



Estimating the Costs and Benefits of Avoided T&D (and Energy)

Workshop of Benefits and Costs of Distributed Generation

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Avoided T&D Capacity (and Energy) – Four Components

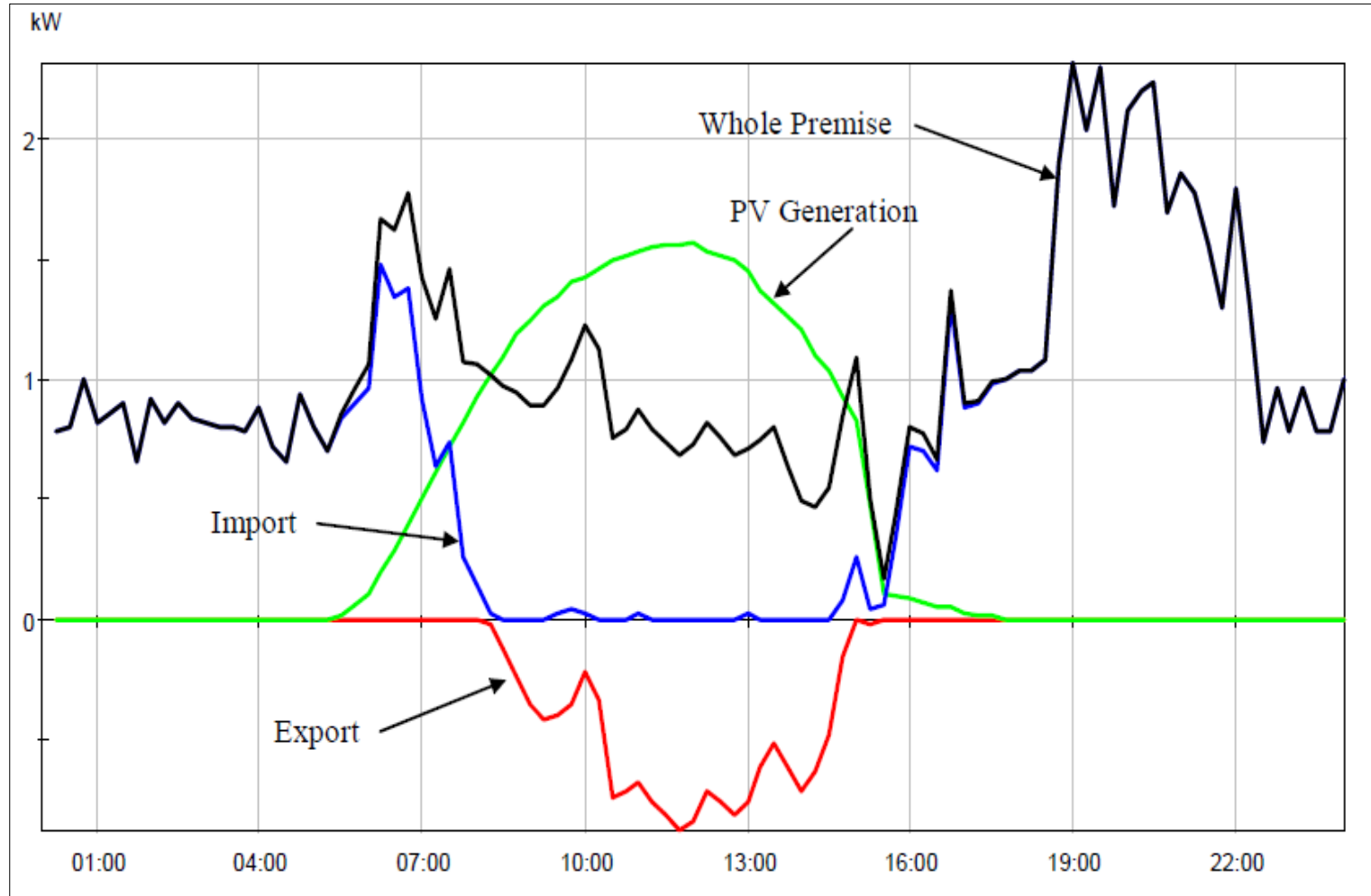
	Distribution	Transmission
Avoided (or incurred) Capacity Investments	X	X
Avoided Energy Losses	X	X

