Battery Interconnection Process

Stakeholder Sub Group

March 29th, 2018
Agenda

- Storage Background
- Storage Guidance Documents & Tariff Updates
- Process Documents
- Salesforce Installer Process
- Storage Configurations
- Storage Review Process, Main Points, & Q’s
Xcel Energy Representatives

Solar Program Team
• Kristin Gaspar, Solar Programs Manager
• Kevin Cray, Solar Trade Relations Manager
• Eric Van Orden, Team Lead, Strategic Segment

Regulatory & Strategy
• Neil Cowan, Specialist, Regulatory Policy
• Eric Maurer, Product Strategy & Development

Xcel Energy Engineering Team
• Tom Malone, Senior Engineer
Disruptive technology

Storage Changes Supply Chains

- Refrigeration transformed food supply by allowing preservation of a highly perishable product
  - Changed delivery mechanisms
    - E.g. No more milk man
  - Created new supply and demand patterns
    - E.g. Winter produce from Chile
- Energy storage may similarly transform when and where electricity is produced, transmitted, and used

GE Monitor-Top refrigerator, c. 1927
• Today, much of the functionality is handled by an on-board computer following firmware and software instructions in order to achieve the desired results.
• Promising developments due to other utilities now grappling with NEM/QF and battery integration.
• People want batteries for 1) backup power in case of grid disconnection, 2) time of use rate arbitrage, 3) feeling of self-consumption, 4) future benefits, 5) its cool
• Total U.S. energy storage deployments reached 431MWh in 2017, a 27% increase from the 340MWh in 2016.
• Behind-the-meter (BTM) deployments reached a record setting 70MW in 2017, nearly the same as 2015 and 2016 combined.
• The Section 201 tariffs on imported solar products cast a shadow over the energy storage market. For 2018-2022, forecasts decreased by 3% for residential, 4% for non-residential.

**2017 U.S. Energy Storage Scorecard**

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2016</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Deployments (MWh)</td>
<td>431</td>
<td>340</td>
<td>Up 27%</td>
</tr>
<tr>
<td>Front-of-the-Meter Deployments (MWh)</td>
<td>281</td>
<td>257</td>
<td>Up 10%</td>
</tr>
<tr>
<td>Behind-the-Meter Deployments (MWh)</td>
<td>150</td>
<td>84</td>
<td>Up 79%</td>
</tr>
<tr>
<td>Total Deployments (MW)</td>
<td>215</td>
<td>231</td>
<td>Down 7%</td>
</tr>
<tr>
<td>Front-of-the-Meter System Price – 2 Hr. ($/kW)</td>
<td>$1,313-$1,800, median $1,538</td>
<td>$1,400-$2,125, median $1,700</td>
<td>Down 10%</td>
</tr>
</tbody>
</table>
Using customer-sited batteries today and in the future

<table>
<thead>
<tr>
<th>Pre-2017</th>
<th>TODAY</th>
<th>FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backup only</td>
<td>Primary use for backup</td>
<td>Integrated, optimized with other technology</td>
</tr>
<tr>
<td></td>
<td>Other options: -Commercial DR -Rate management -Voluntary solar time shifting</td>
<td>Grid examples: -Demand response -Renewable integration -Distribution deferral -Ancillary services</td>
</tr>
<tr>
<td></td>
<td>Interconnection options</td>
<td>Customer examples: -Rate management -Back-up</td>
</tr>
</tbody>
</table>

- [Backup](#) only
- [Primary use for backup](#)
- [Integrated, optimized with other technology](#)
- [Primary use shared btw grid and customer](#)
- [Grid examples](#):
  - Demand response
  - Renewable integration
  - Distribution deferral
  - Ancillary services
- [Customer examples](#):
  - Rate management
  - Back-up
The state of customer-sited batteries

Number of Residential Battery Applications, (2017-2018)*

<table>
<thead>
<tr>
<th>Application Stage</th>
<th>Count of Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Installation Details</td>
<td>14</td>
</tr>
<tr>
<td>Documents and Payments</td>
<td>23</td>
</tr>
<tr>
<td>Engineering Review</td>
<td>24</td>
</tr>
<tr>
<td>Final Documentation</td>
<td>174</td>
</tr>
<tr>
<td>Meter Installation</td>
<td>7</td>
</tr>
<tr>
<td>Completed</td>
<td>42</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>284</strong></td>
</tr>
</tbody>
</table>

