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Pathway 2045: Decarbonizing California through Clean Power and Electrification

November 2019

Pathway 2045 Context

In 2017, SCE issued the Clean Power and Electrification Pathway whitepaper, proposing least-cost pathways to meet California’s 2030 greenhouse gas reduction goals, including:

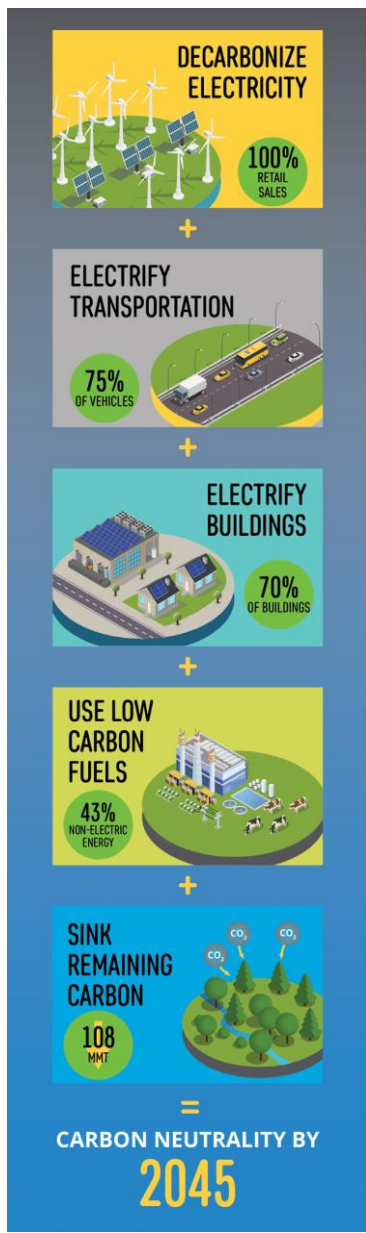
- Provide 80% carbon-free electricity by 2030 (effectively a 70% RPS)
- Electrification of 7 million light-duty vehicles and 1/3 of space and water heating

In 2018, California advanced its policy targets to 2045

- Governor Brown’s Executive Order B-55-18 requires the California economy to become carbon neutral by 2045
- SB 100 requires 100% of electricity retail sales to come from carbon-free resources by 2045, and updates the RPS requirement to 60% in 2030

SCE released an updated whitepaper that builds on the 2030 pathway and presents a vision for reaching California’s 2045 climate goals. It:

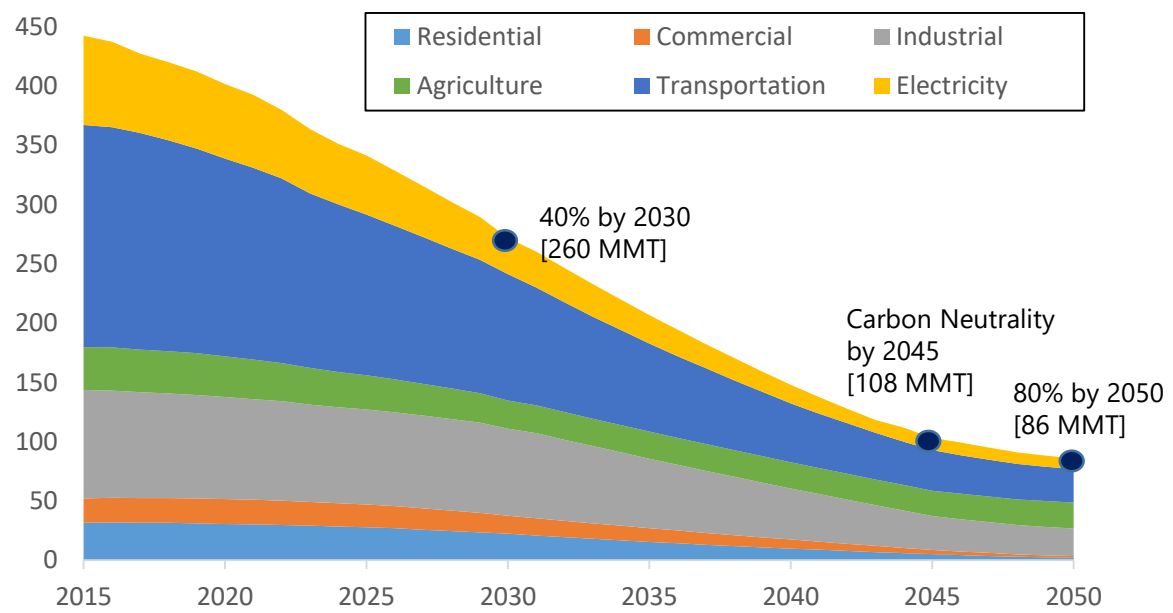
- Establishes that economy-wide carbon neutrality by 2045 will require a transformation of how the state sources and uses energy, especially in transportation and buildings
- Describes the relative cost-effectiveness and feasibility of achieving these goals through an electric-led pathway
- Increases the sense of urgency to achieve 2030 goals, which keeps California on a path to success in 2045



