Putting the Potential Rate Impacts of Distributed Solar into Context

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Report Summary

Full report available here: *https://emp.lbl.gov/publications*

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Introduction

- Growth of distributed solar and concerns about cost-shifting have led to many rate reform proposals
- These proposals often absorb substantial time and administrative resources, *potentially* at the expense of other issues that have greater impact
- Given these tradeoffs, PUCs and utilities might ask:
  - *How large could the effect of distributed solar on retail electricity prices conceivably be?*
  - *And how does that compare to other factors that also affect electricity prices (and are within PUCs' purview)?*

This work provides metrics and benchmarks intended to help prioritize how much attention to devote to evaluating and addressing distributed solar cost-shift concerns

The paper addresses a relatively narrow issue, and does so in an approximate manner

This paper presents **illustrative comparisons** between the potential effects of distributed solar and other drivers of retail electricity prices, drawing existing literature and back-of-the-envelope style analyses

> *Intent is to provide intuition about the relative significance of these different drivers,*
> *<u>not</u> to provide precise estimates*

In addition, the paper also does not:

- Address distributed energy resources (DERs) as a whole
- Address other motivations for retail rate reforms, beyond potential cost-shifting
- Provide a cost-benefit analysis of distributed solar or any other policy, resource, or activity
- Support any particular approach to defining the value of solar

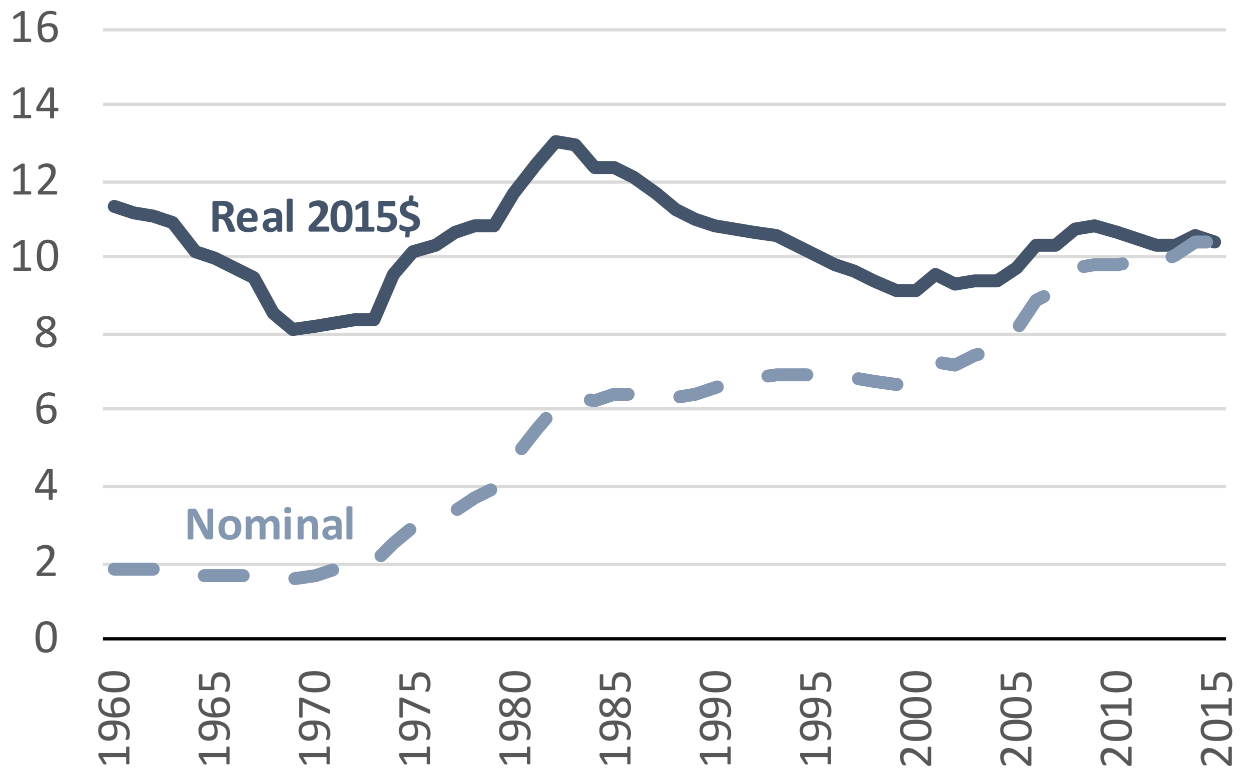
Outline

- Introduction
- **U.S. Retail Electricity Prices: Historical Trends and Current Projections**
- Scaling the Effects of Distributed Solar on Retail Electricity Prices
- Other Drivers for Changes to Retail Electricity Prices
- Conclusions

Inflation-adjusted U.S. prices currently at the long-term average

But have been on slight upward trajectory since 2000

U.S. average retail electricity prices
(cents/kWh)



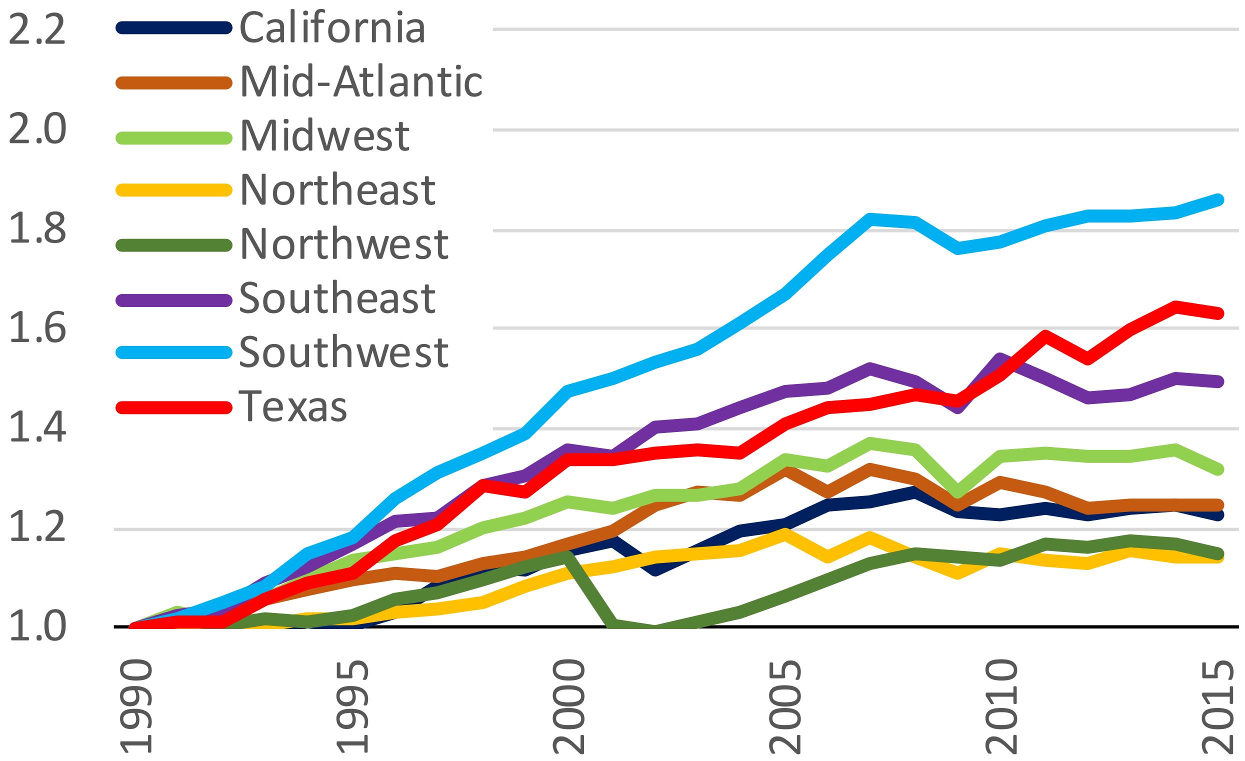
Notes: Represents U.S. average retail electricity prices across all customer segments and utilities, as reported by EIA (2012, 2015c, 2016e). Converted to real dollars based on GDP price deflator (BEA 2016).

- U.S. average retail electricity prices have risen by ~3% per year in nominal terms
- But real prices are at roughly the long-term average (~10 cents/kWh)
- Big swing with oil price shocks in 1970's, followed by steadily declining (real) prices
- Inflection point around 2000; prices have risen gradually since then
  - Extends across most regions
  - Influenced, to varying degrees, by: restructuring, gas prices, utility CapEx growth, state clean energy policies, and slowing load growth

Flat load growth across most regions over the past decade

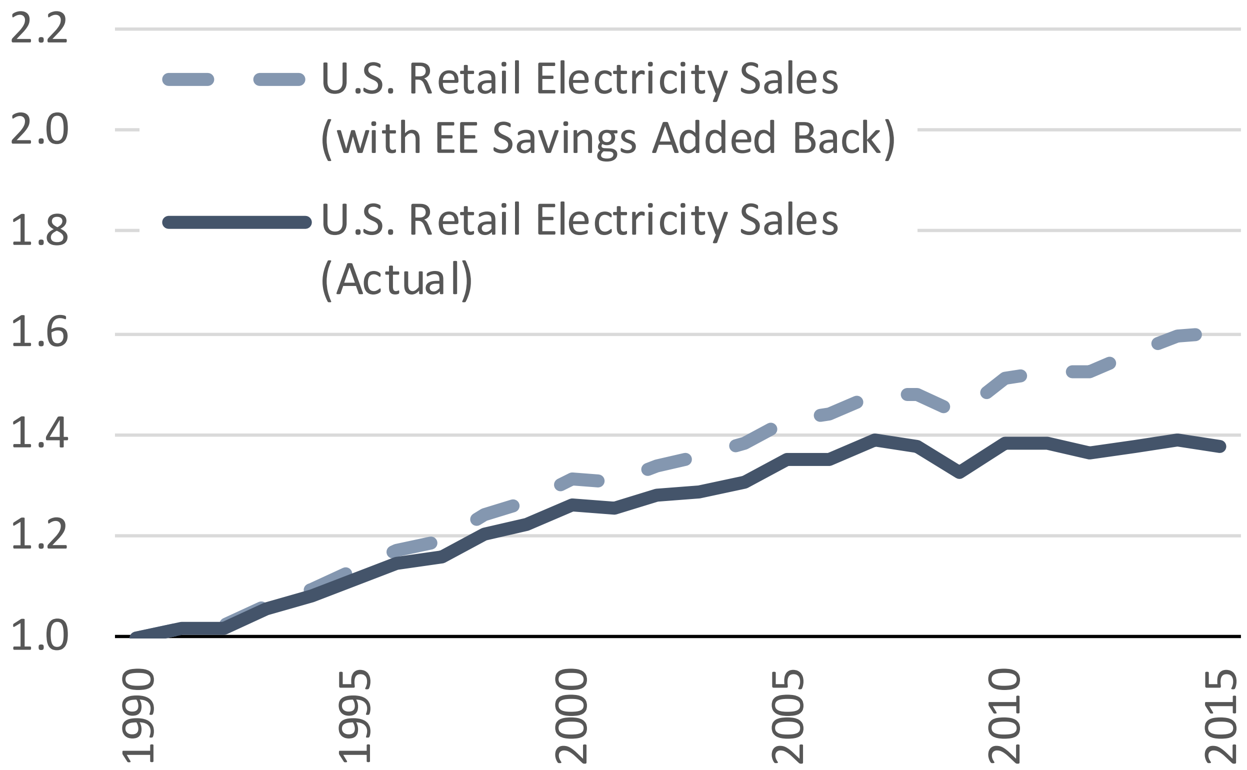
Energy efficiency an important, though not the sole, contributor

Growth in regional retail electricity sales
(Indexed: 1990=1)



Notes: Data represent total retail electricity sales, including both bundled and energy-only sales, as reported by EIA (2015c, 2016e).

Growth in U.S. retail electricity sales
(Indexed: 1990=1)



Notes: Savings from federal appliance standards based on Meyers et al. (2016). Savings from utility ratepayer-funded programs are based on ACEEE data (e.g., Berg et al. 2016) and decayed over time to reflect a 10-yr. avg. measure life. The figure does not account for possible rebound effects.

