SCE's Clean Power and Electrification Pathway
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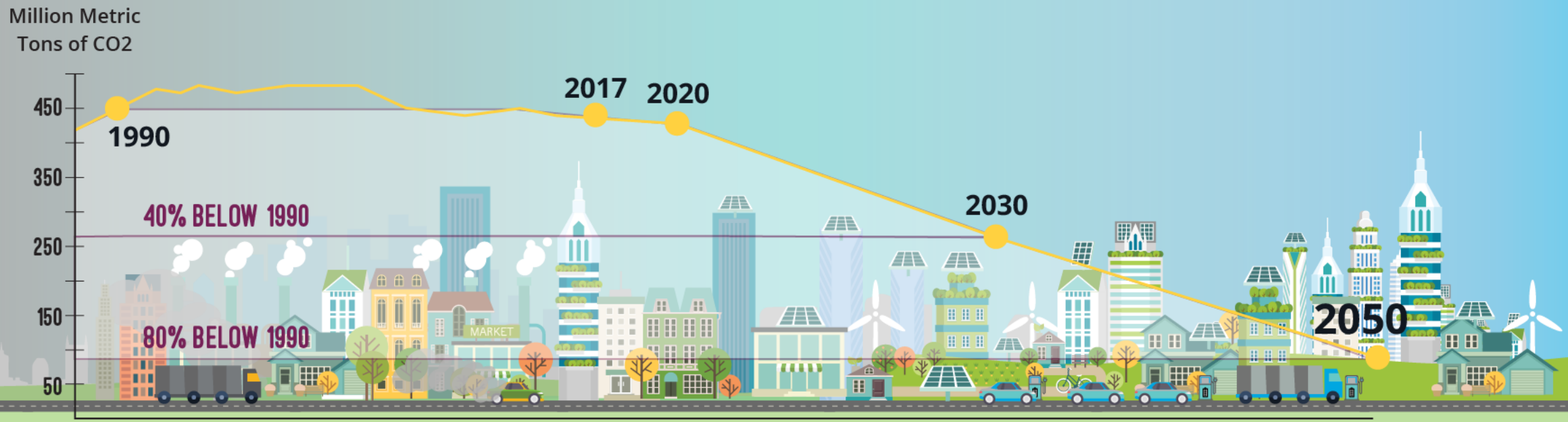
Goals to improve

- California set a goal to **reduce emissions 40%** below 1990 levels by 2030, and 80% by 2050.



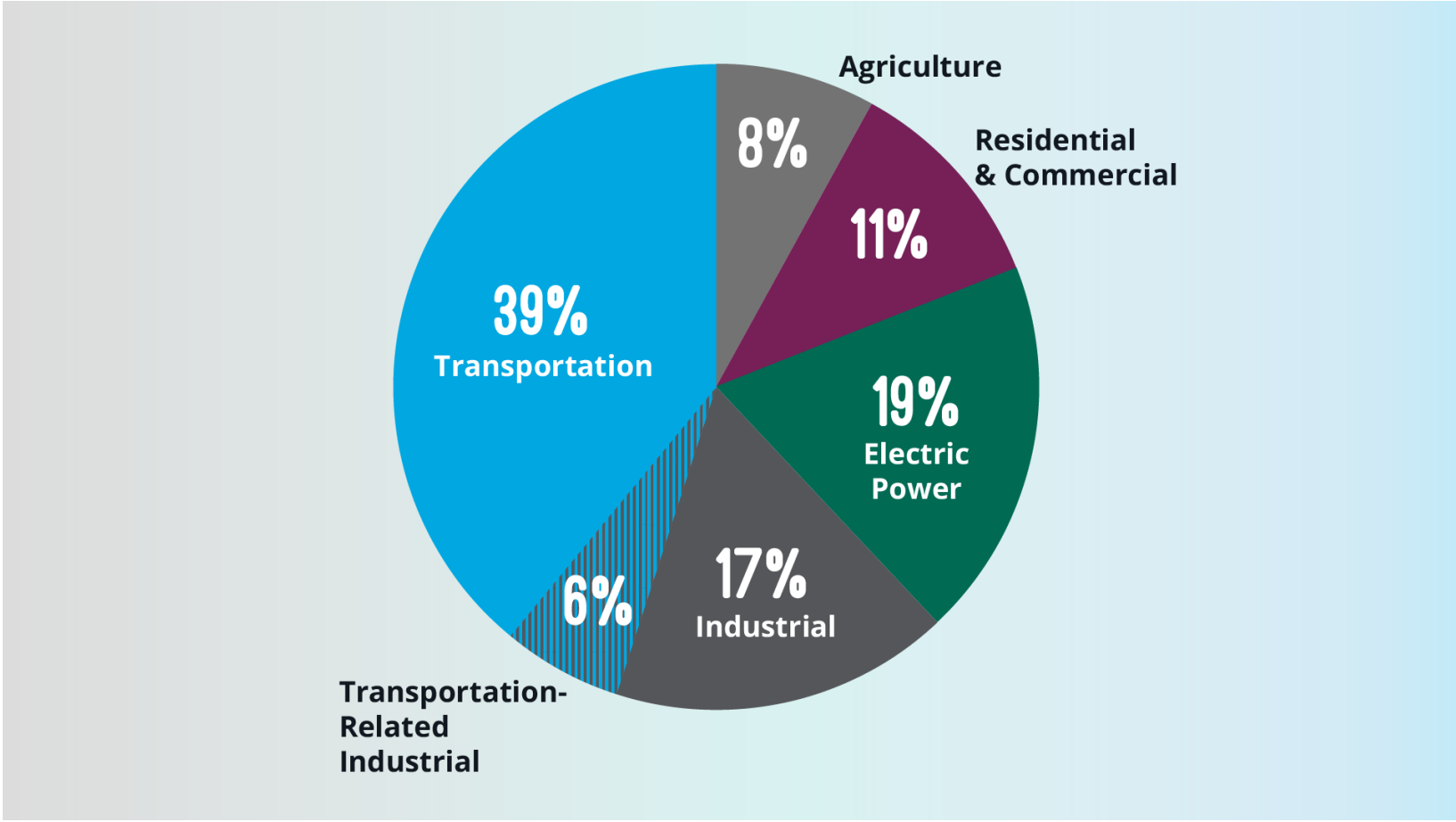
If we want to get to **zero emissions**, eventually we have to **replace** many of the things we rely on today that require combustion.

