

# Coal Replacement Analysis

TEP IRP workshop  
November 2019



# STRATEGEN

Strategen is a mission-driven professional services firm dedicated to decarbonizing the grid

## ASSOCIATIONS

Strategen co-founded and manages the California Energy Storage Alliance (CESA) and the Global Energy Storage Alliance (GESA). Through these organizations, Strategen's policy work has been pivotal in building the energy storage industry in California, the US, and around the world.

## CONSULTING

Since 2005, Strategen Consulting provides analysis and insight to public sector leaders, utilities, developers, and global corporations helping them to achieve transformational and sustainable clean energy strategies.

## EVENTS

Strategen excels in stakeholder engagement, via customized small and large events. Strategen founded Energy Storage North America (ESNA), the largest grid-connected storage conference in North America. ESNA connects over 2000 participants from 30+ countries.

# Study Overview

- Cash-flow analysis of early retirement in 2023 of 11 coal-burning generation units serving Arizona
- Cash-flow analysis of replacing coal-burning units with three alternatives:
  - energy market purchases
  - solar PV & storage plus market purchases
  - wind generation plus market purchases
- Carbon Pricing Risk Assessment
- Estimated securitization of outstanding coal unit debt after early retirement

# Key Inputs

Assumption/Input	Value	Source & Description
Discount Rate	6.78%	Discount rate for Tuscon Electric Power consistent with its 2018 Action Plan 2016
Inflation Rate	1.8%	Based on current inflation rate for the past 12 months (US inflation calculator)
Early Retirement Year	2023	Assuming last day of operations on 12/31/2022

# Unit Data

Plant – Unit	Operating Capacity (MW)	Owner	Online Date	Currently Planned Retirement Date
Apache 3	175	Arizona Electric Power Cooperative Inc.	1979	2035
Coronado 1	380	Salt River Project	1979	None Announced
Coronado 2	382	Salt River Project	1980	None Announced
Craig 2	428	SRP (29%), TSG&T (24%), Platte River (18%), PacifiCorp (19.28%), Xcel (9.72%)	1979	2039
Four Corners 4	770	APS (63%), PNM (13%), SRP (10%), NTEC (7%), TEP (7%)	1969	2038 (APS), 2031 (TEP)
Four Corners 5	770	APS (63%), PNM (13%), SRP (10%), NTEC (7%), TEP (7%)	1970	2038 (APS), 2031 (TEP)
Hayden 2	262	SRP (50%), Xcel (37.4%), PacifiCorp (12.6%)	1976	2036
Springerville 1	387	Tucson Electric Power Company	1985	2040
Springerville 2	406	Tucson Electric Power Company	1990	2045
Springerville 3	417	Tri-State Generation & Transmission Association, Inc.	2006	None Announced
Springerville 4	415	Salt River Project	2009	None Announced
<b>Total</b>	<b>4,792</b>			

