Estimating Interconnection Cost for Distribution-Scale Photovoltaic Systems

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Agenda

Our discussion

- Introduction
- Interconnection Estimating
  - Application Process
  - Technical Standards
  - Cost Factors
  - Reviewing Reports
- Forward Thinking
  - Cost Allocation
  - New Inverter Functionality
- Conclusion
Introduction

Who are we?

A Brief Company History:

- Established in 1980 in Borrego Springs, California
  - Started with strictly rooftop residential systems

- In 2001, we shifted our focus towards grid-tied solar installations
  - Installations for homeowners and small business
  - Moved to San Diego and expanded to Berkeley, CA.

- In 2007, opened the New England Branch

- Few years later, strategic direction changed to focus 100% on commercial and utility markets

“Borrego Solar is one of the most experienced players in a relatively young and fast growing industry. We provide a full suite of solar photovoltaic (PV) services for the commercial and wholesale distributed generation markets: development, design, engineering, procurement, and construction (EPC) and operations and maintenance (O&M).”
Introduction

Who am I?

Shay Banton, E.I.T.

◊ Utility Electrical Engineer
  ◦ Started with Borrego in January of 2017
  ◦ Engineering and estimating resource for Project Developers at Borrego Solar
  ◦ Design and review PV projects

◊ Substation Design Engineer for NiSource in NW Indiana – 14 Months
  ◦ Layout design, protection schemes, and installation sequencing for substations at the
distribution and transmission voltage classes

◊ Graduate of Washington University in St. Louis – 2015
  ◦ Bachelor of Science in Systems Science & Engineering
  ◦ Concentration in Electrical Engineering

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  ◦ Email: sbanton@borregosolar.com
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Interconnection Estimating
Understanding the Application Process

Application Process for Massachusetts, New York, and Illinois

- Process should be constantly reviewed by a Policy Working Group as technology and technical requirements change

**Flowchart:**

1. **Pre-Application Request** → **Utility Report Preparation (10 BD)** → **Pre-Application Report** → **First Evaluation**
2. **Interconnection Application Submittal and Payment** → **Utility Application Review (20 BD)** → **Initial Review / Preliminary CESIR Report** → **Second Evaluation**
3. **Impact Study / CESIR Submittal and Payment** → **Utility Performs Study (55 BD)** → **Impact Study / CESIR Report** → **Third Evaluation**
A Technical Working Group Should be Created to Assist in Standardization

- Will work towards identifying common engineering practices between utilities
- Identify the needs and concerns from developers and utilities which can be sent to policy makers for action

<table>
<thead>
<tr>
<th>Topic</th>
<th>Utility 1</th>
<th>Utility 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-Islanding</td>
<td>Sandia Screening Method - Detailed Islanding Study Performed If Failed</td>
<td>Load Percentage Screen – If Failed, DTT Required. No Detailed Islanding Study</td>
</tr>
<tr>
<td>Direct Transfer Tripping</td>
<td>Required for Anti-Islanding Only Method: Telecom Line or Pulse-Based Power Line Carrier</td>
<td>DTT Required for Anti-Islanding &amp; Loop Scheme Transfers Method: Telecom Line or Radio</td>
</tr>
<tr>
<td>PCC Recloser Threshold</td>
<td>DG ≥ 1000kW @ 15kV, DG ≥ 500kW @ 5kV</td>
<td>DG ≥ 1MW</td>
</tr>
</tbody>
</table>
Interconnection Estimating

Identifying System Upgrade Cost Barriers

Major Cost Factors for Distribution-Scale PV Projects

- **Reconductoring:**
  - Distance to 3-Phase
  - Thermal Rating of the Conductor
  - Voltage Fluctuation and Visible Flicker

- **Substation Modifications:**
  - Bi-Directional Controls
    - Ground Fault Over-Voltage – “3V0”
    - Load Tap Changer – Transformer Voltage Correction
  - Thermal Limitations
    - Nameplate Rating of Equipment

- **Distribution Upgrades:**
  - OCPD Coordination
  - Line Regulator Cogen Modification
Interconnection Estimating

