U.S. Renewables Portfolio Standards
2021 Status Update: Early Release

Galen Barbose

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

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Notes on the 2021 Early Release and the Planned 2021 Full Release

- Berkeley Lab did not issue an RPS Status Update in 2020
- This early release for 2021 is being issued in lieu of the 2020 report
- A subsequent “full release” of the 2021 Status Update will be issued later in the calendar year
- That full release will include further updates to all data elements contained with the present report, as well as new material summarizing state and utility clean energy/zero-carbon targets

Acronyms

ACP: Alternative compliance payment
CCA: Community choice aggregator
CES: Clean energy standard
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 2019, eight states enacted higher RPS targets or created new clean-energy/zero-carbon targets (AZ, DC, MD, NM, NV, VA, WA), in most cases setting targets equal to at least 50% of retail sales.

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 that percentage has declined in recent years, representing 23% of all U.S. RE capacity additions in 2019. However, within particular regions—namely, the Northeast and Mid-Atlantic—RPS policies have remained a dominant driver for RE growth.

Future RPS demand and incremental needs: RPS demand growth through 2030 will require roughly 90 GW of new RE capacity and will require total U.S. non-hydro RE generation to reach 17% of electricity sales (compared to 12% in 2019). Relative to EIA projections, this amounts to roughly one-third of projected RE growth over the next decade.

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 issues.

REC pricing trends: Prices for NEPOOL Class I RECs rose steeply over 2019, reaching $40/MWh and remaining at roughly that level over 2020. PJM Tier I REC prices continued to rise at a modest pace over the course of 2020, reaching $10/MWh by year-end. Prices for solar RECs remained relatively stable over 2020, and continue to exhibit wide variation across states, with the highest prices ($200-450/MWh) in NJ, MA, and DC.

RPS compliance costs and cost caps: RPS compliance costs in 2019 averaged roughly 2.6% of retail electricity bills in RPS states, compared to 2.3% in 2018, with costs in most states ranging from 0.5% to 4.5% of retail electricity bills.

Table of Contents

Additional supporting data and documentation available at: [rps.lbl.gov](rps.lbl.gov)

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

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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 <u>not</u> cover:

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

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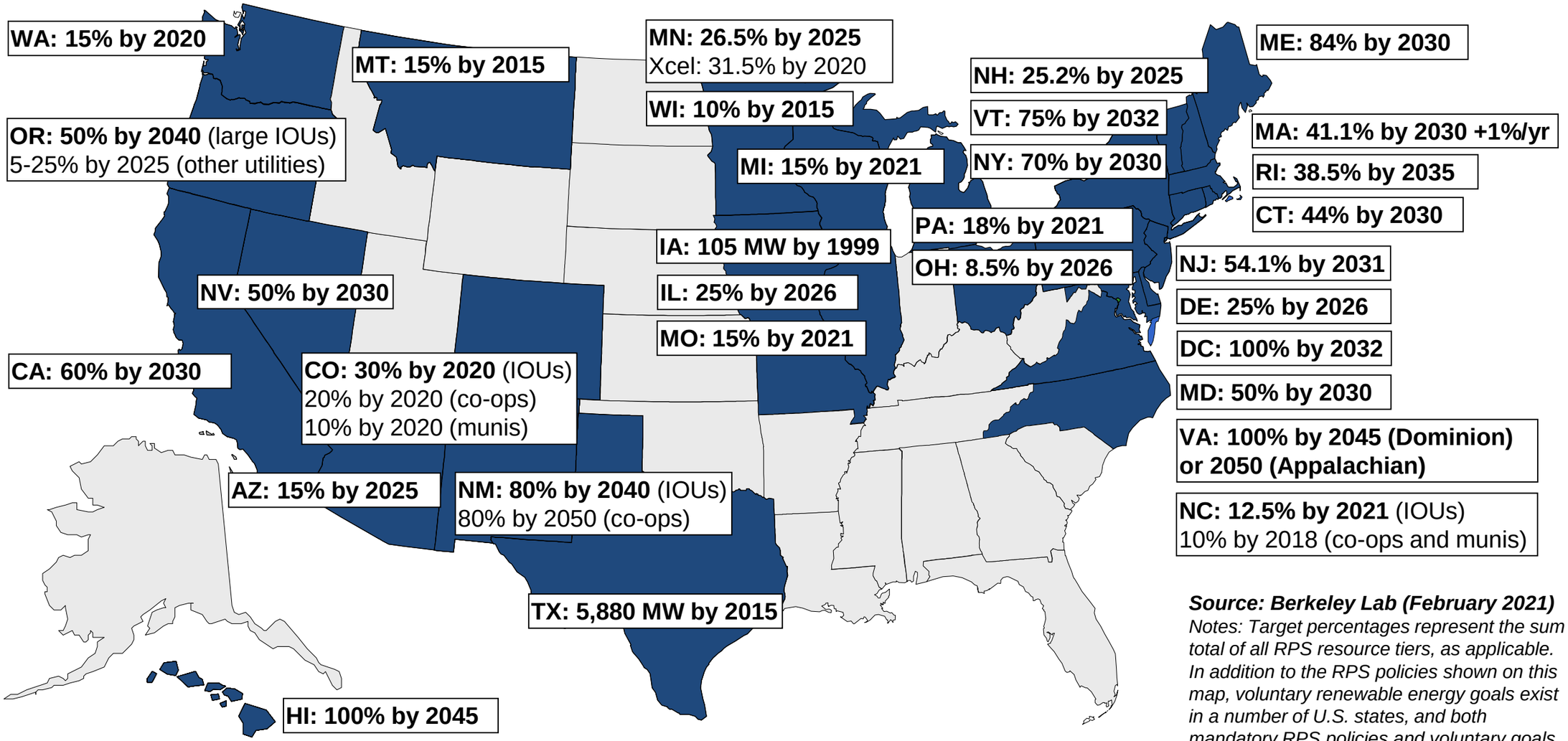
RPS Policies Exist in 30 States and DC

Apply to 58% of Total U.S. Retail Electricity Sales



Source: Berkeley Lab (February 2021)

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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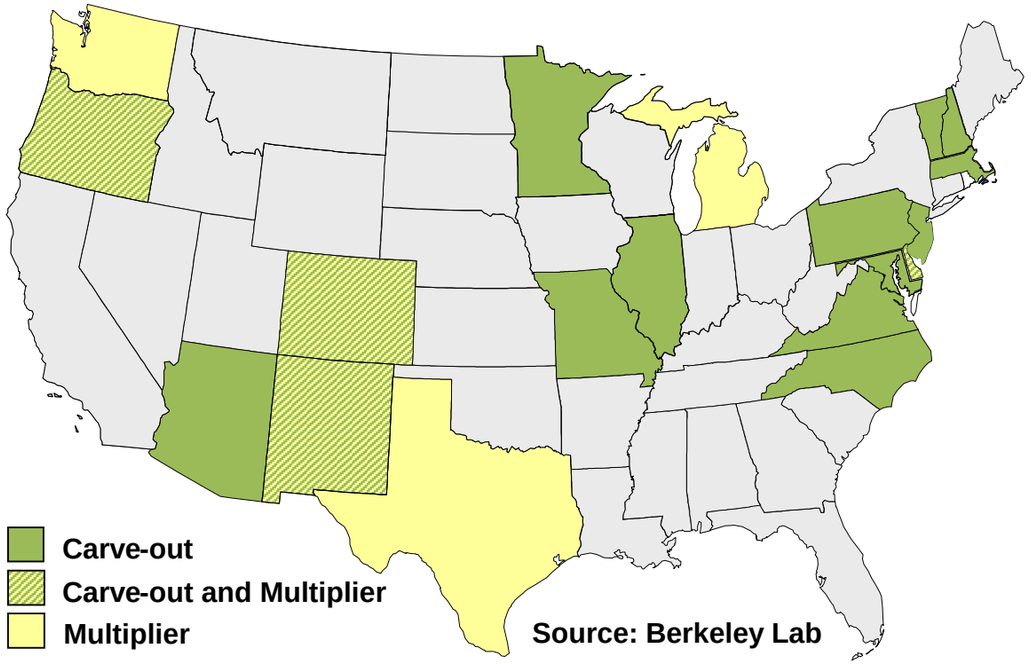
RPS Policies and Rules Vary Significantly from State to State

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

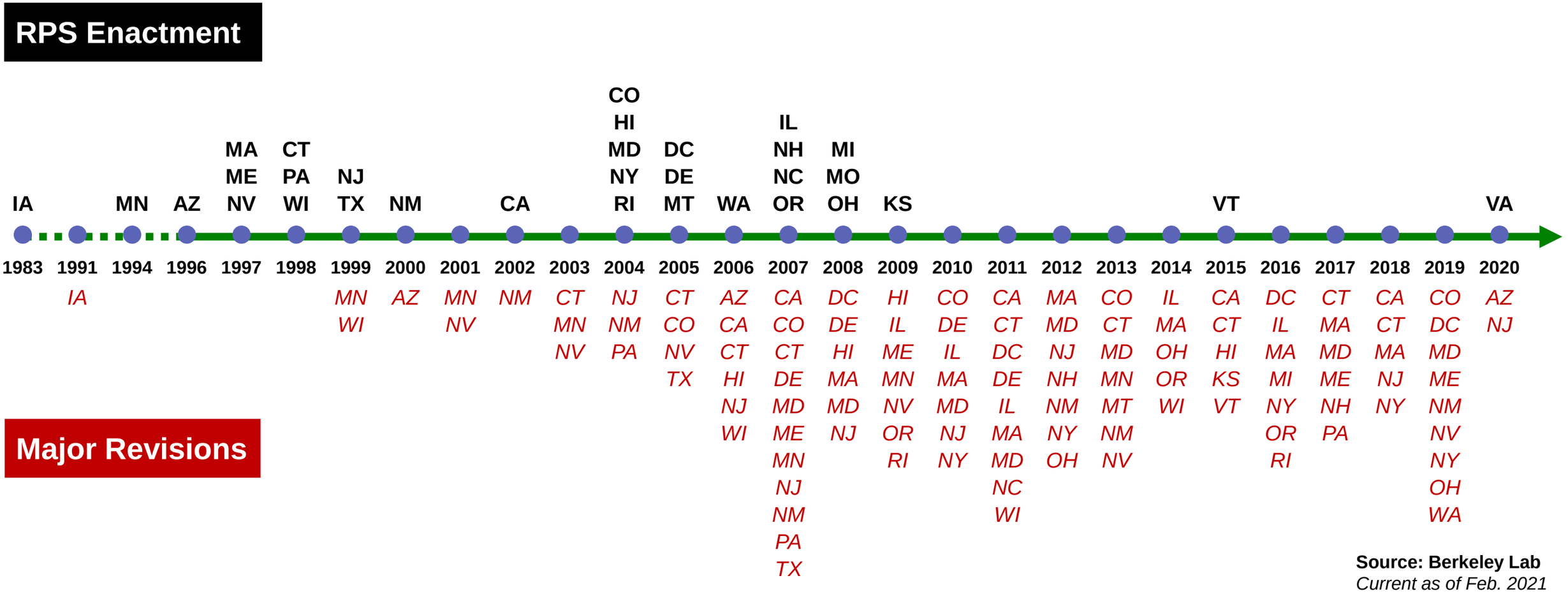
Solar or Distributed Generation (DG) Carve-Outs and Credit Multipliers



