LA100

The Los Angeles 100% Renewable Energy Study

Initial Run Results: Distribution Models

SB100 Scenario

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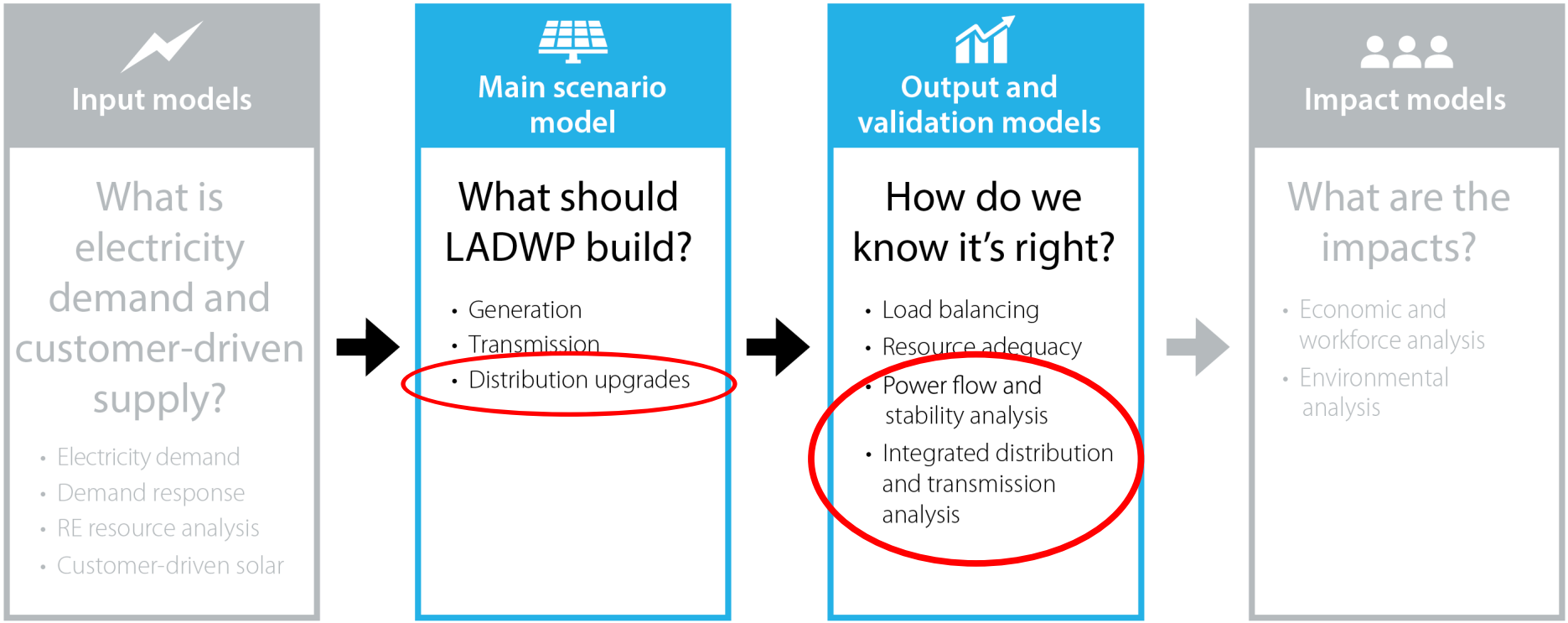
LA DWP Los Angeles Department of Water & Power | NREL Transforming ENERGY

Bulk Power and Distribution Models



Agenda

Output Models, Part 2: Distribution System

1. Analysis Overview
2. Methods Introduction
3. Initial Run Results (4.8kV)
4. Discussion/Q&A

Distribution System Analysis

Overview

Purpose within LA100

What are the impacts on the distribution system of:

- Future electricity demand changes?
- Distributed generation?

Approximately how much would required distribution upgrades cost LADWP?

- Includes distributed generation from:
  - Residential and commercial rooftop solar
  - Larger ground-mounted and carport solar
- Analysis conducted only for 2030 & 2045

Initial Run (Today/March) vs. Final Run (June AG)

What's Included in Initial Run (Today)

2045 analysis

Initial loads (electricity demand)

4.8kV rooftop solar

Two time periods: peak load and high solar with low load

Initial Run results at March AG

Upgrade cost estimates (2030)

34.5kV large-scale local solar (2030)