Electric sector decarbonization and electrification of customer end uses support achievement of carbon neutrality in 2045

State Carbon Emissions Reduction Pathway

Annual million metric tons (MMT)

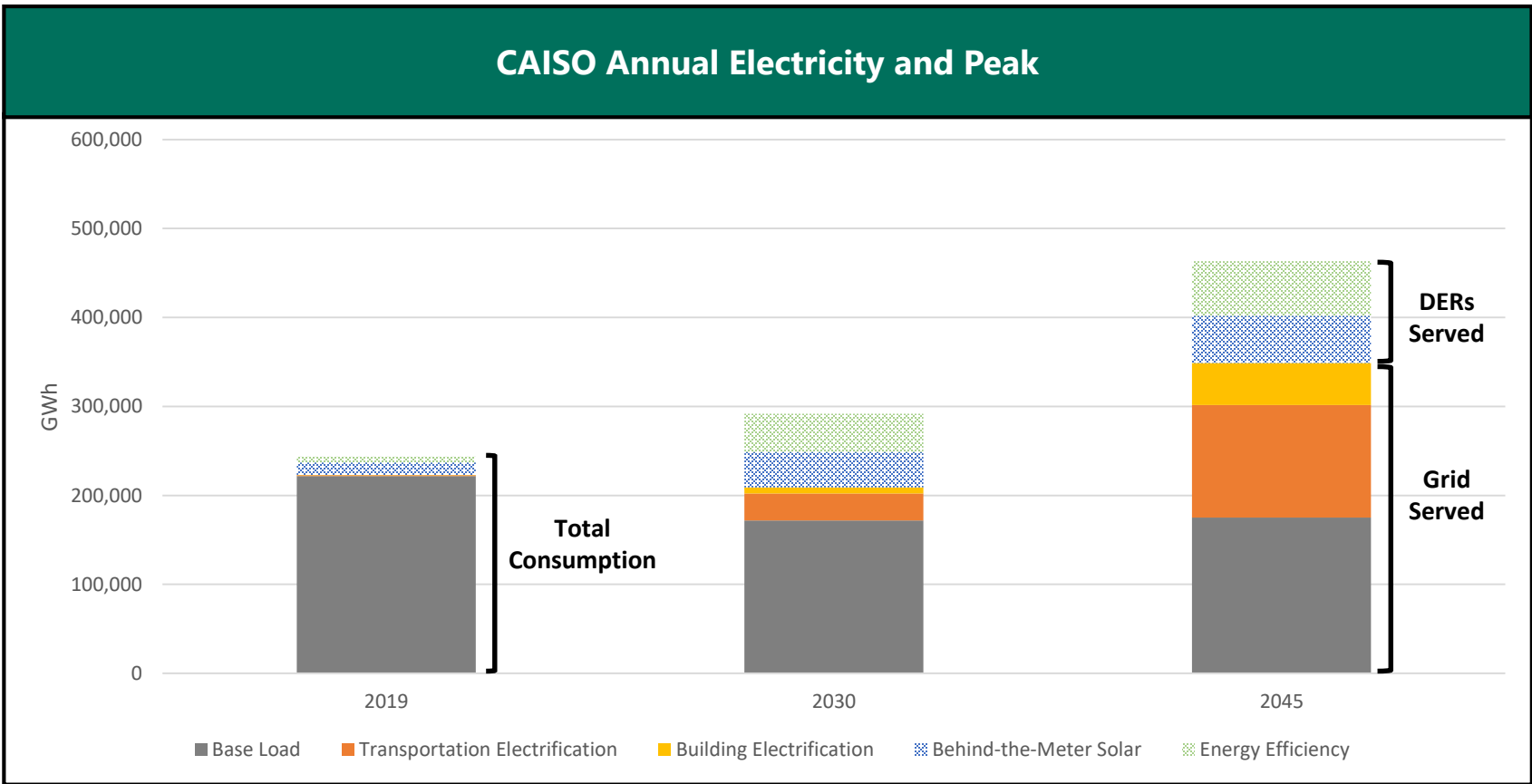


- Nearly carbon-free electricity supporting wide-scale electrification will enable the majority of necessary reductions, but will require significant investments over the next 25 years
- Carbon neutrality is enabled by requiring about 108 million metric tons of offsets through natural working lands and means of carbon sequestration
- Pipeline gas usage will decline by 50% but is an important piece of the overall solution if biomethane can fulfill 40% of the need

