LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #14

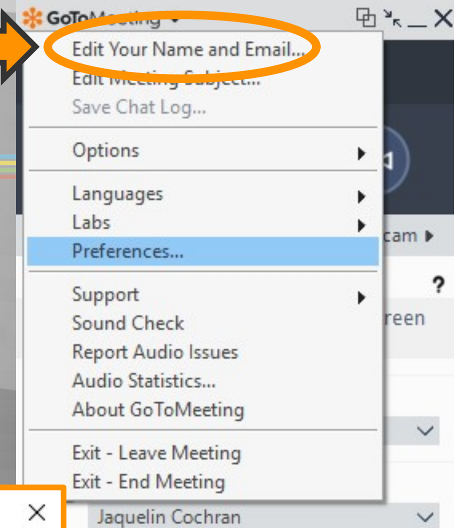
Virtual Meeting #1

December 10, 2020

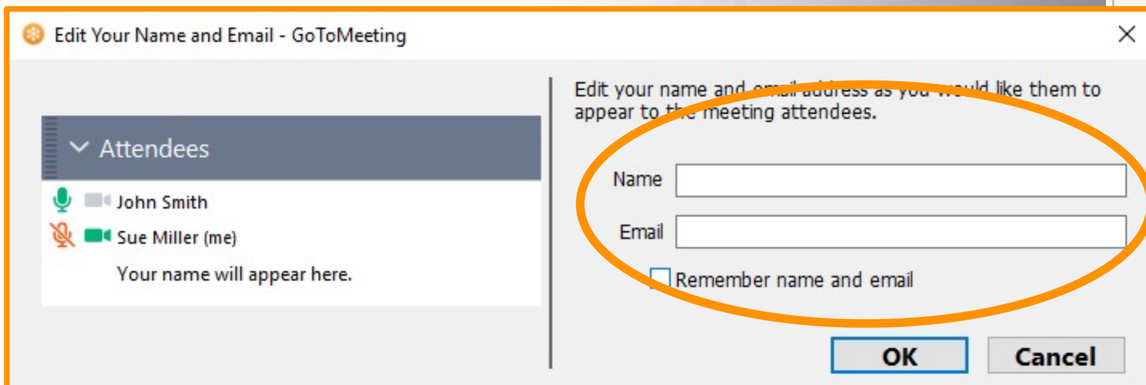
Los Angeles Department of Water & Power | NREL Transforming ENERGY

The Los Angeles 100% Renewable Energy Study

Welcome to the LA100 Advisory Group meeting!
Please consider adding your affiliation to your name identification.



Advisory Group Meeting #14



Virtual Meeting #1

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NREL Transforming ENERGY

Tips for Productive Discussions

Let one person speak at a time

Keep phone/computer on mute until ready to speak

Help ensure everyone gets equal time to give input

Type "Hand" in Chat Function to raise hand

Keep input concise so others have time to participate

Also make use of Chat function

Actively listen to others, seek to understand perspectives

Offer ideas to address questions and concerns raised by others

Hold questions until after presentations

Agenda

Today (December 10)

- Welcome
- Distribution Grid Analysis
- Discussion/Q&A

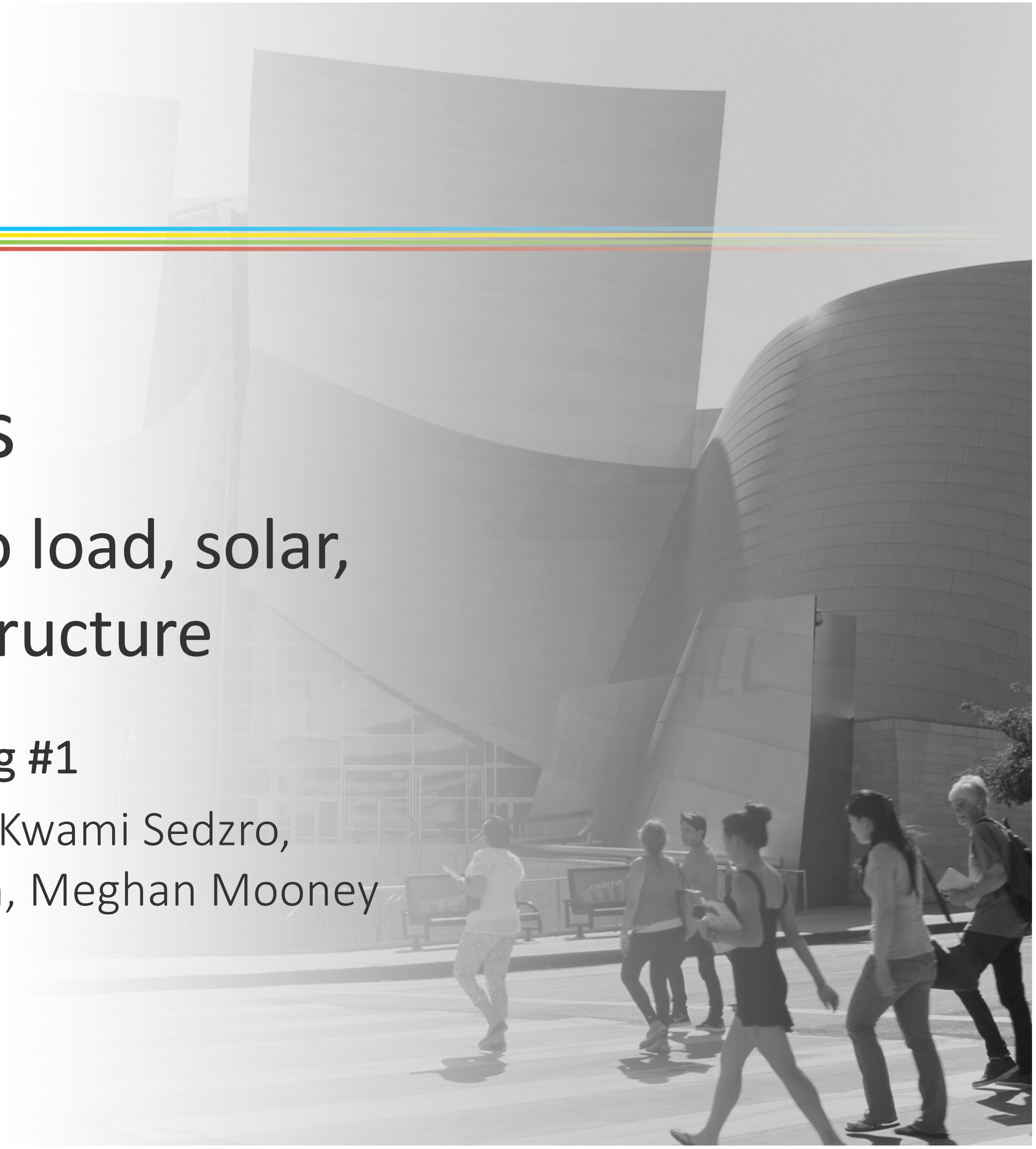
December 17

- Final Updates to Bulk Power Modeling
- Discussion/Q&A
- LA100 Updates
- Open Q&A on Any LA100 Topic

The Los Angeles 100% Renewable Energy Study

Distribution Grid Analysis

Costs and impacts of change to load, solar, and storage to required infrastructure



Advisory Group Meeting #14, Virtual Meeting #1

Bryan Palmintier (speaker), Kelsey Horowitz, Kwami Sedzro, Sherin Abraham, Tarek Elgindy, Jane Lockshin, Meghan Mooney

Los Angeles Department of Water & Power

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Today's discussion

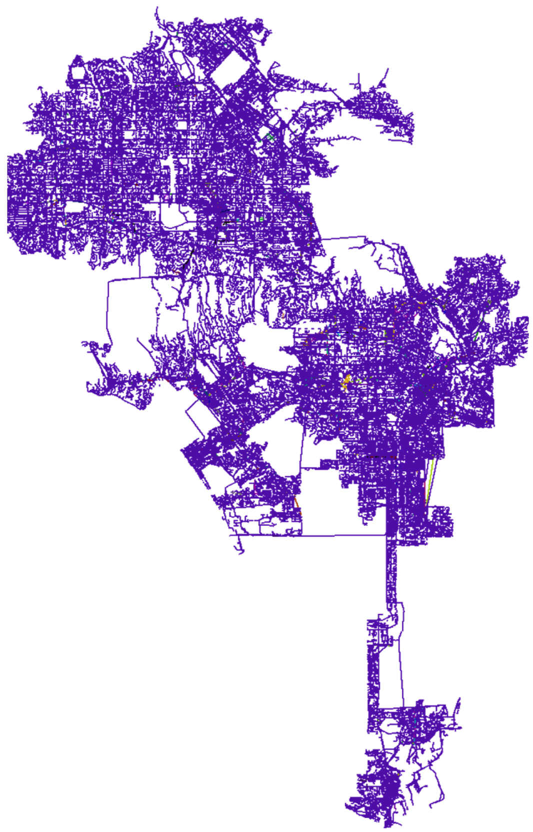
- Costs and upgrades associated with the 4.8 kV local distribution system
- Costs and upgrades associated with the 34.5 kV sub-transmission system
- Incidental deferments: without optimizing, does the addition of solar/storage help offset upgrades?
- Reflections on findings for considering LA100 scenarios

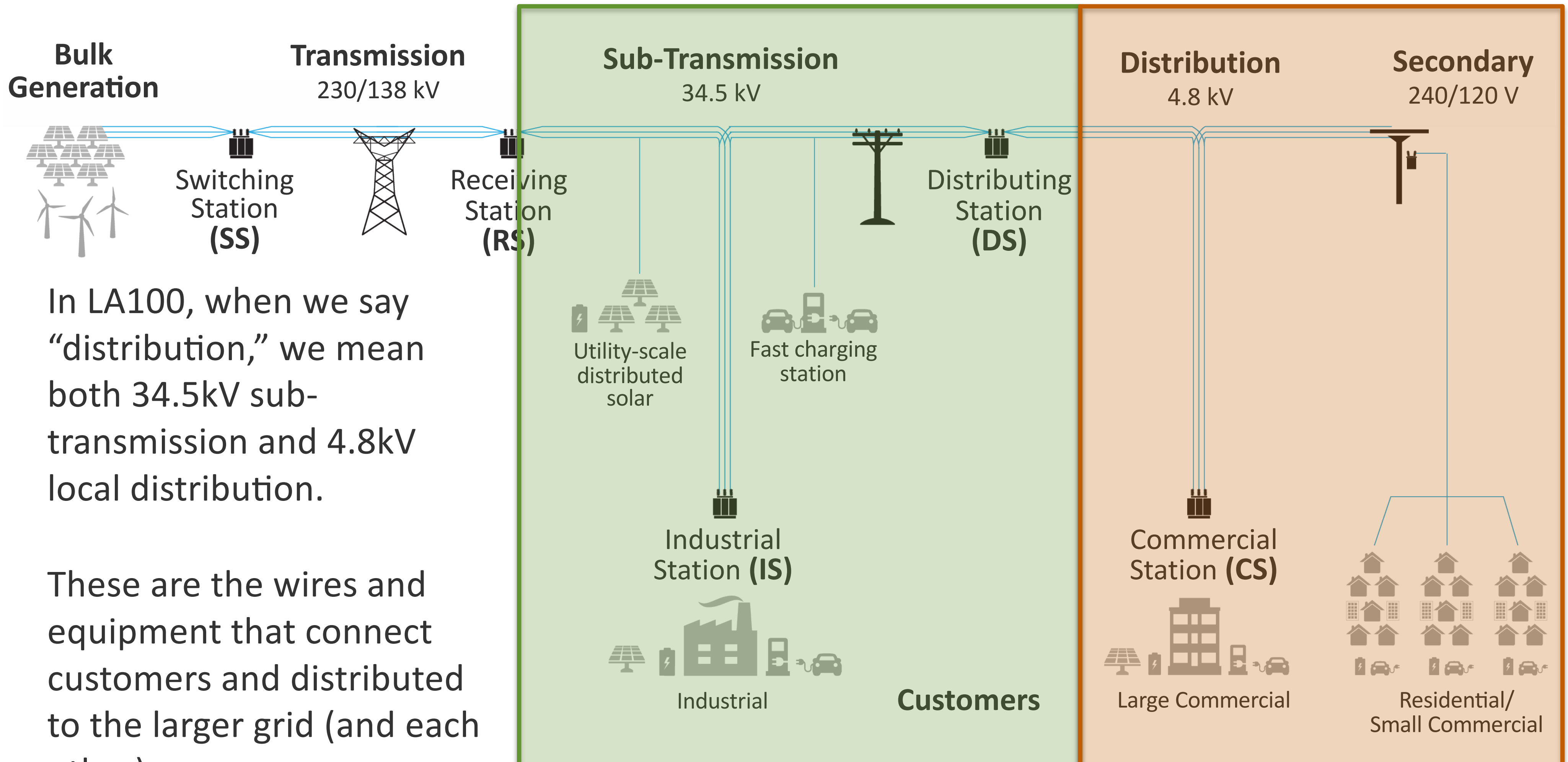
What have we learned?

