LA100

The Los Angeles 100% Renewable Energy Study

Advisory Group Meeting #13

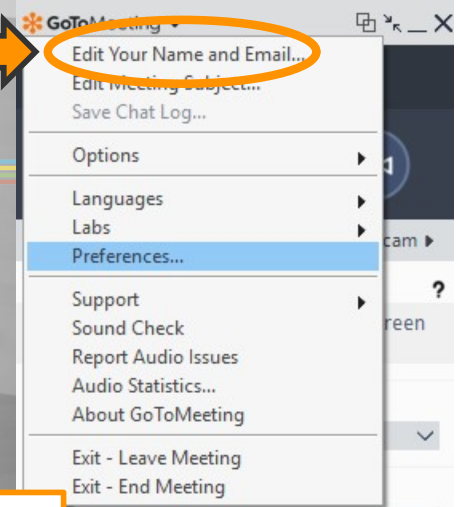
Virtual Meeting #2

Los Angeles Department of Water & Power

NREL Transforming ENERGY

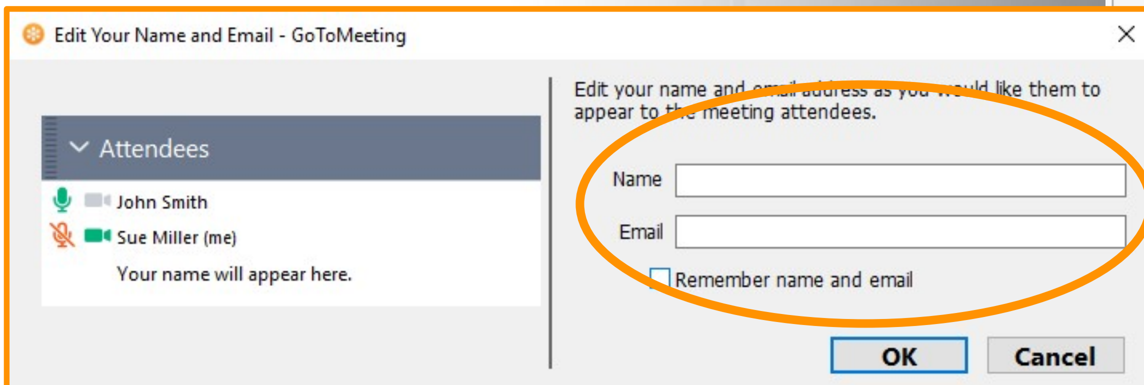
The Los Angeles 100% Renewable Energy Study

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



Advisory Group Meeting #13

Virtual Meeting #2



Los Angeles Department of Water & Power

NREL Transforming ENERGY

Advisory Group #13 Agenda

Note date change for the third meeting (from October 15 to October 29).

October 1

- Community outreach and engagement – LA100 and more broadly (LADWP, NREL)
- Demonstration of Interactive Website (NREL)
- Discussion/Q&A

Today (October 8)

- Welcome
- 100% RE Investment Pathways, Part 1: Technology and Cost Sensitivity Analysis
- Discussion/Q&A

October 22

- Greenhouse Gas Emissions, Power & Non-Power Sectors
- Update to Air Quality Modeling Methods
- Discussion/Q&A

October 29

- 100% RE Investment Pathways, Part 2: Reliability
- Discussion/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

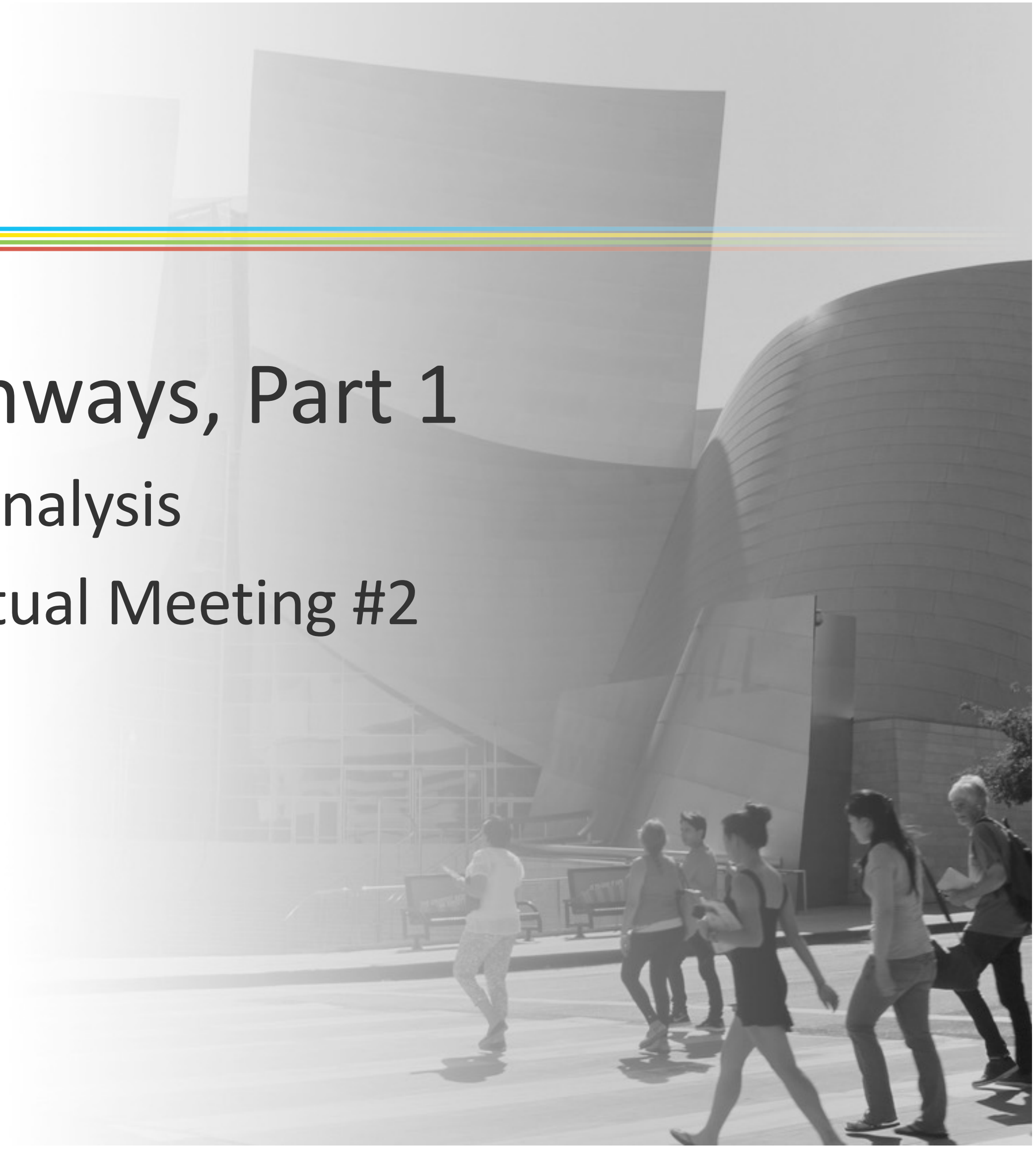
LA100

The Los Angeles 100% Renewable Energy Study

100% RE Investment Pathways, Part 1

Technology and Cost Sensitivity Analysis

Advisory Group Meeting #13, Virtual Meeting #2



Dan Steinberg & Bulk Power Team

National Renewable Energy Laboratory

October 8, 2020

Los Angeles Department of Water & Power | NREL Transforming ENERGY

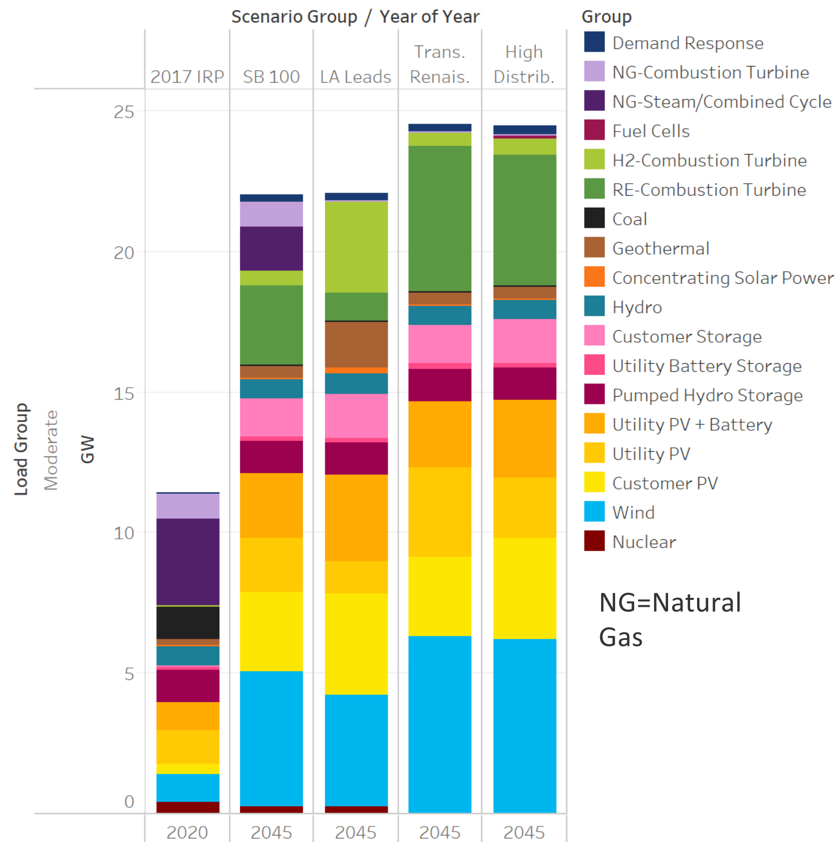
Reminder: Scenarios

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load Stress
		SB100	LA-Leads, Emissions Free (No Biofuels)	Transmission Renaissance	High Distributed Energy Future	SB100	LA-Leads, Emissions Free (No Biofuels)	Transmission Renaissance	High Distributed Energy Future	SB100
	RE Target in 2030 with RECs	60%	100%	100%	100%	60%	100%	100%	100%	60%
	Compliance Year for 100% RE	2045	2035	2045	2045	2045	2035	2045	2045	2045
Technologies that <u>do not</u> vary in eligibility across scenarios	Solid Biomass	N	N	N	N	N	N	N	N	N
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	RE-derived Hydrogen Combustion	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geothermal	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technologies that <u>do</u> vary	Biofuel Combustion	Y	No	Y	Y	Y	No	Y	Y	Y
	Natural Gas	Y	No	No	No	Y	No	No	No	Y
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
Repowering OTC	Haynes, Scattergood, Harbor	N	N	N	N	N	N	N	N	N
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors
WECC	WECC VRE Penetration	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Note, the study also includes a reference case (2017 IRP with minor updates). This case extends through 2036.

Prior Advisory Group: All Pathways to Achieving 100% RE Have a Number of Key Commonalities

- **Wind and solar resources meet the majority of energy needs,** making up 69% to 88% of total energy needs in 2045
- **Storage resources with 4 to 12 hours of storage are key to enabling increased utilization** of wind and solar
- **New in-basin firm renewable capacity—power plants that can come online within minutes and run for hours to days—comprise the least-cost options to maintain reliability** given the assumed retirement of the in-basin OTC generators and reliance on out-of-basin resources for the majority of energy needs

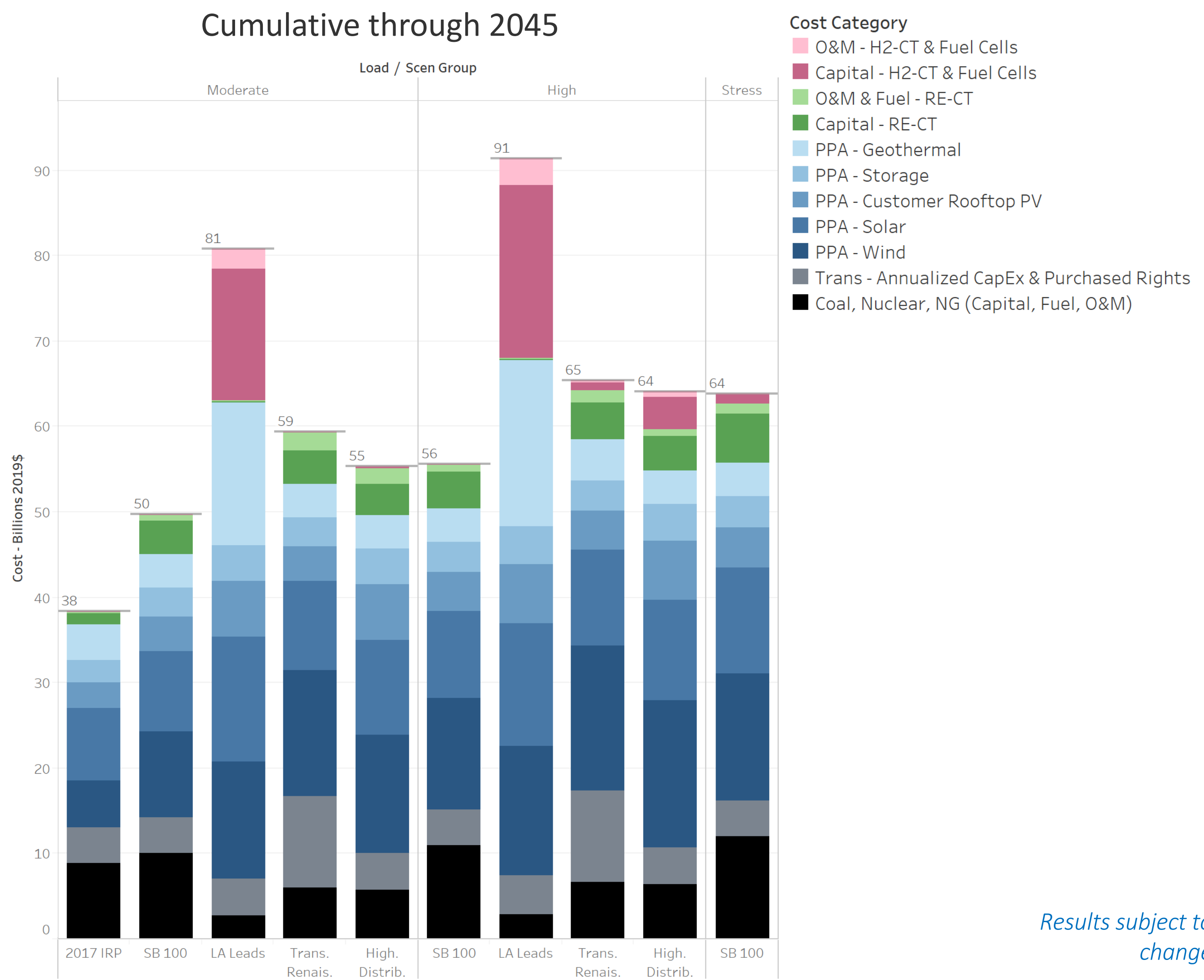


NG=Natural Gas

Results subject to change

Total bulk system costs are dominated by investment in new solar, wind, storage, and geothermal assets.

