

34.5/115 kV Solar Power Plant & Substation Senior Design Project

Senior Design Team 18 - May 2024

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BLACK & VEATCH



Agenda

- Safety Moment
- Substation Components
- Key-Plan Update
- One-Line Update
- Feeder Connections
- Switchgear
- Previous Work
- Feedback and Updates



Safety Moment - Heavy Machinery

- Always be aware of surroundings and others operating in the area
- If you are near heavy machinery that is being operated, pay attention to visual and audio cues
- Make sure that all required certifications are met for operation
- Make sure that all required PPE is being worn in/around machinery



STATE

Substation Components - Liam

- Breakers - SF6 115/145 kV breaker from online seller, also catalog from GE
- Capacitors - not much information, possible catalog from Eaton
- Voltage Regs - single phase 34.5 kV from Eaton catalog
- Power XFMR - 115/34.5 kV, 90 MVA power transformer from online seller (no price but does have nameplate)
- Batteries - large variety (flooded lead acid, gel, nickel cadmium, ect.) from Exponential Power (online seller)
- Possible switchgear - 38 kV enclosed switchgear from Eaton catalog

- Power transformers
- Tap changing equipment
- Steel structures
- Lightning arresters
- Circuit switchers
- SF₆ circuit breakers
- Oil circuit breakers
- Air circuit breakers
- Vacuum circuit breakers
- Disconnect switches
- Coupling capacitors
- Potential transformers
- Current transformers
- High-voltage fuses
- Metal-clad switchgear
- Shunt reactors
- Meters
- Relays
- Supervisory control
- Remote terminal units
- Digital fault recorders
- Capacitors
- Voltage regulators
- Control house
- Conduits
- Control wires
- Control panels
- Power-line carrier equipment
- Microwave equipment
- Batteries



Substation Components - Liam

- Breakers

<https://www.lrselectric.com/sf6-substation-115kv-circuit-breakers-product/>

And

<https://www.gegridsolutions.com/products/brochures/primaryequip/l tcb.pdf>

(34.5 kV catalog)

<https://www.eaton.com/content/dam/eaton/products/electrical-circuit-protection/low-voltage-air-circuit-breakers/eaton-low-voltage-air-circuit-breaker-product-catalog-ca08100005e.pdf>

- Capacitors

<https://www.eaton.com/content/dam/eaton/products/medium-voltage-power-distribution-control-systems/power-capacitors/capacitor-block-banks-and-accessories-catalog-ca230009en.pdf>

- Voltage Regs

<https://www.eaton.com/content/dam/eaton/products/medium-voltage-power-distribution-control-systems/voltage-regulators/32-step-single-phase-voltage-regulator-catalog-CA225001EN.pdf>

- Power XFMR

<https://windaftermarket.com/p/115kv-power-transformer/>

- Batteries

<https://www.exponentialpower.com/products-services/by-application/stationary-standby-power/utility-power-systems/utility-substation-batteries.html>







- Possible switchgear

<https://www.eaton.com/us/en-us/catalog/medium-voltage-power-distribution-control-systems/vacclad-w-38-kv-42-wide-arc-resistant-metal-clad-medium-voltage-.html#tab-3>



