Predicting the Variability of **Economic Performance**

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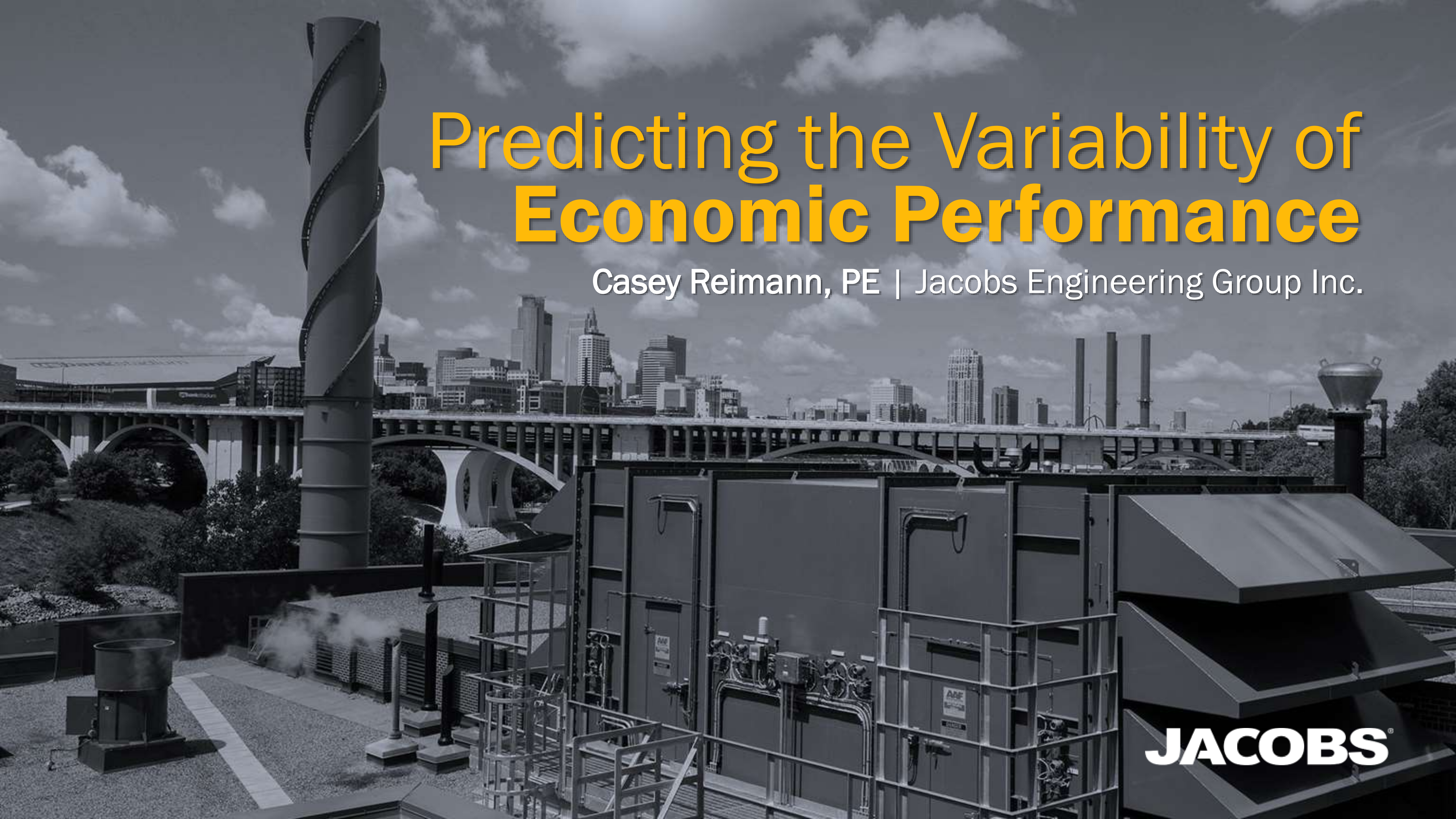

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Right Sizing Process

Develop Load Profiles → **Heat Balance Modeling** → **Financial Analysis** → **Sensitivity Analysis**

Analyze financial performance of a proposed solution against **unforeseen fluctuations**

