Energy+Environmental Economics

2020 ACC Workshop

Greenhouse Gas Value and Emissions

5/8/2020

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Christa Heavey

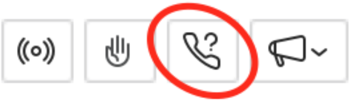
Agenda

- Introduction
- Comparing 2019 and 2020 Vintage ACC Results
- GHG Value
  - From RESOLVE modeling of Reference System Portfolio
- GHG Emissions
  - From SERVM modeling of No New DER case
  - Marginal emissions and portfolio rebalancing
- Example Calculations

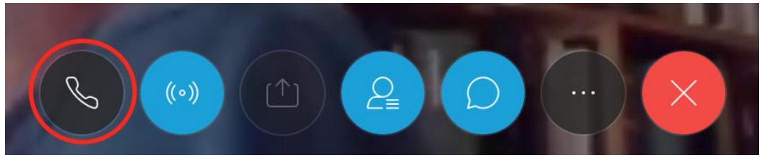
https://www.ethree.com/cpuc-acc-downloads-page/

Logistics

- Please use the Q&A feature to ask questions.
- Questions will be answered during the allotted discussion periods after each section.
- If you have a longer question you would prefer to use your microphone for, you can request to be unmuted by clicking on the button with the phone icon:



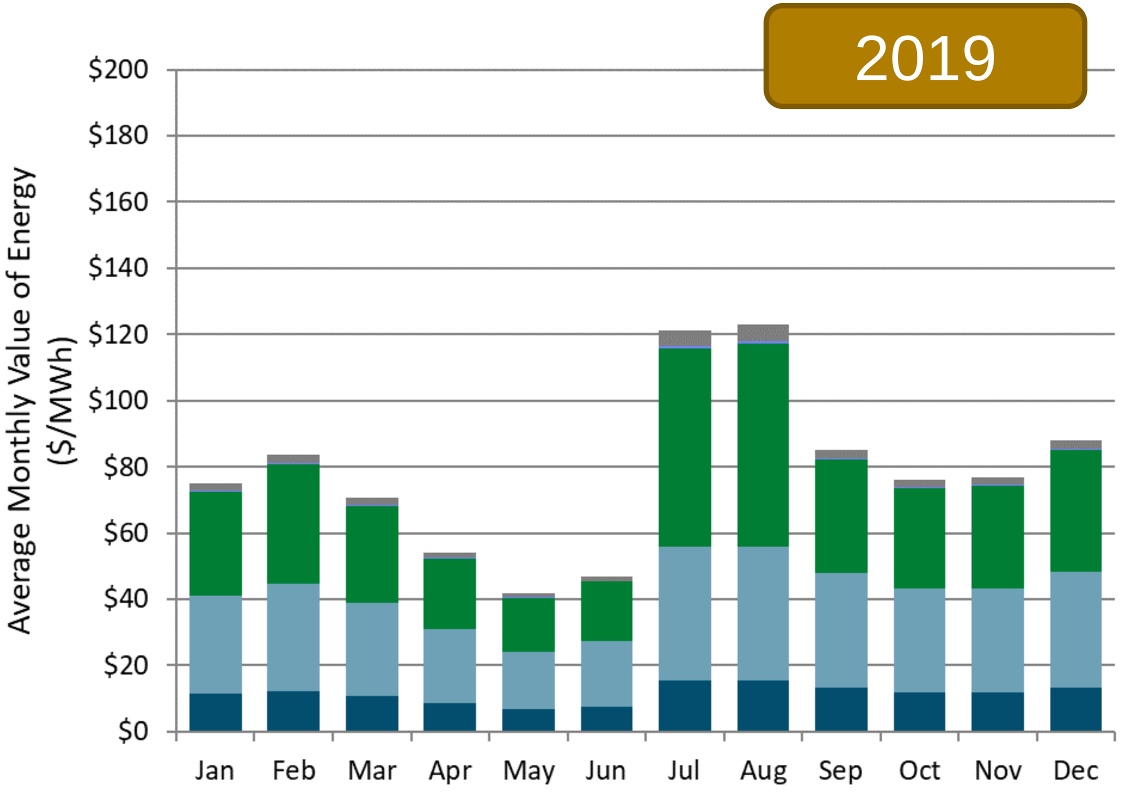
  - Once you are given speaking permissions, you will need to connect your audio by clicking on the phone icon on the main screen:

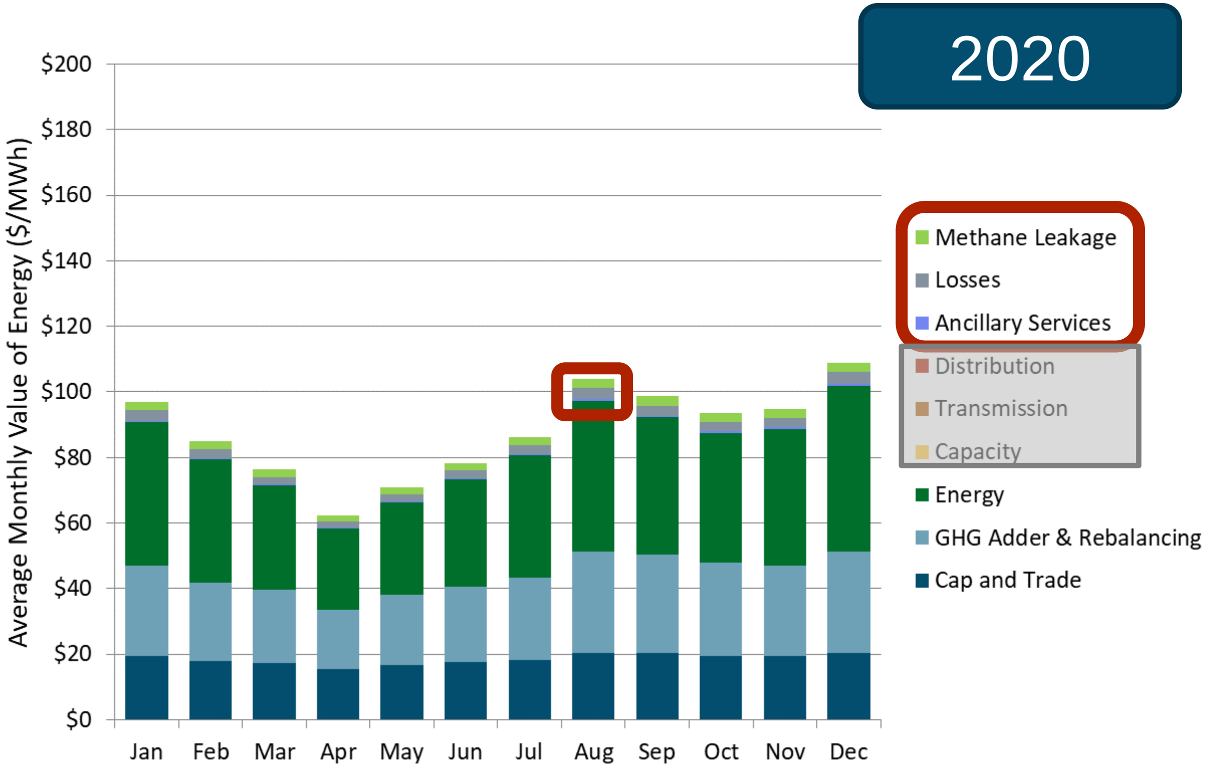


Energy+Environmental Economics

Comparing 2019 and 2020 ACC Results

Monthly Average Avoided Costs (excl. Capacity)



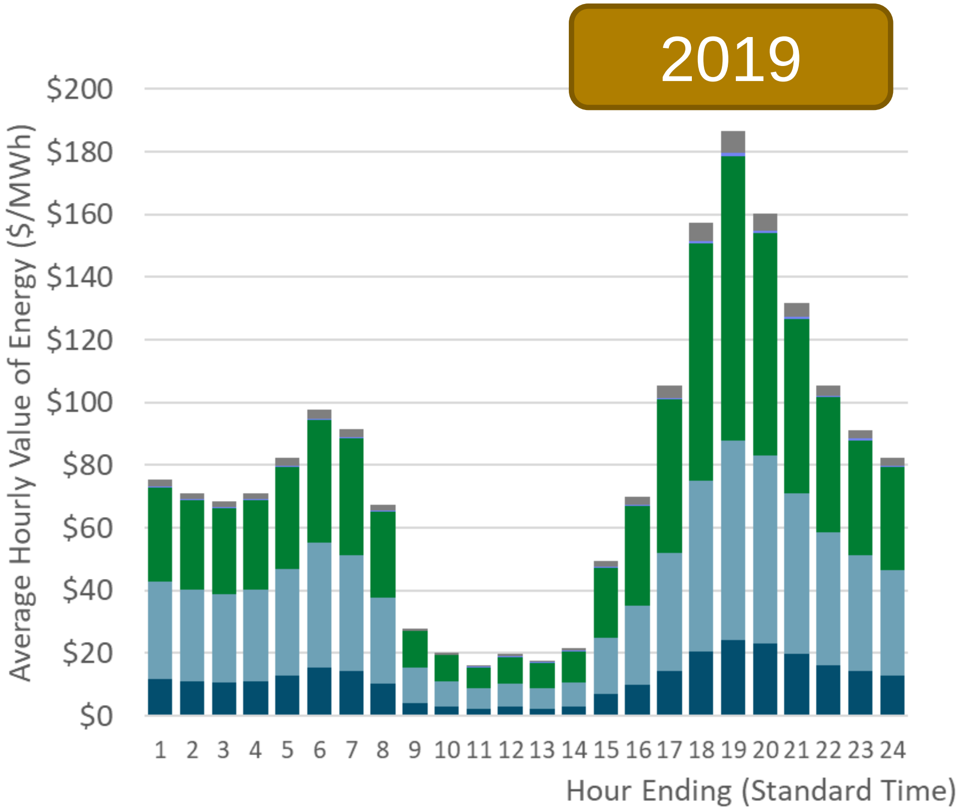


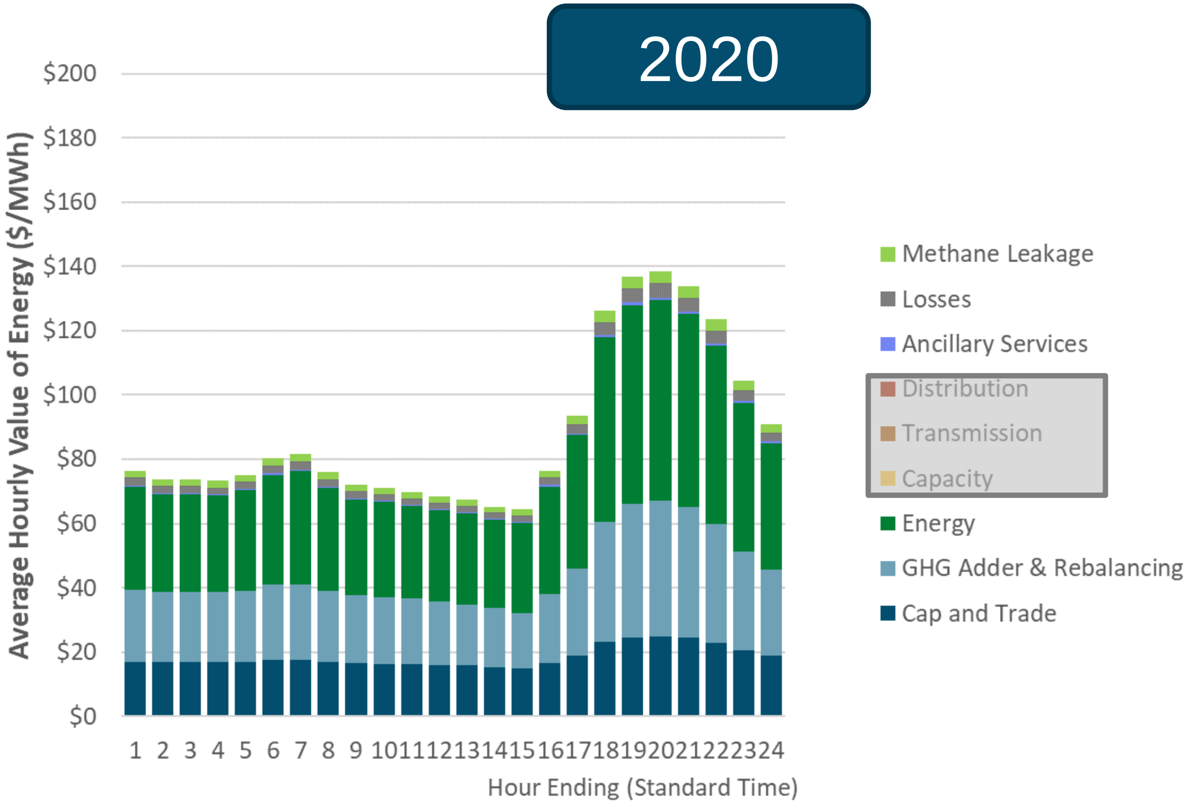
Hold your questions…

- Higher energy and GHG avoided costs in 2020 ACC except during July and August

SCE Climate Zone 9 (Los Angeles) in 2025

Hourly Average Avoided Costs (excl. Capacity)