16 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 Feb. 2021

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 one or more times 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 energy storage targets or "clean peak" standards in tandem with an RPS, in order to address RE integration issues

Developing carve-outs to support specific technologies/applications: Emphasis initially on solar and DG, but some states have phased those out; recent focus on offshore wind, storage, low-income

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, 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 2019

Most proposals sought to strengthen or make small technical changes

RPS-Related Bills since Jan. 2019

	Strengthen	Weaken	Neutral	Total
Introduced	**103**	**30**	**56**	**189**
Enacted	**13**	**1**	**7**	**21**

Data Source: *EQ Research (August 31, 2020) and Berkeley Lab*
Notes: *Companion bills are counted as a single bill*

8 states raised / created new targets:

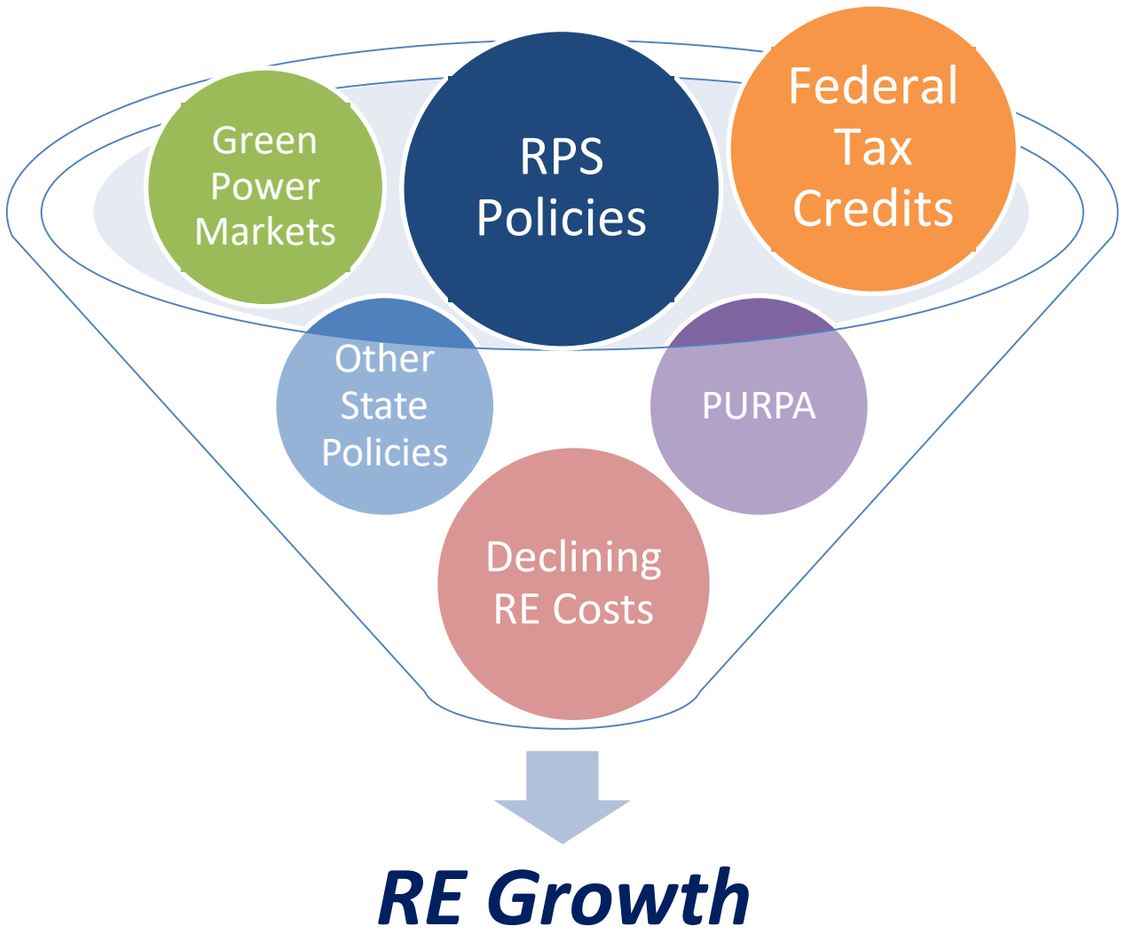
- **AZ:** 100% zero-carbon by 2050 (*ACC proposal under review*)
- **DC:** 100% by 2032, with 10% solar by 2041
- **MD:** 50% Tier 1 by 2030, incl. 14.5% solar + ~9.5% OSW
- **ME:** 50% Class I by 2030
- **NM:** 80% by 2040 (and 100% zero-carbon by 2045)
- **NV:** 50% by 2030
- **VA:** New RPS: 100% by 2045 or 2050; incl. 1% from small-scale
- **WA:** 100% zero-carbon by 2045 (no change to RPS)

Other "significant" revisions include:

- **CO:** Formally adopted clean energy targets for Xcel
- **DC:** Increased solar ACP; new geographic eligibility rules
- **MA:** SMART program solar carve-out doubled to 3.2 GW; new restrictions added on greenfield projects
- **MD:** Reduced ACPs
- **ME:** Created new renewable thermal tier and new long-term contracting requirement
- **NJ:** Replaced SREC program with transitional fixed-price TRECs
- **NM:** Revised cost cap, now based on levelized bus-bar cost
- **NV:** Phased out solar carve-out
- **NY:** Created technology-specific procurement targets for OSW (9 GW by 2035), PV (6 GW by 2025), and storage (3 GW by 2030)
- **OH:** Reduced RPS to 8.5%, exempted large C&I customers, and eliminated solar carve-out

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

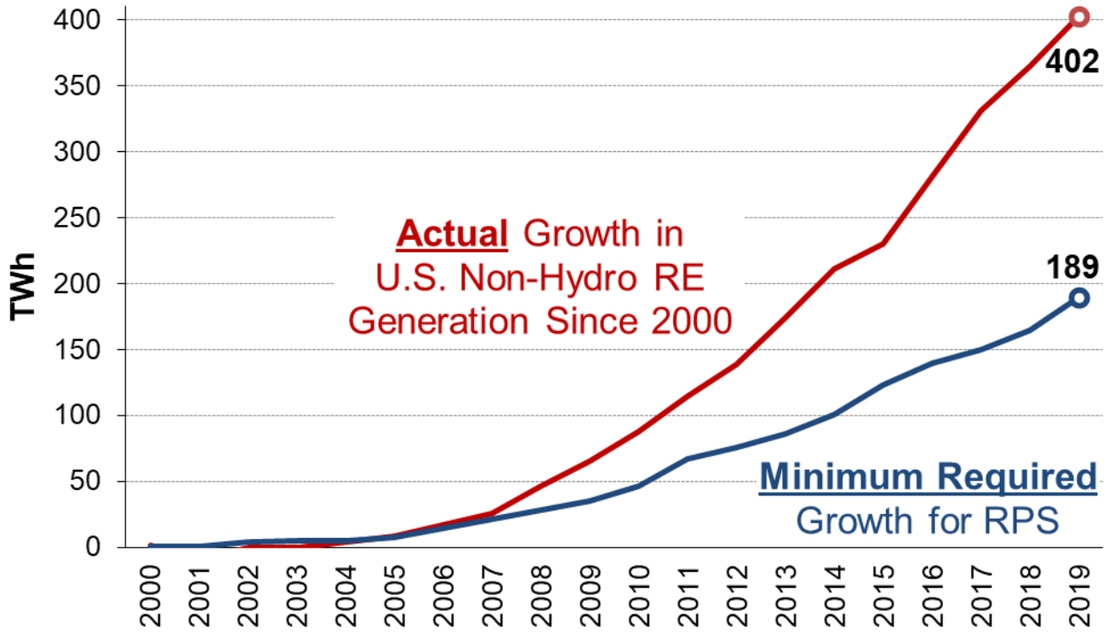
We present two simple approaches to gauge the impact of RPS policies on RE growth—*without claiming strict attribution*:

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

RPS Policies Have Been One Key Driver for RE Generation Growth

RPS requirements constitute 45% of total U.S. RE growth since 2000

Growth in Non-Hydro Renewable Generation: 2000-2019



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 402 TWh since 2000
- RPS policies required a 189 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 (~150 TWh)
  - Economic utility purchases, often supported by integrated resource planning processes
  - Net-metered PV (often not counted towards RPS)

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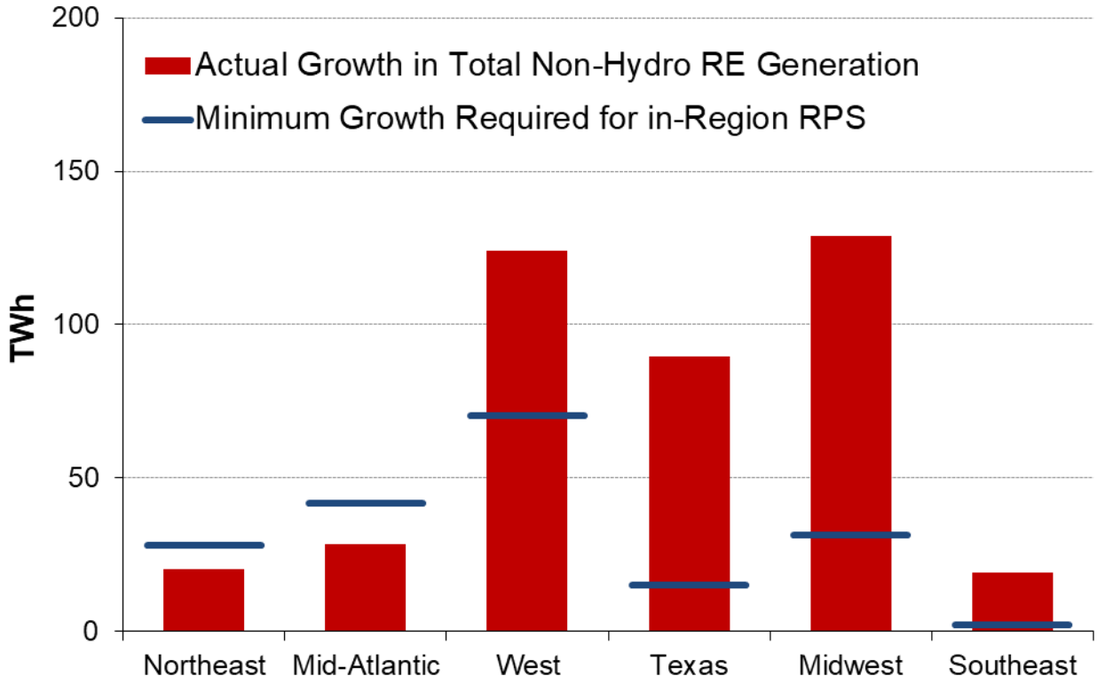
RPS Role in Driving RE Growth Varies by Region

