# Battery Interconnection Process

for Xcel Energy Colorado

## Guidelines & Applications

**September 2018**

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*Information current as of 9.24.2018. This presentation is subject to change based on CPUC docket and “Fenberg” bill implementation in late 2018/2019.

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# 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*

3

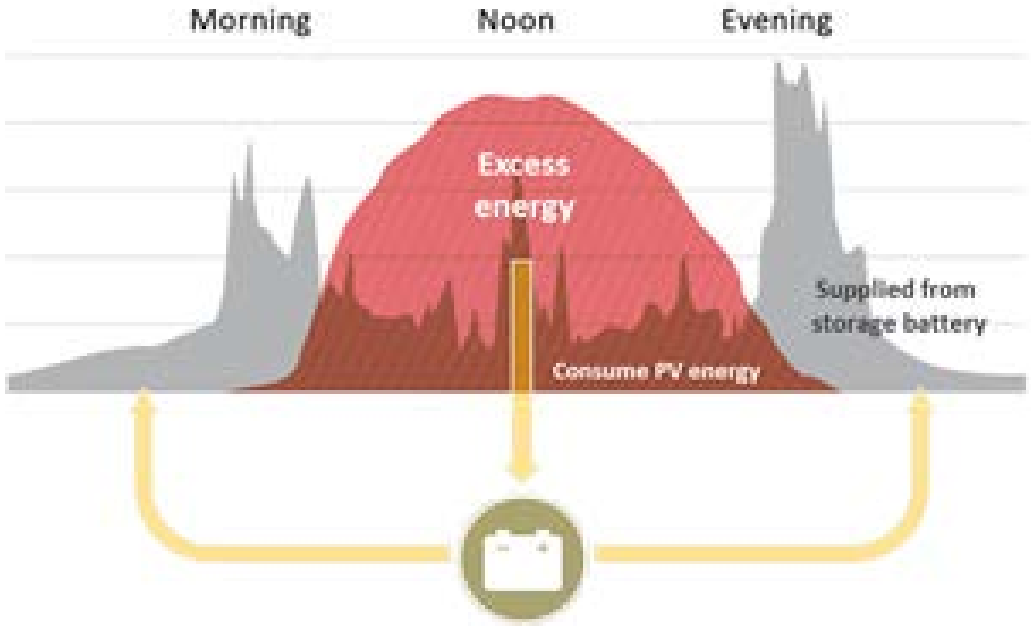
Picture rom digital collection of Mike Manning, retrieved 31 Oct 2013 from http://en.wikipedia.org/wiki/File:Monitor_refer.jpg



4

# Storage Today

- Today, much of the functionality is handled by an on-board computer following firmware and software instructions in order to achieve the desired results.
- 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



# Storage Background

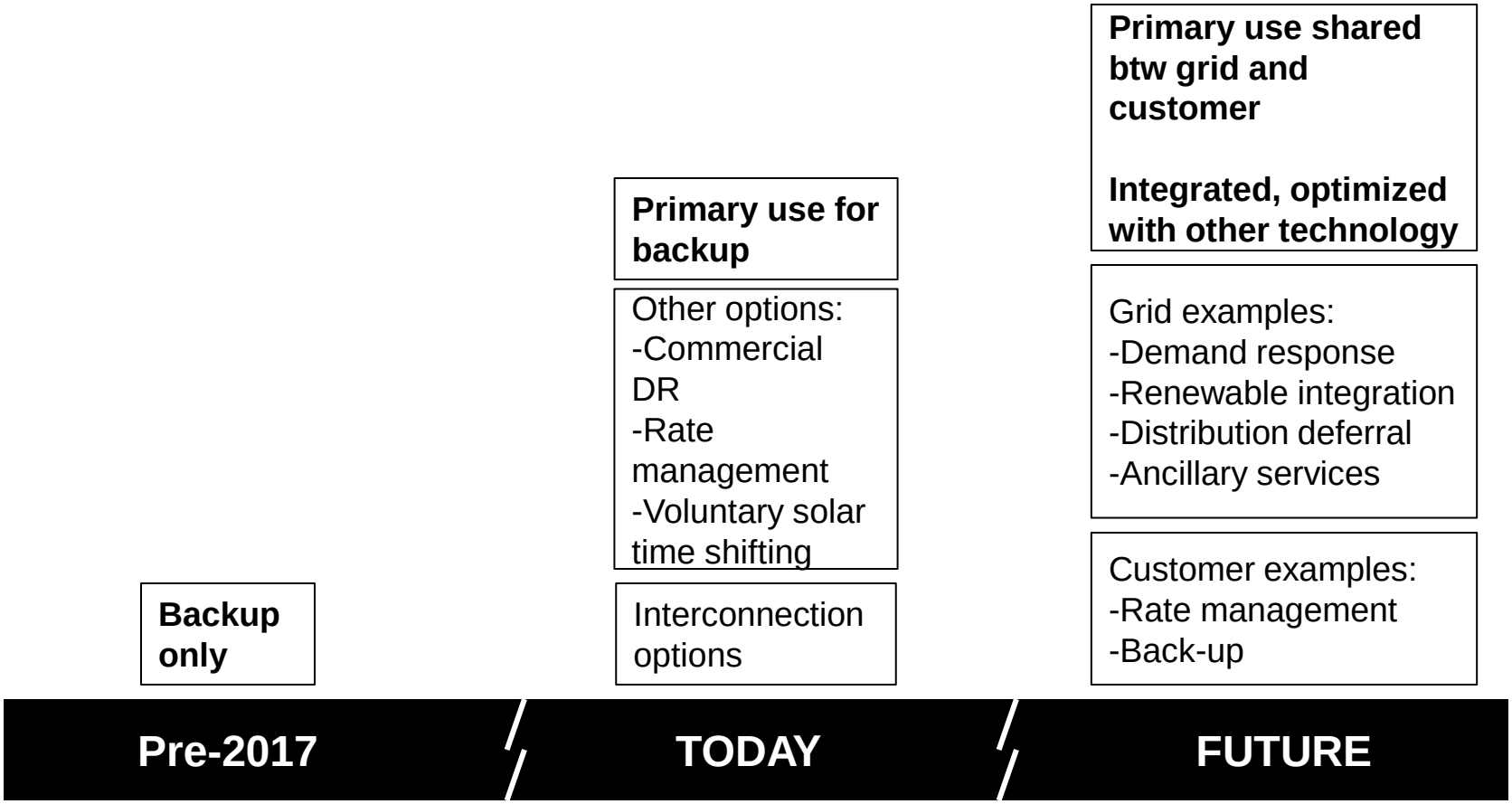
- Total U.S. energy storage deployments reached 431MWh in 2017, a 27% increase from the 340MWh in 2016.
- Behind-the-meter (BTM) deployments reached a record setting 70MW in 2017, nearly the same as 2015 and 2016 combined.
- The Section 201 tariffs on imported solar products cast a shadow over the energy storage market. For 2018-2022, forecasts decreased by 3% for residential, 4% for non-residential

## 2017 U.S. Energy Storage Scorecard

| | 2017 | 2016 | Change |
|---|---|---|---|
| Total Deployments (MWh) | 431 | 340 | Up 27% |
| Front-of-the-Meter Deployments (MWh) | 281 | 257 | Up 10% |
| Behind-the-Meter Deployments (MWh) | 150 | 84 | Up 79% |
| Total Deployments (MW) | 215 | 231 | Down 7% |
| Front-of-the-Meter System Price – 2 Hr. ($/kW) | $1,313-$1,800, median $1,538 | $1,400-$2,125, median $1,700 | Down 10% |
| Cumulative Five-Year Forecast (MW) | 10,242 (2019-2023) | 7,549 (2018-2022) | Up 36% |

*Source:* GTM Research U.S Energy Storage Monitor 2017 Year in Review Report

# Using customer-sited batteries today and in the future



# Storage Guidelines

- Xcel Energy Storage Guidance Documents were created by a multi-party work group approved under the CPUC Comprehensive Settlement Agreement Proceeding No. 16AL-0048E to offer 8 battery configurations effective Jan 1st, 2017
- Guidelines comply with updated PSCo tariffs & rules.
- The Guidelines apply to all sizes of systems from residential up through MW size facilities.
- The export characteristics of each DER are relevant and tied to tariff provisions such as net energy metering (NEM).
- The Guideline oneline diagrams are based on residential size energy storage system (ESS).
- The onelines are conceptual, illustrative, and variations that meet the concepts are allowed.
- 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.