- Higher mid-day and lower evening avoided costs in 2020 ACC

SCE Climate Zone 9 (Los Angeles) in 2025

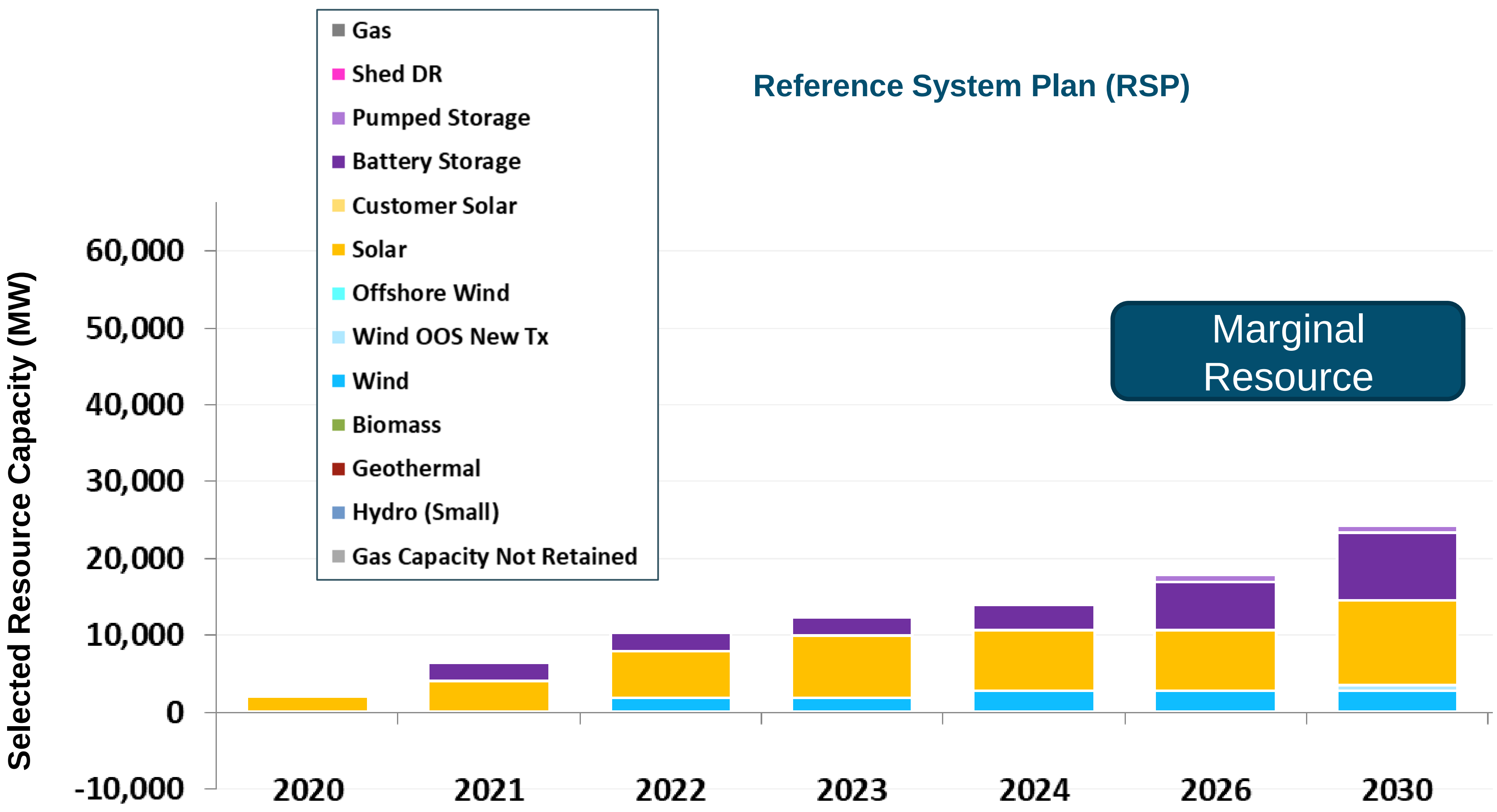
Changing Avoided Cost Paradigm

- **2019 ACC: CCGT and CT are marginal resource**
  - ~ 60% Variable
  - Planning grid for peak capacity
  - Focus on efficient fossil generation and dispatch

- **2020 ACC: Solar and Storage are marginal resource:**
  - ~ 90% fixed cost
  - Planning grid for delivered renewable energy
  - Focus on efficient capital investment

Based on Integrated Resource Planning Proceeding

IRP RESOLVE Modeling of Reference System Portfolio



2030 CAISO Emissions Target of 37.9 MtCO2/year

+ **To meet emissions target by 2030, the RSP builds**
  - **2.8 GW** of in state wind and **0.6 GW** of out of state wind
  - **11 GW** of utility scale solar
  - **8.8 GW** of battery storage
  - **1 GW** of pumped storage
  - **0.2 GW** of added Shed DR

SERVM Production Simulation from IRP

SERVM Framework

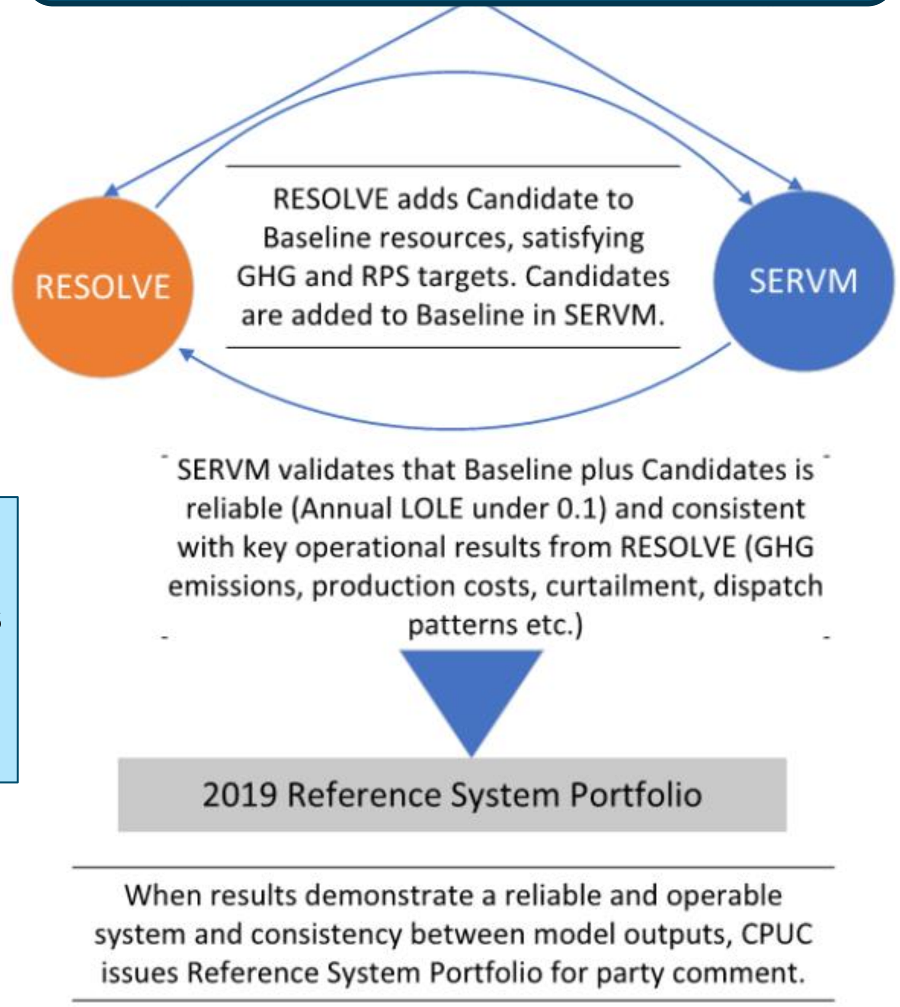
ASTRAPÉ CONSULTING
innovation in electric system planning

- 20+ weather years of 8760 hourly electric consumption demand data for each forecast area in California (currently 8 areas in California, 4 in CAISO and 4 outside CAISO)
- Corresponding 8760 hourly shapes for the same weather years and the same forecast zones for weather dependent load modifiers (BTMPV, EV, TOU, AAEE)

20 **Weather Years** (Equal Probability)	x	**5** **Econ/Demo error points** (Associated Probabilities)	=	**100** **Demand Scenarios** (Associated Probabilities)

Expected Value Across 100 Scenarios
LOLE, GHG, Production Cost

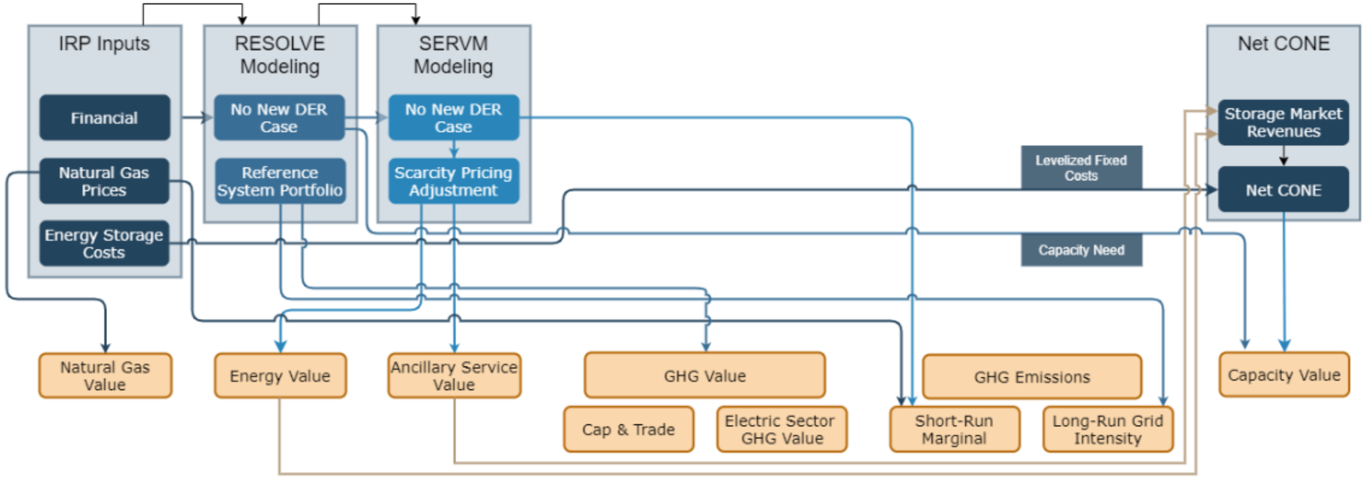
RESOLVE – SERVM Calibration for IRP



Use of RSP and No New DER Case

+ Reference System Plan

- IRP Least-cost portfolio to achieve GHG emissions targets
- ACC uses RESOLVE modeling of RSP for:
  - GHG value
  - planned grid emissions intensity

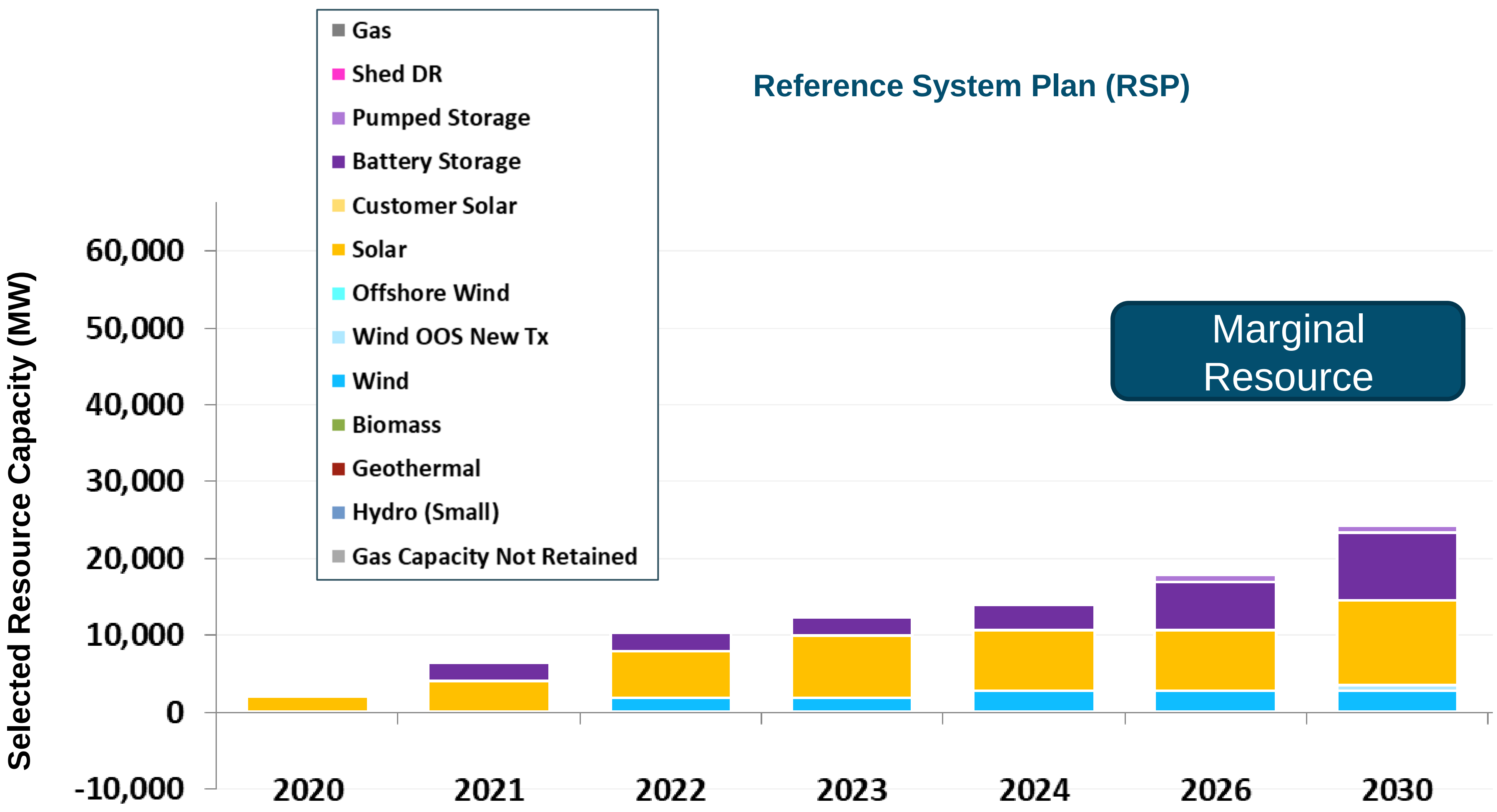


+ No New DER Case

- Counterfactual, what would system costs be without DER
- ACC uses SERVM Modeling of No New DER case for:
  - Marginal GHG emissions