Pathways that do not allow renewable combustion turbines to be built (LA Leads) result in substantially higher cost.



Results subject to change

Part 1 (today): What Have We Learned About Key Drivers of the Technology Pathways and Their Associated Costs?

1. Target definition and eligibility of alternative compliance mechanisms
2. Speed of transition

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3. Evolution of load
4. The trade-offs in large-scale infrastructure deployment

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5. Technology cost assumptions, availability, eligibility

Also allowing plenty of time for discussion and Q&A based on the above and the website

Part 2—Reliability (October 29)

- Understanding how reliability and resiliency are maintained under a future LA power system characterized by a high level of variable generation
  - Operational changes (e.g., reserves)
  - Robustness of resource adequacy to different weather years
  - Delivering power when things go wrong
    - Transmission outages, e.g., due to fires
    - Stability analyses

Reminders

- Results shown today are not final, and are undergoing revisions
- Techs
  - Renewable Combustion Turbine (RE-CT) assumes market-purchased fuels
    - Example fuels: biogas, biofuel, hydrogen, RE-ammonia, RE-methane
    - LA100 study assumes
      - Through 2040: Biofuel/biogas
      - After 2040: Hydrogen
  - Hydrogen Combustion Turbine (H2-CT) and Fuel Cells assume on-site fuel production:
    - Total costs are more expensive than RE-CTs due to technology immaturity
    - Serves as a biofuel alternative in LA Leads

Section 1:

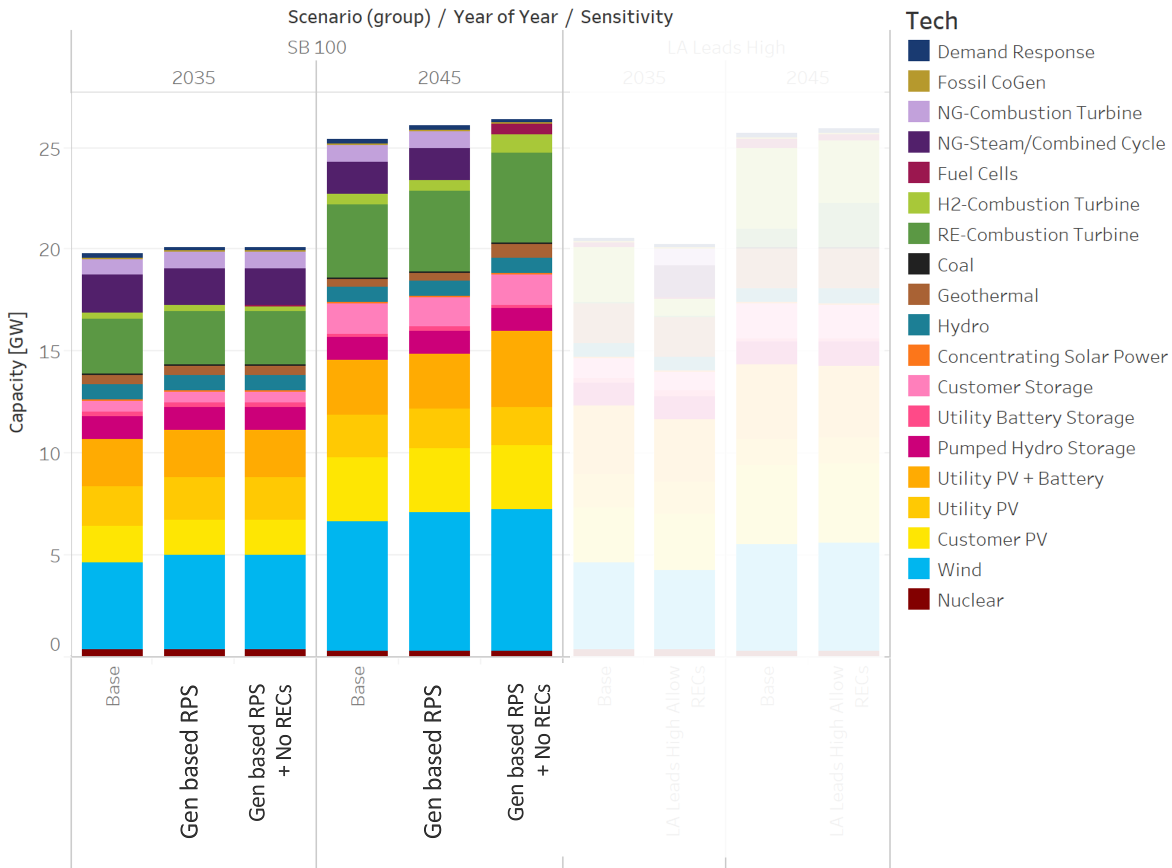
Implications of target definitions (basis) and/or allowing a portion of compliance to be met with renewable energy credits (RECs)

Implications of speed of transition

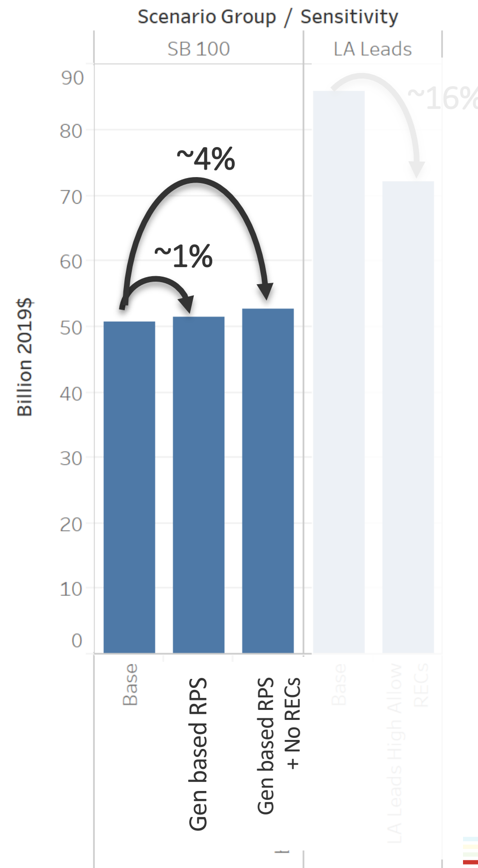
Target Definition and Alternative Compliance Sensitivities

- **Sensitivities on the SB100 – High scenario:**
  - **SB100 – Gen. Based Target**: the 100% target is based on total generation instead of sales; this creates a more stringent target
  - **SB100 – Gen. Based Target & No RECs by 2045:** target is based on generation and RECs are not allowed in 2045 compliance year; fossil cannot provide energy or capacity resources
- **Sensitivities on the LA Leads – High scenario:**
  - **LA Leads with RECs: unbundled RECs are allowed to be used to satisfy up to 10% of the target**

If RECs are allowed, changes in target definition have minor impacts on the pathway and costs; eliminating the eligibility of RECs has greater impact



Cumulative through 2045 (excludes customer PV costs)



Results subject to change

Note: cost estimate for sensitivities are based solely on RPM outputs—detailed operations have not been simulated

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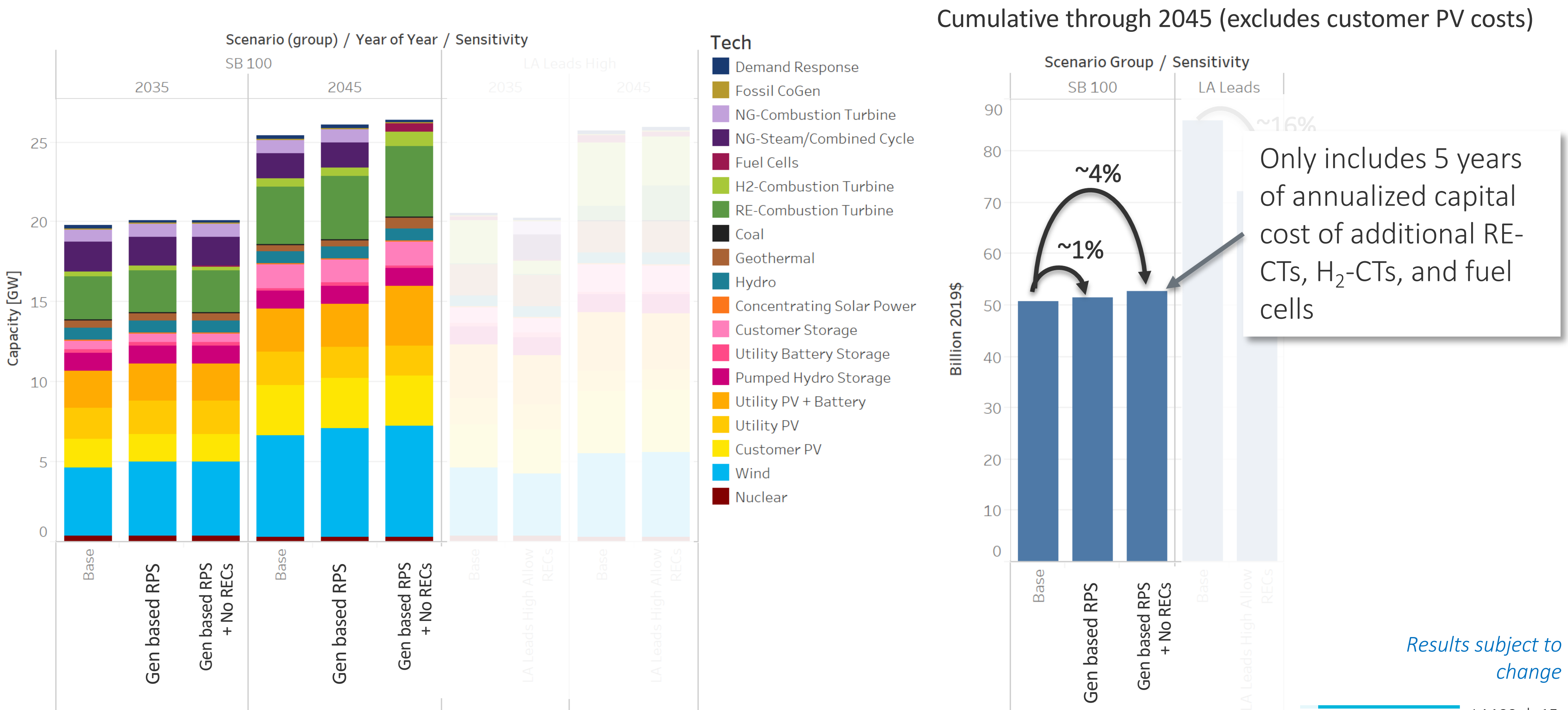

