

TEP Integrated Resource Plan

Advisory Council Meeting

WELCOME

JEFF YOCKEY
DIRECTOR, RESOURCE PLANNING



Tucson Electric Power

PORTFOLIO OVERVIEW AND ASSUMPTIONS



Tucson Electric Power



Portfolio Identification

P01aL1M1E1

P01	Portfolio Name (i.e. 80% renewable energy by 2050)
a	Portfolio variation (i.e. majority solar vs. majority wind)
L1	Load Scenario (electric vehicles, mining)
M1	Market Scenario (Low gas price vs. High gas price)
E1	Emission Scenario (Carbon price vs. No carbon price)



Alternative Scenarios

Load Scenario ID	Description
L1	December 2019 – Expected EV Sales
L2	No load growth
L3	Low load growth (<1%); Low EV Sales; Exclude Rosemont
L4	Exclude Rosemont
L5	Low EV sales
L6	High EV sales

Emission Scenario ID	Description
E1	Federal Carbon Case
E2	No Federal Carbon Case

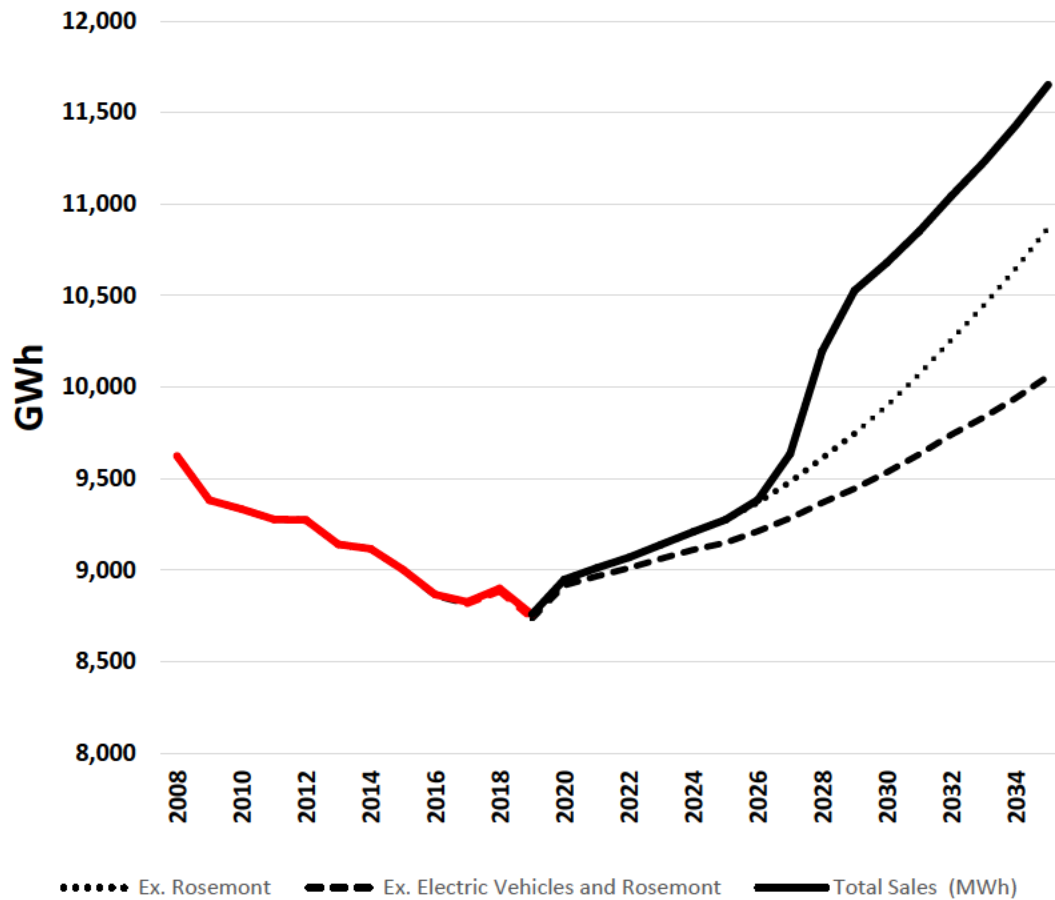
Market Scenario ID	Description
M1	2019 Base Case
M2	2019 High Case
M3	2019 Low Case

Market Scenario ID	Description
M1 E1	2019 Base Case Federal Carbon Price
M2 E1	2019 High Case Federal Carbon Price
M3 E2	2019 Low Case No Federal Carbon Price
E2	2019 Base Case No Federal Carbon Price

