115/34.5kV Solar Power Plant & Substation Design

Team 18 - May 2024

Lightning Talk #2 - Project Plan

Baylor Clark, Liam Grossman, Eduardo Jimenez-Tzompaxtle,
Siti Mohd Radzi, Elymus Schaffer, Chicheng Tang

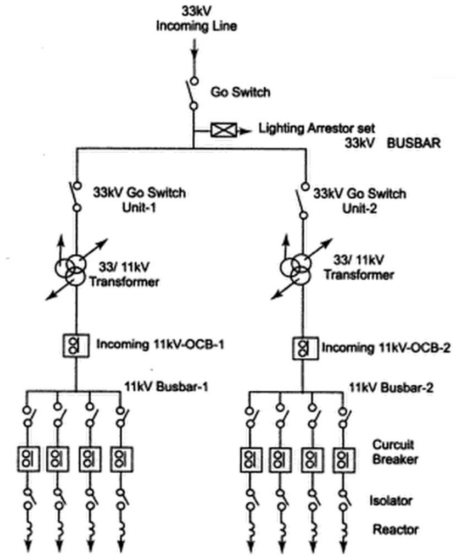
Project Information

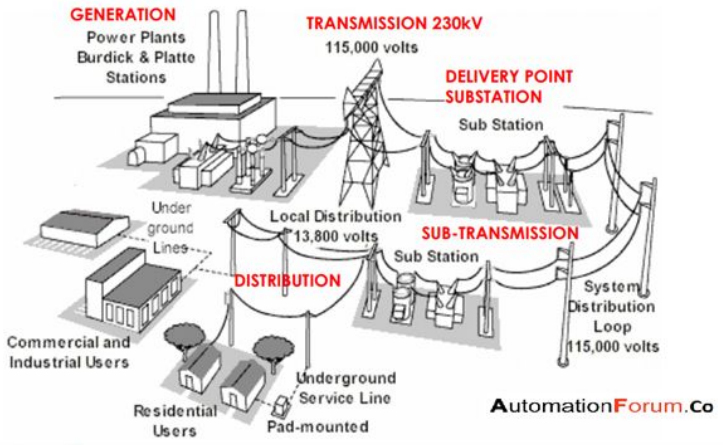
Due to increasing Renewable Energy requirements for utilities, a 34.5/115 kV distribution substation and 60 MW Solar Plant will need to be designed by Iowa State University. We as the project team are responsible for the complete design of solar layout, electrical layout, and associated construction deliverables. Our project team will also perform various calculations required of a typical substation, including load-flow analysis, short-circuit studies, system protection design, and grounding calculations.

Substation Link Solar Field Link

Substation Overview

Transmission lines come into substation at 115 kV. These lines then step down into transformers which take the voltage from 115 kV to 34.5 kV. The line then goes through a switchgear to help service in case of a disaster. After the switchgear, the lines go to bus bars which help distribute the voltage to different lines to be distributed.