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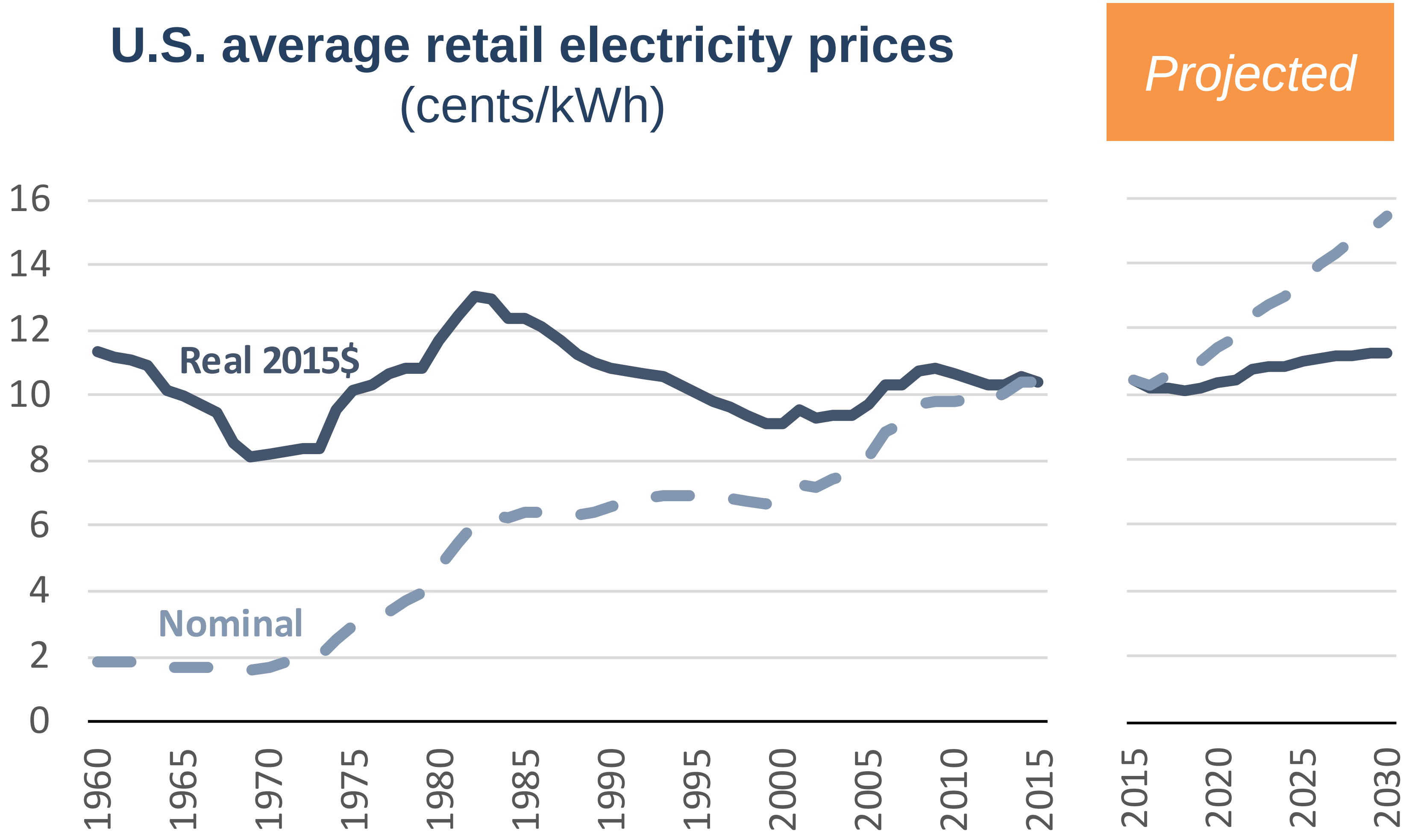
Recent projections forecast continued gradual growth in real prices

U.S. average prices forecast to rise by ~1 cent/kWh (real) by 2030



Notes: Represents U.S. average retail electricity prices across all customer segments and utilities, as reported by EIA (2012, 2015c, 2016e). Converted to real dollars based on GDP price deflator (BEA 2016).

Notes: Based on EIA's 2017 Annual Energy Outlook reference case (EIA 2017).

- Seemingly an end to the era of steadily declining prices (trends since 2000 the “new normal”?)
- Varying rates of escalation across regions
- Many uncertainties underlying these projections, raising the question…

How might distributed solar growth affect these trends?

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Estimating the effect of distributed solar on retail electricity prices

A generic relationship based on 3 fundamental drivers

Expression below applies to cost-of-service based pricing and should be considered a first-order estimation (see Appendix A in full paper for derivation)

$$Percent\ Change\ in\ Retail\ Electricity\ Price = \underbrace{Penetration}_{1} \times \left[\underbrace{\frac{Solar\ Comp.Rate}{CoS}}_{2} - \underbrace{\frac{VoS}{CoS}}_{3} \right]$$

1. Distributed solar generation as a percentage of retail electricity consumption

2. Average payment or bill savings per unit of solar generation, *relative* to the utility's average cost of service (CoS)

   E.g., equal to ~100% for full net metering with flat volumetric rate structure

3. Value of solar (VoS) to the utility (benefits net of costs) *relative* to the utility's CoS

   Agnostic as to whether VoS reflects only short-term or also longer-term impacts

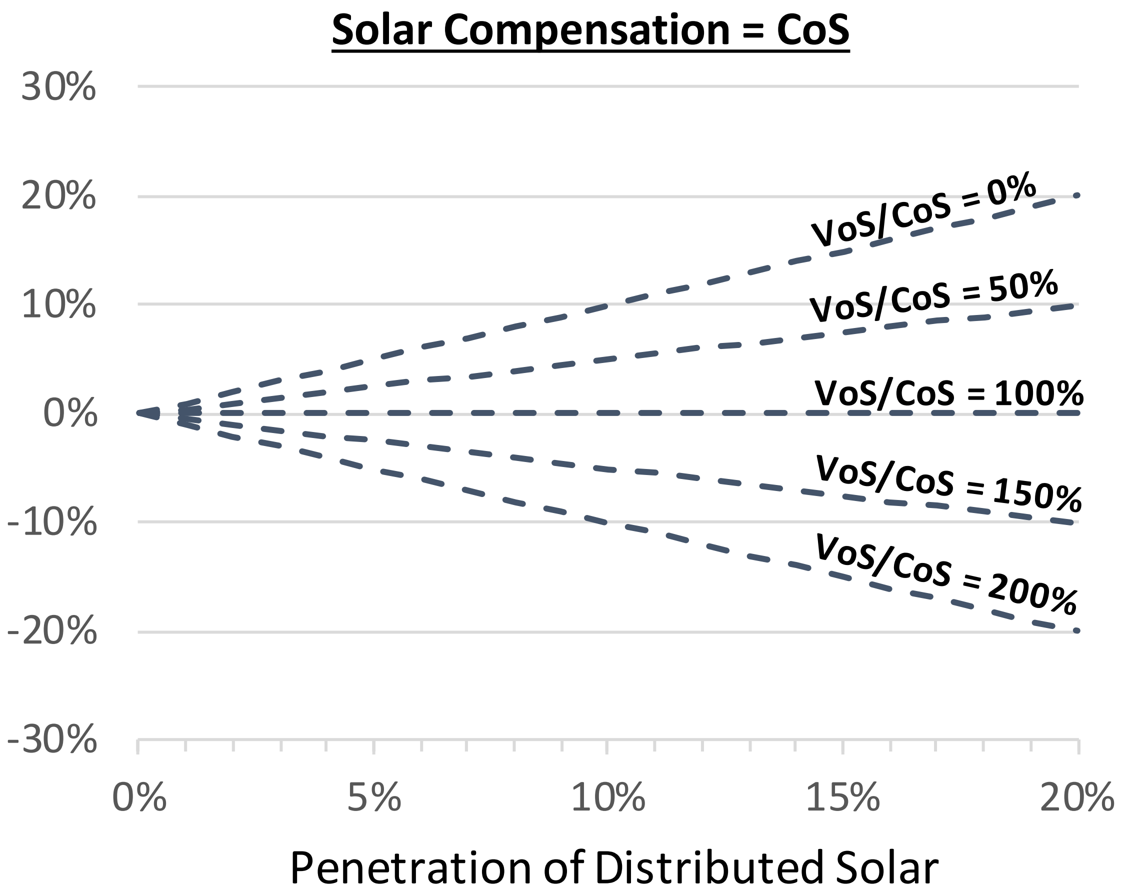
Notes: This simplified construct ignores some complexities of electric ratemaking processes, such as the lag between the time that costs are incurred and when they are added into rates. Although it can be used to estimate an average effect across all customers, the above expression may be more usefully applied on a customer-class specific basis, given differences between residential and commercial rate structures, and the manner in which revenue requirements are allocated to individual customer classes.

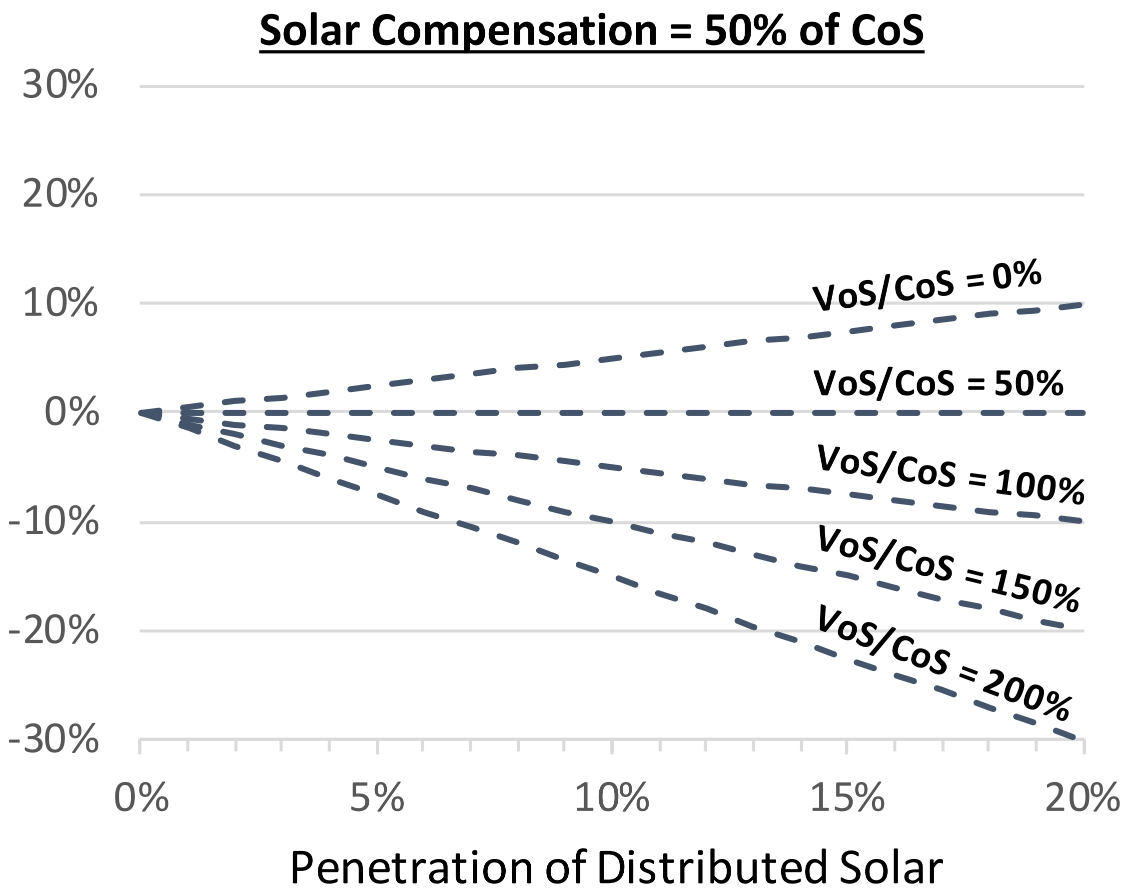
Visualizing the effect of distributed solar on retail electricity prices

Curves are based on the expression from the preceding slide

Percentage change in retail electricity price (y-axis)

Left- and right-hand figures correspond to two different solar compensation rates; each shows how effects of distributed solar on retail electricity prices scale with penetration level and VoS/CoS ratio





Current penetration levels for most utilities are quite low

Top-Ten Utilities for Net-Metered PV Penetration
(year-end 2015)

Penetration among all customers			***Penetration among residential customers only***		
Utility	State	% of Sales	Utility	State	% of Sales
Hawaii Electric Light	HI	12.4%	Maui Electric	HI	18.0%
Maui Electric	HI	12.1%	Hawaii Electric Light	HI	16.9%
Hawaiian Electric	HI	8.1%	Hawaiian Electric	HI	16.8%
Kauai Island Utility Cooperative	HI	7.9%	Kauai Island Utility Cooperative	HI	10.5%
Otero County Electric Cooperative	NM	5.6%	San Diego Gas & Electric	CA	7.7%
San Diego Gas & Electric	CA	5.5%	City of Moreno Valley	CA	6.5%
Washington Electric Cooperative	VT	5.3%	Pacific Gas & Electric	CA	5.3%
Town of Hardwick	VT	5.3%	Otero County Electric Cooperative	NM	5.2%
Trico Electric Cooperative	AZ	4.1%	Groton Dept. of Utilities	CT	4.5%
Pacific Gas & Electric	CA	3.6%	Southern California Edison	CA	3.9%
	Total U.S.	***0.4%***		***Total U.S.***	***0.6%***

