LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #12

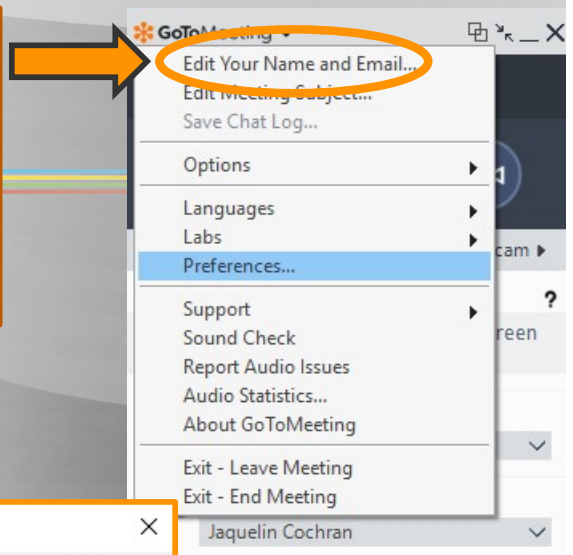
Virtual Meeting #4

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

LA100

The Los Angeles 100% Renewable Energy Study

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



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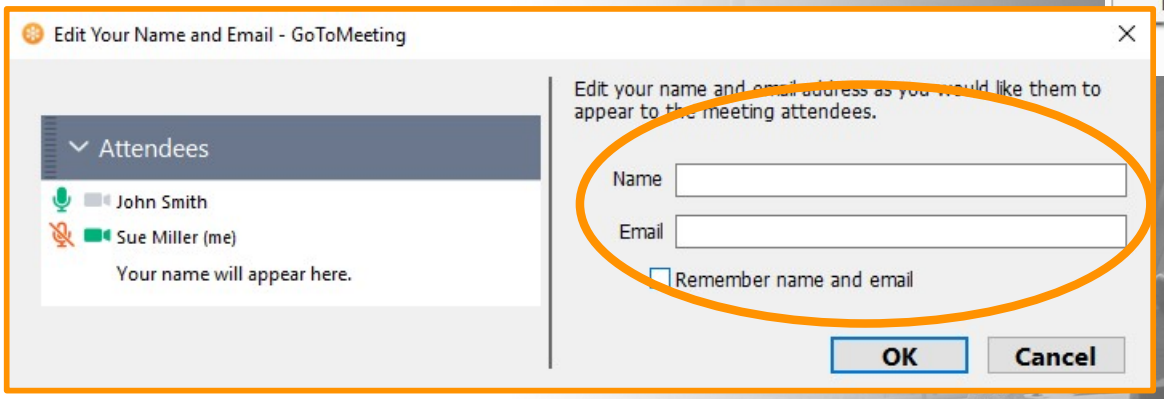

Los Angeles Department of Water & Power | NREL Transforming ENERGY

Agenda

July 9
- LA100 Scenarios—Pathways to 100% RE
- Discussion/Q&A

July 16
- Continue Last Week's Discussion
- Jobs and Economic Analysis
- Discussion/Q&A

July 23
- Environmental Analyses:
  - EJ Updates
  - Air Pollutant Emissions Inventory
  - Mortality and Monetization Methods
- Discussion/Q&A

Today (July 30)
- Welcome
- Distribution Grid Analysis
- Discussion/Q&A

August 6
- Follow-up Q&A

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

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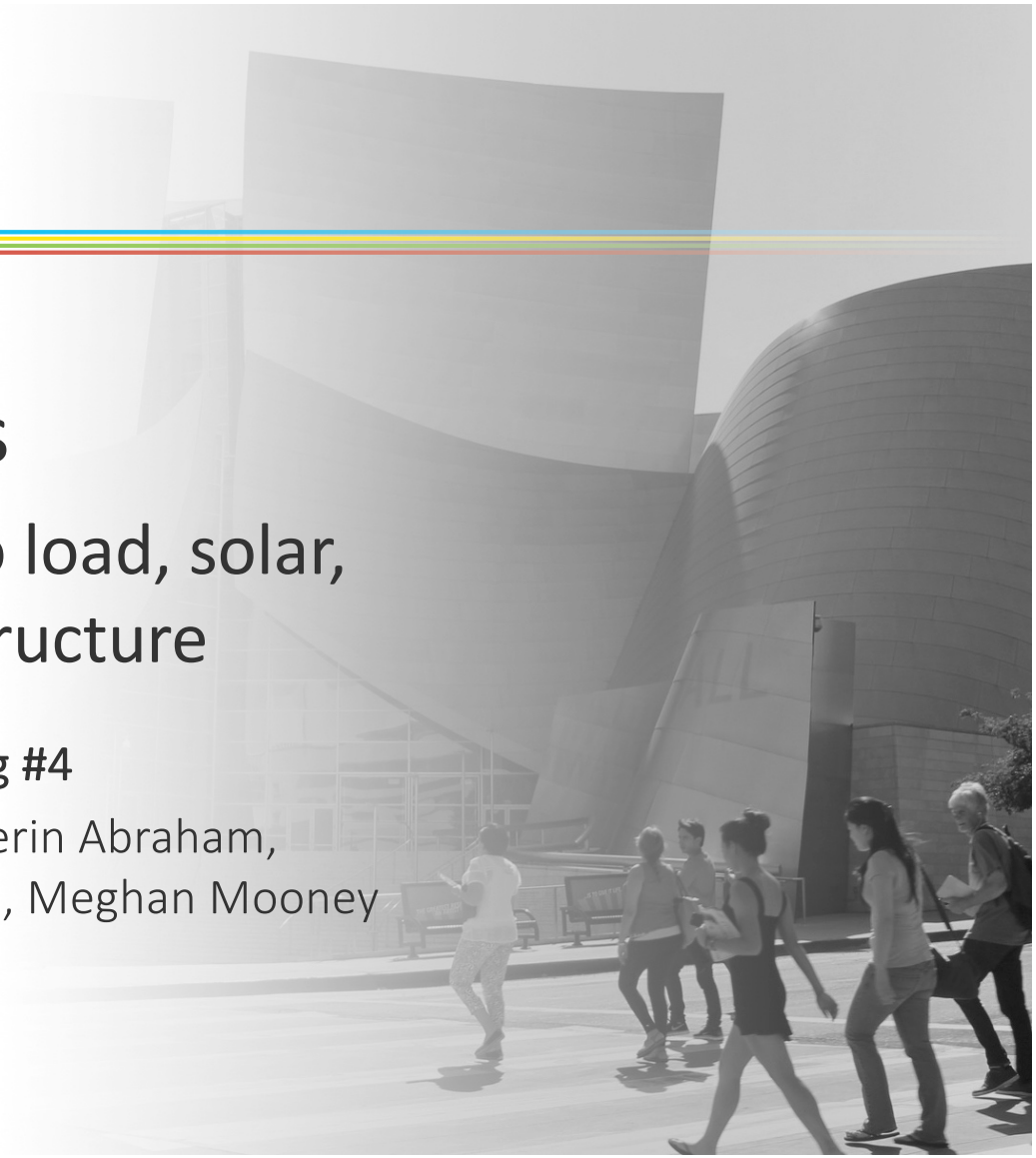
The Los Angeles 100% Renewable Energy Study

Distribution Grid Analysis

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

Advisory Group Meeting #12, Virtual Meeting #4

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



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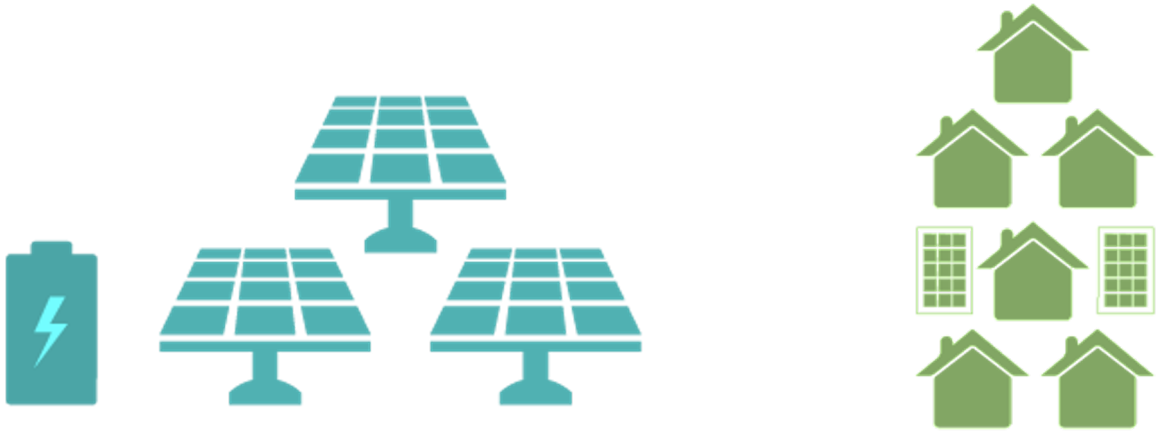
Caveat/Analysis Status

- These are DRAFT results.
- Numbers will be updated for the final analysis and will change.
- Core findings could also change somewhat for the final results.

