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CPUC Integrated Resource Planning: SB 100 Framing Study Scenarios

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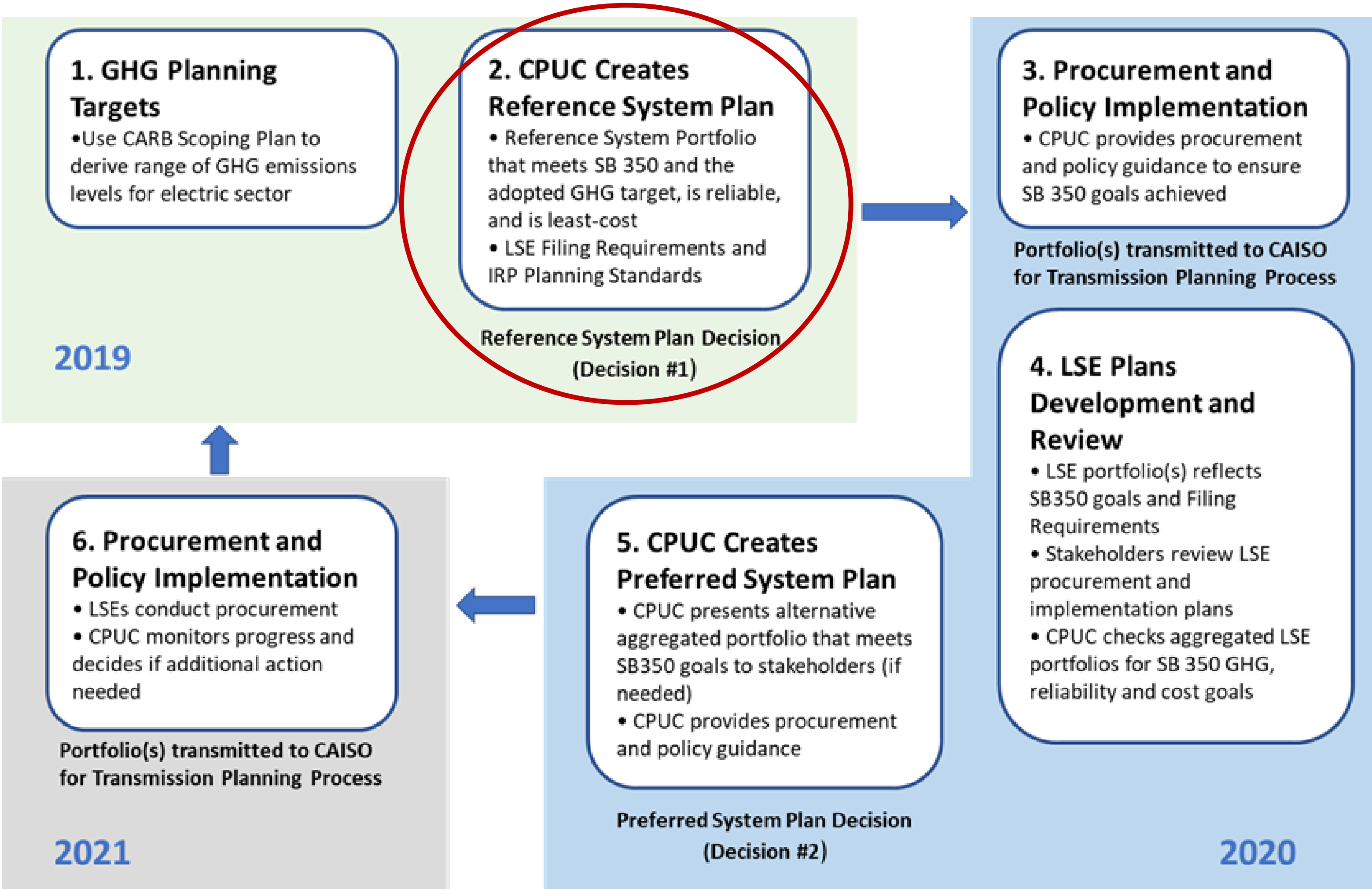
Integrated Resource Planning (IRP) at the CPUC

- The value proposition of integrated resource planning is to reduce the cost of achieving GHG reductions and other policy goals by looking across individual LSE boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be found.
- Goal of 2019-20 IRP cycle is to ensure that the electric sector is on track to help California reduce economy-wide GHG emissions 40% from 1990 levels by 2030, and to explore how achievement of SB 100 2045 goals could inform IRP resource planning in the 2020 to 2030 timeframe.
- California today is a complex landscape for resource planning:
  - Multiple LSEs including utilities, CCAs, and ESPs
  - Multiple state agencies (CPUC, CEC, Air Resources Board) and CAISO
  - Partially deregulated market

Overview of the IRP 2019-20 Process



Purpose of SB 100 2045 Framing Study

- Explore how 2045 goal under SB 100 could affect the outlook for electricity sector GHG emissions and resource planning in the 2030 timeframe.
- Provide analysis that includes context from other sectors.
- Inform Commission decision-making around the appropriate 2030 GHG planning target for CPUC-jurisdictional LSEs and the Reference System Portfolio to meet that target.
- Primarily informational and directional regarding least-regrets investments needed by 2030.