1. **Some distribution upgrades are required** for load and solar; but:
   - Only a few items per feeder
   - Fairly easy to fix: mostly service transformers
   - Only ~1% of bulk system costs
2. **Cost of distribution upgrades for (larger) non-rooftop solar varies with location but are generally low**.
   - Grid costs much lower than (already low) solar costs
     - Distribution Grid is not limiting local solar
3. **The 100% pathways use a fraction of the available in-basin solar/storage capacity**
   - Largely because very large-scale solar cost (a lot) less, and
   - Additional value streams not studied, (e.g. deferred substation upgrades) or hard to monetize (e.g. resiliency)
4. **There are synergies between upgrades for load and solar:**
   - Upgrades designed for solar and load together are cheaper than sequentially supporting load then solar
   - Full non-wires alternatives study may find more

What's New in These Results

- Final results for the 4.8 and 34.5 kV systems
  - Revised non-rooftop solar inputs (due to bulk power system revisions)
  - Cost estimates for all scenarios
  - Non-rooftop solar integration costs
- Unprecedented scale of distribution analysis complete
  - Entire basin. ~1500 feeders/circuits (>80% of system)
  - A dozen load/solar timepoints
  - Multiple possible patterns of rooftop solar adoption
- Impacts of location on non-rooftop solar integration costs

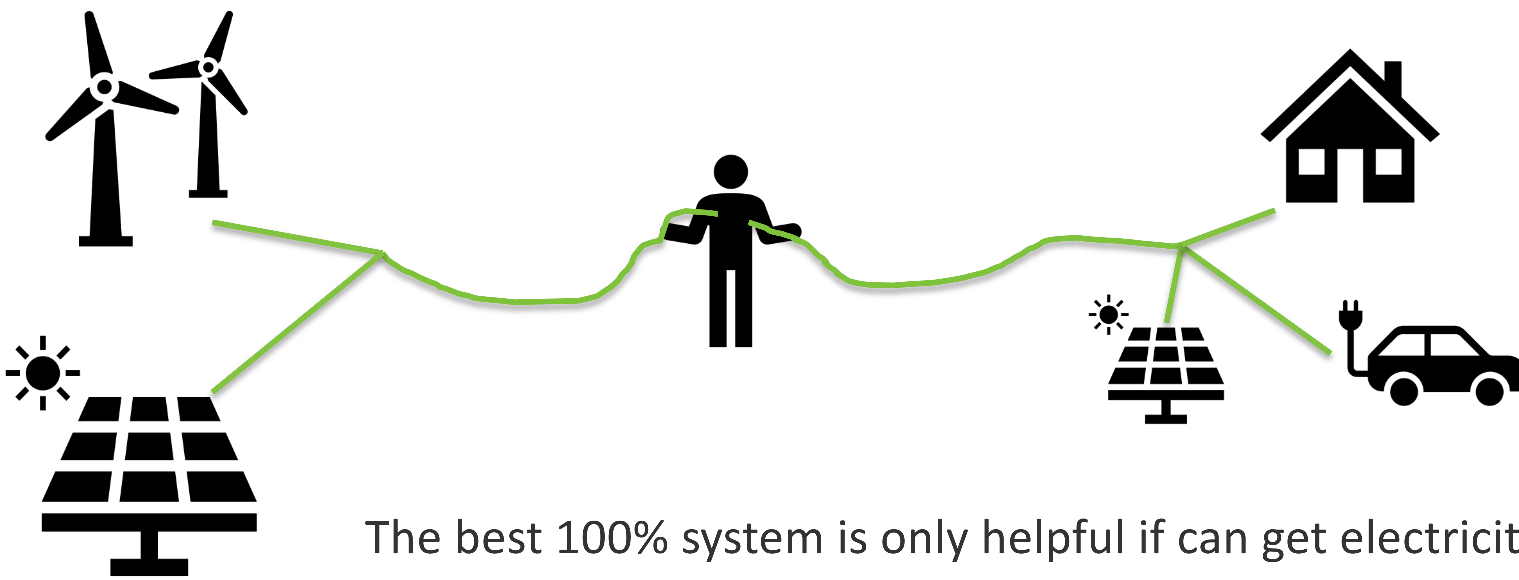




In LA100, when we say "distribution," we mean both 34.5kV sub-transmission and 4.8kV local distribution.

These are the wires and equipment that connect customers and distributed to the larger grid (and each other)

Why Distribution?



The best 100% system is only helpful if can get electricity to the customer...

And increasingly customers/others want to share their solar/storage production

Categories of In-Basin Renewable Resources

Utility-scale resources built to meet overall system needs

Based on bulk capacity expansion modeling

Resources located at existing OTC sites

Transmission tied

100 MW to 1.5 GW/site

"Non-rooftop" Solar and Storage

Connected to 34.5kV.

Located based on GIS analysis.

up to 84 MW/site potential

up to 16 MW/site built

Distribution Connected

Rooftop Solar and Customer-adopted storage

Both 4.8kV and 34.5kV

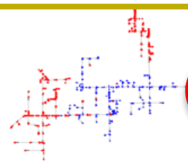
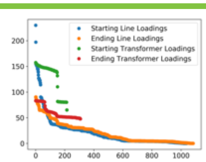
Based on customer adoption models

1 kW to 10s MW/premise

Changes in 100% Systems: Distribution Analysis

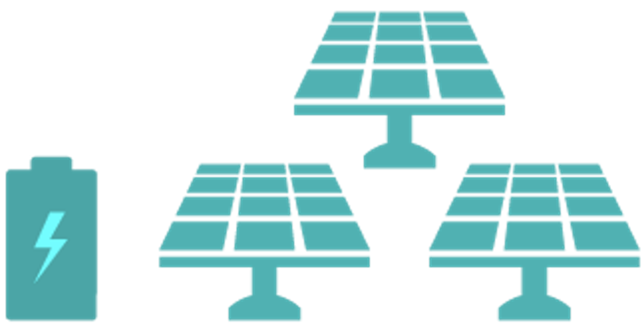
Traditional and Low RE Systems	100% RE Systems
Size based on single peak load planning time point	Multiple design points: Load, EVs, Load vs solar, etc.
Regulation to manage voltage drop	Regulation to manage voltage drop (load) and rise (generation)
	Non-traditional sources of voltage control (advanced inverters)

Methods for Distribution Cost Analysis

	(1) Build Electric Models (>1400 feeders, >80% of system)	*Input data for these electrical models comes from LADWP (GIS/PGES) and reflects the best knowledge of their current system*
	(2) Allocate (LA100) loads and attach local solar and storage	*Our best guess, but loads are a complex allocation problem with some known errors, and DER patterns only capture a few possible patterns*
	(3) Power flow modeling to identify overloads or voltage problems	*Models of the future, based on the real physics of the system. A dozen timepoints to capture multiple critical conditions*
	(4) Identify upgrades to solve these problems (Using NREL algorithms)	***Upsize*** *to larger transformer or lines,* ***Change settings*** *on voltage regulators or capacitors,* ***Install New*** *voltage regulators or capacitors*
$	(5) Estimate the corresponding costs	*Unit cost data from LADWP based on their actual costs*

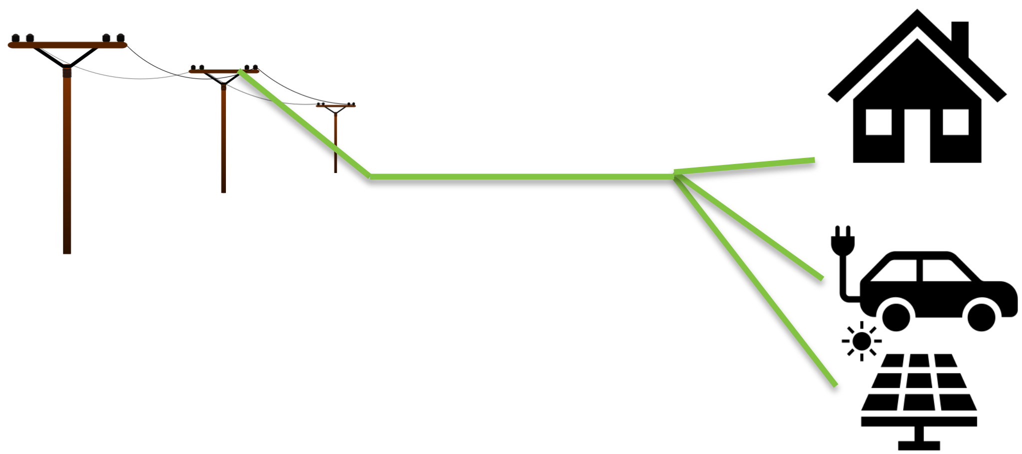
Key Question

- How do changes in **load** and deployment of **distributed solar and storage** associated with 100% renewable energy pathways **affect** LADWP's **electrical distribution system**?



What are we looking for in Distribution Powerflow?

1. **Overloads:** Lines & Transformers
   - Larger loads
   - Net power from solar/storage



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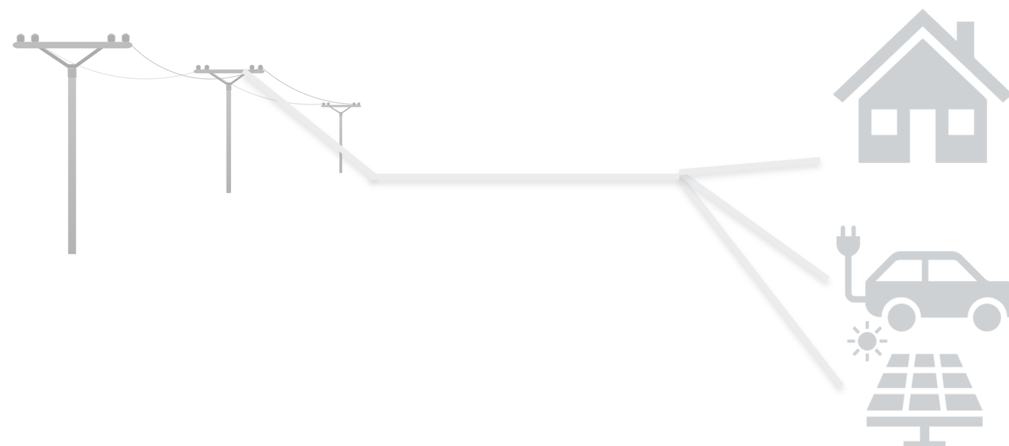

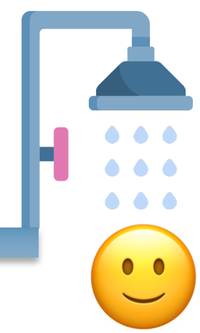

Voltage is kind of like water pressure

Shower: freepix@flaticon.com

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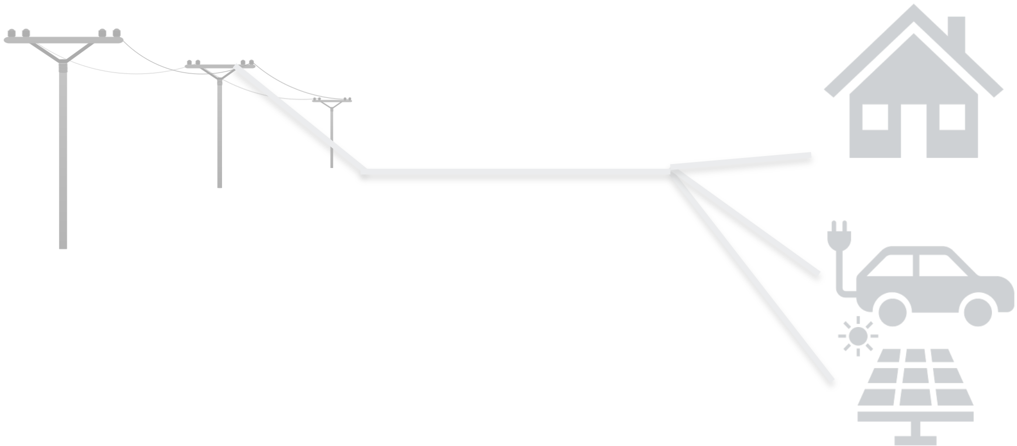