Reviewing the Data Provided by Utilities

### Pre-Application Stage – “Snapshot of the EPS”

<table>
<thead>
<tr>
<th>Report Requirement</th>
<th>MA</th>
<th>NY</th>
<th>What does this reveal about the circuit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Name/ID</td>
<td>✓</td>
<td>✓</td>
<td>Allows comparison to previous projects on same circuit</td>
</tr>
<tr>
<td>Voltage at Proposed Site</td>
<td>✓</td>
<td>✓</td>
<td>Determines protective requirements and helps estimate circuit capacity</td>
</tr>
<tr>
<td>Voltage at Substation</td>
<td>✓</td>
<td>✓</td>
<td>Difference between sub and site indicates line transformer or split-phase</td>
</tr>
<tr>
<td>Number of Phases at Site</td>
<td>✓</td>
<td>✓</td>
<td>Whether or not we require a 3Ø line extension</td>
</tr>
<tr>
<td>Distance to 3-Phase</td>
<td>✓</td>
<td>✓</td>
<td>Estimating cost of reconductoring</td>
</tr>
<tr>
<td>Aggregate Connected DG</td>
<td>✓</td>
<td>✓</td>
<td>Estimate circuit capacity and what upgrades have been installed</td>
</tr>
<tr>
<td>Aggregate In-Queue DG</td>
<td>✓</td>
<td>✓</td>
<td>Helps determine what upgrades will be triggered by queued projects</td>
</tr>
<tr>
<td>Type of Circuit</td>
<td>✓</td>
<td>X</td>
<td>Estimate how much distribution protection upgrades will cost</td>
</tr>
<tr>
<td>Other Feeders in Area?</td>
<td>✓</td>
<td>X</td>
<td>Allows us to estimate for different feeders with different characteristics</td>
</tr>
<tr>
<td>Est. Circuit Capacity</td>
<td>X</td>
<td>?</td>
<td>How much DG can fit on circuit without excessive upgrades</td>
</tr>
<tr>
<td>Circuit Peak Load</td>
<td>X</td>
<td>✓</td>
<td>Further insight into circuit capacity</td>
</tr>
<tr>
<td>Substation Name</td>
<td>?</td>
<td>X</td>
<td>Allows comparison to previous projects on same substation</td>
</tr>
<tr>
<td>Substation Bank Capacity</td>
<td>X</td>
<td>✓</td>
<td>Insight into whether or not future projects can be placed in the area</td>
</tr>
<tr>
<td>Substation Peak/Min Load</td>
<td>X</td>
<td>✓</td>
<td>Bi-directional control threshold</td>
</tr>
<tr>
<td>Distance to Substation</td>
<td>X</td>
<td>✓</td>
<td>Estimating cost of extensive reconductoring</td>
</tr>
</tbody>
</table>
# Interconnection Estimating

## Reviewing the Data Provided by Utilities

### Initial Review/Preliminary Screening – Final Review before the SIS

<table>
<thead>
<tr>
<th>Report Requirement</th>
<th>MA</th>
<th>NY</th>
<th>What does this reveal about the circuit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Application Data</td>
<td>?</td>
<td>X</td>
<td>Determine if anything has changed from previous evaluation</td>
</tr>
<tr>
<td>Preliminary Study Results</td>
<td>X</td>
<td>✓</td>
<td>Assist in determining what major issues might come up during study</td>
</tr>
<tr>
<td>Circuit Peak Load</td>
<td>✓</td>
<td>X</td>
<td>Insight into circuit capacity</td>
</tr>
<tr>
<td>Conductor Size/Rating</td>
<td>?</td>
<td>X</td>
<td>Insight into circuit capacity and potential cost of reconductoring</td>
</tr>
<tr>
<td>Avail. Fault Current at POI</td>
<td>?</td>
<td>?</td>
<td>Allows for stiffness calculation for the circuit or it used to satisfy design requirements for pre-study submittal documents</td>
</tr>
<tr>
<td>Cost of SIS / CESIR</td>
<td>✓</td>
<td>✓</td>
<td>Necessary for calculating risk of moving forward with a study</td>
</tr>
</tbody>
</table>
System Impact Study – Comparing Outcome vs. Estimate

- **Step 1:** Compare Component Values in Estimate to Impact Study Costs
  - Reconductoring, substation modification, protection upgrades, etc.

- **Step 2:** Are Any of the Costs Out of Line with Expectations Derived from Previous Projects?
  - If so, contact utility for further discussion

- **Step 3:** Update Estimating Tool for Increased Accuracy on Future Estimates

- **Step 4:** Pushing Back on Utility Requirements with Lower Cost Solutions:
  - Solve flicker with off-unity inverter operation, deter capacity upgrades with storage, etc.