Emissions contributors

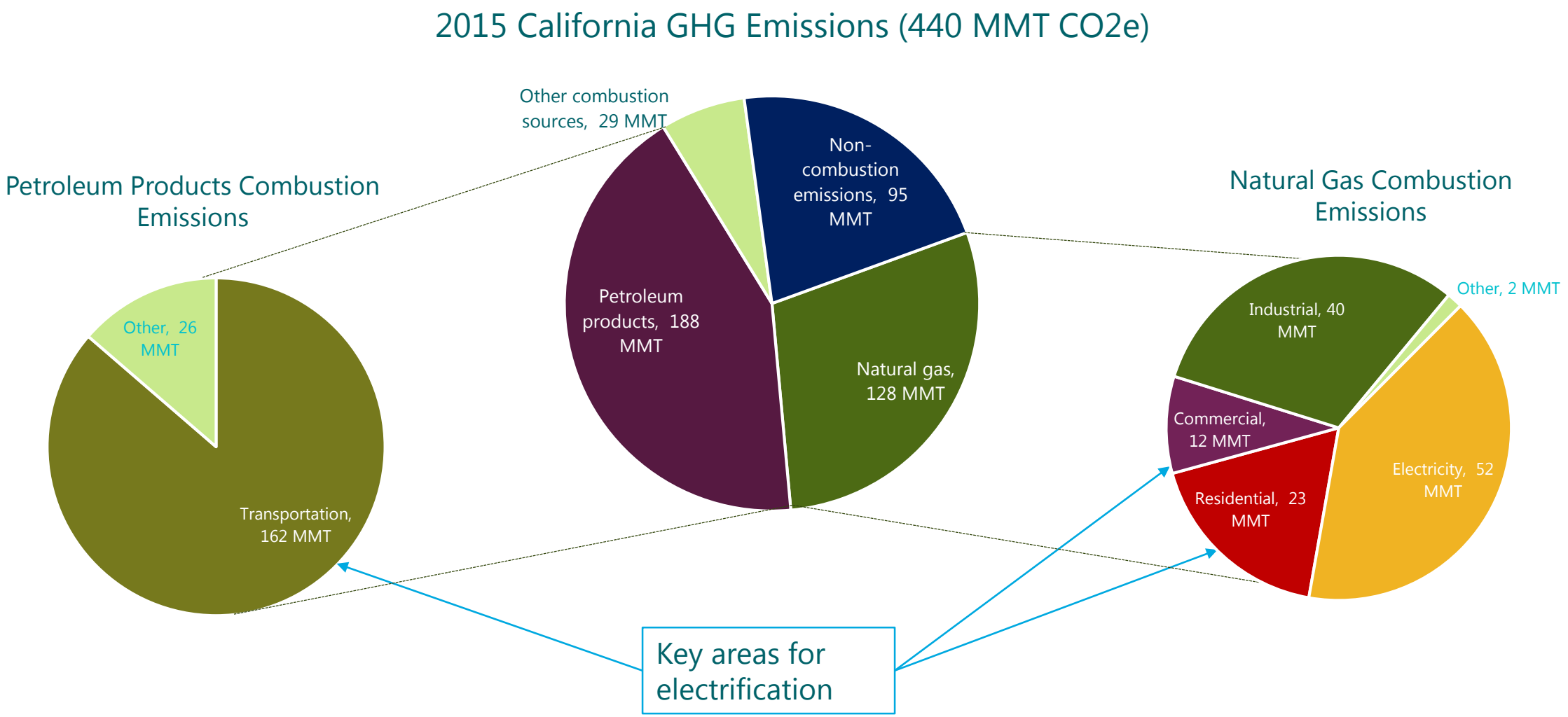
- The largest contributor is **transportation**, followed by the electric sector.

  Industrial, and commercial and residential sectors trail not too far behind.

- The most **practical and economical** way to create real change is for sectors to **work together** to find an affordable alternative to fossil fuels.



Fossil Fuel combustion accounts for 80% of CA's GHG Emissions



Source: ARB CA GHG Emissions Inventory

SCE's approach to modeling what's needed to meet CA's GHG abatement goals

	CARB Scoping Plan - 2017	SCE Economic Scenario	Clean Power & Electrification
What is it?	• California Air Resources Board plan to achieve GHG abatement goals • Economy-wide pathway/allocation of measures across sectors	• SCE-built economic viewpoint focusing on 3 primary sectors (Transportation, Residential, Energy Supply) and several (e.g. residential water heaters, light duty PHEVs)	• SCE-built perspective on a feasible, lowest societal cost path to reach the GHG target • Overlays economic scenario with opportunities to expand cost-effective and feasible abatement through additional levers
How is it built?	• Represents current policies and known commitments as well as additional measures • Facilitated through the PATHWAYS model	• Cost and efficiency inputs built with market based analysis for several key measures • Estimation of economically driven technology adoption / fuel penetration (e.g., TCO, price parity analysis)	• Combines economic scenario of TCO-based consumer adoption with viewpoint on initiatives to lower TCO or drive adoption through policy measures • Facilitated through PATHWAYS model
Abatement results	• Relies on Cap and Trade to fill gaps in meeting GHG abatement goal	• Reduces total cost of abatement for CA, does not meet GHG abatement goal • Updates abatement cost estimates, informs perspective on measures to be expanded	• Achieves CA GHG abatement goals through layered view of economic adoption and economic / policy initiatives

Multiple scenarios were evaluated for feasibility and cost

Scenario Measures and Impacts	Clean Power and Electrification	Renewable Natural Gas	Hydrogen Pathway
Carbon-Free Electricity	80%	60%	80%
Management of Over-Gen	10 GW Battery Storage	Power to Gas	Hydrogen Production
Transportation LDV	7 Mil EVs 24% of LDV Stock	7 Mil EVs 24% of LDV stock	2 Mil EVs 4 Mil Fuel Cell Vehicles 22% of LDV stock
	~13% Reduction in Transportation Related Refinery Throughput		
Transportation MDV&HDV	9% MDV, 6% HDV use CNG	12% MDV, 12% HDV use CNG	4% HDV use Fuel Cells 7% MDV, 6% HDV use CNG
	15% MDV, 6% HDV are EV	7% MDV, 1% HDV are EV	
Space and Water Heating	30% Electrification	42% of Natural Gas Replaced by RNG, 7% of Natural Gas Replaced by Hydrogen	30% Electrification
Fuels and Other End Uses	7% of Natural Gas replaced by RNG		7% of Natural Gas Replaced by Hydrogen
Risks	Dependent on Broad Adoption of Electrified Technologies	- Power to Gas Technology not Commercially Available - Relies on Significant Imports of Biomass	Lack of Hydrogen Delivery Infrastructure
Average Abatement Cost	$37/metric ton	$47/metric ton	$70/metric ton
Incremental Abatement Cost	$79/metric ton	$137/metric ton	$262/metric ton

