will follow all appropriate standards for conductors being able to handle rated fault currents.

2.6. SUBSTATION PROTECTIVE RELAYING & CONTROL SYSTEM DESIGN

The team will be expected to design a protective relaying scheme for the substation. This will include circuit breakers, circuit switches, and other components. All models will be verified for proper operation via their datasheets.

3. EXCLUDED FROM PROJECT SCOPE

3.1. SITE SURVEY INFORMATION

The design team will not be expected to evaluate and consider different geographical areas for feasibility of potential siting. The client has agreed to provide the design team with elevation cuts at a later date.

3.2. SYSTEM SIMULATION AND TESTING

While all due diligence will be paid to make sure the system is built for safe and reliable operation, no simulations will be ran on the design. No other type of formal testing will be done with the exception of the grounding software to be chosen. Verification of the team's design documents will be done via design review meetings with the client, Black & Veatch. A review with external professionals is also planned.

4. DELIVERABLES

The following list of expected deliverables was set forth by Black & Veatch. The first deliverable will be to develop an engineering man-hour budget and schedule for this project in order to plan the overall senior design project. Black & Veatch will work with our team to manage the scope of the project to allow completion during the Fall and Spring semesters.

Some examples of these deliverables include but are not limited to equipment sizing calculations, substation layout drawings, station power design, protection and control schematics & project schedules.

4.1. FIRST SEMESTER (Fall 2014)

- Development of an engineering man-hour budget and schedule for the project with tracking of hours spent on each task (for comparison to actual budgeted engineering man-hours, presented at each design review).
- One-line Diagram
- Design Panel Layouts
- Design Schematic Document
- Calculations to determine service transformer and station power requirements.
- Selection of equipment size and requirements including circuit breaker, disconnect switches, CCVTs, PTs, station service transformer, etc.

4.2. SECOND SEMESTER (Spring 2015)

- Calculations to determine battery and battery charger size.
- Calculations to determine cable sizing.
- Calculations to determine grounding requirements.
- Complete Wiring Diagrams
- Design physical layout
- Bus and Insulator Design
- Design Justifications
- Three-line Diagrams

5. SPECIFICATIONS

The new distribution substation designed by this senior design group will be expected to meet certain criteria. Several of the criteria will be decided by the group after doing the associated calculations to determine sizings and ratings of our substation and all ancillary equipment.

6. CONCEPT SKETCH / MOCKUP

This design project has been broken down into five different phases to better facilitate it. A block diagram below lists the five different phases and its intermediate steps.