GHG Value (from RSP)

IRP RESOLVE Modeling of Reference System Portfolio



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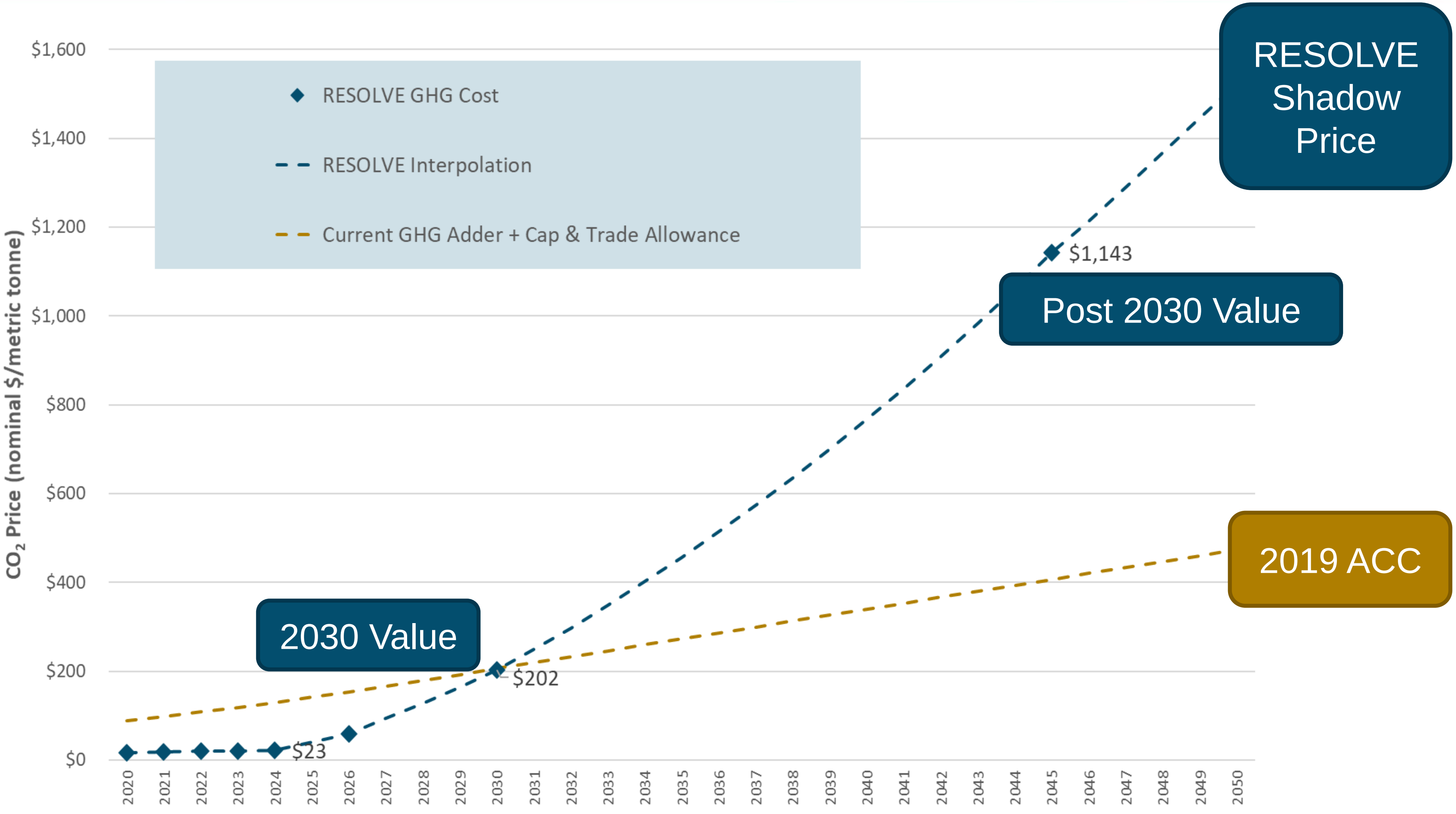
+ **To meet emissions target by 2030, the RSP builds**
  - **2.8 GW** of in state wind and **0.6 GW** of out of state wind
  - **11 GW** of utility scale solar
  - **8.8 GW** of battery storage
  - **1 GW** of pumped storage
  - **0.2 GW** of added Shed DR

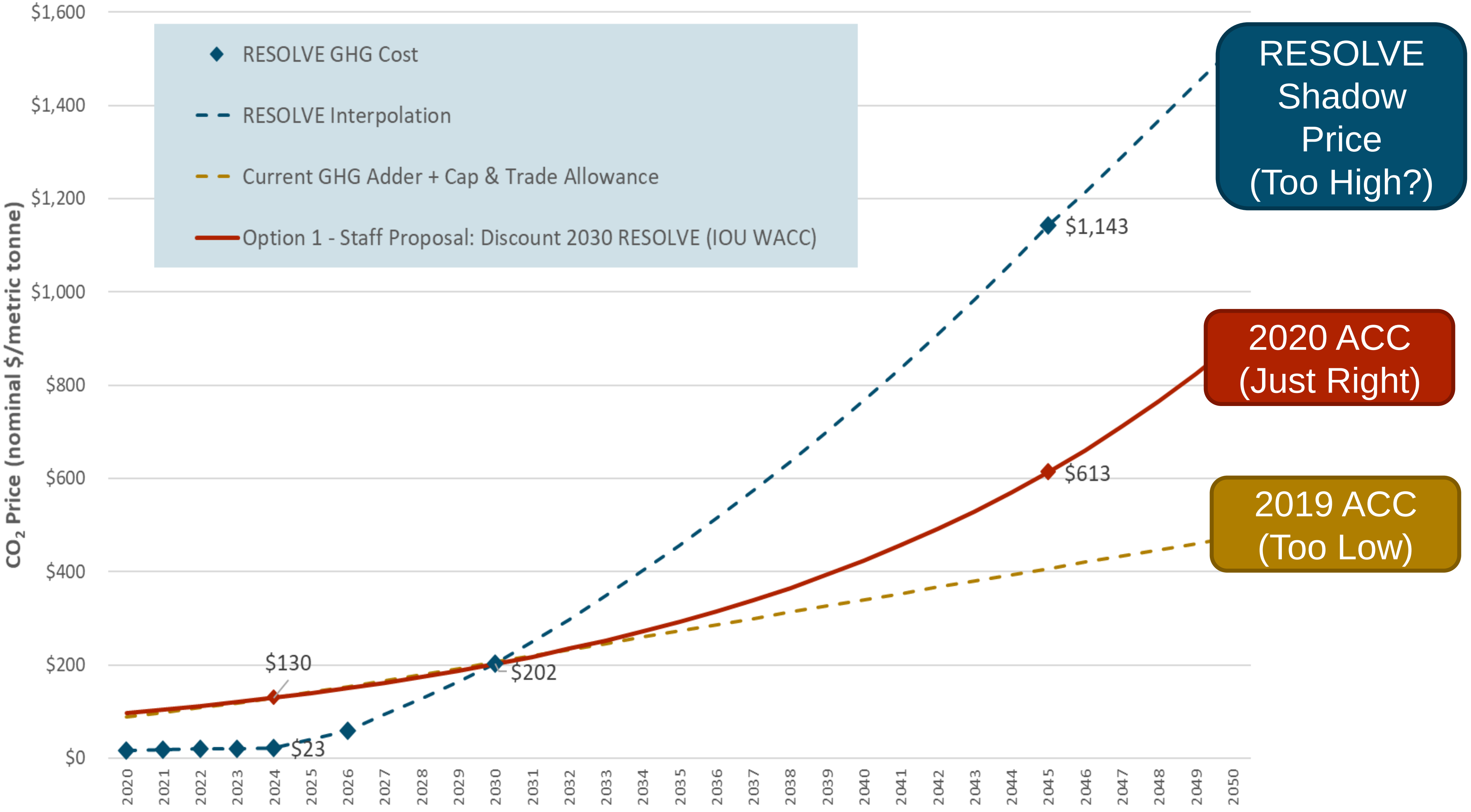
GHG Value from RESOLVE Modeling of RSP

- **RESOLVE GHG shadow price: cost of reducing an additional unit of GHGs**
- **Near-term: RESOLVE price is very low, matching the cap and trade price because GHG is not a binding constraint in the model**
- **Long-term: Price is very high, due to more stringent GHG targets**



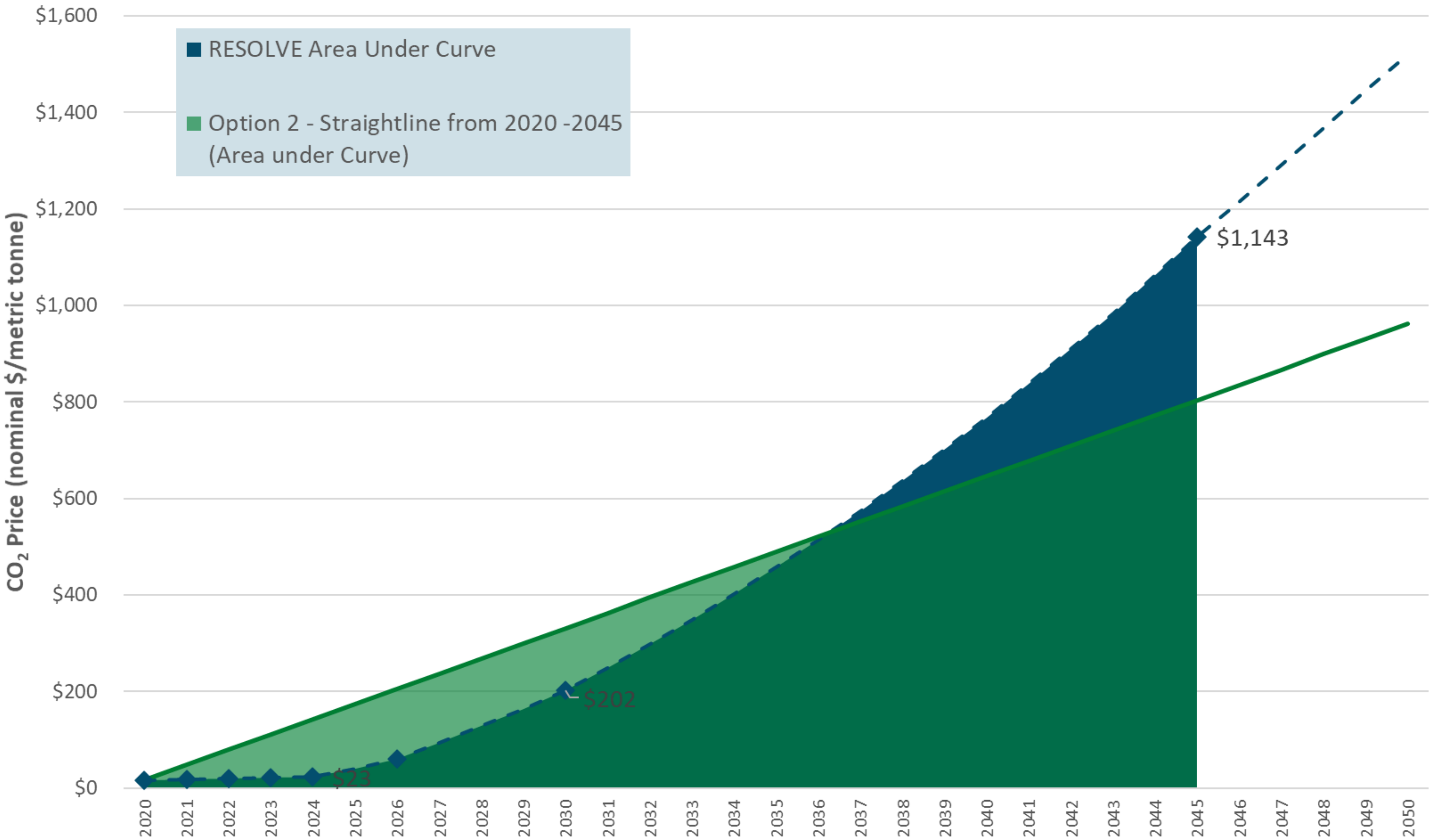
1) Discount 2030 Value at Utility WACC

- **Rationale: represents 2030 RESOLVE shadow price, but discounted to today**
- **Provides consistency with the 2019 ACC in the near-term, but results in higher prices long-term when GHG constraints are more stringent**



