Title
U.S. Renewables Portfolio Standards: 2019 Annual Status Update

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U.S. DEPARTMENT OF ENERGY

U.S. Renewables Portfolio Standards

2019 Annual Status Update

Galen Barbose

July 2019

Download report and supporting materials at: rps.lbl.gov

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Acronyms

ACP: Alternative compliance payment

CCA: Community choice aggregator

DG: Distributed generation

DPU: Department of Public Utilities

EIA: Energy Information Administration

ESP: Electricity service provider

GW: Gigawatt

GWh: Gigawatt-hour

IOU: Investor-owned utility

LSE: Load-serving entity

MSW: Municipal solid waste

MW: Megawatt

MWh: Megawatt-hour

NEPOOL: New England Power Pool

OSW: Offshore wind

POU: Publicly owned utility

PPA: Power purchase agreement

PUC: Public utilities commission

RE: Renewable electricity

REC: Renewable electricity certificate

RPS: Renewables portfolio standard

SACP: Solar alternative compliance payment

SREC: Solar renewable electricity certificate

TWh: Terawatt-hour

Highlights

Evolution of state RPS programs: States continue to refine and revise their RPS policies. Among other significant changes since the start of 2018, ten states enacted higher RPS targets (CA, CT, DC, MA, MD, NE, NJ, NM, NV, and NY), in most cases setting targets equal to at least 50% of retail sales. One state (OH) reduced its RPS targets.

Historical impacts on renewables development: Roughly half of all growth in U.S. renewable electricity (RE) generation and capacity since 2000 is associated with state RPS requirements, though not all of that is strictly attributable to RPS policies. Nationally, the role of RPS policies has diminished over time, representing just under 30% of all U.S. RE capacity additions in 2018. However, within particular regions—especially the Northeast and Mid-Atlantic, and to a lesser extent the West—RPS policies continue to serve a central role in motivating RE growth.

Future RPS demand and incremental needs: RPS demand growth will require roughly a 50% increase in U.S. RE generation by 2030, equating to 73 GW of new RE capacity. To meet future RPS obligations, U.S. non-hydro RE generation will need to reach 17% of electricity sales by 2030 (compared to 12% today), though other drivers will also continue to influence RE growth.

RPS target achievement to-date: States have generally met their interim RPS targets in recent years, with only a few exceptions reflecting unique, state-specific policy designs.

REC pricing trends: Prices for NEPOOL Class I RECs fell in 2018, before rebounding in early 2019, while PJM Tier I REC prices have remained relatively flat. Price trends for solar RECs vary by state, with the highest prices in DC, MA, and NJ.

RPS compliance costs and cost caps: RPS compliance costs—which reflect only a sub-set of all impacts (see slide 38)—totaled $4.7 billion in 2018, equating to 2.6% of average retail electricity bills in RPS states, compared to $4.0 billion and 1.7% of retail bills in 2017. Cost increases from rising RPS targets have been offset to some degree by falling RE costs and REC prices.

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Additional supporting data and documentation available at: rps.lbl.gov

- RPS annual percentage targets by state
- RPS demand projection and underlying load forecasts
- RPS historical compliance data

Evolution of State RPS Programs

What is a Renewables Portfolio Standard (RPS)?

aka Renewable Energy/Electricity Standard (RES)

Renewables Portfolio Standard

A requirement on retail electric suppliers…

To supply a minimum percentage or amount of their retail load…

With eligible sources of renewable energy

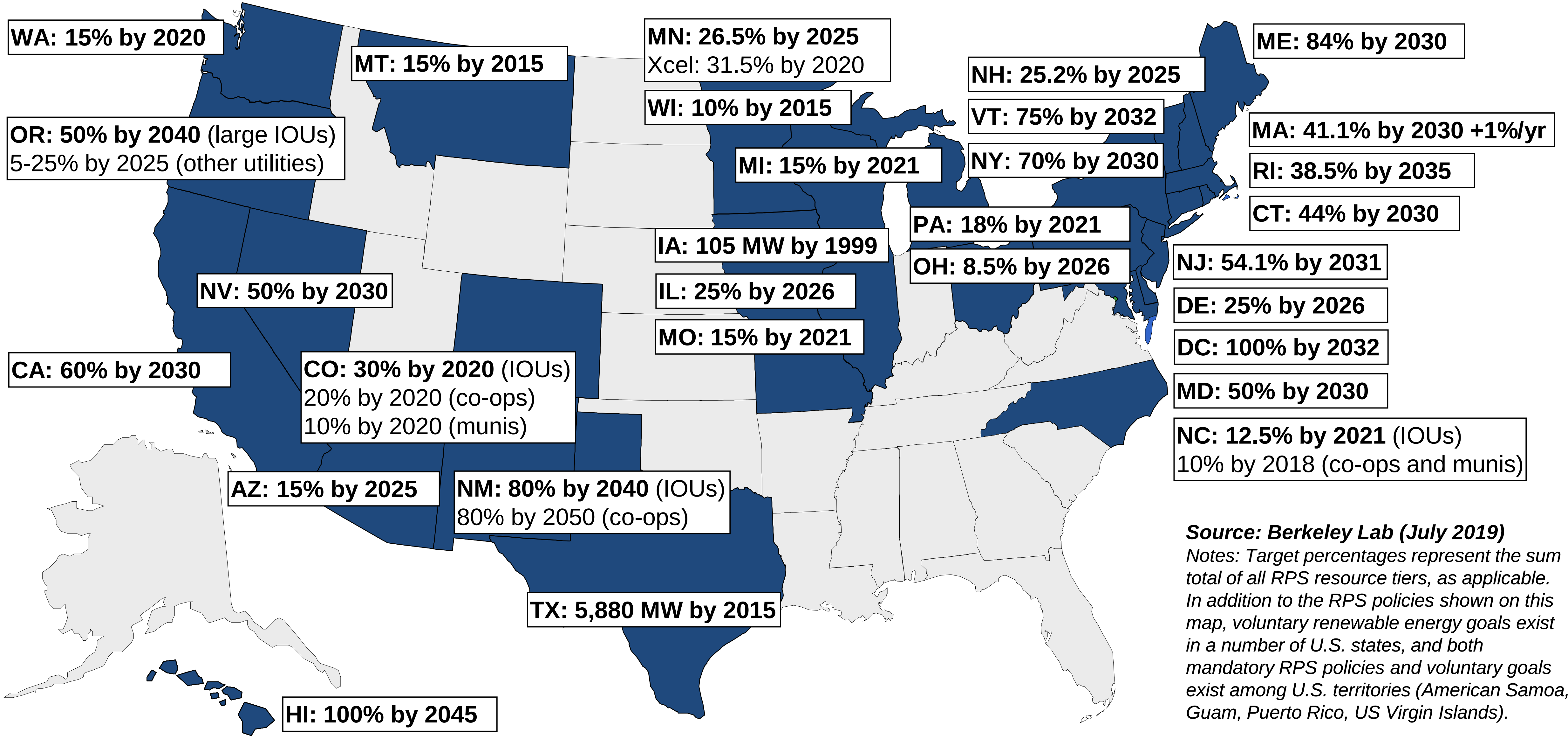
Typically	Backed with penalties of some form
Often	Accompanied by a tradable renewable energy certificate (REC) program to facilitate compliance
Never	Designed the same in any two states

This report covers U.S. state RPS policies. It does not cover:

- Voluntary renewable electricity goals
- Broader clean energy requirements without a renewables-specific component (briefly discussed in a side-bar)
- RPS policies outside of the United States or in U.S. territories

RPS Policies Exist in 29 States and DC

Apply to 56% of Total U.S. Retail Electricity Sales



Source: Berkeley Lab (July 2019)

Notes: Target percentages represent the sum total of all RPS resource tiers, as applicable. In addition to the RPS policies shown on this map, voluntary renewable energy goals exist in a number of U.S. states, and both mandatory RPS policies and voluntary goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

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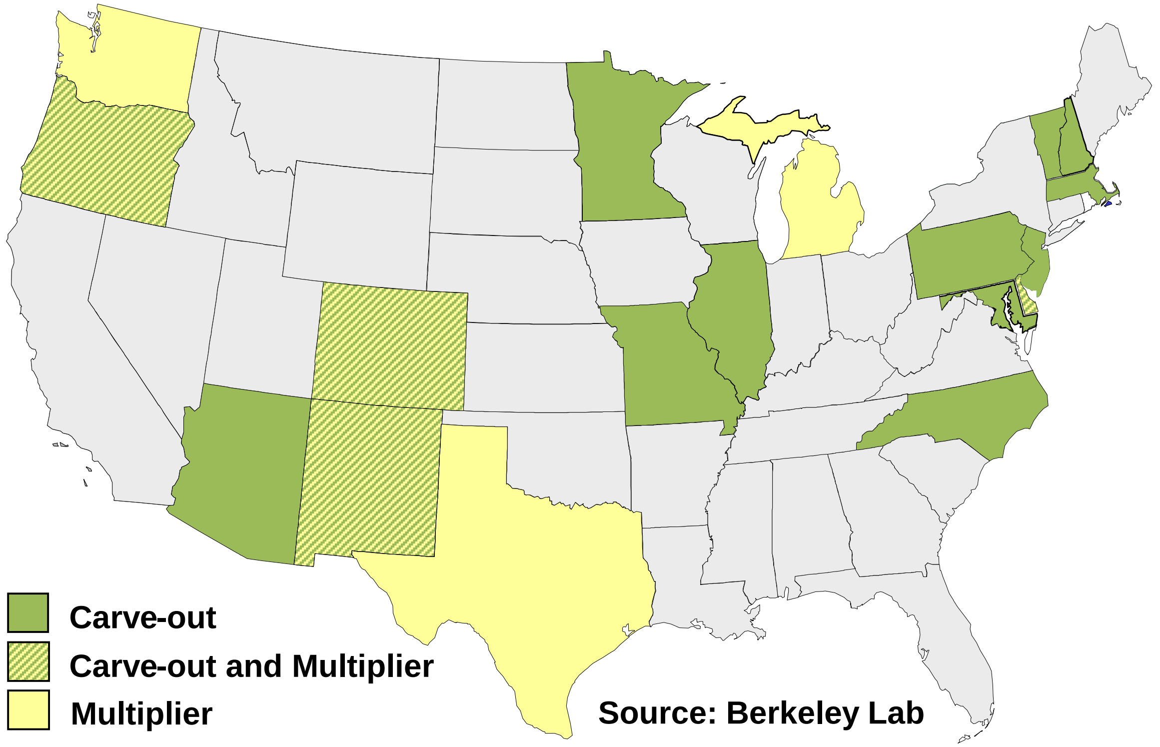
RPS Policies and Rules Vary Significantly from State to State

Major Variations Across States

- Targets and timeframes
- Entities obligated and exemptions
- Eligibility rules related to technology, vintage, location, and deliverability
- Use of resource tiers, carve-outs, or multipliers (e.g., see map)
- REC definitions, limitations, and tracking systems
- Contracting requirements or programs
- RPS procurement planning/oversight
- Compliance enforcement methods, reporting, and flexibility rules
- Existence and design of cost caps, alternative compliance payment rates

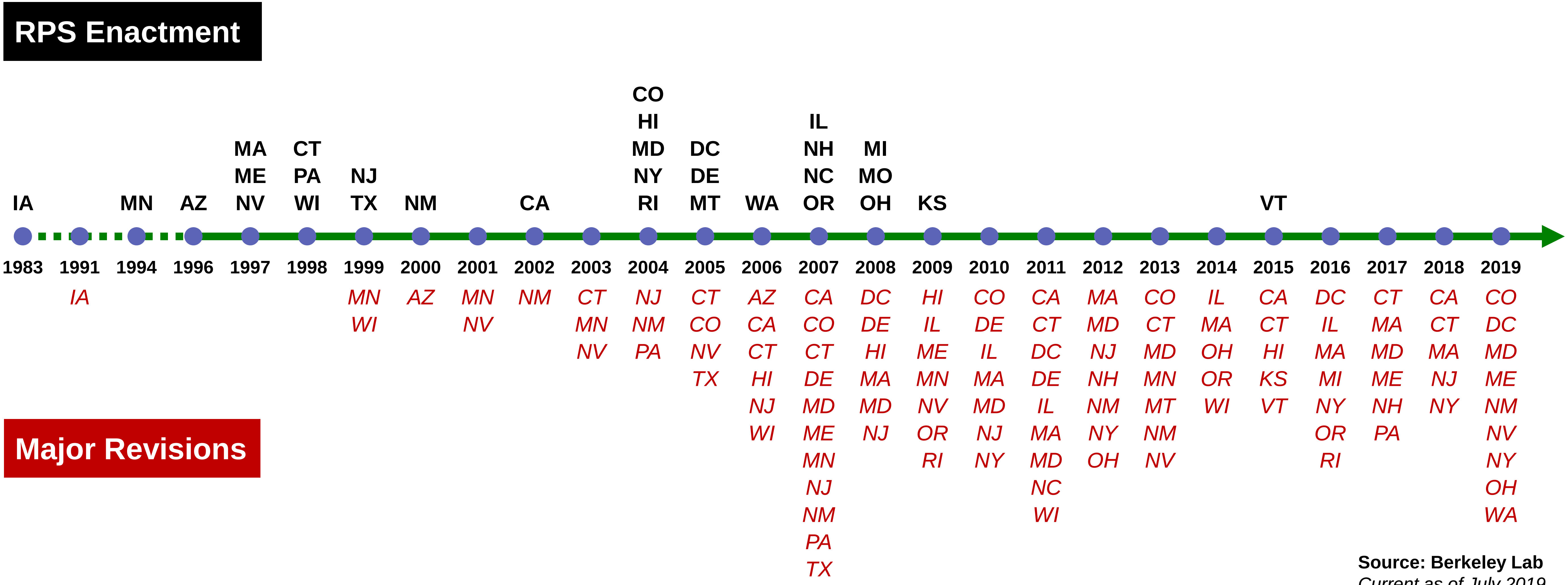
Solar or Distributed Generation (DG) Carve-Outs and Credit Multipliers



15 states + D.C. have solar or DG carve-outs, sometimes combined with credit multipliers; 3 other states only have credit multipliers

Most RPS Policies Have Been on the Books for a Decade or More

But states continue to make regular and significant revisions



Source: Berkeley Lab
Current as of July 2019

General Trends in RPS Revisions

Increasing and extending RPS targets: More than half of all RPS states have raised their overall RPS target or carve-out at some point since initial RPS adoption; many in recent years

Embedding RPS within broader clean electricity standards: Several states have created 100% zero-carbon electricity targets or targets for other zero-emission resources, in concert with the RPS

Addressing valuation and integration issues: Several states have created separate “clean peak” standards or energy storage targets in tandem with an RPS, in order to address RE integration issues

Developing “carve-outs” to support specific renewable technologies: Emphasis initially on solar and DG, but some states have phased those out; recent focus on offshore wind and thermal RE

Long-term contracting programs: Often aimed at regulated distribution utilities in competitive retail markets; have sometimes targeted specific types of resources (solar/DG, offshore wind)

Adjusting alternative compliance payment (ACP) rates and cost caps: Both increases and decreases have occurred as states seek to achieve compliance at least-cost

Refining resource eligibility rules: Particularly for hydro and biomass (e.g., related to project size, vintage, eligible feedstock, repowered facilities); also geographic eligibility rules

RPS Legislation and Other Revisions since January 2018

Most proposals sought to strengthen or make small technical changes

RPS-Related Bills since Jan. 2018

	Strengthen	Weaken	Neutral	Total
Introduced	**92**	**37**	**61**	**190**
Enacted	**12**	**3**	**7**	**22**