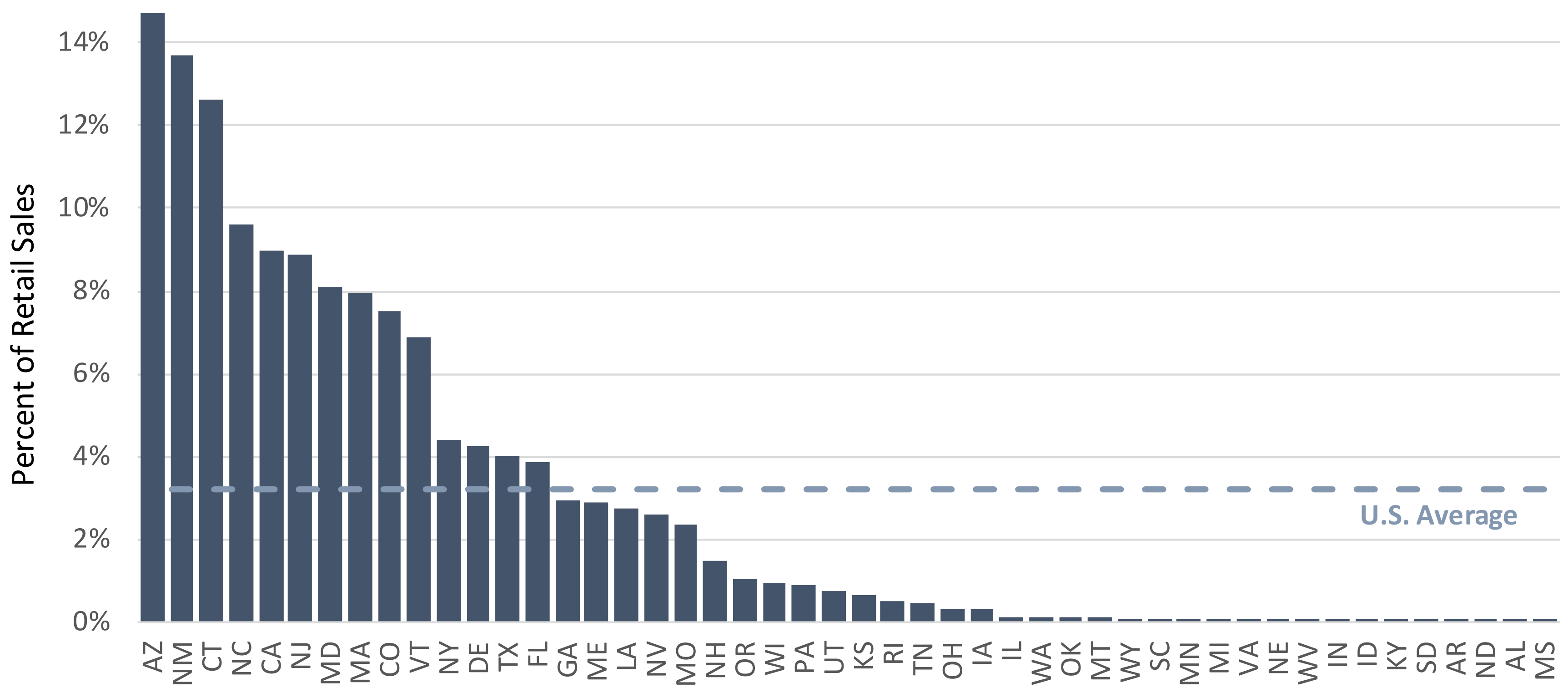
Notes: Based on data for NEM PV capacity and retail electricity sales reported through form EIA-861 (EIA 2016g). Net-metered PV generation is estimated using the PVWatts software with the program's default assumptions (NREL 2016).

- A few utilities have net-metered solar penetration >5% of retail sales, and several (in HI) top 10%
- But most utilities have quite low penetration levels
  - U.S. average penetration was just 0.4% across all utilities
  - Most had yet to reach even one-tenth of that
- Residential penetration rates somewhat higher

For the vast majority of utilities, current PV penetration levels are far too low for any discernible effect on retail electricity prices to have occurred

High penetration levels are expected to remain concentrated within a small set of states

Projected rooftop solar penetration levels in 2030
(from NREL 2016 Standard Scenarios Report)



Notes: Based on central case scenario from Cole et al. (2016), which projects solar adoption in the contiguous United States (i.e., excludes Hawaii and Alaska). Penetration levels calculated from projected capacity based on estimated state-level capacity factors (NREL 2016) and retail sales projections developed by applying EMM-level growth rates from the Annual Energy Outlook 2016 reference case (EIA 2016a) to historical state-level retail sales data (EIA 2015c).

- Recent forecasts project total U.S. distributed solar generation grows to 2-4% of electricity sales by 2030
- High penetration levels remain concentrated within a relatively small set of states
- Latest NREL forecast projects that:
  - Three states in contiguous U.S. surpass 10% penetration by 2030
  - Seven others reach 5%
  - But most states remain below 1%
  - U.S. average = 3.2%

At higher penetration levels, value of solar becomes more relevant

Prior studies generally show VoS/CoS of roughly 50-150%

Summary of Recent VoS Studies

Region	Author (Year)	VoS (2015 cents/kWh)		VoS/CoS	
		Core	Core+	Core	Core+
Arizona (APS)	SAIC (2013)	3.7	n/a	31%	n/a
Arizona (APS)	Crossborder Energy (2013a)	24.6	n/a	204%	n/a
Arizona (APS)	Crossborder Energy (2016)	16.9	18.9	144%	161%
California	E3 (2013)	n/a	14.6	n/a	98%
California	Crossborder Energy (2013b)	11.0	20.2	74%	135%
Colorado (PSCo)	Xcel (2013)	7.2	8.4	71%	83%
Maine	Clean Power Research (2015)	13.8	24.3	106%	185%
Massachusetts	Acadia (2015)	15.9	23.2	93%	136%
Mississippi	Synapse (2014)	14.6	17.4	148%	176%
Nebraska	Lincoln Electric System (2014)	3.8	n/a	47%	n/a
Nevada	E3 (2014b)	n/a	13.1	n/a	134%
Nevada	SolarCity/NRDC (2016)	10.3	11.2	109%	118%
North Carolina	Crossborder Energy (2013c)	11.6	12.9	122%	136%
PJM Region	Clean Power Research (2012)	7.5	17.6	51%	121%
Tennessee Valley Authority	TVA (2015)	6.9	7.3	73%	77%
Texas (Austin Energy)	Clean Power Research (2013a)	9.1	11.2	90%	111%
Texas (San Antonio)	Clean Power Research (2013b)	13.3	16.0	143%	173%
Utah	Clean Power Research (2014)	8.3	11.9	97%	139%
Vermont	VT Public Service Dept. (2014)	n/a	24.4	n/a	163%

- Value of solar (VoS) study results vary considerably
  - Reflects differences in scope, methodology, and the characteristics of regions analyzed
- When counting a limited set of "core" costs and benefits (see notes below), most studies fall within 50-150% of the utility's average CoS
  - Lower end reflects low capacity value; mostly just avoided fuel and power purchase expenses
- "Core+" numbers include additional utility value categories (but not societal benefits); range shifted upward

Notes: "Core" VoS estimates consist of only avoided energy, RPS purchases, generation capacity, reserves, ancillary services, T&D capacity, and losses, and are net of any solar integration costs. "Core+" estimates include additional ratepayer benefits, which, depending on the study, may include items such as: reduced fuel price risk, reduced costs of future carbon regulations, and cost savings associated with reduced wholesale electricity and/or natural gas prices. Broader societal benefits are excluded from both VoS categories, as the present analysis is focused solely on ratepayer impacts. Cells are marked "n/a" if the VoS value was not estimated or identifiable. For studies that included multiple scenarios, we selected the reference case. For studies that presented ranges, we report the mid-point. The VoS/CoS percentages are calculated by dividing the VoS by the average retail electricity price for the corresponding state or utility, in the year in which the study was performed.

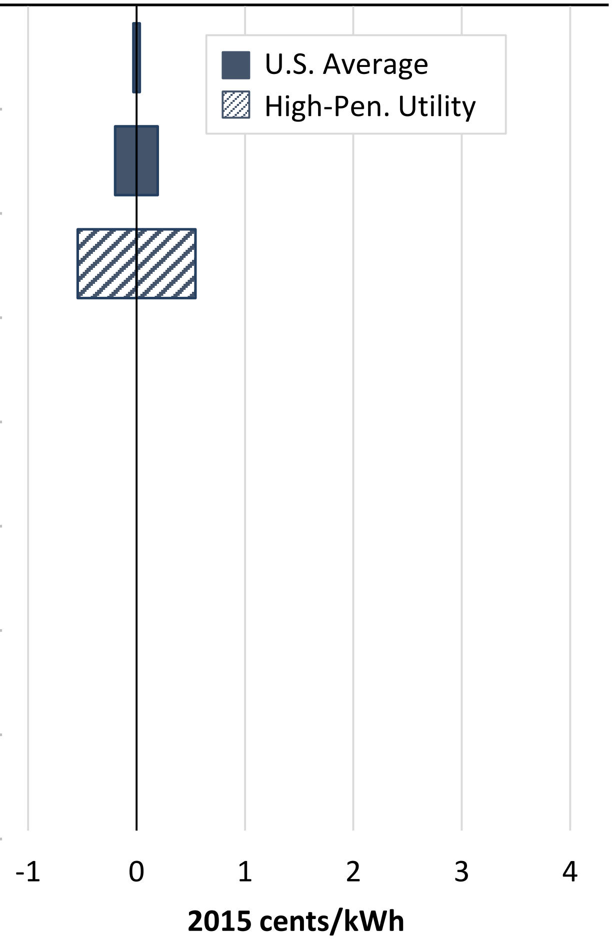
Three benchmark ranges for the potential effects of distributed solar on retail electricity prices

Indicative ranges for potential effects on average retail electricity prices

Net-Metered PV: Impact at *current penetration levels (0.4%)*, across a range of VoS assumptions, with purely volumetric rates (U.S. average)

Net-Metered PV: Impact at *projected 2030 penetration levels (3.2%)*, across a range of VoS assumptions, with purely volumetric rates (U.S. average)

Net-Metered PV: Impact at *10% penetration*, across a range of VoS assumptions, with purely volumetric rates (high-pen. utility, U.S. avg. price)



***Electricity price impacts at three distributed solar penetration levels** (using earlier expression):*

Current U.S. average	±0.03 cents/kWh
2030 U.S. average	±0.2 cents/kWh
At 10% penetration	±0.5 cents/kWh

- Ranges based on VoS/CoS ratio of 50-150%
- Assumes solar compensation equal to utility average CoS (i.e., full NEM with volumetric rate structure)
  - Ranges would be shifted downward for rate structures with fixed or demand charges (as with most commercial rates)

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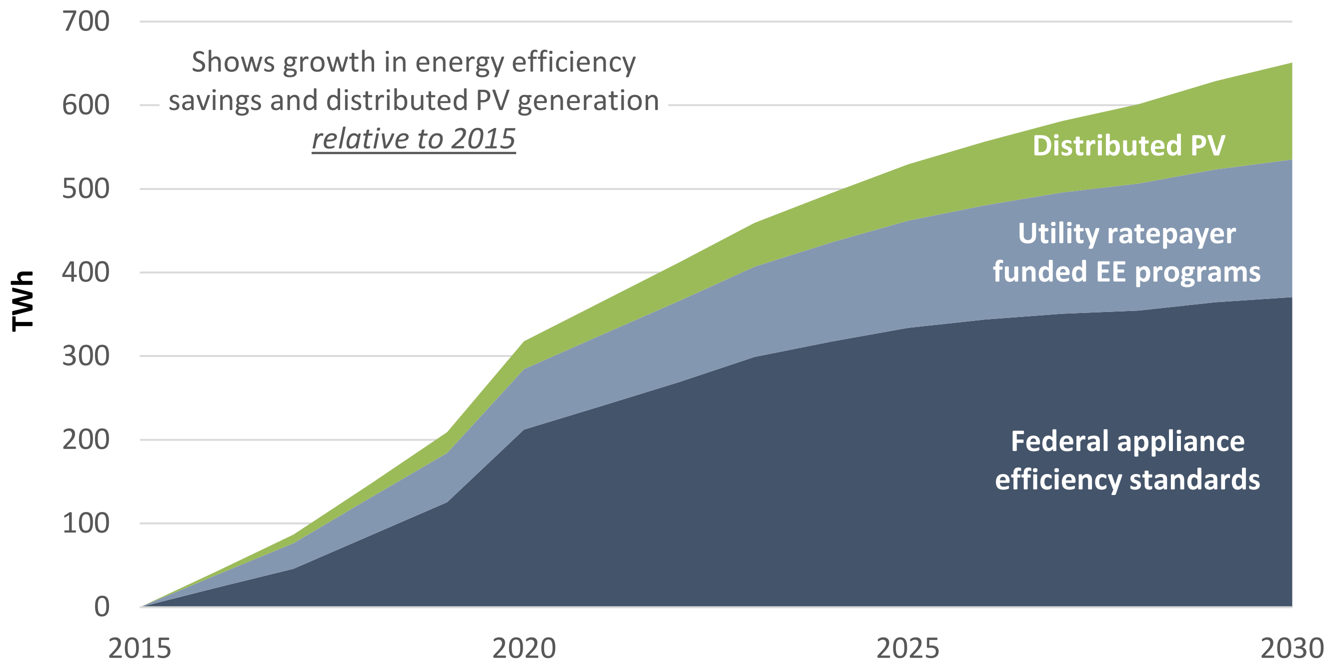
- Introduction
- U.S. Retail Electricity Prices: Historical Trends and Current Projections
- Scaling the Effects of Distributed Solar on Retail Electricity Prices
- **Other Drivers for Changes to Retail Electricity Prices**
  - energy efficiency programs and policies
  - natural gas prices
  - renewables portfolio standards
  - state and federal carbon policies
  - capital expenditures by electric utilities
- Conclusions

Discussion of these other drivers:

- Not a comprehensive set of drivers, and partially overlapping
- Focuses just on potential rate impacts; not a cost-benefit analysis
- Illustrative and approximate, focusing on the year 2030

Energy efficiency has a far greater impact on electricity sales than distributed solar

Growth in U.S. energy efficiency savings and distributed PV generation



Notes: Data on federal appliance efficiency standards are adapted from Meyers et al. (2016), relying on supporting documentation provided directly by the authors. Data on utility ratepayer-funded EE programs are adapted from the mid-case projection in Barbose et al. (2013), requiring extrapolation from 2025 to 2030 and application of a decay function to accumulate savings from measures installed in successive years. Data on distributed PV are adapted from Cole et al. (2016), with generation estimated from reference-case nameplate capacity based on state-specific capacity factors. EE projections in the figure are intended to represent savings net of free riders, but do not reflect any possible rebound effects, nor does the figure include naturally occurring EE.

