Definitions

- **T&D Capacity**: Maximum amount of energy demand that can be served by T&D equipment; “size of the pipe” that sends energy to customer load
- **T&D Avoidance**: The value of avoiding the need to expand Transmission and Distribution capacity to meet peak loads
- **T&D Deferral**: The value of delaying the date at which T&D equipment needs to be expanded
- **Marginal Cost**: The added cost to serve an additional unit of demand
- **Equipment Life Extension**: The value of extending the useful life of distribution infrastructure by reducing load and thermal stress
- **Specified avoidance/deferral**: Use of DERs to avoid or defer a specific planned Transmission or Distribution project
- **Unspecified avoidance/deferral**: The generalized value of DERs to avoid or defer otherwise needed T&D projects
- **Regression analysis**: Statistical analysis that estimates the relationship between two or more variables
Avoided T&D Capacity

• Load forecast drives T&D planning for added capacity.
  • Projections of increasing energy demand in the future necessitate T&D capacity additions
  • Analogy: Adding occupants and bathrooms to a home might require buying a larger hot water heater; converting a garage to an in-law apartment might require a larger diameter pipe
  • Energy demand naturally increases due to economic and population growth

• DERs contribute to reducing the long-term load forecast.
  • Serve end use loads directly, reduce peak demand on the grid
  • Reduce peak loads that contribute to congestion

• DERs avoid T&D capacity costs by reducing the load forecast, which reduces the need to add capacity.
Avoided T&D Capacity

Self-Generation Lowers Peak Demand Forecasts
Avoided T&D Capacity
Recent cases of DERs Avoiding Transmission

• In its 2017-2018 Transmission Plan, CAISO cancelled or modified 41 planned transmission projects

• “The changes were mainly due to changes in local area load forecasts, and strongly influenced by energy efficiency programs and increasing levels of residential, rooftop solar generation” – CAISO

• The cancelled/modified projects saved $2.6 billion in future costs
Avoided T&D Capacity
Recent Cases of DERs Avoiding Transmission

Californians Just Saved $192 Million Thanks to Efficiency and Rooftop Solar

“This is really proof of what we and other energy advocates have been saying for some time.”

JULIA PYPER | MAY 31, 2016

Solar growth puts Fresno high-voltage line on hold

By Tim Sheehan
tsheehan@fresnobee.com

- CAISO also cancelled $192 million worth of projects in the 2016-2017 Transmission Plan due to solar + efficiency

- In late 2016 CAISO deferred construction of the Gates-Gregg transmission line, saving between $115 million - $145 million
Avoided T&D Capacity
Calculation of Marginal / Avoided T&D Costs

- DERs reduce long-term forecast of peak demand.
- Need to calculate how T&D investments change as a function of peak demand.
  - Long-run marginal cost or avoided cost of T&D capacity per kW increase or decrease in peak demand
  - If:
    - we know how much it costs in T&D infrastructure to serve an additional kW of peak demand, and
    - we know how much DERs reduce peak demand
  - Then we arrive at avoided T&D value

- Marginal T&D costs are used to set retail rates for IOUs in CA, so we can start with that method
Avoided T&D Capacity

Calculating Marginal/Avoided T&D – NERA Method

- National Economic Research Associates (NERA) Method to calculate long-run marginal capacity costs
  - Well-established method in utility marginal cost studies since 1970s
  - Regression of T or D investments versus peak capacity (not peak loads) – separates out the investments driven by peak demand

- Method
  - Collect 10 years of historical and 5 years of forecast investment data, plus data on T or D system capacity
  - Regression: investments vs. capacity
  - Slope of the regression line is $ per kW marginal/avoided cost of T or D capacity
  - Add allocation of general plant to T or D
  - Apply RECC factor to determine annual $ per kW-year
  - Add T or D annual O&M costs per unit of investment
Avoided T&D Capacity

Example 1: SCE Avoided Distribution Costs

NERA regression of SCE cumulative distribution investments versus B-Bank capacity
# Avoided T&D Capacity

## Example 1: SCE Avoided Distribution Costs

<table>
<thead>
<tr>
<th>Steps</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regression – SCE D investments vs. nameplate B-Bank capacity</td>
<td>720 $ per kW</td>
</tr>
<tr>
<td>2. <em>plus</em> General Plant Loader @ 7.3%</td>
<td>53 $ per kW</td>
</tr>
<tr>
<td>3. Subtotal</td>
<td>773 $ per kW</td>
</tr>
<tr>
<td>4. <em>times</em> RECC @ 11.13%</td>
<td>86 $/kW-year</td>
</tr>
<tr>
<td>5. <em>plus</em> O&amp;M Costs from FERC Form 1</td>
<td>21 $/kW-year</td>
</tr>
<tr>
<td>6. Total Avoided Distribution</td>
<td>107 $/kW-year</td>
</tr>
</tbody>
</table>
Avoided T&D Capacity