# Cash Flow Analysis

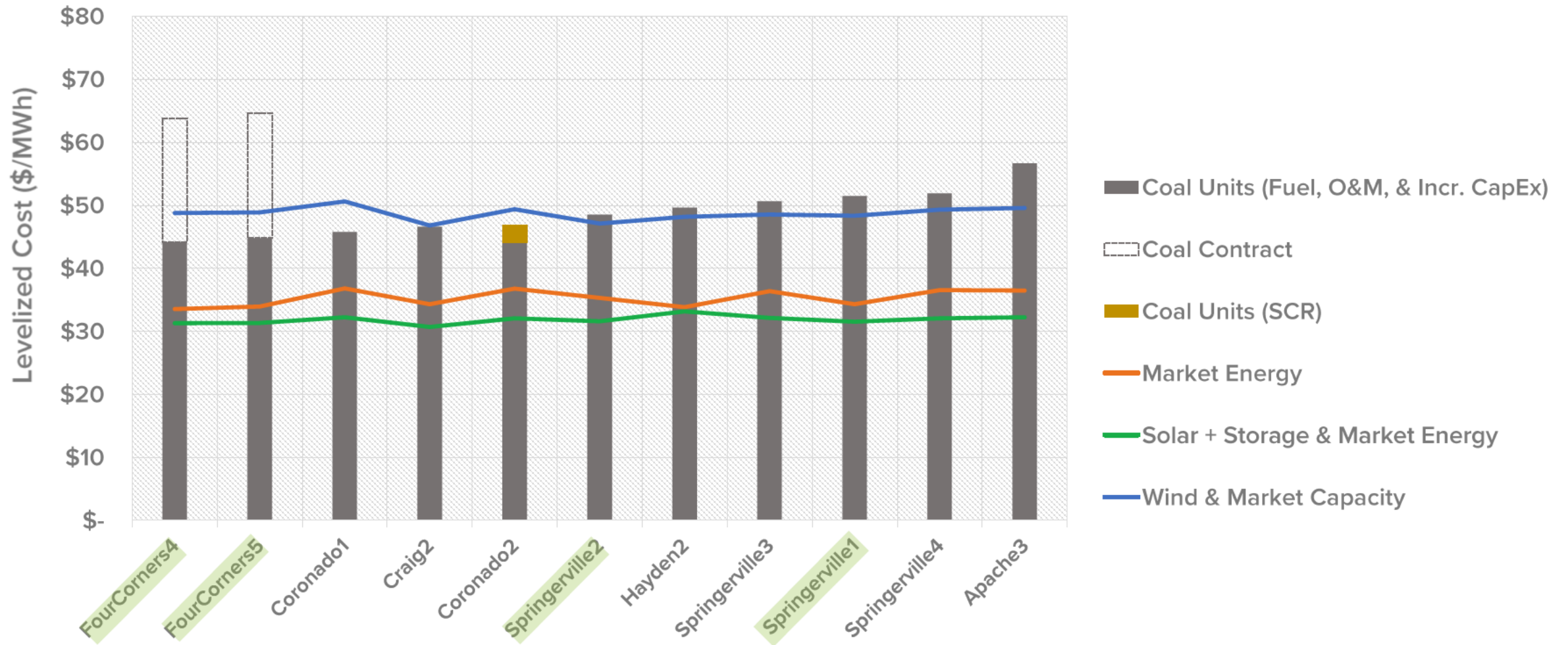
## Coal Fleet Cash Flow Analysis:

- Analysis up to 2050 (or earlier announced retirement date)
- Costs included: fuel, operations and maintenance (O&M, both fixed and variable), incremental new capital expenditures, and dismantling costs