- Net-metered PV and energy efficiency (EE) can both impact retail electricity prices by reducing electricity sales
  - Though also differ in important ways (intermittency, peak coincidence, customer access, etc.)
- Reduction in electricity sales from EE (utility programs + federal appliance standards):
  - **35x** greater than distributed solar (to-date)
  - **5x** greater than distributed solar (2015-2030 growth)

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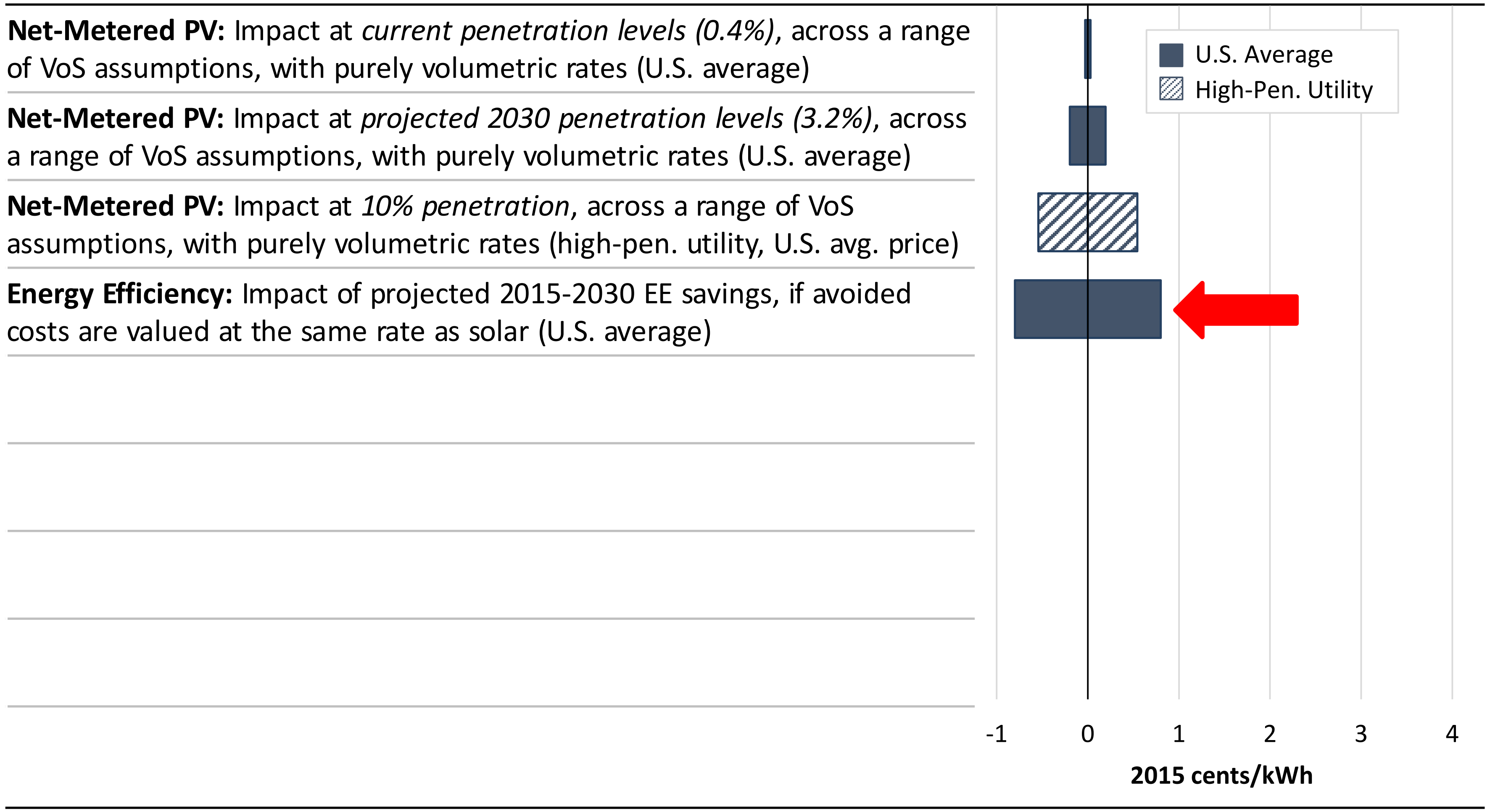
Potential rate impacts of energy efficiency correspondingly larger

Indicative ranges for potential effects on average retail electricity prices

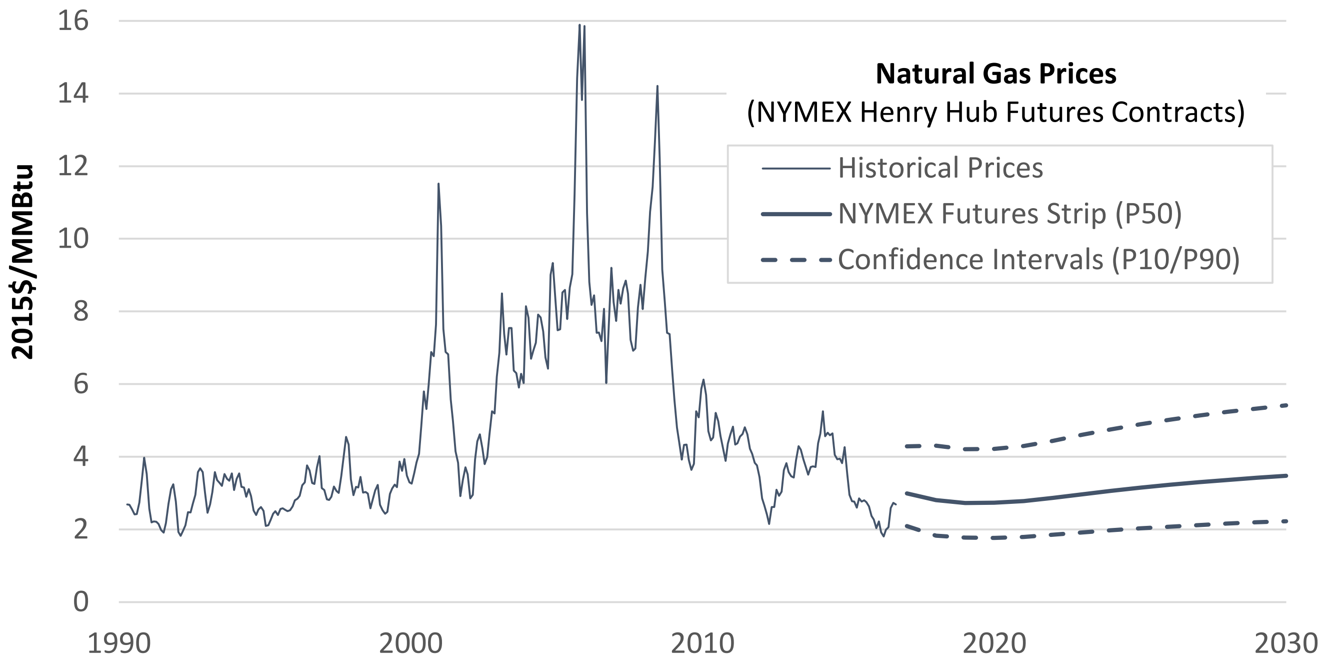


If value of EE savings to utility falls within 50-150% of CoS...

- EE savings growth through 2030 would yield up to a **±0.8 cent/kWh** change in U.S. average retail electricity prices
- EE experiences suggests that short-term rate impacts from reductions in electricity sales may be acceptable if:
  (a) Resources yield net cost savings to utility ratepayers over long run
  (b) Adequate opportunities exist for all ratepayers to participate

Natural gas prices are low but uncertain

Historical natural gas prices and confidence intervals for future prices



Notes: Historical Prices are the monthly average price of NYMEX Henry Hub futures contracts for delivery in the following month, converted to real dollars based on quarterly GDP deflators (BEA 2016). Confidence Intervals for NYMEX futures prices were derived by Bolinger (2017), based on historical volatility in returns on natural gas futures contracts and NYMEX futures prices as of Sept. 19, 2016. The confidence intervals shown here represent the 10th and 90th percentile values (P10 and P90).

- Electricity prices increasingly linked with natural gas prices
- Gas prices currently near historical lows, but prone to extreme volatility
  - Risk skewed upward
  - Limited long-term financial hedging
  - Fuel costs passed through to ratepayers
  - Electricity price effects amplified in restructured markets
- Electric sector modeling studies show that <u>for each $1/MMBtu increase in gas prices</u>, retail electricity prices in 2030 would increase by:
  - 0.4 cents/kWh (U.S. average)
  - 1 cent/kWh or more in restructured markets

Higher-than-expected gas prices could significantly impact electricity prices, but risks can be mitigated

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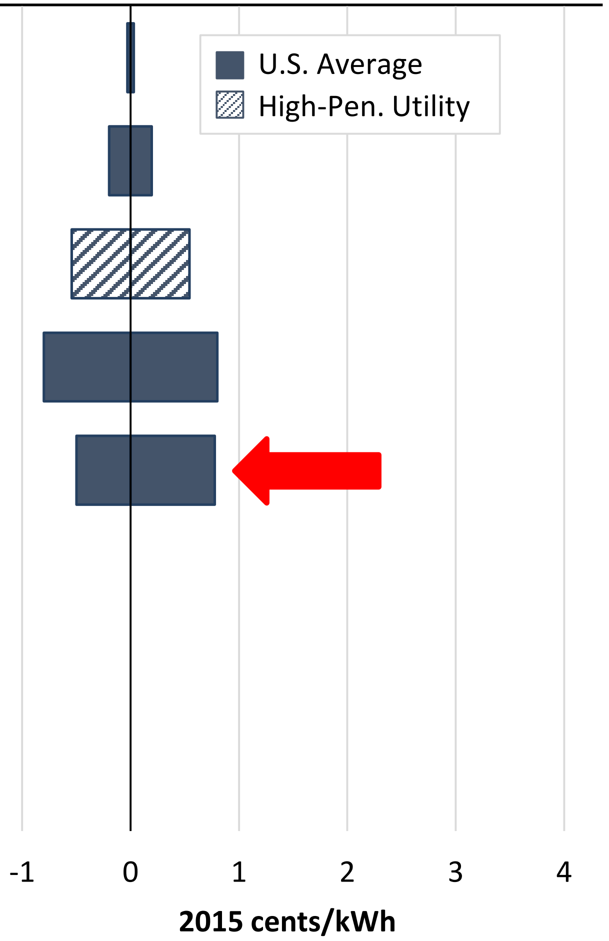
Net-Metered PV: Impact at *10% penetration*, across a range of VoS assumptions, with purely volumetric rates (high-pen. utility, U.S. avg. price)

Energy Efficiency: Impact of projected 2015-2030 EE savings, if avoided costs are valued at the same rate as solar (U.S. average)

Natural Gas: Range in retail electricity price across $10^{th}/90^{th}$ percentile gas price confidence intervals for 2030 (U.S. average)



Across the $10^{th}/90^{th}$ percentile gas price confidence levels for 2030 (\$2.2-\$5.4/MMBtu):

- U.S. average retail electricity prices range from **0.5 cents/kWh lower** to **0.8 cents/kWh higher** than under expected gas prices
- Restructured regions could see increases of 1.5-2.2 cents/kWh
- Utilities and PUCs can manage exposure to long-term gas price risk through resource planning and resource diversification

