Energy Technologies Area Lawrence Berkeley National Laboratory

U.S. Renewables Portfolio Standards

Preliminary 2018 Annual Status Report

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Related resources available at: *rps.lbl.gov*

Maryland RPS Working Group

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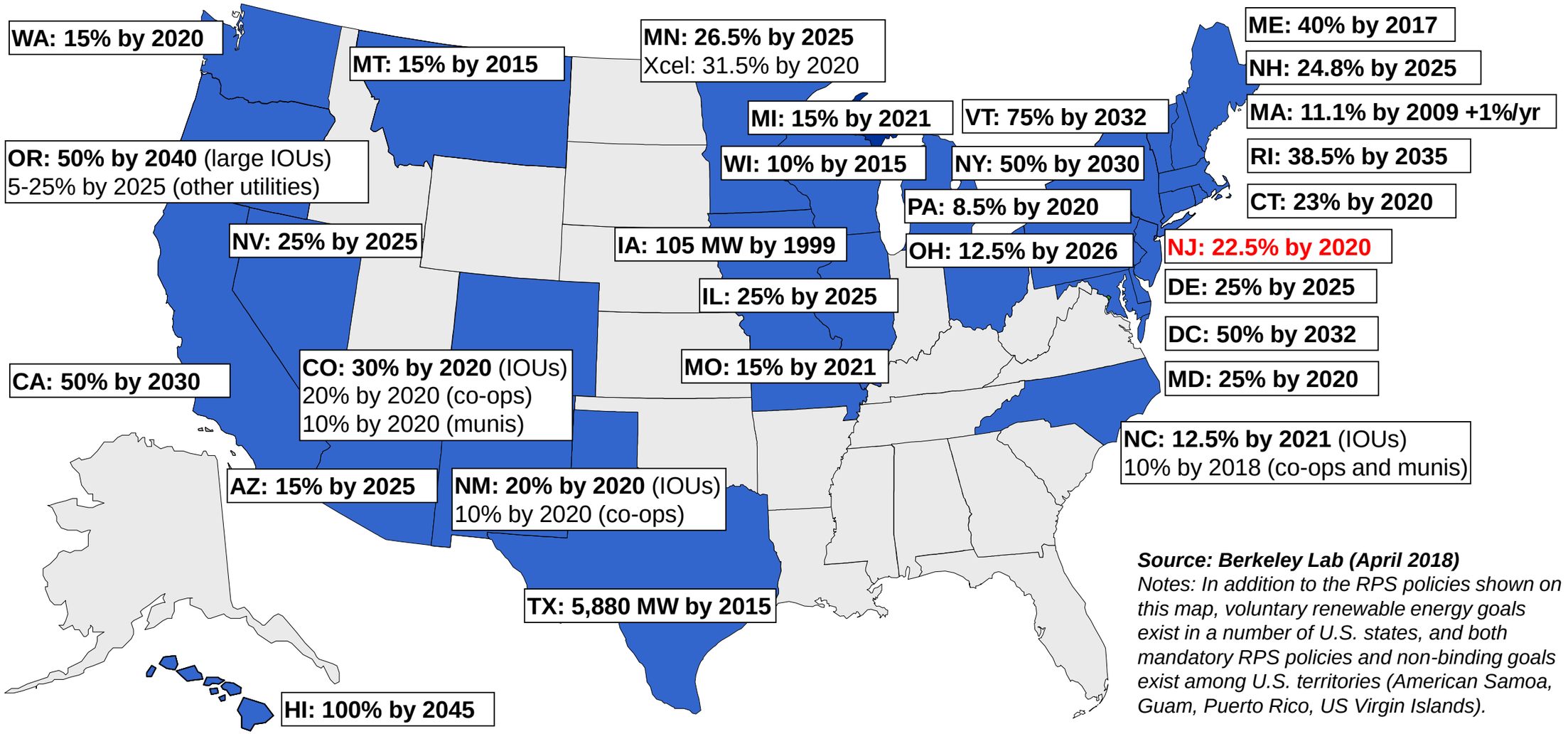
RPS Policies Exist in 29 States and DC

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



Source: Berkeley Lab (April 2018)

Notes: 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 non-binding goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

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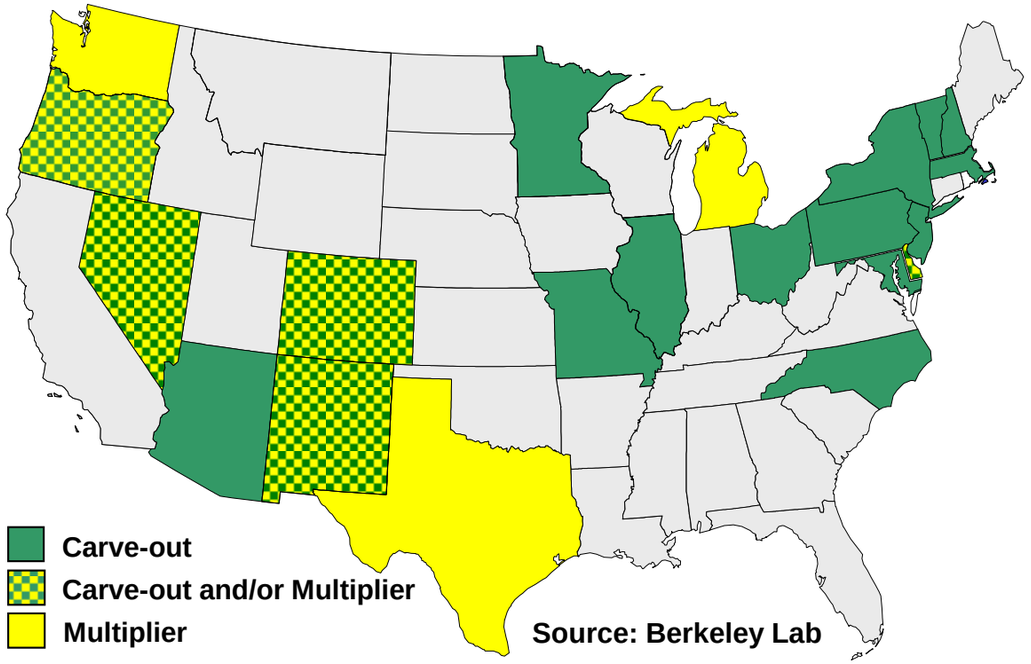
RPS Policies and Rules Are Not Uniform

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

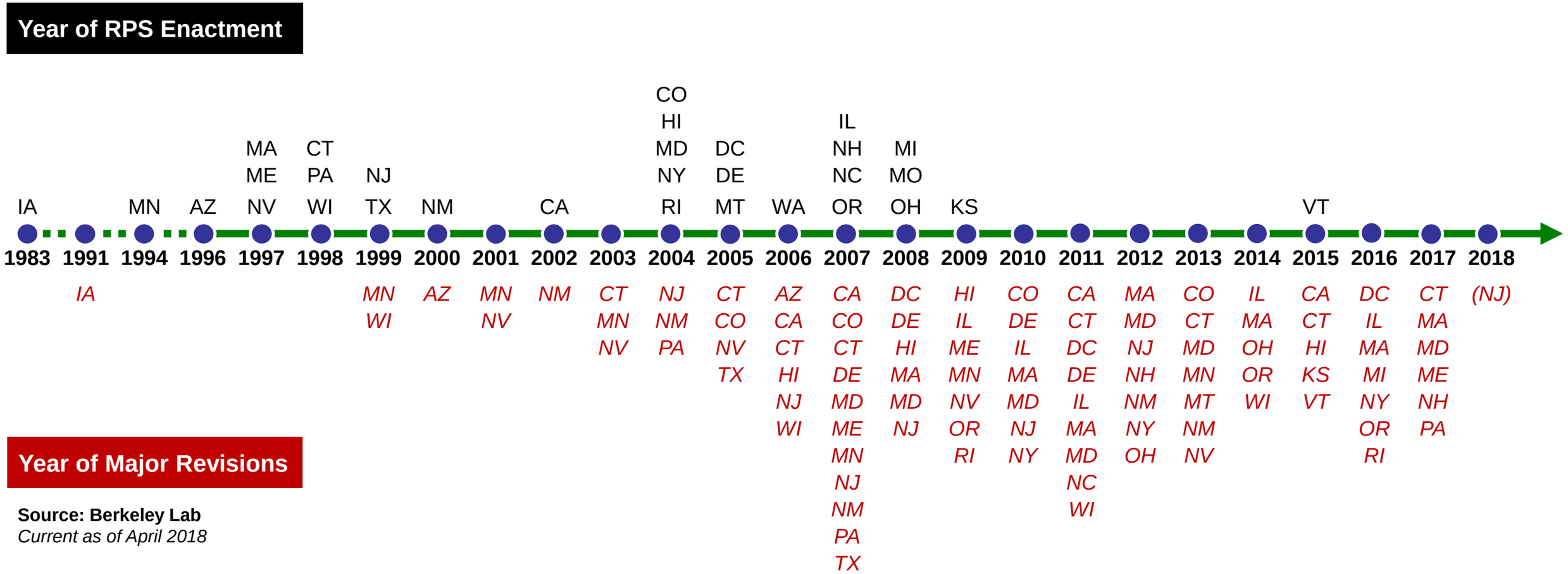
Solar or Distributed Generation (DG) Carve-Outs and Credit Multipliers



18 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 in Place for at Least 10 Years

States continue to make regular and significant revisions



Source: Berkeley Lab
Current as of April 2018

General Trends in RPS Revisions

Increase and extension of RPS targets: More than half of all RPS states have raised their overall RPS targets or carve-outs since initial RPS adoption; many in recent years

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

Honing 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

Loosening geographic preferences or restrictions: Sometimes motivated by concerns about Commerce Clause challenges or to facilitate lower-cost compliance

In addition, although many states have introduced bills to repeal, reduce, or freeze their RPS programs, only two (OH, KS) have thus far been enacted

RPS Legislation and Other Revisions in 2017 and 2018-to-date

Most proposals sought to strengthen or make small technical changes

RPS-Related Bills Introduced and Enacted in 2017 & 2018

	Strengthen	Weaken	Neutral	Total
Introduced	**96**	**56**	**62**	**214**
Enacted	**11**	**1**	**11**	**23**

Data Source: EQ Research (February 28, 2018)

Notes: Includes legislation from 2017 sessions and from 2016-2017 sessions active in 2017, as well as legislation active in 2018 sessions. Companion bills are counted as a single bill.