# Storage Guidelines Cont…

Guidelines posted on xcelenergy.com:

- How to Interconnect webpage
- Solar Developer Resources 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)

# Storage Configurations

AC, Standby Energy Storage 1A
AC, Non-Net Metered, Non-Export 1B
AC, Non-Net Metered, Non-Export W/Gen 1C
AC, Net Metered, Standby Energy Storage 2A
AC, Net Metered, 100% Renewable Export 2B
AC, Net Metered, Non-Export 2C
DC, Net Metered, 100% Renewable Export 3A
DC, Net Metered, 100% Renewable Export 3B

Xcel Energy - Colorado

**Energy Storage Configurations**
**Summary Matrix of Requirements**

3/29/2018

| | AC Coupled Battery | | | | | | DC Coupled Battery | |
|---|---|---|---|---|---|---|---|---|
| | 1A | 1B | 1C | 2A | 2B | 2C | 3A | 3B |
| **Configuration^** | *Standby Energy Storage Only* | *Energy Storage Operation in Parallel without Generation* | *Energy Storage Operation in Parallel with Self-Generation* | *Standby Energy Storage with NEM Eligible Renewable Generation* | *Parallel Energy Storage Charged 100% by NEM Eligible Renewable Generation !* | *Parallel Energy Storage Operation Subject to Non-Export* | *Hybrid Inverter with a Second Load Meter !* | *Hybrid Inverter with a Transfer Switch !* |
| **Interconnection Type** | For Customers without Generation or Storage in Parallel with Self-Generation | | | For Net Electric Metering (NEM) and Solar*Rewards | | | | |
| **Pair with Renewable Energy?** | Yes or No | | | Yes | | | | |
| **Parallel Operation Allowed?** | No | Yes | | No | Yes | | Yes | |
| **Interconnection Review Required?** | No^^ ^^^ | Yes | | No^^ ^^^ | Yes | | Yes | |
| **Storage Charging** | Utility or Self-Generation | | | Utility or Generation | 100% Renewable Generation | Utility or Generation | 100% Renewable Generation | |
| **Storage Discharging** | Standby System^^^ | Non-Export* | | Standby System^^^ | Export of 100% Renewable Generation Only | Non-Export* | Export of 100% Renewable Generation Only | |
| **Production Meter?** | No | | | No | Yes | | Yes | |
| **Telemetry and Control?** | Determined by total DER as addressed in PUC Rules, Interconnection Requirements | | | | | | | |
| **Agreements and Forms*** ** | Attestation of Conformance to NEC Article 702^^^ | Interconnection Agreement, Operation Mode to be Identified in IA** | | Attestation of Conformance to NEC Article 702^^^ | Interconnection Agreement, Operation Mode to be Identified in IA** | | Interconnection Agreement, Operation Mode to be Identified in IA** | |

* 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 eligable 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.
^^ AHJ 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.

# Configuration Selection Tool

- The interconnection application configuration designation must match the tariff functionality being requested, not what diagram looks most like the proposed diagram. Each configuration is making a specific operational, tariff, and metering review request. Requesting a configuration that does not match the applicant's desired functionality and equipment can significantly delay the interconnection review.

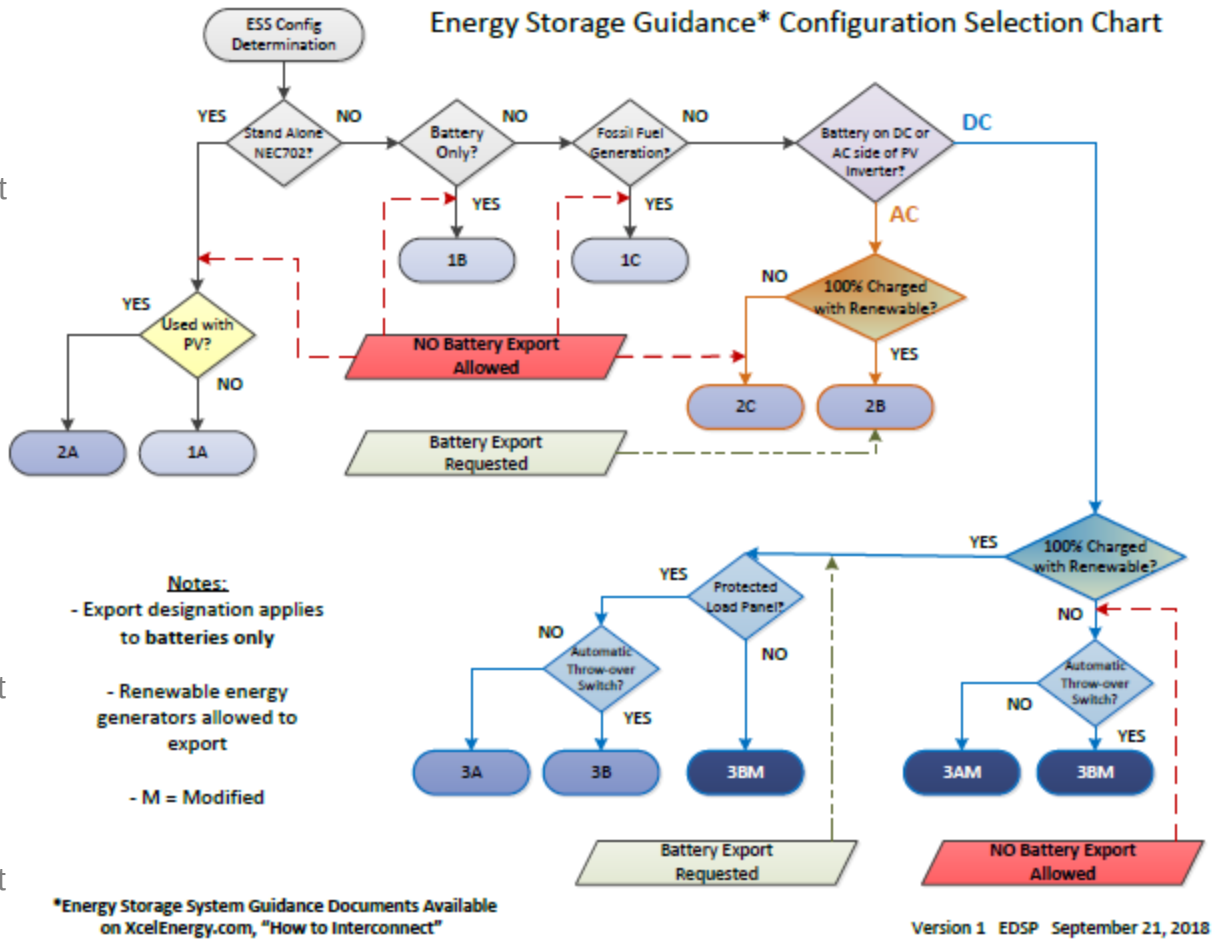
- Applicant is to provide a narrative supported by specific manufacturer documentation references (not full copies of instruction or installation manuals) that fully illustrate how the system complies with the proposed ESS configuration and that includes the scheme which physically or via software passwords locks down the configurations and restricted access for make changes to the manufacturer, developer, or installer.

# Configuration Selection Tool – Flow Chart

The flow chart steps the user through the pertinent questions for the applicant's design and will lead to a unique configuration designation.

The questions that must be answered to select a configuration designation are:

1. Does the ESS operate in parallel with the utility or is it stand alone; i.e. NEC 702 compliant?
2. Is the generation energy source fossil fueled?
3. Does the ESS connect on the AC or DC side of the PV inverter3?
4. If AC, is the ESS charged from only a renewable4 source5?
    - If renewable, the battery may discharge to the grid.
    - If non-renewable, do controls prevent battery discharge to the grid?
5. If DC, is the ESS charged from only a renewable source? o If renewable, the battery may discharge to the grid.
    - If non-renewable, do controls prevent battery discharge to the grid?
    - Is a protected load panel (PLP) installed on a DC side design?



