REPORT FROM

OFFICE OF PUBLIC ACCOUNTABILITY

Date:	April 12, 2019
To:	The Board of Water & Power Commissioners David Wright, General Manager, Department of Water & Power Nancy Sutley, Assistant GM of Water & Power, Sustainability
From:	Frederick H. Pickel, Ph.D., Executive Director/Ratepayer Advocate
Reference:	Preliminary OPA review of the DWP Worley Parsons / Navigant draft study on Once-Through Cooling alternatives

RECOMMENDATIONS

1. The Office of Public Accountability/Ratepayer Advocate (OPA) recommends that the Department of Water & Power (DWP) avoid irrevocable actions or inaction that reduce the alternatives for replacing or eliminating the remaining Once-Through Cooling (OTC) power generation at the Scattergood, Harbor, and Haynes generation plant sites (the OTC plants). This would include, for example, selling, leasing, assigning, mortgaging, securitizing or otherwise disposing of or encumbering real estate, emissions allowances, or other key assets, resources, or permits.

2. OPA recommends continued study of the near-term (under 5 years) and intermediate-term (up to 2030) alternatives for the OTC plants. This should include consideration of more agile fossil generation mixed with dispatchable renewable resources before, during, or after the OTC plants cease to use ocean cooling.

DISCUSSION

1. OPA, extensively assisted by the Brattle Group, monitored DWP's independent consulting team led by Worley Parsons and Navigant during their year-long study of the OTC alternatives. The OPA's Brattle representative was embedded with the consulting team. Brattle's preliminary analysis of the draft DWP OTC study is attached.

2. The Brattle analysis suggests that the best mix of resources to replace OTC units is sensitive to assumptions that include carbon prices, fuel prices, discount rates, and the

unit costs of generation. The best cost and carbon reduction opportunities change when these sensitivities are evaluated. Technology maturity along with its related unit cost and timing effects constitute large risks to DWP ratepayers.

3. The draft OTC study, presented to the Board in November of 2018, did not include consideration of more agile generators like peaking units or reciprocating engines in or near these OTC sites.

4. The Brattle analysis suggests that mixing some faster ramping fossil generation at these sites may be economically attractive as a hedge on timing long term investments, even if unit costs are very high.

5. OPA believes this additional analysis may:

   1) reveal opportunities for DWP to improve the reliability of DWP service and voltage support near load pockets like the airport and the harbor,

   2) balance the cost, carbon reduction, innovation and investment timing of rapidly evolving non-fossil and storage resources, and thus

   3) allow DWP to safely select a more aggressive reduction of carbon sooner than would otherwise be feasible.

   Additional operational analysis to explore the reliability of faster ramping fossil options should be included in future studies like DWP's Strategic Long-Term Resource Plan and its 100% renewable study with the National Renewable Energy Lab.

cc: The City Council Committee on Energy, Climate Change & Environmental Justice
The Honorable Eric Garcetti, Mayor
Sharon Tso, Chief Legislative Analyst
Richard H. Llewellyn, City Administrative Officer

LADWP OTC Study
Carbon Emission Analysis

Preliminary - FOR DISCUSSION PURPOSES

PREPARED FOR
RPA/OPA

PREPARED BY
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February 20, 2019

Revised March 1, 2019

THE Brattle GROUP

Preliminary: These results will not be final until LADWP finalizes its OTC Report.

Executive Summary

- OTC Study was reviewed from a GHG emissions perspective.
  - Can the OTC Study show a viable path for achieving the LA 100% goal?
- High–level analyses performed
  - Which of the 12 Final Alternative Cases (hereafter referred to as "Cases") are in line with the SB 100 goal and timeline?
  - How sensitive are the OTC Study results to various assumptions?
  - What is the per-unit cost of carbon reduction?
  - Are there alternatives to the repowering of existing Scattergood units ?
- Preliminary conclusions (warranting further analyses)
  - Study results (NPV calculations) are sensitive to assumptions.
  - When compared to each other, NPVs by Case could fall within the noise range of ±5%.
  - Given the uncertainty of the assumptions for the non-emitting resources, which are rapidly developing, investment timing may be one of the most critical considerations.
  - Small-scale investments for bridging purposes may help retain reliability while identifying the ideal investment type and timing.

Agenda

- Review of OTC Study Results
  - Study Overview and Assumptions
  - Study Results Summary (Modified Results)
  - Range of Assumptions and Uncertainty
- OTC Study Cases and SB 100
  - Which of the 12 Alternative Cases are in line with the SB 100 goal and timeline?
- OTC Study Results Observations
  - Total Costs and Carbon Emissions: How the 12 Alternative Cases compare to the Baseline Case.
    - Discount Rate Sensitivities
    - Higher and Lower Range Cost Assumptions Sensitivities
    - Combined Assumptions Sensitivities
  - Per Unit of Carbon Reduction Cost
  - Scattergood Repowering Alternatives (Delayed OTC compliance)
- Appendix

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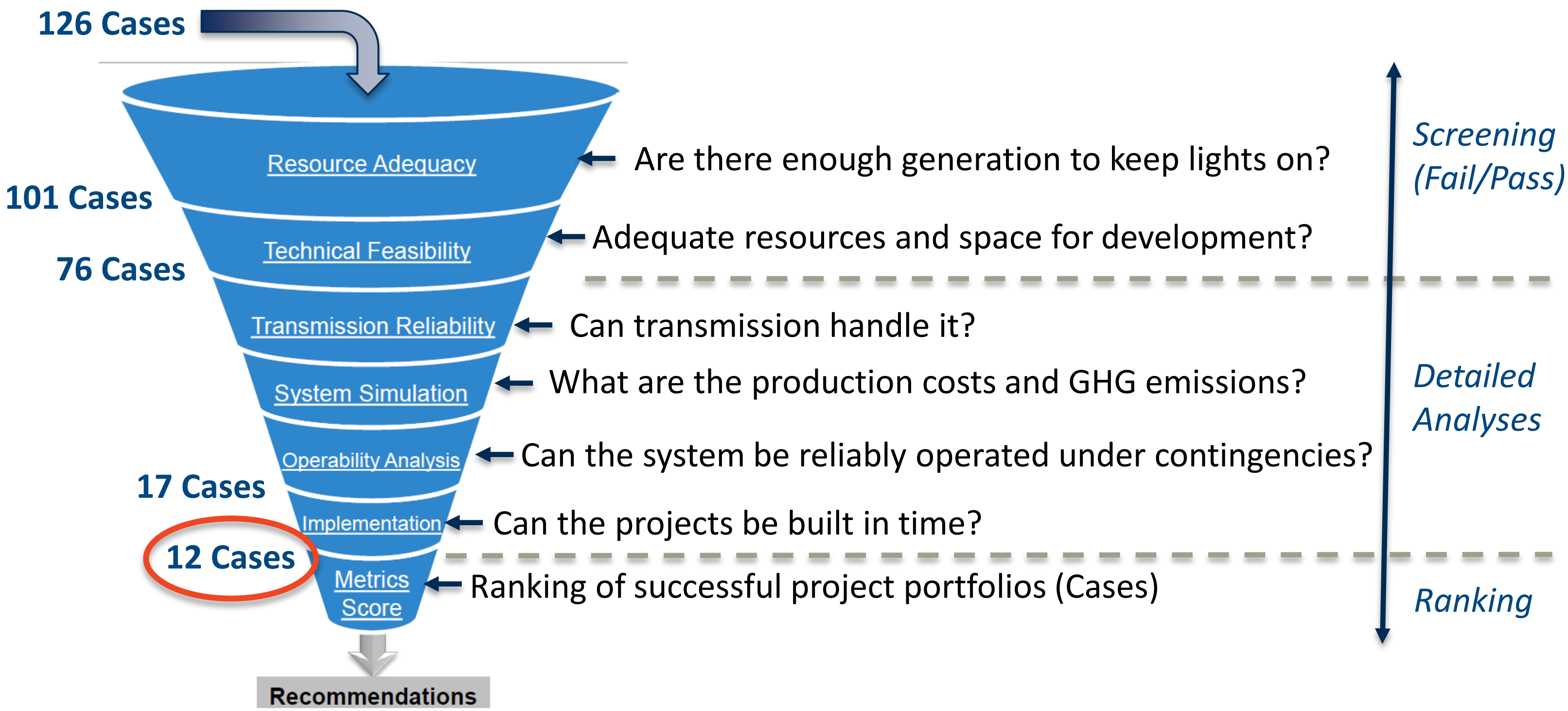
Study Overview and Assumptions

- Study Scope and Period
  - Study scope is to evaluate alternatives to LADWP's 2016 IRP OTC repowering plan.
    - Study compares alternative options to repowering OTC units using non-emitting resources.
  - Study period is over 22 years (2021 through 2042).
    - Study performs ProMod simulation for three years (2022, 2027, and 2036).
      - *2022*: Pre-OTC repowering (2021 – 2024).
      - *2027*: After Scattergood repowering (2025 – 2029) before Haynes/Harbor repowering.
      - *2036*: After Haynes/Harbor repowering (2030 – 2042).

      Market conditions are assumed to be at equilibrium after 2036 (operational reliability through production has not been confirmed for 2037 and after).
- Study Results
  - 12 Final Alternative Cases were evaluated and compared against the Baseline Case (with all OTC Units repowered)
    - Net Present Value (NPV) calculations assume 5.3% discount rate.
    - All NPV calculations are performed for a Higher and Lower Range Cost assumptions.
      - Most comparisons in this document (and the OTC Study presentation) use the *Higher Range Cost assumptions* for comparison.

Study Approach

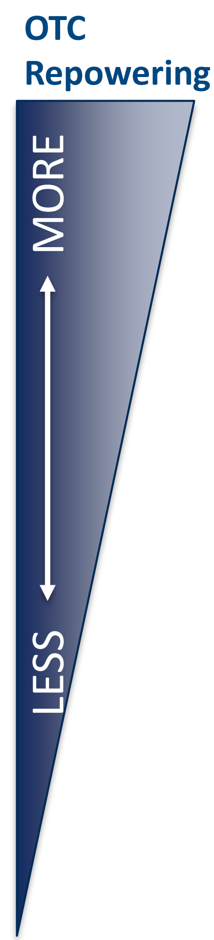
- Study Approach for evaluating non-emitting alternatives to LADWP's 2016 IRP OTC repowering plan.



Source: OTC Study Update presentation

Final 12 Cases Summary

Cases	Repowered Projects	Mitigation Alternatives	NPV Costs ($ billions)*1	GHG Emissions*2
Base	All	None	15.38	5.90
I	Scattergood & Haynes (x3)	Energy Storage (ES)	15.58	5.85
II	Haynes (x3) & Harbor		15.58	5.80
III	Scattergood, Harbor & Haynes (x2)		15.58	5.85
IV	Haynes (x3)		15.98	5.75
V	Scattergood, Harbor & Haynes (x1)		16.68	5.80
VI		Solar, ES, EE, DR	16.58	5.60
VII	Scattergood and Harbor		17.78	5.60
VIII		Solar, Wind, ES, Geo, EE, DR, Tx	17.58	5.30
IX	Scattergood		17.48	5.30
X	Harbor		18.18	4.80
XII	None		19.38	5.30
XI		Solar, Wind, ES, Geo, Tx	20.28	5.10



*1: The OTC Study group has revised NPV calculations for several cases and therefore may not match those from the earlier presentations. See Appendix for details.
*2: GHG emissions reported here are the expected annual averages from 2022, 2027, and 2036 ProMod simulations.