*Data current as of Wednesday, March 28
Storage Guidance Documents

- Jan 1st, 2017  Xcel Energy Storage Guidance Documents were approved under the CPUC Comprehensive Settlement Agreement to offer 8 battery configurations.
- Guidelines comply with updated PSCo tariffs & rules.
  a) The export characteristics of each DER are relevant and tied to tariff provisions such as net energy metering (NEM).
- Guidelines posted on:
  a) How to Interconnect webpage on XE.com
  b) Solar Installer webpage

Storage Guidance 1 (Non-Renewable) (PDF)
Storage Guidance 2 (Renewable, Utility-side of Production Meter) (PDF)
Storage Guidance 3 (Renewable, PV-side of Production Meter) (PDF)
Electric Rate Book Updates

Effective March 10, 2018 – Schedule NM now includes monetization of the Roll-over credits and storage systems operating in parallel with the grid. Sheet No. 112D

RULES AND REGULATIONS

Service supplied under this rate schedule is subject to the terms and conditions set forth in the Company’s Rules and Regulations on file with the Commission and the following conditions:

1. Customer will be responsible for installation and maintenance of the Retail Renewable Distributed Generation. Company will install, own, and maintain suitable metering and other equipment necessary for measuring the production from the Retail Renewable Distributed Generation as well as net of the electric energy supplied by Company and the energy produced by the Retail Renewable Distributed Generation. An Energy Storage System may be combined and charged by the Customer’s Retail Renewable Distributed Generation System. If the Customer’s Energy Storage System is charged solely by the Retail Renewable Distributed Generation, the Customer’s Energy Storage System may participate in the Company’s Net Metering Service; otherwise, if the Energy Storage System is charged by any other source the Customer’s Retail Renewable Distributed Generation may participate in the Company’s Net Metering Service provided the Energy Storage System does not export power through the Service Meter, except for, inadvertent or de minimis exports. Company will work with the Customer to determine the appropriate location of its meters and metering equipment for separate Retail Renewable Distributed Generation Production Meters and the meter to assess load that is served from the generation side of the Production Meter.
Electric Rate Book Updates Cont…

Schedule PV – updated to include Energy Storage systems with PV.

SCHEDULE PV

ENERGY STORAGE SYSTEMS WITH PV

Customers may elect to own, operate, and maintain their PV System in conjunction with an Energy Storage System consistent with technical guidance as posted to the Company’s web site. If the Customer’s Energy Storage System is charged solely by the renewable generation, the Customer’s Energy Storage System may participate in the Company’s Net Metering Service; otherwise, if charged by any other source, except for, inadvertent or de minimis exports, the Energy Storage System must not export power through the Service Meter.

The configuration of the Customer’s Energy Storage System consistent with the Company approved configuration may affect the production of REC’s due to the losses associated with the operation of the Energy Storage System. If the Customer chooses a configuration that result in a reduction of REC production, as measured by the Company’s meter or meters, approval of the installation will be contingent on the Customer’s acceptance of the reduction of REC’s.

For Customers who choose to design and implement an Energy Storage System that is paired with their PV on the PV side of the Production Meter, the Company will require an additional meter where applicable in conformance with Company standards to assess any load that is served from the generation side of the Production Meter and to measure REC’s when appropriate. The Customer will be responsible for a Load Meter Charge as found on their applicable service schedule.
Battery Configurations

