Presentation to NASEO

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Storage 101

- Storage is neither generation nor load although it can appear as either.
  - Policy and technical problems when it is pigeonholed into one or the other.
  - Storage only shifts in time some other generation source
- Grid storage has been available for over a century
  - Pumped Hydro (1909); Largest pumped hydro in world is Dominion Power Bath County, VA
  - Rechargeable Batteries (lead acid 1860s)
- The innovation in storage that is creating the buzz is lower cost multiple recharge batteries (Li-ion)
- Storage is both capacity (MW) and duration (MWh)
  - Example: 2MW Storage System with 1MWhr of batteries

Need for Storage

- ✓ Super fast responding resources provide flexibility and stability to grid operators reducing costs and improving reliability
- ✓ Consumers are increasingly demanding emergency backup for power outages
- ✓ Increased penetration of intermittent solar power and other RE creates a need for additional power balancing technologies

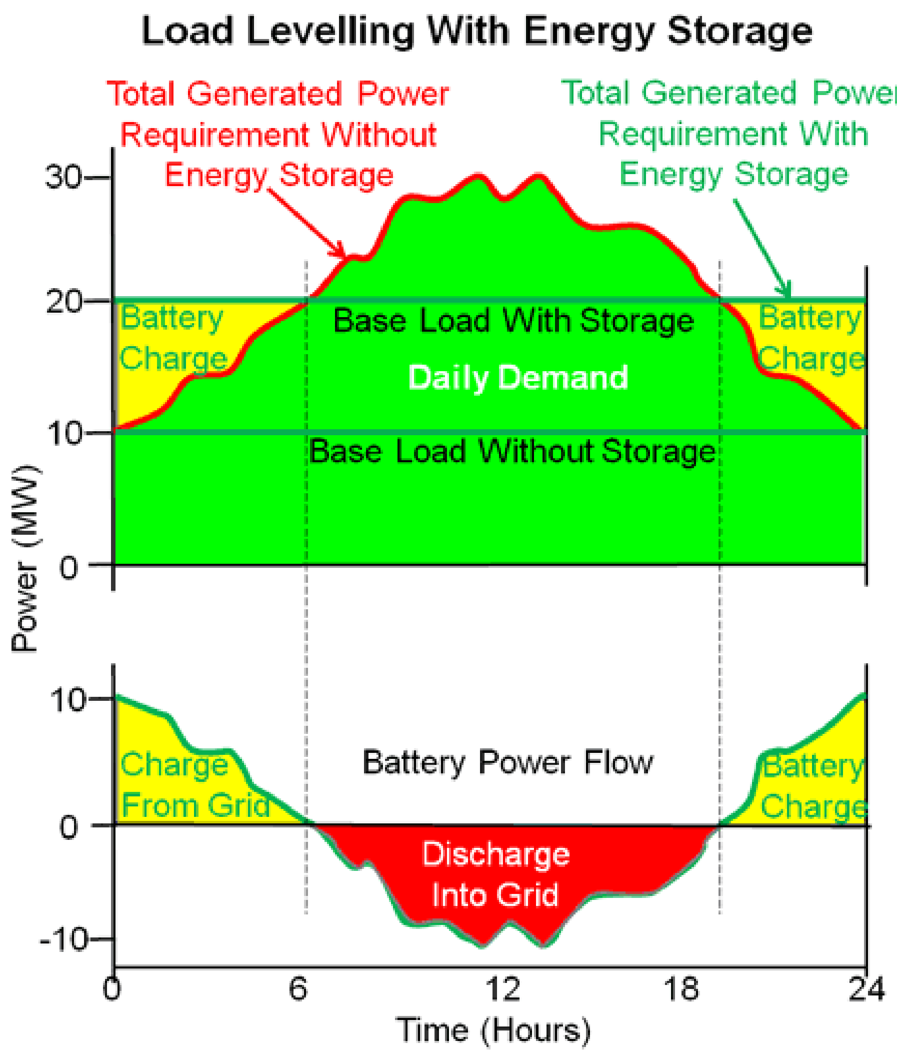
Financed Storage provides early access for customers

SOLAR GRID storage

Making Solar Better

Need for Storage

- ✓ Grid power production needs and costs vary by time of day
- ✓ This is the ultimate use case for storage but is only cost effective save for reducing the highest customer peak demand based retail utility tariffs
- ✓ No ISO/RTO market rates support cost effective storage for peak load reduction



Making Solar Better

Storage Values & Potential

- Value= High - Fast grid frequency regulation | Potential: 1% of grid capacity : 30min.
- Value= High – peak load reduction for customers |Potential ?:1hr
- Value= High/low – backup power uninterrupted power | Potential ? 2-8hrs
- Value = Medium - Capacity| Potential = 10-15% of grid: 4-6hrs
- Value= Low – full load leveling | Potential: 30-40% of grid capacity : 6-12hrs

Early storage markets are high value, low volume.
Later markets will be lower value but significantly higher volume