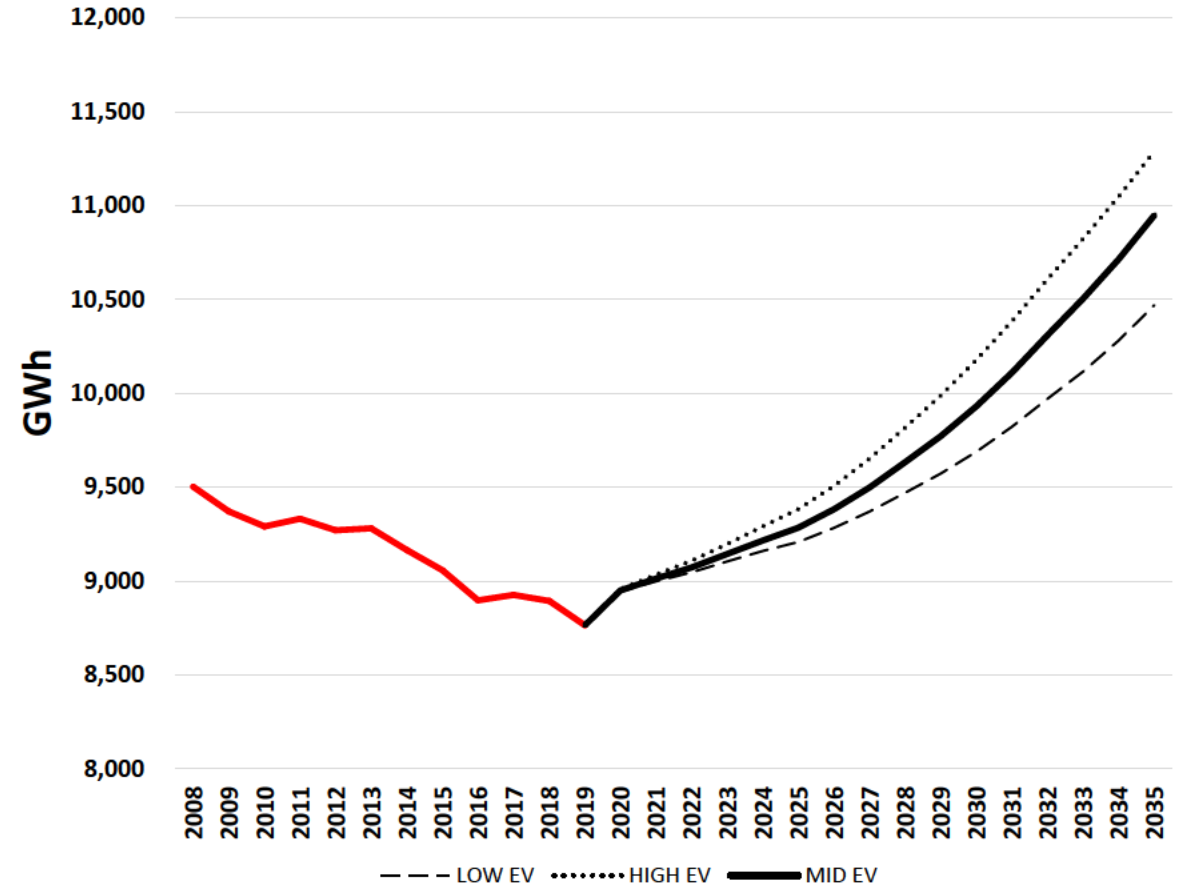


Load Forecast

Retail Load



Electric Vehicle Load



Historical in Red



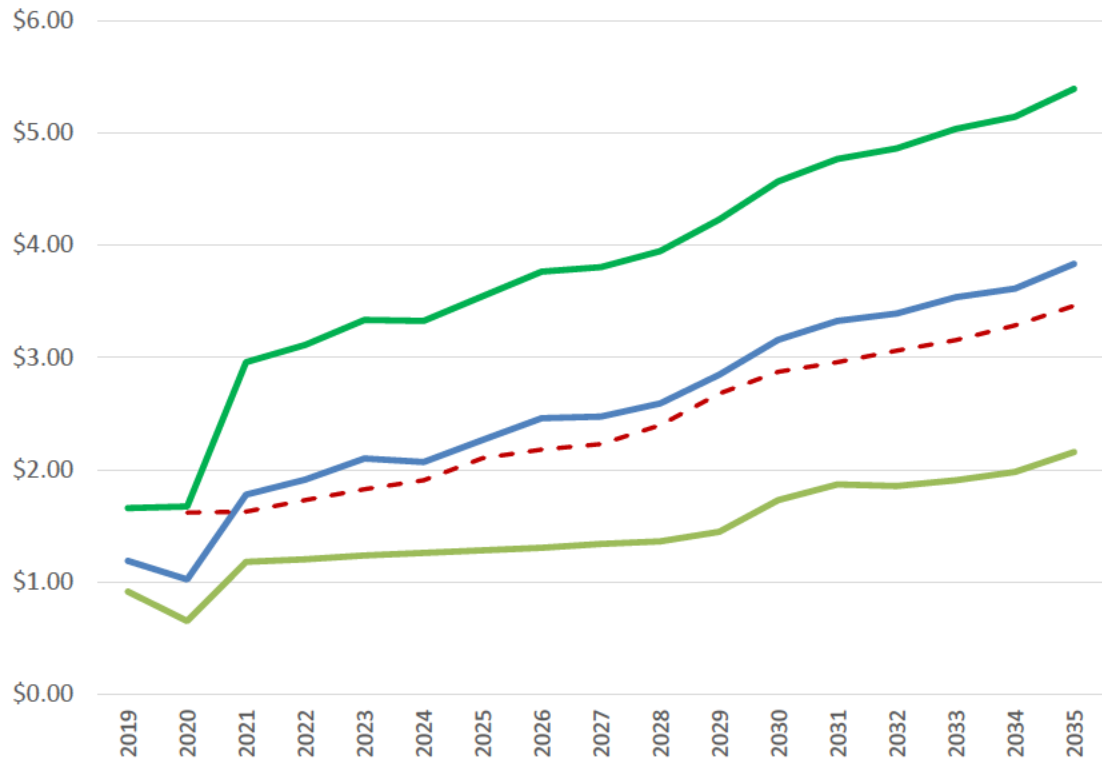
Technology Cost Assumptions

Base Year for Cost Multiplier					Gas CT - Aero	Gas CT - Frame	Gas NGCC - Conventional, Wet Cooled	Reciprocating Engines	Solar Thermal - No Storage	Solar Thermal - Six Hour Storage	Solar PV - Fixed Tilt (>20 MW)	Solar PV - Tracking (>20 MW)	Wind - Onshore	Battery Storage 4h	Battery Storage 8h	Small Modular Nuclear	
	2019																
Performance Inputs		Units	Active	User Override													
Capital Costs	US Avg Installed Cost	\$/kW			\$900	\$750	\$1,000	\$850	\$4,900	\$7,550	\$900	\$1,100	\$1,300	\$1,440	\$2,592	\$5,100	
Fixed O&M	US Avg Unit Cost	\$/kW-yr			\$12.72	\$12.72	\$34.98	\$12.00	\$65.00	\$80.00	\$18.73	\$20.81	\$30.00	\$36.01	\$8.85	\$145.83	
Variable O&M	US Avg Unit Cost	\$/MWh			\$7.14	\$7.14	\$2.77	\$4.50	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$2.31	
	Heat Rate	Btu/kWh			9,800	10,500	7,200	8,500								9,500	
Financing Selection																	
Resource Life		hrs			30	30	30	30	20	35	20	20	30	20	20	30	
Cost Multipliers																	
Capital Cost Multiplier	2019	%			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
	2020	%			1.020	1.020	1.020	1.020	0.919	0.919	0.938	0.938	1.008	0.941	0.941	1.020	
	2021	%			1.040	1.040	1.040	1.040	0.914	0.914	0.885	0.885	1.015	0.891	0.891	1.040	
	2022	%			1.061	1.061	1.061	1.061	0.908	0.908	0.818	0.818	1.023	0.850	0.850	1.060	
	2023	%			1.082	1.082	1.082	1.082	0.901	0.901	0.793	0.793	1.030	0.820	0.820	1.080	
	2024	%			1.104	1.104	1.104	1.104	0.894	0.894	0.791	0.791	1.037	0.796	0.796	1.100	
	2025	%			1.126	1.126	1.126	1.126	0.886	0.886	0.789	0.789	1.044	0.776	0.776	1.120	
	2026	%			1.149	1.149	1.149	1.149	0.878	0.878	0.789	0.789	1.050	0.756	0.756	1.140	
	2027	%			1.172	1.172	1.172	1.172	0.868	0.868	0.789	0.789	1.058	0.737	0.737	1.160	
	2028	%			1.195	1.195	1.195	1.195	0.858	0.858	0.788	0.788	1.065	0.712	0.712	1.180	
	2029	%			1.219	1.219	1.219	1.219	0.848	0.848	0.788	0.788	1.072	0.690	0.690	1.200	
	2030	%			1.243	1.243	1.243	1.243	0.836	0.836	0.788	0.788	1.079	0.669	0.669	1.220	
	2031	%			1.268	1.268	1.268	1.268	0.853	0.853	0.787	0.787	1.087	0.662	0.662	1.240	
	2032	%			1.294	1.294	1.294	1.294	0.870	0.870	0.787	0.787	1.095	0.655	0.655	1.260	
	2033	%			1.319	1.319	1.319	1.319	0.888	0.888	0.787	0.787	1.102	0.648	0.648	1.280	
	2034	%			1.346	1.346	1.346	1.346	0.905	0.905	0.786	0.786	1.110	0.641	0.641	1.300	
	2035	%			1.373	1.373	1.373	1.373	0.923	0.923	0.786	0.786	1.118	0.634	0.634	1.320	