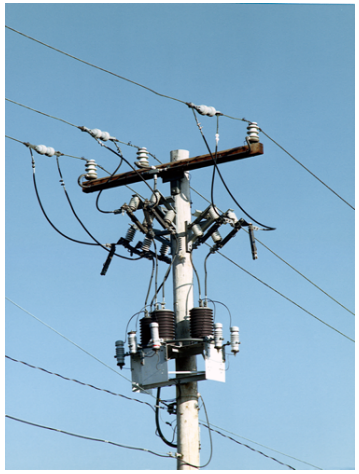
Key Questions

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



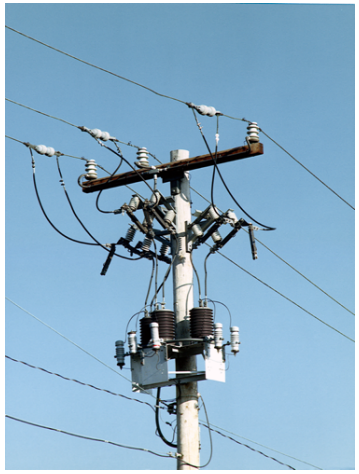
Key Questions

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



Key Questions

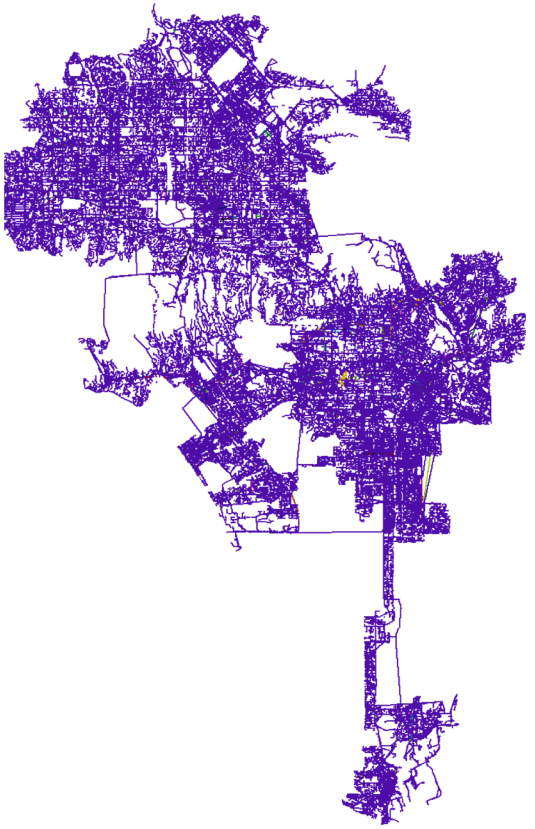
- Does **increased distributed solar and storage** deployment in a 100% renewable energy future provide an opportunity for **deferring distribution system upgrades**?



To be covered in the fall Advisory Group meeting

Key Questions

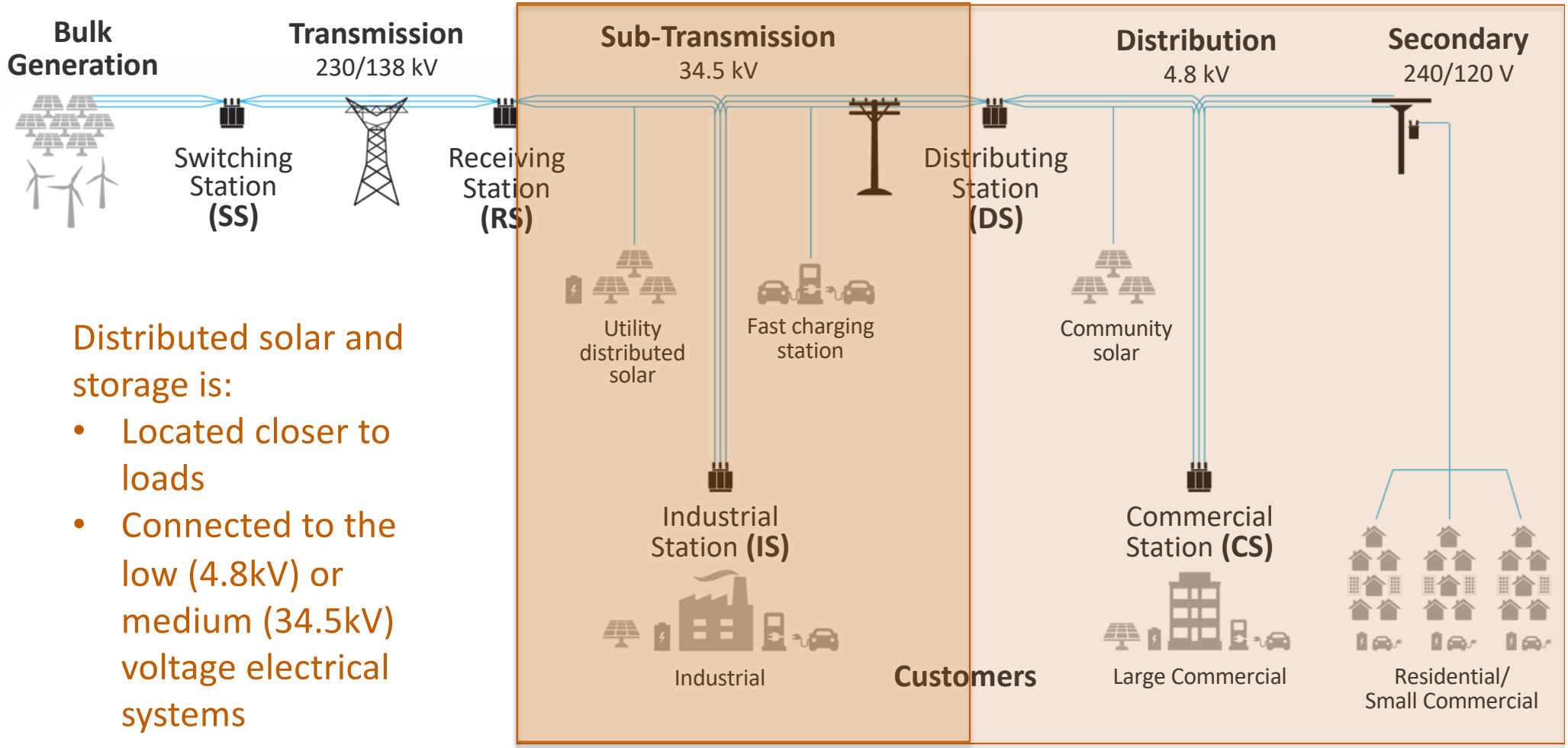
- Where could **utility-scale distributed solar ("local solar")** be deployed within LA with the **lowest distribution system costs** in 2045?



Key Questions

- **Where** will **distributed solar and storage** as well as **distribution infrastructure upgrades** be **built** with respect to **disadvantaged communities**?
- What are the **potential impacts** to those **communities** and **how could they benefit**?

To be covered in the fall Environmental Justice Advisory Group meeting



Distributed solar and storage is:

- Located closer to loads
- Connected to the low (4.8kV) or medium (34.5kV) voltage electrical systems

Categories of In-Basin Renewable Resources

Utility-scale resources built to meet overall system needs

Based on capacity expansion modeling

Resources located at existing OTC sites

Transmission tied

100 MW to 1.5 GW/site

Local Solar

Connected to the 34.5kV distribution system. Located based on GIS analysis.

4 kW to 84 MW/site potential
4 kW to 16 MW/site built

Distribution Connected

Customer-adopted storage and rooftop solar

dGen

1 kW to 10s MW/premise

Flow of Core Distribution Analysis
Through 2030

Snapshot analysis shown today

1. Today (2020) → Some circuits have known overloading or voltage challenges today (data from LADWP). Data and model issues also exist.
We assume these circuits are upgraded in order to isolate effects of new load and solar growth.

