

<b>DOCKETED</b>	
<b>Docket Number:</b>	23-SB-100
<b>Project Title:</b>	SB 100 Joint Agency Report
<b>TN #:</b>	268979
<b>Document Title:</b>	SB 100 Inputs and Assumptions
<b>Description:</b>	N/A
<b>Filer:</b>	Mikayla Roberts
<b>Organization:</b>	California Energy Commission
<b>Submitter Role:</b>	Commission Staff
<b>Submission Date:</b>	3/9/2026 2:47:04 PM
<b>Docketed Date:</b>	3/9/2026



# **Inputs and Assumptions**

California Energy Commission  
February 19, 2026



# Table of Contents

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## Modeling – Slide 3

- Scenarios
- Models
- Demand Scenarios
- Resource Costs
- Resource Potentials
- Policy Assumptions
- Fuel Assumptions
- Summary

## Land Use – Slide 43

- Context
- Capacity Density Metrics
- Land Use Methodology



# Acronyms

Acronym	Meaning
AAEE	Additional Achievable Energy Efficiency
AAFS	Additional Acheivable Fuel Substitution
ATB	Annual Technology Baseline
CARB	California Air Resources Board
CEC	California Energy Commission
CPUC	California Public Utilities Commission
ELCC	Effective Load Carrying Capacity
GHG	Greenhouse Gas
HDSAM	Hydrogen Delivery Scenario Analysis Model
IEPR	Integrated Energy Policy Report
IRA	Inflation Reduction Act
IRP	Integrated Resource Planning
LOLE	Loss of Load Expectation

Acronym	Meaning
MDHD	Medium Duty Heavy Duty
MMT	Million Metric Tons
NERC	North American Energy Reliability Committee
NLR	National Laboratory of the Rockies
PRM	Planning Reserve Margin
PSP	Preferred System Plan
RA	Resource Adequacy
VO&M	Variable Operations & Maintenance
WECC	Western Electric Coordinating Council



# Purpose and Context

- This slide deck articulates the key inputs and assumptions (I&A) used for SB 100 analysis performed as part of the 2025 SB 100 Report.
- These slides focus on the key inputs & assumptions, and does not exhaustively list every piece of data used in SB 100 analysis.
- The Joint Agencies have sought to align inputs and assumptions across their various planning and modeling efforts as much as possible.
  - However, there are still divergences, as each agency has different operational mandates and conducts modeling to serve different purposes and at different times.



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# Scenarios



# Scenarios (cont.)

Scenario	Demand	DER/DF	Transportation Sector Hydrogen	SB100	Power Sector GHG Emissions	Planned Capacity	Technology Treatment	Land Use Screen
Reference	Policy Compliance	Moderate	Policy Compliance	Retail Sales	6.9 MMT by 2045	CPUC PSP through 2039	Economic	Core
Comparison	Policy Compliance	Moderate	Policy Compliance	Retail Sales	6.9 MMT by 2045	CPUC PSP through 2030	Economic	Core
SB100 Only	Policy Compliance	Moderate	Policy Compliance	Retail Sales	None	CPUC PSP through 2030	Economic	Core
25 GW Offshore Wind	Policy Compliance	Moderate	Policy Compliance	Retail Sales	6.9 MMT by 2045	CPUC PSP through 2030	25 GW of offshore wind by 2050	Core
15 GW Carbon Capture	Policy Compliance	Moderate	Policy Compliance	Retail Sales	6.9 MMT by 2045	CPUC PSP through 2030	45Q Tax Credit Extension	Core
Combustion Retirement	Policy Compliance	Moderate	Policy Compliance	Expanded Load Coverage	6.9 MMT by 2045	CPUC PSP through 2030	All in-state combustion retired by 2045	Core
Higher Hydrogen Demand	High Hydrogen Transportation Demand	Moderate	High Hydrogen Transportation Demand	Retail Sales	6.9 MMT by 2045	CPUC PSP through 2030	Economic	Core

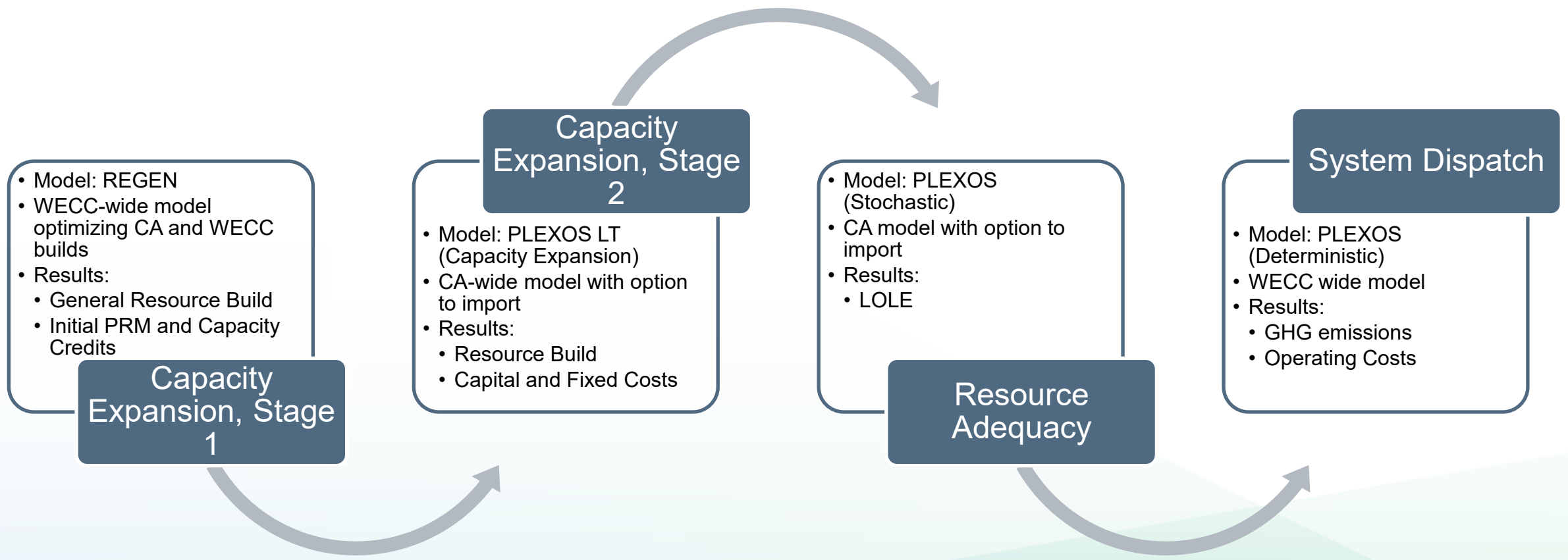
Red text indicates deviations from default assumptions



# Models



# Electricity System Supply Model





# Demand Assumptions



# SB 100 Demand Scenarios

Scenario Number	Demand Scenario		SB100 Supplemental Assessments	
	Scenario Name	Major Scenario Specifications	Demand Flex Assumptions	Electrolysis Load From H2 Projections
1	Policy Scenario	AAEE 3, AAFS 4, FSSAT 4, Policy Scenario TE, 2023 IEPR PV & Storage	Moderate	Moderate levels of hydrogen driving electrolysis energy
2	Policy Scenario (High Hydrogen Use)	Policy Scenario modified to substitute some hydrogen for electricity in MDHD Trucking in the Transportation sector (85% of Scoping Plan amount)	Moderate	Higher levels of hydrogen driving electrolysis energy

**Note:** Neither of the SB 100 Supplemental Assessments are included in the hourly 8760 loads by planning area for any Demand Scenario. These are separate inputs into the production cost model which will determine their hourly impacts through the dispatch process.



# Demand Scenario Inputs

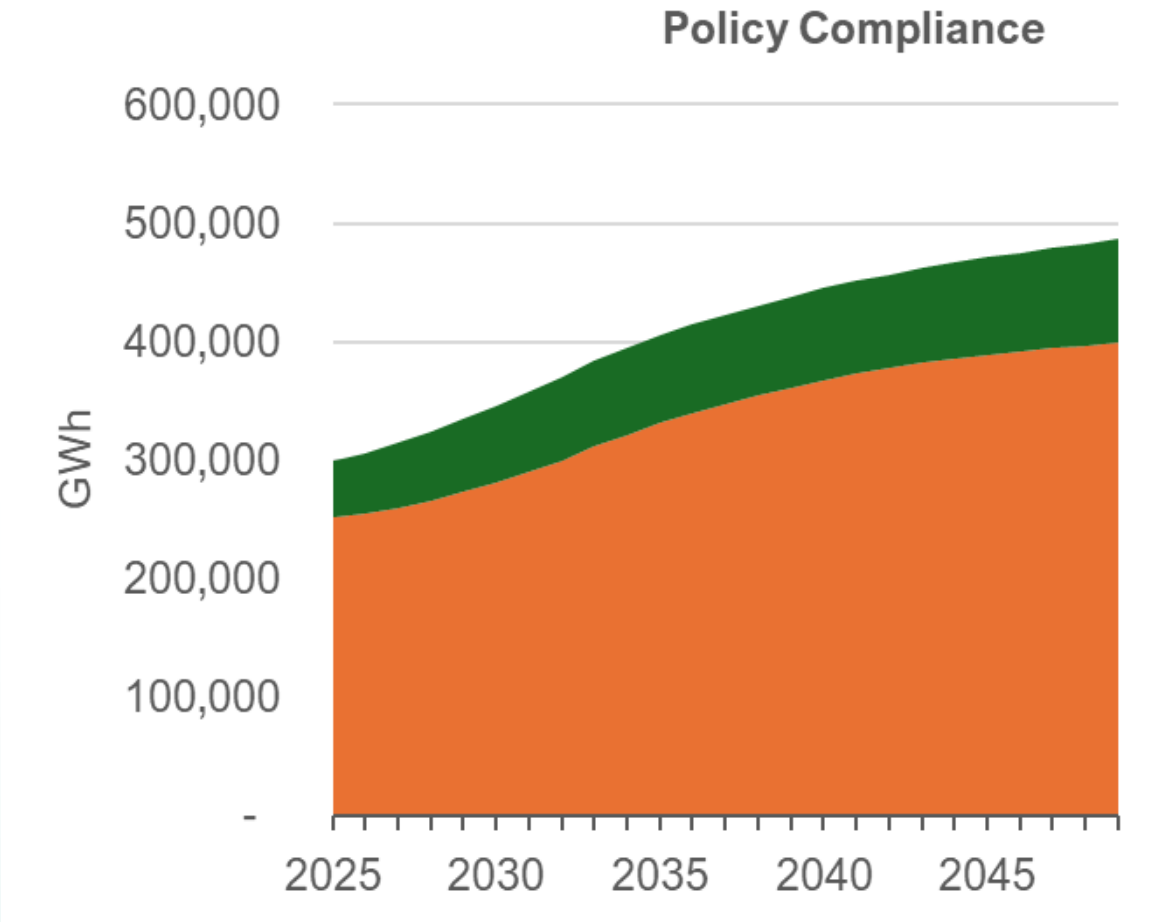
Demand scenarios expand on the California Energy Demand Forecast framework and tools. Demand scenario based on the 2023 IEPR.