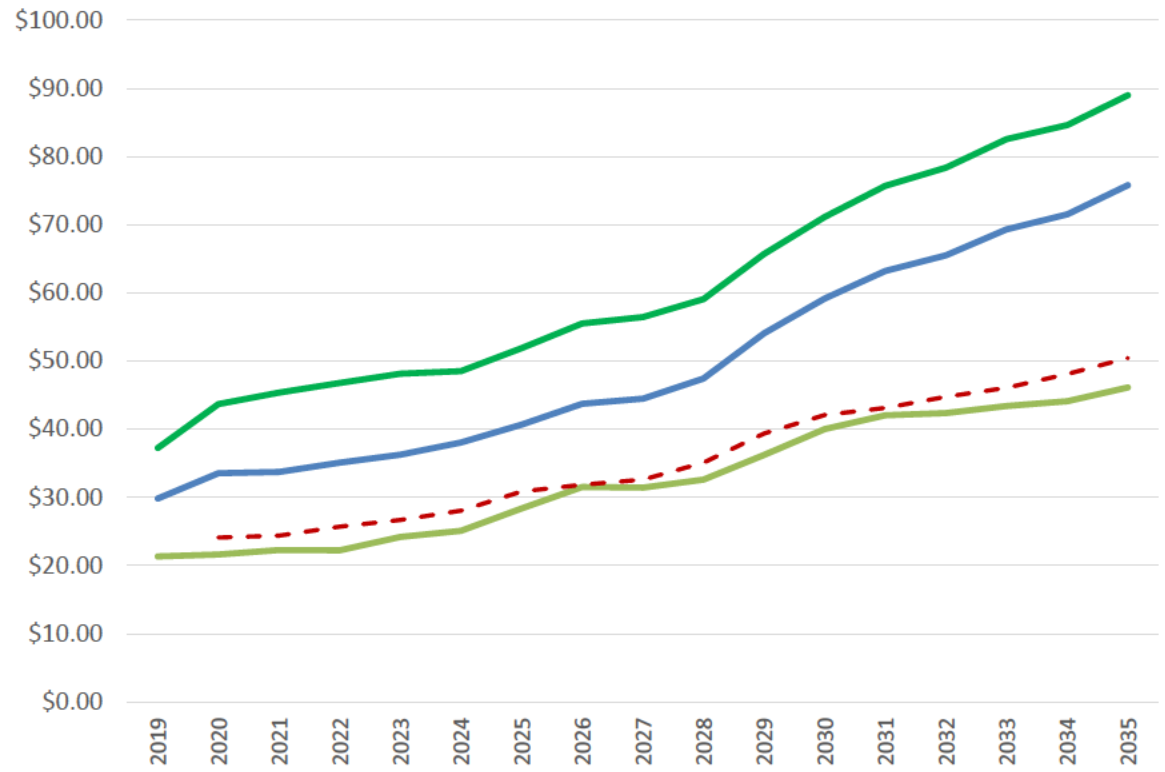
Market Assumptions

Permian Natural Gas (\$/MMBtu)



— M1-Base with Carbon Price — M2-High Carbon
— M3-Low No Carbon - - - PIRP Permian Pricing

Palo Verde Market (\$/MWh)



— M1-Base Carbon — M2-High Carbon
— M3-Low No Carbon - - - PIRP Palo Verde Pricing



CO₂ Pricing

Carbon Prices

	Carbon Price (\$/short ton)
	Federal Carbon Tax
	nominal
2028	2.40
2029	4.89
2030	7.48
2031	10.17
2032	12.97
2033	15.87
2034	18.89
2035	22.02

PORTFOLIO CONSTRUCTION

LEE ALTER,
LEAD SUPPLY SIDE PLANNER



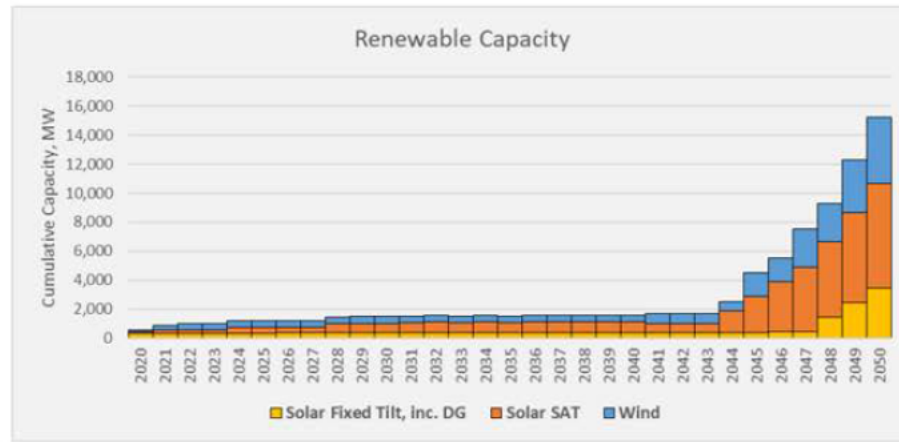
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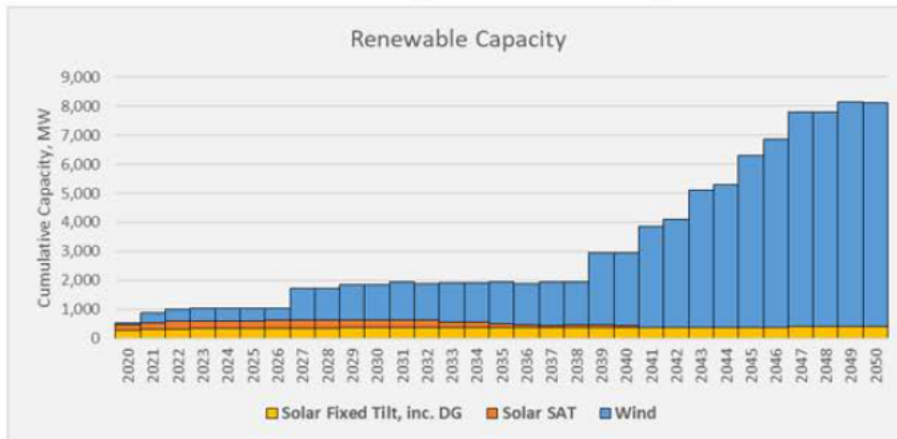
Capacity Expansion

Effect of Two Basic Aurora Settings on Capacity Expansion Results: [Renewable Capacity](#)