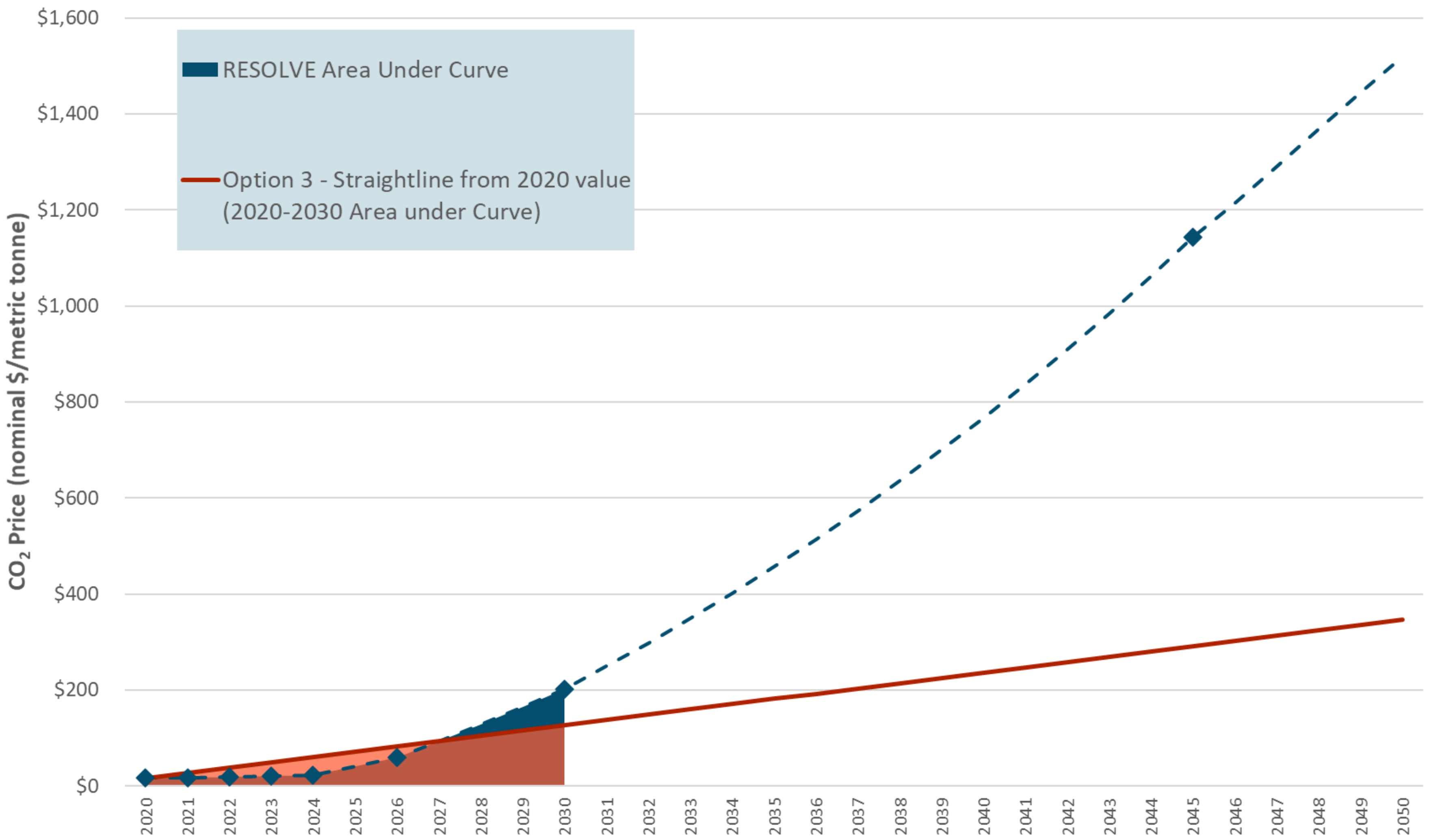
2) Area Under the Curve 2020 - 2045

- Rationale: matching the area means that the average price will equal that of RESOLVE for the time period (2020-2045)
- However, this method results in very high prices very early on relative to the 2019 ACC



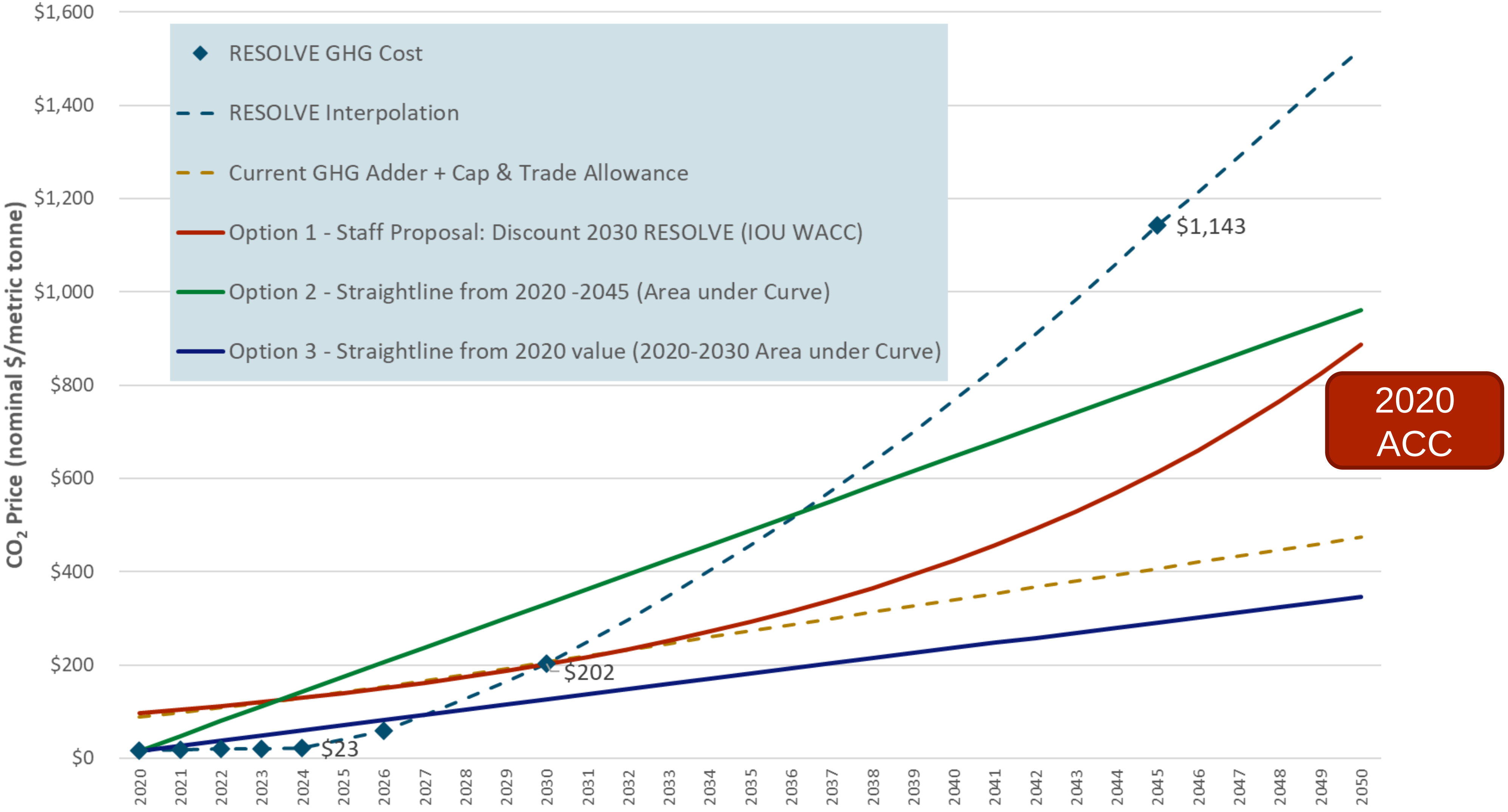
3) Area Under the Curve 2020-2030

- Rationale: same as Option #2 – by matching the area of the RESOLVE curve, the average price is the same for that time period (2020-2030)
- However, only considering 2020-2030 results in very low long-term prices

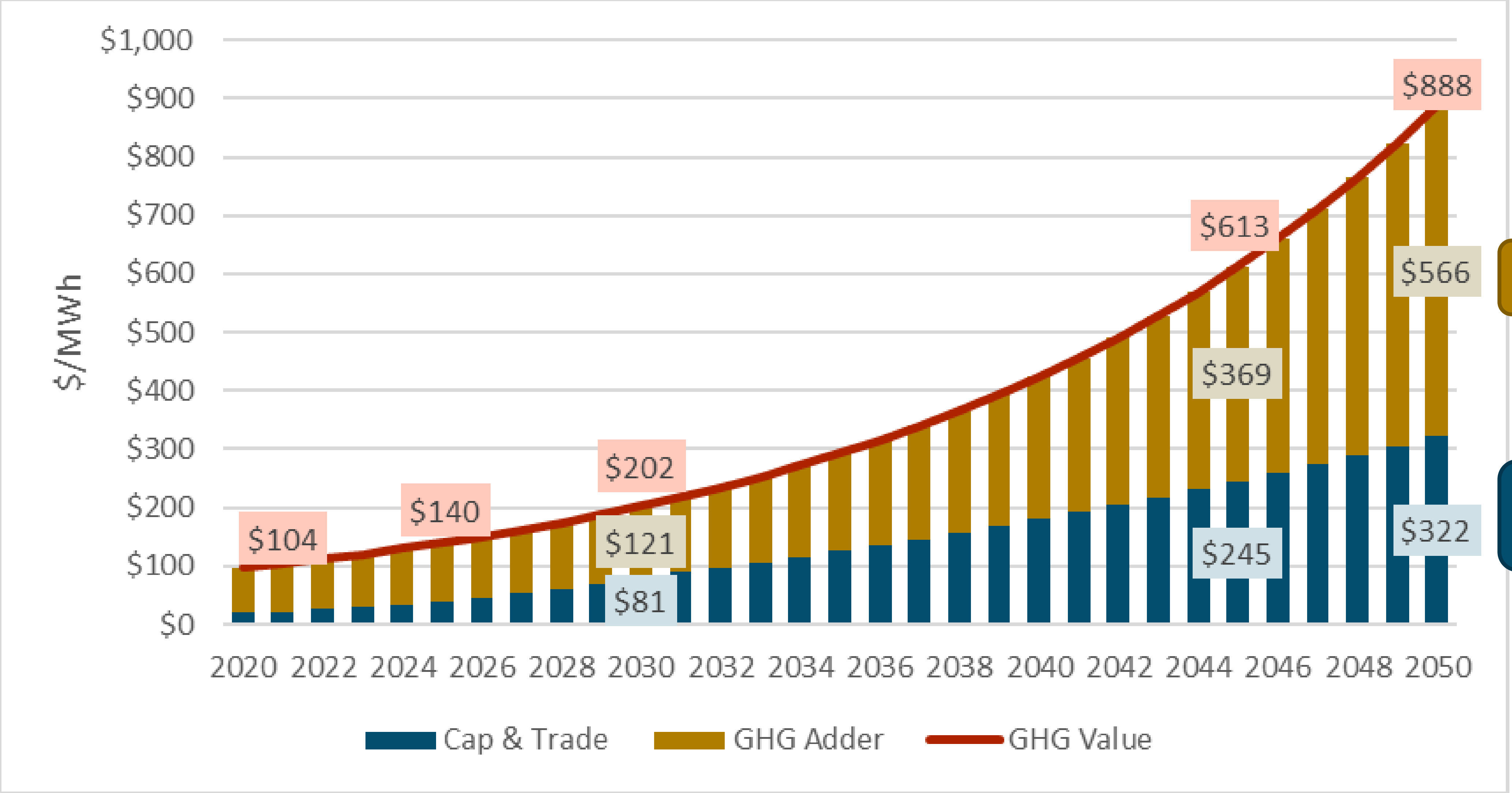


All Together Now

- Option 1 strikes a balance between aligning with the 2019 ACC in the near-term and generating higher prices in the long-term to more accurately value the cost of reducing GHGs
- Provides consistency with the IRP outputs by using RESOLVE 2030 value