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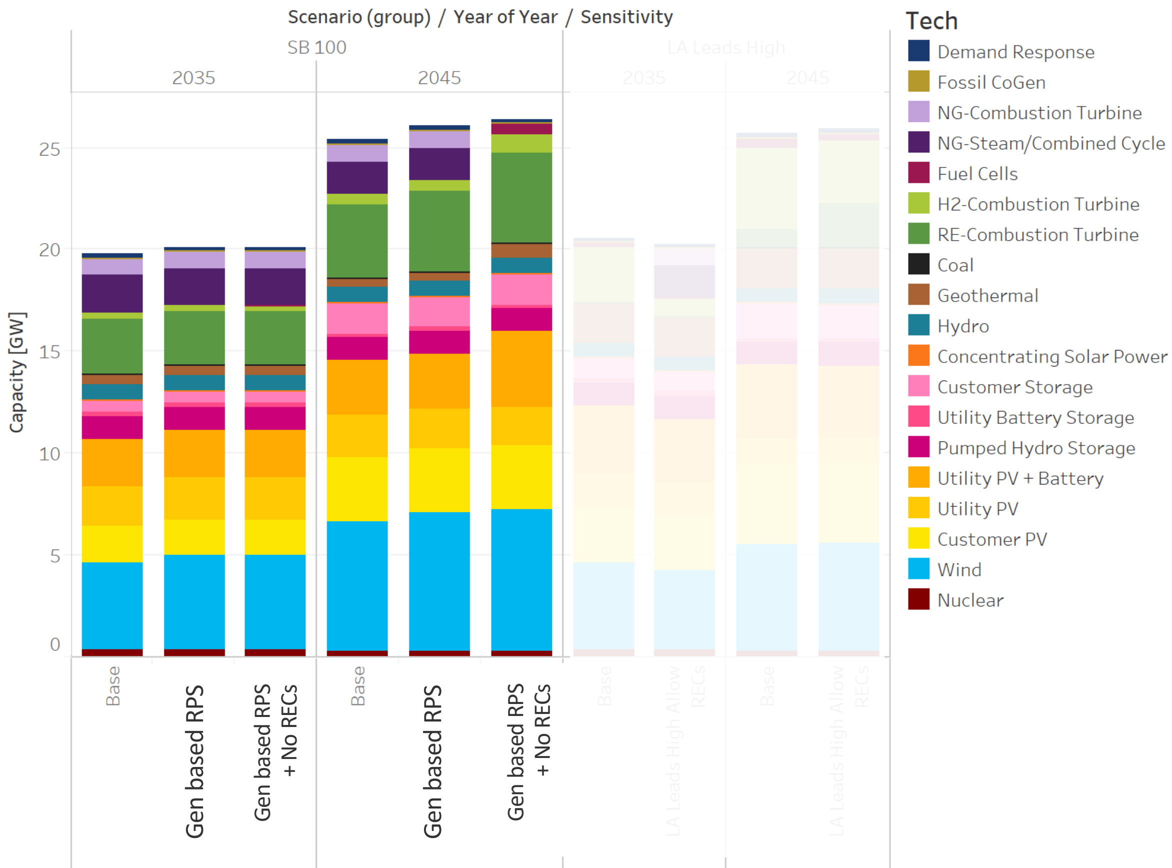
Results subject to change

Eliminating the eligibility of RECs has greater impact, particularly under a full accounting



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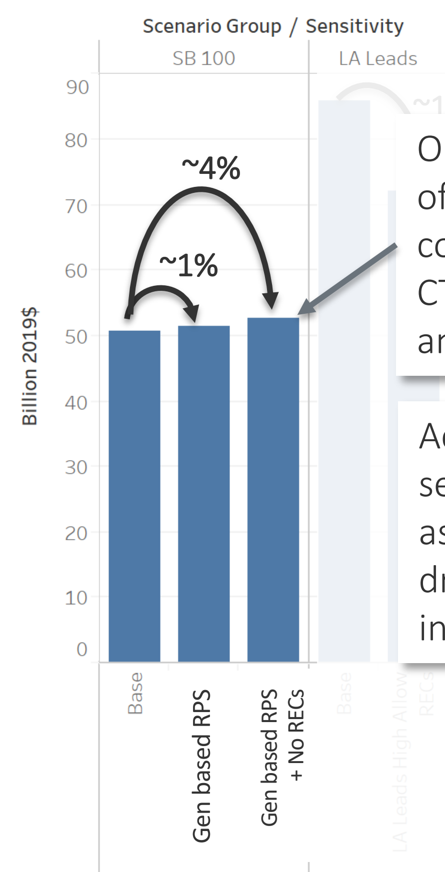


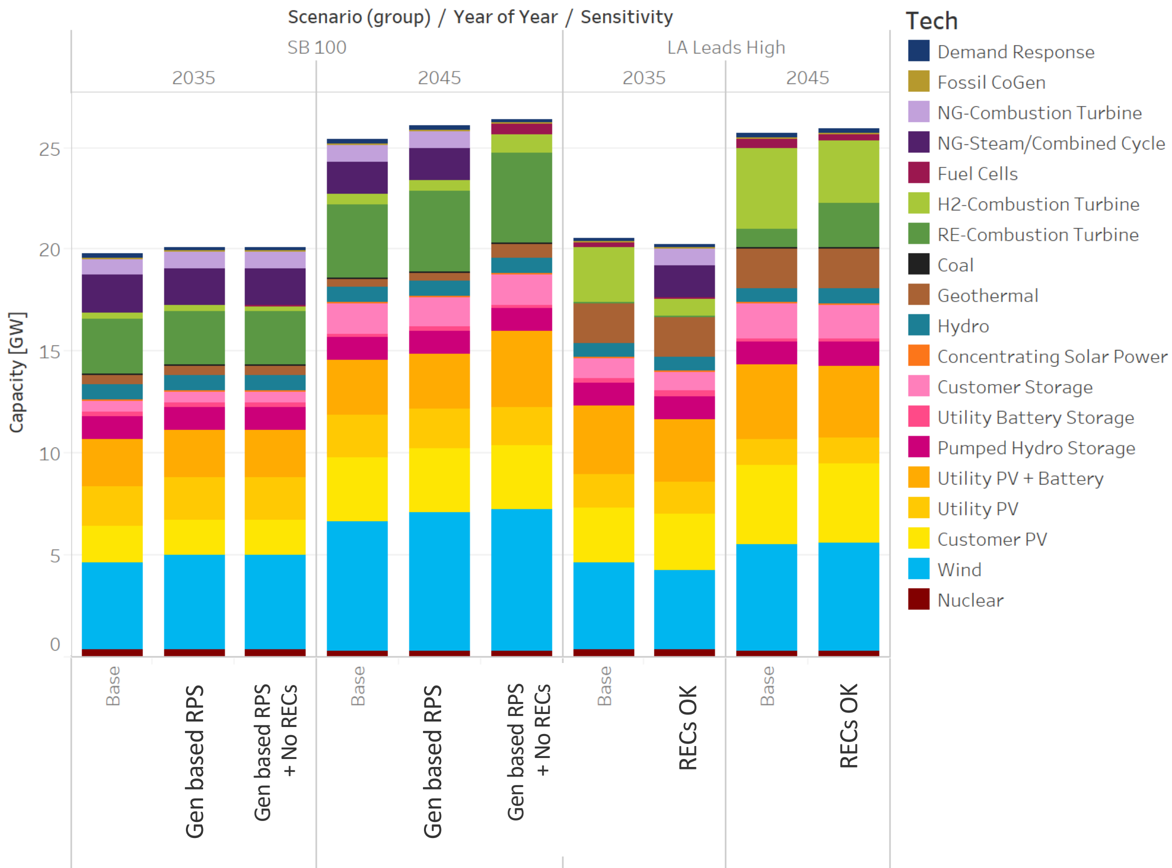
Only includes 5 years of annualized capital cost of additional RE-CTs, H_2-CTs, fuel cells, and geothermal

Accounting for total service of debt on assets (through 2074) drives the difference in cost to ~23%

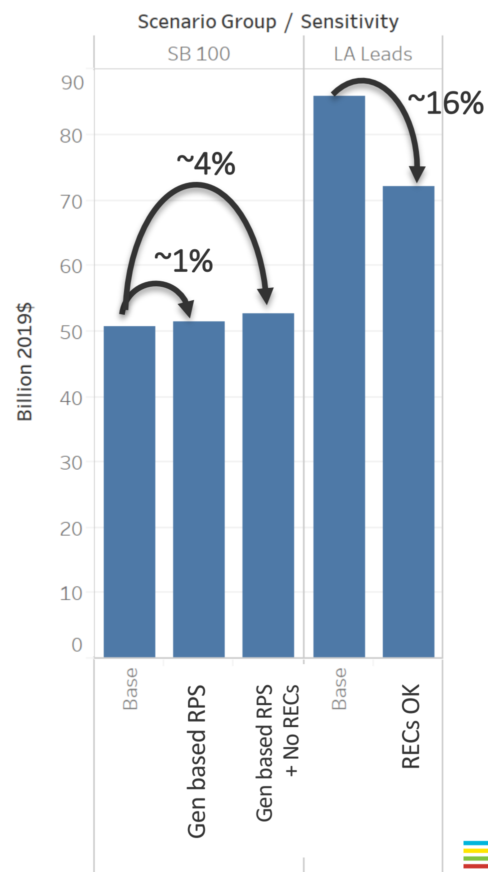
Results subject to change

Note: cost estimates for sensitivities are based solely on RPM outputs—detailed operations have not been simulated

Allowing RECs through 2040 in LA Leads (i.e., shifting 100%, no-REC target to 2045) reduces costs by 16% by 2045



Cumulative through 2045 (excludes customer PV costs)



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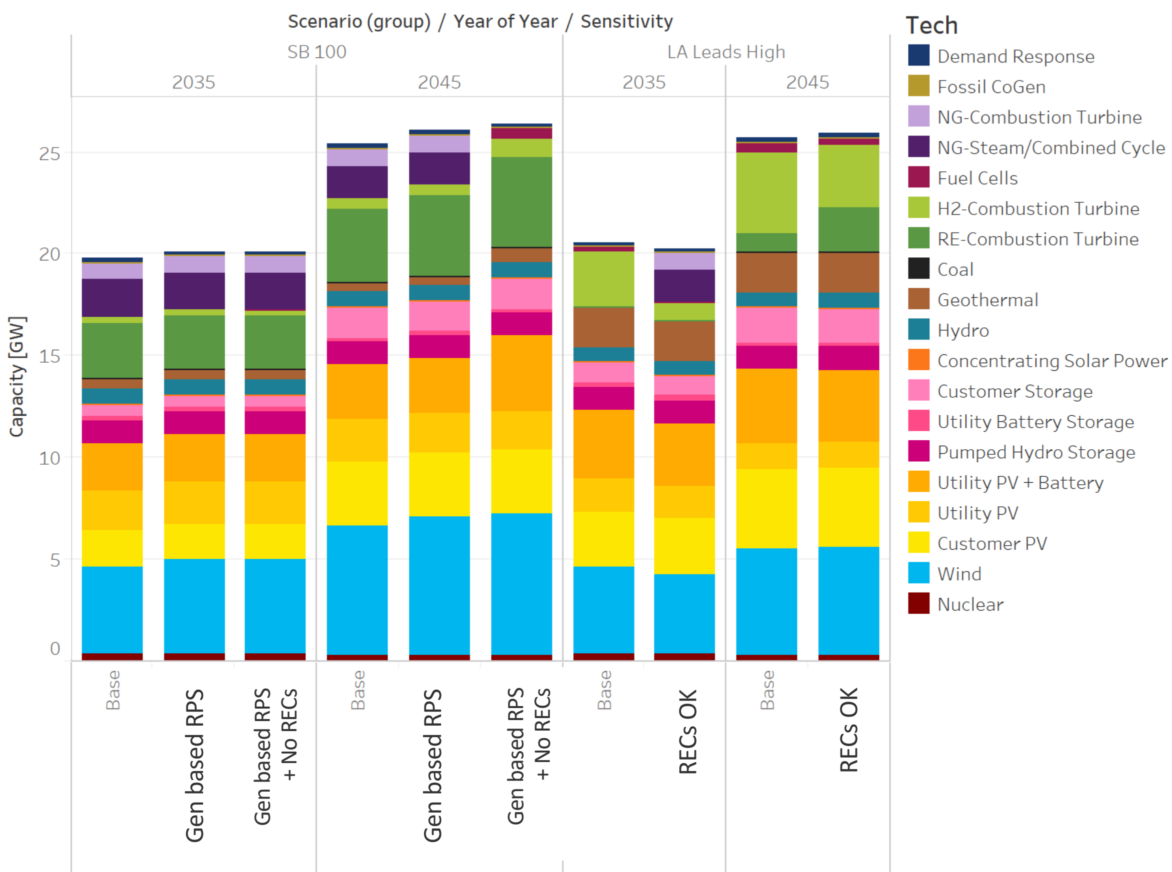

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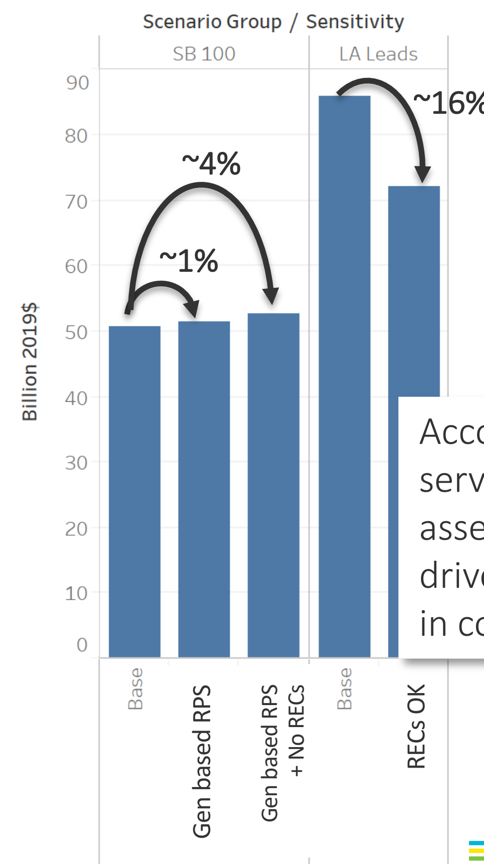


Accounting for total service of debt on assets (through 2074) drives the difference in cost to ~11%

Note: cost estimates for sensitivities are based solely on RPM outputs—detailed operations have not been simulated

Results subject to change

Section 1:

Implications of target definitions (basis) and/or allowing a portion of compliance to be met with RECs