# Storage Documents

- We define the **Declaration** 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. The Declaration is uploaded by the Application Owner – generally the Installer.
    - Declaration 1A and 2A
    - Declaration 1B and 1C
    - Declaration 2B, 2C
    - Declaration 3A, 3B
- **Exhibit D** captures the facility specific requirements determined in the review by the Area Engineer. The requirements are conditional to permit ongoing operation. Exhibit D is part of the Interconnection Agreement.
- The **Interconnection Agreement** and Exhibit D are used for all DER technologies up to 10 MWs in size.

# Electric Rate Book

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

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 Cont…

Schedule PV (Sheet No. 113) – 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 RECs 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 RECs.

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 RECs when appropriate. The Customer will be responsible for a Load Meter Charge as found on their applicable service schedule.

# Important Definitions

"**Energy Storage System (ESS)**"- 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.

# Storage Pre-Review Process

# Initial Review of Storage Packages

- First of a design applications of energy storage systems are reviewed in detail based on Declaration and submitted information.
- We request a storage review package from the installer or manufacturer prior to any Declaration being submitted to the Application Portal.
- To confirm meeting of settlement provisions requires extensive detailed review of operating manuals and often inquiries with manufacturer.
- Subsequent applications are compared with initial Declaration & oneline.
    - Details are still important, but more specific to system arrangement matched to first-of-design Declaration and operational requirements.

# Storage Review Main Points

- Guidelines apply to all tariff classes eligible for hosting storage.
- Application must declare intended operating mode(s) and configuration.
  - Note: that Declaration mode names should match the names in the manual.
- Different modes have different thermal and voltage regulation duties.
- 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.
- 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.
- Application size for PV + Storage will usually be based on the lessor of combined inverter nameplate ratings or limiting element (shared inverter).

# Storage Review Main Points (cont.)

- 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.
- There are two levels of review – in-depth and ongoing.
  - In-depth is performed for first use of a storage design and mode of operation.
  - Ongoing is a brief verification review that submitted design matches in-depth pre-reviewed design and mode of operation.
  - All ongoing reviews are subject to review of metering and site specific system concerns.
- 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.
- In-depth review are based on Declaration information to ensure correct values and manuals are used.

# Legacy Installation Qualification Criteria

- Storage added to legacy residential PV systems without required disconnect switch or Production Meter (PM) prior to 4/11/2011:
  - Initial Solar*Rewards residential PV systems did not require PM.
  - Disconnect switch was not required for a couple of years.
  - Legacy residential PV installed during above periods are grandfathered.
  - For Guideline 3A, the second load meter is not required when there is a protected load panel. This results in a 3B Modified design.

# Tariffs

- All customers are subject to service tariffs for their power consumption.
- These tariffs do not allow export of self-generated power, including stored in ESS, except for renewable power.
- Renewable power may be exported under Schedule NM, Net Metering, and Schedule PV, Photovoltaic Service.
- Storage Review Requirement, Schedule NM, Sheet 112D:

  "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."

# Tariffs (cont.)

- Net Metering is only available for netting customer load against on-site qualifying renewable sources.
- Storage is treated as renewable resource if it is solely charged by qualifying renewable on-site source.
- Net Metering cannot be allowed if on-site source is not a qualifying renewable source as required by legislation.
    - Other IOUs are challenged by same criteria, including CA.
- 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.
- Any customer eligible for net metering will cease being eligible if non-qualifying source that can export to grid is included.
- 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.

# In-depth Review Common Issues

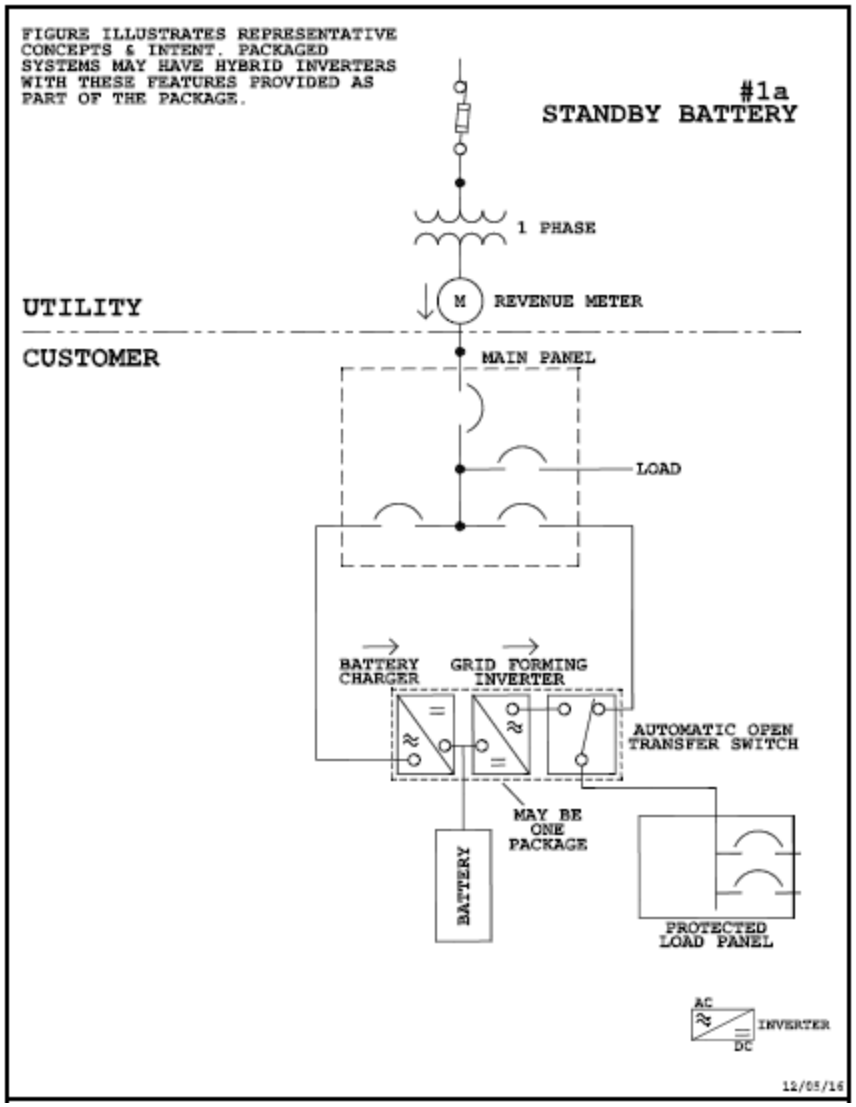
- ESS designs can be grouped into three general designs:
  - Standby
  - No battery export allowed
  - Battery export allowed
- Standby meets NEC 702 requirements and never parallels with grid.
- No-battery-export may supply customer loads but the revenue meter outflow must not exceed the on-site renewable source's output.
  - Whole house backup & load supply usually requires a separation device and inverter input from a meter in series with grid revenue meter.
- Battery export must have battery solely charged by an on-site eligible renewable source.
  - Inverter functionality after outage or prolonged poor PV output might use grid power to recharge the battery. This is a frequent approval problem.

