Disaggregating Future Retail Electricity Rate Growth

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U.S. DEPARTMENT OF ENERGY

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How much will retail electricity rates grow over the next 10 years and what will drive future changes?

Context

- The retail rate impacts of a number of emerging trends (e.g., rapid deployment of EVs and storage, transmission build-out for large-scale renewables deployment, and grid modernization) are unknown.
- Decision-makers are concerned about the potential future rate impacts on energy affordability and equity.

Prior work

- Recent Berkeley Lab research found wholesale price reductions but modest retail rate increases over the past 10 years due, in part, to large increases in capital expenditures (CapEx). Results were reported on average across a large number of utilities and based on historical data.
- Prior research estimating *future* rate growth can be organized into three approaches: (1) specific policies and their consequent retail rate impacts; (2) system cost and load modeling without disaggregation of drivers; and (3) utility-specific IRPs with heterogeneous modeling methods and data access (that make it hard to generalize beyond their territory). All approaches lack a more robust and nuanced understanding of the key drivers of retail rates, specifically their interactions and uncertainty of future growth.

Scope

- Explore how the variability and contributions of individual retail rate drivers affect future retail rate growth (10-year time horizon).

Approach and key assumptions

- Characterize a generic investor-owned and vertically-integrated electric utility representing average costs
- All major cost categories represented as first year values with range of compound annual growth rates (CAGRs) to characterize variability
  - No line-item generation CapEx and no explicit generation portfolio
  - CAGR ranges based on historical FERC Form 1 (FF1) analysis results, but altered when there is compelling literature to support different future growth rates
- Retail sales, peak demand, and customer counts represented at utility level
  - Annual utility electricity retail sales level is based on starting year value that grows by a CAGR
  - Use-per-customer and system load factor held constant throughout analysis period
  - Annual system load shape is scaled up to match annual utility electricity retail sales to produce an hourly system load curve
  - Coincident peak demand level set annually based on maximum value from system load curve
- Rate design is purely a volumetric energy rate (¢/kWh)
  - Results focus exclusively on all-in volumetric energy rate based on annual general rate case (GRC) with current test year and no regulatory lag (i.e., perfect cost recovery)
  - Research is, therefore, not focused on earnings, return on equity (ROE), or other issues associated with cost recovery

Our analytical assumptions do not account for all factors contributing to the growth in retail electricity rates

Our rate projections assume…	Actual rates are impacted by…	Implications for our results…
Perfect cost recovery and no regulatory process or ratemaking features	Infrequent rate cases, historic test years, and regulatory lag for implementation of new rates	Should have little to no effect on contribution of individual rate drivers
No optimization of least cost revenue requirement or minimum system costs	Incremental system costs scaled to meet incremental load (e.g., “used and useful” requirement)	Contributions of individual rate drivers and their relative size may be over- or under-estimated depending on regional- or utility-specific conditions
All utility costs are included in the revenue requirement	Exclusion and/or disallowance of certain costs through regulatory decisions	
Rate driver growth ranges are informed by long-run historical trends for large sample of utilities	More recent historic or current costs and that reflect locational characteristics	

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Three types of analysis to understand the contribution, uncertainty, and variability of rate drivers

Deterministic

- Use Medium CAGRs for all rate driver inputs

Uncertainty in isolation

- Use random draws from triangular distribution of CAGRs (i.e., Low, Medium, and High) for each rate driver input with all others held at Medium CAGR

Joint uncertainty

- Use random draws from triangular distributions of CAGRs for all rate driver inputs jointly based on historical correlations