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

Growth in Non-Hydro Renewable Generation: 2000-2019



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 and Mid-Atlantic: RPS needs have outpaced actual RE growth, suggesting that RPS demand has been a key driver

West: Actual RE growth has exceeded RPS requirements, partly due to net metered PV in CA

Texas and the Midwest: RE growth has far outpaced RPS needs, driven by attractive wind energy economics

Southeast: Negligible regional RPS demand (NC), though some RE growth serves RPS demand in PJM

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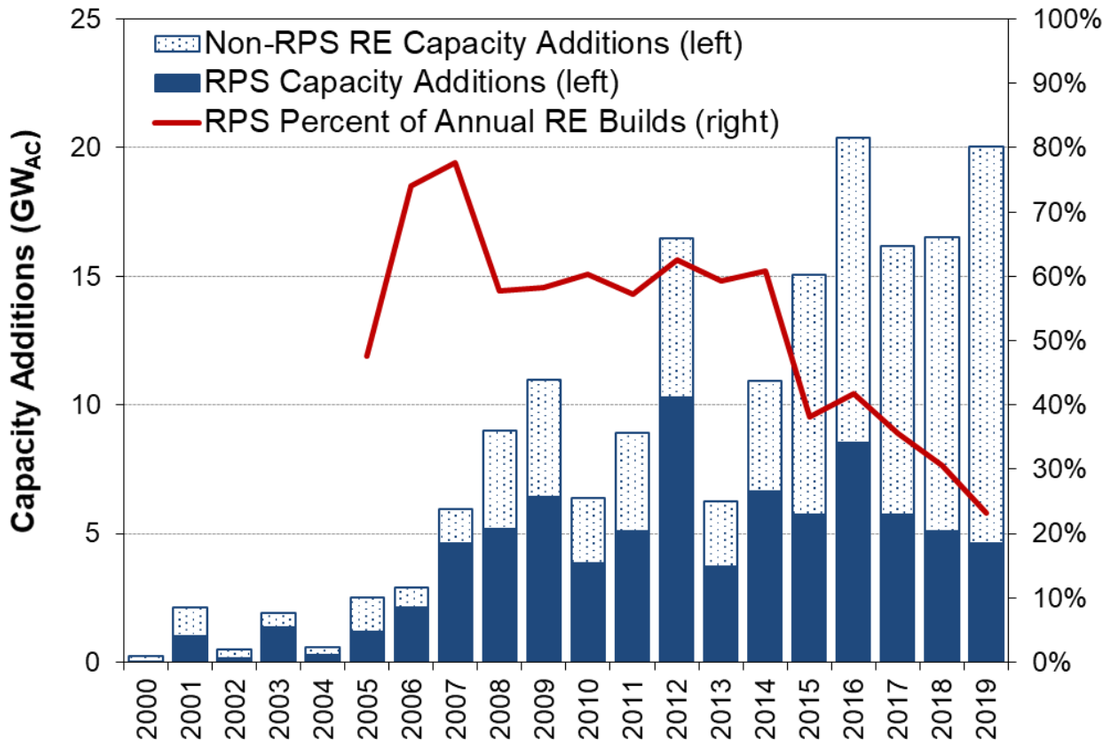
RPS' Have Provided a Stable Source of Demand for RE New-Builds

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 since 2000 serve RPS compliance needs (82 GW of 174 GW)
  - On average, roughly 6 GW/yr added annually for RPS over the past decade, varying within narrow band
  - 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 23% in 2019)
- 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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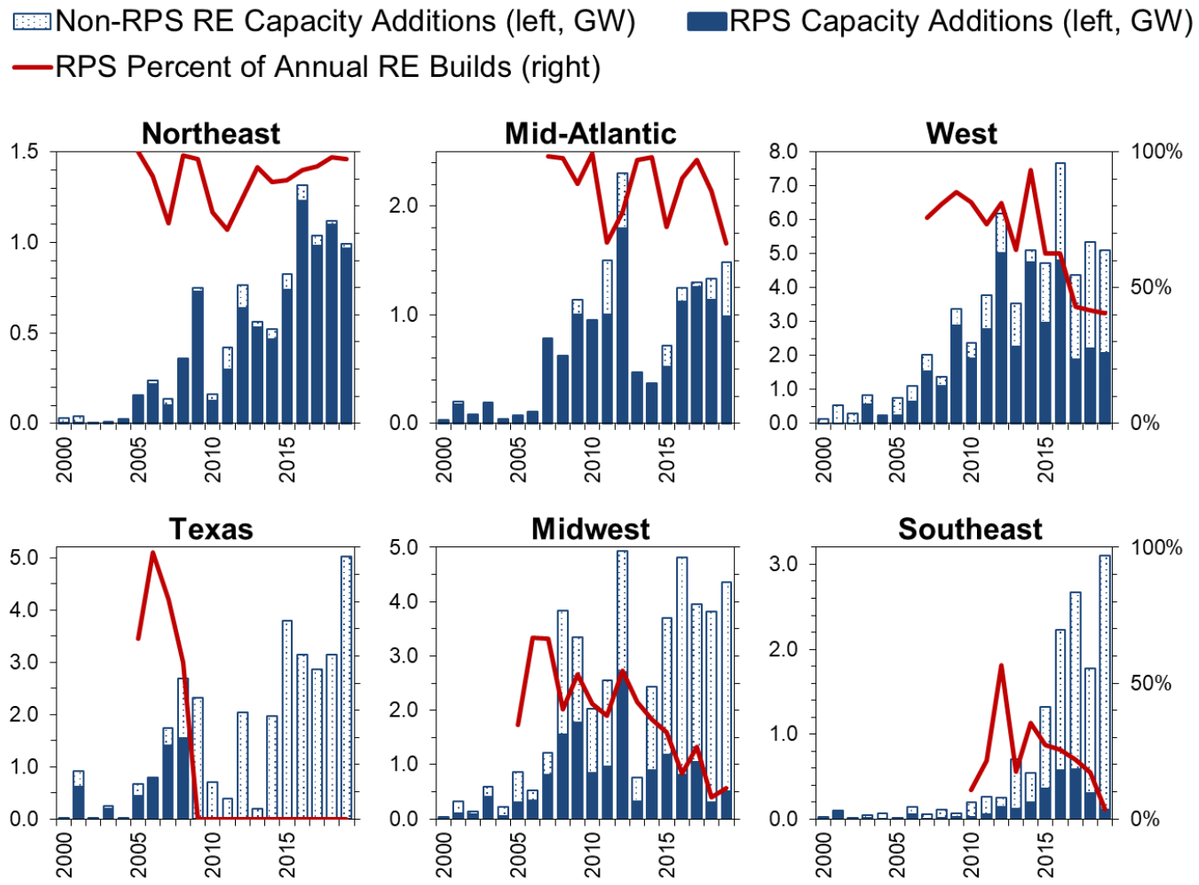
RPS Policies Remain Central to RE Growth in Particular Regions

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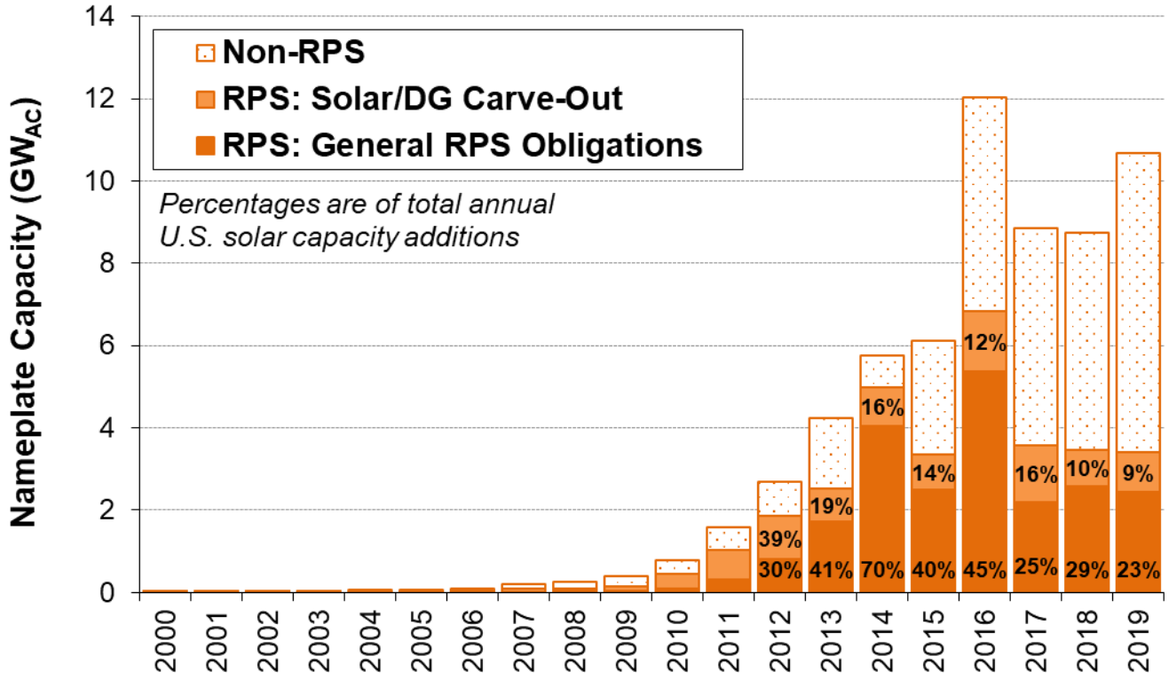
RPS' Have Had Greater Role in Driving Growth of Solar than Wind