Key Plan and Symbols

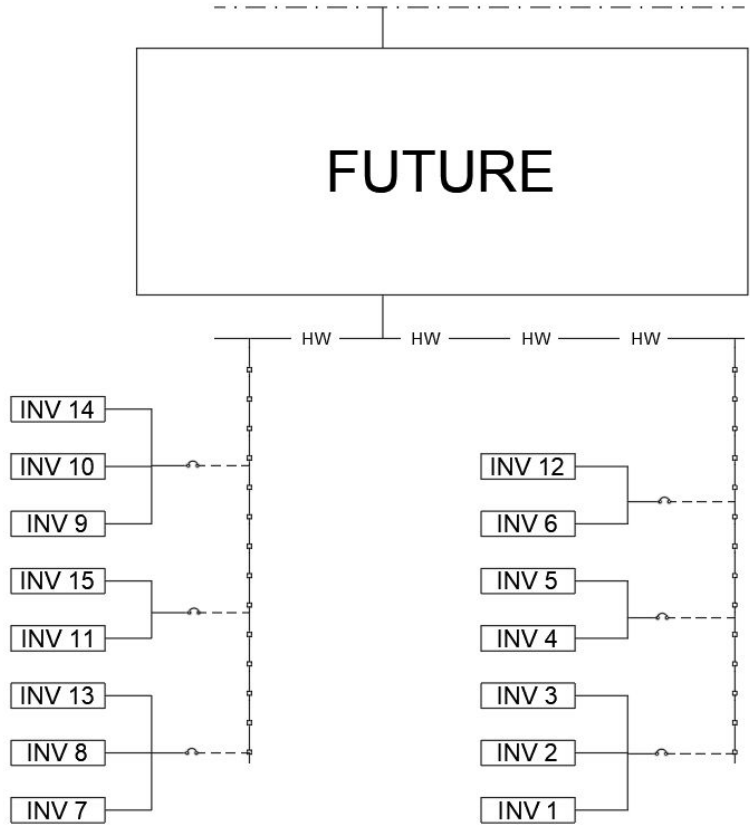
LINE SYMBOLS

	CONDUCTOR
	UNDERGROUND CONDUCTOR
	FEEDER
	34.5kV BUS
	EQUIPMENT OUTLINE
	115kV BUS

- Updated line types and labels



One-Line



- Added CB's, no size yet, will work on them
- Feeder to bus connection
- Future will be done in the next few weeks as we fully design the substation
- Updated cover sheet as well

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Updated Site Plan



- Changed the wiring site plan to match one-line made by Eli
- Used feeder line-type

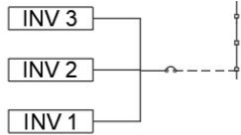
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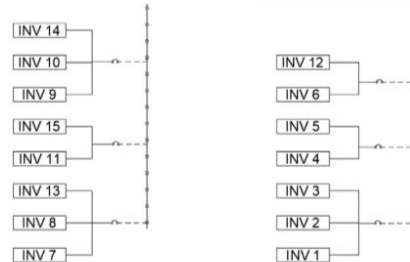
Feeder Connections

- Collector: inputs from the inverter skid, the sum of the inverter skids (step-up the voltage) to the 34.5 kV bus.



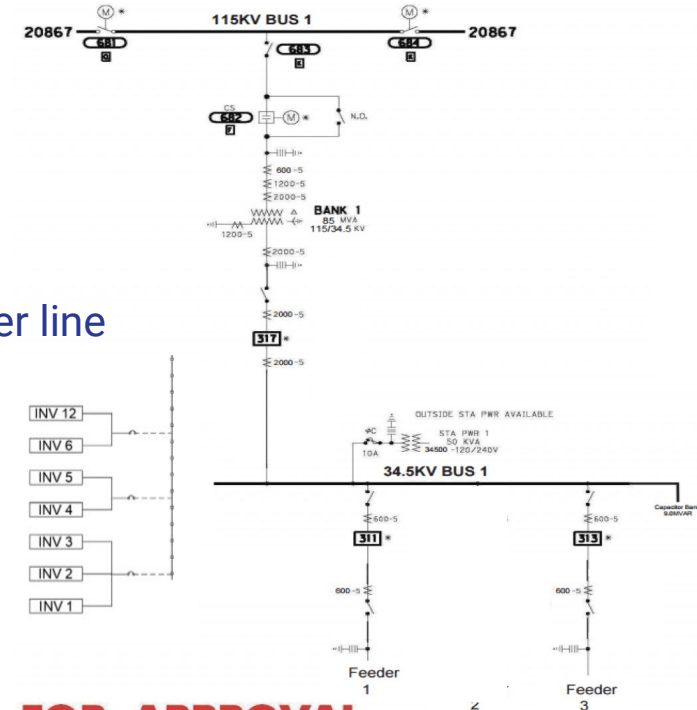
- 2 or 3 inverter skids per string, 3 inverter string per feeder.
- 6 inverter string totals, with 15 total inputs from 15 arrays.
- Feeder: Transmit power from the collector to the bus 34.5kV (substation).
 - Each feeder with 3 terminals, will be added with surge/lightning arresters for line protection along with the circuit breakers, and relays.
- Primary line transformer: Stepping up the voltage from 34.5kV to transmission level, 115kV.
- Circuit breakers: Interrupt current flow if fault detected by relays. They would be placed at each feeder line and primary line.