SCE's Integrated Clean Power and Electrification Pathway

80% carbon-free energy

- An effective statewide IRP process will be a critical enabler
- The location of the additional 30 GW will influence need for increased transmission capacity
- Significant amount of storage required, but can be reduced with a more balance among resources

7 million vehicles

- Collaboration and education between OEMs, charging companies, policymakers and electric utilities is needed
- A durable multi-year funding stream for incentives is important until EV prices come down
- Funding needed for the expansion of infrastructure to support necessary EV growth

Nearly 1/3 of space and water heating

- Update building codes and standards; use 2022 cycle (not 2025)
- Collaboration between manufacturers, repair service providers and policymakers is needed to raise awareness and availability of space and water heating
- Need to explore additional policies to support

The electric system will need to be strengthened and modernized to enable increasing electrical demand, flexibility, and resiliency

Solution Part 1: Clean the power grid

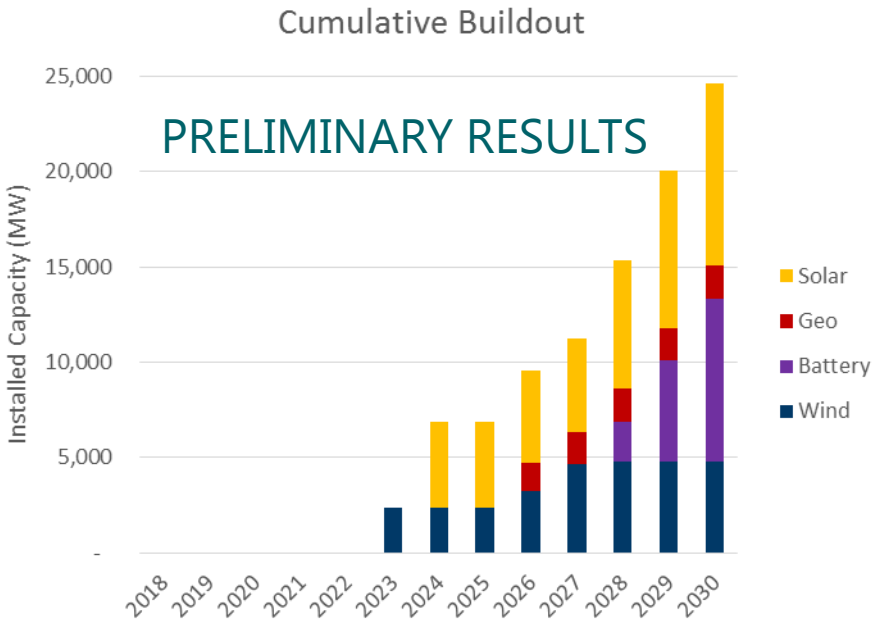
- By 2030, create an electric generation mix powered by at least **80% carbon-free resources.**
- More **solar**, **wind**, **hydropower** and other zero-emission sources, along with **battery storage.**
- Currently at about 40%.

Resources to decarbonize the bulk power system

- Significant **new utility-scale renewable generation** capacity
- **New transmission capacity**
- Mitigating an extreme "duck curve" through at least **10 GW of battery storage,** and **new controllable charging loads** from EVs and space and water heating

Clean Power & Electrification Incremental CAISO portfolio

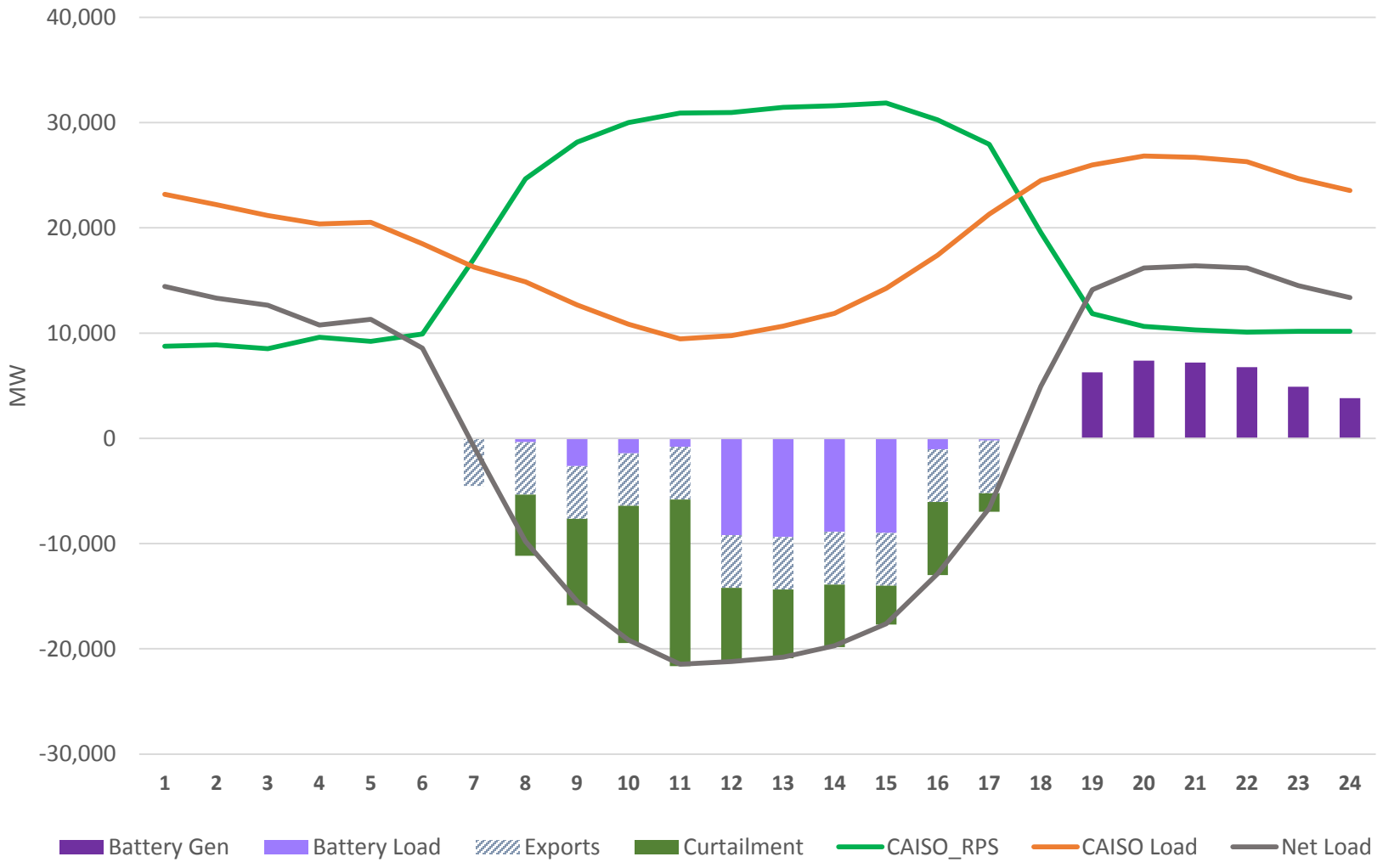
Optimized Cumulative CAISO New Resource Build