Example 1: SCE avoided CAISO transmission costs

SCE (Non-RPS) CAISO-level Transmission Plant Investment vs. A-Bank Capacity

\[ y = 221.83x - 7 \times 10^6 \]

\[ R^2 = 0.8231 \]
Avoided T&D Capacity

Example 1: SCE avoided CAISO transmission costs

<table>
<thead>
<tr>
<th>Steps</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regression – CAISO non-RPS T vs. nameplate A-Bank capacity</td>
<td>227 $ per kW</td>
</tr>
<tr>
<td>2. <em>plus</em> General Plant Loader @ 7.3%</td>
<td>17 $ per kW</td>
</tr>
<tr>
<td>3. Subtotal</td>
<td>243 $ per kW</td>
</tr>
<tr>
<td>4. <em>times</em> RECC @ 9.94%</td>
<td>24 $/kW-year</td>
</tr>
<tr>
<td>5. <em>plus</em> O&amp;M Costs from FERC Form 1</td>
<td>7 $/kW-year</td>
</tr>
<tr>
<td>6. Avoided CAISO Transmission</td>
<td>31 $/kW-year</td>
</tr>
</tbody>
</table>
Avoided T&D Capacity

Benefits of NERA regression

- Uses long-term data (15 years)
- Includes projects where capacity is a secondary benefit.
- Captures how peak capacity needs impact all types of projects
- Avoids debate over which projects are “deferrable.”
- If a DER can provide peak capacity, it will avoid T&D costs
Avoided T&D Capacity
Allocating avoided / marginal T&D costs to hours

• Use peak capacity allocation factors (PCAFs)
  • Derived from the hourly profile of loads above a threshold of 90% of the peak load
  • Weighted by how much an hourly load exceeds the 90% threshold
  • Use substation or DPA loads for distribution
  • Use system loads for transmission
• Example of use of SCE system-level PCAFs
Avoided T&D Capacity
Allocating avoided / marginal T&D costs to hours

- Example of use of SCE system-level PCAFs

Figure 1: Summer 2024 (May - October) Marginal Costs

- Distribution
- Sub-transmission
- CAISO Transmission
- MGCC - flex.
- MGCC - peak
- MEC
Avoided T&D Capacity

Further Assistance

- Marginal capacity costs may not be part of SMUD ratemaking.
- IOU data is readily available in FERC Form 1.
- Undertaking NERA regression marginal avoided cost for SMUD will likely require refinement to the method.
- Tom Beach and Associates could assist SMUD’s consultant in applying the method to SMUD’s ratemaking.
Equipment Life Extension

- It has been shown that adding solar PV on distribution circuits can extend the life of a substation transformer by reducing thermal loading throughout the day.

- Thermal loading (i.e. heat buildup) caused by energy demand throughout the day can cause wear and drive the need for replacement.

- A 1993 study by the Pacific Energy Center found:

  “Grid-support PV defers a substation transformer upgrade by supplying power on the low voltage side of a transformer during peak usage. The reduced transformer load results in decreased transformer temperatures and longer life. A cooler transformer can accommodate additional load growth and enable the utility to defer purchase of a new transformer until fully needed.”

- The study found that 500 kW of PV could defer a transformer upgrade for 4.6 years for a value of $398,000.
THE VALUE OF GRID-SUPPORT PHOTOVOLTAICS TO SUBSTATION TRANSFORMERS

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Pacific Gas and Electric Company*
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Abstract — Strategically sited grid-support photovoltaic (PV) applications have been proposed to provide value (cost savings) to electric utilities experiencing transmission and distribution (T&D) system overloads. These applications can potentially defer transformer and transmission line upgrades, extend equipment maintenance intervals, reduce electrical line losses, and improve distribution system reliability. This paper calculates the economic value of strategically placed grid-support PV to a substation transformer. Results at Pacific Gas and Electric Company indicate that the 0.50 MW PV plant in Kerman, California can defer a transformer upgrade for 4.6 years for a value of $398,000. These results are site specific.

I. INTRODUCTION

The standard practice of electric utilities experiencing transmission and distribution (T&D) system overloads is to upgrade equipment. In 1988, it was hypothesized that strategically sited photovoltaics (PV) could benefit overloaded parts of the T&D system [1]. An evaluation methodology was developed and applied to a test case (Kerman Substation near Fresno, California). Simulated data suggested that value of PV to the T&D system could exceed its value to the bulk generation system [1].

PVUSA developed plant specifications [2] and designed a research test plan [3] to determine the value of PV to the T&D and bulk generation systems. The Kerman PV plant, completed in June, 1993, is reported to be the first grid-support PV demonstration in the world.

Grid-support PV can provide many values to T&D systems. It can defer transformer and transmission line upgrades, extend equipment maintenance intervals, reduce electrical line losses, and improve distribution system reliability, all with cost savings to utilities.

This paper focuses on the economic value of strategically placed grid-support PV to substation transformers. It calculates the transformer upgrade deferral value for the Kerman Substation using the following approach. Reduction in the transformer’s hottest-spot temperature is determined using an IEEE transformer temperature model and measured transformer and PV plant data on the 1993 peak load day. The temperature reduction is converted to allowable load increase and then to years of deferral using annual load growth estimates. Value is a function of years of deferral and other economic parameters.

II. APPROACH
Equipment Life Extension
Proposed Methodology

• The value of equipment life extension is likely to be highly variable by location, and thus extensive study may be required to arrive at a precise value.

• A skilled consultant may be able to use sampling techniques to arrive at a generalized value for equipment life extension using a sample of representative substations in SMUD’s system, accounting for:
  • Age of equipment
  • Load growth
  • Available capacity remaining

• In addition, there is overlap between equipment life extension and Distribution capacity that would need to be taken into account:
  • I.e. some equipment may require replacement because it is both near the end of its useful life and close to causing a capacity violation.
Thank You!

Questions and Discussion