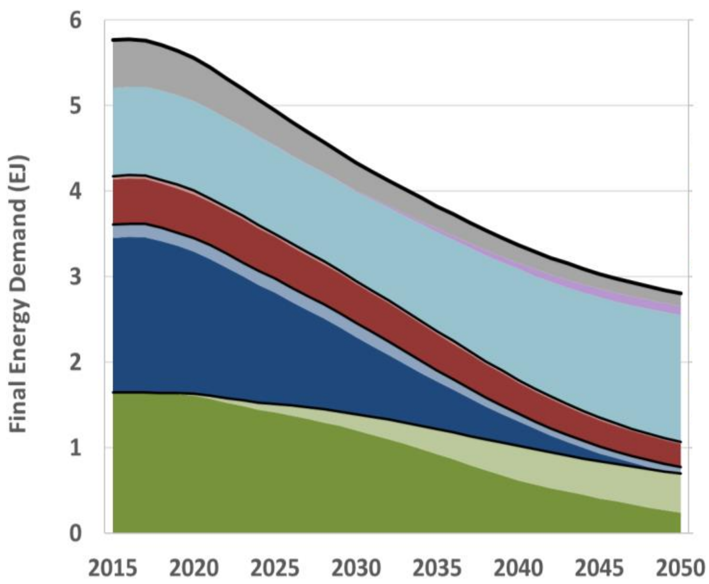
SB 100 2045 Framing Study Scenarios

- While the CPUC IRP focuses on infrastructure decisions between present day and 2030, some near-term decisions may depend on changes to the electricity sector that result from post-2030 economy-wide decarbonization.
- Three scenarios are explored in the 2045 Framing Studies that reflect different decarbonization strategies in the CEC Deep Decarbonization report:*
  - High Electrification
  - High Biofuels
  - High Hydrogen
- The three scenarios have the same economy-wide GHG constraint of 86 MMT by 2050 (80% below 1990 levels).
- The electric sector GHG emissions target and electricity loads vary by scenario and are a product of complex cross-sectoral interactions within each scenario. Electricity-sector GHG emissions and electric loads by sector are outputs of the PATHWAYS model.

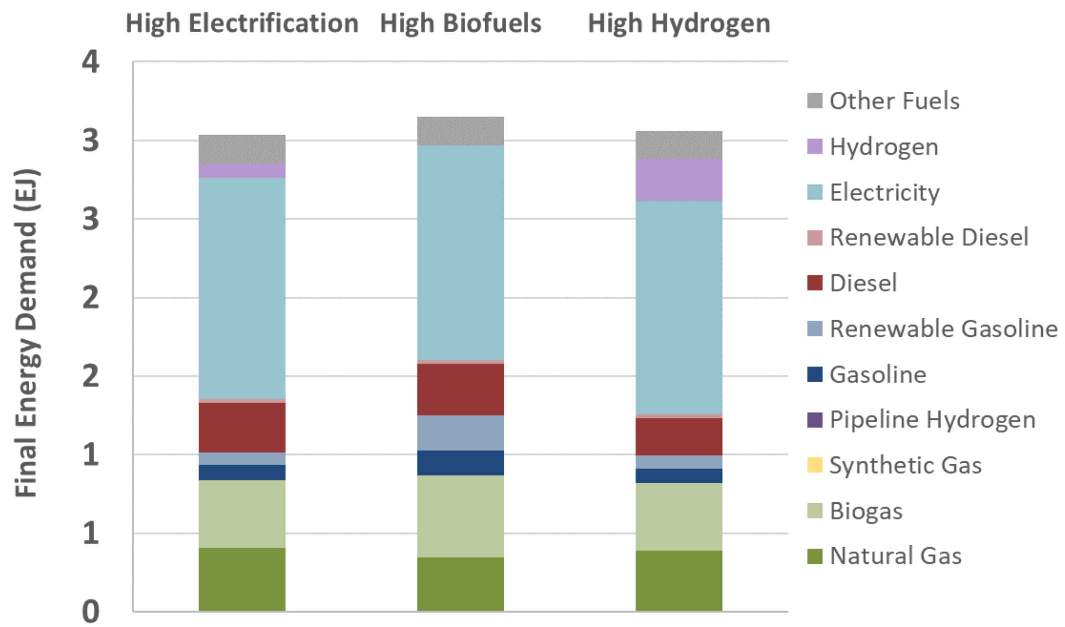
*CEC, 2018, *Deep Decarbonization in a High Renewables Future.*
https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