(MW)	2023	2024	2025	2026	2027	2028	2029	2030	Total
Geothermal	0	0	0	1,463	256	0	0	0	1,719
Solar	0	4,470	0	391	0	1,915	1,468	1,369	9,612
Wind	2,383	0	0	845	1,411	138	0	0	4,777
Battery	0	0	0	0	0	2,095	3,201	3,251	8,547
Total Renewables	2,383	4,470	0	2,699	1,667	2,052	1,468	1,369	16,108
Total Buildout (+Storage)	2,383	4,470	0	2,699	1,667	4,148	4,669	4,620	24,656

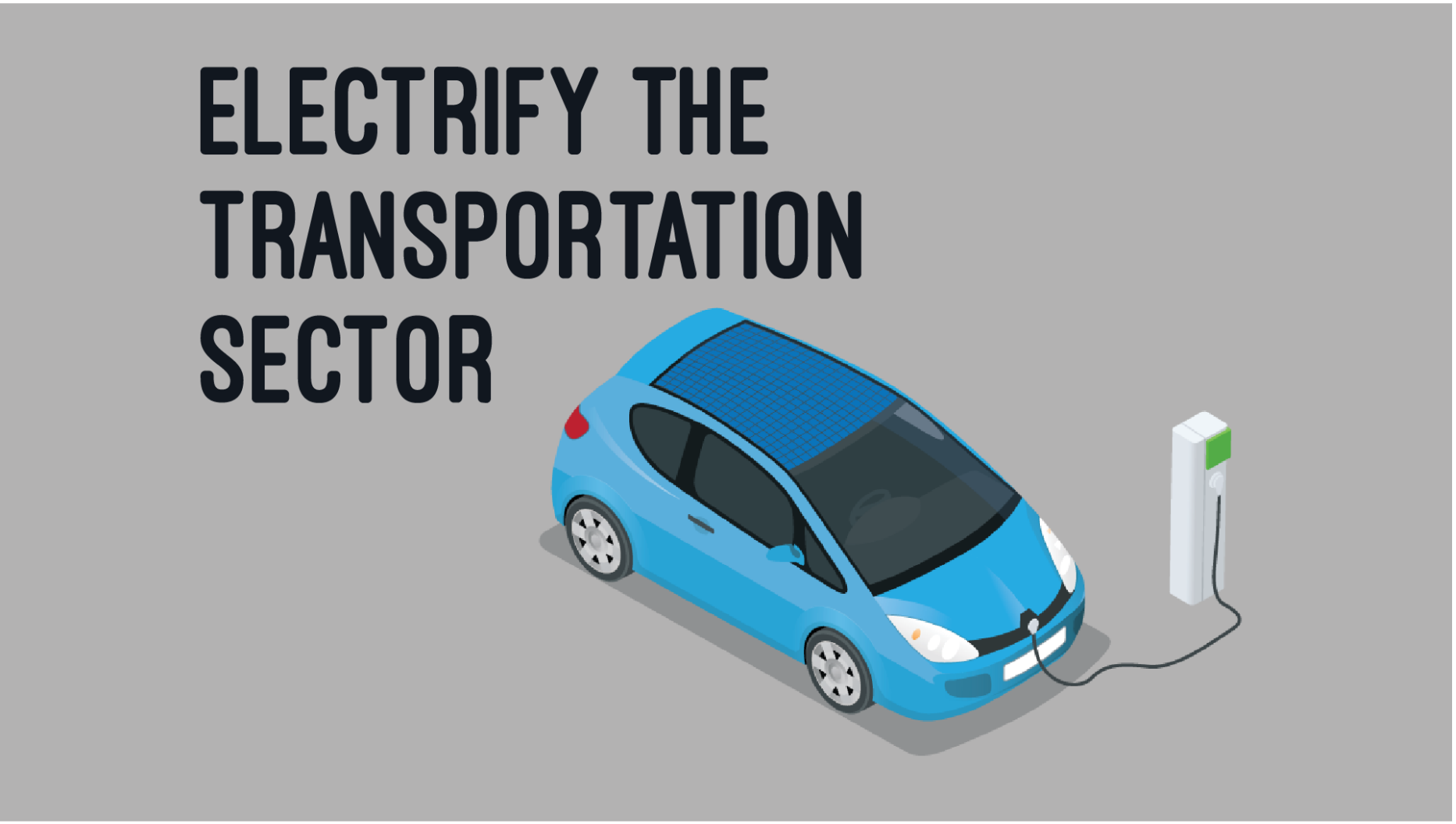
- **Model Assumptions:**
  - 2017 SCE CP&E load and shapes
  - RESOLVE resource cost, performance, and potential assumptions
  - 5,000 MW export limit
  - OTC gas retirements
  - DERs are not selectable resources
- **2023-2024 Procurement:** 6,800 MWs of economic wind and solar procurement
- **2026-2030 Procurement:** Remainder of build-out to meet carbon constraint
- **Storage:** 8+MW of 4-Hour battery storage chosen despite availability of longer duration products
- **2030 Imports:** Minimal unspecified imports

The worst day in Spring of 2030



Over-generation is mitigated by 10K MW battery charging load and moderate curtailment (17% of renewable curtailment on the worst day)

Solution Part 2: Electrify vehicles



- By 2030, **electrify 25% of cars and trucks** – about 7 million in total.
- Transportation accounts for **39%** of emissions today.
- Use **zero-emission** electric generation to power zero-emission vehicles.