Value in Predicting Economic Performance

Mitigate…

Reaffirm optimal plant layout

Identify critical variables

Sensitivity

Knowledge

Variables that Affect Performance

DOE escalation rates

Electricity cost

Capital cost

Availability

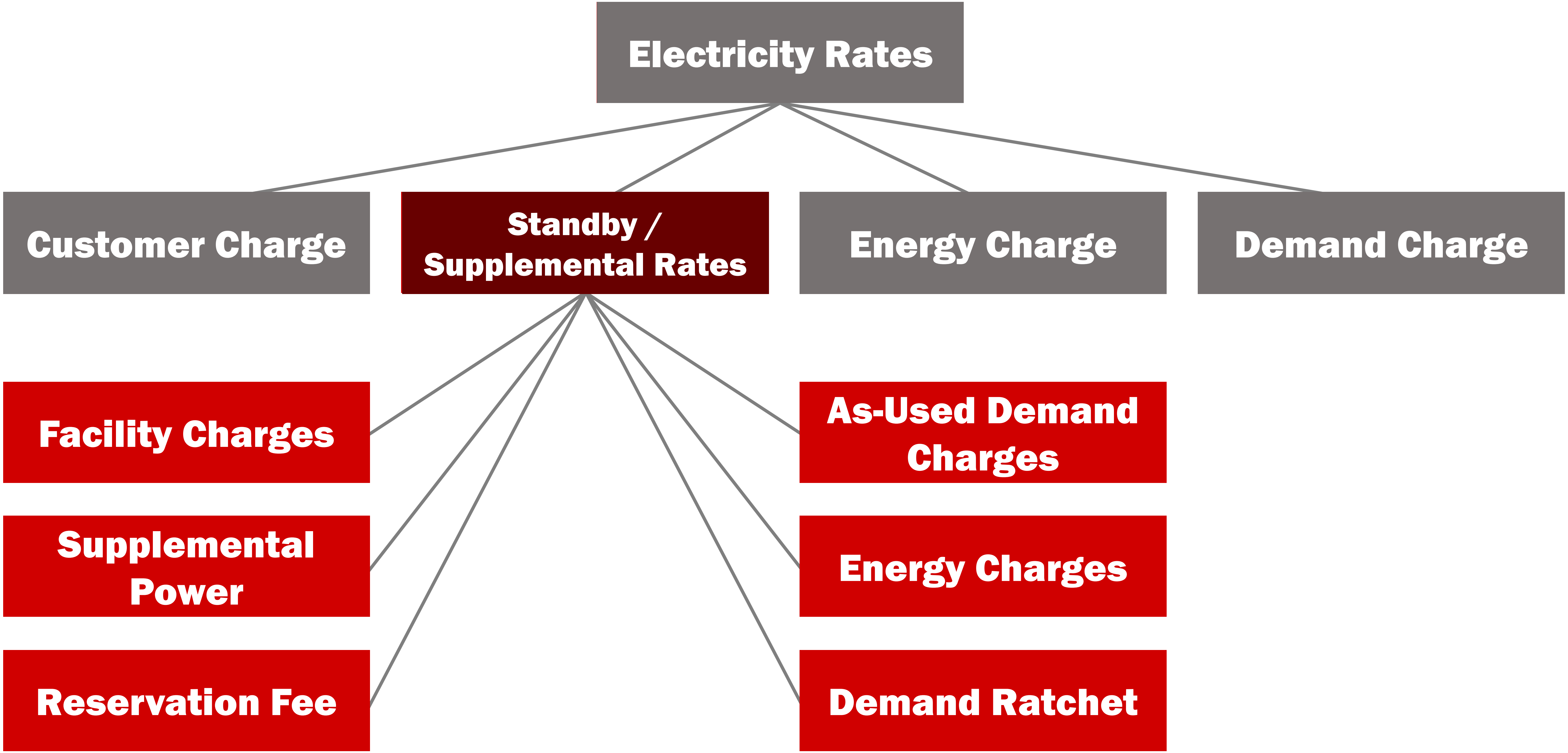
Fuel cost

DOE Escalation Rates

Year	Nat Gas	Electric	Fuel Oil
2027	-0.26%	0.23%	1.01%

Published rates are **projections**

Florida Utility Rate Escalations (based on DOE Projections, Excludes Inflation)			
Year	Nat Gas	Electric	Fuel Oil
2019	9.04%	1.57%	2.69%
2020	3.51%	1.75%	13.39%
2021	1.51%	0.88%	8.86%
2022	1.67%	0.94%	2.96%
2023	1.64%	0.20%	1.63%
2024	1.35%	0.73%	1.46%
2025	1.51%	0.46%	1.11%
2026	0.44%	0.49%	0.46%
2027	-0.26%	0.23%	1.01%
2028	0.00%	-0.26%	1.31%
2029	-0.96%	-0.16%	1.52%
2030	1.50%	0.20%	1.14%
2031	1.47%	0.49%	1.39%
2032	1.62%	0.68%	0.94%
2033	1.34%	0.55%	1.02%
2034	0.91%	0.54%	1.22%
2035	1.97%	0.48%	0.75%
2036	2.58%	0.60%	0.50%
2037	2.44%	1.01%	1.64%
2038	2.68%	1.25%	0.89%
2039	4.11%	1.54%	0.80%
2040	1.94%	0.88%	0.75%
2041	1.06%	0.60%	0.79%
2042	1.11%	0.60%	0.23%
2043	1.10%	0.62%	0.16%
2044	1.16%	0.59%	0.04%
2045	1.27%	0.66%	0.16%
2046	1.27%	0.66%	-0.19%
2047	1.27%	0.66%	0.23%
2048	1.27%	0.66%	0.43%
2049	1.27%	0.66%	0.13%


Electricity Rates
Customer Charge
Standby / Supplemental Rates
Energy Charge
Demand Charge
Facility Charges
Supplemental Power
Reservation Fee
As-Used Demand Charges
Energy Charges
Demand Ratchet