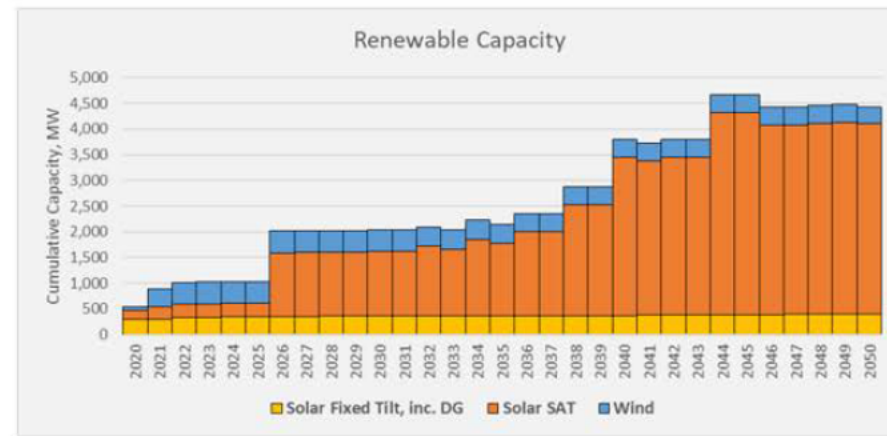
Base Case



Increase Planning Reserve Margin to 15%



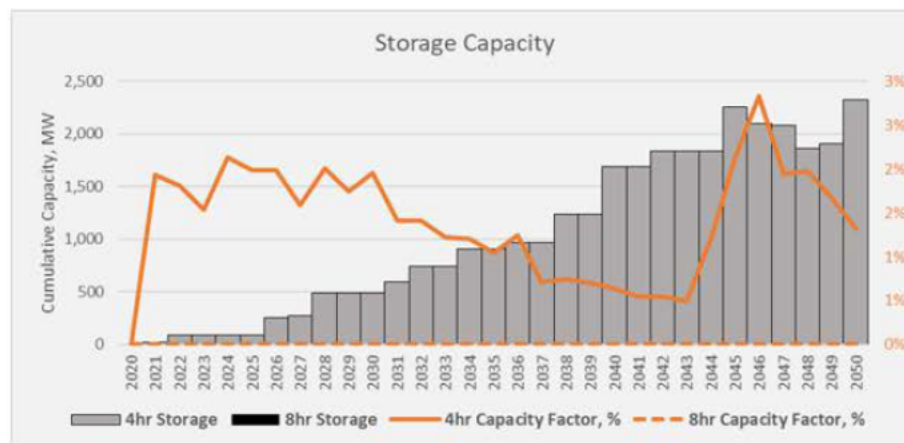
Reduce Dispatch Sampling Frequency



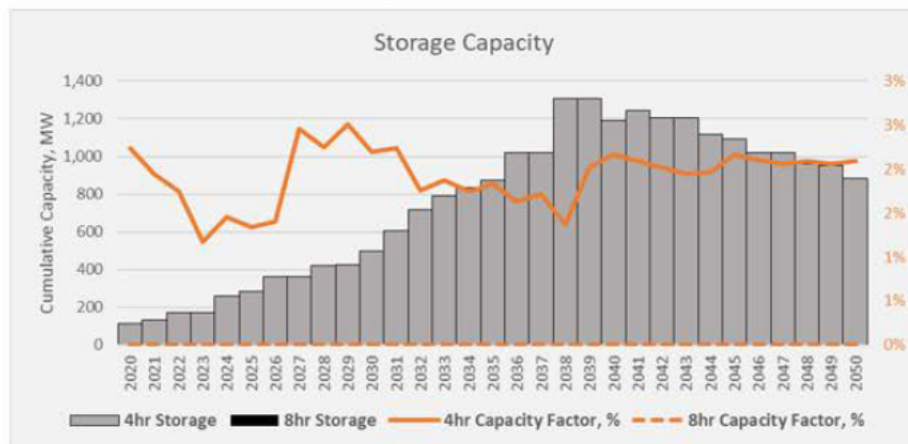
Capacity Expansion Cont.

Effect of Two Basic Aurora Settings on Capacity Expansion Results: Storage Capacity

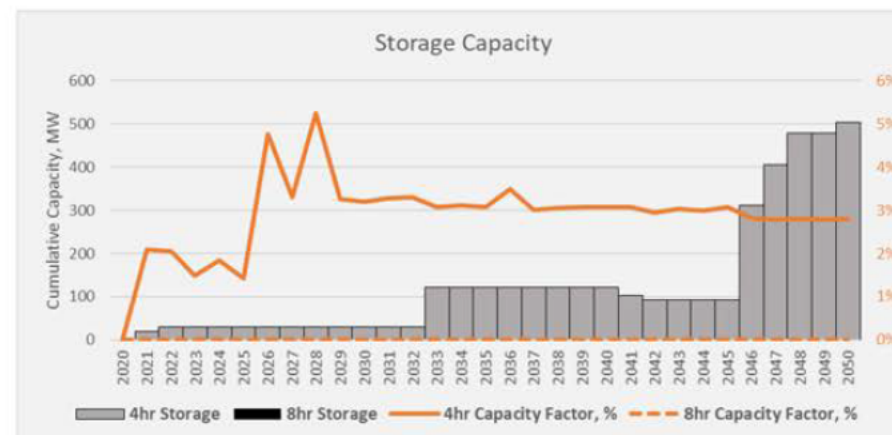
Base Case



Increase Planning Reserve Margin to 15%



Reduce Dispatch Sampling Frequency



Portfolio Builder

High-Level Inputs and Outputs of TEP Spreadsheet Used to Estimate Renewable and Storage Capacity Needed to Achieve Alternative Policy Goals

Inputs	2028	2035	2050
New Solar, MW	550	650	6,000
New Wind, MW	250	250	3,000
Summer Fossil-Fired Capacity, MW	2,128	1,914	0
Inputs			
Existing Storage Capacity, MW	30	30	0
Existing Storage Energy, MWh	120	120	0
New Storage Capacity, MW	150	650	3,600
Hours	4	4	10
New Storage Energy, MWh	600	2,600	36,000
Total Storage Capacity, MW	180	680	3,600
Total Storage Energy, MWh	720	2,720	36,000
Output			
Retail Sales Served by RE	49.5%	45.3%	115.9%
Shortfall Hours	5	17	54
(as percent of all hours)	0.1%	0.2%	0.6%
Shortfall Energy, GWh	0	3	65
(as percent of generation requirements)	0.0%	0.0%	0.4%
Shortfall Capacity, MW	128	486	2,744
Renewable Curtailment, GWh	302	7	13,513
(as percent of RE generation)	6%	0%	46%