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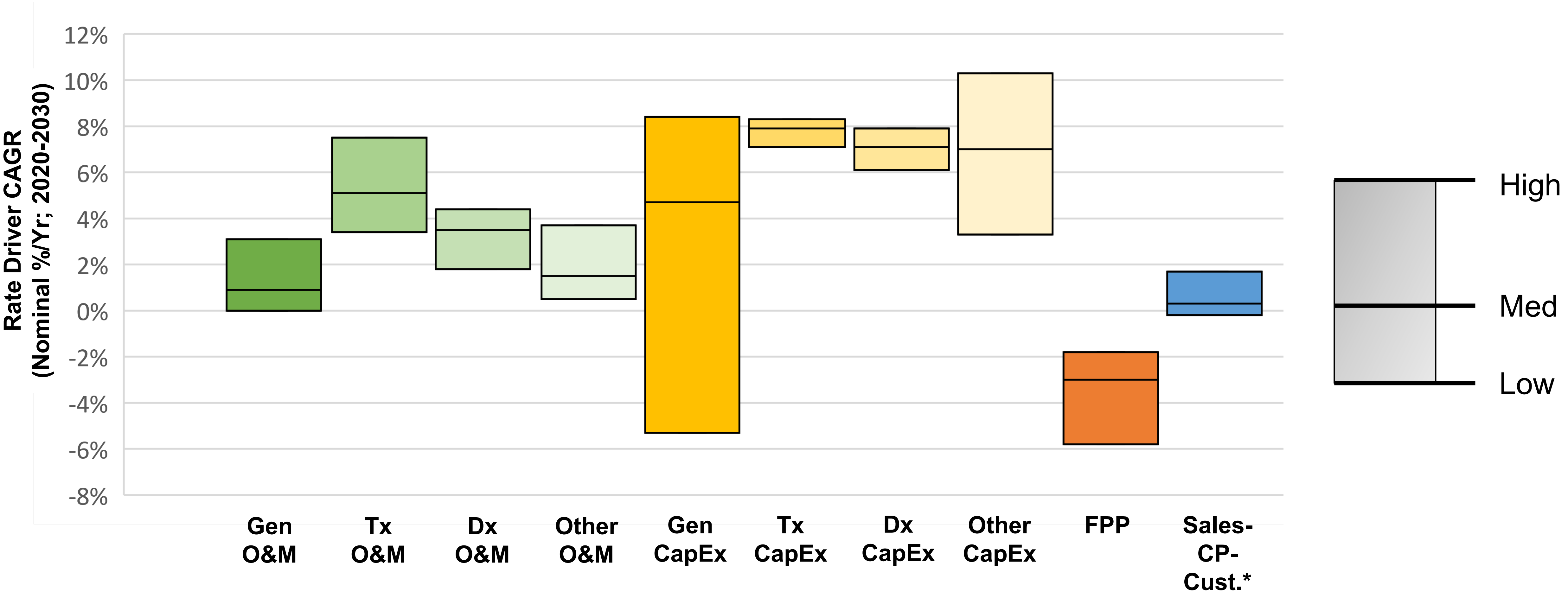
We include all major cost- and non-cost-related drivers of retail rates in the analysis

Fuel and Purchased Power (FPP)	Cost-Related Rate Drivers
Generation Non-fuel O&M* (Gen O&M)	Cost-Related Rate Drivers
Transmission Non-fuel O&M (Tx O&M)	Cost-Related Rate Drivers
Distribution Non-fuel O&M (Dx O&M)	Cost-Related Rate Drivers
Other Non-fuel O&M (Other O&M)	Cost-Related Rate Drivers
Generation CapEx (Gen CapEx)	Cost-Related Rate Drivers
Transmission CapEx (Tx CapEx)	Cost-Related Rate Drivers
Distribution CapEx (Dx CapEx)	Cost-Related Rate Drivers
Other CapEx	Cost-Related Rate Drivers
Retail Sales (Sales)	Non-Cost-Related Rate Drivers
Peak Demand (CP)	Non-Cost-Related Rate Drivers
Customers (Cust)	Non-Cost-Related Rate Drivers

* O&M = Operations and Maintenance

Low, Medium, and High rate driver growth rate assumptions



*We assume no change in utility load factor and use-per-customer, therefore, sales, CP, and customers grow at the same annual rate

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Breaking out retail rates into component pieces

- In order to understand what is driving the overall retail rate growth between 2020 and 2030, we disaggregate the full retail rate into components
- This is possible for all cost-related drivers (numerator in the retail rate calculation)
  - Depreciation, debt service cost, equity return, and tax expenses can be disaggregated into Gen, Tx, Dx, and Other CapEx costs
  - By dividing each annual value by retail sales, we can derive a rate component for Gen, Tx, Dx, and Other CapEx, respectively
- Non-cost related drivers produce impacts on *both* cost-related rate drivers (numerator) and retail sales (denominator); so we elected to not depict the impact of non-cost related drivers on retail rate components as it is not directly comparable to cost-related drivers

Retail Rate ($/kWh)

$$\frac{\Sigma \text{ Cost-Related Drivers (\$)}}{\text{Retail Sales (kWh)}}$$

Rate Components

$$\frac{\text{Other CapEx (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Dx CapEx (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Tx CapEx (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Gen CapEx (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Other O\&M (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Dx O\&M (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Tx O\&M (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{Gen O\&M (\$)}}{\text{Retail Sales (kWh)}}$$

