2019-20 IRP: Preliminary Results Workshop

CPUC Energy Division

October 8, 2019

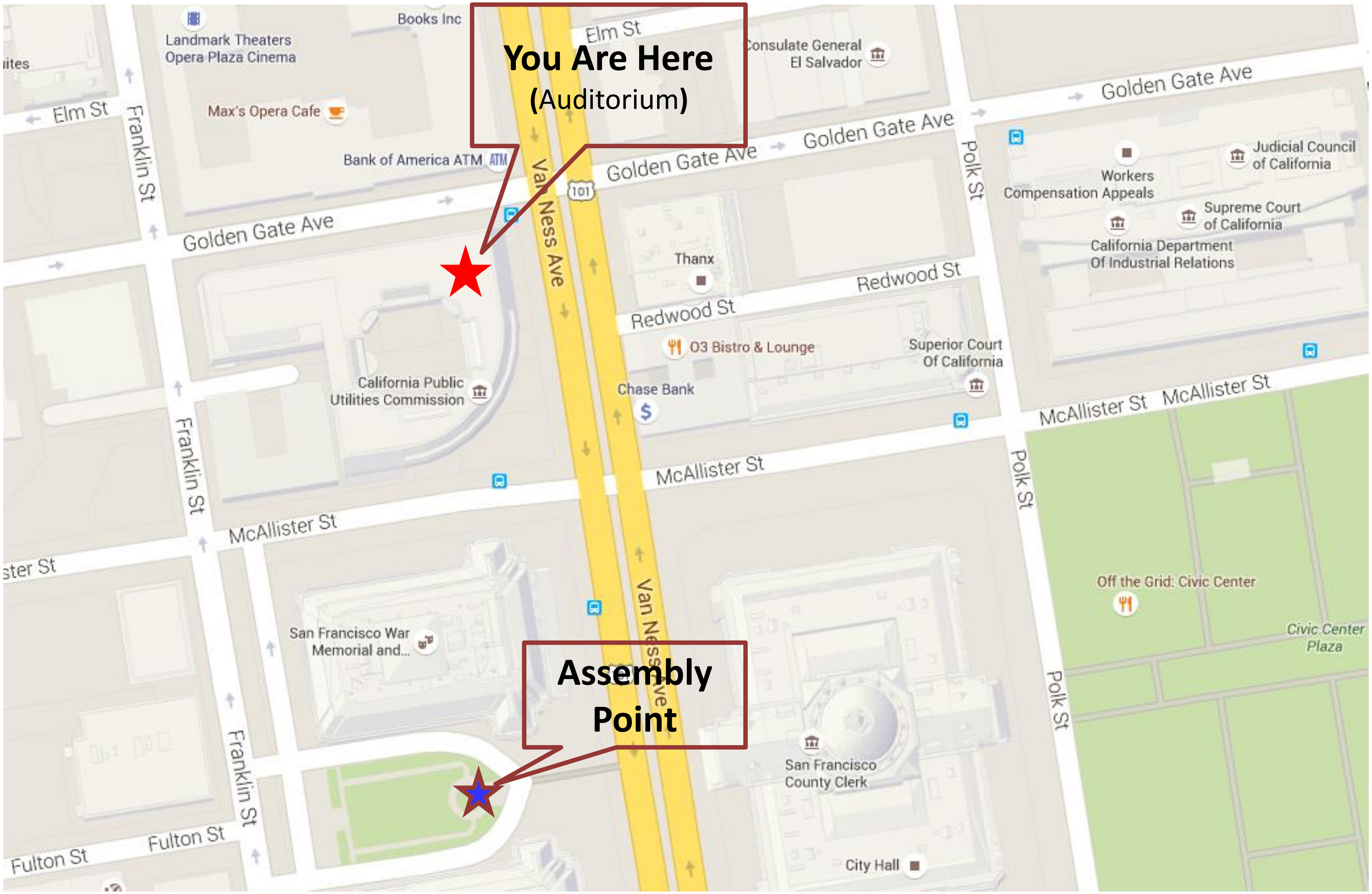
Introduction

- Housekeeping
  - Staff introductions
  - Informal workshop, not on the record
  - Safety information and logistics
- Workshop purpose and agenda

Safety and Emergency Information

- In the event of an emergency, please proceed out the exits.
- We have four exits: Two in the rear and one on either side of the speakers.
- In the event that we do need to evacuate the building:
  - Our assembly point is the Memorial Court just north of the Opera House.
  - **For the Rear Exits:** Head out through the courtyard, and down the front steps. Continue south on Van Ness Ave, and continue toward the Memorial Court.
  - **For the Side Exits:** Go out of the exits and you will be on Golden Gate Avenue. Proceed west to Franklin Street. Turn south onto Franklin Street, and continue toward the Memorial Court.

Evacuation Map



Call-in Information

WebEx:

https://centurylinkconferencing.webex.com/centurylinkconferencing/j.php?MTID=mbd7ab13c1b18ed4f6de8d08300db057f

Meeting number: 710 632 447

Meeting password: !Energy1

Call-in: 1-866-830-2902

Passcode: 245 3758

- Remote callers will be placed in listen-only mode by default. Please submit questions via the WebEx chat.
- We will have dedicated Q&A at the end of each agenda item.
- Please state your name and organization when asking a question.

Other Information

Wi-Fi Access

- SSID: cpucguest
- login: guest
- password: cpuc93019

IRP Website

- http://www.cpuc.ca.gov/irp/
- All staff work products are available for download

Restrooms

Out the Auditorium doors and down the far end of the hallway.

Workshop Agenda

- **I. Introduction** **10:00 – 10:10**
  Nathan Barcic, CPUC
- **II. IRP Background and Introduction to 2019 RESOLVE Modeling** **10:10 – 10:25**
  CPUC IRP staff
- **III. Model Calibration Process and Results** **10:25 – 11:45**
  CPUC Energy Resource Modeling staff
- **IV. Core Policy Case Results** **11:45 – 12:30**
  CPUC IRP staff

Lunch

- **V. Overview of Selected Sensitivities and Results** **1:30 – 2:30**
  CPUC IRP staff

Stretch Break

- **VI. 2045 Framing Study** **2:45 – 3:30**
  E3 staff
- **VII. Busbar Mapping Proposal** **3:30 – 4:00**
  CPUC IRP staff

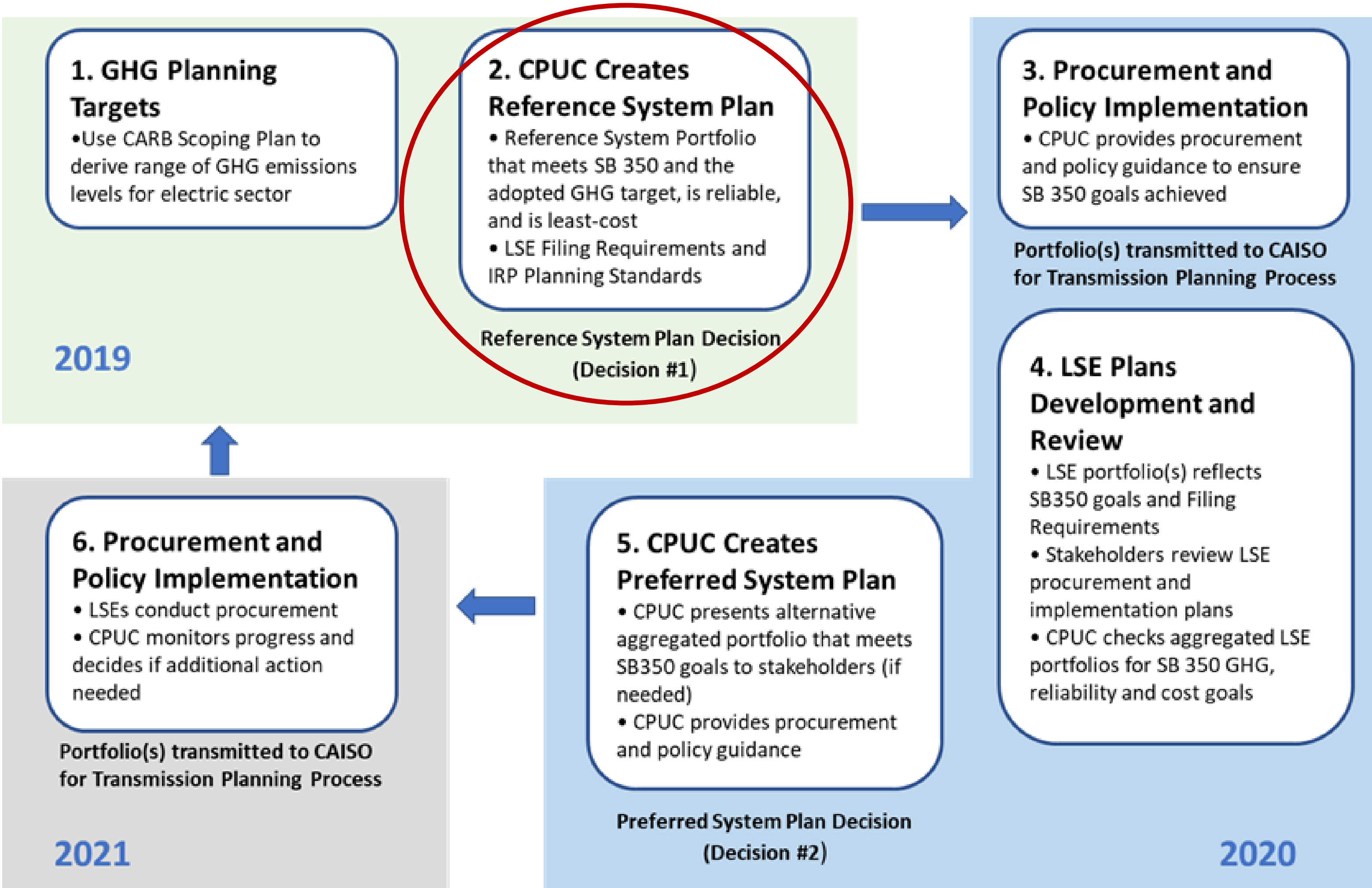
Purpose of this Presentation

- These results provide IRP stakeholders with information about the resource portfolios California should procure to meet SB 350 goals in 2030: greenhouse gas (GHG) emissions reductions, reliability, and least cost.

The analytical foundation includes:

- Comparison of portfolios under three Greenhouse Gas (GHG) Planning Targets for the electric sector.
- Presentation of sensitivities that explore the impact of certain assumptions changes on the optimal portfolio of resources.
- Explanation of modeling and resource assumptions and updates.
- Exploration of how California can make progress towards deep GHG emissions reductions in the electric sector in 2045.

Overview of the IRP 2019-20 Process



Process for 2019 IRP Reference System Portfolio Development

Step #	Activity	Estimated Date
1	Data Development	March-June 2019
2	Informal release: core model inputs + MAG presentation	June 2019
2a	Informal party comment on Step 2 content	July 2019
3	Input validation for RESOLVE & SERVM models	July 2019
4	Develop calibrated modeling results	July-Sept 2019
5	Informal release of complete RESOLVE model and draft results	October 2019
6	Formal release of Proposed 2019 IRP Reference System Plan	November 2019
7	Formal party comment on Proposed 2019 Reference System Plan	November 2019
8	Formal release of 2019 Reference System Plan Proposed Decision	January 2020
9	Formal party comment on 2019 Reference System Plan PD	January 2020
10	Commission Decision on 2019 Reference System Plan	February 2020
11	Transmittal of 2019 IRP portfolios to 2020-21 CAISO TPP	February 2020

Summary of Documents Released in Conjunction with IRP 2019 Preliminary Results

- IRP 2019 Preliminary Results slide deck
  - Preliminary modeling results associated with 2019 Reference System Portfolio development under multiple potential GHG targets
  - 2045 Framing Study
- Updated IRP 2019-20 Draft Inputs & Assumptions document
  - Resources, transmission, and assumptions used for IRP 2019-20 capacity expansion and production cost modeling
- Updated RESOLVE model and accompanying documentation
  - The RESOLVE model used to generate Preliminary Results is available for use by parties, along with upstream inputs and assumptions spreadsheets and related information
- Updated SERVM model input datasets
  - Incremental to data presented at the 6/17 MAG on baseline model inputs
- Calibration Results slide deck
  - Results of calibration of RESOLVE portfolios using the SERVM model

RESOLVE MODELING RESULTS

Types of Cases Modeled

- **Core Policy Cases**: Three cases that reflect different potential GHG trajectories for the electric sector.
  - Purpose: Compare the impacts of different GHG goals on portfolio composition, costs, and emissions.
- **Core Policy Sensitivities:** Variations on the core policy cases that reflect changes to one or more of the default assumptions about the future (e.g., load, resource costs).
  - Purpose: Determine how different future conditions could affect portfolio composition, costs, and emissions.
- **SB100 2045 Framing Study:** Three cases that reflect different potential GHG and load trajectories for the electric sector based on different economy-wide decarbonization pathways.
  - Purpose: Explore how 2045 goal under SB100 and economy-wide decarbonization targets could affect outlook for electricity sector GHG emissions and resource planning in 2030 timeframe.

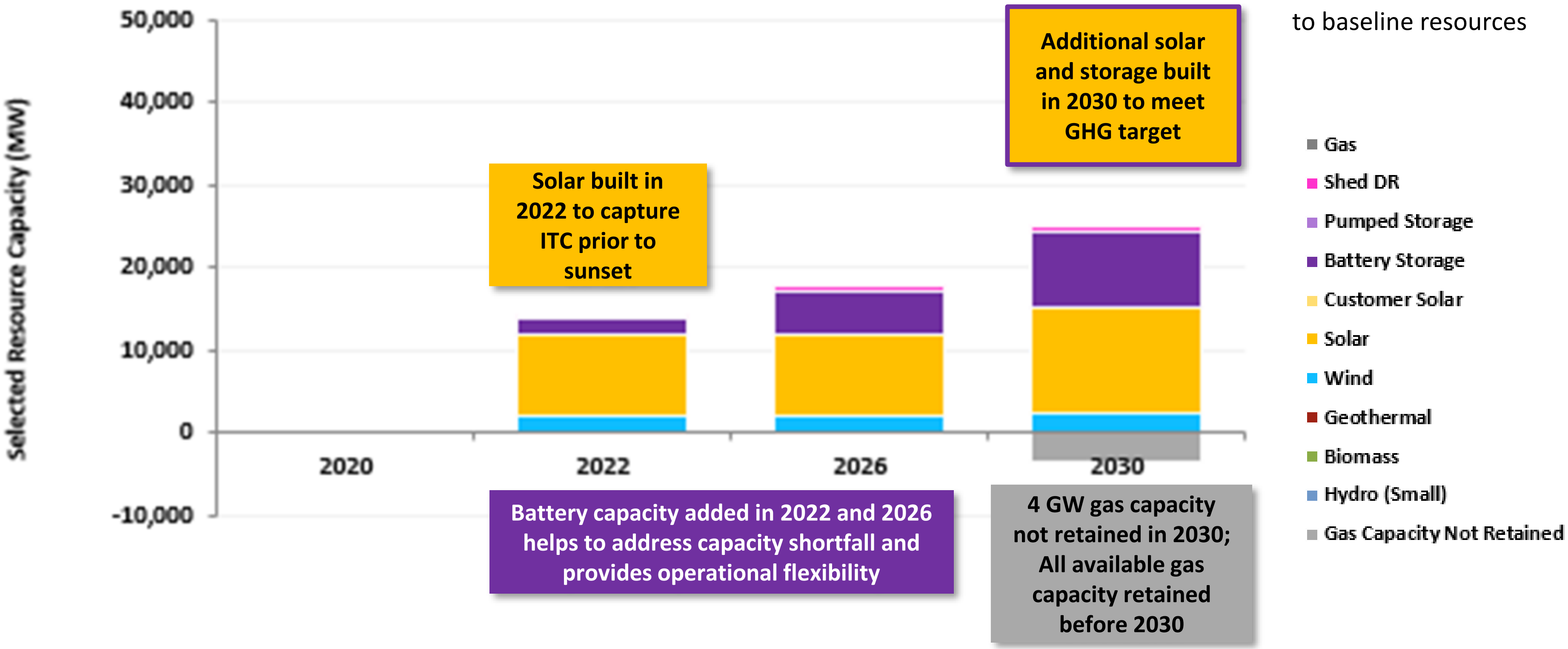
2019 Core GHG Cases

- **46 MMT* Case (Default)**
  - Achieves the Commission-established electric sector planning target
  - Demand forecast: CEC 2018 IEPR Mid AAEE
  - Baseline resources assumed to be online as defined in Section 2.3 of this presentation
  - Considered "Default" case in 2019 IRP modeling as it most closely resembles adopted policy from the 2018 IRP Preferred System Plan (PSP)
- **38 MMT Case**
  - Represents the midpoint between 46 MMT and the low end of CARB's established range for the electric sector
  - Includes all constraints and assumptions from Default Case
- **30 MMT Case**
  - Represents the low end of CARB's established range
  - Includes all constraints and assumptions from Default Case

*In the IRP 2017-18, emissions from behind the meter CHP facilities were not included as part of the electric sector emissions. To align with CARB's GHG accounting methodology, emissions from behind-the meter CHP, which were estimated as 4 MMT in the last cycle, are now included as electric sector emissions in the 2019/2020 Reference System Plan. Thus, the 46 MMT target in IRP 2019-20 translates to approximately a 42 MMT GHG target in IRP 2017-18.