- Transmission System - above 69 kV
- Sub-transmission/Distribution System - up to 69 kV

Avoided T&D Capacity and Energy

- **Avoided/Deferred T&D Capacity**
 - Dependent upon peak coincidence and lumpy investments in system that is growing, or on peak and energy reduction in system maintenance
 - May or may not avoid or defer investment in T&D infrastructure
 - May cause additional investment in Distribution infrastructure
- **Avoided Energy Losses on T&D System**
 - Need to account for relative power displaced from grid vs energy generated and inserted onto the grid
 - Applied to MWh avoided from consumption from the grid
 - Probably should not be applied to MWh generated and injected onto the grid
 - Displaced energy based on methodologies already discussed
- **Storage and managed load could be game-changers to how avoided T&D is calculated**

Predictable but not Coincidental with Peak – Residential Example



Source: CPUC California Solar Initiative 2009 Impact Evaluation Final Report, June 2010.

Avoided/Deferred Transmission Capacity Component

- For avoided transmission investment, need to determine relative coincidence of DPV with system (transmission) peaks
- Deferred transmission is more difficult to ascertain than deferred distribution unless penetration levels are high and targeted
 - Serves multiple load areas
 - Lumpy, long lead time investments, leads to typically significant DPV penetration to be “meaningful”
 - Optimization of transmission and generation, including DPV is a challenge, which may need to be broken down into discrete parts
 - Not just DPV, but complexion of all system resources – including variable central station renewables – needs to be accounted for

Avoided/Deferred Distribution Capacity Component

- Distribution system impacts more discrete (good and bad news)
 - Requires more (potentially overwhelming) granular data – ideally on a feeder by feeder basis
 - DPV coincidence with local distribution peak is important
 - Types of inverters important
 - DG penetration with traditional inverters may cause over voltages
 - Advanced inverters can help alleviate/actively assist in regulating voltages on distribution feeders
 - Impact on already overloaded feeders
 - Potential impact on extension of service life, reduction in equipment sizing and system performance/reliability

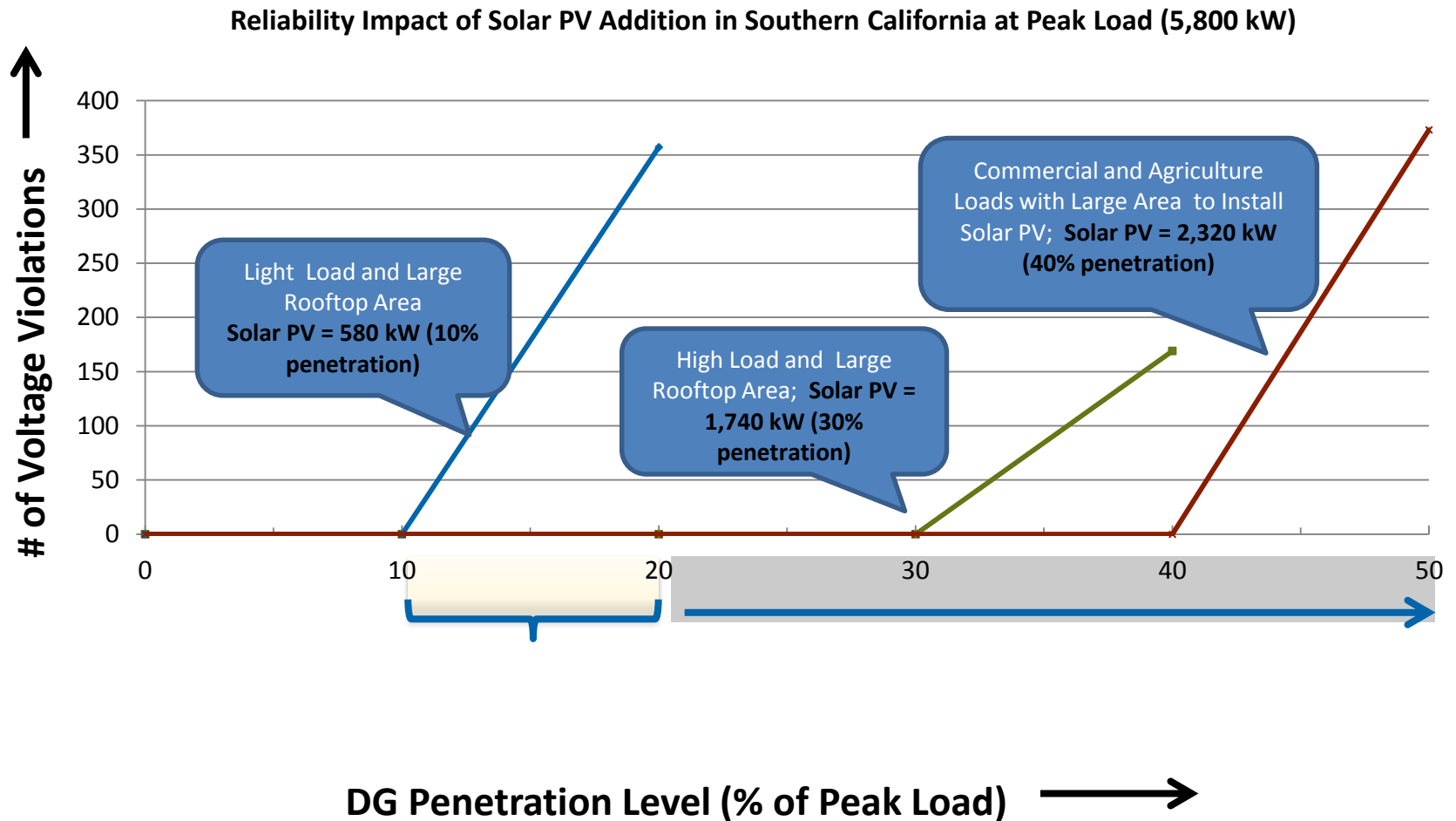
T&D Capacity Component – Lowers or Defers Infrastructure Investment