Study Results (12 Cases) Ranking

Evaluation Metrics

- 12 sensitivities of category weights tested

Category	Category Weight	Sub-Category	Legend	Description
Environmental Impact	45%	Green House Gas Emission Reductions		Average GHG reduction over 20 years
		Natural Gas Use Reductions		Average natural gas usage over 20 years
Development Risk	40%	Implementation Risk, e.g. construction and customer EE/DR		Ability to complete all projects through construction and implement customer programs
		Technology Risk		Maturity of the proposed technologies, especially utility scale energy storage and DERMS
		Outage Scheduling Risk		Ability to obtain necessary system outages to bring projects on-line into the system
Organizational	5%	Organizational Risk		Changes in the organization structure, business processes, and decision making
Costs	10%	Total Cost	$	NPV* over Base Case Scenario

*NPV does not include financial analysis of financing costs or reduced revenue through energy efficiency

Rankings

Rank	Technical Scoring	Eliminated Gas Repowering	Technical + Cost Scoring	Eliminated Gas Repowering
1	VI	Eliminate 630 MW at Haynes	I	Eliminate 245 MW at Harbor
2	V	Eliminate 630 MW at Haynes	III	Eliminate 460 MW at Haynes
3	I	Eliminate 245 MW at Harbor	VI	Eliminate 630 MW at Haynes
4	III	Eliminate 460 MW at Haynes	V	Eliminate 630 MW at Haynes
5	X	Eliminate 1,090 MW at Haynes and 326 MW at Scattergood	II	Eliminate 326 MW at Scattergood
6	IX	Eliminate 1,090 MW at Haynes and 245 MW at Harbor	IX	Eliminate 1,090 MW at Haynes and 245 MW at Harbor
7	VIII	Eliminate 1,090 MW at Haynes	X	Eliminate 1,090 MW at Haynes and 326 MW at Scattergood
8	II	Eliminate 326 MW at Scattergood	VIII	Eliminate 1,090 MW at Haynes
9	VII	Eliminate 1,090 MW at Haynes	VII	Eliminate 1,090 MW at Haynes
10	XI	Eliminate all 1,661 MW	IV	Eliminate 326 MW at Scattergood and 245 MW at Harbor
11	IV	Eliminate 326 MW at Scattergood and 245 MW at Harbor	XI	Eliminate all 1,661 MW
12	XII	Eliminate all 1,661 MW	XII	Eliminate all 1,661 MW

Recommendation

Study Recommendation

- Case VI
  - Eliminate 2 of the 3 re-powering projects at Haynes
  - Repower Scattergood
  - Repower Harbor

Current LADWP Repowering Strategy			
Unit Designation	Technology	Capacity (net MW)	Net Dependable Capacity (MW)
Scattergood 8,9	1 - CCCT Small F/G Class 1x1 Dry	346	337
Harbor 15,16,17	CCCT Mid Aero 2x1 Dry	251	245
Haynes 17,18	1 - CCCT Small F/G Class 1x1 Dry	346	337
Haynes 19,20	1 - CCCT Small F/G Class 1x1 Dry	346	337
Haynes 21,22	1 - CCCT Small F/G Class 1x1 Dry	346	337

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29

Source: OTC Study Update presentation

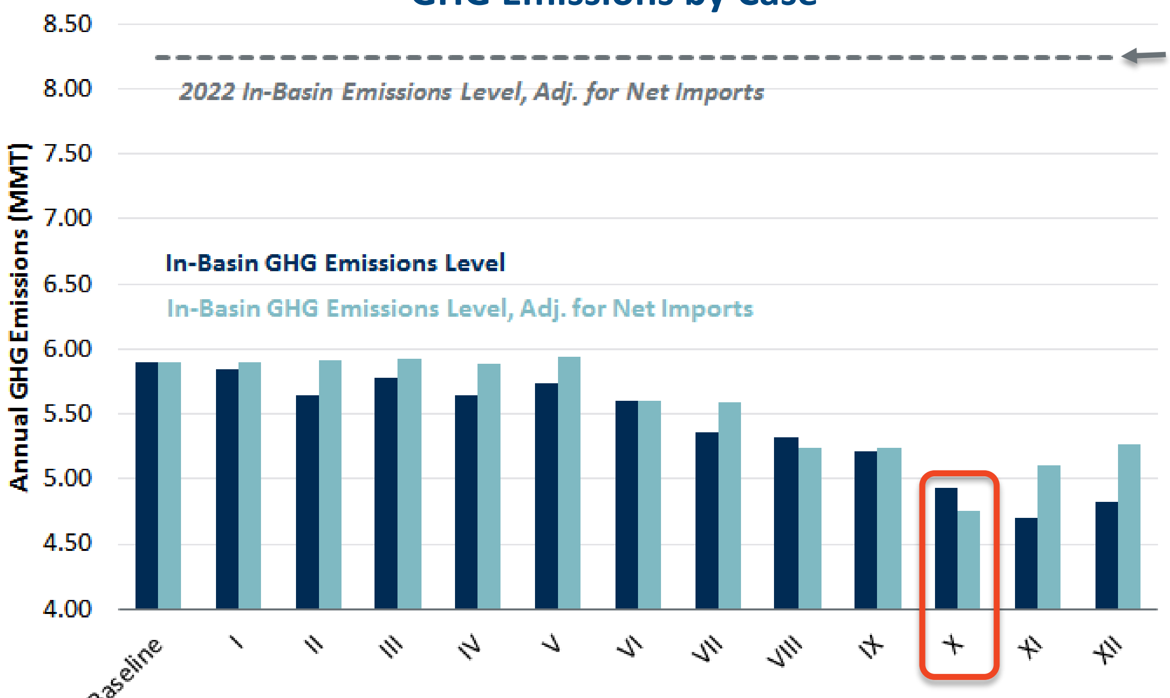
GHG Emissions

For each Case, the OTC Study calculates two GHG emission metrics:

- In-Basin only emissions
- In-Basin emissions adjusted for emissions from net imports

While Cases XI and XII (no OTC repowering) have the lowest In-Basin emissions, Case X has the lowest adjusted emissions.

GHG Emissions by Case



Expected 2022 emissions level in OTC Study. Compare to historical emissions levels (from 2017 SLTRP*):

- **1990: 17.9 MMT**
- **2016: 10.7 MMT**

* Access the 2017 Strategic Long-Term Resource Plan (SLTRP) here: https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB655007&RevisionSelectionMethod=LatestReleased

Notes: GHG Emissions by Case are expected averages from 2022, 2027 and 2036 ProMod simulations.

High and Low Range Cost Assumptions

High and Low Range Cost Assumptions by Resource and Cost Type

Resource	Low Range	High Range
OTC Repowering Capital Costs (2016 $/kW)		
Scattergood 8 & 9	$1,350	$1,200
Haynes 17 & 18	$1,450	$1,300
Haynes 19 & 20	$1,450	$1,300
Haynes 21 & 22	$1,450	$1,300
Harbor 15 & 16	$1,650	$1,500
Mitigation Alternative Capital Costs (2016 $/kW)		
Storage (4-hour)	$1,500	$1,700
Rooftop Solar	$2,324	$2,961
Incremental EE	$0	$0
Incremental DR	$0	$0
Geothermal	$5,000	$6,000
Wind	$1,900	$2,100
Floating Solar	$1,600	$1,800
Land-Based Solar (In-basin)	$1,400	$1,600
Net Interchange Costs (2016 $/MWh)*		
Range, Depending on Year and Scenario	$0 - $3	$2 - $8

* Net Interchange Cost ranges are estimated based on ProMod outputs for scenarios V and XII.

High Range cost assumptions (favorable to OTC repowering) are used as the default for Case comparison in the OTC Study.

Uncertainty of cost assumptions indicates error range for total cost NPV to be *around 5% (≈$0.75 B, compared to Baseline of $15 B)*.

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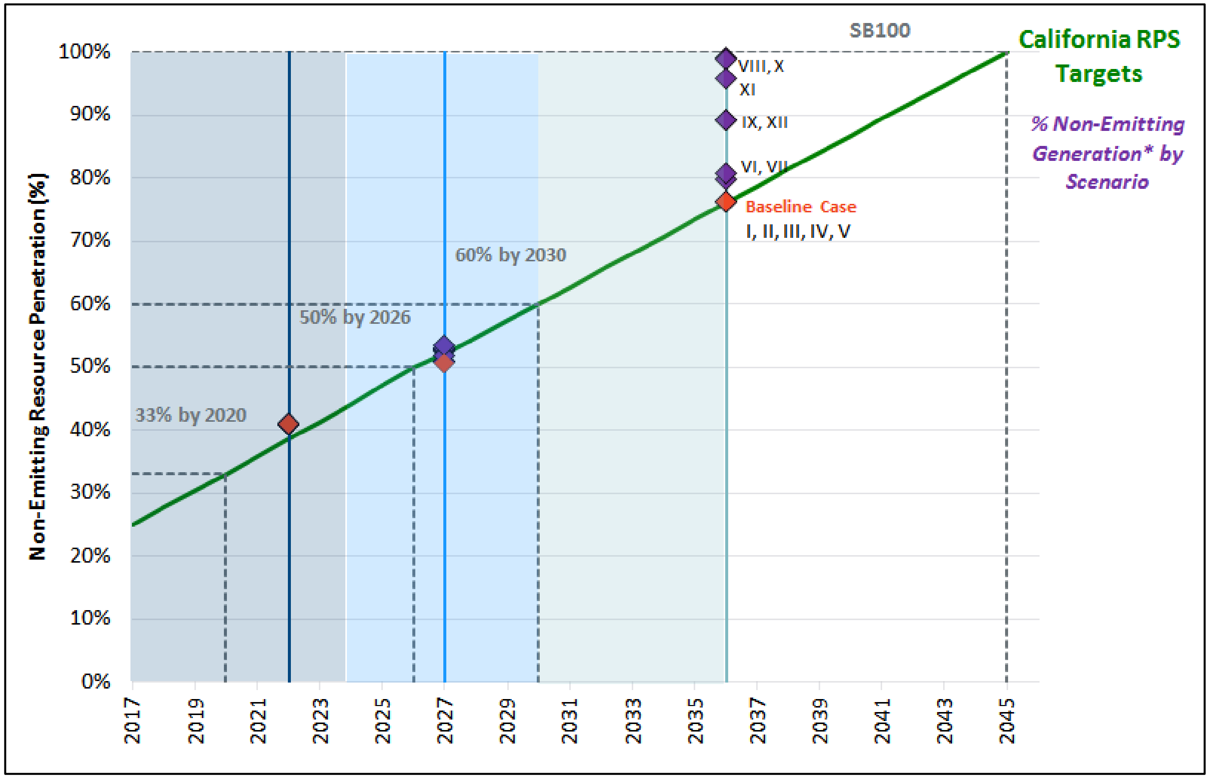
Path to SB 100 – 1/2