<table>
<thead>
<tr>
<th>Configuration</th>
<th>AC, Standby Energy Storage 1A</th>
<th>AC, Non-Net Metered, Non-Export 1B</th>
<th>AC, Non-Net Metered, Non-Export W/Gen 1C</th>
<th>AC, Net Metered, Standby Energy Storage 2A</th>
<th>AC, Net Metered, 100% Renewable Export 2B</th>
<th>AC, Net Metered, Non-Export 2C</th>
<th>DC, Net Metered, 100% Renewable Export 3A</th>
<th>DC, Net Metered, 100% Renewable Export 3B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnection Type</td>
<td>For Customers without Generation or Storage in Parallel with Self-Generation</td>
<td>For Net Electric Metering (NEM) and Solar*Rewards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair with Renewable Energy?</td>
<td>Yes or No</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Parallel Operation Allowed?</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Interconnection Review Required?</td>
<td>No^^ ^^^</td>
<td>Yes</td>
<td>No^^ ^^^</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Storage Charging</td>
<td>Utility or Self-Generation</td>
<td>Utility or Self-generation</td>
<td>100% Renewable Generation</td>
<td>Utility or Generation</td>
<td>100% Renewable Generation Only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Discharging</td>
<td>Standby System^&amp;</td>
<td>Non-Export^&amp;</td>
<td>Standby System^&amp;</td>
<td>Export of 100% Renewable Generation Only</td>
<td>Non-Export^&amp;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production Meter?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
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<tr>
<td>Telemetry and Control?</td>
<td>Determined by total DER as addressed in PUC Rules, Interconnection Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agreements and Forms***</td>
<td>Attestation of Conformance to NEC Article 702***</td>
<td>Interconnection Agreement, Operation Mode to be Identified in IA**</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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* Inadvertent Export Allowed per Settlement Guidance documents.
** Operating Mode needs to be identified and also include requirements as indicated above for storage charging and storage discharging. Such as charging from on-site renewable energy source that is eligible for net electric metering (NEM), non-export requirements, or stand-alone storage system.
*** All storage configurations require an Attestation Form to be completed by the installer and submitted with the Application. The Attestation specifies the Configuration designation, the means used to lock-down access to the Configuration, and Operating Mode selection.
^ Configuration and Operating Modes must be locked-down so user cannot change. If no lock-down, all available Operating Modes must be reviewed, mitigated as needed, and documented in the Interconnection Agreement, Exhibit D.
^^ AHU inspection required. If a PV or other source is installed at the same time as the storage, the facility must be reviewed.
^& If Operating Mode is not locked-down, a full review and Interconnection Agreement is required.
! Variations from diagram drawings allowed. 2B, 3A, and 3B may be configured for non-export with mixed source source charging.
We define the **Attestation** as providing the upfront information needed by the engineering team to expedite the review process. Without it, more time is required to research the functionality within the inverter, which may or may not be well communicated in the inverter manual or other documentation.

- a) Attestation 702 1A and 2A
- b) Attestation 1, 1B and 1C
- c) Attestation 2C, 2B
- d) Attestation 3A, 3B

**Exhibit D** captures the results of the review by the Area Engineer that affect the ongoing operation requirements of the facility after it is in service. Requirements identified in the attestation that is uploaded to the application by the installer.

The **Interconnection Agreement** and Exhibit D are used for all DER technologies up to 10 MWs in size.
Important Definitions

“Energy Storage System” - is a system designed and operated to capture electrical energy produced at one time for use at a later time. (Tariff definition)

“Operating Mode” - a combination of the functionality in the physical Configuration and the functionality in the software programming some of which is not shown in the Configuration diagram. Operating Mode is the combined function designed to achieve an Operating Objective that may vary with a change of settings. Operating Modes are established as a function, not by a diagram designation. Operating Modes include, but are not limited to, battery non-export, maximize self-consumption, maximize export, perform time shifting, and perform peak shaving. A change of Operating Mode may constitute a change of Operating Objective.

“Material Change” - any modification to the system that causes the system to operate contrary to the approved operating configuration shall be considered a material change and shall be considered a material breach of IA Agreement.
Installer Battery Application Process

“How do I submit a new solar application with a battery backup?

- Check “Battery Backup” checkbox on the System Details tab
“How do I submit a standalone or retrofit battery application?

- On the Start tab choose a “DG” Program Type
- Then choose “Battery” as the DG Fuel Type
Installer Battery Application Process

“What information do you need to know about the battery?

• Complete all required fields in the Battery Details section
Installer Battery Application Process

“What information do you need to know about the battery?