Potential Solution(s)	2019	2030	2045
Carbon-free electricity	55%	80%	100%
Electric Vehicles	0.6 million	7.5 million	26 million
Building Electrification	~10%	~33%	~70%
Pipeline Gas Usage ¹	2,136 Bcf ²	1,668 Bcf	1,031 Bcf
Biomethane	1%	5%	39%

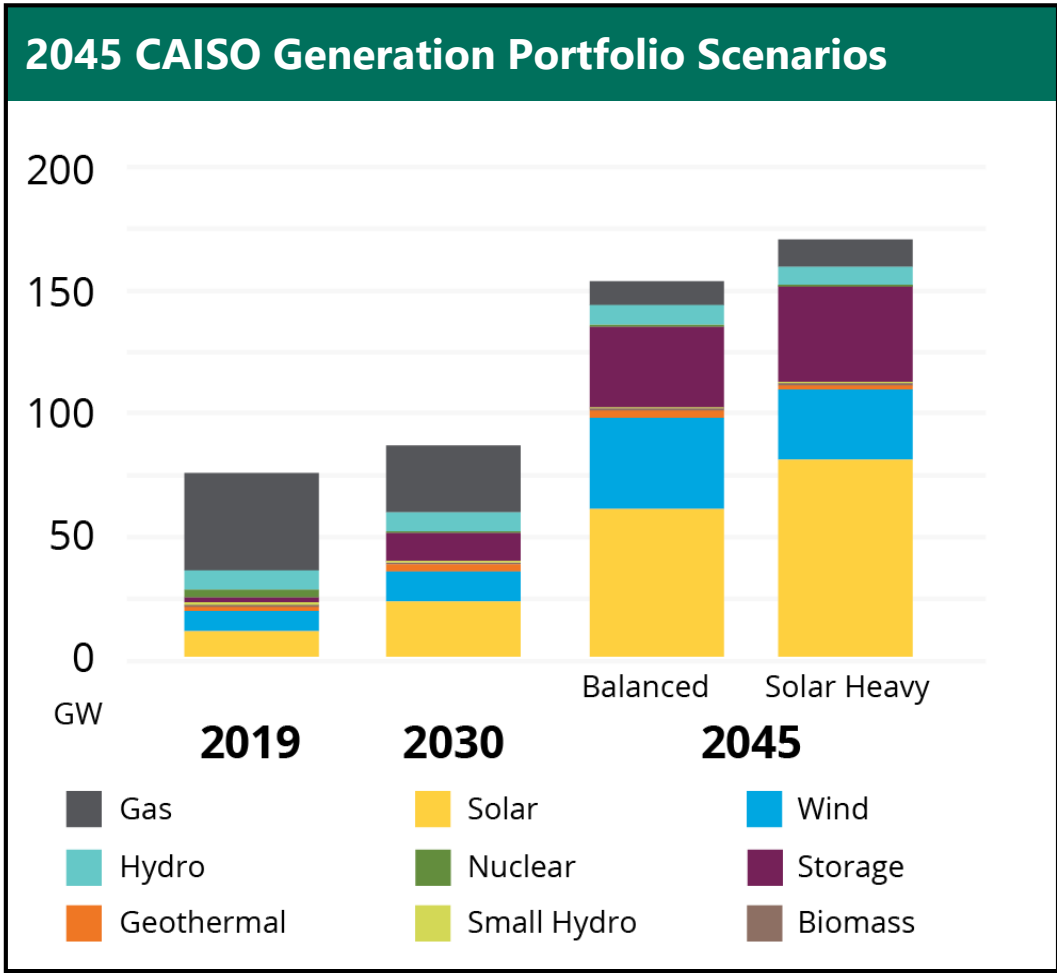
¹ Includes fossil natural gas, biomethane and hydrogen
² BCF: billion cubic feet

Decarbonization through electrification significantly increases annual electricity demand and peak load to serve by 2045