$$\frac{\text{FPP (\$)}}{\text{Retail Sales (kWh)}}$$

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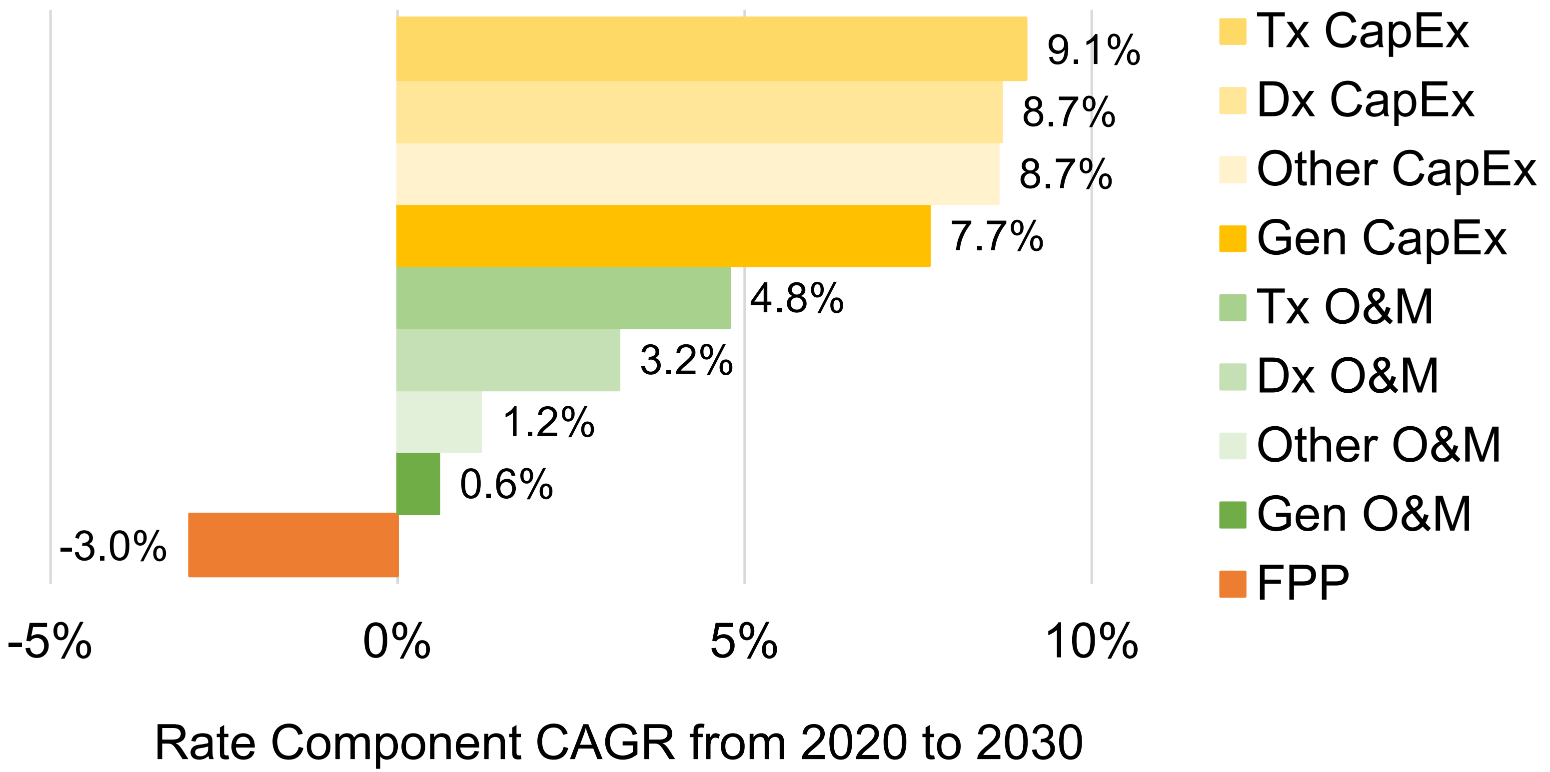
What rate components contribute the most to future retail rate growth?

Assuming medium CAGR for all drivers, CapEx costs drive increases in retail rate growth



Future retail rate growth is driven by sizable increases in all CapEx costs offset by modest FPP cost reductions

As a result, Gen CapEx is the largest rate component in 2030

Ordered Share of Retail Rate	
2020	**2030**
FPP 27%	Gen CapEx 25% (Δ +7%)
Gen CapEx 18%	Tx CapEx 16% (Δ +6%)
Gen O&M 11%	Dx CapEx 13% (Δ +5%)
Other O&M 11%	FPP 13% (Δ -13%)
Tx CapEx 10%	Other O&M 8% (Δ -3%)
Dx CapEx 8%	Gen O&M 8% (Δ -3%)
Tx O&M 8%	Tx O&M 8% (Δ +1%)
Dx O&M 5%	Dx O&M 4% (Δ -0%)
Other CapEx 3%	Other CapEx 4% (Δ +1%)

The largest component of rates goes from FPP (27% of total share) in 2020 to Gen CapEx (25% of total share) in 2030