What's Not Included Today but Will Be in Final Run

2030 & 2045 analysis

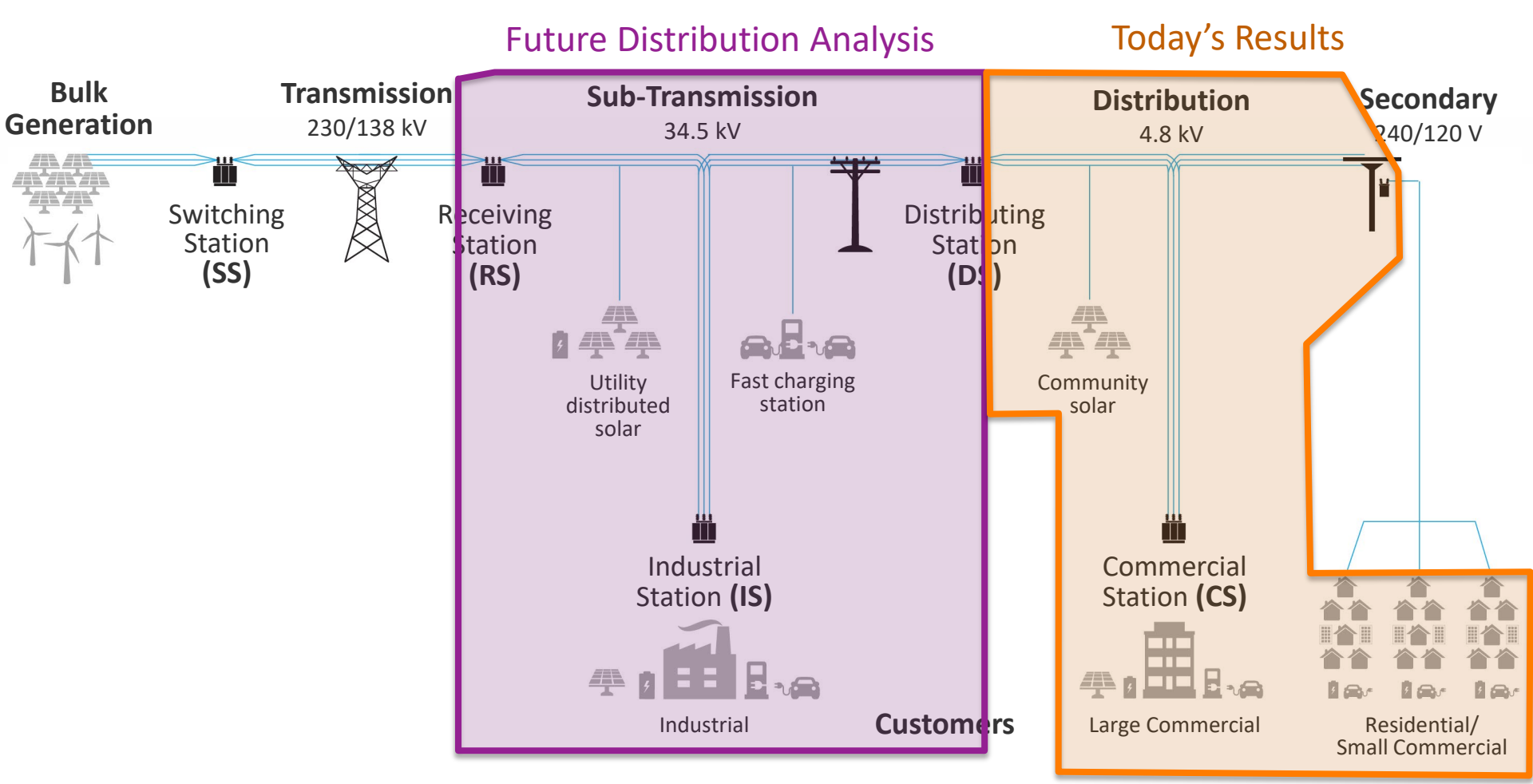
Revised loads, including EVs, buses, fast charging

Distribution upgrade cost estimates

34.5kV large-scale local solar

Local storage

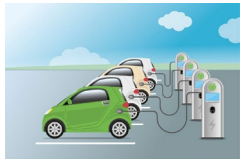
Time-series analysis for impacts and curtailments


Future Distribution Analysis
Today's Results
Bulk Generation
Transmission
230/138 kV
Sub-Transmission
34.5 kV
Distribution
4.8 kV
Secondary
240/120 V
Switching Station (SS)
Receiving Station (RS)
Distributing Station (DS)
Utility distributed solar
Fast charging station
Community solar
Industrial Station (IS)
Commercial Station (CS)
Industrial
Large Commercial
Residential/ Small Commercial
Customers

LA100 Distribution Modeling Efforts: Load and Solar

1. Today → There are some circuits that already have known overloading or voltage challenges (data from LADWP)

2. 2030 Load-only
   2045 Load-only



→ Distribution impacts of load changes due to electric vehicle adoption, energy efficiency, demand response, and other sources

Then add solar:

3. 2030 with solar*
   2045 with solar*

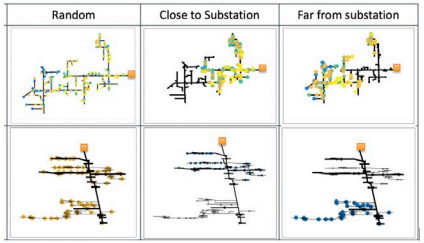
→ Distribution impacts of both rooftop and utility-scale local solar
* For Final Run: add storage

LA100 Distribution Modeling Efforts: Analysis Types

Rooftop solar adoption
(dGen)

System-wide expansion plan for ~1-5 MW local solar at 34.5kV
(RPM)

Random solar deployments



Projection of customer adoption on each roof
5 samples/feeder

Distribution Impact Analysis

Power flow analysis to look for voltage violations and thermal impacts of customer-adopted solar

Aggregated up and input to capacity expansion model

Hosting Capacity Analysis

- Snapshot hosting capacity —all feeders
- Dynamic hosting capacity — select feeders

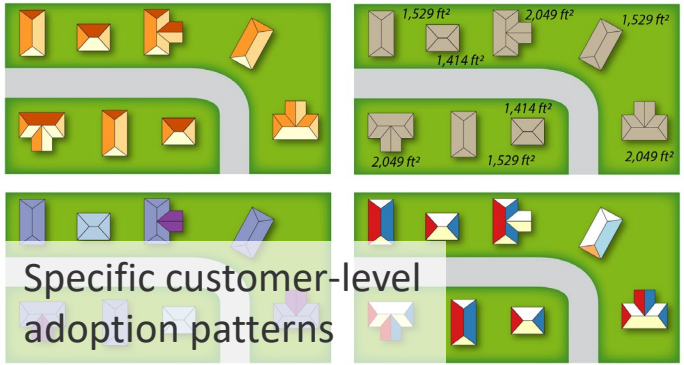
What is Impact Analysis?

Distribution power-flow study of future operations to check for violations, including:

- **Voltages:**
  - Under: typically from high loads
  - Over: typically from distributed generation (e.g. solar)*
- **Overloads:**
  - Transformers
  - Lines

Two approaches:

1. **Absolute:** Are upgrades needed?
2. **Relative:** How do things change?



