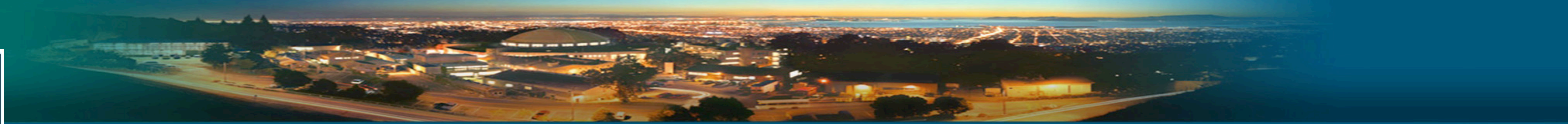


Energy Technologies Area   Lawrence Berkeley National Laboratory

U.S. Renewables Portfolio Standards

2018 Annual Status Report

Galen Barbose

Lawrence Berkeley National Laboratory

Renewable Energy Markets 2018

October 10, 2018

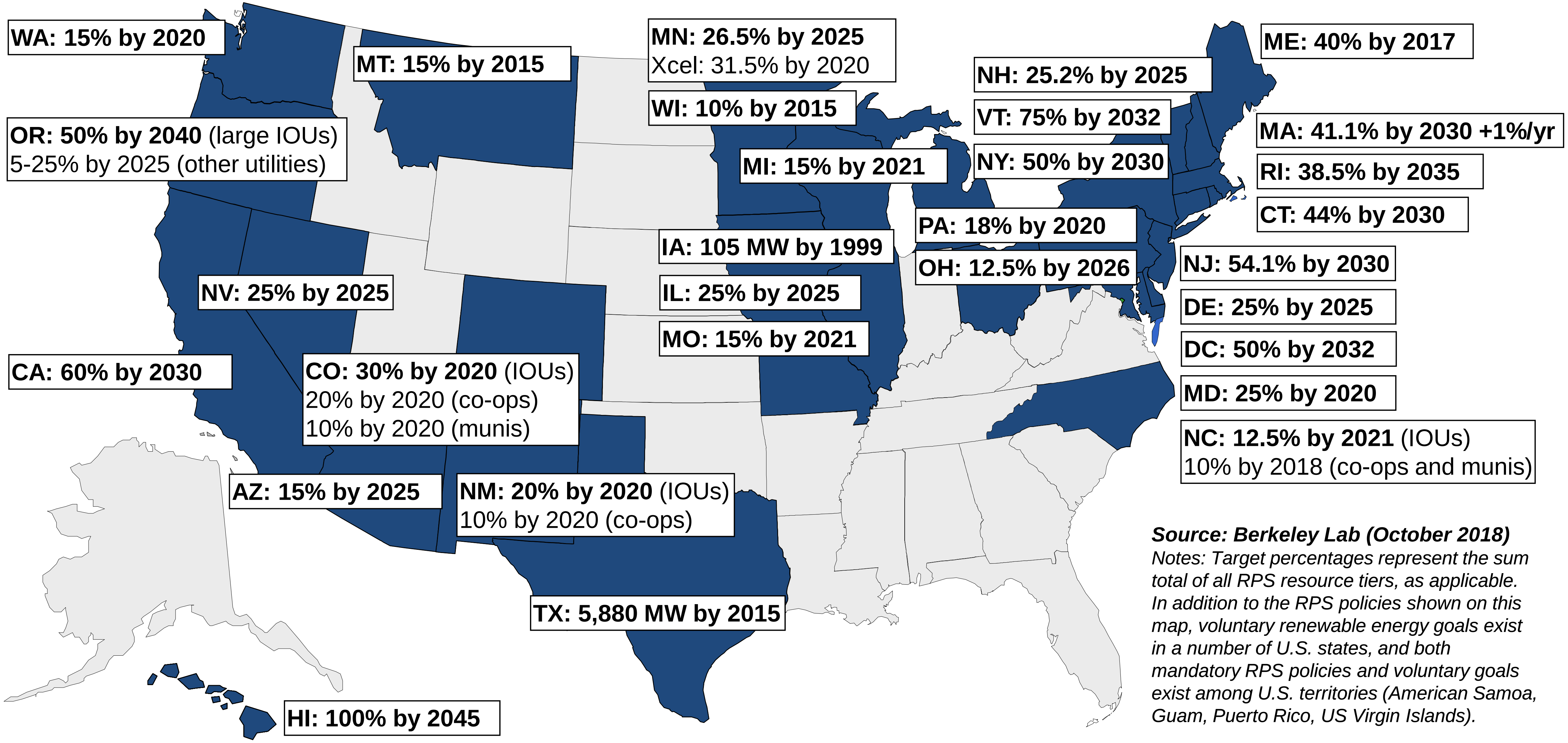
More information available at: *rps.lbl.gov*

This work was funded by the Office of Electricity Delivery and Energy Reliability (Transmission Permitting & Technical Assistance Division) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Table of Contents

RPS Policies Exist in 29 States and DC

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



Source: Berkeley Lab (October 2018)

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).