2. 2030 Load-only → Distribution impacts of load changes due to electric vehicle adoption, energy efficiency, demand response, and other sources of load growth

Then add solar and storage:

3.  2030 with solar and storage → Distribution impacts of all distributed solar and storage

Flow of Core Distribution Analysis
Through 2045

Snapshot analysis shown today

1. 2030 → With the circuits upgraded to accommodate all load changes as well as solar and storage deployment to 2030

2. 2045 Load-only → Distribution impacts of load changes due to electric vehicle adoption, energy efficiency, demand response, and other sources of load growth

Then add solar and storage:

3.  2045 with solar and storage → Distribution impacts of all distributed solar and storage

Flow of Distribution Analysis to Look at the Additional Costs to Add Local Solar

1. Today

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

We assume these circuits are upgraded in order to isolate effects of new load and solar growth.

2. 2045 Load, Customer Adopted Solar and Storage

3. Then add local solar

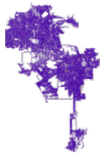
Get curves of the costs to integrate local solar up to the technical potential

Relationship to LADWP's Planned Distribution Upgrades

- LADWP makes distribution system upgrades through its Power System Reliability Program (PSRP)

PSRP Upgrades	Both	Upgrades in the LA100 Distribution Analysis
Replacement of aging infrastructure	Upgrades to address known overloads	Upgrades to address existing voltage issues due to existing load and solar
New circuit build-out	Upgrades to address expected load growth in the near-term	Upgrades to address data and load allocation errors in our electrical models
Other upgrades unrelated to load growth		Upgrades to address modeled load growth in the long-term
		Upgrades to address modeled solar and storage adoption in the long-term

Methods for Distribution Cost Analysis

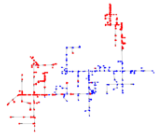


(1) Generate electrical models of LADWP's entire distribution system

Input data for these electrical models comes from LADWP and reflects the best knowledge of their current system

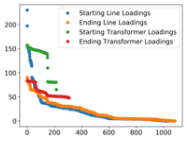
(2) Allocate loads modeled under LA100 to the distribution equipment

Our best guess, but this is a complex allocation problem and there are some known errors



(3) Power flow modeling to identify any voltage or thermal overloading problems on the distribution system

Models of the future, but based on the real physics of the system



(4) Use NREL's algorithms to determine what upgrades can solve any problems

Upgrade transformer, upgrade lines, change settings on voltage regulators or capacitors, install new voltage regulators or capacitors

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(5) Calculate the total cost of upgrades by multiplying the unit cost of each upgrade by the number of upgrades needed

Unit cost data from LADWP and based on their actual costs

Core Findings

DRAFT Results. Subject to Change.

- Upgrading the distribution system today can resolve existing issues and decrease the cost of integrating new loads, distributed solar, and distributed storage associated with 100% renewable electricity pathways.
- Local solar and storage are needed to achieve 100% renewable energy in all scenarios, and these can cost money to integrate on the distribution system depending on where they are located.
- However, this cost is lower if you first upgrade the distribution system to accommodate load growth and customer-adopted solar and storage.
- The estimated capital cost of distribution system upgrades needed *for changes associated with 100% renewable electricity pathways* from 2020 to 2045 ranges from $190M to $460M depending on the scenario. But this could be an underestimate.
  - The lowest distribution upgrade costs are in scenarios with lower levels of customer-adopted solar and load
  - However, spatially and temporally correlated loads and solar can be synergistic in reducing distribution costs in other scenarios

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Core Findings

- These costs are low compared to annual distribution spending at LADWP today
- We are carefully reviewing these results now

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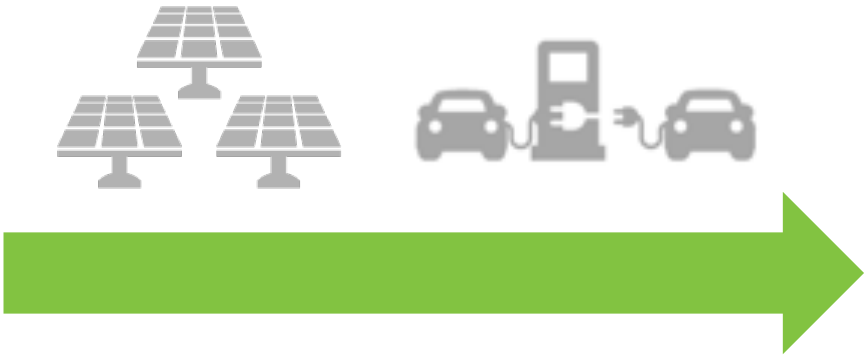
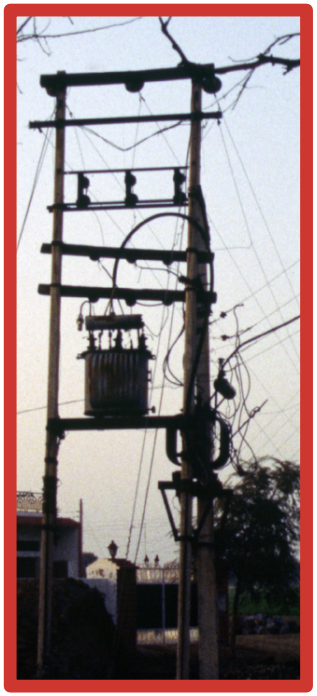
Upgrading the distribution system today can resolve existing issues and decrease the cost of integrating new loads, distributed solar, and distributed storage associated with 100% renewable electricity pathways.

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

Distribution transformer loaded at 115%



Important note: Not all circuits are adversely affected by PV or EVs and require upgrades (more on this later)

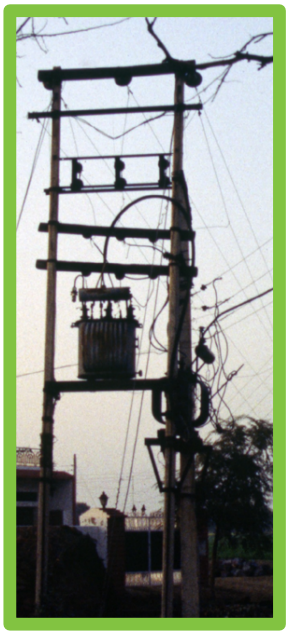


Distribution transformer loaded at 125%

Example of the Benefits of Upgrading the Existing Distribution System

Distribution transformer loaded at 115%

Upgrade transformer



Distribution transformer loaded at 75%

Distribution transformer loaded at 85%

Considerations for Where to Prioritize Distribution Upgrades

(1) Where existing distribution system equipment is overloaded

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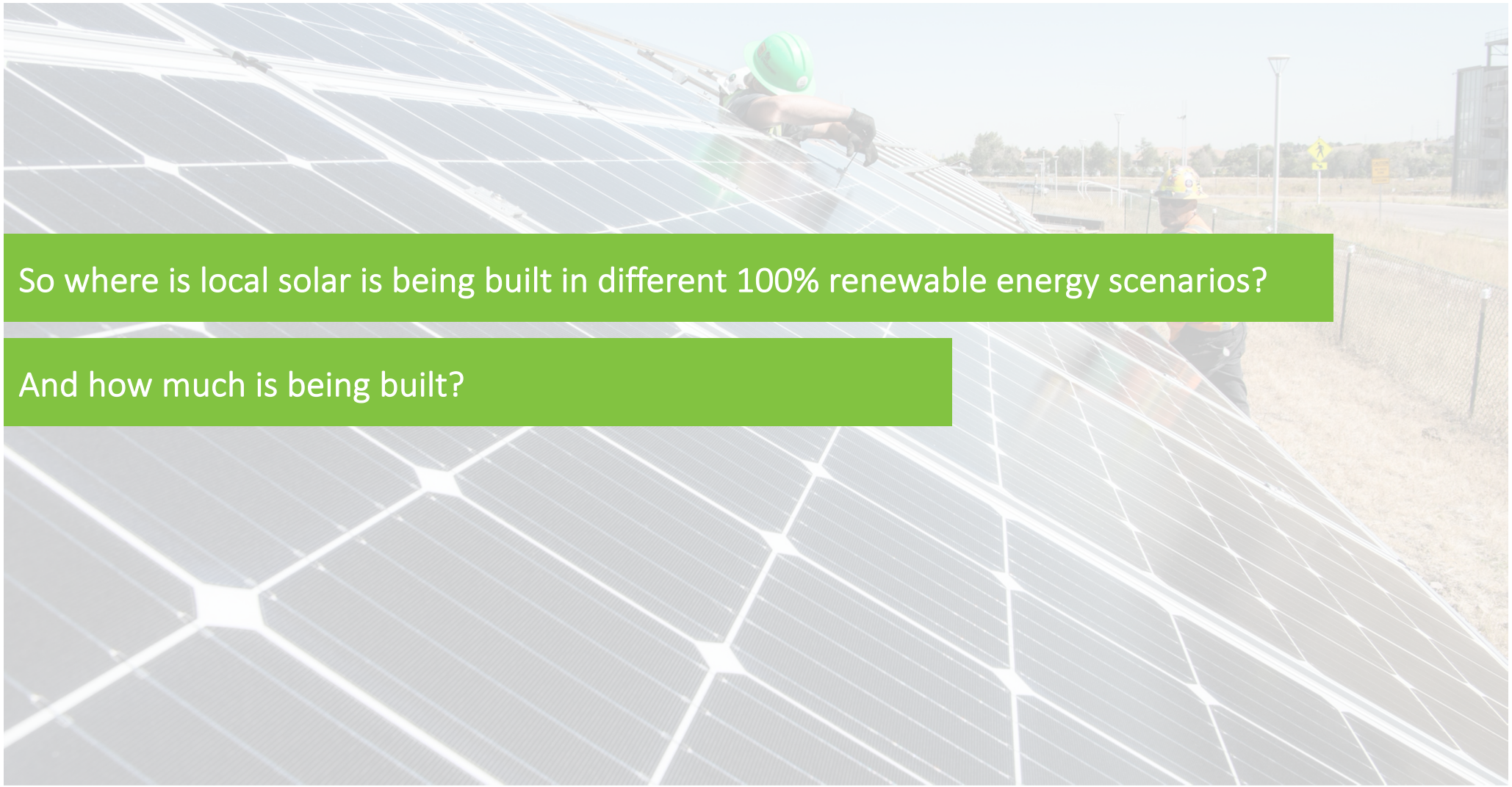
(2) Where there is the most benefit from using distributed energy resources to achieve 100% renewable energy considering overall costs and which communities benefit from distribution upgrades