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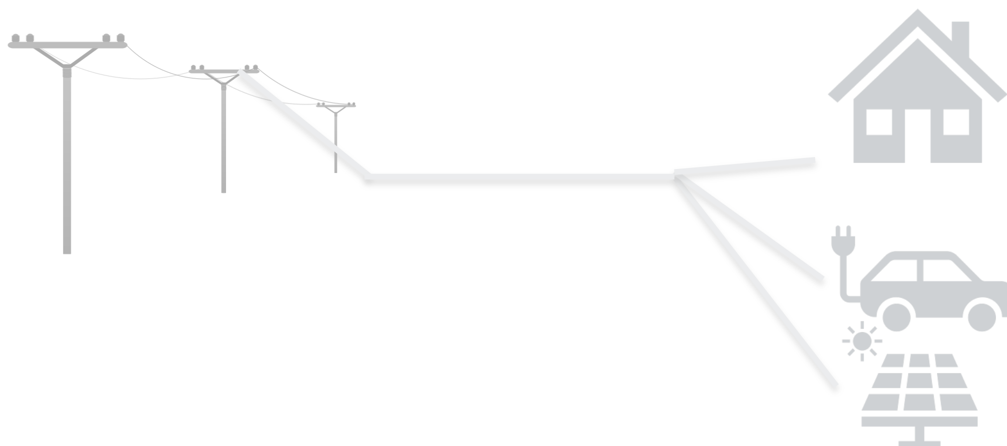
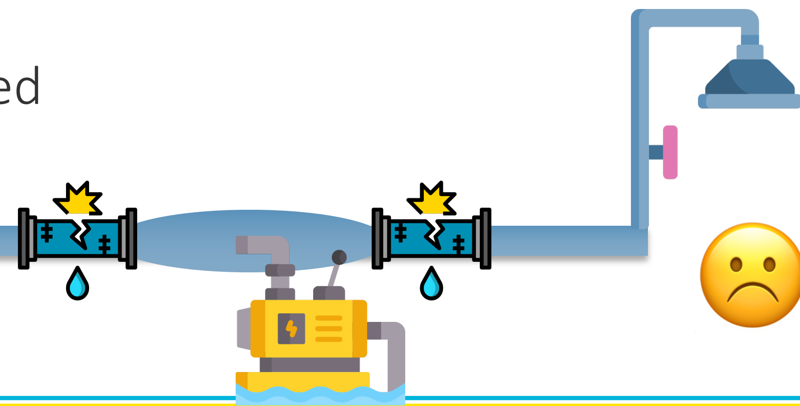
What are we looking for in Distribution Powerflow?

1. Overload: Lines & Transformers
   – Larger loads
   – Net power from solar/storage
2. Voltage challenges
   – Loads: typically undervoltage
   – Solar: typically overvoltage
     • Partially mitigated with advanced inverters





Voltage is kind of like water pressure

Pump and Shower: freepik@flaticon.com, Leaky Pipe: saurang@flaticon.com

Questions?

Up Next:

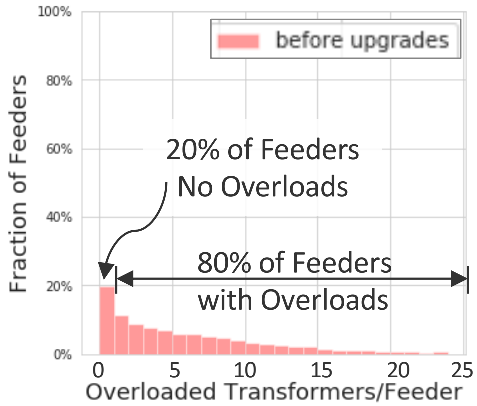
LA100 Upgrades and Costs

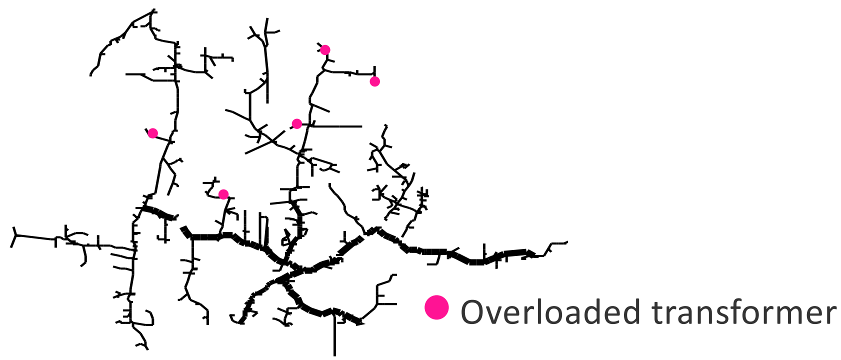
Deployment of Non-Rooftop Local Solar

So what happens during LA100?

- Overloads: Occurs throughout the city but only on a few components within each location
  - Occurs on ~80% of feeders
  - Each feeder has hundreds of transformers, of which only a few experience overloads

4.8kV Overloads: Distributed, Moderate. All years





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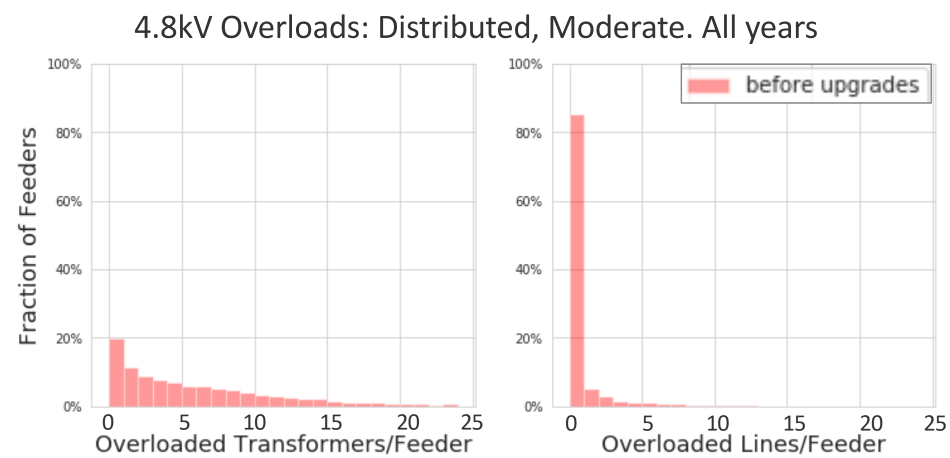
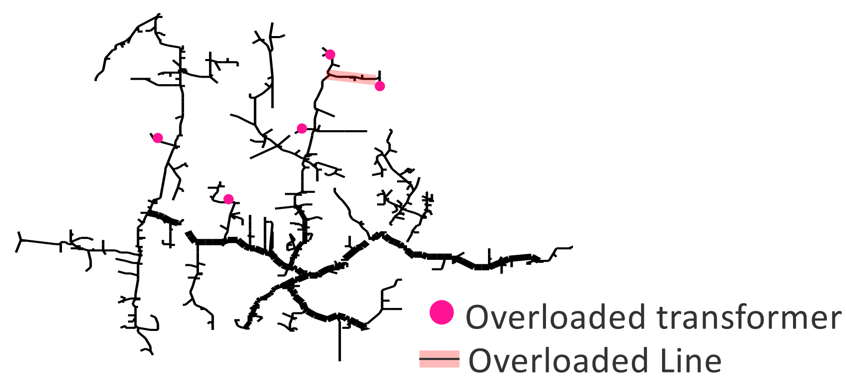
    - Good because more expensive





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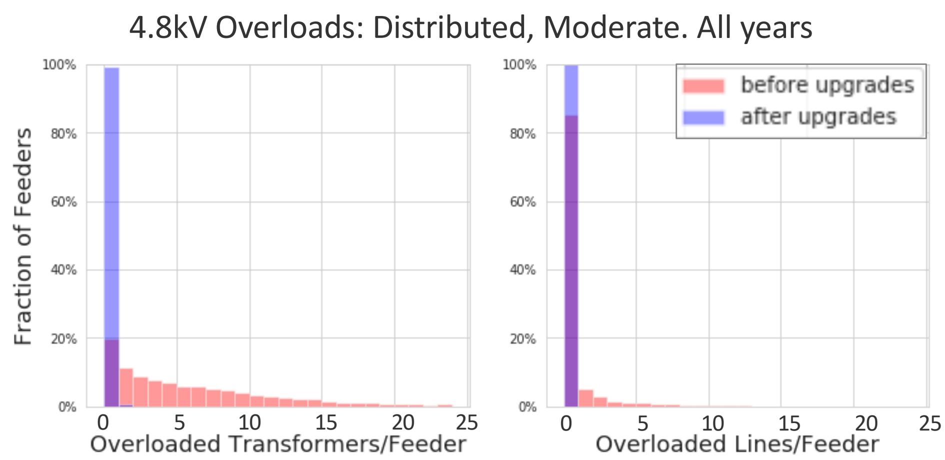
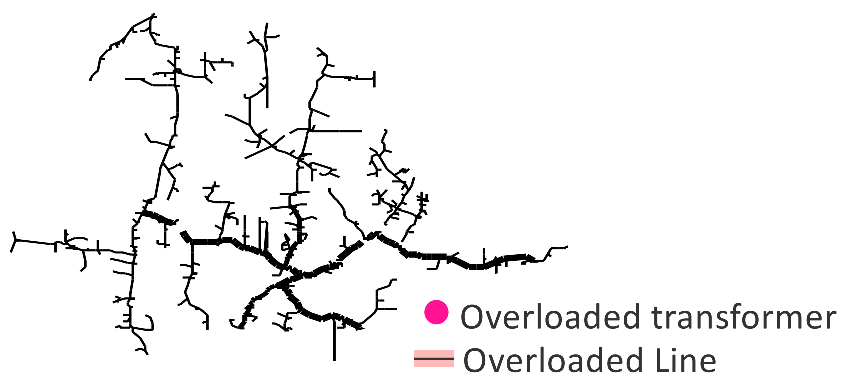
  - Readily fixed with upgrades





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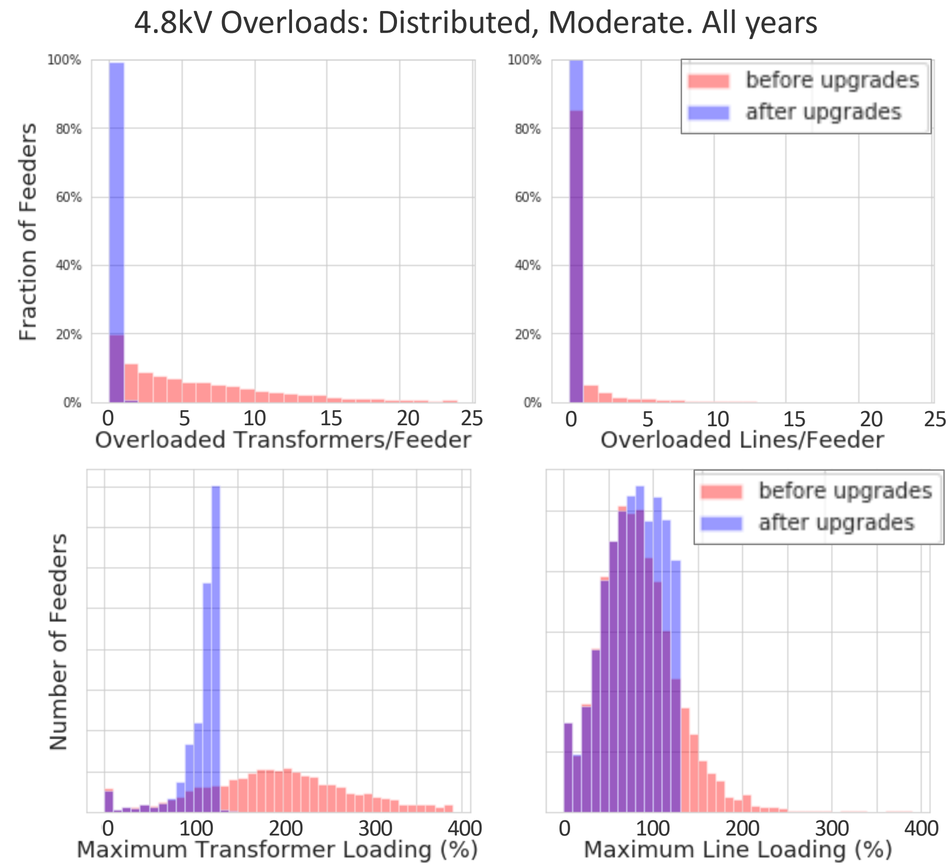
  - Readily fixed with upgrades
    - Loading <125% Threshold
- Voltage: Similar Results