Final Energy Demand by Fuel, Statewide

High Electrification



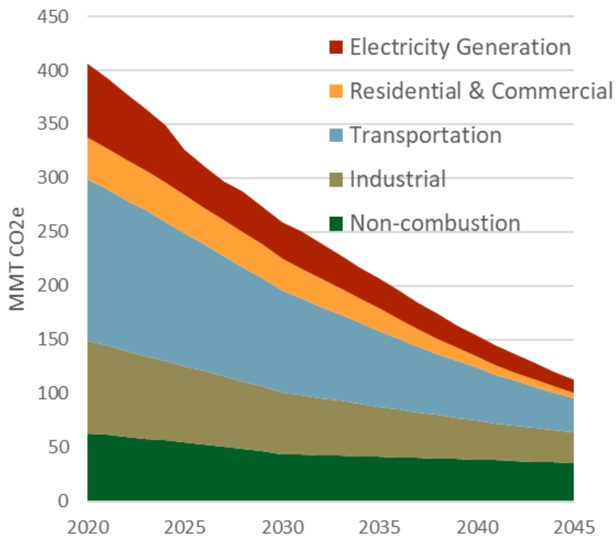
2045 – Comparison Between Scenarios



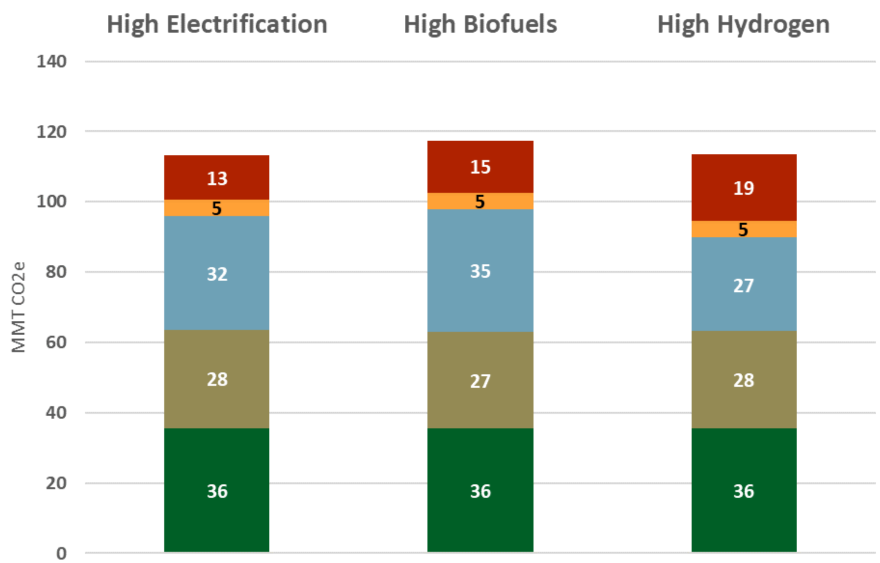
- Demand for electricity, hydrogen and biofuels varies by scenario

GHG Emissions by Sector, Statewide

High Electrification

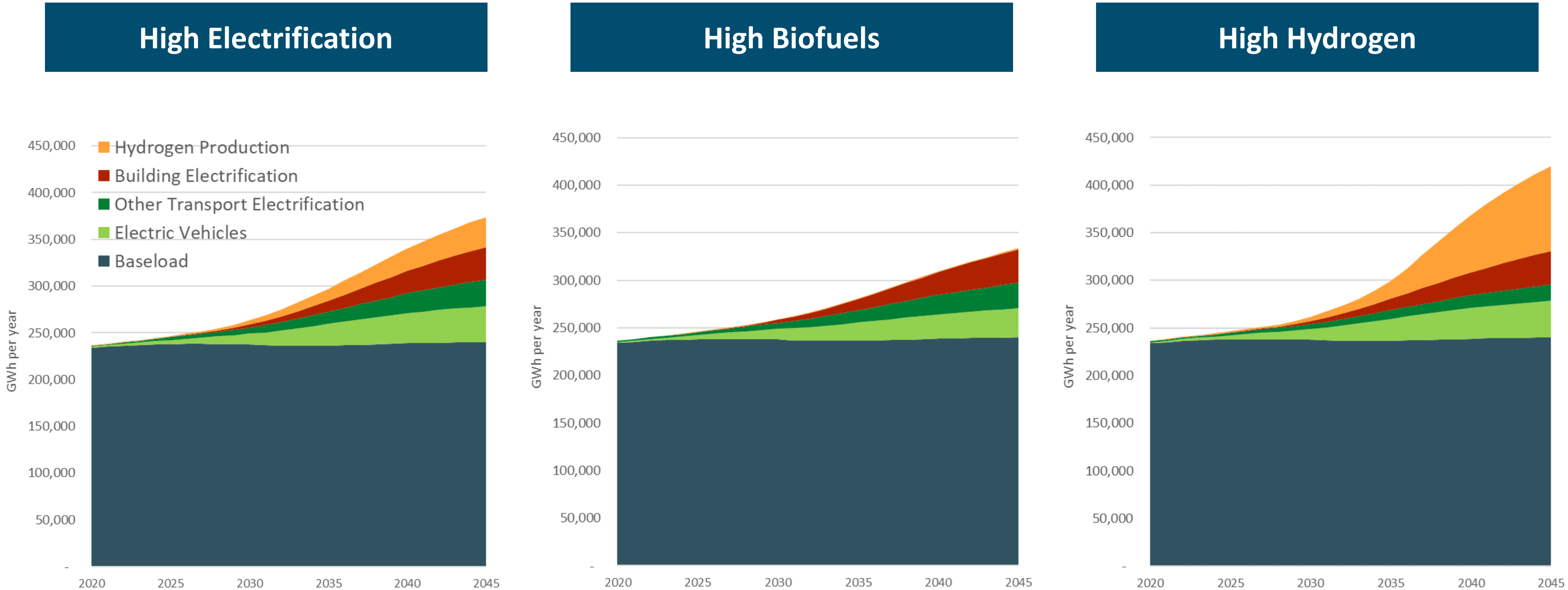


2045 – Comparison Between Scenarios



- All scenarios meet the same economy-wide 2050 GHG target, but result in different energy systems