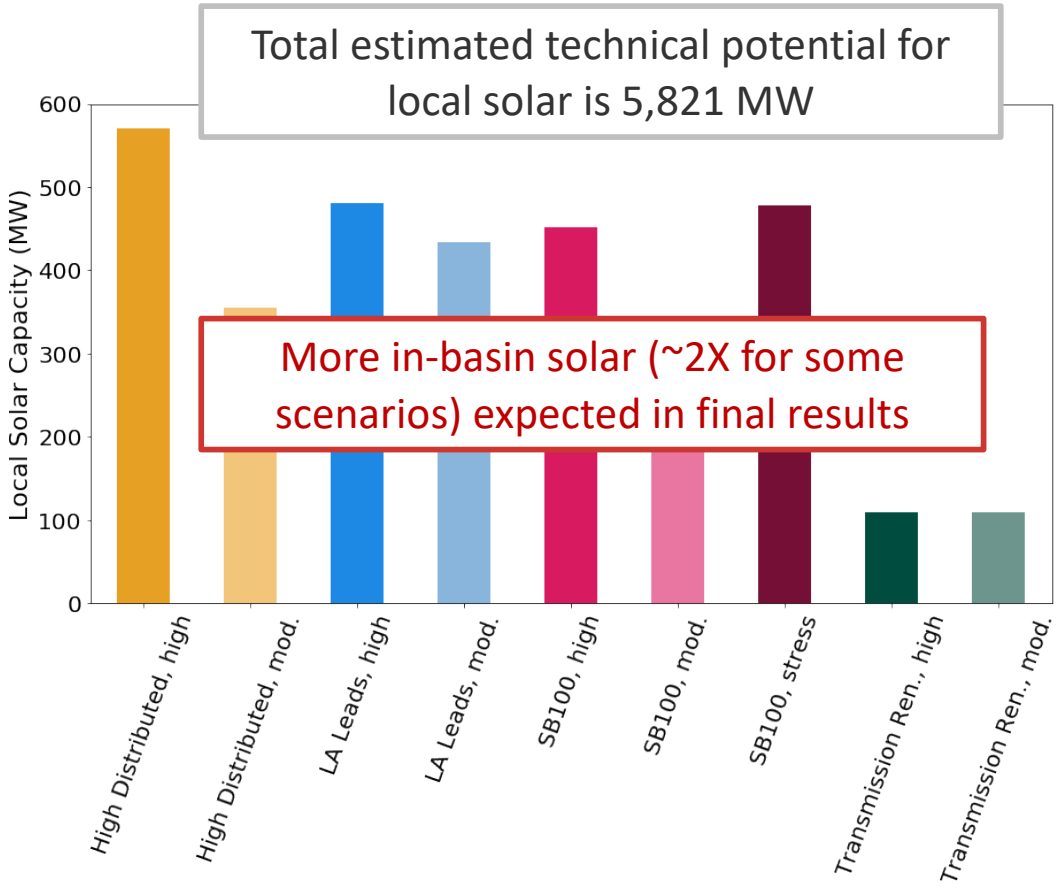


So where is local solar is being built in different 100% renewable energy scenarios?

And how much is being built?

Local Solar Capacity by Scenario by 2045

- These systems are all connected to the 34.5kV distribution system in our analysis
- Local solar sites include:
  - Parking lot canopy
  - Ground-mount solar
  - Ground-mount hybrid solar + battery systems



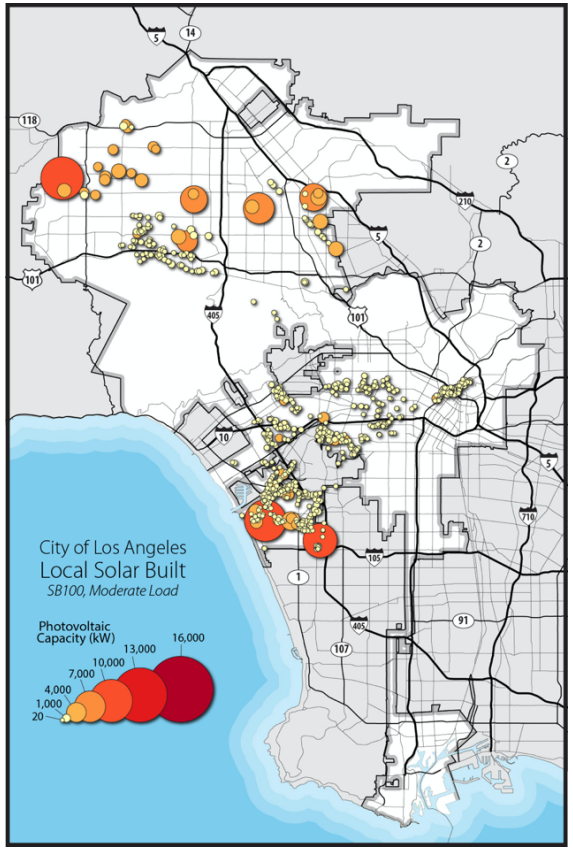
DRAFT Results. Subject to Change.

Locating Local Solar and Storage In Basin

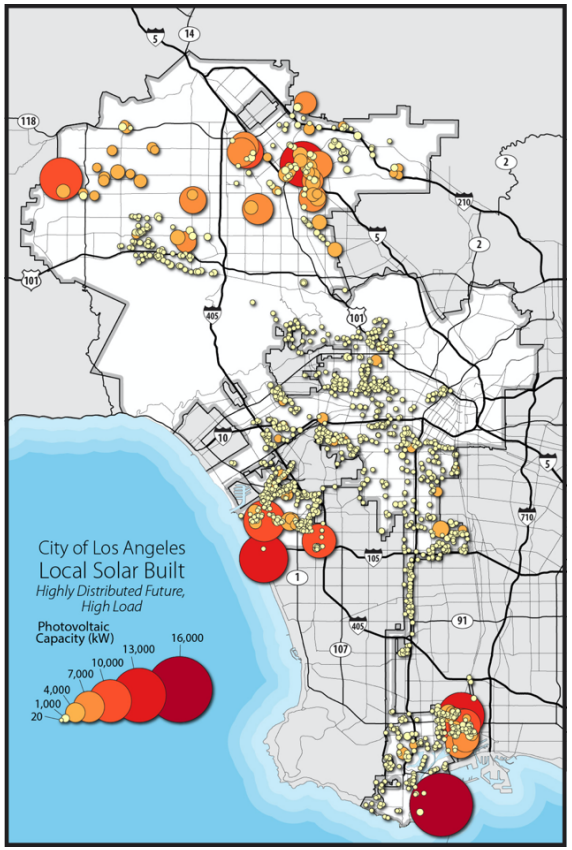
- Potential sites are rank-ordered according to the estimated levelized cost of energy of the solar
- Sites are then deployed according to this order until the capacity expansion needs for each region are satisfied