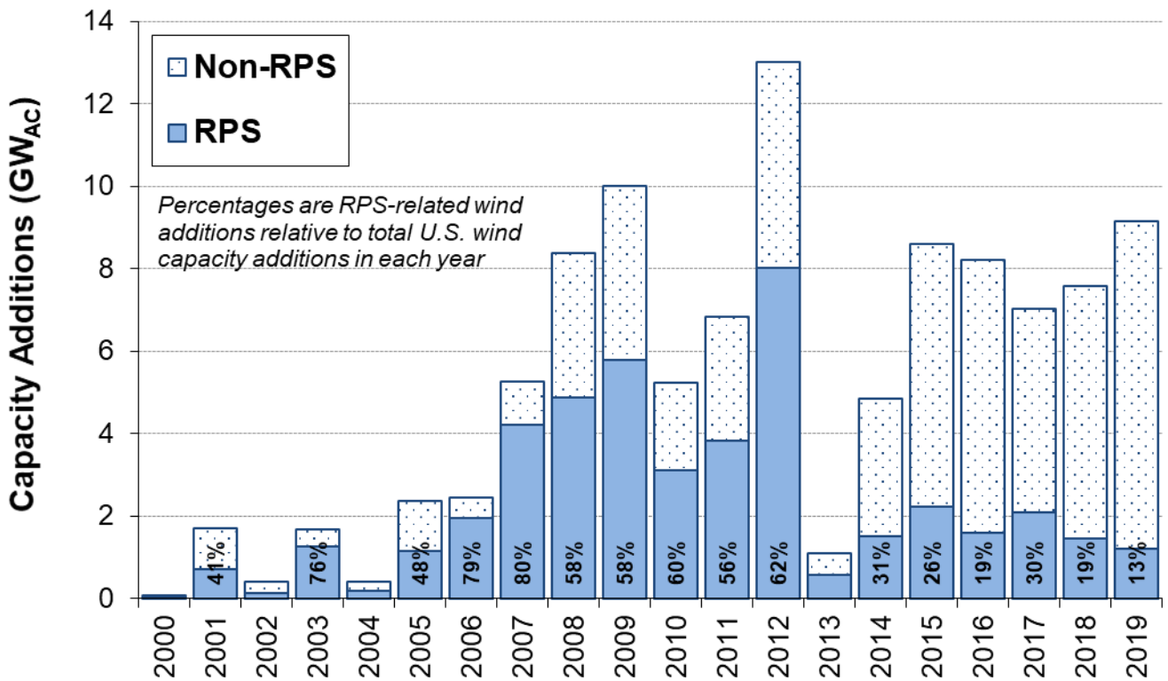
Though recent growth for both technologies has mostly occurred outside of RPS'

In 2019, **32%** of solar capacity additions serve RPS needs (23% for general RPS obligations + 9% for carve-outs) while **13%** 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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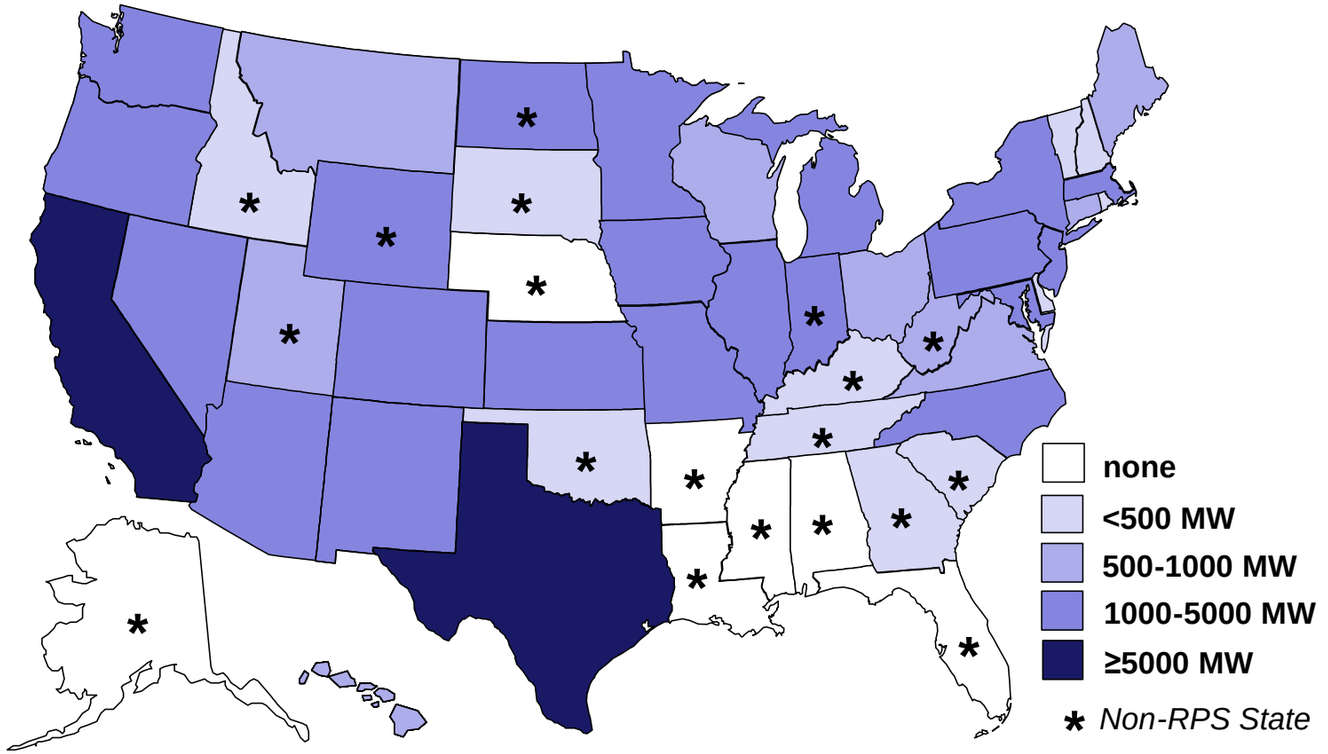
RPS Policies Have Spurred Some RE Growth in Non-RPS States

Roughly 11% (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: 2000-2019



Source: Berkeley Lab

Notes: States denoted "Non-RPS State" if an RPS did not exist at any point over the 2000-2019 period. See previous slides for decision rules on how RPS Capacity Additions are determined

Future RPS Demand and Incremental Needs

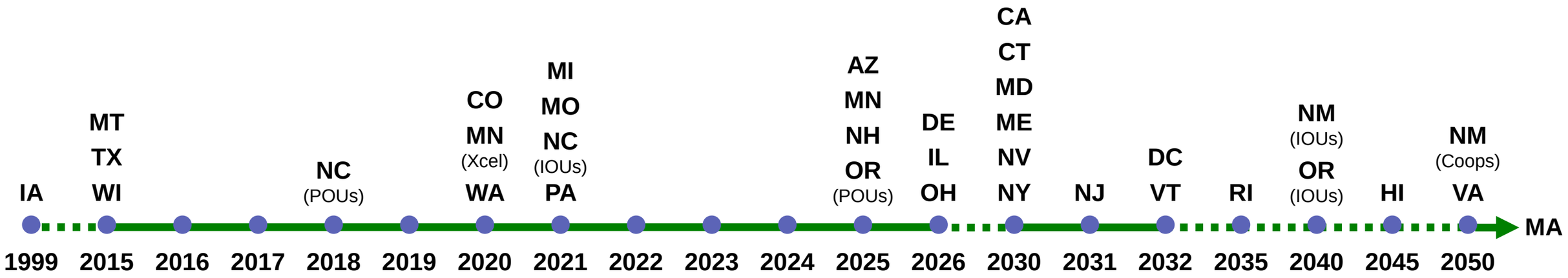
Half of States Have Longer-Term Targets (2030 or Beyond)

Year of Maximum RPS Percentage Requirement

10 states have already passed their final RPS target year or will do so this year

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

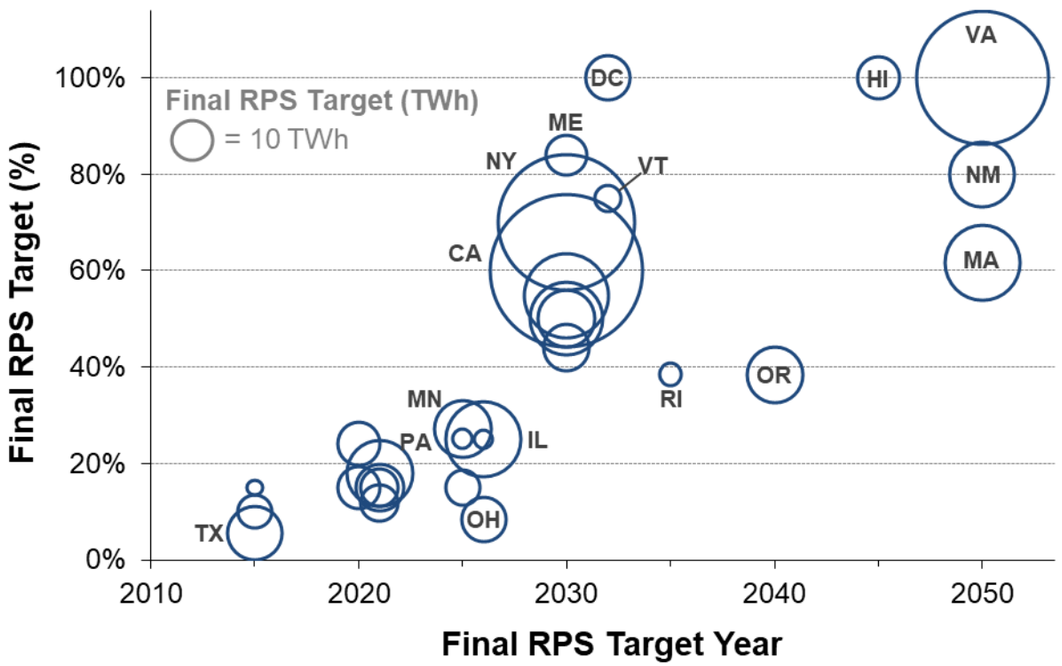
15 states have targets extending to 2030 or beyond (MA has no final target year)



Ultimate RPS Target Levels Vary Widely

Though can sometimes be difficult to compare directly

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 2050.