- Upload a completed Attestation for the battery configuration followed in addition to the Line Diagram and Site Plan

- Battery design must be shown on the Line Diagram for consideration
• If approved by Engineering, the application will move on to Final Documentation
• If a rejection occurs, the installer will receive an email with further instructions
• For storage applications, wait until both engineers reply to re-submit for approval (if applicable)
Storage Review Process
First of a design applications of energy storage systems are reviewed in detail based on attestation and submitted information.

1. We request a storage review package from the installer or manufacturer prior to any applications being submitted to the Application Portal.

2. To confirm meeting of settlement provisions requires extensive detailed review of operating manuals and often inquiries with manufacturer.

3. Subsequent applications are compared with initial Attestation & oneline.
   a) Details are still important, but more specific to system arrangement matched to first-of-design attestation and operational requirements.
Storage Review Main Points

1. Guidelines apply to all tariff classes eligible for hosting storage.
2. Application must declare intended operating mode(s) and configuration.
   a) Note: that Attestation mode names should match the names in the manual.
3. Different modes have different thermal and voltage regulation duties.
4. Operating Mode selection of storage inverters must not be readily accessible to the customer. This is required since some operating modes are not eligible for some tariffs, with NEM being greatest challenge.
5. If mode selection or specific settings necessary for tariff compliance are readily accessible to customer, an extended review of all accessible modes will be done and restrictions and mitigations, if needed, will be required.
6. Application size for PV + Storage will usually be based on the lessor of combined inverter nameplate ratings or limiting element (shared inverter).
1. Storage is reviewed as a source as other sources are reviewed and separately reviewed as load as other loads are reviewed for those designs eligible to charge batteries from grid.

2. There are two levels of review – in-depth and ongoing.
   a) In-depth is performed for first use of a storage design and mode of operation.
   b) Ongoing is brief verification review that submitted design matches in-depth pre-reviewed design and mode of operation.
   c) All ongoing reviews are subject to review of metering and site specific system concerns.

3. Any changes in Guideline configuration, equipment model, or firmware (that modifies/adds operating modes) are not covered by prior global reviews and may require a new in-depth review.

4. In-depth review are based on Attestation information to ensure correct value and manuals are used.
Legacy Installation Qualification Criteria

Storage added to legacy residential PV systems without required disconnect switch or Production Meter (PM):

a) Initial Solar*Rewards residential PV systems did not require PM.
b) Disconnect switch was not required for a couple of years.
c) Legacy residential PV installed during above periods are grandfathered.
d) For Guideline 3A, the second load meter is not required when there is a protected load panel.
1. The Guidelines for Energy Storage Systems (ESS) apply to all sizes of systems from residential up through MW size facilities.

2. The tariffs such as net metering apply to all size facilities.

3. The Guideline oneline diagrams are based on residential size ESS.

4. The onelines are conceptual, illustrative, and variations that meet the concepts are allowed.

5. Designs that do not meet defined configurations may be considered, must be identified as custom, and will be evaluated on same tariff compliance criteria and Guideline principles.

6. Guidelines were created by a multi-party work group to implement the storage part of Settlement in PUC Proceeding No. 16AL-0048E.
1. All customers are subject to service tariffs for their power consumption.
2. These tariffs do not allow export of self-generated power, including stored in ESS, except for renewable power.
3. Renewable power may be exported under Schedule NM, Net Metering, and Schedule PV, Photovoltaic Service.
4. Storage Review Requirement, Schedule NM, Sheet 112D:
   a) “An Energy Storage System may be combined and charged by the Customer’s Retail Renewable Distributed Generation System. If the Customer’s Energy Storage System is charged solely by the Retail Renewable Distributed Generation, the Customer’s Energy Storage System may participate in the Company’s Net Metering Service; otherwise, if the Energy Storage System is charged by any other source the customer’s Retail Renewable Distributed Generation may participate in the Company’s Net Metering Service provided the Energy Storage System does not export power through the Service Meter, except for, inadvertent or de minimis exports.”
1. Net Metering is only available for netting customer load against on-site qualifying renewable sources.