Capacities of Local Solar and Storage Sites by 2045

SB100, Moderate Load



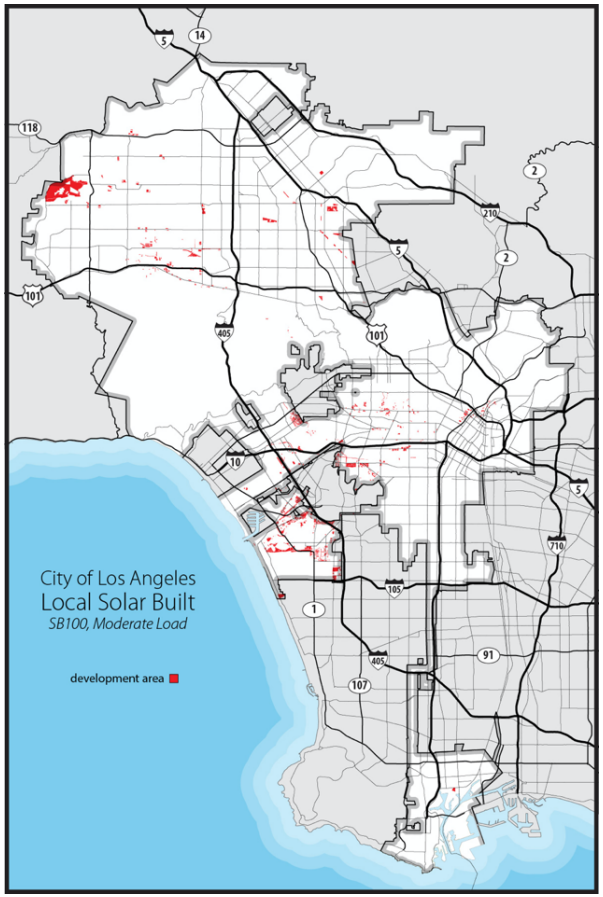
High Distributed Future, High Load

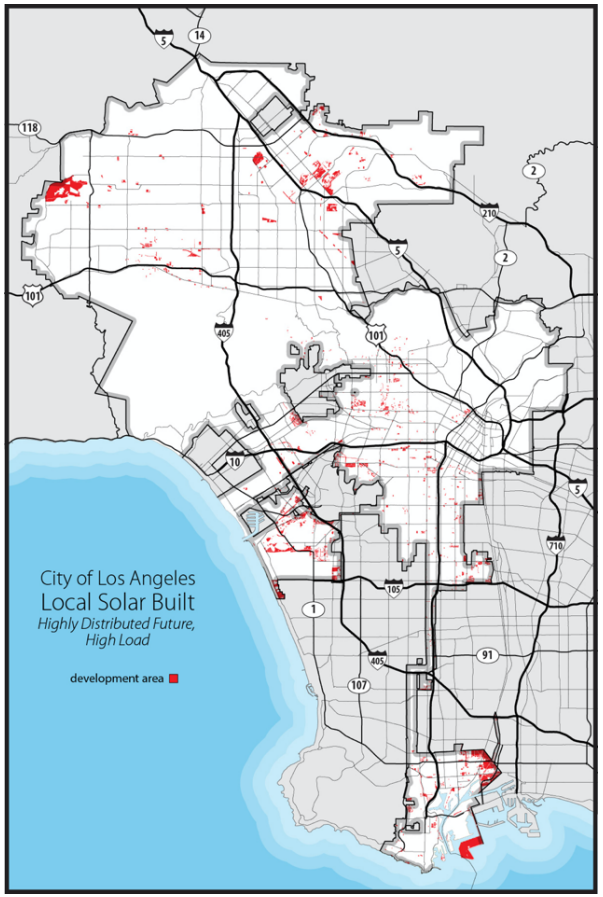


- Although the total capacity of local solar << the technical potential, almost 100% of the technical potential is built in certain regions.
  - This is driven by transmission constraints in those regions.
  - These constraints are exacerbated in the high distributed future case where no new transmission is allowed, even though there is more customer-adopted solar.

DRAFT Results. Subject to Change.

Land Usage of Solar and Storage Sites by 2045





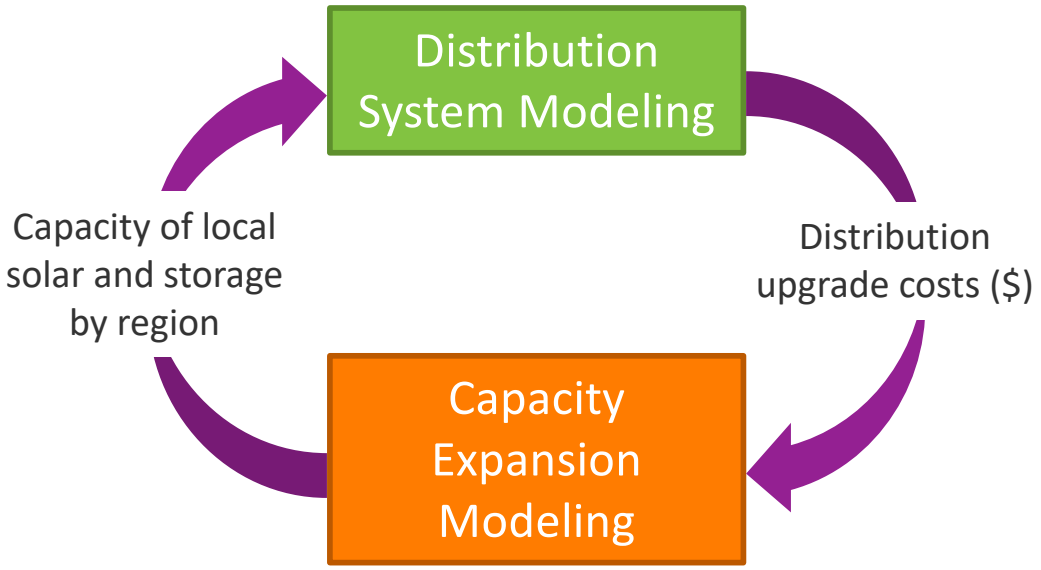
The total land area required for these resources is small, even in the High Distributed Future scenario, which has the greatest amount of local solar and storage

DRAFT Results. Subject to Change.

Accounting for Distribution Upgrade Costs for Local Solar in the Broader LA100 Analysis

The levelized cost of energy does not reflect distribution upgrade costs

- We calculate these costs separately and will feed them back into the capacity expansion model



This brings us back to our next key insights:

Local solar and storage are needed to achieve 100% renewable energy in all scenarios, and these can cost money to integrate on the distribution system depending on where they are located.

However, this cost is lower if you first upgrade the distribution system to accommodate load growth and customer-adopted solar and storage.

Cost could even be negative (net deferral benefit) **on the 34.5kV system** if the local solar is installed first, and we've seen some evidence of that. More to come next Advisory Group meeting.

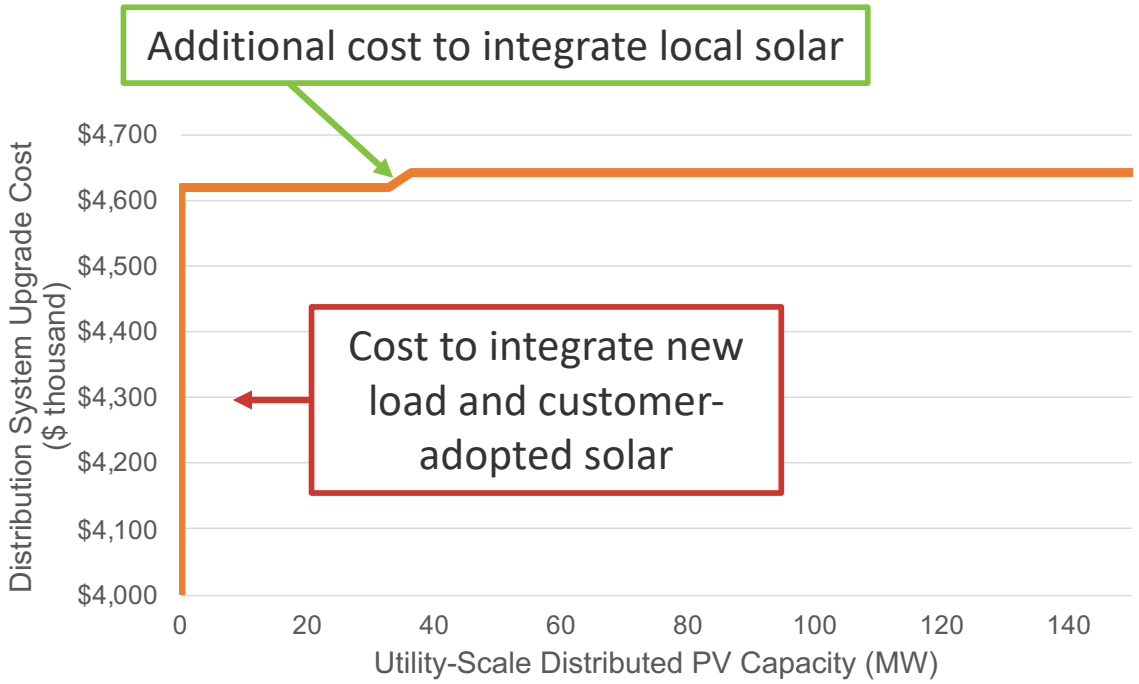
DRAFT Results. Subject to Change.