- States can generally be grouped into three sets
  - One contingent of states with final RPS targets of roughly 15-25% by 2020-2025
  - A large group of states with much higher targets (typically 50-100%) by 2030
  - A smaller set of states with similarly high targets but longer timeframes (2045-2050)
- Comparing nominal percentage targets can be misleading, due to differences in policy design
  - E.g., large hydro eligibility, exempt load, etc.
- CA, NY, and VA stand out in terms of their absolute TWh RPS demand, owing to both their aggressive percentage targets and large sizes

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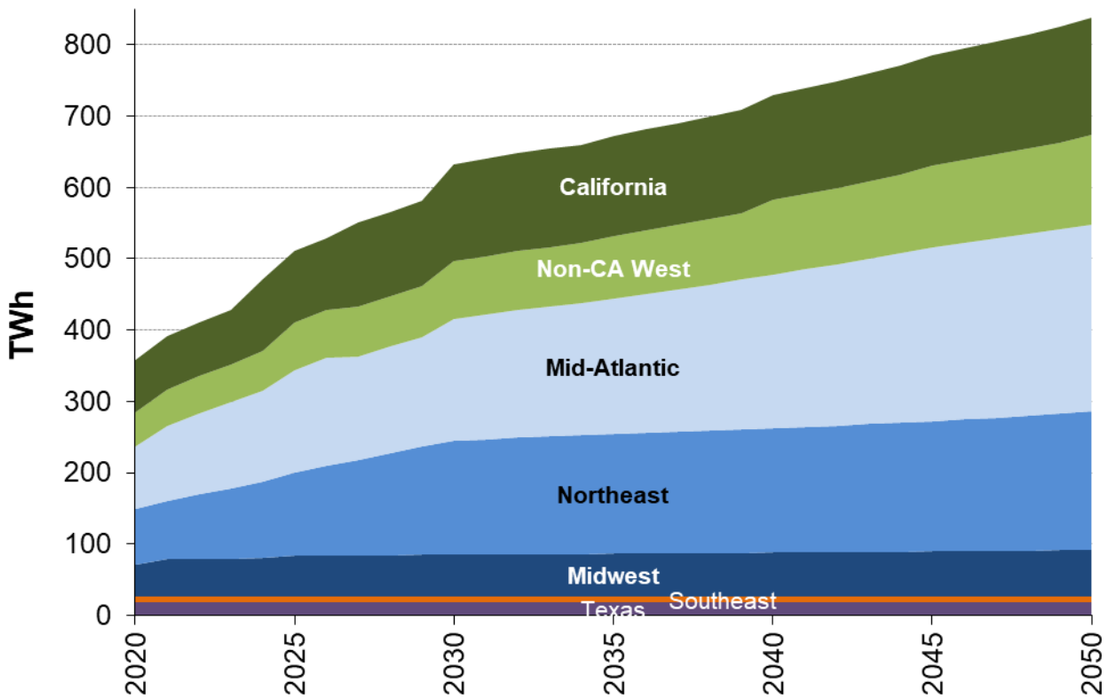
Projected U.S. RPS Demand

Grows over time with rising targets and load growth

Projected RPS Demand (TWh)



- Represents gross RPS compliance requirements
- Growth is steepest through 2030, reaching 630 TWh, tapering off thereafter as most states pass their final target year, reaching 840 TWh by 2050
- To be sure, increased demand does not equate to required increase in supply, as some utilities/regions are ahead of schedule
  - Also, banked RECs can meet some RPS demand growth

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.

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

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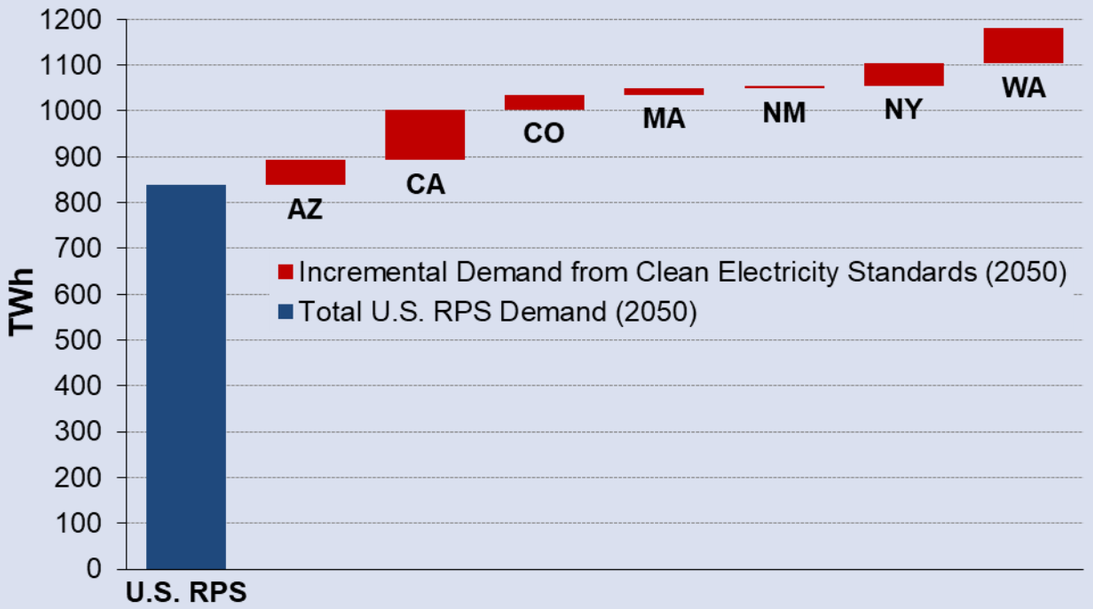
Side Bar: Broader clean electricity standards may add to longer-term RPS demand, to the extent they are met with RE

- 7 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)
  - Typically layered on top of, or includes, an RPS
- These clean electricity standards add ~350 TWh (~40%) more additional clean energy demand by 2050, above and beyond RPS requirements
  - Not all will be met with RE
  - The bulk of that is associated with CA and WA

* *These policies not otherwise included in this report*

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

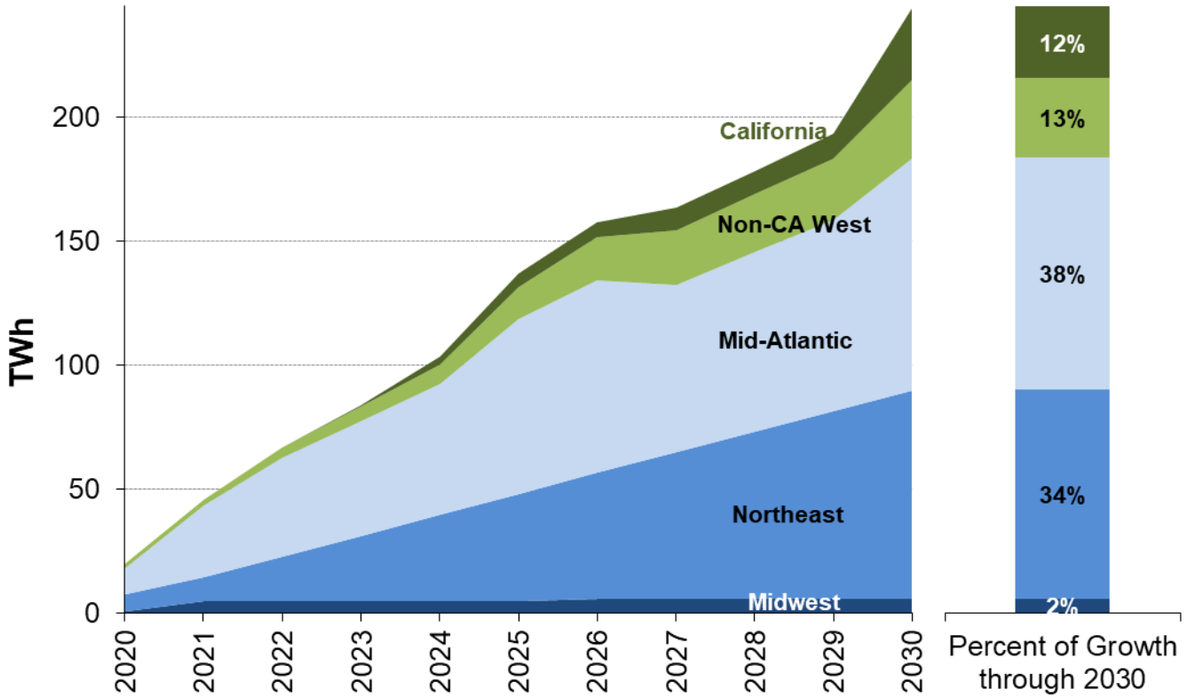


Notes: Incremental Demand from Clean Electricity Standards represents additional demand for clean electricity, above and beyond the RPS in each state. Only mandatory standards are included here, though a number of other states have established non-binding clean electricity goals.

Required Increase in RPS Generation Supply

250 TWh by 2030, ~50% increase in U.S. Non-Hydro RE from 2019

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 2019. 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 2019 (see figure notes for further details)
- Accounting for REC banking over the forecast period, per each state's rules
- With varying assumptions about surplus REC sales by regulated utilities, depending on the state

- **Mid-Atlantic:** Incr. needs driven by recent RPS revisions throughout the region, though termination of OH RPS after 2026 frees up supplies for other states
- **Northeast:** Consists mostly of NY, about 80%
- **California:** IOUs over-supplied due to load migration to CCAs, and assumed to sell surplus RECs
- **Non-CA West:** Roughly half from NV, the next-largest NM, in both cases reflecting recent RPS revisions