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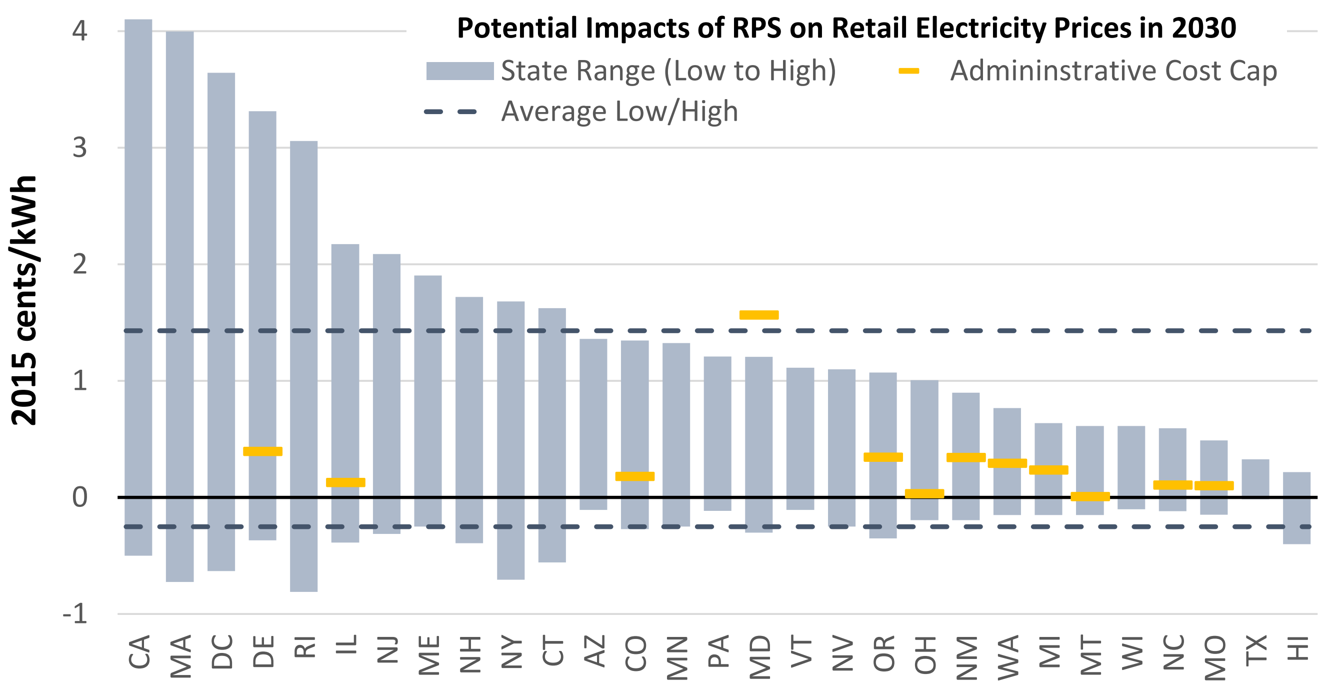
RPS rate impacts relatively small thus far, but could rise with increasing RPS targets

Illustrative range in potential impacts of RPS policies on retail electricity prices in 2030



Notes: The ranges are based on a simplified set of assumptions and should be considered illustrative only. Averages are load-weighted. Administrative cost caps are often specified by statute in percentage terms, in which case they are translated here into units of cents/kWh based on projected retail electricity prices in 2030.

- RPS compliance cost data: average price effects of 0.1 cents/kWh in RPS states to-date
  - Rising targets could put upward pressure on rates
- We estimate potential state-level RPS rate impacts in 2030 across broad set of assumptions
  - Upper bounds are a fairly extreme scenario: assume that REC prices are trading at their caps and that other administrative caps not enforced
  - Smaller retail price effects are expected in practice, and even decreases are possible
  - Effects vary across states, depending on RPS stringency, DG carve-outs, and ACPs
- Average effect (dashed lines) ranges from a **0.3 cent/kWh decrease** to **1.4 cents/kWh increase**

States and utilities have the ability limit RPS rate impacts through RPS design and other supportive measures

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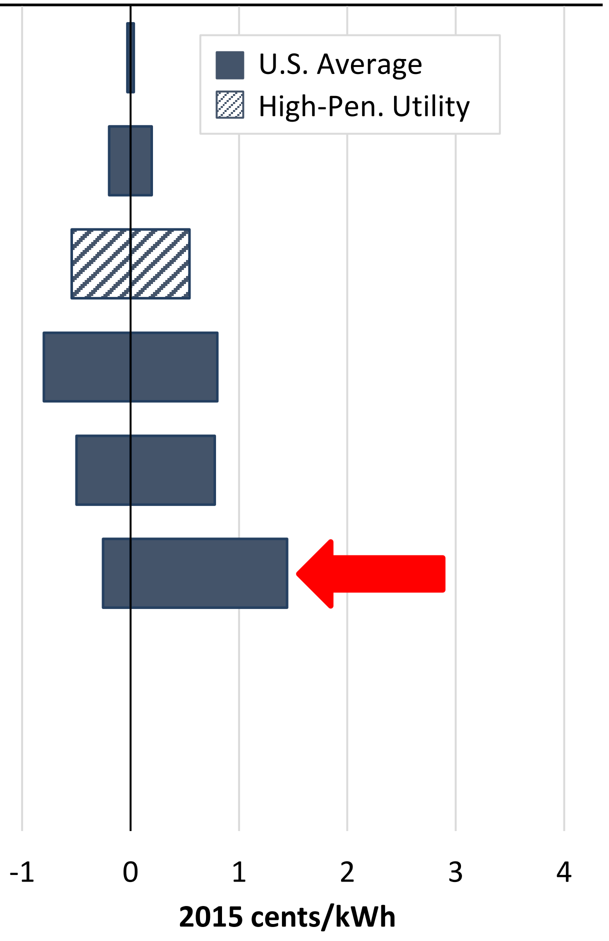
Natural Gas: Range in retail electricity price across 10th/90th percentile gas price confidence intervals for 2030 (U.S. average)

RPS: Impact in 2030 across low and high cost scenario assumptions (U.S. average, among RPS states)



States can limit RPS-related price increases by ensuring sufficient RPS supplies, for example, by:

- Facilitating long-term contracting
- Easing siting & transmission expansion

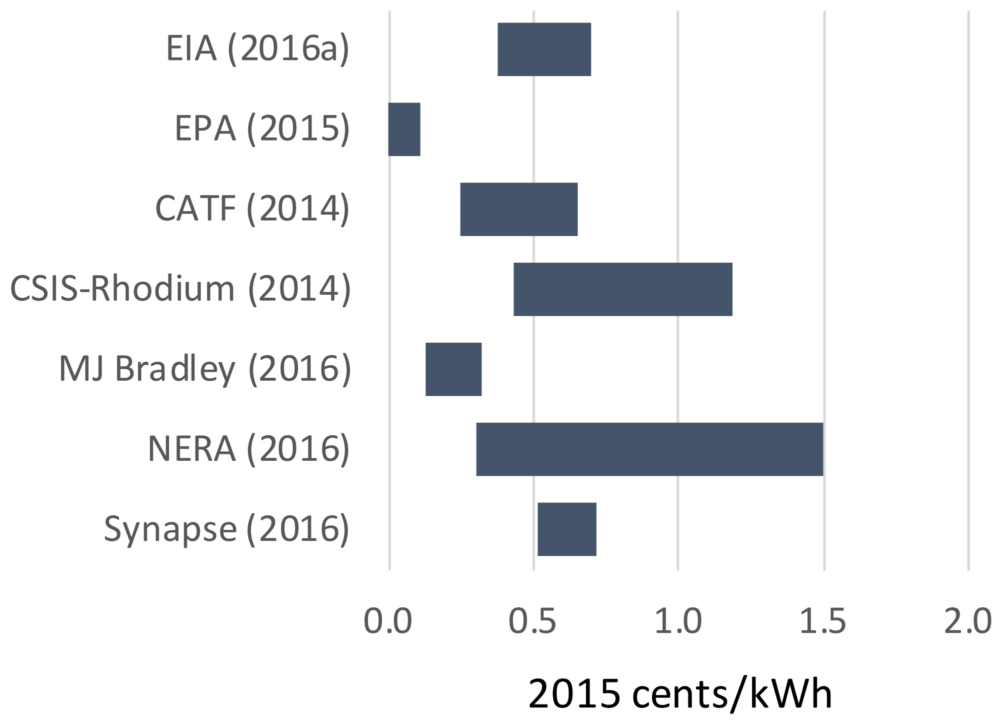
States also have leverage through the structure and administration of the RPS itself:

- Eligibility rules
- Alternative compliance payment (ACP) rates
- Disposition of ACP revenues
- Dynamic RPS targets

State/regional carbon policies have so far had limited rate impacts

But future effects from state or federal programs are uncertain

Projected impact of CPP on retail electricity prices: Comparison of electricity market studies



Notes: Ranges represent price impacts across multiple CPP scenarios, typically for the year 2030, though some studies only report impacts for other years or the average impact over a period of years. Differences across studies partly reflect varying vintages and thus whether they evaluated the proposed or final CPP rule, whether they included the renewable energy tax credit extenders passed in 2015, and underlying assumptions about future natural gas prices.

- Existing state and regional carbon programs (in California and the Northeast) have had limited effects on retail electricity prices so far
  - Complementary policies and price caps have kept allowance prices low
  - Allowance revenues allocated for bill credits
- Modeling studies of CPP show varying effects on electricity prices, depending on how states implement the federal standard
  - Estimates range from a **0.0-1.5 cent/kWh** increase in U.S. average retail electricity prices in 2030
  - For example: mass- vs. rate-based, allowance allocation, scope of allowance trading
  - Wider ranges for some states and regions

States can limit effects of carbon policy on retail electricity prices through policy design and risk management

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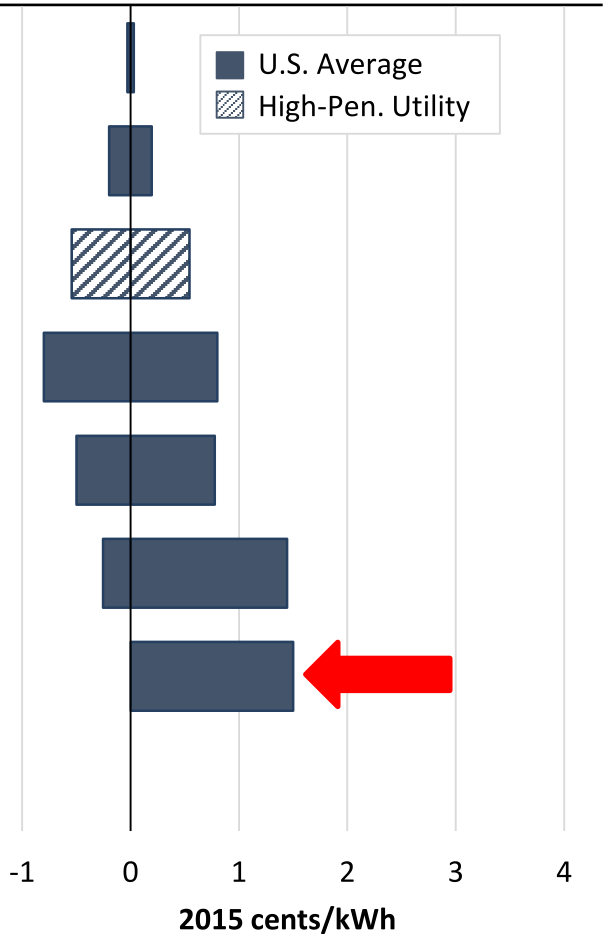
Natural Gas: Range in retail electricity price across 10th/90th percentile gas price confidence intervals for 2030 (U.S. average)

RPS: Impact in 2030 across low and high cost scenario assumptions (U.S. average, among RPS states)

Carbon: Impact of CPP in 2030 across multiple studies, each considering multiple implementation scenarios (U.S. average)



States and utilities have several points of leverage for limiting the rate impacts

- Carbon policy design issues are instrumental in determining the rate impact (especially allowance allocation)
- Utilities and PUCs can manage exposure to long-term carbon regulatory risk through resource planning and diversification

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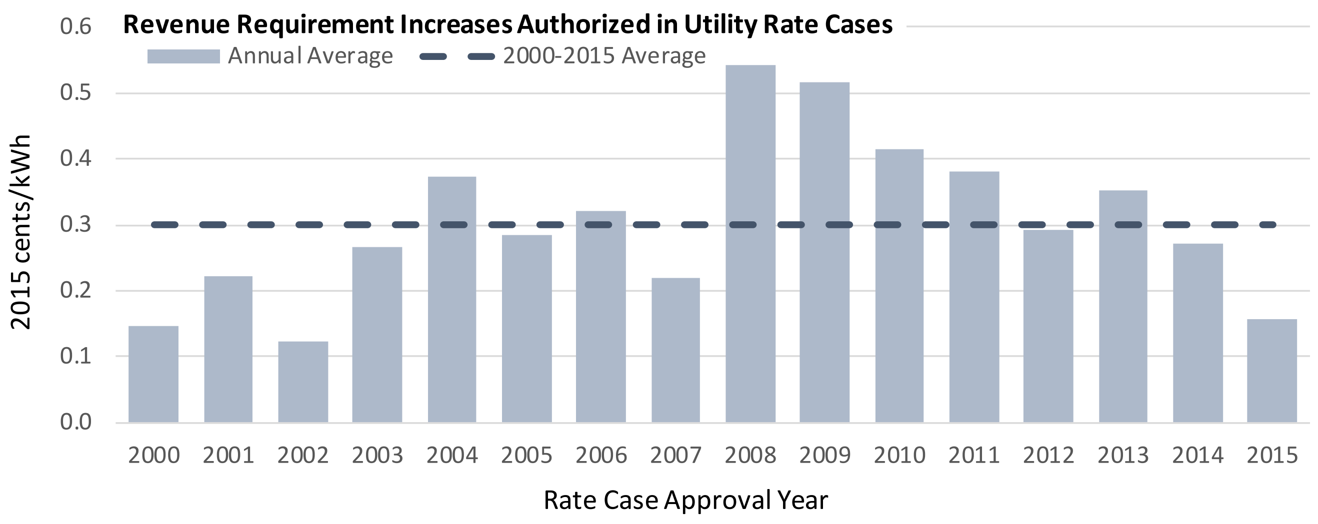
Capital expenditures by regulated utilities put upward pressure on retail electricity prices

Utility revenue requirement increases authorized in general rate cases



Notes: The figure is based on data from general rate cases for vertically integrated utilities (SNL Energy, April 2016). Revenue requirement increases are translated into units of cents/kWh by dividing the authorized dollar increase by each utility's retail electricity sales. Annual averages across rate cases in each year are weighted based on each utility's electricity sales.