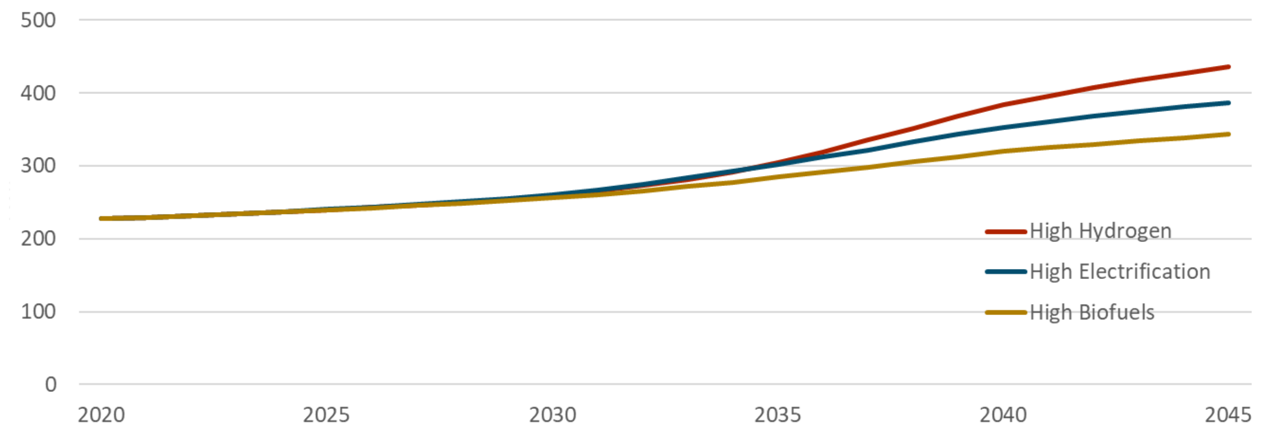
CAISO Electricity Loads



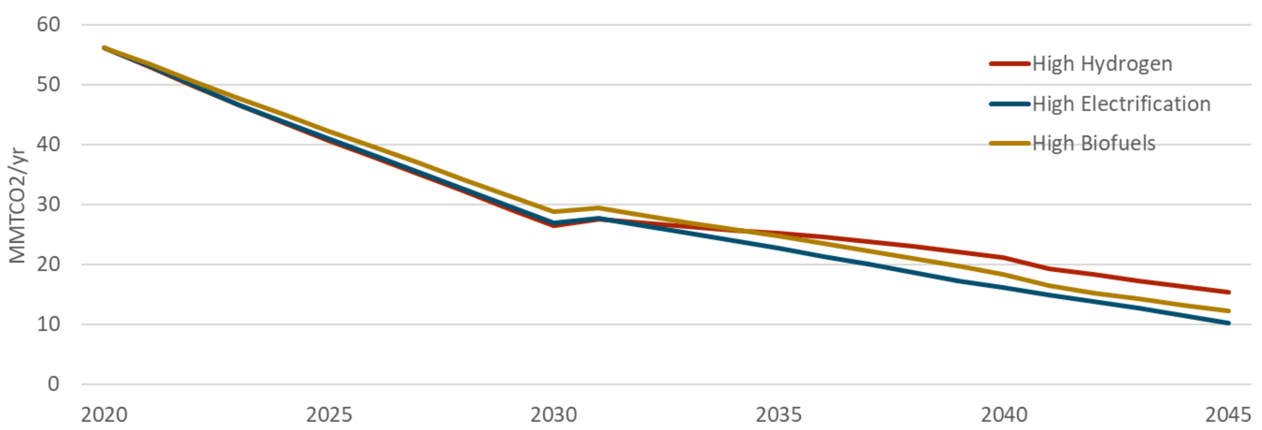
- Electricity loads vary by scenario and are a product of complex cross-sectoral interactions within each scenario
- Electrifying buildings, transportation and industry, and hydrogen electrolysis are key drivers of higher electric sector loads

Pathways Inputs into RESOLVE

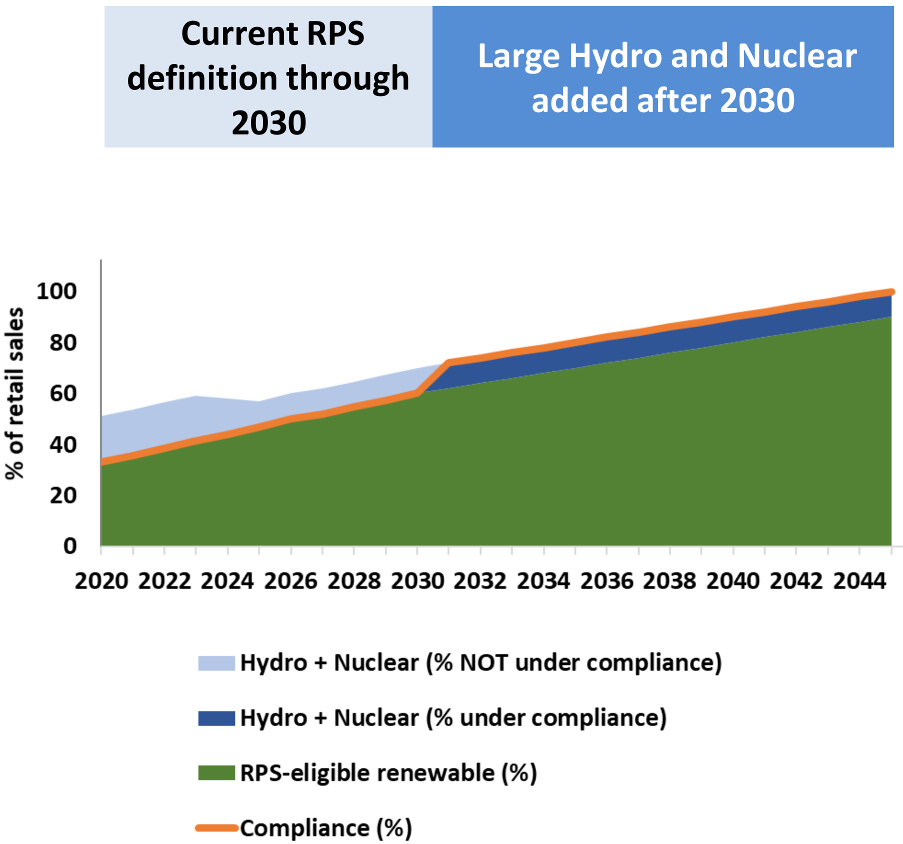
CAISO Electricity Demand (TWh)



CAISO Electricity GHG Target ($MMTCO_2$/yr)