**Special Cases:**

- Cost sharing for large upgrades might not have been estimated yet
- If Anti-Islanding Mitigation is required, determine if Risk of Islanding Study should be commissioned
- Internal cost sharing mechanism for multiple site projects
Forward Thinking:

Cost Allocation & New Inverter Functionality
Forward Thinking: Cost Allocation

Current Method

Post-Upgrade Reimbursement in NY & MA

Process:
- Impact Study reveals that DG project triggers major substation upgrades
- DG project moves forward with interconnection absorbing full upgrade costs
- Projects behind them in queue that interconnect are required to pay the “upgrade triggering” developer a percentage of the upgrade cost

\[
(Cost \ of \ Sub \ Upgrades \ [\$]) \times \frac{Proposed \ Project \ [kW]}{(Aggregate \ DG \ Post \ Upgrade+Proposed \ Project) \ [kW]}
\]

Pros & Cons:
- Pros:
  - Better than lack of cost sharing which still exists in some territories
- Cons:
  - Prevents installation of small projects until large project interconnects
  - Risk for large projects that absorb upgrade cost
  - Small DG projects installed after project pay larger percentage than if cost allocation was done prior to the upgrade being triggered
Pilot Program in the National Grid New York Territory

Process:
- Substations with large amounts of queued DG will have 3V0 Upgrades Installed
- Each project greater than 50kW wishing to interconnect will then pay a percentage of the total cost of the upgrade
  \[
  \text{Cost of Sub. Upgrades} \times \frac{\text{Proposed Project [kW]}}{\text{Substation DG Capacity [kW]}}
  \]

Pros & Cons:
- Pros:
  - Equal burden for all interconnecting projects
  - Allows small projects to still be viable due to reduced allocation amount
  - Places initial burden on utility who can handle initial capital cost versus small developers who cannot
- Cons:
  - Does not account for distribution circuit upgrades that certain projects will still have to absorb with no reimbursement policy in place
Forward Thinking: Cost Allocation

Post-Upgrade Cost Reimbursement Compared to Preemptive Upgrade Cost Example

**Assumptions:**
- Substation Capacity: 14MVA
- 3V0 Threshold: 4MW
- Cost of 3V0 Upgrades: $350,000

<table>
<thead>
<tr>
<th>Order of Projects:</th>
<th>5,000kW</th>
<th>50kW</th>
<th>500kW</th>
<th>2,000kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Upgrade</td>
<td>$222,287.89</td>
<td>$3,465.35</td>
<td>$31,531.53</td>
<td>$92,715.23</td>
</tr>
<tr>
<td>Preemptive Upgrade</td>
<td>$125,000.00</td>
<td>$1,250.00</td>
<td>$12,500.00</td>
<td>$50,000.00</td>
</tr>
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<th>50kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Upgrade</td>
<td>$224,348.79</td>
<td>$100,000.00</td>
<td>$23,333.33</td>
<td>$2,317.88</td>
</tr>
<tr>
<td>Preemptive Upgrade</td>
<td>$125,000.00</td>
<td>$50,000.00</td>
<td>$12,500.00</td>
<td>$1,250.00</td>
</tr>
</tbody>
</table>

**Conclusion:**
- Pro: Preemptive upgrades always results in lower upgrade cost for projects
  - Counter: DG projects do not anticipate these cost when being the first to install on a given substation
- Con: If substation DG capacity is never met then the utility looses money on the investment
  - Counter: Over-saturation is a higher concern than under-saturation
First Wave of Implemented Inverter Functionality:

- Transmission operators are requiring that ride-through capabilities be implemented in order to assist the grid during a transmission fault event
- Pros: Ride-through capabilities only extend the time in which inverters will remain connected to the grid which increases output
- Cons: Will require UL 1741-SA listed inverters which can be more expensive than non-listed

Utility Dynamic Volt-Var & Operating Control of DG:

- Utilities might require additional control functions of privately owned DG
- Pros: Would increase the reliability of the grid
- Cons: Would essentially give the utility full control over the customer’s revenue

Illinois Feed-In Tariff for Smart Inverters:

- Tariff attempts to fix revenue issue by requiring utilities to pay a specified amount to developers who install and provide advanced control of their inverters to the utilities.
- Still working on language describing the terms of use for inverter curtailment by the utility
Conclusion
Conclusion

Reducing Interconnection Cost Through Standardization and Transparency

Creating dedicated policy and technical working groups at the state level:
- Allows Developers and Utilities to work through technical and process requirements as the industry develops.

Quick adoption of the latest IEEE standards:
- IEEE 1453 – Recommended Practice for the Analysis of Fluctuating Installations on Power Systems
- IEEE 1547 Revision – Standard for Interconnecting Distributed Resources with Electric Power Systems

Increased amount of circuit and substation data provided to developers:
- Reduced workload for both utilities and developers which could eventually eliminate stages of the interconnection process.
- Examples of useful information:
  - Status of bi-directional controls at a substation or on a circuit
  - Increased understanding of utility protection schemes
- California utilities have interconnection maps with important circuit capacity data.
Thank You

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