BATTERY SYSTEM AUGMENTATION

WHY AUGMENTATION

- Optimize present value of cost by minimizing upfront CAPEX
- Leverage expected cost declines in batteries
- Invest in augmentations if they create additional revenues based on adding more capacity

THE PROBLEMS WITH AUGMENTATION

- Scant market data on existing augmentations
- Uncertainty of price projections (who predicted the Covid price spikes?)
- Uncertainty of future revenue (which options will be available in 5, 10, or 20 years?)
- It is difficult to accurately model all possible variables

→**Thus: The best plan is no plan; just flexibility and preparation**

TECHNICAL RISKS - DO NOT MIX OLD AND NEW CELLS ON SAME BUS:

- Capacity differences (voltage deltas) between old and new cells will limit performance
- Cell temperature differentials will impact battery performance and/or warranty
- BMS will be key:
  A. Dumb BMS - will force the mixed batteries to operate based on the higher current limit of new batteries and accelerate degradation of old batteries
  B. Smart BMS - will know the limits of the old batteries and cater to the lower limits, therefore limiting the mixed bus to the lowest limit

RECOMMENDED METHODS OF AUGMENTATION

AC-COUPLED

Implementation

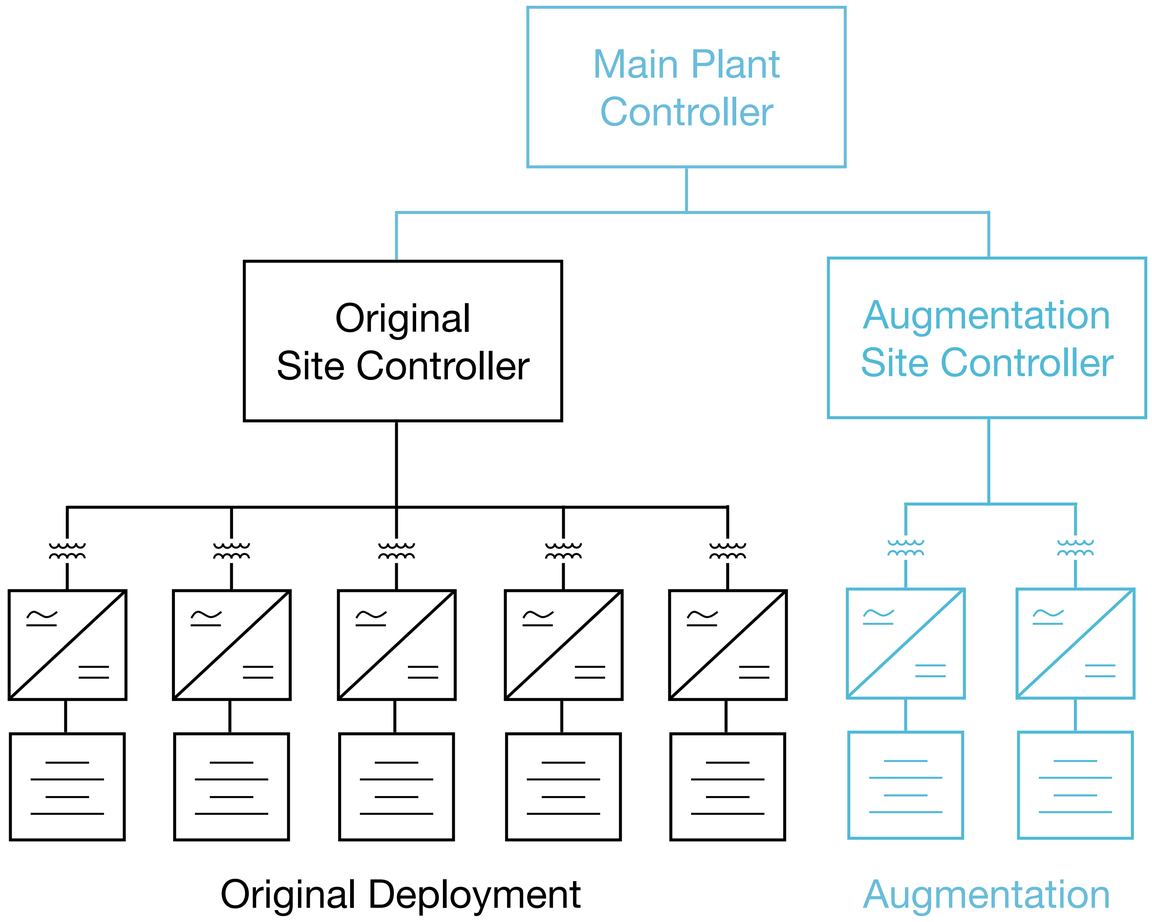
- De-rate original site
- Add new sets of PCS + Batt + MVT