Modeling SB 100 in RESOLVE

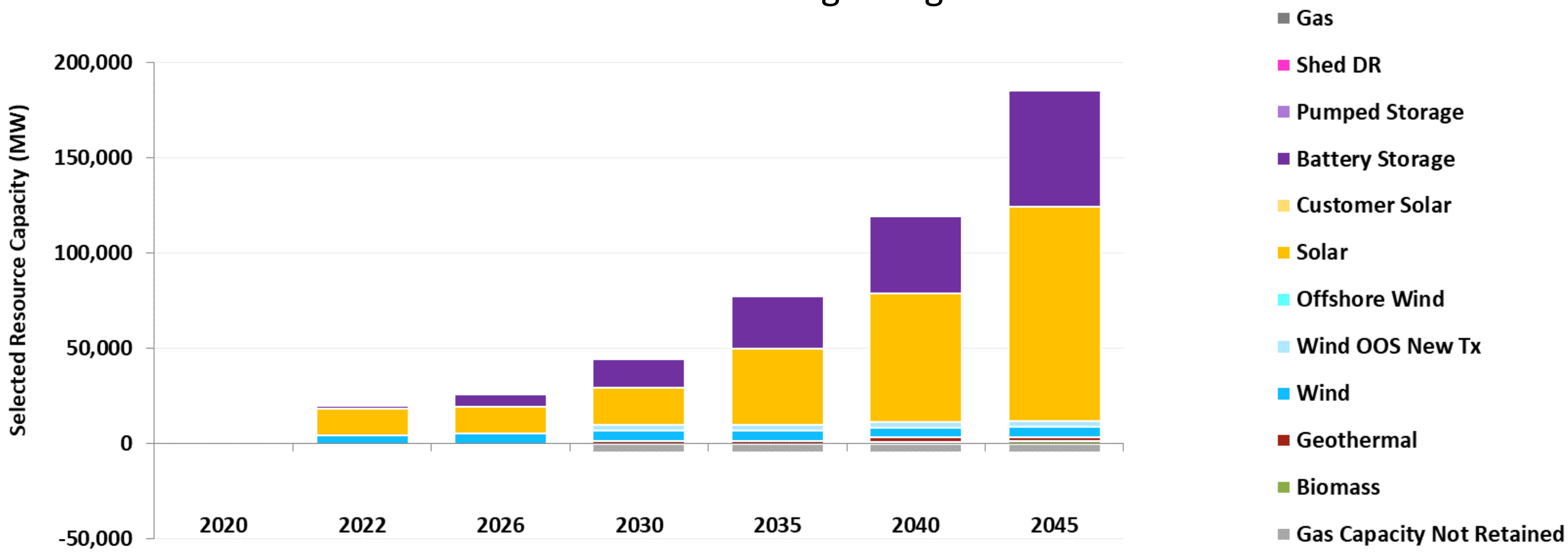


*Total retail sales includes pumping loads after 2030 (not shown)

- SB 100 does not define "zero carbon resources"
  - Renewables, nuclear and hydro are assumed to be eligible resources under SB 100 post-2030
- SB 100 interpreted as a percent of retail sales
  - Through 2030: current RPS definition retained
  - After 2030: nuclear and large hydro are added to eligible resources
- SB 100 requires GHG-free generation to equal electricity retail sales in 2045 and, as modeled in RESOLVE, gas generation is not prohibited for the following reasons:
  - Exported GHG-free power counts towards the SB100 requirement, leaving room for some internal load to be met with GHG-emitting resources
  - Transmission and distribution losses (~8% of demand) are not counted as retail sales, and may be met with GHG-emitting resources
- All of the 2045 framing studies include some natural gas power plants
  - The model makes economic decisions on how much existing gas capacity to retain, but must retain some gas plants for local reliability
  - All natural gas combined heat and power capacity is ramped down between 2030 and 2040

Resource Build: High Electrification

- Resources in chart are selected by RESOLVE and are in addition to baseline resources
- RESOLVE does not retain some thermal resources beginning in 2030



- Solar and batteries dominate
  - Li-Ion batteries have 6-8 hours of duration from 2030 through 2045
- Around 700 MW of long duration (12-hr) pumped storage is selected in 2026
- Maximum resource potential built for onshore wind
  - The option to build offshore wind is allowed in a 2045 sensitivity
- Biomass and geothermal provide resource diversity and firm capacity, but are a small portion of the portfolio