Data Source: *EQ Research (February 28, 2019), with several amendments*
Notes: *Companion bills are counted as a single bill*

10 states increased their RPS targets:

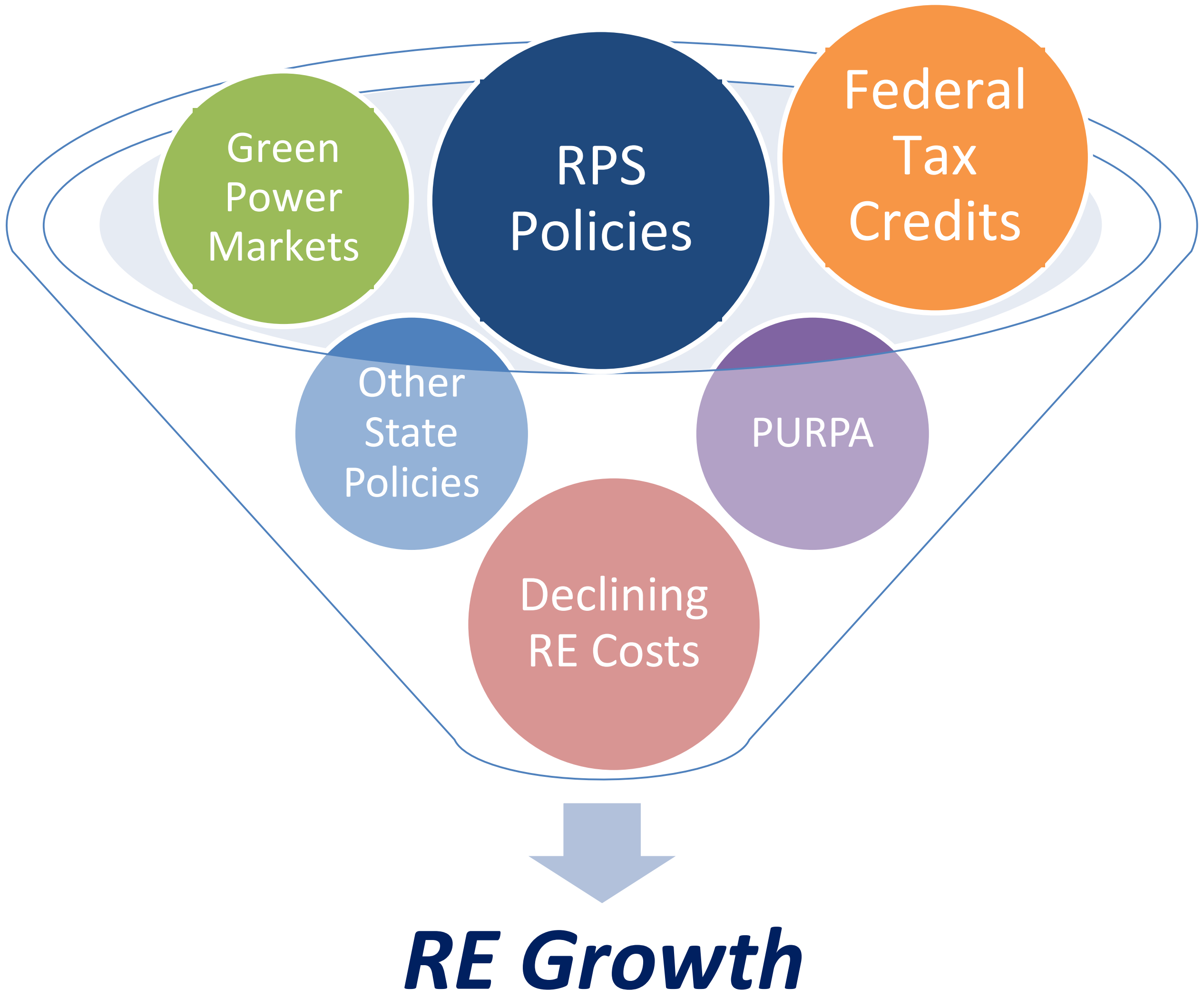
- **CA:** 60% by 2030 (and 100% zero-carbon by 2045)
- **CT:** 40% Class I by 2030
- **DC:** 100% by 2032, with 10% solar by 2041
- **MA:** Annual increase of 2% of sales/year over 2020-2029
- **MD:** 50% Tier 1 by 2030, incl. 14.5% solar + ~9.5% OSW
- **ME:** 50% Class I by 2030
- **NJ:** 50% Tier 1 by 2030
- **NM:** 80% by 2040 (and 100% zero-carbon by 2045)
- **NV:** 50% by 2030
- **NY:** 70% by 2030 (and 100% zero-carbon by 2040)

Other "significant" revisions include:

- **CO:** Formally adopted clean energy targets for Xcel
- **CT:** Reduced ACP; created long-term contracting program
- **DC:** Increased solar ACP; new geographic eligibility rules
- **MA:** Added a clean peak standard
- **MD:** Reduced ACPs
- **ME:** Created new renewable thermal tier and new long-term contracting requirement
- **NJ:** Phased out solar carve-out; increased offshore wind energy carve-out to 3,500 MW; created new RPS cost cap
- **NM:** Revised cost cap, now based on levelized bus-bar cost
- **NV:** Phased out solar carve-out
- **NY:** Created offshore wind procurement program with a target of 2,400 MW by 2030
- **OH:** Reduced RPS to 8.5%, exempted large C&I customers, and eliminated solar carve-out
- **WA:** 100% zero-carbon by 2045 (no change to RPS)

Historical Impacts of State RPS Policies on Renewables Development

RPS Policies Exist amidst a Broader Array of Market and Policy Drivers for RE Growth



Parsing out the incremental impact of individual drivers for RE growth is challenging, given the many overlaps and interactions

We present two simple approaches to gauge the impact of RPS policies on RE growth—*without claiming strict attribution*:

1. Compare total historical RE growth to the minimum amount required to meet RPS demand
2. Quantify the portion of historical RE capacity additions directly serving entities with RPS obligations

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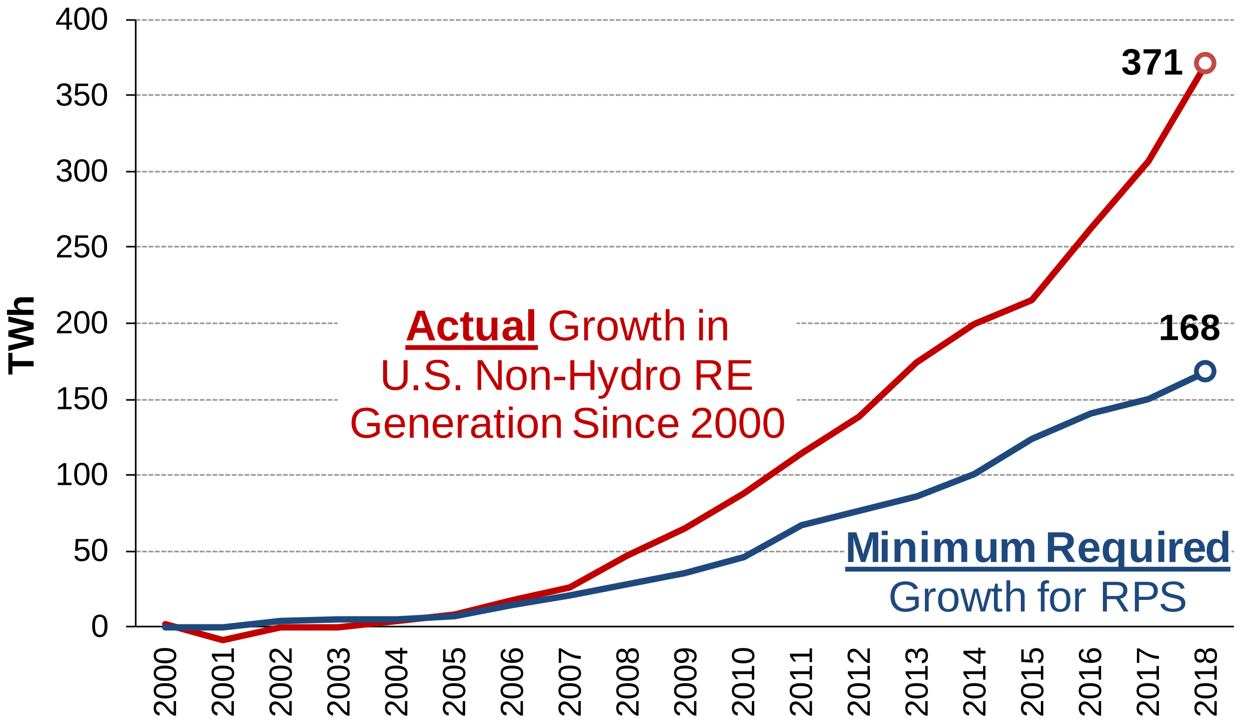
RPS Policies Have Been One Key Driver for RE Generation Growth

RPS requirements constitute roughly half of total U.S. RE growth since 2000

Growth in Non-Hydro Renewable Generation: 2000-2018



Notes: Minimum Growth Required for RPS excludes contributions to RPS compliance from pre-2000 vintage facilities, and from hydro, municipal solid waste, and non-RE technologies. This comparison focuses on non-hydro RE, because RPS rules typically allow only limited forms hydro for compliance.

- Total non-hydro RE generation in the U.S. grew by 371 TWh since 2000
- RPS policies required a 168 TWh increase over the same period (45% of total RE growth)
  - Not strict attribution: some of that would have occurred without RPS
  - At the same time, RPS may have helped to stimulate RE cost reductions and industry development, facilitating RE growth outside of RPS programs
- RE growth outside of RPS's associated with:
  - Voluntary green power markets (~100 TWh), including corporate procurement
  - Economic utility purchases, often supported by integrated resource planning processes
  - Net-metered PV (often not counted towards RPS)

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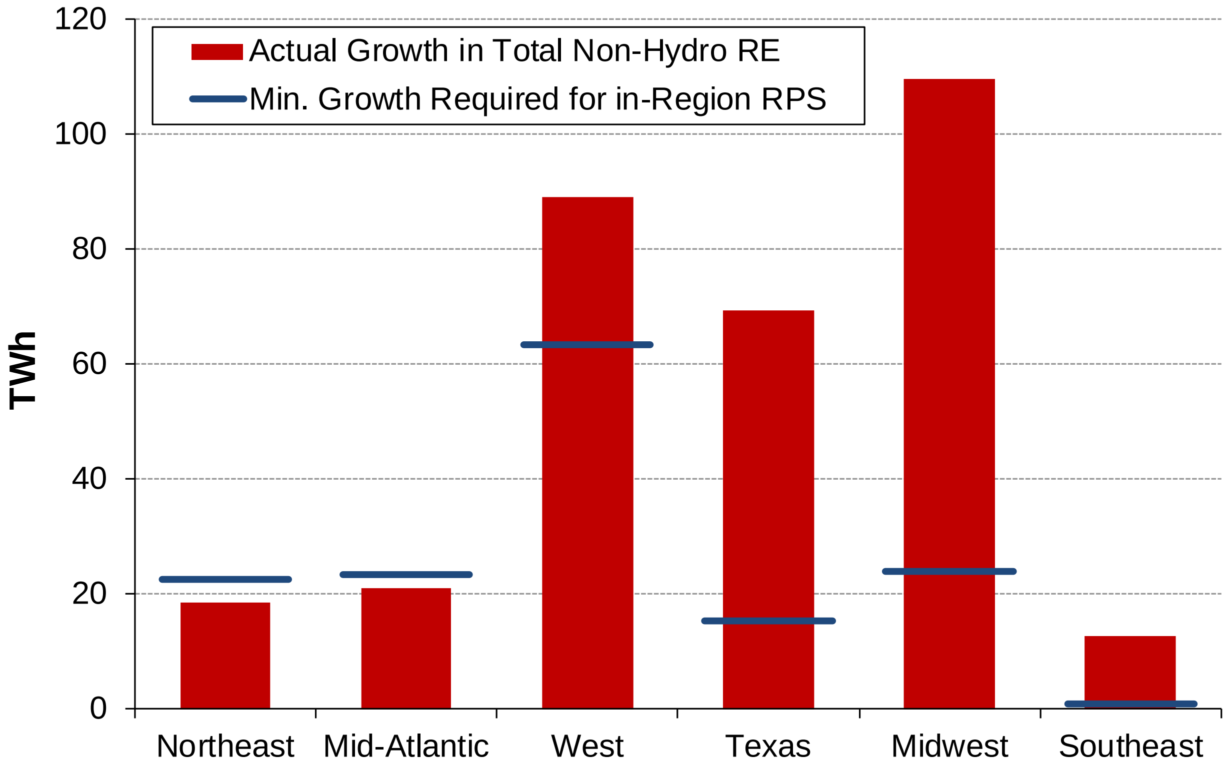
RPS Role in Driving RE Growth Varies by Region

Most critical in the Northeast, Mid-Atlantic, West; less so in other regions

Growth in Non-Hydro Renewable Generation: 2000-2018



Notes: Northeast consists of New England states plus New York. Mid-Atlantic consists of states that are primarily within PJM, in terms of load served.

Northeast, Mid-Atlantic, West

- Actual RE growth corresponds well to RPS needs
- RE growth in the Northeast and Mid-Atlantic has slightly lagged RPS needs, which are also served by imports
- The West has had by far the most RPS-required growth; actual RE growth has been even greater, partly due to net metered PV in CA (~14 TWh)

Texas and the Midwest

- RE growth has far-outpaced RPS needs, driven by attractive wind energy economics

Southeast

- Negligible regional RPS demand (only NC), though some RE growth serves RPS demand in PJM
- Recent RE growth driven by utility procurement of large-scale solar that now clears utility economic screens

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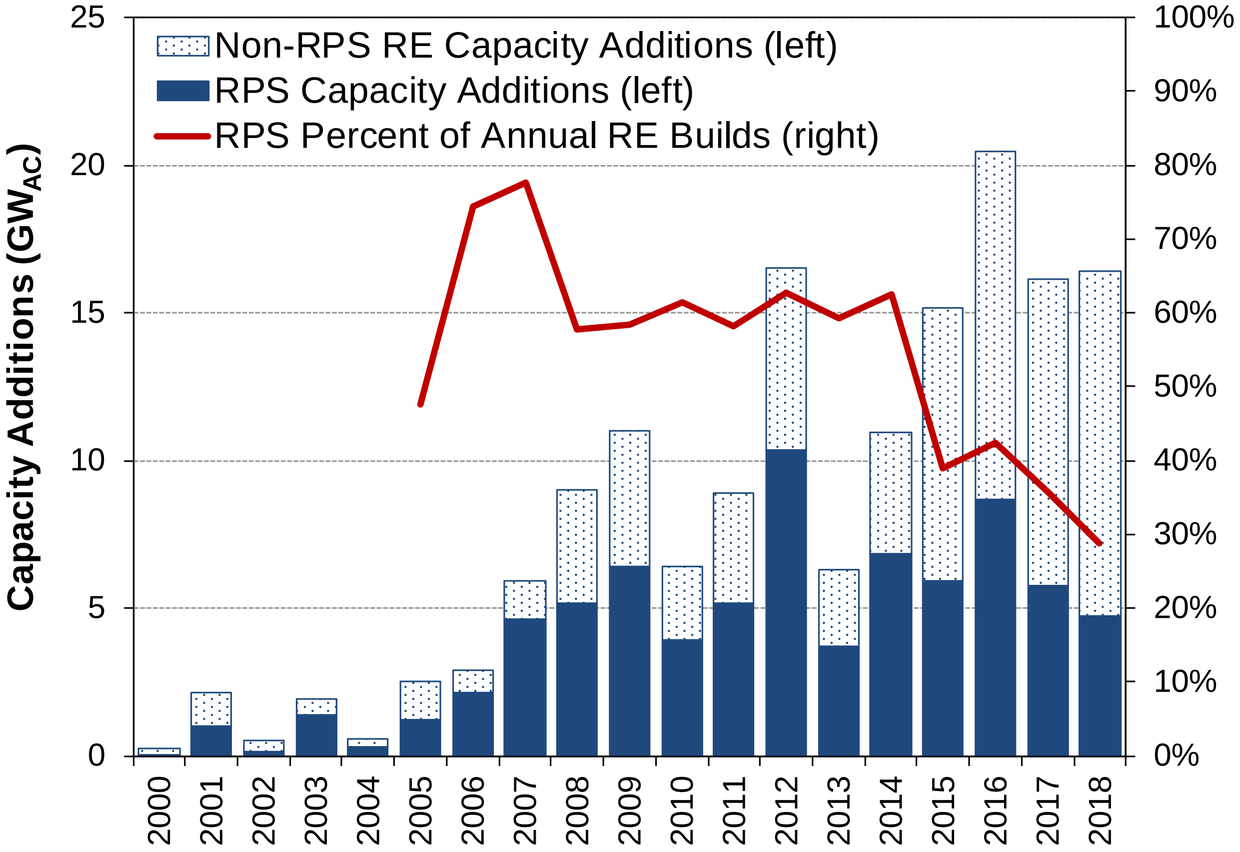
RPS' Have Provided a Stable Source of Demand for RE New-Builds

Though RPS *portion* of annual RE capacity additions has declined in recent years

Annual Renewable Capacity Additions



Notes: RPS Capacity Additions consist of RE capacity contracted to entities with active RPS obligations or certified for RPS eligibility within the REC tracking systems used by MISO, PJM, ISO-NE, or NYISO.