Two feeder line



Example

5.3.2 Arcadia Substation One-Line Diagram



FOR APPROVAL

PRELIMINARY
REV. 10-17-14, 11.11

* - EMS CONTROL

ELECTRIC OPERATIONS - C. G. & E. CO.

Arcadia

238

Switchgears - Eduardo

3 Type of switchgears

- Low voltage: from 1,000 to 1500 V
- Medium: from 3.3 kV to 33 kV
- High voltages: from 36 kv and above

Will be mostly be working with medium and high voltage switchgears.

Air insulated

- Terminals touch the air
- Occupy more land than other switchgear
- Mostly used in low voltage

Gas insulated

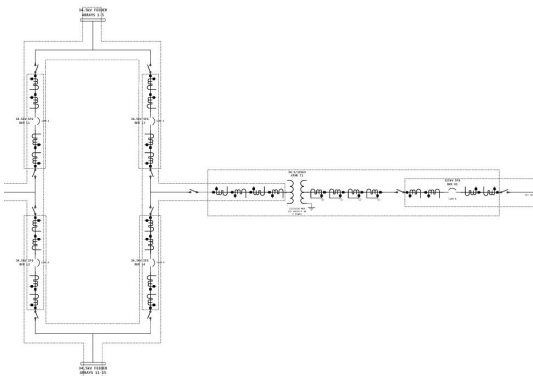
- Terminals are covered with Sulphur Hexafluoride
- Mostly used in cities
- Are used in high voltage

Oil circuit and Vacuum breakers are commonly used in medium voltage switchgears.



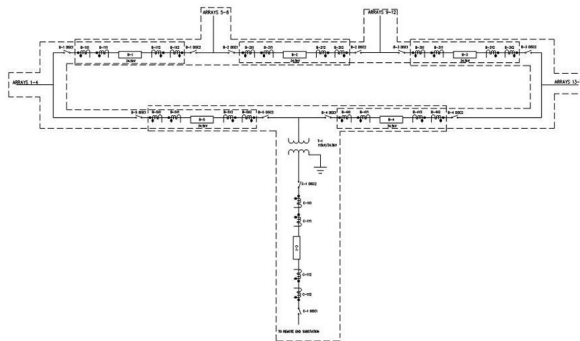
STATE

Previous Work - Chicheng



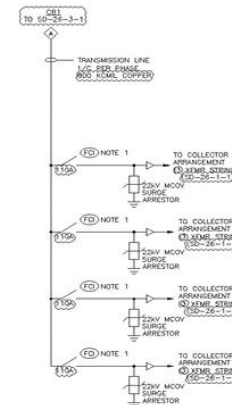
Sdmay 21 Ring Bus Connection

- Three Feeders
- Five Circuit Breakers (4 Low, 1 High)



Sdmay 20 Ring Bus Connection

- Four Feeders
- Six Circuit Breakers (5 Low, 1 High)



Sdmay 19 Single Bus Connection

- Three Feeders
- Six Relays (4 with combiner box, 2 work with xfm.)
- Four Combiner Box (Low Voltage)



Feedback and Updates

- Tasks: Updates
 - Bell: research/lead calculations for semester
 - Liam: SEL research/relay information
 - Eli: One-line/design work
 - Baylor: Site plan and calculations
 - Eduardo: Justify why we chose ring style/key plan stuff
 - Chicheng: Look into protection/grounding info

