Auxiliary Metering for PV+BESS Hybrid Systems: An Independent Review

Presented by: Pterra Consulting

6/9/2020
About this report

• NYSERDA/NYS DPS engaged Pterra to provide a review of the technical aspects of auxiliary metering for BESS+PV installations

• Scope:
  • Research technical information from manufacturers of devices and instrument transformers used by NY utilities for metering, specifically with respect to accuracy for metering purposes.
  • Research type and characteristic of loads that may be subject to auxiliary metering at developer sites.
  • Review existing standards applicable to metering accuracy.
  • Survey other jurisdictions with regards to requirements auxiliary metering.
Outline

• Summary of technical issues
• Accuracy-Related Metering Practice in New York
• Simulations of a sample facility
• Alternative Metering Options
• Practice in Other Jurisdictions
• Conclusions
Summary of Technical Issues

The main technical contention is the accuracy difference between:
- Having a single service meter at one location
- Having an additional secondary service meter (the “auxiliary” meter)
Summary of Technical Issues

- National Grid indicates that it uses the 0.3% standard accuracy class for IT while other utilities may use 0.15% extended range IEEE C57.13.6 accuracy class.

- The IEEE standard does not specify accuracy limits for IT loads below 5% or 10% of rating

- Data provided by Industry for a PV/BESS plant rated 1950/1950 kW show auxiliary loads in the 0.27-0.6% range of plant rating.

For 6-12 hours a day, a single meter can be measuring in the 5-10% range of the IT

- The auxiliary loads comprise of Heating, Cooling, Fan, No Load Loss, Auxiliary for PV, Auxiliary for Battery
Clarifying Load and Burden

• Current transformer load and burden

• For a BESS+PV facility:
  • Loads are mainly cooling/heating load and losses
  • Burden comprises of relays and other small loads, conductors size and lengths
  • Accuracy classes assume the burden rating of the instrument transformer is not exceeded
  • Generally, keep burden as low as possible
Error in Instrument Transformers

- Two sources of error in instrument transformers, ratio error and phase angle error
- The combination of the two errors is the Transformer Correction Factor (TCF)

Unshaded region (below 10%)
- Has no mandated accuracy
Accuracy-Related Metering Practice in New York - NYSDPS Metering Dept

• Department of Public Service 16 NYCRR Part 92 Operating Manual March 14, 2003 documents the state’s guidance for meter testing

• 4.iv Test Loads
  • Heavy Load: 60% - 110% of the “ampere rating”
  • Light Load: 5% - 10% of the “ampere rating”

\[
\text{Final Average Accuracy (FAA)} = \frac{4 \times \text{HL} + 4 \times \text{LL}}{5}
\]

• 5.g Watt-hour meter tests – new meters must register 99.2%-100.8%

• Meter Service Providers are responsible for in-service testing of all meters under its control

• CT-rated meters are subject to one of the following three test methods:
  - Variable Interval-
    • Minimum number of meters tested each calendar year is based on the performance of meters of previous year as determined using a formula including the number of meters that tested outside of the range of 98% to 102%.
    • If calculated rate exceeds 8%, special remediation program is required to reduce population of out of limit meters.
  - Periodic-
    • All watt-hour meters installed on customers' premises tested at least once every 8 years.
  - Selective-
    • Minimum number of meters tested each calendar year shall be based on the performance of meters in previous year as determined by a formula including the number of meters that tested outside of the range of 98% to 102%.
    • There are exceptions for devices determined to have performance issues, minimum test population and new meter types in the first year of service.

"Out of limit" in-service meters are meters that test outside the range of 98% to 102%.

Referee Testing - to determine whether a meter is defective or incorrect to the detriment of the customer. Meter is acceptable when the final average accuracy test is outside the range of 98% to 102%.
Accuracy-Related Metering Practice in New York – New York Utilities

- Meters used for single-meter multi-use facilities such as CHP, gas plant or stand-alone BESS:
  - Net,
  - Bidirectional,
  - Time-of-use,
  - Recorder-equipped meters,
  - Load profile or interval

- Revenue meters from Itron, Aclara and Landis + Gyr, ABB, Electro Industries, Ametek, Transdata

- Instrument Transformers are typically 0.3% standard accuracy. In special cases, may use 0.15% extended range CTs. GE – example.

- Testing for accuracy
  - Testing Programs based on DPS 15 NYCRR Part 92.
    - New meters - Part 92 Section 5.v.
    - Statistical sampling program. (Part 92 Section 6.ix.)
    - There is a variable testing program. (Part 92 Section 6.viii.)
  - NYISO meters tested at least every 2 years
    - Interchange testing with other utilities annually

- No correction factors applied

- Occasional use of loss compensation
Summary of Accuracy Standards in New York

• In service meters statistically acceptable if register within 98%-102% of loads being measured
  • Testing emphasizes high loading over light loading
  • Designated in this study as Level 1 Standard

• Utilities generally use standard accuracy class instrument transformers
  • 0.6% error above 10% of rated current
  • Below 10% rated current, error will follow excitation and phase angle curves of device
  • Designated in this study as Level 2 Standard