- Roughly half of all RE capacity additions over the past decade serve RPS compliance needs (78 GW of 154 GW)
  - On average, roughly 6 GW/yr added annually for RPS over the past decade
  - Has provided a floor in down years (e.g., 2010, 2013)
- The relative contribution of RPS' to new RE builds has been declining in recent years (from 60% in 2008-14 to just under 30% in 2018)
- These recent trends partly due to a boom in RE builds, much of which is happening outside of RPS programs:
  - Strong wind growth in Texas and the Midwest
  - Emergence of utility-scale PV in non-RPS markets
  - Net-metered PV (especially in California)

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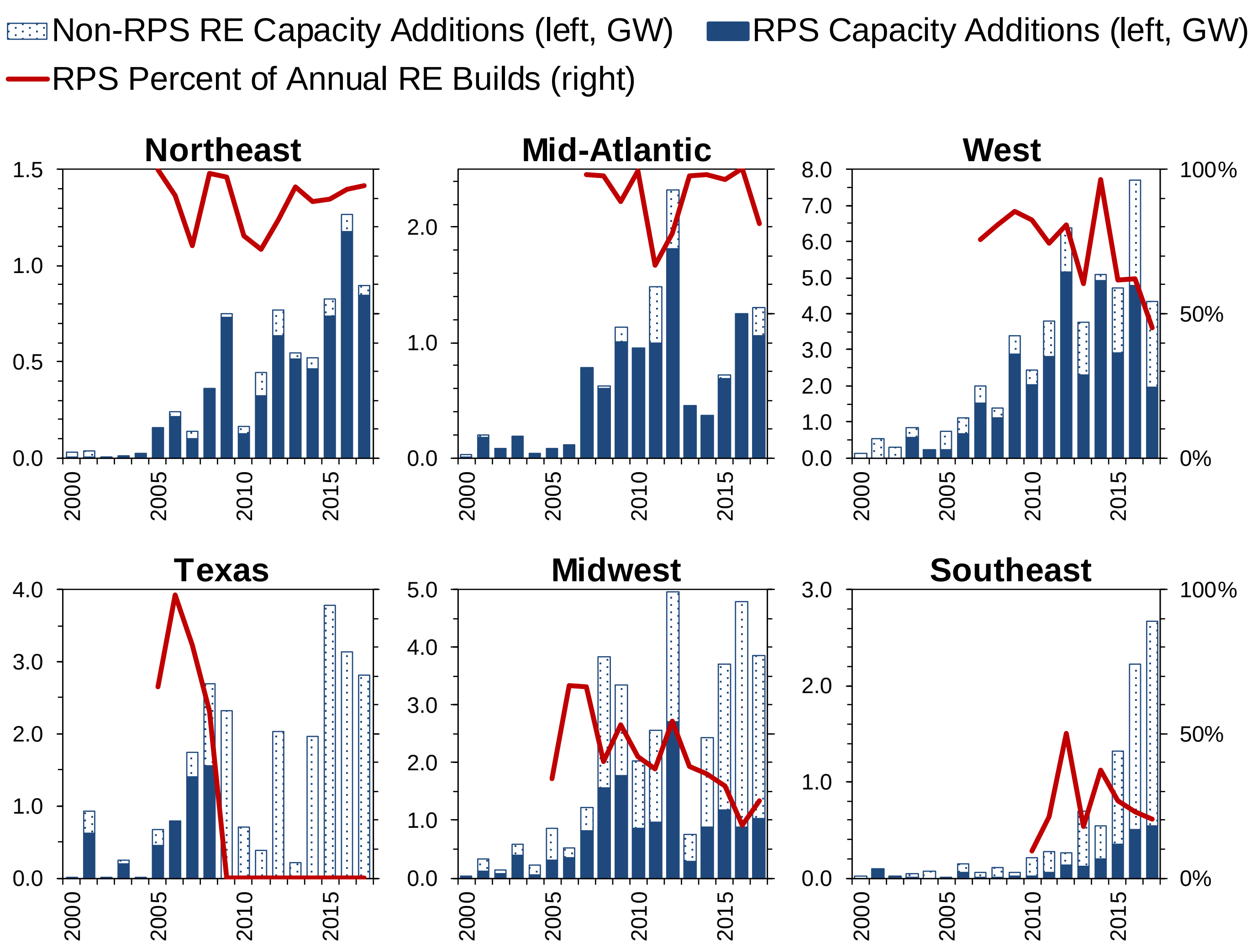
RPS Policies Remain Central to RE Growth in Particular Regions

Recent RE additions in Northeast and Mid-Atlantic primarily serve RPS demand



Notes: See previous slides for regional definitions and for decision rules on how RPS Capacity Additions are determined

RPS policies have been a ***larger*** driver in…

- **Northeast:** Relatively small market, but almost all capacity additions serving RPS demand
- **Mid-Atlantic:** Combo of solar carve-out capacity and wind projects (merchant or corporate procurement, but RPS-certified and likely selling RECs for RPS needs)
- **West:** The bulk of U.S. RPS capacity additions in recent years; split evenly between CA and other states

But have been a ***smaller*** driver in…

- **Texas:** Achieved its final RPS target in 2008 (7 years ahead of schedule); all growth since is Non-RPS
- **Midwest:** Lots of wind development throughout the region, some contracted to utilities with RPS needs
- **Southeast:** RE growth almost all utility-scale PV; primarily driven by PURPA and utility procurement, but some serving RPS demand in NC and PJM

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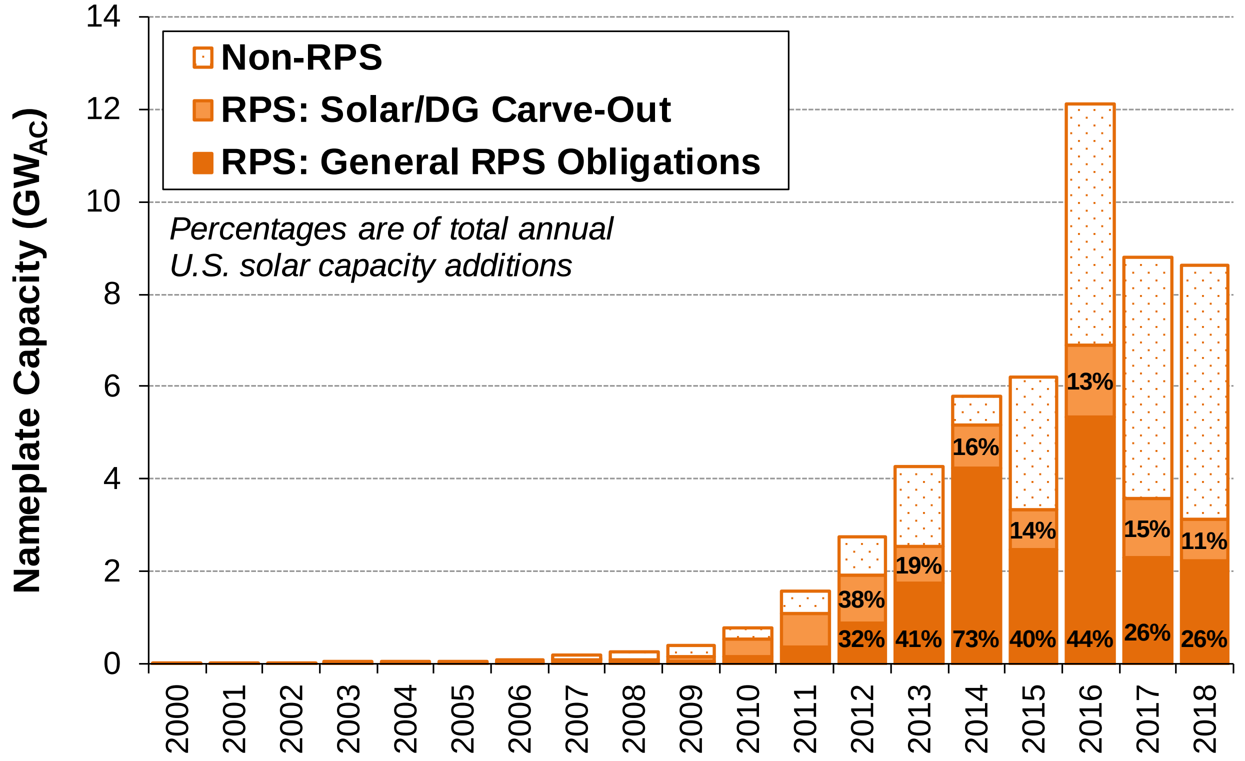
RPS' Have Had Greater Role in Driving Growth of Solar than Wind

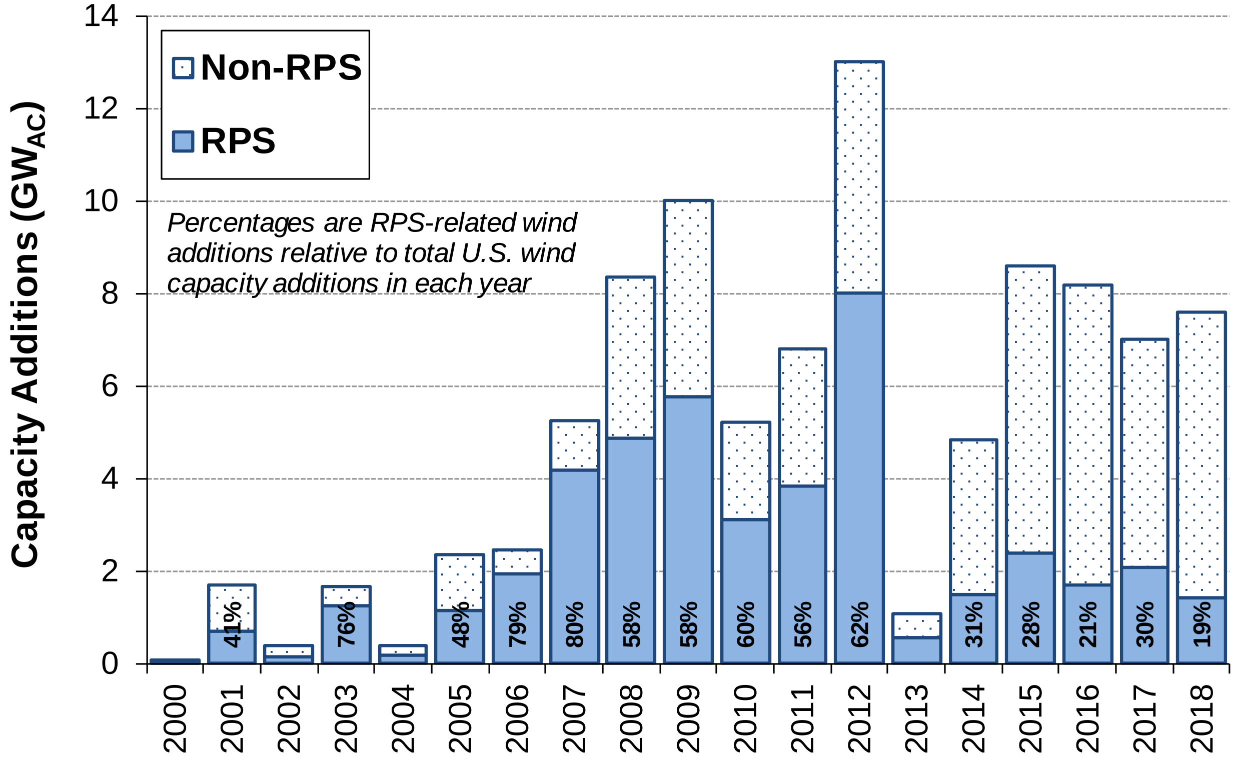
Though recent growth for both technologies has mostly occurred outside of RPS'

In 2018, **37%** of solar capacity additions serve RPS needs (26% for general RPS obligations + 11% for carve-outs) while **19%** of all wind additions were dedicated to RPS demand

Solar Capacity Additions



Wind Capacity Additions



Notes: See previous slides for decision rules on how RPS Capacity Additions are determined