- Positive Value –
 - DPV relieves transmission congestion – potentially measured by LMP differences, or scenario based modeling
 - DPV offsets some amount of peak demand on system, thereby offsetting/deferring T&D capacity expansion
 - Average based on peak coincidence assigned across system
 - Marginal values assigned based on modeling
 - For Distribution:
 - Calculate feeder specific values of offset/deferred distribution capacity investment, requires load flow modeling
 - Potentially group feeders into prototypical sites
 - DPV offsets some amount of wear and tear on system, thereby offsetting/deferring T&D equipment replacement investments

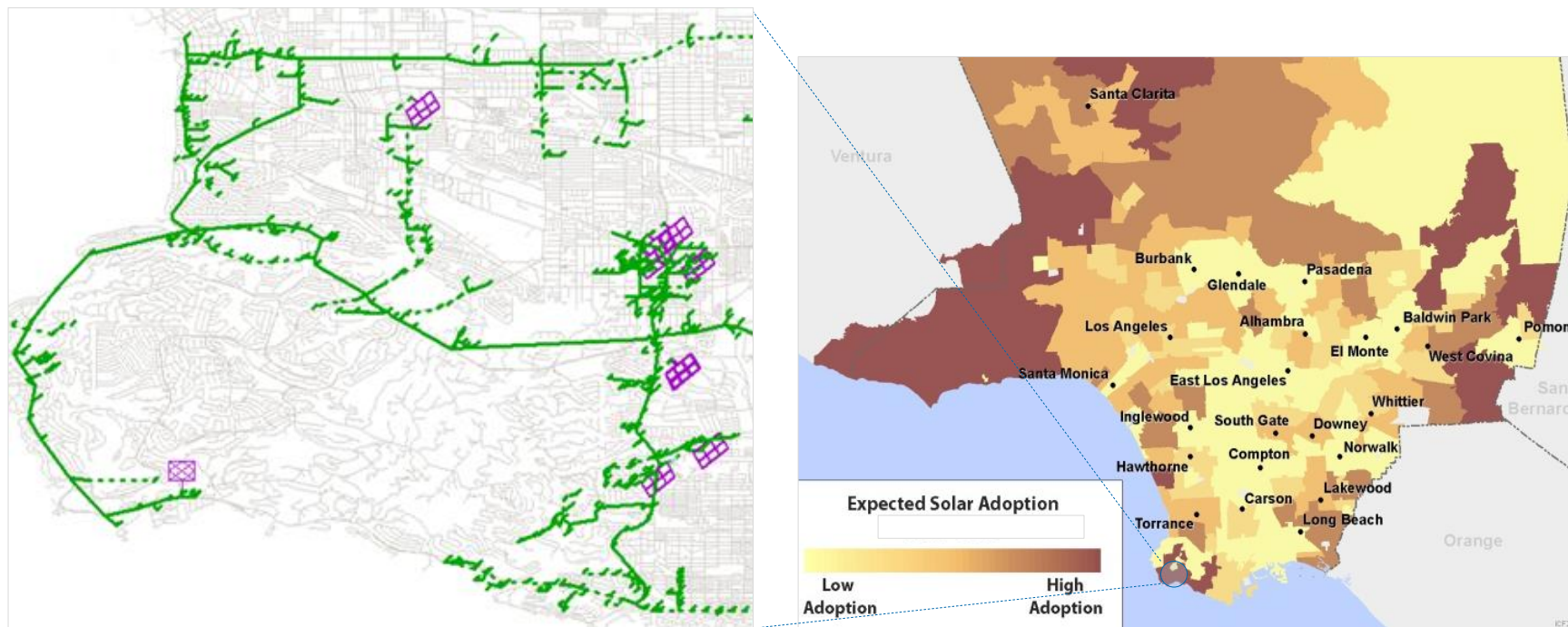
T&D Capacity Component – Requires Infrastructure Investment