Upgrading the Distribution System to Accommodate Load and Customer-Adopted solar

- The distribution system will need to be upgraded to accommodate load growth
- Upgrades will also be needed to integrate some of the customer-adopted solar

Additional Cost of Distribution Upgrades to Incorporate Local Solar

Upgrading to address any distribution system problems associated with load or customer-adopted solar can enable deployment of utility-scale local solar at low additional cost



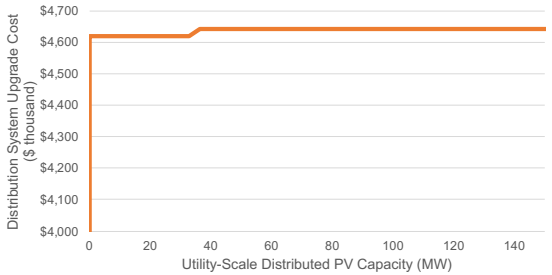
DRAFT Results. Subject to Change.

Example shown for one region in LA

Does What Comes First Affect the Total Cost?

1st

2nd



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versus

1st

2nd

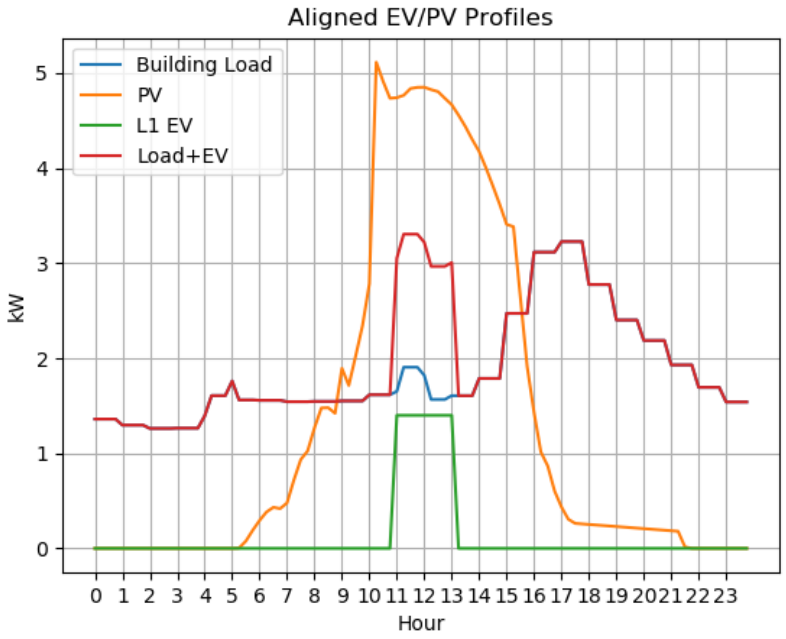
???

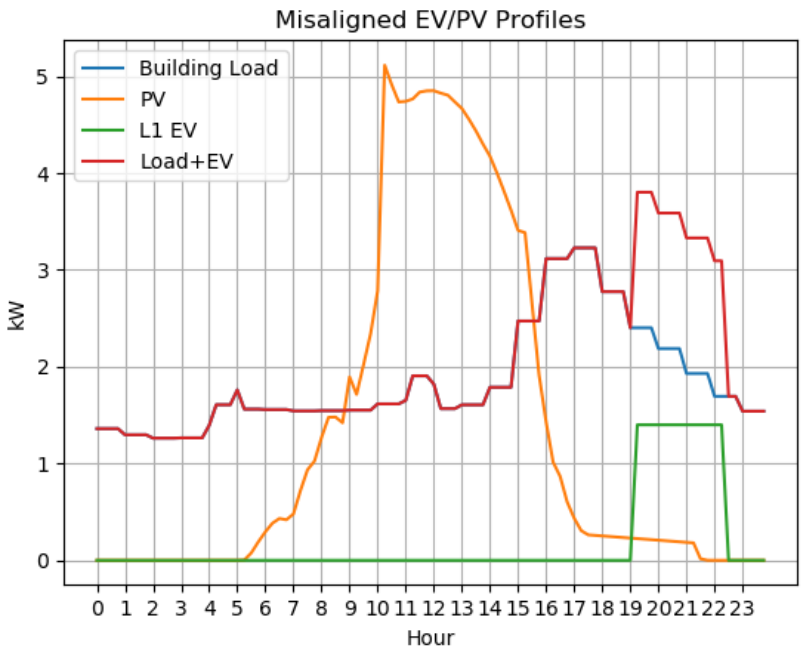
Does What Comes First Affect the Total Cost?

- There will be some benefits for integrating load and customer solar if local solar comes first, BUT
  - This applies **only to the 34.5kV system**, where local solar is installed.
  - Load and customer adopted solar is more spatially widespread, and so it is more likely that the upgrades made to integrate those resources benefit local solar than vice-versa.

- We don't have a quantitative answer yet as to how total costs compare in each case.

Load can increase hosting capacity of solar AND solar can increase the hosting capacity of load (depending)

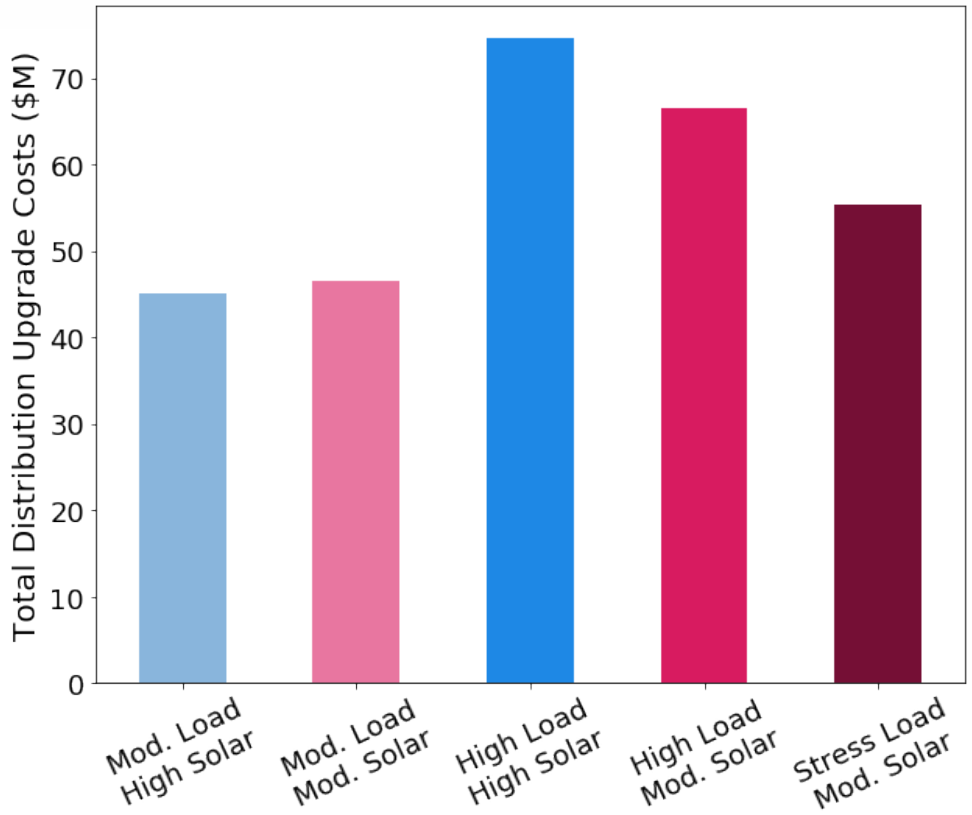




- Energy storage, properly dispatched, can align profiles and increase hosting capacity.
  - This may not always be the cheapest option from a distribution perspective.