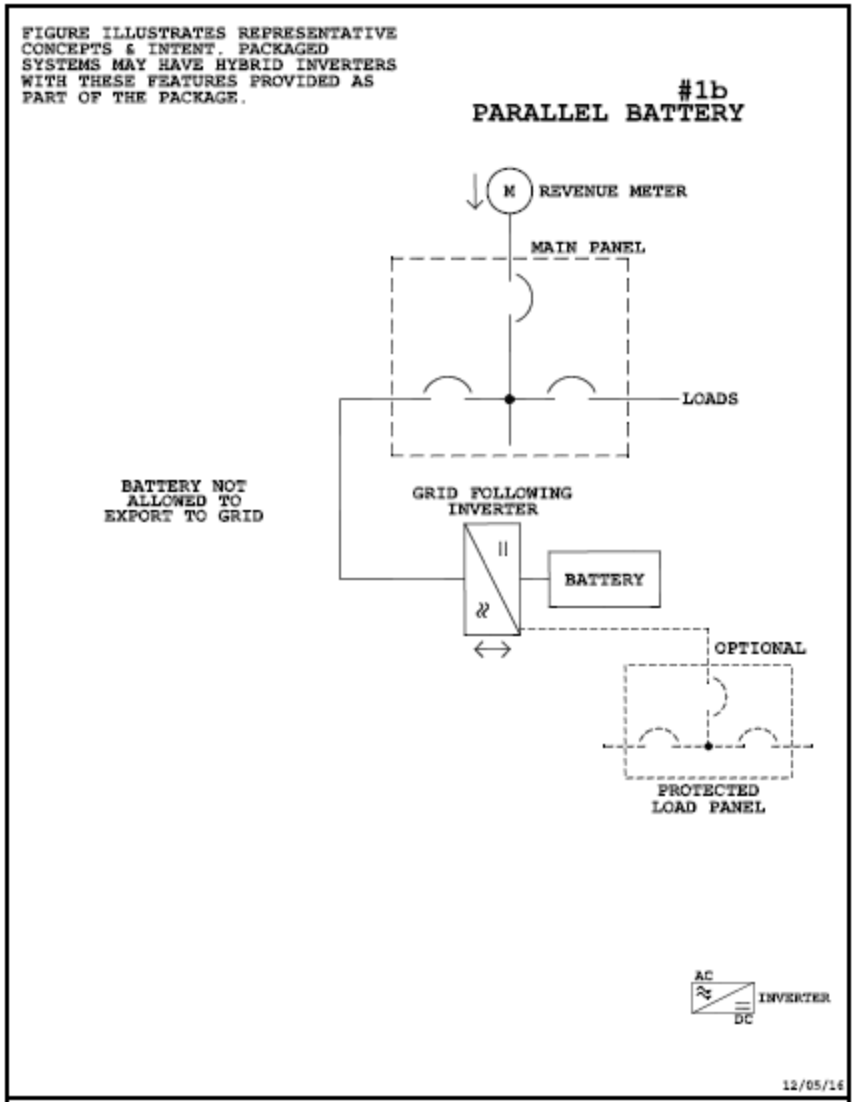
# Guideline Drawings

# Guideline Overview

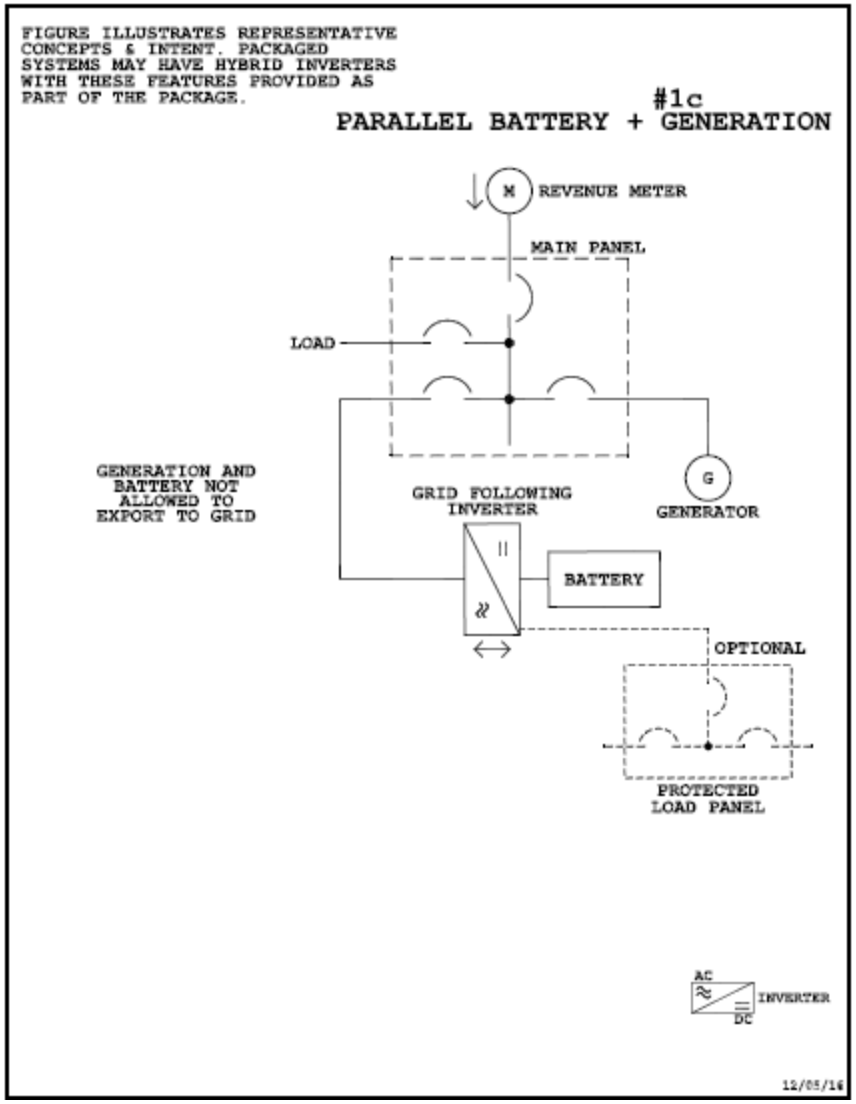
- Guideline diagrams are conceptual and variations are allowed.
- Diagrams are meant to be illustrative configurations and not prescriptive.
- Diagram designations are referring to concept illustrated and not referring to specific configuration illustrated.
- Guideline configurations 2B, 3A, and 3B can 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.