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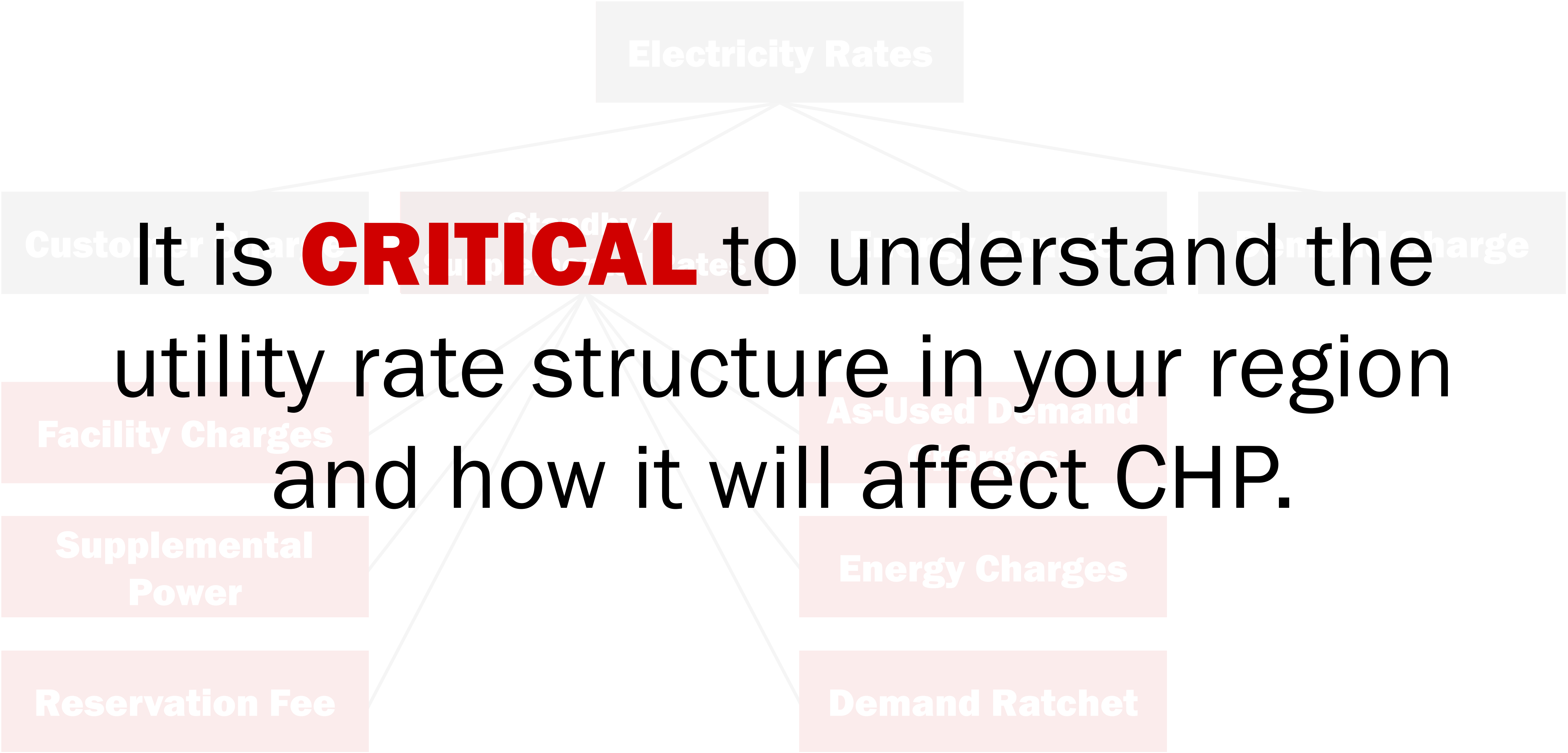

It is **CRITICAL** to understand the utility rate structure in your region and how it will affect CHP.

Standby / Supplemental Rates

Rates are **inconsistent** among utilities

Rates are commonly developed assuming **outages occur at peak times**

Rates impact **operating strategy**

Demand charge ratchet can turn a one-time demand peak into a **long-term fee**

Excessive stand-by rates and other charges will negatively impact the economics of CHP

Standby / Supplemental Rates

Utility Policy	Standby/ Supplemental Rate Description	Impact to CHP
Potomac Electric Power Company Schedule S (2014)	• Charges for demand with a minor reservation fee to secure capacity • Billing demand is based upon a monthly peak demand with no ratchet	**Favorable**
Georgia Power Schedule BU-5 (2018)	• Demand-based and energy charges are on a declining schedule • Billing demand is based upon 30-minute maximum during the month • 12-month ratchet	**Unfavorable**
Texas Public Utility Commission Various Utility Contract Demand Policies (2014)	• No standby rates developed for CHP • Standby rates are negotiated by utilities on a case-by case basis	**Neutral**

Source: ACEE

Capital Cost

Seems like a big deal now, but……

Does not factor heavily compared to efficiency over a life cycle analysis

Capital Cost Case Study

Option	Estimated Installed Costs	Annual Purchased Utility Costs		30-Year Life Cycle Cost	
		Fuel	Electricity	Total	Savings
83% Efficient Steam Boiler	$1,000,000	$3,575,000	$40,269	$121,387,433	N/A
84% Efficient Steam Boiler	$1,100,000	$3,536,981	$39,233	$120,187,375	$1,200,058