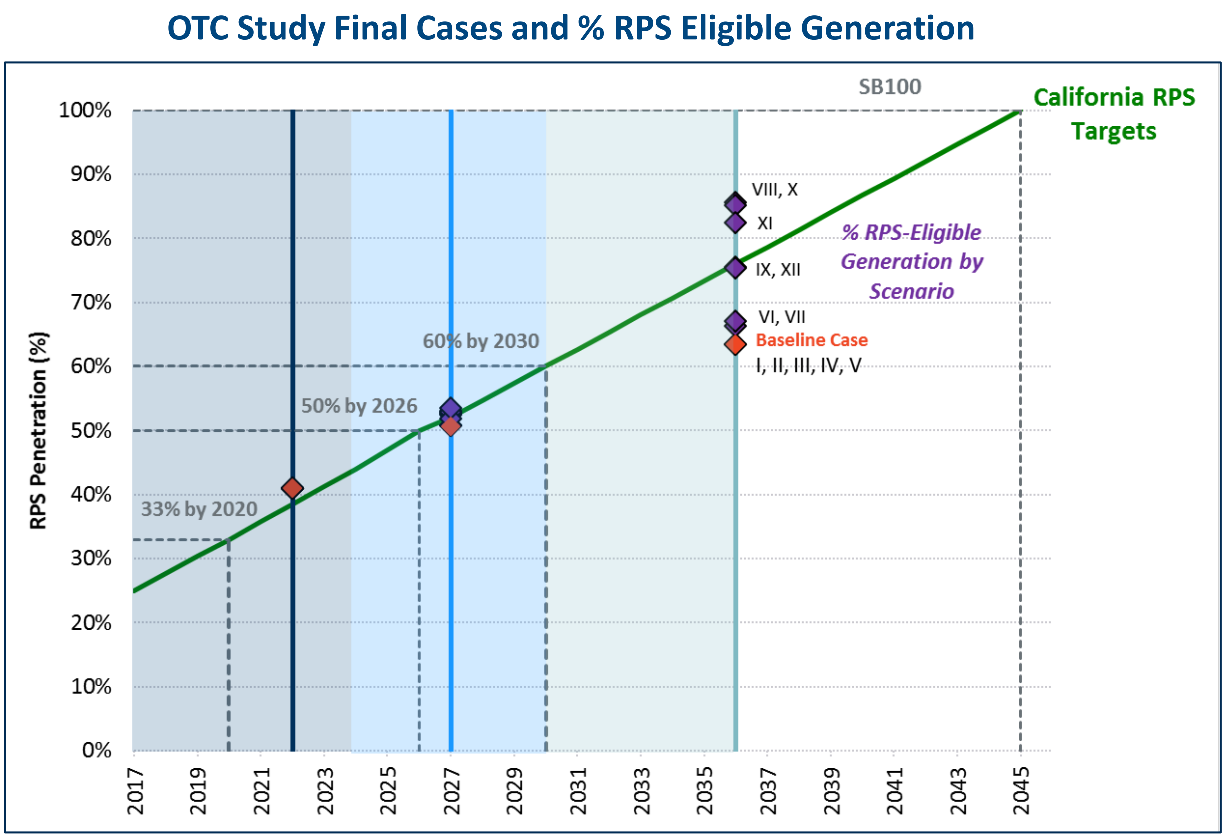
OTC Study Final Cases and % Non-Emitting Generation*



* *Note*: Non-Emitting Generation includes generation from RPS-eligible resources for 2017-2030. After 2030, generation from other non-emitting resources (most notably, Palo Verde) are included.

Observation: All 12 Final Cases (each case is shown in the purple diamonds) are on track to achieve SB 100 by 2045.

Path to SB 100 – 2/2



Observations:

- If SB 100 is defined to only include RPS eligible resources, several cases (including the Base Case) may require a post-2036 boost to achieve SB 100 by 2045.
- Case VI and VII may (with very little margin) satisfy the 60% by 2030 target.

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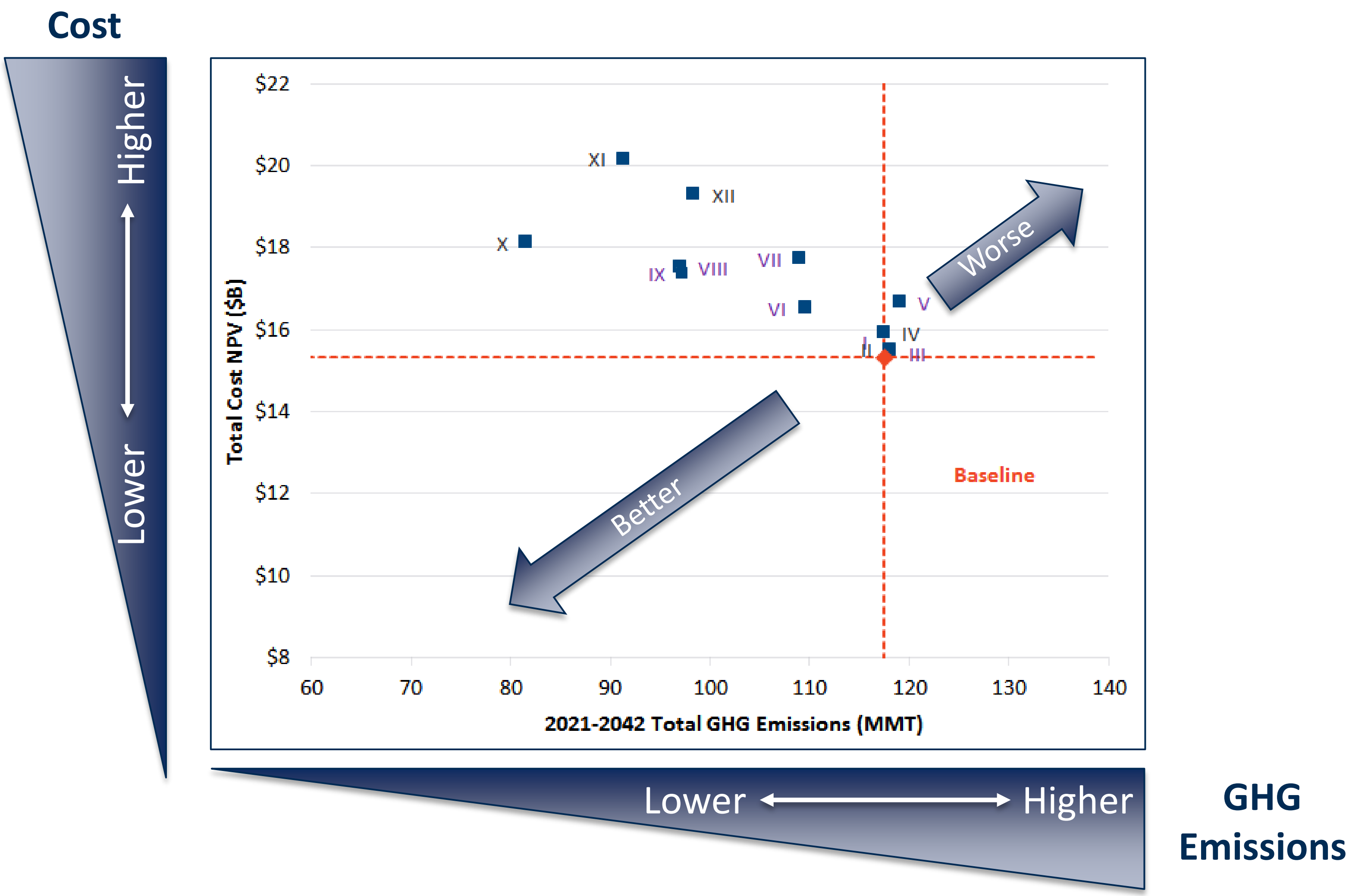
Total Costs and Carbon Emissions

- Compares the 12 Final Alternative Mitigation Case NPVs to the Baseline Case (with all OTC units repowered) NPV.
  - GHG emissions reflect total In-Basin emissions adjusted for net imports, over the 22 year study period.
    - Emission quantities are not discounted over the years.
  - All NPVs calculated for the 22 year study period (2021-2042) using cash flow data provided by OTC Study team.
    - Uncertainty of various assumptions indicates NPV difference of 5% or so to be within noise of analyses.
  - Sensitivities analyzed for:
    - Discount Rate Sensitivities
    - Higher and Lower Range Cost Assumptions Sensitivities
    - Combined Assumptions Sensitivities

Case Comparison – Cost and Emissions



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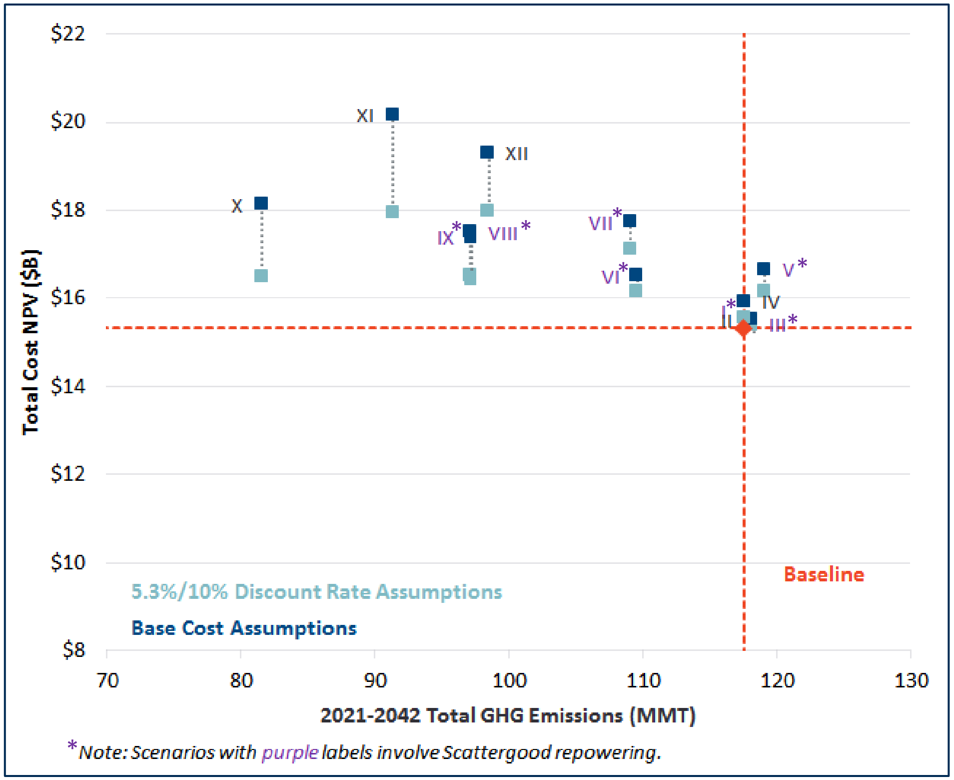
5.3% / 10% Discount Rate – All Years

Discount Rate (DR) Sensitivity



- Navy marks show NPVs for *5.3% DR Case* (assumes 5.3% discount rate for everything).
  - Includes Baseline Case.
- Teal marks show NPVs for *5.3%/10% DR Case* (assumes 5.3% discount rate for OTC repowering and LADWP operational costs, and 10% discount rate for other investments).

Current LADWP-wide emission is assumed to be around 181 MMT. (based on 2022 ProMod simulation results)

- Impact of discount rate choice is much larger for higher number Cases (with less OTC repowering).

Lower Range Cost Assumptions – All Years

Higher Range vs. Lower Range Assumptions Sensitivity

- Navy marks show NPVs for Higher Range assumptions.
- Teal marks show NPVs for Lower Range assumptions.
  - Includes Baseline Case.

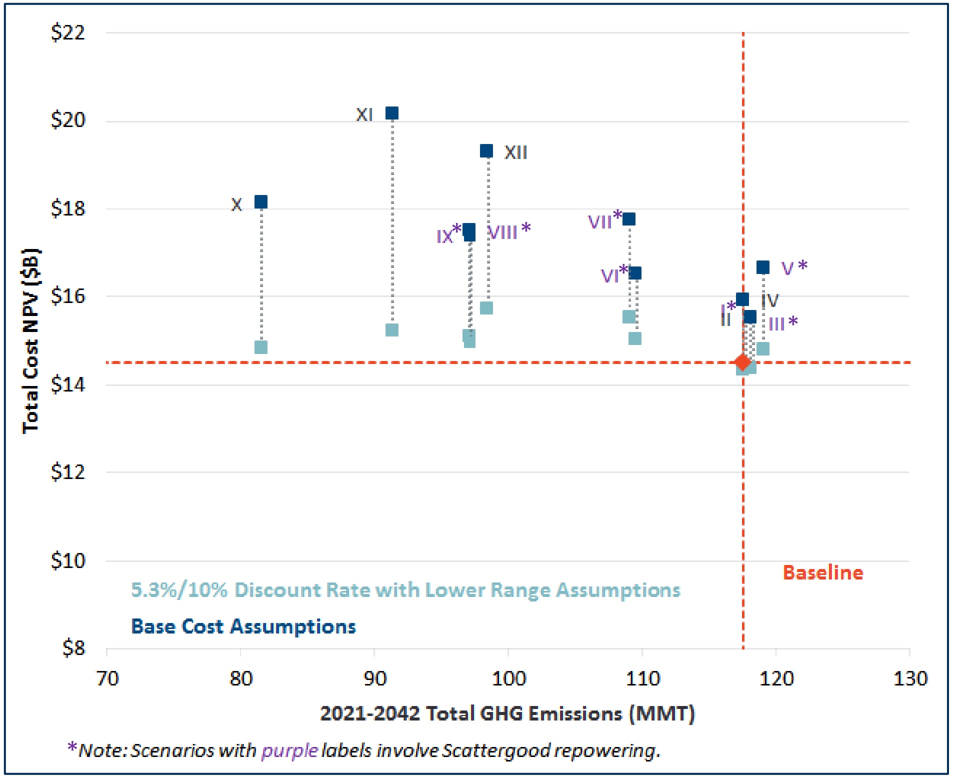
Both assume 5.3% DR Case.