Contrasts to previous years with more prevalent efforts to repeal or weaken RPS requirements

"Major" RPS revisions made in 2017 and 2018-to-date:

- **CT:** Created long-term contracting requirement
- **MD:** Increased and accelerated RPS to 25% by 2020
- **ME:** Extended the RPS from 2017 (previously the final year) to 2032, maintaining the 2017 target level
- **NC:** Reduced cost cap for residential customers; created new competitive procurement program (2,660 MW over ~4 years)
- **NH:** Increased and accelerated solar carve-out to 0.7% by 2020
- ***NJ:*** *Increases and extends RPS to 50% by 2030; phases out solar carve-out (not yet signed into law)*
- **PA:** Modified eligibility rules for solar carve-out to require that facilities are connected or deliver to in-state electric grid

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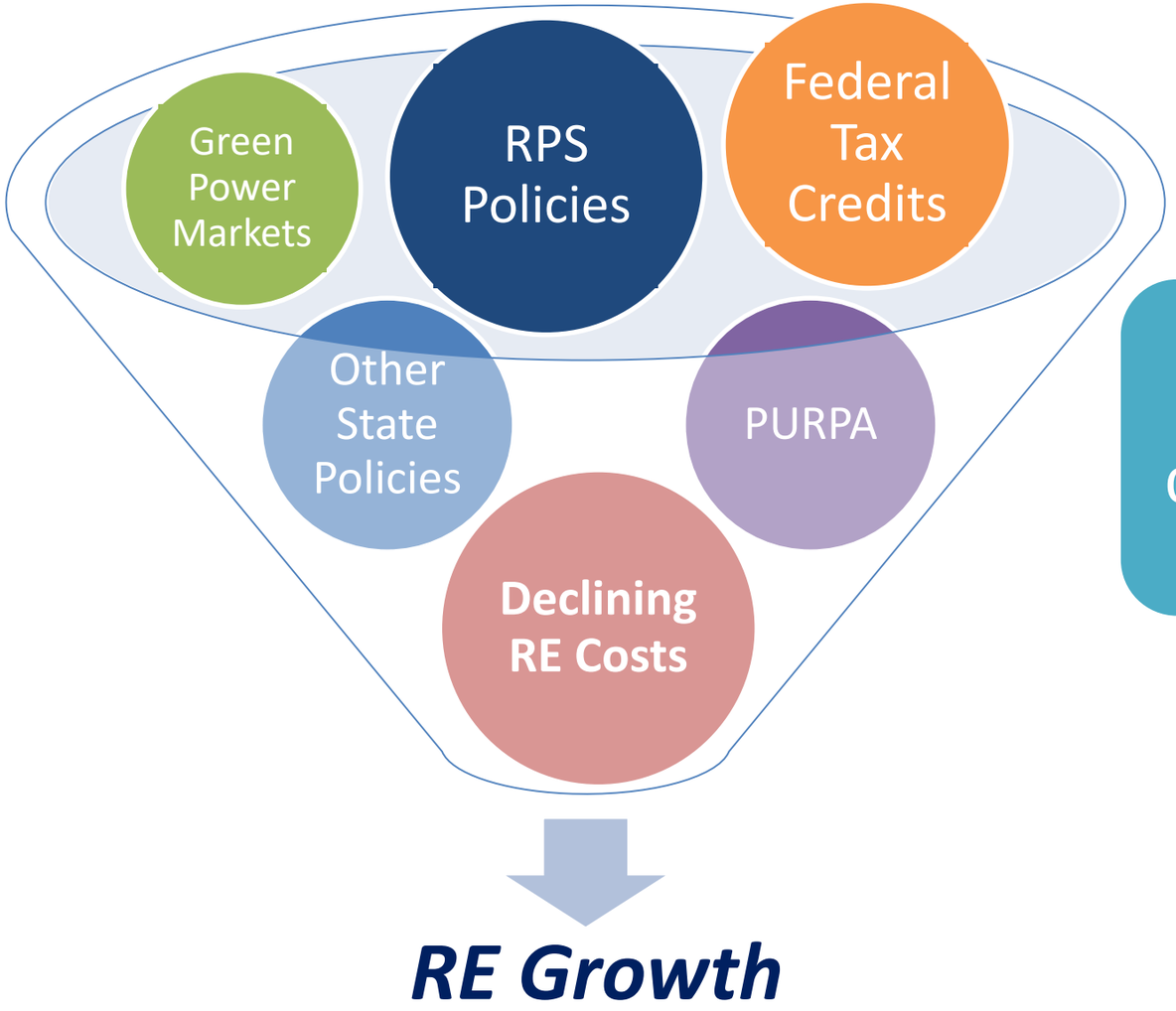
RPS Policies Exist amidst a Broader Array of Market and Policy Drivers for RE Growth

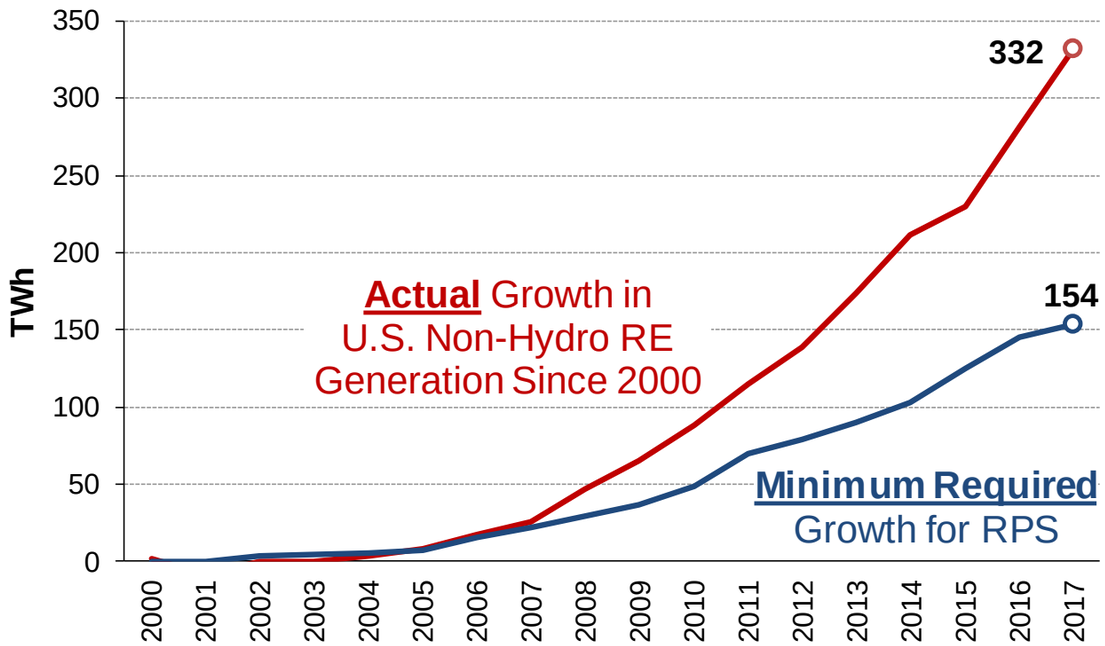


Separating out the incremental impact of any one driver is quite challenging, given potential overlaps and interactions

RPS Policies Have Been One Key Driver for RE Generation Growth

RPS requirements constitute 46% of total U.S. RE growth since 2000

Growth in Non-Hydro Renewable Generation: 2000-2017



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 332 TWh from 2000-2017
  - Many factors contributed to that growth (tax credits, other incentives, cost declines, etc.)
- RPS policies required 154 TWh increase over that period
  - Not strict attribution: some of that would have occurred without RPS
- Additional RE growth associated with:
  - Voluntary green power markets (~95 TWh in 2016, per NREL)
  - Economic utility purchases
  - Accelerated RPS procurement

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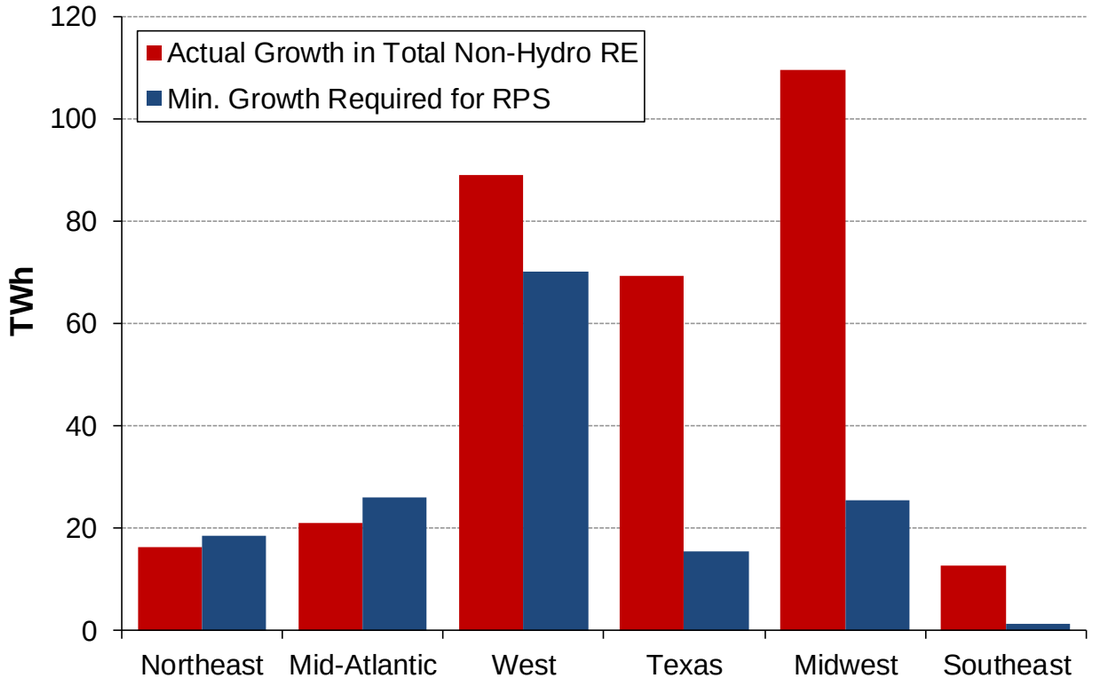
RPS Role in Driving RE Growth Varies by Region

Seemingly most critical in the Northeast, Mid-Atlantic, West

Growth in Non-Hydro Renewable Generation: 2000-2017



Notes: Northeast consists of New England states plus New York. Actual growth shown for that region is estimated based on new RE capacity that meets the vintage requirements for RPS eligibility. Mid-Atlantic consists of states that are primarily within PJM (in terms of load served).