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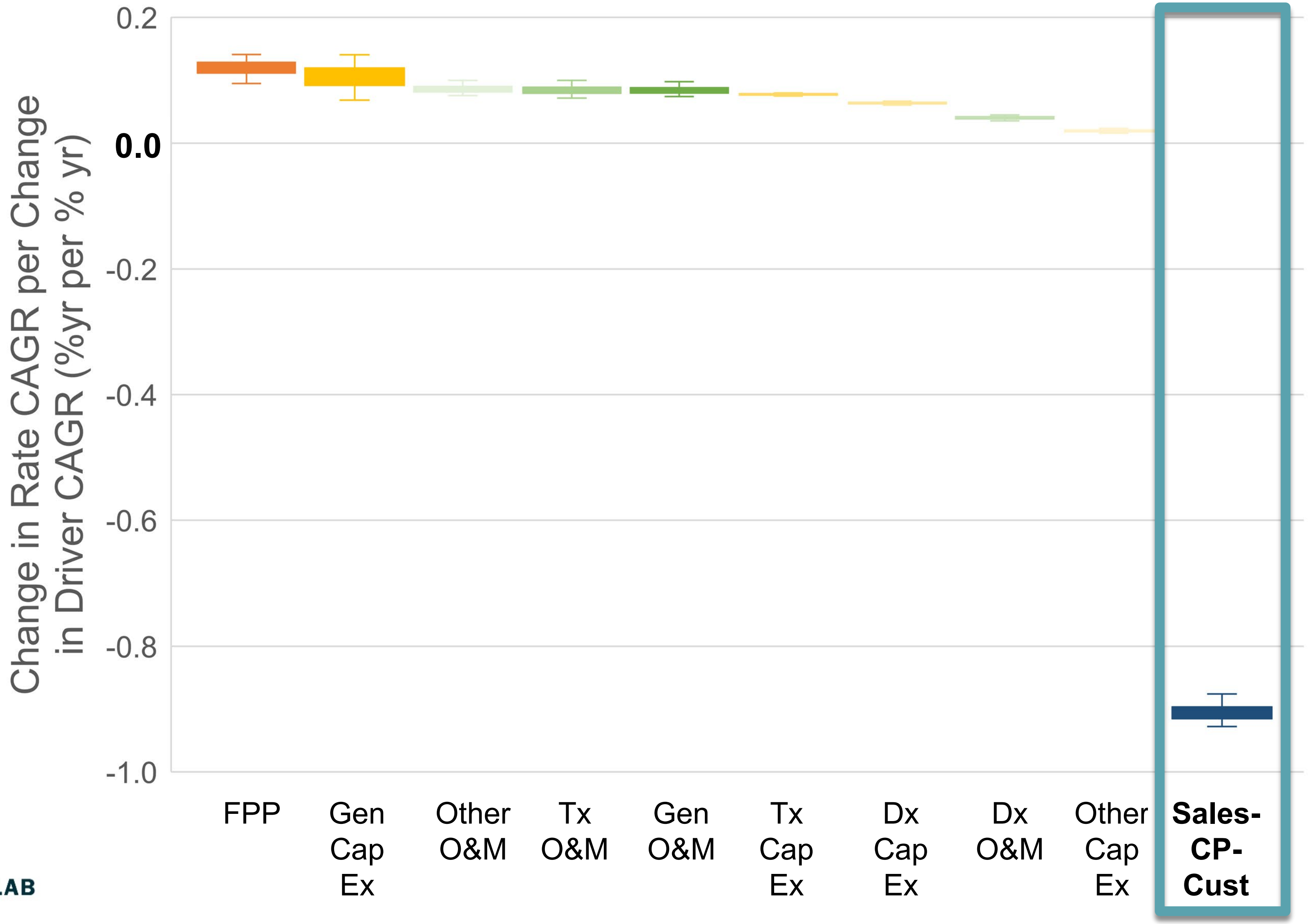
How sensitive is future retail rate growth to variability in the growth of each rate driver, in isolation?

A 1% increase in the CAGR of Sales-CP-Cust results in a 0.88-0.93% decrease in CAGR of rates, in isolation



Interpretation:
The x-axis identifies the specific rate driver that is allowed to vary while all others are held at their medium CAGR. The y-axis identifies how much the growth in retail rates changed (%) as a result of the change in the growth of that specific rate driver (%) on a normalized basis (i.e., elasticity). Ordering based on the magnitude of the average elasticity in the identified rate component.