## Replacement Analysis :

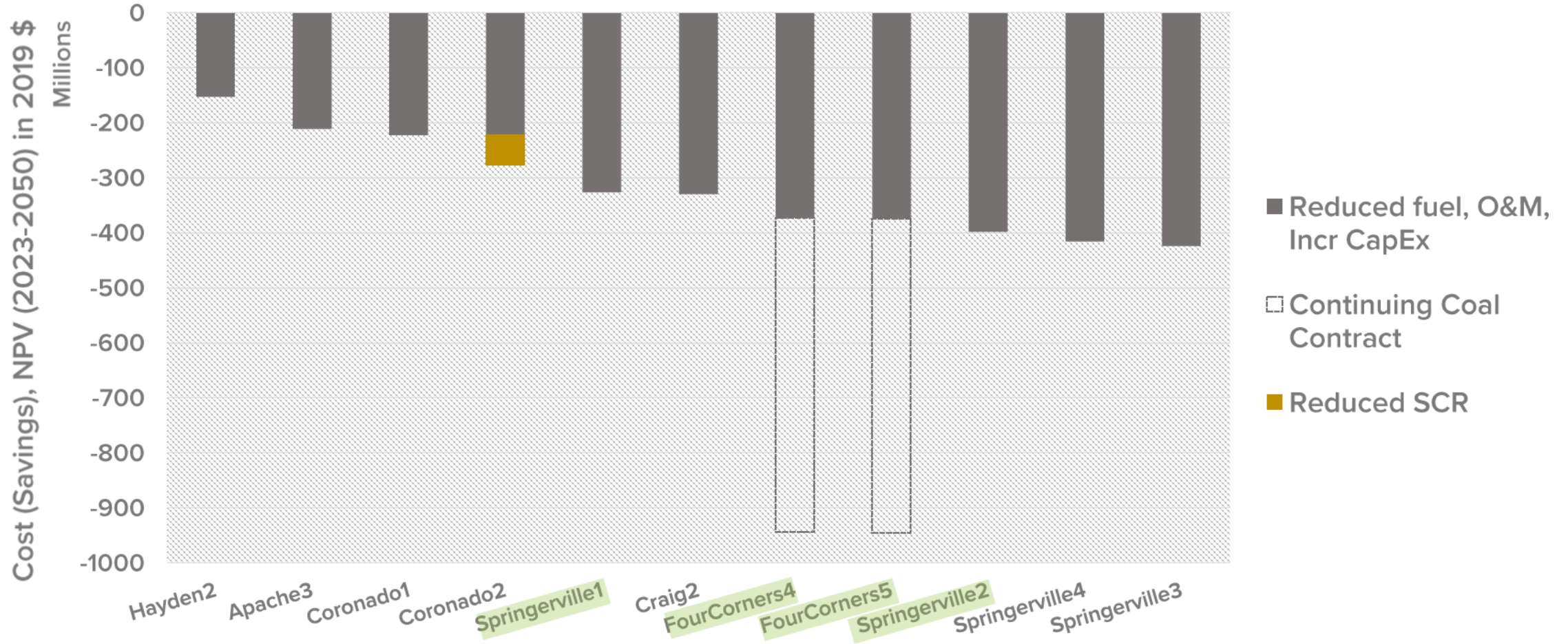
- Forward market purchases:
  - simulated to match hourly coal unit generation
  - prices consistent with that in the Palo Verde Index
- Solar PV + Storage plus market energy purchases:
  - sized to provide equivalent capacity
  - additional market purchases to match hourly coal generation
  - storage dispatch optimized to minimize the cost of additional market purchases
  - storage charging from solar for >75%
- Wind plus market capacity purchases:
  - sized to provide equivalent energy
  - additional market capacity purchases to ensure equivalent capacity

# Levelized Cost of Energy (LCOE) (Equivalent Resource Comparison)



Replacing coal units with a resource providing equivalent energy and capacity (solar & wind) is more economic than the continuing operation of the coal units studied.

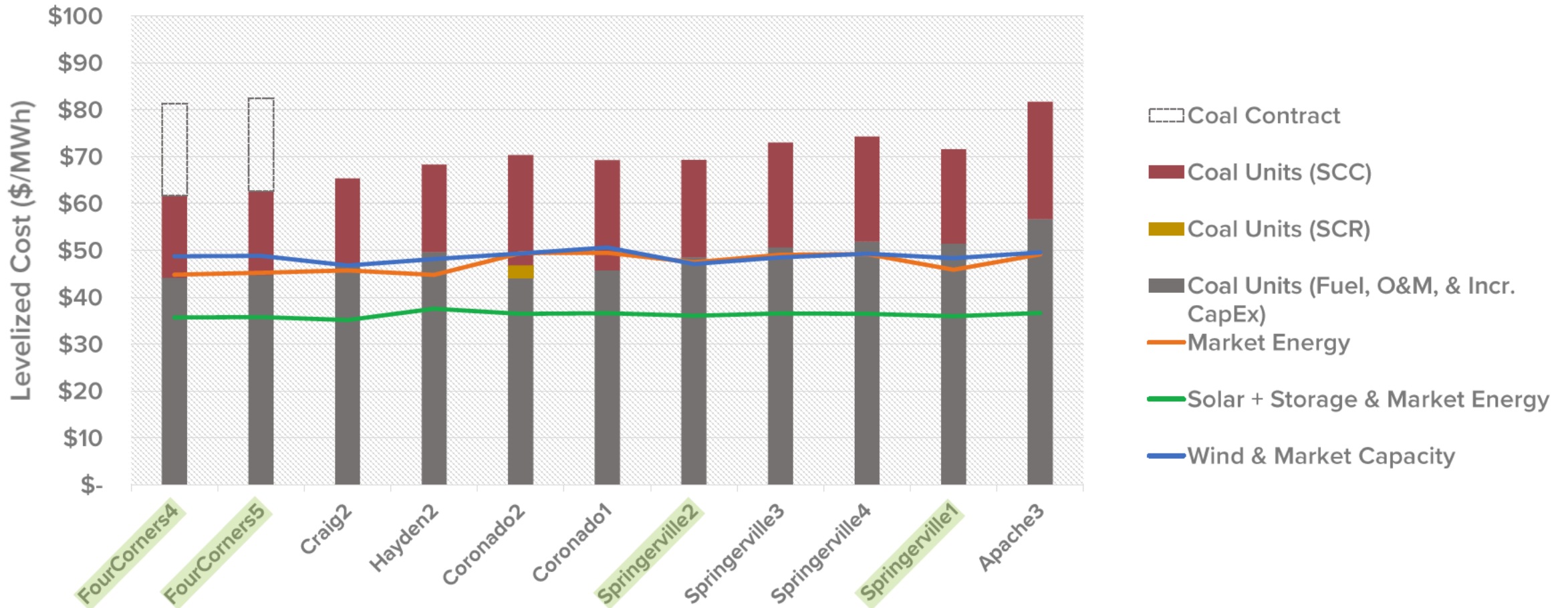
## Costs (Savings) from Replacing Coal-burning Generation with a Solar PV + Storage Resource and Market Energy