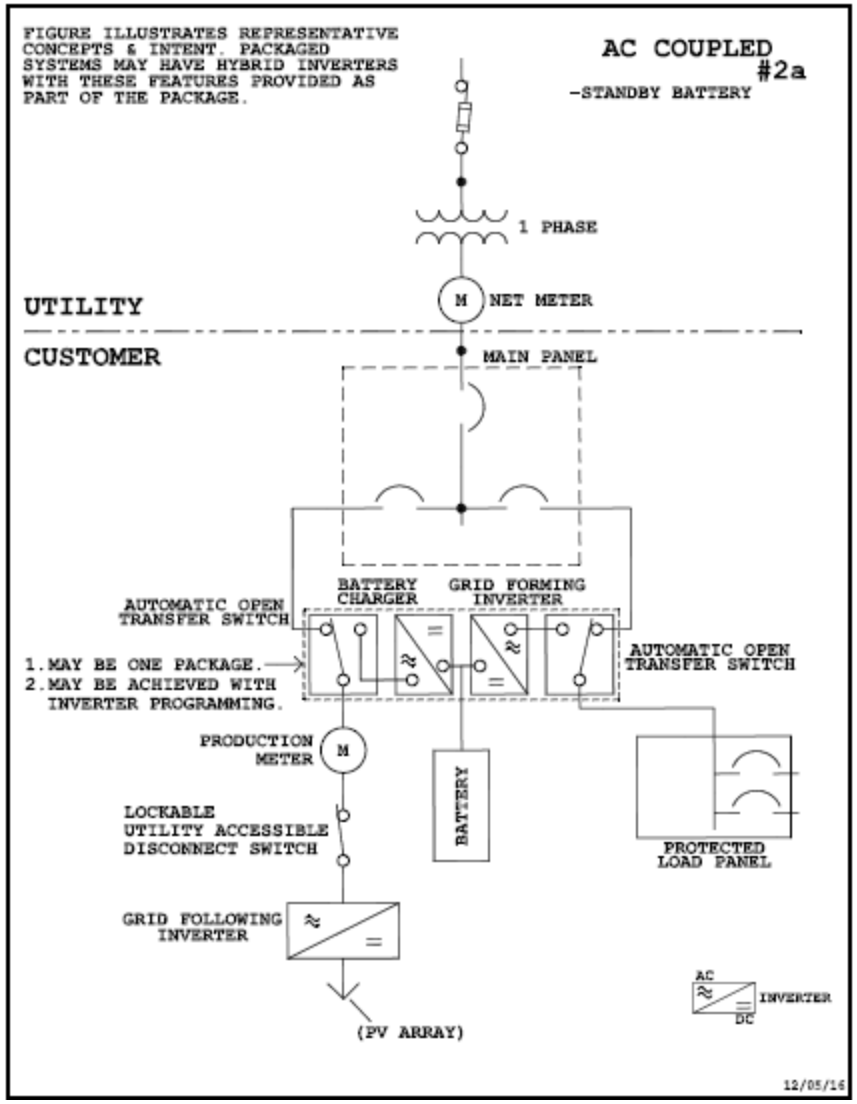
# Standby 1A and Parallel Backup 1B



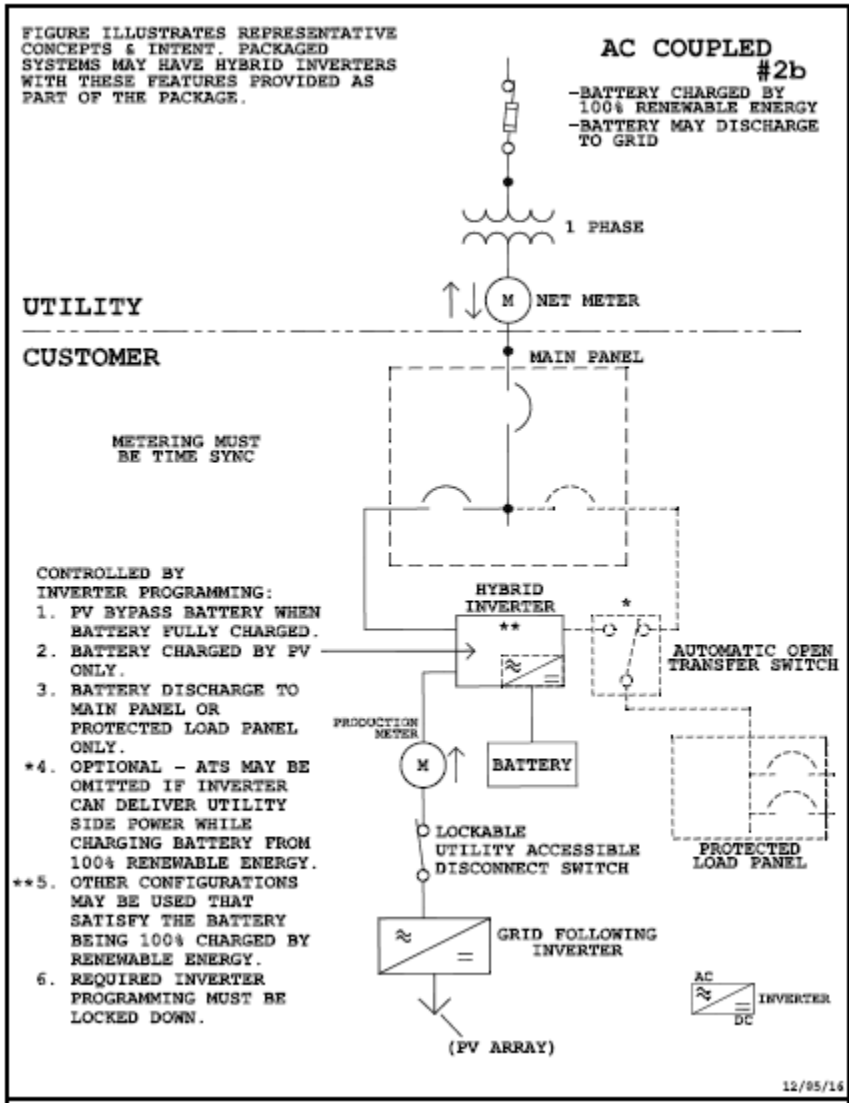



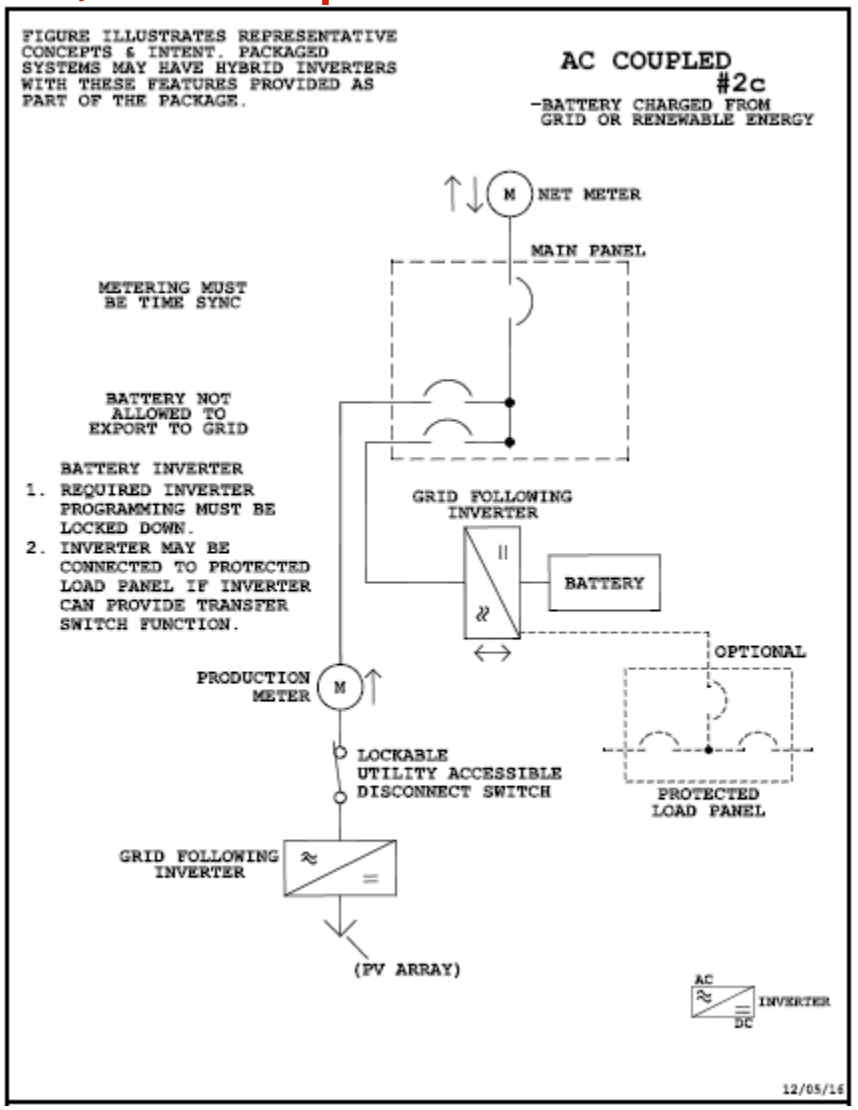
# Parallel Battery & Self Generation 1C
# Standby Battery, PV, & NEM 2A