Current LADWP-wide emission is assumed to be around 181 MMT.
(based on 2022 ProMod simulation results)

- Impact of Higher Range vs Lower Range assumption is much larger for higher number Cases (with less OTC repowering)

Combined Cost Sensitivities – All Years

Combined (Higher/Lower Range + Discount Rate) Sensitivity



- Navy marks show NPVs for 5.3% DR Case with Higher Range assumptions.
- Teal marks show NPVs for 5.3%/10% DR Case with Lower Range assumptions.
  - Includes Baseline Case.

Current LADWP-wide emission is assumed to be around 181 MMT.
(based on 2022 ProMod simulation results)

- Combined effect eliminates NPV difference among the various Cases, favoring higher number Cases (with less OTC repowering).

Carbon Cost Analysis – 1/2

The NPVs of total costs (2017 $ billions) for each Case are shown in the table below for various levels of carbon price assumption.

- Cases are listed in order of lowest total cost to highest total cost.
- Teal highlighting indicates when the order of a Case remains consistent.

Base		2x		4x		6x		8x		10x		12x	
Carbon Price Assumptions ($/metric ton emissions)													
2022	$18.66		$37.32		$74.64		$111.96		$149.28		$186.59		$223.91
2027	$23.79		$47.58		$95.16		$142.74		$190.32		$237.90		$285.48
2036	$36.90		$73.81		$147.62		$221.42		$295.23		$369.04		$442.85
Ranking of Cases by Total Cost NPV (2017 $B)													
Baseline (B)	**$15.33**	*III*	$17.92	*II*	$22.90	*X*	$27.67	*X*	$31.49	*X*	$35.31	*X*	$39.13
III	$15.42	***B***	**$17.95**	*III*	$22.92	*IX*	$27.72	*IX*	$31.86	*XII*	$35.84	*XII*	$39.52
I	$15.49	*II*	$17.97	*I*	$23.16	*II*	$27.83	*XII*	$32.17	*IX*	$35.99	*XI*	$39.52
II	$15.50	*I*	$18.05	***B***	**$23.19**	*III*	$27.91	*XI*	$32.48	*XI*	$36.00	*IX*	$40.13
IV	$15.92	*IV*	$18.35	*IV*	$23.22	*IV*	$28.08	*VIII*	$32.70	*VIII*	$37.04	*VIII*	$41.38
VI	$16.51	*VI*	$18.85	*VI*	$23.53	*VI*	$28.20	*II*	$32.76	*VI*	$37.56	*VII*	$42.18
V	$16.65	*V*	$19.11	*IX*	$23.58	*I*	$28.27	*VI*	$32.88	*II*	$37.69	*VI*	$42.23
IX	$17.38	*IX*	$19.45	*X*	$23.85	*VIII*	$28.36	*III*	$32.91	*VII*	$37.74	*II*	$42.61
VIII	$17.50	*VIII*	$19.67	*VIII*	$24.02	***B***	**$28.43**	*IV*	$32.94	*IV*	$37.80	*IV*	$42.67
VII	$17.73	*VII*	$19.95	*V*	$24.03	*XII*	$28.49	*VII*	$33.29	*III*	$37.90	*III*	$42.90
X	$18.12	*X*	$20.03	*VII*	$24.40	*VII*	$28.84	*I*	$33.38	*I*	$38.49	*I*	$43.60
XII	$19.30	*XII*	$21.13	*XII*	$24.81	*V*	$28.95	***B***	**$33.68**	*V*	$38.79	*V*	$43.71
XI	$20.16	*XI*	$21.92	*XI*	$25.44	*XI*	$28.96	*V*	$33.87	***B***	**$38.92**	***B***	**$44.16**

Values based on Brattle calculation using Higher Range Cost assumptions based cash flow data.

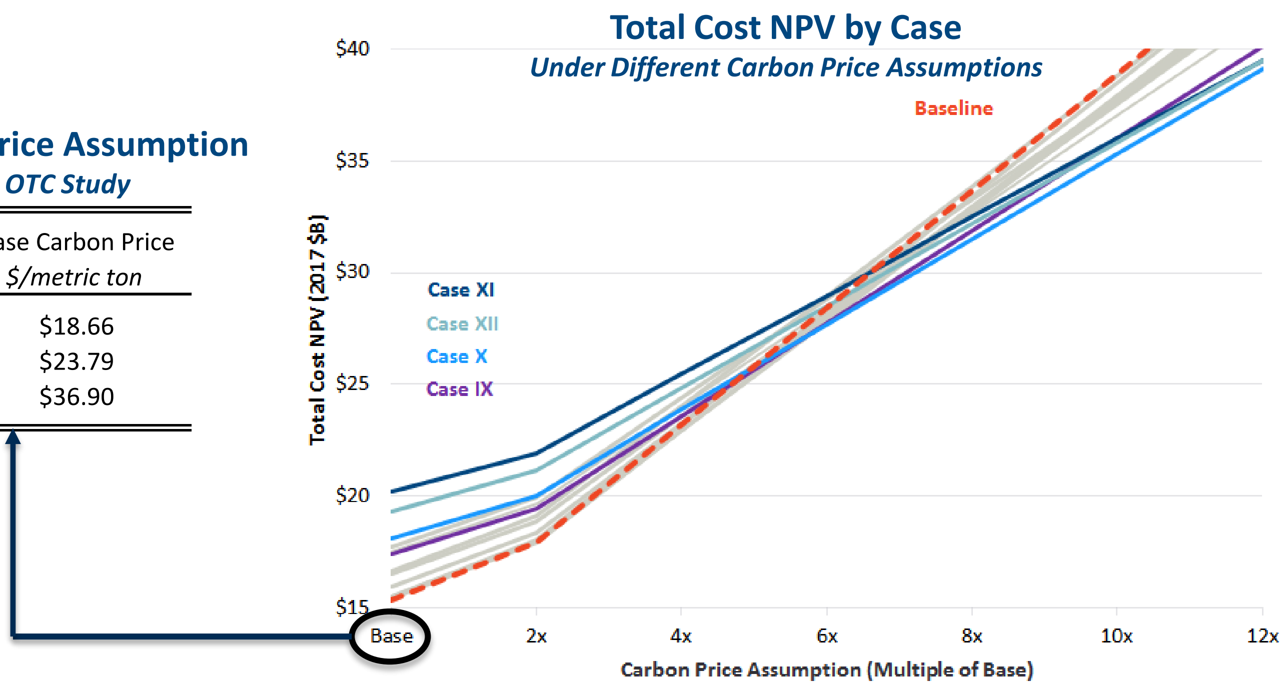
Carbon Cost Analysis – 2/2

As carbon price assumptions increase, the **total cost NPVs** increase for all Cases, but at different rates.

Base Carbon Price Assumption

Used for OTC Study

Year	Base Carbon Price *$/metric ton*
2022	$18.66
2027	$23.79
2036	$36.90



Observations:

- The Baseline NPV is the lowest cost option under Base carbon price assumptions, but becomes the highest cost option when carbon prices increase.
- Cases that involve less or no OTC repowering (IX, X, XI, XII) have comparatively low costs when carbon prices increase.

Per Unit Carbon Reduction Cost Analysis

As carbon price assumptions increase, the **per unit carbon reduction costs** increase for all Cases, but at different rates.

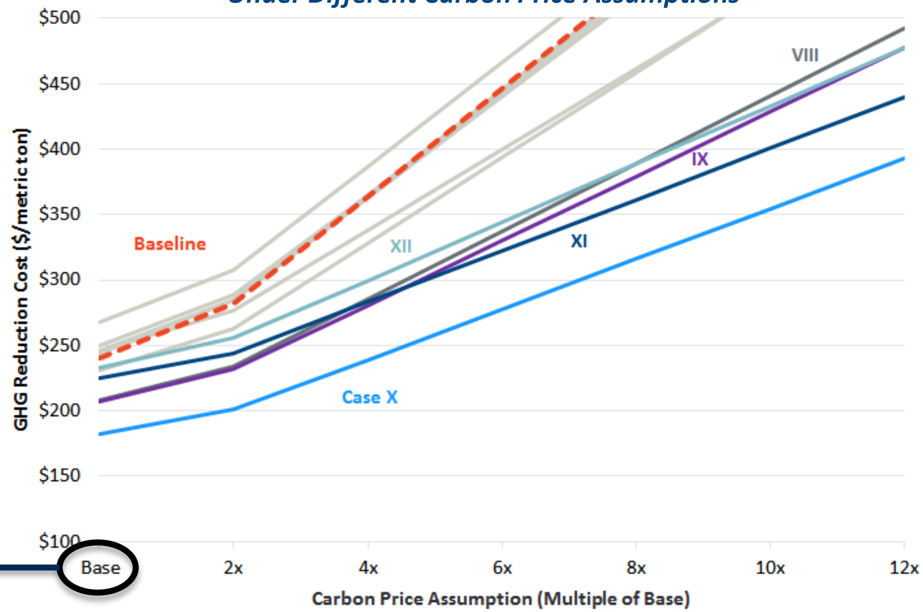
Base Carbon Price Assumption

Used for OTC Study

Year	Base Carbon Price *$/metric ton*
2022	$18.66
2027	$23.79
2036	$36.90

Per Unit Carbon Reduction by Case

Under Different Carbon Price Assumptions



Observations:

- Case X consistently has the lowest per unit cost of carbon reduction cost.
- Cases that involve no OTC repowering (XI and XII) have comparatively low per unit carbon reduction costs when carbon prices increase.

Scattergood Repowering Alternatives – 1/3

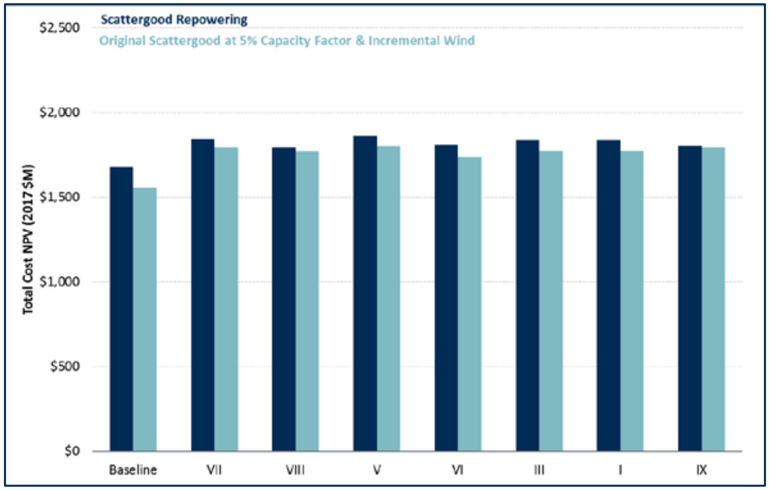
Additional analyses for delaying the existing Scattergood units OTC compliance date by ten years (~2035).