Sectors	Inputs	Models/Tools
Res, Com, Ind	Baseline Forecast	Sector Models
Res, Com, Ind	Energy Efficiency Impacts	AAEE /AAFS Programmatic Tool
Res, Com, Ind	AAFS: Programmatic Impacts	AAEE /AAFS Programmatic Tool
Res, Com, Ind	AAFS: Combustion Control Measures	FSSAT Tool
Transportation	Baseline Forecast	Transportation Models
AG +WP	Baseline Forecast	Agricultural Model
AG +WP	Energy Efficiency Impacts	AAEE/AAFS Programmatic Tool
TCU	Baseline Forecast	TCU Model
PV & Storage	Baseline Forecast	dGen, Title 24, Standalone Storage Models



# SB 100 Demand Scenario – Total Consumption

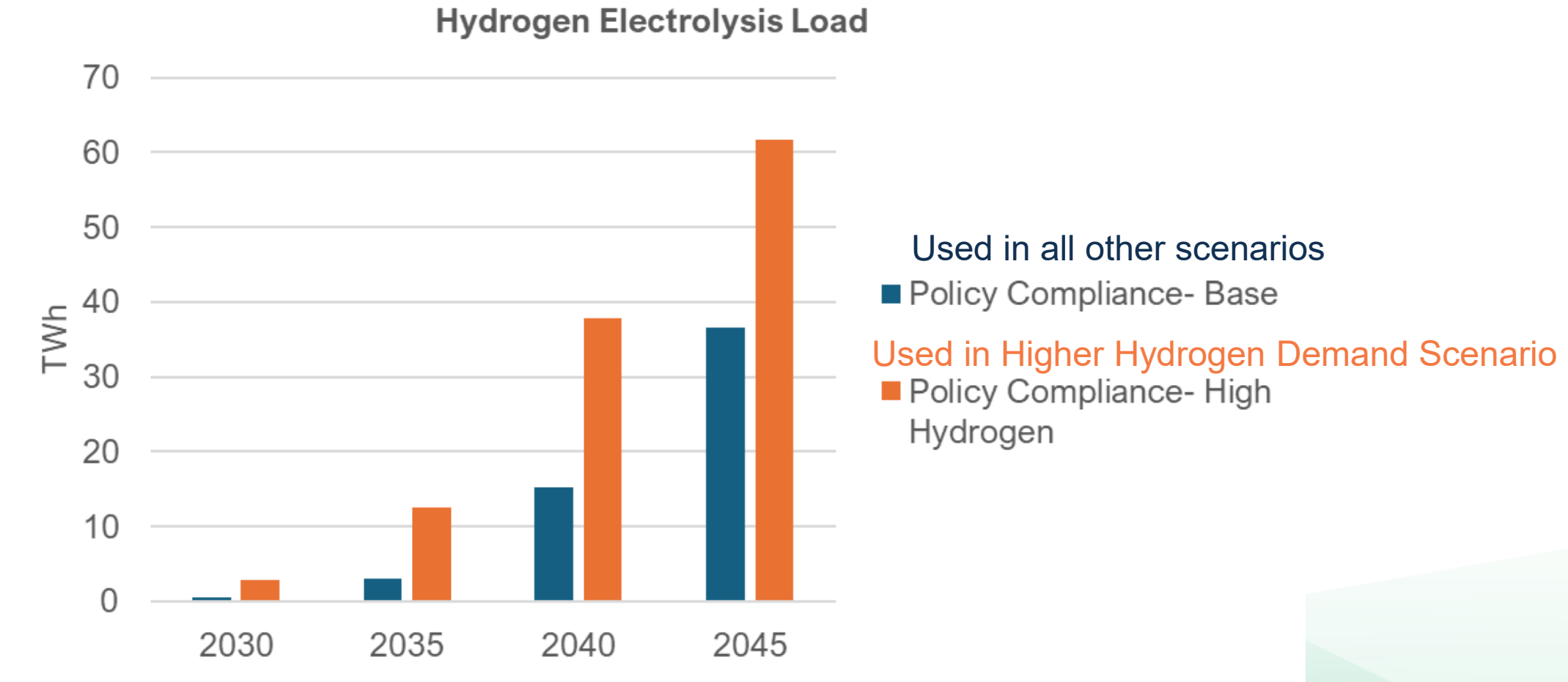
- The 2023 Demand Scenarios project was used for this modeling.
- This is a hypothetical demand scenario looking at the system under high electrification.



■ Total Self Generation  
■ Total Managed Sales



# Hydrogen Electrolysis Demand



Hydrogen loads are modeled as 1/2 baseload, 1/2 dispatchable



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# Existing Resource Assumptions



# Expansion Candidates

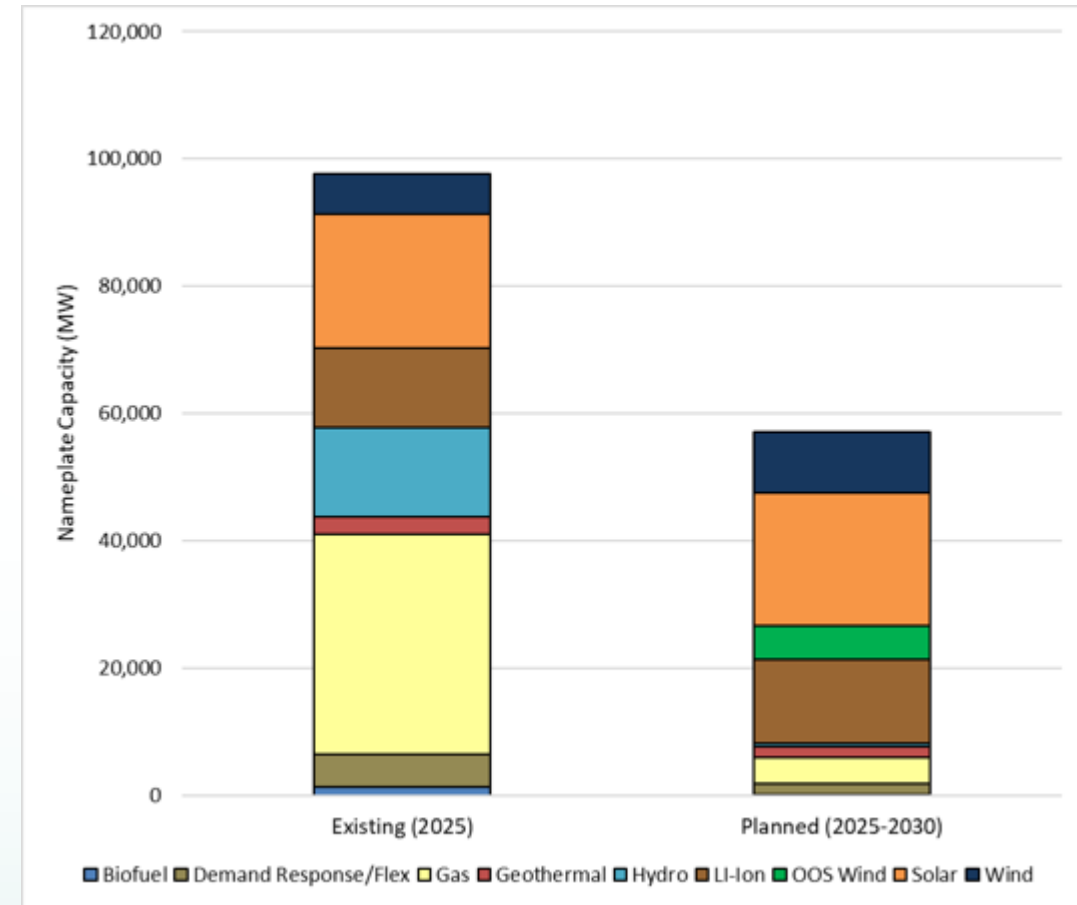
Technology	Available in California?*	Equipment Lifetime
fossil gas Combined Cycle without CO <sub>2</sub> capture	No	60
fossil gas Combustion Turbine	No	60
fossil gas Combined Cycle with 97% CO <sub>2</sub> capture	No	60
Retrofit of fossil gas Combined Cycle with 95% CO <sub>2</sub> capture	Yes	N/A
Retrofit of fossil gas Combined Cycle to Hydrogen	Yes	N/A
Hydrogen Combined Cycle	Yes	60
Hydrogen Combustion Turbine	Yes	60
Hydrogen Fuel Cell	Yes	20
Biomass without CO <sub>2</sub> capture	Yes	60
Biomass with 90% CO <sub>2</sub> capture	Yes	60
Nuclear (Generation III)**	No	80
Advanced Nuclear**	No	60
Geothermal***	Yes	30
Onshore Wind	Yes	25
Offshore Wind (Floating)	Yes	25
Front of the Meter Customer-Owned Solar	Yes	30
Solar Photovoltaic (Fixed Tilt, Single Axis, Double Axis)	Yes	30
Concentrating Solar Power (CSP)	Yes	60
Lithium Ion Batteries	Yes	20
Long-Duration Energy Storage	Yes	20
Pumped Hydro Storage	No	100

- These are candidates for SB100 modeling.
- SB100 Report is not a venue for determining compliance.
- \*All technologies in this table available in WECC but only those marked Yes are candidates in California
- \*\*Excluded from CA based on PRC moratorium on new nuclear plants until there is means for permanent disposal of nuclear waste.
- \*\*\*Conventional geothermal only.



# Installed Capacity in California

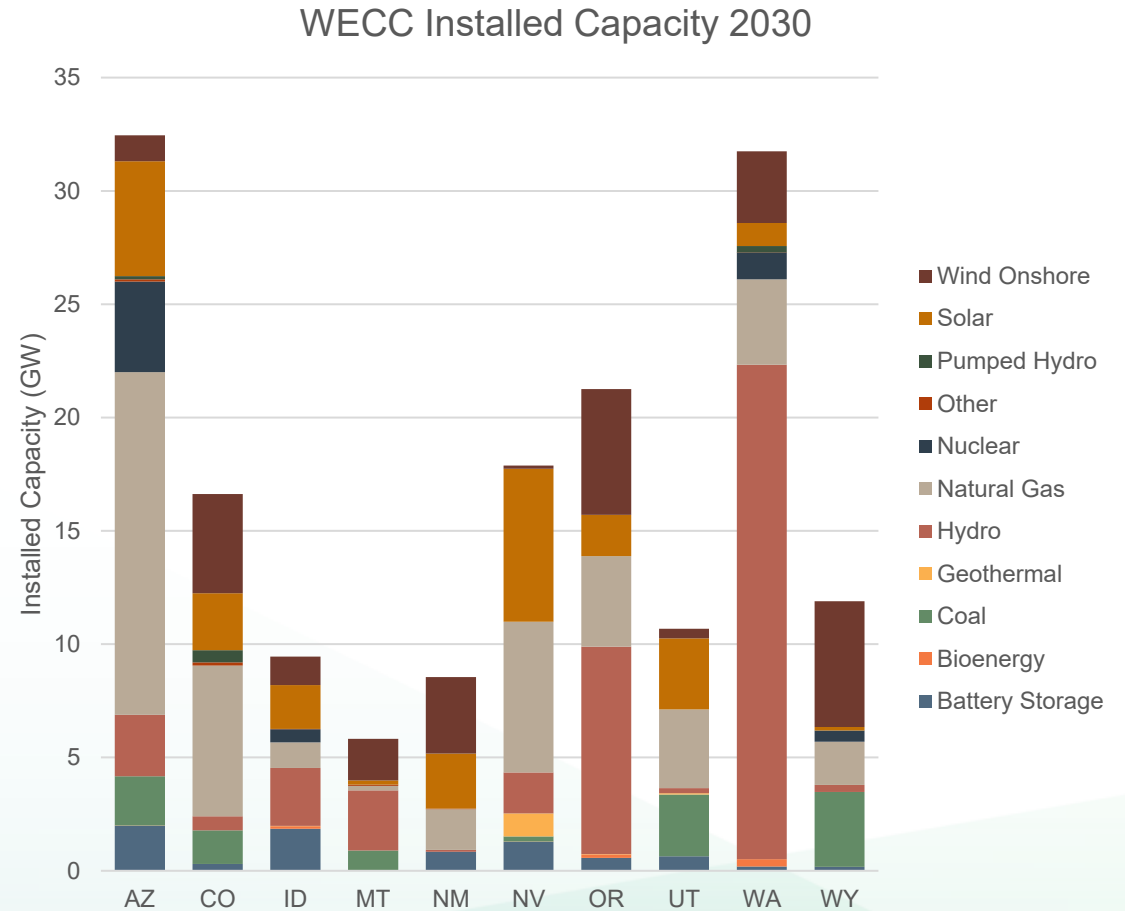
- Existing resources sourced from CEC's Quarterly Fuels and Energy Report data, last updated in 2023.
- Planned resources sourced from CPUC's 2023 Adopted Preferred System Plan
- Planned resources for non-CAISO regions align with assumptions from PSP, based on Supply Form filings.
- Planned resources built before 2030 are included in all scenarios as part of the baseline build.