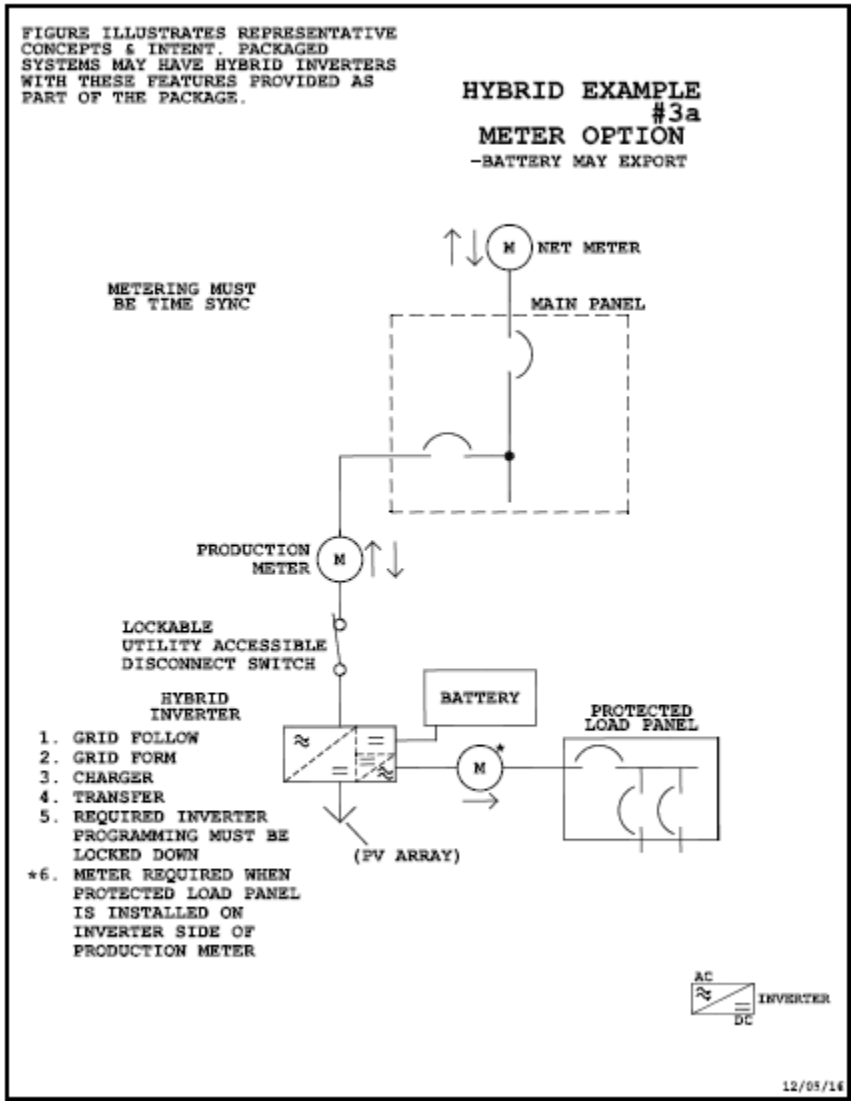



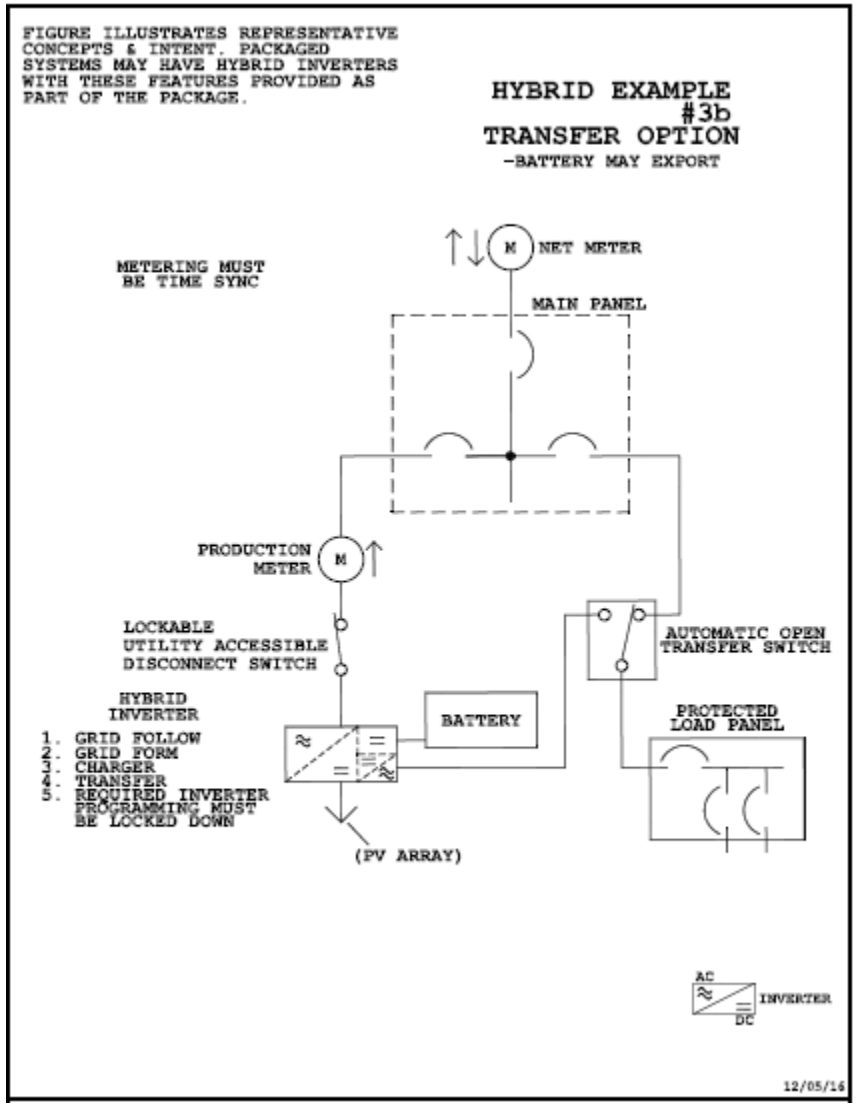
# AC Coupled Battery, PV, NEM Export 1B
# AC Coupled Battery, PV, NEM, No Export 1C



# DC Coupled Battery, PV, NEM, PLP 3A
# DC Coupled Battery, PV, NEM, PLP, ATS 3B



# APPROVED Storage Configurations

# Inverter Suppliers with Approved ESS Designs Approved to Duplicate with Minor Review

- ✓ Tesla
- ✓ Schneider
- ✓ StorEdge
- ✓ Outback
- ✓ Enphase
- ✓ Sonnen

- Approvals to date for Guidelines 2C, 3A, 3B and 3B Modified 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.
  - Safety review is straight forward & quick. Tarriff review is difficult & time consuming.

# Going Forward

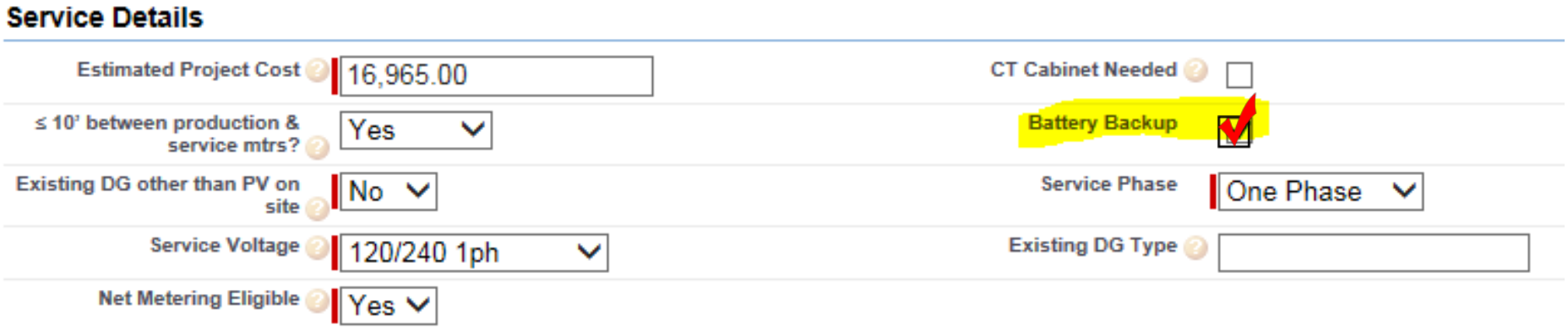
- Standardization of functions and testing of inverters will expedited review and acceptance of PV inverters.
  - PV inverters have one function & configuration with simple tarriff compliance.
- ESS does not have standardization of non-safety functions and tariff compliance yet.
  - ESS has multiple functions and many configuration variations.
  - No standardization for tariff compliance exists.
  - CA is working on net metering compliance verification design criteria.
  - UL is working on similar approaches.
  - Storage today in this respect is similar to PV prior to initial standards.
  - Standards plus utility & installer experience will allow convergence on expedited approvals and processing similar to PV.
  - IEEE has started P1547.9 Interconnection of Energy Storage Distributed Resources with Electric Power System. This will establish guidance for ESS interconnections.