The Transportation Electrification Pathway to 2030

24% of cars and light trucks
7 Million total

+

15% of medium-duty trucks and vans
180,000 total

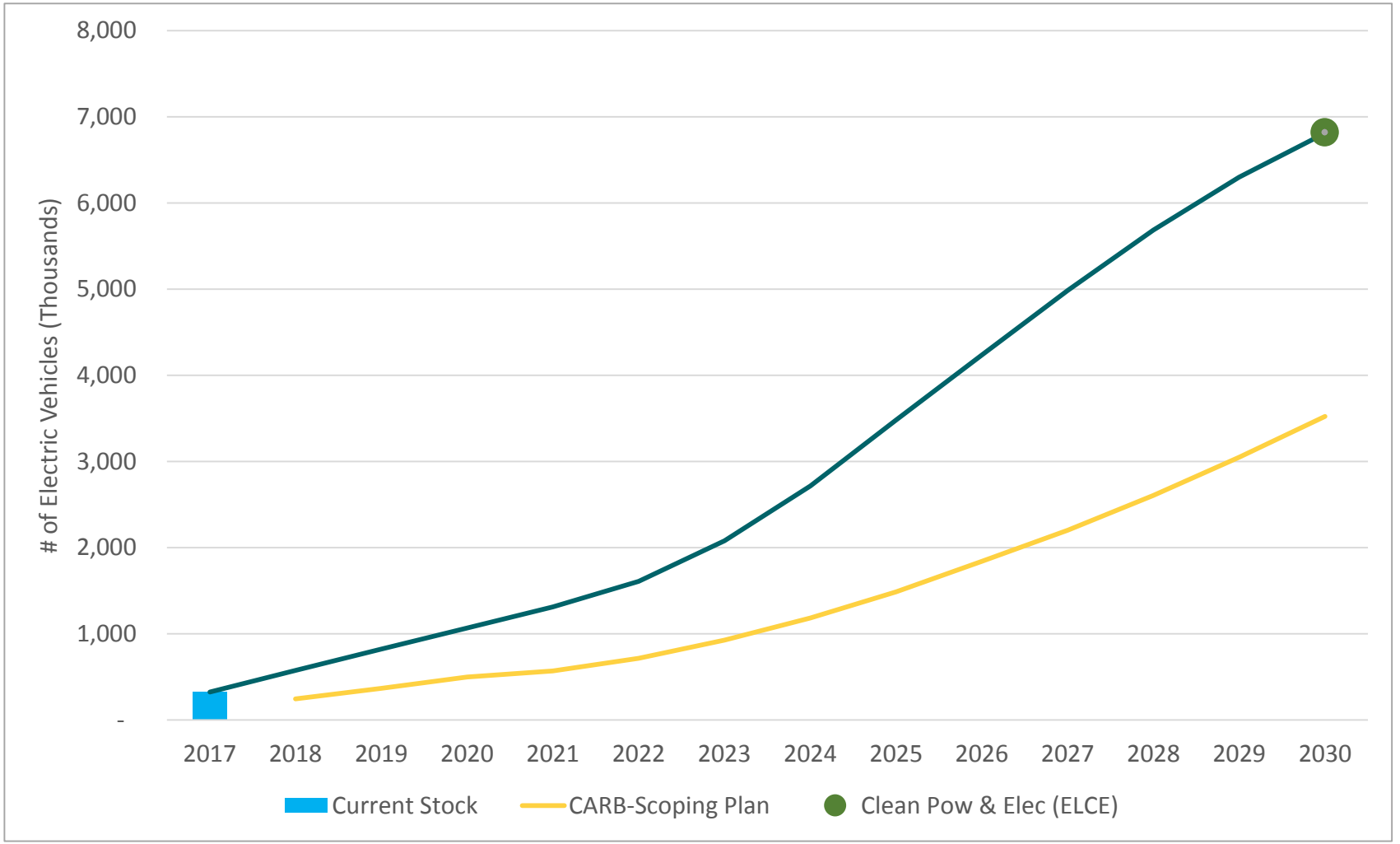
+

6% of heavy-duty trucks and buses
22,000 total

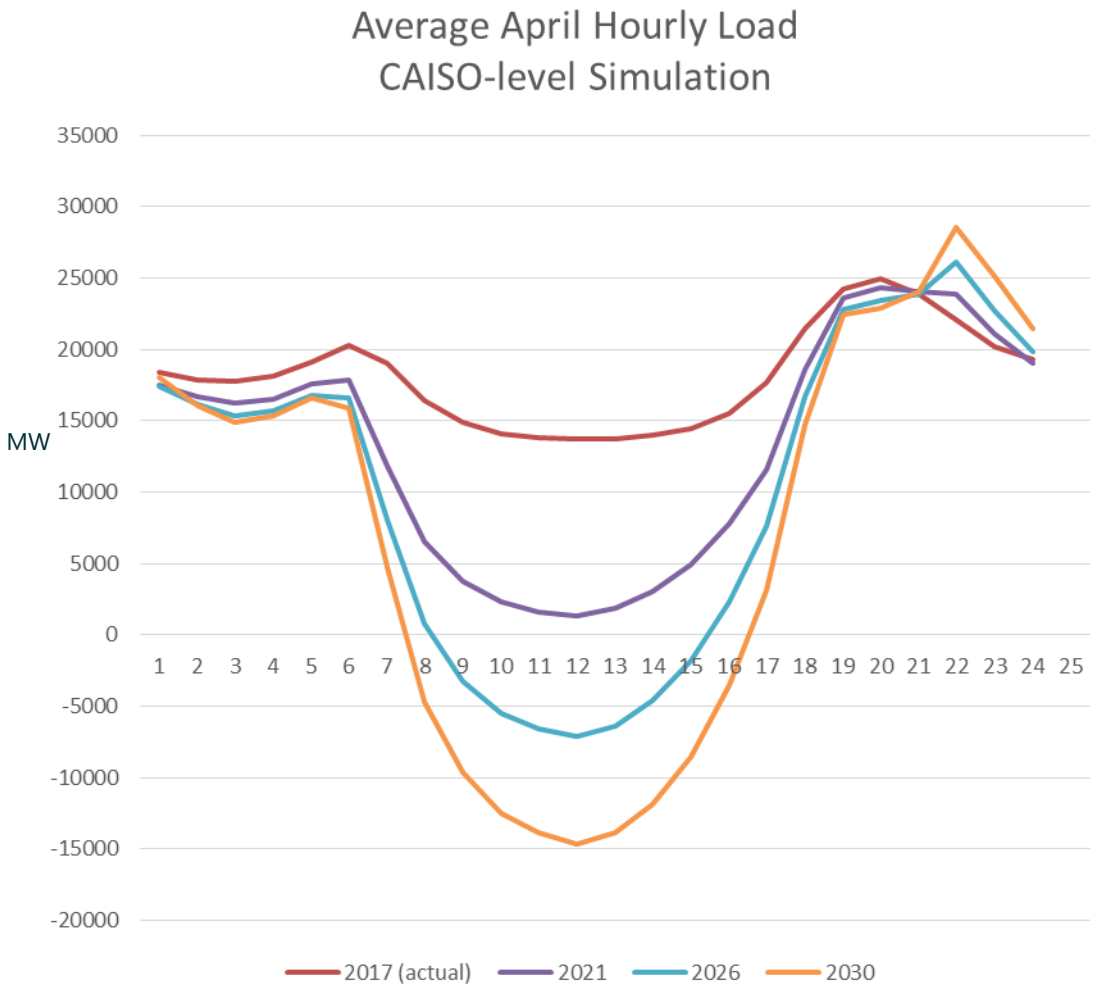
=

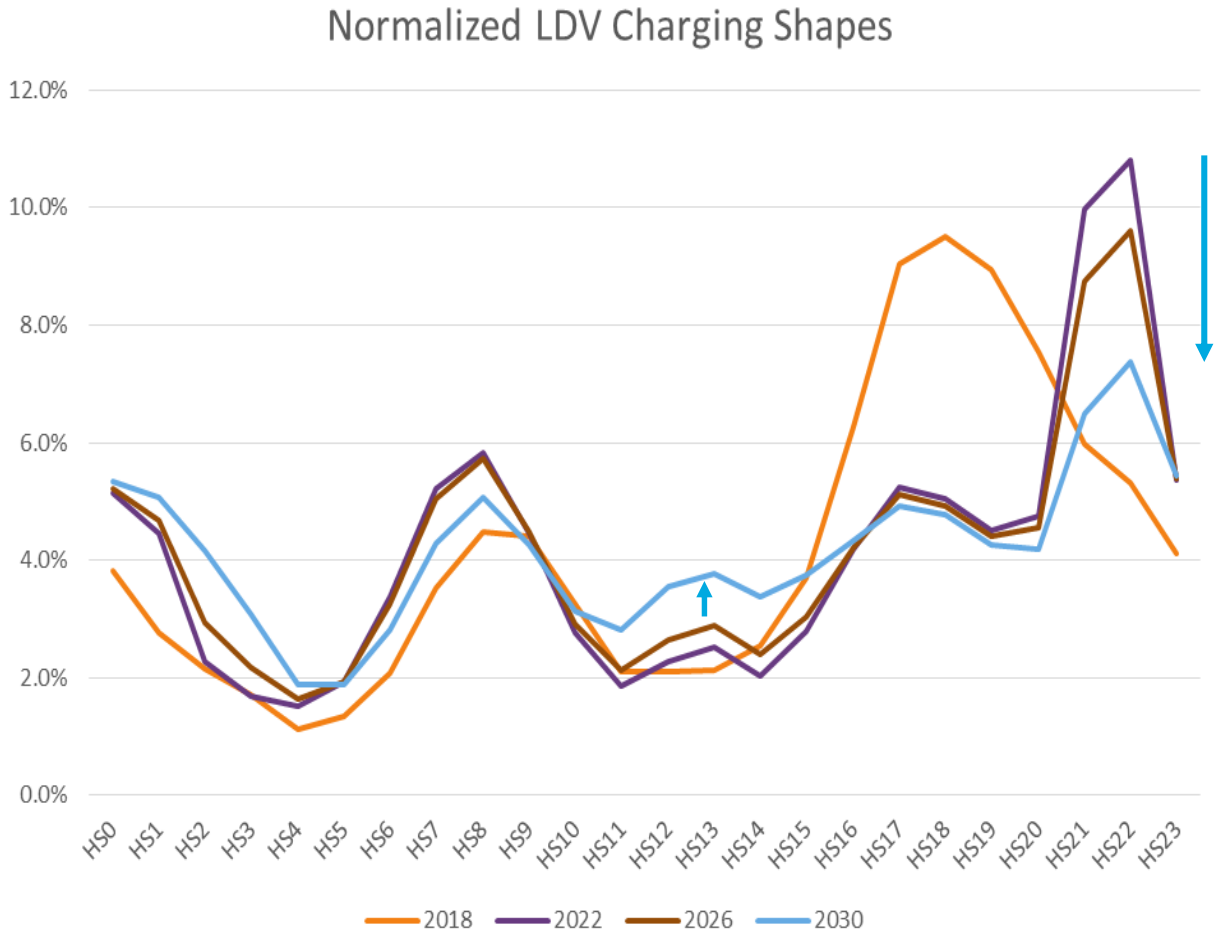