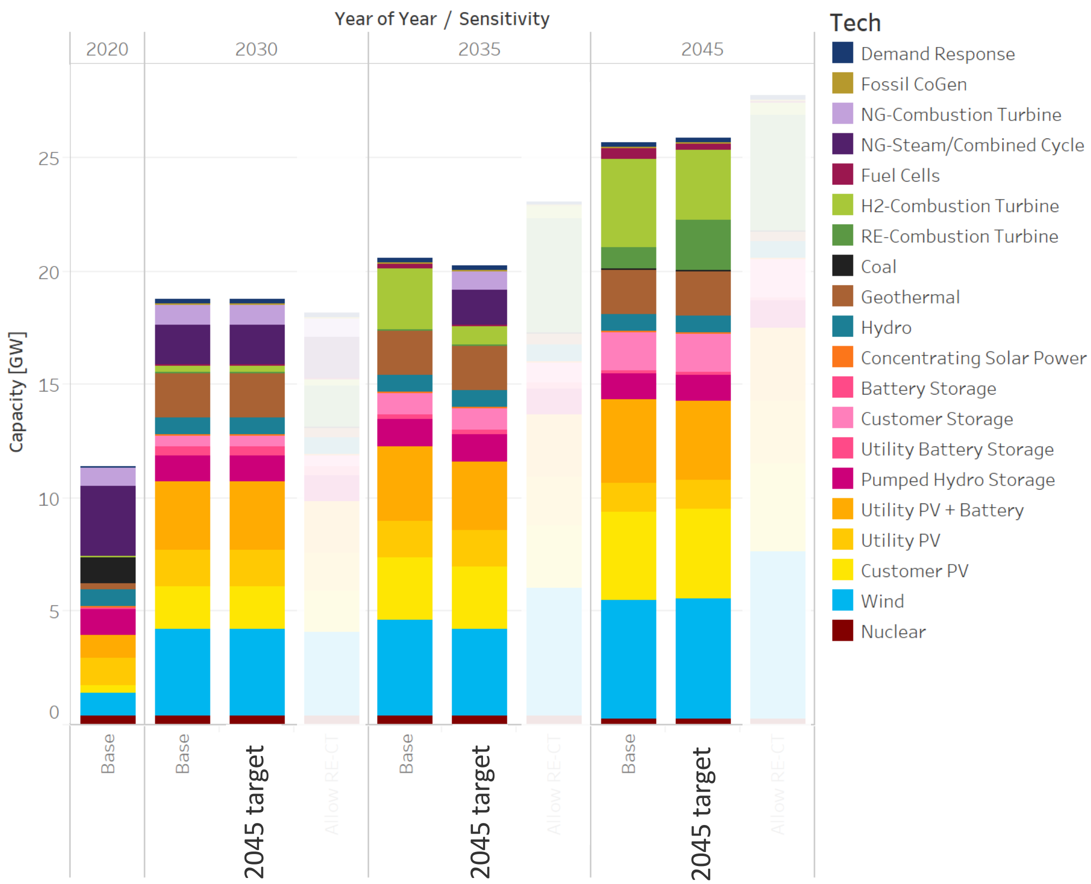
Implications of speed of transition

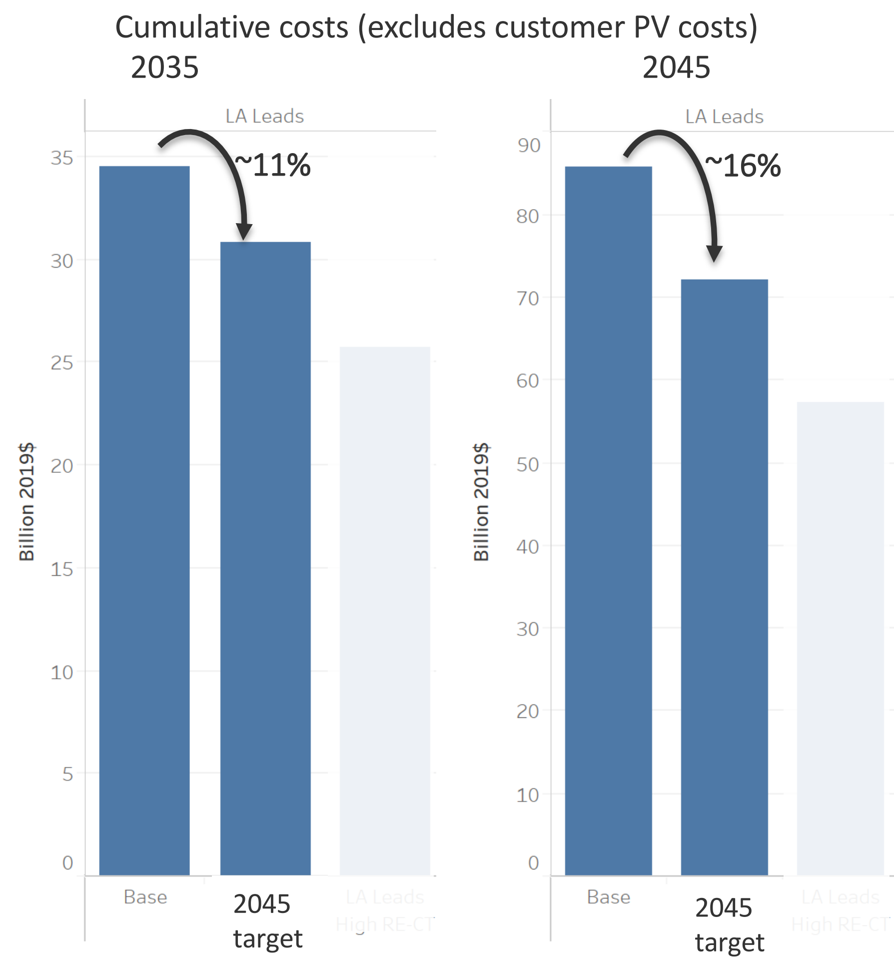
Speed of Transition: Sensitivities

- Sensitivities on the LA Leads case:
  - **LA Leads 100% RE target compliance by 2045 instead of 2035:** unbundled RECs are allowed to be used to satisfy up to 10% of the target in all but the final year
  - **LA Leads with RE-CTs:** renewable combustion turbines (i.e., biofuels through 2040) are allowed

Speed of Transition

Results subject to change

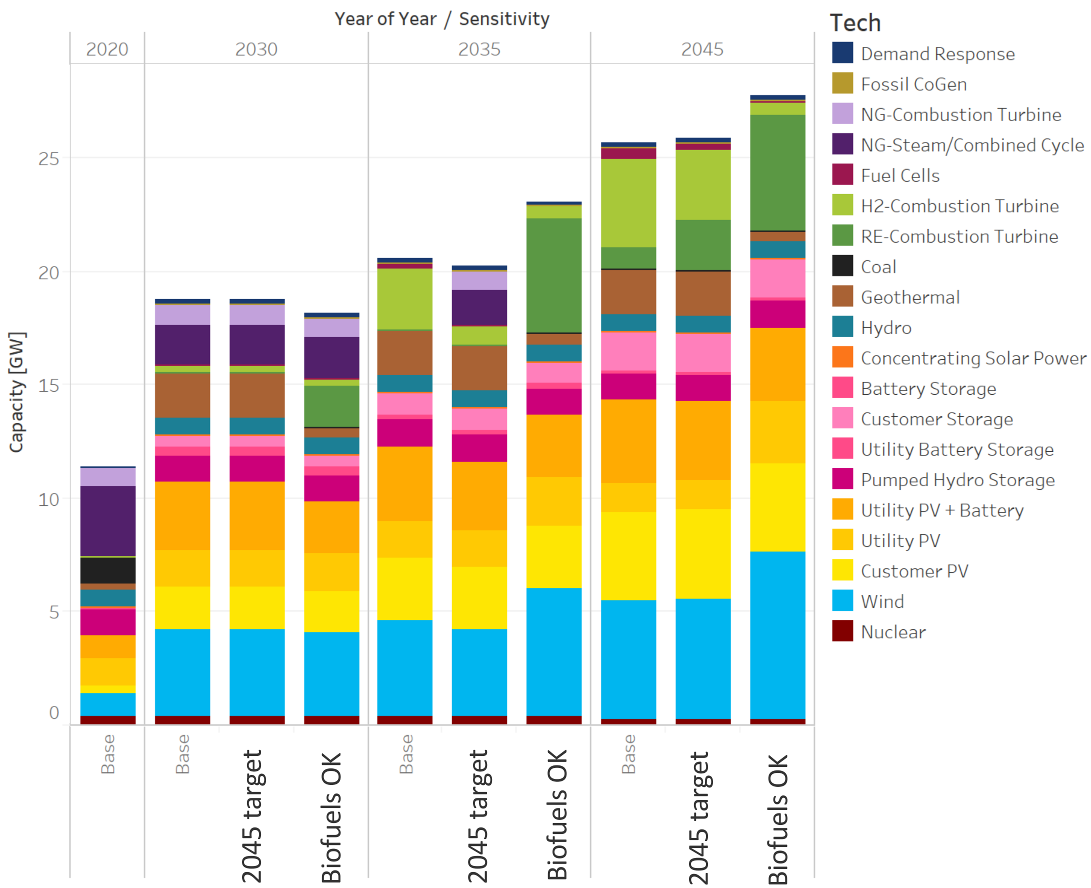




Note: cost estimates for sensitivities are based solely on RPM outputs—detailed operations have not been simulated

Cost of LA Leads Is More Sensitive to Biofuel Exclusion Rather than Speed of Transition

Results subject to change



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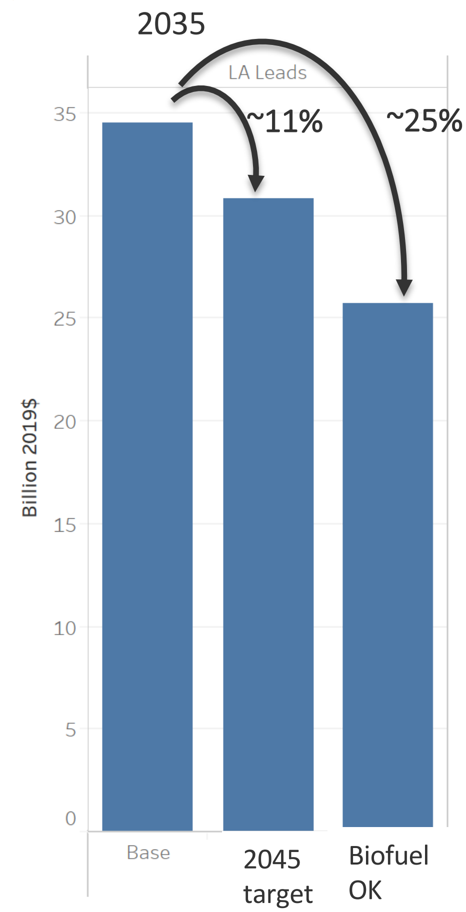
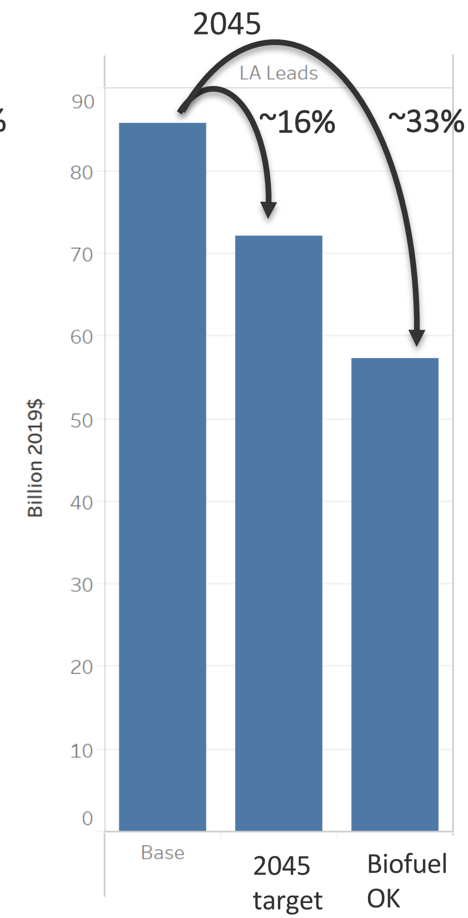
Cumulative costs (excludes customer PV costs)





Section 2:

Q&A

Section 2:

Implications of alternative load futures

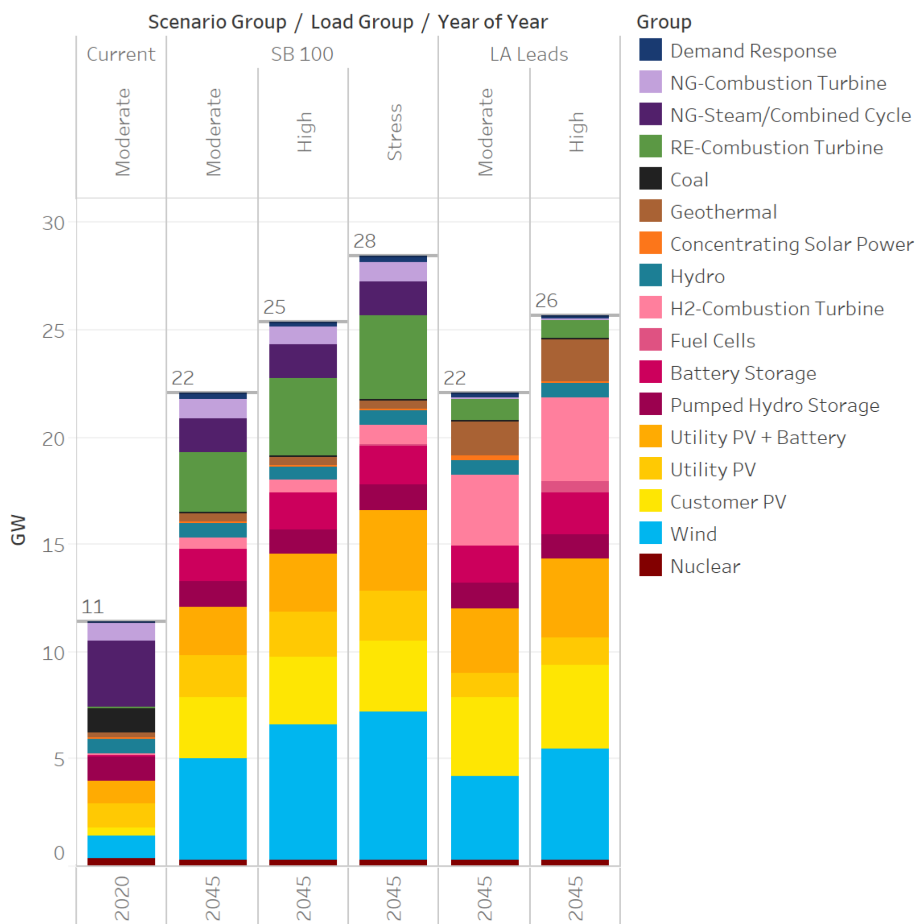
Tradeoffs in large-scale infrastructure development