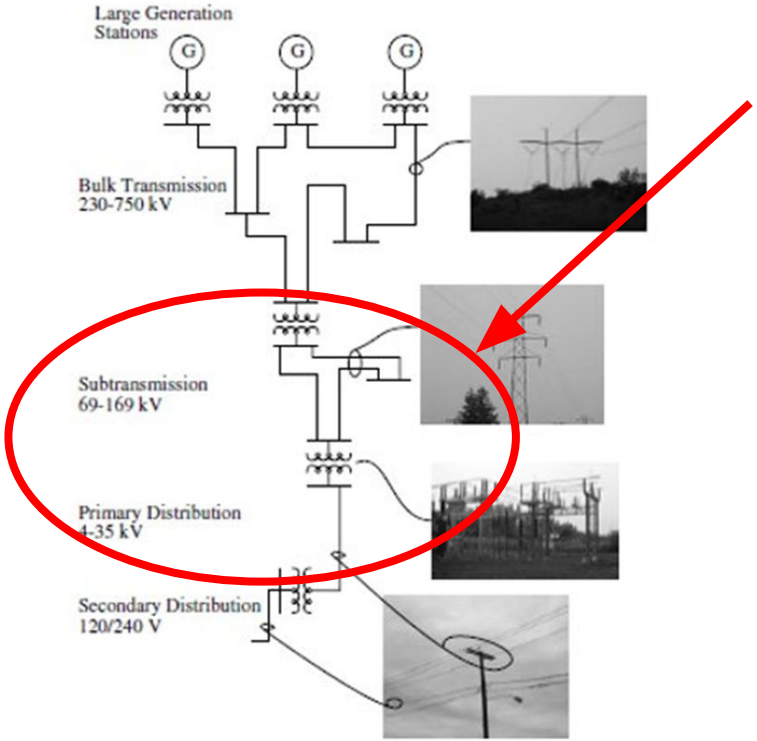


Feeders -> SG -> XFMR -> SG -> Circuit Breaker -> Busbar -> Outgoing Feeders

The circuit diagram to the left shows an overview of a typical substation circuit. This shows a 33/11 kV system and transformer, but similar principles apply to our project.

Substation One-Line Substation Picture

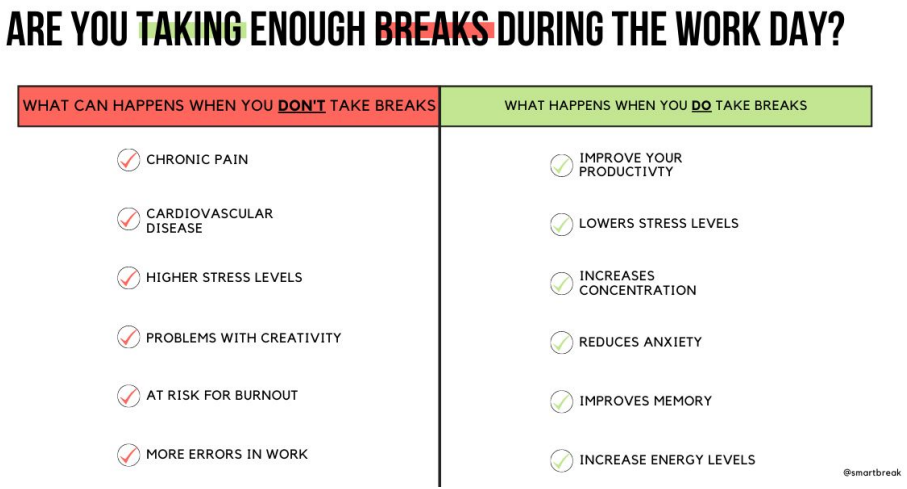
Electricity Infrastructure – Solar Farms (PV systems)



- Solar Farms (Photovoltaic systems) are usually interconnected to the grid at either the **sub-transmission voltage** or **primary distribution level**.
- Solar systems provide a DC output that must be inverted and stepped-up before making a network (grid) interconnection.

Safety Moment - Importance of Regular Breaks

- Both Mental and Physical Benefits
- Breaks help boost overall productivity
  - Pushing through work can lower performance
- Prevents decision fatigue and reduces possible errors
- Neglecting breaks can lead to burnout
- Study on Duration of Breaks
  - Shorter more frequent breaks in the morning
  - Longer breaks in afternoon and evening