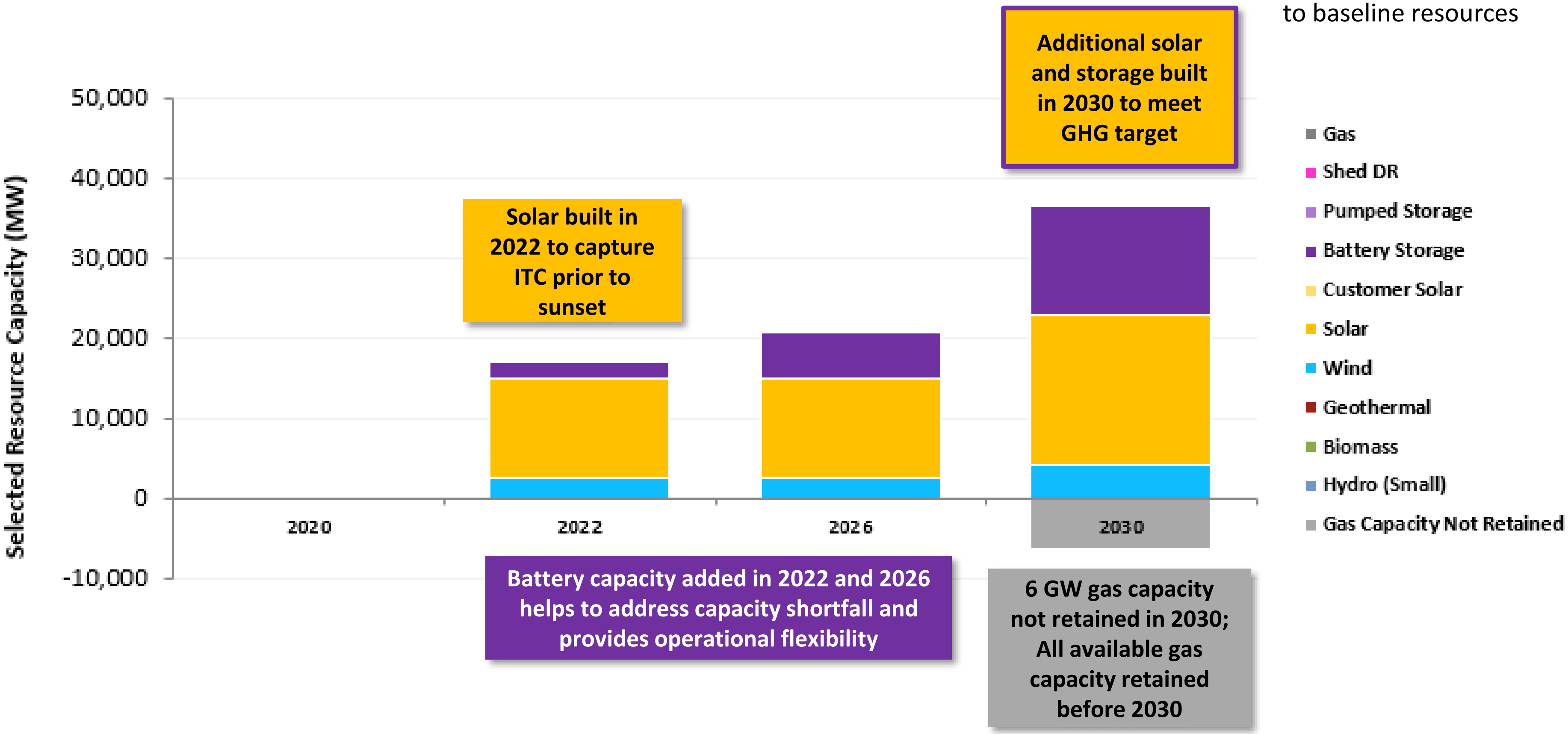
RESOLVE Output: Resources Selected in 46 MMT Case

Note: all resources shown in this chart are selected by RESOLVE and are in addition to baseline resources



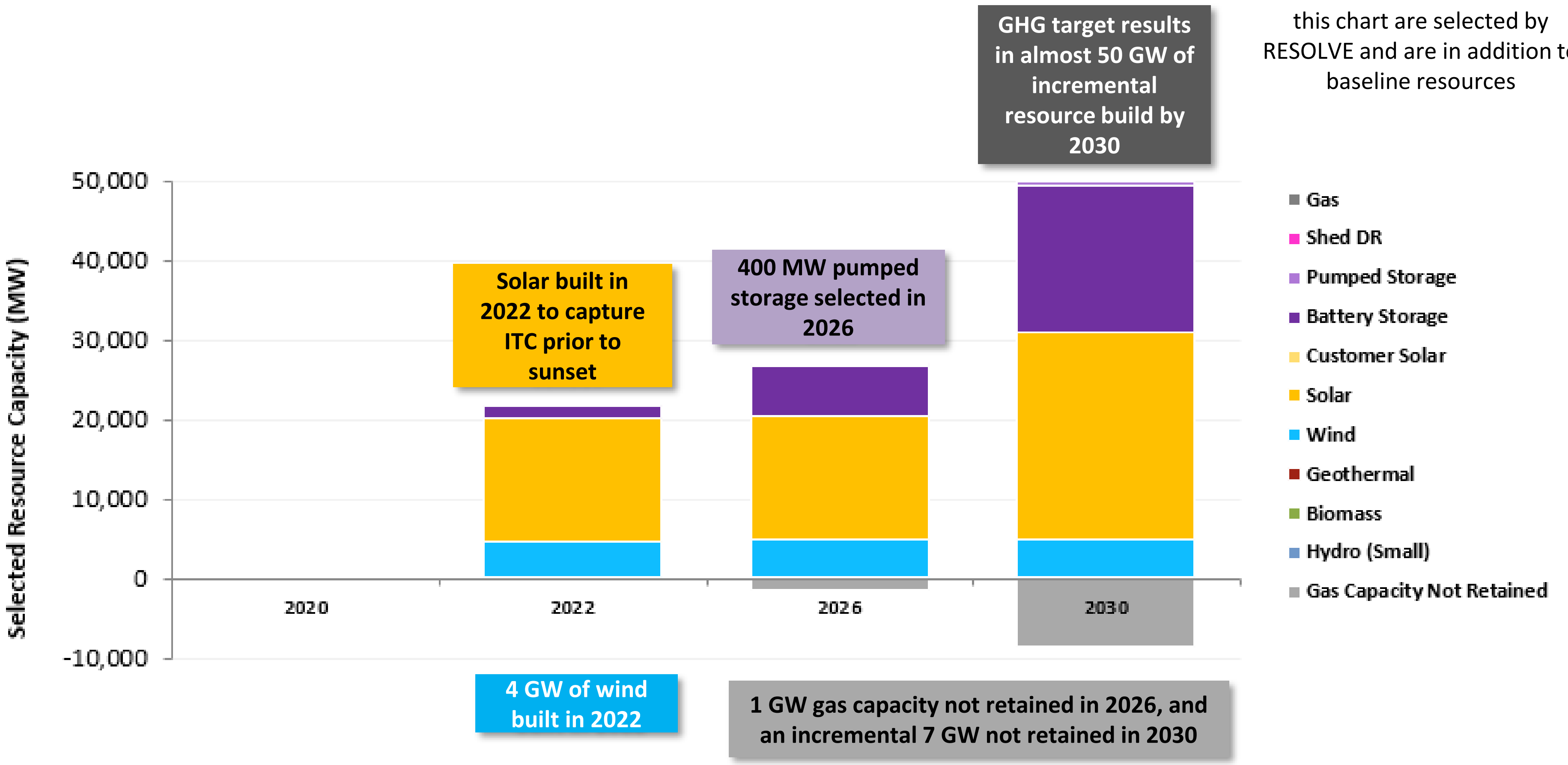
RESOLVE Output: Resources Selected in 38 MMT Case

Note: all resources shown in this chart are selected by RESOLVE and are in addition to baseline resources

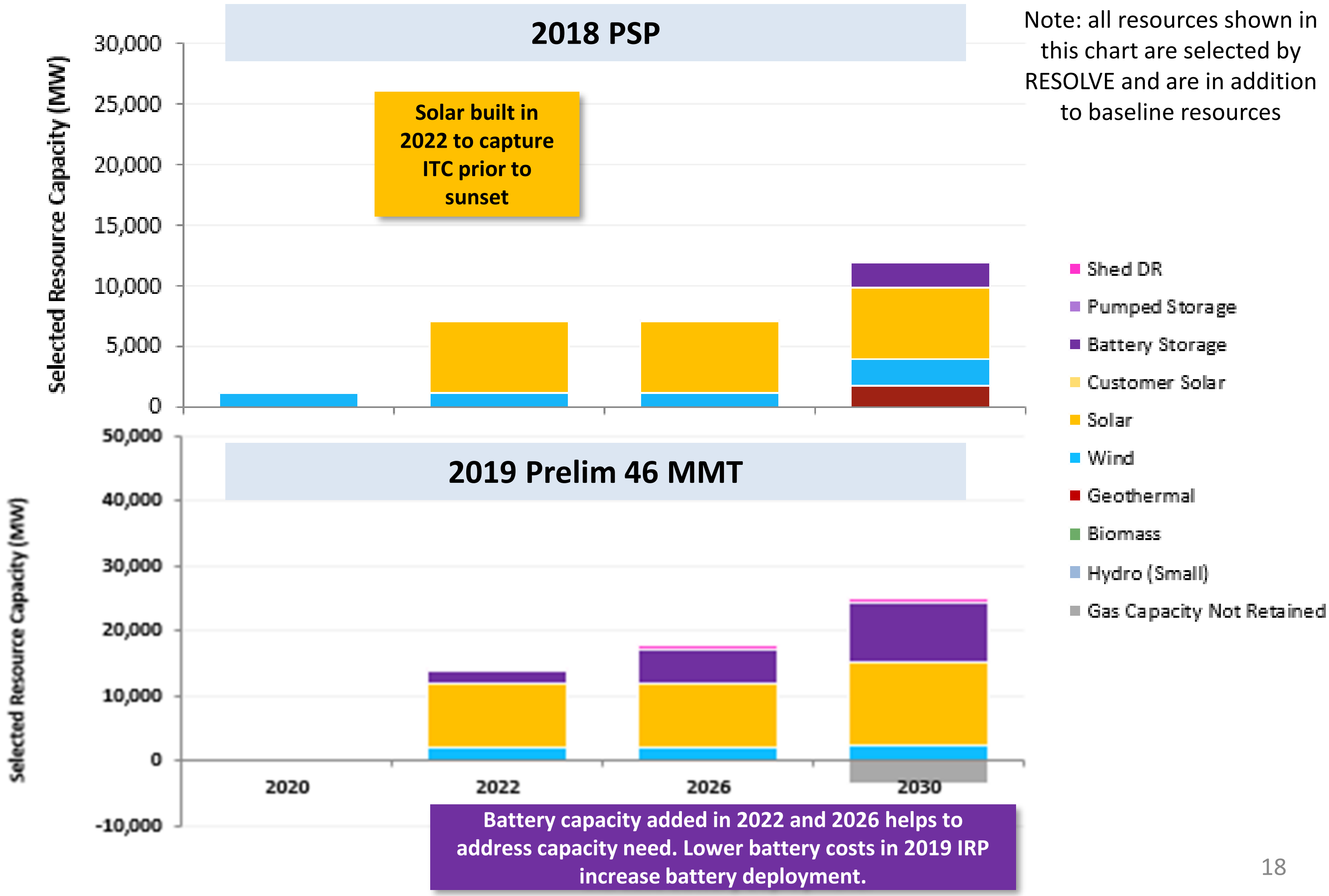


RESOLVE Output: Resources Selected in 30 MMT Case

Note: all resources shown in this chart are selected by RESOLVE and are in addition to baseline resources



Comparison of 2019 Preliminary 46 MMT to 2018 PSP: Resource Build



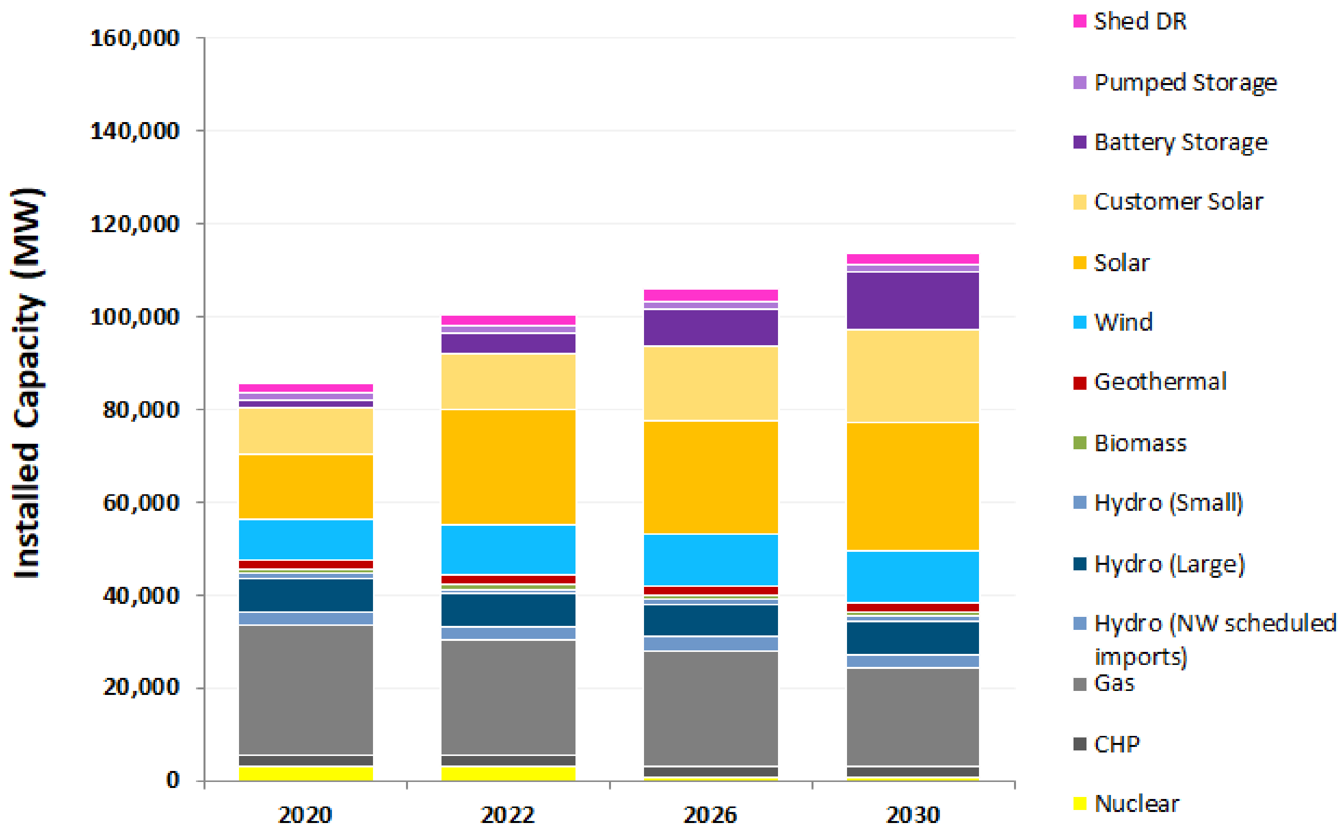
Note: all resources shown in this chart are selected by RESOLVE and are in addition to baseline resources