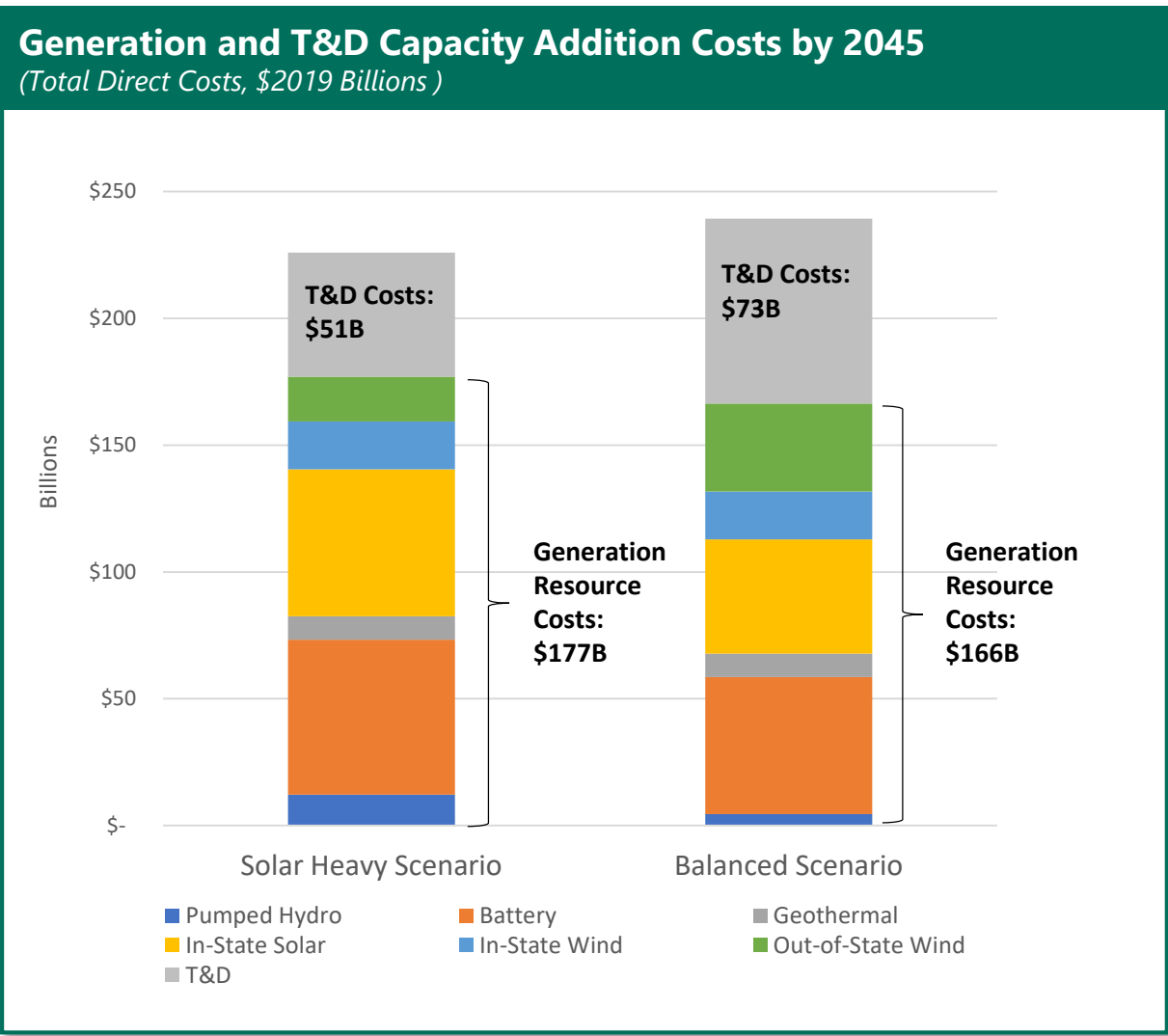
Grid served CAISO energy consumption is expected to see 60% increase by 2045, heavily driven by transportation and building electrification. CAISO system peak will increase by approximately 40% to 68,000 MW.