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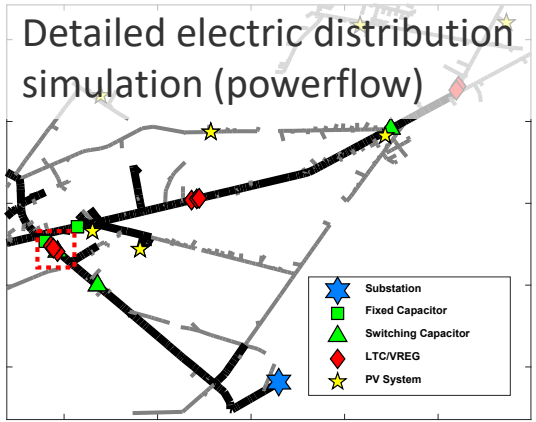


**Note: Advanced inverters can help manage both over & under voltages*

What Is Hosting Capacity? And How Is It Computed?

The amount of solar that can be added to a feeder without causing operational changes

Key Items:

- Voltage violations
- Overloads
  - Transformers
  - Lines

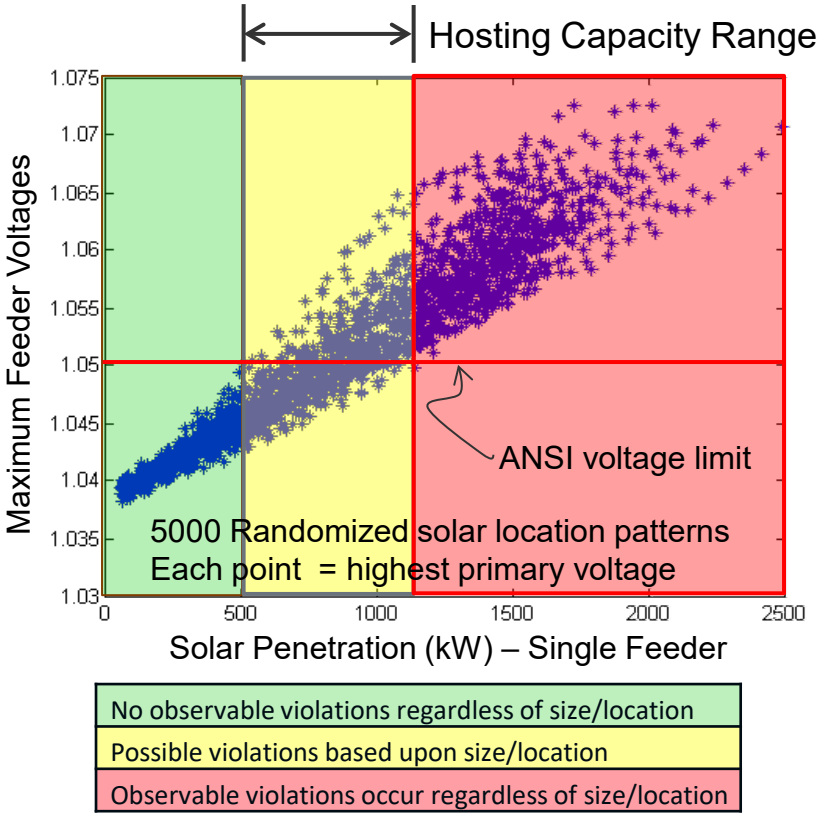


Figure Adapted from: Jeff Smith, EPRI, "Alternative Screening Methods solar Hosting Capacity in Distribution Systems", Presented at HiPen Solar Forum 2013, Feb 13-14, San Diego, CA.

What Is Hosting Capacity? And How Is It Computed?

The amount of solar that can be added to a feeder without causing operational changes

Key Items:

- Voltage violations
- Overloads
  - Transformers
  - Lines

Key Points:

- Up to a certain point, integrating distribution-connected solar is “free”
- Location matters … a lot
- Advanced inverters can boost hosting (e.g., 2-3x)
  - Included for all new solar in LA100
- Hosting capacity is not a hard limit … but we have to pay for upgrades

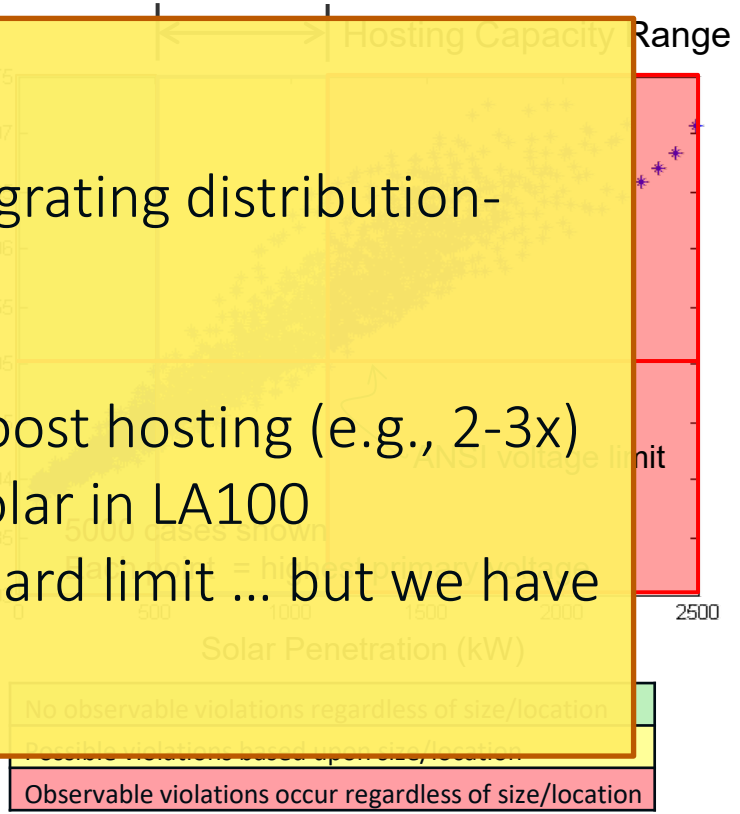


Figure Source: Jeff Smith, EPRI, “Alternative Screening Methods solar Hosting Capacity in Distribution Systems”, Presented at HiPen Solar Forum 2013, Feb 13-14, San Diego, CA.