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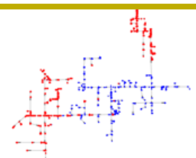
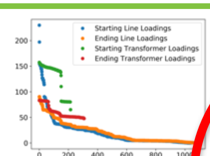
	(3) Power flow modeling to identify overloads or voltage problems	*Models of the future, based on the real physics of the system. A dozen timepoints to capture multiple critical conditions*
	(4) Identify upgrades to solve these problems (Using NREL algorithms)	***Upsize*** *to larger transformer or lines,* ***Change settings*** *on voltage regulators or capacitors,* ***Install New*** *voltage regulators or capacitors*
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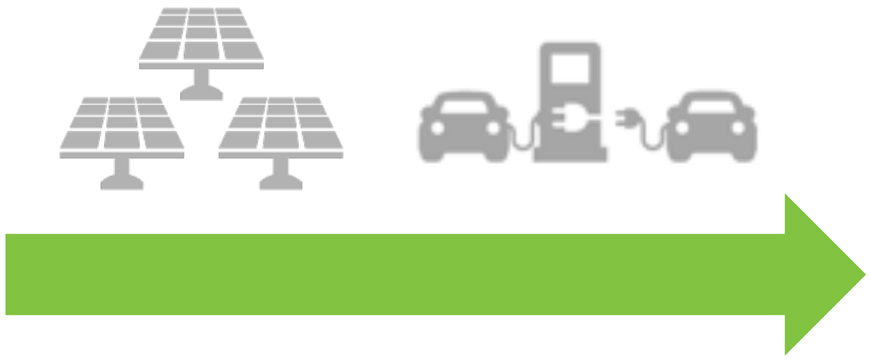
Example of the Implications if Distribution System is Not Upgraded to Resolve Existing Issues

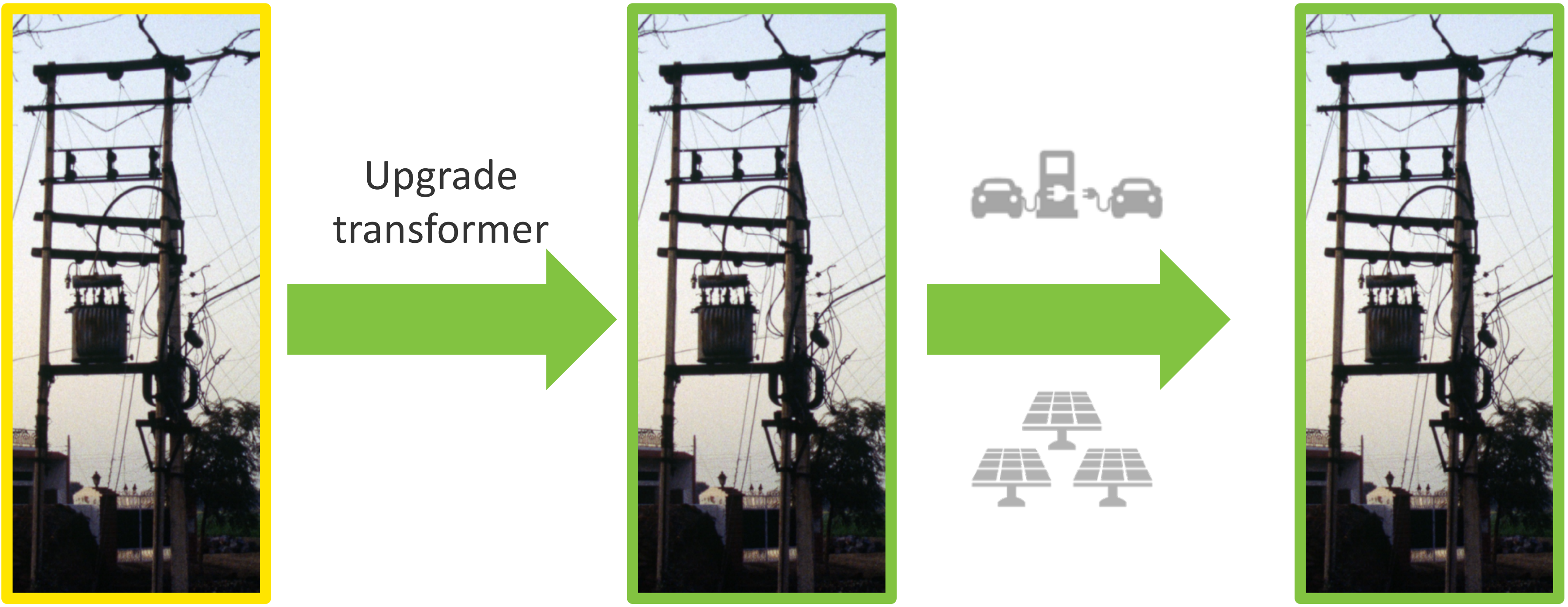
Today
Distribution transformer loaded at 115%



Important note: Not all circuits are adversely affected by PV or EVs

Future
Distribution transformer loaded at 145%

Example of the Implications if Distribution System is Not Upgraded to Resolve Existing Issues



Today
Distribution transformer
loaded at 115%

Tomorrow
Distribution transformer
loaded at 75%

Future
Distribution transformer
loaded at 85%

Flow of Core Distribution Upgrade Analysis

12 Timepoints considered for each year

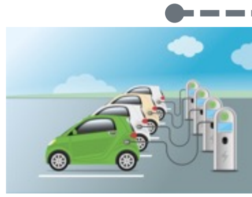
1. Today (2020) — Some circuits have known overloading or voltage challenges today (data from LADWP). Data and model issues also exist.

Upgrades

2. Tomorrow (2020) — **We assume these circuits are upgraded in order to isolate effects of new load and solar growth.**

Upgrades

3. 2030 Load, Solar, and Storage —
   - Load: electric vehicle adoption, energy efficiency, and other growth
   - Distributed Solar and Storage

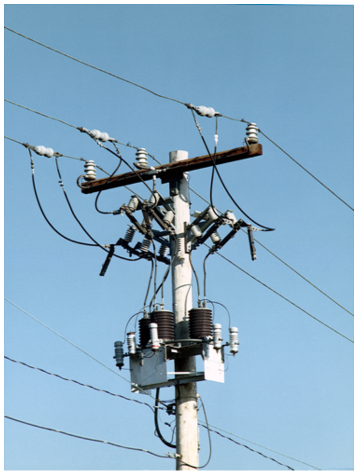


Upgrades

4. 2045 Load, Solar, and storage — Additional Load, Solar, and Storage changes

Key Questions

- What are the **costs** associated with **distribution system upgrades** to accommodate these changes?



Caveats

- These results ***do not include:***
  - The cost to resolve any existing issues on distribution
    - They only reflect costs associated with 100% renewable energy pathway changes
  - Routine maintenance and capital costs unrelated to load growth or solar and storage deployment
    - e.g., replacement of components due to aging

Caveats

- This analysis considers only autonomous advanced solar inverter functions + traditional infrastructure upgrades and control changes

- System-wide upgrades and/or use of emerging solutions could result in different costs, but need further study
  - From 4.8kV to 12.47 kV system upgrade
  - Distributed Energy Management Systems (DERMS)
  - Advanced Distribution Management System (ADMS)

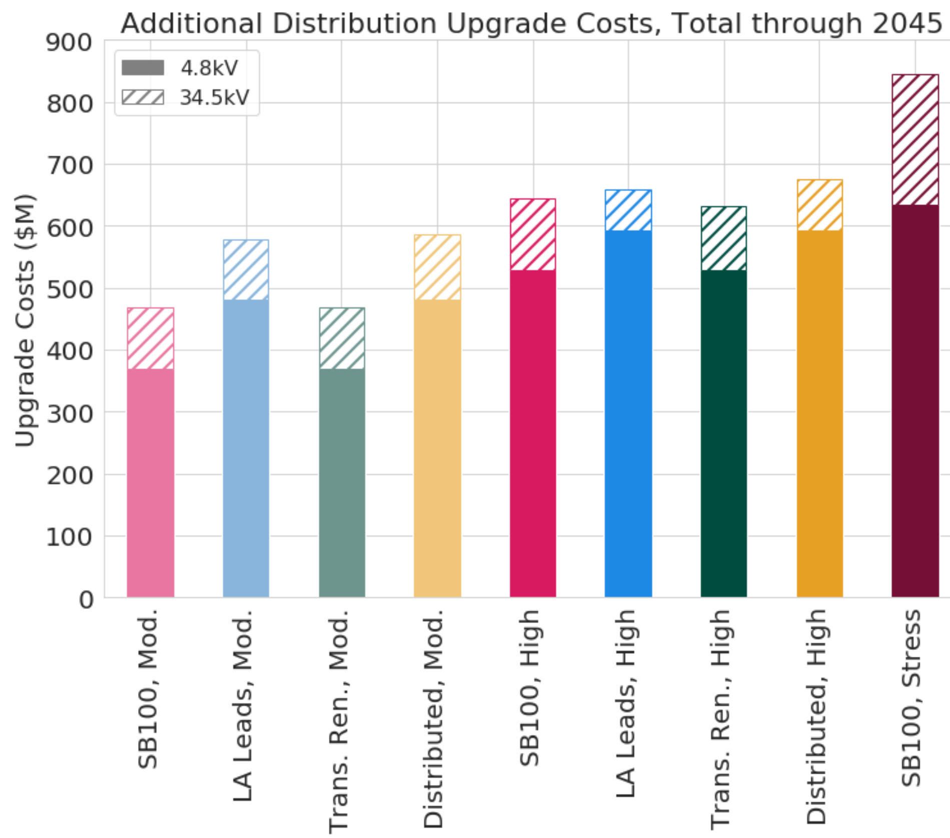
Volt-Var + Volt-Watt

Caveats

- Our data aren’t perfect
- This is our best estimate
- Results should be considered an estimation for purposes of evaluating LA100 pathways and cost drivers

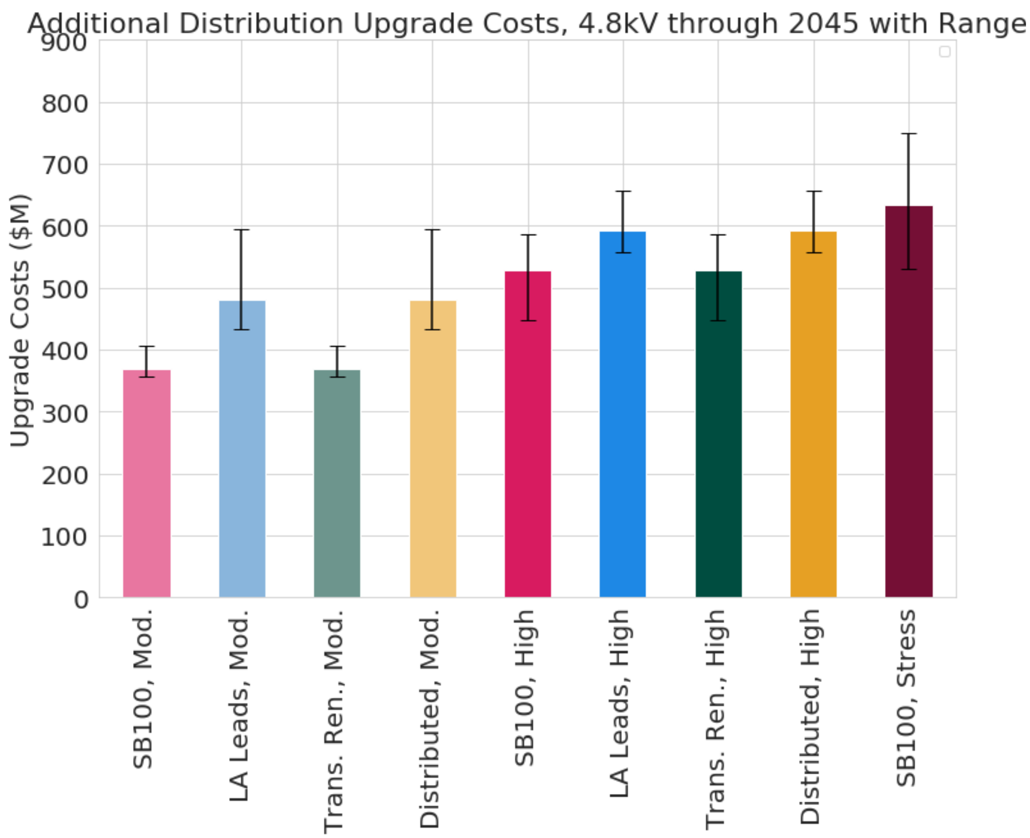
Key Findings—Distribution Costs

- Driven by 4.8kV (75-90%)
- Strongly influenced by load electrification
  - High Load = higher cost
- Somewhat higher with higher rooftop solar/customer storage
- Much lower than Bulk costs
  - Bulk ~100x larger
  - Distribution costs are for grid upgrades only, not cost of the solar equipment