Comparison of 2019 Preliminary 46 MMT to 2018 PSP: Summary Metrics

Metric	2018 Preferred System Plan	2019 Preliminary 46 MMT Case
CAISO GHGs (BTM CHP GHGs excluded)	**34 MMT**	**32.4 MMT**
Selected Resources (by 2030)	• **2.2 GW wind** • **5.9 GW solar PV** • **2.1 GW battery storage** • **1.7 GW geothermal**	• **2.4 GW wind** • **12.6 GW solar PV** • **9.3 GW battery storage** • **440 MW shed DR**
Selected Renewables *(on existing Tx)*	**9.8 GW**	**15 GW**
Levelized Total Resource Cost (TRC)	**$44.5 billion/yr**	**$46.3 billion/yr**
Marginal GHG Abatement Cost	**$219/metric ton**	**$109/metric ton**
System Planning Reserve Margin (resulting from addition of new resources)	**22%**	**15%**

- 2018 PSP assumed ~2x the RA import capacity of the 2019 Preliminary Results and did not include economic gas retention (retained all available gas through 2030)
- Cost projections of solar PV and batteries are roughly half of 2017 IRP assumptions
- There are different underlying load and baseline assumptions between the two cases
- Updated BTM CHP assumptions result in a slightly more stringent GHG target

Total Resource Stack: 46 MMT Case



Core Policy Case Results in 2045 Context

- The Core Policy Cases show portfolio results with a planning horizon of 2030.
- The 2045 Framing Study reflects analysis performed on different decarbonization strategies in the CEC Deep Decarbonization report* and focuses on three potential pathways: High Electrification, High Biofuels, and High Hydrogen.
- The 2045 studies generally retain more gas capacity than in the 2030 Core Policy Cases, particularly the 38 and 30 MMT cases.
- An additional sensitivity (slide 102) demonstrates more gas capacity retained in each of the 2030 Core Policy Cases if a 2045 planning year is added to the analysis.
- This suggests that context outside of the 2030 Core Planning Cases should be used to inform any decisionmaking regarding the optimal portfolio of resources for 2030.

*Deep Decarbonization in a High Renewables Future. Available at: https://ww2.energy.ca.gov/2018publications/CEC-500-2018-012/CEC-500-2018-012.pdf

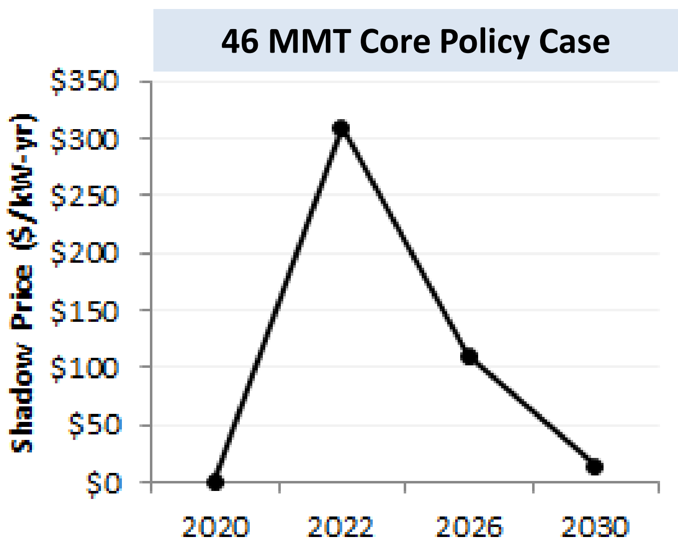
GHG Goals Are Expected to Lead to Reduced Utilization of Fossil Plants

- Expansion of renewable and storage resources in response to GHG planning targets results in lower energy production on a fleet-wide basis from dispatchable gas resources.
- Total gas plant capacity is relatively independent from gas plant usage.
- Dispatchable gas plants can provide power during times when energy-limited resources (solar and storage for example) are not able to produce.
- Under more stringent GHG targets, gas plants are increasingly retained for capacity rather than energy and are dispatched less frequently. Related content in other portions of this presentation:
  - Slide 38, explanation of economic retention functionality in RESOLVE
  - Slide 56, discussion of context of Core Policy Case gas retention in broader context, including 2045
  - Slide 76, description of existing gas generation in the context of 2022 capacity shortfall and increased battery storage penetration

CAPACITY NEED

Capacity Need and Price

- RESOLVE's Planning Reserve Margin (PRM) constraint ensures that system resource adequacy needs are met in each period
- If the baseline resource capacity does not meet the 15% PRM target, RESOLVE will build additional resources until the target is met
- The marginal cost of meeting the PRM constraint (the "shadow price") reflects the difficulty of meeting the constraint

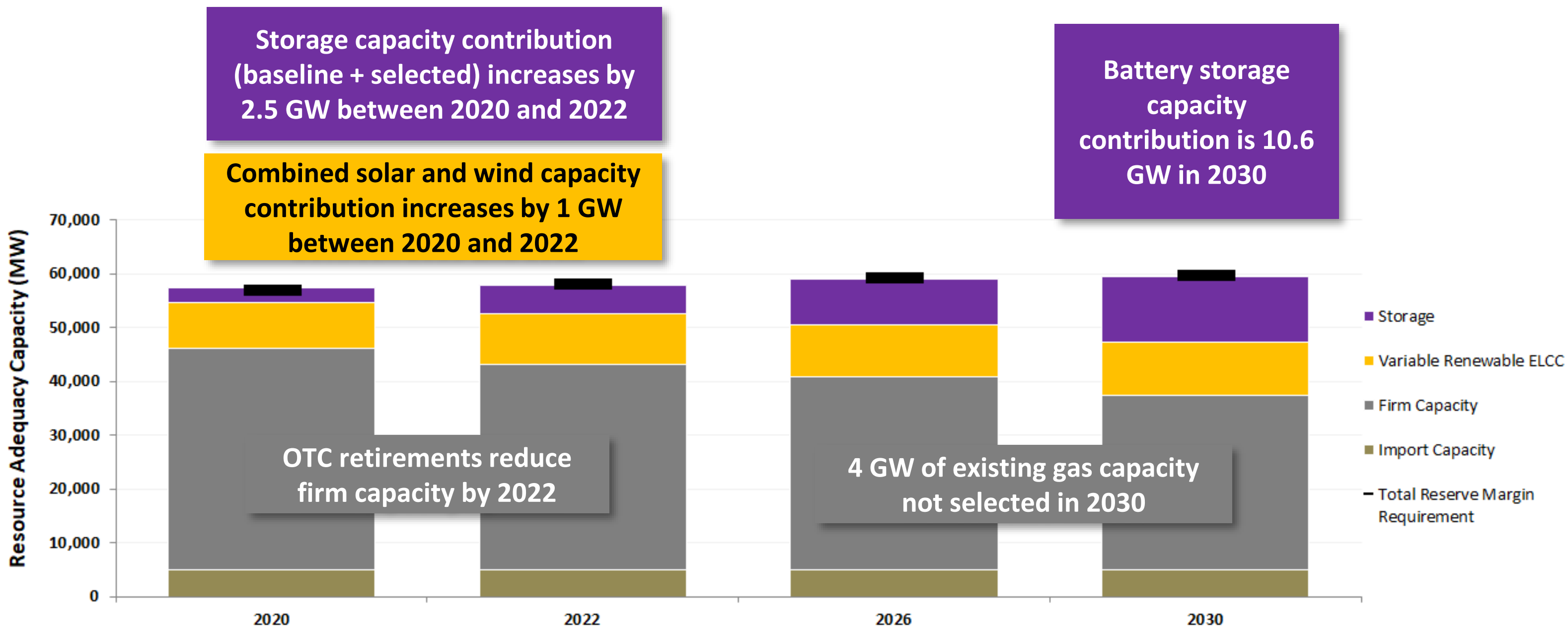


Capacity need in 2022 and 2026 results in high PRM prices that reflect the net capacity cost of building new infrastructure

Lower prices in 2020 and 2030 reflect cost of retaining existing gas resources

Resources to Address Capacity Shortfall: 46 MMT Case

- 2022 capacity shortfall met with predominantly new battery storage and solar resources
- After 2022, marginal solar capacity value is minimal due to resource saturation
- Battery capacity represents large source of new capacity by 2030, with 12.5 GW of batteries (both baseline and selected) providing 10.6 GW of RA capacity
  - Marginal ELCC of 4-hour Li-Ion batteries in 2030 is 65%



Firm Capacity = Gas, CHP, Hydro, Nuclear, Geo, and Bio

SENSITIVITY CASE RESULTS

Sensitivity Definitions

Sensitivity	Description
Reference	Core Policy Case
New OOS Tx	Out-of-state resources on new transmission available
Low OOS Tx Cost	Out-of-state resources on new transmission available with 25% lower out of state transmission costs than default
High OOS Tx Cost	Out-of-state resources on new transmission available with 25% higher out of state transmission costs than default
High Solar PV Cost	Higher projections of future solar PV cost
PV ITC Extension	30% Investment Tax Credit (ITC) for solar PV is maintained indefinitely
High Battery Cost	Higher projections of future battery cost
Paired Battery Cost	Li-Ion battery costs are reduced due to ITC benefits and shared infrastructure from co-locating
Low RA Imports	2 GW of RA import capacity assumed
High RA Imports	Maximum (10.2 GW) RA import capacity assumed
2045 End Year	Core Policy Cases are run with 2045 as end year
High Load	High IEPR baseline load trajectory assumed

RESOLVE Output:
Impact of Sensitivities on Incremental Cost

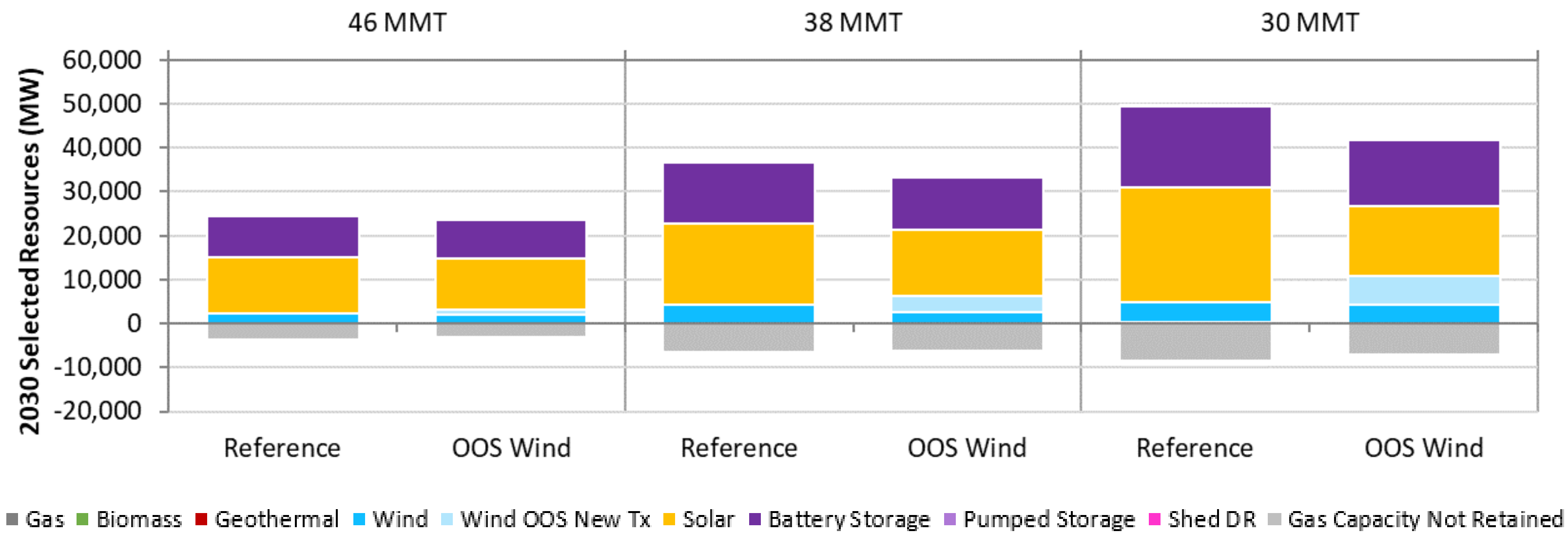
"Incremental TRC" calculated relative to 46MMT Reference case (highlighted in orange)

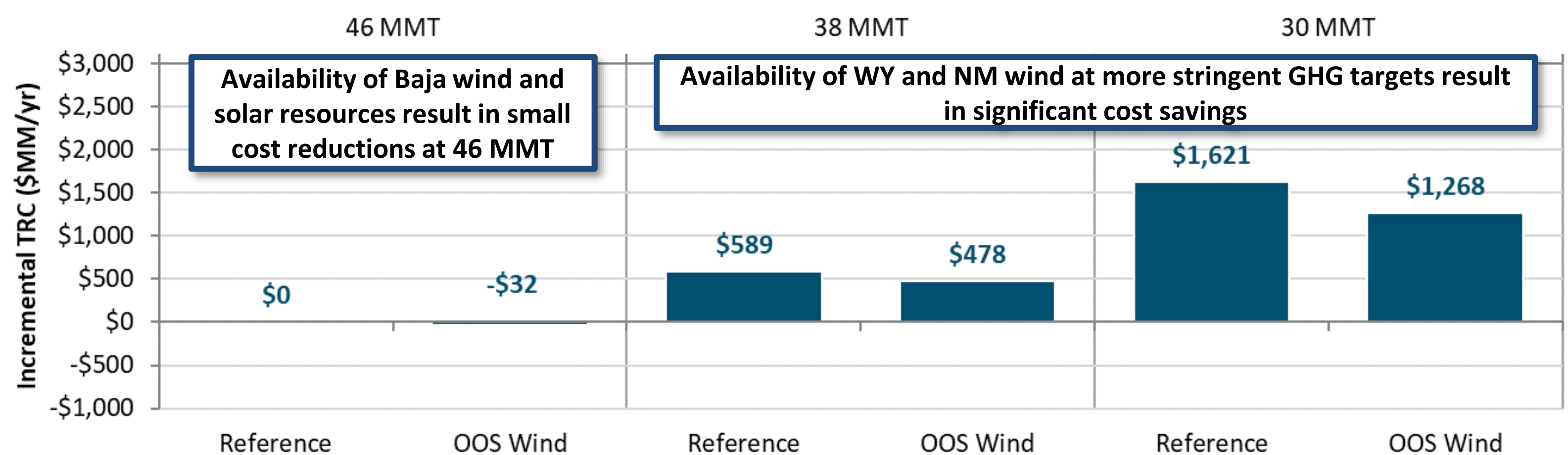
"Change from Reference" calculated relative to corresponding "Reference" case