OVERVIEW OF RESULTS

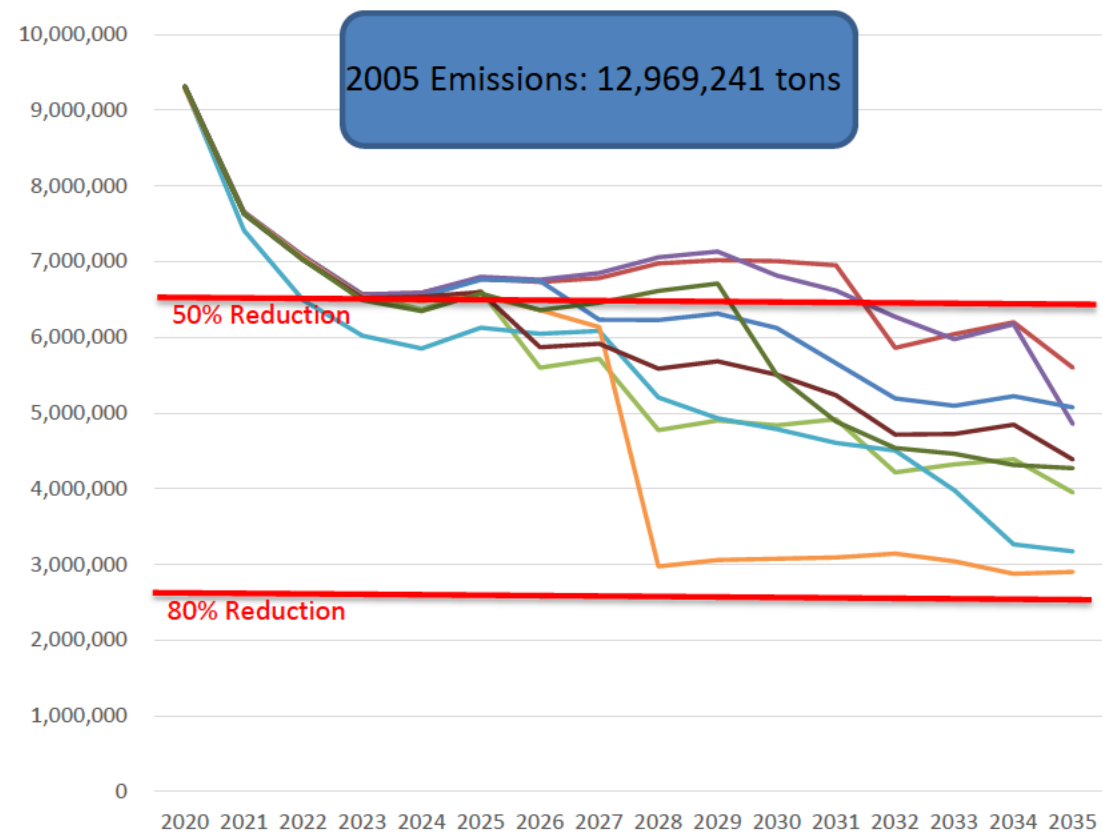


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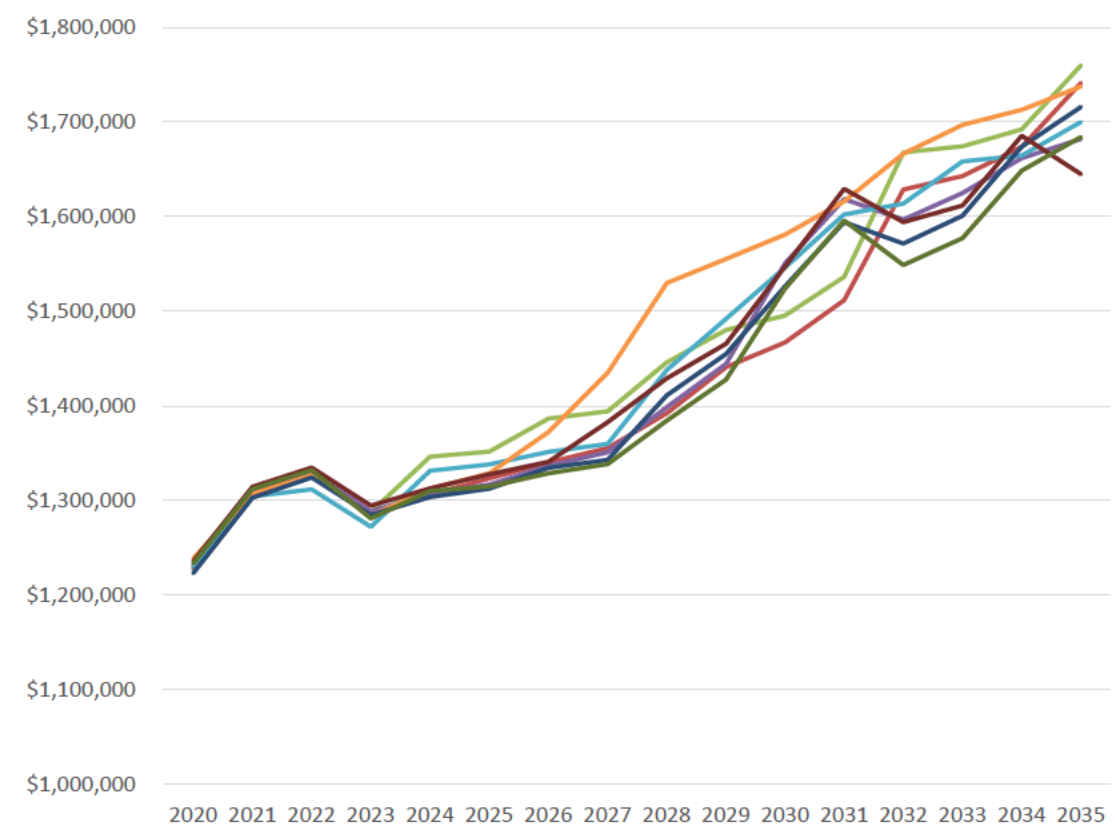
Portfolio Results

Annual CO₂ Emissions (tons)



- P01aL1M1E1
- P02aL1M1E1
- P06aL1M1E1
- P16aL1M1E1
- P08aL1M1E1
- P10aL1M1E1
- P09aL1M1E1
- P09bL1M1E1


Annual Revenue Requirement (\$000)



- P01aL1M1E1
- P02aL1M1E1
- P06aL1M1E1
- P16aL1M1E1
- P08aL1M1E1
- P10aL1M1E1
- P09aL1M1E1
- P09bL1M1E1



Portfolio Dashboards and Data



Portfolio ID: P01aL1M1E1
Date: 3/23/2020 11:25:25 PM

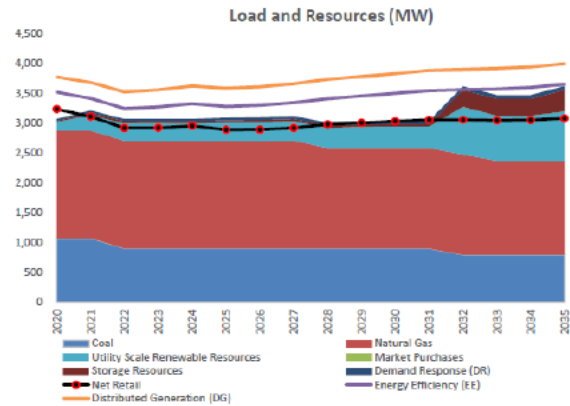
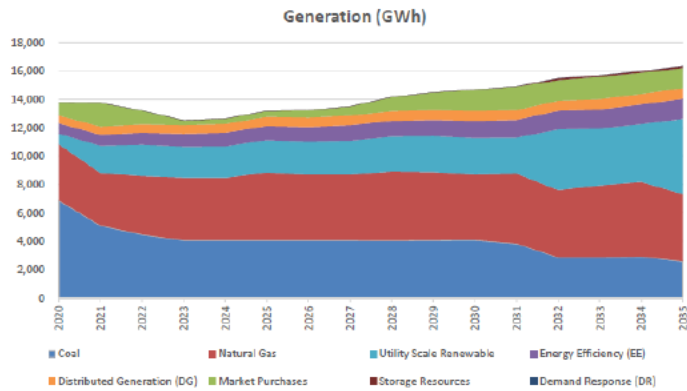
PRELIMINARY DRAFT - For Discussion Purpose Only

Portfolio Description

- Renewable energy is 30% of sales by 2030, begins increasing to 80% by 2050.