- Incurred Cost –
 - DPV can cause need for additional distribution infrastructure investment through overloading distribution feeders at times of high solar generation and low native load
- Generally requires use of Load-flow modeling to:
 - Analyze least-cost system solutions from high DPV penetration
 - Identify feeders that are at risk of reliability violations from DPV
 - Assess engineering solutions – upgrading transformers or conductors, adding voltage regulators, smart inverters, etc.
 - Potentially group distribution feeders by their load profiles and current capacities

Reliability Issues Are Possible Even at Low DER Penetration Rates





Time Series Analysis (Typical Summer Day) with Solar PV at High Load Locations – 9 AM (30%)¹



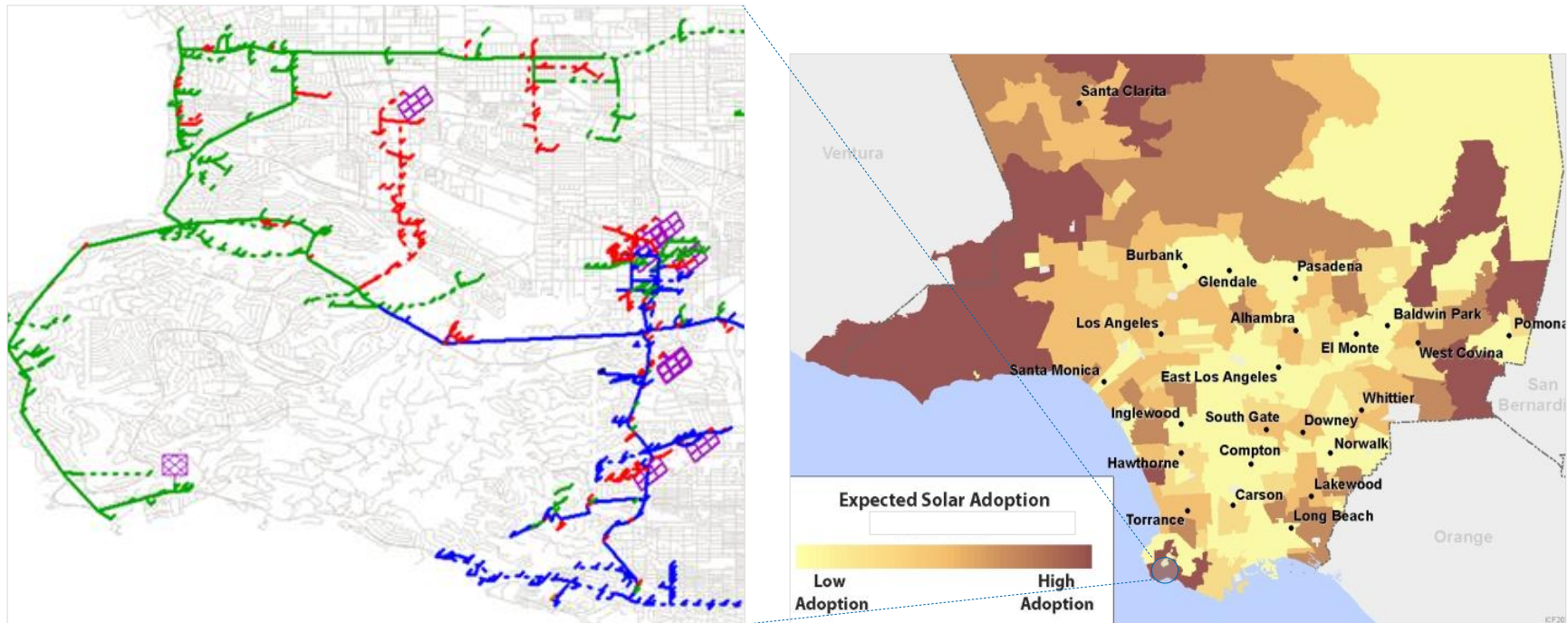
No voltage violations are observed at 9:00 AM