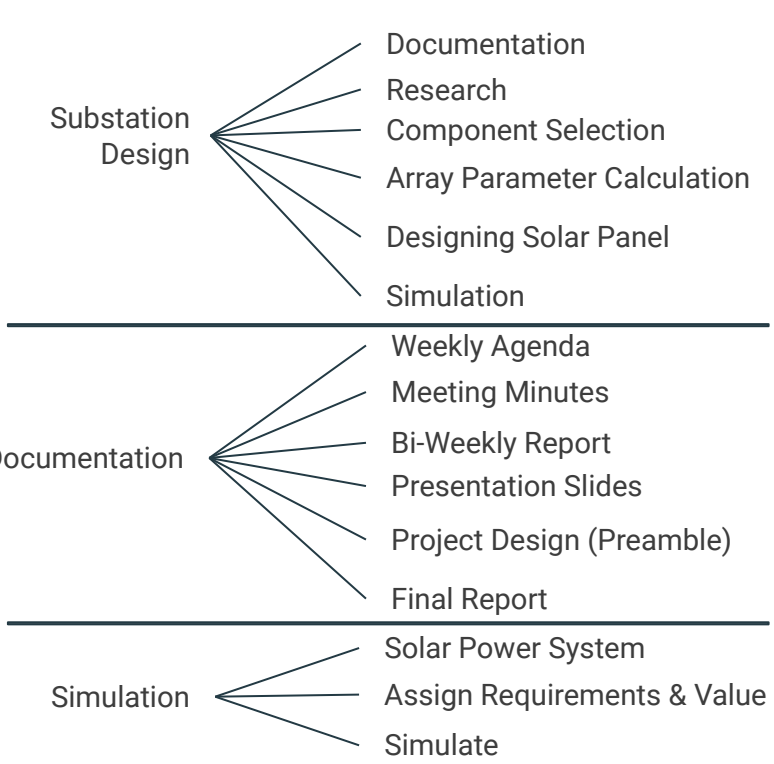
Baylor

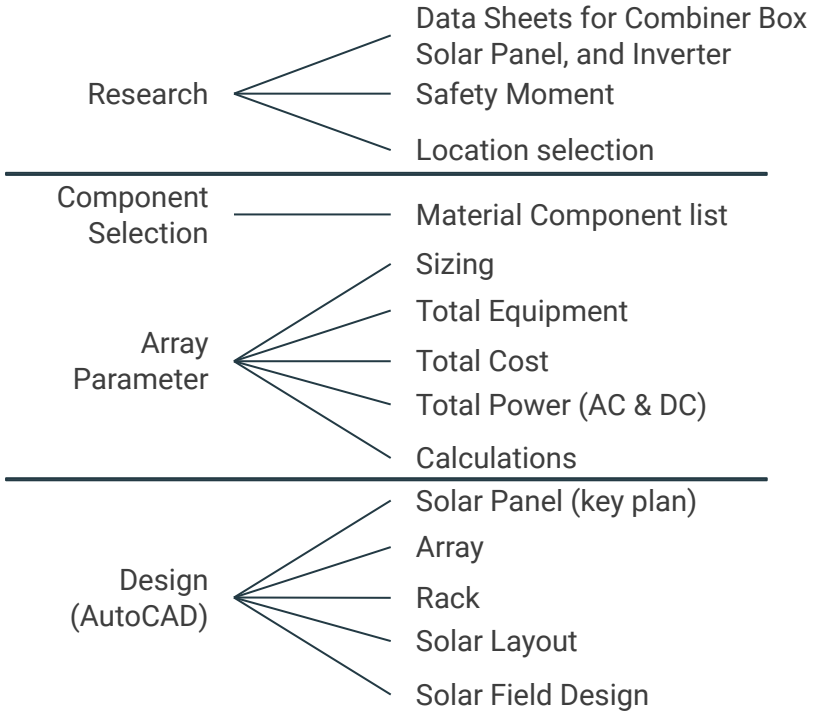
Harvard Business Review Michigan State University

Image Link

Project Plan

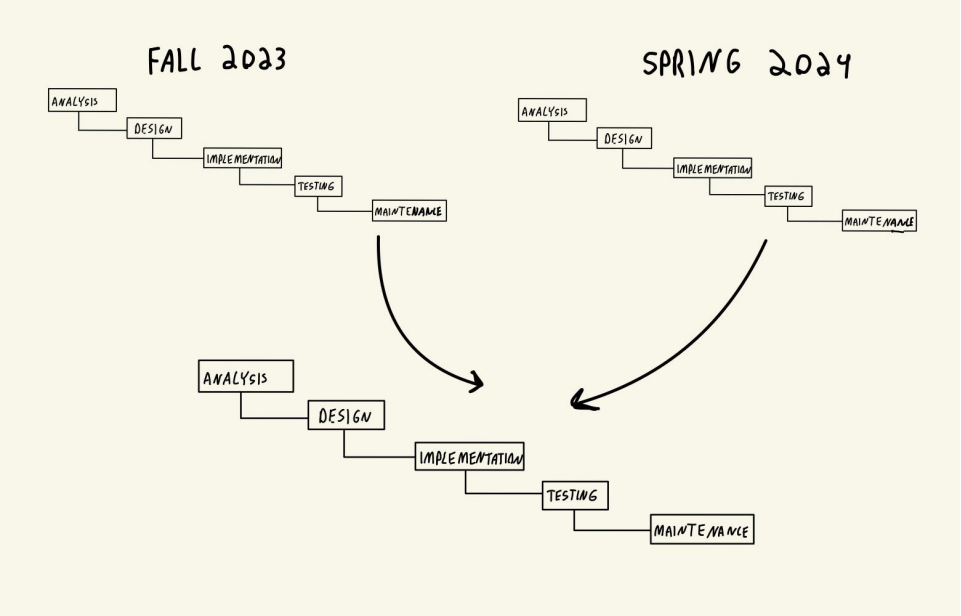
Task Decomposition





Project Management Style - Waterfall

- Waterfall Management Style emphasizes the completion of certain phases of design before moving on to the next phase
- Each semester will follow a waterfall methodology from design to maintenance phase
  - Additionally, an overarching waterfall methodology will be used across both semesters
- Our gantt chart was modeled to emulate this waterfall methodology