# Rest of WECC Resources

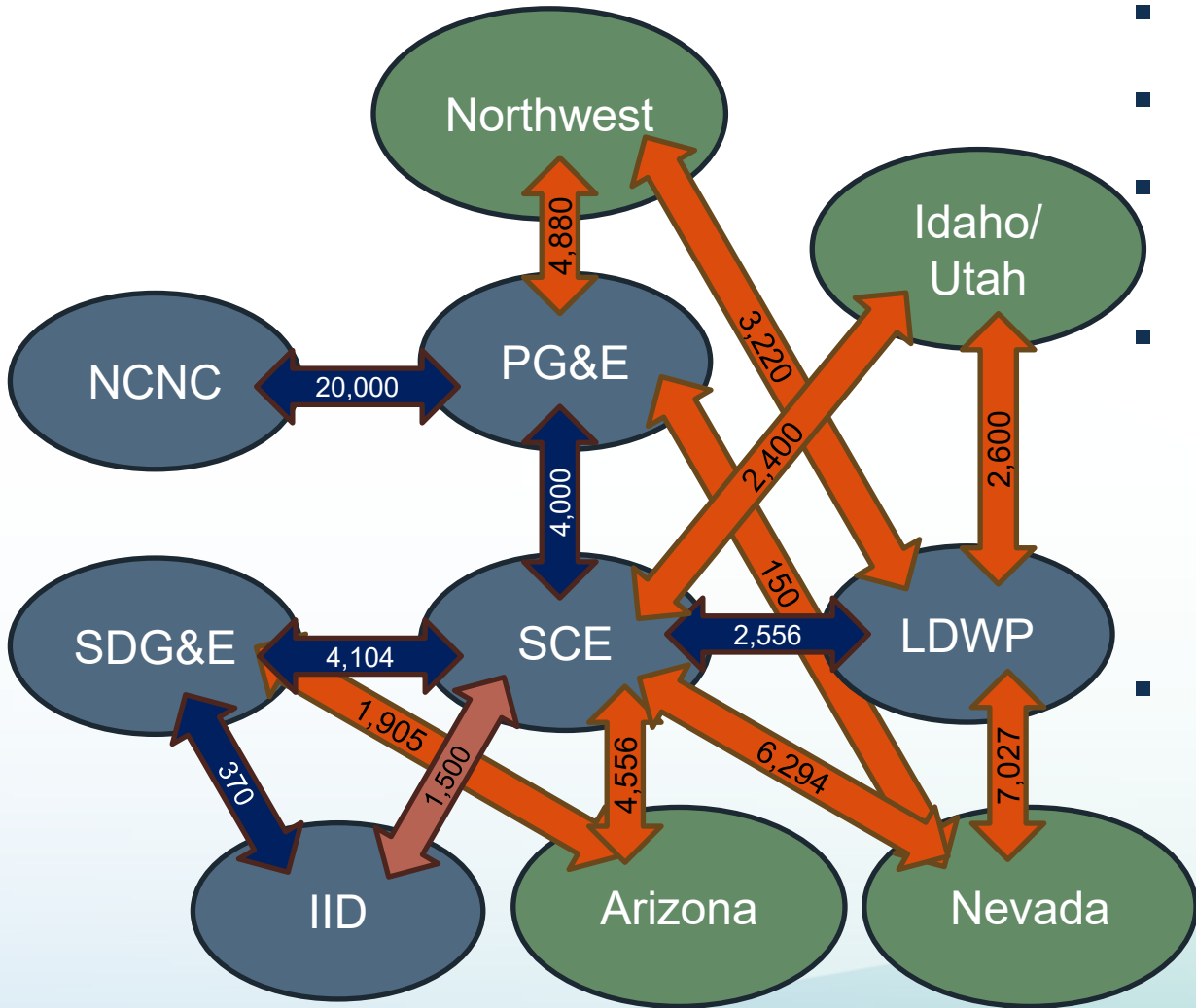
- All resources sourced from WECC Anchor Data Set 2032, including existing and planned.
- REGEN model builds additional WECC resources out to 2045.



Sources: WECC Anchor Dataset – ADS 2032

# Transmission

## Transfer Capacity (MW)



- Statewide CA imports are limited to 12,450 MW
- Statewide CA exports are limited to 4,000 MW
- These import limitations apply in all hours for all models
- Planned transmission expansions include:
  - Transwest
  - SWIP North
  - Sunzia
  - Desert Southwest Reinforcement
- Additional transmission to interconnect selected resources is not modeled, but included in NLR ATB build costs

# Resource Costs



# Approach to Resource Costs

- Based on NLR ATB 2024 unless noted otherwise
- Includes subsidy regime under the Inflation Reduction Act, which has since been partially repealed by the One Big Beautiful Bill Act in July 2025
- Subsidy regime includes Investment Tax Credit and Production Tax Credit out to 2050 for all renewable resources, including wind and solar.
- Adjusted for:
  - California-specific grid connection costs for offshore wind, based on CAISO TPP study
  - Federal tax credits: Investment Tax Credit, Production Tax Credit, 45Q, 45V
  - CO<sub>2</sub> and hydrogen transportation and storage



# Non-ATB Resource Assumptions

- Capital costs for hydrogen resources are based on costs for gas resources in NRL ATB and adjusted based on adders from SB423:
  - Combustion turbine capital and O&M costs are 20% larger
  - Combined cycle capital and O&M costs are 15% larger
  - Heat rates is assumed to be 10% larger through 2035 and 5% larger thereafter
  - Fuel cell capital and operations & maintenance costs are 15% lower, heat rates are the same
- Biomass with 90% capture costs are proprietary EPRI estimates. For future costs, the learning rate for the fossil gas with 97% capture found in NRL ATB is used.
- Long-duration energy storage costs and efficiencies are based on a public McKinsey report, “Net-zero power: Long duration energy storage for a renewable grid” (2021). The 24+hour archetype is used, with costs representing metal-air batteries.



# Capital Cost Adjustments

## Capital Cost of Generators in 2035 (\$/kW)

Technology	Base Plant Capital	Investment Tax Credit <sup>1</sup>	Offshore Grid Connection	CO <sub>2</sub> Storage	Local CO <sub>2</sub> Pipeline	Regional CO <sub>2</sub> Pipeline	Total
Fossil Gas Combined Cycle without CO <sub>2</sub> capture	1742	0	0	0	0	0	1742
Fossil Gas Combustion Turbine	1279	0	0	0	0	0	1279
Retrofit of fossil gas Combined Cycle with 95% CO <sub>2</sub> capture	1151	0	0	55	72	0-95	1278-1373
Hydrogen Combined Cycle	1997	0	0	0	0	0	1997
Hydrogen Combustion Turbine	1535	0	0	0	0	0	1535
Hydrogen Fuel Cell*	1355	0	0	0	0	0	1355
Biomass without CO <sub>2</sub> capture	4972	-1492	0	0	0	0	3480
Biomass with 90% CO <sub>2</sub> capture	7911	0	0	55	240	0-95	8206-8301
Nuclear (Generation III)	6751	-2025	0	0	0	0	4726
Advanced Nuclear	7280	-2184	0	0	0	0	5096
Geothermal	5714	-1714	0	0	0	0	4000
Onshore Wind	1293	0	0	0	0	0	1293
Offshore Wind (Floating)	5046	-1514	115 - 2696	0	0	0	3647-6228
FTM Solar	1228	0	0	0	0	0	1228
Solar Photovoltaic (Single Axis)	887	0	0	0	0	0	887
Concentrating Solar Power (CSP)	4628	0	0	0	0	0	4628

Based on NLR ATB 2024, deflated to 2021 USD by 8%



# Energy Storage Assumptions

Technology	Roundtrip Efficiency	Storage Duration (hours)
Lithium-ion Battery – 8hr	92%	8
Lithium Ion Battery – 4hr	92%	4
Long duration Storage	60%	25



# All Tax Credits Applied to Units, 2035

Technology	Investment Tax Credit (\$/kW)	Production Tax Credit (\$/MWh)	45Q (\$/MWh)	45V* (\$/MWh)
Retrofit of Fossil Gas Combined Cycle with 95% CO <sub>2</sub> capture	0	0	-20.30	0
Hydrogen Combined Cycle	0	0	0	-53.74
Hydrogen Combustion Turbine	0	0	0	-53.74
Hydrogen Fuel Cell	0	0	0	-53.74
Biomass without CO <sub>2</sub> capture	-1492	0	0	0
Biomass with 90% CO <sub>2</sub> capture	0	0	0	0
Nuclear (Generation III)	-2025	0	0	0
Advanced Nuclear	-2184	0	0	0
Geothermal	-1714	0	0	0
Onshore Wind	0	-14.64**	0	0
Onshore Wind, Energy Community	0	-15.90**	0	0
Offshore Wind (Floating)	-1514	0	0	0
FTM Solar	0	0	0	0
Solar Photovoltaic	0	-14.64	0	0
Solar Photovoltaic, Energy Community	0	-15.90	0	0
Concentrating Solar Power (CSP)	0	0	0	0
Long Duration Energy Storage	-405	0	0	0
Lithium Ion Storage, 8 hour	-632	0	0	0
Lithium Ion Storage, 4 hour	-375	0	0	0

\*Hydrogen fuel prices are determined endogenously by the model based on electricity costs. 45V credits are applied to modules generating hydrogen via electrolysis. Generally the subsidy is high enough to keep hydrogen fuel prices in the model at or below \$0.

\*\*PTC applies for 10 years at a value of \$25. The capacity expansion models can't account for a tax credit expiring in different years so the value was lowered and extended across the 15 year horizon instead.