Alternative Load Future: Core Cases

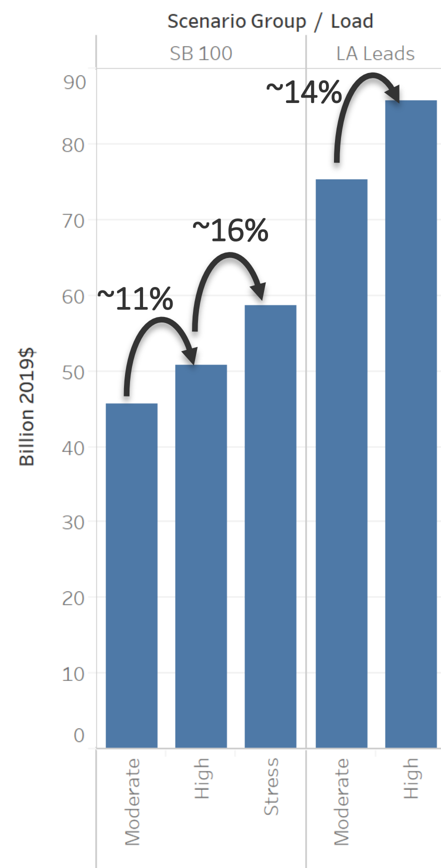
- **SB100:** alternative load futures (moderate, high, stress)
- **LA Leads:** alternative load futures (moderate, high)

Electrification increases total costs, but energy efficiency and demand response can mitigate cost increases

Results subject to change



Cumulative through 2045 (excludes customer PV costs)



% Increase over Moderate Load Case	High	Stress
Peak Load	10%	30%
Total Load	19%	30%
SB 100 Cost	11%	16%
LA Leads Costs	14%	n/a

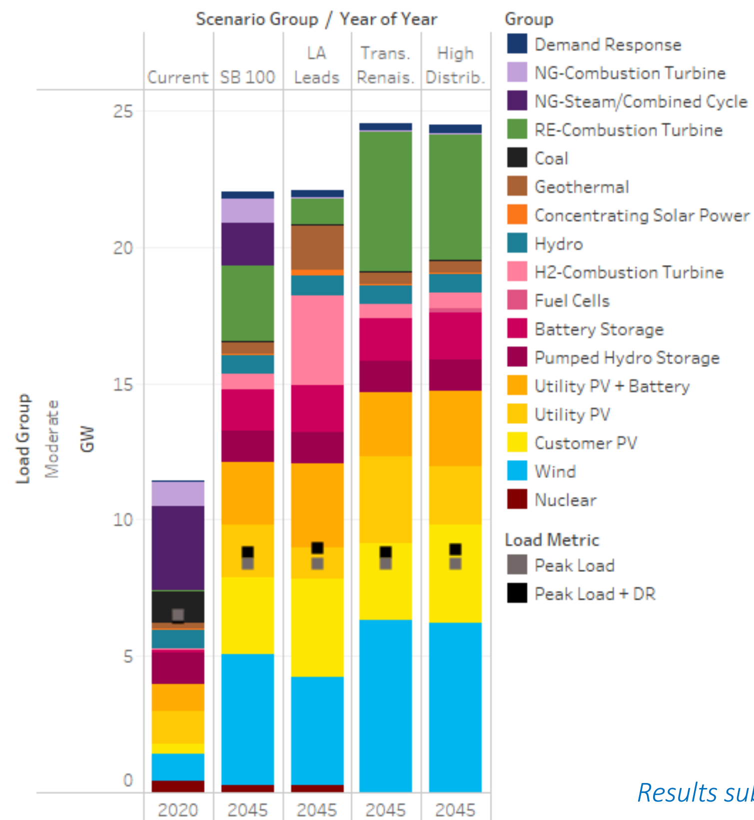
Section 2:

Implications of alternative load futures

Tradeoffs in large-scale infrastructure development

Renewable Resources Would Be Deployed at a Rapid Pace

- Core scenarios require rapid buildout of variable generation (wind and solar) assets
  - 2021-2035: average of ~370 MW/yr to 556 MW/yr
  - 2021-2045: average of ~330 MW/yr to 570 MW/yr
- In-basin RE-CTs and H_2-CTs must also be sited and constructed rapidly
  - 2.4 GW to 4.2 GW by 2035
  - 3.3 GW to 7 GW by 2045

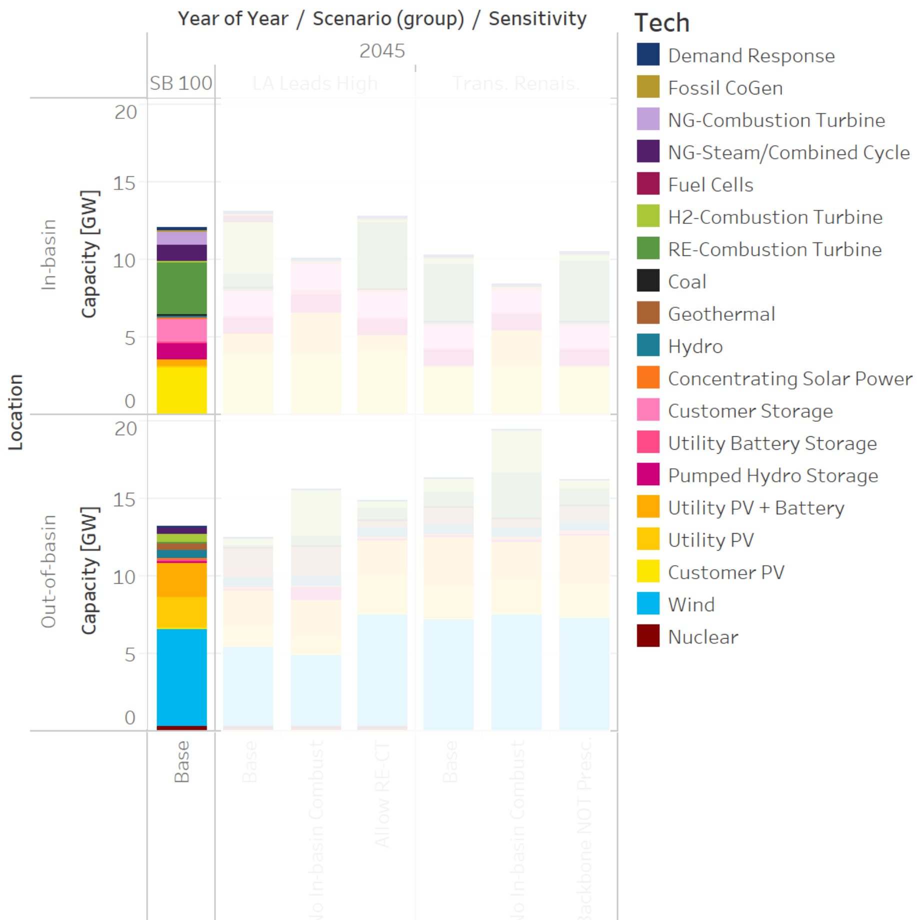


Results subject to change

Trade-offs in Large-Scale Infrastructure: Sensitivity Cases

- LA Leads High:
  - **LA Leads – No In-Basin Combustion:** no new combustion turbines (H_2 or other fuels) or fuel cells can be sited in basin
  - **LA Leads – RE-CT:** allows the siting of renewably fueled (e.g., biofuel) combustion turbines in basin
- Transmission Renaissance High:
  - **Tx. Renais. – No In-basin Combustion:** no new combustion turbines (H_2 or other fuels) or fuel cells can be sited in basin
  - **Tx. Renais. – No prescribed backbone:** the DC backbone is allowed to be built, but is not required to be built

Tradeoffs in Large-Scale Infrastructure



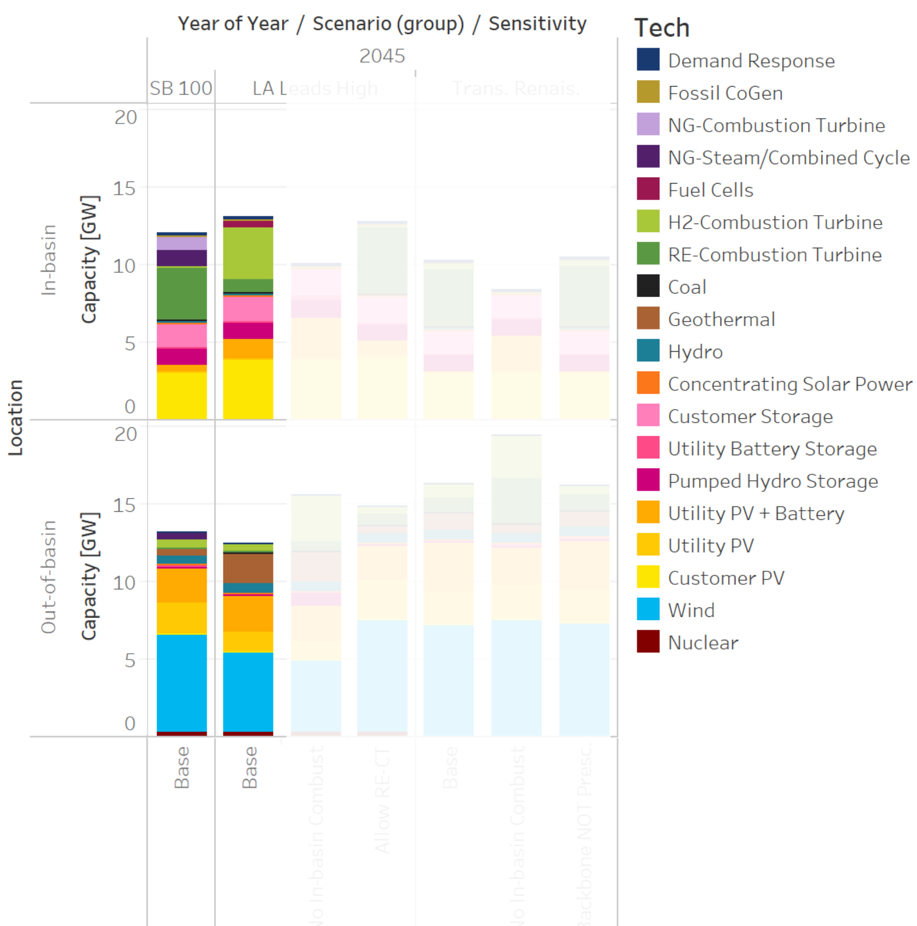
Transmission Builds

Scenario (group) / Scenario

Location	SB 100 SB 100 High	LA Leads LA Leads High Base	LA Leads LA Leads High No Inbasin Combustion	LA Leads LA Leads High RE-CT	Trans. Renais. Trans. Renais. High	Trans. Renais. Trans. Renais. High No Inbasin Combustion	Trans. Renais. Trans. Renais. High No Presc. Backbone
In Basin	839 MW 9 lines 72.9 km	708 MW 7 lines 69.5 km	5,163 MW 17 lines 174.8 km	1,319 MW 9 lines 83.1 km	1,613 MW 8 lines 70.5 km	5,563 MW 14 lines 147.0 km	775 MW 5 lines 42.3 km
In Basin DC					7,500 MW 3 lines 60.0 km	7,500 MW 3 lines 60.0 km	2,228 MW 3 lines 60.0 km
Out of Basin	106 MW 1 lines 56.7 km	2,511 MW 3 lines 378.9 km	2,523 MW 3 lines 378.9 km		309 MW 3 lines 164.1 km	620 MW 2 lines 142.7 km	280 MW 3 lines 164.1 km
Out to In					1,700 MW 1 lines 109.6 km	1,700 MW 1 lines 109.6 km	1,543 MW 1 lines 109.6 km