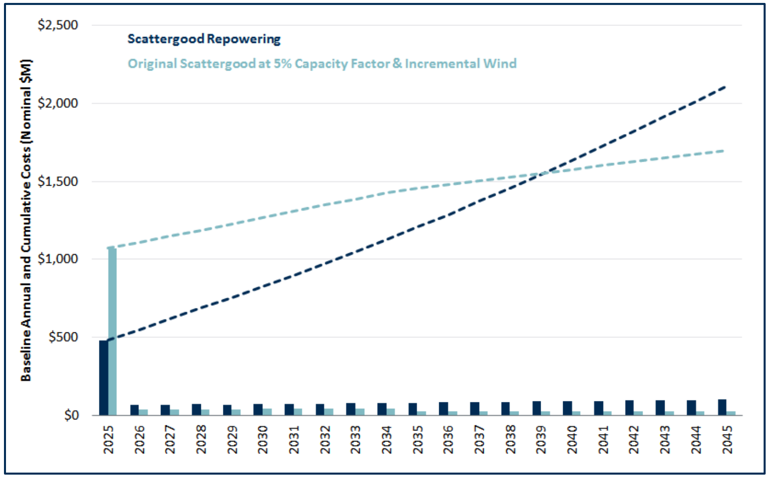
- Operating Scattergood at 5% capacity factor (annual average) can yield lower overall NPV (calculated through 2045) than for Alternative Mitigation Cases that repowers Scattergood.
  - Most mitigation alternative costs (with the exception of rooftop solar, shown in red text in the table below) will yield lower NPVs.
  - No operational restrictions are considered.
- Potentially indicates replacing OTC units with smaller units (simple cycle GTs or RICE units) with lower investment costs to be a viable solution.

Alternatives	Assumed Annual Capacity Factor	Investment Costs ($/kW)	
		Lower Range	Higher Range
Wind	30%	$1,900	$2,100
Storage (4-hour)	75%	$1,500	$1,700
Geothermal	90%	$5,000	$6,000
Rooftop Solar	25%	$2,324	$2,961
Land-Based Solar (In-basin)	25%	$1,400	$1,600
Floating Solar	25%	$1,600	$1,800

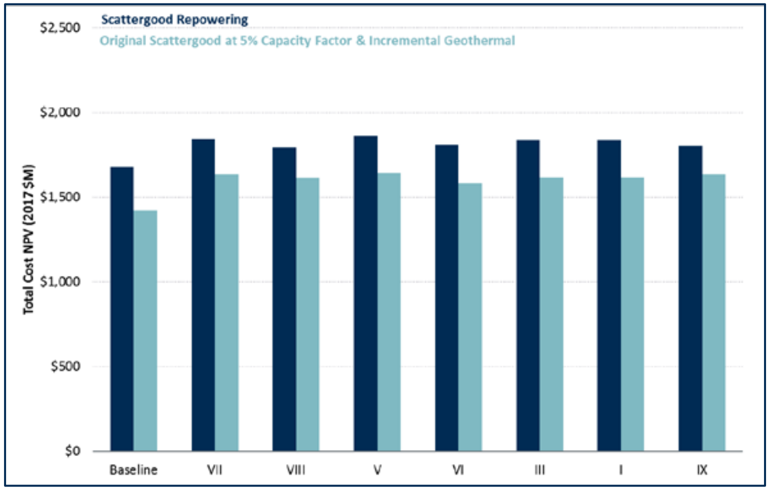
Scattergood Repowering Alternatives – 2/3

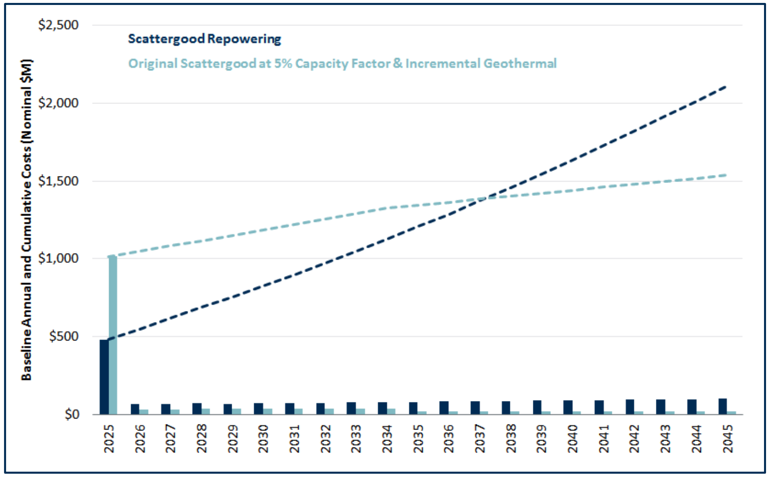
Scattergood @ 5% CF + Wind



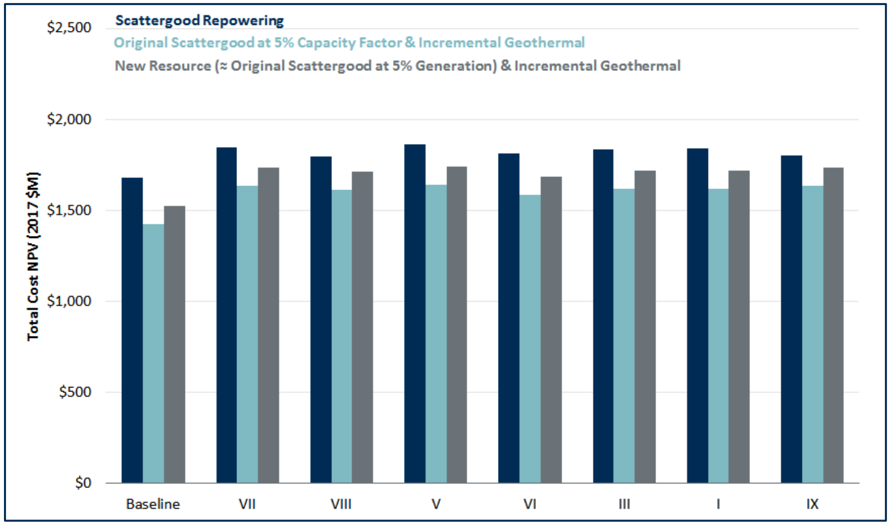


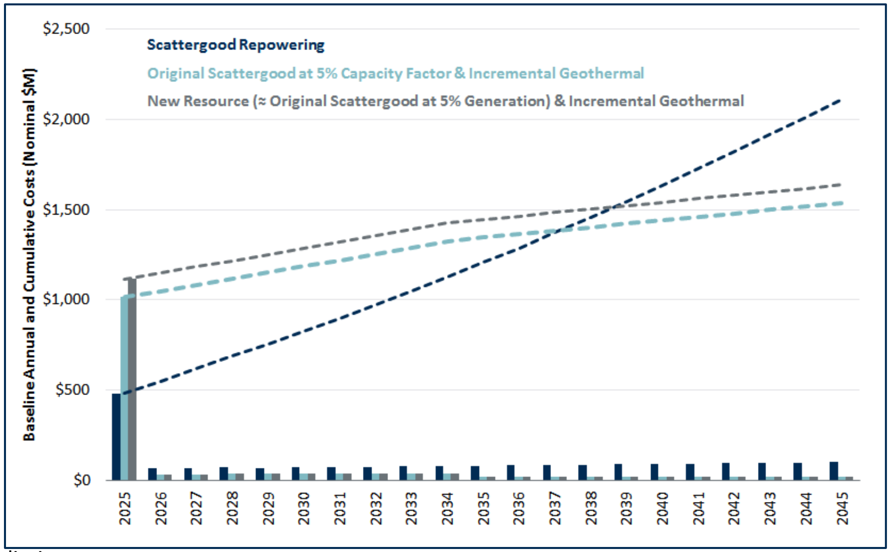
Scattergood @ 5% CF + Geothermal





Scattergood Repowering Alternatives – 3/3





The addition of a new gas-fired unit in 2025 (to replace existing Scattergood running at 5% capacity factor) can also yield lower overall NPV.

Assumptions for New Gas Unit

Metric	Assumption
Capacity	50 MW
Capacity Factor	30%
Investment Cost	$2000/kW
Operating Costs	= Original Scattergood

Note: If the new investment is a 20 MW unit with investment costs of $1,500/kW and operating costs of 80% Original Scattergood (reflecting higher fuel efficiency), then the grey bar would become about equal to the teal bar.

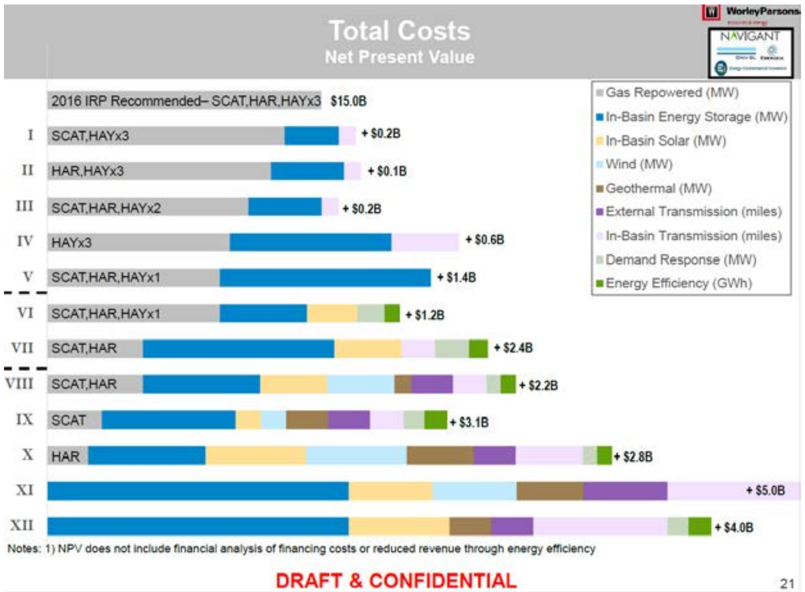
Agenda

- Review of OTC Study Results
  - Study Overview and Assumptions
  - Study Results Summary (Modified Results)
  - Range of Assumptions and Uncertainty
- OTC Study Cases and SB 100
  - Which of the 12 Alternative Cases are in line with the SB 100 goal and timeline?
- OTC Study Results Observations
  - Total Costs and Carbon Emissions: How the 12 Alternative Cases compare to the Baseline Case
    - Discount Rate Sensitivities
    - Higher and Lower Range Cost Assumptions Sensitivities
    - Combined Assumptions Sensitivities
  - Per Unit of Carbon Reduction Cost
  - Scattergood Repowering Alternatives (Delayed OTC compliance)
- Appendix

Appendix

- Review of OTC Study Results
  - Updates to NPV Calculations
  - Study Results GHG Emissions
  - Uncertainty Ranges and Cost Sensitivities
- OTC Study Results Observations
  - Discount Rate Sensitivities
    - 10% Discount Rate – All Years
    - 5.3% / 10% Discount Rate – 2036 Only
  - Carbon Cost Analysis Sensitivity
  - Carbon Reduction Cost Analysis
  - Scattergood Repowering Alternatives