# Existing Generator Assumptions

	Forced Outage Rate (%)	Maintenance Frequency (Events/year)	Mean Time to Repair (Hours/event)	Min Time to Repair (Hours/event)	Min Down Time (Hours)	Min Up Time (Hours)	Start Cost (\$/MW)	VO&M Charge (\$/MWh)
<b>Biogas CC</b>	4.06	2.21	74	15	8	6	79	2.8
<b>Biogas CT</b>	10.08	3.09	70	7	1	1	69	4.8
<b>Biogas IC</b>	6.58	4.03	35	2	1	1	69	5
<b>Biomass ST</b>	11.86	2.45	154	26	8	10	129	2.8
<b>Coal ST</b>	9.2	2.79	118	15	12	24	129	2
<b>Geothermal</b>	9.9	2.6	128	19	12	24	0	3
<b>Hydro</b>	8.25	3	63	13	1	1	0	2.5
<b>NG CC</b>	4.06	2.21	74	15	8	6	79	2.8
<b>NG CT</b>	10.08	3.09	70	7	1	1	69	4.8
<b>NG IC</b>	6.58	4.03	35	2	1	1	69	4.8
<b>NG ST</b>	11.75	2.55	143	22	8	10	129	2.8
<b>Nuclear</b>	2.16	0.13	122	24	168	168	0	1
<b>Oil CT</b>	10.08	3.09	70	7	1	1	69	4.8
<b>Oil IC</b>	6.58	4.03	35	2	1	1	69	4.8

Sources for generator properties are located on the slide titled “Existing Generator Property Sources”



# Existing Generator Assumptions Sources

- Heat Rate curves for existing CA plants in the dispatch model were developed by CEC staff based on 5-minute data from CEMS for reporting plants. Generic curves are developed and used for non-reporting plants. Data was developed in 2021 using plant data for 2018 and 2019.
- Heat rate curves for existing and planned WECC facilities in the dispatch model are based on data from the 2022 Anchor Data Set.
- Heat rates for expansion plants in REGEN and PLEXOS LT are based on NLR ATB.
- VO&M Charges for existing and planned PSP resources are based on generic bids from 2018 CAISO variable operations and maintenance cost report.\* VO&M charges for expansion candidates are based on NRL ATB.
- Start Cost, Min Up Time, and Min Down Time data based on NLR Eastern Renewable Generation Integration Study (2016, uses EIPC study base data) for unit class characteristics.\*\*
- Forced Outage Rates and Maintenance Frequency based on NERC GADS Brochure 4.\*\*\*

\*Nexant. (2018, December 21). Variable Operations and Maintenance Costs Report Submitted to: California Independent System Operator. From

[www.caiso.com/documents/variableoperationsandmaintenancecostreport-dec212018.pdf](http://www.caiso.com/documents/variableoperationsandmaintenancecostreport-dec212018.pdf)

\*\*NRL (2016, August). Eastern Renewable Generation Summary. <https://www.nrel.gov/grid/ergis.html>

\*\*\*NERC. (2022, 8 1). Generating Unit Statistical Brochure 4 2017-2021 All Units Reporting. From Generating Unit Statistical Brochures: <https://www.nerc.com/pa/RAPA/gads/Pages/Reports.aspx>



# Operating Reserves

- Spin, Non-Spin, and Regulation-Up reserves are included in the PLEXOS model.
- Spin and non-spin reserves are modeled as a percentage of system load, each representing 3% of the system’s net energy for load.
- Regulation reserves are modeled as an hourly profile, following an average day per month (“12x24”) reserve requirement that sets a unique regulation requirement for each hour in the day depending on the month. The source of this profile is the CAISO PLEXOS database.

Reserve Name	Quantity	Response Time (min)	Response Duration (min)	Violation Results in Load Shed?
CAISO Spin	3% Net Energy for Load	10-minutes	30-minutes	Yes
Muni Spin	3% Net Energy for Load	10-minutes	30-minutes	Yes
CAISO Non-Spin	3% Net Energy for Load	10-minutes	60-minutes	No
Muni Non-Spin	3% Net Energy for Load	10-minutes	60-minutes	No
CAISO Reg-Up	12x24: 140-740 MW	10-minutes	30-minutes	No
Muni Reg-Up	12x24: 24-120 MW	10-minutes	30-minutes	No

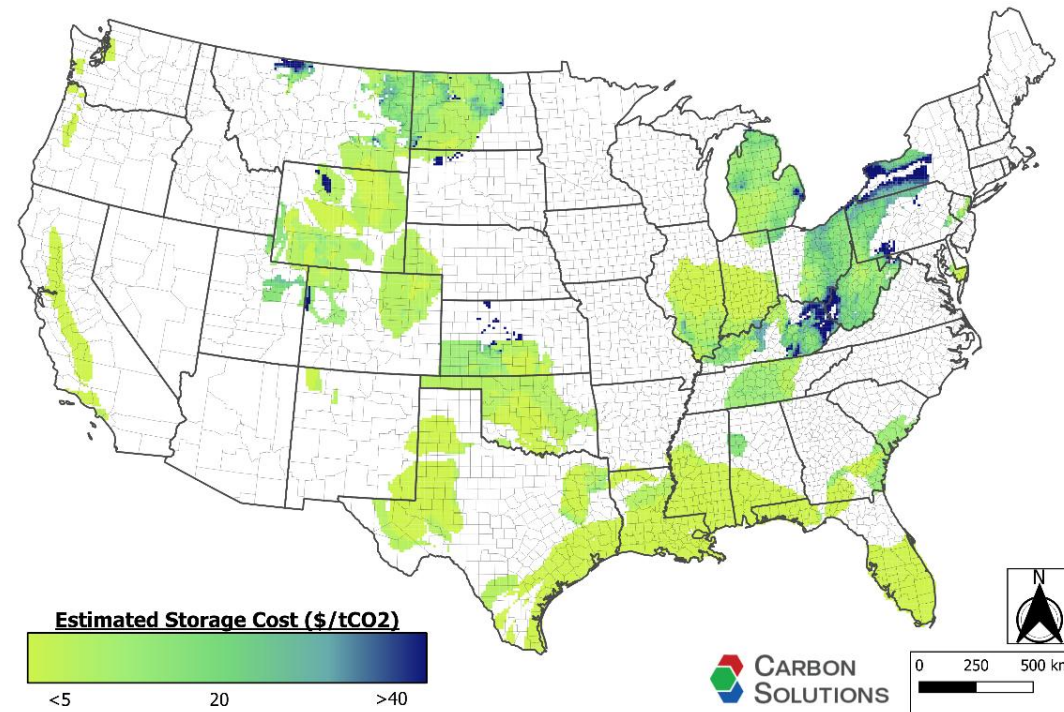
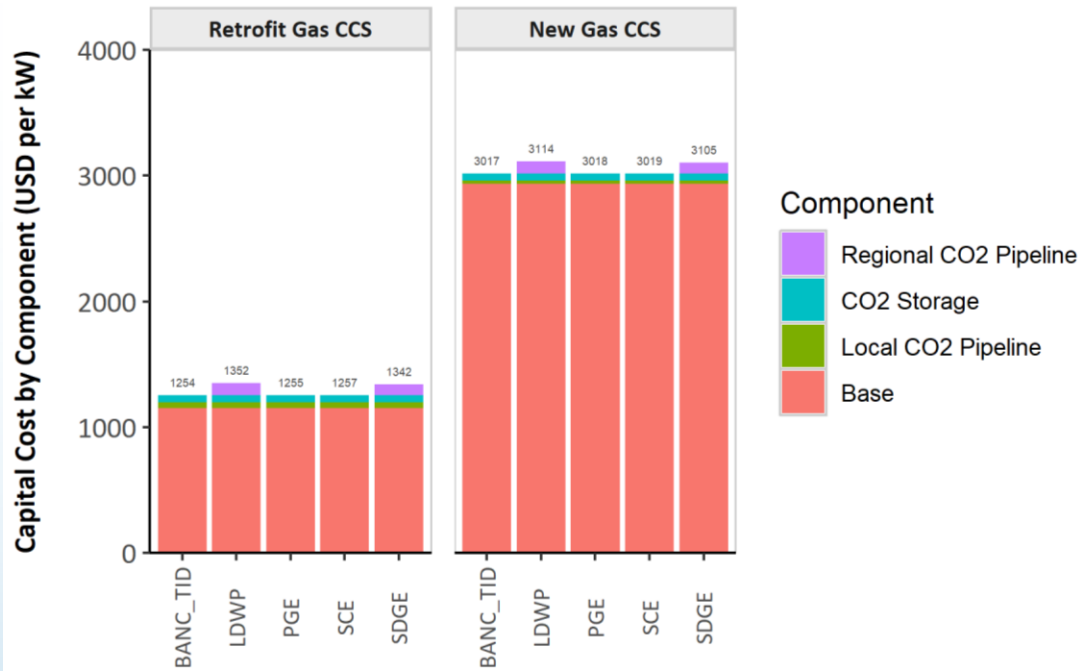


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# Resource Potentials

# CO<sub>2</sub> Storage Potentials

- EPRI worked with Carbon Solutions to develop supply curves for CO<sub>2</sub> storage in saline formations for each state in the continental U.S.
- For regions without CO<sub>2</sub> storage, pipelines to storage capacity must be built. This is represented by additional capital cost charges shown below on the left.





# Planned CCS Projects

- 45Q Subsidy for CCS plants expires in 2033 under current law
- SB100 modeling assumes that the lead time for retrofitting plants and building storage infrastructure is long, so the number of plants that can be built before 2033 and get the subsidy is limited to those projects already in development.

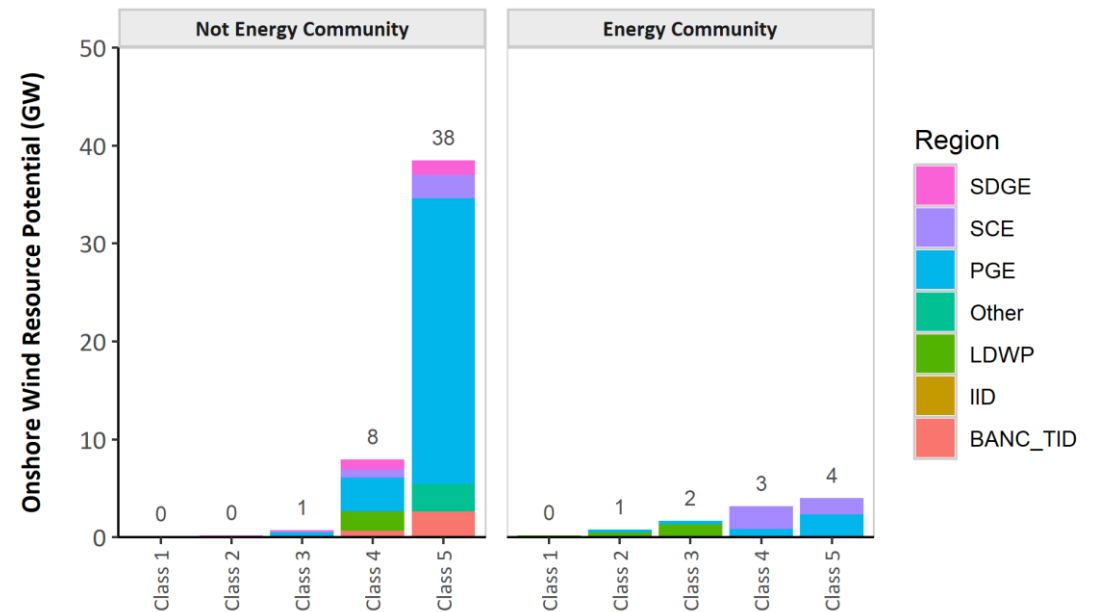
Plant Name	Plant Type	Retrofit Capacity	Sub-Region	Planned/Option	Year Available
Sutter	Combined Cycle	550	NCNC	Planned	2030
Elk Hills	Combined Cycle	550	SCE	Option	2035
Los Medanos	Combined Cycle	500	PG&E	Option	2035



# Wind Potentials and Profiles

- CEC Core Land Use Screen determines land available for resource development.
- Wind locations are assigned to ten resource classes based on long-run average wind speed (1950-2022) in the Global Wind Atlas and whether they are in areas that qualify as IRA energy communities.
- Hourly generation profiles sourced from ERA, and those generation shapes are then derated based on the more granular long-run wind speeds in the Global Wind Atlas.
- Most wind available to be built by the model is low-CF class 5 wind not currently considered commercially viable.