Distribution System Analysis

Methodology

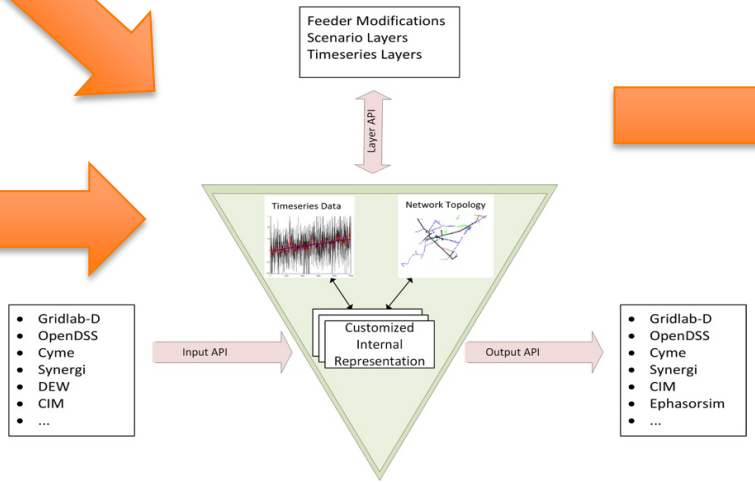
Step 1: Build Electric Models of LA's Distribution System

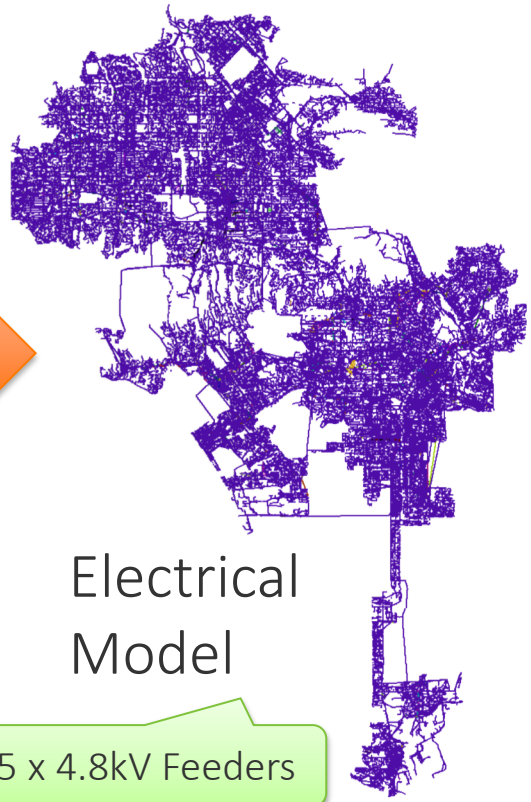
Geospatial and Equipment Data

Typical Technical Parameters

DiTTo

Github.com/NREL/ditto





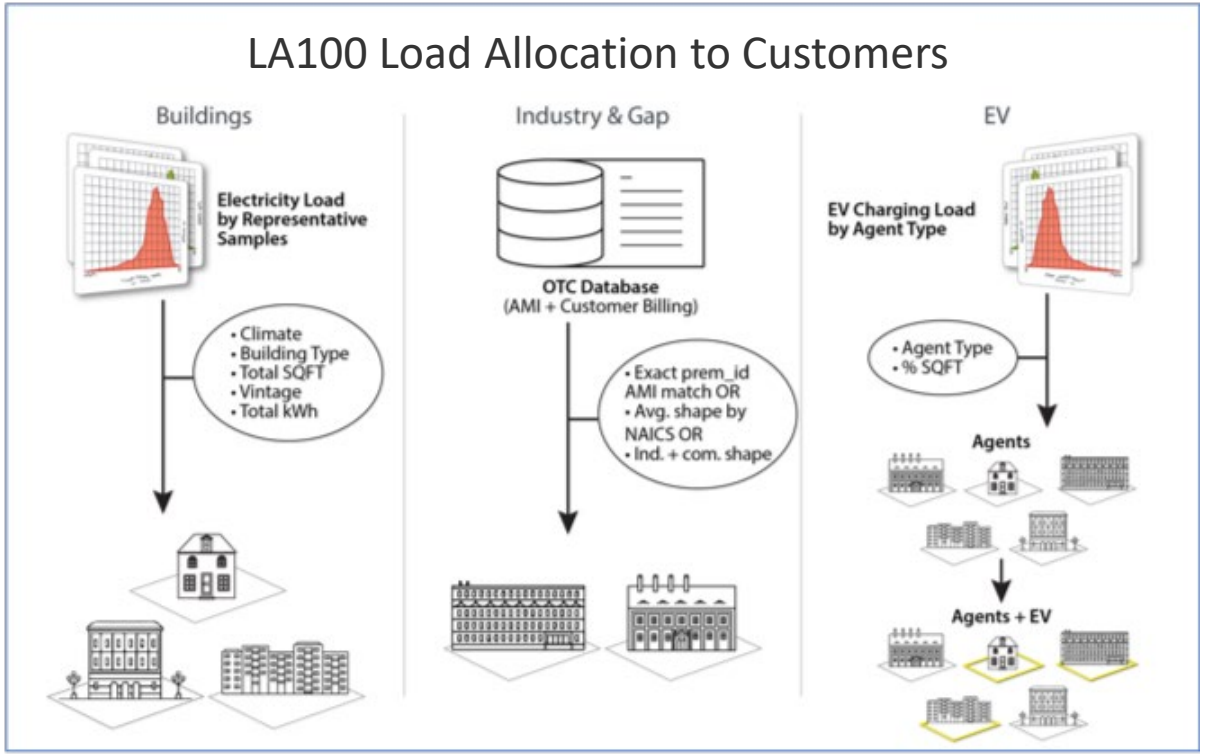
Electrical Model

1,675 x 4.8kV Feeders

Step 2: Add Loads and Solar

Matched to individual customers:

- Building loads
- Electric vehicle loads
- Distributed solar adoption
- Customer storage (soon)



Step 3: Lots of Computations

500,000+ Powerflows

Pre-Processing
- Powerflow with PyDSS
- Identify Items to Fix

DiTTO
- Feeder Model Creation
- dGen Solar Deployments

Hosting Capacity Setup
- Hosting Capacity Solar Deployments
- Config File Creation

Impact Analysis Setup
- Config File Generation

DISCO — Distribution grid Integration Solution COst
- Model Input Creation
- Configure Model Inputs
- Run Powerflow with PyDSS
- Post Processing Layer 1: Impact and Hosting Capacity Analysis
- Post Processing Layer 2: Create Summary Dataframes

Data Analysis
LA100-specific Jupyter Notebooks, scripts, etc.
- Interactive Data Analysis

Step 3: Lots of Computations–What We Evaluate Today

Based on two time points: “peak demand” and “high solar with low demand”

1. **Violations because of 2045 load changes:**
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. **Differences in violations due to 2045 local solar**
   - Impact analysis: customer deployments
3. **Combined load and solar impact analysis:**
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare **2045 load-only** impacts to **today**

Compare 2045 **with** and **without solar**

May be better or worse with solar

Compare **2045 load + solar** to **today**

Distribution System Analysis

Initial Run Results (4.8kV)

SB100-Moderate Load 2045

Reminder: Load and Solar Adoption Levels

- Peak 4.8kV Load = 3.2 GW
  - Bottom-up Building Models (moderate efficiency)
  - Light-duty Electric Vehicles (moderate adoption)
- Total 4.8kV Rooftop Solar = 2.1 GW
  - Based on dGen results (moderate adoption)

Initial Run: **Load** Analysis, 2045 Compared to Today

Based on two time points: "peak demand" and "high solar with low demand"

1. Violations because of 2045 load changes:
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

Compare 2045 Load + Solar to today

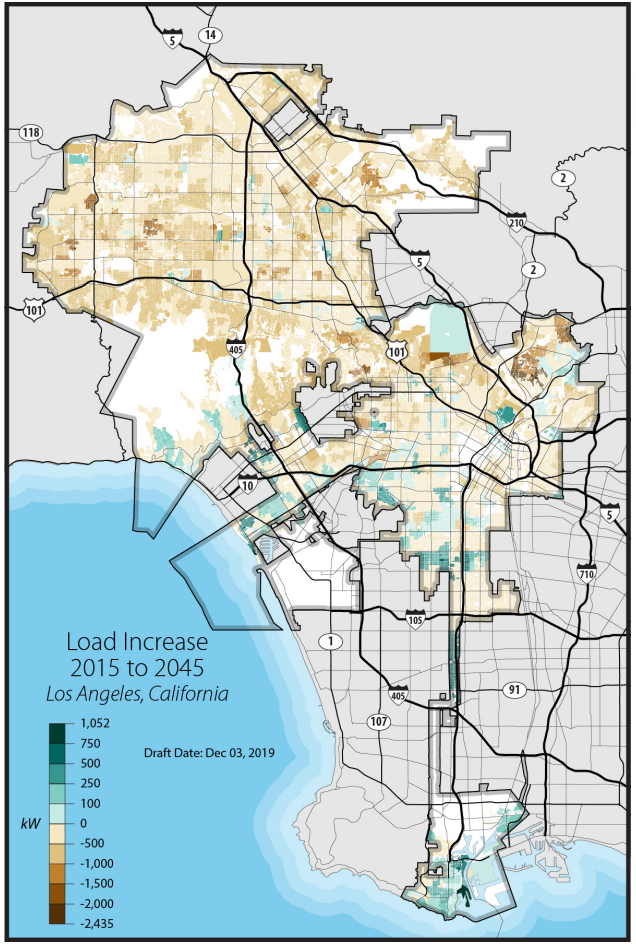
Initial Run
4.8kV

Distribution Impacts of **Load-only**

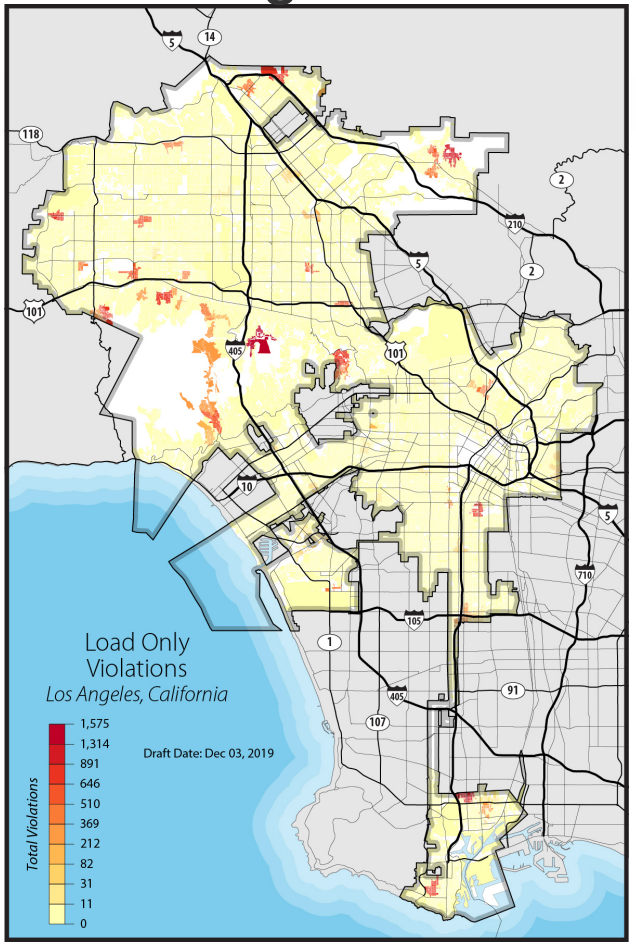
(2045 SB100 Moderate)