Reference Case Description

Retirements		
Plant/Unit	MW	Year
San Juan Unit 1	170	2022
Noth Loop Units 1-3	71	2027
Sundt CT Units 1-2	50	2027
Four corners Units 4 and 5	110	2031
Sundt Steam Unit 3	104	2032
Sundt Steam Unit 4	156	2037



Portfolio Description: **P01aL1M1E1**

Preliminary and For Discussion Puposes Only. Do Not Quote or Cite

Portfolio Changes

	MW	2020	2021	2022	2023	2024
Total Coal		0	0	(170)	(170)	(170)
Total Gas		0	0	0	0	0
Renewable Energy		0	345	453	452	450
Battery Storage		0	30	30	30	30

Financial

NPV Through 2035 (\$000)

	2020	2021	2022	2023	2024
\$14,165,458 Total Revenue Requirements	\$ 1,228,069	\$ 1,307,399	\$ 1,328,425	\$ 1,287,265	\$ 1,306,488
Total Bill impact c/kWh	13.69 c/kWh	14.46 c/kWh	14.59 c/kWh	14.03 c/kWh	14.13 c/kWh
Weighted Average Cost of Capital (WACC)	6.49%				
Enter Last Year for NPV:	2035				

Environmental

Cumulative Through 2035

	2020	2021	2022	2023	2024
95,870,154 Direct CO2 Emissions, tons	9,087,070	7,249,124	6,841,831	6,492,625	6,501,295
3,920,184 Purchased Power CO2 Emissions, tons	230,608	401,615	229,346	70,628	82,477
99,790,339 Total CO2 Emissions, Tons	9,317,678	7,650,738	7,071,177	6,563,253	6,583,771

GHG EMISSION TARGET UPDATE

BEN MCMAHAN, PHD
WILL HOLMGREN, PHD
UNIVERSITY OF ARIZONA



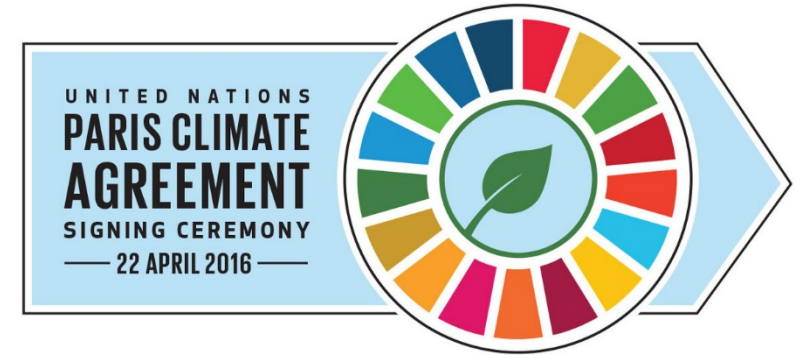
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Pledge to **limit warming to well below 2°C** above pre-industrial levels, with a **target of 1.5 °C**.

US Nationally Determined Contributions (NDCs):

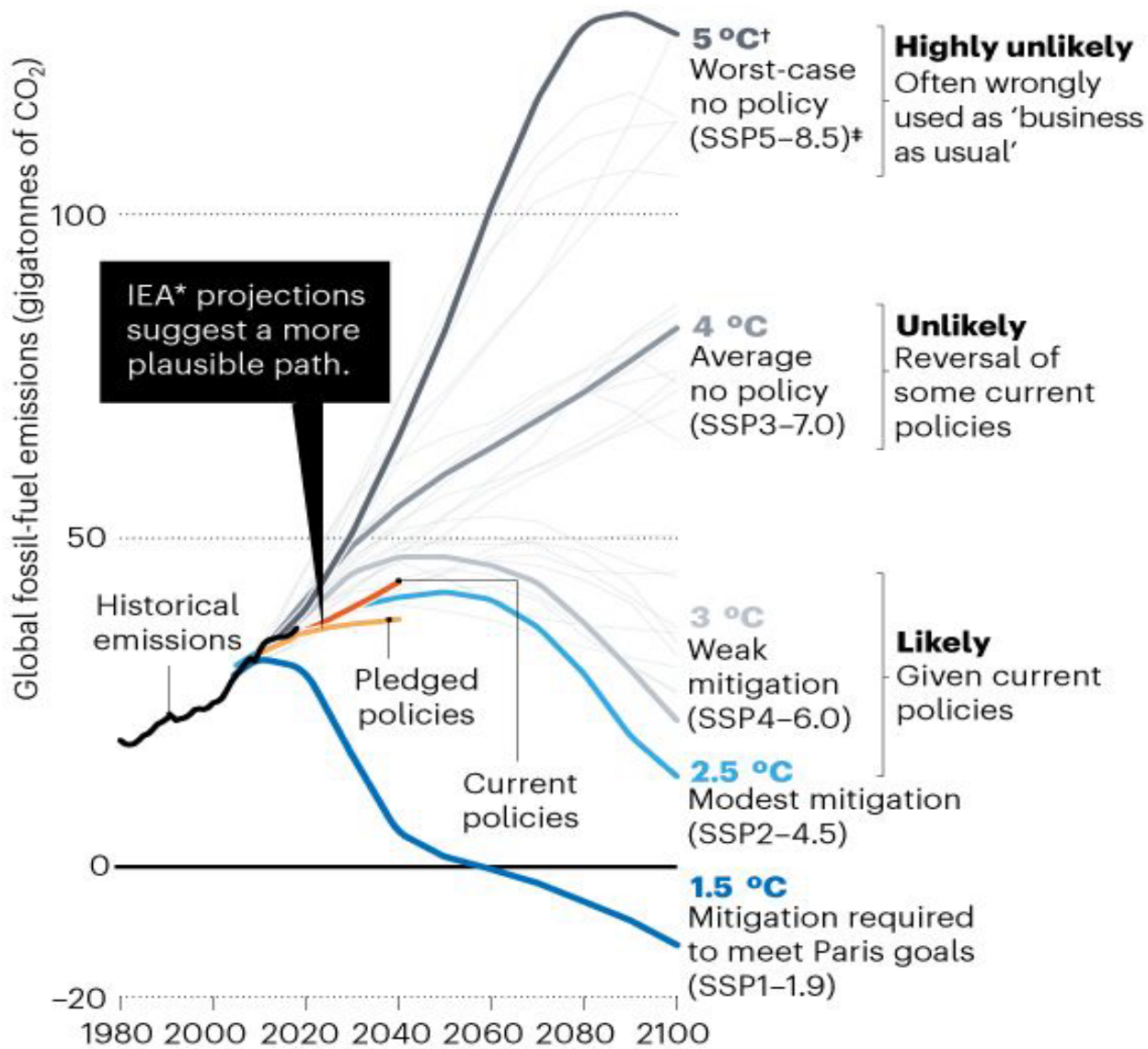
*“The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by **26%-28% below its 2005 level in 2025** and to make best efforts to reduce its emissions by 28%.”*