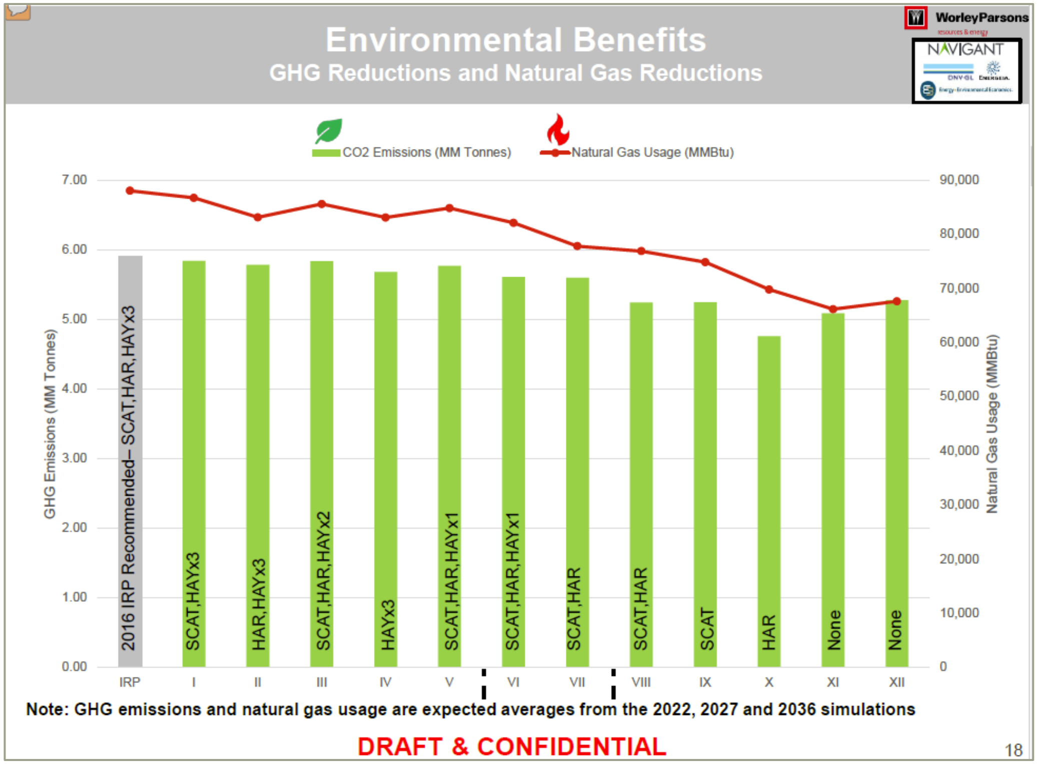
Updates to NPV Calculations



Rank	Alternative	NPV	NPV (Δ to Baseline)
Baseline		$15B	-
2	I	$15.0B - $15.2B	$0B - $0.2B
1	II	$14.9B - $15.2B	($0.1B) - $0.2B
2	III	$15.0B - $15.2B	$0B - $0.2B
4	IV	$15.1B - $15.6B	$0.1B - $0.6B
5	V	$15.7B - $16.3B	$0.7B - $1.3B
6	VI	$15.8B - $16.2B	$0.8B - $1.2B
9	VII	$16.6B - $17.4B	$1.6B - $2.4B
8	VIII	$16.4B - $17.2B	$1.4B - $2.2B
7	IX	$16.3B - $17.1B	$1.3B - $2.1B
10	X	$16.7B - $17.8B	$1.7B - $2.8B
12	XI	$17.5B - $19.9B	$2.5B - $4.9B
11	XII	$17.3B - $19.0B	$2.3B - $4B

- Presentation shows Baseline Case NPV of $15 billion, and not the 2016 IRP.
- All Alternative Case NPVs are compared to the Baseline NPV.
  - OTC Study NPVs are calculated over 22 years.
- Cases highlighted in yellow above were updated.
  - NPV delta is against the Baseline Case NPV of $15.0 B.
  - Baseline Case has a range of $14.6 B - $15.4 B, which average to $15.0 B.

Study Results GHG Emissions



Source: OTC Study Update presentation

Uncertainty Ranges

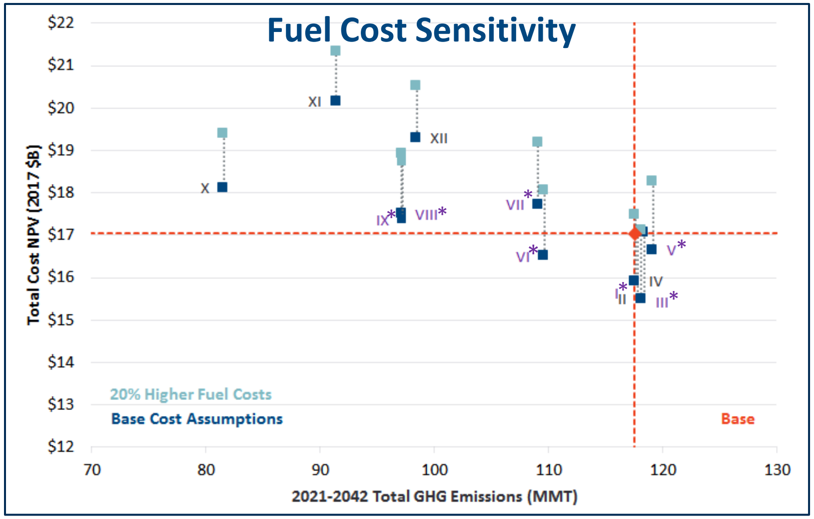
- OTC Study results have uncertainty ranges.

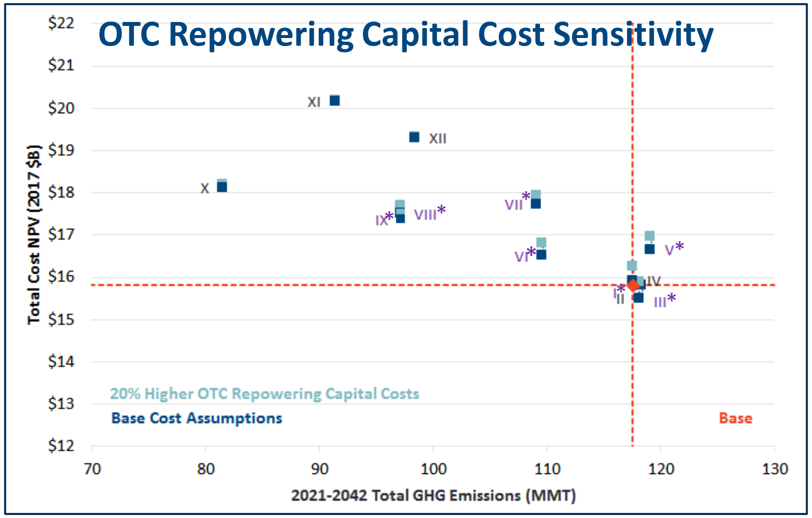
Sensitivity Cost Ranges

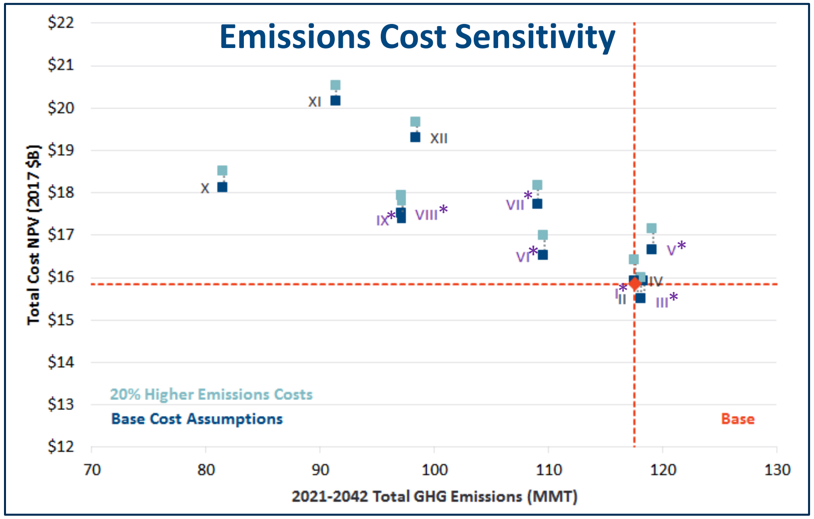
	NPV Total Costs (2017 $B)		Delta from Case A	
Cost Type	Case A	Case B	Absolute (2017 $B)	% of Case A
OTC Study Baseline	***High: $15.38***	Low: $14.65	$0.74	4.8%
Brattle Calculation from OTC Cash Flow Data				
Baseline	***High: $15.33***	Low: $14.53	$0.80	5.2%
Higher gas price (20%) sensitivity		Higher Gas Price: $17.04	$1.71	11.2%
Higher emission price (20%) sensitivity		Higher Emission Price: $15.85	$0.52	3.4%

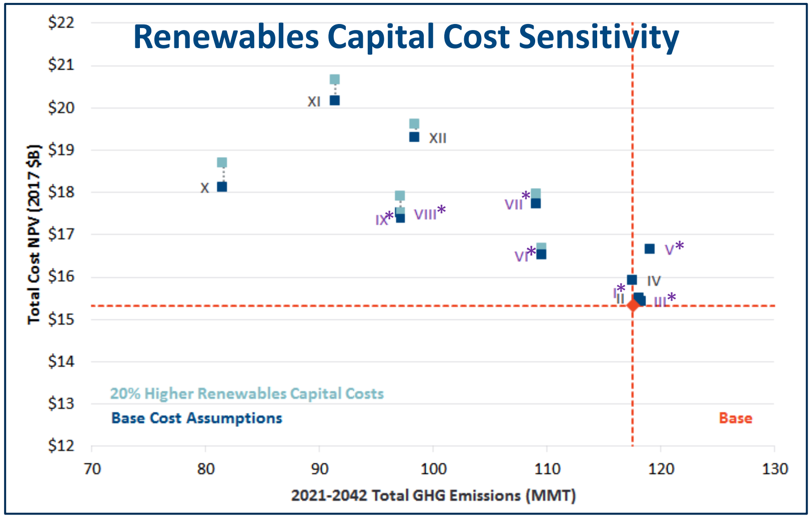
- The general range of error appears to be *around 5% (≈$0.75 B).*
  - Fuel price sensitivity is larger compared to other input assumptions.
  - Emission costs and Renewable Capital costs follow.