Storage Provides Many Additional Values

Market Services

Electric Energy Time-Shifting
Frequency Response
Frequency Regulation Up
Frequency Regulation Down
Ramping
Real-Time Energy Balancing
Synchronous Reserve (Spin)
Non-Synchronous Reserve
Black Start

Capacity Products

System Electric Supply Capacity
Local Electric Supply Capacity
Resource Adequacy

Generation Services

Intermittent Resource Integration (Ramping & Voltage Support)

Variable Energy Resource Shifting, Voltage Sag, Rapid Demand Support

Supply Firming

Transmission/Distribution

Peak Shaving: Load Shift
Transmission Peak Capacity Deferral
Transmission Operation
Transmission Congestion Relief
Distribution Peak Capacity Deferral
Distribution Operation (Voltage/VAR Support)

Additional Grid Benefits

Reduced fossil fuel use
Increased renewables
Grid Reliability
Faster build time
Modularity/incremental build
Mobility
Flexibility of purpose
Voltage Optimization
Locational flexibility
Multi-site aggregation
Demand charge reduction
UPS / Reliability
Self-consumption

Not All Applications Monetizable Today. . .

Solar Grid storage

Storage + PV
(like peanut butter & chocolate)

Value	Storage Customer sited	Grid Storage – Distribution	Grid Storage - Transmission	PV + Storage - Grid	PV+ Storage – customer*
Freq. Reg.	✓	✓	✓	✓	✓
Blackstart				✓	?
Capacity	?	?	✓	✓	✓
Synch resources	✓	✓	✓	✓	✓
VAR	✓	✓	✓	✓	✓
Voltage Reg.	✓	✓			✓
Tax credit				✓	✓
Backup power	Very Limited				✓
Ckt. Voltage optimization	✓				✓
Reduces PV cost				✓	✓

*policy issues may prevent some uses

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Solar Grid Storage Thesis

Storage costs are too high

- Customer cost to add storage exceeds the value (est. 2x cost with storage)

Storage enhances the value of solar energy deployment for customers

- Solar customers (particularly residential) value **backup power** – allowing on-site solar to function during grid outages.
- Firms peak power reduction.
- Shared inverter *(**provided to solar installation at 0 to ½ cost of PV-only inverter**)*

Storage can be utilized by the electric grid

- Transmission grid services (ancillary markets)
  - FR; Freq. response; Spinning reserve;
  - VAR support; Peak power reduction (competitive with gas peakers)
  - Bulk power time shift (need very low cost storage)
- Local grid services (no markets yet)

Actually Deploying Storage in Markets

SGS idea is to make storage cost effective and provide storage as a service:

- Turnkey storage system in a shipping container – includes inverter and battery to be installed alongside solar energy systems. Li-ion battery systems
- Solar Grid Storage finances storage addition
- Solar Grid Storage maintains and operates system for 10 years
- SGS pays for the cost of the system from ITC & revenues from ISO grid ancillary services also:
  - Small developer fee – about ½ the cost they would pay for inverter
  - Backup power fee

PowerFactor 500
500kW + 250kWh

SOLAR GRID storage

Making solar better

Key Policy Issues for Storage

- Ensure policies encourage customer sited storage with solar/wind
  - Highest value application
  - Backup power (most outages are in final mile)
- Allow/encourage storage systems to provide grid functions
  - All storage systems including customer sited should have open access to grid markets
  - Allow aggregation of small systems and low barrier; PJM good example of 100kW but can aggregate small systems to reach that threshold
  - Virtual power plant model should be encouraged
- Markets encourage best use of technology. Caution: duration requirement.
- Net metering is a must
  - Storage economics destroyed if there is a different charge rate from discharge credit
  - PJM/FERC recognize net metering need for storage.
- Avoid Standby and other discouraging charges on customers w/ storage

Punitive charges will encourage customers to cut the wires = no revenue support

Key Policy Issues for Storage – cont.

- Incentives are needed to jumpstart the market just like solar
- 14% cost decline curve with 2x manufacturing
- Incentives should help markets not supplant them
  - CA initiative is utility run and does not support a real market – can skew to lower value applications
  - PJM is solely market based without incentives
  - Incentives should have a long term feature where early incentives are high with low volume of storage installations but decline as cost of storage declines with higher volume deployments
- Incentive restructuring damages early stage markets
  - PJM retooling market will be disruptive
  - Poor market design did not have supply/demand safety valve
- Many storage values are hard to monetize in a market
  - Encourage distribution utility use of storage either in market or direct incentives

Storage Future

- Much in storage today looks like PV solar 15 years ago
- Cost reductions up to 75% are realistic
- If EV market becomes a major auto market, storage costs need to be ½ to ¼ of current costs

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Value of storage to customer

- How much would a customer pay for storage?
  - Residential
  - Commercial (one data point – 1c/kWh)
  - Demand reduction and changing tariffs
- Marketing play
- Customer value/payment determines the cost effectiveness gap