Removing 17,000 tons of NOx and 58 million metric tons of greenhouse gas emissions from California's Neighborhoods by 2030

By 2030, we need to increase light duty electric vehicle stock close to *20 times* from today's levels



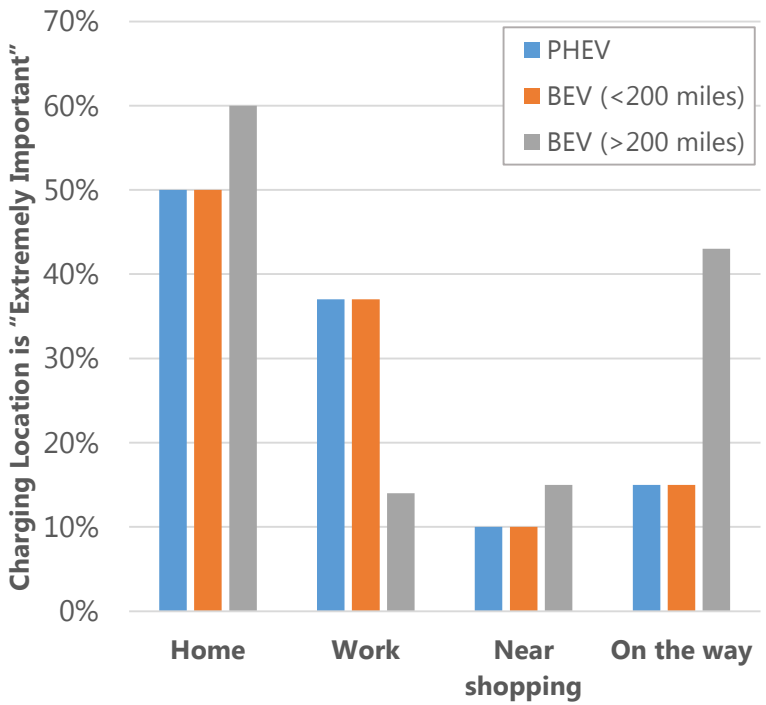
Managing charging behavior helps maximize GHG reduction and minimizing system costs





