Energy Storage in the Evolving Electric System

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Context – decarbonizing the grid

- Solar PV – scalable, clean energy source – keeps getting cheaper & more efficient
- But high volumes of PV create challenges:
  - Causes system over-generation mid-day
  - Displaces flexible generation
  - Creates back-flow on distribution feeders
  - Output starts to fade as late afternoon demand starts to peak

Storage may be the game changer

- **Scalable energy storage could meet the challenges of high-volume PV**
  - At grid-scale: Charge at low/negative over-gen prices & make good use of mid-day excess supply
  - Co-locate with PV & wind to smooth output to the grid
  - Discharge to mitigate steep ramp & late afternoon peak
  - Provide 2-way DR, frequency response & regulation
  - With rooftop PV: Minimize back-flow on distribution
  - Manage local variability locally & flatten load profiles

But ... storage is not generation

- "Energy storage" comprises a diverse array of emerging technologies and capabilities
  - Compressed air, flywheel, hydrogen/biogas, gravity on rails, pumped hydro, batteries, et al
  - Scalable to fit diverse applications
  - *Consuming provides as much value as producing*
  - Revenue opportunities that value all storage capabilities are not yet well defined

Storage entails a paradigm shift

- Value services, not just KWh or KW
  - Thermal storage in buildings
  - De-carbonize transportation
  - Reduce need for flexible conventional generation
- Storage can decentralize reliability
  - Improving physical & cyber security & resilience
- Change in the electric system is being driven as much bottom-up as top-down
  - Regulators as facilitators, enablers of change

CAISO market pathways for energy storage

- Grid-level storage can interconnect as a generator with positive/negative output
  - Charges/discharges at wholesale LMP
- Provide energy, reserves, regulation under non-generator resource (NGR) model
  - Applicable at both grid & distribution levels
- Provide demand response (energy, reserves) under proxy demand resource (PDR) model

CAISO initiatives

- Distributed Energy Resource Provider (DERP)
  - Aggregator can form a virtual resource from diverse DER types – (filing Q1-2016)

- Energy Storage & Distributed Energy Resources (ESDER) – (filing Q1-2016)
  - Additional PDR performance metrics useful for storage

- ESDER Phase 2 – (est. filing Q1-2017)
  - Enhance PDR for 2-way dispatch & regulation
  - Expand options for multiple-use configurations

Emerging opportunities

- Distribution-level services

  - Real-time operations & deferment of infrastructure – specifications being developed in state proceedings
  - Procurement & compensation mechanisms TBD

- Multiple-use applications

  - Locating behind the meter maximizes opportunities
  - Provide services to customer, distribution & wholesale
  - On utility side, provide services to distribution & participate in wholesale market

~~Barriers~~ Open Questions

- Multiple-use scenarios – storage serves and earns revenues from multiple entities
    - When do wholesale/retail rates apply?
    - Which entity (T, D, customer) has operational priority?
    - How to sort out possible double payment for the same performance?
    - How can customer/distribution uses coexist with resource adequacy must-offer requirements?
    - How can storage be operated & compensated as a T/D asset and participate in wholesale market?

More open questions

- How to redefine responsibilities at the T-D interface?
- How to value and reward flattening of local & system load profiles?
- With volatility a cost driver of reliable operation, how to pay resources for mitigating volatility and charge those that add volatility to the system?
  - Provide incentives to combine storage with PV/wind to accelerate de-carbonization of the grid
- How to compensate storage for the value of local resilience, enhanced system security?
- How to enable bottom-up customer-driven system change?