Final 2020 ACC GHG Value



GHG Value (RESOLVE)

GHG Adder

Cap & Trade (IEPR)

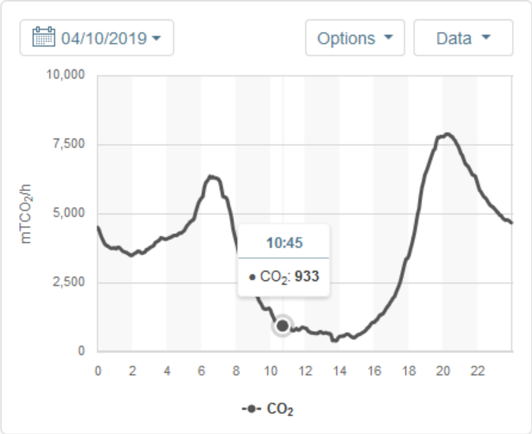
GHG Emissions

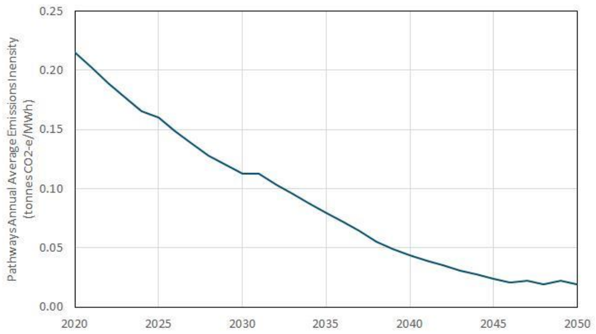
GHG Emissions Framework for Avoided Cost

Hourly marginal emissions

Average grid emissions intensity will decline

Portfolio rebalancing



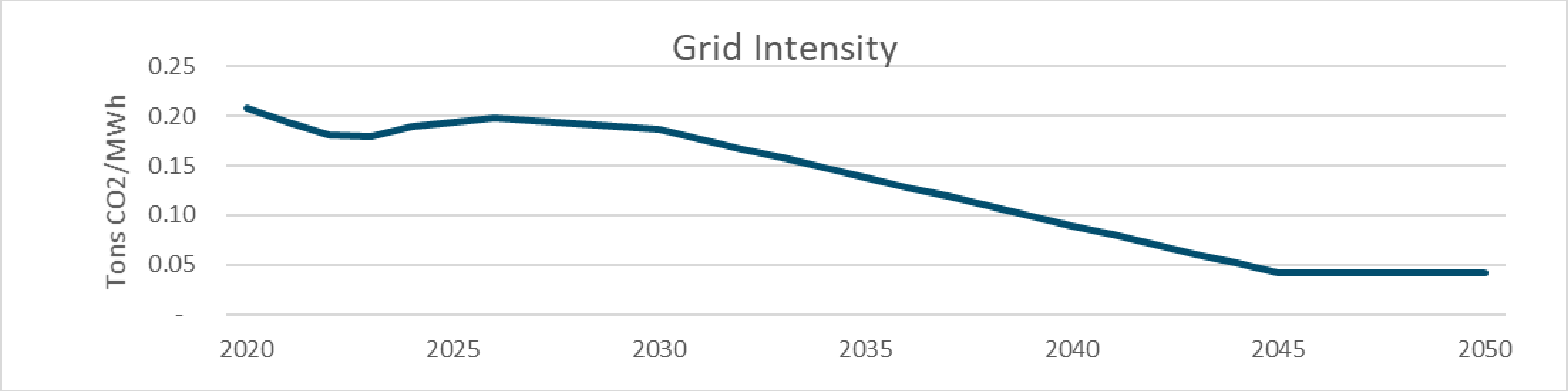


- Marginal emissions depend on DER load shapes
- In long-run emissions from electricity will decline over time
- Portfolio will be rebalanced to achieve emissions target

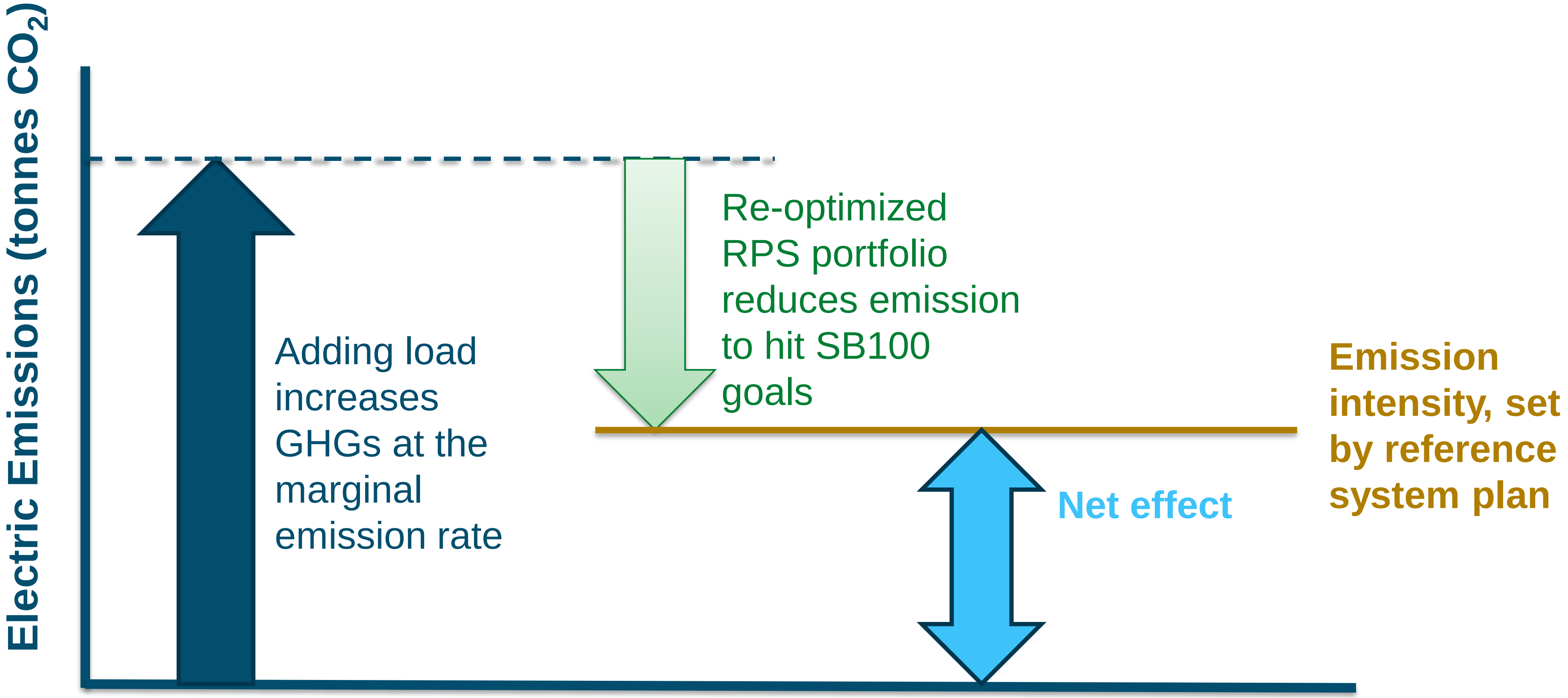
GHG target will be met, but portfolio cost will be higher or lower depending on shape of DER impacts

Average Grid Intensity (from RSP)

	2020	2021	2022	2023	2024	2026	2030	2045	
Load	242,188	244,541	247,401	249,495	251,191	253,790	257,010	382,590	*GWh*
Retail sales	207,479	207,382	208,055	208,238	208,092	207,224	203,413	294,207	*GWh*
CAISO Emissions	43	40	38	37	39	41	38	12	*MMtCO2/Yr*
Grid Emissions Intensity	0.21	0.19	0.18	0.18	0.19	0.20	0.19	0.04	*tCO2/MWh*
Allowable Heat Rate	3,913	3,649	3,415	3,378	3,557	3,725	3,511	785	*Btu/kWh*



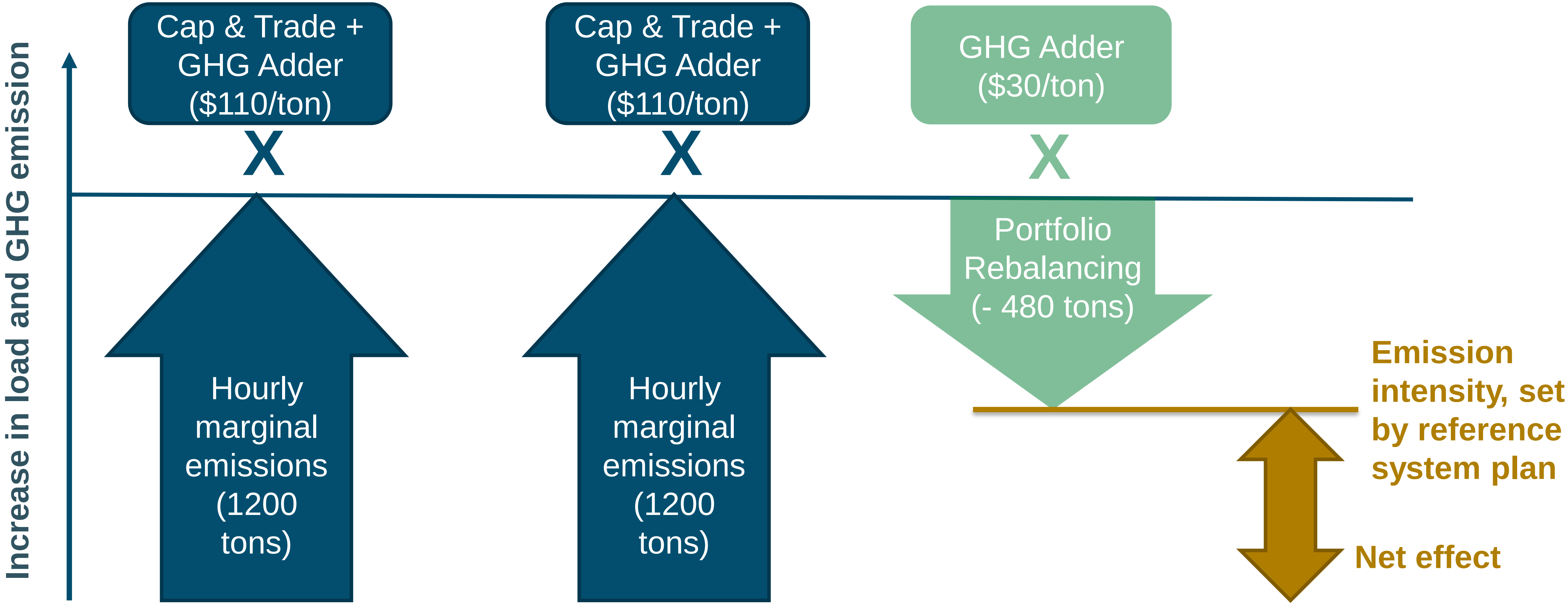
GHG Marginal Emissions and Portfolio Rebalancing



2019 ACC
$132,000

2020 ACC
$132,000 - $14.400 = $117,600

Step 1:
Marginal Emissions — Step 2:
Rebalancing = Net cost



Simple Example Calculations

Simple Example: Three Grid Resources

GHG	MWh
1,600 tons	4,000 MWh
	3,000 MWh
	3,000 MWh
Grid Intensity	
0.16 tons/MWh	10,000 MWh

- **Combined Cycle Gas Turbine (CCGT)**
  - $50/MWh
  - 0.4 Tons/MWh
- **Solar**
  - $25/MWh
  - High marginal curtailment for new solar
- **Solar + Long-duration Storage**
  - $94/MWh
  - Marginal resource needed to delver carbon free energy

Added Load – EV Charging

- **Add 3,000 MWh of Evening EV Charging**
- **Hourly marginal impact – 1,200 tons GHG**
  - Evening load is provided by CCGT
  - Increases emissions intensity from 0.16 to 0.22 tons/MWh
- **Portfolio Rebalancing**
  - To achieve intensity of 0.16 tons/MWh
  - For additional 3,000 MWh, only 480 tons GHG is allowable to achieve intensity target
  - Additional 1,200 MWh is allowable from CCGT
    - (1,200 MWh x 0.40 tons/MWh = 480 tons)
  - Remaining 1,800 MWh to serve EV load must come from more expensive PV + long-duration storage

			Evening EV Charging		
	Cost	IRP Plan	Hourly Marginal Impact	Portfolio Reblanacing	
Portfolio	$/MWh	MWh	MWh	MWh	
Combined Cycle Gas Turbine (CCGT)	$50	4,000	7,000	5,200	
PV	$25	3,000	3,000	3,000	
PV & Long-duration Storage	$94	3,000	3,000	4,800	Rebalancing
Total MWh		10,000	13,000	13,000	Cost
Total Cost of Generation		$ 557,000	$ 707,000	$ 786,200	$ 79,200
					Allowable Tons
Tonnes GHG		1,600	2,800	2,080	**480**
GHG Intensity (Tons/MWh)		**0.16**	**0.22**	**0.16**	