Replacing coal units with a Solar PV & Storage resource, complemented with energy market purchases results in net savings of \$3.5 billion.



# Levelized Cost of Energy (LCOE) and Levelized Carbon Cost (Hypothetical Carbon Price)



Accounting for carbon costs dramatically increases the potential savings of coal unit retirement

# Takeaways

			Arizona	TEP
Coal Units			11 units, 4.8 GW	Springerville 1&2, FourCorners 4&5 (7%)
Potential Savings from Replacement (billions, NPV)	Market Energy	O&M, Incr. Capital	\$2.8	\$0.65
		O&M, Incr. Capital, & Carbon	\$5.9	\$1.32
	Solar PV (& Storage)	O&M, Incr. Capital	\$3.5	\$0.78
		O&M, Incr. Capital, & Carbon	\$10.2	\$2.16
	Wind	O&M, Incr. Capital	\$0.3	\$0.07
		O&M, Incr. Capital, & Carbon	\$7.2	\$1.59
Additional Savings from Securitization (illustrative example)			Springerville, Unit 1 \$23 million	

Replacement portfolios were assumed to start operating in 2023.  
 Total Savings include only units for which replacement lead to positive savings.  
 AZ study includes a hypothetical price based on APS IRP carbon analysis.

# Potential TEP Savings (\$ million)

Unit	Solar plus Storage + Market Energy		Market Energy		Wind + Market Capacity	
	Savings (O&M, Incr. Capital )	Savings (Carbon)	Savings (O&M, Incr. Capital )	Savings (Carbon)	Savings (O&M, Incr. Capital )	Savings (Carbon)
FourCorners 4 (TEP)	\$26	\$84	\$22	\$56	\$(9)	\$90
FourCorners 5 (TEP)	\$26	\$85	\$22	\$56	\$(8)	\$90
Springerville 1	\$326	\$469	\$287	\$218	\$53	\$516
Springerville 2	\$398	\$742	\$318	\$342	\$34	\$824
<b>Total</b>	<b>\$777</b>	<b>\$1,380</b>	<b>\$649</b>	<b>\$672</b>	<b>\$69</b>	<b>\$1,521</b>