Project Milestones

- Research Equipment
  - Collect 3 data sheets for PV panels, combiner boxes, and solar inverters
  - Research necessary components and present our understanding of them
- Select Components
  - Finalize component selection
  - Find appropriate location for construction
- Array Parameters
  - Use array calculation tool to select solar farm sizing (number of panels, combiner boxes, inverters, ect)
  - Component numbers and arrangement should result in an AC output of 60 MW and a DC to AC ratio of approximately 1.3
  - Component costs will be calculated to provide overall array cost
  - Voltage drop calculations will be done to provide realistic power loss statistics
- Design Solar Array (AutoCAD)
  - Solar array will be designed in AutoCAD based on array calculation tools
  - A professional title block will be created for array drawings
- Solar Farm Simulation
  - The solar farm will be set up within a simulation software (ETAP)
  - The power flow of the solar farm will be simulated
  - Array parameters will be checked and adjusted to ensure all necessary deliverables are met

Project Timeline/Schedule

FALL 2023 - SOLAR POWER PLANT DESIGN

PHASE

1 — **RESEARCH (Week 1-3)**
Collect data sheets for PV cells and solar farm components

2 — **PLANNING (Week 4-6)**
Finalize equipments and components for solar power plant

3 — **DESIGNING (Week 7-9)**
Create preliminary design sketch, and finalize actual design on AutoCAD

4 — **CALCULATION (Week 10-12)**
Perform voltage-drop calculation, economic analysis and do necessary amendments

5 — **SIMULATION (Week 13-15)**
Simulate solar circuit and analyze power flow

SPRING 2024 - SUBSTATION DESIGN

PHASE

1 — **RESEARCH (Week 1-3)**
Collect data sheets for substation equipments

2 — **PLANNING (Week 4-6)**
Finalize equipments for substation

3 — **DESIGNING (Week 7-9)**
Designing one-line diagram of the substation

4 — **CALCULATION (Week 10-12)**
Perform power flow calculation and economic analysis