Results subject to change

Tradeoffs in Large-Scale Infrastructure



Transmission Builds

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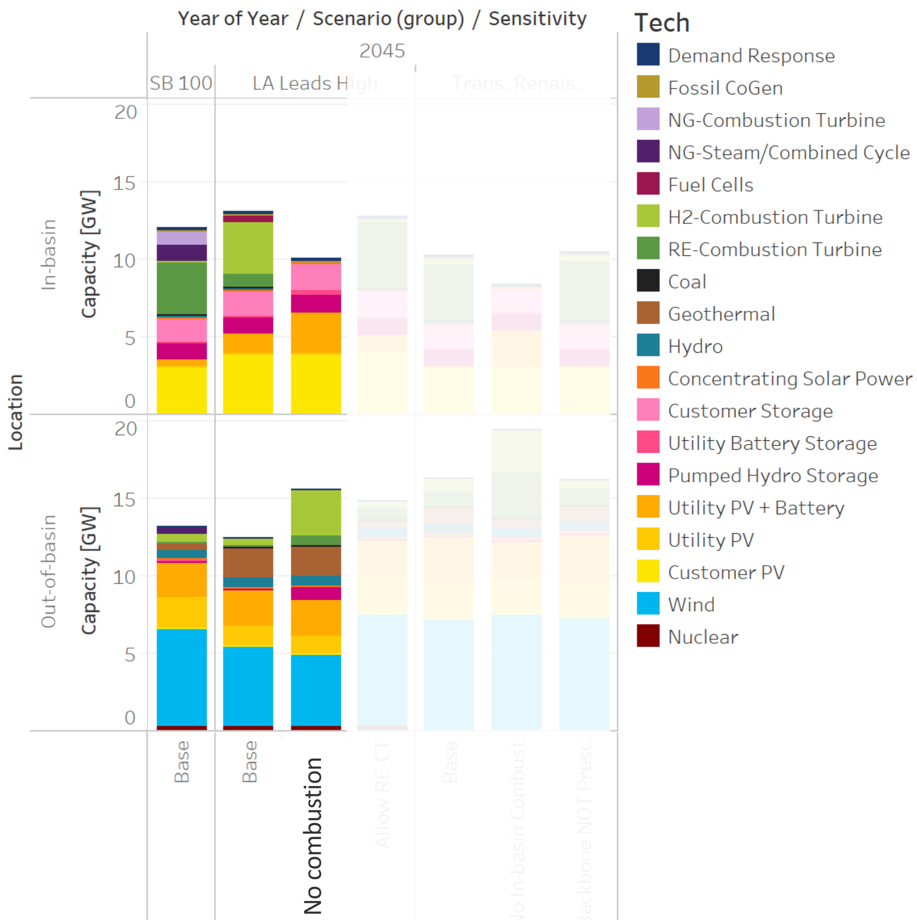
Results subject to change

LA Leads: not allowing in-basin combustion would require a substantial increase in in-basin transmission



Transmission Builds

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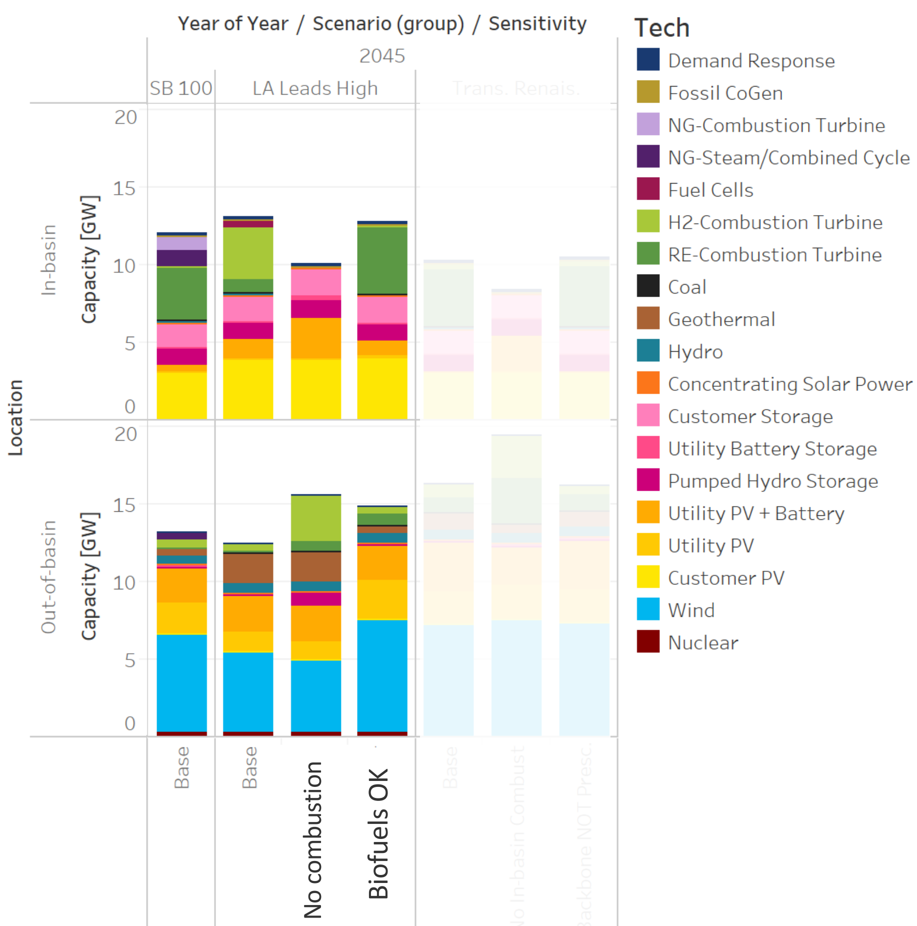
Results subject to change

LA Leads: allowing biofuels (through 2040) would require a small increase in in-basin transmission and eliminate the need for new out-of-basin transmission



Transmission Builds

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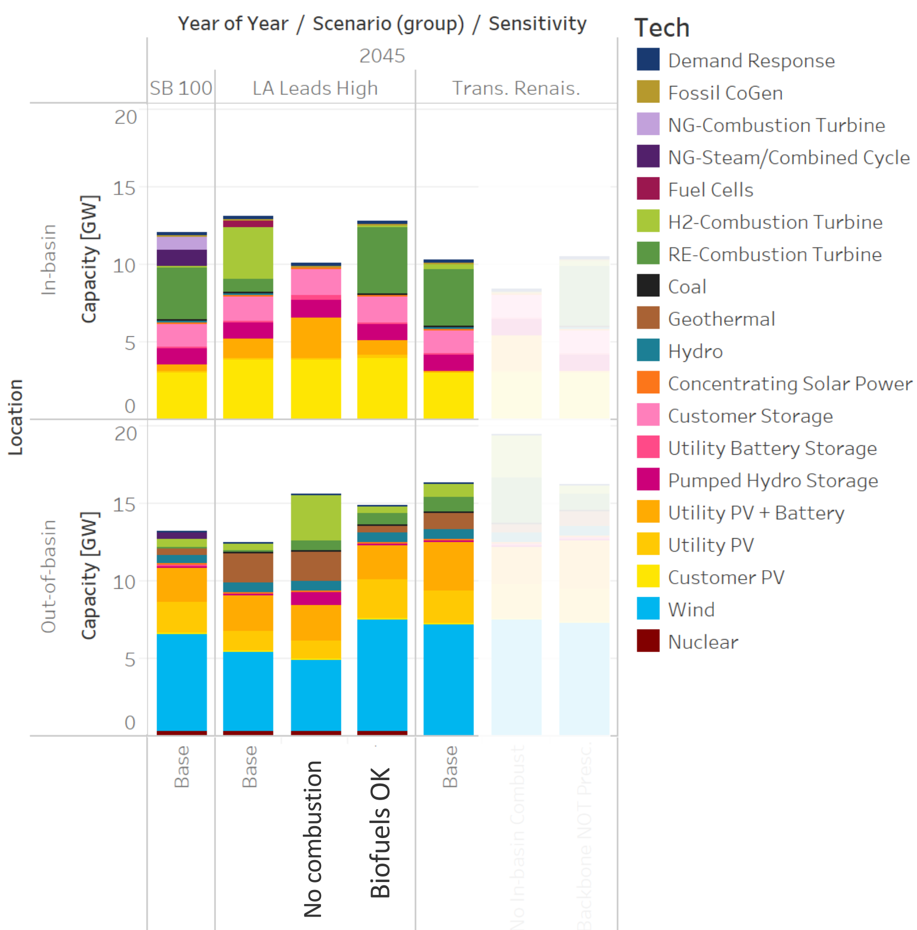
Results subject to change

Tradeoffs in Large-Scale Infrastructure

Results subject to change



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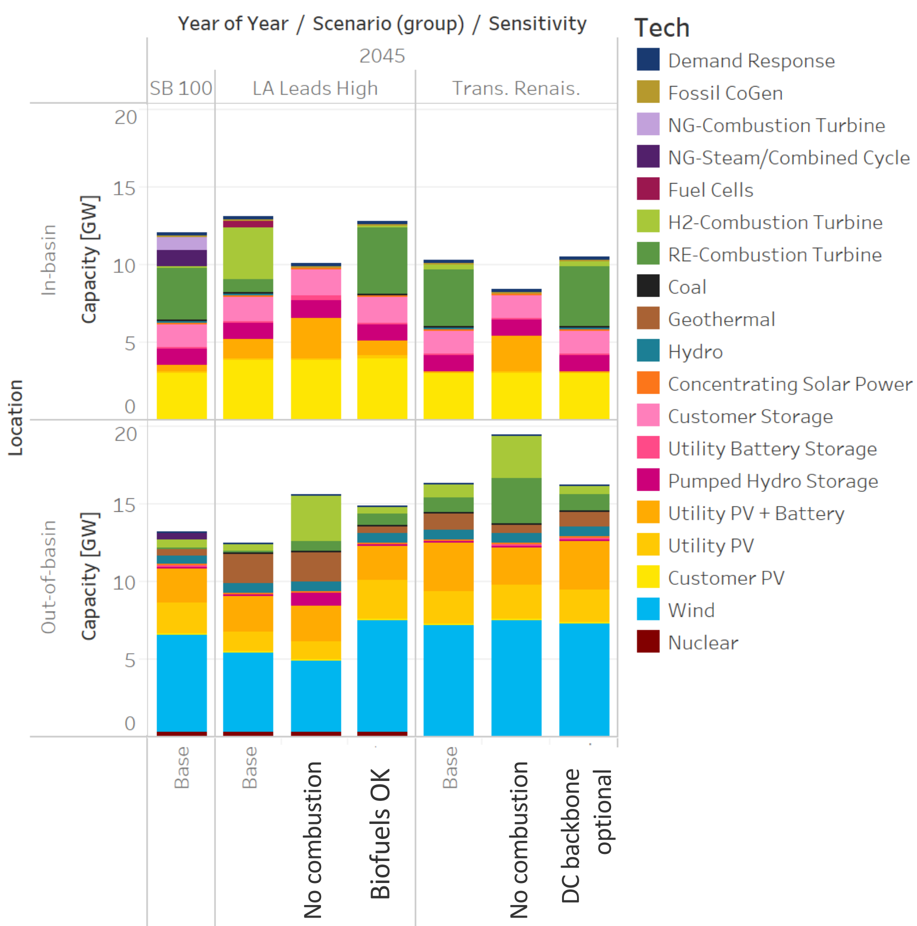
Results subject to change

Eliminating in-basin combustion would require substantially more in-basin transmission, even with a DC backbone; making the backbone optional results in reduced size of backbone



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In Basin	839 MW 9 lines 72.9 km	708 MW 7 lines 69.5 km	5,163 MW 17 lines 174.8 km	1,319 MW 9 lines 83.1 km	1,613 MW 8 lines 70.5 km	5,563 MW 14 lines 147.0 km	775 MW 5 lines 42.3 km
In Basin DC					7,500 MW 3 lines 60.0 km	7,500 MW 3 lines 60.0 km	2,228 MW 3 lines 60.0 km
Out of Basin	106 MW 1 lines 56.7 km	2,511 MW 3 lines 378.9 km	2,523 MW 3 lines 378.9 km		309 MW 3 lines 164.1 km	620 MW 2 lines 142.7 km	280 MW 3 lines 164.1 km
Out to In					1,700 MW 1 lines 109.6 km	1,700 MW 1 lines 109.6 km	1,543 MW 1 lines 109.6 km

Results subject to change

Section 2:

Q&A

Section 3:

Implications of alternative technology futures

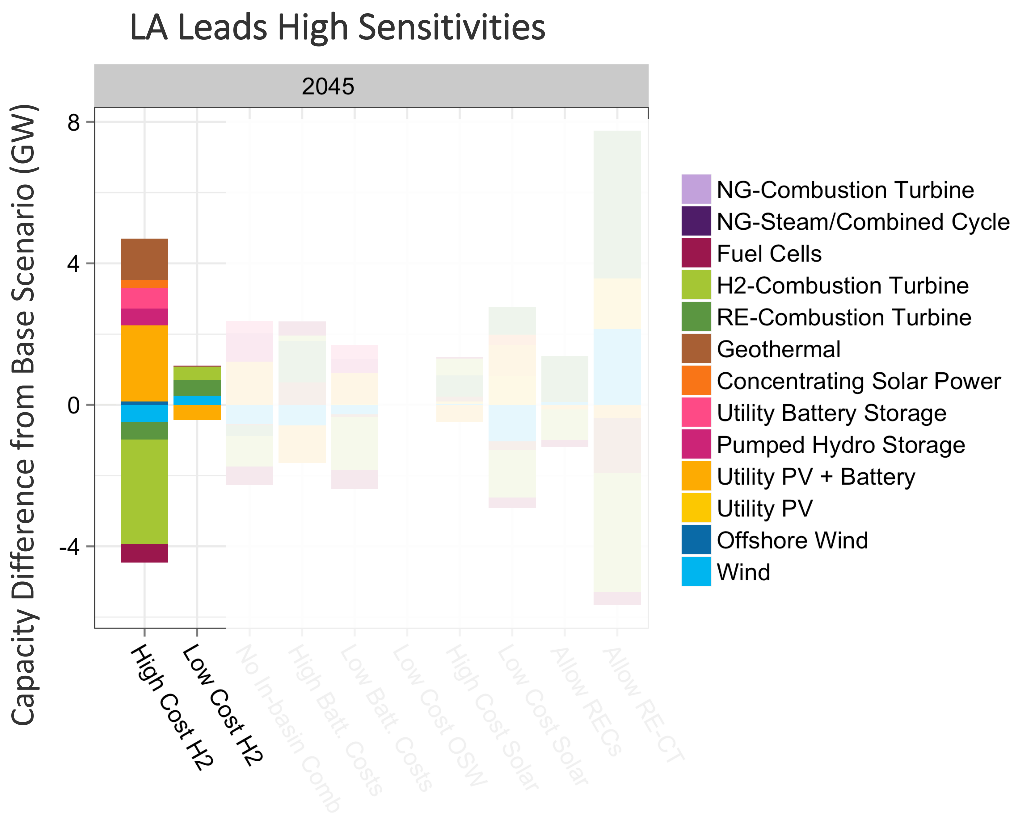
Alternative Assumptions About the Future Cost and Availability or Eligibility of Technologies Can Drive Shifts in Deployment