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Ed Burgess

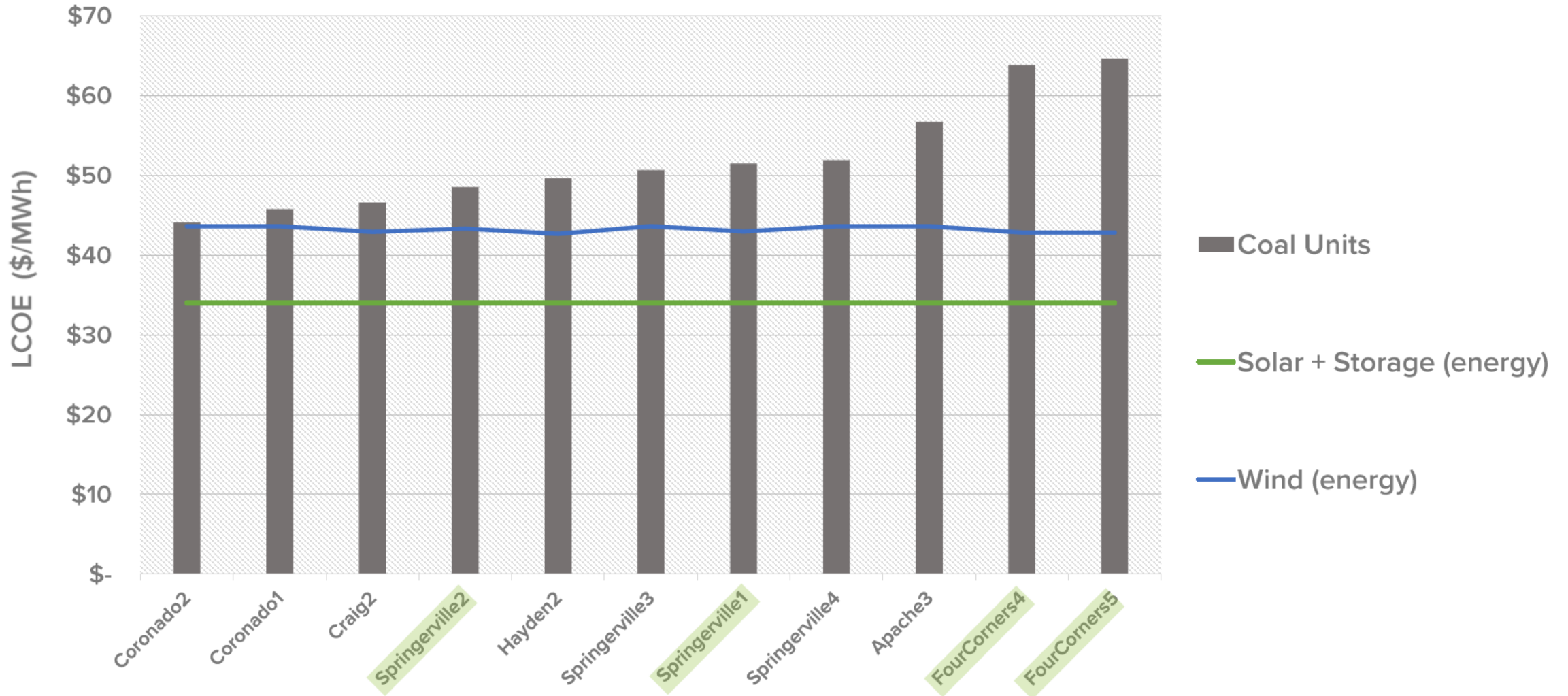
Director

+1 (941) 266-0017

[eburgess@strategen.com](mailto:eburgess@strategen.com)