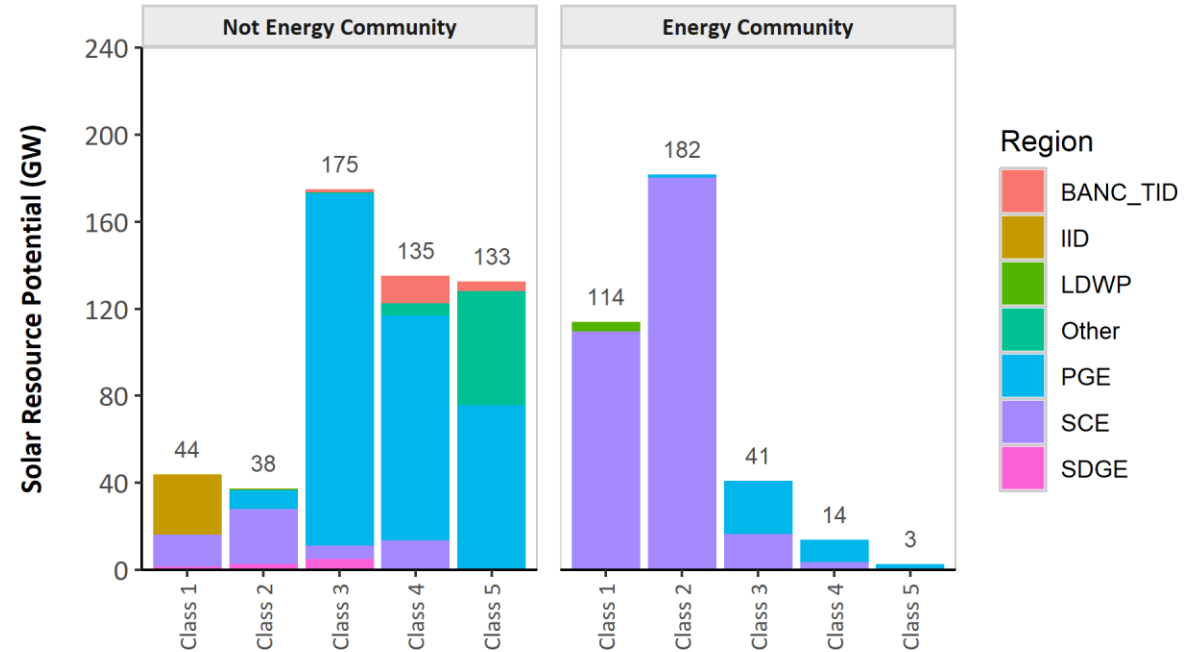
Onshore Wind Resource	Long-run average wind speed (100m hub height)
Class 1 (Best)	9 – 15 m/s
Class 2	8 – 9 m/s
Class 3	7 – 8 m/s
Class 4	6 – 7 m/s
Class 5 (Worst)	5 – 6 m/s





# Solar Potentials and Profiles

- Solar locations are assigned to ten resource classes based on long-run average DNI (1950-2022) and whether they are in areas that qualify as IRA energy communities.
- Hourly DNI are converted to hourly gross capacity factors based on models of solar PV technologies, including fixed-tilt, single-axis, and double-axis.
- Unique hourly solar profiles are developed for each resource class, technology and model region. Technologies share the resource within each resource class.
- Capacity factors vary more by technology than region or class and all regions of CA have access to large amounts of high-quality solar resources.





# Existing Resource Profiles

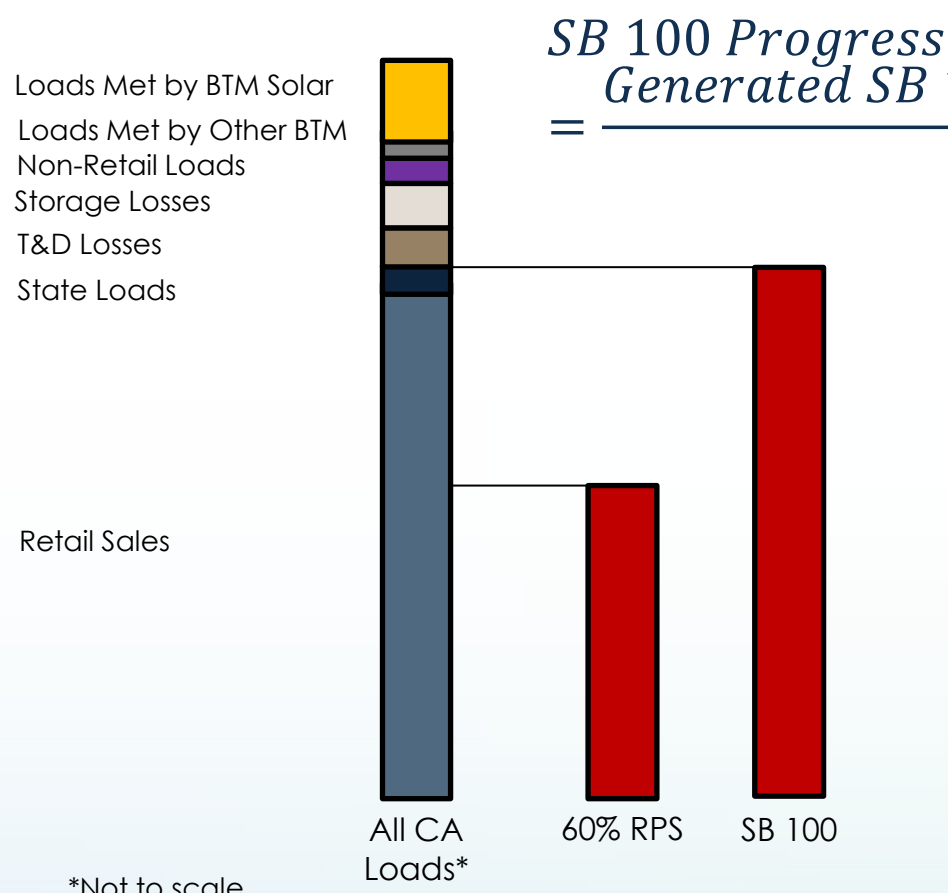
- Profiles for existing wind were built using NLR's Wind Toolkit for years 2007-2014 and calibrated using the EIA 923 monthly historic generation data.
- Profiles for existing wind for weather years 2015-2022 were built by aggregating CAISO subpoena data by Wind Resource Area.
- Profiles for existing solar were built using the National Solar Radiation Database version 3.2.2 and NLR's System Advisor Model.
- Existing and Planned resources for WECC use the profiles from the 2022 WECC ADS. Expansion candidates in WECC use the class-based profiles built in the REGEN process.
- In PLEXOS, the planned PSP resources use aggregated profiles built from the same process as existing resources. In REGEN, the planned resources use the class-based profiles built in the REGEN process. Both PLEXOS and REGEN use the class-based profiles built in the REGEN process for expansion candidates.
- The PLEXOS RA model uses profiles for all 15 weather years. The PLEXOS LT and Dispatch model use wind and solar shapes for the 2016 weather year.



# Policy Assumptions



# Accounting for SB 100 and SB 1020 Targets



## SB 100 Resource Target

Year	Retail Sales	Energy Procured for State Loads
2030	N/A	N/A
2035	90%	100%
2040	95%	100%
2045	100%	100%

**Note:** The 60% RPS will be enforced for all years.

\*Not to scale



# GHG Emissions

- The model includes electricity sector 2045 GHG emissions consistent with the 2022 Scoping Plan Scenario’s level of emissions needed to reduce economy-wide anthropogenic GHG emissions by 85% as mandated by AB 1279
- Interim emissions align with the CPUC IRP and SB 350 2030 GHG planning target range in CARB Board Resolution 22-21.
- Unspecified Imports are assigned an average emissions factor of 0.21 tons/MWh.
- Clean resources in dedicated regions can provide imports to CA that are considered GHG-free and RP/SB100 qualifying just in relation to this report.
- Biomass and geothermal resources have no associated GHG emissions.

Year	CAISO GHG Emissions (MMT)	Statewide GHG Emissions (MMT)
2030	24.3	30
2035	20.3	25
2040	13.7	16.9
2045	7.1	6.9



# Reliability, PRM, and ELCCs

- There are various reliability parameters used for SB 100 analysis. Those used in this study are not meant to capture any single of California's various jurisdictions, but an aggregation of all of them.
- The PRM for the model is set to 17% at peak. The policy applies to the state as a whole, given that many entities contract with generators outside the boundaries of their region.
- Renewable ELCCs determined by REGEN based on the average renewable output in the 1% of hours with highest net loads.
- Hydro ELCCs are set to the maximum monthly rating described in the hydro properties slide. As the peak month shifts in certain regions from summer to winter, the ELCC of hydro shifts as well.
- ELCCs for gas, batteries, and other firm resources are set to the maximum capacity of the unit.
- Imports do not have a firm capacity value, including resources built outside the state for SB100 targets.
- Reliability is primarily verified through a full LOLE study for each scenario rather than PRM and ELCCs. The PRM can be adjusted upwards for the state or individual regions if reliability targets are not met. Reliability targets are met in all scenarios except Combustion Retirement without adjustment.
- ELCCs for renewables vary by scenario. The numbers below are for the Comparison scenario.

	Solar	North CA Wind	South CA Wind	Offshore Wind	Hydroelectric	All Other
2030	0.006	0.371	0.196	0.474	0.661	1.000
2035	0.016	0.189	0.163	0.430	0.654	1.000
2040	0.015	0.145	0.153	0.369	0.645	1.000
2045	0.012	0.120	0.138	0.359	0.649	1.000



# Retirements and Retention

- Resources with a set retirement date retire per statute. This includes Diablo Canyon retiring before the study window begins in 2030.
- Most CHP resources are assumed to phase out linearly before 2040, in alignment with the PSP.
- All other gas resources in California are retained and not subject to economic retirements.
- Planned retirements in WECC are sourced from the WECC ADS. Other resources are not subject to economic retirements.