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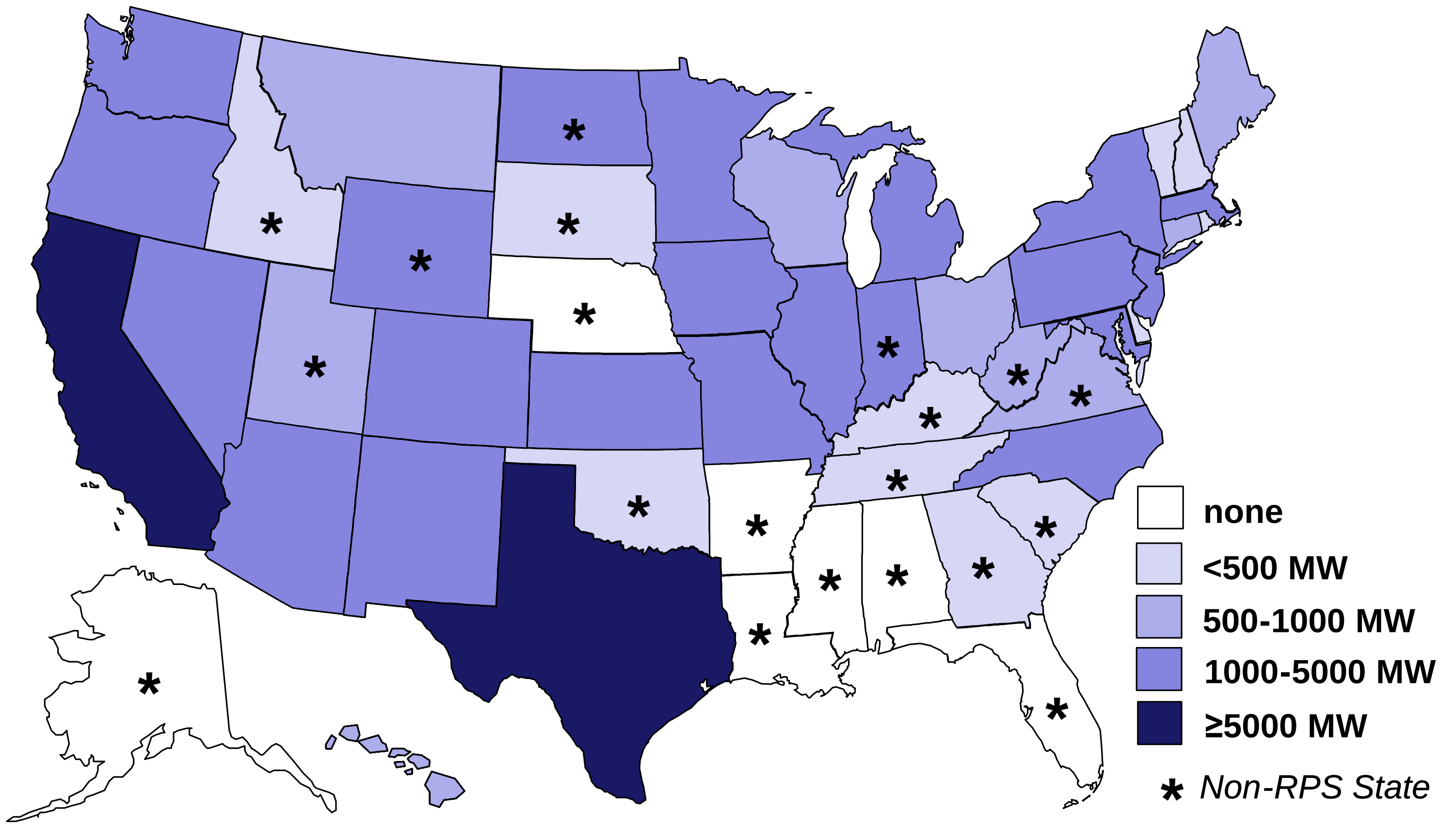
RPS Policies Have Spurred Some RE Growth in Non-RPS States

Roughly 10% (9 GW) of RPS additions built in Non-RPS states

- RPS capacity additions extend to 13 states without an RPS
  - Most significant: IN, ND, WY
- Two others (IA, KS) with no further RPS obligations host significant RPS capacity for others
- Illustrative of the broader role of inter-state commerce for RPS compliance
  - Extensive trade among states within the same RTO market (esp. NEPOOL and PJM)
  - More generally, RPS states often rely on resources in neighboring states and regions
  - Subject to some limitations due to RPS eligibility rules, and to available inter-state transmission capacity and pricing

RPS Capacity Additions: 2000-2018



Source: Berkeley Lab

Notes: States denoted "Non-RPS State" if an RPS did not exist at any point over the 2000-2018 period. See previous slides for decision rules on how RPS Capacity Additions are determined

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Future RPS Demand and Incremental Needs

Almost Half of State RPS Targets Rise Until at Least 2030

In most cases reflecting recent RPS revisions

Year of Maximum RPS Percentage Requirement

4 states have already passed their final RPS target year

6 others will do so within the next few years

6 states will hit their final RPS target year in 2025 or 2026

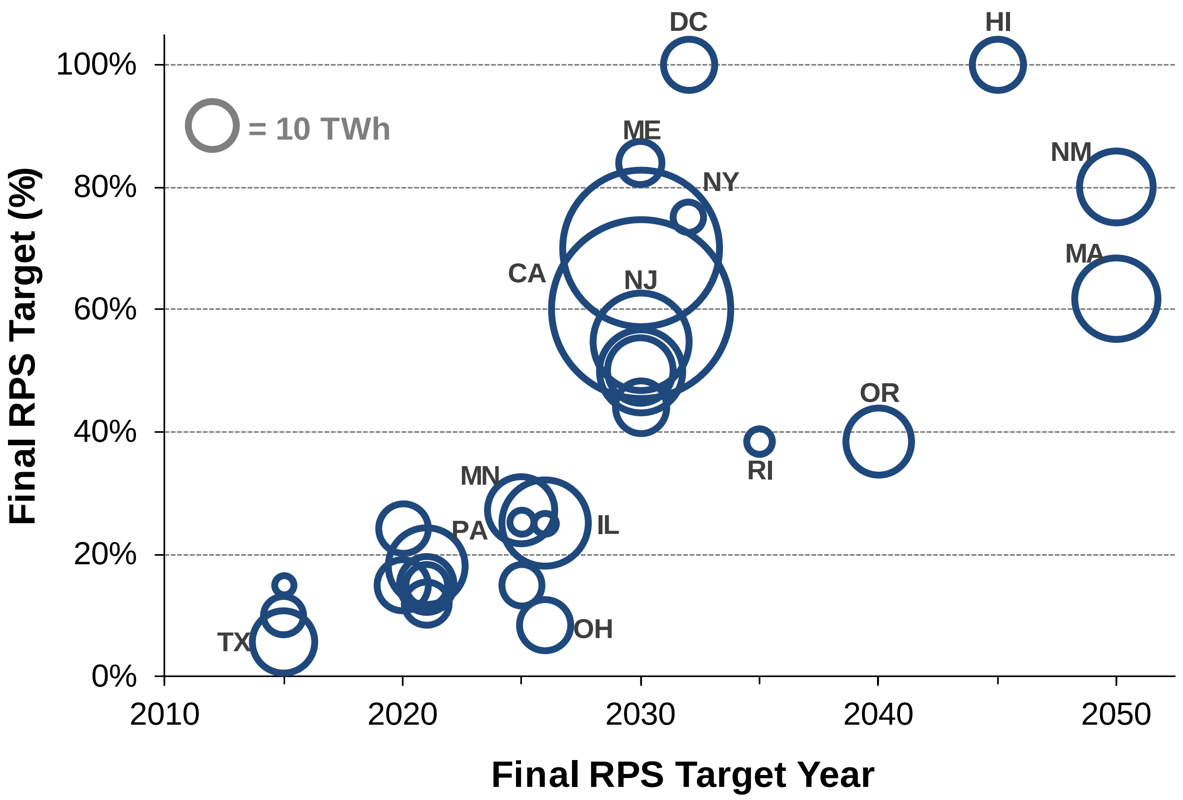
14 states have targets extending to 2030 or beyond (MA has no final target year)

1999	IA
2015	MT, TX, WI
2016	
2017	
2018	NC (POUs)
2019	
2020	CO, MN (Xcel), WA
2021	MI, MO, NC (IOUs), PA
2022	
2023	
2024	
2025	AZ, MN, NH, OR (POUs)
2026	DE, IL, OH
2030	CA, CT, MD, ME, NV, NY
2031	NJ
2032	DC, VT
2035	RI
2040	NM (IOUs), OR (IOUs)
2045	HI
2050	NM (Coops)
→	MA

Ultimate RPS Target Levels Vary Widely

Higher targets tend to have longer lead-times

Final RPS Targets and Target Years



Notes: Final RPS Target Year refers to the year in which the statewide RPS percentage target reaches its maximum, typically remaining at that level in subsequent years. For states with RPS targets that differ across LSEs, the percentage targets shown are a weighted average, based on retail sales among RPS-obligated LSEs. Note that MA's RPS target continues to rise indefinitely; for illustrative purposes, we show the target for the year 2050.

- States can generally be grouped into two sets
  - One contingent of states with final RPS targets of roughly 15-25% by 2020-2025
  - Most others have targets of 50-100% by 2030-2050
- In total, 11 states plus DC with RPS targets of at least 50%
- Largest TWh impacts come not just from states with high percentage targets, but also from a few relatively large states with lower targets
- Can be difficult to meaningfully compare targets between states, given varying policy design (e.g., treatment of large hydro)

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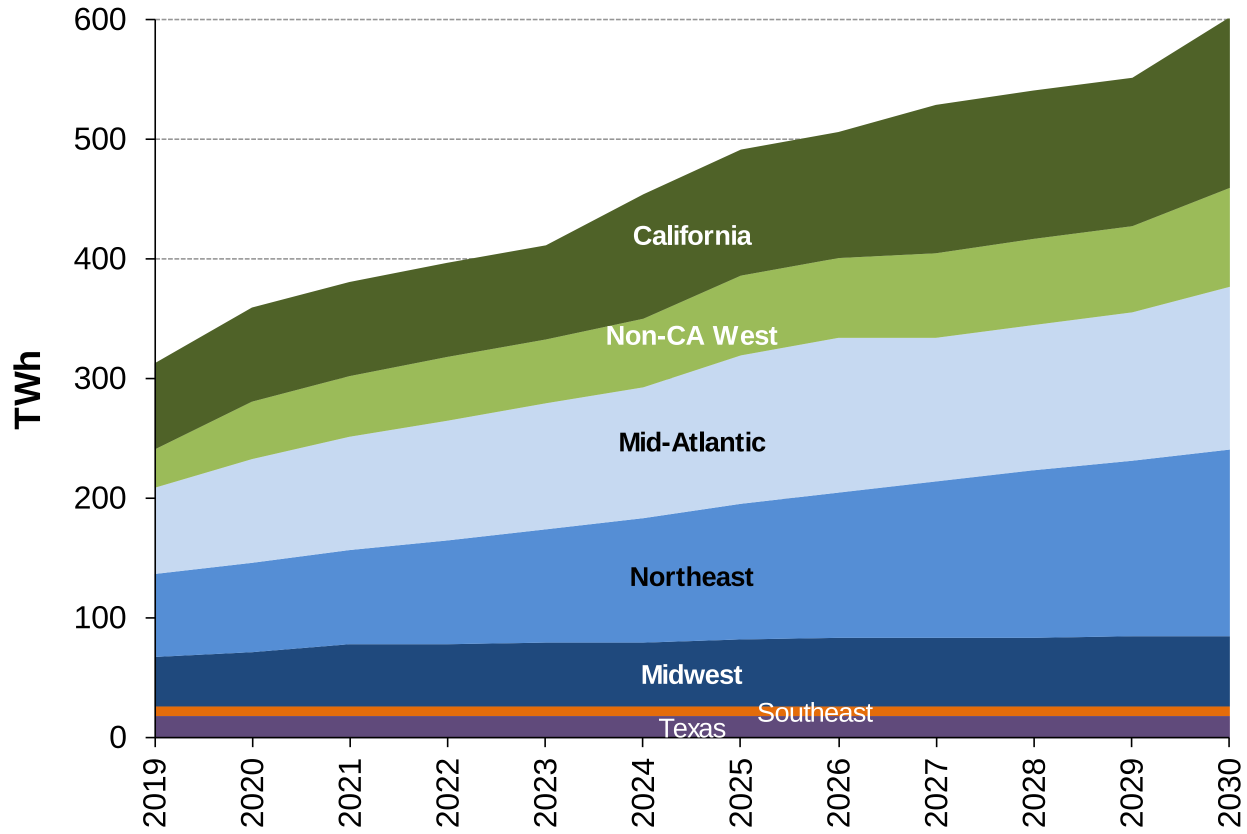
Projected U.S. RPS Demand (total compliance requirements)

Roughly doubles by 2030

Projected RPS Demand (TWh)



Notes: Projected RPS demand is estimated based on current targets, accounting for exempt load, likely use of credit multipliers, offsets, and other state-specific provisions. Underlying retail electricity sales forecasts are based on regional growth rates from the most-recent EIA Annual Energy Outlook reference case.

- Under current policies, total RPS demand grows from 310 TWh in 2019 to 600 TWh in 2030
  - Represents the total RE or RECs needed to satisfy RPS compliance requirements in each year
- To be sure, increased demand does not equate to required increase in supply
  - Some utilities and regions are ahead of schedule, others are behind
  - Some growth in RPS demand will be met with banked RECs

State-level RPS demand projections through 2050 available for download at: rps.lbl.gov

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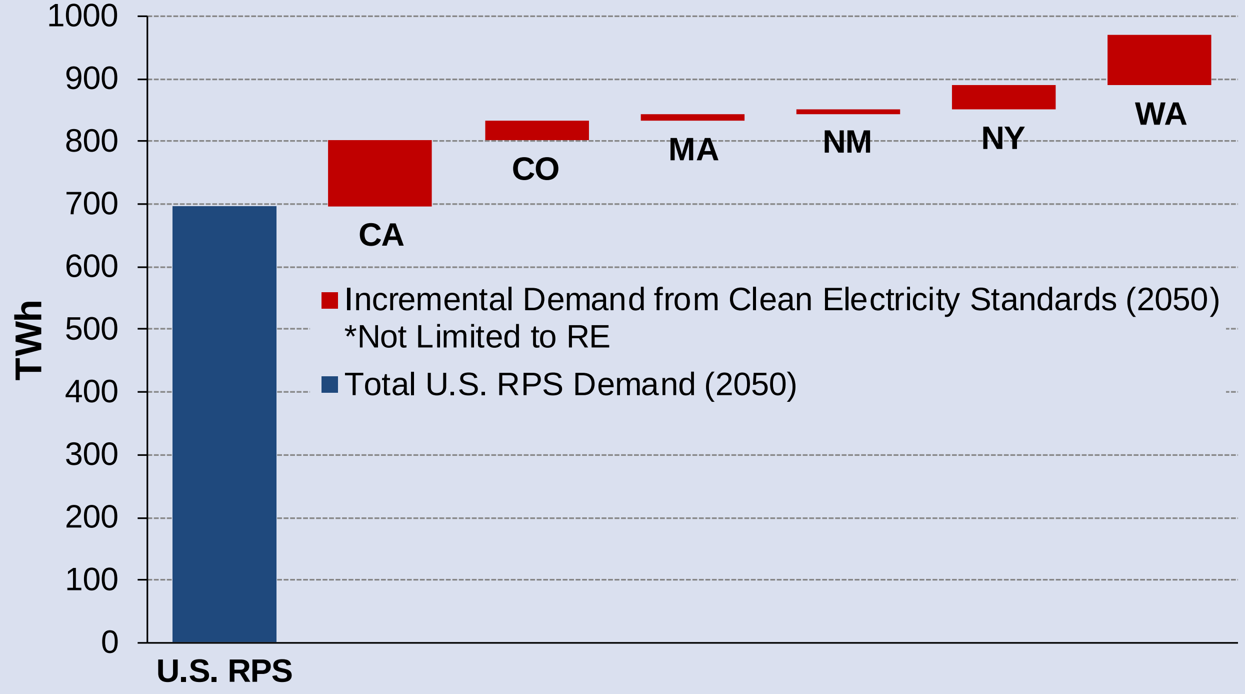
Side Bar: Broader clean electricity standards may add to longer-term RPS demand, to the extent they are met with RE

- U.S. RPS demand grows to 700 TWh by 2050
  - Growth from 2030-2050 reflects underlying load growth, as well as the handful of states with RPS targets that rise further over that period
- Several states have established broader “clean” or “zero-carbon” electricity standards
  - Typically on the order of 80%-100% of sales and with relatively long timeframes (by 2040-2050)
- Those clean electricity standards add 270 TWh of additional demand by 2050, above and beyond RPS requirements
  - The bulk of that is associated with CA and WA
  - Not all will necessarily be met with RE

**** These policies not otherwise included in this report***

Projected Demand from State RPS and Broader Clean Electricity Standards (2050)

