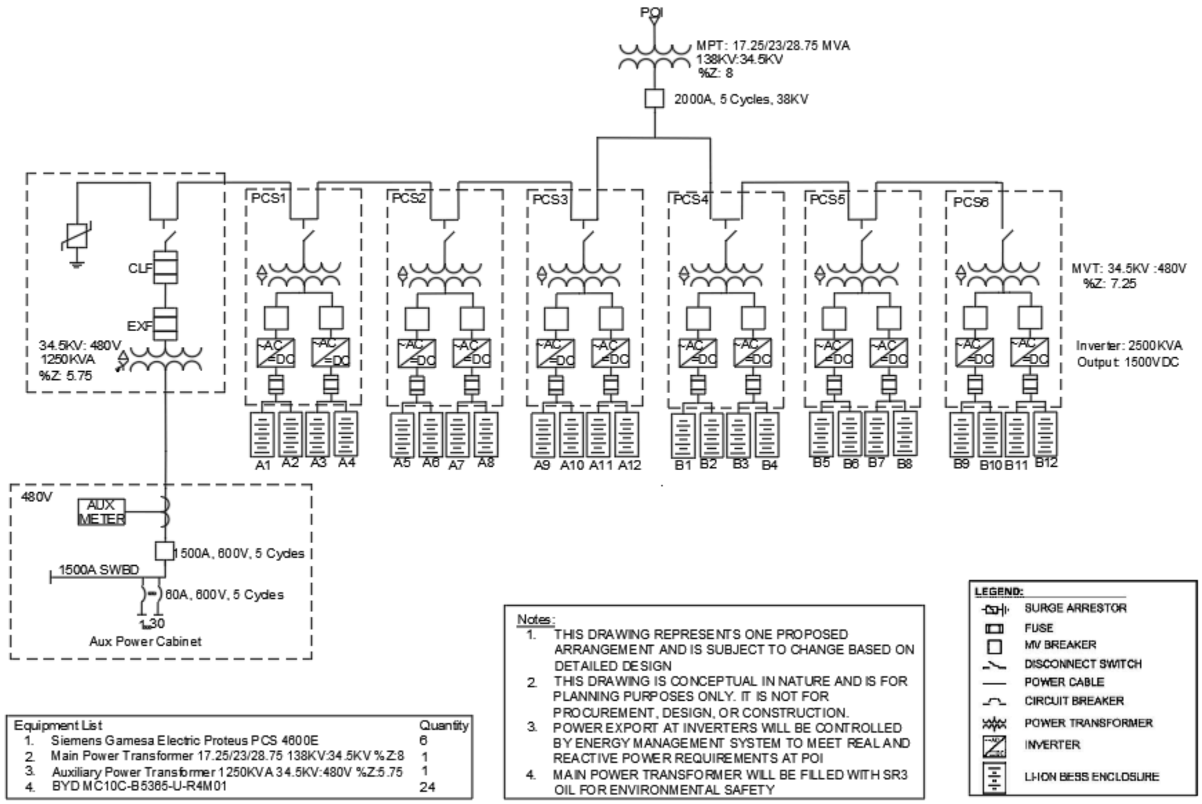

Utility Scale Lithium-ion Battery Energy Storage System

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Sddec24-18

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Overview

For this project, the team had to meet several functional design requirements. The project must be able to deliver 25MW for 4 hours. The project must have a 20-year cycle and two augmentations throughout the battery's life. The client also stated that the product must have an overbuild of 10% at BOL (beginning of life). The project requires a 7-15 acre, flat plot of land. This document outlines why the team selected the batteries and PCS's for this project during the design process.

Batteries

For this project, the team had three primary batteries to choose from. These choices were BYD, Lithium, and LG. The team decided to select BYD. BYD was chosen because it required the least batteries while having the best ambient operating temperature range. BYD was also chosen over Hithium because of its versatility with the inverter options provided. If a BYD battery were to fail, the loss of power once the battery is disconnected from the design would be less than 5%, whereas the loss of power due to a Hithium battery once disconnected would be close to 20%. As a result, BYD has the potential to be more reliable due to its redundancy in our design.

Batteries				
	BYD 0.25C	BYD 0.5C	Hithium 0.5C	LG 0.25C
Capacity (kWh)	5365	4659	5015	19624
Nominal Power (kW)	1236	2125	2507.5	4906
Output Voltage	1081.6 - 1497.6	1081.6 - 1497.6	1,123.2 - 1497.6	1101.6 - 1468.8
Operational Ambient Temperature Range	-30°C ~ +55°C	-30°C ~ +55°C	-30°C ~ +55°C	-30°C ~ +50°C
Batteries Required @10% Overbuild	20.50326188	23.61021678	21.93419741	5.605381166

PCS's

After selecting a battery, the team wanted to choose the PCS with optimal performance. The team narrowed down the number of PCS's by eliminating any options that could not handle the voltage ranges output by the battery. From there, it was determined that the Siemens Gamesa 4600E would allow for the least number of BYD batteries connected to the PCS's while also having the most capacity to spare.

PCS			
	EPC 50-100181	Power Electronics	Siemens Gamesa
Output (kW)	6000	4200	4607
DC Voltage	720 - 1500	913 - 1500	1075 - 1500
Nominal AC Voltage (VRMS)	480 - 690	13800 - 34500	User Defined
Operational Ambient Temperature Range	-20°C ~ +60°C	-25°C ~ +60°C	-20°C ~ +60°C
# of BYD Batteries Per Inverter	4.854368932	3.398058252	3.727346278
# BYD Batteries Per Inverter	5	4	4
# of PCS Skids Required @10% Overbuild	4.166666667	5.952380952	5.426524853
Min # of PCS Skids Required @10% Overbuild	5	6	6

Calculations

$S = P + jQ$ $P = 25\text{ MW} / 100\text{ MWh} \rightarrow 10\%\text{ BOL}$

$Q = S\sin(\varphi)$ $PF = 0.95$

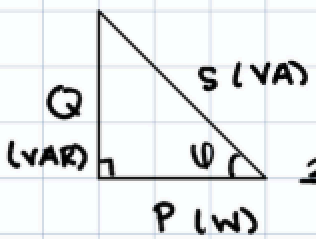
$S = \dfrac{P}{PF}$ → BYD: 1236 kW (battery)

→ Mgen: 4.2 MVA (inverter)

→ 4 battery containers / inverter

→ we need ~24 battery containers

→ we will need 6 inverters total



$$\frac{25000\text{ kW}}{1236\text{ kW}} = 22.23 \times \underbrace{1.1}_{10\%\text{ BOL}} = 22.25 \sim 24 \text{ battery containers}$$

→ Calculating reactive power comes from the inverter; battery produces active power

$P = |V||I|\cos(\theta_v - \theta_i)$

$Q = |V||I|\sin(\theta_v - \theta_i)$

$S = P + jQ = \sqrt{P^2 + Q^2}$

$$S = \frac{P}{PF} = \frac{25\times10^6}{0.95} = 26.34 \times 1.1 = 28.95\text{ MVA needed}$$

inverter:

$PF = 0.95$

$S = 4.2\text{ MVA}$

$4.6\times10^6 \times 6$ inverters $\approx$ 27.6 MVA

(inverter)

6 inverters × 4 hrs = 24 batteries needed

$Q = S\sin(\varphi)$ $\cos^{-1}(0.95) = 18.19°$

$Q = (28.95)\sin(18.19)$

$Q = 9.037\text{ MVAR}$