2. Storage is treated as renewable resource if it is solely charged by qualifying renewable on-site source.

3. Net Metering cannot be allowed if on-site source is not a qualifying renewable source as required by legislation.
   a) Other IOUs are challenged by same criteria, including CA.

4. Storage is not a renewable source if charged by other than a qualifying source, such as with grid power or generator, such as diesel. It is not eligible to participate in net metering.

5. Any customer eligible for net metering will cease being eligible if non-qualifying source that can export to grid is included.

6. Verifying this eligibility is primary purpose of in-depth review. Unauthorized changes in settings or operating modes can result in loss of net metering eligibility.
1. ESS designs can be grouped into three general designs:
   a) Standby
   b) No battery export allowed
   c) Battery export allowed

2. Standby meets NEC 702 requirements and never parallels with grid.

3. No-battery-export may supply customer loads but the revenue meter outflow must not exceed the on-site renewable source’s output.
   a) Whole house backup & load supply usually requires separation device and inverter input from meter in series with grid revenue meter.

4. Battery export must have battery solely charged by an on-site eligible renewable source.
   a) Inverter functionality after outage or prolonged poor PV output can use grid power to recharge the battery. This is a frequent approval problem.
Guideline Drawings
Guideline Overview

- Guideline diagrams are conceptual and variations are allowed.
- Diagrams are meant to be illustrative configurations and not prescriptive.
- Diagram designations are referring to concept illustrated and not referring to specific configuration illustrated.
- Guideline configurations 2B, 3A, and 3B can be set up to prevent battery export and be approved as non-exporting.
- Since functionality provided by firmware is not obvious, the functions are either listed or illustrated with a hardware equivalent.
Parallel Battery & Self Generation 1C
Standby Battery, PV, & NEM 2A
AC Coupled Battery, PV, NEM Export 1B

AC Coupled Battery, PV, NEM, No Export 1C

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**Figure Illustrates Representative Concepts & Intent. Packaged Systems May Have Hybrid Inverters With These Features Provided As Part of the Package.**

**AC Coupled 2b**

- Battery charged by 100% renewable energy
- Battery may discharge to grid

**Utility**

**Customer**

Metering must be time sync

Controlled by inverter programming:
1. PV bypass battery when battery fully charged.
2. Battery charged by PV only.
3. Battery discharge to main panel or protected load panel only.

*Optional - ATS may be omitted if inverter can deliver utility side power while charging battery from 100% renewable energy.*

**AC Coupled 2c**

- Battery not allowed to export to grid
1. Required inverter programming must be locked down.
2. Inverter may be connected to protected load panel if inverter can provide transfer switch function.

**Grid Following Inverter**

Optional

Production meter

Lockable utility accessible disconnect switch

Protected load panel

**PV Array**

11/05/14
DC Coupled Battery, PV, NEM, PLP 3A
DC Coupled Battery, PV, NEM, PLP, ATS 3B
APPROVED Battery Configurations
Inverter Suppliers with Approved ESS Designs
Approved to Duplicate with Minor Review

✓ Tesla
✓ Schneider
✓ StorEdge
✓ Outback

• Approvals to date for Guidelines 2C, 3A, and 3B designs.
• Each approval was design specific.
• Multiple configurations approved for some inverter brands.
• Each inverter brand may be configured in multiple configurations.
• Approval by inverter model or brand is not possible.
• Interconnection approval is based on safety and tarriff compliance.
• Approval is not based on brand or type of battery.
  a) Safety review is straight forward & quick. Tarriff review is difficult & time consuming.
Going Forward

- Standardization of functions and testing of inverters expedited review and acceptance of PV inverters.
  a) PV inverters have one function & configuration with simple tariff compliance.
- ESS does not have standardization of non-safety functions and tariff compliance yet.
  a) ESS has multiple functions and many configuration variations.
  b) No standardization for tariff compliance exists.
  c) CA is working on net metering compliance verification design criteria.
  d) UL is working on similar approaches.
  e) Storage today in this respect is similar to PV prior to initial standards.
  f) Standards plus utility & installer experience will allow convergence on expedited approvals and processing similar to PV.