Valuation of Energy Storage Co-located with Solar PV Generation

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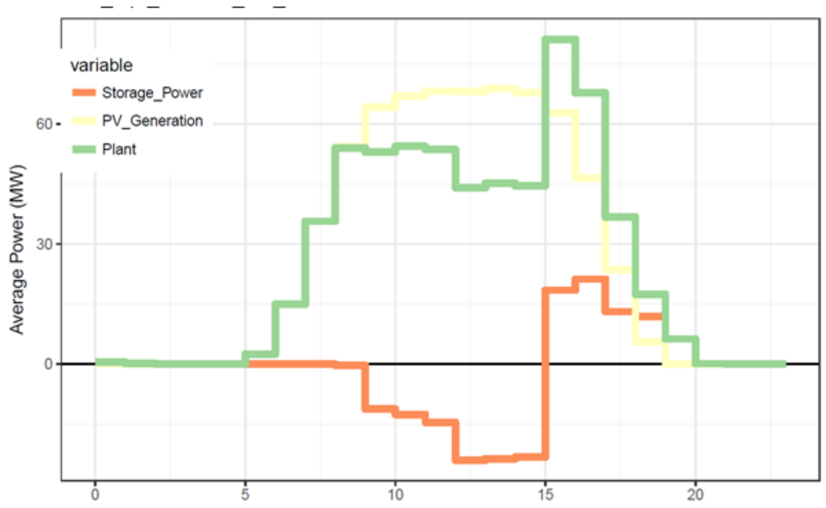
Objectives and benefits

- Behind-the-meter storage co-located with PV for customer economic objectives
  - Overcome interconnection restrictions
- Distribution or transmission-connected storage
  - Increase capacity value of the system
- General benefits
  - Avoid curtailment
  - Access additional rebates and incentives (FITC)



Sinergy of using PV and storage together

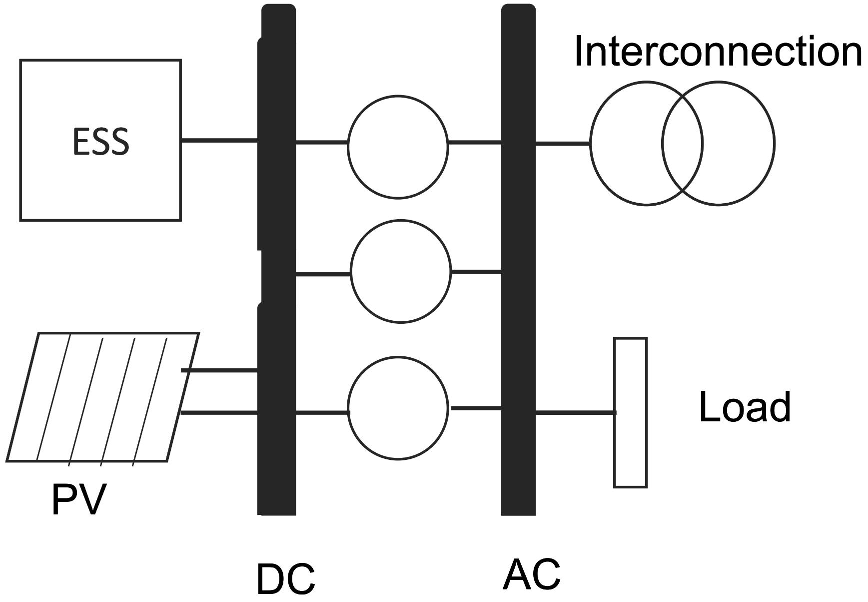
Configurations

PV controllability:

- Curtailable
- Non-curtailable

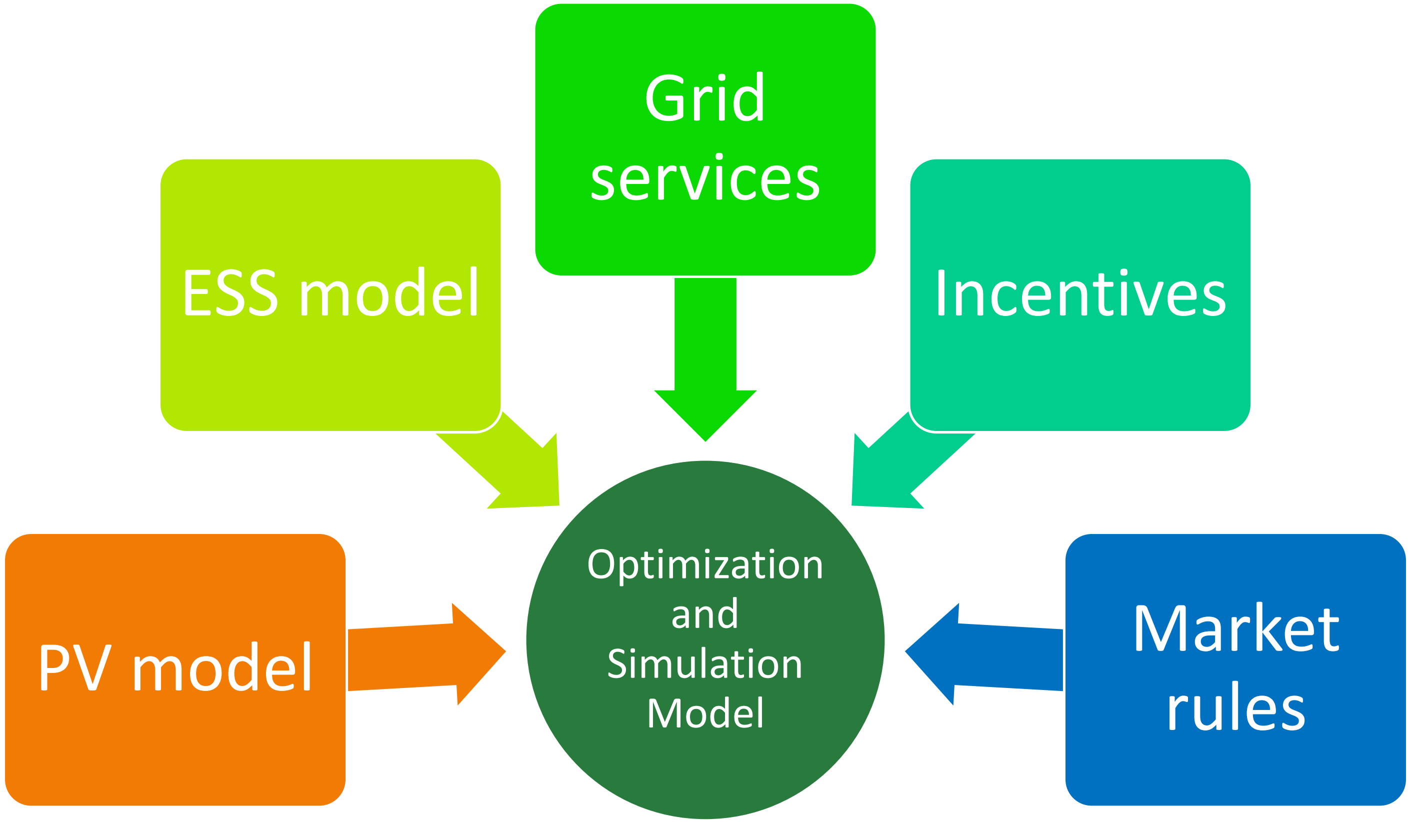
Interconnection/inverter constraints:

- DC-coupled
- AC-coupled



Different configurations will imply different benefits, challenges, and limitations

Modeling Approach



Grid Services Model

- Two types of services:

Performance objective

- Impose constraints on the ESS operation
- Revenue associated to them:
  - Avoided costs
  - Capacity payments
  - Contractual payments

- Resource adequacy
- Transmission upgrade deferral
- Distribution upgrade deferral
- Backup power

Economic objective

- Driven by prices
- Modeled through dispatch /capacity optimization

- Wholesale energy market participation
- Ancillary services
- Customer:
  - Energy charge
  - Demand charge

System Model

Energy Storage

Dynamics

- SOC evolution due to power dispatch and capacity use
- Degradation, State of Health

Constraints

- SOC bounds, power dispatch bounds

Costs

- Capital, replacement, O&M, disposal

Solar PV

Generation

- PV system generation (without curtailment)