# Salesforce Application Process

# Battery Storage Application

**“How do I submit a new <u>solar application</u> with a <u>battery</u>?**

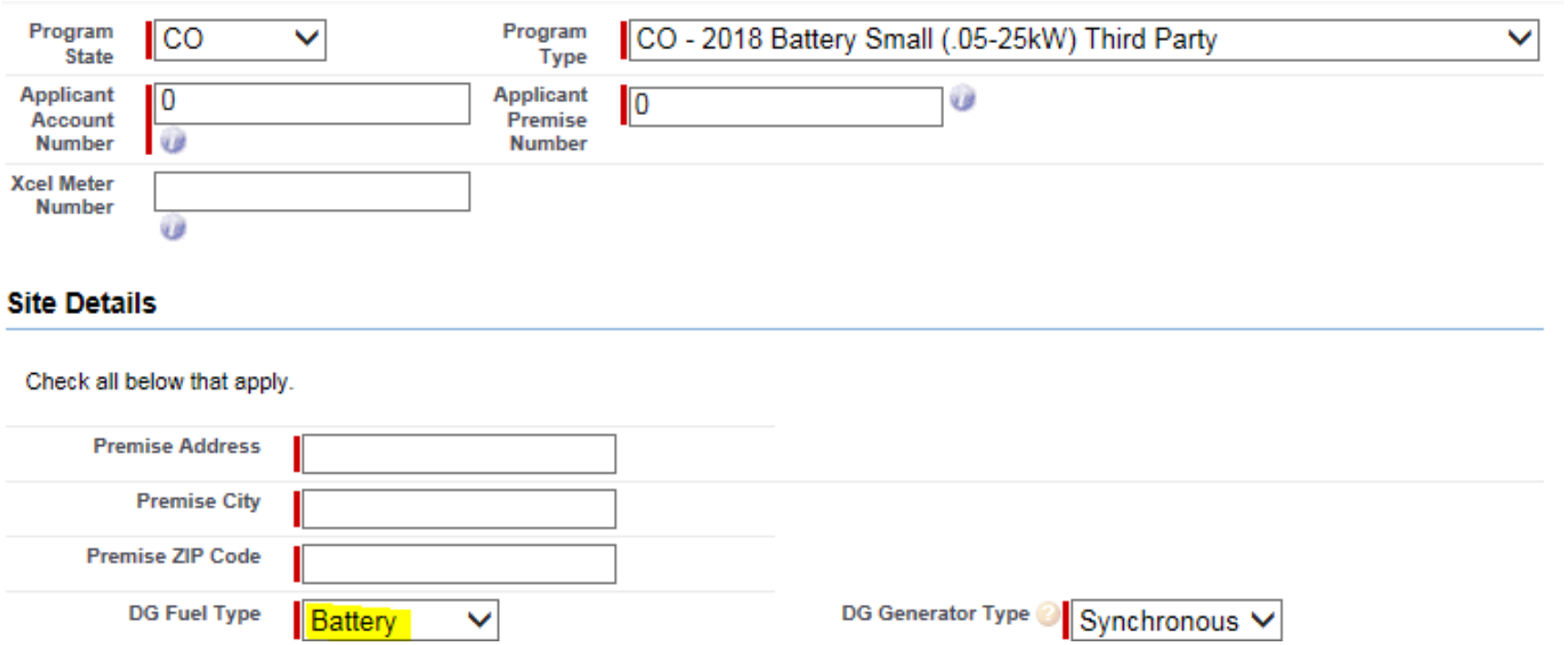
- Check “Battery Backup” checkbox on the System Details tab



# Battery Storage Application Cont…

**“How do I submit a <u>standalone or retrofit battery</u> application?**

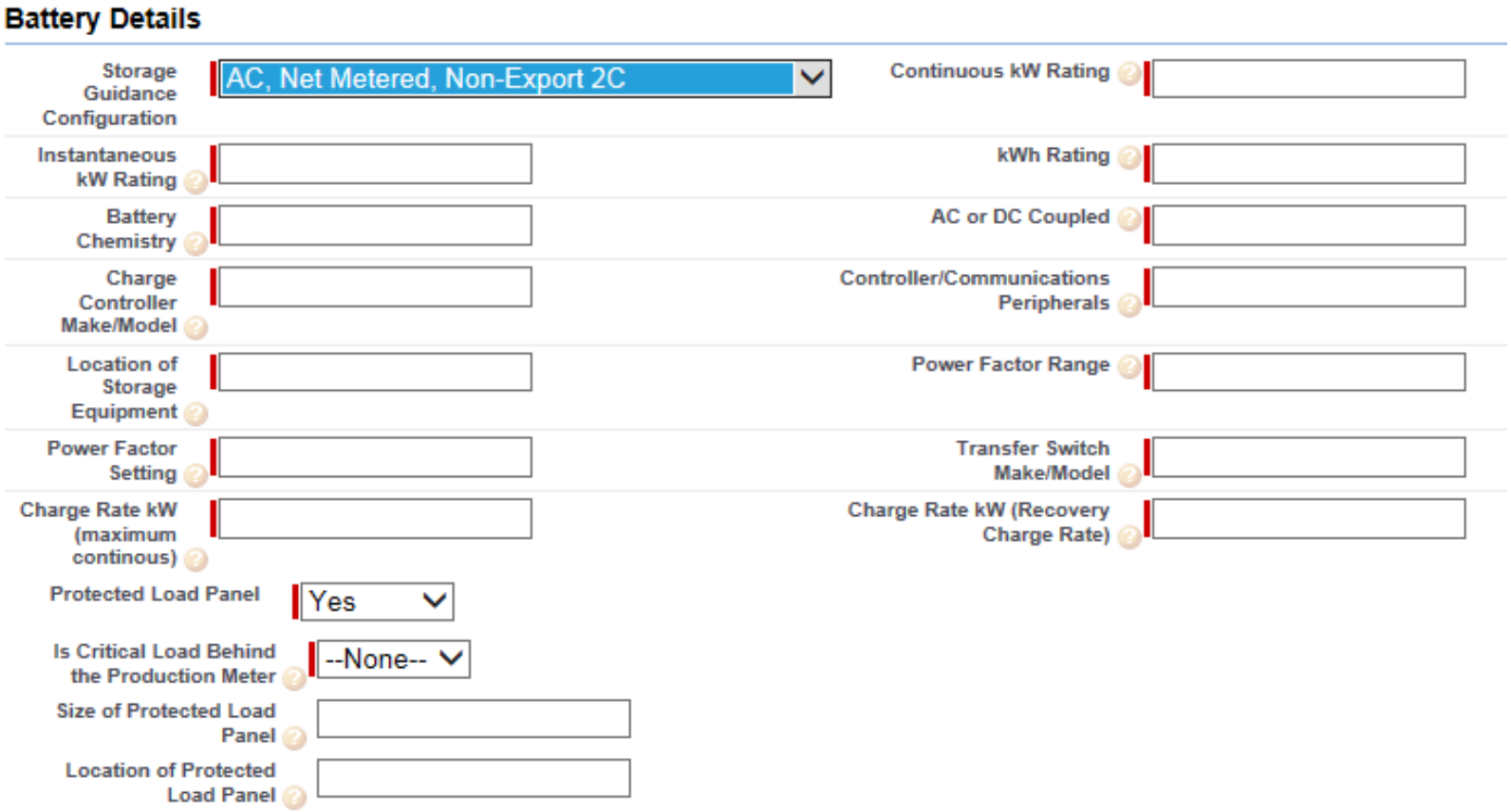
- On the Start tab choose a “Battery” Program Type
- Then choose “Battery” as the DG Fuel Type