Cost Sensitivities – 20% Increase



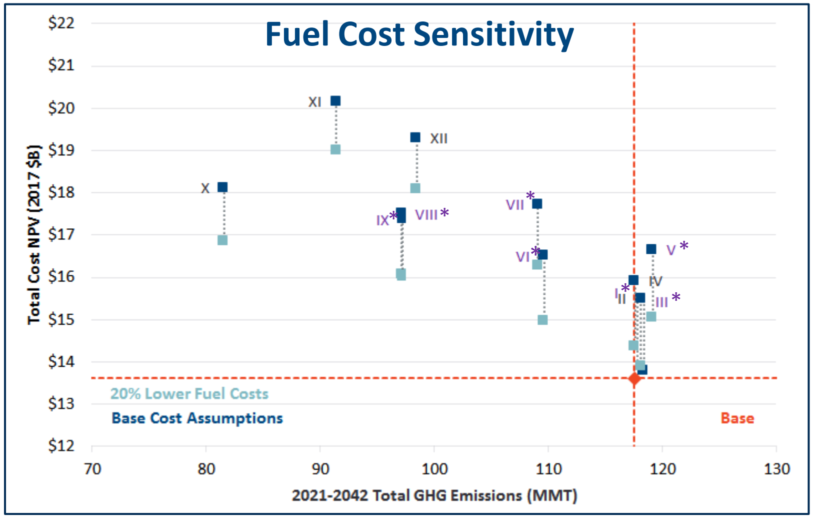


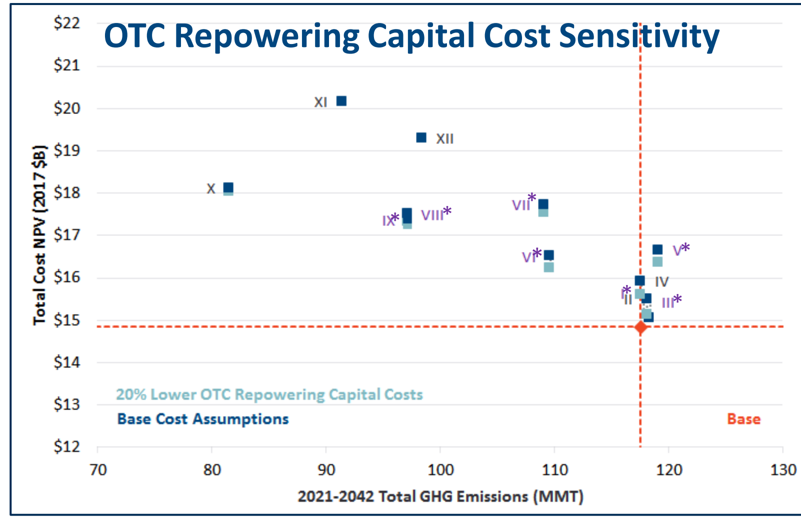


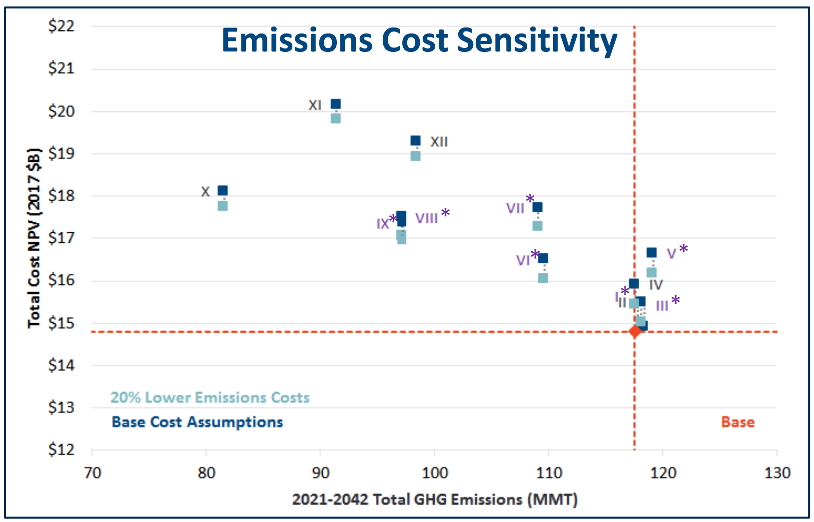


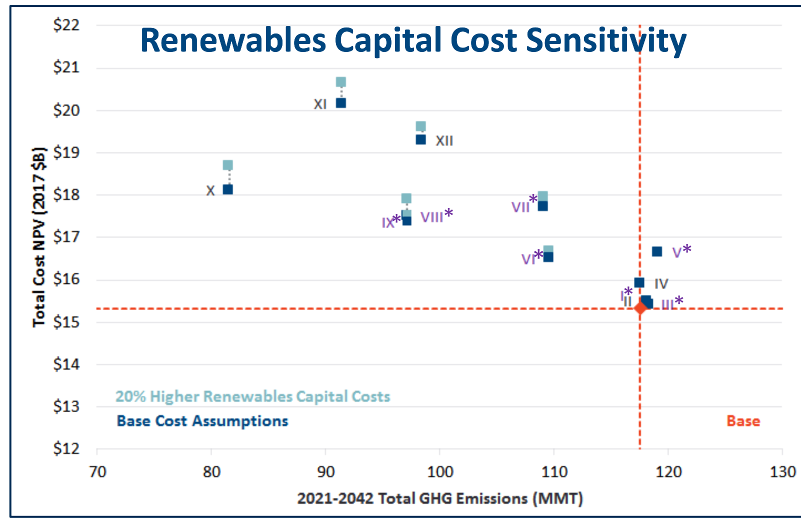
* *Note*: Scenarios with purple labels involve Scattergood repowering.

Cost Sensitivities – 20% Reduction





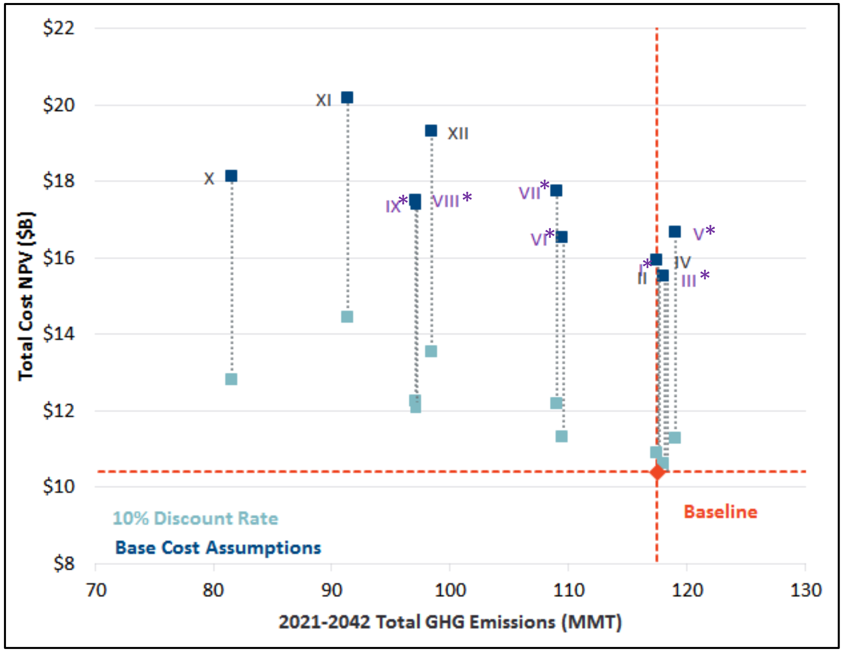




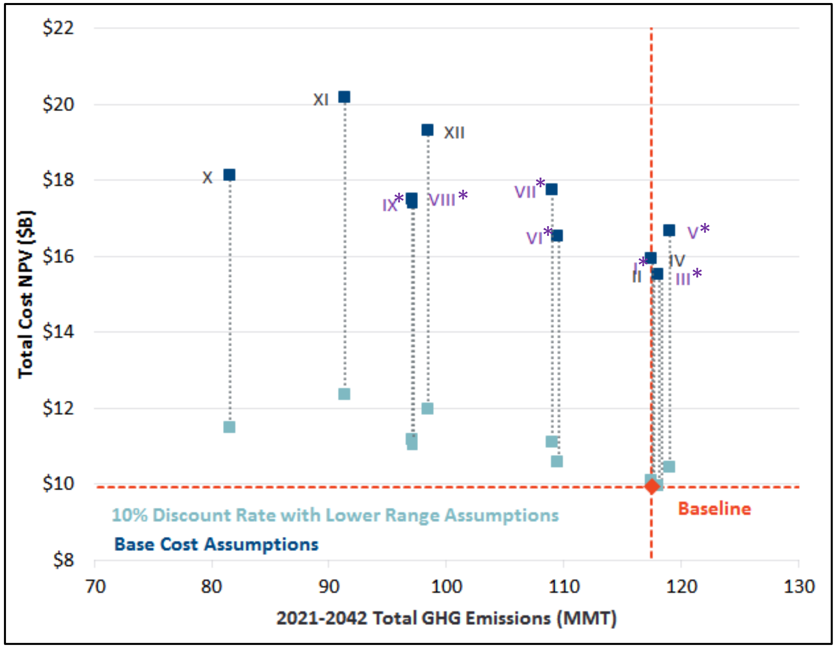
* *Note*: Scenarios with purple labels involve Scattergood repowering.

10% Discount Rate – All Years

10% Discount Rate Sensitivity



Lower Cost Range + 10% Discount Rate Sensitivity



* *Note*: Scenarios with purple labels involve Scattergood repowering.

- Navy marks show NPVs for 5.3% DR Case with Higher Range assumptions.
- Teal marks show NPVs for 10% DR Case (assumes 10% discount rate for all investment and operating costs).
  - Chart on the left applies 10% DR to higher range cost assumptions; chart on the right applies 10% DR to lower range cost assumptions.
  - Includes Baseline Case.

GHG emission quantity not discounted.

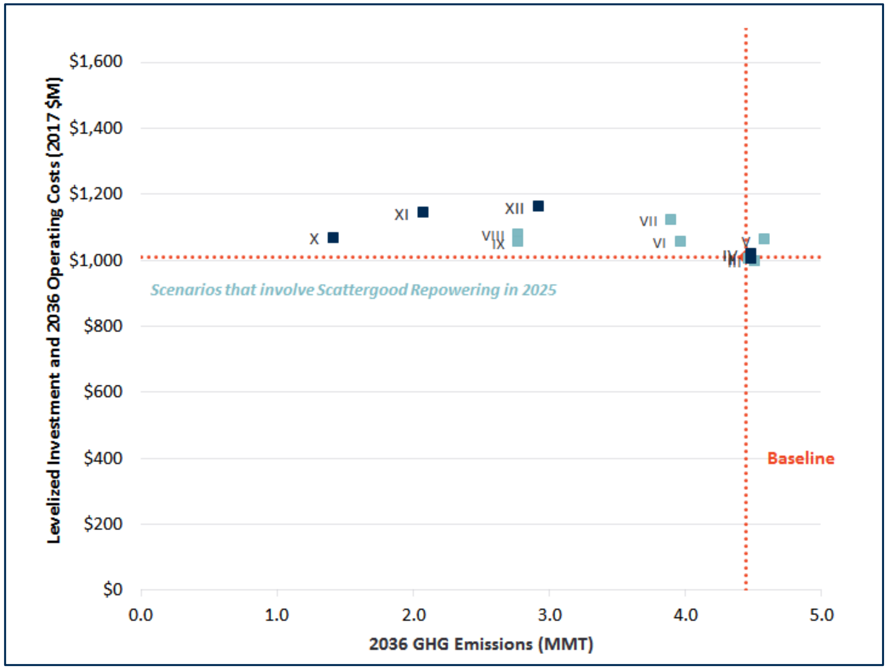
5.3% / 10% DR – 2036 Only

2036 Cost and Emissions by scenario for the 5.3% / 10% DR Case, under high and low range cost assumptions.

- Assumes 5.3% discount rate for OTC repowering and LADWP operational costs, and 10% discount rate for other investments.

High Range Assumptions

Low Range Assumptions



Carbon Cost Analysis – Sensitivity

The table below shows Case rankings by NPVs of total costs (2017 $ billions) for various levels of carbon price assumption.

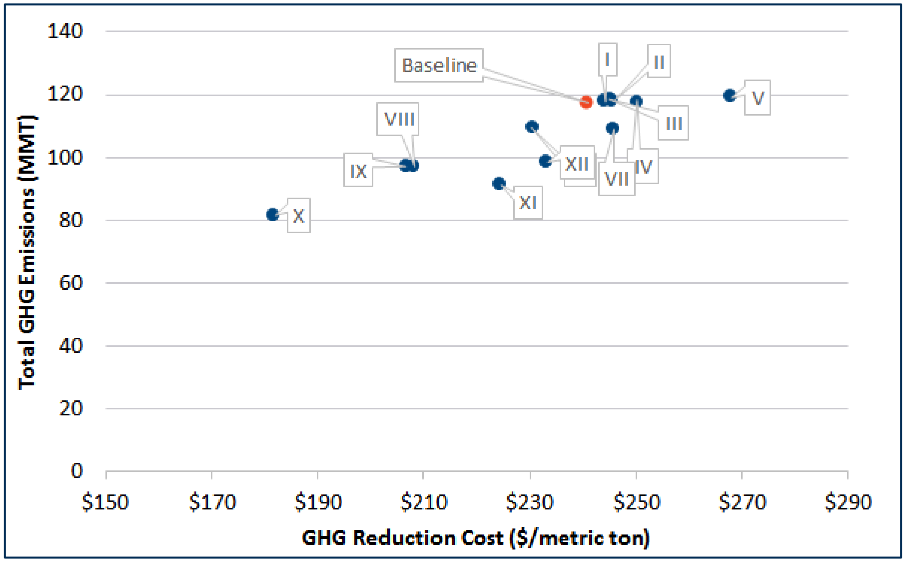
- Assumes Lower Range cost assumptions and 5.3% / 10% discount rate.