Northeast, Mid-Atlantic, West

- Actual RE growth closely matches RPS needs
- Northeast and Mid-Atlantic rely, to some degree, on RECs from neighboring regions to meet compliance obligations

Texas and the Midwest

- Actual RE growth far outpaced RPS needs, given favorable wind energy capacity factors/economics in those regions

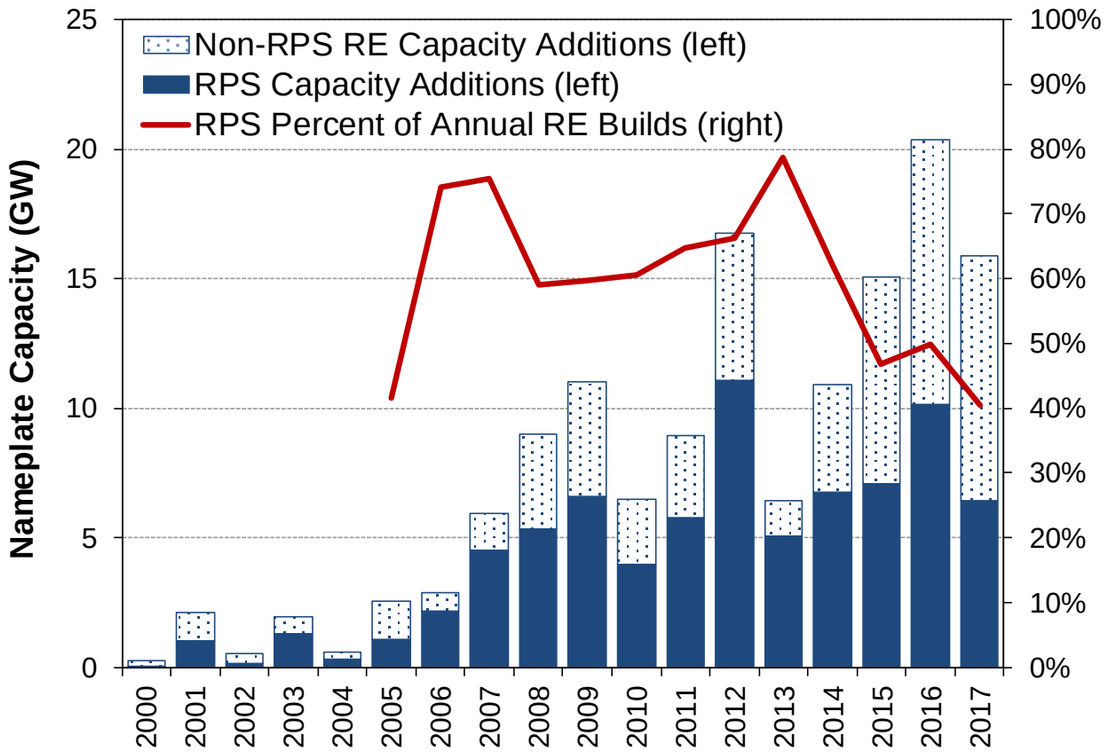
Southeast

- Minimal RE growth or RPS demand, with just a single RPS state (North Carolina)

RPS's Have Provided a Stable Source of Demand for RE Growth

Though RPS *portion* of total RE growth has declined in recent years

Annual Renewable Capacity Additions

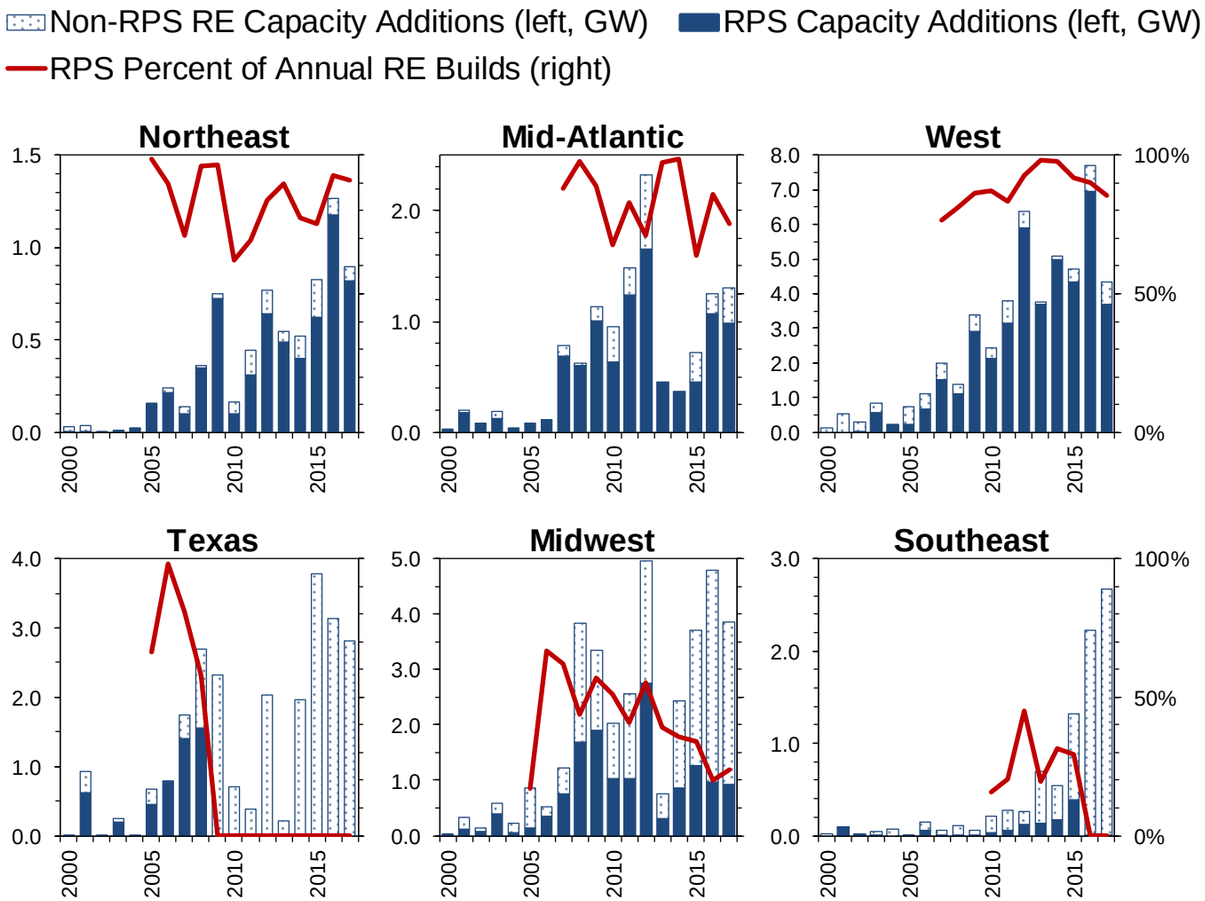


Notes: RPS Capacity Additions consists of RE capacity contracted to entities with active RPS obligations or sold on a merchant basis into regional RPS markets.

- Cumulatively, 140 GW of RE capacity added in the U.S. since 2000
  - Just over half of that capacity (57%) consist of projects servicing RPS obligations
- Over the past decade, 5-10 GW per year of RE capacity added for RPS demand (6 GW/yr on average)
  - Has provided a floor in down years (e.g., 2013)
- In recent years, the RPS-portion of new RE builds has been lower than previously (40% in 2017 vs. 60-80% in 2007-14)
  - Partly due to rebounding wind growth in TX and Midwest, some serving corporate procurement and other voluntary green power markets
  - Also the result of net-metered PV in California and some utility-scale PV in non-RPS markets

RPS Policies Remain Central to RE Growth in Particular Regions

70-90% of 2016 RE additions in Northeast, Mid-Atlantic, West serve RPS demand



Notes: Northeast consists of New England states plus New York. Actual growth shown for that region is estimated based on new RE capacity that meets the vintage requirements for RPS eligibility. Mid-Atlantic consists of states that are primarily within PJM (in terms of load served).

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

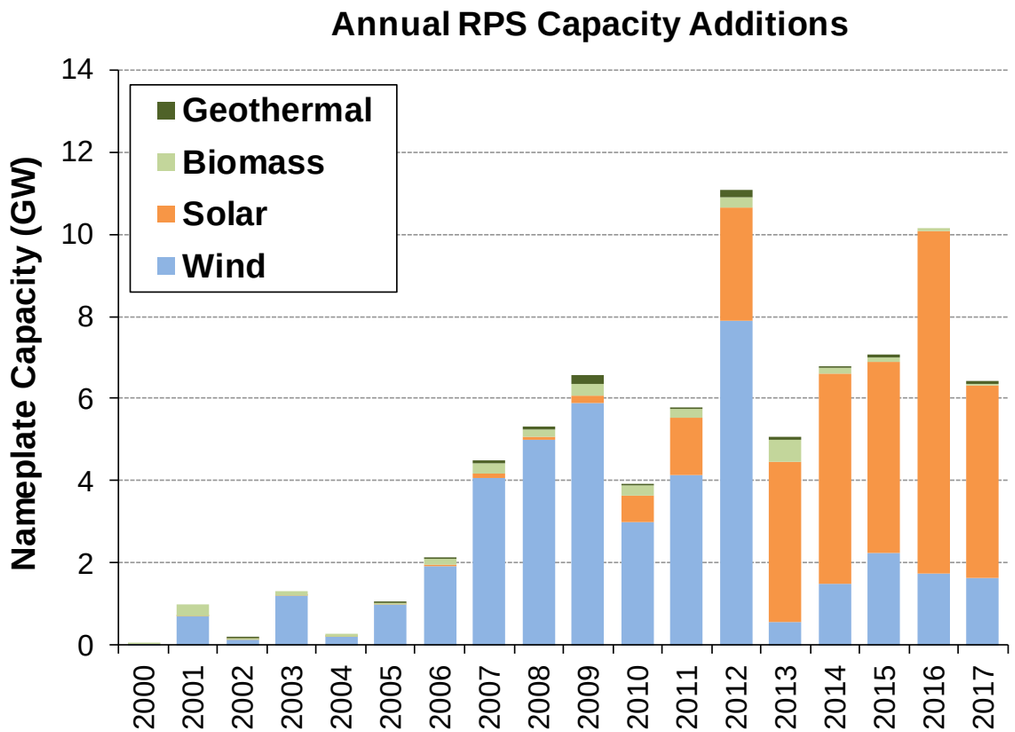
- **Northeast:** Relatively small market, but almost all capacity additions serving RPS demand
- **Mid-Atlantic:** Combo of solar carve-out capacity and wind projects (merchant or corporate procurement, but RPS-certified and likely selling RECs for RPS needs)
- **West:** The bulk of U.S. RPS capacity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

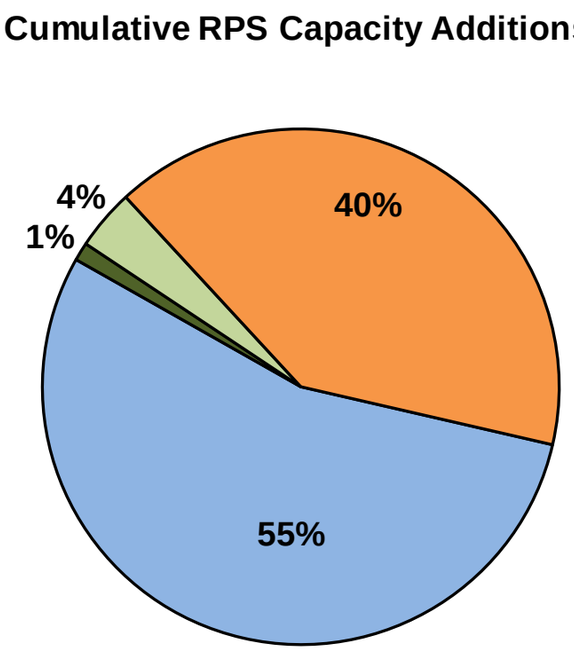
But have been a ***smaller*** driver in…

- **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

Wind Was Historically the Dominant Source of New-Build for RPS, But Solar Has Recently Taken the Mantle

RPS Capacity Additions by Technology Type





Notes: "RPS Capacity Additions" represent RE capacity contracted to entities subject to an RPS or sold on a merchant basis into regional RPS markets. On an energy (as opposed to capacity) basis, wind represents approximately 75%, solar 16%, biomass 5%, and geothermal 4% of RPS-related renewable energy growth.