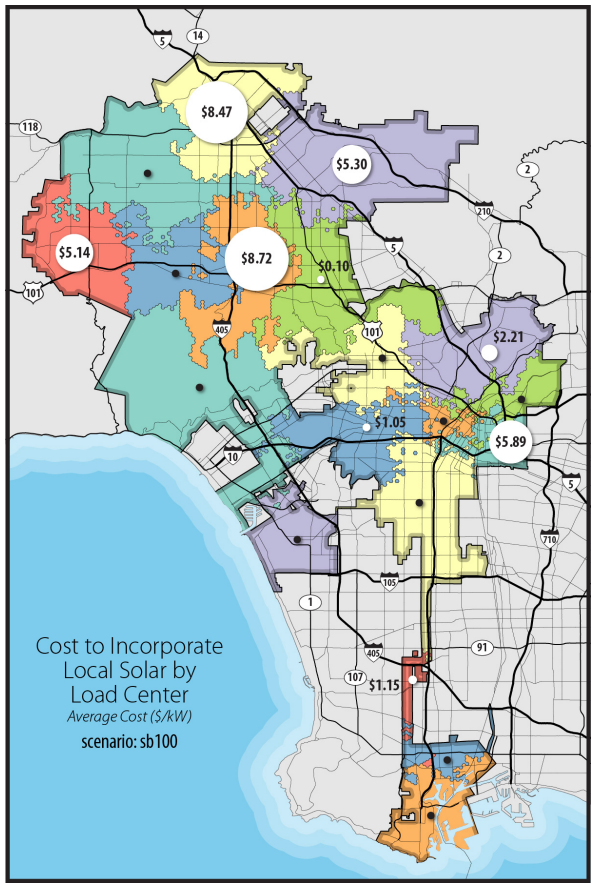
Load differences drive the need for system-wide distribution upgrade costs more than differences in the amount of customer-adopted solar

Distribution System Cost of Integrating Just New Load and ***Customer-Adopted*** Solar by 2045 on the 34.5kV system



DRAFT results. Subject to change.

Additional Average Cost to Integrate Local Solar by Region *Up to the Technical Potential*



- Additional cost is a small fraction of the average local solar installed system cost (<5%), but does vary regionally
- Higher average $/kW is driven by lower technical potential in some regions, rather than higher total cost to reach the technical potential

DRAFT Results. Subject to Change.

Effects of Load on the Additional Average $/kW to Integrate Local Solar

- In SB100 Stress Load case, we are seeing currently a wider range of $/kW values compared to SB100, High Load
  - Higher maximum $/kW cost in the Stress case
  - Initial deferral analysis suggests slightly negative $/kW regions for the Stress case
- Suggests higher load cases could have more deferral benefits, but that this is not true everywhere in the city
  - In some locations, the greater amount of local solar needed in higher load cases triggers higher upgrade costs

DRAFT Results. Subject to Change.

DRAFT results. Subject to change.

The estimated total capital cost of distribution system upgrades needed for all changes associated with 100% renewable electricity pathways from 2020 to 2045 ranges from $190M to $460M depending on the scenario.

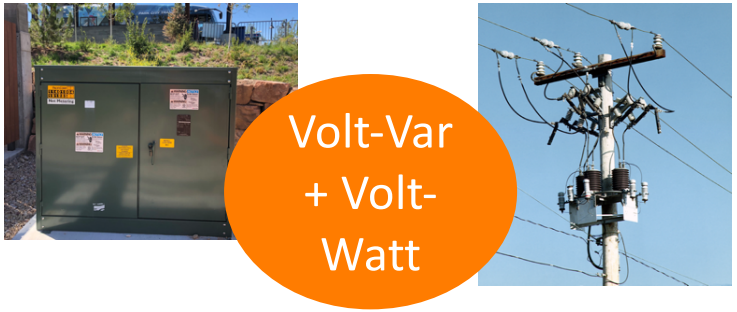
- These costs are low compared to annual distribution spending at LADWP today
- We are carefully reviewing these results now

Caveats

- This is draft analysis and will be updated for the final results
- Again, 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

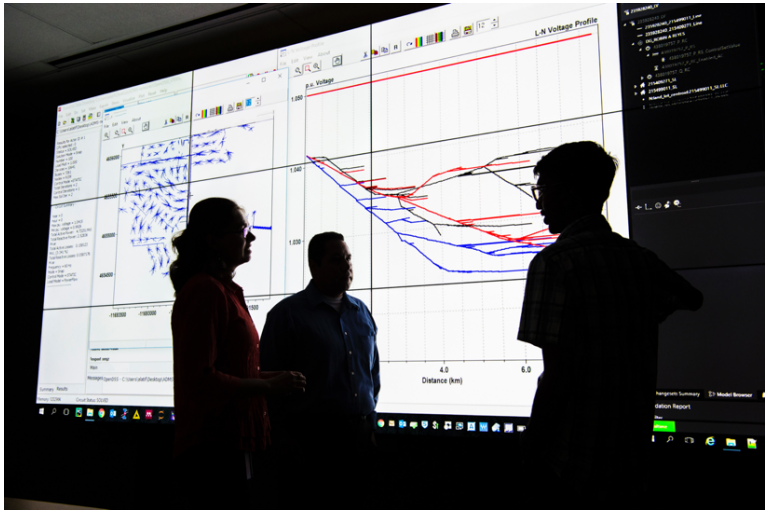
- This analysis considers only autonomous advanced solar inverter functions + traditional infrastructure upgrades and control changes



- 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)

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



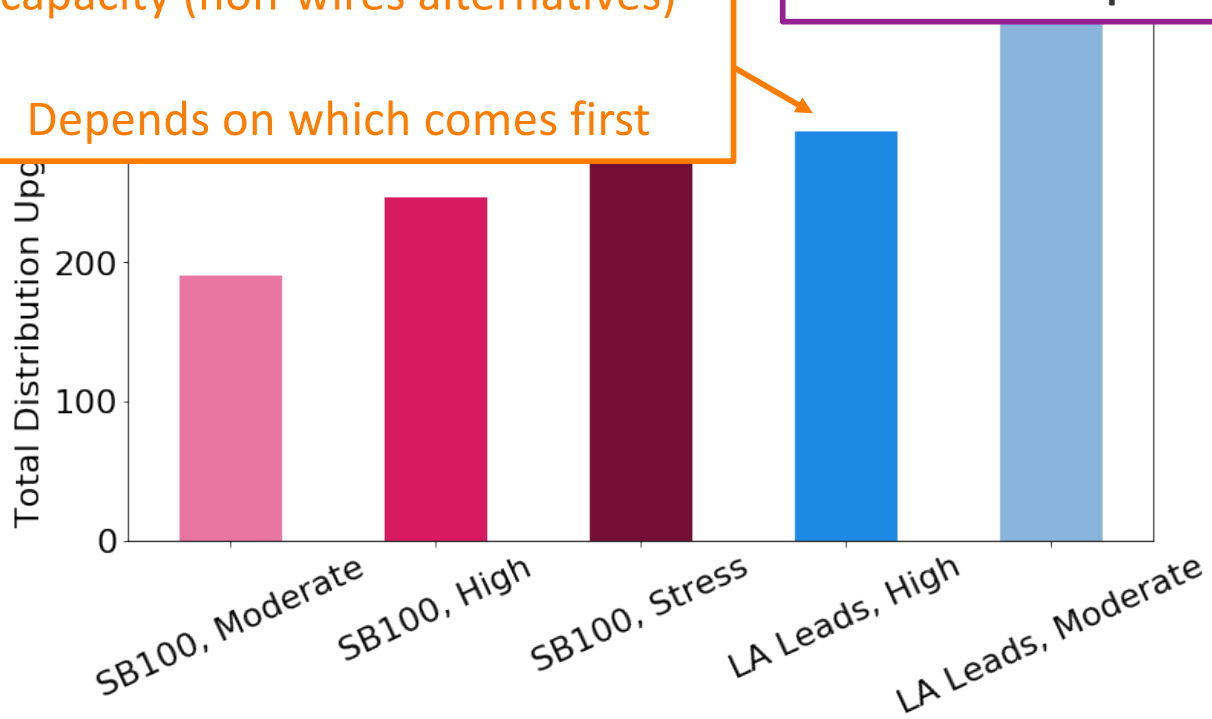
Estimated Distribution System Capital Upgrade Costs by Scenario in 2045

to Accommodate 100% Renewable Energy Changes

Due to load expanding solar hosting capacity
– or –
Solar expanding the load hosting capacity (non-wires alternatives)

Depends on which comes first

We are also looking at the potential **spread** in these costs based on **uncertainty** in **where customers adopt solar**



DRAFT results. Subject to change.