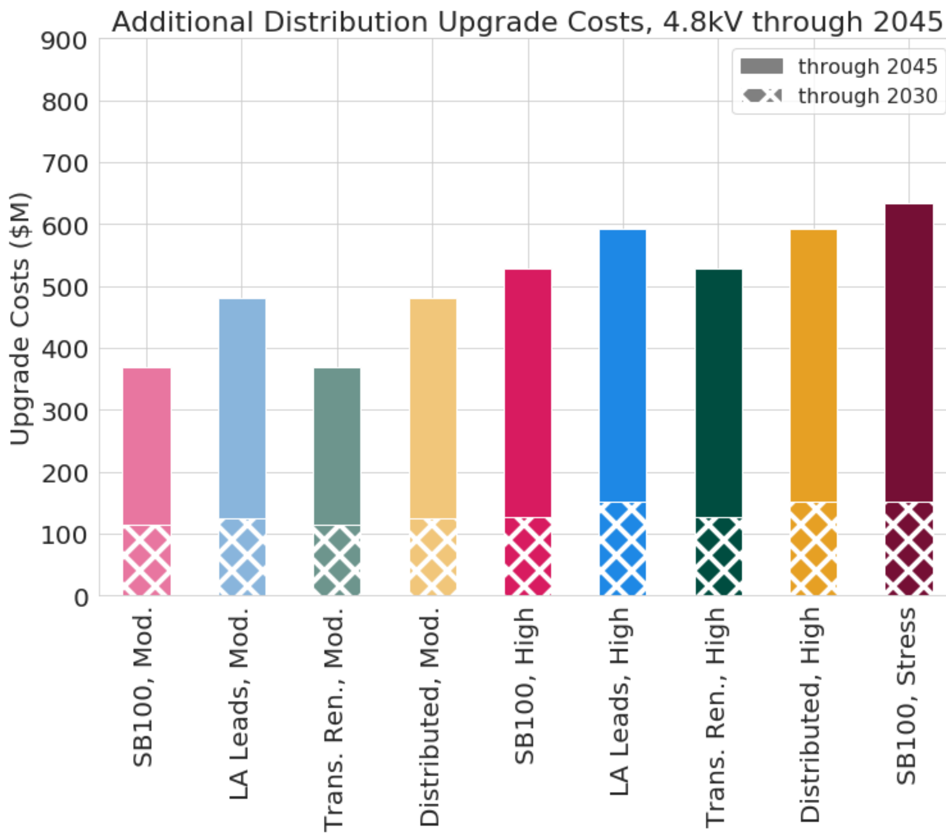
Key Findings—Distribution Costs—Zooming in on 4.8kV

- Results within ~10% for various adoption patterns for rooftop solar/storage



Key Findings—Distribution Costs—Zooming in on 4.8kV]

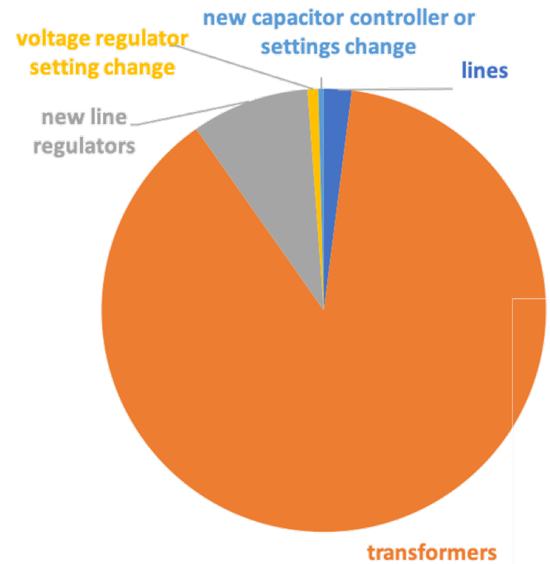
- Results within ~10% for various adoption patterns for rooftop solar/storage
- Largely (24-31%) driven by investment between 2030 and 2045



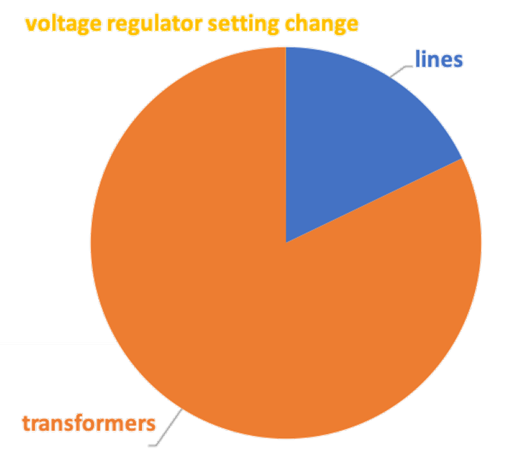
Cost of Distribution Upgrades by Type in 2045

- Upgrading transformers (and lines) also resolves many voltage issues
  - This could be why we see fewer upgrade of voltage-regulating equipment
- Additional upgrades for voltage:
  - Controls are cheap
  - New equipment less so

Upgrade costs by type (LA Leads, Mod.)



4.8kV

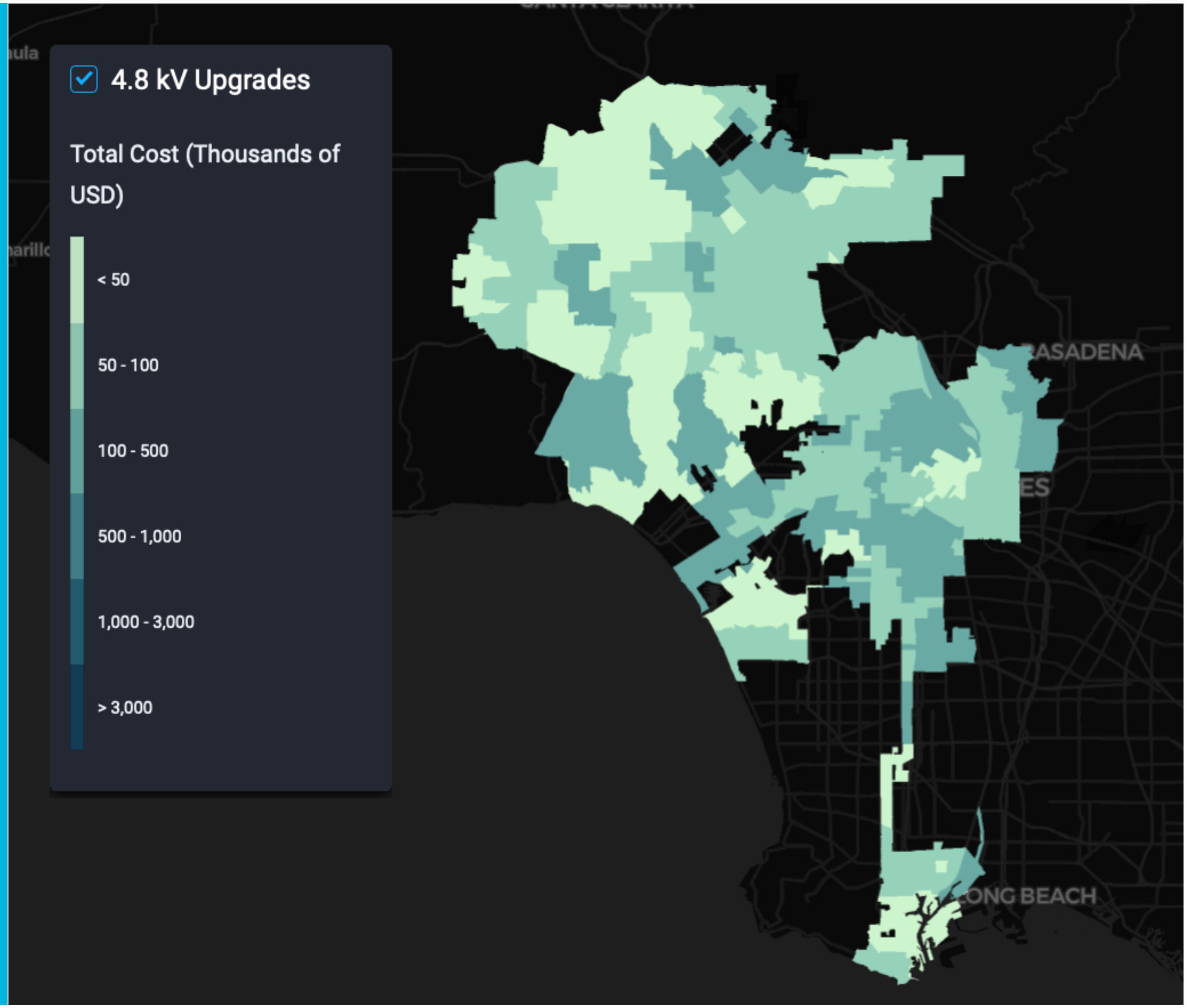


34.5kV

Where are these local distribution upgrade investments?

Today-Tomorrow (2020)

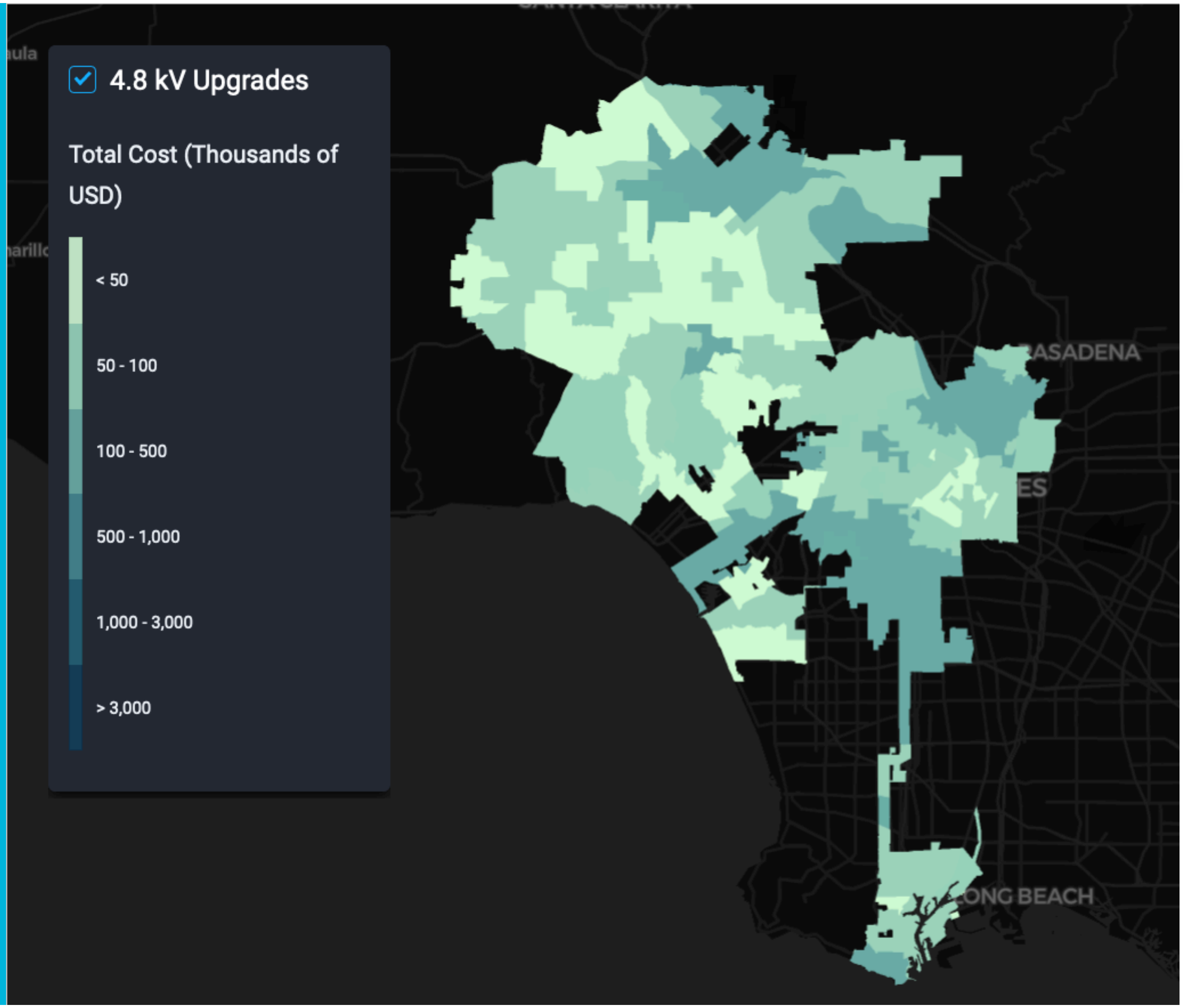
SB100, High Load



Where are these local distribution upgrade investments?