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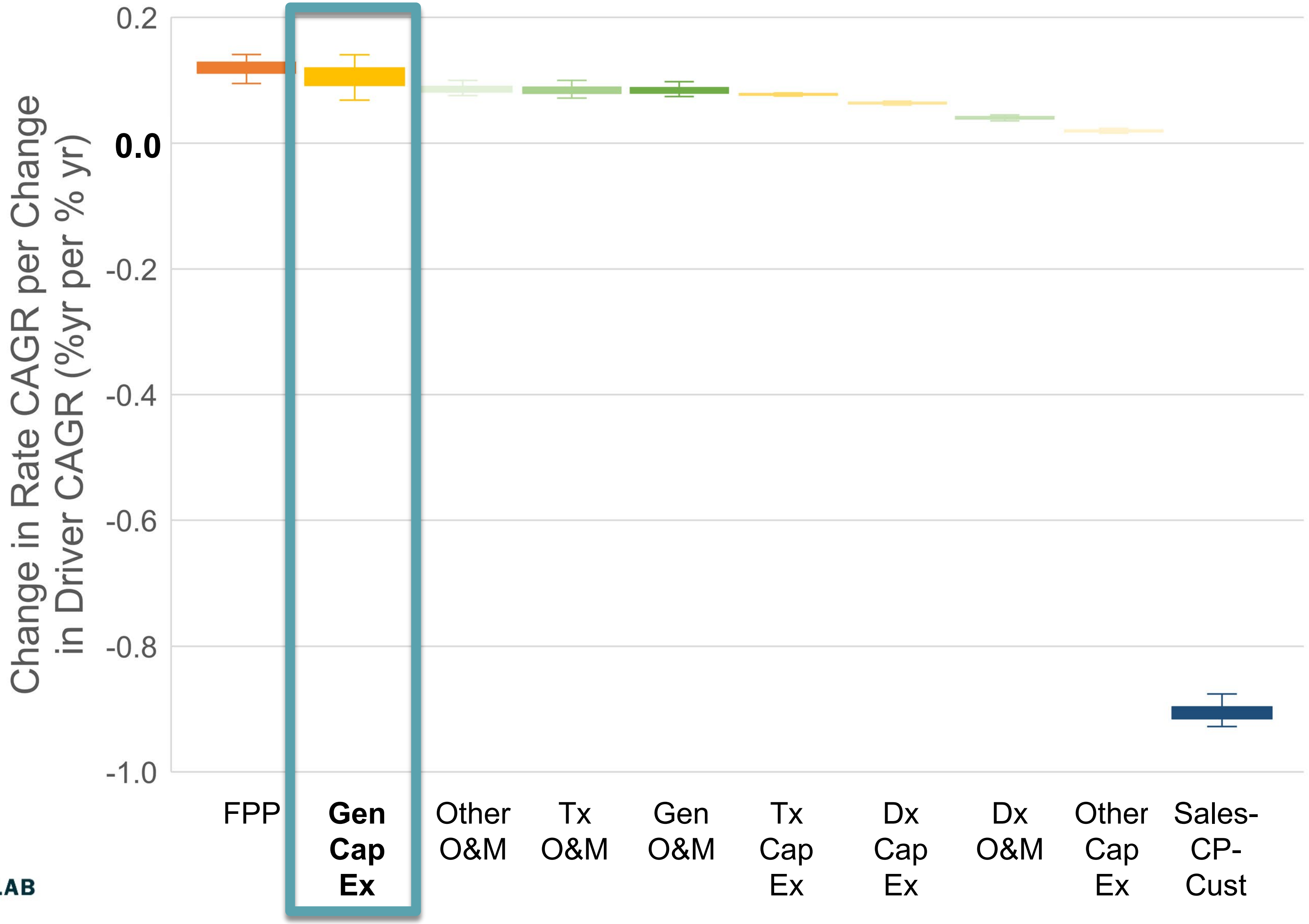
A 1% increase in the CAGR of Gen CapEx costs results in a 0.07%-0.14% increase in CAGR of rates, in isolation



Interpretation:
The x-axis identifies the specific rate driver that is allowed to vary while all others are held at their medium CAGR. The y-axis identifies how much the growth in retail rates changed (%) as a result of the change in the growth of that specific rate driver (%) on a normalized basis (i.e., elasticity). Ordering based on the magnitude of the average elasticity in the identified rate component.

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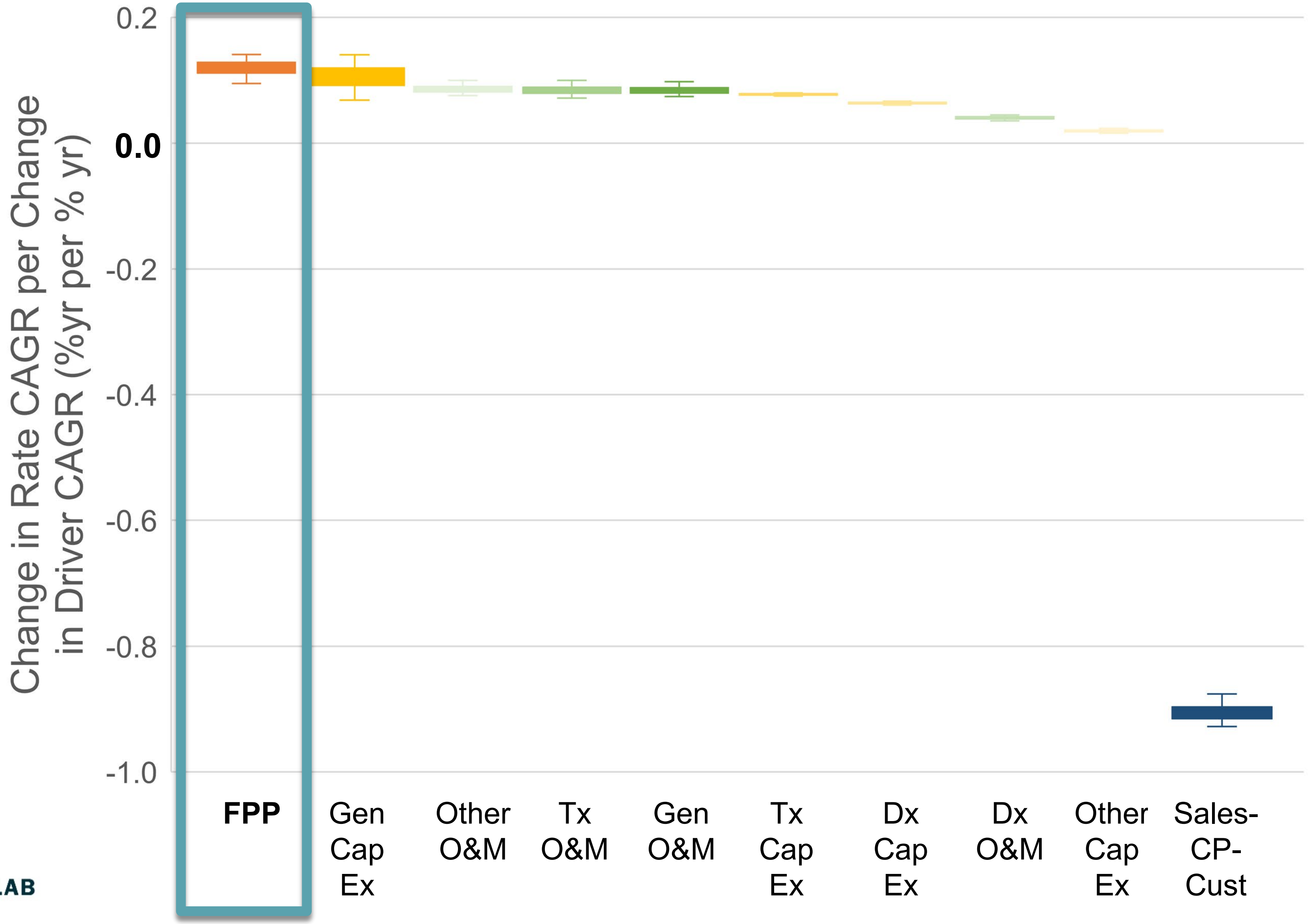
A 1% decrease* in the CAGR of FPP results in a 0.10%-0.14% decrease in CAGR of rates, in isolation