	Incremental Cost ($MM/yr)			Change from Reference ($MM/yr)		
Sensitivity	**46 MMT**	**38 MMT**	**30 MMT**	**46 MMT**	**38 MMT**	**30 MMT**
Reference	**$0**	**$589**	**$1,621**			
Low RA Imports	$294	$840	$1,833	**+$294**	**+$252**	**+$212**
High RA Imports	-$141	$563	$1,579	**-$141**	**-$26**	**-$42**
Paired Battery Cost	-$461	$88	$1,008	**-$461**	**-$501**	**-$613**
High Battery Cost	$602	$1,451	$2,634	**+$602**	**+$862**	**+$1,013**
PV ITC Extension	-$330	$297	$1,152	**-$330**	**-$292**	**-$469**
High PV Cost	$614	$1,351	$2,441	**+$614**	**+$762**	**+$819**
Low OOS Tx Cost	-$37	$362	$1,125	**-$37**	**-$227**	**-$496**
New OOS Tx	-$32	$478	$1,268	**-$32**	**-$111**	**-$353**
High OOS Tx Cost	-$30	$513	$1,412	**-$30**	**-$76**	**-$209**
High Load	$793	$1,533	$2,608	**+$793**	**+$944**	**+$987**

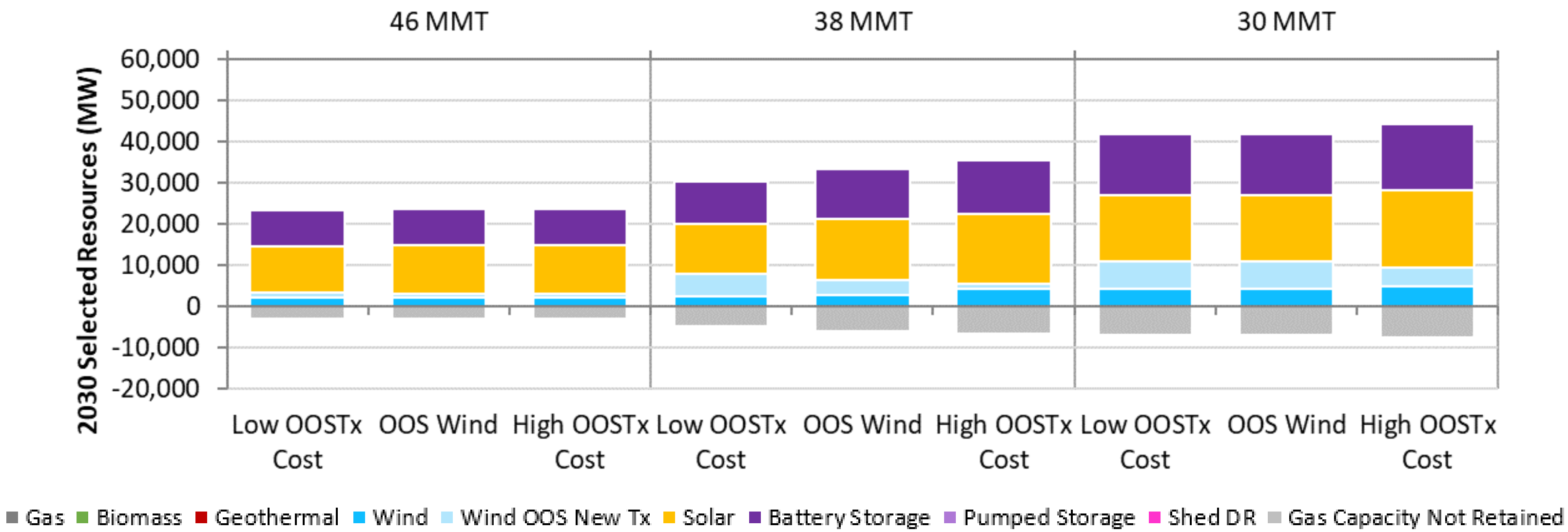
TRANSMISSION SENSITIVITIES

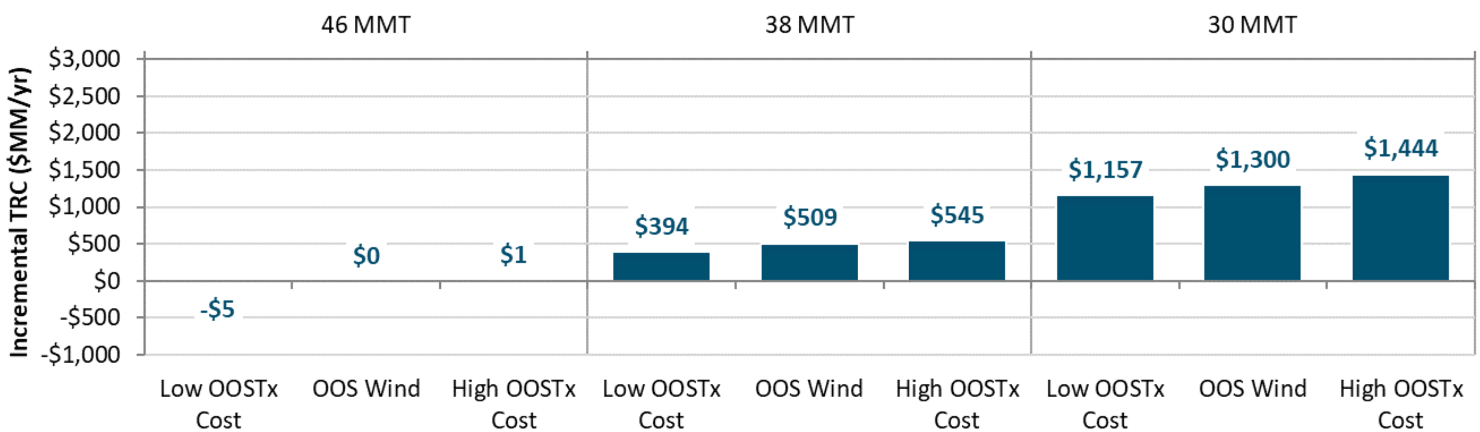
New Out of State Transmission Sensitivity





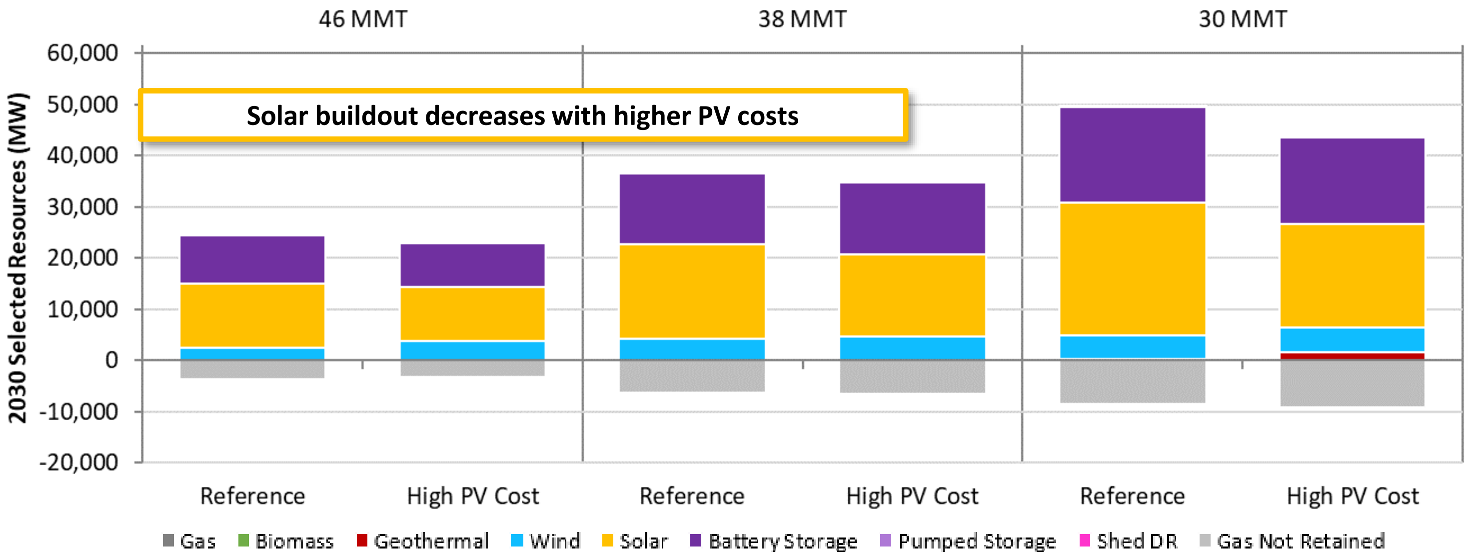
New Out of State Transmission Cost Sensitivities



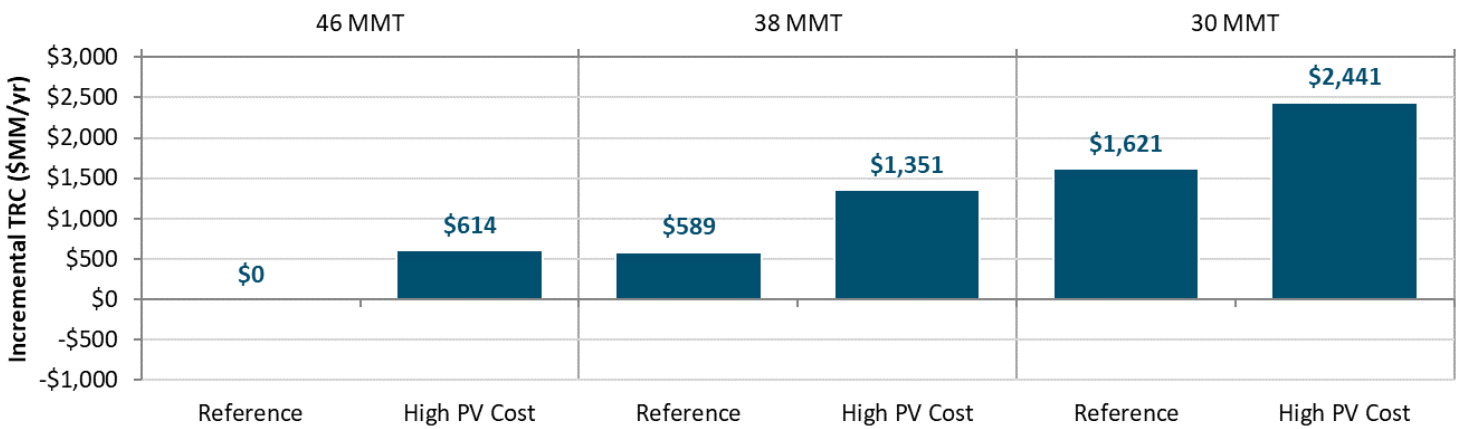


COST SENSITIVITIES

Solar Cost Sensitivities: High PV Cost

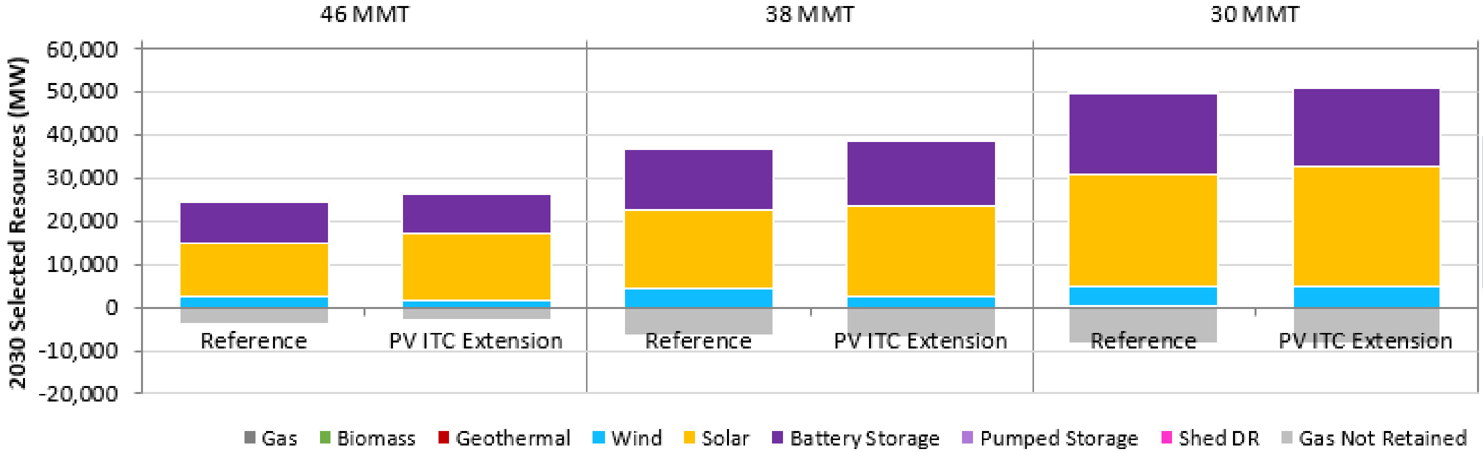


Geothermal (1.7 GW) included in portfolio if solar costs are higher than reference

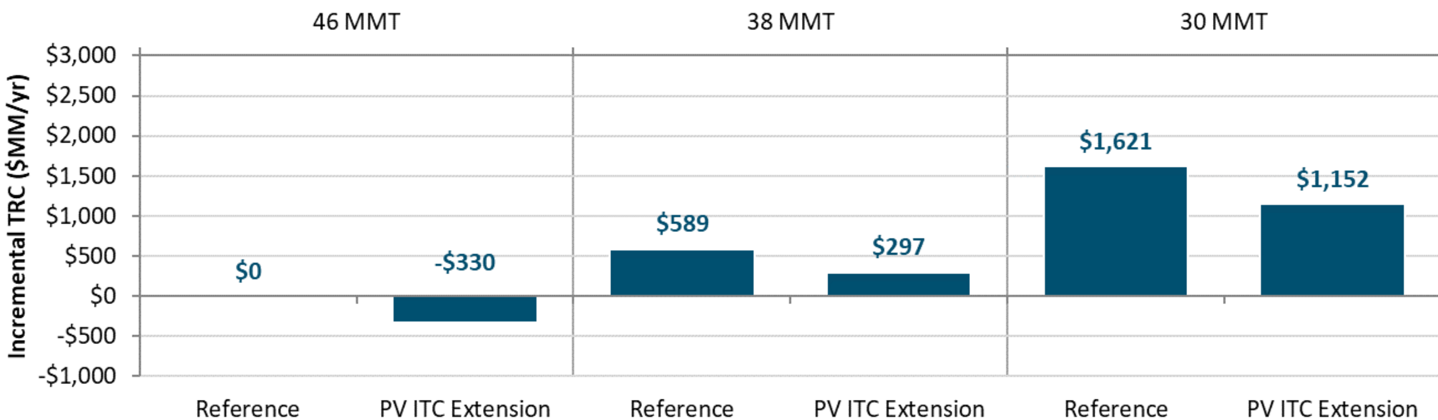


Solar resources are more expensive, resulting in cost increases relative to Reference