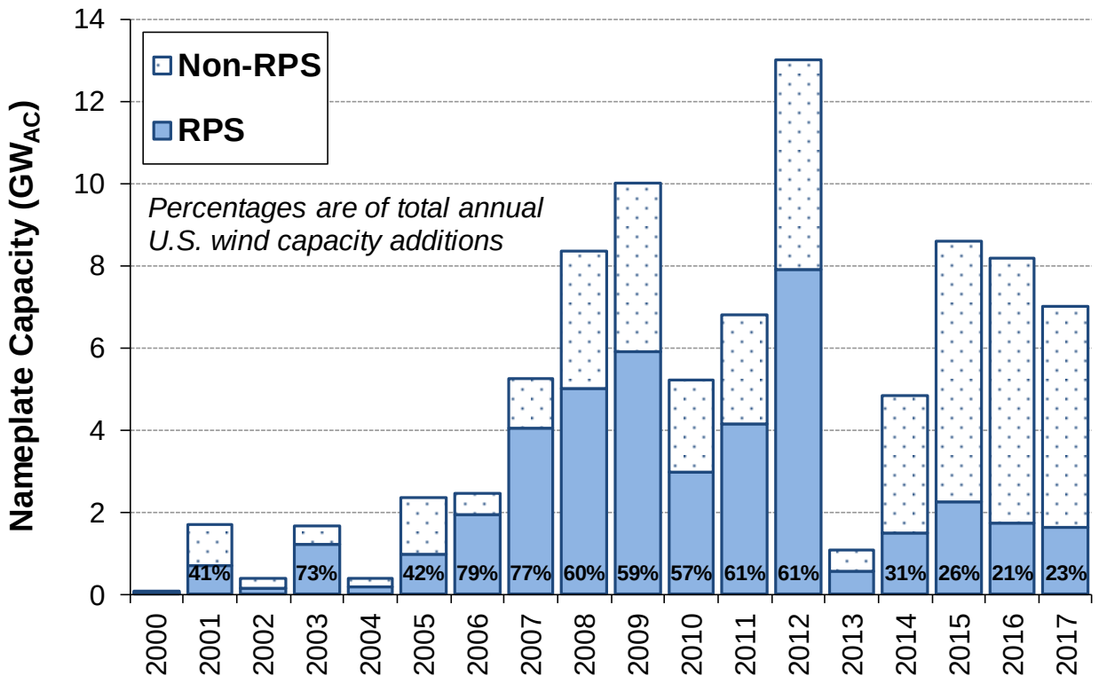
Wind is 55% of all RPS builds to-date, but solar was 73% of 2017 RPS builds

- Prominence of solar among recent RPS builds reflects:
  - Prevalence of solar carve-out requirements
  - Increasing cost-competitiveness of utility-scale solar vis-à-vis wind
- Wind capacity growth still strong, but recent additions primarily not for RPS

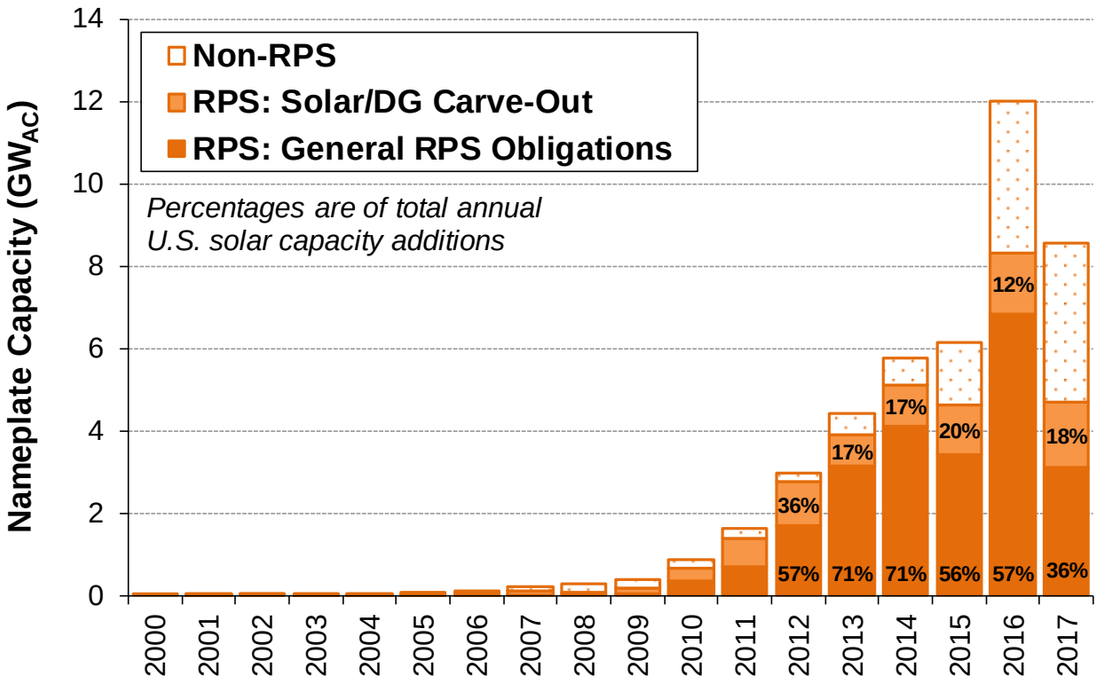
Recent Wind Additions Built Primarily Outside of RPS Requirements, While Solar is More-Concentrated in RPS States

In 2017, **23%** of all wind additions were dedicated to RPS demand, compared to **54%** for solar (36% for general RPS obligations + 18% for carve-outs)

Wind Capacity Additions



Solar Capacity Additions



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- Historical impacts on renewables development
- **Future RPS demand and incremental needs (relative to end-of-2016)**
- RPS target achievement to-date
- REC pricing trends
- RPS compliance costs and cost caps
- Outlook

States Are Starting to Approach Final Target Years

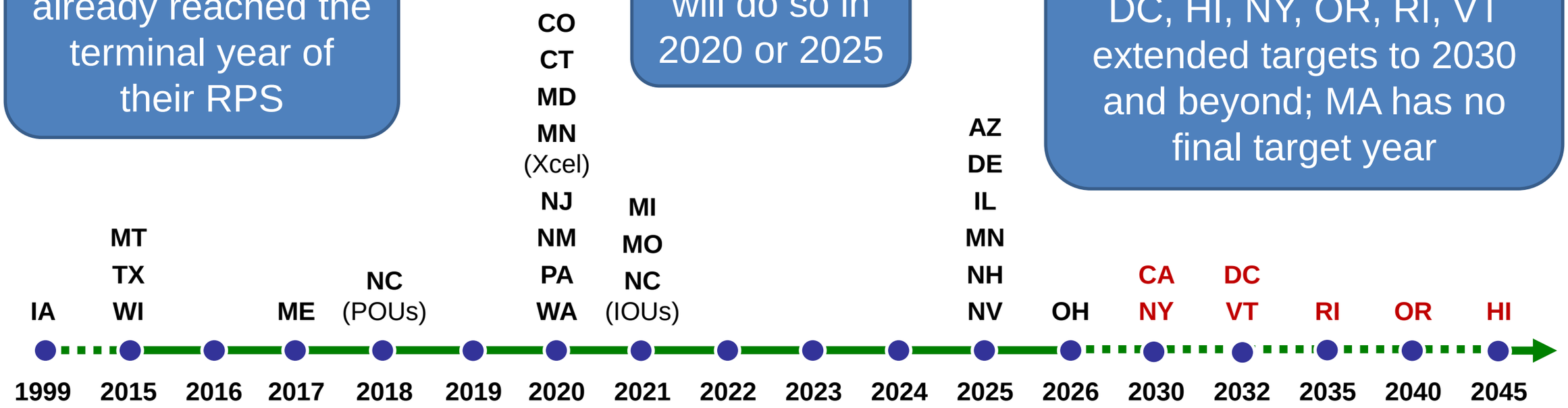
Half of all RPS states reach their final target year by 2021

Year of Final RPS Target

Several states have already reached the terminal year of their RPS

Most others will do so in 2020 or 2025

Recent revisions in CA, DC, HI, NY, OR, RI, VT extended targets to 2030 and beyond; MA has no final target year

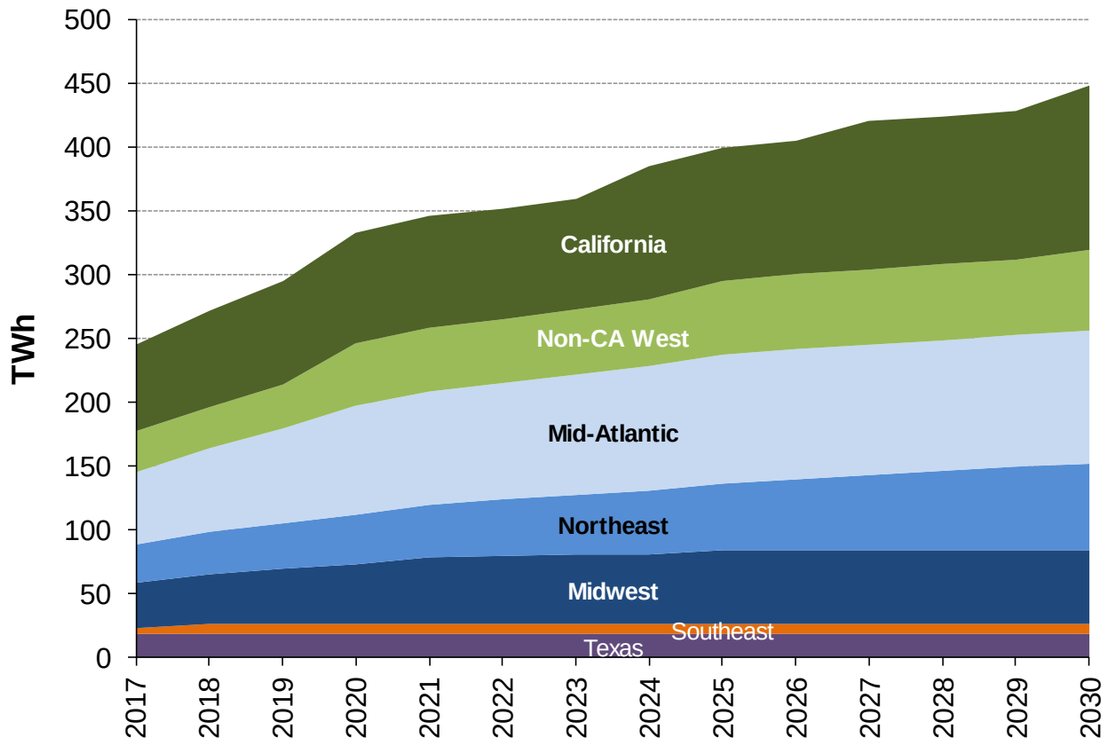


RPS needs will continue to slowly grow after final targets, due to load growth and RE retirements