100 MMBtu boiler: $1,000,000

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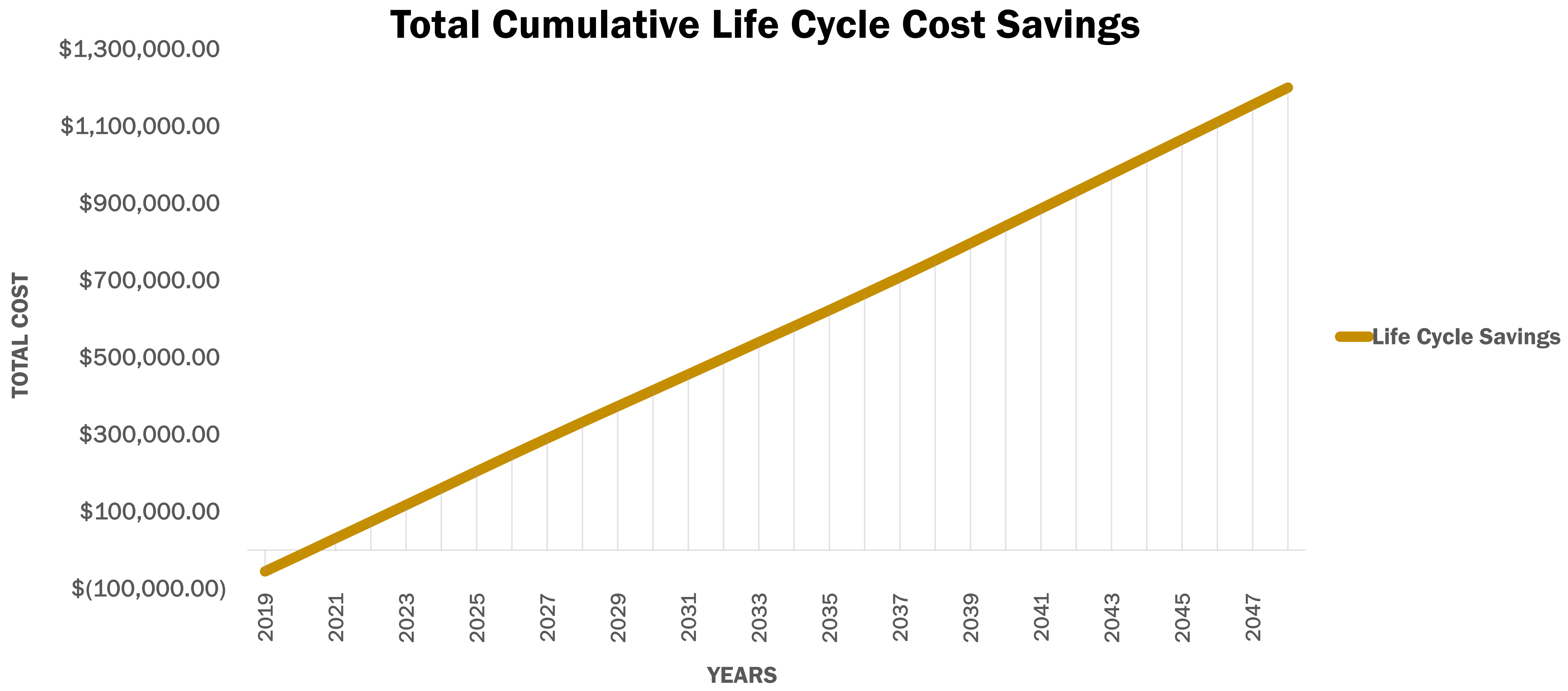