	Solar	North CA Wind	South CA Wind	Offshore Wind	Hydroelectric	All Other
2030	0.006	0.371	0.196	0.474	0.661	1.000
2035	0.016	0.189	0.163	0.430	0.654	1.000
2040	0.015	0.145	0.153	0.369	0.645	1.000
2045	0.012	0.120	0.138	0.359	0.649	1.000



# Fuel Assumptions

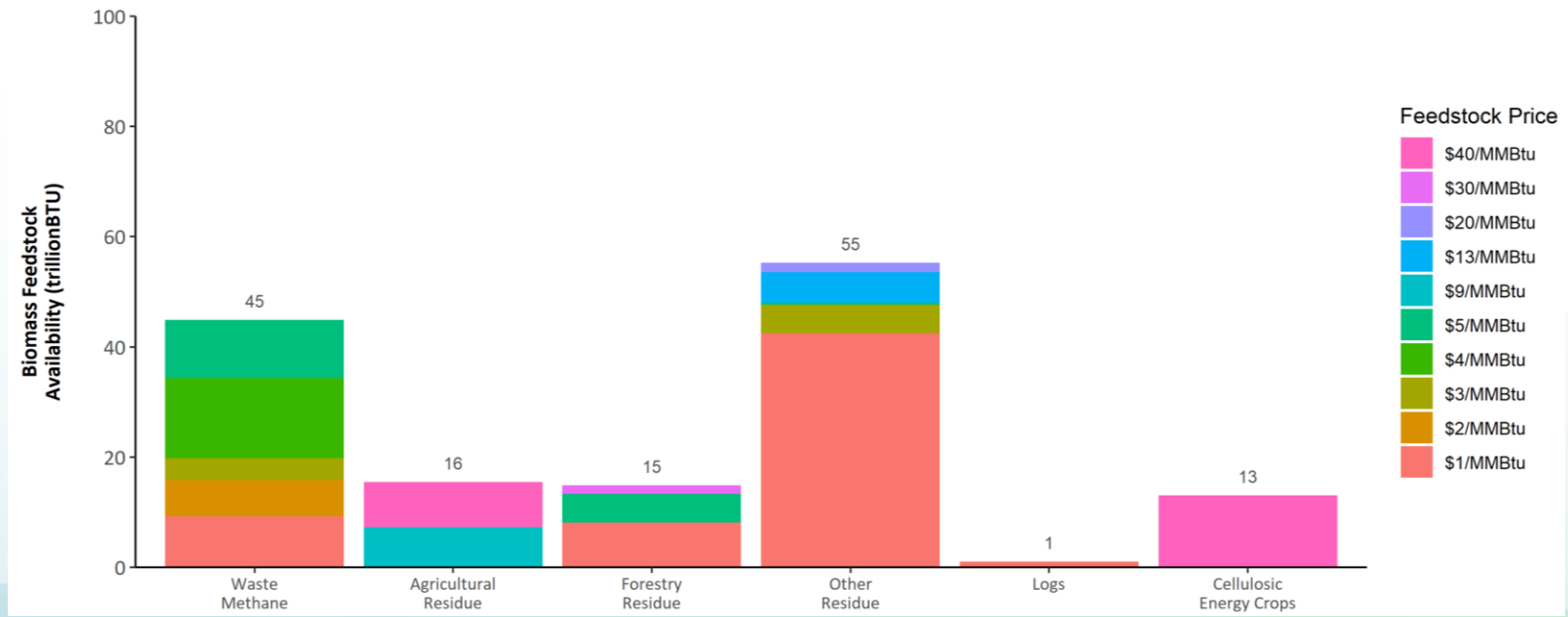
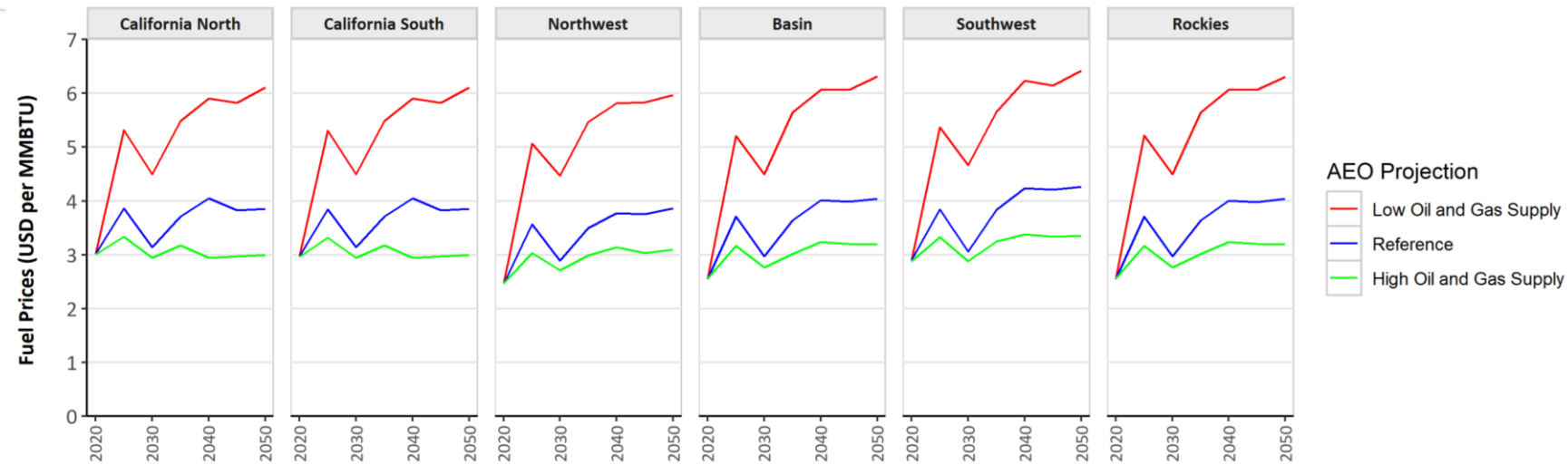


# Fossil Gas, Uranium, and Biomass Prices

- Projected fuel prices for fossil gas, diesel, coal, refined fuel oil, and uranium are sourced from the Energy Information Administration's Annual Energy Outlook (AEO) 2023.

Modeling uses the Reference projection and prices in 2022 USD are deflated to 2021 USD using an inflation rate of 7%.

- The supply curves for biomass were developed using the Forest and Agricultural Sector Optimization Model (FASOM) created by the US Dept. of Agriculture.





# Hydrogen Modeling

- REGEN models hydrogen production, storage, delivery, and generation costs.
- International Energy Agency (IEA) Future of Hydrogen (2016) and Global Hydrogen Review (2024) provide the CAPEX, fixed O&M costs and efficiencies for hydrogen production technologies.
- Capital costs and potentials for storing hydrogen in depleted oil and gas reservoirs are sourced from the 2023 EPRI report, *Hydrogen Storage for US-REGEN Model: Cost and Availability* which is not CA-specific.
- There is a fixed cost of \$10/mmBtu that represents the cost of intra-regional hydrogen distribution. This cost is also derived from Argonne's HDSAM.

## Hydrogen

Technology	Parameter	Units	Today	2030	Long term
Water electrolysis	CAPEX	USD/kW <sub>e</sub>	900	700	450
	Efficiency (LHV)	%	64	69	74
	Annual OPEX	% of CAPEX	1.5	1.5	1.5
	Stack lifetime (operating hours)	hours	95 000	95 000	100 000
Natural gas reforming	CAPEX	USD/kW <sub>H2</sub>	910	910	910
	Efficiency (LHV)	%	76	76	76
	Annual OPEX	% of CAPEX	4.7	4.7	4.7
	Emission factor	kgCO <sub>2</sub> /kgH <sub>2</sub>	8.9	8.9	8.9
Natural gas reforming with carbon capture	CAPEX	USD/kW <sub>H2</sub>	1 680	1 360	1 280
	Efficiency (LHV)	%	69	69	69
	Annual OPEX	% of CAPEX	3	3	3
	CO <sub>2</sub> capture rate	%	90	90	90
	Emission factor	kgCO <sub>2</sub> /kgH <sub>2</sub>	1.0	1.0	1.0
Coal gasification	CAPEX	USD/kW <sub>H2</sub>	2 670	2 670	2 670
	Efficiency (LHV)	%	60	60	60
	Annual OPEX	% of CAPEX	5	5	5
	Emission factor	kgCO <sub>2</sub> /kgH <sub>2</sub>	20.2	20.2	20.2
Coal gasification with carbon capture	CAPEX	USD/kW <sub>H2</sub>	2 780	2 780	2 780
	Efficiency (LHV)	%	58	58	58
	Annual OPEX	% of CAPEX	5	5	5
	CO <sub>2</sub> capture rate	%	90	90	90
	Emission factor	kgCO <sub>2</sub> /kgH <sub>2</sub>	2.1	2.1	2.1



# Summary



# Key Inputs Across Models

Key Inputs	REGEN	PLEXOS LT (Capacity Exp)	PLEXOS RA (Resource Adequacy)	PLEXOS PCM (Deterministic Production Cost)
Clean Energy Policy - WECC	Public Sources	N/A	N/A	Public Sources
Electricity Demand	CA – 2023 Demand Scenario WECC - EPRI Analysis	CA – 2023 Demand Scenario	CA – 2023 Demand Scenario	CA – 2023 Demand Scenario WECC - EPRI Analysis
Planned Resources	CA- CPUC's PSP, POU IRPs WECC - Anchor Dataset	CA- CPUC's PSP, POU IRPs	CA- CPUC's PSP, POU IRPs	CA- CPUC's PSP, POU IRPs WECC - Anchor Dataset
Existing Resources	CA- Quarterly Fuel and Energy Report, CAISO, Filings WECC - Anchor Dataset	CA- Quarterly Fuel and Energy Report, CAISO, Utility filings	CA- Quarterly Fuel and Energy Report, CAISO, Utility filings	CA- Quarterly Fuel and Energy Report, CAISO, Utility filings WECC - Anchor Dataset
Candidate/Expansion Technologies	Specified Options	CA-REGEN output	PLEXOS LT	PLEXOS LT
Renewable Profiles	Existing – REGEN Profiles Planned – REGEN Profiles New – REGEN Profiles	Existing – Generator-specific CEC Profiles Planned – Statewide Profiles New – REGEN Profiles	Existing – Generator-specific CEC Stochastic Profiles Planned – Statewide Stochastic Profiles New – REGEN Stochastic Profiles	Existing – Generator-specific CEC Profiles Planned – Statewide Profiles New (CA and WECC) – REGEN Profiles WECC Existing – WECC ADS
Fuel Prices	EIA Annual Energy Outlook	EIA Annual Energy Outlook	EIA Annual Energy Outlook	EIA Annual Energy Outlook
System Topology	CA - Balancing Authorities WECC - States	CA - Balancing Authorities WECC – OOS Renewable candidates	CA - Balancing Authorities	CA - Balancing Authorities WECC - Superregions
Transmission	CA – Existing CA Dataset WECC – EPA Integrated Planning Model Platform v6	CA – Existing CA Dataset WECC – EPA Integrated Planning Model Platform v6	CA – Existing CA Dataset WECC – EPA Integrated Planning Model Platform v6	CA – Existing CA Dataset WECC – EPA Integrated Planning Model Platform v6
Reserve Requirements	Simplification of Balancing Authority Requirements	Balancing Authority Requirements	Balancing Authority Requirements	Balancing Authority Requirements