# Battery Storage Application Cont…

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

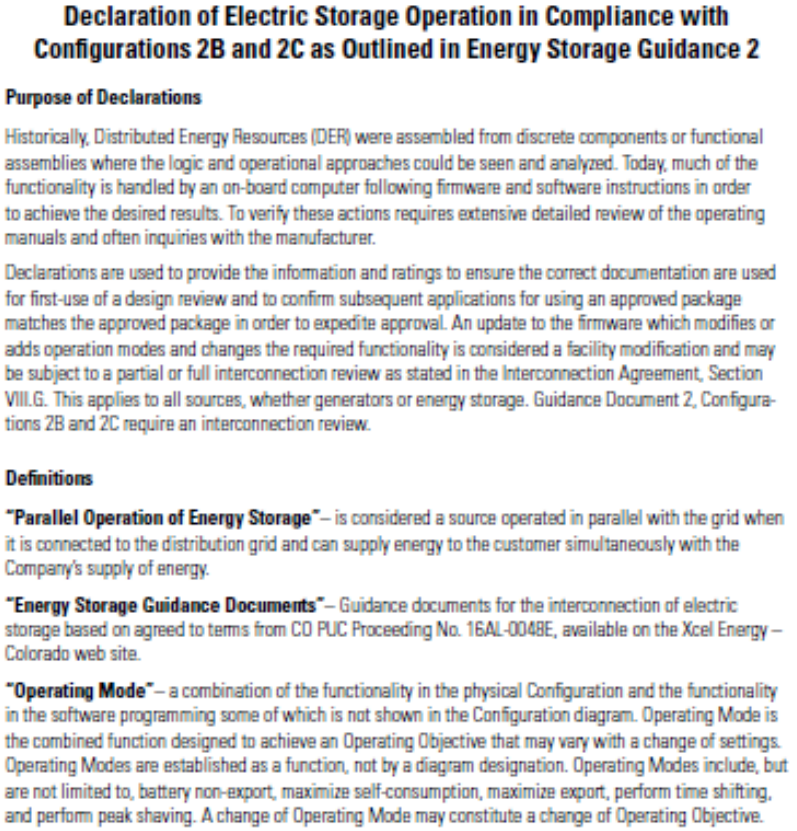
- Complete all required fields in the Battery Details section



# Battery Storage Application Cont…

**“What else is needed to submit an application with a battery?”**

- Every application with battery must submit a completed Declaration
- Declaration forms are available for download from the Solar Developer Resources webpage and from the Document for Download section of the application:
  - Declaration 1A and 2A
  - Declaration 1B and 1C
  - Declaration 2B and 2C
  - Declaration 3A and 3B
- Declarations provide the upfront information needed by the engineers to expedite the review process.



**Declaration of Electric Storage Operation in Compliance with Configurations 2B and 2C as Outlined in Energy Storage Guidance 2**

**Purpose of Declarations**

Historically, Distributed Energy Resources (DER) were assembled from discrete components or functional assemblies where the logic and operational approaches could be seen and analyzed. Today, much of the functionality is handled by an on-board computer following firmware and software instructions in order to achieve the desired results. To verify these actions requires extensive detailed review of the operating manuals and often inquiries with the manufacturer.

Declarations are used to provide the information and ratings to ensure the correct documentation are used for first-use of a design review and to confirm subsequent applications for using an approved package matches the approved package in order to expedite approval. An update to the firmware which modifies or adds operation modes and changes the required functionality is considered a facility modification and may be subject to a partial or full interconnection review as stated in the Interconnection Agreement, Section VIII.G. This applies to all sources, whether generators or energy storage. Guidance Document 2, Configurations 2B and 2C require an interconnection review.

**Definitions**

**"Parallel Operation of Energy Storage"**– is considered a source operated in parallel with the grid when it is connected to the distribution grid and can supply energy to the customer simultaneously with the Company's supply of energy.

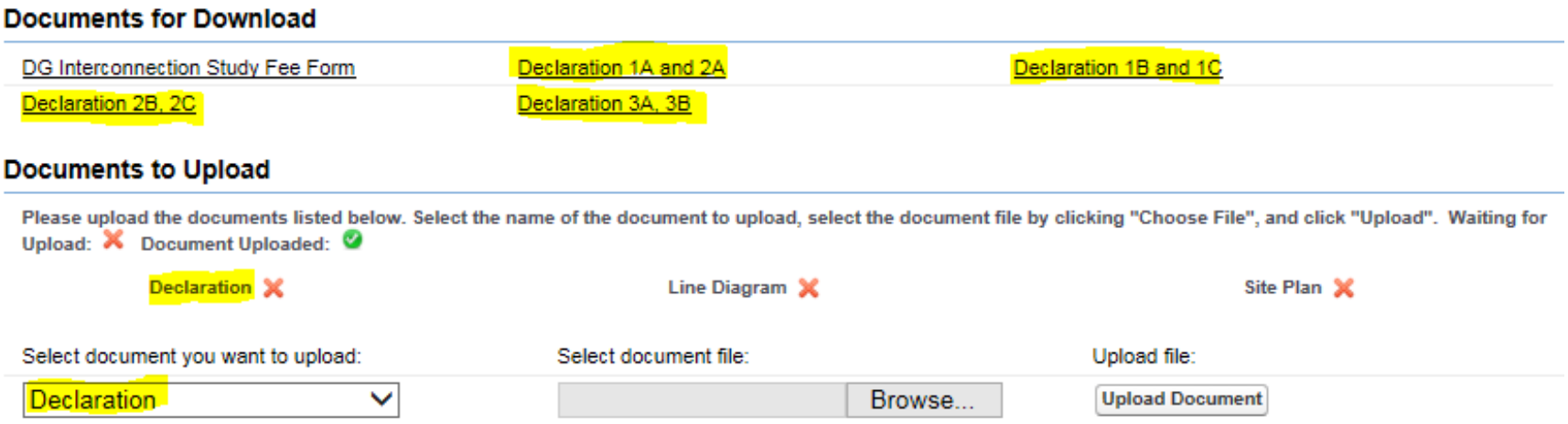
**"Energy Storage Guidance Documents"**– Guidance documents for the interconnection of electric storage based on agreed to terms from CO PUC Proceeding No. 16AL-0048E, available on the Xcel Energy – Colorado web site.

**"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.

# Battery Storage Application Cont…

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

- Upload a completed Declaration 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

# Engineering Review

**Approval History**

| Action | Date | Status | Assigned To | Actual Approver | Comments | Overall Status |
|---|---|---|---|---|---|---|
| **Step: Engineering Review (Pending for unanimous approval)** | | | | | | Pending |
| Reassign \| Approve / Reject | 2/27/2018 2:44 PM | Pending | David Wynkoop | David Wynkoop | | |
| | 2/28/2018 8:22 AM | Approved | Tom Malone | Tom Malone | Approved for non-metering requirements. | |
| **Approval Request Submitted** | | | | | | |
| | 2/27/2018 2:44 PM | Submitted | | | | |
| **Step: Engineering Review** | | | | | | Rejected |
| | 2/16/2018 2:59 PM | Rejected | Tom Malone | Tom Malone | Conditionally approved. Installer must provide on, one-line or separate document, how the inverter software will be programmed to not allow battery to be charged from the Xcel Energy grid. | |
| **Approval Request Submitted** | | | | | | |
| | 2/13/2018 6:58 AM | Submitted | David Wynkoop | David Wynkoop | Auto-Submitting | |

- 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)

# Battery Storage Application Cont…

**“What is required to approve an application with a battery?”**

- Exhibit D of the Interconnection Agreement lists the Operating Requirements for Energy Storage Systems

**Applicable If Energy Storage Systems Are Involved:**

**Three energy storage guidance Documents address configurations and requirements related to the terms of CO PUC Proceeding No. 15AL-0048. Energy storage interconnections are allowed as addressed in these energy storage guidance documents. The interconnection principles illustrated also apply to large interconnections, as permitted in the filed tariffs. In the event of a conflict between this Operating Agreement and energy storage guidance documents, the energy storage guidance documents shall rule. Energy storage system interconnections not included in this proceeding must be documented and be in accordance with the Engineering Study and applicable tariffs.**

**Nothing under energy storage guidance documents shall be construed to limit the export of actual onsite renewable self-generation that is net metered in compliance with the approved tariffs.**

- Area Engineer will populate Exhibit D when necessary and will be signed by the installer confirming the operation of the battery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