5 — **SIMULATION (Week 13-15)**
Simulate solar farm and substation power flow

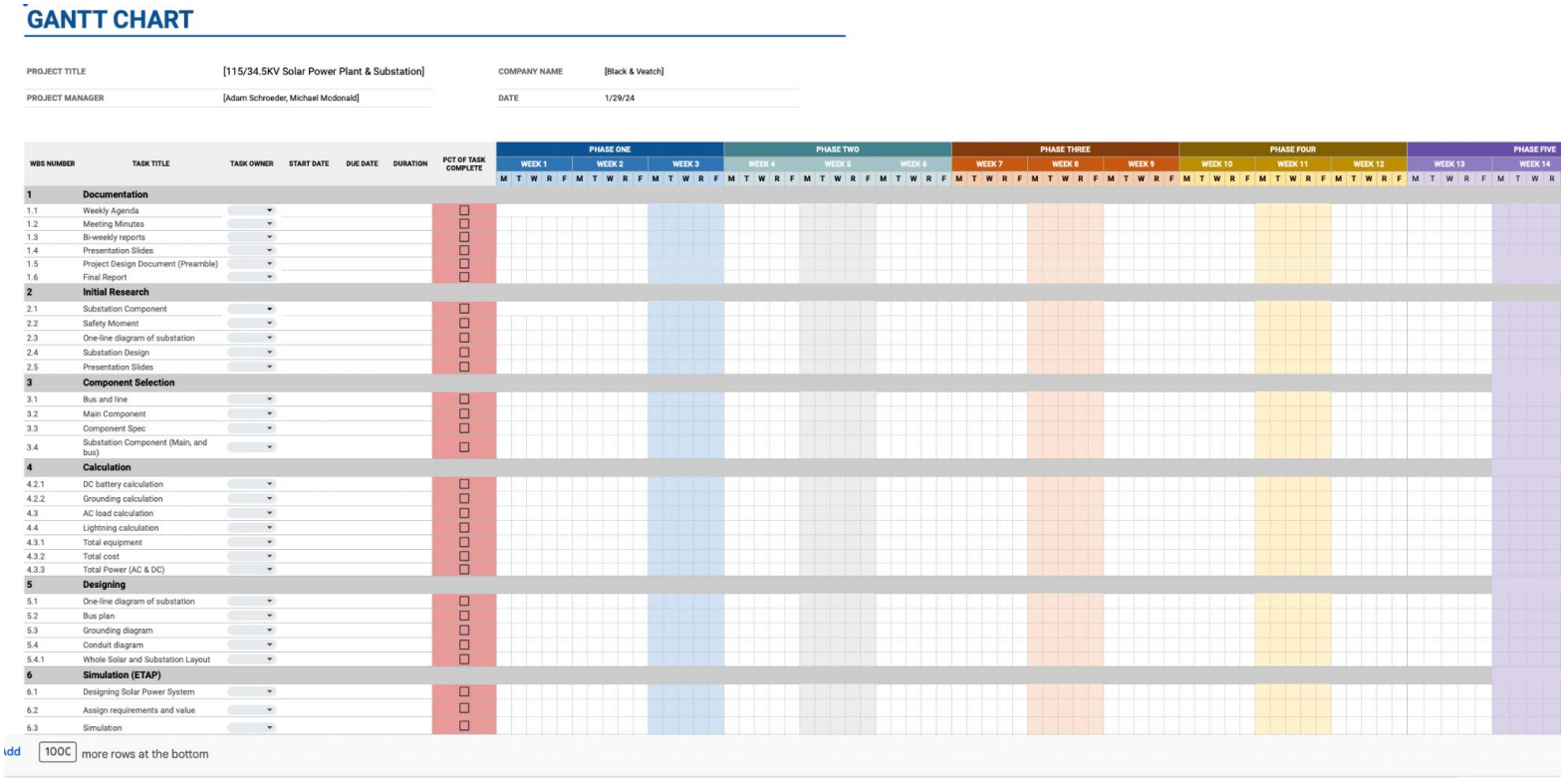
Gantt Chart - Fall 2023

PROJECT TITLE	[115/34.5KV Solar Power Plant & Substation]	COMPANY NAME	[Black & Veatch]
PROJECT MANAGER	[Adam Schroeder, Michael Mcdonald]	DATE	9/12/23

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	**Documentation**					
1.1	Weekly Agenda	Baylor	08/30/2023			☐
1.2	Meeting Minutes	Bell	08/30/2023			☐
1.3	Bi-weekly report	Eli	08/30/2023			☐
1.4	Presentation Slides	ALL	08/30/2023			☐
1.5	Project Design Document (Preamble)	ALL	08/30/2023			☐
1.6	Final Report	ALL				☐
2	**Research**					
2.1	Data sheet Utility PV Solar Panel	Liam	9/12/23	9/20/23		☐
2.2	Safety Moment	Eli	9/12/23	9/20/23		☐
2.3	Data sheet for Combiner Box	Eduardo	9/12/23	9/20/23		☐
2.4	Data sheet for Inverter	Chicheng	9/12/23	9/20/23		☐
2.5	New Mexico Vs Iowa as location for power plant	Bell	9/12/23	9/20/23		☐
2.6	Substation Design	Eli & Baylor	9/12/23	9/20/23		☐
3	**Component Selection**					
3.1	Material components lists		9/14/23	9/20/23		☐
3.2	Location		9/14/23	9/20/23		☐
3.4	Substation Component (Main, and bus)		9/14/23	9/20/23		☐
4	**Array Parameter Calculation**					
4.1	String size		9/20/23	10/4/23		☐
4.2	Electrical rack size		9/20/23	10/4/23		☐
4.3	CB capacity		9/20/23	10/4/23		
4.4	Array design		9/20/23	10/12/23		☐
4.5	Array size		9/20/23	10/12/23		☐
4.6	Total equipments		9/20/23	10/12/23		☐
4.7	Total cost and budget		9/20/23	10/12/23		☐
4.8	Total Power (AC & DC)		9/20/23	10/12/23		☐
4.9	Voltage drop calculation		9/20/23			☐
5	**Designing Solar Panel (AutoCAD)**					
5.1	Solar Panel (key plan, elevation, grounding)			11/2/23		☐
5.2	Array			11/2/23		☐
5.3	Rack			11/2/23		☐
5.4	Solar Layout			11/2/23		☐
5.5	Solar Field Design					☐
6	**Simulation**					
6.1	Designing Solar Power System			11/23/23		☐
6.2	Assign requirements and value			11/23/23		☐
6.3	Simulation			11/23/23		☐