Solar Cost Sensitivities: PV ITC Extension

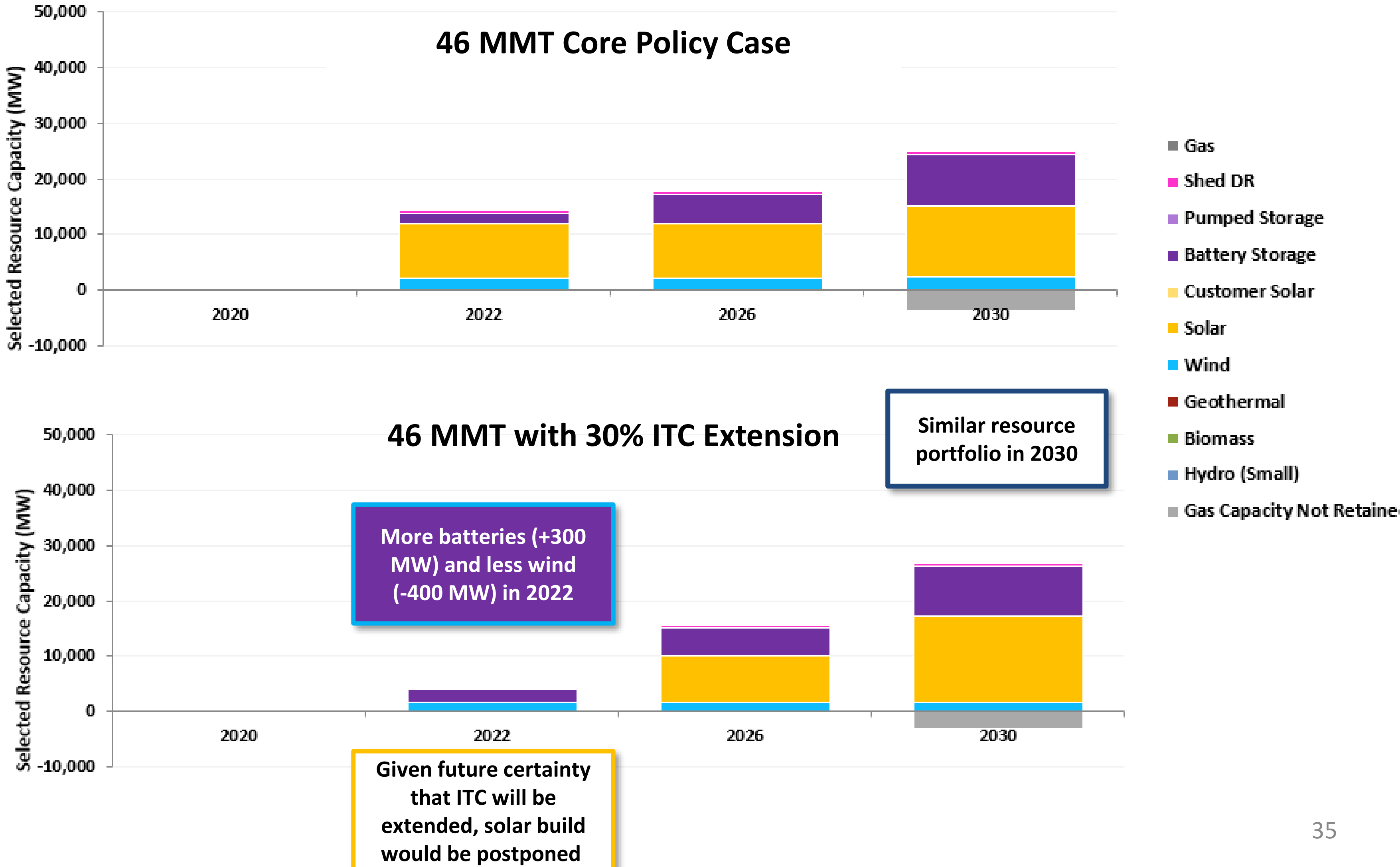


2030 Resources portfolios similar with and without ITC extension

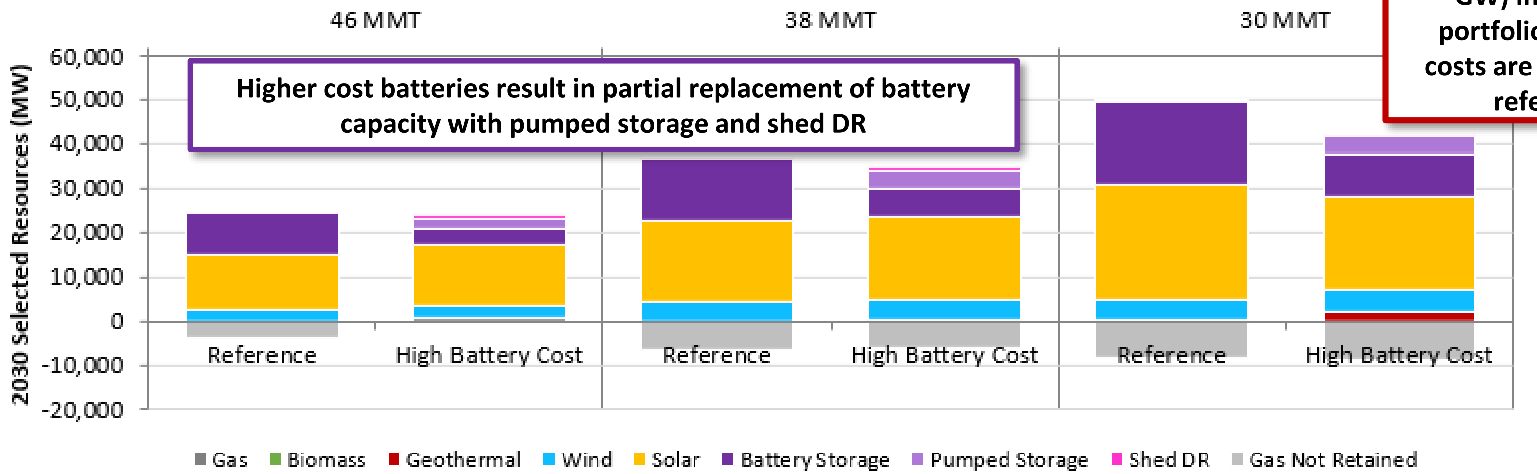


Costs decrease with ITC extension because lower cost solar is available through 2030

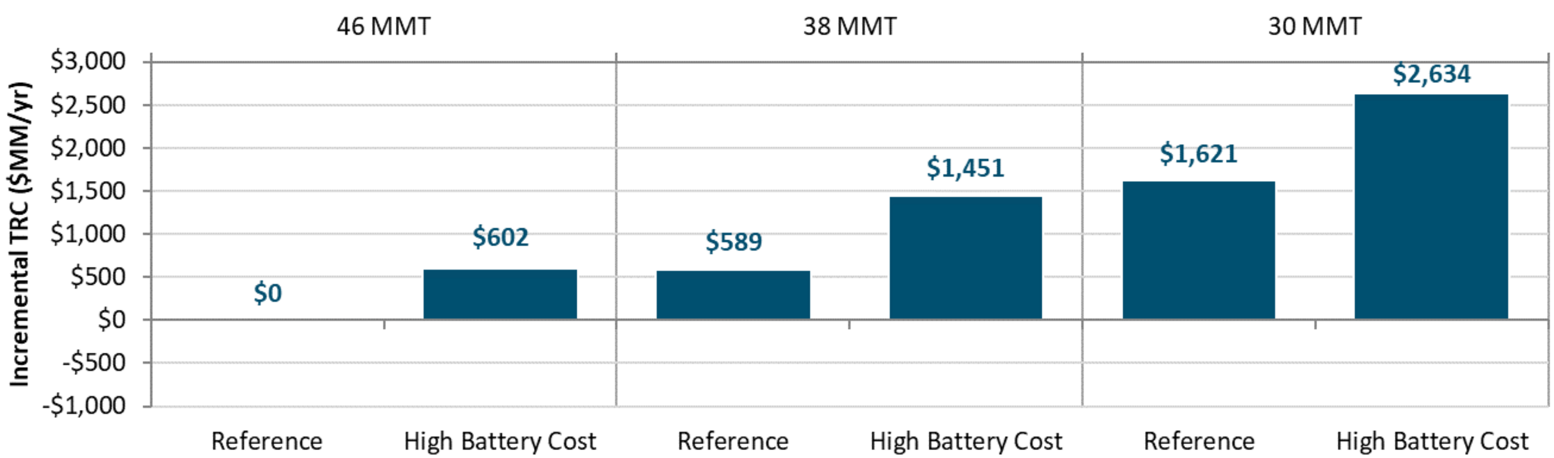
Solar Cost Sensitivities: PV ITC Extension, Comparison with 46 MMT Core Policy Case



Battery Cost Sensitivities: High Cost



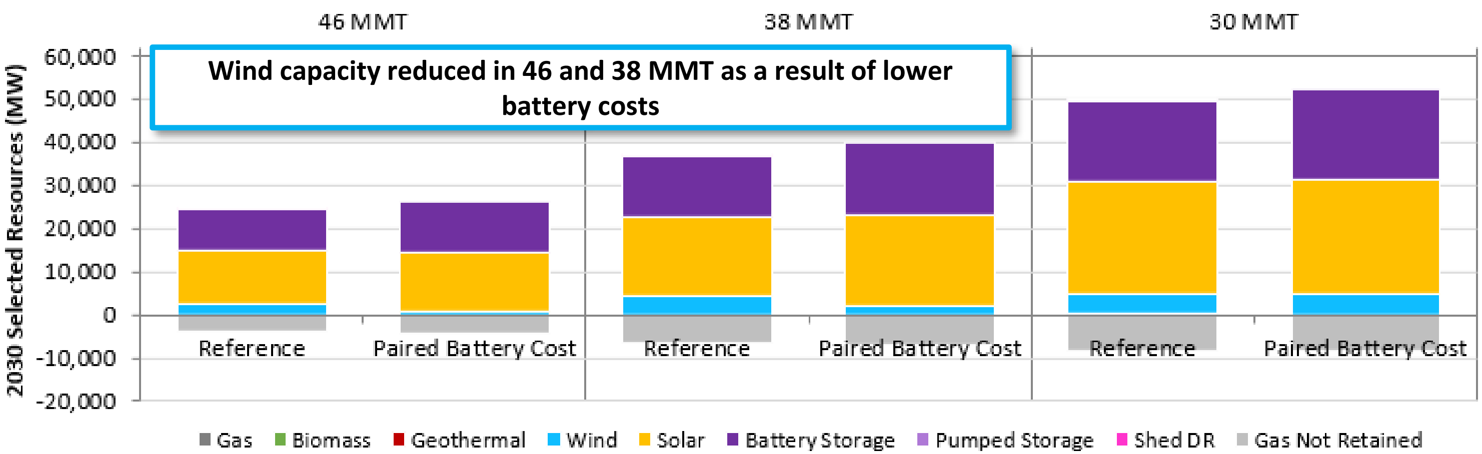
Geothermal (2.2 GW) included in portfolio if battery costs are higher than reference

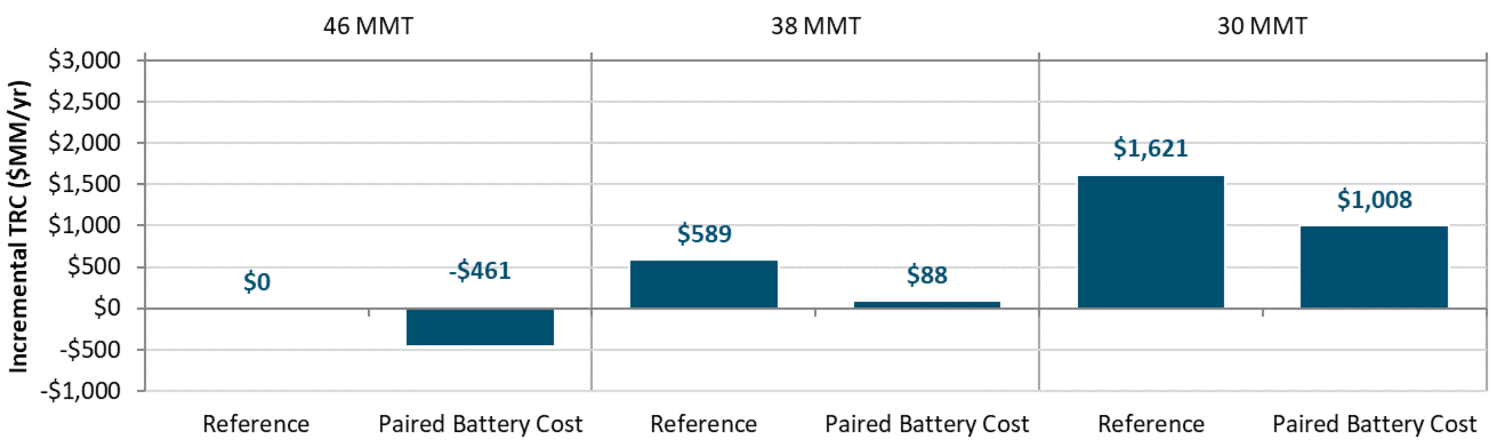


More expensive batteries result in higher system costs

Battery Cost Sensitivities: Paired Battery Costs

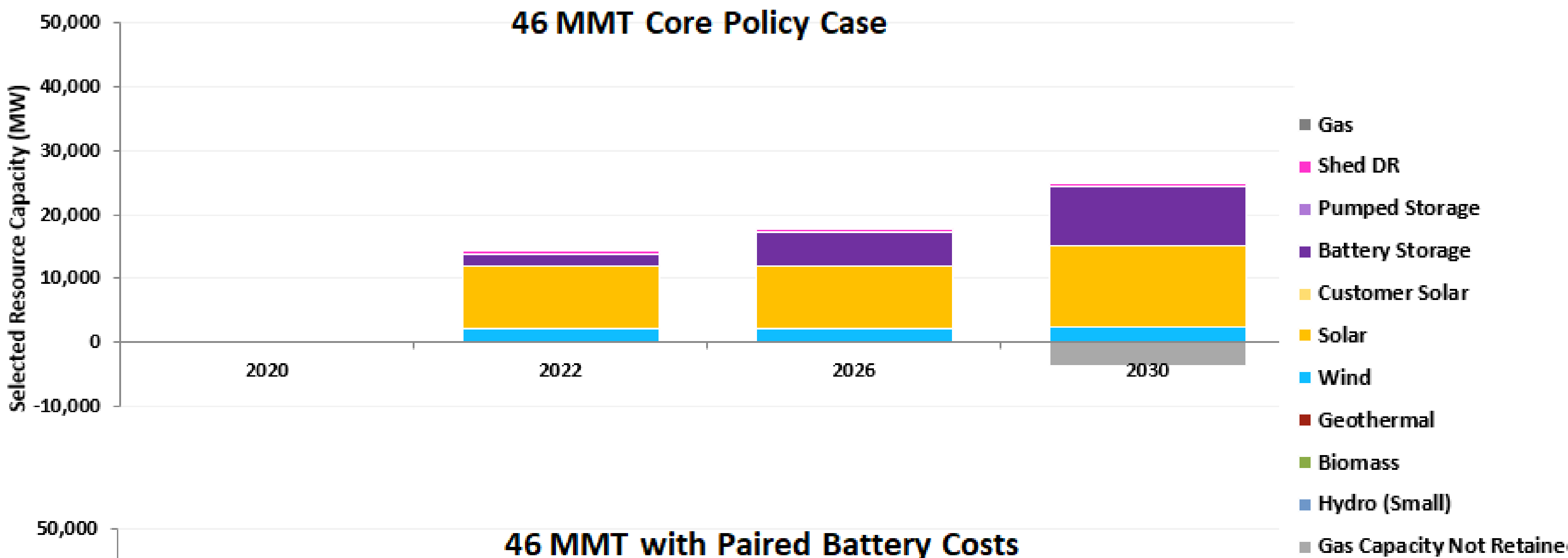
Reduced battery costs from pairing results in modest increases in 2030 battery capacity

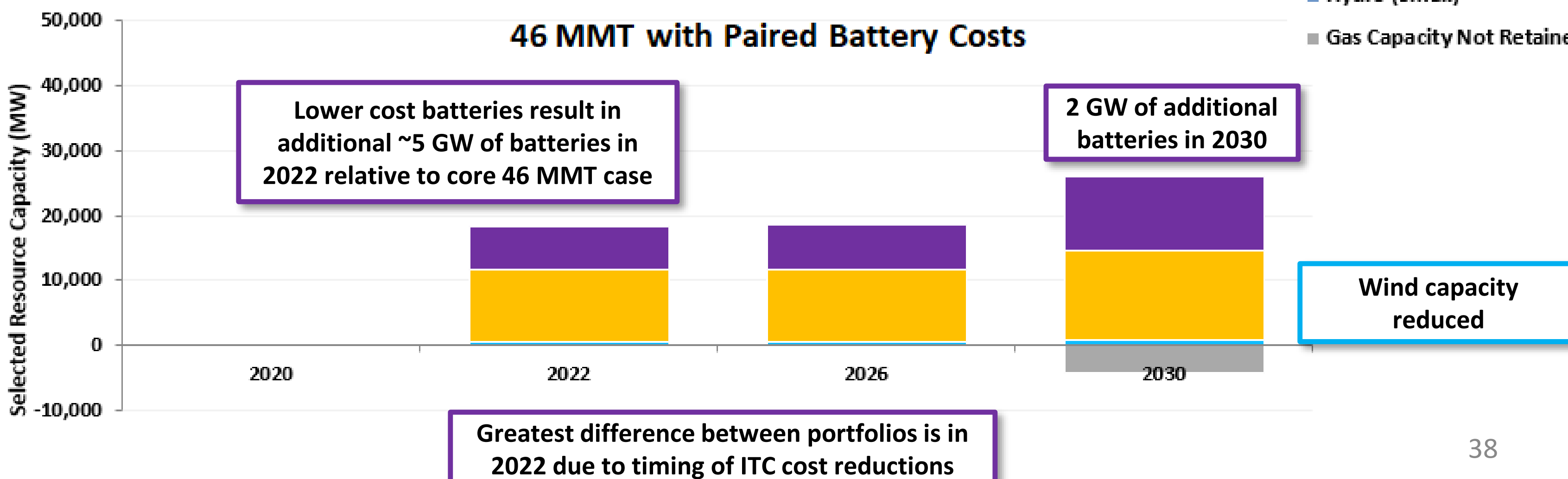




Costs decrease with paired battery costs, especially for near-term battery installations.
As shown on next slide, near-term ITC cost reductions drive earlier installation of batteries.
ITC-driven cost reductions are an upper bound due to the lack of charging constraints.