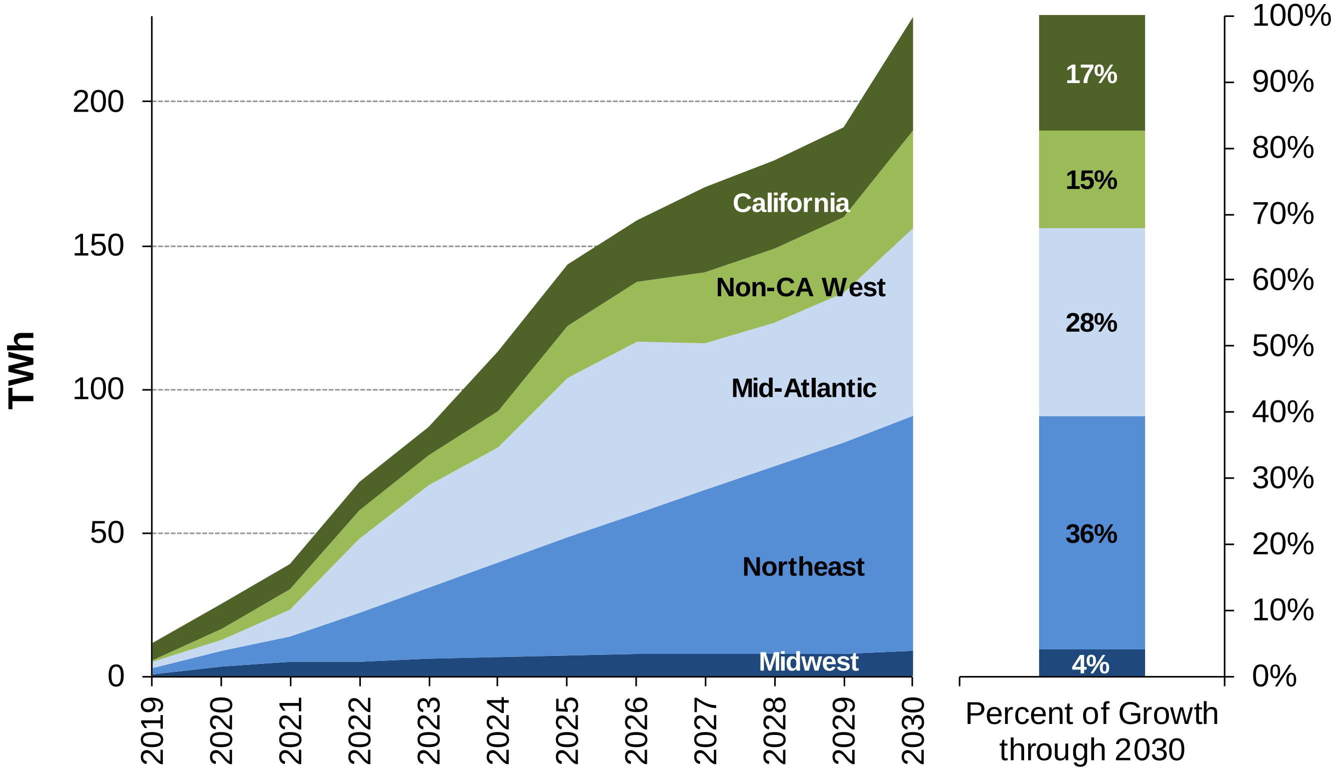


Notes: Incremental Demand from Clean Electricity Standards represents additional demand for clean electricity, above and beyond the RPS in each state. Only legislatively established standards are included here, though a number of other states have established non-binding clean electricity goals.

Required Increase in RPS Generation Supply

230 TWh by 2030, ~50% increase in U.S. RE generation

Required Increase in RPS Generation (TWh)



Notes: For regulated states, incremental RPS needs are estimated on a utility-specific basis, based on each utility's RPS procurement and REC bank as of year-end 2017. For restructured states, incremental RPS needs are estimated regionally, based on the pool of RPS-certified resources registered in the regional REC tracking system, allocated among states based on eligibility, demand, and other considerations.

Required increase in RPS supply estimated:

- Relative to *available* RPS resources as of year-end 2018 (see figure notes for further details)
- Accounting for REC banking over the forecast period, per each state's rules
- Assuming no excess REC sales by regulated LSEs

- **Northeast:** The greatest incremental need among regions, of which NY represents about 80%
- **Mid-Atlantic:** Incr. needs driven by a raft of recent RPS revisions throughout the region; termination of OH RPS after 2026 frees up supplies for other states
- **California:** IOUs almost fully resourced; incremental needs associated primarily with other LSEs (CCAs, POUs, ESPs)
- **Non-CA West:** Roughly half from NV, the next-largest NM, in both cases reflecting recent RPS revisions

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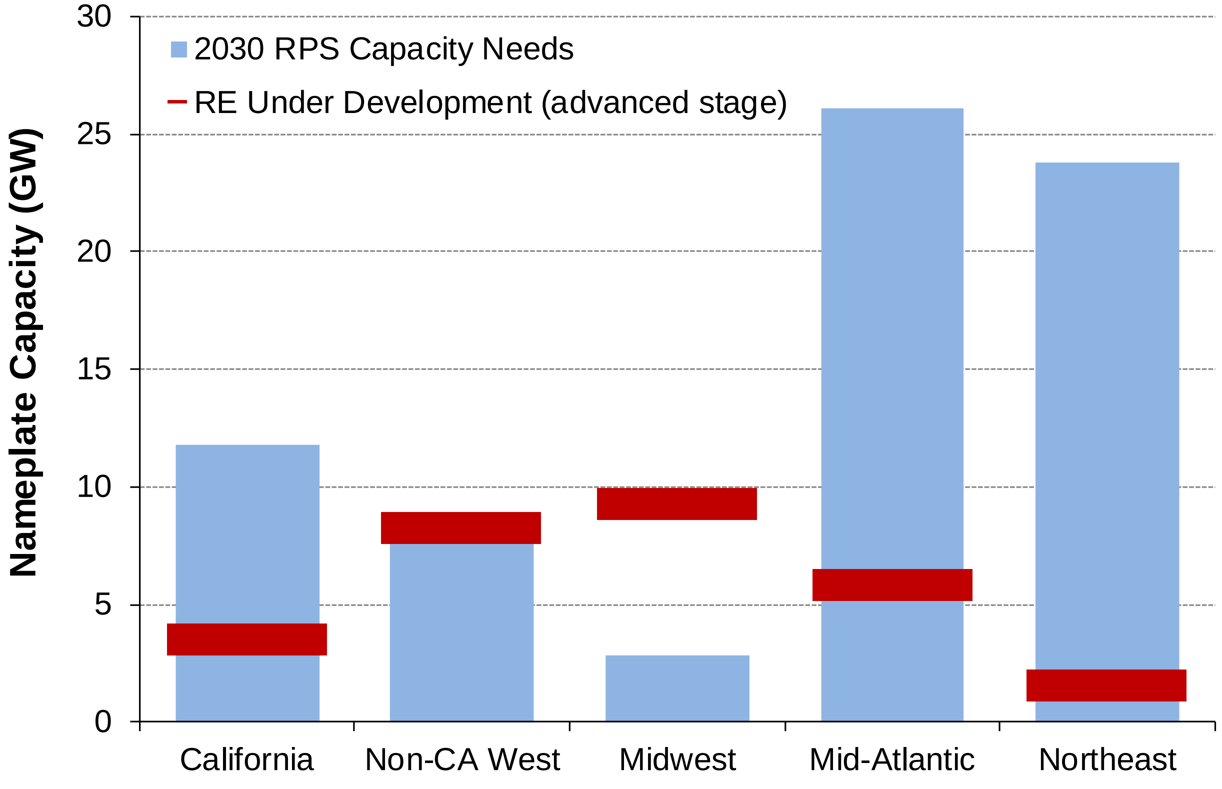
Required RE Capacity Builds for RPS

Roughly 73 GW needed by 2030

- Includes 11 GW associated with solar carve-outs and ~10 GW for offshore wind mandates
  - Mostly in the Mid-Atlantic and Northeast
- Equates to an overall avg. build-rate of 7 GW/yr.
  - On par with historical RPS build-rates
- New RE capacity currently under development will meet some of that incremental need
  - Not all of that capacity will be available for RPS needs or is completely fungible within a region
  - Some capacity under development may serve adjacent regions (e.g., Midwest RE serving Mid-Atlantic RPS')
- Retirement of existing RPS capacity: Not captured in this analysis, but will require additional new RE capacity over the longer term

Required RPS Capacity Additions (GW)

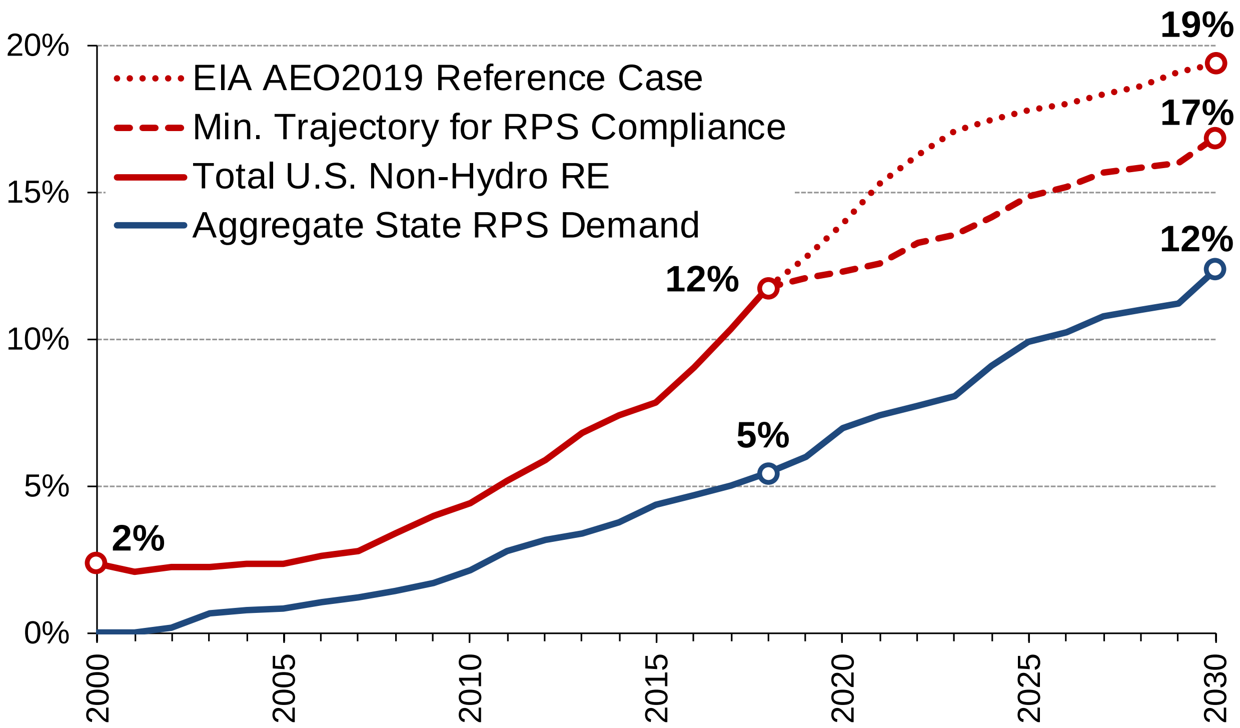


Notes: Calculated from estimated incremental generation needed to meet RPS demand, based on state-specific assumptions about the mix and capacity factor of new RPS supply. RE Under Development consists of units permitted or under construction, site preparation, or testing as of May 2019, plus units that entered commercial operation in 2019, based on data from ABB-Ventyx Velocity Suite.

Comparison of U.S. RPS Demand and RE Supply

EIA-forecasted RE growth projected to well-exceed minimum RPS needs

U.S. RPS Demand vs. RE Supply
(% of U.S. Retail Electricity Sales)



Notes: The figure focuses on non-hydro RE, given the limited eligibility of hydro for state RPS obligations. Accordingly, the Aggregate State RPS Demand excludes historical and projected contributions by hydro as well as by municipal solid waste, demand-side management, and other non-RE technologies.

- In aggregate, state RPS targets equate to 12% of U.S. retail electricity sales by 2030
- To meet those targets, total U.S. RE supply will need to reach 17% of retail sales
  - Accounts for the fact that not all existing RE supplies are available for future RPS demand
- EIA projects greater RE growth, reaching 19% of retail sales by 2030
  - Rapid growth prior to expiration of ITC/PTC in early 2020s, followed by slower growth through 2030
  - Illustrating that RPS policies remain just one driver for continued RE growth

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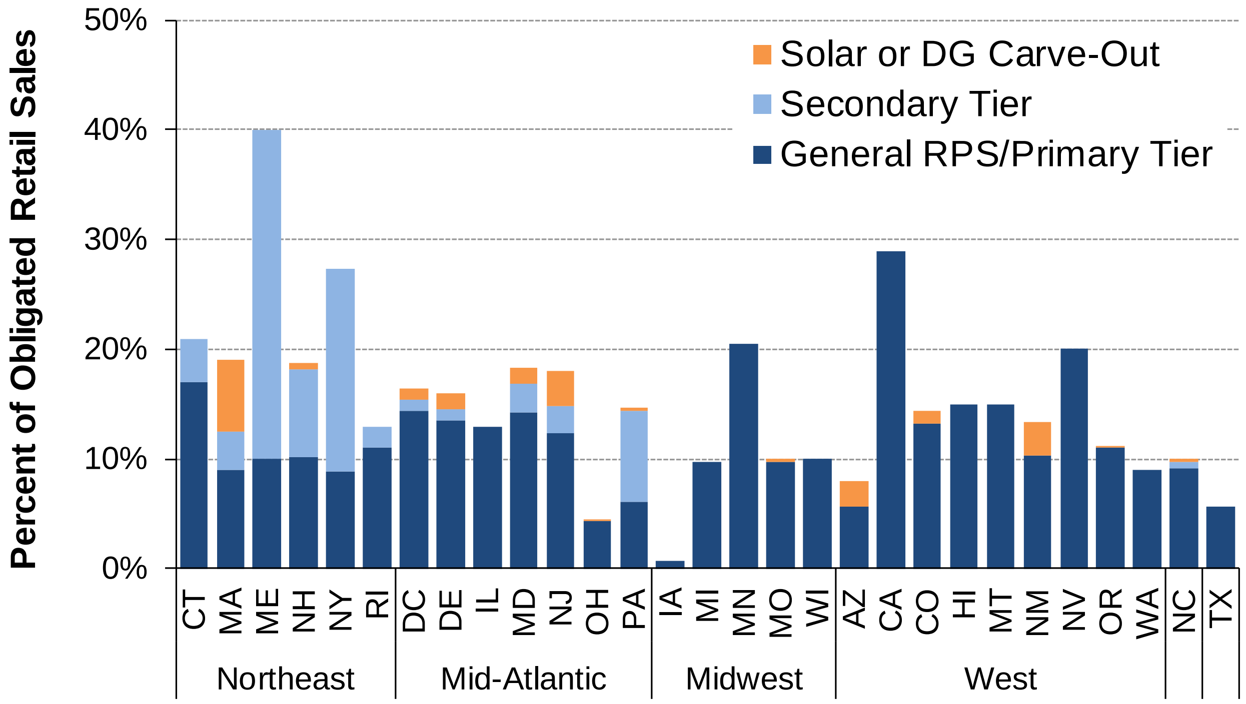
RPS Target Achievement To-Date

Interim Annual RPS Targets Continue to Ramp Up

Aggregate RPS requirements generally ranged from 10-20% of sales in 2018

Annual 2018 RPS Targets



Notes: General RPS/Primary Tier includes New England Class I and PJM Tier 1, and otherwise refers to the non-carve-out portion of RPS requirements in each state. Secondary Tier refers to any separate obligations for pre-existing resources, non-renewable generation technologies, or other secondary resource types. For NY, the General RPS/Primary Tier includes both the Tier I target under the current RES as well as the Main Tier and Customer Sited Tier targets under the state's legacy RPS, while the Secondary Tier consists of the residual portion of the overall RES target.