- Capital expenditures (CapEx) in electric industry have been on the rise, despite flat load growth
  - T&D is 60% of total industry CapEx since 2000, and growing faster than generation CapEx
- CapEx by regulated utilities recovered through revenue requirements approved in rate cases
- Revenue requirement increases authorized in utility rate cases have averaged 0.3 cents/kWh (per rate case) since 2000
  - Reflects net effect of new assets entering the rate base, as existing assets become fully depreciated
- Corresponding impact on retail rates depends on relative rate of growth in electricity sales; more pronounced effects when load growth is low

The effects of CapEx on retail electricity prices going forward depends on the level of investment and cost of capital

Estimated impact of future capital expenditures on retail electricity prices

	Low	High
Annual CapEx through 2030 ($2015)	$100 billion/yr (constant)	6% real annual growth, from $100 billion in 2015
Weighted-average cost of capital (WACC)	6%	9%
Impact on average retail electricity prices in 2030 ($2015)	**1.6 cents/kWh**	**3.6 cents/kWh**

Notes: The low case CapEx trajectory is based on ASCE (2016), which estimates total electric industry infrastructure investments needed through 2040 in order to meet load growth. The CapEx growth rate in the high case is equal to average annual growth from 2000-2015, where annual CapEx is calculated in the manner described in footnote 18. In both cases, we assume that 75% of future CapEx investments are made by regulated entities (based on a 50/50 split between generation and T&D, and the assumption that half of generation investments and effectively all T&D investments are made by regulated entities). The low and high WACC assumptions are based on the minimum and maximum annual industry averages over the 2000-2015 period, calculated from data published by Damodaran (2016) and S&P Global Market Intelligence (2016). Both scenarios assume an average 30-year depreciation life for new CapEx investments, and use forecasted U.S. retail electricity sales from the EIA's 2016 Annual Energy Outlook reference case to translate dollar costs into cents/kWh (EIA 2016a).

Consider two plausible (though not particularly extreme) CapEx trajectories

- **Low:** CapEx remains flat at current levels; consistent with ASCE estimate of minimum level needed for reliability, but no major transformation
- **High:** CapEx grows at 6% per year (in real terms), equal to average growth rate over 2000-2015
- Cost of capital reflects historical range for regulated electric utilities
- Estimated impacts on average retail electricity prices reflect the gross effect of new investments
- Greater or more-accelerated impacts possible for some utilities (e.g., those with new nuclear plants or major grid modernization initiatives)

Among issues explored in this work, electric-utility CapEx likely to have the greatest impact on future retail electricity prices

Indicative ranges for potential effects on average retail electricity prices

Net-Metered PV: Impact at *current penetration levels*, across a range of VoS assumptions, with purely volumetric rates (U.S. average)

Net-Metered PV: Impact at *projected 2030 penetration levels*, across a range of VoS assumptions, with purely volumetric rates (U.S. average)

Net-Metered PV: Impact at *10% penetration*, across a range of VoS assumptions, with purely volumetric rates (high-pen. utility, U.S. avg. price)

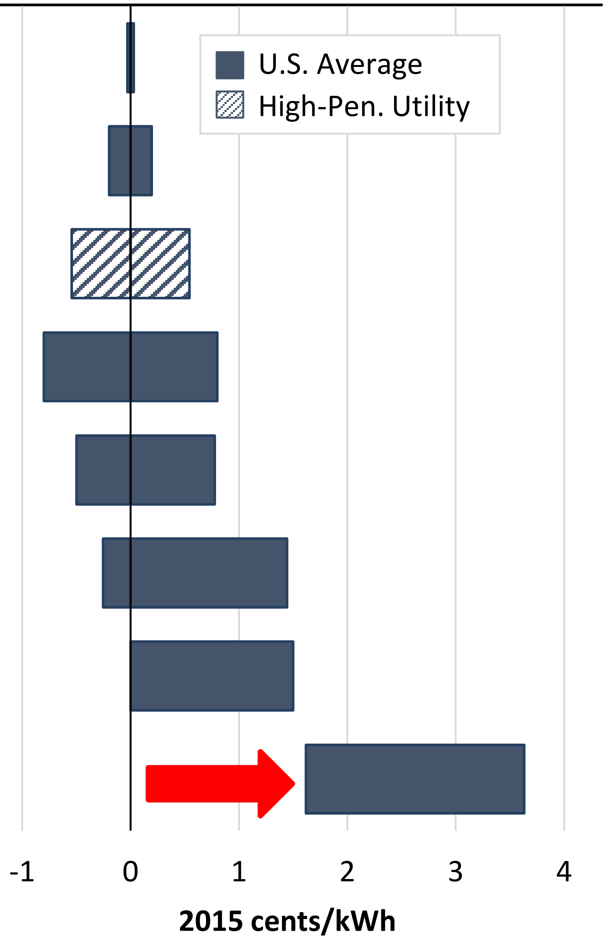
Energy Efficiency: Impact of projected 2015-2030 EE savings, if avoided costs are valued at the same rate as solar (U.S. average)

Natural Gas: Range in retail electricity price across $10^{th}/90^{th}$ percentile gas price confidence intervals for 2030 (U.S. average)

RPS: Impact in 2030 across low and high cost scenario assumptions (U.S. average, among RPS states)

Carbon: Impact of CPP in 2030 across multiple studies, each considering multiple implementation scenarios (U.S. average)

CapEx: Gross impact of electric-industry CapEx through 2030, across range of CapEx trajectories and WACC (U.S. average)



- Estimates suggest a potential effect of **1.6-3.6 cent/kWh** on U.S. average retail electricity prices in 2030
- Relatively large effects on prices say nothing about potential benefits or prudence of such investments
- But simply highlight that this is an area where regulatory oversight can play a crucial role in managing retail electricity price escalation

Outline

- Introduction
- U.S. Retail Electricity Prices: Historical Trends and Current Projections
- Scaling the Effects of Distributed Solar on Retail Electricity Prices
- Other Drivers for Changes to Retail Electricity Prices
- **Conclusions**

Conclusions

- **Effects of distributed solar on retail electricity prices generally small compared to other issues**
  - Reforms of net metering rules or retail rate structures may still be warranted, but other objectives (e.g., economic efficiency) likely provide a more compelling rationale
- **Where concerns about minimizing retail electricity price remain a priority, other areas may prove more impactful**
  - E.g., CapEx oversight, utility resource planning, efforts to ensure sufficient RPS supply
- **For states/utilities with exceptionally high distributed solar penetration, effects on retail prices could approach the same scale as other important drivers (among residential classes)**
  - Questions about VoS become more important to assessing possible cost-shifts, and to mitigating it by facilitating higher-value forms of deployment
- **Experiences with energy efficiency offer lessons for states witnessing especially high distributed solar penetration**
  - As solar costs continue to decline, grid-friendly PV technologies advance, and initiatives to broaden solar access continue, issues of cost-shifting from distributed solar will become more similar to those of energy efficiency

For Further Information

Download the full report

https://emp.lbl.gov/publications/putting-potential-rate-impacts

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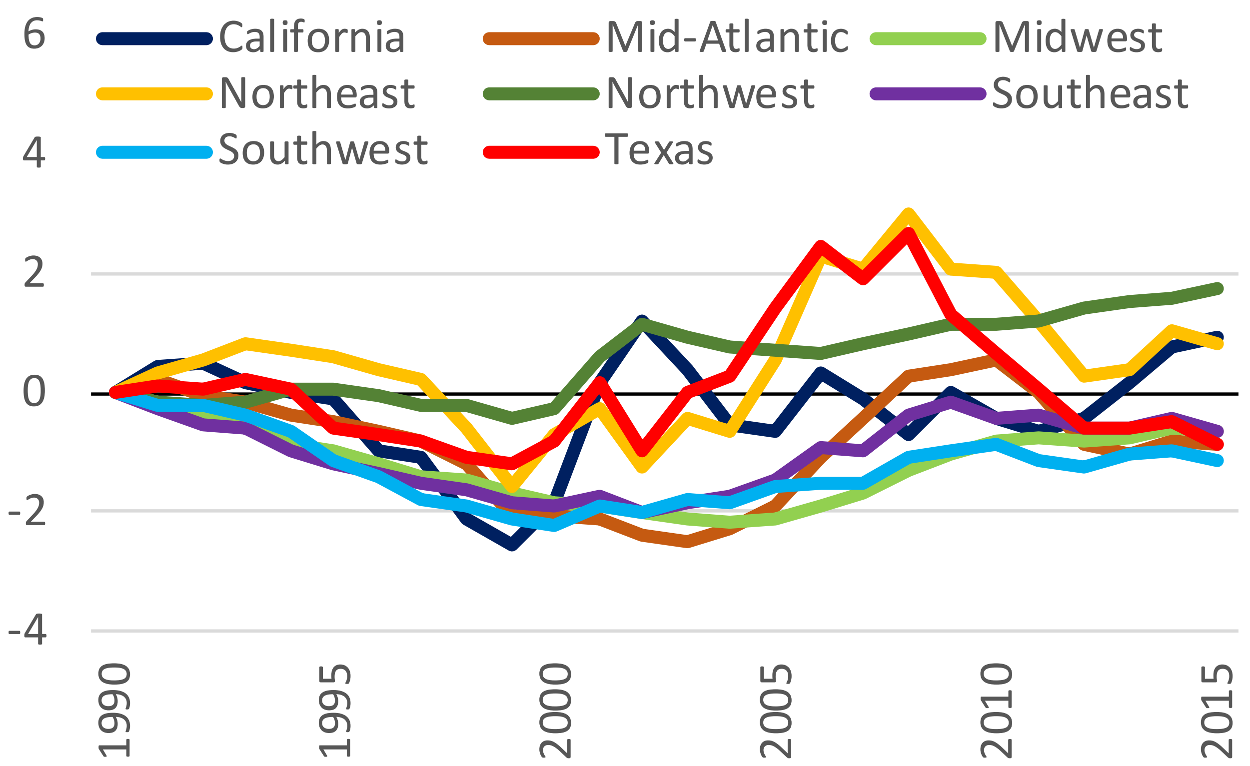
Upward price trend since 2000 extends across most regions

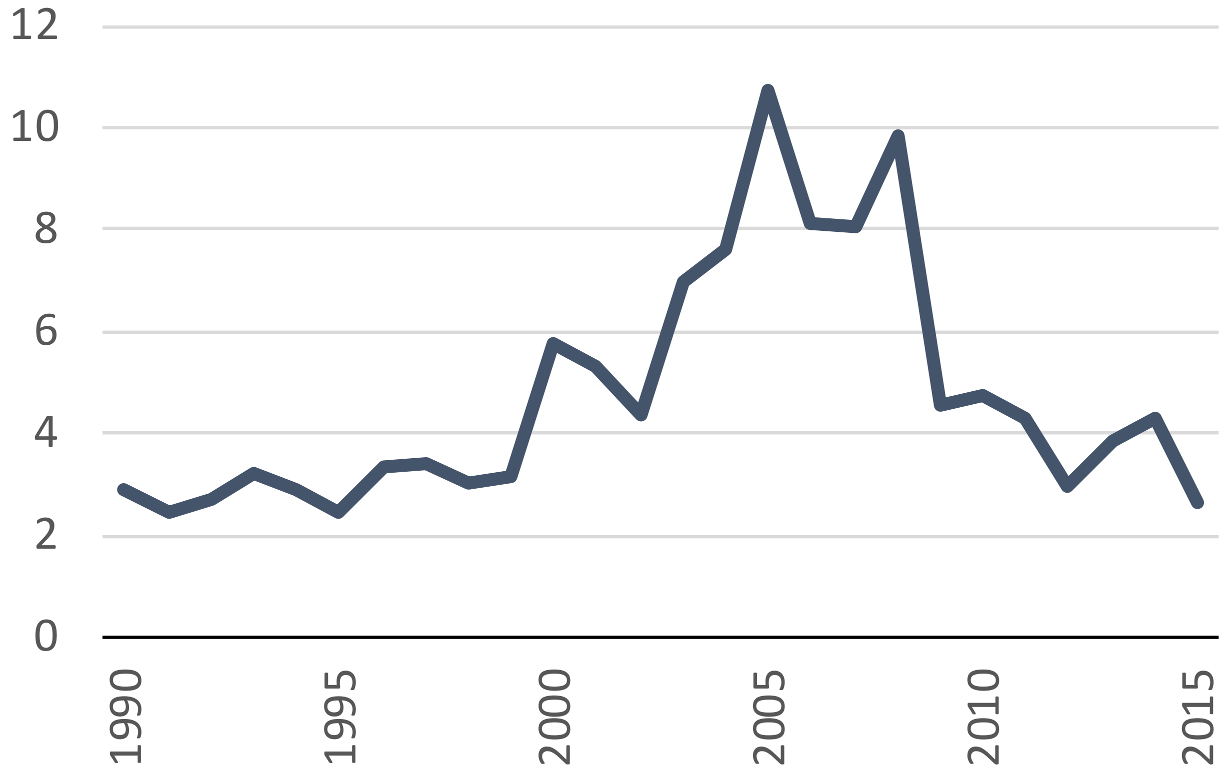
Large swings in intervening years partly due to fluctuating gas prices

Growth in regional retail electricity prices
(Real cents/kWh, change from 1990)



Notes: Values represent the change in price relative to 1990. See Slide 5 notes for sources.