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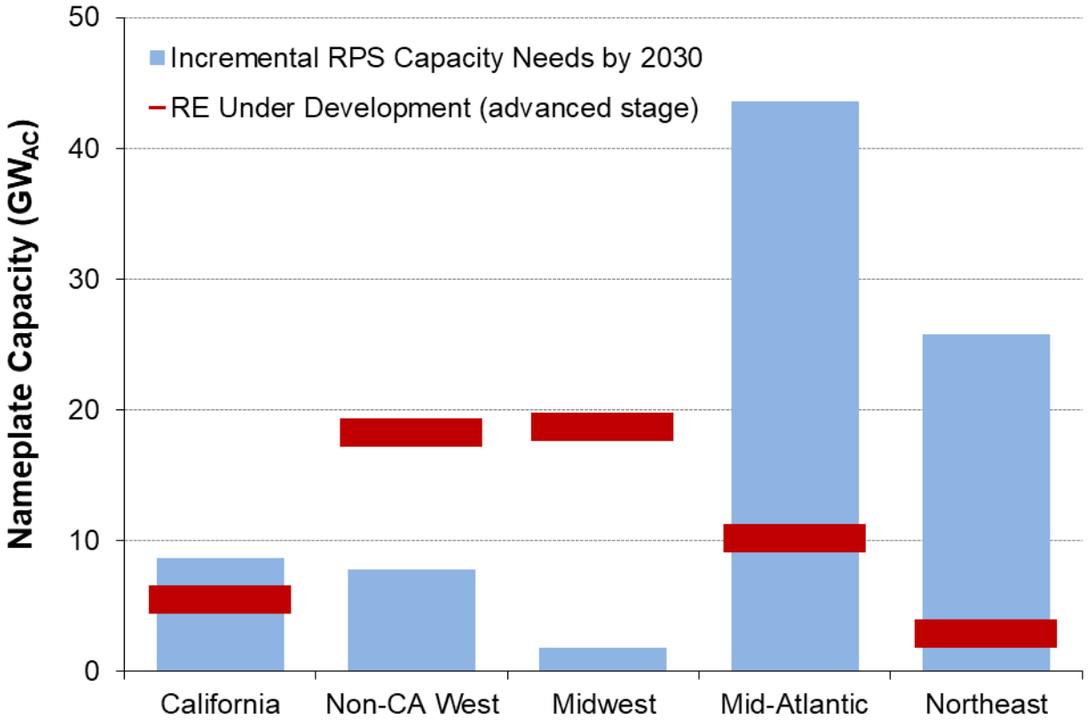
Required RE Capacity Builds for RPS

Roughly 90 GW needed by 2030 (relative to 2019 available supply)

- Primarily for the Mid-Atlantic and Northeast
- Putting these aggregate needs into context:
  - More than doubles the amount of RPS capacity additions to-date (82 GW through 2019)
  - Equates to an avg. RPS build-rate of 8 GW/yr. (compared to historical rate of 6 GW/yr)
- 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')

Required RPS Capacity Additions (GW)

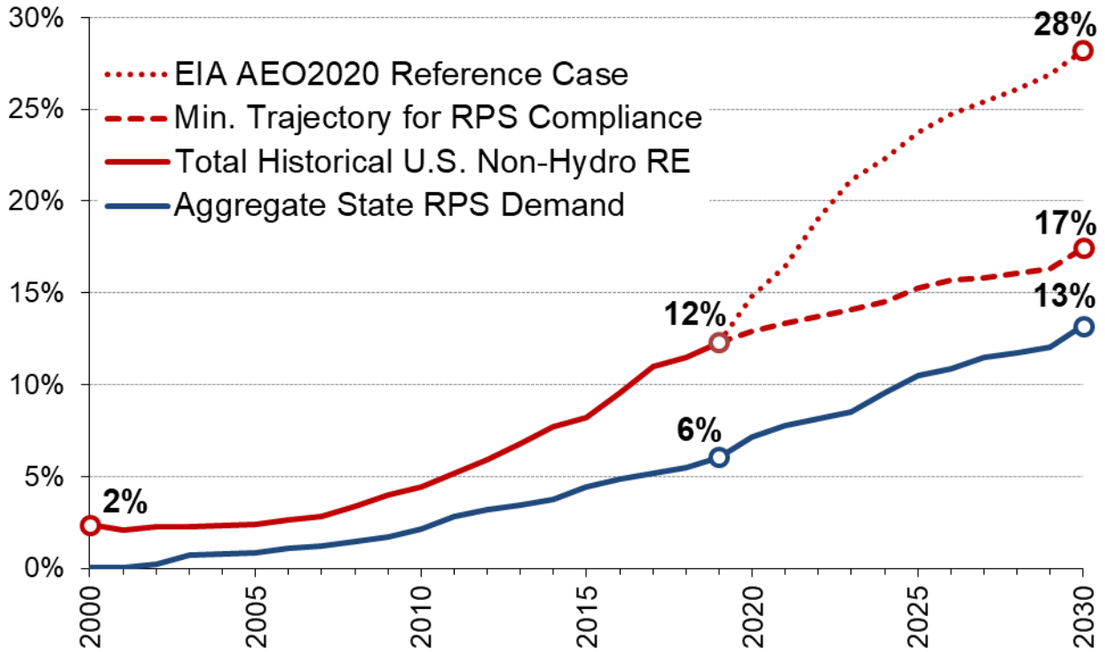


Notes: Calculated from estimated incremental generation needed to meet RPS demand, based on state-specific assumptions about the mix and capacity factor of new RPS supply. RE Under Development consists of units permitted or under construction, site preparation, or testing as of Feb. 2021, plus units that entered commercial operation in 2020 or 2021, based on data from ABB-Ventyx.

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 13% of U.S. retail electricity sales by 2030
- To meet those targets, total U.S. non-hydro RE supply will need to reach 17% of retail sales
  - Accounting for the fact that not all existing RE supplies are available for RPS compliance
- EIA projects non-hydro RE generation reaching 28% of retail sales by 2030
  - Rapid growth prior to expiration of ITC/PTC in early 2020s, followed by slower growth through 2030
  - Suggests that roughly one-third of RE growth over the next decade is associated with rising RPS demand

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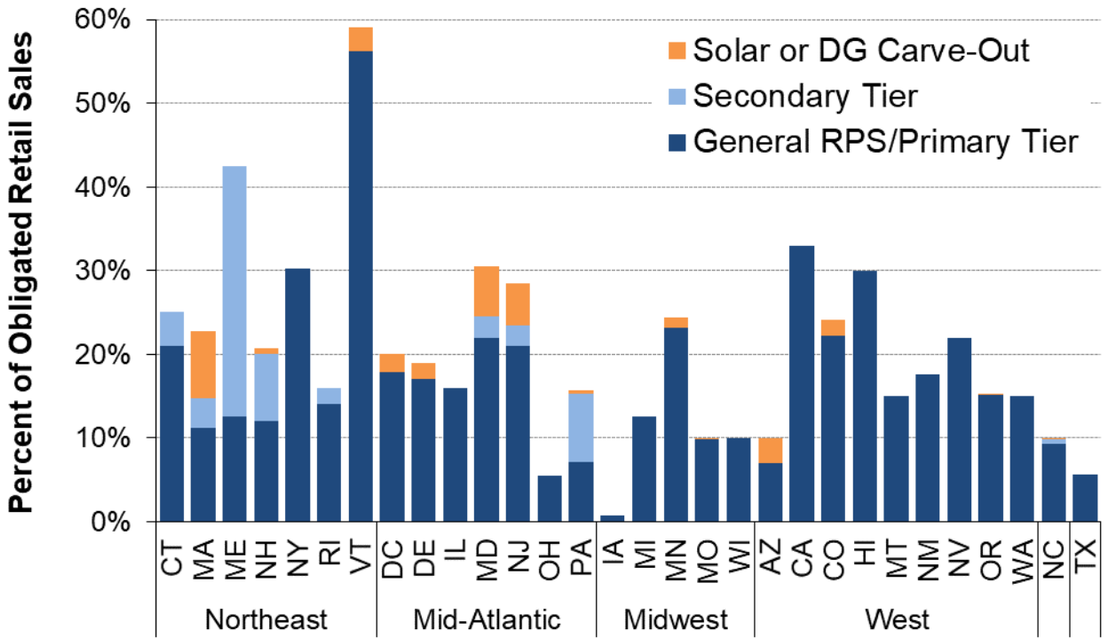
RPS Target Achievement To-Date

Interim Annual RPS Targets Continue to Ramp Up

Aggregate RPS requirements generally ranged from 10-30% of sales in 2020

Annual 2020 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 1-56% of retail sales in 2020, though were typically 10-30%
  - Secondary Tiers, which vary significantly in the scope of eligible resources, ranged from 2-30% of retail sales (where used), though were generally <4%, and have been phased out in several states (DC, DE)
  - Solar and DG Carve-Outs, in place in 14 states in 2020, were as high as 8% of retail sales (MA), but were typically <2%

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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

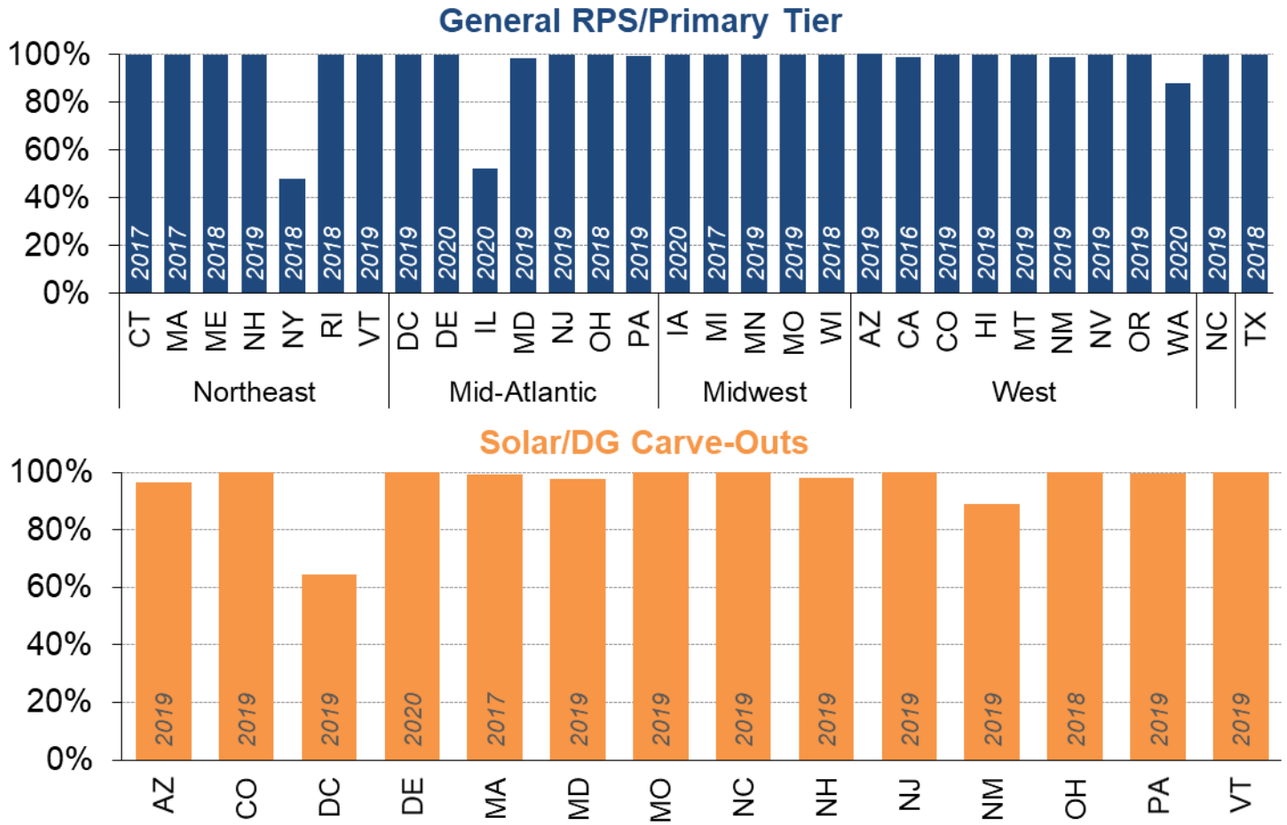

Figure notes: "General RPS Obligations" refers to the non-carve-out portion of RPS requirements in each state. For New England states, it refers to Class I obligations, and for PJM states it refers to Tier I obligations. The years overlaid on each bar refer to the most-recent compliance year for which 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 (General RPS):** Reflects procurement lag under IPA's new long term planning process, decision to forego short-term RECs to meet near-term shortfalls
  - **NY (General RPS):** LSE reliance on ACPs seemingly reflects transitional issues during the first years of the new RES Tier 1 regime, rather than true under-supply