Projected RPS Demand (i.e., total RPS compliance requirement)

Total U.S. RPS demand rises roughly 80% 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 roughly 245 TWh in 2017 to 450 TWh in 2030*
  - This represents the total amount of RE or RECs needed to meet RPS compliance in each year
- To be sure, increased demand does not equate to required increase in supply
  - Some utilities and regions ahead of schedule, others are behind
  - Some growth in demand will likely be met with banked RECs

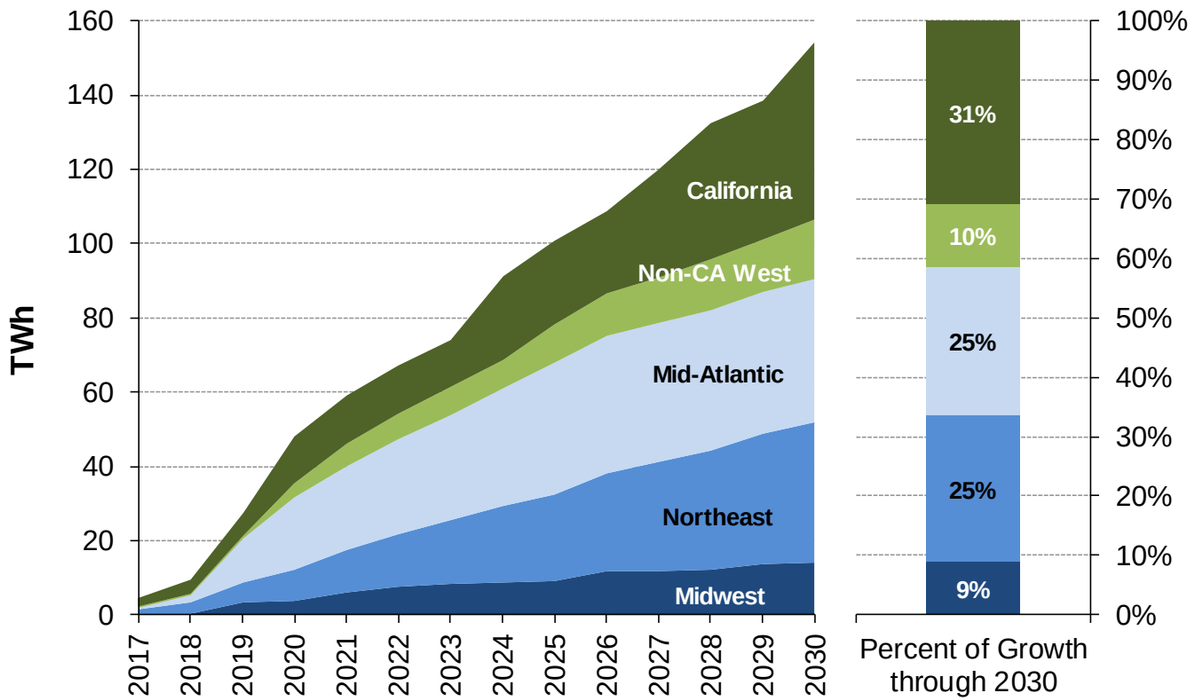
* Latest NJ RPS legislation increasing the state's RPS to 50% by 2030 is *not* reflected in these projections; would add ~20 TWh by 2030

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

Required Increase in RPS Generation Supply

Equates to roughly 50% increase in U.S. renewable energy 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 2016. 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 2016 (see figure notes for further details)
- Accounting for REC banking over the forecast period, per each state's rules

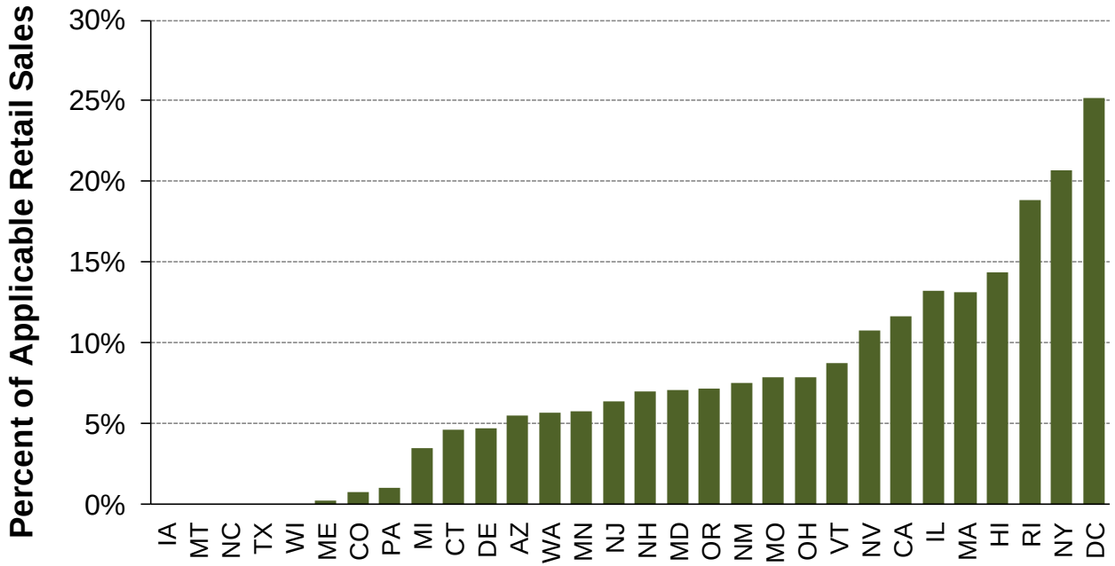
- 150 TWh increase in RPS resources needed to meet RPS demand growth through 2030
  - By comparison, current U.S. RE = ~330 TWh
- Relatively steady rate of growth at aggregate national level; some regions are lumpy
- Greatest incremental needs in:
  - California (50% statewide RPS by 2030)
  - Mid-Atlantic (well distributed among states)
  - Northeast (mostly NY's 50%-by-2030 CES)

Residual RPS Procurement Needs by 2030

8 states with (effectively) no remaining need; 8 others with needs >10% retail sales

- Residual RPS procurement needs a function of target rise, current surplus, and REC banking rules
  - DC, NY, RI targets rise by 20-30% of retail sales by 2030
  - CA, HI, OR have similar target rise, but much smaller residual procurement needs due to current surplus and (in CA/OR) relatively permissive REC banking rules
- For regional REC markets (New England and PJM), residual needs may be more meaningfully expressed in aggregate regional terms
  - NEPOOL residual needs = 10% of retail sales by 2030
  - PJM residual needs = 7% of retail sales by 2030
- For some states, residual needs continue to rise beyond 2030 with increasing RPS targets and/or depletion of REC banks

Residual RPS Procurement Needs by 2030
(Percent of Applicable Retail Sales)



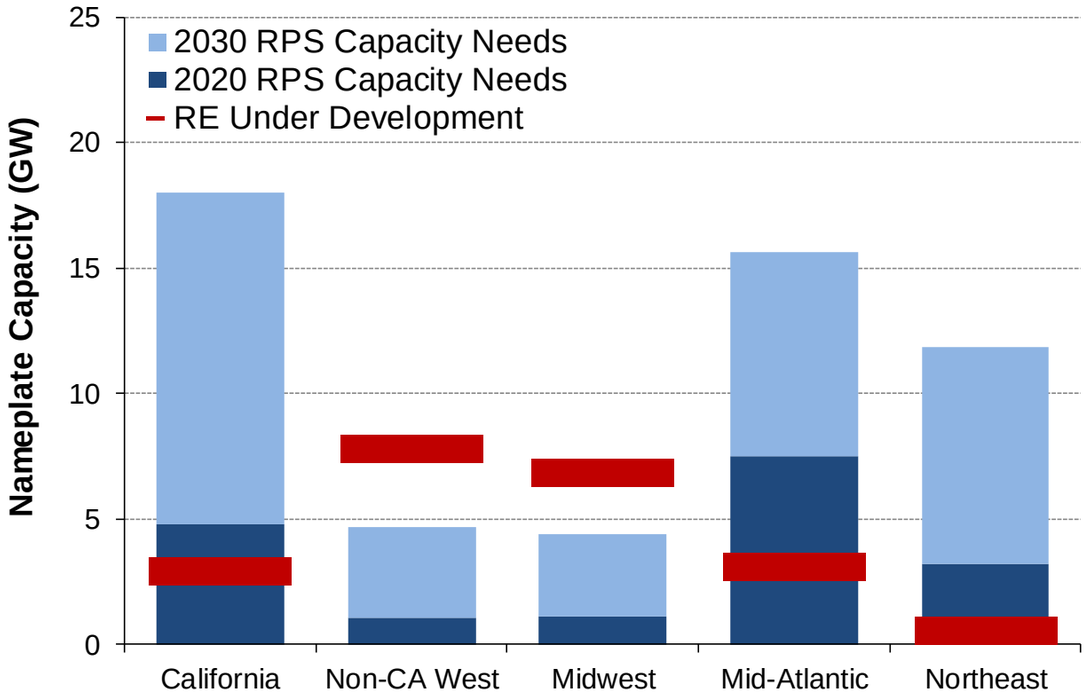
Notes: For regulated states, residual procurement needs are estimated on a utility-specific basis, based on each utility's RPS procurement and REC bank as of year-end 2016, assuming no future sales of surplus RECs and accounting for the accumulation of banked RECs over time, per each state's rules. For New England and PJM states, aggregate regional procurement needs are allocated among states in proportion to each state's growth in RPS demand through 2030. For PJM, aggregate procurement needs are calculated separately for the "premium" states with more restrictive eligibility rules (DE, MD, NJ, PA) and for others (DC, IL, OH).

Required RE Capacity Builds for RPS

Roughly 18 GW needed by 2020, 55 GW by 2030

- Equates to:
  - 40% increase in U.S. RE capacity by 2030
  - Average build-rate of 4 GW per year (compared to ~6 GW/yr historically)
- RE already under development will likely meet some portion of remaining RPS needs
  - Could meet all RPS needs in Non-CA West and Midwest
  - May also serve RPS demand in neighboring regions
- Northeast residual needs to be met primarily through long-term contracts
  - NYSERDA procurements, MA (offshore wind, SMART, other clean energy), CT ZREC/LREC, etc.