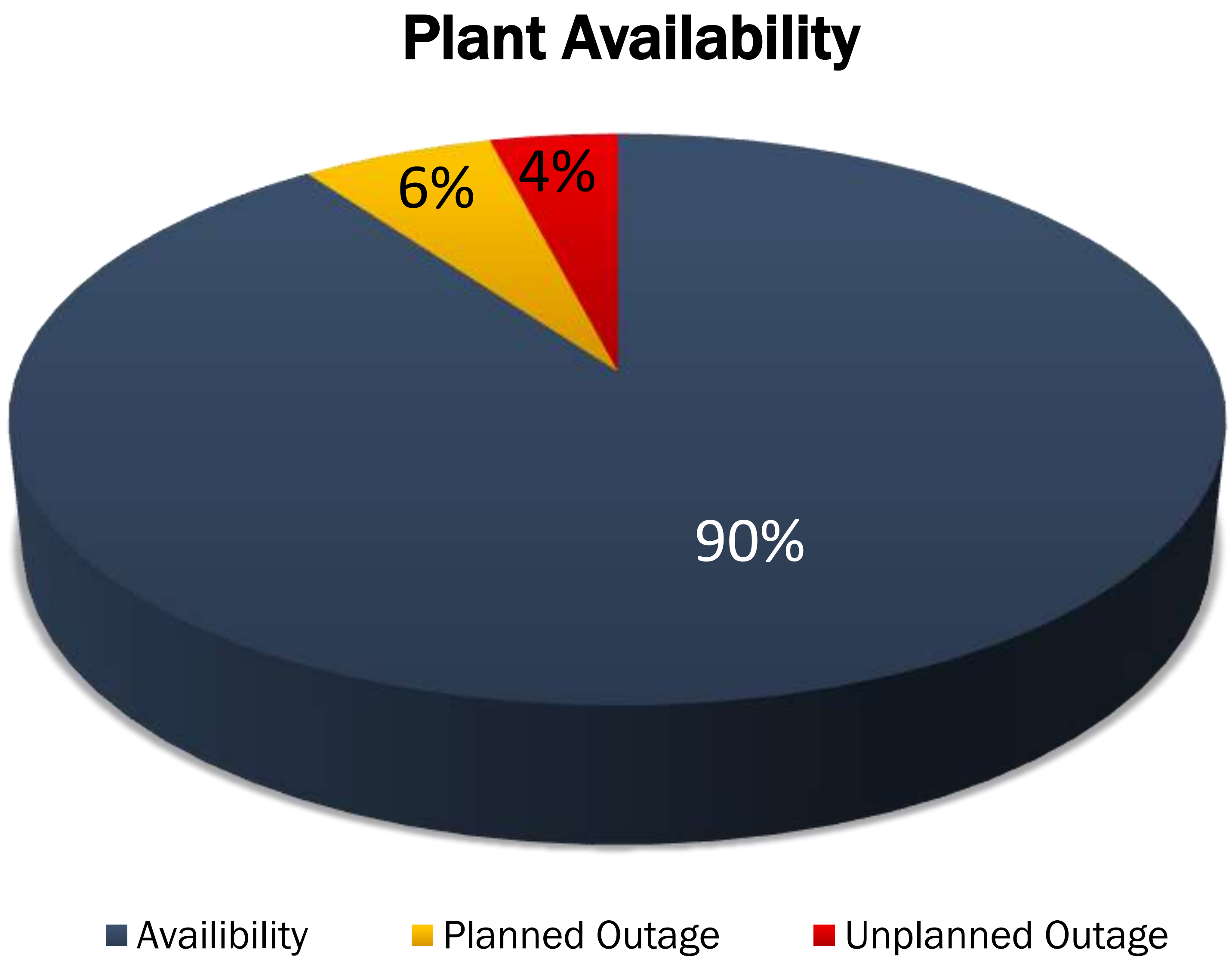
Adding an economizer: Increases **cost** by 10%
Improves **efficiency** by 1%