- Each state's RPS target ramps up over time, typically increasing annually, though sometimes less frequently
- Many states' RPS targets are segmented into multiple tiers and/or carve-outs, each of which ramps up according to a designated schedule
  - General RPS/Primary Tier targets ranged from 1-29% of retail sales in 2018, though were typically 10-15%
  - Secondary Tiers, which vary significantly in the scope of eligible resources, ranged from 1-30% of retail sales (where used), though were generally <4%
  - Solar and DG Carve-Outs, in place in 14 states in 2018, were as high 7% (in MA), but were typically <3% of retail sales

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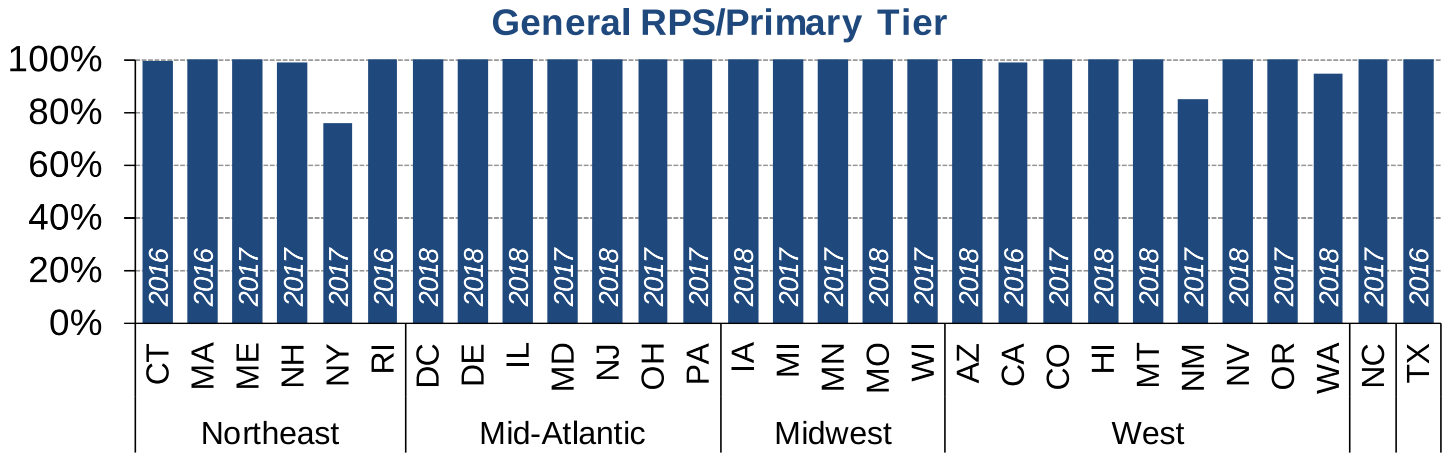
States Have Generally Met Their Interim Targets

Exceptions typically reflect unique state-specific issues

Percentage of RPS Obligations Met with RECs or RE
For most-recent compliance year available in each state



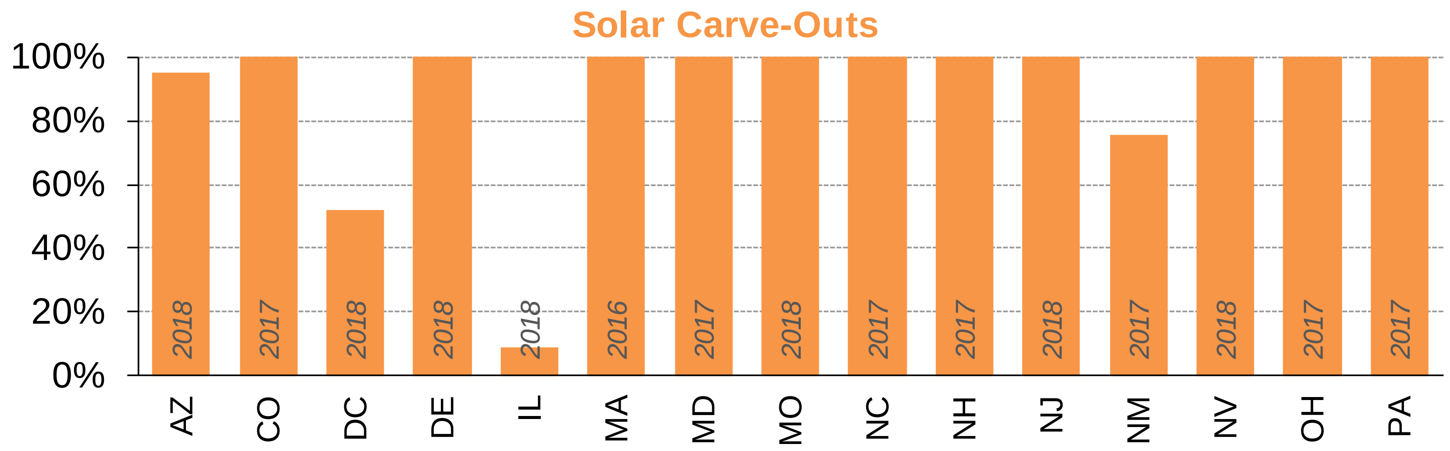


Figure notes: "General RPS Obligations" refers to the non-carve-out portion of RPS requirements in each state. For New England states, it refers to Class I obligations, and for PJM states it refers to Tier I obligations. The years overlaid on each bar refer to the most-recent compliance year for which compliance data are available in each state.

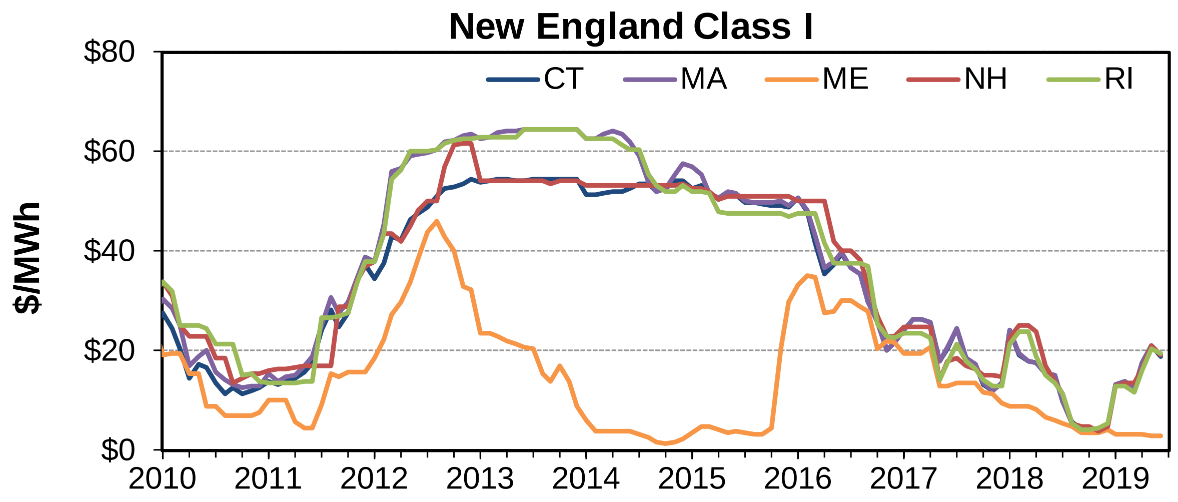
Compliance with interim RPS targets typically demonstrated through annual compliance filings, albeit with some lag (sometimes >1 year)

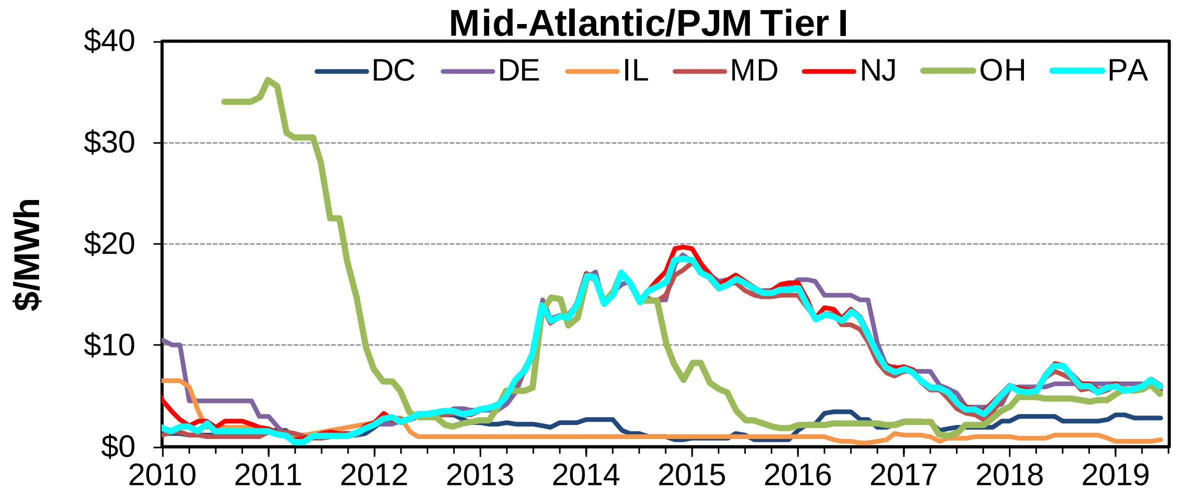
- Many states/utilities well ahead of schedule, while others have met interim targets by relying on stockpiles of banked RECs from prior years
- Relatively few instances where interim targets significantly missed
  - **DC (Solar):** In-district eligibility requirements restrict the pool of supply
  - **IL (Solar):** Procurement of short-term solar RECs suspended while state transitions to a new program
  - **NM (General RPS & Solar):** Procurement reduced due to large-customer cost caps
  - **NY (General RPS):** LSE reliance on ACPs seemingly reflects transitional issues during the first year of the new RES Tier 1 regime, rather than true under-supply

REC Pricing Trends

REC Pricing Trends for Primary Tier RPS Obligations

New England prices slid in 2018 before rebounding, remained flat in PJM





Source: Marex Spectron. Plotted values are the average monthly closing price for the current or nearest future compliance year traded in each month.

REC prices are a function of supply-demand balance, expectations therein, and ACP rates

- As a result, REC prices can be volatile and sensitive to changes in eligibility rules
- Regional markets in New England and Mid-Atlantic emerge based on common pools of eligible supply

New England:

- Growing regional supplies pushed prices to an all time low (<$10/MWh, compared to $55-65 ACP levels)

Mid-Atlantic/PJM:

- Bifurcated market based on geographic eligibility rules (more restrictive rules & higher prices in NJ/PA/MD/DE)
- Wind growth in PJM and adjacent states drove prices down from historical peak, prior to recent rebound

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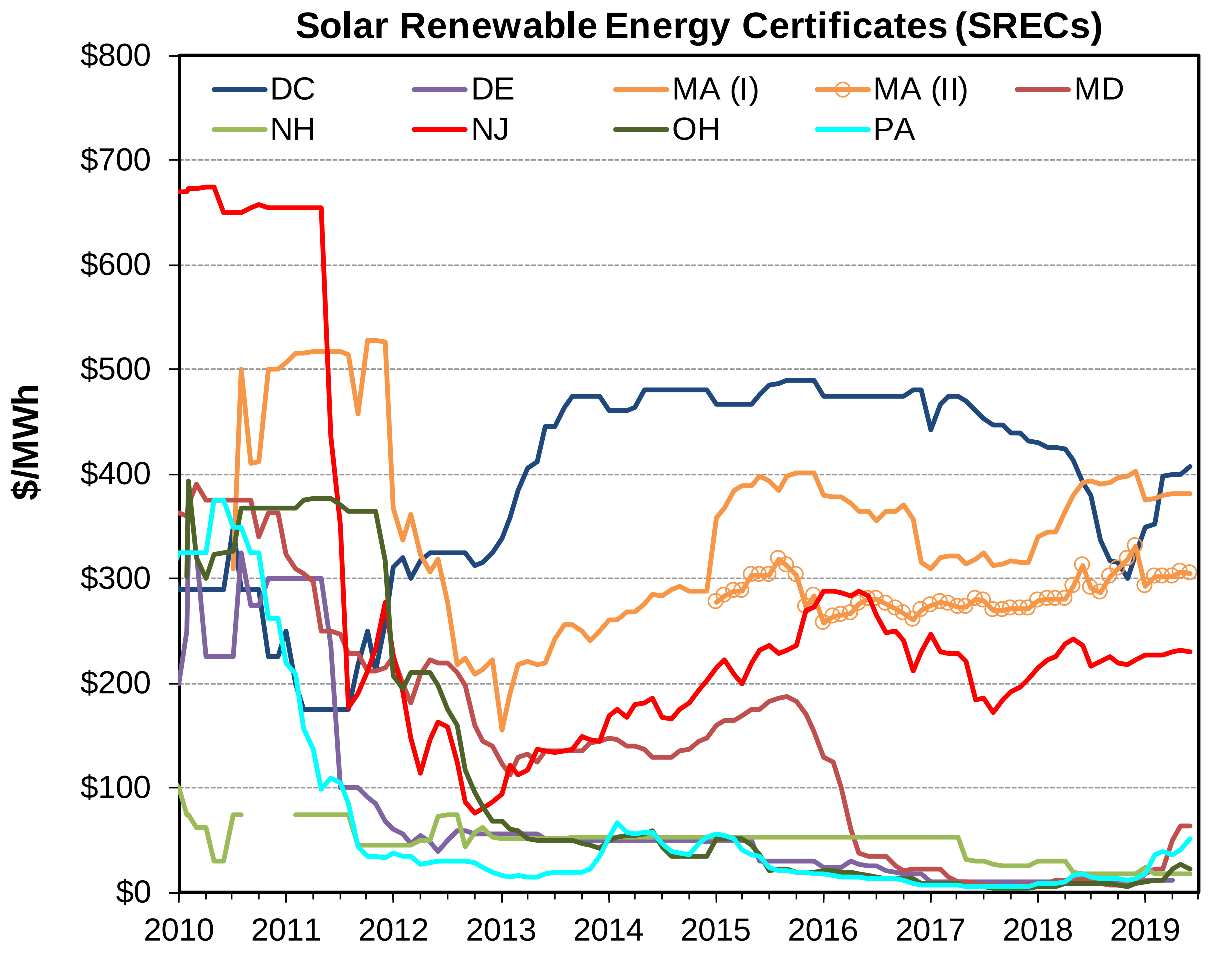
SREC Pricing Trends for RPS Solar Carve-Outs

2018 has seen some movement in DC, NJ, MA; other states remain over-supplied



Sources: Marex Spectron, SRECTrade, Flett Exchange. Depending on the source used, plotted values are either the mid-point of monthly average bid and offer prices or the average monthly closing price, and generally refer to prices for the current or nearest future compliance year traded in each month.