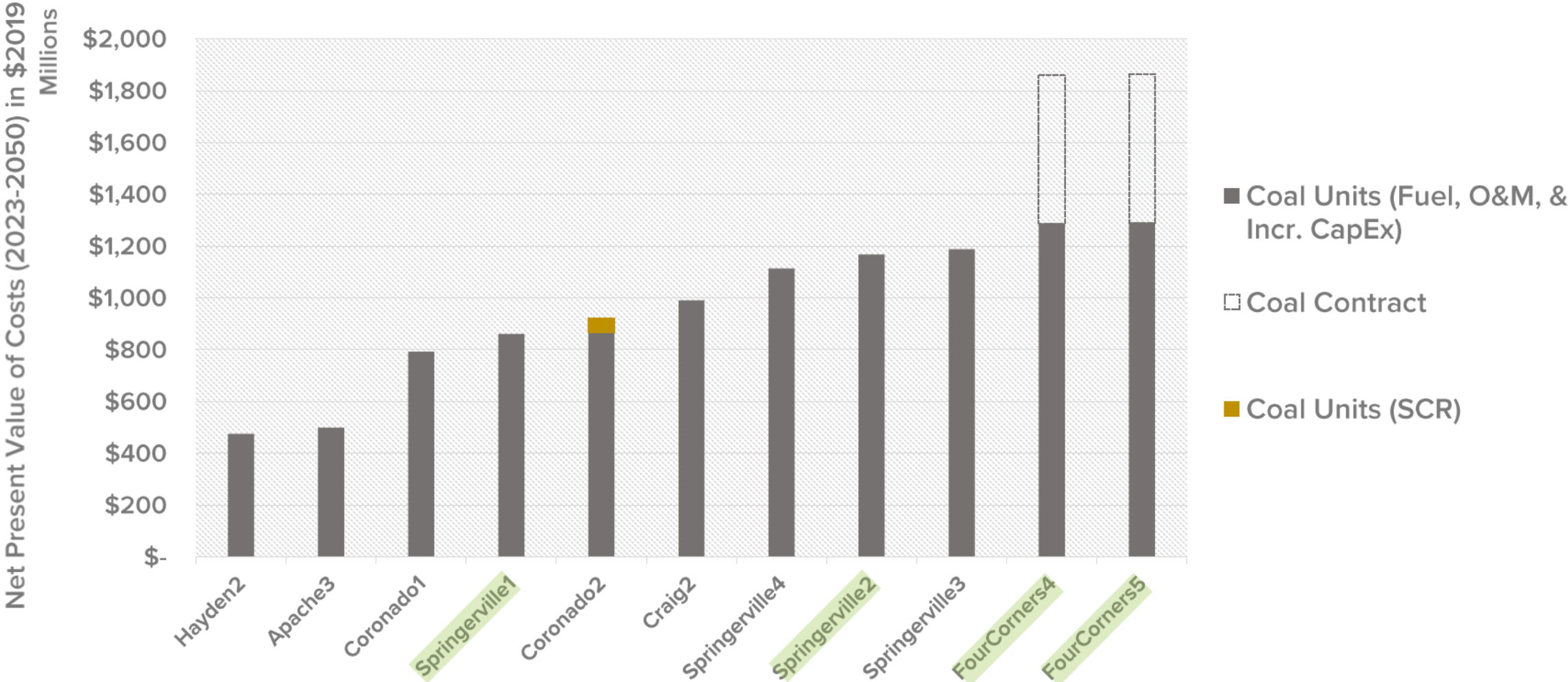
Thank You!