Battery Cost Sensitivities: Paired Battery Costs, Comparison with 46 MMT Core Policy Case

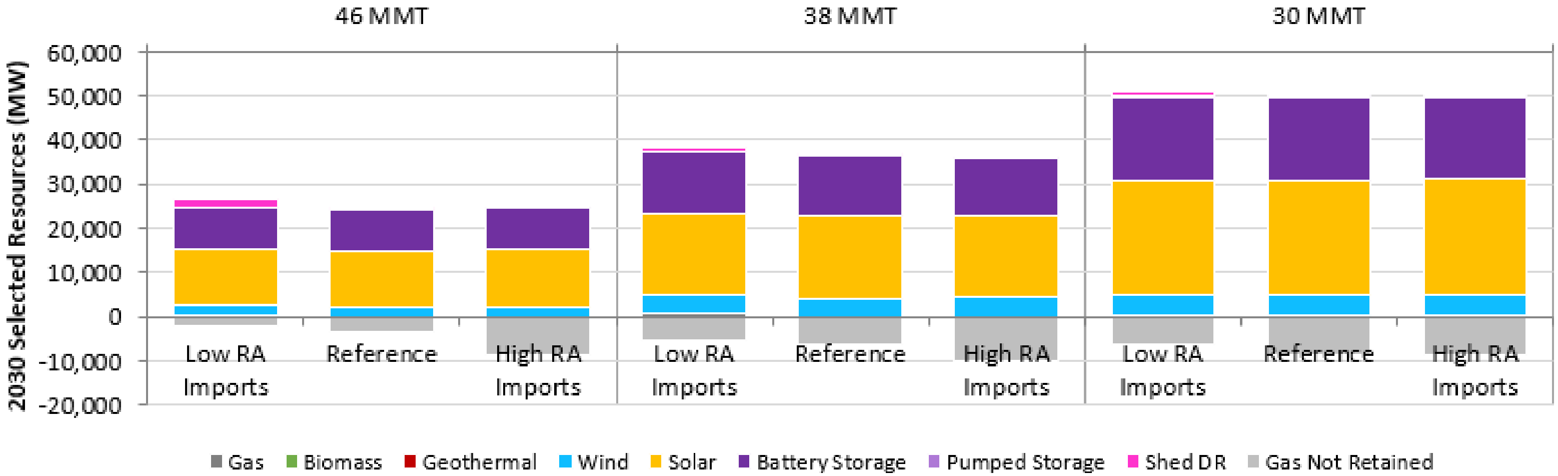


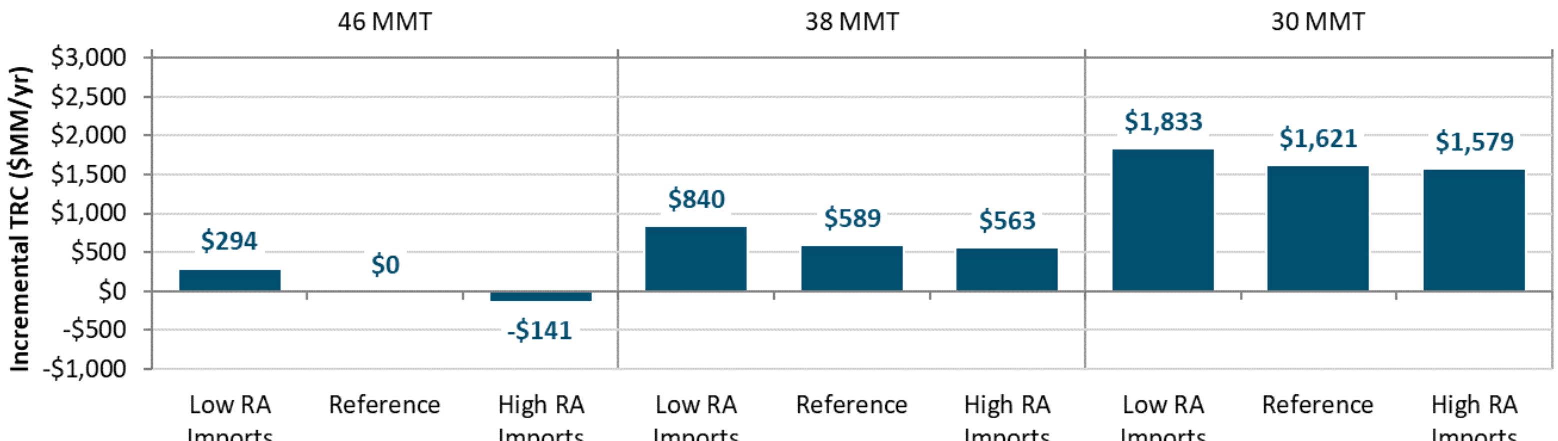


RESOURCE ADEQUACY AND LOAD SENSITIVITIES

Imports Sensitivities

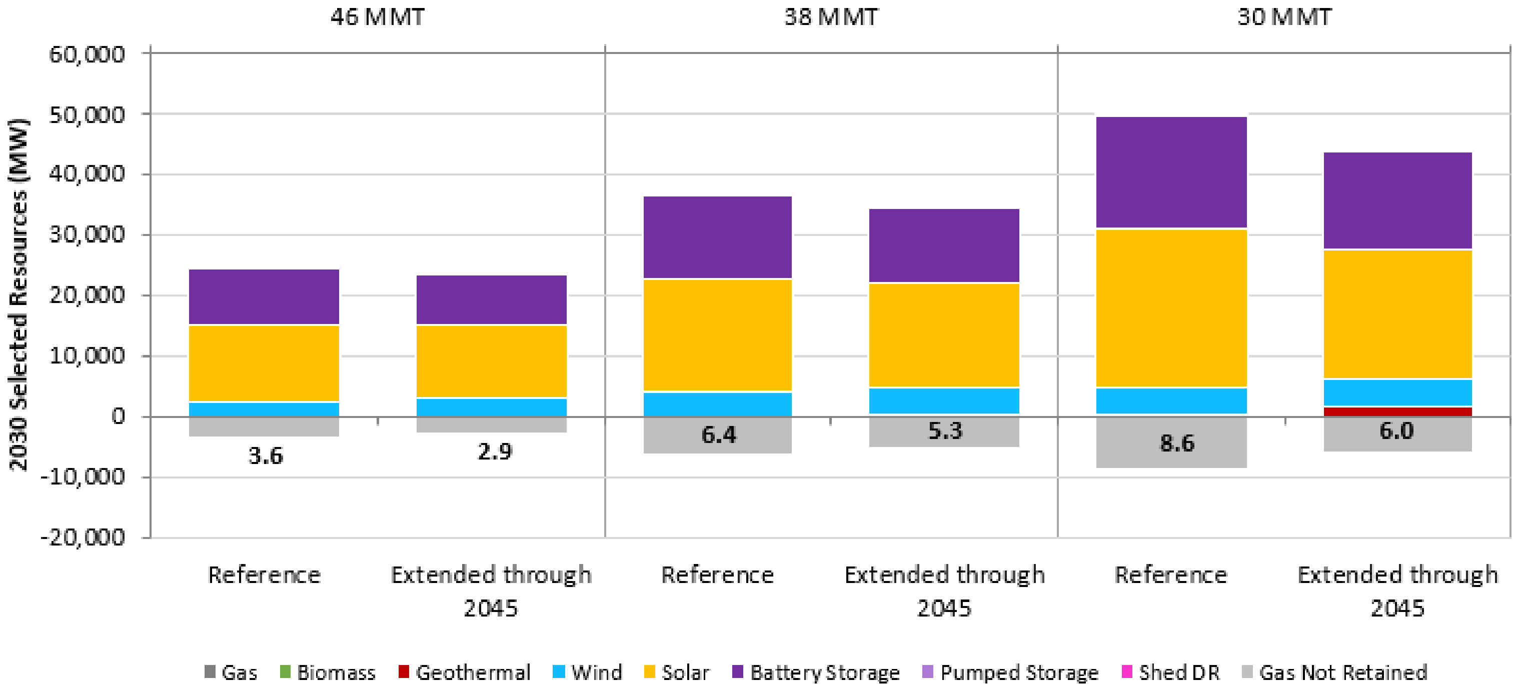
Lower available RA import capacity results in higher levels of gas retention





Lower levels of available RA import capacity can result in selection of additional and/or more expensive resources to meet resource adequacy requirements, potentially increasing costs to CAISO ratepayers.
Note: cost of contracting with OOS resources for resource adequacy not included in optimization. As a result, the cost differences shown here represent an upper bound.

2045 End Year Sensitivity



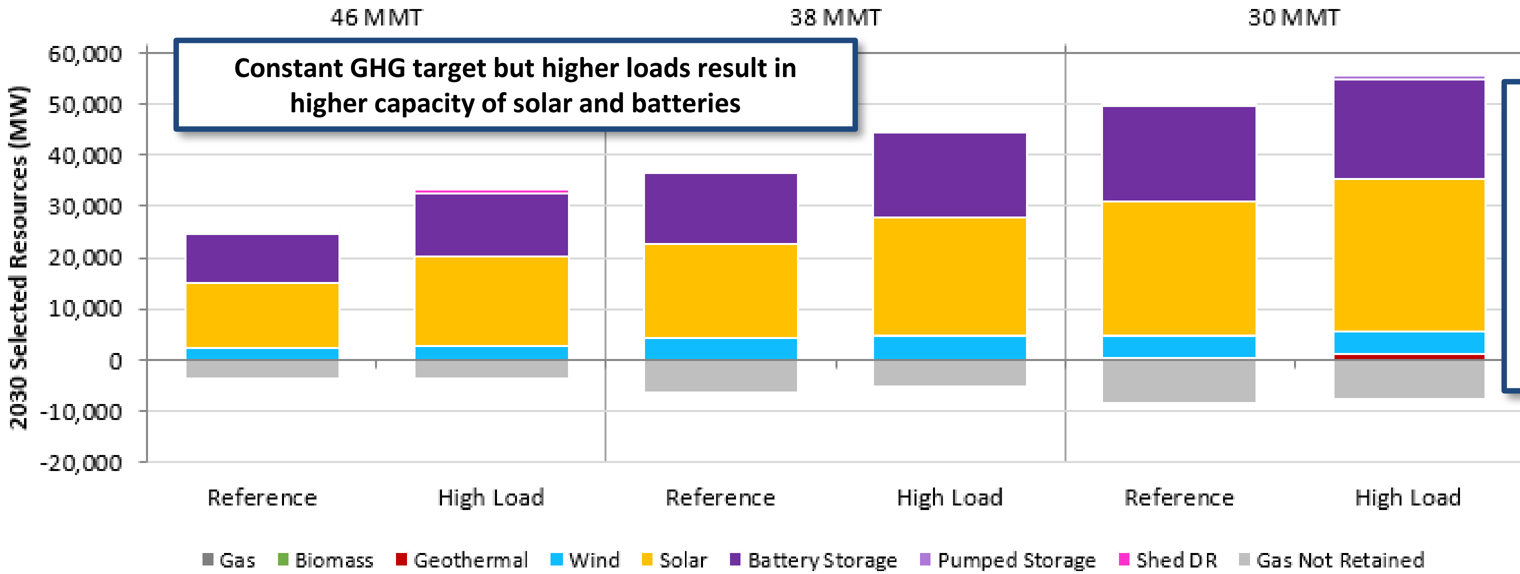
An additional ~1 - 2.5 GW of gas retained if case is extended through 2045

Post-2030 load and GHG targets can significantly impact 2030 portfolio. Gas retention in 2030 is higher across all 2030 GHG targets if 2045 is considered.

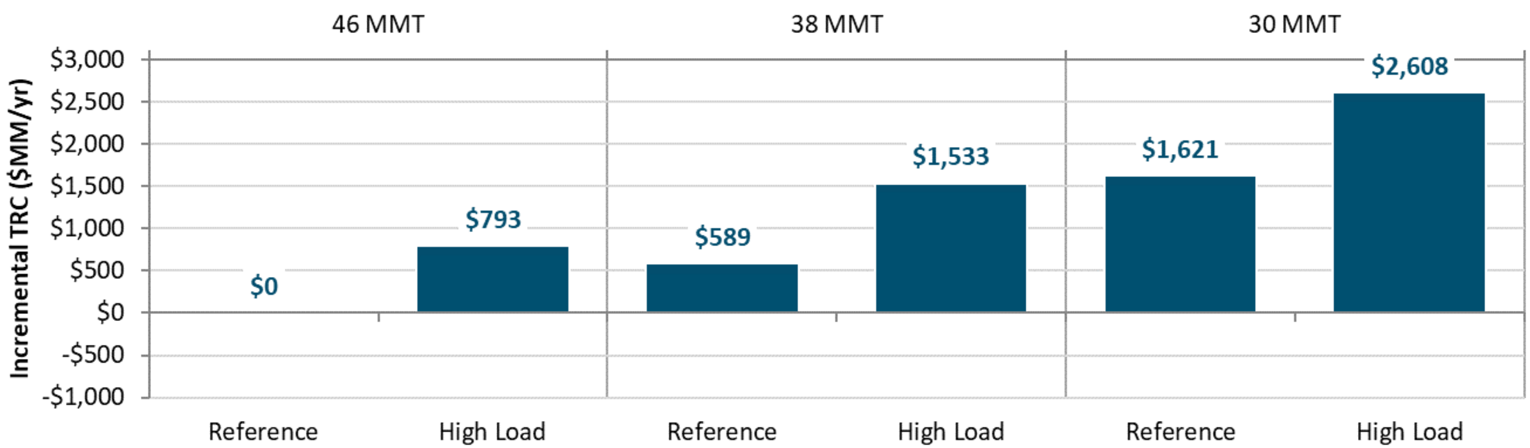
The 2045 End Year Sensitivity includes loads that are broadly consistent with the 2045 High Biofuels Framing Study. Loads in the High Biofuels scenario are lower than the other two framing study scenarios. Is likely that more gas capacity would be retained under higher load levels, which would increase the difference in gas retention between the 2030 core policy cases and cases that include a 2045 end year.

High Load

Constant GHG target but higher loads result in higher capacity of solar and batteries



Geothermal and pumped storage selected under higher load projections and a 30 MMT target



Higher load projections result in higher total resource cost because more load must be served while meeting the same GHG target.