Results subject to change

However, the overall roles of variable generation, storage, and firm capacity resources remain consistent

Higher H_2 costs → growth in alternative sources of firm capacity

Lower H_2 costs → small changes, as H_2 already heavily relied upon

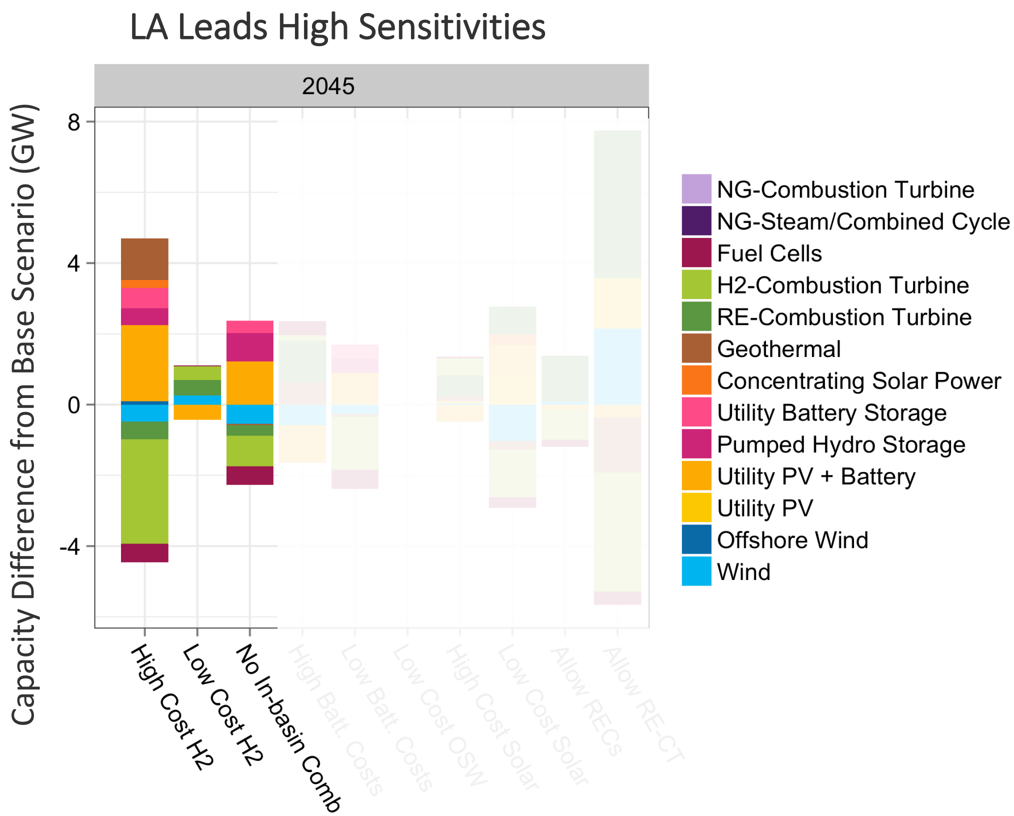


Results subject to change

Alternative Assumptions About the Future Cost and Availability or Eligibility of Technologies Can Drive Shifts in Deployment

Results subject to change

No in-basin combustion or fuel cells → shift from in-basin CT and fuel cell technologies to PV+battery, pumped hydro, and battery storage



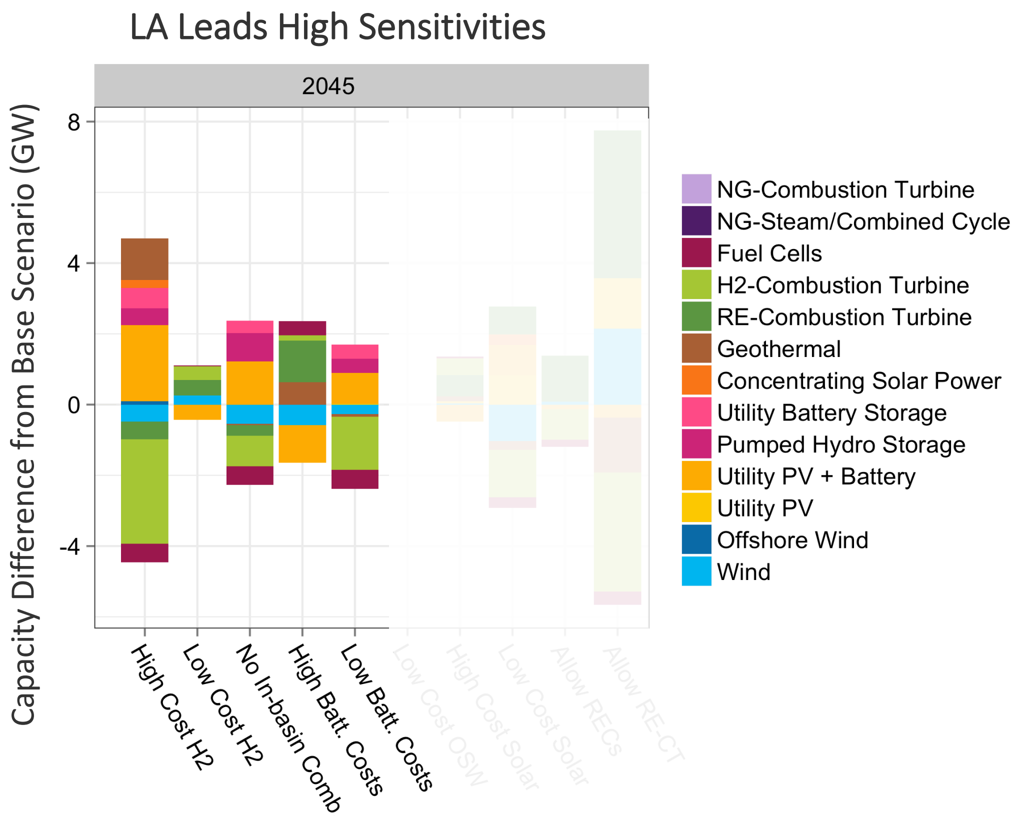
Results subject to change

Alternative Assumptions About the Future Cost and Availability or Eligibility of Technologies Can Drive Shifts in Deployment

Results subject to change

Higher battery costs → more geothermal and hydrogen storage

Lower battery costs→ more medium-duration storage and less hydrogen storage



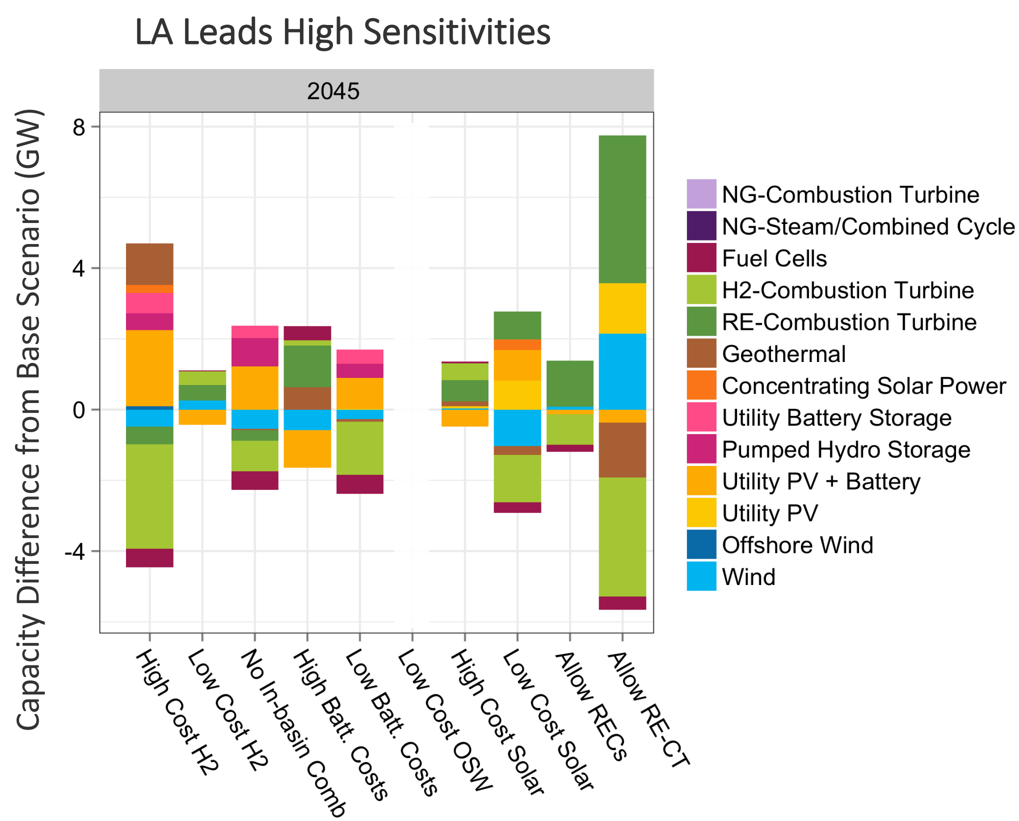
Results subject to change

Alternative Assumptions About the Future Cost and Availability or Eligibility of Technologies Can Drive Shifts in Deployment

Results subject to change

High cost solar → more reliance on H_2 storage

Low cost solar → more reliance on PV for energy (less on wind), capacity resources shift to PV+battery, concentrated solar power, and delay the need for H_2 storage

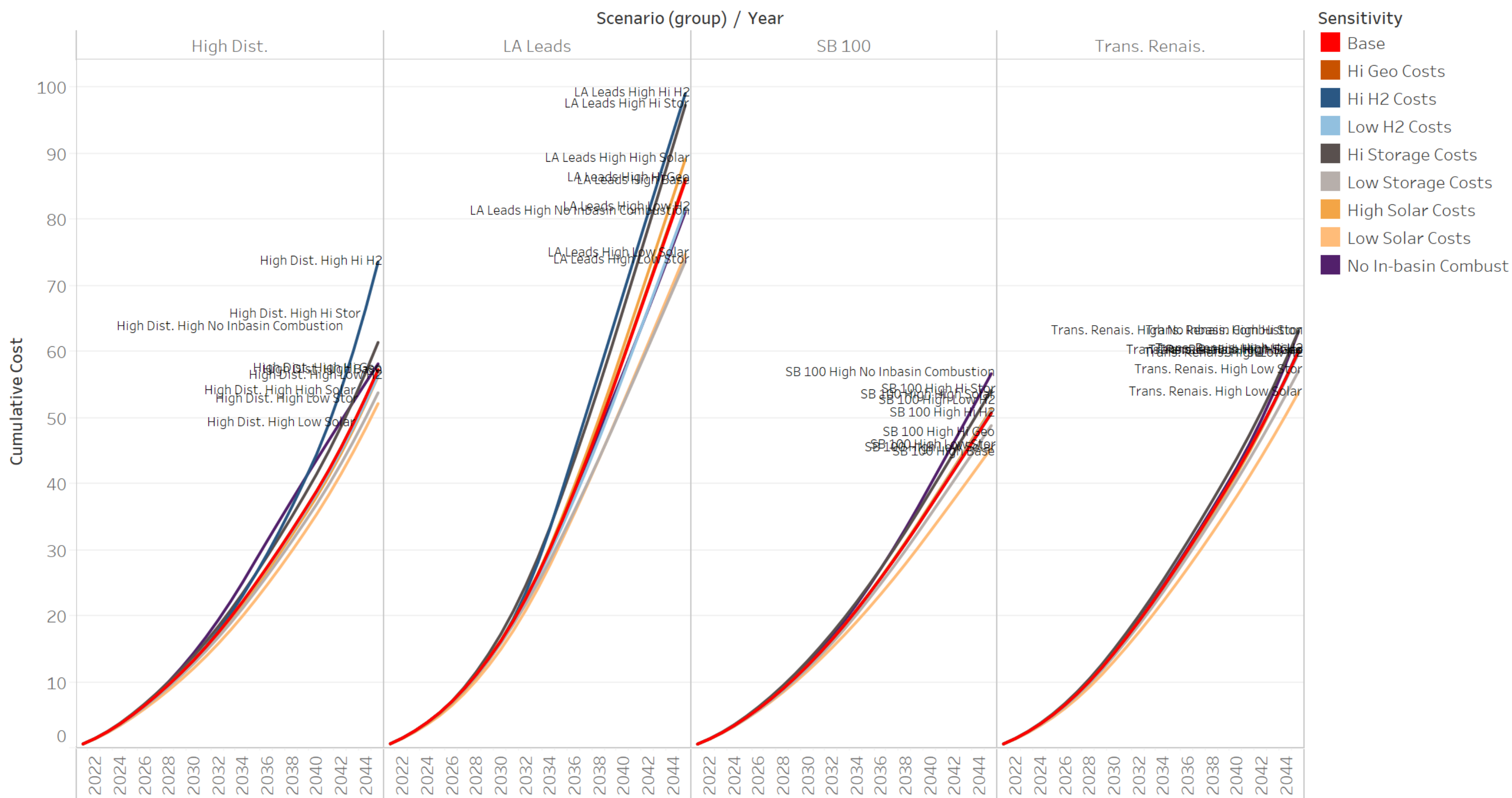


Results subject to change

Costs are sensitive to assumptions, particularly under LA Leads; value in maintaining options