• Utilities may occasionally use extended accuracy class instrument transformers
  • 0.3% error above 5% of rated current
  • Below 5% rated current, error will follow excitation and phase angle curves of device
  • Designated in this study as Level 3 Standard
Simulation Testing of Maximum Error

- Sample test facility
- Simulation 8760 hours of operation
- Considers
  - Single or 2 meter configuration
  - Level 1, 2 or 3 Standards for accuracy
    - Assuming maximum error that can occur under each standard; for example, under Level 1, the error is assumed to be 2%
  - Full sun or low sun for the year
    - Full sun – no cloudy days during the year
    - Low sun – 25% cloudy days (absolutely no PV production during the day) during the year
  - High auxiliary load (up to 10% of plant maximum output)
Sample Facility

• Hybrid PV+ESS system
  • PV Capacity (kW-DC): 4163
  • Inverter AC Power Rating (kW-AC): 1950
  • ESS Nameplate Power (kW-AC): 1950
  • ESS Usable Capacity (kWh-AC): 4460

• PV output is net of no-load, collector and transformer losses

• Separate transformers for PV, BESS and auxiliary load

• Annual net energy:
  • 5,384,750 kWh

• Auxiliary Load Profile is as shown in an earlier slide but increased to about 10% of plant rating
Simulation Results – Maximum Error at Full Sun

- Largest max error occurs at Level 1 Standard at 101 MWhr for single meter, comprising 2% of total registry
  - Two meter configuration increases this by 12.8 MWhr or 0.24% of total registry
- Level 2 and Level 3 Standards show lower max errors
  - Single meter Level 2 max error 55 MWhr and Level 3 max error 31 MWhr
  - Two meter configuration has lower max errors: Level 2 max error 45 MWhr and Level 3 max error 21 MWhr

### Maximum Error (all error values are +/-)

<table>
<thead>
<tr>
<th></th>
<th>Single meter</th>
<th>Two-meter</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main meter</td>
<td>Aux meter</td>
<td>Combined Max Error*</td>
</tr>
<tr>
<td></td>
<td>kWhr (+/-)</td>
<td>kWhr (+/-)</td>
<td>kWhr (+/-)</td>
</tr>
<tr>
<td><strong>Level 1 Standard</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>101,283</td>
<td>107,695</td>
<td>6,412</td>
</tr>
<tr>
<td></td>
<td>2.00%</td>
<td>2.00%</td>
<td>2.00%</td>
</tr>
<tr>
<td><strong>Level 2 Standard</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55,478</td>
<td>41,569</td>
<td>3,547</td>
</tr>
<tr>
<td></td>
<td>1.10%</td>
<td>0.77%</td>
<td>1.11%</td>
</tr>
<tr>
<td><strong>Level 3 Standard</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31,216</td>
<td>20,068</td>
<td>1,900</td>
</tr>
<tr>
<td></td>
<td>0.62%</td>
<td>0.37%</td>
<td>0.59%</td>
</tr>
</tbody>
</table>

* Assuming the combination is an overreading of the main meter and an underreading of the auxiliary meter or vice versa

** Using absolute value of difference

### Total Energy to be Metered (kWhr)

<table>
<thead>
<tr>
<th></th>
<th>Total Energy 1 (single meter)</th>
<th>Two-meter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Total Energy 2)</td>
<td>(Total Energy 3)</td>
</tr>
<tr>
<td><strong>Main</strong></td>
<td>5,064,149</td>
<td>5,384,750</td>
</tr>
<tr>
<td><strong>Auxiliary</strong></td>
<td>320,601</td>
<td></td>
</tr>
</tbody>
</table>
Simulation Results – Maximum Error at Low Sun

- Low Sun conditions result in lower total registry and therefore lower max errors across all meters simulated and for all levels relative to the High Sun case
- As with the High Sun results:
  - For Level 1, the single meter has lower maximum error than the 2-meter
  - For Levels 2 and 3, the single meter has higher maximum error than the 2-meter

### Maximum Error (all error values are +/-)

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<tr>
<td></td>
<td>kWhr (+/-)</td>
<td>% total energy 1</td>
<td>kWhr (+/-)</td>
</tr>
<tr>
<td>Level 1 Standard</td>
<td>82,246</td>
<td>2.00%</td>
<td>87,434</td>
</tr>
<tr>
<td>Level 2 Standard</td>
<td>45,481</td>
<td>1.11%</td>
<td>34,340</td>
</tr>
<tr>
<td>Level 3 Standard</td>
<td>25,870</td>
<td>0.63%</td>
<td>17,009</td>
</tr>
</tbody>
</table>

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** Using absolute value of difference

### Total Energy to be Metered (kWhr)

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<tbody>
<tr>
<td>Total Energy 2</td>
<td>Main</td>
</tr>
<tr>
<td>(Total Energy 3)</td>
<td>Auxiliary</td>
</tr>
<tr>
<td>4,112,284</td>
<td>4,371,680</td>
</tr>
<tr>
<td></td>
<td>259,396</td>
</tr>
</tbody>
</table>