2045 FRAMING STUDY

Purpose of SB100 2045 Framing Study

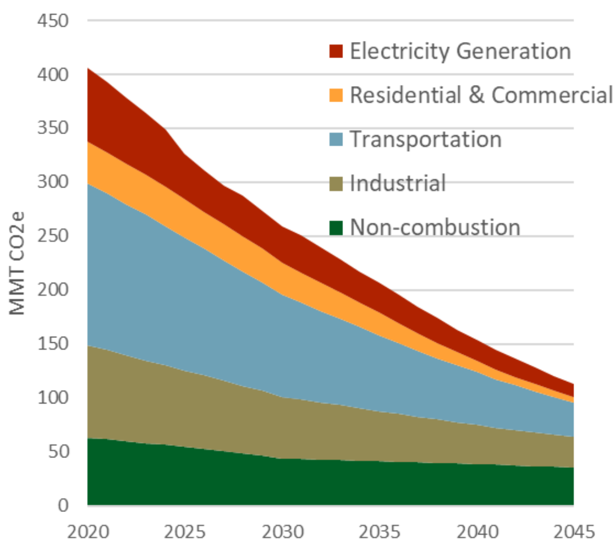
- Explore how 2045 goal under SB100 could affect the outlook for electricity sector GHG emissions and resource planning in the 2030 timeframe.
- Provide analysis that includes context from other sectors.
- Inform Commission decision-making around the appropriate 2030 GHG planning target for CPUC-jurisdictional LSEs, as the Reference System Portfolio to meet that target.
- Primarily <u>informational</u> and <u>directional</u> regarding least-regrets investments needed by 2030.

SB100 2045 Framing Study Scenarios

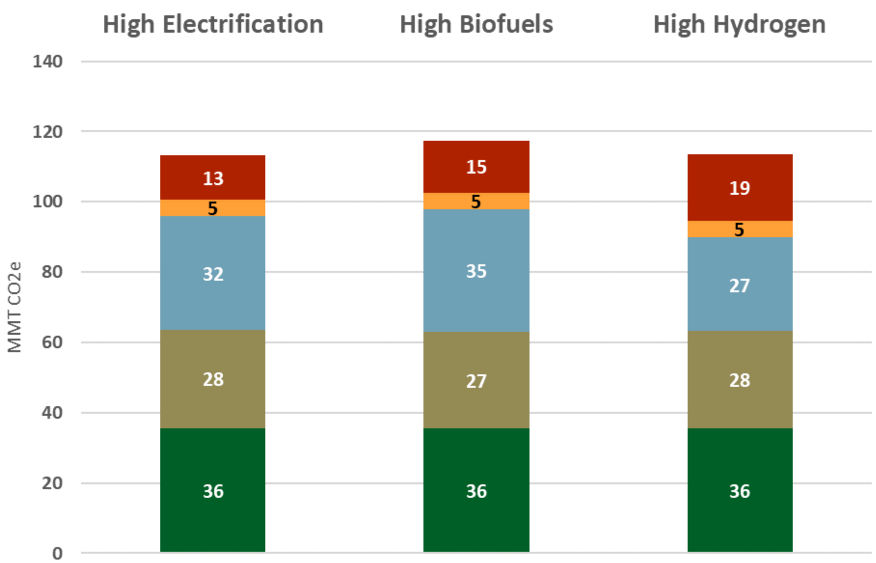
- While the CPUC IRP focuses on infrastructure decisions between present day and 2030, some near-term decisions may depend on changes to the electricity sector that result from post-2030 economy-wide decarbonization.
- Three scenarios are explored in the 2045 Framing Studies that reflect different decarbonization 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).
- 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.

GHG Emissions by Sector, Statewide

High Electrification



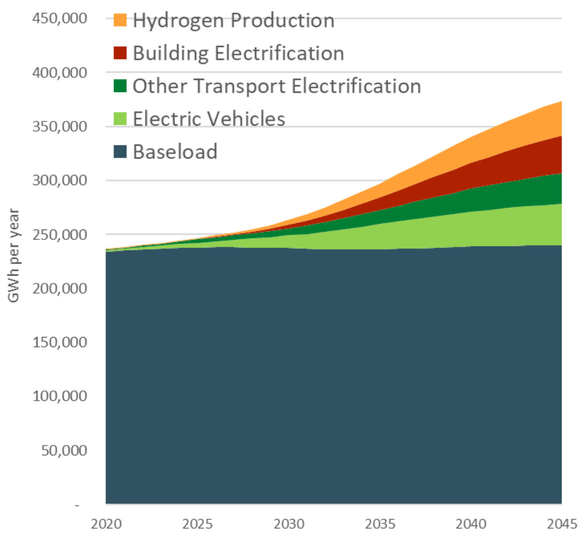
2045 – Comparison Between Scenarios



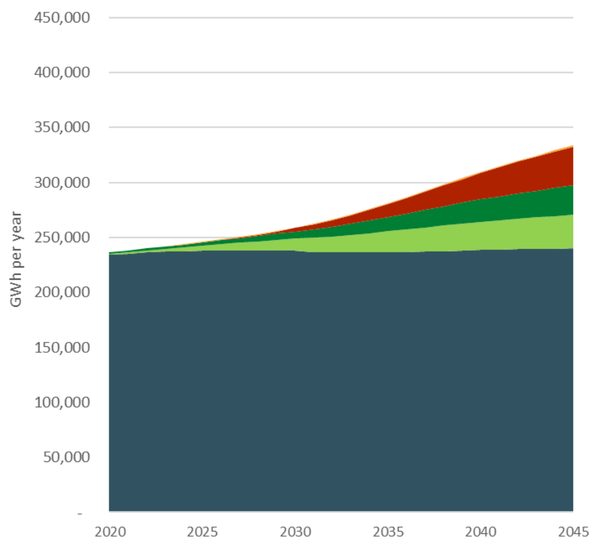
- All scenarios meet the same economy-wide 2050 GHG target, but result in different energy systems

CAISO Electricity Loads

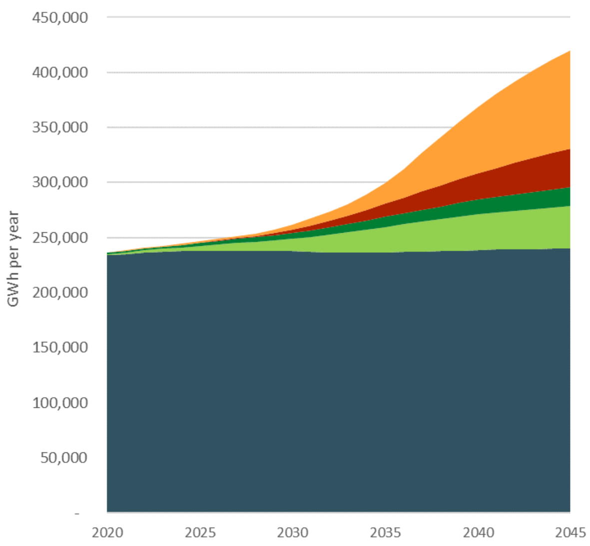
High Electrification



High Biofuels

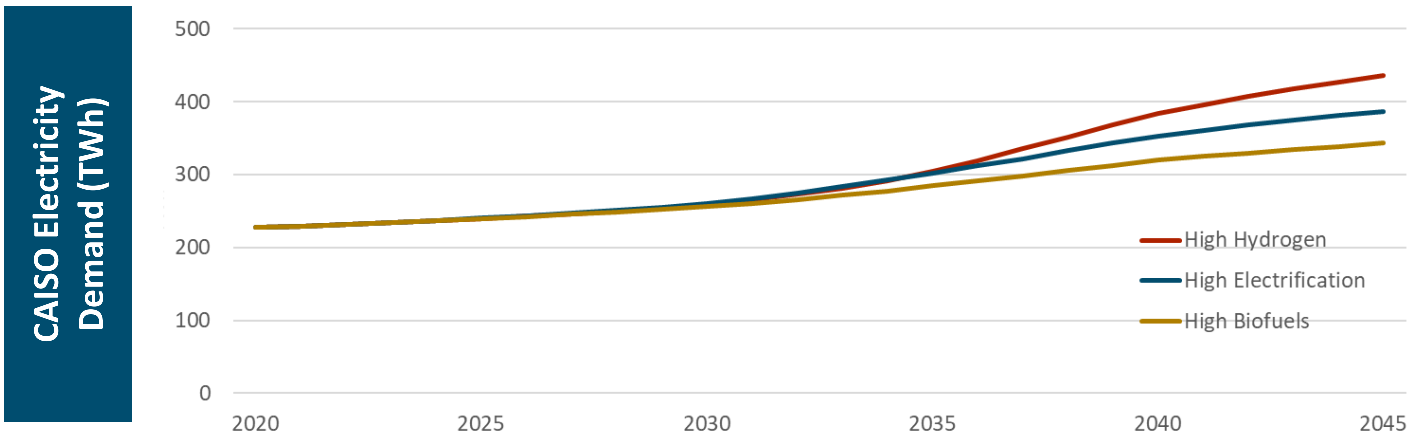


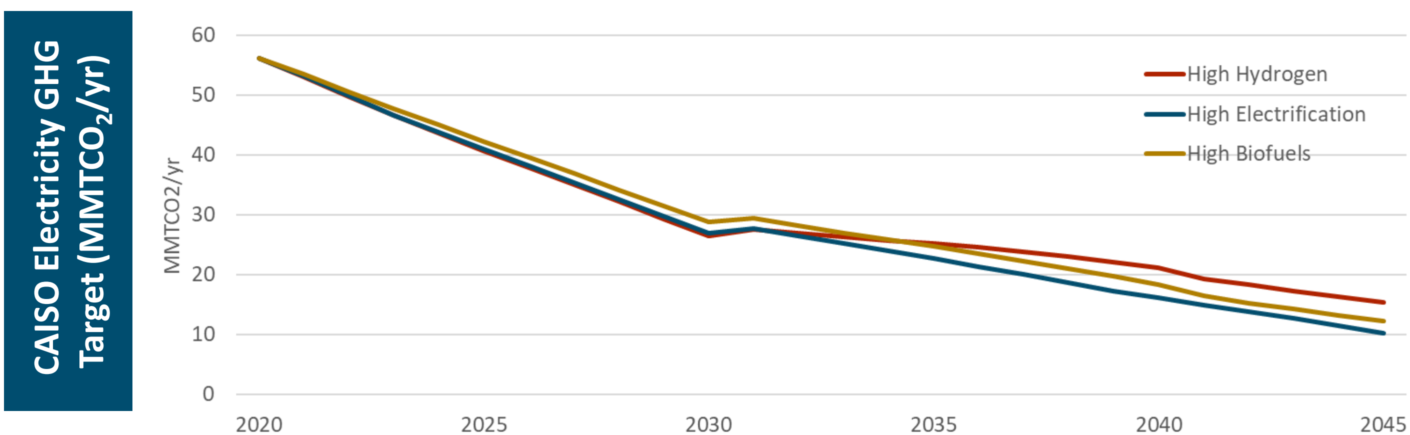
High Hydrogen



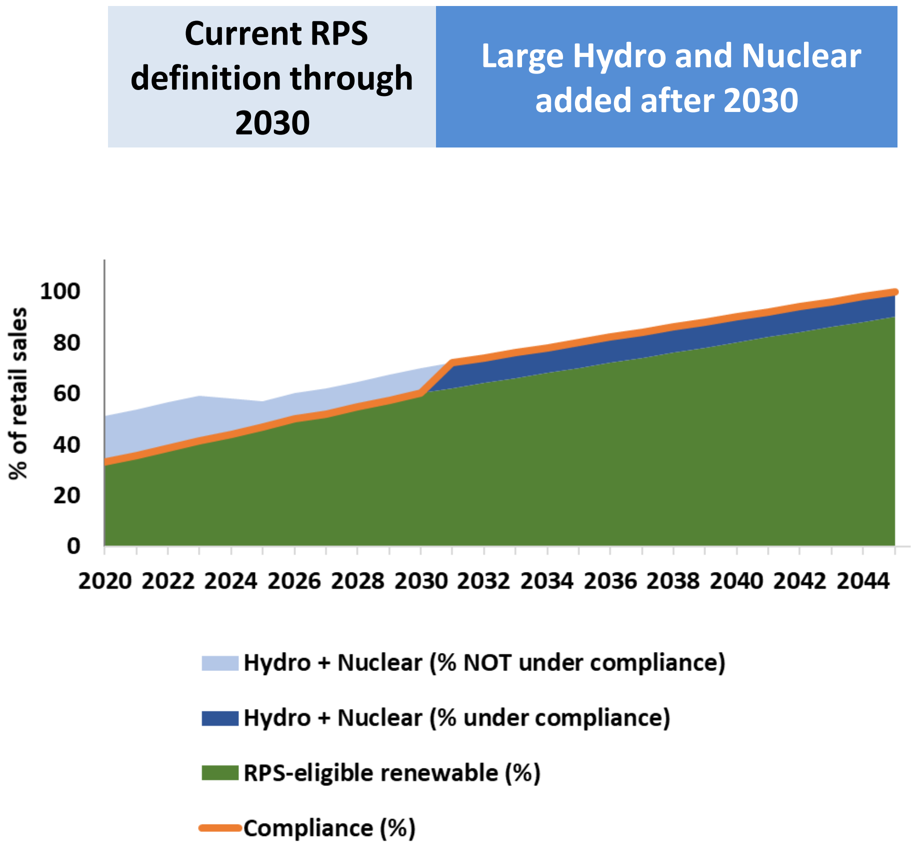
- Electricity loads vary by scenario and are a product of complex cross-sectoral interactions within each scenario
- Electrifying buildings, transportation and industry, and hydrogen electrolysis are key drivers of higher electric sector loads

Pathways Inputs into RESOLVE





Modeling SB 100 in RESOLVE

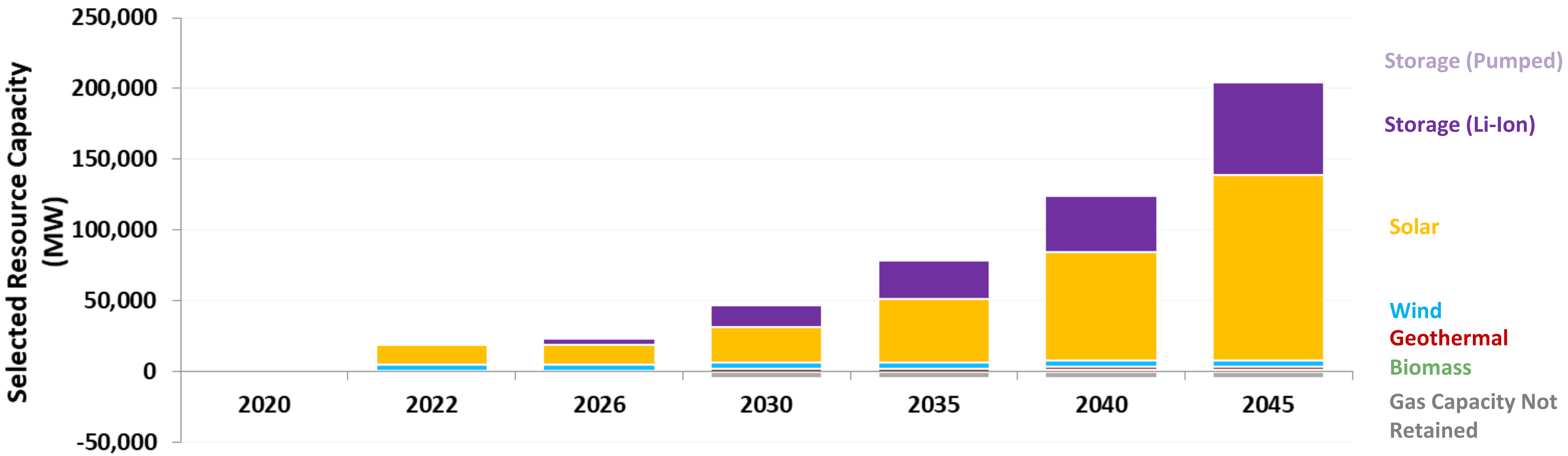


*Total retail sales includes pumping loads after 2030 (not shown)