Capital Cost



Availability: Associating Monetary Value

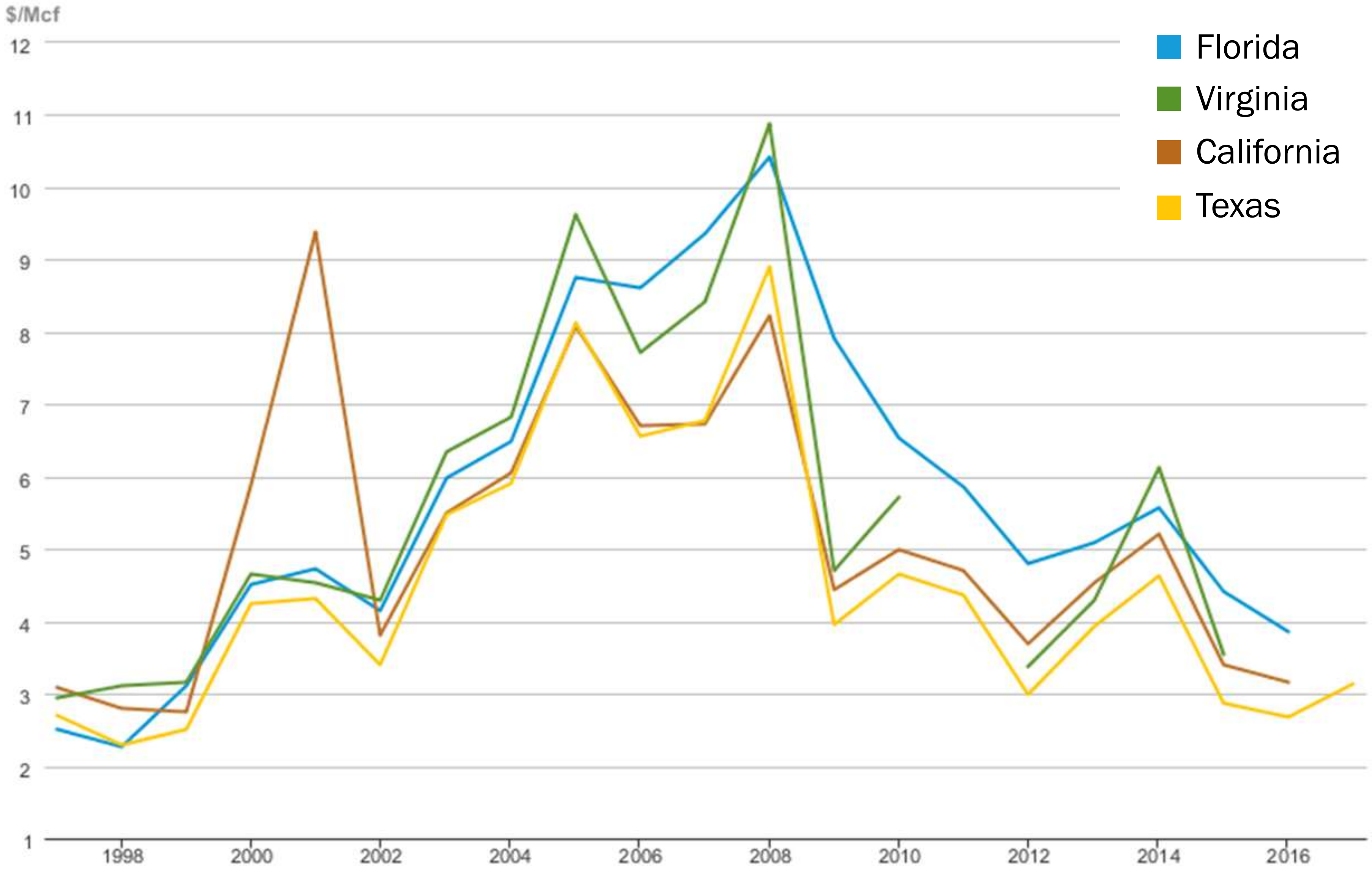


- ✓ Capital cost for redundancy
- ✓ Fuel cost
- ✓ Electric (standby rates)
- ✓ O&M cost

Fuel Cost

- ✓ Fluctuations in fuel prices
- ✓ Flexibility to go offline when it is not economical
- ✓ Firm/ interruptible fuel supplies
- ✓ Curtailment
- ✓ Secondary fuel source
  - ✓ Impacts to Title 5 emission permits

Natural Gas Prices



Source: US Energy Information Administration

Life Cycle Chart

Option	Estimated Installed Costs	Annual Purchased Utility Costs (2018 rates, Current Loads)			Annual O&M Costs	30-Year Life Cycle Cost	
		Fuel	Electricity	Standby Electric		Total	Savings
Baseline (Packaged Boilers)	$203,978,000	$4,380,580	$38,254,718	N/A	$1,983,333	**$1,564,015,040**	N/A
CHP, ~8MW Capacity	$219,787,000	$5,958,995	$33,736,345	$1,199,473	$2,556,435	**$1,559,276,337**	$4,738,703
CHP, ~13MW Capacity	$223,819,000	$6,884,897	$31,058,311	$1,487,964	$2,768,891	**$1,532,631,240**	$31,383,800
Combined Cycle, ~25MW Capacity	$245,347,000	$11,223,101	$24,658,125	$2,103,435	$3,542,275	**$1,563,795,232**	$219,807
Combined Cycle, ~36MW Capacity	$254,674,000	$14,303,809	$17,877,833	$2,748,931	$4,066,892	**$1,520,908,765**	$43,106,275
Combined Cycle, ~50MW Capacity	$258,240,000	$20,501,979	$10,677,087	$3,290,554	$4,645,233	**$1,568,353,205**	-$4,338,165