Required Increase in RPS Capacity (GW)

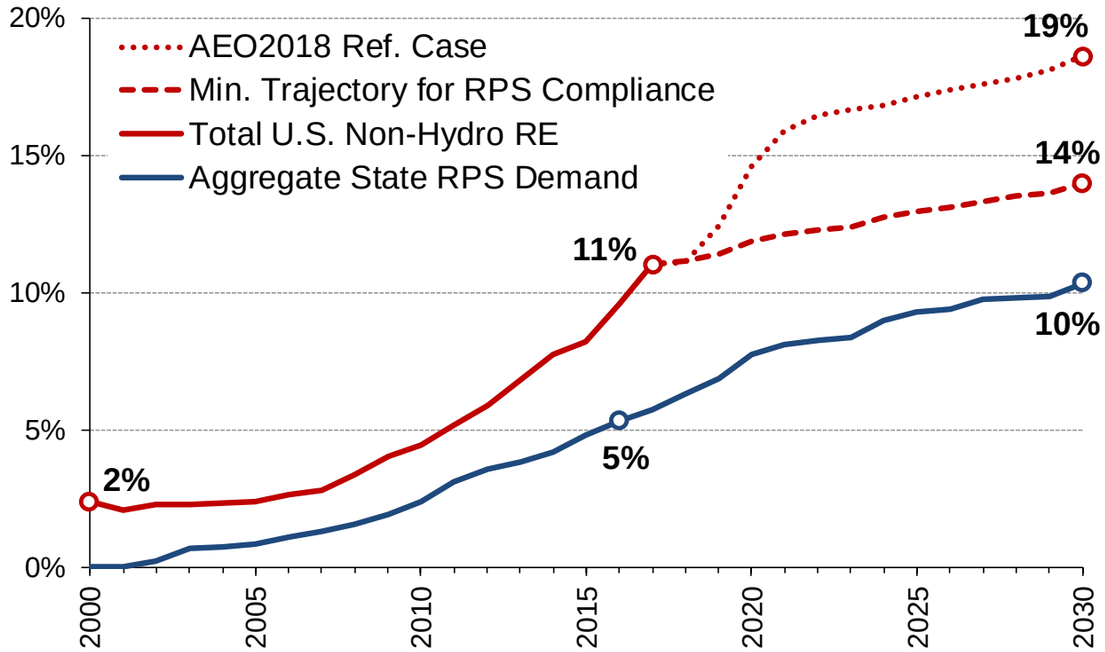


Notes: Calculated from estimated incremental generation needed to meet RPS demand, based on state-specific assumptions about the mix and capacity factor of new RPS supply. RE Under Development consists of units permitted or under construction, site preparation, or testing as of June 2017, plus units that entered commercial operation in 2017, 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 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 10% of U.S. retail electricity sales by 2030
- However, to meet those targets, total U.S. RE supply will need to reach 14% of retail sales
  - Accounts for the fact that not all existing RE supplies are available for future RPS demand
- EIA projects much greater RE growth, reaching 19% of retail sales by 2030
  - Rapid growth prior to expiration of ITC/PTC
- RPS policies clearly just one driver for continued RE growth
  - Other drivers: tax credits, RE cost declines, corporate procurement

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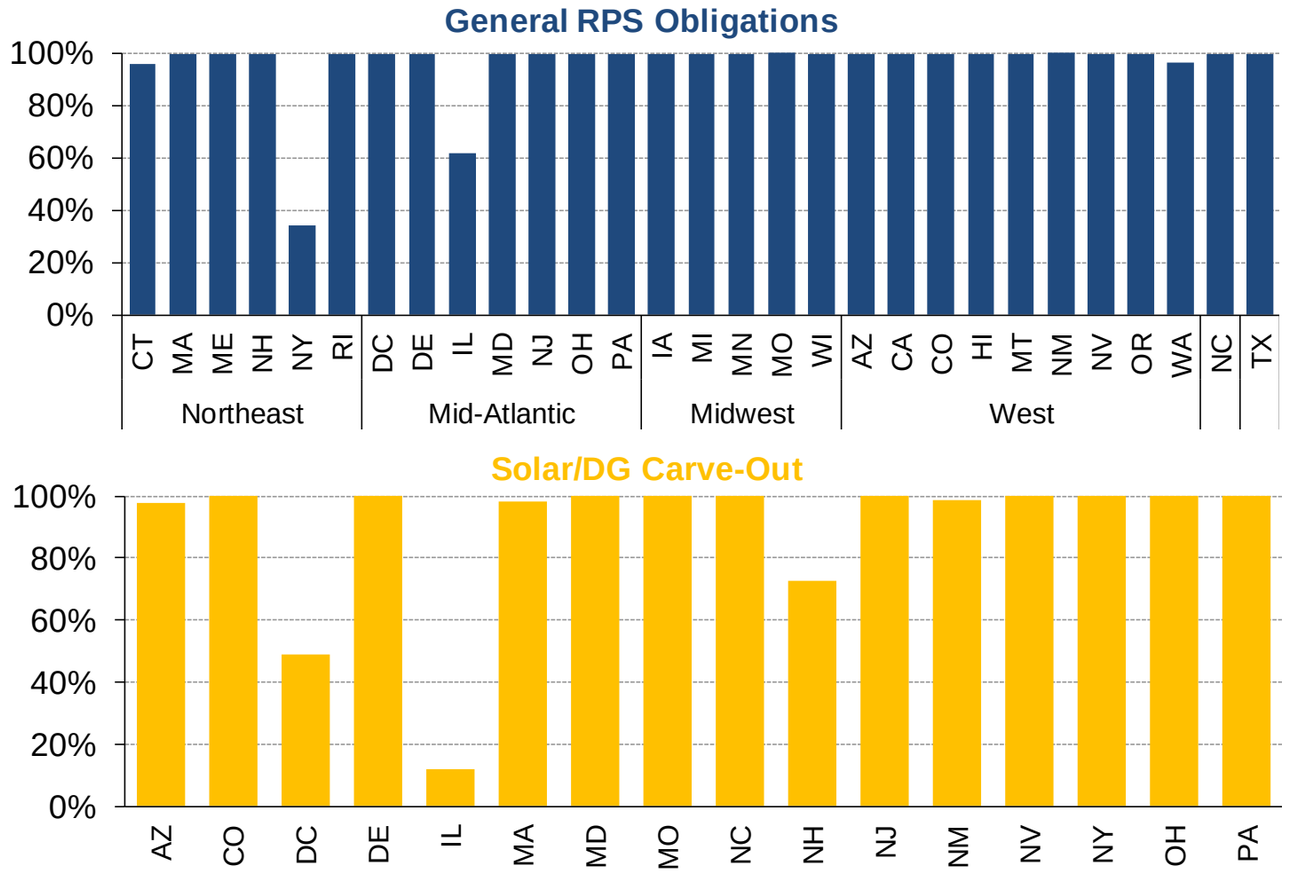
States Have Generally Met Their Interim RPS Targets

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



- Many states/utilities well ahead of schedule, easily meeting interim targets
- Others met interim targets only by relying on stockpile of banked RECs from prior years
- Relatively few instances where interim targets significantly missed
  - **DC (Solar):** In-district eligibility requirements limit pool of supply
  - **IL (General RPS & Solar):** Alternative retail suppliers required to meet 50% of RPS with ACPs
  - **NH (Solar):** Unusually low solar ACPs have led to SRECs flowing into neighboring Class I markets
  - **NY (General RPS):** Procurement has lagged targets, partly due to budget constraints

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.

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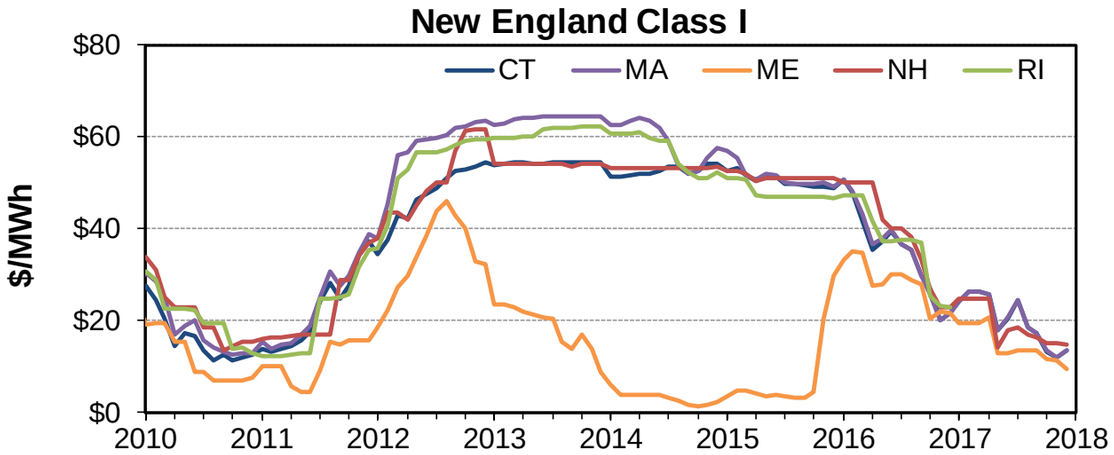
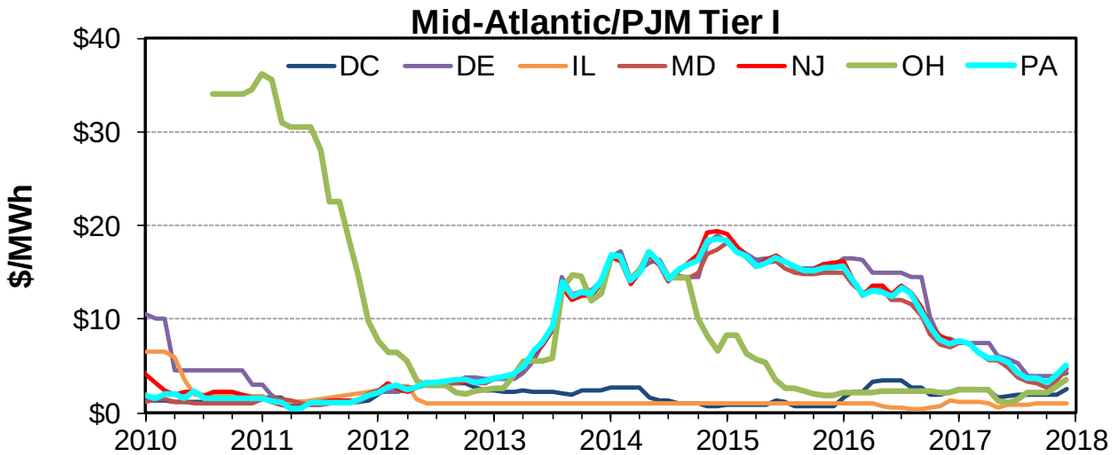
REC Pricing Trends for General RPS Obligations

Most markets saw significant decline in 2017





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 ACP rates and current/expected supply-demand balance

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

New England:

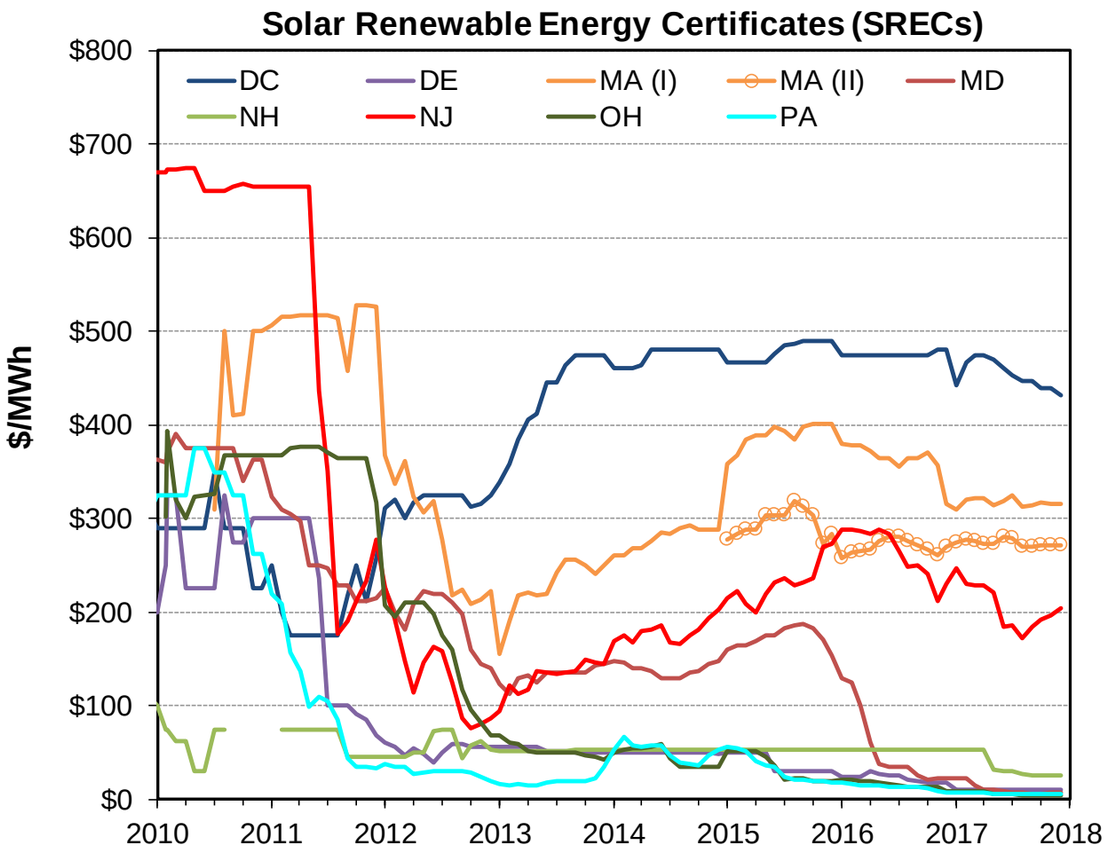
- Growing regional supplies have pushed prices to near all time lows (<$20/MWh, compared to $55-65 ACP levels)

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 driving prices down

SREC Pricing Trends for RPS Solar Carve-Outs

No major shifts in 2017: high states stayed high, and low states stayed low



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 and limited market footprint
- **MA:** Price movements bounded by clearinghouse floor and SACP
- **NJ:** Fairly well-balanced market, but looming oversupplies
- **MD:** Substantial over-supply emerged in 2015-2016 causing prices to bottom out, where they have remained
- **DE, PA**, **OH** heavily oversupplied, in part due to eligibility of out-of-state projects
- **NH:** Low solar ACP ($55/MWh)

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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

Restructured Markets

- 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
- ***Limitations:*** Growing use of bundled PPAs; ignores merit order effect and some transmission/integration costs

Regulated Markets

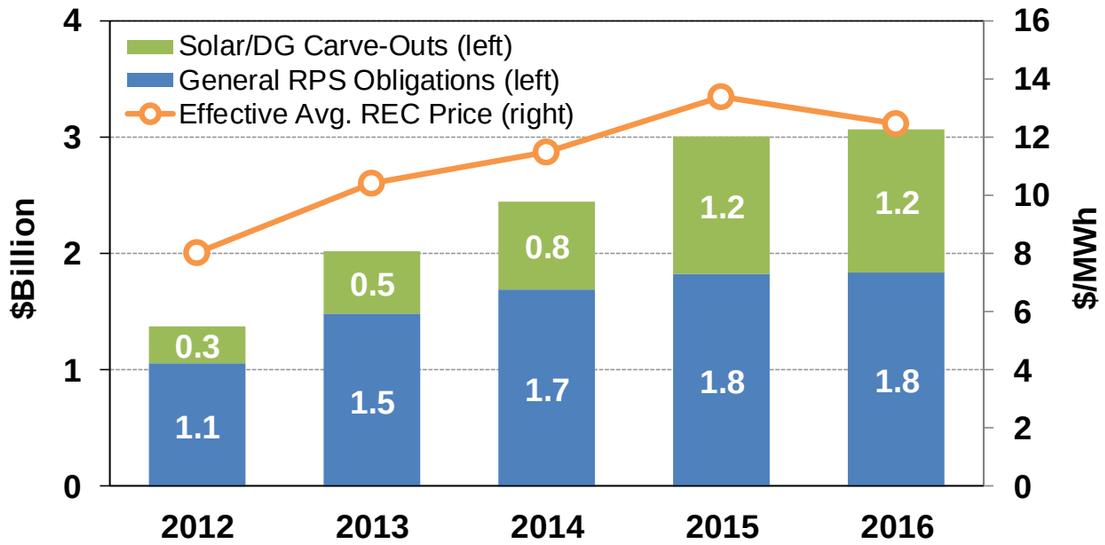
- We synthesize available utility and PUC compliance cost estimates
- Estimates compare gross RPS procurement costs to a counterfactual (e.g., market prices or a long-term avoided cost projection)
- ***Limitations:*** Varying methods across states; incomplete or sporadic reporting (no data for several states)

Compliance cost reporting is lagged → Data available for many states only through 2016

Aggregate U.S. RPS Compliance Costs

Held flat at ~$3.0B from 2015 to 2016, after steadily rising in prior years

Total RPS Compliance Costs



Notes: General RPS obligations consist of all non-solar/DG carve-out requirements, including both primary and secondary tiers. Costs were extrapolated to several states/utilities without available data, based on other states/utilities in the region. Effective Avg. REC Price is a weighted average based on REC procurement volumes across all tiers and states (including regulated states where REC prices are implied).

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

- General historical trend:
  - Cost growth over time driven by increasing targets
  - Solar/DG carve-outs a growing share of aggregate RPS compliance costs (driven by NJ and MA)
- Cost growth from 2015 to 2016 dampened by falling REC prices and RE costs
- Important note: Total U.S. RPS compliance costs highly sensitive to California
  - We use PUC estimates, which rely on the all-in cost of a combined-cycle gas turbine as the basis for avoided costs
  - Alternate IOU avoided cost estimates based on short-term market prices yield RPS compliance costs roughly $3.2B higher in 2016 (increasing total U.S. costs to $6.2B)*

** The CPUC has noted several concerns with the IOUs' approach: namely, that many of the IOUs' other generation resources, including nuclear and large hydroelectric generation, also would not be cost-effective compared to spot market prices, and that the utilities likely would not be able to procure such a large volume in the spot market. In addition, relying on actual realized spot market prices does not account for the merit order effect.*

RPS Compliance Costs as a Percentage of Customer Bills

Averaged 1.6% of retail electricity bills in 2016

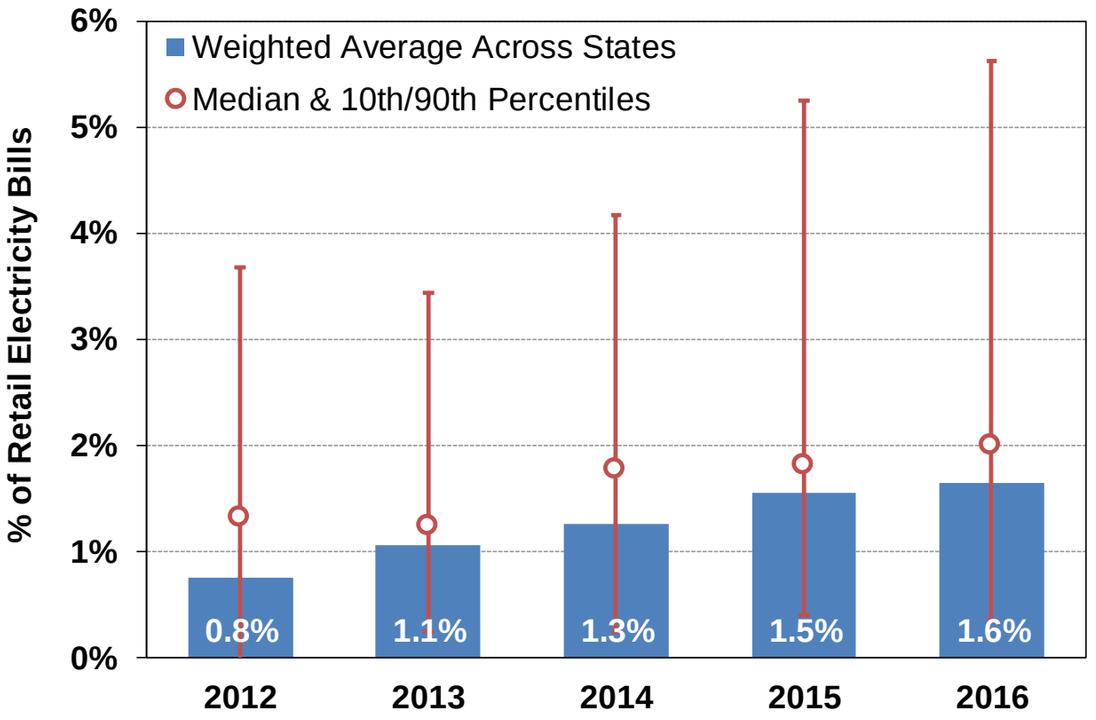
A proxy for "rate impact", albeit a rough one:

- Some impacts (merit order effect, integration costs) not fully captured
- 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 generally risen over time with rising targets, as discussed on previous slide
- Wide variability across states, as evident by percentile bands, ranging from 0.4% to 5.6% in 2016 (10th to 90th percentile range) → more detail on next slide