Legend

- Low Voltage Violation (<95%)
- Normal Voltage (95% - 105%)
- High Voltage Violation (>105%)
-  Source or Substation
-  Rooftop Solar PV Arrays






¹30% measured at 5pm.
Source: ICF DEEP Analysis.

Time Series Analysis (Typical Summer Day) with Solar PV at High Load Locations – 1 PM (30%)¹



Number of low and high voltage violations are observed at 1:00 pm

Legend

- | | | | |
|---|--------------------------------|---|-------------------------|
|  | Low Voltage Violation (<95%) |  | Source or Substation |
|  | Normal Voltage (95% - 105%) |  | Rooftop Solar PV Arrays |
|  | High Voltage Violation (>105%) | | |

¹30% measured at 5pm.
Source: ICF DEEP Analysis.

T&D Avoided Energy Loss Component

- Unlike avoided capacity, offset energy will always be a positive value (not including cost of ancillary services)
- Methodologies exist for calculating the avoided losses from T&D systems associated with Energy Efficiency*
- Use of average vs marginal losses often debated
- Also dependent on level of penetration and clustering
- Appropriate when energy consumption from the grid is off-set as a result of on-site generation
- Inappropriate when on-site energy consumption is low and on-site energy generation is high – resulting in net exports to the grid
 - Appropriate to evaluate neighborhood load

*See E3's Energy Efficiency Avoided Costs 2011 Update", Energy and Environmental Economics, Dec 2011

T&D Avoided Energy Loss Component

- T&D losses do not always act as a simple multiplier on energy and capacity benefits
- Question of temporal and locational specificity
 - Average losses on T&D system are 6% (EIA)
 - Marginal losses are often higher - 12%* , up to 15-20%**
 - Locational losses can differ significantly
- Most avoided energy loss benefit is derived when solar PV generation is correlated to heavy loading periods when congestion and transformer thermal conditions tend to exacerbate losses**

* “Distributed Renewable Energy Operating Impacts and Valuation Study”, R.W.Beck, Jan 2009.
(<http://files.meetup.com/1073632/RW-Beck-Report.pdf>)

**CPR as reported in “A Regulator’s Guidebook”, Interstate Renewable Council, Inc.
(<http://www.irecusa.org/2013/10/experts-propose-standard-valuation-method-to-determine-benefits-and-costs-of-distributed-solar-generation>)

T&D Avoided Energy Component – Potential Methodologies*

- T&D average loss rate
 - Assumes DPV avoids an average combined loss for T&D
- T&D marginal combined loss rate
 - Calculates representative marginal loss rate as a function of time
 - usually still combined
- Locational marginal loss rate
 - Calculates marginal loss rate at different locations in the system – clear distinction between T & D
- Loss rate determined by power flow modeling
 - Uses detailed time series power flows for T&D

* “Methods for Analyzing the Benefits and Costs of DPG to the US Electric Utility System
(<http://www.nrel.gov/docs/fy14osti/62447.pdf>)

Question 1

- What are the major cost elements for avoided T&D costs that need to be included in evaluations of distributed energy resources, and what are the problems associated with the development of the data and their application in studies?

Question 2

- What are the major benefit streams for avoided T&D costs that need to be included in evaluations of distributed energy resources, and what are the problems associated with the development of the data and their application in studies?

Question 3

- What are the methods, models and analysis tools that need to be used in evaluations of distributed energy resources, and what are the problems associated with their application in studies?

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