Curtailment

- PV capacity at the connection with the energy storage system

Costs

- Capital, O&M

Other elements

Site load

- Customer load
- Feeder load

System load

- Load to determine capacity contribution

Interconnection

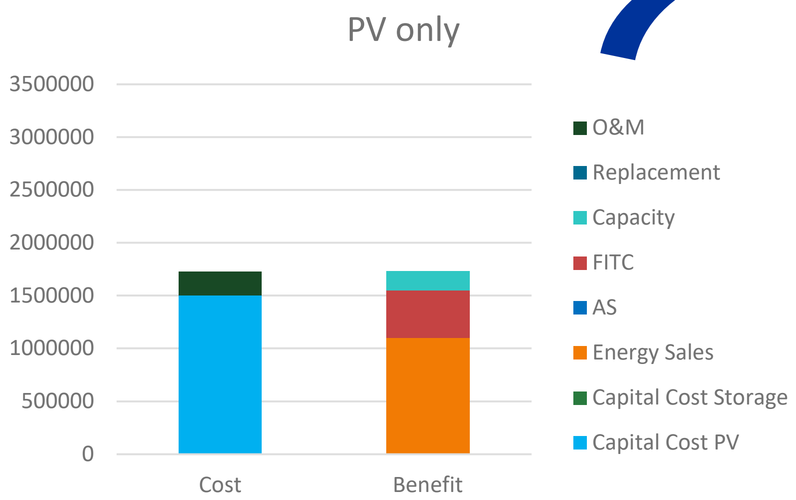
- Interconnection constraints

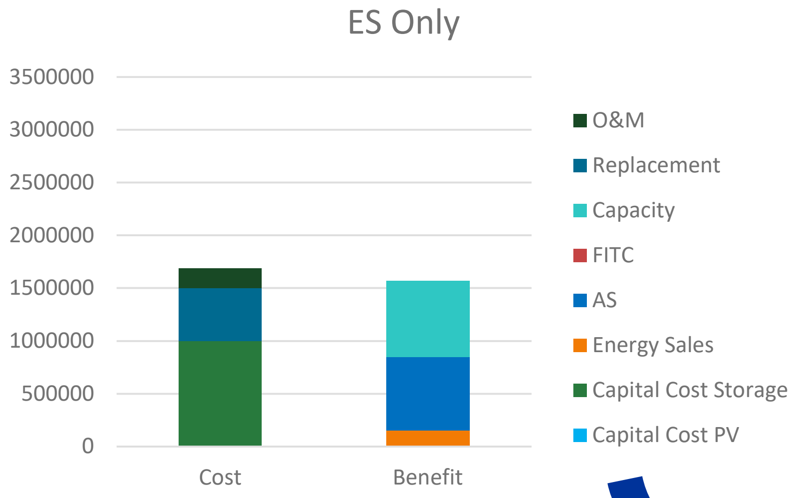
Other Aspects to Consider

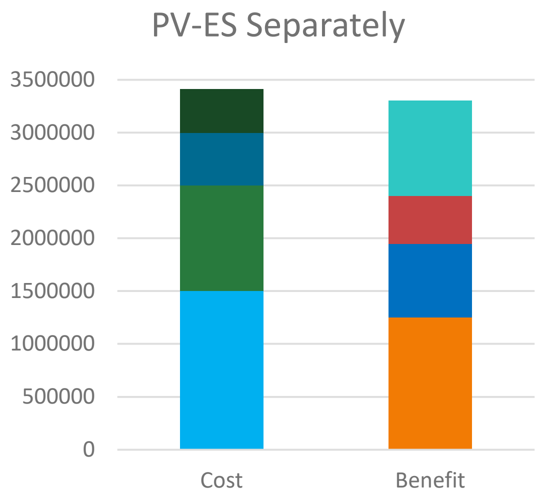
- Other value streams:
  - Renewable smoothing
  - Resilience (customer)

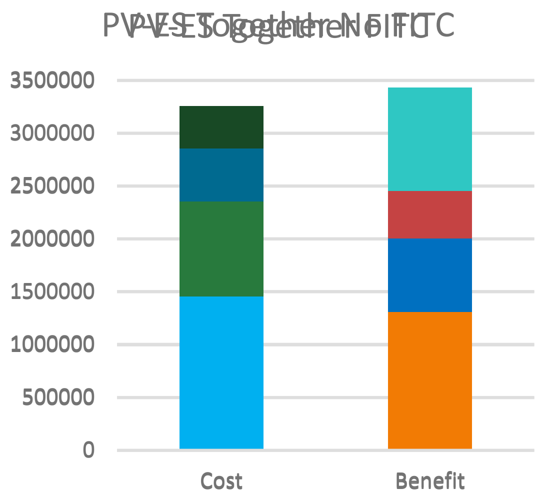
- Trade-offs:
  - Limit operation to obtain incentives vs forfeiting incentives to maximize operational benefits
  - Install larger (and more expensive) system now to attain incentives and manage degradation vs revamping in the future at lower cost

Example









Each case has pros and cons. Economics are case-specific

Conclusions

- As usual, value of storage co-located with PV depends on many variables

- Multiple conditions must be analyzed in order to find the most compelling business case

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