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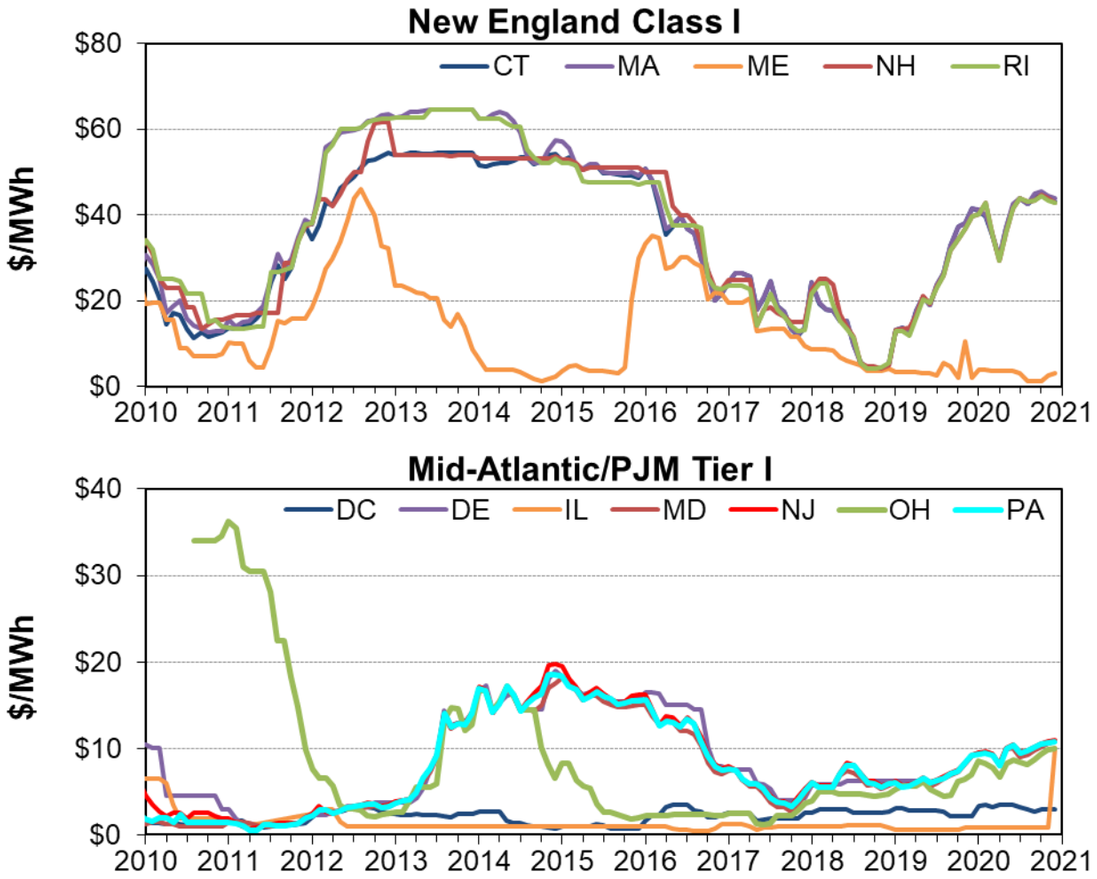
REC Pricing Trends

REC Pricing Trends for Primary Tier RPS Obligations

Prices in 2020 remained high in New England, rose slightly in PJM



Source: Marex Spectron. Plotted values are the mid-point of monthly average bid and offer prices 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:

- Rising targets pushed Class I prices up dramatically in 2019 to ~$40/MWh, where they remained through 2020
- Lower prices in Maine due to broader biomass eligibility

Mid-Atlantic/PJM:

- Bifurcated market based on geographic eligibility rules (more restrictive rules & higher prices in NJ/PA/MD/DE)
- Prices rising slowly with growth in regional RPS targets, reaching ~$10/MWh by end of the year

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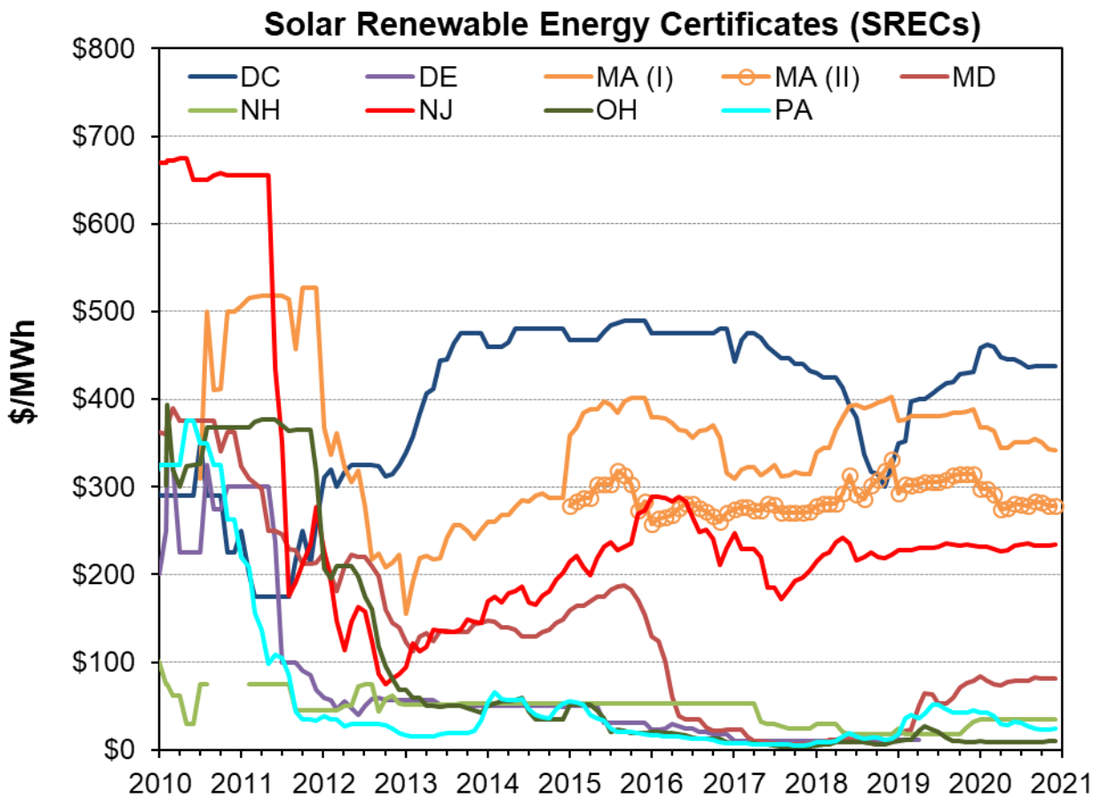
SREC Pricing Trends for RPS Solar Carve-Outs

Prices in most states remained flat through 2020



Source: Marex Spectron. Plotted values are the mid-point of monthly average bid and offer 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
- **MA:** Price movements bounded by clearinghouse floor and SACP
- **NJ:** Pricing has remained relatively stable, partly through legislative changes to the target level
- **MD:** Prices rose in 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 different metrics; we summarize costs primarily in terms of a percentage of average retail electricity bills in each RPS state

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 39 for additional details and indicative ranges for the potential magnitude of those omitted impacts

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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 2019

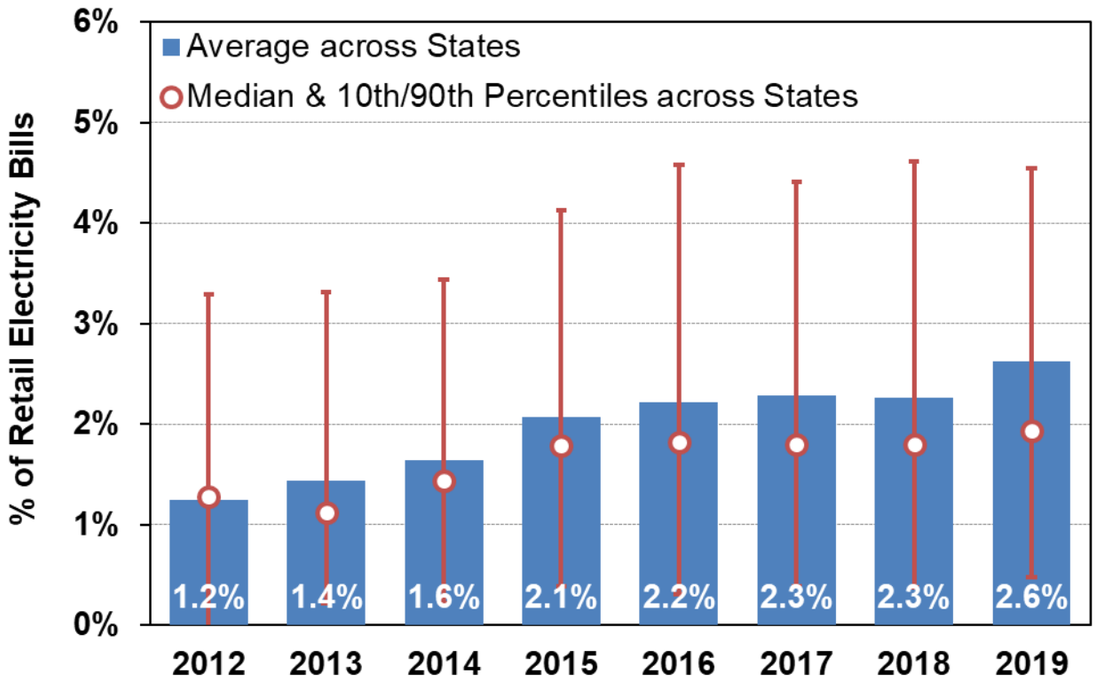
A proxy for "rate impact", albeit a rough one:

- 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 0.5% to 4.5% in 2019 (more detail on the next slide)

RPS Compliance Costs

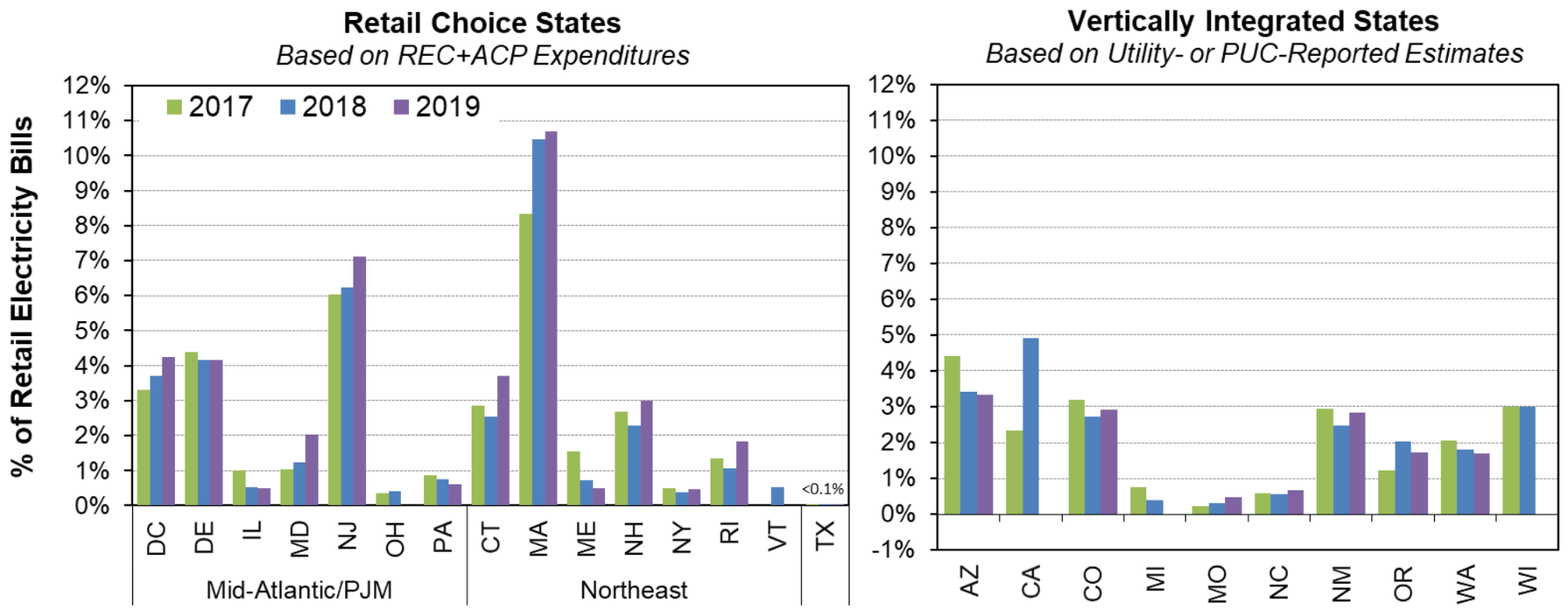
Percentage of Average Retail Electricity Bill



State-Specific RPS Compliance Costs

Reflect differences in 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

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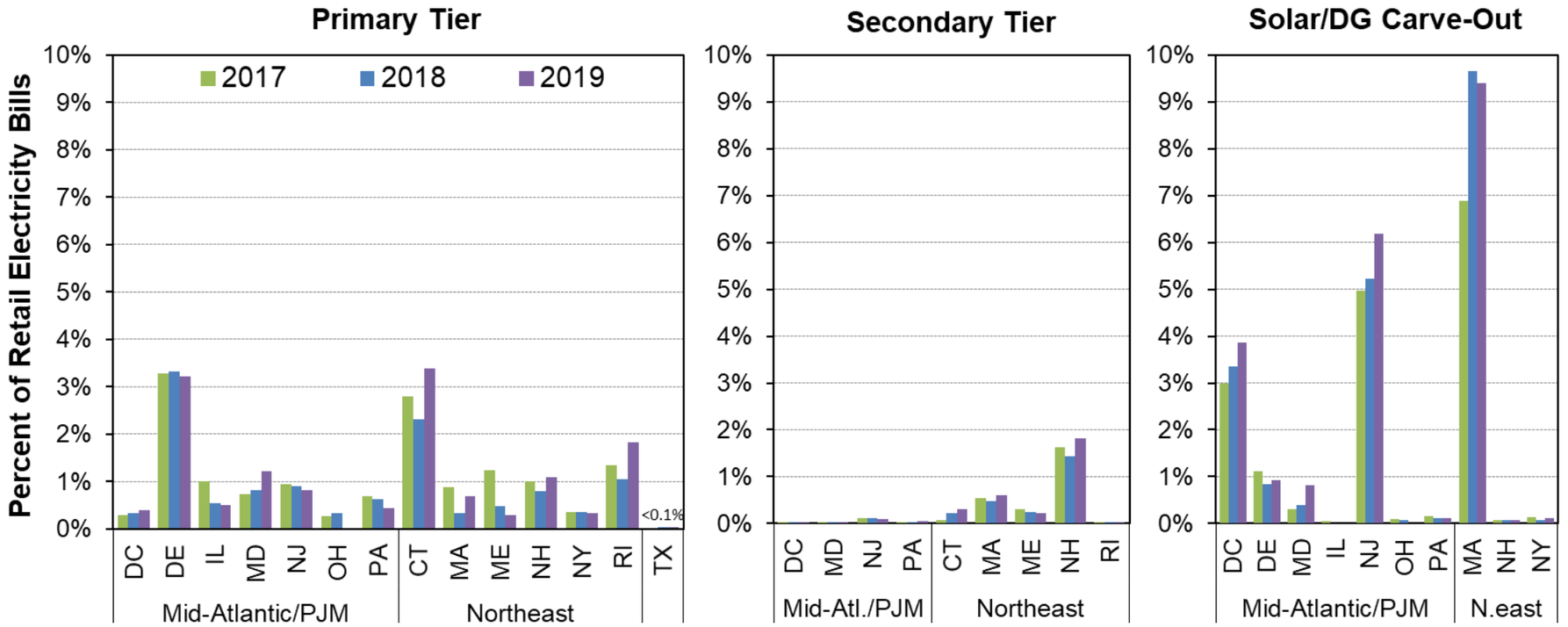
RPS Compliance Costs by Resource Tier

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: Rising REC prices and targets put upward pressure on compliance costs in 2019, muted in some states by long-term contracts

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

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RPS Cost Containment Mechanisms

May cap growth in RPS compliance costs

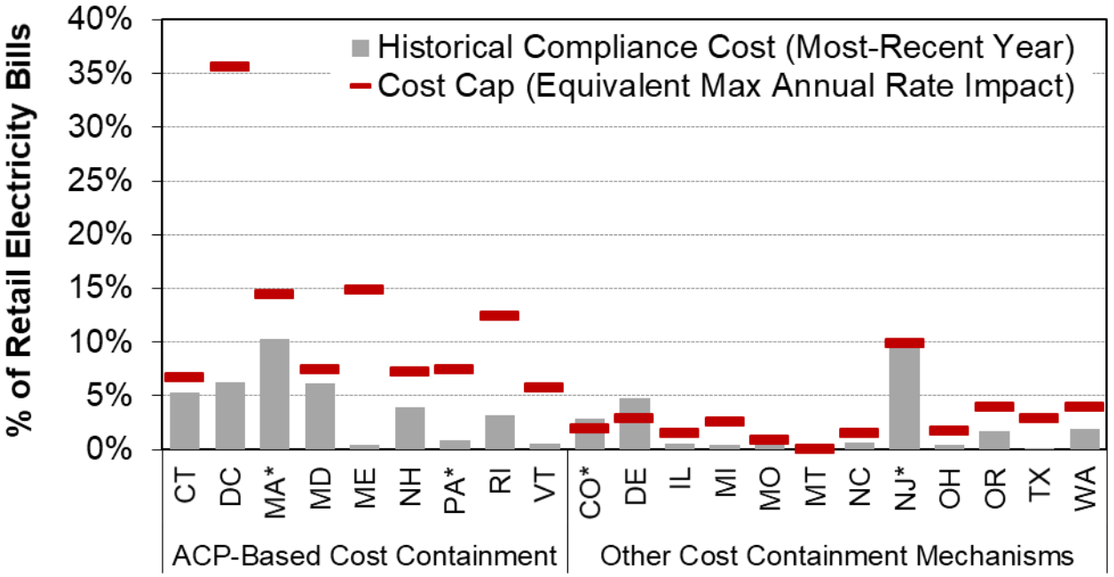
- Going forward, RPS compliance costs will depend on RE technology costs and REC prices, electricity prices, natural gas prices, tax policy, and a variety of other factors

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
- Federal policy and wholesale market design
- 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

References

Mills, A.D., D. Millstein, R. Wiser, J. Seel, J.P. Carvallo, S. Jeong, and W. Gorman. 2019. *Impact of Wind, Solar, and Other Factors on Wholesale Power Prices: An Historical Analysis—2008 through 2017.* Berkeley, CA: Lawrence Berkeley National Laboratory.

Wiser, R., G. Barbose, J. Heeter, T. Mai, L. Bird, M. Bolinger, A. Carpenter, G.A. Heath, D. Keyser, J. Macknick, A.D. Mills, and D. Millstein. 2016. *A Retrospective Analysis of the Benefits and Impacts of US Renewable Portfolio Standards*. Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory.

Wiser, R., A. Mills, J. Seel, T. Levin, A. Botterud. 2017. *Impacts of Variable Renewable Energy on Bulk Power System Assets, Pricing, and Costs*. Lawrence Berkeley National Laboratory and Argonne National Laboratory.

Wiser, R. and M. Bolinger. 2018. *2017 Wind Technologies Market Report.* Washington D.C.: U. S. Department of Energy.

Contacts

Galen Barbose: glbarbose@lbl.gov, (510) 495-2593

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