The NDC was to be followed by “deep, economy-wide” transformations to achieve **80% reductions under 2005 emissions by 2050**.



SCIENCE
BASED
TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION



Source: Hausfather & Peters (2020)

<https://www.nature.com/articles/d41586-020-00177-3>

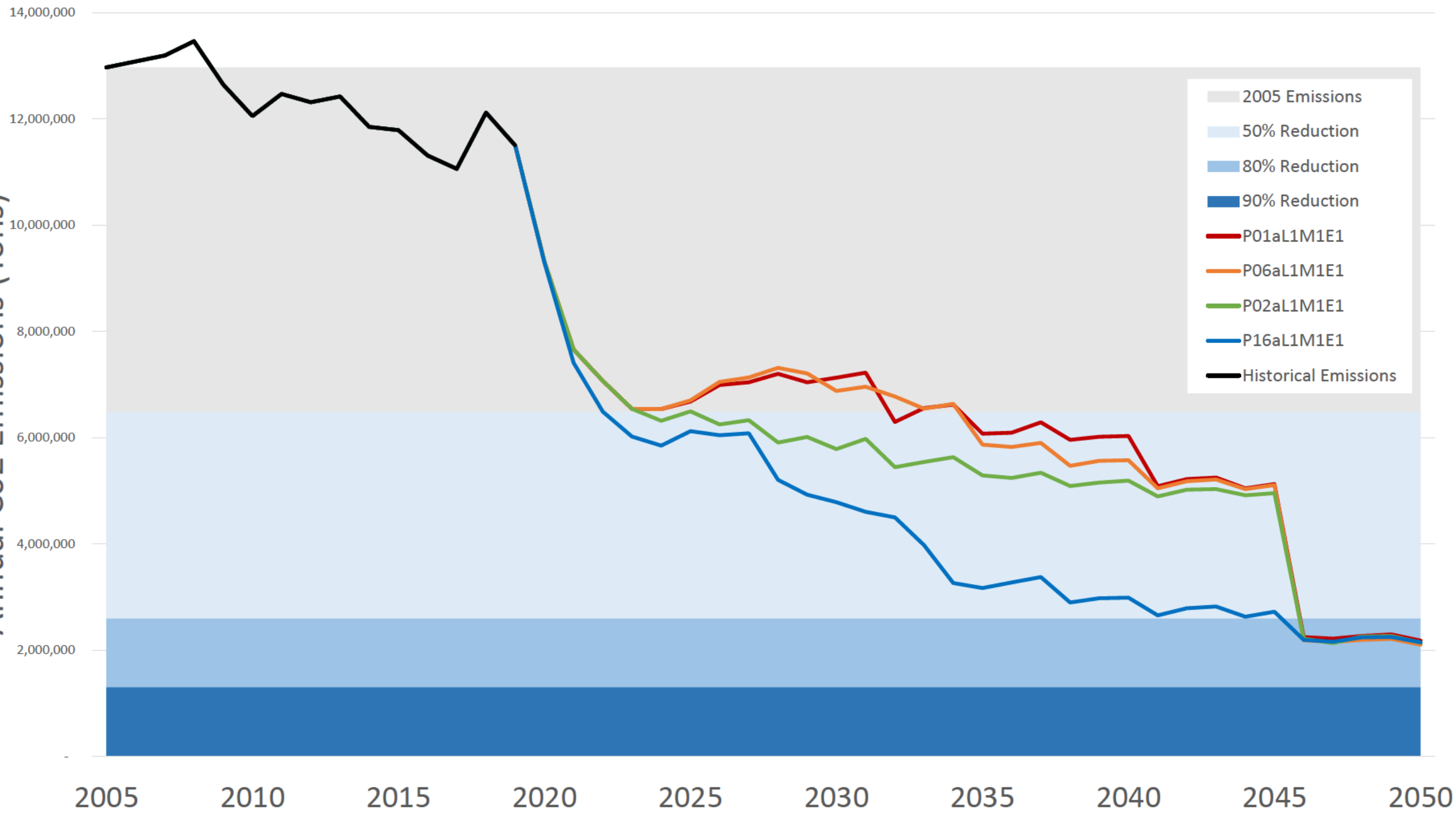
Some progress limiting warming (i.e. GHG reductions are working)