2045 generation capacity is similar between scenarios, development risk tradeoffs will drive what is realized



- #### Solar Heavy Scenario (Pathway 2045)
- Relies primarily on in-state resources, but subject to development constraints
 - Maintains CAISO import limit, avoiding interstate transmission upgrades
 - Import costs entirely driven by state-of-origin integration costs
- #### Balanced Scenario
- Doubles out-of-state resources, including Utah and Idaho wind with higher integration costs
 - Doubles current CAISO import limit, requiring interstate transmission upgrades
 - Import costs are 3 times that of the solar heavy scenario
 - Requires regional coordination

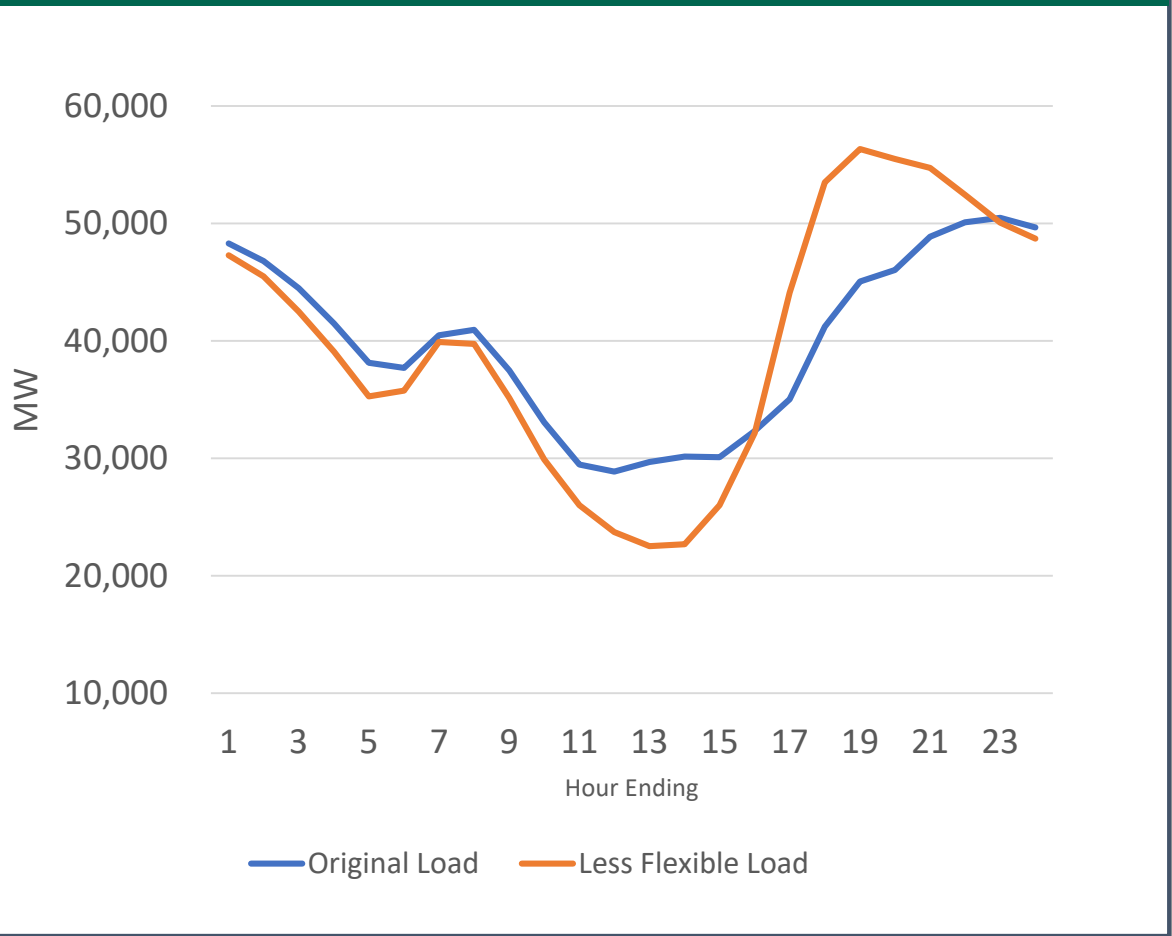
2045 transmission and distribution (T&D) costs are dependent on the underlying resource buildout



Management of flexible customer loads can help reduce electric sector costs

2045 Average CAISO Load Shapes

Managed EV charging vs Un-Managed Charging



- Customer flexible load management (e.g. EV charging, water heating load) will be key to help manage system costs in a high electrification future.
- Lack of load management translates to additional energy storage to meet energy needs while satisfying GHG constraints.
- By 2045, annual value of load flexibility is estimated at \$1-\$3 billion depending on grid conditions, i.e. ramping needs, and amount of load that can be shifted.

Customer affordability is key to decarbonize California

- Customer adoption of electrification supports economy-wide energy efficiency due to the efficiency advantage of electric motors
- If Pathway 2045 is implemented cost-effectively, customer total energy costs maintain median income affordability
- Today, and in 2045, customers who adopt home solar, electric vehicles, and electric space and water heating appliances save significantly on energy costs over non-adopters