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# Land Use Context

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# Capacity Density Metrics

# Capacity Density Metrics for SB 100 Land Use Analysis

Energy Technology	Capacity Density (Acres/MW)
Solar	7.6 - 10
Wind	25 - 46.4
Offshore Wind	49.2 - 82.3
Geothermal	5 - 9
Battery Energy Storage System	0.1

- Derivation of these values shown on subsequent slides.
- Capacity density estimates acres of land area or sea space needed to support a megawatt of installed capacity.
- For each scenario, the values in the table above were multiplied by the MW of build to calculate total land area and sea space required.
- Lower and upper bound values capture uncertainty in project size and layout

# CPUC Capacity Densities

CPUC Inputs and Assumptions 2023		
Resource Type	Land-use Factor	
Solar (IRP modeling)	30 MW/km <sup>2*</sup>	8.2 acres/MW
Solar (Busbar Mapping Methods)	24.7 MW/km <sup>2</sup>	10 acres/MW**
Wind	6.2 MW/km <sup>2*</sup>	40 acres/MW
Geothermal	N/A	5 acres/MW**

*\*Inputs & Assumptions, 2022 – 2023 Integrated Resource Planning (IRP) October 2023. Values have since been updated in subsequent IRPs.*

*\*\*Compact Dashboard 25-26 TPP Base Case 2025-02-20*

# Research Methods

Energy Technology	Lower Bound Source	Upper Bound Source
<b>Solar</b>	Literature Review + CEC GIS spatial analysis	Stakeholder Input
<b>Wind</b>	Stakeholder Input	Literature Review + CEC GIS spatial analysis
<b>Offshore Wind</b>	Literature Review	
<b>Geothermal</b>	Literature Review	
<b>Battery Energy Storage System</b>	Literature Review	

# Literature Review Summary Findings

Energy Technology	Direct Land-use Intensity Range (Acres/MW)	Direct Land-Use Intensity (Acres/MW)	Total Land-Use Intensity Range (Acres/MW)	Total Land-Use Intensity (Acres/MW)	Source	Year
Solar					<a href="#">Land-Use Requirements for Solar Power Plants in the United States</a>	2013
Solar PV	5.8 - 9.0	7.2	7.5 - 8.1	7.9		
Solar CSP	2.0 - 9.0	7.7	4.7 - 9.5	10.0		
Wind	0.15 - 15	0.7	25 - 124	89	Land Use for Wind, Solar, and Geothermal Electricity Generation Facilities in the United States	2012
Geothermal	1.0 - 28.0	1.0	2.0 - 80	9.0	Land Use for Wind, Solar, and Geothermal Electricity Generation Facilities in the United States	2012

Definitions [per NLR](#): The total area corresponds to all land enclosed by the site boundary. The direct area comprises land directly occupied by solar arrays, access roads, substations, service buildings, and other infrastructure.

# Summary of Solar and Wind Geospatial Analysis

Energy Technology	Capacity Density (Acres/MW)	Source
<b>Solar</b>		
RPS Dataset	7.6	CEC GIS Spatial Analysis
QFER, EIA Dataset	7.3	CEC GIS Spatial Analysis
<b>Wind</b>		
750-meter buffer	59.7	CEC GIS Spatial Analysis
300-meter convex hull	46.4	CEC GIS Spatial Analysis

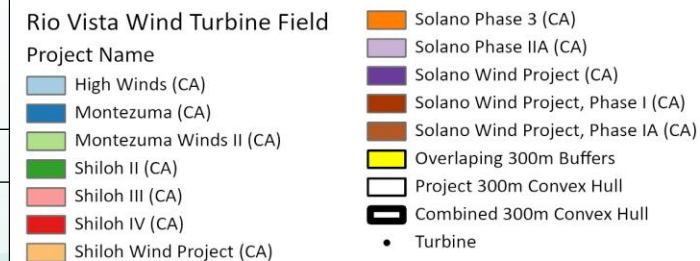
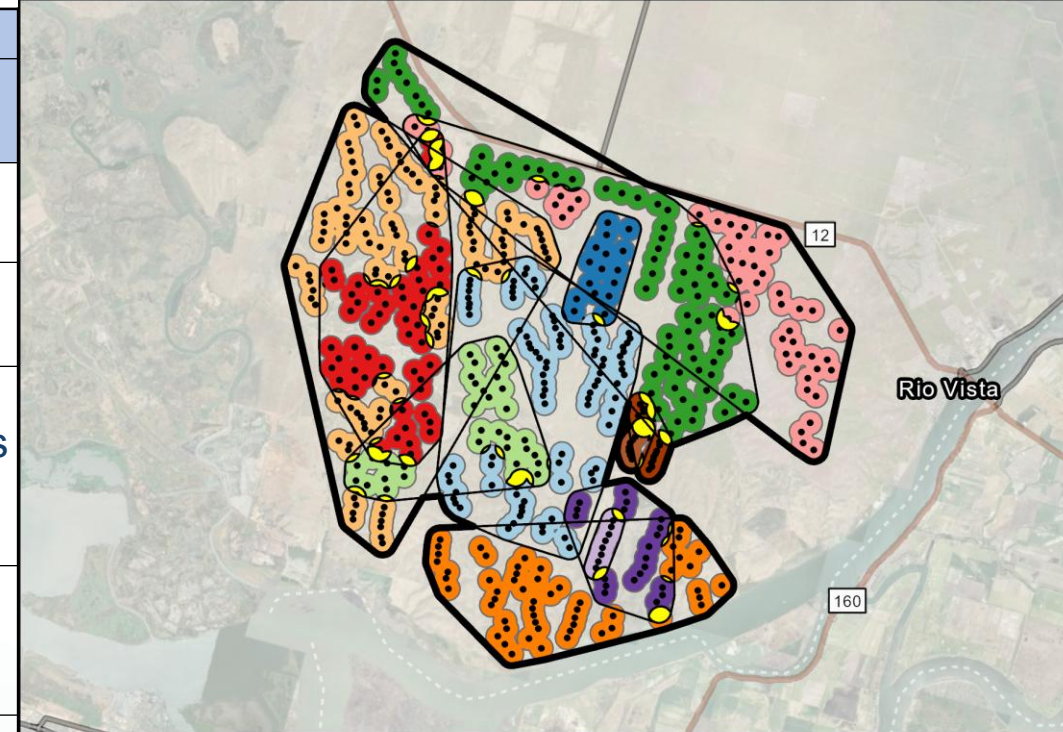
# Solar Analysis

Analysis Framework	Method
Step 1	Overlay USPVDB polygon data layer (filtered to CA projects with nameplate capacity 20 MW or greater) with CEC Solar Footprints (filtered to ground-mounted arrays only)
Step 2	Manually merge individual CEC Solar Footprint arrays to total project boundary from USPVDB.
Step 3	Sum the capacity of USPVDB solar projects that fall within modified CEC Solar Footprint polygons.
Step 4	Visually inspect to ensure appropriate USPVDB solar project nameplate capacity is summed within summed CEC Solar Footprint polygon
<b>Results (acres/MW)</b>	
<b>Mean (Results of Steps 1-3 above)</b>	<b>7.6</b>
<b>Large Scale Solar Association (LSA)</b>	<b>10</b>

# Wind Analysis

Convex Hull Example: 300-meter Convex Hull in Rio Vista Wind Turbine Field

Analysis Framework	Method
	Environmental Research Letter Method Harrison-Atlas et al*
Step 1 Main Approach to Define Project Area	300-meter buffer around turbines
	Create convex hull around buffers of each project
Step 2	When projects overlap, merge project footprints to create a single wind project footprint.
Step 3	Nameplate capacity of each merged project is summed within each convex hull
Output	Able to assign a nameplate capacity per footprint to calculate capacity density
Results of Steps 1-3 above	<b>46.4 acres/MW</b>
California Wind Energy Association (CalWEA)	<b>25 acres/MW</b>



\*Dynamic Land Use Implications from an Expanding Wind Energy Portfolio Reveal Geographic Challenges for a Low Carbon Energy Transition by Dylan Harrison-Atlas, Anthony Lopez, Eric Lantz (2021)

# Literature Review Summary Findings for Other Technologies

Energy Technology	Capacity Density (Acres/MW)	Source	Year
Offshore Wind*	82.3	The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032	2020
	46.6	Offshore Wind Energy Technical Potential for the Contiguous United States (NREL)	2022
	49.2	Offshore Wind Research California Study Results (NREL)	2022
	61.8	Offshore Wind Market Report: 2023 Edition (NREL)	2023
Geothermal	9	Land Use for Wind, Solar, and Geothermal Electricity Generation Facilities in the United States	2012
Battery Energy Storage System	0.03 - 0.09	Repowering Coal-Fired Power Plants for Battery Energy Storage	2023