Interpretation:
The x-axis identifies the specific rate driver that is allowed to vary while all others are held at their medium CAGR. The y-axis identifies how much the growth in retail rates changed (%) as a result of the change in the growth of that specific rate driver (%) on a normalized basis (i.e., elasticity). Ordering based on the magnitude of the average elasticity in the identified rate component.

* The change in framing from increase to decrease in the rate driver is due to the fact that the growth in this rate driver, in contrast to all others, is contracting during the analysis period.

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How uncertain and variable are the contributions of rate drivers?

Rate drivers will vary jointly in reality, so need to establish how their growth rates are correlated*

	Gen CapEx	Tx CapEx	Dx CapEx	Other CapEx	Gen O&M	Tx O&M	Dx O&M	Other O&M	FPP	Sales-CP-Cust
Gen CapEx	1.00									
Tx CapEx	0.50	1.00								
Dx CapEx	0.60	0.75	1.00							
Other CapEx	0.65	0.60	0.74	1.00						
Gen O&M	0.80	0.63	0.75	0.71	1.00					
Tx O&M	0.38	0.65	0.66	0.55	0.47	1.00				
Dx O&M	0.64	0.74	0.93	0.72	0.77	0.70	1.00			
Other O&M	0.67	0.72	0.90	0.75	0.85	0.59	0.88	1.00		
FPP	-0.04	0.09	0.10	0.01	-0.02	0.01	0.06	0.05	1.00	
Sales-CP-Cust	0.70	0.75	0.90	0.75	0.85	0.62	0.93	0.91	0.06	1.00