34.5kV versus 4.8kV Distribution Upgrade Costs

- 68% to 86% of the costs are on the 4.8kV system, depending on the scenario
- Fewer 34.5kV upgrades required, even though most upgrades are more expensive per unit on 34.5kV
  - Because hosting capacity is higher on higher voltage distribution circuits
- This ratio could change when we incorporate the higher levels of local solar now being built (stay tuned!)

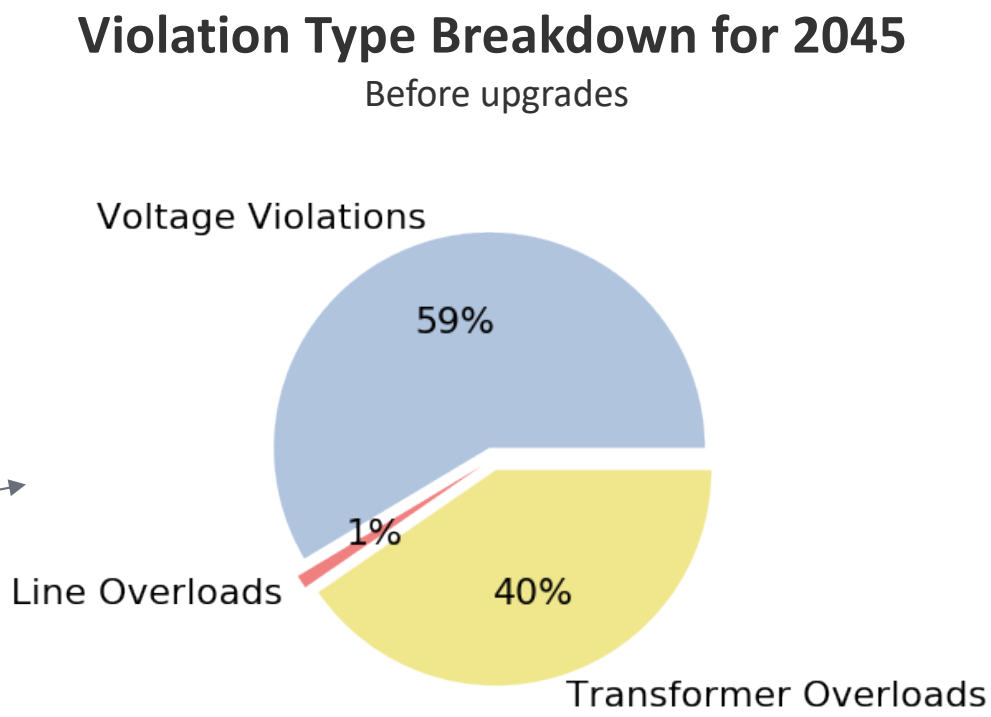
DRAFT results. Subject to change.

How Many Circuits Need to be Upgraded, and Why?

69% of distribution circuits may need some upgrades by 2045 to accommodate 100% renewable pathways

Can each be caused by load, solar, or storage

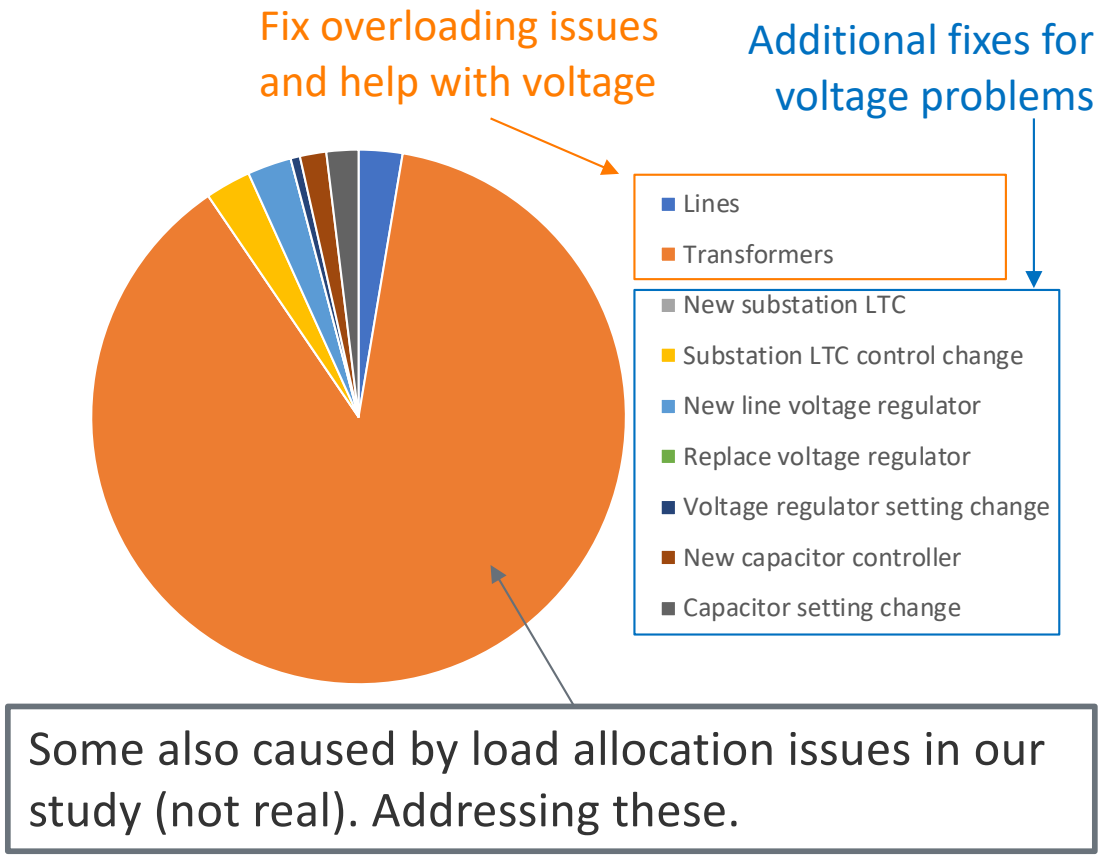
- Can also be caused by load allocation issues in our study (not real)



DRAFT results. Subject to change.

Cost of Distribution Upgrades by Type in 2045

- Upgrading transformers (and lines) first resolves many voltage issues
  - This could be why we see fewer upgrade of voltage-regulating equipment
- Typically, additional upgrades to address voltage challenges are also typically cheaper per unit



DRAFT results. Subject to change.

Additional Distribution Upgrade Costs Not Yet Captured

- Our analysis has identified the need to replace some circuits
  - The cost for full circuit replacements is not currently accounted for in our analysis
  - Instead, our cost algorithm puts lines and transformers in parallel on existing circuits
  - Looking into estimating new circuit costs with LADWP and adding to our estimates

Recap

Core Findings

DRAFT Results. Subject to Change.

- Upgrading the distribution system today can resolve existing issues and decrease the cost of integrating new loads, distributed solar, and distributed storage associated with 100% renewable electricity pathways.
- Local solar and storage are needed to achieve 100% renewable energy in all scenarios, and these can cost money to integrate on the distribution system depending on where they are located.
- However, this cost is lower if you first upgrade the distribution system to accommodate load and customer-adopted solar and storage.
- The estimated capital cost of distribution system upgrades needed *for changes associated with 100% renewable electricity pathways from 2020 to 2045* ranges from $190M to $460M depending on the scenario. But this could be an underestimate.
  - The lowest distribution upgrade costs are in scenarios with lower levels of customer-adopted solar and load
  - However, spatially and temporally correlated loads and solar can be synergistic in reducing distribution costs in other scenarios

Distribution Impacts and Costs for Different LA100 Scenarios

- The LA Leads Moderate Load scenario has the highest estimated distribution system upgrade cost
  - We think this is driven by high levels of customer-adopted distributed resource spatially located with load
- Transmission Renaissance Moderate Load has the lowest distribution upgrade cost
  - But it has fewer distributed solar and storage systems

DRAFT Results. Subject to Change.

Advisory Group Meeting #13 Preview

- Potential for energy efficiency, solar, and storage to defer distribution deferrals: Non-wires alternatives “lite”
  - Where and when do solar and storage help versus hurt the distribution system?
- Where will distributed solar and storage as well as distribution infrastructure upgrades be built with respect to disadvantaged communities? What are the potential impacts to those communities and how could they benefit?
- Updated results after feedback cycles with capacity expansion modeling

Thank you!
Questions?

The Los Angeles 100% Renewable Energy Study