	$/Ton	Tons	Tons	Tons	Total $
Hourly Marginal Emissions: Cap and Trade Price	$80		1,200	1,200	$ 96,000
Hourly Marginal Emissions: GHG Adder	$30		1,200	1,200	$ 36,000
Portfolio Rebalancing: GHG Adder	$30			(480)	$ (14,400)
Allowable increase in GHG Emissions					$ 117,600
	Average $/Ton of incremental GHG			$98/Ton	
	Average $/MWh GHG Value			$39/MWh	

Incremental Cost of Supply Rebalance				$79,200
			$79,200/720=	$110/Ton
CCGT GHG Intensity (Tons/MWh)	0.40			

Added Load – EV Charging (2)

Three Categories of GHG Emissions

- $80/ton Cap & Trade Price
- $30/ton GHG Adder
- $110/ton GHG Value (Electric Sector)

Hourly Marginal Emissions – Cap & Trade

- 1,200 tons at $80/ton

Hourly Marginal Emissions – GHG Adder

- 1,200 tons at (additional) $30/ton

Portfolio Rebalancing – GHG Adder

- 480 tons of allowable emissions at $30/Ton

Total Cost: $117,000

- $98/Ton (for 1,200 tons)
- $39/MWh (for 3,000 MWh)

			Evening EV Charging		
	Cost	IRP Plan	Hourly Marginal Impact	Portfolio Reblanacing	
Portfolio	$/MWh	MWh	MWh	MWh	
Combined Cycle Gas Turbine (CCGT)	$50	4,000	7,000	5,200	
PV	$25	3,000	3,000	3,000	
PV & Long-duration Storage	$94	3,000	3,000	4,800	Rebalancing Cost
Total MWh		10,000	13,000	13,000	
Total Cost of Generation		$ 557,000	$ 707,000	$ 786,200	$ 79,200

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Incremental Cost of Supply Rebalance		$79,200
	$79,200/720=	$110/Ton

CCGT GHG Intensity (Tons/MWh)	0.40

Added Load – Daytime Cooling

- **Add 3,000 MWh of Daytime Cooling**
- **Hourly marginal impact – 200 tons GHG**
  - 2,500 MWh from Solar PV (reducing curtailment)
  - 500 MWh from CCGT
- **Portfolio Rebalancing**
  - To achieve intensity of 0.16 tons/MWh
  - For additional 3,000 MWh, only 480 tons GHG is allowable to achieve intensity target
  - Additional 1,200 MWh is allowable from CCGT
    - (1,200 MWh x 0.40 tons/MWh = 480 tons)
  - Procurement of more expensive PV + long-duration storage can be reduced by 700 MWh

Daytime Commercial Cooling

	Cost	IRP Plan	Hourly Marginal Impact	Portfolio Reblancing	Rebalancing Cost
Portfolio	$/MWh	MWh	MWh	MWh	
Combined Cycle Gas Turbine (CCGT)	$50	4,000	4,500	5,200	
PV	$25	3,000	5,500	5,500	
PV & Long-duration Storage	$94	3,000	3,000	2,300	
Total MWh		10,000	13,000	13,000	
Total Cost of Generation		$ 557,000	$ 644,500	$ 613,700	$ (30,800)

					Allowable Tons
Tonnes GHG		1,600	1,800	2,080	**480**
GHG Intensity (Tons/MWh)		**0.16**	**0.14**	**0.16**	

	$/Ton	Tons	Tons	Tons	Total $
Hourly Marginal Emissions: Cap and Trade Price	$80		200	200	$ 16,000
Hourly Marginal Emissions: GHG Adder	$30		200	200	$ 6,000
Portfolio Rebalancing: GHG Adder	$30			(480)	$ (14,400)
Allowable increase in GHG Emissions					$ 7,600
	Average $/Ton of incremental GHG			$38/Ton	
	Average $/MWh GHG Value			$3/MWh	

Incremental Cost of Supply Rebalance	-$30,800
($30,800)/(280)=	$110/Ton

CCGT GHG Intensity (Tons/MWh)	0.40

Added Load – Daytime Cooling (2)

Three Categories of GHG Emissions

- $80/ton Cap & Trade Price
- $30/ton GHG Adder
- $110/ton GHG Value (Electric Sector)

Hourly Marginal Emissions – Cap & Trade

- 200 tons at $80/ton

Hourly Marginal Emissions – GHG Adder

- 200 tons at (additional) $30/ton

Portfolio Rebalancing – GHG Adder (Minus)

- 480 tons of allowable emissions at $30/Ton

Total Cost: $7,600

- $38/Ton (for 200 tons)
- $3/MWh (for 3,000 MWh)

			Daytime Commercial Cooling		
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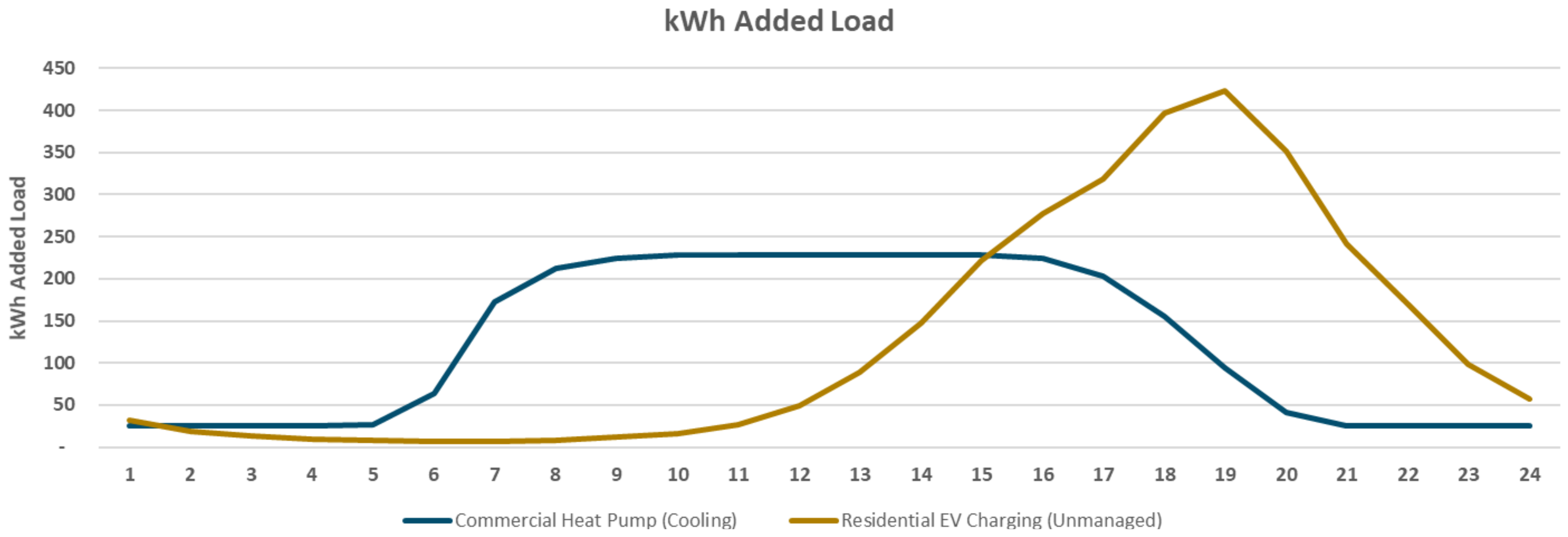
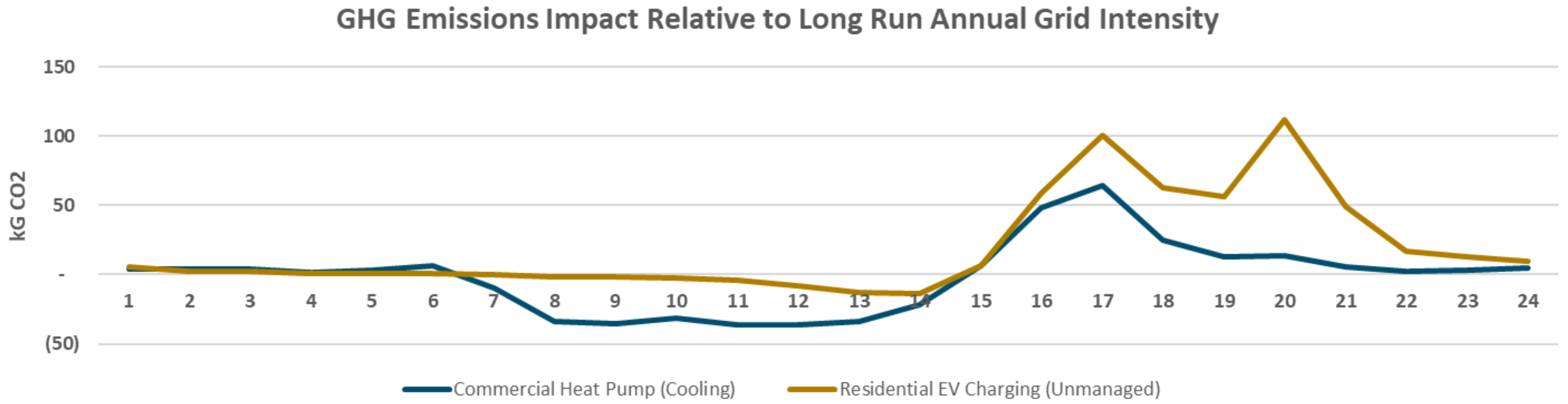
Incremental Cost of Supply Rebalance		-$30,800
	($30,800)/(280)=	$110/Ton

CCGT GHG Intensity (Tons/MWh)	0.40

Load Shape Example Calculations

Added Load: Load Shapes





Summary Calculations

Emissions Category	Emissions Valued at:	$/Ton	Residential EV Charging		Commercial Cooling	
			Tons GHG	$ GHG Value	Tons GHG	$ GHG Value
Marginal Emissions	Cap and Trade	$80	931	$74,492	448	$35,819
	GHG Adder	$30	931	$27,934	448	$13,432
Portfolio Rebalancing	GHG Adder	$30	(480)	($14,400)	(480)	($14,400)
Total Marginal Emissions				**$88,026**		**$34,852**
	Average $/Ton			**$95**		**$78**
	Average $/MWh GHG Value			**$29**		**$12**

3,000 MWh EV Charging

931 Tons Hourly Marginal Emissions

- 931 tons x $80/ton Cap and Trade
- 931 tons x $30/ton GHG Adder

Portfolio Rebalancing (minus)

- 480 tons x $30/ton GHG adder

$95/Ton **$29/MWh**

3,000 MWh Cooling

448 Tons Hourly Marginal Emissions

- 448 tons x $80/ton Cap and Trade
- 448 tons x $30/ton GHG Adder

Portfolio Rebalancing (minus)

- 480 tons x $30/ton GHG adder

$78/Ton **$12/MWh**

Two Ways to the Same Answer

Emissions Category	Emissions Valued at:	$/Ton	Residential EV Charging		Commercial Cooling	
			Tons GHG	$ GHG Value	Tons GHG	$ GHG Value
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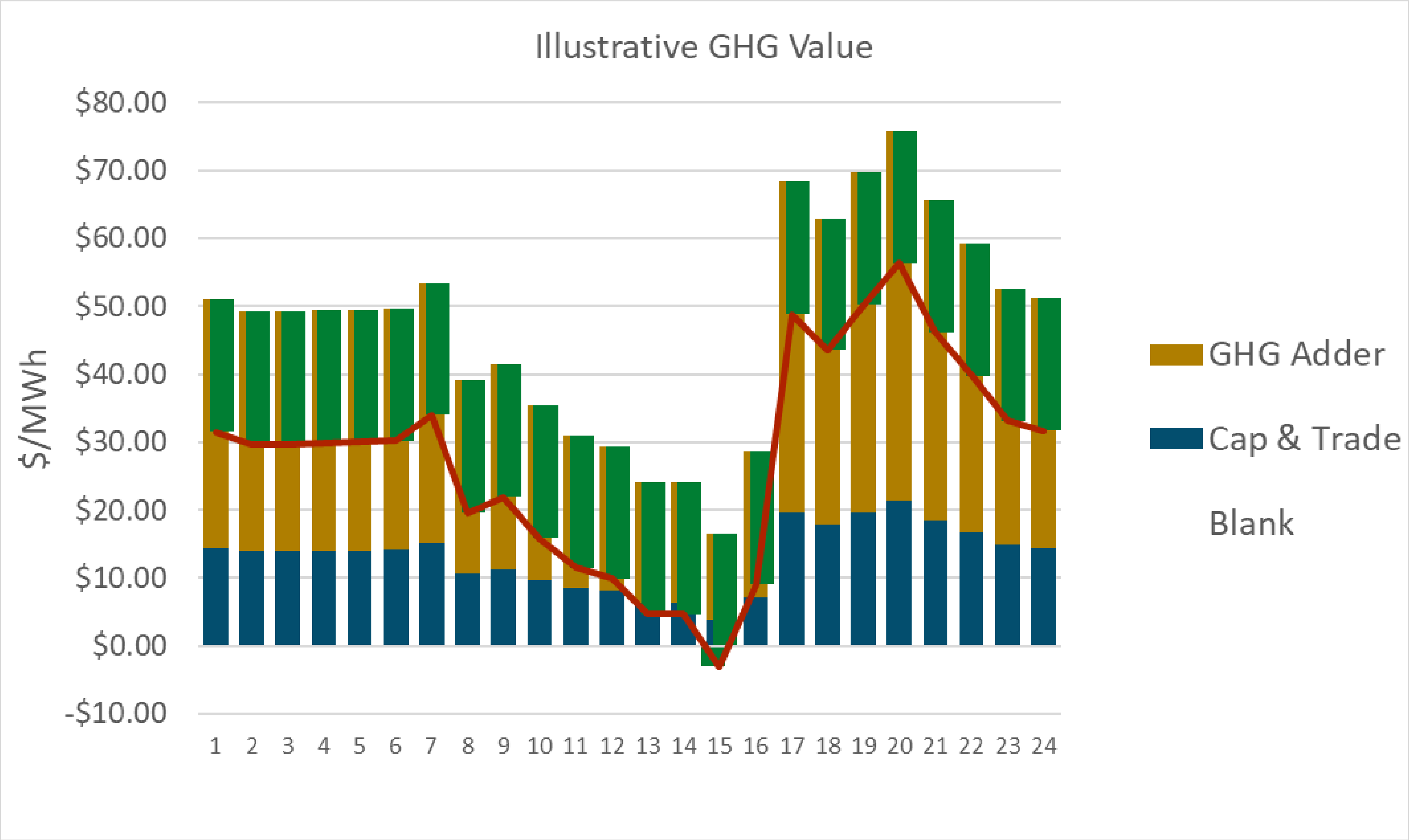
Emissions Category	Emissions Valued at:	$/Ton	Residential EV Charging		Commercial Cooling	
			Tons GHG Impact	$ GHG Value	Tons GHG Impact	$ GHG Value
Hourly Marginal Emissions	Cap and Trade	$80	931	$74,492	448	$35,819
Portfolio Rebalancing	GHG Adder ($110 - $80)	$30	451	$13,534	(32)	($968)
Allowable Emissions			**480**	**$88,026**	**480**	**$34,852**
	Average $/Ton			**$95**		**$78**
	Average $/MWh GHG Value			**$29**		**$12**