## Levelized Cost of Energy (Simple Comparison)



Recent solar and wind PPA prices are lower than the coal units' projected LCOE

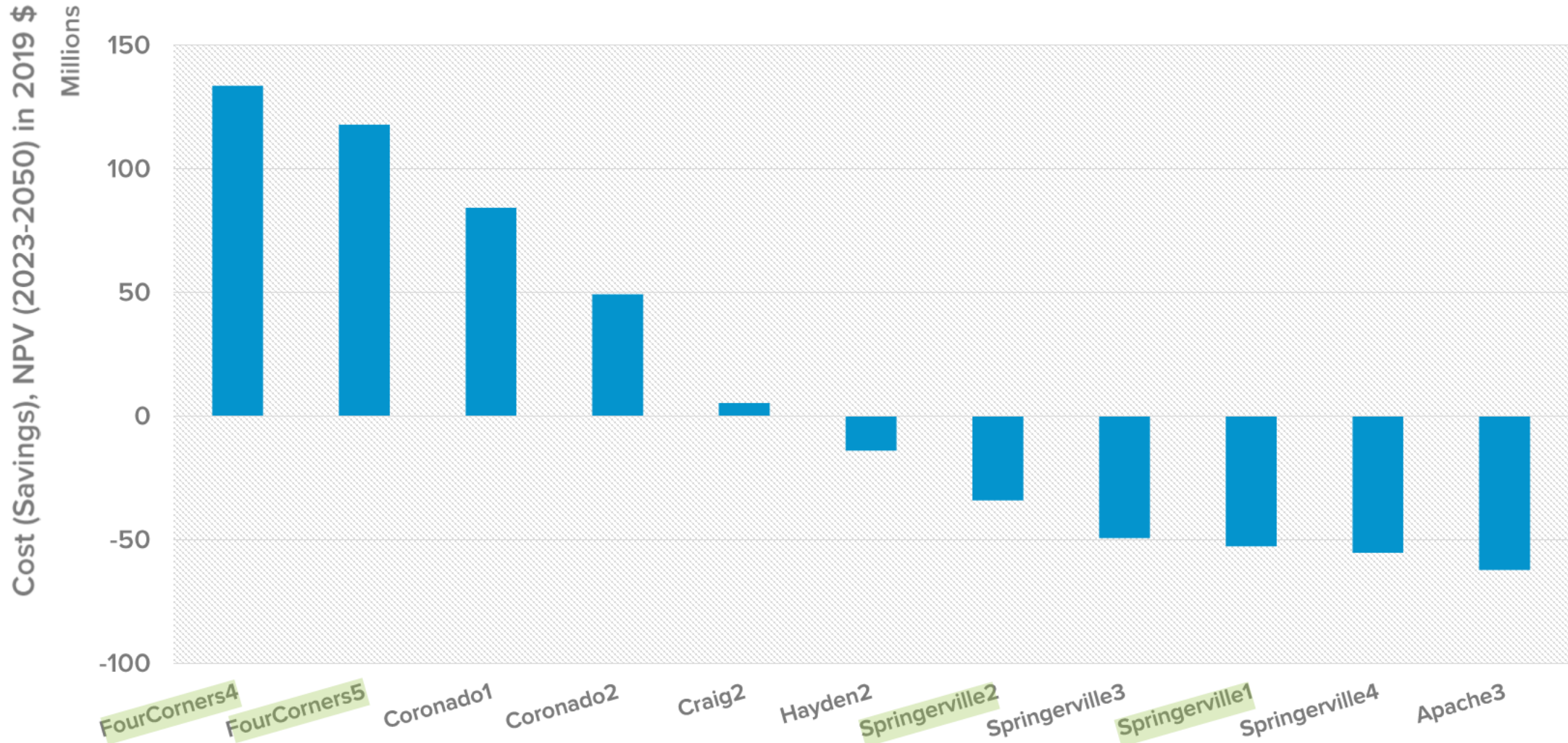
# Avoided Cost of Arizona Coal-burning Generation in case of retirement



**Early retirement of the 11 units serving Arizona results in avoided costs of \$10.6 billion.**

Avoided costs do not account for the cost of the replacement resource.

# Costs (Savings) from Replacing Coal-burning Generation with Wind



Replacing coal units with a wind resource, complemented with capacity market purchases results in net savings of \$0.3 billion in Arizona.

# Coal Unit Inputs

Assumption/Input	Value	Source & Description
Fuel Costs	Varies by plant	Based on values reported (or modeled) in S&P Global Market Intelligence database. Average of 2016-2018 values adjusted for inflation were assumed in 2019 and escalated at inflation rate for subsequent years.
Variable O&M Costs	Varies by plant	Based on values reported (or modeled) in S&P Global Market Intelligence database. Average of 2016-2018 values adjusted for inflation were assumed in 2019 and escalated at inflation rate for subsequent years.
Fixed O&M Costs	Varies by plant	Based on values reported (or modeled) in S&P Global Market Intelligence database. 2019 values are based on average costs of 2016-2018 adjusted for inflation. Future costs were escalated at inflation rate.
Incremental Capital Costs	\$20-27/kW-yr	Based on EIA NEMS model: \$20/kW-yr. (adjusted for inflation) assumed for plants <30 years and, \$27/kW-yr. (adjusted for inflation) assumed for plants >30 yrs.
Dismantling Costs	Varies by plant	Based on Exhibit B to settlement agreement in Colorado PUC case 16A-0231E for the Craig and Hayden plants. For other units, dismantling costs were assumed to be equal to the per-MW average costs of the Xcel units.
Capacity Factor	Varies by plant	Based on average of 2016-2018 as reported in S&P Global Market Intelligence database
Retirement Date ("Business as Usual" Case)	Varies by plant	Based on utilities' IRPs.