\* *Aligns with CEC AB 525 Sea Space Report*

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# Land Use Methodology

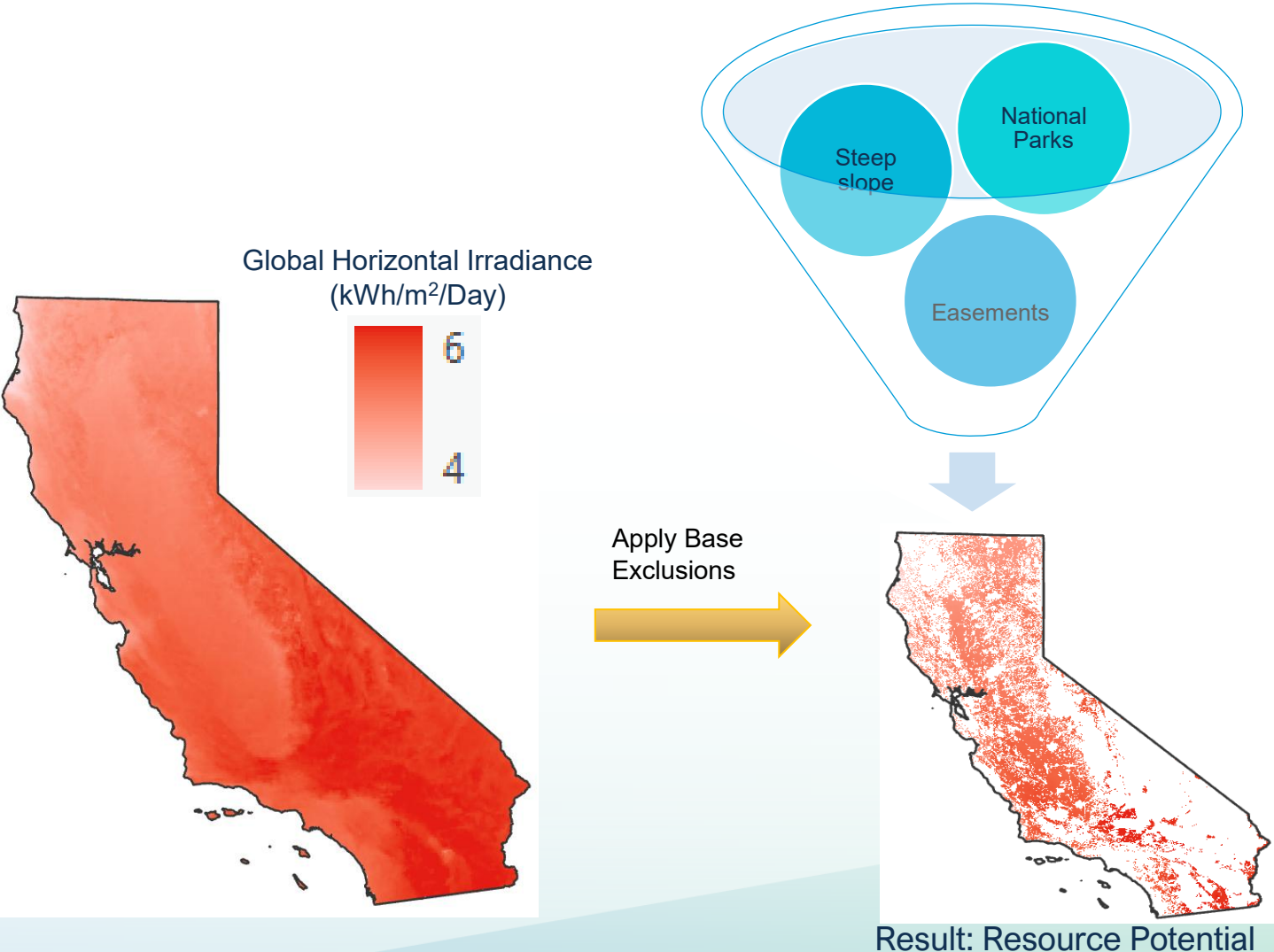
# Definitions

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- **Total resource potential** is area where resources could feasibly be developed and are not precluded by protected areas or techno-economic exclusions. See CEC's [\*Land-Use Screens for Electric System Planning\*](#) report for more details.
- **Near grid areas:** These are areas near existing and planned substations (15-mi radius), as well as areas planned for new energy development.

# Resource Potential – Solar Example

Apply Protected Areas and Techno-Economic Exclusions (Base Exclusions)



# How are Near Grid Areas determined?

Substations from CPUC  
IRP and CAISO TPP  
planning processes

Substations with  
commercial interest and  
resource potential  
(LADWP, SMUD or IID)

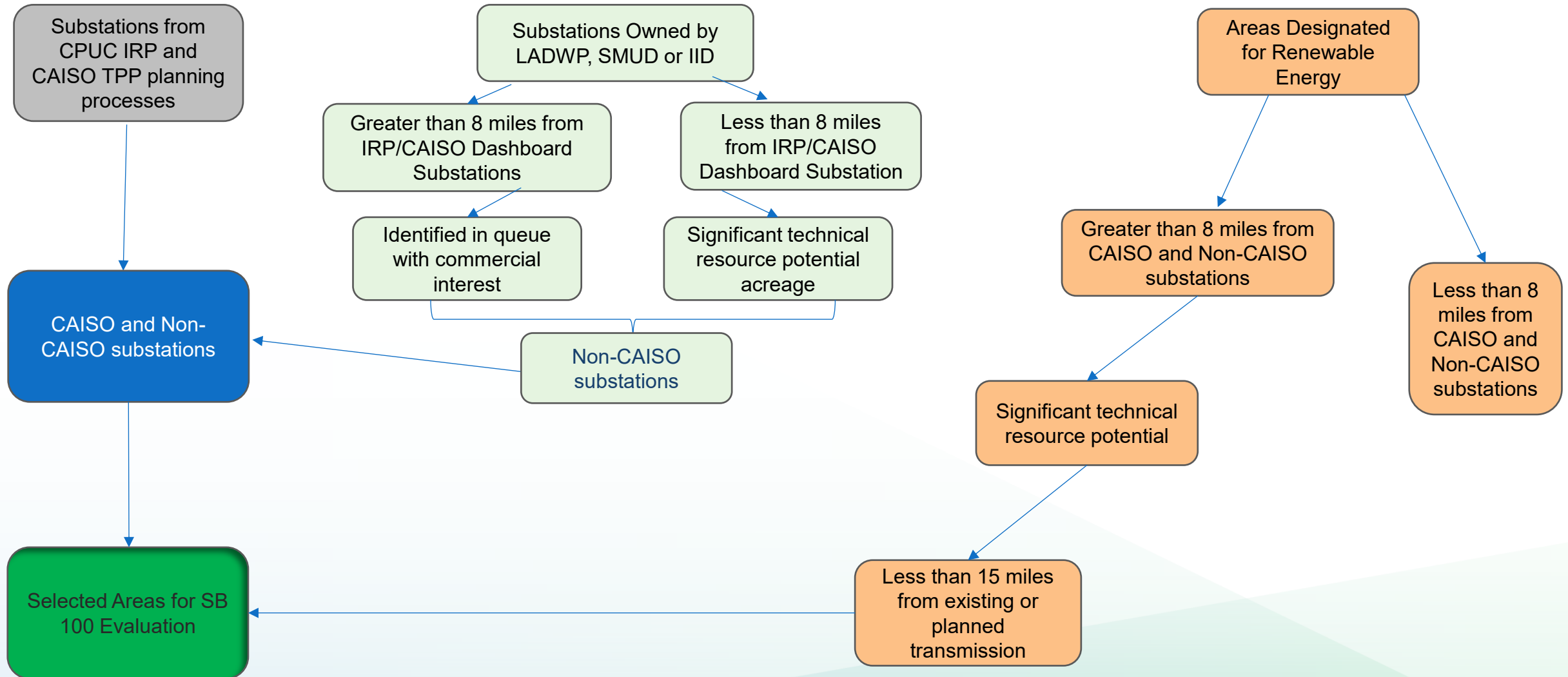
CAISO and Non-  
CAISO substations

Areas Designated for  
Renewable Energy with  
resource potential (not near  
existing substations)

Selected Areas for  
SB 100 Evaluation

- Defined area of the state where generation resources are most likely to be developed.
- Uses existing and proposed substation areas and new areas with designated lands for renewable energy development.
- Consistent with approach in IRP busbar mapping and CAISO Transmission Planning busbar mapping processes.

# Details on how Near Grid Areas are Determined for SB 100 Analysis





# **2025 SB 100 Report Inputs and Assumptions Air Quality-Related Public Health & Social Cost of GHGs**

March 2026

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# **Air Quality-Related Public Health Impacts**

## **Criteria Pollutant Emissions**

# Criteria Pollutant Emissions

## Methods: Fuel Type

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- Fuel offtake and generation by generation type from electric system modeling
- Biofuel offtake split by fuel type (biogas vs biomass) and by prime mover (e.g., turbine/engine type) by creating a REGEN-specific weighted average using 2023 Energy Information Administration (EIA) generation amounts by prime mover using Plexos facility data\*
- Other fuel offtake allocated to the most conservative of the most representative prime mover/fuel types for each REGEN using 2023 EIA generation amounts by prime mover using Plexos facility data
- Assumed carbon capture and storage (CCS) is applied to retrofitted fossil gas combined-cycle turbines and that the carbon capture system does not have any additional effect on the exhaust stack emissions

\* EIA. 2023. [Electric Power Operations For Individual Power Plants \(Annual and Monthly\)](#).

# Criteria Pollutant Emissions Methods: Emission Factors

- NO<sub>x</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> emission factors from CPUC Proposed Inputs & Assumptions: SERVM 2024 Data Updates in Support of Resource Adequacy (RA) and Integrated Resource Planning (IRP)\*
- VOC emission factors from U.S. EPA AP-42\*\* for all generation types except Coal – Steam Turbine
  - Fossil gas combined cycle, fossil gas combustion turbine, and fossil gas steam turbine use natural gas-fired stationary turbine emission factors (Chapter 3.1); fossil gas internal combustion use 4-stroke, lean burn, reciprocating engine emission factors (Chapter 3.2)
  - Wood residue combustion emission factors (Chapter 1.6) used for biomass/wood
- VOC emission factors for Coal – Steam Turbine from CA-GREET3.0\*\*\* model for coal-fired utility boilers

\* CPUC. 2024. [Proposed Inputs & Assumptions: SERVM 2024 Data Updates in Support of Resource Adequacy \(RA\) and Integrated Resource Planning \(IRP\)](#).

\*\* US EPA. [AP-42: Compilation of Air Emissions Factors](#).

\*\*\* CARB. 2019. [CA-GREET3.0 Model](#).

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**Air Quality-Related Public Health Impacts  
U.S. EPA Co-Benefits Risk Assessment  
Health Impacts Screening and Mapping  
Tool (COBRA) Health Impacts**

# Methods: COBRA

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- **Emissions:** Scaled emissions from REGEN zones to county using population modeled California Emission Projection Analysis Model (CEPAM) utility emissions from 2030
  - TIER1NAME = Fuel Combustion: Electric Utility
  - TIER2NAME = Gas
  - TIER3NAME = Natural
  - Stack Height = LOW
- **Population:** Used California Department of Finance population projections, using BenMAP split across age groups for the projected year
- **Incidence:** Used BenMAP incidence estimates for the projected year
- **Valuation:** Default 2023 COBRA valuation and default 2% discount rate

# Methods: Scaling of Emissions to County Level for COBRA

- The following equations illustrate the scaling process:

Equation 1:

$$CEPAM\ Total\ Emissions\ REGEN_x = \sum_{county=i}^{county=n} CEPAM\ Emissions\ Fraction\ County_i$$

Equation 2:

$$Scaled\ Scenario\ Emissions\ County_i = Scenario\ Emissions\ REGEN_x \times \frac{CEPAM\ Emissions\ Fraction\ County_i}{CEPAM\ Total\ Emissions\ REGEN_x}$$

Equation 3:

$$PopWeight_i = \frac{County\ Population\ in\ REGEN_i}{Total\ Population\ in\ County_i}$$

Equation 4:

$$CEPAM\ Emissions\ Fraction\ County_i = PopWeight_i \times CEPAM\ Emissions\ County_i$$

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# **Social Cost of Greenhouse Gases (SC-GHG)**

# SC-GHG Methods: Costs

- Cost per metric ton of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) for the modeled year use estimates determined by U.S. EPA for different discount rates\*
- Values adjusted from 2020\$ to 2023\$ using the California Consumer Price Index for All Urban Consumers

2045 SC-GHG Estimates Used in Analysis (2023\$ per MT)			
	2.5% discount rate	2% discount rate	1.5% discount rate
CO <sub>2</sub>	\$220	\$334	\$530
CH <sub>4</sub>	\$3,633	\$4,368	\$5,487

\* U.S. EPA. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review.” EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. November 2023. [https://www.epa.gov/system/files/documents/2023-12/epa\\_scghg\\_2023\\_report\\_final.pdf](https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf)

# SC-GHG Methods: Emissions

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- CO<sub>2</sub> emissions from fossil fuel combustion sources (natural gas and “other” category) from electric system modeling
- CH<sub>4</sub> emissions from natural gas supply chain leakage calculated from fossil gas fuel offtake assuming a 2.3% leak rate (Alvarez, R., et al. 2018\*) and 90% methane content\*
- SC-GHG results are presented at the state level relative to a 60% RPS scenario

\* Alvarez et al. 21 June 2018. [Assessment of methane emissions from the U.S. oil and gas supply chain | Science](#)