Example GHG Avoided Costs for One Day

- **2025 SCE CZ 9 (Los Angeles)**
  - 1 Day in April

- **$40/ton Cap & Trade**
- **$100/ton GHG Adder**
- **$140/ton GHG Value**

- **Grid Intensity 0.19 tons/MWh**

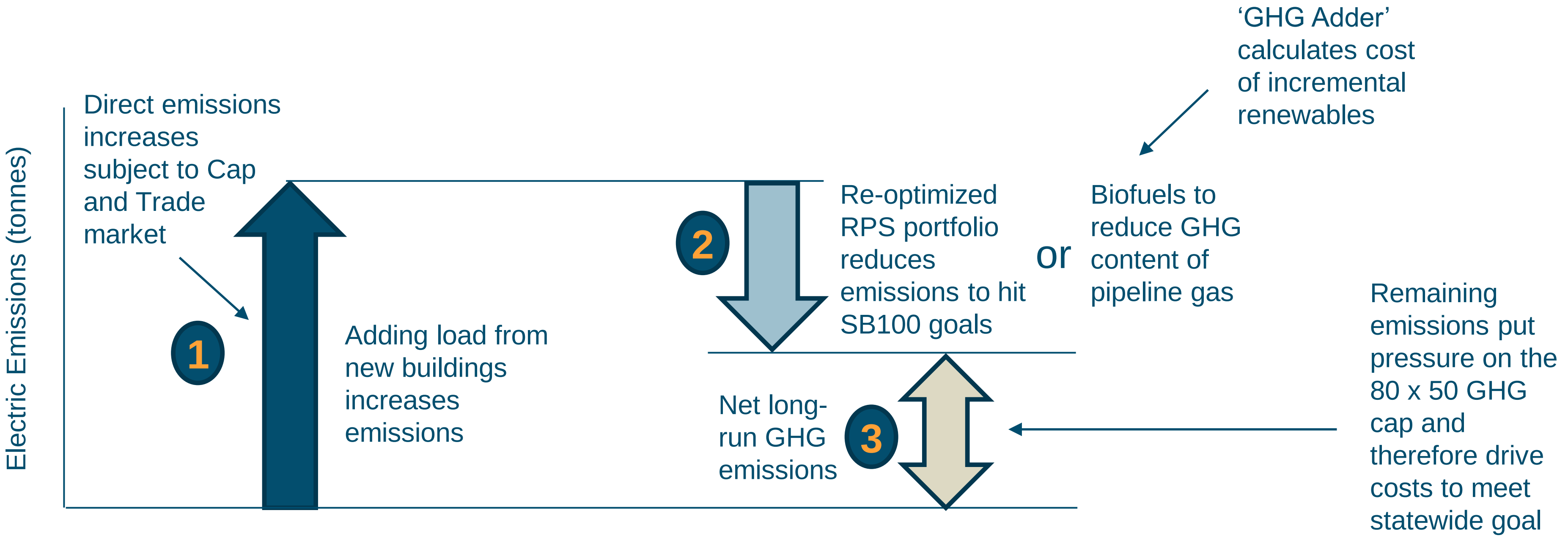


Appendix

CEC TDV - Emissions Accounting for Electricity

+ **Three emissions cost streams for electricity**

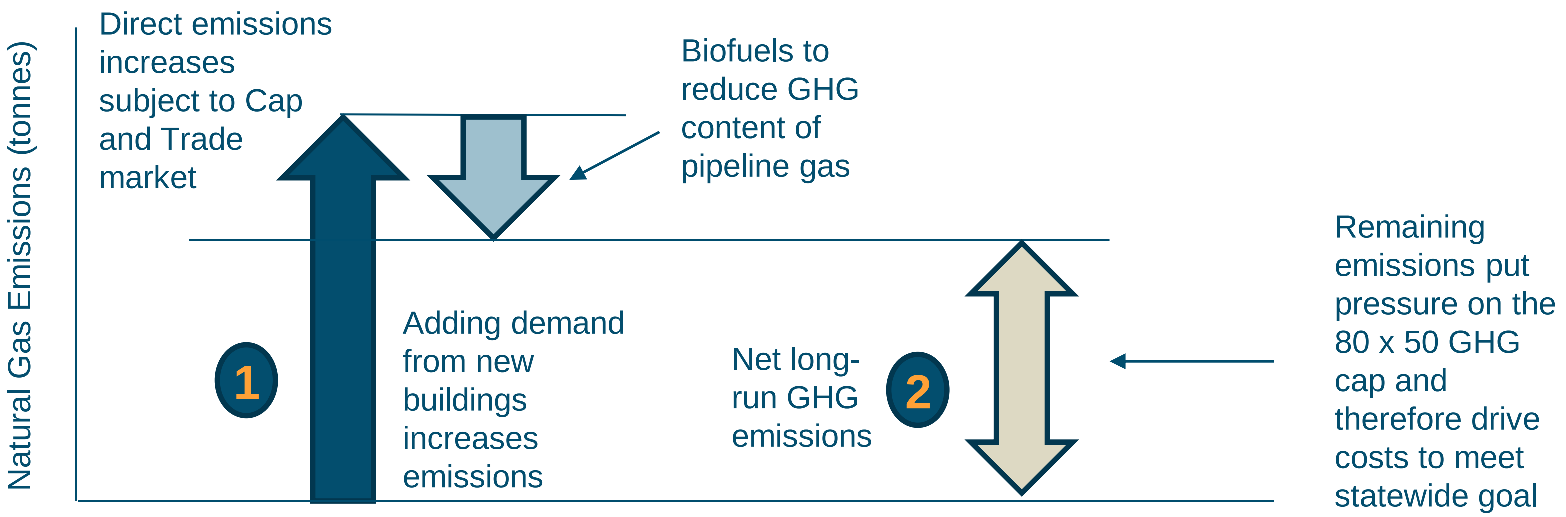
    1. **Cap and Trade Emissions**: Direct plant emissions from directly serving load
    2. **GHG Adder:** Additional cost of procuring the necessary supply-side resources to achieve the electricity-sector long run emissions intensity target. Replaces previous 'RPS Adder' field
    3. **Emissions Abatement:** Economy-wide cost of abating remaining emissions after supply-side actions have been taken



CEC TDV - Emissions Accounting for Natural Gas

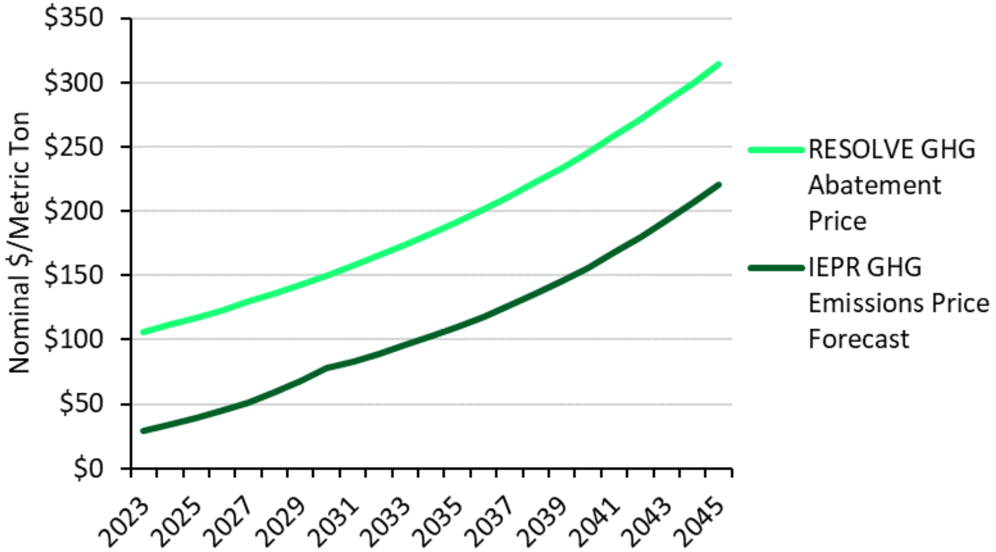
- **Two emissions cost streams for natural gas**
  1. **Cap and Trade Emissions**: Direct emissions from non-renewable gas delivered (net of RNG)

     Additional cost of procuring renewable natural gas included in the commodity price.
  2. **Emissions Abatement:** Economy-wide cost of abating remaining emissions after supply-side actions have been taken



CEC TDV - GHG Emissions Accounting

- **Cap and Trade Emissions:** Cost from IEPR GHG Allowance Price forecast; direct cost of emissions from combusting natural gas, factored into retail rates
- **Emissions Abatement:** Assumed that in a SB32-compliant future, cheapest economy-wide incremental emissions reduction is from electricity supply side, so RESOLVE GHG Abatement price is used. Represents cost of meeting state economy-wide emissions target



Used for Electricity GHG Reduction and Used for Economy-side Abatement

Used for GHG Allowance Price

No New DER Case

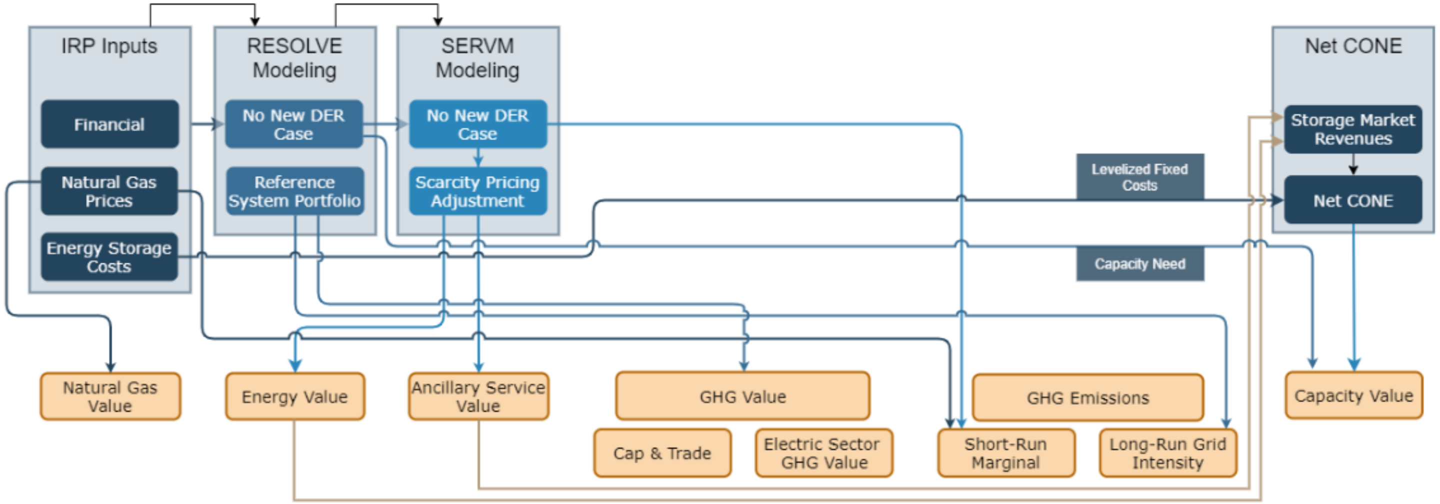
Use of RSP and No New DER Case

+ Reference System Plan

- IRP Least-cost portfolio to achieve GHG emissions targets
- Included CEC Integrated Energy Policy Report (IEPR) forecast of DER
- ACC uses RSP for:
  - GHG value
  - planned grid emissions intensity