Base		2x		4x		6x		8x		10x		12x	
Carbon Price Assumptions ($/metric ton emissions)													
2022	$18.66		$37.32		$74.64		$111.96		$149.28		$186.59		$223.91
2027	$23.79		$47.58		$95.16		$142.74		$190.32		$237.90		$285.48
2036	$36.90		$73.81		$147.62		$221.42		$295.23		$369.04		$442.85
Ranking of Cases by Total Cost NPV (2017 $B)													
III	$14.28	*X*	$16.73	*XI*	$20.52	*XI*	$24.04	*XI*	$27.56	*XI*	$31.08	*XI*	$34.60
IV	$14.33	*IV*	$16.77	*X*	$20.55	*X*	$24.37	*X*	$28.19	*X*	$32.01	*X*	$35.83
II	$14.35	*III*	$16.78	*IX*	$21.17	*XII*	$24.93	*XII*	$28.60	*XII*	$32.28	*XII*	$35.96
I	$14.40	*II*	$16.82	*XII*	$21.25	*IX*	$25.30	*IX*	$29.44	*IX*	$33.58	*IX*	$37.72
Baseline (B)	**$14.52**	*I*	$16.96	*VIII*	$21.60	*VIII*	$25.94	*VIII*	$30.28	*VIII*	$34.62	*VIII*	$38.96
V	$14.80	*XI*	$17.00	*IV*	$21.63	*IV*	$26.49	*VII*	$31.09	*VII*	$35.54	*VII*	$39.99
X	$14.82	*IX*	$17.03	*II*	$21.75	*VII*	$26.65	*IV*	$31.35	*VI*	$36.07	*VI*	$40.75
IX	$14.96	***B***	**$17.14**	*III*	$21.78	*II*	$26.67	*VI*	$31.40	*IV*	$36.22	*IV*	$41.08
VI	$15.03	*V*	$17.26	*VI*	$22.04	*VI*	$26.72	*II*	$31.60	*II*	$36.53	*II*	$41.46
VIII	$15.09	*VIII*	$17.26	*I*	$22.07	*III*	$26.77	*III*	$31.77	*III*	$36.76	*III*	$41.76
XI	$15.24	*VI*	$17.37	*V*	$22.18	*V*	$27.09	*V*	$32.01	*V*	$36.93	*V*	$41.85
VII	$15.53	*XII*	$17.57	*VII*	$22.20	*I*	$27.18	*I*	$32.29	*I*	$37.40	*I*	$42.51
XII	$15.73	*VII*	$17.76	***B***	**$22.39**	***B***	**$27.63**	***B***	**$32.87**	***B***	**$38.11**	***B***	**$43.36**

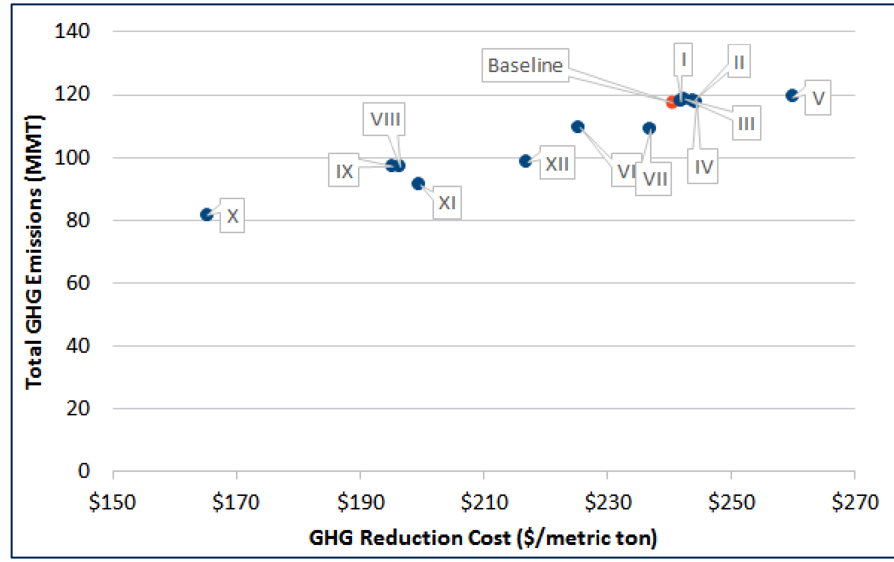
Values based on Brattle calculation using Higher Range Cost assumptions based cash flow data.

Carbon Reduction Cost Analysis – 1/2

5.3% DR Case Per Unit Carbon Reduction Cost



5.3%/10% DR Case Per Unit Carbon Reduction Cost



Note: GHG emissions reflect total emissions over the 22-year study period.

Observation: Per unit cost of carbon reduction is also lower for higher number Cases (with less OTC repowering).

Carbon Reduction Cost Analysis – 2/2

Per unit carbon reduction costs ($/metric ton) for each Case are shown in the table below for various levels of carbon price assumption.

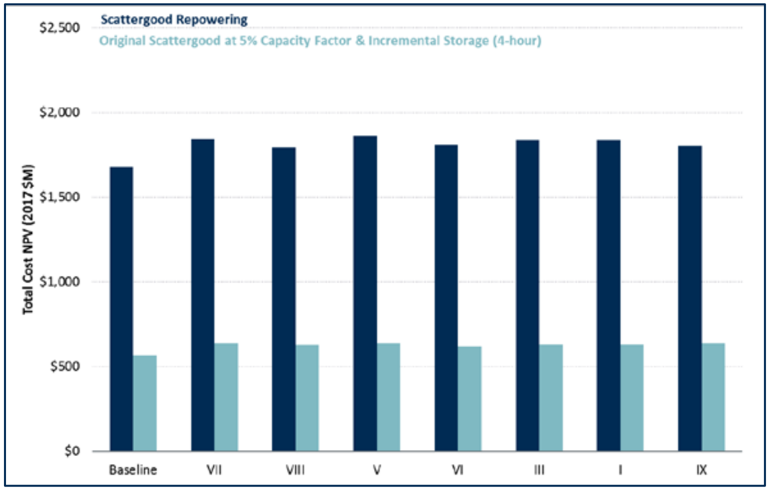
- Cases are listed in order of lowest cost of reduction to highest cost of reduction.
- Yellow highlighting indicates when the order of Cases switches.

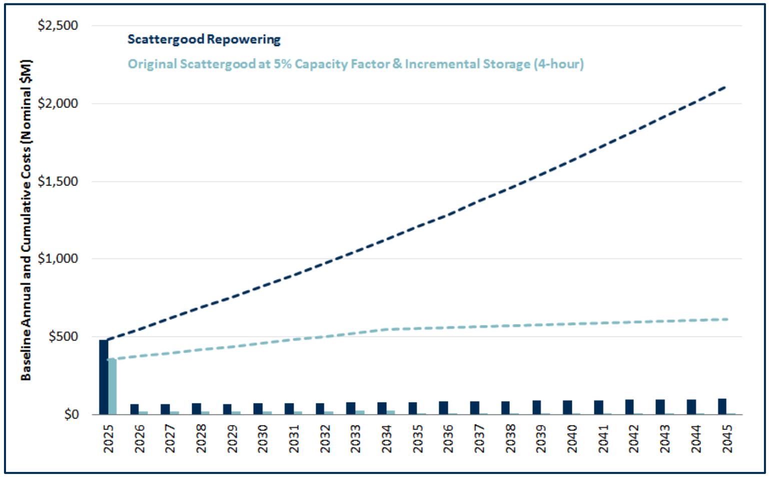
Base		2x		4x		6x		8x		10x		12x	
Carbon Price Assumptions ($/metric ton emissions)													
2022	$18.66		$37.32		$74.64		$111.96		$149.28		$186.59		$223.91
2027	$23.79		$47.58		$95.16		$142.74		$190.32		$237.90		$285.48
2036	$36.90		$73.81		$147.62		$221.42		$295.23		$369.04		$442.85
Ranking of Cases by per Unit Carbon Reduction Cost (2017 $/metric ton reduction)													
X	$181.83	*X*	$201.00	*X*	$239.34	*X*	$277.68	*X*	$316.02	*X*	$354.36	*X*	$392.71
IX	$206.86	*IX*	$231.49	*IX*	$280.74	*XI*	$322.47	*XI*	$361.66	*XI*	$400.85	*XI*	$440.05
VIII	$208.21	*VIII*	$234.03	*XI*	$283.27	*IX*	$329.99	*IX*	$379.24	*IX*	$428.49	*XII*	$477.64
XI	$224.48	*XI*	$244.08	*VIII*	$285.67	*VIII*	$337.31	*XII*	$388.76	*XII*	$433.20	*IX*	$477.74
VI	$230.56	*XII*	$255.43	*XII*	$299.87	*XII*	$344.31	*VIII*	$388.95	*VIII*	$440.58	*VIII*	$492.22
XII	$233.21	*VI*	$263.21	*VI*	$328.51	*VI*	$393.80	*VI*	$459.09	*VII*	$523.15	*VII*	$584.79
Baseline (B)	**$240.71**	*VII*	$276.59	*VII*	$338.23	*VII*	$399.87	*VII*	$461.51	*VI*	$524.39	*VI*	$589.68
I	$244.17	***B***	**$281.87**	*II*	$362.84	*II*	$440.95	*IV*	$517.63	*IV*	$594.04	*IV*	$670.45
III	$245.27	*I*	$284.44	***B***	**$364.19**	*IV*	$441.22	*II*	$519.06	*II*	$597.17	*II*	$675.28
II	$245.67	*II*	$284.73	*III*	$364.46	*III*	$443.91	*III*	$523.37	*III*	$602.83	*III*	$682.28
VII	$245.78	*III*	$285.00	*IV*	$364.81	*I*	$445.51	*I*	$526.05	*I*	$606.59	*I*	$687.13
IV	$250.19	*IV*	$288.39	*I*	$364.97	***B***	**$446.51**	***B***	**$528.83**	***B***	**$611.14**	***B***	**$693.46**
V	$268.13	*V*	$307.73	*V*	$386.93	*V*	$466.13	*V*	$545.33	*V*	$624.54	*V*	$703.74

Values based on Brattle calculation using Higher Range Cost assumptions based cash flow data.

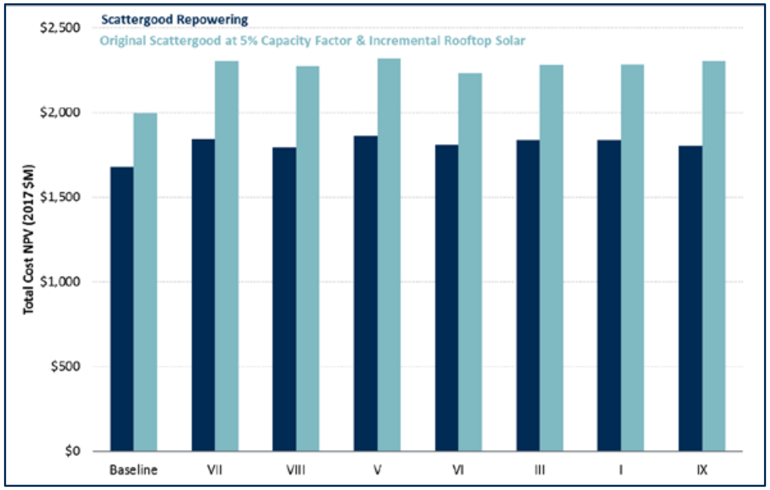
Scattergood Repowering Alternatives

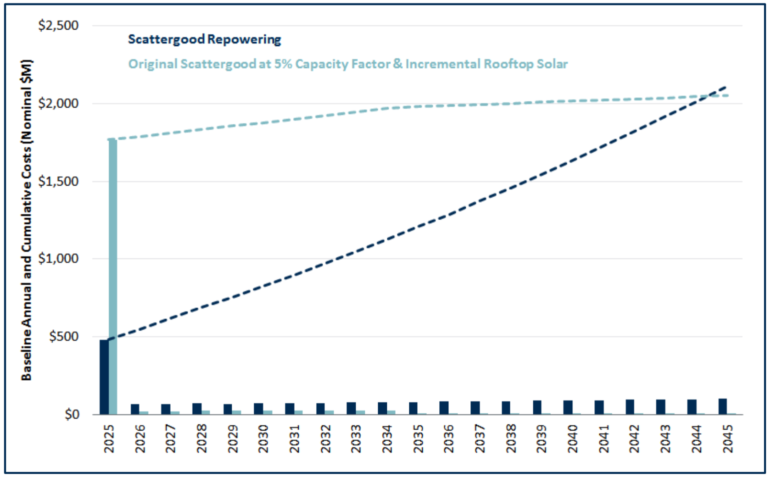
Scattergood @ 5% CF + Storage





Scattergood @ 5% CF + Rooftop PVs





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