Note: Loads do not include demand response shifts

2045 Load Increase



Resulting Violations

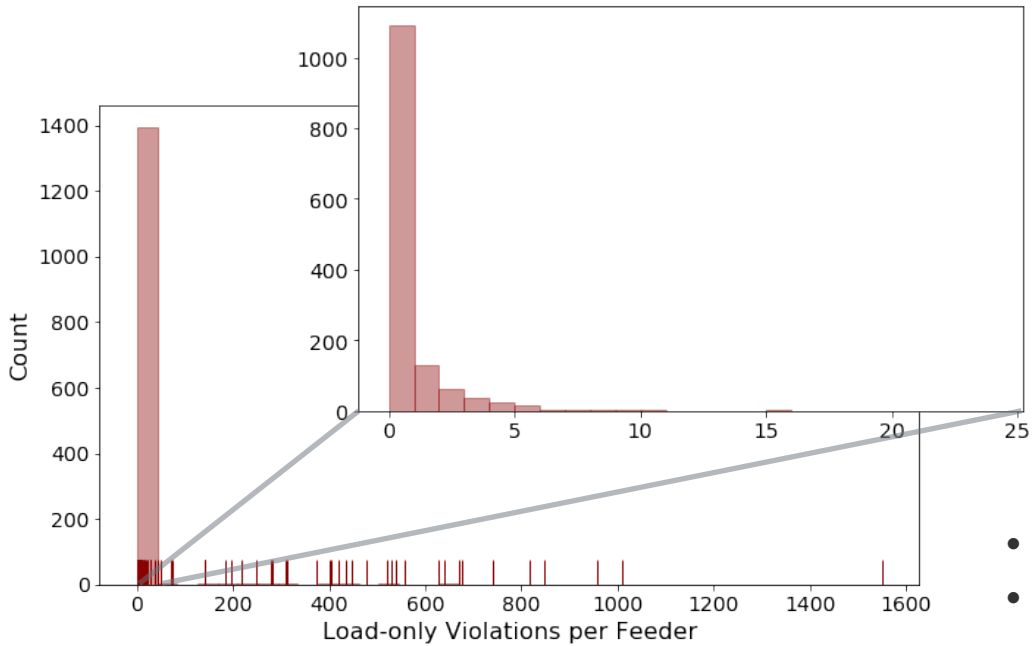


Initial Run – For Discussion Purposes Only; Subject to Change

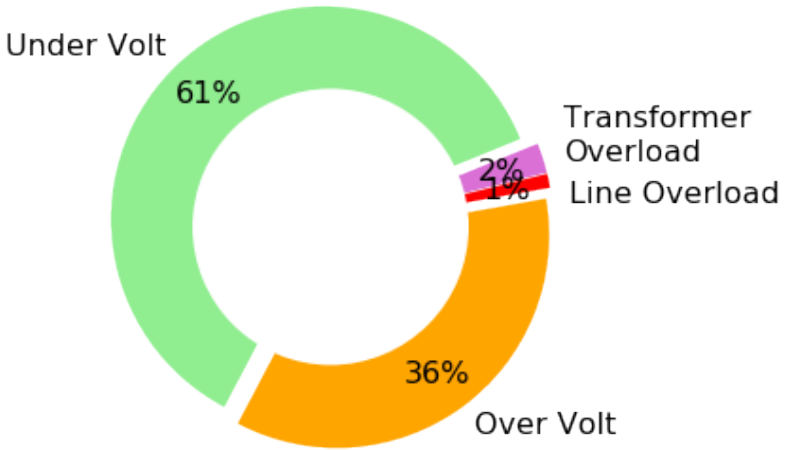
Initial Run:
Distribution Impacts of 2045 **Load-only** (continued)

4.8kV, 2045 SB100-Moderate

Violations per Feeder (Load-only)



Violation Type Breakdown



- 86% of feeders OK with new loads
- Most remaining require only few upgrades

Initial Run: **Solar** Analysis, 2045 With and Without Solar

Based on two time points: "peak demand" and "high solar with low demand"