SREC pricing is highly state-specific due to *de facto* in-state requirements in most states and varying ACPs

- **DC:** Acute undersupply due to in-district requirements; downward trend in 2018 due to grandfathering provisions
- **MA:** Price movements bounded by clearinghouse floor and SACP
- **NJ:** Fairly well-balanced market; looming oversupplies averted by recent legislation
- **MD:** Substantial over-supply emerged in 2015-2016 causing prices to bottom out; slight uptick in early 2019 after higher targets enacted
- **DE, PA, OH** heavily oversupplied, in part due to eligibility of out-of-state projects
- **NH:** Low solar ACP ($55/MWh)

RPS Compliance Costs and Cost Caps

RPS Compliance Costs

Definition, data sources, and limitations

RPS Compliance Costs: Net cost to the load-serving entity (LSE), above and beyond what would have been incurred in the absence of RPS*

Can be measured in terms of: (1) absolute dollar magnitude, (2) cost per MWh of RPS generation, and (3) cost as a percentage of retail electricity bills

Retail Choice States

- RPS compliance primarily via unbundled RECs
- We estimate RPS compliance costs based on REC plus ACP expenditures
- Rely wherever possible on PUC-published data on actual REC costs; otherwise use broker spot market prices

Vertically Integrated States

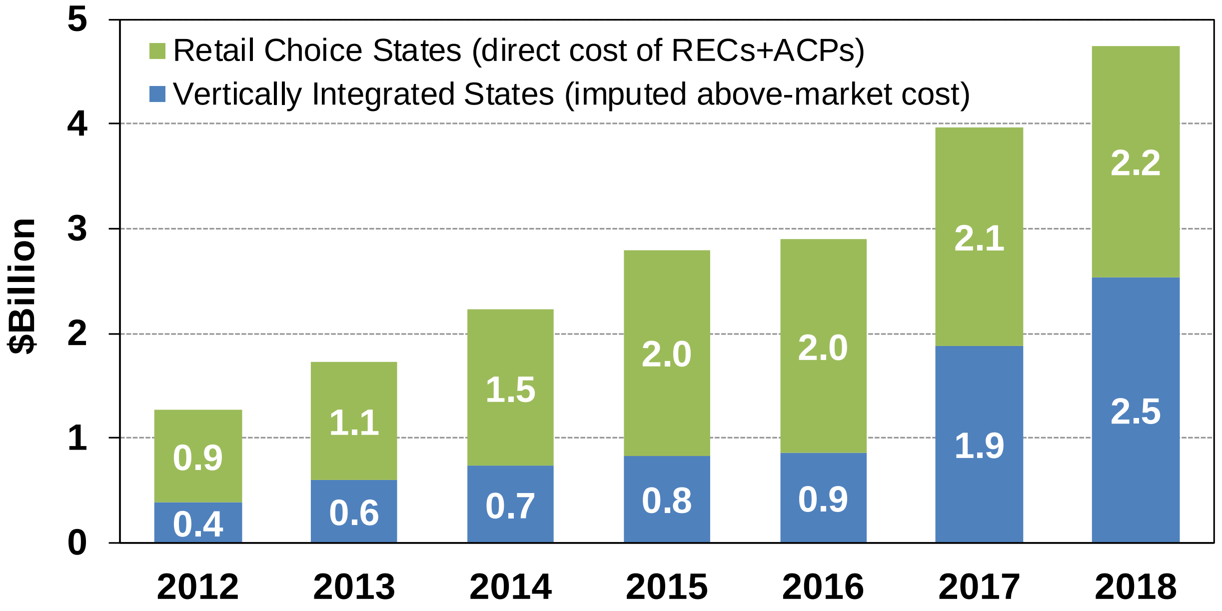
- RPS compliance primarily via bundled PPAs
- We synthesize available utility and PUC compliance cost estimates, which rely on varying methods
- Compliance costs imputed by comparing gross RPS procurement costs to a counterfactual (e.g., market prices or a long-term avoided cost projection)

***Key Limitation:** The underlying data and methods used here represent only a partial accounting of the full suite of costs and benefits associated with RPS policies—see slide 38 for additional details and indicative ranges for the potential magnitude of those omitted impacts

Aggregate U.S. RPS Compliance Costs

Totaled roughly $4.7B in 2018, up from $4.0B in 2017

RPS Compliance Costs: Absolute Dollar Amount



Notes: Retail Choice States include New England, PJM, and New York; the costs shown for that group primarily reflect REC purchases and ACPs. Vertically integrated States consist of all others; costs shown for that group reflect PUC/utility estimates for the above-market cost of RPS resources. Costs were extrapolated for states/utilities without available data, based on other states/utilities in the region.

These data should be considered a rough approximation given diverse methods used to estimate compliance costs across states

- **In general, two countervailing dynamics**
  - RPS targets growing over time
  - While RE costs (or REC prices) are falling
- **Retail choice states**
  - Falling REC prices since 2015 have largely offset increasing targets, leading to flat costs, in aggregate
- **Vertically integrated states**
  - Effect of falling PPA prices muted by mix of older (more expensive) and newer (less expensive) RPS resources
  - Methodological issues muddy the waters: cost increases over 2016-2018 associated primarily with changes in how the California PUC estimates avoided costs*

** To calculate the above-market cost of RPS resources, the CPUC compares RPS procurement costs to the all-in cost of a combined-cycle gas turbine (the "Market-Price Referent" or MPR). The CPUC has made several updates to the MPR in recent years, which resulted in reductions in the MPR and corresponding increases in the relative cost of RPS resources.*

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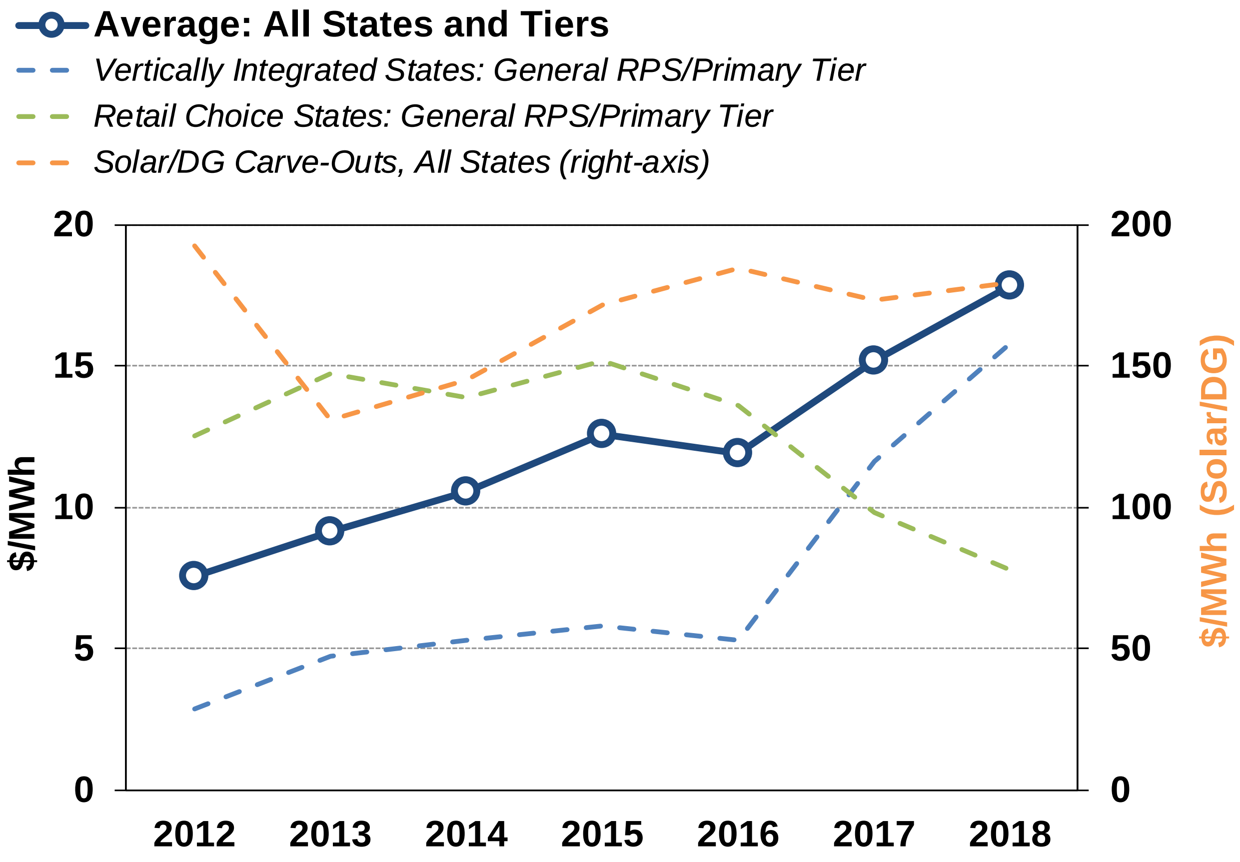
RPS Compliance Costs per MWh of RE

Averaged $18/MWh in 2018, up from $15/MWh in 2017

Compliance Costs per MWh of RPS Generation



Notes: See earlier slides for definitions of General RPS/Primary Tier and for Vertically Integrated vs. Retail Choice states.

Represent the "price premium" for RPS resources above standard generation supply; equivalent to the average REC price in many states

- The average RPS compliance cost premium is a composite of trends across states and RPS resource tiers
  - Average costs per MWh for vertically integrated states, have been rising in recent years, primarily reflecting methodological changes in CA (see prior slide)
  - Primary-tier compliance costs in retail choice states have been falling, reflecting falling REC prices
  - Solar/DG carve-out costs are an order of magnitude higher than other RPS compliance costs on a per-MWh basis, and have been relatively flat in recent years when averaged across all states

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Side Bar: Impacts Omitted from RPS Compliance Cost Estimates

Depending on the state and associated compliance-cost estimation method, some RPS impacts—including both costs and benefits—may be either omitted or only partially captured in the RPS compliance cost estimates presented here:

- **Balancing costs:** To the extent that these costs are "socialized" rather than paid directly by the generator (e.g., through an integration tariff), they will not be reflected in REC costs and PPA rates. Most RE integration studies show costs of **$1-10/MWh** of wind and solar, with variation partly reflecting the size of the balancing area, RE penetration level, and scope of costs included (Wiser and Bolinger 2018; Wiser et al. 2017).
- **T&D network upgrades:** Beyond any dedicated grid-tie costs paid directly by the generator, RE may also impact the need for T&D network upgrades, whose costs are socialized. Based on a recent synthesis of transmission cost estimates for utility-scale wind and solar (Gorman et al. 2019), those resources typically entail average transmission network costs ranging from **$2-10/MWh** of RE. RPS policies can also impact distribution network costs, to the extent that RPS obligations are met with distributed RE (primarily via solar/DG carve-outs). Those impacts are highly system-specific and may be either positive or negative, with studies of distribution network *costs* often ranging from **$0-10/MWh** and studies of T&D network *benefits* due to avoided or deferred investments often ranging from **$4-50/MWh** (Gorman et al. 2019).
- **Wholesale market price suppression:** Increased penetration of RE reduces average market clearing prices in bulk power energy and capacity markets, at least over the short run—representing a consumer benefit in the form of a wealth transfer from generators. Studies of historical energy-market price effects have found reductions of $0-12/MWh of load served, at varying RE penetration levels and over varying durations (Mills et al. 2019). Depending on the fraction of load exposed to spot market prices, those price reductions correspond to consumer benefits ranging from roughly **$0-300/MWh** of RE generation, with a median of ~$30/MWh across studies and assumptions. These benefits, however, may be partially offset by payments to utilities for the non-depreciated portion of retired baseload plants, to the extent that those retirements are driven by RE growth.
- **Energy and capacity value deflation:** The energy and capacity value of wind and solar generally decline with penetration, due to a combination of market price suppression during hours when solar and wind are generating, increased curtailment, and reduced capacity credit. Depending on the specific methods used to estimate RPS compliance costs, these value deflation effects may not be fully captured. Based on a comprehensive literature survey, Wiser et al. (2017) estimate that these value deflation effects are equivalent to a cost of ~**$5/MWh** for wind at low penetrations. At 15% penetration, the equivalent costs range from **$5-15/MWh** for wind and from **$10-30/MWh** for solar.
- **Broader societal impacts:** Beyond those costs and benefits directly incident on utilities and ratepayers, RPS policies have broader effects that may also have motivated their enactment and be relevant to their evaluation. Wiser et al. (2016) evaluated a subset of those impacts on a retrospective basis, estimating **$26-101/MWh** of human health benefits from reduced air pollution, **$7-64/MWh** of global benefits from reduced carbon emissions, and **$13-37/MWh** of consumer benefits from reduced natural gas prices, among other impacts.

RPS Compliance Costs as a Percentage of Customer Bills

Averaged 2.6% of retail electricity bills in 2018

A proxy for “rate impact”, albeit a rough one:

– Some impacts, both positive and negative, not fully captured (as discussed on the preceding slide)

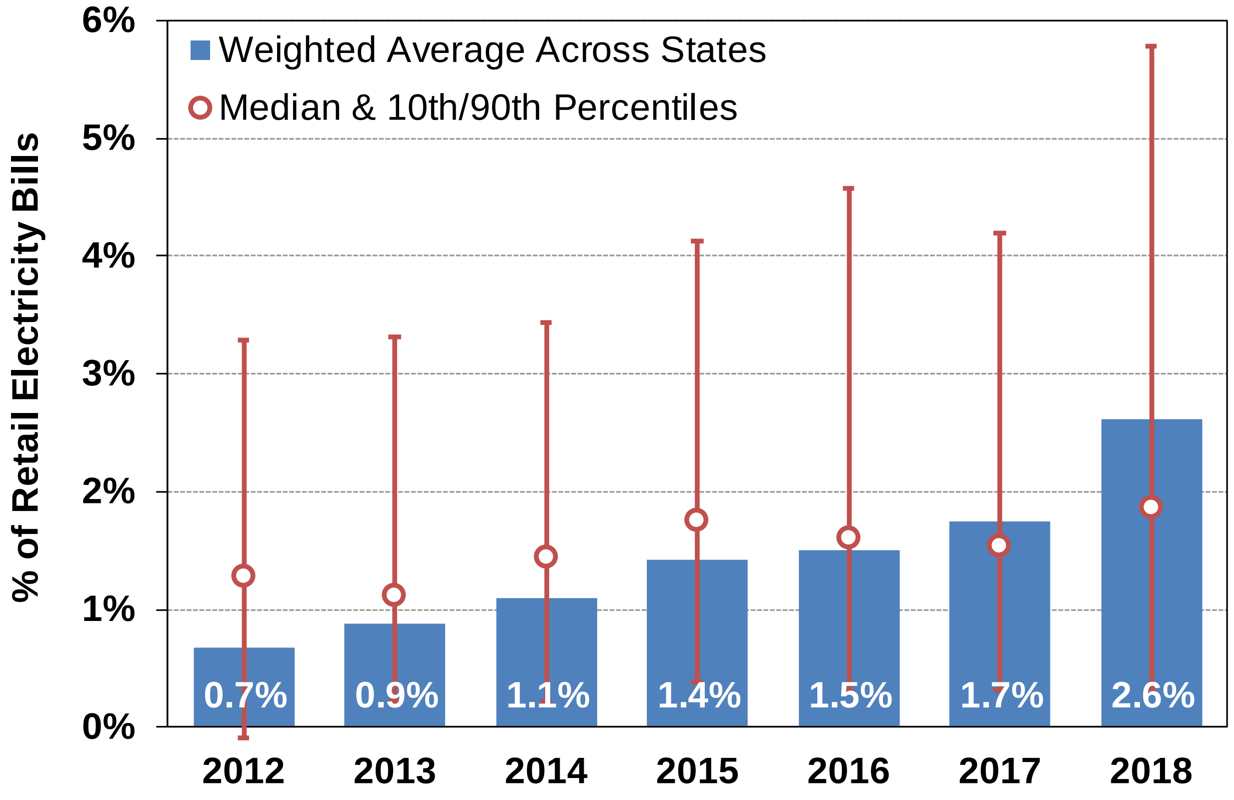
– Compliance costs borne by LSE not always fully or immediately passed through to ratepayers

– ACPs may be credited to ratepayers or recycled through incentive programs

- Costs as a percent of retail bills have risen over time with rising targets, as discussed on previous slide
- Wide variability across states, as evident by percentile bands, ranging from 0.3% to 5.8% in 2018 (more detail on later slide)

RPS Compliance Costs

Percentage of Average Retail Electricity Bill



Notes: Annual averages are weighted based on revenues from retail electricity sales subject to RPS obligations in each state.