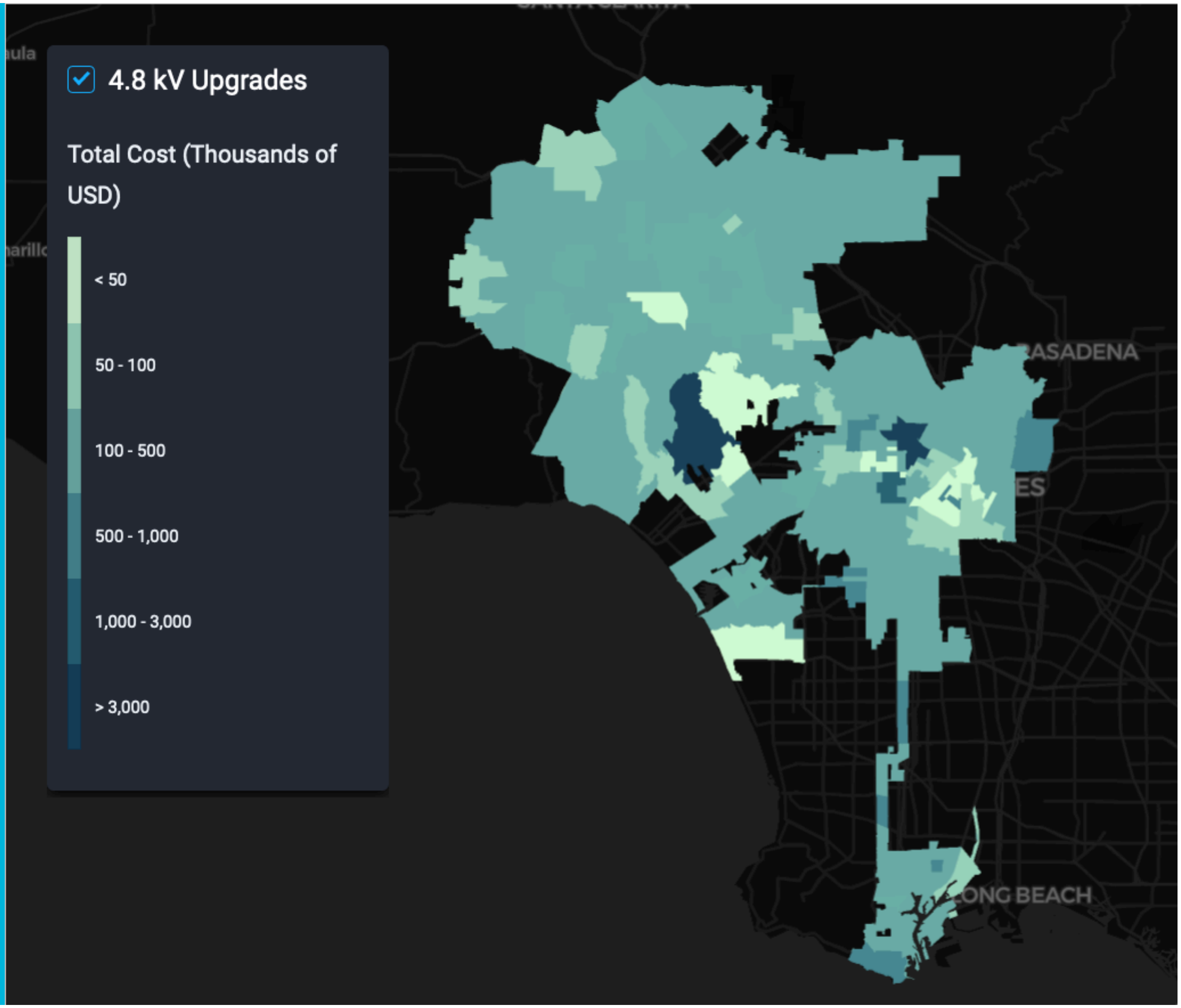
Tomorrow-2030

SB100, High Load



Where are these local distribution upgrade investments?

2030 - 2045



SB100, High Load

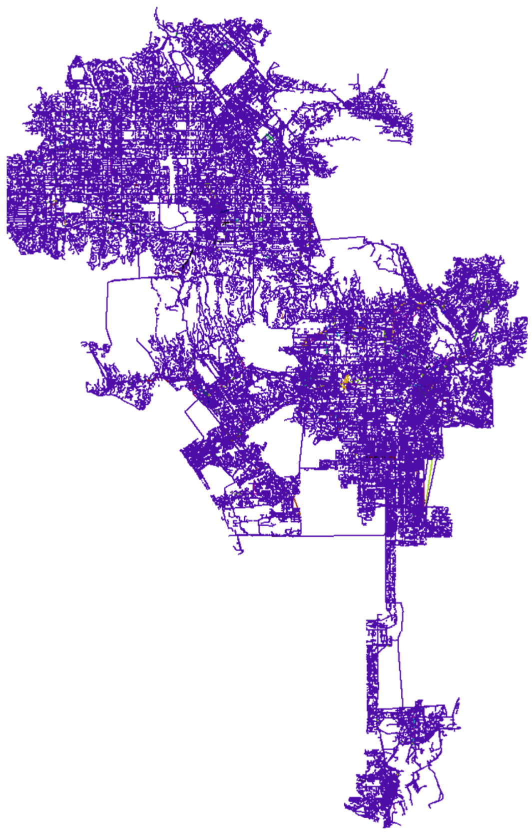
Questions?

Up Next:

Deployment of Non-Rooftop Local Solar

Key Questions

- Where could **non-rooftop solar** be deployed within LA with the **lowest distribution system costs** in 2045?



Flow of Distribution Analysis to Look at the Additional Costs to Add Non-Rooftop Solar

1 Today

Some circuits have known overloading or voltage challenges today (data from LADWP). Data and model issues also exist.

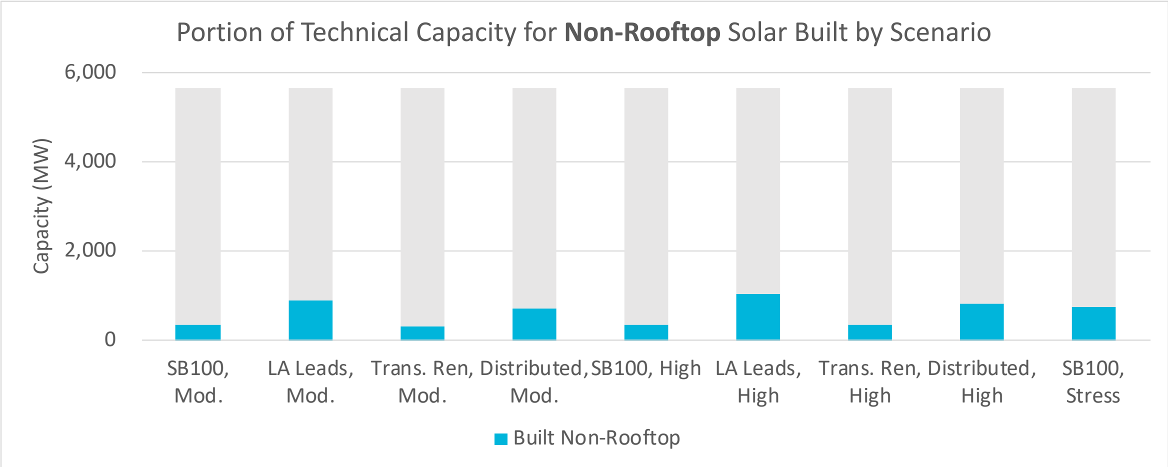
2A 2045 Load, Customer Adopted Solar and Storage

2B 2045 with possible non-rooftop solar

Get curves of the costs to integrate local solar up to the technical potential

How much non-rooftop solar gets built?

- Overall, 5-20% of potential capacity, but...



"Non-rooftop" Solar and Storage

Connected to 34.5kV.
Located based on GIS analysis.

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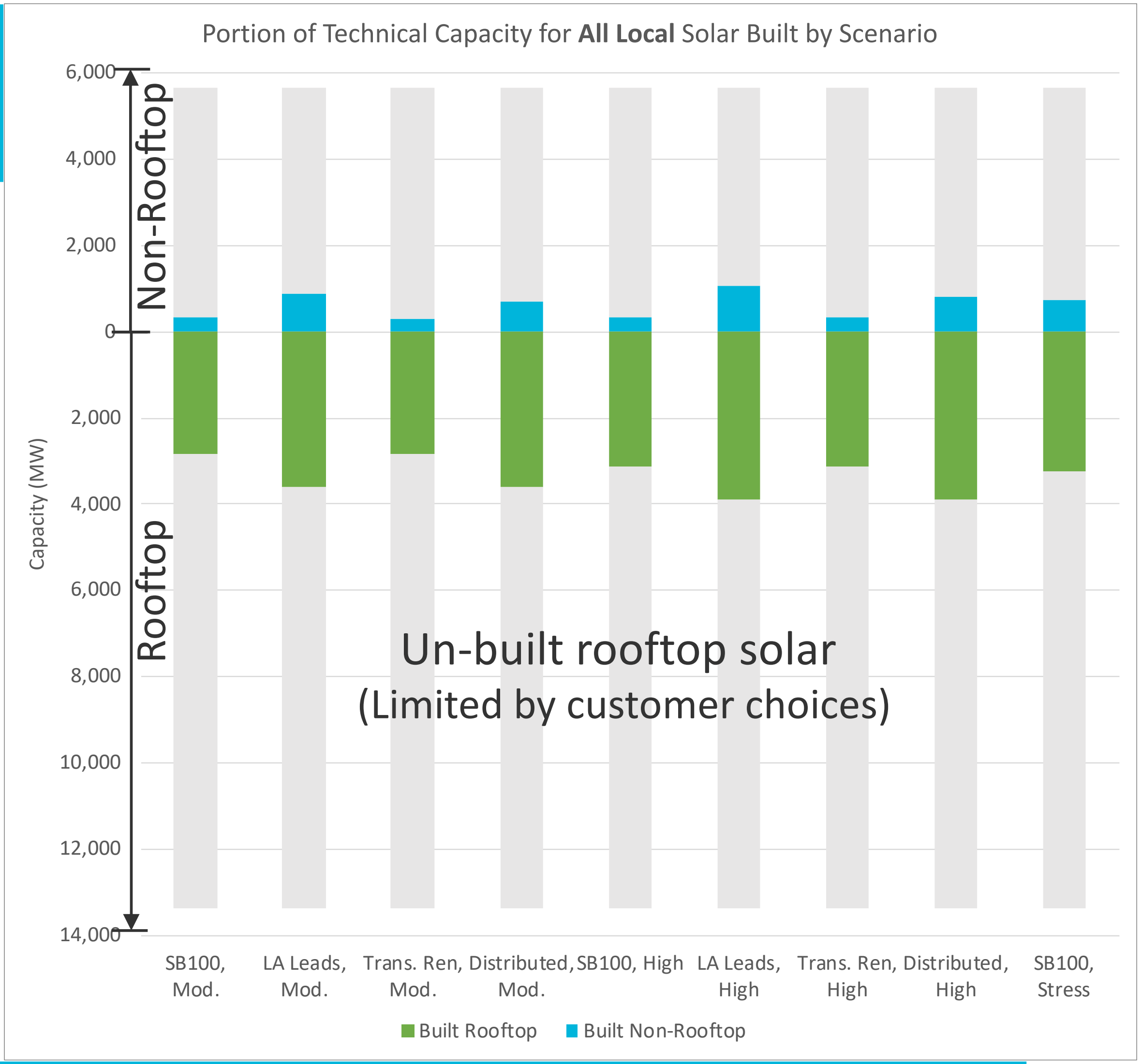

How much non-rooftop solar gets built?