1. Violations because of 2045 load changes:
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

May be better or worse with solar

Compare 2045 Load + Solar to today

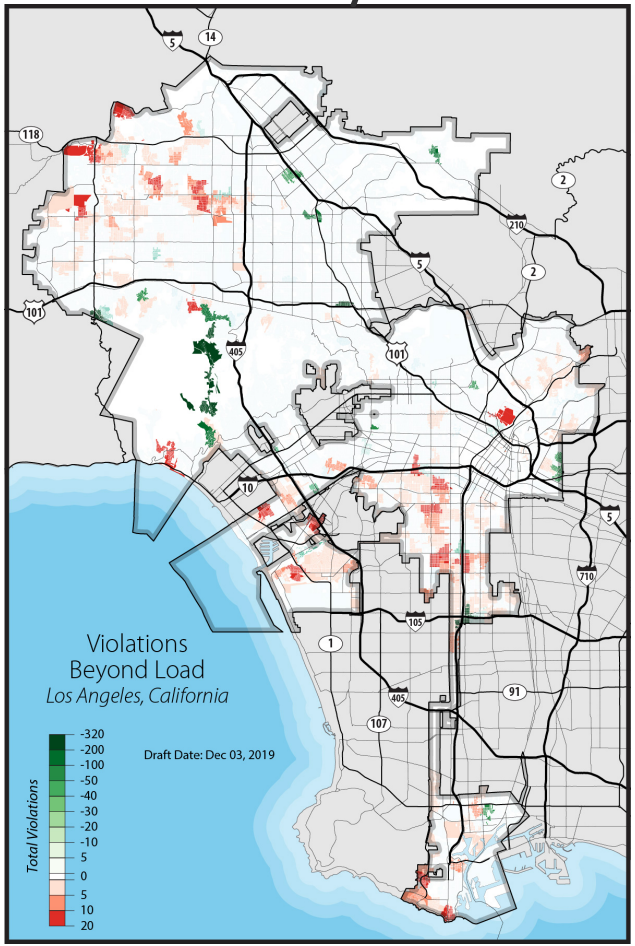
Violations Beyond Load

Initial Run
4.8kV

Distribution Impacts of **Rooftop Solar**

(2045 SB100 Moderate)

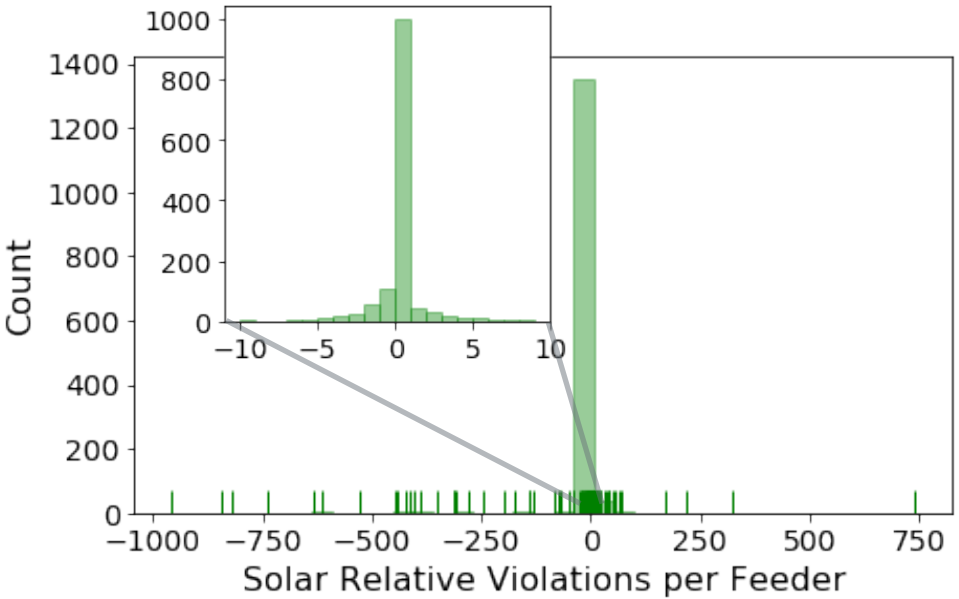
Note: Loads do not include demand response shifts

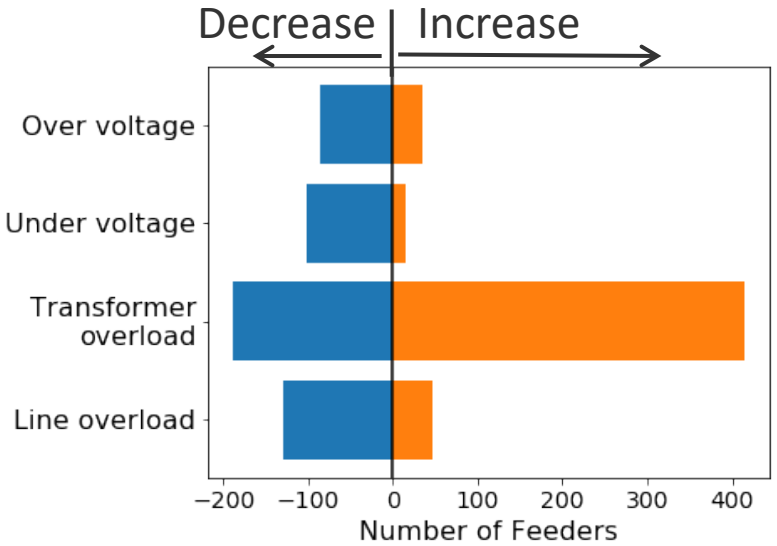


Initial Run:
Distribution Impacts of 2045 **Rooftop Solar** (continued)

4.8kV, 2045 SB100-Moderate

Violation Change with Solar vs. Load-only





Total Violation Count:

- Up: 14% of Feeders
- Down: 18%
- The same: 69%

Initial Run: **Load and Solar** Analysis, 2045—Will It Fit?

Based on two time points: "peak demand" and "high solar with low demand"

1. Violations because of 2045 load changes:
   - Overvoltage
   - Undervoltage
   - Line overload
   - Transformer overload
2. Differences in violations due to 2045 local solar
   - Impact analysis: customer deployments
3. Combined load and solar impact analysis:
   - Are upgrades needed?
   - If not, how difficult are needed upgrades?