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

But states continue to make regular and significant revisions

Year	RPS Enactment	Major Revisions
1983	IA	
1991		*IA*
1994	MN	
1996	AZ	
1997	MA, ME, NV	
1998	CT, PA, WI	
1999	NJ, TX	*MN, WI*
2000	NM	*AZ*
2001		*MN, NV*
2002	CA	*NM*
2003		*CT, MN, NV*
2004	CO, HI, MD, NY, RI	*NJ, NM, PA*
2005	DC, DE, MT	*CT, CO, NV, TX*
2006	WA	*AZ, CA, CT, HI, NJ, WI*
2007	IL, NH, NC, OR	*CA, CO, CT, DE, MD, ME, MN, NJ, NM, PA, TX*
2008	MI, MO, OH	*DC, DE, HI, MA, MD, NJ*
2009	KS	*HI, IL, ME, MN, NV, OR, RI*
2010		*CO, DE, IL, MA, MD, NJ, NY*
2011		*CA, CT, DC, DE, IL, MA, MD, NC, WI*
2012		*MA, MD, NJ, NH, NM, NY, OH*
2013		*CO, CT, MD, MN, MT, NM, NV*
2014		*IL, MA, OH, OR, WI*
2015	VT	*CA, CT, HI, KS, VT*
2016		*DC, IL, MA, MI, NY, OR, RI*
2017		*CT, MA, MD, ME, NH, PA*
2018		*CA, CT, MA, NJ, NY*

Source: Berkeley Lab
Current as of October 2018

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

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

Addressing valuation and integration issues: Though still an emerging trend, several states have created separate “clean peak” standards or energy storage targets in tandem with an RPS

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

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 2018 (to-date)

Most proposals sought to strengthen or make small technical changes

RPS-Related Bills Introduced and Enacted in 2018

	Strengthen	Weaken	Neutral	Total
Introduced	48	22	31	101
Enacted	4	1	6	11

Data Source: EQ Research (August 31, 2018)
Notes: Includes legislation from 2018 sessions, 2017-2018, and 2018-2019 sessions. Companion bills in both chambers are counted as a single bill.

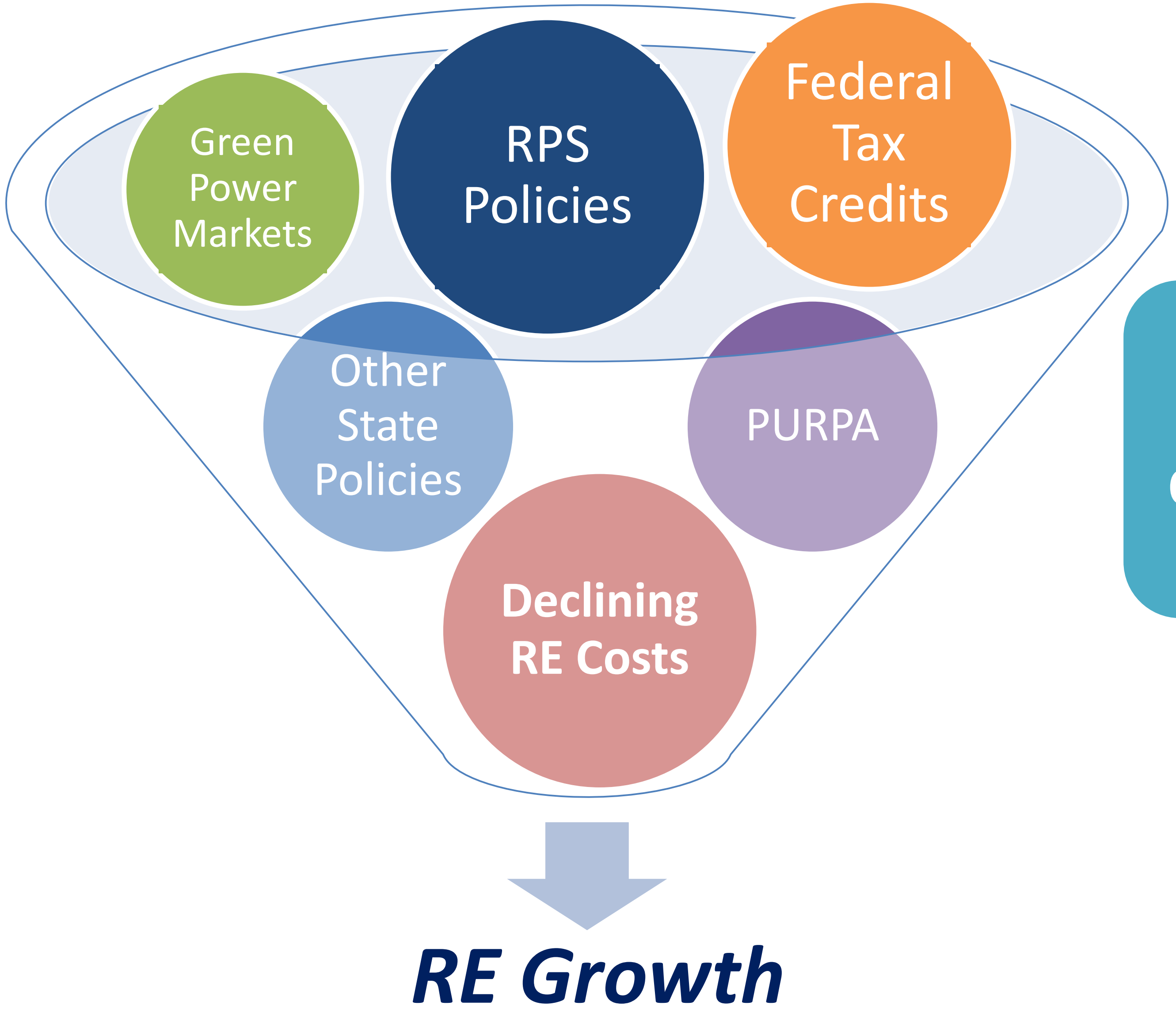
"Major" RPS revisions in 2018:

- **CA:** Increased RPS to 60% by 2030 and added goal of 100% zero-carbon electricity by 2045
- **CT:** Increased and extended Class I target to 40% by 2030, reduced Class I ACP rate, and created a new long-term contracting program
- **MA:** Increased Class I growth rate to 2% of retail sales per year over 2020-2029 period, and added a clean peak standard
- **NJ:** Increased and extended Tier I target to 50% by 2030, phases out solar carve-out, increased offshore wind energy carve-out to 3,500 MW, and created new caps on RPS compliance costs
- **NY:** Created offshore wind procurement program with a target of 2,400 MW by 2030

Table of Contents

- Evolution of state RPS programs
- **Historical impacts on renewables development**
- Future RPS demand and incremental needs
- REC pricing trends
- RPS compliance costs
- Outlook

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

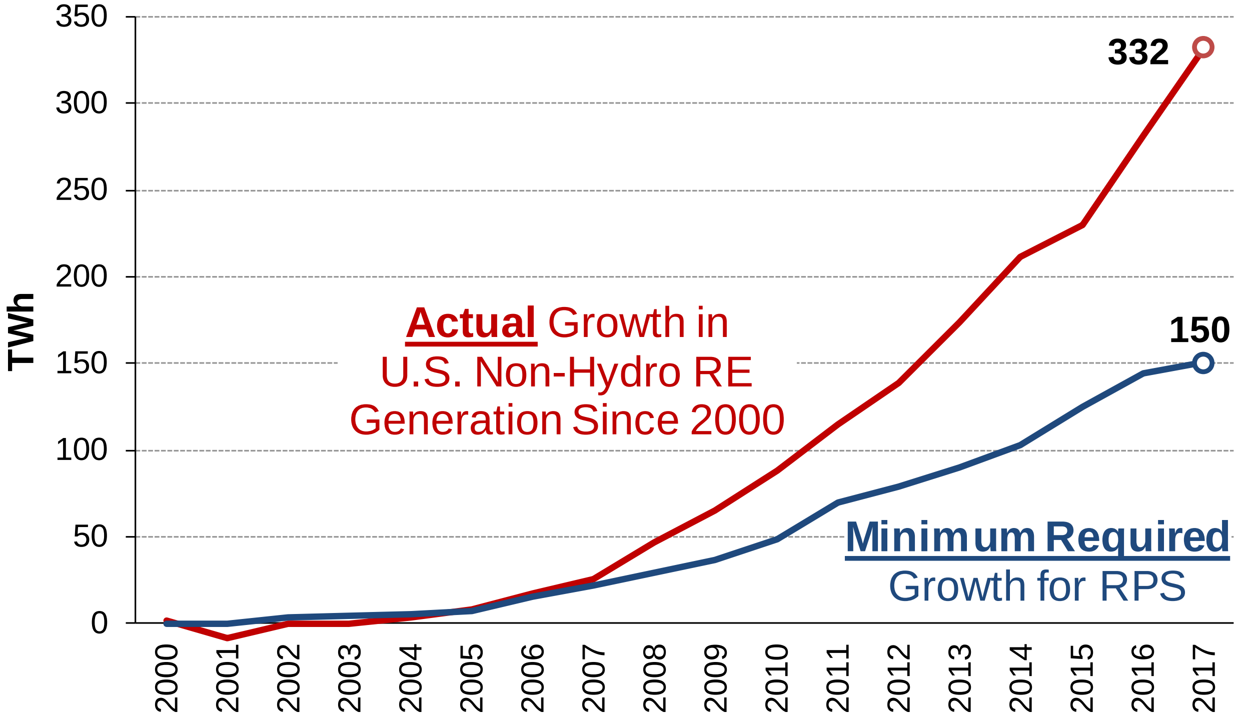