- Will inform SB100 joint agency report process
- SB100 does not define "zero carbon resources"
  - Renewables, nuclear and hydro are assumed to be eligible resources under SB100 post-2030
- SB100 interpreted as a percent of retail sales
  - Through 2030: current RPS definition retained
  - After 2030: nuclear and large hydro are added to eligible resources
- SB100 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 on (thorough 2045)
- Around 450 MW of long duration (12-hr) pumped storage is selected in 2026
- Wind:
  - Maximum resource potential built for onshore wind. Only in-state wind allowed in base case.
  - 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

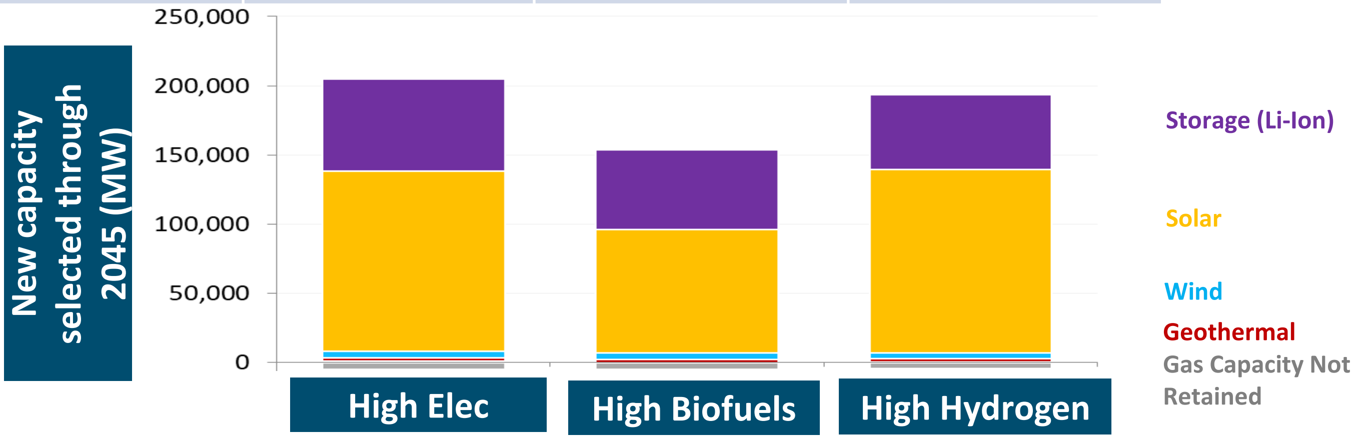
Key Scenario Metrics in 2045

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	**\$555/tCO_2**	**\$493/tCO_2**	**\$480/tCO_2**
Effective SB100 % Note: 100% CES target enforced	**109%**	**107%**	**105%**
Gas capacity not retained Note: Does not include OTC retirements	**4.9 GW**	**4.6 GW**	**4.1 GW**
Reserve Margin	**72 GW**	**70 GW**	**70 GW**
Curtailment + storage losses	**23%**	**21%**	**18%**
Levelized Total Resource Cost (TRC) Note: Electrolysis capital cost not included	**\$57.2 bn/yr**	**\$55.1 bn/yr**	**\$56.9 bn/yr**
Incremental TRC *(relative to High Electrification)*	-	**(\$2.1 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

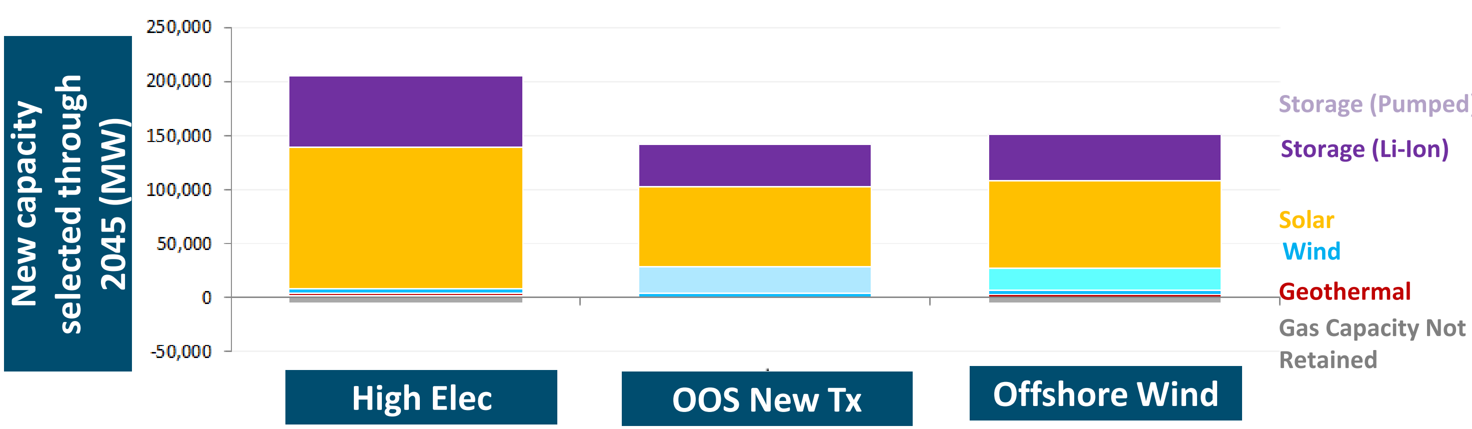


High Electrification: Wind and Tx Sensitivities

Metric	High Electrification (Base)	OOS New Transmission (mostly wind)	Offshore Wind available
CAISO load in 2045 (TWh)	**425**	**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	**\$554/tCO_2**	**\$410/tCO_2**	**\$520/tCO_2**
Effective SB100 % Note: 100% CES target enforced	**109%**	**107%**	**108%**
Gas capacity not retained (GW) **Note: Does not include OTC retirements.**	**4.9 GW**	**0.5 GW**	**5.2 GW**
Achieved RA Reserve Margin (target = 15%)	**15%**	**15%**	**16%**
Curtailment + storage losses (%)	**23%**	**15%**	**19%**
Levelized Total Resource Cost (TRC)	**\$57.2 bn/yr**	**\$56.1 bn/yr**	**\$56.0 bn/yr**
Incremental TRC *(relative to High Electrification)*	**-**	**(\$1.1 bn/yr)**	**(\$1.1 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

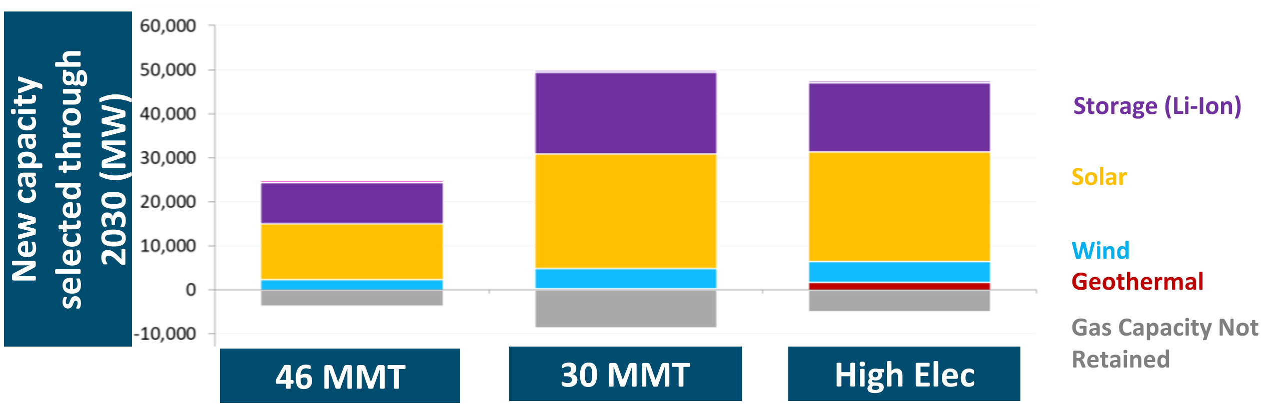


Looking Beyond 2030 Highlights Potential Path dependencies for 2030 Portfolios

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	24.3	26.9
Marginal GHG Abatement Cost	$109/tCO_2$	$248/tCO_2$	$293/tCO_2$
Effective RPS % Note: 60% target enforced	60%	79%	77%
Gas capacity not retained in 2030 (GW) Note: Does not include OTC retirements.	3.6 GW	8.6 GW	4.9 GW
Achieved RA Reserve Margin (target = 15%)	15%	15%	17%

30 MMT and High Electrification runs similar in 2030

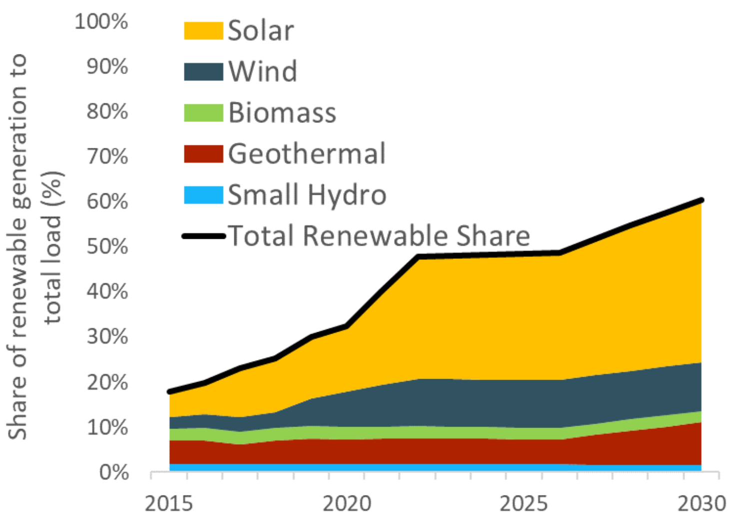
Comparing the 30 MMT and High Electrification scenarios, an increase in electrification loads post-2030 results in more gas retention in 2030



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

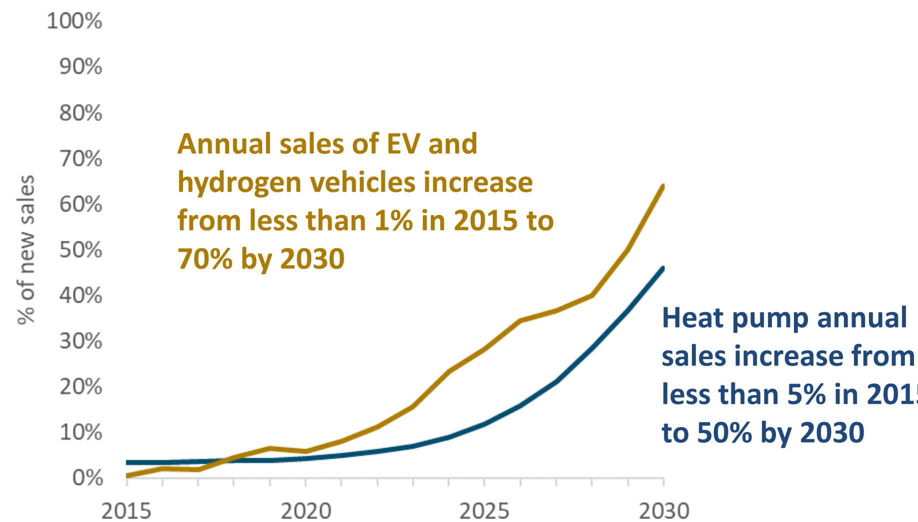
- Meeting the 2030 target requires accelerated progress in all other sectors with aggressive effort compared to the historical trajectory.

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



Source: E3 RESOLVE High Electrification scenario

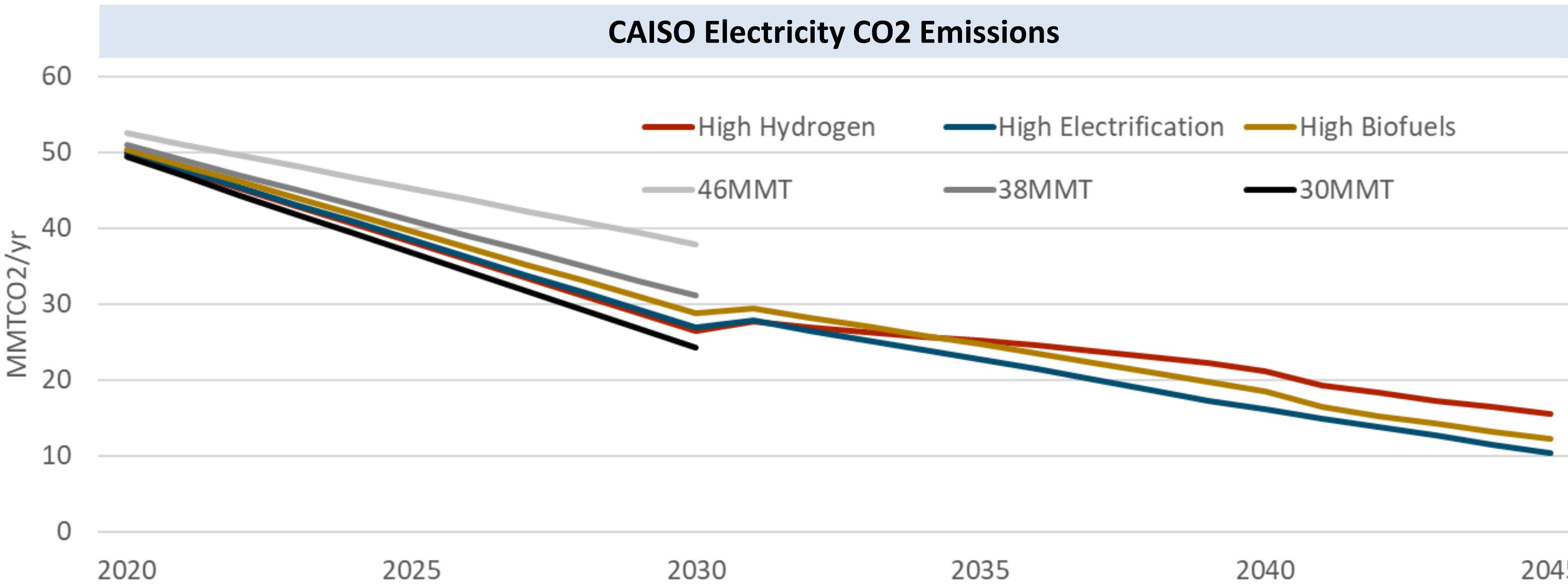
The sales share of electric heat pumps and ZEVs need to ramp up rapidly from single digits to more than 50% by 2030



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?

GHG Target Comparison Shows Deeper Reductions in 2030 Under 2045 Framing Studies than 46 MMT Scenario



•46MMT scenario includes ~60% RPS in 2030, roughly consistent 2030 requirements under SB100

•The High Hydrogen, High Electrification, and High Biofuels scenarios all exceed a 60% RPS in 2030, and have lower GHG emissions in 2030 than the 46MMT scenario. These scenarios are consistent with the statewide PATHWAYS scenarios (CEC 2018) that achieve a 40% reduction in economy-wide GHG emissions by 2030, relative to 1990 levels

•In the PATHWAYS (CEC 2018) scenarios, the electricity sector reduces GHG emissions more than other sectors, and exceeds the minimum regulatory requirements under SB100, due to lower GHG abatement costs in the electricity sector relative to other sectors, and due to the implementation challenges of achieving a 40% reduction in GHG emissions from some of the other sectors by 2030

Key Takeaways from 2045 Framing Study

- Looking beyond 2030 helps to inform near-term thermal retention decisions.
- Resource build under a more ambitious 2030 target (30 MMT) is more in line with 2045 scenarios.
- All three 2045 Framing scenarios rely heavily on solar and batteries to meet load and GHG policy requirements.
- 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 isn't clear to what extent other sectors will achieve reductions.