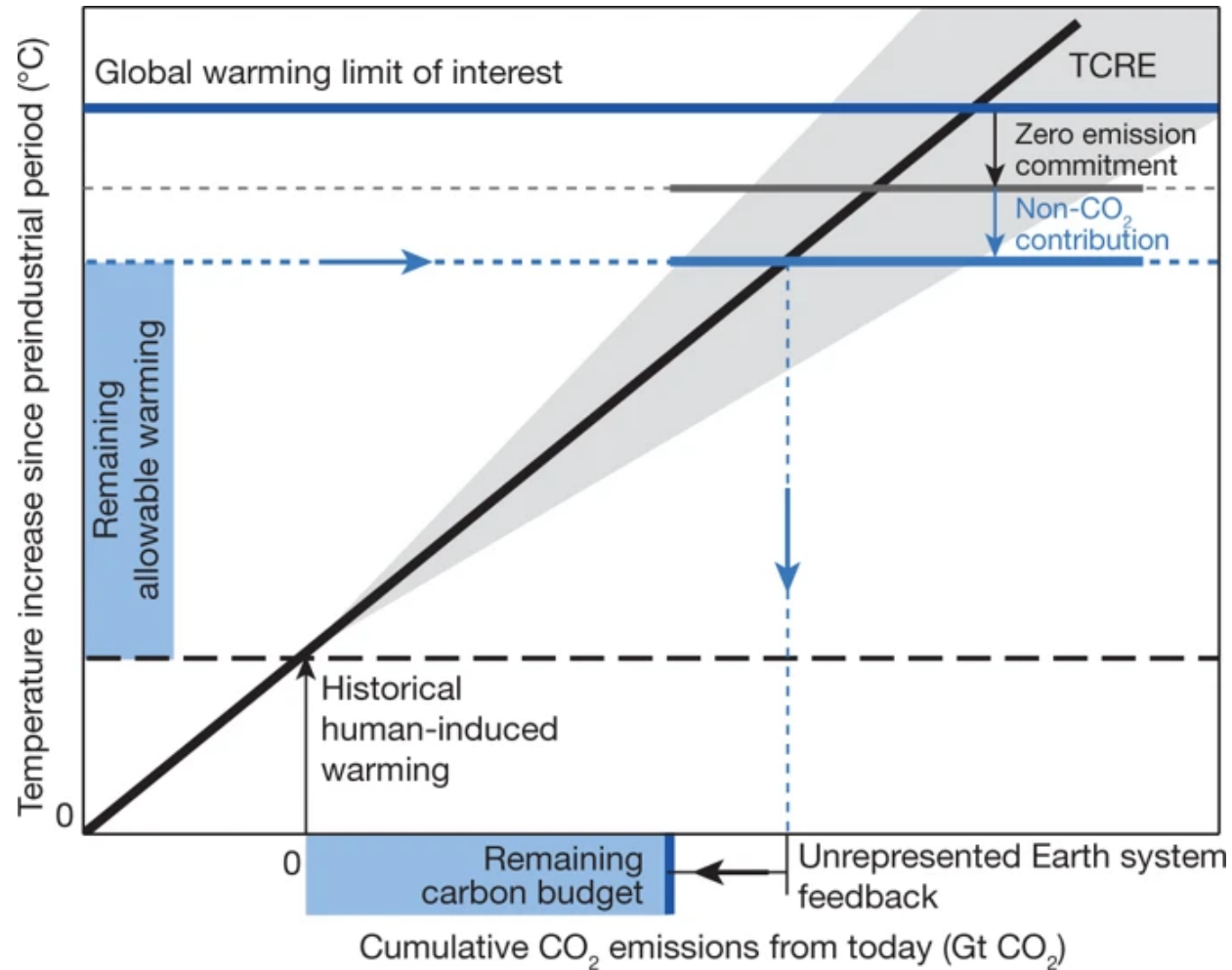
Ample room to improve - 1.5C and even 2C require aggressive action

Sectoral Decarbonization: Utilities

- Reduction Framework
- 80-90% reduction in 2050 emissions by 2050 (well below 2C)
- Negative Emissions/CCS (1.5C)

Annual CO2 Emissions (Tons)





(Remaining) Carbon Budget

Given known role of CO₂ in warming, sets discrete budget for remaining CO₂ emissions given warming targets

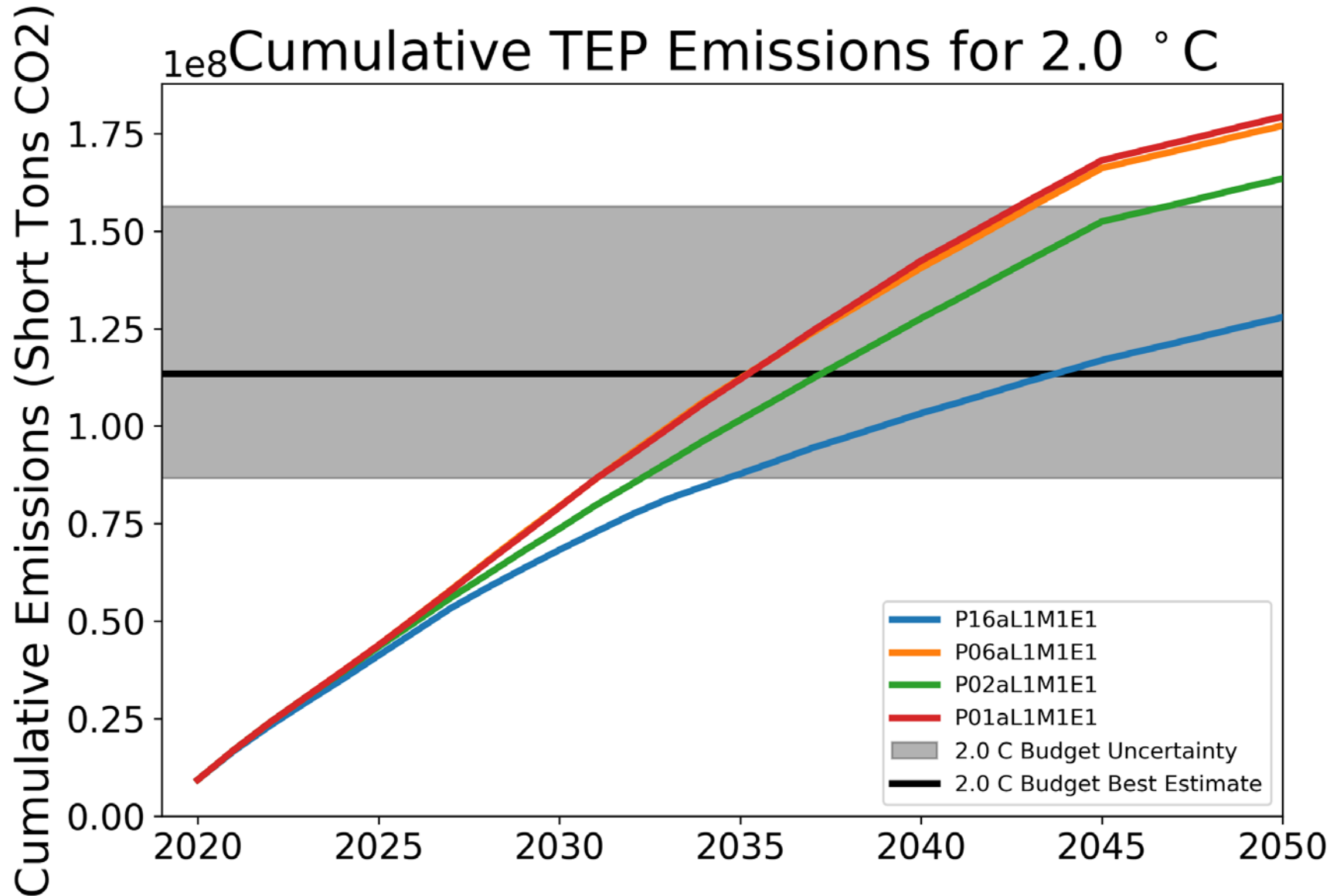
In practice for IRP portfolios

Sets an emissions budget based on national and sectoral share of cumulative CO₂ emissions for warming targets (1.5C, 2C, 3C, etc.)

Estimating and tracking the remaining carbon budget for stringent climate targets

Rogelj et. al. (2019)

<https://www.nature.com/articles/s41586-019-1368-z>



Preliminary Example

Still fine-tuning based on estimated parameters

Demonstrates what output will look like, but not final results

Two Key Outcomes

Assess warming targets for each portfolio

Compare portfolios (cost/impact/timing/etc)



Next Steps

- Written Comments to TEP by April 3
 - Including suggestions for Scenario runs
- Revised Portfolios by April 14
- Draft IRP to Advisory Council for Review Mid- to Late-May