RPS Compliance Costs

Percentage of Average Retail Electricity Bill

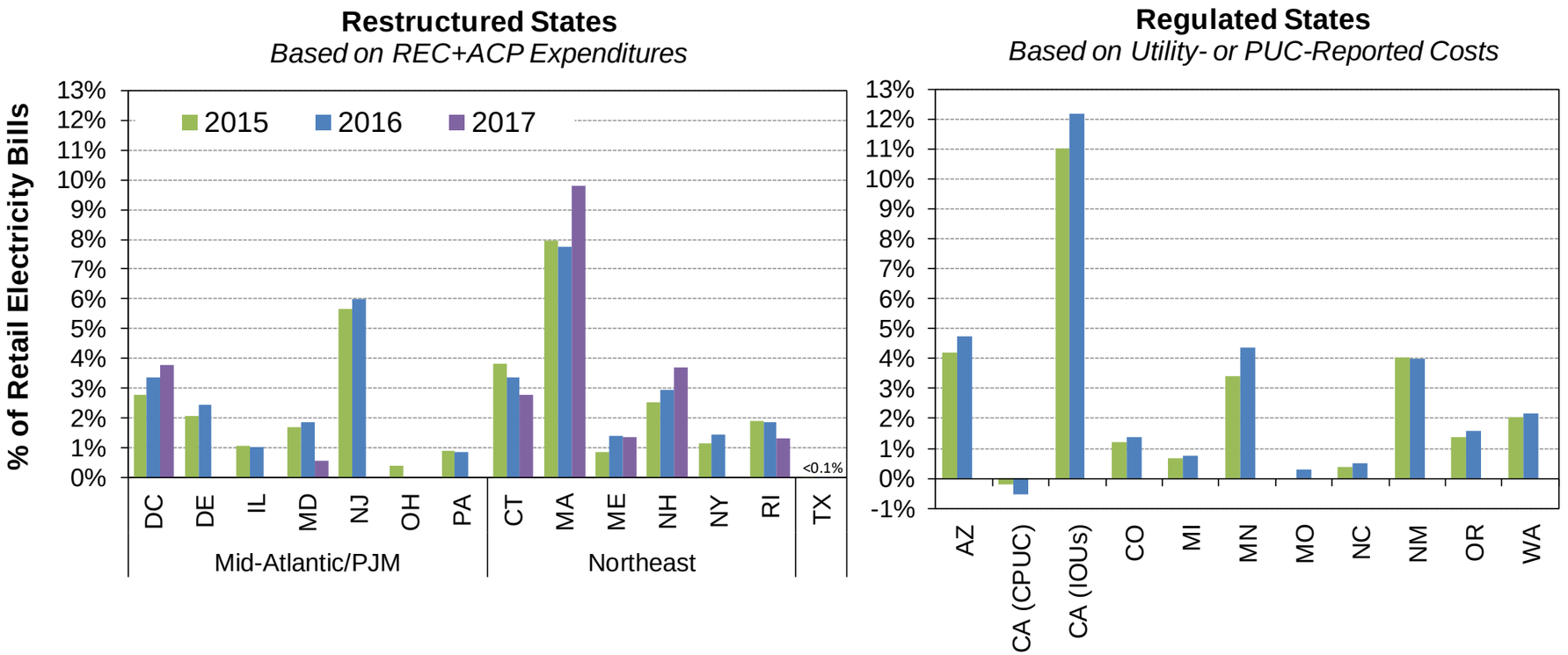


Notes: Annual averages are weighted based on each state's total revenues from retail electricity sales. Using IOU avoided cost estimates for CA, rather than the CPUC's estimates, would raise the U.S. weighted average costs substantially (e.g., to 3.4% of retail electricity bills in 2016).

State-Specific RPS Compliance Costs

Including 2017 data where available

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



Notes: RPS compliance cost estimates for restructured 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 (i.e., DE, IL, NJ, and PA), compliance years are mapped to the table based on the start date of each compliance year. Among regulated states, compliance cost data are wholly unavailable for IA, HI, MT, NV, WI; these states are therefore omitted from the chart. The two sets of values for CA reflect alternate avoided-cost estimates (see earlier slide for explanation and discussion).

Cross-state cost variation reflects differences in:

- RPS target levels
- Resource tiers/mix
- REC prices
- Wholesale electricity prices
- Reliance on pre-existing resources
- State-specific cost calculation methods (see notes regarding CA)

Falling REC prices in 2017 led to declining RPS costs in some restructured states

- Muted to some degree by existing long-term contracts and banked RECs

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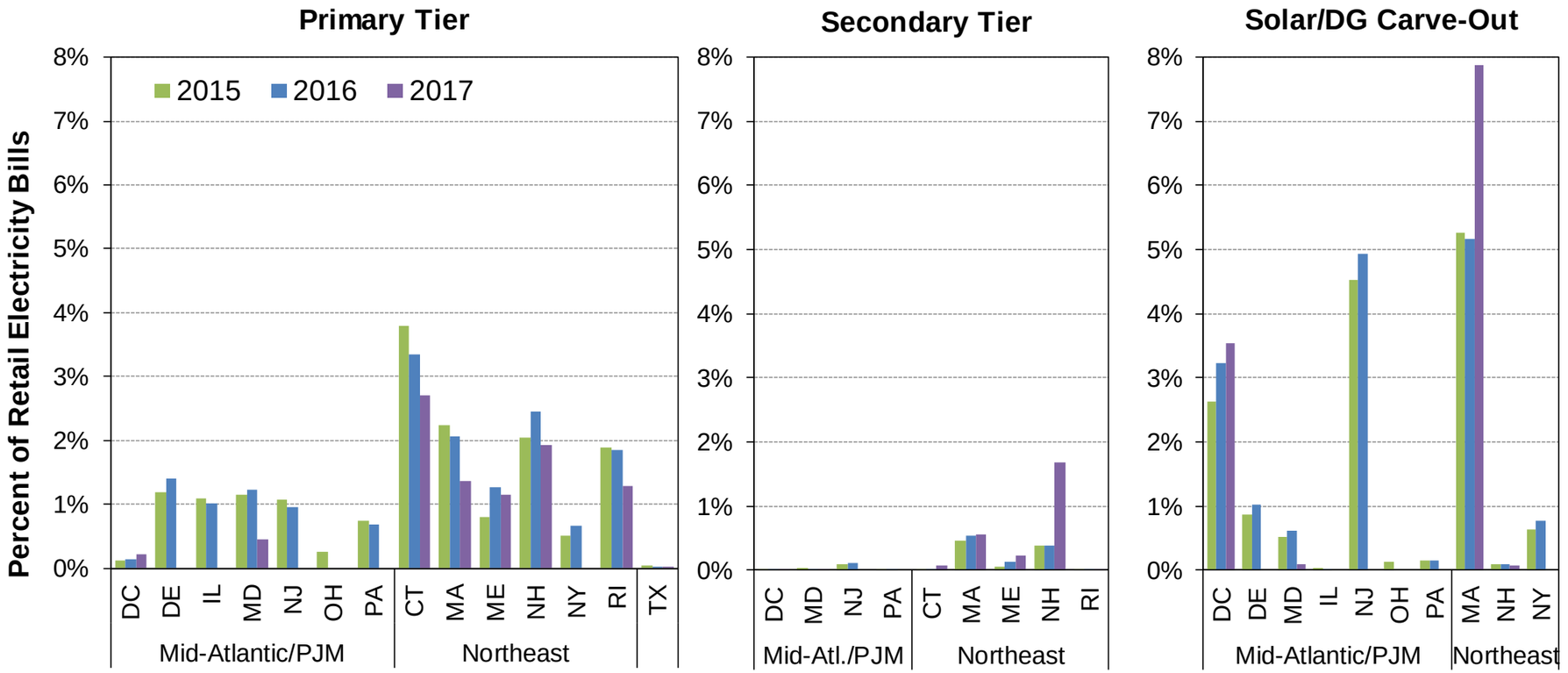
RPS Compliance Costs by Resource Tier

Restructured states only

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



Notes: RPS compliance cost estimates for restructured 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 (i.e., DE, IL, NJ, and PA), compliance years are mapped to the table based on the start date of each compliance year. Several regulated states also include RPS carve-outs, but compliance cost data typically are not available for those carve-outs specifically.

Primary Tier: Geographic trends reflect differences in PJM Tier 1 and NEPOOL Class I REC prices; 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 largest component of RPS compliance costs in several states (DC, NJ, MA) with high SREC prices and/or relatively high targets

RPS Cost Containment Mechanisms

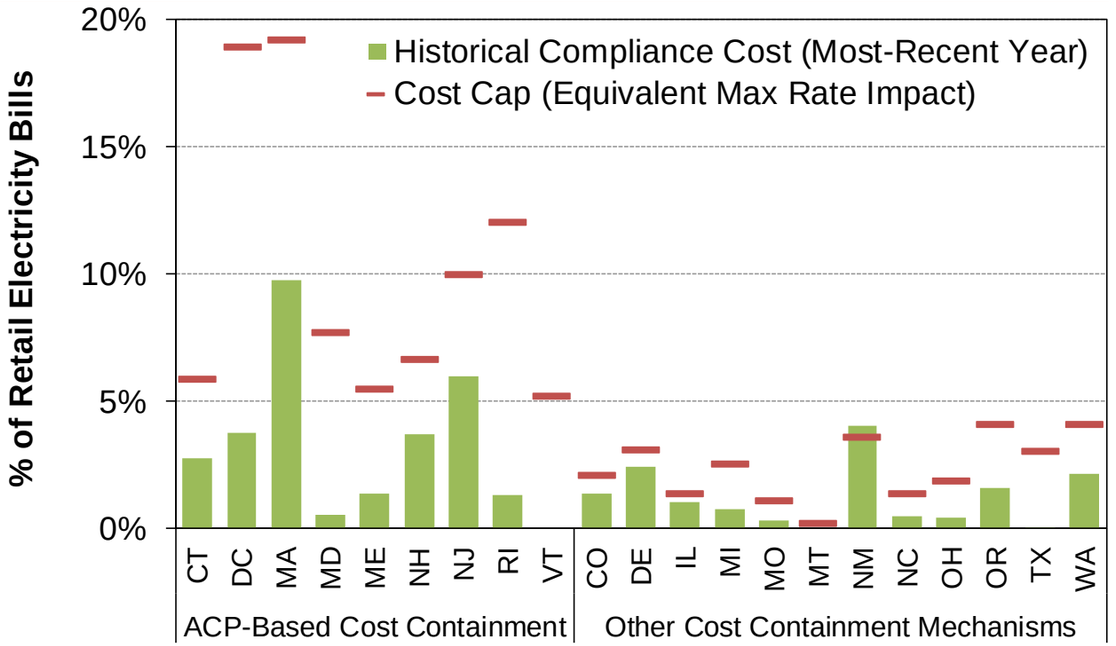
Will cap growth in RPS compliance costs in most states

RPS policies have various cost containment mechanisms

- ACPs (which cap REC prices)
- Caps on rate impacts or revenue-requirements
- Caps on surcharges for RPS cost recovery
- RE contract price caps
- Renewable energy fund caps
- Financial penalties
- Regulatory oversight of procurement

- Highest cost caps (10-20% of electricity bills) occur in states relying only on ACPs for cost containment and with relatively aggressive targets and/or high ACP rates
- Cost caps in states with other cost containment mechanisms are generally more restrictive (1-4% of bills)
  - → Have already led to curtailed procurement in NM, and are close to binding in several other states (DE, IL)

Recent Costs Compared to Cost Caps



Notes: Each state's cost containment mechanism was translated into the equivalent maximum allowed rate impact for the final year in the RPS. For states with an ACP, this corresponds to the scenario in which the entire RPS obligation in the final RPS year is achieved with ACPs or RECs priced at the ACP rate. For MA, the cost cap is based on 2019 compliance obligations, and does not yet account for the SMART program. Excluded from the chart are states currently without any explicit mechanism to cap incremental RPS costs (AZ, CA, IA, HI, MN, NV, NY, PA, WI), though many of those states have other kinds of mechanisms or regulatory processes to limit RPS costs.

Table of Contents

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

- RPS compliance costs and ACPs/cost caps
- Legislative and legal challenges to state RPS programs, including possible federal pre-emption
- Whether additional states decide to increase and extend RPS targets as they approach their final target year
- Other ongoing refinements (e.g., REC banking rules, long-term contracting programs, eligibility rules, etc.)
- The many related issues affecting RE deployment (integration, transmission, siting, net metering, etc.)

For Further Information

RPS reports, presentations, data files, resources

rps.lbl.gov

All renewable energy publications

emp.lbl.gov/reports/re

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