Community Energy Storage
Expanding PV Opportunities

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Community Energy Storage - Expanding PV Opportunities

• **Big Picture – Solar has a bright future**
  – Constraints – Well known issues
  – Solutions – Storage is firmly in the picture

• **Unique fit – Community Energy Storage (CES)**
  – Introduction to CES
  – Power Smoothing
  – Solar Energy Time Shifting

• **Bonus – Additional Benefits**
  – Extraordinary Reliability
  – System Level Impact

• **Q&A**
Big Picture – Solar has a bright future

Photovoltaic (PV) Generation is being introduced at various scales and at various locations through the power system

- Large PV farms (along with wind)
- Moderate three phase; small farms or at commercial facilities
- Small single phase; primarily residential
Incentives and declining costs are accelerating PV installations.
Big Picture – Solar has a bright future

Why the Concern about issues such as solar on the grid?

Cumulative installed DISTRIBUTED PV in US is doubling every 2 years! Residential Installations are growing even faster.

“Solar DG may overtake Wind in 10 years.”
Jon Wellinghoff, FERC Chairman
Big Picture – Solar has a bright future; Constraints

High PV penetration – great but not all good, The issues:

• Variability of power flow -> voltage fluctuations
• Reverse power flow -> high voltage
• Reduced daily minimum power -> worsening Load Factor
  which also means poor generation capacity factor
Big Picture – Solar has a bright future; Constraints

Variability at a single site is evident

Variability is aggregated across multiple sites regionally; synchronized by local irradiance
Big Picture – Solar has a bright future; Constraints

Reverse power flow results locally when PV exceeds consumption.

Reverse power flow may aggregate at the feeder level.
Big Picture – Solar has a bright future; Constraints

Diurnal profile of PV generation pushes mid-day demand down

Late day peak is not offset

• Poor apparent Load Factor
• High ramp rate

### Typical March Day – significant change starting in 2015

![Chart Courtesy of CAISO](chart.png)
From Sandia National Laboratories - Smoothing Definition

• PV Smoothing – the use of an energy storage system (ESS) to mitigate rapid fluctuations in variable photovoltaic power output

Purpose:
• Feeder level – voltage flicker and voltage excursions outside desired bands can result from unsmoothed PV
• Transmission level – PV variability can require additional operating reserve to be set aside and can cause traditional generation to cycle more than otherwise

Method:
• ESS is used to absorb or supply power at appropriate times as determined by a control system resulting in a smoother combined PV + ESS power output

Big Picture – Solar has a bright future; better with storage
Big Picture – Solar has a bright future; better with storage

California example

Storage is mandated as part of the move towards higher reliance on renewable generators

Expected Activities For Storage in 2014: California Storage Procurement Targets Ruling – Need for Tools

- On October 17th, 2013, the California CPUC voted 5-0 to implement the targets shown in the chart
- Ruling also included an additional 1% of Peak Load by Energy Service Providers
- Excluded large pumped hydro and CAES Systems
- Included Customer sided storage – up to 50%
- Allowed the 3 IOU utilities to rate-base storage
  - Utility perception?
Big Picture – Solar has a bright future; better with storage

**Energy storage is firmly in the picture; advancing technology**

A great deal of research ongoing around the world, especially on batteries

- Argonne National Labs recently received $120-M funding for Joint Center for Energy Storage Research (JCESR)
- Has a 5-5-5 vision
  - 5x the energy density of current lithium ion technology
  - at 1/5 the cost
  - within 5 years
- They are looking to push battery technology beyond lithium ion
Energy Storage comes in many forms

Source Storage
100’s of MW
(Pumped hydro/CAES)

Distribution Bulk Storage
10’s of MW
(NaS, Li-Ion, Lead Acid)

Distribution Grid Edge Storage
10’s of kW
(Li-Ion)
Unique fit – Community Energy Storage (CES)

The best solution is distributing the stabilizing influence (storage) to the point of destabilizing influence (PV generator)

Locally:
• Supplies or absorbs real power on a fast basis to smooth variable output of PV generators
• Reduces or eliminates reverse power flow, storing at or near the PV
• Supplies or absorbs reactive power to keep local voltage within limits
Unique fit – Community Energy Storage (CES)

The best solution is distributing the stabilizing influence (storage) to the point of destabilizing influence (PV generator) … which then has a positive impact on the rest of the system

Feeder and System Level:
• Combined impact of multiple, distributed storage units stabilizes power flow and voltage along the feeder
• Stores solar energy near the point of generation for later release, offsetting feeder peak demand, improving apparent system load factor
• Smoothed power plus energy time shift combine to reduce supplemental generating capacity needs
Distributed Energy Storage
- Transforming Power Systems at the Distribution Level

Distributed Energy Management Controller (DEM)

 CES Units
With small three phase systems
Connected along feeder at MV
Commercial / Industrial sites
Renewable generation installations

250 kVA Converter shown
Battery technology may vary
2 or 3 hour duration
- Transforming Power Systems at the Distribution Level

With small single phase systems

CES – Community Energy Storage Converter; 25 kVA, 240/120 V

Li Ion Battery;
25 kW, 50 to 75 kWh
Community Energy Storage – CES Unit

- Small energy storage unit connected to the secondary of transformers
- Serves a few houses or small commercial loads
- Scalable storage at “edge” of the grid
- Tames power flow variability from local PV
- Eliminates reverse power flow from local PV
- Provides Local backup
- Participates in Substation and Feeder Level storage applications
Local to the customer - CES Components

Small Footprint

25 kVA
25, 50, or 75 kWh
240/120 V
- Transforming Power Systems at the Distribution Level by providing flexible use for multiple benefits
- Transforming Power Systems at the Distribution Level by aggregating storage impact and benefits

**System Level**
- Capacity Relief
- Improve capacity factor
- System Stability
- Ancillary services

**Station / Feeder Level:**
- Peak shaving, load leveling
- Reactive Power Compensation
- Renewable energy time shifting
- Voltage Stabilization
- Reduce cold load / load transfer

**Local level:**
- Reliability (islanding)
- Renewable smoothing
- Voltage control
- Store excess solar generation
Supports Local, Regional, or Central Operations

Central Monitoring and Control
- System Level Energy Management

Regional Control
- Substation Transformer
- Feeder
- Group

Local Control: Connected customers

Groups:
- Group 1
- Group 2
Unique fit – Community Energy Storage (CES)

Locally: Supplies or absorbs real power on a fast basis to smooth variable output of PV generators
Unique fit – Community Energy Storage (CES)

Power smoothing; controlling local variation

Feeder level mitigation, depending on PV and CES penetration
Unique fit – Community Energy Storage (CES)

Use of CES Unit to Prevent Reverse Power Flow on Phase C (5th September)

- 4th September Real Power Demand
- Demand (with CES Operation)
Unique fit – Community Energy Storage (CES)

Energy time shifting

Solar Energy time shifting is similar to peak shaving with modified timing and objectives
CES Islanding Event 4/8

- Residential customer islanded after grid outage
- Customer remained with power for approximately 5 hours after outage occurred
Nearly ideal example of PV and CES in balance during an extended outage, 25 Hours
Questions?

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