6/9/2020

Technical Review of Auxiliary Metering Rev 1
Simulation Results – Sensitivity to Lower Auxiliary load (Full Sun Assumption)

### Maximum Error (all error values are +/-)

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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>kWhr (+/-)</td>
<td>% total</td>
<td>kWhr (+/-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>energy 1</td>
<td>kWhr (+/-)</td>
</tr>
<tr>
<td>Level 1</td>
<td>106,413</td>
<td>2.00%</td>
<td>106,413</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>44,294</td>
<td>0.83%</td>
<td>44,294</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>23,061</td>
<td>0.43%</td>
<td>23,061</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Assuming the combination is an overreading of the main meter and an underreading of the auxiliary meter or vice versa

** Using absolute value of difference

- At lower auxiliary load levels, the maximum error differences are smaller between one and two-meter configurations

** Total Energy to be Metered (kWhr)

<table>
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<th>Total Energy 1 (single meter)</th>
<th>Total Energy 2</th>
<th>Total Energy 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,320,630</td>
<td>5,384,750</td>
<td>64,120</td>
</tr>
</tbody>
</table>
Summary of Findings from Simulations

• The 98%-102% registry range (Level 1) as a minimum performance for meters sets the maximum error range that metering delivers
  • Using this standard, the addition of a second meter increases the maximum error and thus makes the overall measurement less accurate.

• However, if the performance standard is based on the selection of CT accuracy class using either standard (Level 2) or extended (Level 3), the two-meter configuration decreases the maximum error

• The magnitude of the increase or decrease in maximum error is in the range of 0.17-0.25% of the total annual registry in MWhr. (This range reduces to 0.04-0.05% if the auxiliary load is lower).

• Limitations
  • Results are applicable to a 2 MW PV+BESS plant.
  • Auxiliary loads may vary although the simulations assume the worst case where auxiliary loads are at 10% of plant rating
  • Simulations do not account for tariff pricing variations such as time-of-use, variable pricing or interval pricing
Alternative Designs

• As an alternative to the basic auxiliary meter design:
  • Use sub-meter
    • instead of auxiliary meter located at or close to the POI, it is located inside the plant and telemetered
  • Alternative 1: sub-meter is located on the grid side of auxiliary transformer
    • To avoid double-counting, sub-meter reading is netted out of main meter reading
  • Alternative 2: sub-meters are placed on the load/generation side of each plant transformer
Alternate Plant Configuration 1

23 kV - Utility System

With Sub-Meter
Alternate Plant Configuration 2

With Sub-Meter, With Auxiliary Transformer
# Practice in Other Jurisdictions

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Metering Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>California per CPUC</td>
<td>Two meters not presently required. Load Serving Entities and storage providers must determine and establish up-front their desired metering configuration.</td>
</tr>
<tr>
<td>California – PG&amp;E</td>
<td>Metering method to be determine by agreement with customer. Options include use of load reference, auxiliary or sub-metering, and formula-based estimation</td>
</tr>
<tr>
<td>California - SDGE</td>
<td>Separate metering of Wholesale and Station power. Sub-metering allowed. Will consider alternative metering arrangements</td>
</tr>
<tr>
<td>New York - NYISO</td>
<td>Follows NYS Guide for Revenue Quality Metering. Does not indicate specific requirements for number of meters</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Rule 14H. No specific metering requirements</td>
</tr>
<tr>
<td>Midwest – Xcel Energy</td>
<td>Metering based on tariffs. Production meter need depends on size and program rule</td>
</tr>
</tbody>
</table>
Metering Approaches Proposed in Other Jurisdictions

• Station Power Load Reference – Station Power Load Reference value is established by measuring the Retail Station Power loads at Idle Charging State. Reference point set initially via field tests and adjusted annually based on the maximum demand values obtained in the prior 12 months.

• Separate Retail Station Power Meter – Retail Station Power is separately metered. The bill is determined from actual usage data obtained from either the auxiliary meter or the station power sub-meter.

• Estimation Of Metered Data – By agreement of utility and customer, a derivation methodology is applied. Derivation may include reliance on third-party metering.
Conclusions

- For basic net metering schemes, the maximum potential metering error increases with the addition of a 2nd meter based on the accuracy standard set forth in DPS 16 NYCRR Part 92 which designates as “Out of limit” in-service meters that test outside the range of 98% to 102%. The overall potential accuracy of measurement thus decreases with a second meter.
  - Using the accuracy performance of CTs as a basis, a second meter does increase the accuracy of measurement.
  - If alternative pricing schemes are applied (other than net metering) an economic assessment is needed to determine if requiring an auxiliary meter is still warranted.

- The magnitude of the decrease or increase in maximum error are in the range of 0.17-0.25% of the total annual registry. Use of an estimated cost for the potential registry differential may be more economical than actually installing a second meter.

- Even if auxiliary metering is required, use of sub-meters may avoid costs of wiring the meter from the point of interconnection.

- Other jurisdictions are either agnostic or leave the secondary metering requirements to individual utilities.