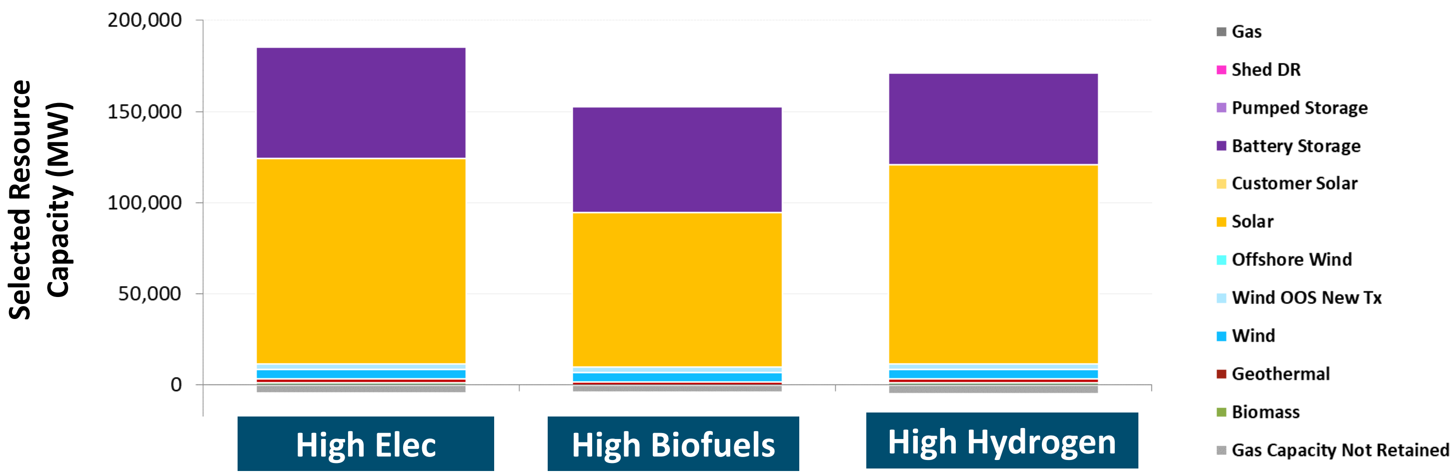
Key Scenario Metrics in 2045

Metric	High Electrification	High Biofuels	High Hydrogen
CAISO load in 2045	**425 TWh**	**383 TWh**	**459 TWh**
CAISO GHG Target in 2045	**10.3 $MMTCO_2$/yr**	**12.3 $MMTCO_2$/yr**	**15.5 $MMTCO_2$/yr**
Marginal GHG Abatement Cost	**$587/$tCO_2$**	**$458/$tCO_2$**	**$493/$tCO_2$**
Effective SB 100 % Note: 100% CES target enforced	**109%**	**106%**	**104%**
Gas capacity not retained Note: Does not include OTC retirements	**4.5 GW**	**4.1 GW**	**4.8 GW**
Reserve Margin Requirement	**71 GW**	**69 GW**	**69 GW**
Curtailment + storage losses	**24%**	**20%**	**18%**
Levelized Total Resource Cost (TRC) Note: Electrolysis capital cost not included	**$55.5 bn/yr**	**$53.5 bn/yr**	**$55.2 bn/yr**
Incremental TRC *(relative to High Electrification)*	-	***($2 bn/yr)***	***($0.3 bn/yr)***

More zero-GHG generation is procured to meet GHG targets than is required to meet the RESOLVE SB100 constraint, resulting in > 100%

Almost all gas capacity retained due to high peak demand post-2030

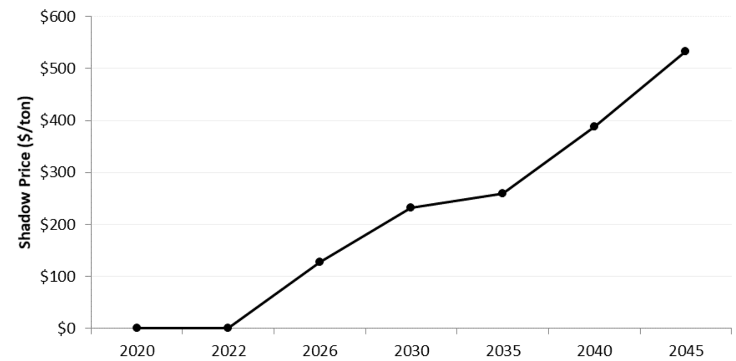
Hydrogen load flexibility substitutes for storage and reduces curtailment relative to high electrification, but would require significant electrolyzer investment



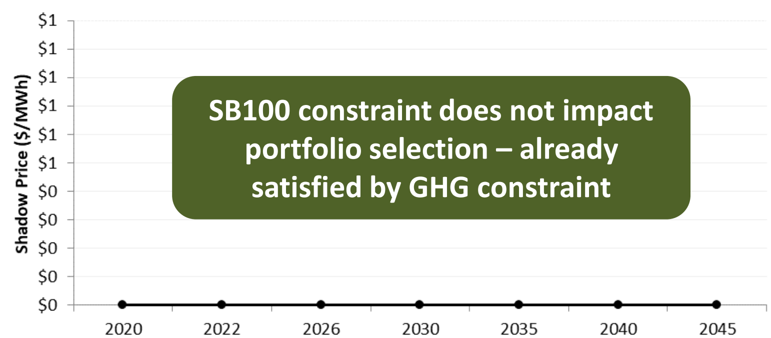
Multiple Constraints: High Electrification

- RESOLVE portfolios are the least cost solution to meet many different requirements (“constraints”)
- Three important constraints may drive portfolio selection: GHG, RPS/SB100, and Planning Reserve Margin
- In any modeled year, one or many of the constraints could drive portfolio selection.
- Constraints that drive selection have a high “shadow price,” – a high cost to meet the constraint.
- A shadow price of zero indicates that the constraint is not impacting the solution.
  - The constraint could be removed and the optimal portfolio would not change.