- Overall, 5-20% of potential capacity, but...
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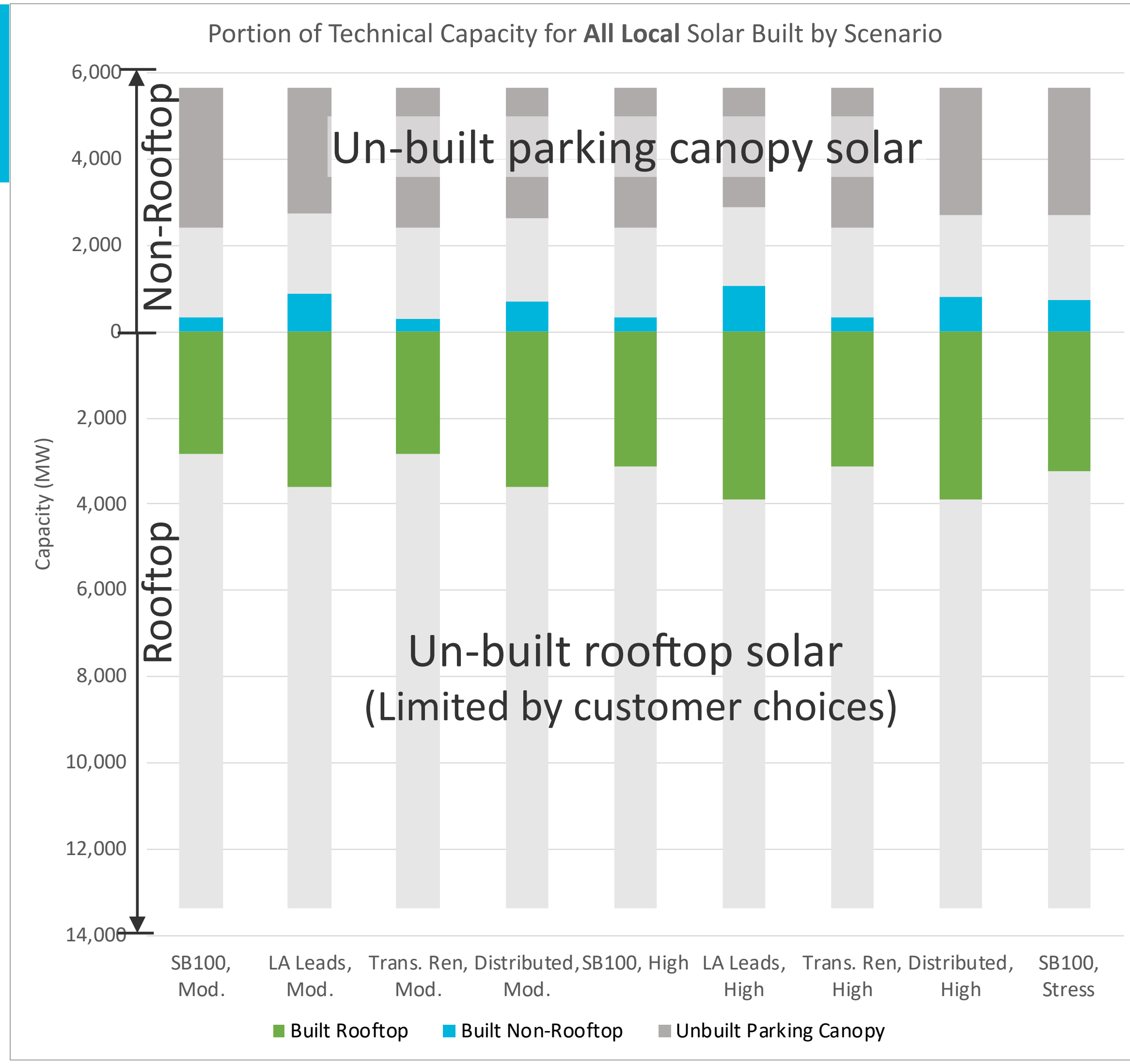
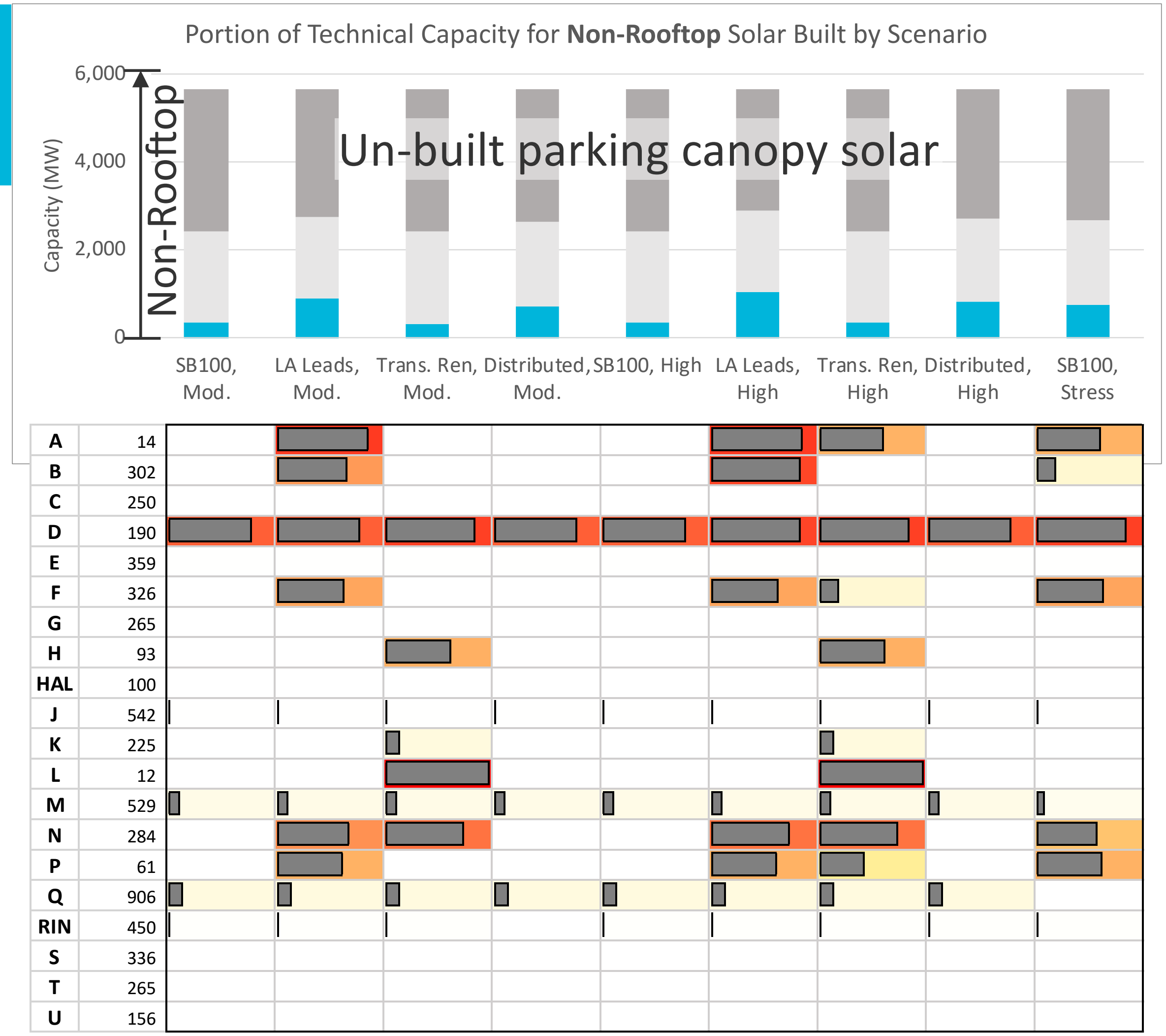
  - 58% non-rooftop is parking canopy (harder)



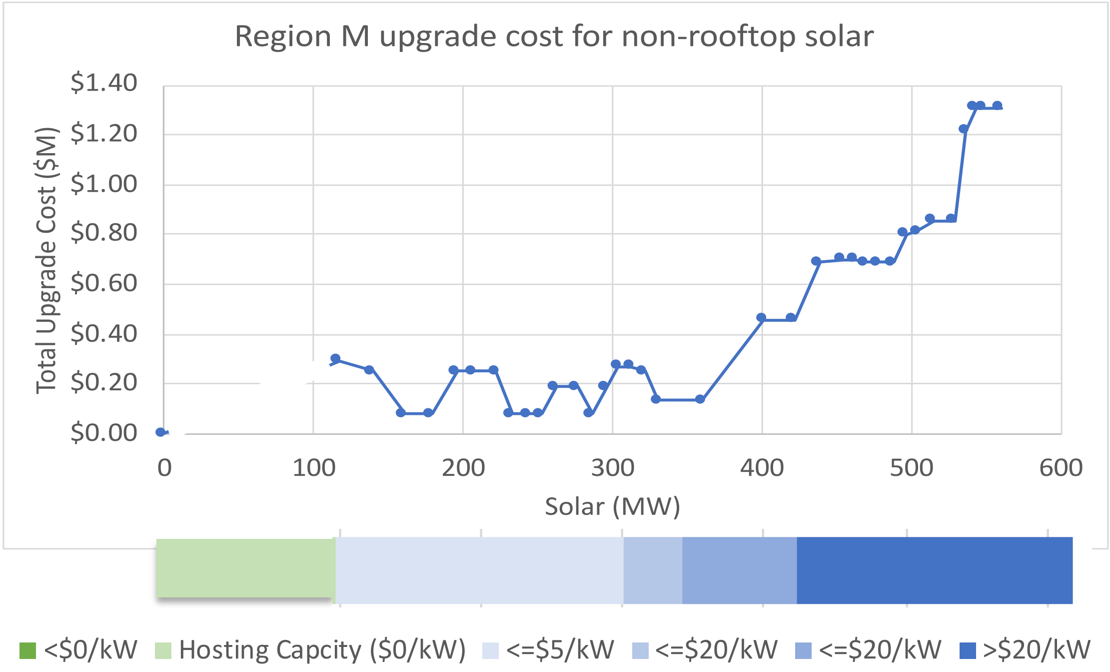
How much non-rooftop solar gets built?

- Overall, 5-20% of potential capacity, but...
  - Lots of rooftop solar
  - 58% non-rooftop is parking canopy (harder)
- Build-out is non-uniform
  - In some scenarios, cross-basin congestion and other factors cause higher local value



How do grid integration costs change with capacity?

- Typically, "hockey stick"-like
  – Zero cost at first
  – Then low cost
  – Higher cost at higher install levels

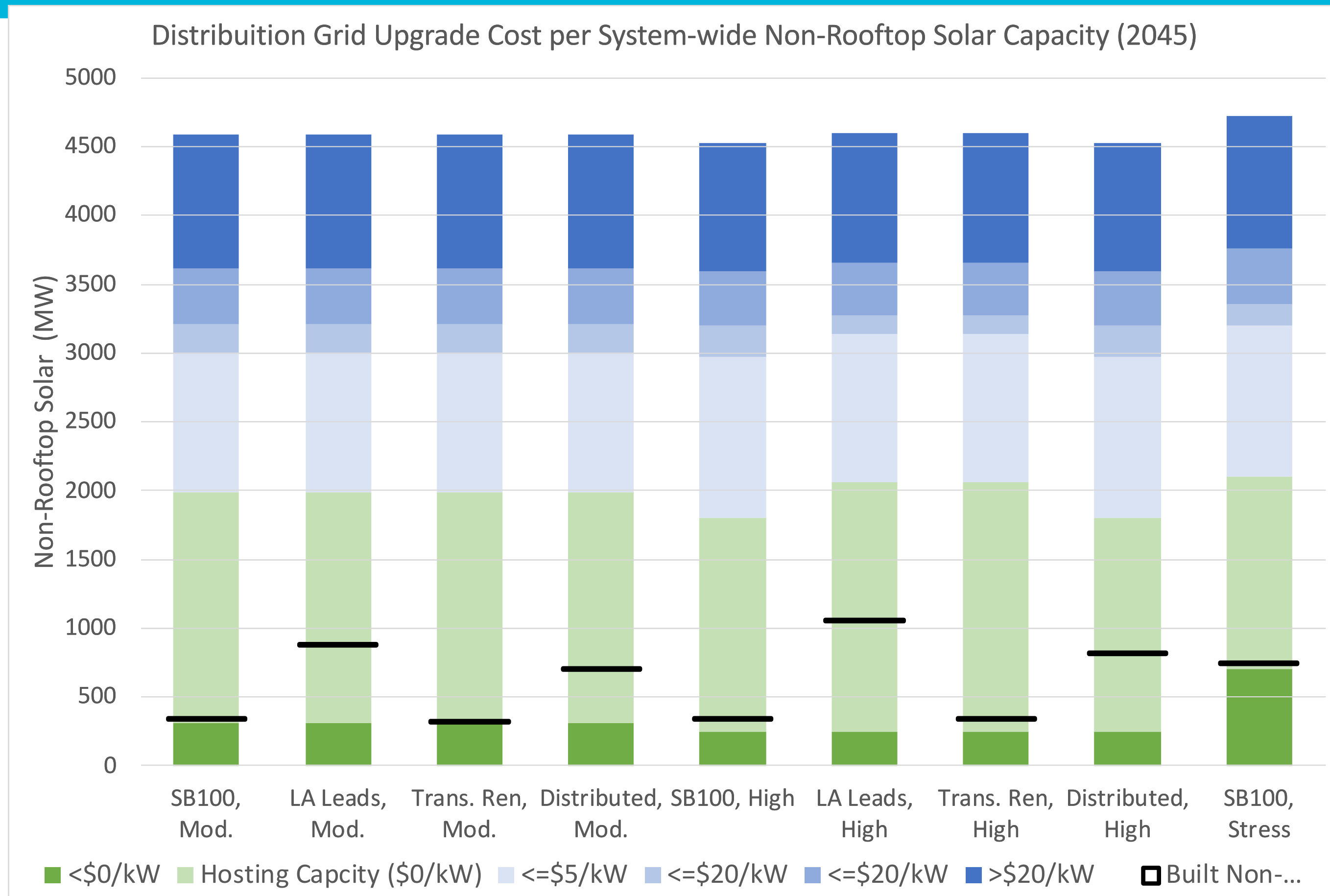


How do grid integration costs change with capacity?