Compare 2045 load-only impacts to today

Compare 2045 with and without solar

Compare 2045 Load + Solar to today

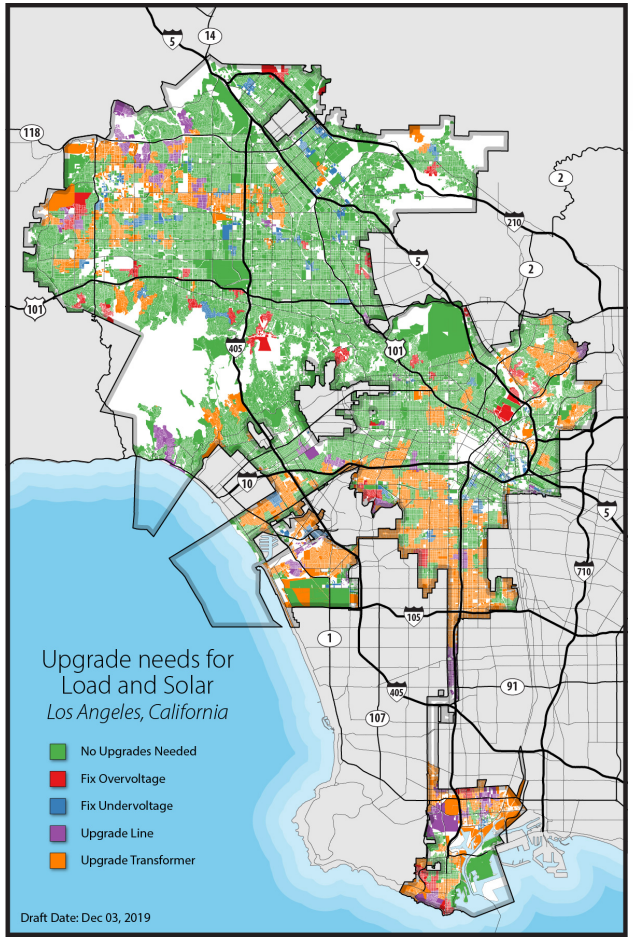
Are Upgrades Needed?

2045 SB100-Moderate

Initial Run 4.8kV

Are upgrades needed to accommodate estimated **load + rooftop solar**? If not, how hard will it be to upgrade?

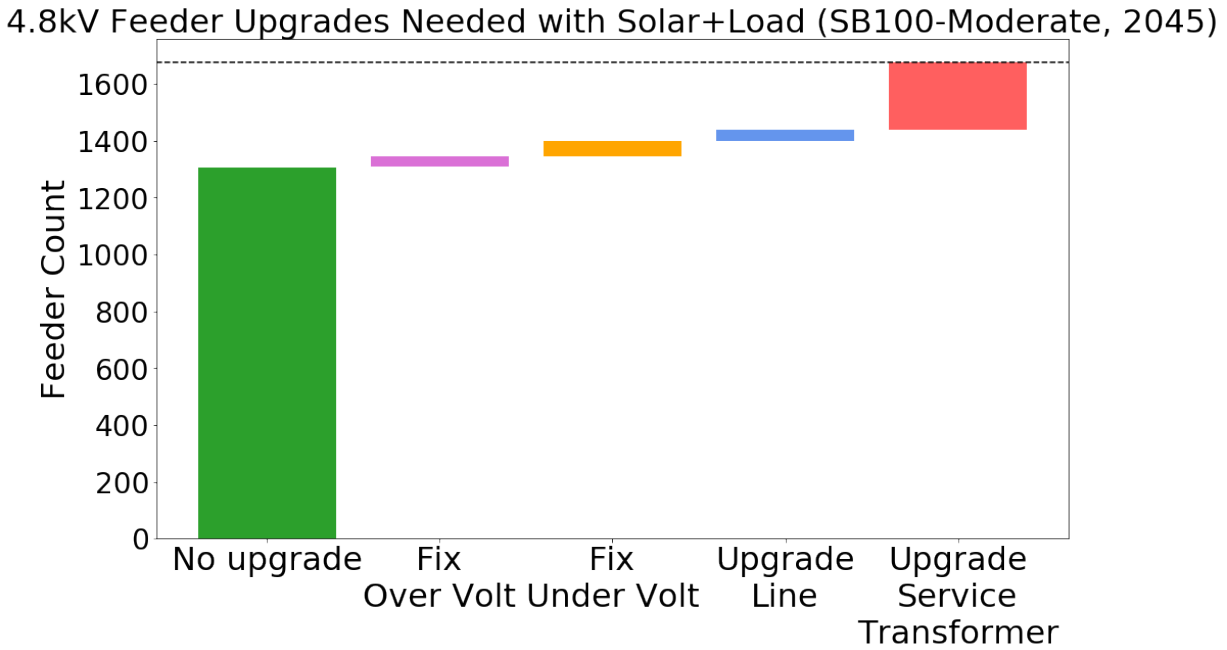
Note: Loads do not include demand response shifts



- No upgrades needed
- Fix overvoltage, typically from solar ($-$$)
- Fix undervoltage, typically from load ($-$$)
- Line upgrade ($$$+)
- Service transformer upgrade ($-$$)

Initial Run:
Are Upgrades Needed with **Loads and Rooftop Solar**?

4.8kV, 2045 SB100-Moderate



- No upgrades needed in 78% of feeders with new loads and solar
- Only 2.3% of feeders would require line upgrades ($$$)

Initial Run Summary for SB100 Moderate

- **Expected load changes are OK for most (86%) 4.8kV feeders**
  - Most common concern = undervoltage
- Adding rooftop solar can both:
  - Increase violations (14% of feeders) and
  - Decrease violations (18% of feeders)
- **Most 4.8kV feeders (78%) are OK with both solar and rooftop PV**
- But these results will change for Final Run

Coming Up

March

- Distribution analysis and upgrade cost estimates for 2030, including:
  - Analysis of large-scale local solar on 34.5kV lines

June

- Distribution analysis and upgrade costs for 2030 and 2045 based on:
  - Revised loads, including EVs, buses, and fast charging
  - Local storage
  - Full time-series analysis for impacts and curtailments

Questions?