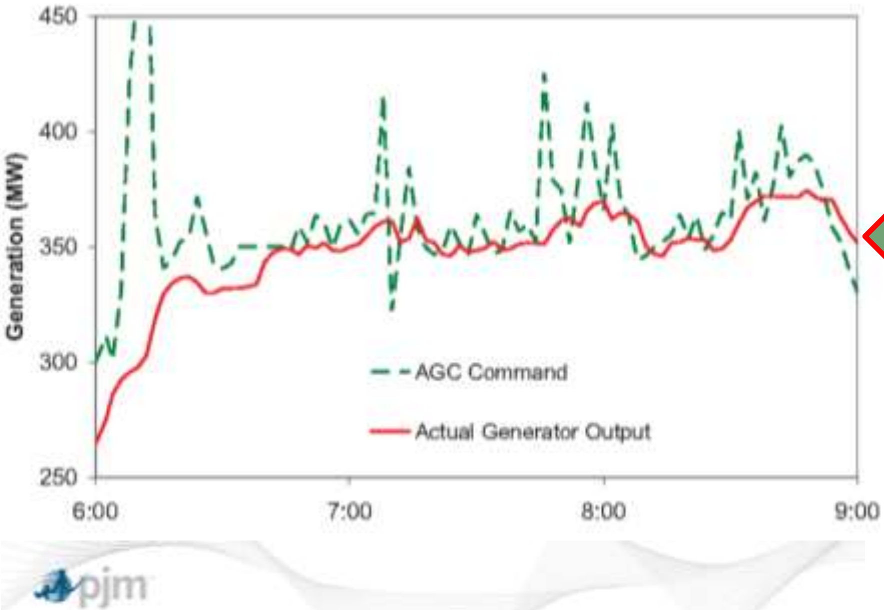
Are there storage economies of scale?

- Do larger substation based storage installations cost less than customer sited installations?
- What functionality is gained with a customer sited storage approach?
- How does customer value compare to economies of scale?

The DC bus – solar buildings of the future

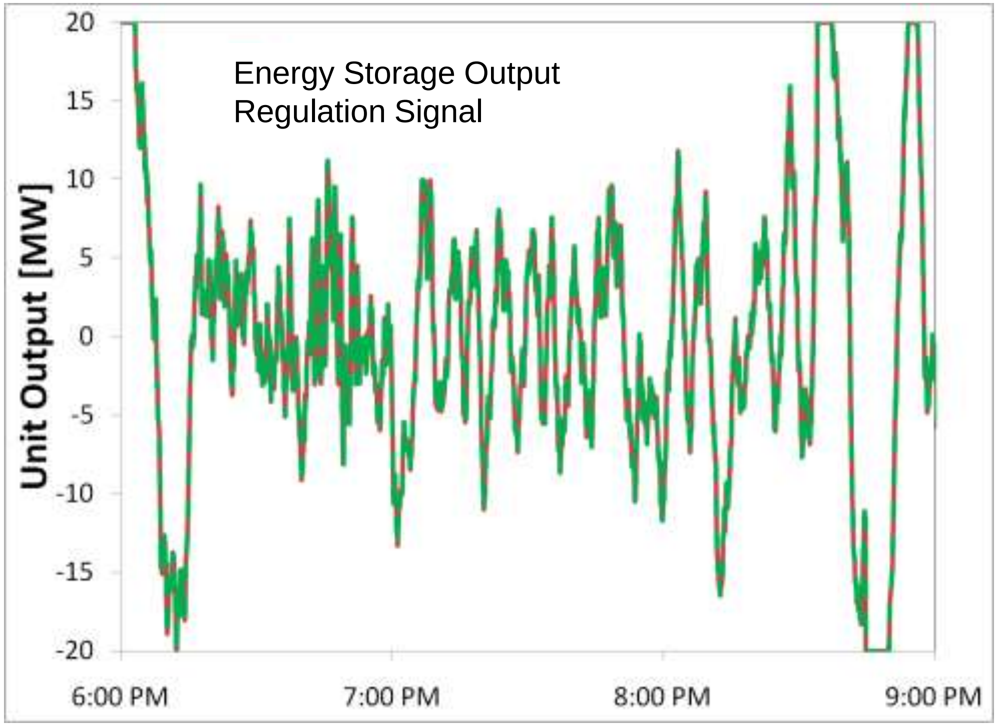
- Residential use of DC power increasing
  - Computers; video; amplifiers; lighting
  - Inverter based DC air-conditioning – super high SEER
  - Home design to allow reasonable non-grid operations
- Data centers. 30% reduction in power needs if DC sourced. Increase of 10-15% in solar PPA if DC sold/ metered.
- Commercial applications.

Regulation and Frequency Regulation: Performance Matters…



A fossil plant following a regulation command signal

Energy Storage accurately following a regulation command signal



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Optimization of storage

- As storage deployment increases, how are the optimal values and operations for customer, local grid and transmission grid determined?
- Models needed