Access to charging at home and at work is a top priority for EV drivers

Importance of Charging Locations
(EV OWNERS, CALIFORNIA, 2015-2017)

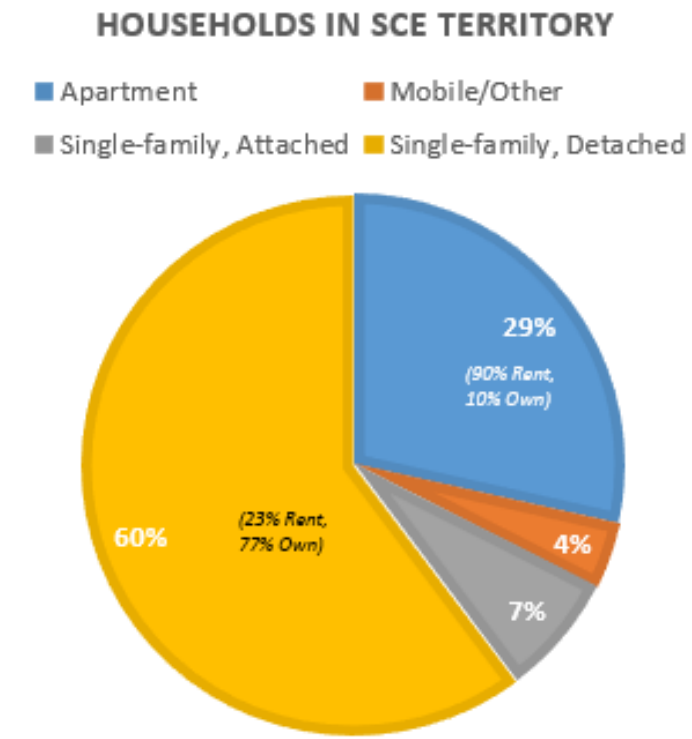


Source: CARB 2017 Accelerated Clean Cars Review

- Charging at home is expected to continue to be dominant preference for EV drivers
- Charging at workplaces is beneficial for PHEV and short-range BEV drivers and some long-range BEVs
- Workplace charging benefits adoption through increased visibility, decreased range anxiety, and trusted conversation with coworkers
- Short-dwell locations (i.e., shopping centers) do not significantly increase eVMT[2]

Notes:
[1] Long-range BEVs capable of meeting roundtrip commute mileage
[2] Most EVs can meet daily mileage needs to short-dwell locations (i.e., running errands). Additionally, UC Davis research shows that short-range PHEV drivers likely to not charge unless free and no hassle.

A diversified infrastructure strategy would support increased EV adoption across all customer types



Source: US Census Bureau

Single Family Dwellings:

Not certain that we need to fund this segment, but piloting through the residential make-ready rebate program.

Multiunit Dwellings:

Charge Ready Pilot demonstrated uptake challenges in this segment. Given the preference for home charging, the size, and the relationship to disadvantaged communities, we need to do more to serve this segment.

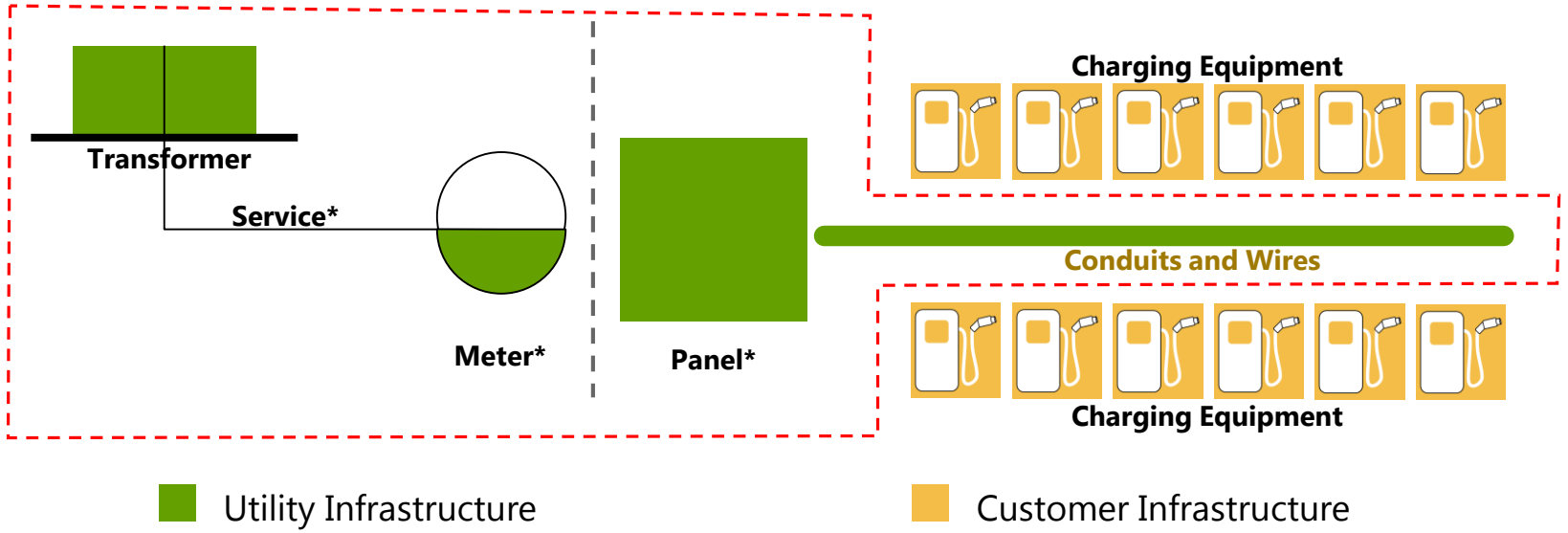
Away-from-Home Charging:

Workplace and public charging locations reduce range anxiety across both residential dwelling types and support EV owners who do not have access to home charging. We need to ramp up our efforts in this category to properly serve current EV owners and to help increase EV adoption across all customer segments.