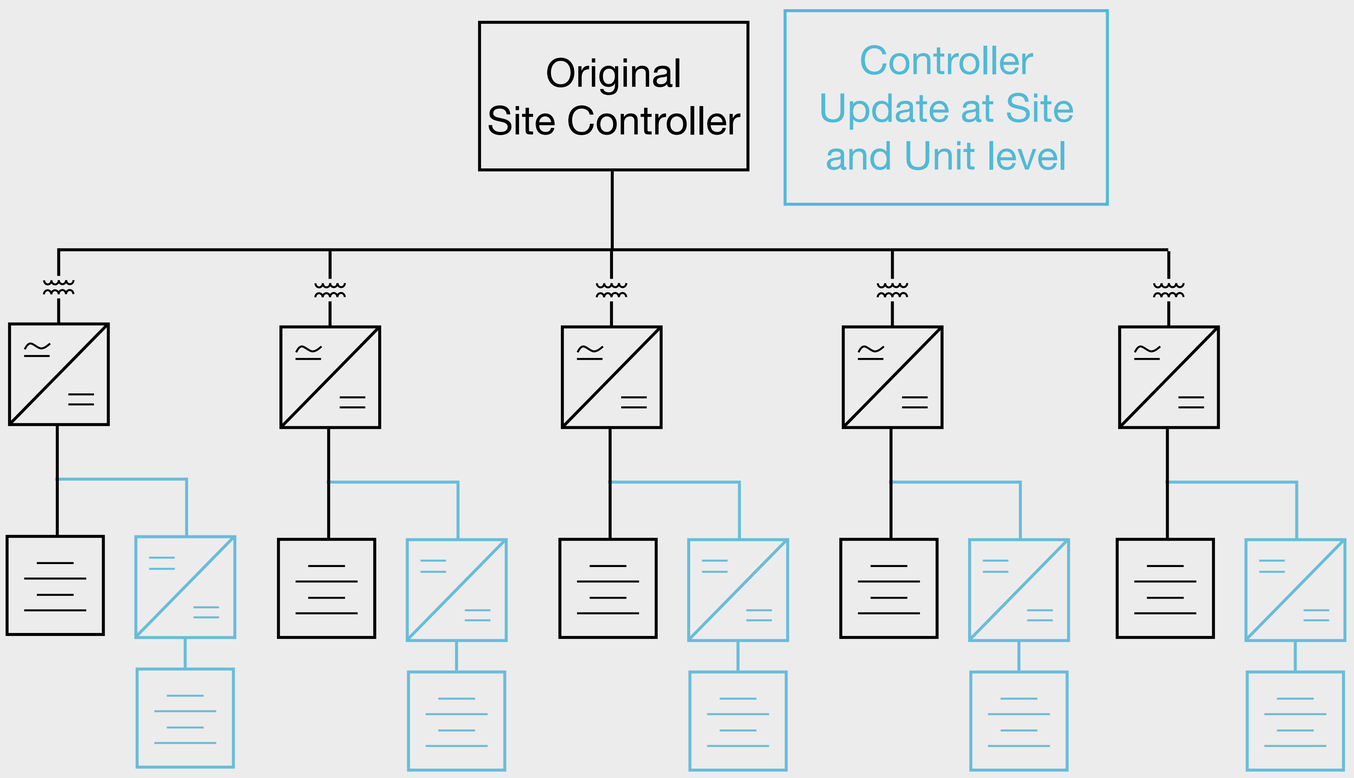
Risks and Considerations

- Interconnection Agreement will be impacted
- Need to plan for the additional space
- Equipment landscape: specifications and vendors may be different in the future
- Ideal for larger projects with >10 BESS
- Challenging for small projects with < 10 BESS

Benefits

- Derating the power of the existing system increases the duration
- Separate EMS for the augmentation reduces integration risk
- Leverage new technology that is cost efficient
- Complete flexibility on battery chemistry, vendor, and technology





DC-COUPLED

Implementation

- Add new batteries behind existing batteries via DC-DC Converter
- Works for large or small projects

Risks and Considerations

- Controls are complex (managing energy to and from old vs new batteries)
- Lack of DC-coupled augmentation examples
- Efficiency losses; the new batteries will have a lower Round Trip Efficiency (RTE)
- Warranty risk: will the DC-DC converters impact parameters?
- Battery Management System (BMS) integration - existing EMS will either need to add a new BMS to the existing controls or entire unit controller must be reprogrammed

Benefits

- No impact to Interconnection Application
- Complete flexibility on battery chemistry, vendor, and technology
- Flexibility on quantity of batteries added; can add individual battery racks or multiple racks

ADDITIONAL CONSIDERATIONS

- Site provisioning
- Re-mobilization costs
- Physical space for re-mobilization
- Control Updates
- Site protections (DC Fault Currents)
- Cable Sizing
- Balance of Site Components