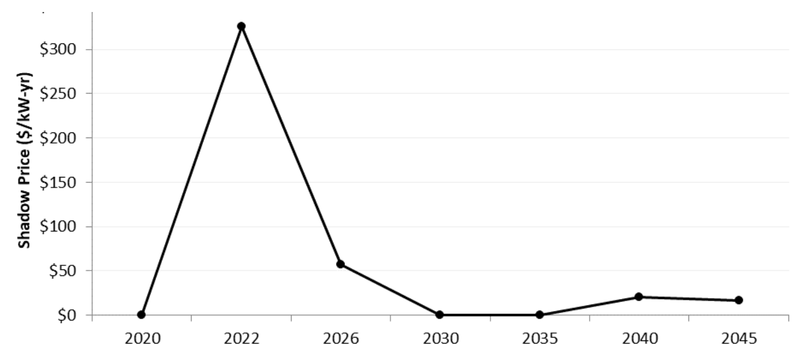
GHG



RPS/SB100



Resource Adequacy / Planning Reserve Margin

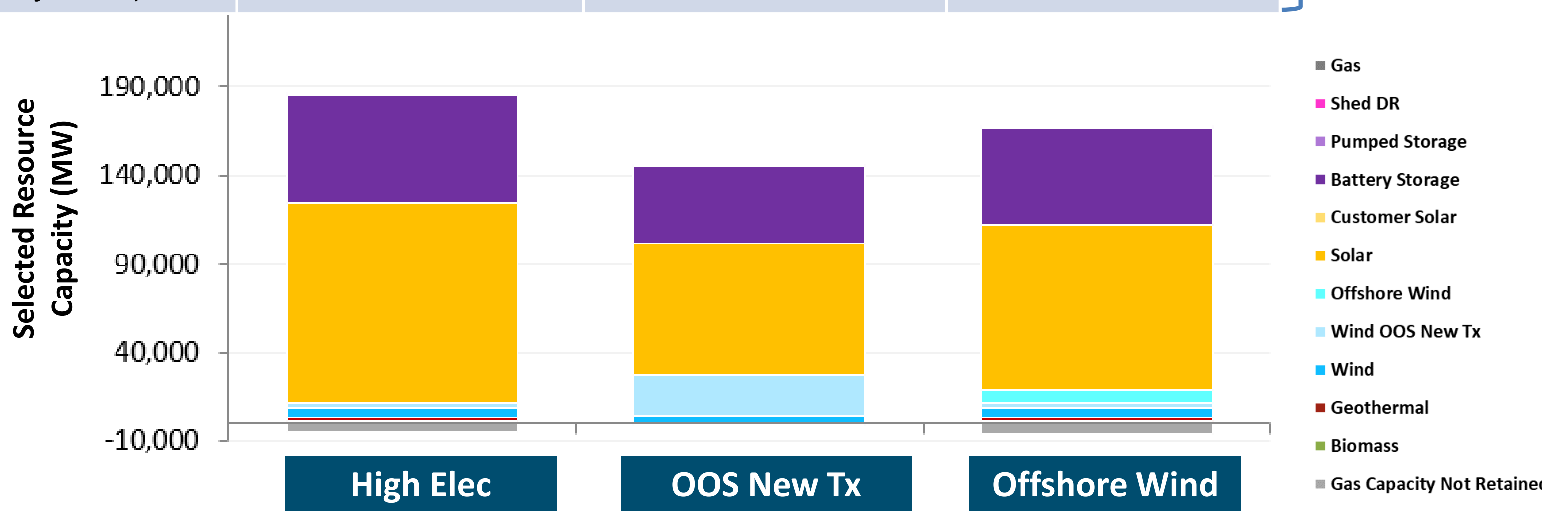


High Electrification: Wind and Tx Sensitivities

Metric	High Electrification (Base)	OOS New Transmission (mostly wind)	Offshore Wind available
CAISO load in 2045 (TWh)	**425 TWh**	**425**	**425**
CAISO GHG Target in 2045	**10.3 $MMTCO_2$/yr**	**10.3 $MMTCO_2$/yr**	**10.3 $MMTCO_2$/yr**
Marginal GHG Abatement Cost	**\$587/tCO_2**	**\$408/tCO_2**	**\$539/tCO_2**
Effective SB100 % Note: 100% CES target enforced	**109%**	**107%**	**108%**
Gas capacity not retained (GW) **Note: Does not include OTC retirements.**	**4.5 GW**	**1 GW**	**5.2 GW**
Reserve Margin Requirement	**71 GW**	**71 GW**	**71 GW**
Curtailment + storage losses (%)	**24%**	**15%**	**21%**
Levelized Total Resource Cost (TRC)	**\$55.5 bn/yr**	**\$54.8 bn/yr**	**\$55.3 bn/yr**
Incremental TRC *(relative to High Electrification)*	**-**	***(\$0.7 bn/yr)***	***(\$0.2 bn/yr)***

Gas capacity necessary to maintain reliability, even with significant buildout of OOS or offshore resources