Annual average natural gas prices
(Real $/MMBtu)

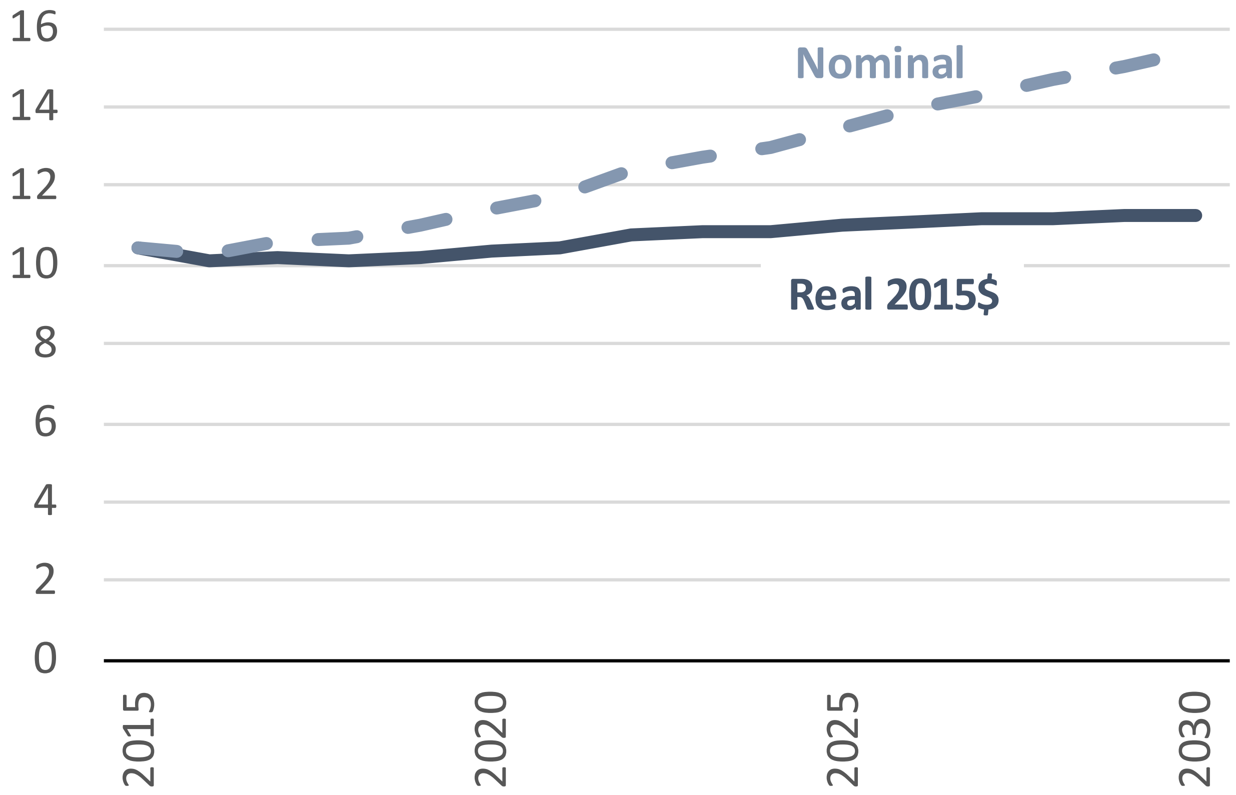


Notes: Annual average of daily prices for NYMEX Henry Hub futures contracts for delivery in the following month.

Flat load growth across most regions over the past decade

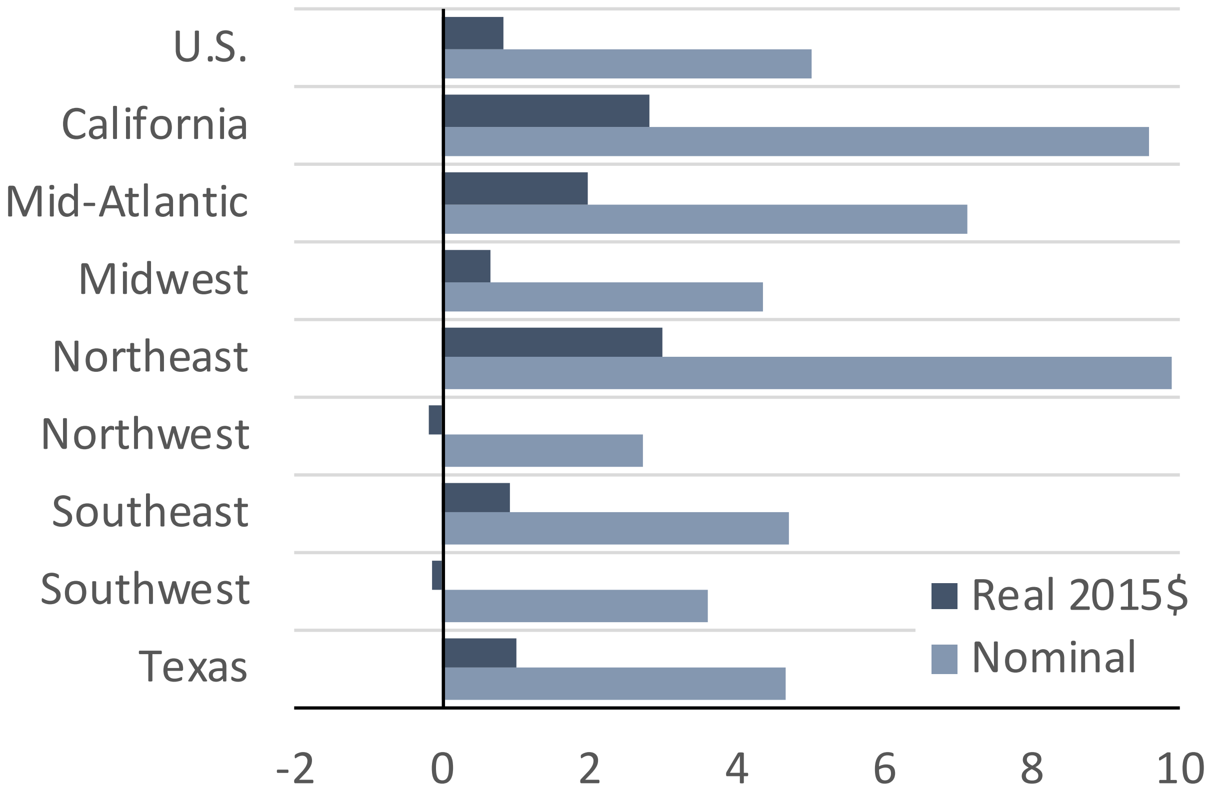
Energy efficiency an important, though not the sole, contributor

Projected U.S. average retail electricity prices (cents/kWh)



Notes: Based on EIA's 2017 Annual Energy Outlook reference case (EIA 2017).

Total increase in regional electricity prices from 2015-2030 (cents/kWh)



Notes: See Figure 7 for source. Based on projected retail prices for EIA Electricity Market Module regions, aggregated into the larger regional groupings shown here.

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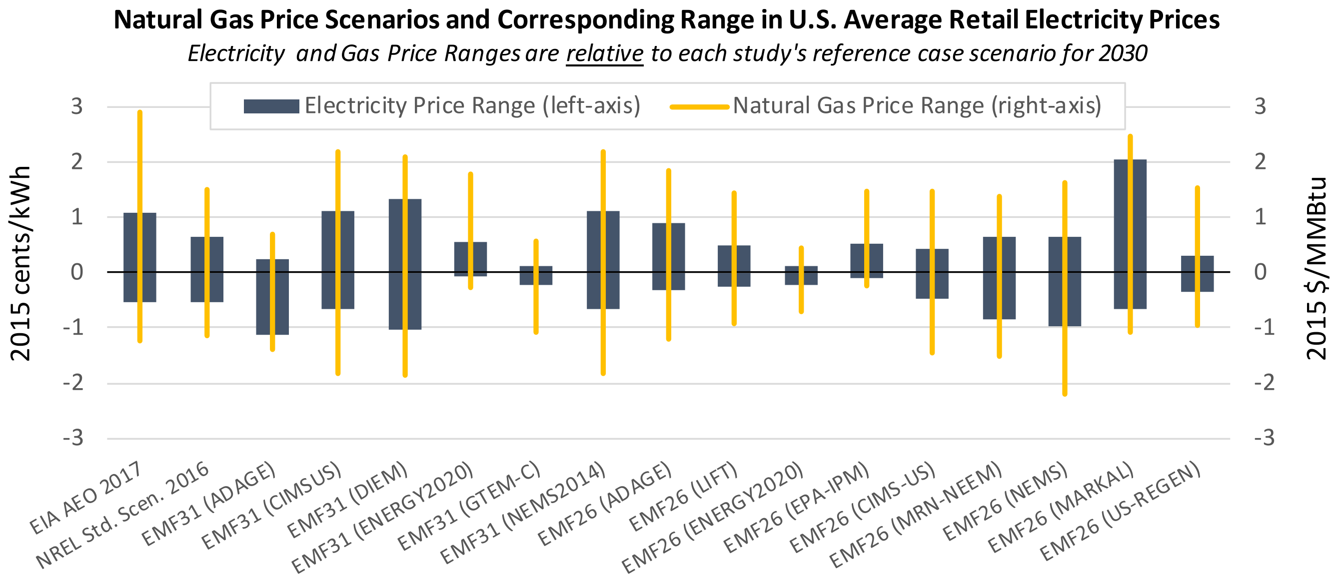
Sensitivity of retail electricity prices to natural gas prices

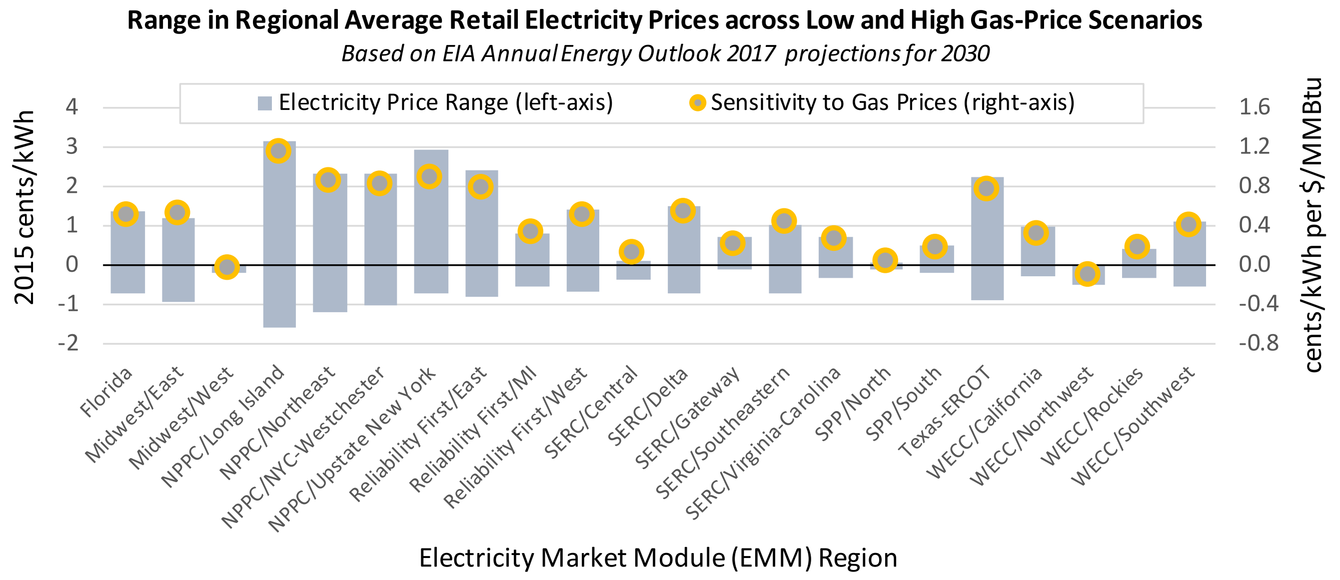
Summary of electric sector modeling studies

Retail electricity prices across natural gas price scenarios: Comparison of electricity market studies



Notes: The ranges for EIA AEO 2017 are based on the low and high oil and gas resource and technology side cases (EIA 2017). The ranges for the NREL Standard Scenarios study are based on the low fuel price and high fuel price scenarios (Cole et al. 2016). The EMF31 studies are from the Stanford Energy Modeling Forum's project "EMF 31: North American Natural Gas Markets in Transition," which consists of a common set of scenarios explored by different modeling teams, using the models identified in parentheses (Stanford University 2016). The ranges shown are from low and high shale resource scenarios. The EMF26 studies are based on an earlier set of analyses by Energy Modeling Forum participants (Stanford University 2013), and the ranges shown are again from a set of low and high shale resource scenarios. For further details on scenario assumptions and modeling details, please refer to the source documents. All gas prices shown represent Henry Hub.