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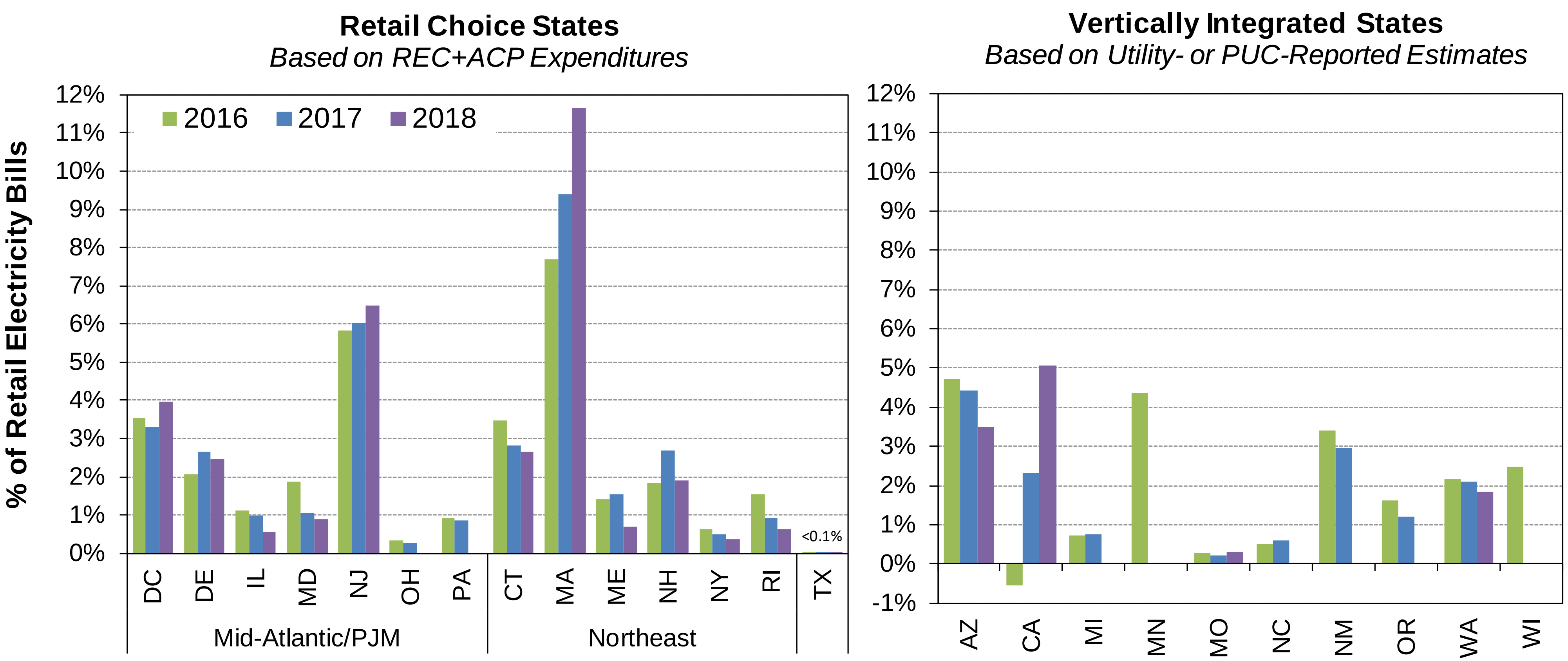
State-Specific RPS Compliance Costs

Reflect differences in both policy design and underlying RE economics

RPS Compliance Costs *(Percentage of Average Retail Electricity Bill)*



Notes: RPS compliance cost estimates for retail choice states are based, whenever possible, on the average cost of all RECs retired for compliance, including both spot market purchases and long-term contracts. For states with compliance years that begin in the middle of each calendar year (DE, IL, NJ, and PA), compliance years are mapped to the figure based on the end-date of each compliance year. Compliance cost data are wholly unavailable for IA, HI, MT, NV, and VT; these states are therefore omitted from the chart.

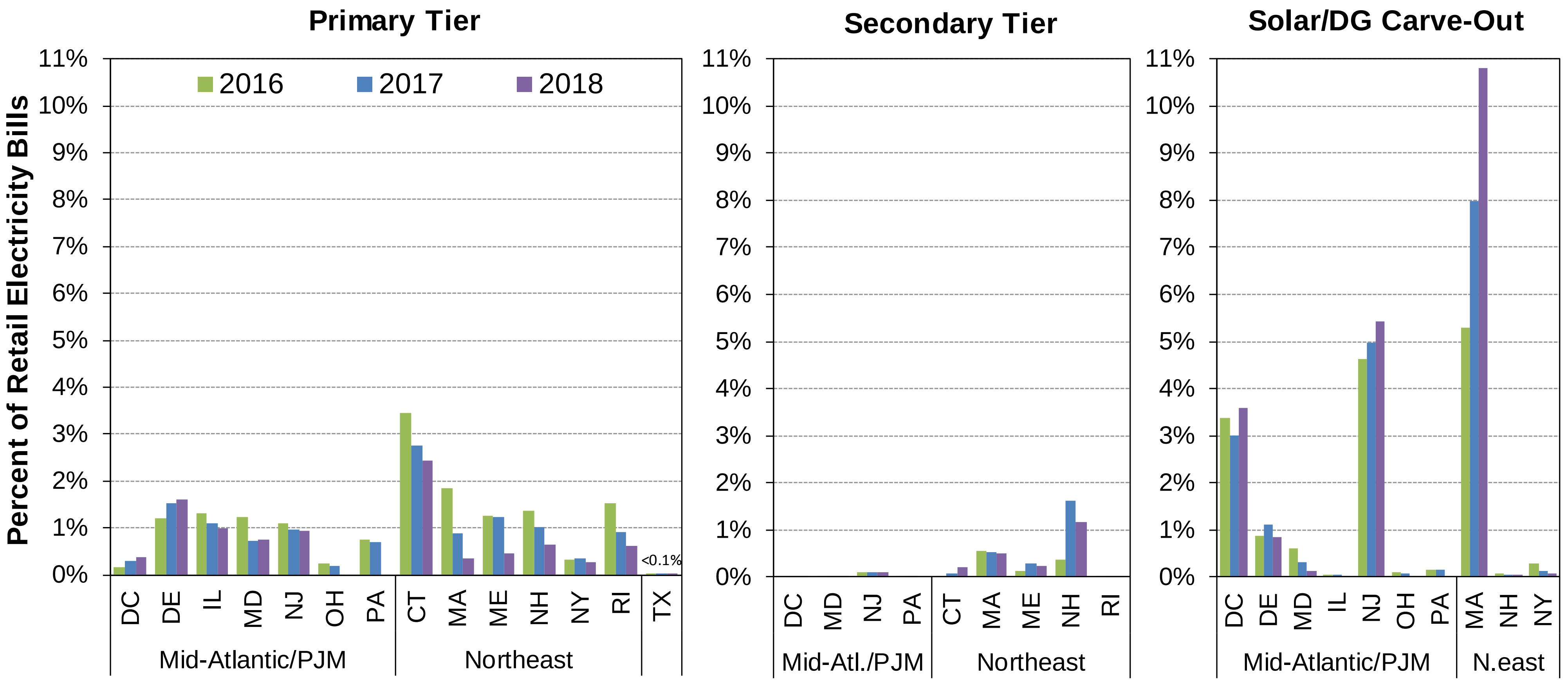
Varied RPS compliance costs across states reflect differences in:

- RPS target levels
- Resource tiering/mix
- Local RE costs/ characteristics
- REC prices
- Balance between short- and long-term procurement instruments
- Reliance on pre-existing resources
- Wholesale electricity prices
- State-specific cost calculation methods

RPS Compliance Costs by Resource Tier

Retail choice states only

RPS Compliance Costs *(Percentage of Average Retail Electricity Bill)*



Notes: RPS compliance cost estimates are based, whenever possible, on the average cost of all RECs retired for compliance, including both spot market purchases and long-term contracts. For states with compliance years that begin in the middle of each calendar year (DE, IL, NJ, and PA), compliance years are mapped to the figure based on the end-date of each compliance year.

Primary Tier: Geographic differences related to PJM Tier 1 vs. NEPOOL Class I REC prices and reliance on spot vs. long-term purchases; fairly consistent downward trend with falling REC prices

Secondary Tier: Generally a marginal contributor to overall RPS compliance costs, due to low REC prices

Solar/DG Carve-Out: The dominant component of RPS compliance costs in several states (DC, NJ, MA) with high SREC prices and/or relatively high targets

Side Bar: Other RPS Rate Impact Estimates

The RPS compliance cost estimates here are based on a bottom-up approach; other studies have explored the same question using different methods, including:

- **Electric sector modeling**, which uses capacity expansion and/or production cost models to compare system costs under scenarios with and without RPS policies; typically used for prospective rather than historical analysis
- **Econometric analysis**, which uses statistical techniques (multi-variate regressions) to isolate the effect of RPS policies, controlling for other confounding factors

A sample of these studies are summarized below, illustrating a wide range in estimated rate impacts

Study*	**Method**	**Timeframe**	**Estimated Effect of RPS Policies on Retail Electricity Prices**
Mai et al. 2016	Electric sector modeling	2015-2030	Across a set of sensitivities, U.S. average rate impacts in 2030 range from a 2% decrease to a 1% increase. Two regions with the most aggressive RPS policies had projected rate impacts under some sensitivity cases of as much as 11% (Pacific region) and 13% (Northeast region). Projected rate impacts for all other regions fall within a range of a 4% decrease and a 2% increase.
Greenstone et al. 2019	Econometric	1990-2015	Estimates an average rate increase of 11% after 7 years from enactment and 17% after 12 years from enactment.
Morey & Kirsch 2013	Econometric	1990-2011	Based on US average retail prices in 2011, the estimated effects correspond to a 3.8% average rate impact for residential customers, 1.8% for commercial customers, and 1.3% for industrial customers.
Tra 2016	Econometric	2001-2012	Estimates a 3% increase in residential and commercial rates, but no effects from increasing the stringency of the RPS.
Upton & Snyder 2017	Econometric	1990-2013	Estimates that RPSs are associated with roughly an 11% increase in electricity prices compared to other states with similar economic and political conditions and similar renewable energy generation potential.
Wang 2014	Econometric	1990-2011	Depending on model specification and variable definition, found statistically significant increases ranging from 5-7.5%.

** Excluded from this table are a number of studies that have applied simple descriptive analysis to compare electricity prices between RPS states and non-RPS states, as those studies often include no or limited control variables, and in general are not analytically sophisticated enough to support causal attribution*

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RPS Cost Containment Mechanisms

May cap growth in RPS compliance costs

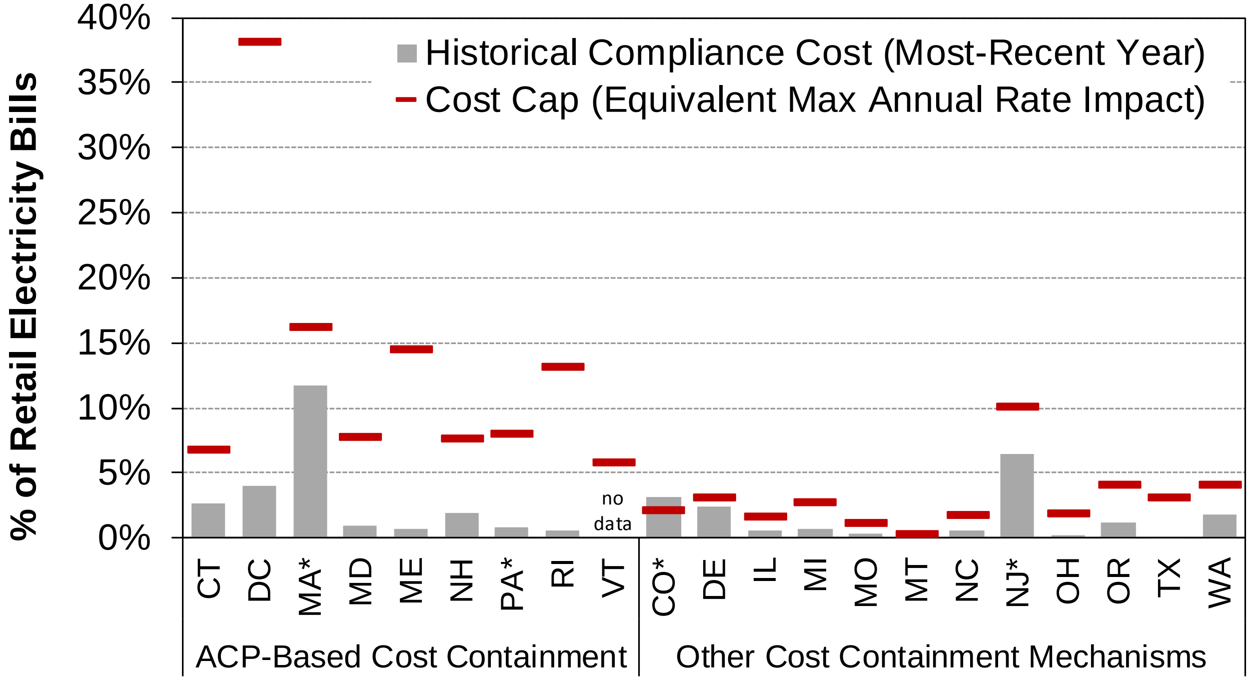
- Going forward, RPS compliance costs will depend on RE technology costs and REC prices, electricity prices, natural gas prices, tax policy, and a variety of other factors

RPS policies have various cost containment mechanisms

- ACPs (which cap REC prices)
- Caps on rate impacts or revenue requirements (gross or net)
- Caps on RPS surcharges
- RE contract price caps
- Financial penalties
- Regulatory oversight of procurement

- Size of caps varies widely, but typically less than 10% of retail electricity bills (higher in several states with particularly aggressive targets or high ACP rates)
- In a few instances (IL, NM), states or utilities have hit rate impact caps and temporarily curtailed RPS procurement
- Some cost containment mechanisms are more like "soft" caps (due to discretion in enforcement or in how costs are calculated, applicability to only a portion of the RPS, and multi-year averaging or use of balancing accounts)

Recent Costs Compared to Effective Cost Caps



** See below for additional details on states marked with an asterisk.*

Notes: Each state's cost containment mechanism was translated into the equivalent maximum allowed rate impact. These represent the maximum possible single-year impact, not the maximum long-term or average impact, which would be less. For ACP states, this generally corresponds to a scenario in which the final RPS target is achieved entirely with ACPs. For MA, ACPs do not apply to the SMART program; we therefore used the DPU's estimated cost of $85/MWh for that portion of the RPS. The cost cap in PA does not apply to the solar carve-out, and the cost cap in NJ does not cover the offshore wind carve-out. For CO, the cap represents the maximum allowable surcharge, but actual compliance costs borne by the utility in any individual year may be greater (and are smoothed out over time via balancing accounts). Excluded from the chart are states without any explicit mechanism to cap incremental RPS costs, though many of those states have other mechanisms or regulatory processes to limit RPS costs.

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Outlook

The Future Role & Impact of State RPS Programs Will Depend On…

- Whether additional states decide to increase and extend RPS targets and/or adopt broader “clean electricity” mandates encompassing RE
- Other ongoing RPS policy refinements (e.g., REC banking rules, long-term contracting programs, eligibility rules, etc.)
- Complementary efforts to address RE integration and valuation issues, including continuing evolution of wholesale electricity market design
- RE cost and REC price trajectories, and the attendant impacts on RPS compliance costs

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