+ No New DER Case

- Removes DER associated with utility programs
- Counterfactual, what would system costs be without DER
- ACC uses No New DER case for:
  - Marginal GHG emissions



Energy+Environmental Economics

Comparison of 2019 and 2020 ACC Curtailment

Looking Back 2019 ACC Underestimated Curtailment

+ **2019 ACC understated the number of curtailment hours compared to actual curtailments in CAISO**

Total Curtailment Hours	
2019 ACC NP15 & SP15 (all-year)	1111
2019 CAISO (Jan – Aug)	1379

ACC NP15 and SP15 Curtailment 2019

NP 15 & SP 15

2019 ACC

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	3	5	5	5	4	1	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	1	29	29	30	30	30	30	29	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	1	30	30	30	30	30	30	30	30	30	27	-	-	-	-	-	-	-
5	-	-	-	-	-	-	3	31	31	31	31	31	31	31	31	31	31	-	-	-	-	-	-	-
6	-	-	-	-	-	-	2	30	30	30	30	30	30	30	30	27	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CAISO System Curtailment 2019 (note that data from Sep - Dec was not available at the time of data collection)

CAISO System Curtailment (2019 Jan - August)

Actual Curtailment Reported by CAISO

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-	-	-	-	-	-	-	-	7	4	2	2	4	4	4	8	1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	4	6	9	2	8	5	8	11	9	4	-	-	-	-	-	-	-
3	1	-	-	-	-	-	2	16	18	14	16	16	16	17	20	19	11	-	-	-	-	-	-	-
4	-	-	-	-	-	1	9	12	15	18	18	17	16	13	13	18	17	5	-	-	-	-	-	-
5	-	1	1	-	1	6	18	13	19	22	22	19	17	20	18	19	17	9	4	2	1	1	-	-
6	-	-	-	-	11	19	19	18	16	16	12	16	12	16	20	14	19	16	1	-	-	-	-	-
7	-	-	-	-	7	14	22	19	19	18	26	19	18	19	19	21	24	12	2	-	-	-	-	-
8	-	-	-	-	-	19	18	20	17	22	21	20	15	18	18	11	17	7	-	2	-	-	-	-
9																								
10																								
11																								
12																								

Curtailment data from Sep to Dec was not available at the time of data collection

Curtailment Hours Currently in 2020 ACC

- Curtailment hours derived from SERVM prices are significantly lower in 2020 ACC, using implied heat rate methodology

Total Curtailment Hours	
2020 ACC NP15 & SP15	82
2030 ACC NP15 & SP15	233

ACC Curtailment Hours, SEVRM Implied Marginal Heat Rate

NP15 & SP15

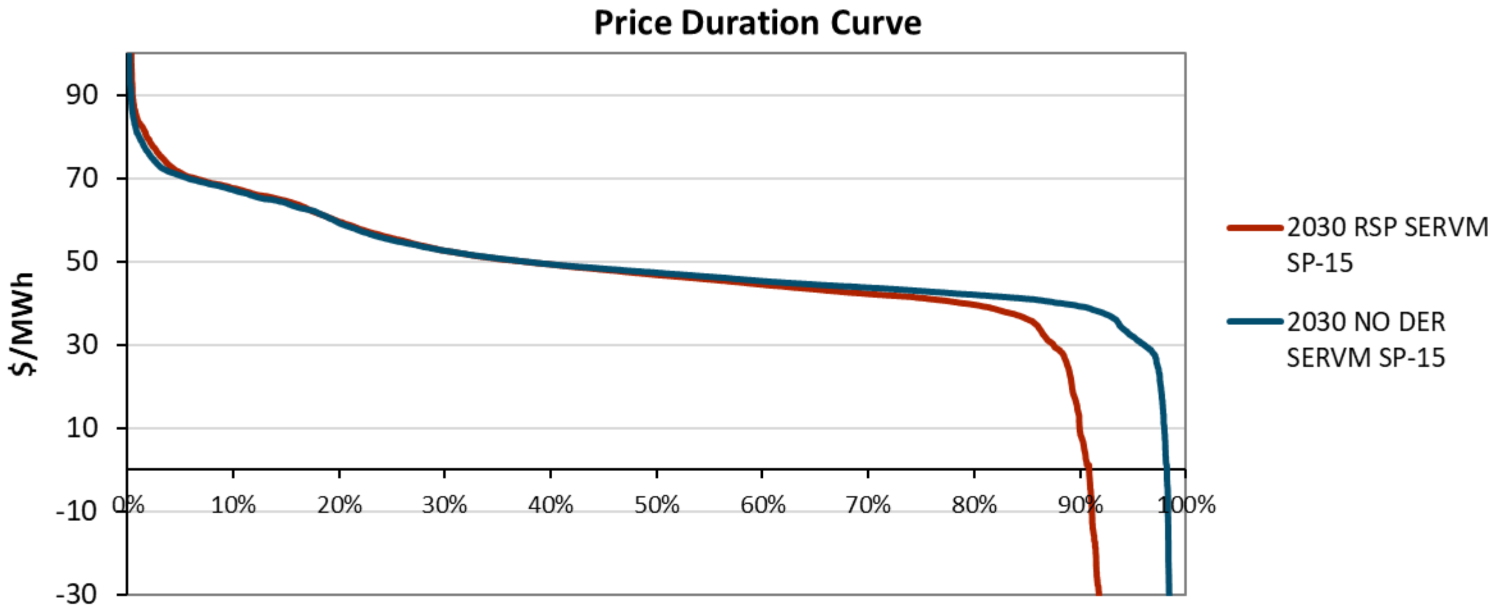
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	5	3	4	2	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	2	1	1	1	1	1	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	1	4	6	5	7	7	3	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	3	3	4	5	6	1	-	-	-	-	-	-	-	-
2020	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7	11	1	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	1	2	8	13	17	27	25	17	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	4	13	21	19	11	-	-	-	-	-	-	-
2030	6	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	4	1	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	2	6	10	3	2	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Keep holding your questions…

2030 No DER vs RSP SERVM Energy Prices

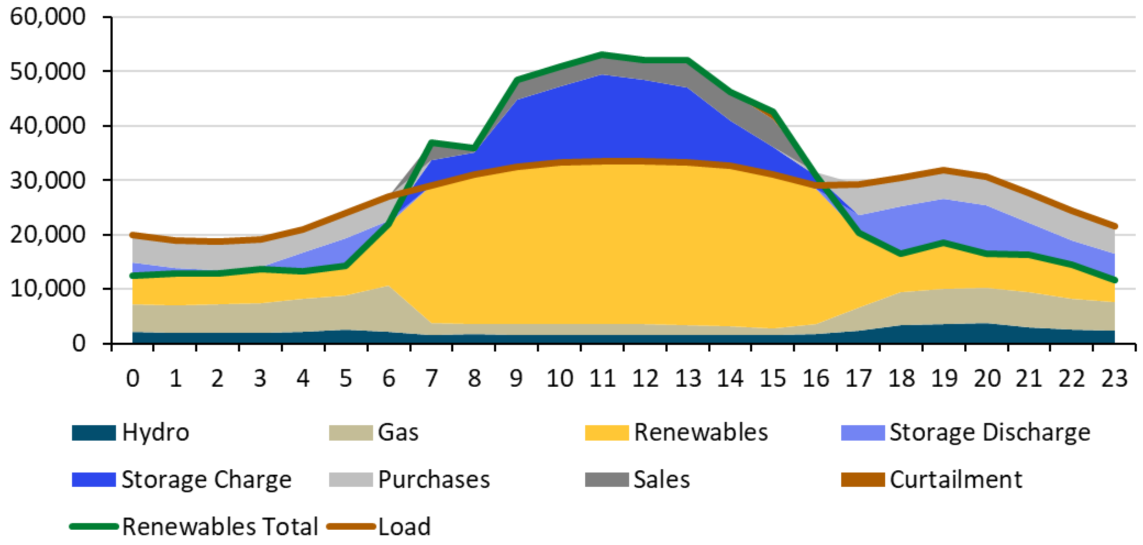
- Price duration curve shows approximately 2% of hours have negative prices in No DER case
- Approximately 10% of hours have negative prices in RSP case
- Difference due to difference in resource build, as both cases meet binding RPS, emissions targets



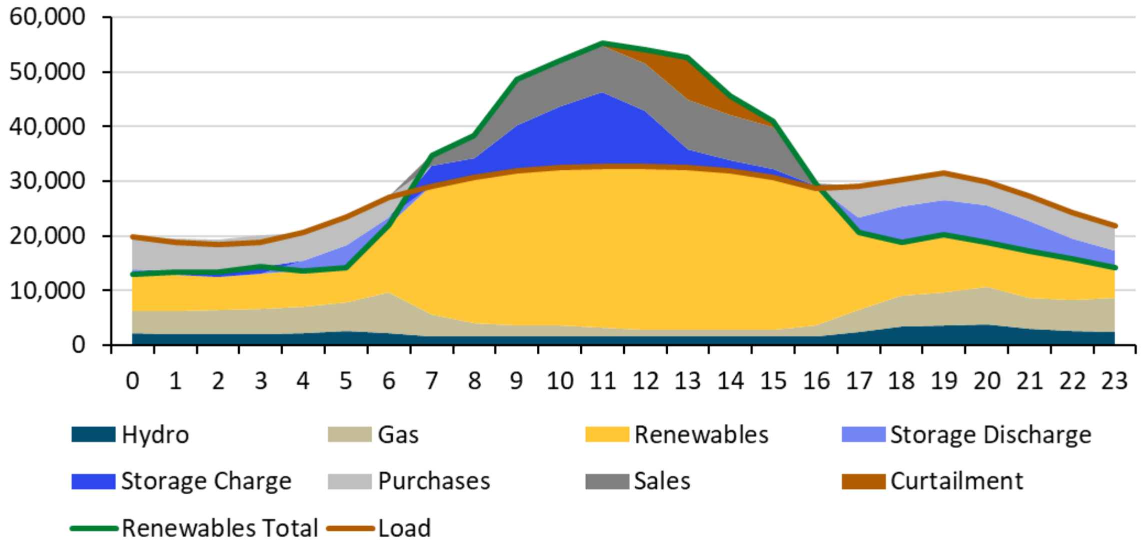
No New DER Case has less curtailment than RSP

2030 No DER vs RSP Spring Day SERVM Dispatch

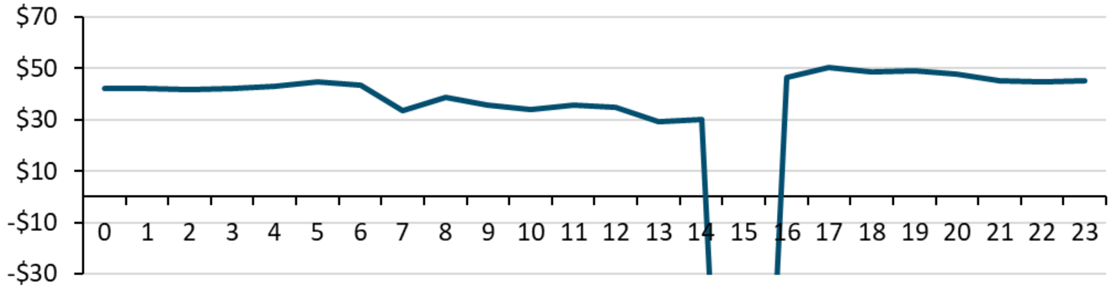
April 12, 2030 No DER SERVM Dispatch



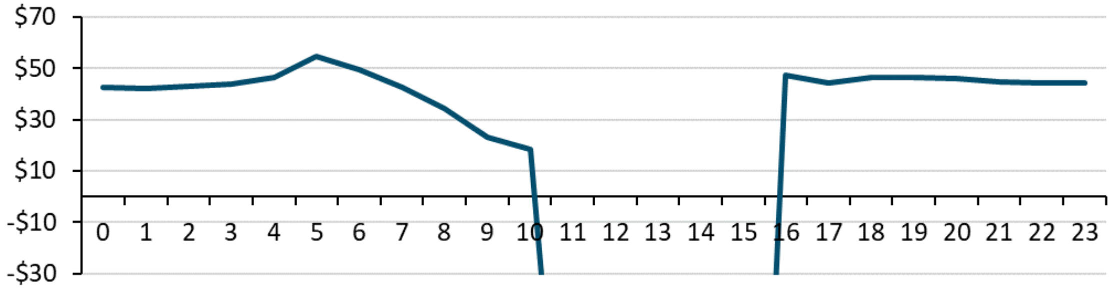
April 12, 2030 RSP SERVM Dispatch



April 12, 2030 No DER CAISO-avg Market Price



April 12, 2030 RSP CAISO-avg Market Price



Increased storage, decreased solar in No DER case limit curtailment hours in SERVM