PHASE	WEEKS	DAYS (each week)
PHASE ONE	WEEK 1, WEEK 2, WEEK 3	M T W R F
PHASE TWO	WEEK 4, WEEK 5, WEEK 6	M T W R F
PHASE THREE	WEEK 7, WEEK 8, WEEK 9	M T W R F
PHASE FOUR	WEEK 10, WEEK 11, WEEK 12	M T W R F
PHASE FIVE	WEEK 13, WEEK 14	M T W R

Gantt Chart - Spring 2024



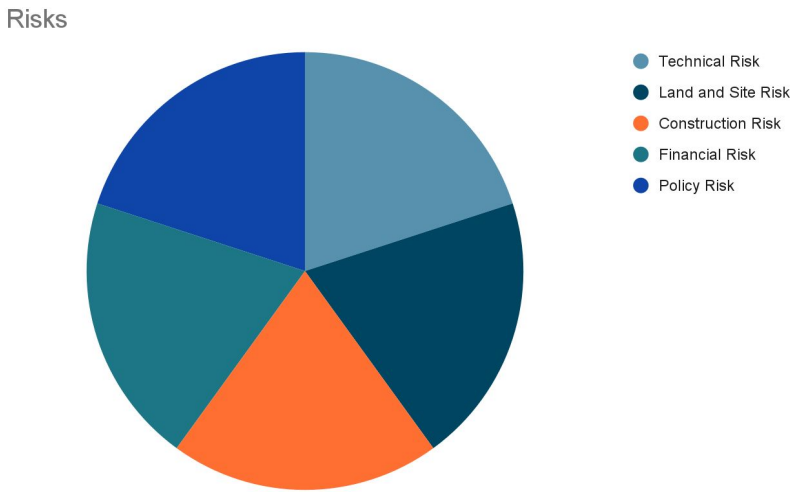
GANTT CHART

PROJECT TITLE	[115/34.5KV Solar Power Plant & Substation]	COMPANY NAME	[Black & Veatch]
PROJECT MANAGER	[Adam Schroeder, Michael Mcdonald]	DATE	1/29/24

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE	PHASE ONE			PHASE TWO			PHASE THREE			PHASE FOUR			PHASE FIVE	
							WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
							M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R
1	**Documentation**																			
1.1	Weekly Agenda																			
1.2	Meeting Minutes																			
1.3	Bi-weekly reports																			
1.4	Presentation Slides																			
1.5	Project Design Document (Preamble)																			
1.6	Final Report																			
2	**Initial Research**																			
2.1	Substation Component																			
2.2	Safety Moment																			
2.3	One-line diagram of substation																			
2.4	Substation Design																			
2.5	Presentation Slides																			
3	**Component Selection**																			
3.1	Bus and line																			
3.2	Main Component																			
3.3	Component Spec																			
3.4	Substation Component (Main, and bus)																			
4	**Calculation**																			
4.2.1	DC battery calculation																			
4.2.2	Grounding calculation																			
4.3	AC load calculation																			
4.4	Lightning calculation																			
4.3.1	Total equipment																			
4.3.2	Total cost																			
4.3.3	Total Power (AC & DC)																			
5	**Designing**																			
5.1	One-line diagram of substation																			
5.2	Bus plan																			
5.3	Grounding diagram																			
5.4	Conduit diagram																			
5.4.1	Whole Solar and Substation Layout																			
6	**Simulation (ETAP)**																			
6.1	Designing Solar Power System																			
6.2	Assign requirements and value																			
6.3	Simulation																			

dd 100 more rows at the bottom

Risks/Risk Management



1. **Technical Risk**
   a. Technology selection
   b. System Design
2. **Land and Site Risk**
   a. Land Acquisition
   b. Site Condition
3. **Construction Risk**
   a. Project Delays
   b. Cost
4. **Financial Risk**
   a. Financing Issues
5. **Policy Risk**
   a. Permit and Approvals
   b. Government Policies Changes