Regional differences in the sensitivity of retail electricity prices to natural gas prices



Notes: Data are based on the low and high "oil and gas resource and technology" side cases. Upper and lower bounds of electricity price ranges are relative to reference case scenario. Sensitivity to Gas Prices refers to the ratio of the range in electricity prices, between the low and high cases, to the corresponding range in Henry Hub natural gas prices. For a map identifying EIA's EMM regions: https://www.eia.gov/forecasts/aeo/pdf/nerc_map.pdf

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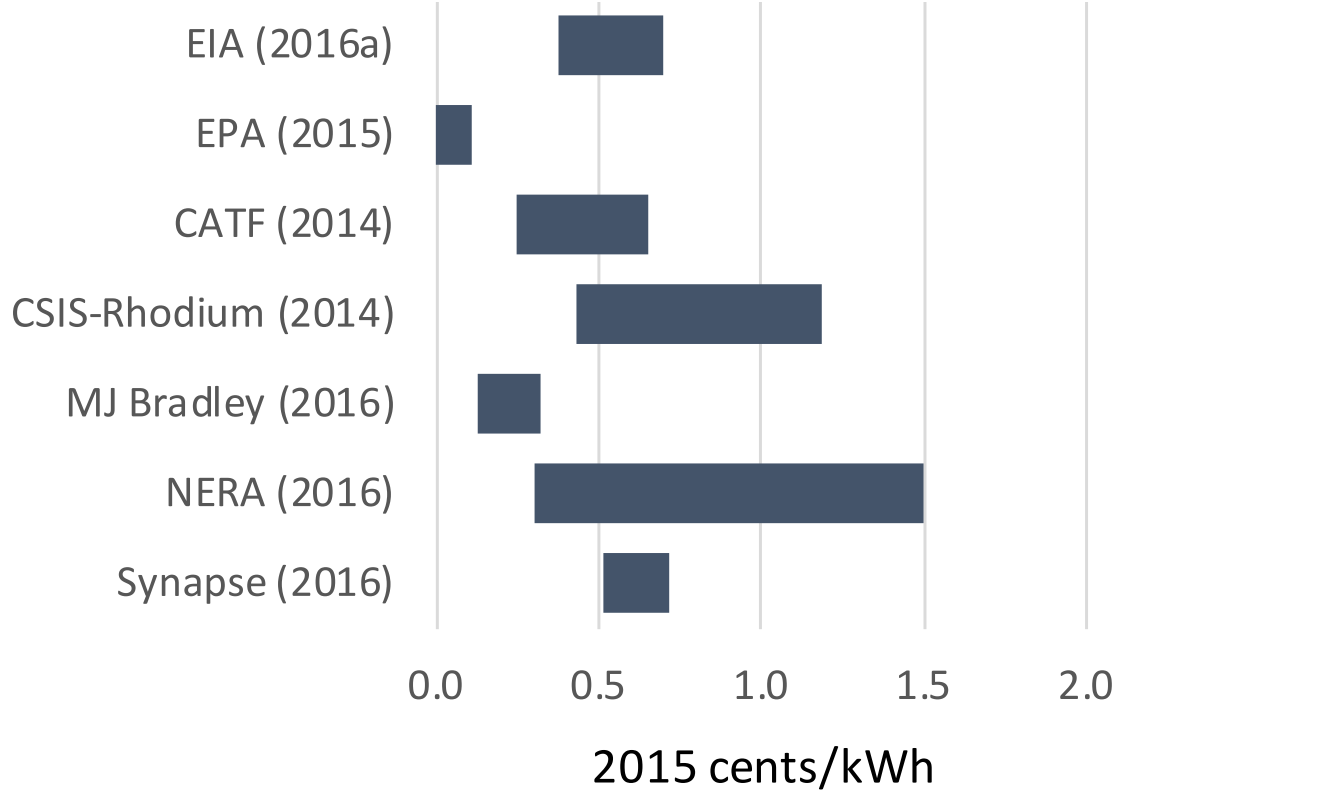
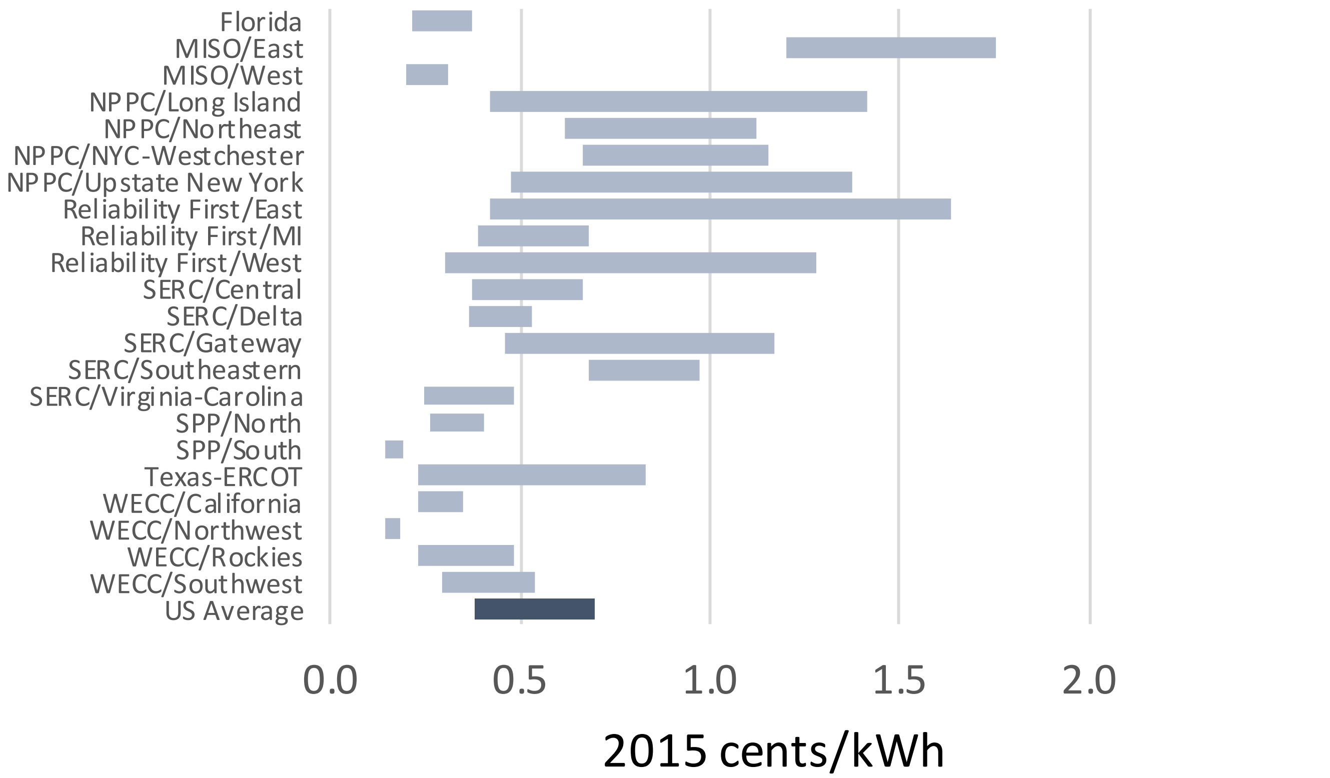
Impacts of CPP on retail electricity prices depend on state-level implementation details and vary by region

Projected impact of CPP on retail electricity prices: Comparison of electricity market studies



Notes: Ranges represent price impacts across multiple CPP scenarios, typically for the year 2030, though some studies only report impacts for other years or the average impact over a period of years. Differences across studies partly reflect varying vintages and thus whether they evaluated the proposed or final CPP rule, whether they included the renewable energy tax credit extenders passed in 2015, and underlying assumptions about future natural gas prices.

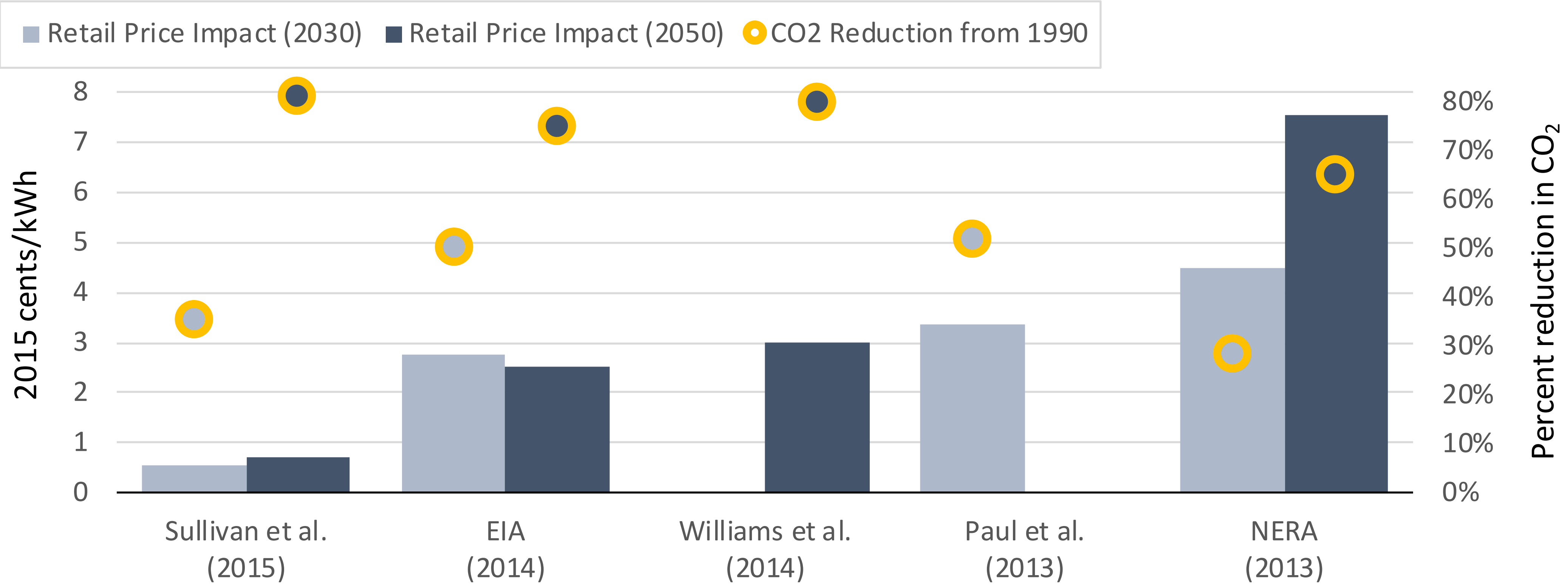
Regional differences in EIA's estimates of the CPP's impact on retail electricity prices



Notes: Data are from EIA's 2016 Annual Energy Outlook (EIA 2016a). The ranges for each Electricity Market Module region are calculated by comparing prices between each CPP scenario and the "Reference case without Clean Power Plan" scenario, for the year 2030. For a map identifying EIA's Electricity Market Module regions, see: https://www.eia.gov/forecasts/aeo/pdf/nerc_map.pdf

Impacts of CPP on retail electricity prices depend on state-level implementation details and vary by region

Projected impact of potential long-term carbon policies on retail electricity prices: Comparison of electricity market studies



Notes: Each of the studies modeled scenarios with carbon dioxide emission taxes or targets that become progressively more stringent until 2040 (EIA 2014) or 2050 (all others). Retail price impacts represent the difference between U.S. average retail prices in the policy case and the study's baseline "no-policy" case. For Williams et al. (2014) and NERA (2013), the percentage emissions reductions shown are economy-wide; for the other studies, they are for the electric power sector, specifically. Not all studies reported results for the years 2030 and 2050. For EIA (2014), projections for the year 2040 are plotted in lieu of 2050 values. For Paul et al. (2013), 2035 values are plotted in lieu of 2030. And for NERA (2013), 2033 and 2053 values are plotted in lieu of 2030 and 2050, respectively.

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