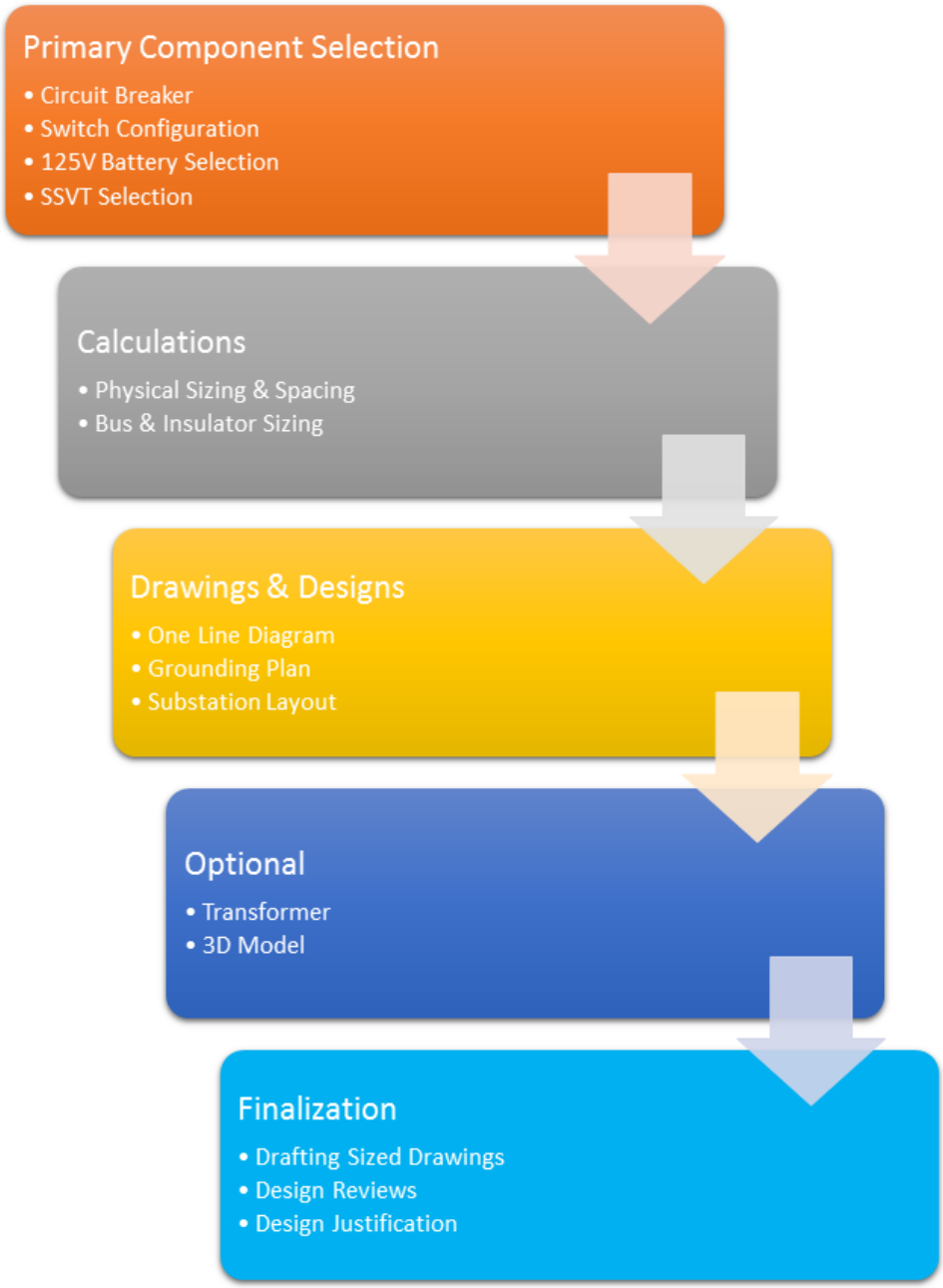

Figure 1: Design Phase Block Diagram

7. REQUIREMENTS

No physical items are expected within the scope of this project. All the requirements are for the proper design of a functional substation.

7.1. RESOURCE REQUIREMENTS

We will need access to the computer-aided design software package AutoCAD to be able to build our one-line and three-line diagrams. We may also need access to a ground fault calculation software. This may turn out to be WinGIS.

8. WORK BREAKDOWN STRUCTURE

Every team member is expected to be up-to-date with the entirety of the project. In order to ensure that the project plan is carried out successfully, each team member has been designated to a particular role so as maximize efficiency by everyone becoming proficient in their area of expertise. Additionally, due to our large group size, some roles will have two team members. This works well because it gives all team members a task to complete each week.

Matt Backes: Team Leader
Kiran Rane: Key Concept Holder
Bhargav Gouni: Key Concept Holder
Ryan Jerve: Communications Leader
Faran Malik: Communications Leader
Sohail Suryavanshi: Webmaster

9. PROJECT SCHEDULE

September: Learn project scope, develop project plan
October: Develop man-hour budget, modify one-line diagram
November: Design panel layouts, design schematic diagrams
December: Develop design document, station battery design
January: Station service and transformer and power requirements, complete wiring diagrams and cable sizing
February: Design physical layout and grounding
March: Complete bus and insulator sizing design
April: Complete project report, design project poster, IRB presentation practice
May: Presentation

10. RISKS

Designing a substation often involves some risks associated with it. While designing a substation, the designers need to consider various risks such as its location, its weather conditions, protection and control and complying with project deadlines. Proximity of the substations to wetlands to avoid its flooding and its proximity to animals such as rodents can have some adverse effects on the substation functioning. In a similar way, choosing of appropriate protection and control hardware can be a risk as well.

10.1. RISKS TO THE PROJECT TIMELINE

It is easy to get distracted and wander off from the project timeline. Best possible practices and measures should be taken to work hand in hand with the planned project timeline.

11. MARKET/LITERATURE SURVEY

This project will require a significant amount of market research and literature research. We will need to do some literature research to gain background knowledge on the components of a substation. The team will also need to do some literature research on the various protection schemes for a substation. We will need to delve into current market product datasheets to select components that are necessary and fill our specifications. A significant time requirement will be needed for the market research to make sure we have done a thorough review for the best product available for our specific situation.