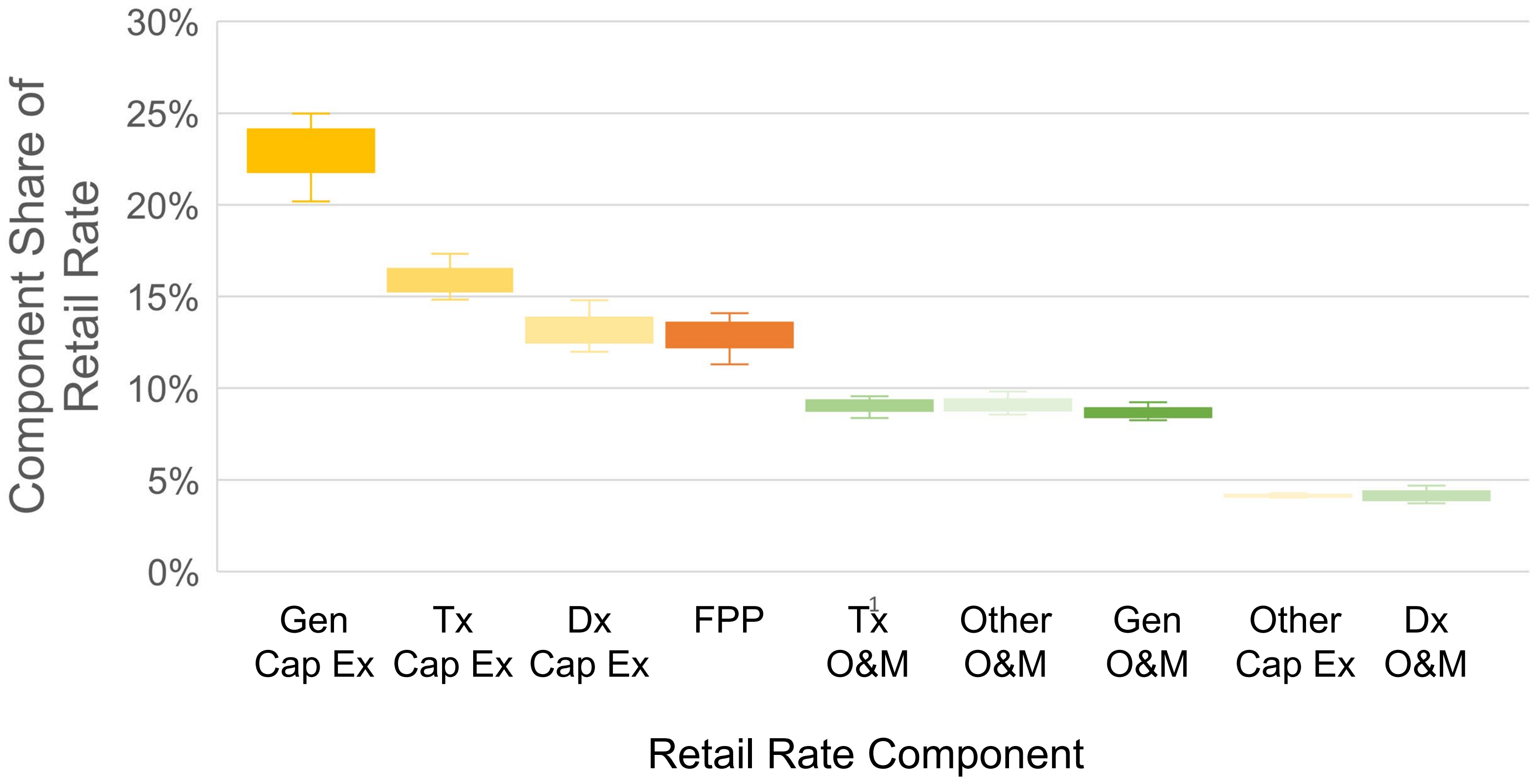
-1.0 0.0 1.0

Spearman Correlation Coefficient

- Historical FF1 data suggests retail sales are highly positively correlated (r>0.9) with Dx O&M, Other O&M, and Dx CapEx; more modestly correlated with Tx CapEx (r=0.75), Gen CapEx (r=0.70), or Tx O&M (r=0.62)
- Strongest positive correlation (r>0.65) in cost-related rate drivers exists between the same type of CapEx and O&M (e.g., Gen); generally weaker cross-correlation across types of CapEx and O&M
- FPP costs ($/MWh) are not correlated with any other rate driver (|r|≤0.1)

* Correlation is an estimate of how related two variables are: do they consistently move together, apart, or randomly in different directions?

When variability is applied jointly to all rate drivers, Gen CapEx remains the largest but is also the most uncertain rate component



Interpretation:
The x-axis identifies the specific retail rate component. The y-axis identifies how much that share of the rate component in 2030 varies when the annual growth in all rate drivers varies jointly.

*** Ordering based on the magnitude of the median in the identified rate component.

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Conclusions and Discussion

Conclusions

- Future retail rate growth is driven by sizable increases in all CapEx costs, when assuming medium growth rates in all rate drivers.
  - Generation CapEx is the largest component of retail rates in 2030 (comprising 25% of the total retail rate), replacing FPP costs which was the largest contributor in 2020 (comprising 22% of total retail rate)
- Considering the contributions and variability of each rate driver in isolation:
  - Rate growth is very sensitive to growth in sales/customers/peak demand whereby a 1.0% increase in the growth of sales/customers/peak demand results in a 0.9% reduction in the growth of rates
  - Growth in FPP and CapEx both have smaller but more uncertain impacts on rate growth: a 1% increase in either results in a 0.10-0.14% or 0.07-0.14% increase in the growth of rates
- Considering the contributions and variability of each rate driver jointly:
  - Generation CapEx remains the largest and is now the most uncertain component of retail rates in 2030

Discussion

- Results suggest factors that minimize retail rate growth and/or decrease its uncertainty include:
  - Higher growth in sales (e.g., electrification) because proportional increases result in a fairly similar reduction in retail rates, which are far greater than any other rate driver;
  - Managing the growth in generation CapEx and FPP costs through efforts to improve system load factor (e.g., peak-focused demand response, customer-scale energy storage); and
  - Continuing to drive down the costs of fuel and purchased power through increased deployment of renewable energy.
- Absolute rate impacts may be less important than the ordering of drivers and relationship to one another in the context of identifying actions to address future rate growth.
  - Stochastic analysis that factors in relationships of rate drivers can prioritize actions.
  - Whether rate impacts manifest will come down to individual state policies and decisions that mitigate or exacerbate these relationships.