DC Fast Charge (DCFC) charging locations also reduce range anxiety, but more expensive compared to long-dwell and residential charging; corridor DCFC locations are needed (EVSE providers are competing to install); we are exploring the concept of urban DCFC locations through our Urban DCFC pilot.

Charge Ready – light duty infrastructure program

$22M funding to build “make-ready” infrastructure for light-duty EV charging stations



SCE:

- Installs, owns & maintains all electrical infrastructure for 1,000+ ports
- Rebates charging equipment and installation

Customer/Site Host:

- Owns, operates & maintains charging equipment
- Provides usage data to SCE

New rates to accelerate EV adoption[1]

- **New Features**
  - Available Q1-Q2 20191
  - No demand charges years 1-5
  - Demand charges phased in years 6-10
  - Will maintain lower demand charges than current EV rates ongoing

Metering:
- EV rates available for separately-metered charging installation

Encouraging off-peak charging:
- Higher energy rates on-peak (4-9 PM)

[1]Pending CPUC Approval

Medium/Heavy Duty Infrastructure Program[1]

Funding for medium- and heavy-duty vehicle charging infrastructure - Build make readies and charging station rebates for electric trucks, buses, shuttles, port and material handling equipment

SCE:

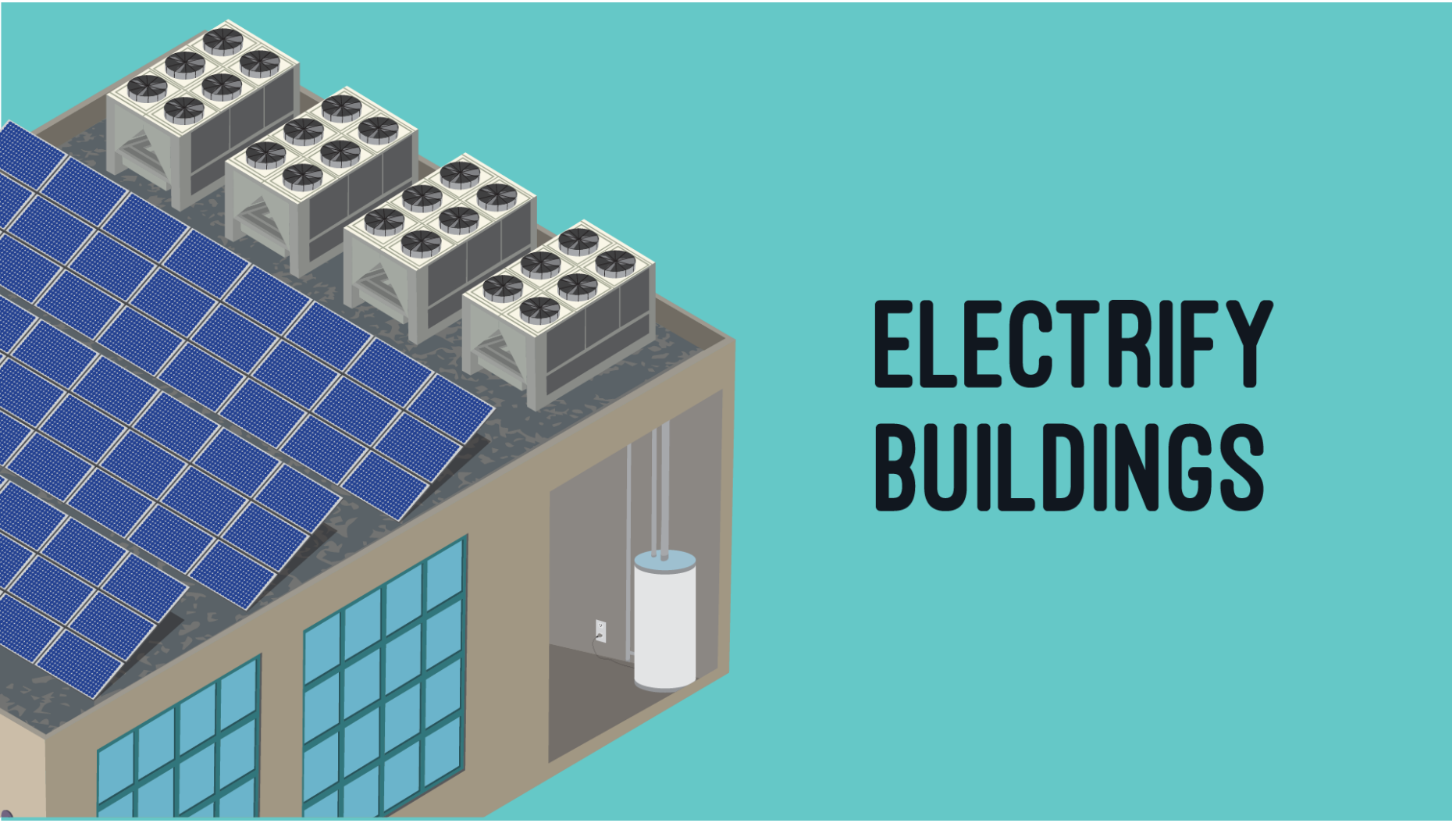
- Installs, owns & maintains all electrical infrastructure
- Rebates charging equipment and installation

Customer/Site Host:

- Owns, operates & maintains charging equipment
- Provides usage data to SCE

[1]Pending CPUC Approval

Solution Part 3: Electrify buildings



- By 2030, electrify **one-third** of space and water heating in buildings.
- Buildings use **fossil fuels** for space & water heating, and they **don't *need* to**.
- Now powered by clean, **affordable** electricity.

Building electrification summary

- The Clean Power and Electrification Pathway calls for **1.9 MMT of GHG abatement from building electrification (BE)** in SCE's territory
- **BE efforts are focused on space and water heating**—as they offer the greatest carbon abatement potential in the residential and commercial sectors
- Natural gas currently dominates space and water heating in California (over 90%)
- To succeed, **BE requires innovative policy changes that could be an example for climate policy transformations required in other sectors.** These include advancing building code changes and promoting customer adoption of new technologies, emulating the success of the Energy Efficiency and Demand Response portfolios