Environmental Impacts

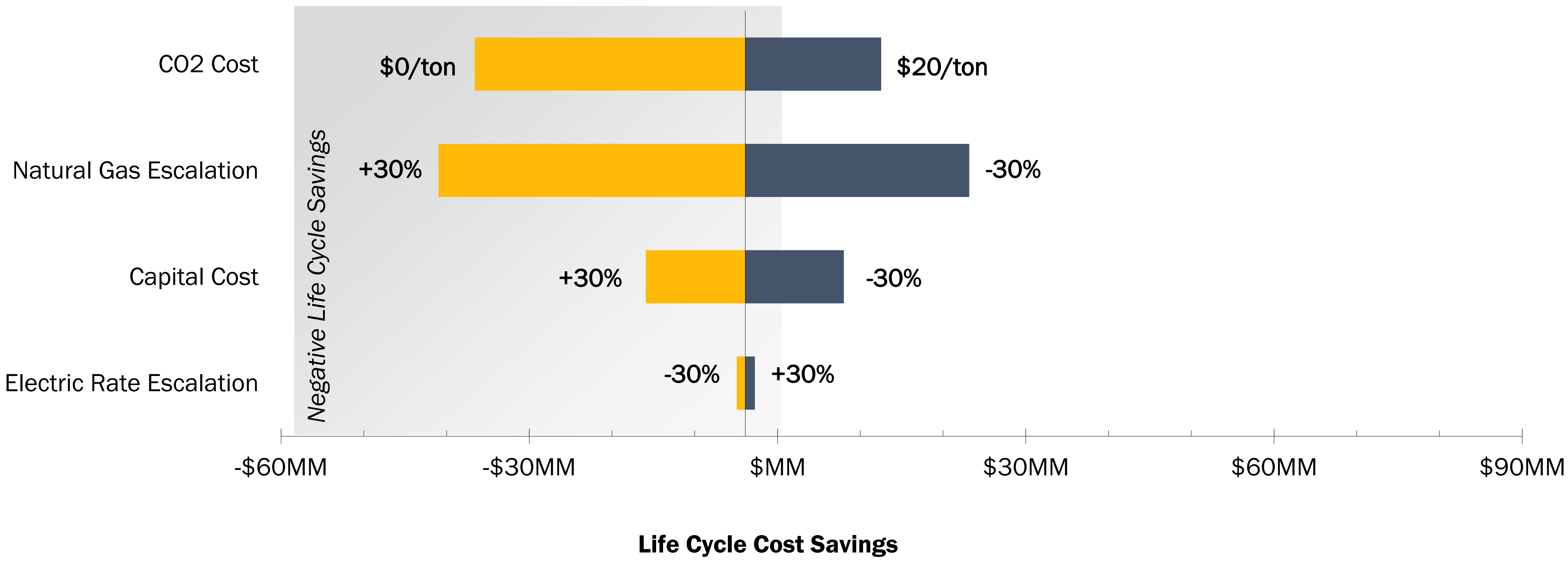
CO_2 reduction = **$**

Social Cost

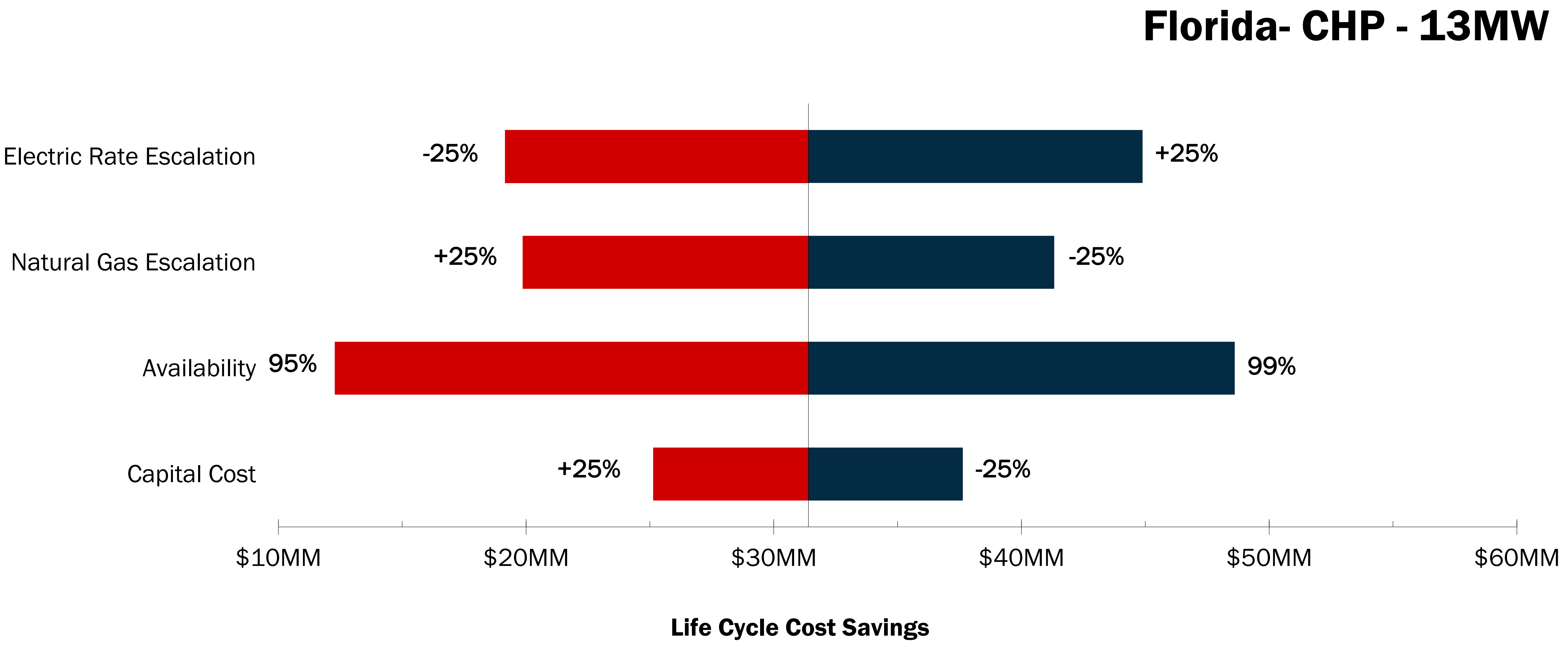
Option	CO_2 Emissions (Tons)		Annual CO_2 Cost
	Annual Total	Reduction vs. Baseline	$10/ Ton
Baseline (Packaged Boilers)	401,526	N/A	N/A
CHP, ~8MW Capacity	376,254	25,272	**$252,720.06**
CHP, ~13MW Capacity	360,970	40,556	**$405,561.82**
Combined Cycle, ~25MW Capacity	348,599	52,928	**$529,276.35**
Combined Cycle, ~36MW Capacity	318,154	83,372	**$833,721.38**
Combined Cycle, ~50MW Capacity	321,118	80,408	**$804,082.68**