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UTILITY CHARACTERIZATION AND RATE DRIVER GROWTH RATE ASSUMPTIONS

Utility Characterization
Sales, Peak Demand, and Customers

	Retail Sales	Peak Demand	Customers
2019 Value	20,092 GWh	4,072 MW	962,851
CAGR (Low|Med|High)	-0.2%|0.3%|1.7%	-0.2%|0.3%|1.7%	-0.2%|0.3%|1.7%

- **2019 Level**
  - Directly applied sample weighted average FERC Form 1 (FF1) data for 2019
  - Derived peak demand based on 56% annual load factor
- **CAGR**
  - By imposing constant use-per-customer and load factor over entire analysis period, all CAGRs apply to all three categories of data
  - Assumption derived from FF1 data analysis that showed the three are highly correlated with each other

- Lower bound value is directionally consistent with historical analysis as well as several regional forecasts (i.e., Texas and California) that assumed negative sales growth in some scenarios. Texas' lowest forecast was -0.6%. California was the outlier even lower at -1.6%.
- The medium value is consistent with several regional and national sales forecasts which assume some retail sales growth >0.0% and <1.0%.
- The upper bound value is much higher than historical because of literature with upper bound load growth in the 1.5%-2.0% range

Utility Characterization
Fuel and Purchased Power Costs

	FPP
2019 Value	$39/MWh
CAGR (Low|Med|High)	-5.8% |-3.0%|1.7%

- **2019 Level**
  - Directly applied 2019 FF1 sample weighted average utility fuel and purchased cost ($/MWh) for 2019
- **CAGR**
  - Lower bound value is consistent with recent historical analysis, as other FPP forecasts (e.g., EIA's AEO) have consistently over-forecasted cost growth (i.e., positive CAGRs)
  - The medium value is also consistent with recent historical analysis for the same reason
  - The upper bound value is much higher than historical to match EIA AEO's upper bound growth forecasts in the 1.5%-2.2% range

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Utility Characterization
(Non-Fuel) Operations & Maintenance Costs

	Generation	Transmission	Distribution	Other
2019 Value	$311M	$202M	$120M	$1,252M
CAGR (Low|Med|High)	0.0%|0.9%|3.1%	3.4%|5.1%|7.5%	1.8%|3.5%|4.4%	0.5%|1.5%|3.7%

- **2019 Levels**
  - Derived 2019 FF1 sample weighted average Generation, Transmission, Distribution, and Other O&M normalized values ($/Cust) for 2019
  - Applied these normalized values to the number of customers to derive starting year values
- **CAGR**
  - Lower, medium, and upper bound CAGRs are consistent with recent historical analysis
  - There is no literature that categorically and descriptively forecasts O&M costs
  - Any proposed deviation from historical FF1 CAGRs would be arbitrary on our part

Utility Characterization
Capital Structure and Cost of Capital

	Share of Debt	Debt Service Cost	Authorized ROE
2019 Value	56%	4.0%	9.65%

- **2019 Level**
  - **Capital Structure:** EEI 2019 Financial Review provided the share of debt in the utility's capital structure for all U.S. electric utilities (~56%)
  - **Debt Service Cost:** EEI 2019 Financial Review provided the ratio of interest expenses and total short- and long-term debt for all U.S. electric utilities
  - **Authorized ROE**: S&P Global Market Intelligence reported that the average U.S. electric utility in 2019 received authorization to earn 9.65% return on equity

Utility Characterization
Rate Base

	Gross Plant in Service	Accumulated Depreciation	Avg. Asset Service Life	ADIT Percent
2019 Value	$12,671M	$4,815M	34 years	95%

- **2019 Level**
  - Calculated the weighted average normalized FF1 Gross Plant in Service and Accumulated Depreciation ($/Cust) for 2019
  - Applied these normalized values to the number of customers to derive starting year values
  - Derived the FF1 average asset lifetime, based on the inverse ratio of 2019 depreciation expense and gross-plant in service
  - Maintained previous FINDER analysis assumptions about ADIT percentage

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Utility Characterization
Capital Expenditure Budgets

	Generation	Transmission	Distribution	Other
2019 Value	$563M	$298M	$258M	$79M
CAGR (Low|Med|High)	-5.3%|4.7%|8.4%	7.1%|7.9%|8.3%	6.1%|7.1%|7.9%	3.3%|7.0%|10.3%

- **2019 Levels**
  - Derived 2019 FF1 sample weighted average Generation, Transmission, Distribution, and Other CapEx normalized values ($/Cust) for 2019
  - Applied these normalized values to the number of customers to derive starting year values
- **CAGR**
  - Lower, medium, and upper bound CAGRs are consistent with recent historical analysis
  - The literature for Generation, Transmission, and Distribution CapEx forecasts reflects substantial uncertainty on the direction of change from current budgets based on differing assumptions

- Recent EEI and S&P Global short-term (2020-2022) U.S. electric utility CapEx forecasts predict flat spending on a CAGR basis; but EEI notes that these near-term forecasts have historically underestimated spending (i.e., 6-10% for 2nd year of forecast and 20-25% for 3rd year of forecast)
- After accounting for historical underestimation of these forecasts, growth rates for Transmission and Distribution are consistent with low end CAGRs from historical analysis and medium CAGRs for Generation.