Results subject to change

Impact of technology cost and availability assumptions on total cumulative costs



Q & A

Extra slides for context

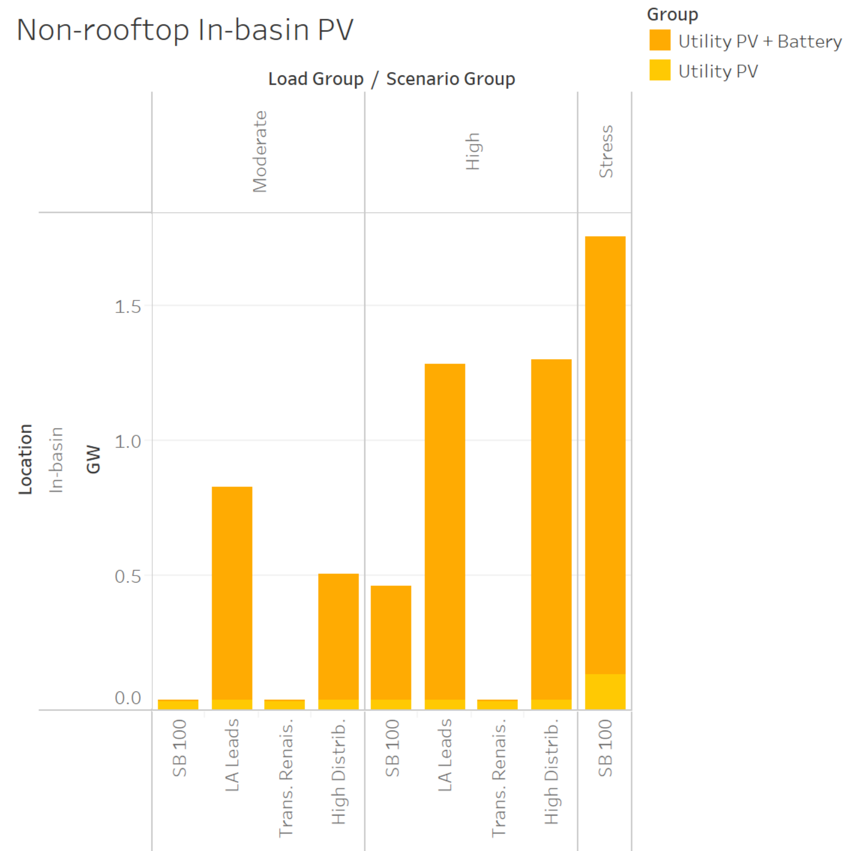
Role of In-Basin Resource Sensitivities

- Rely solely on the core LA100 scenarios:
  - SB100—Moderate, High, Stress Load
  - LA Leads—Moderate and High Load
  - Transmission Renaissance—Moderate and High Load
  - High Distributed Energy Future—Moderate and High Load

In-Basin Assets Driven by Requirement to Meet Load Locally

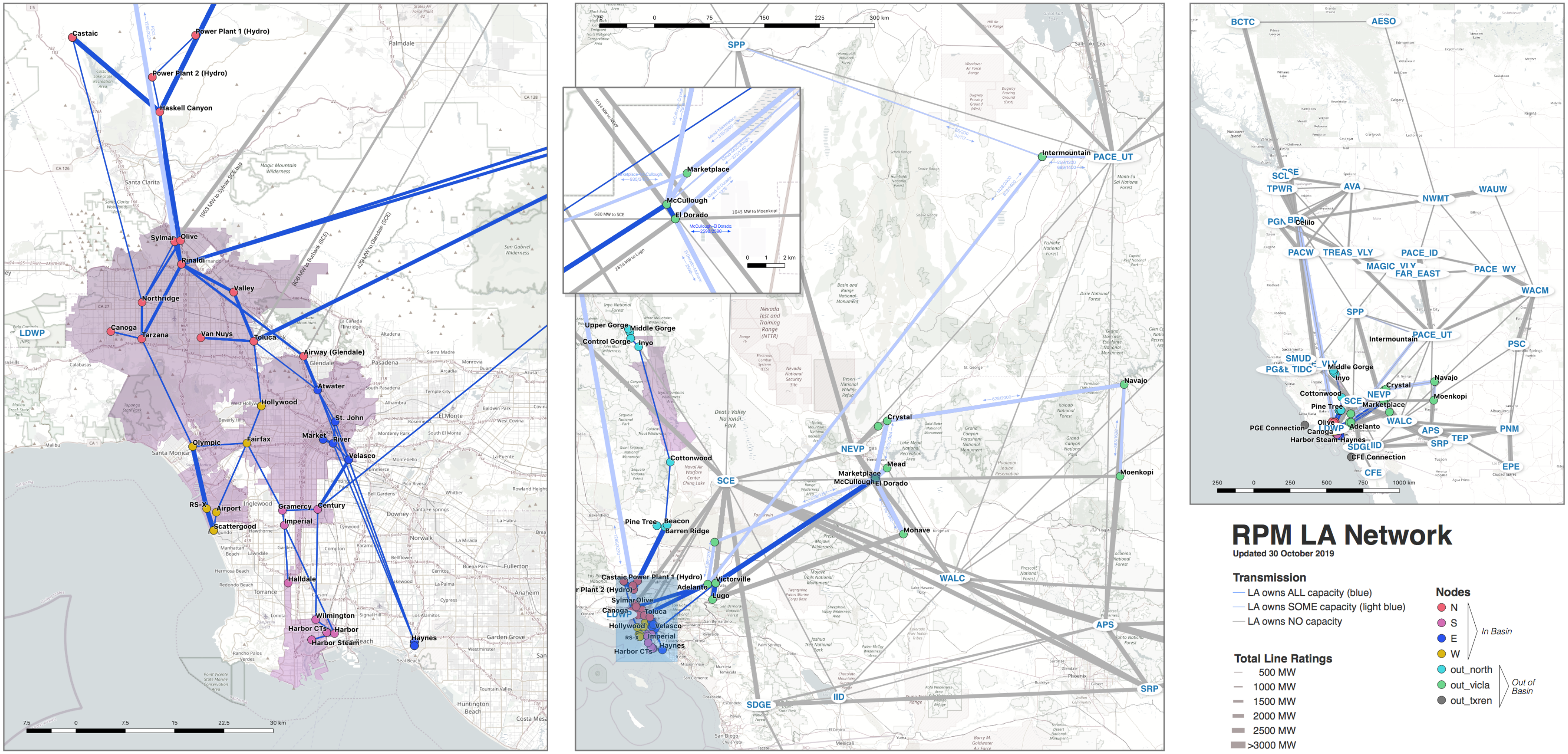
Results subject to change

- In-basin firm capacity deployed across all scenarios [covered last AG]
- Non-rooftop in-basin solar (utility deployed) and co-located storage offers substantially higher value to the grid when in-basin capacity is higher cost, not eligible, and/or when load is more extreme

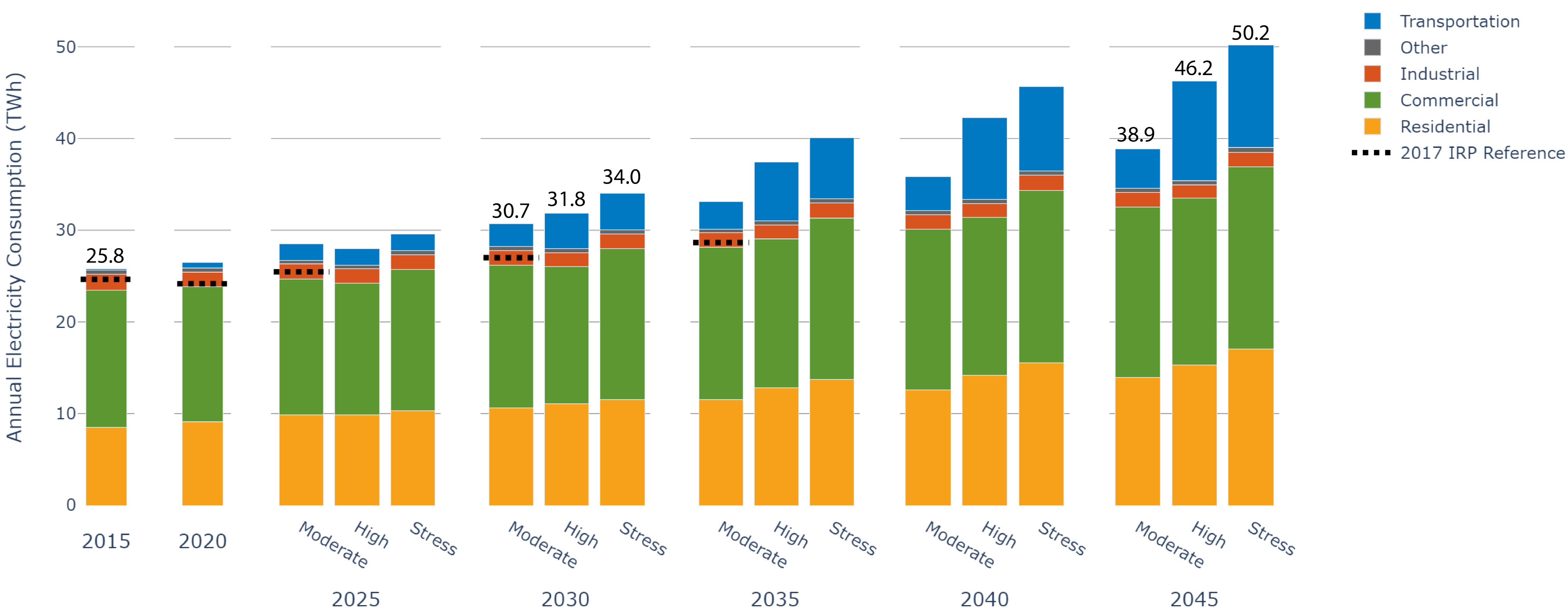


Results subject to change

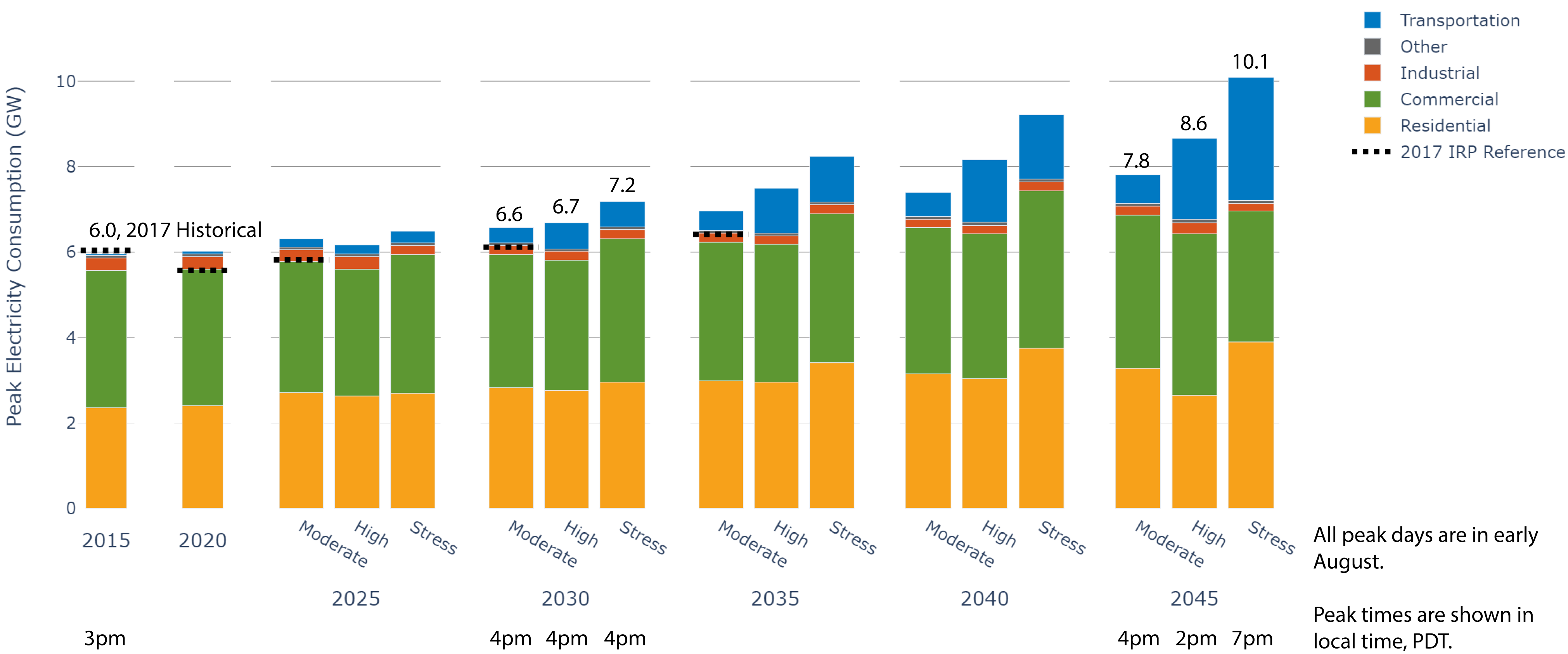
LADWP Transmission Network



Annual Electricity Consumption (TWh) by Sector



Peak Demand (GW) by Sector



All peak days are in early August.

Peak times are shown in local time, PDT.