CHP **Sensitivity Analysis**

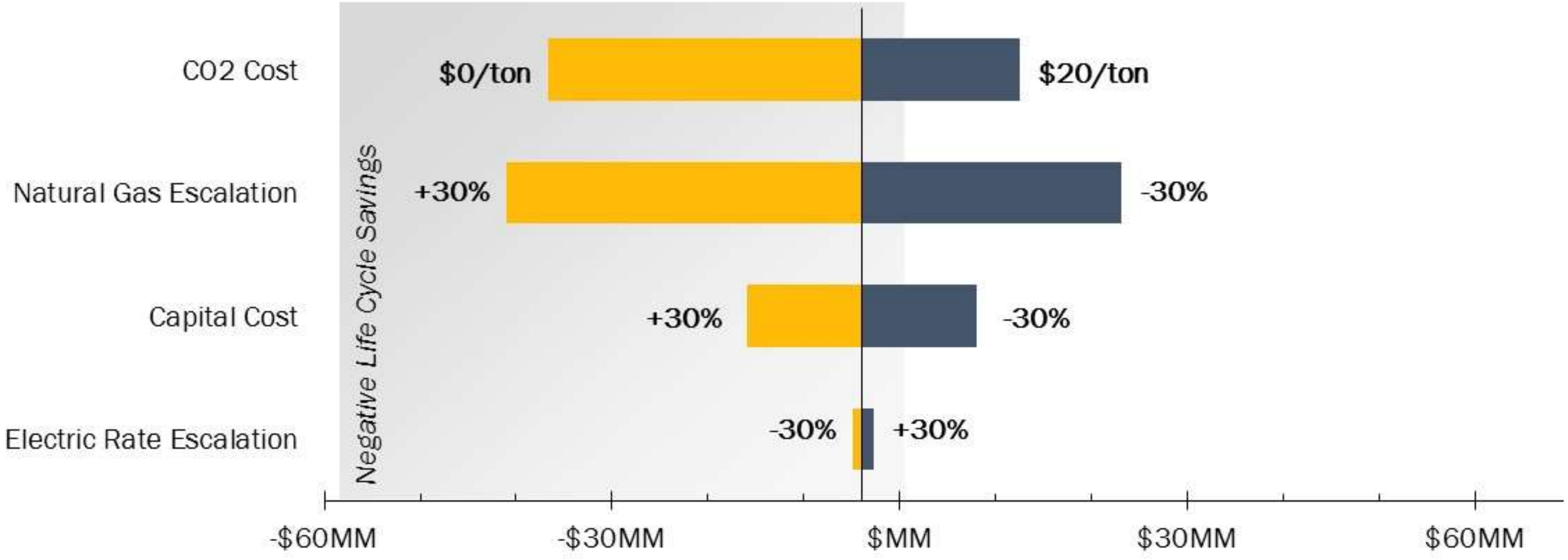
Virginia – CHP – 13MW



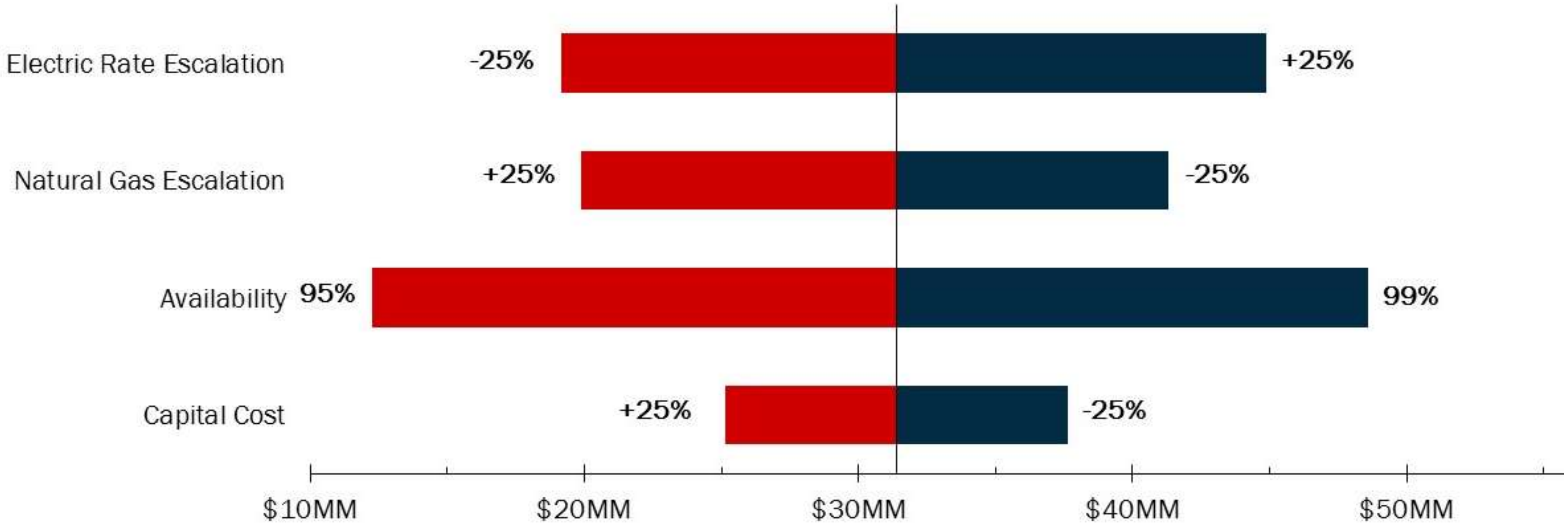
CHP **Sensitivity Analysis**



Virginia



Florida



Key **Takeaways**

Don't take a RISK

CHP is Sensitive about DECAF

Understand your rate structure

CHP is <u>NOT</u> a universal solution

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