<sup>[1]</sup> See: [https://www.eia.gov/outlooks/aeo/workinggroup/coal/pdf/2016\\_EMM%20Coal%20Workshop%20Presentation%20\(6-13-16\).pdf](https://www.eia.gov/outlooks/aeo/workinggroup/coal/pdf/2016_EMM%20Coal%20Workshop%20Presentation%20(6-13-16).pdf)

<sup>[2]</sup> See: [https://www.dora.state.co.us/pls/efi/efi\\_p2\\_v2\\_demo.show\\_document?p\\_dms\\_document\\_id=852810&p\\_session\\_id=](https://www.dora.state.co.us/pls/efi/efi_p2_v2_demo.show_document?p_dms_document_id=852810&p_session_id=)

<sup>[3]</sup> Arizona Electric Power Cooperative. Accessed at: <https://docket.images.azcc.gov/0000179477.pdf>

Tri-State Generation and Transmission Association, Inc. Accessed at: <https://www.tristategt.org/sites/tristate/files/PDF/resourceplan/2015%20Electric%20resource%20plan.pdf>

Arizona Public Service IRP. Accessed at: <https://www.aps.com/library/resource%20alt/2017IntegratedResourcePlan.pdf>

Tucson Electric Company. Accessed at: <https://www.tep.com/wp-content/uploads/2019/07/TEP-Preliminary-Integrated-Resource-Plan-070119-FINAL-Version-2.pdf>



# Replacement Resource Inputs

Assumption/Input	Value	Source & Description
Solar + Storage PPA	\$33.99/MWh	Based on proposal to Central Arizona Project for a 20-year PPA for 20 MW of solar generation, minimum storage dispatch capability of 17MW, and a total energy capacity of 60 MWh.
Storage Duration	3.5 hours	
Solar PV + Storage Incremental Capacity Value	80% of the nameplate of solar	Assuming a 20% incremental capacity value for utility solar, and a 100% value for solar plus 4 hours of storage, Strategen estimates a conservative 80% capacity value.
Solar Generation Profile	-	NREL's System Advisor Model (1 axis tracking system at the unit location)
Wind Cost	\$18.97/MWh	Sagamore PPA escalating at 2%.
Wind Capacity Factor	44%	Consistent with the analysis presented at APS IRP stakeholder Meeting in April, 2019
Wind Capacity Value (NM)	30%	
Wind Transmission Cost (2019)	\$10/MWh	
Production Tax Credit	40-60%	The Sagamore PPA price qualifies for a 100% Production Tax Credit (PTC). However, newer wind projects considered in this analysis would qualify for a lower PTC. The PPA price was thus adjusted upwards by \$11.84/MWh.
Market Energy Prices	Varies	Based on OTC Global Holdings Forward Power Index for Palo Verde as of 30/08/2019.
Capacity Price (2019)	\$39.48/kW-yr	Blended cost between short- and long- term cost of a gas resource according to APS IPR 2017 & 2019 (preliminary).

<sup>1</sup> See: <https://www.cap-az.com/documents/meetings/2019-05-02/1754-050219-WEB-Final-Packet-Board-Meeting.pdf>

<sup>2</sup> Direct Testimony of David T. Hudson on behalf of Southwestern Public Service Company, Case No. 17-00044-UT. Accessed at: <http://164.64.85.108/infodocs/2017/3/PRS20236617DOC.PDF>.

# Carbon Pricing Risk Assessment Inputs

Assumption/Input	Value	Source & Description
Carbon price (2025)	\$16/metric ton	Based on APS's IRP carbon assumption, which is based on California price, and begins in 2025.
Escalation rate	2.5%	
Discount Rate	3%	Used only for computing the net present value of the cost of carbon portion of the analysis.

[!\[\]\(abb44ace9219d58e63915b19b4fbcaee\_img.jpg\) APS IRP Stakeholder Meeting, April 2019. Accessed at: \[https://www.aps.com/library/resource%20alt/April-4-2019-IRP%20Workshop\\\_F.NAL.pdf\]\(https://www.aps.com/library/resource%20alt/April-4-2019-IRP%20Workshop\_F.NAL.pdf\)](https://www.aps.com/library/resource%20alt/April-4-2019-IRP%20Workshop_F.NAL.pdf)