Availability of additional wind resources reduces curtailment and costs

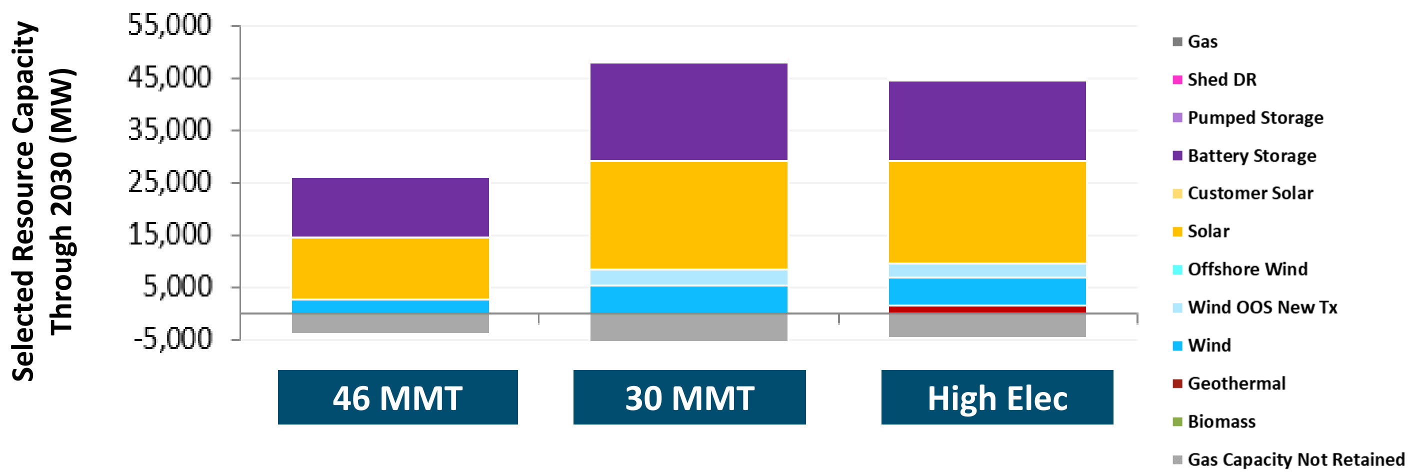


Looking Beyond 2030 Highlights Potential Path Dependencies of 2030 Portfolios

Metric in 2030	46MMT in 2030	30MMT in 2030	High Electrification in 2030 (ends in 2045)
CAISO load in 2030 (TWh)	257	257	275
CAISO GHG Target in 2030	37.9 $MMTCO_2$/yr	24.3 $MMTCO_2$/yr	26.9 $MMTCO_2$/yr
Marginal GHG Abatement Cost	\$113/tCO_2	\$212/tCO_2	\$258/tCO_2
Effective RPS % Note: 60% target enforced	60%	78%	77%
Gas capacity not retained in 2030 (GW) Note: Does not include OTC retirements.	3.7 GW	7.7 GW	4.5 GW
Achieved RA Reserve Margin (target = 15%)	15%	15%	18%

30 MMT and High Electrification runs similar in 2030

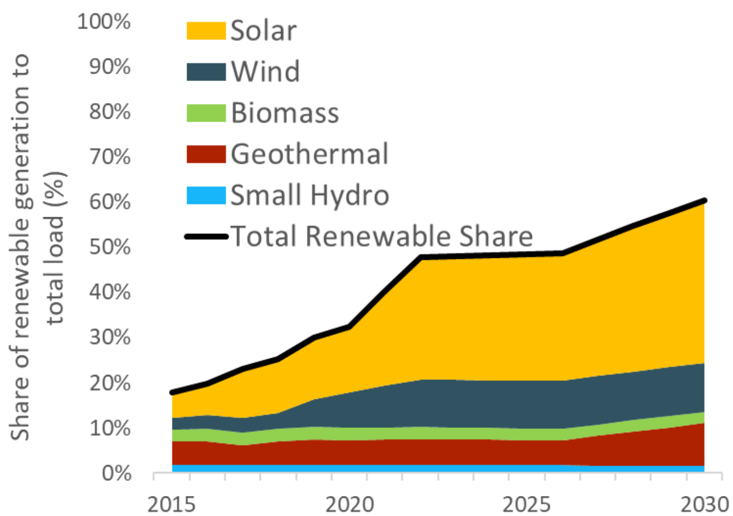
Comparing the 30 MMT and High Electrification scenarios, an increase in electrification loads post-2030 results in more gas retention in 2030



PATHWAYS Electricity GHG Targets Assume Maximum Level of Effort in Other Sectors

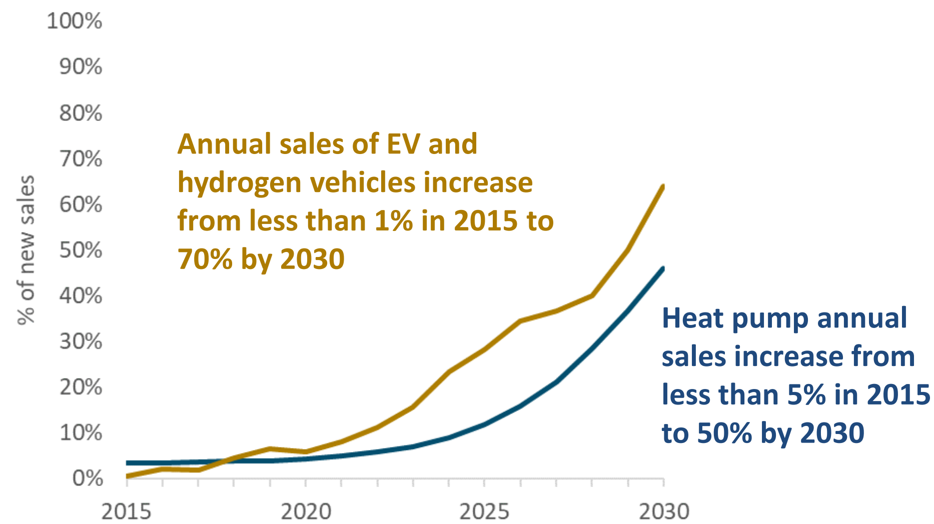
- Meeting the 2030 GHG planning target requires accelerated progress in all other sectors with aggressive effort compared to the historical trajectory.

Renewable generation share increases steadily from 18% in 2015 to 60% by 2030



Source: RESOLVE High Electrification scenario

The sales share of electric heat pumps and ZEVs need to ramp up rapidly from single digits to more than 50% by 2030



Source: E3 2018 report CEC-500-2018-012, High Electrification Scenario

- Recent trends suggest challenges in achieving intended progress
  - Increased LDV GHG emissions in year 2017 inventory
  - Uncertainty over implementation of fuel economy standards
- How should the costs and risks of achieving GHG mitigation in the electricity sector be compared to the other sectors?

Key Takeaways from 2045 Framing Study

- Looking beyond 2030 helps to inform near-term thermal retention decisions.
- New resource build in 2030 under the 30 MMT core policy case is similar to that of the High Electrification scenario in 2030.
- Thermal retention in 2030 under the 46 MMT core policy case is more in line with the High Electrification scenario in 2030.
- All three 2045 Framing scenarios rely heavily on solar and batteries to meet load and GHG goals.
- Availability of out-of-state or offshore wind displaces in-state solar and batteries and lowers costs. Resource diversity lowers the cost of meeting long-run GHG goals.
- PATHWAYS electricity GHG targets assume maximum level of achievement in other sectors but it is not certain to what extent other sectors will achieve those expected reductions.