- Built capacities are generally in the low range of system-wide upgrade costs.

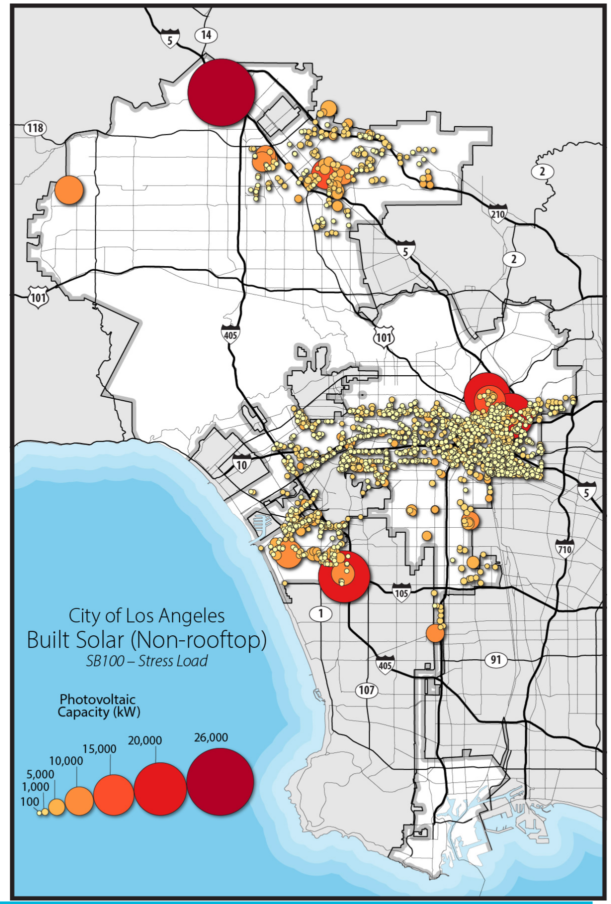
Note these capacities are system wide, meaning:

- *Regions with locally high penetration may have non-zero integration costs*
- *The total capacity for each bar corresponds to non-rooftop solar siting based on grid costs*



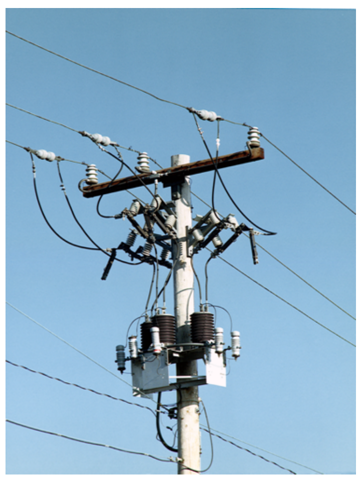
Key Findings: Non-rooftop solar integration

- Distribution integration does not add much to cost of utility-scale solar
  - Non-customer local solar capacity that gets built is a small fraction of technical potential
  - Regions can accommodate a lot of solar with no 34.5kV upgrades
  - Integration costs for our scenarios are low compared to cost of the generation (the solar panels and storage)



Key Questions

- Does **increased distributed solar and storage** deployment in a 100% renewable energy future provide an opportunity for **deferring distribution system upgrades**?



Caveats

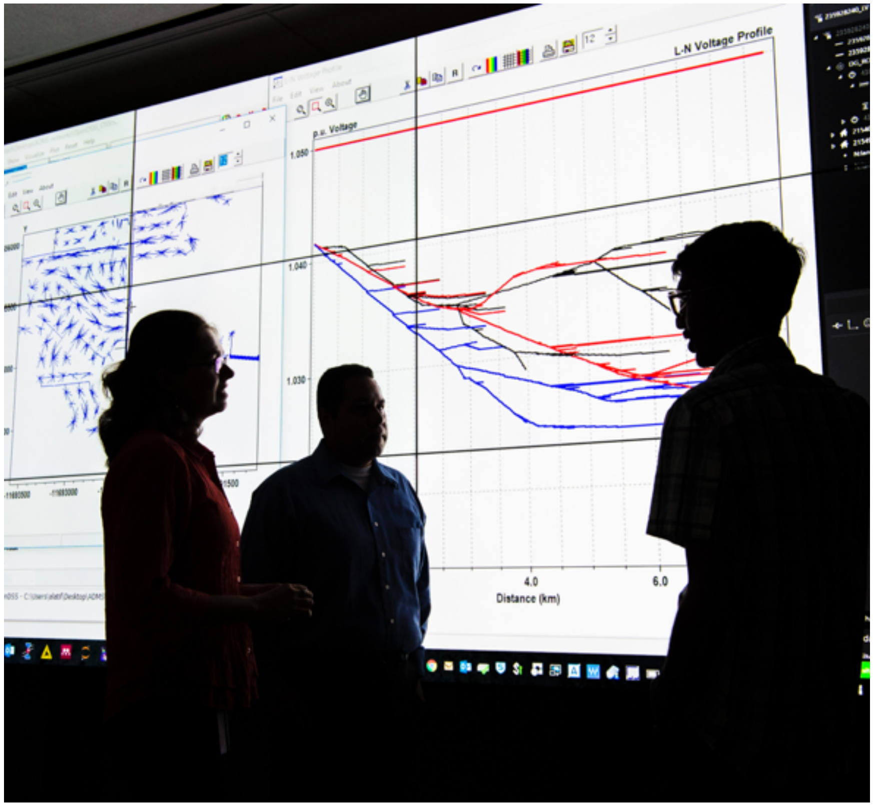
Incidental Deferment only:

- Grid designed to support load and distributed generation.
- Generation location not optimize for grid value

Not all value streams included for deferment.

For example: Substation Expansion

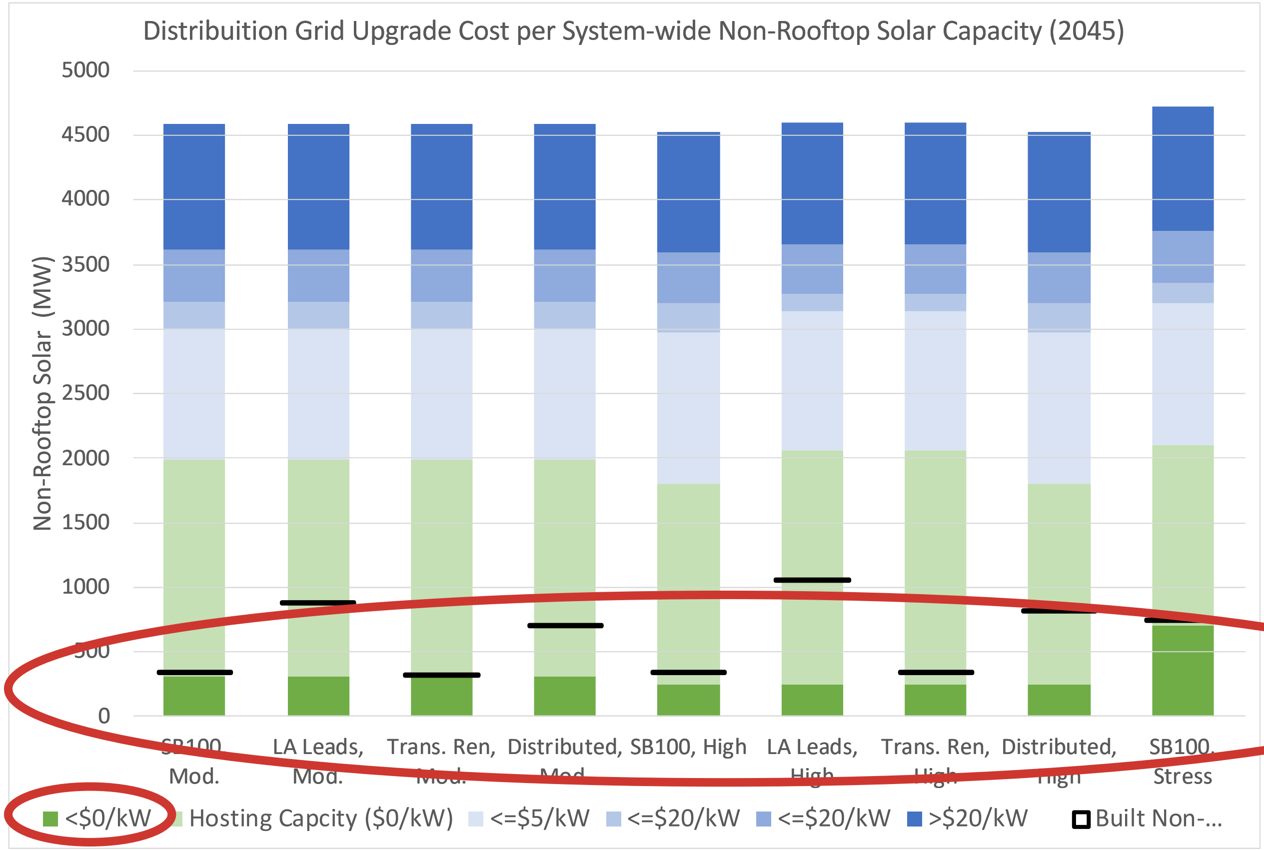
- Included
  - Equipment costs
  - Labor
- Not included
  - Land cost
  - Community Resistance



Incidental Deferment Value: Non-rooftop solar

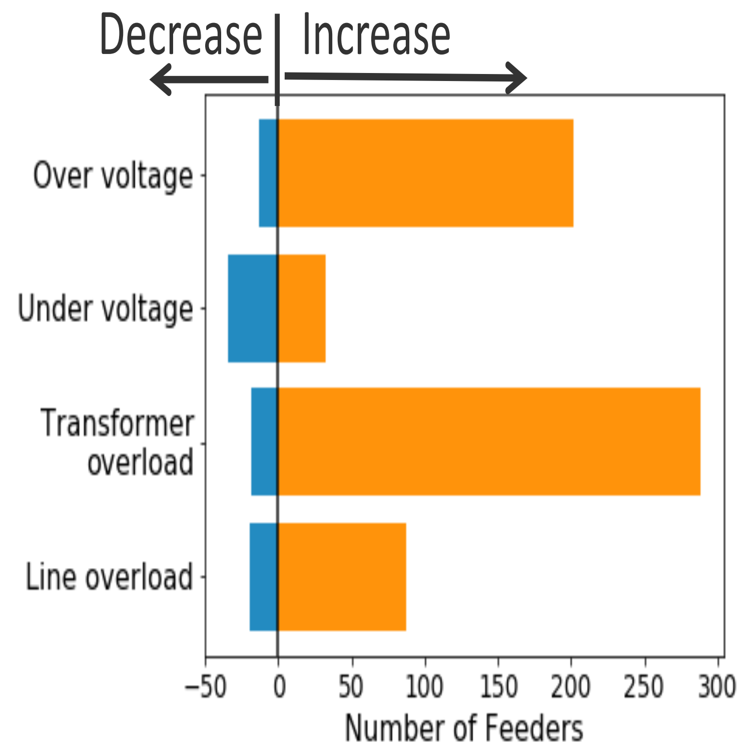
Reminder:

Up to these levels, the upgrade cost with non-rooftop solar is lower than without.



Incidental Deferment: 4.8kV Rooftop Solar

- In 5-10% of cases, the addition of Solar (and Storage) reduces the number of violations seen on 4.8kV feeders



Summary

1. **Some distribution upgrades are required** for load and solar; but:
   - Only a few items per feeder
   - Fairly easy to fix: mostly service transformers
   - Only ~1% of bulk system costs
2. **Cost of distribution upgrades for (larger) non-rooftop solar varies with location, but are generally low**.
   - Grid costs much lower than (already low) solar costs
     - Distribution Grid is not limiting local solar
3. **The 100% pathways use a fraction of the available in-basin solar/storage capacity**
   - Largely because very large-scale solar cost (a lot) less, and
   - Additional value streams not studied, (e.g. deferred substation upgrades) or hard to monetize (e.g. resiliency)
4. **There are synergies between upgrades for load and solar:**
   - Upgrades designed for solar and load together are cheaper than sequentially supporting load then solar
   - Full non-wires alternatives study may find more

Thank you!
Questions?

The Los Angeles 100% Renewable Energy Study