Separating out the incremental impact of any one driver is challenging, given potential overlaps and interactions

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: 2000-2017



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.

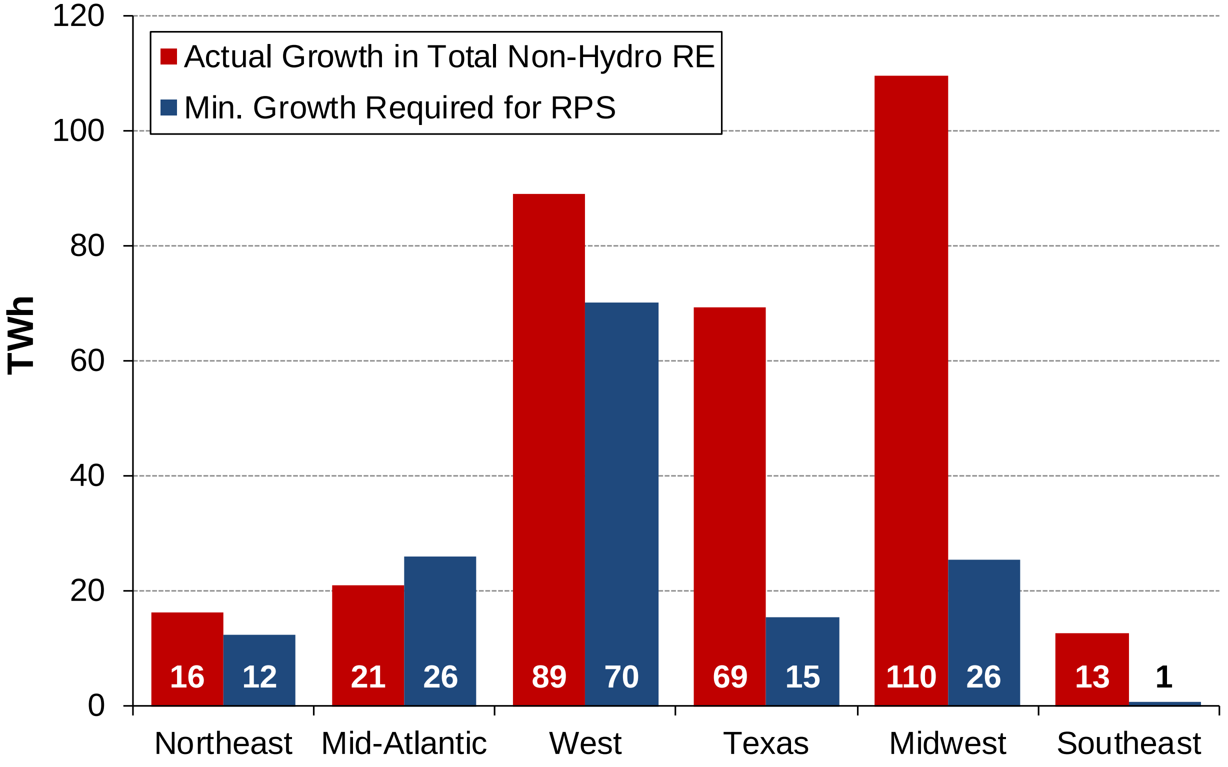
- Total non-hydro RE generation in the U.S. grew by 332 TWh from 2000-2017
- RPS policies required 150 TWh increase over that period
  - Not strict attribution: some of that would have occurred without RPS
  - By the same token, some growth beyond the 150 TWh might be indirectly attributable to RPS's
- RE growth outside of RPS's associated with:
  - Voluntary green power markets, including corporate procurement
  - Economic utility purchases

BERKELEY LAB

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 corresponds relatively well with 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, driven by attractive wind energy economics

Southeast

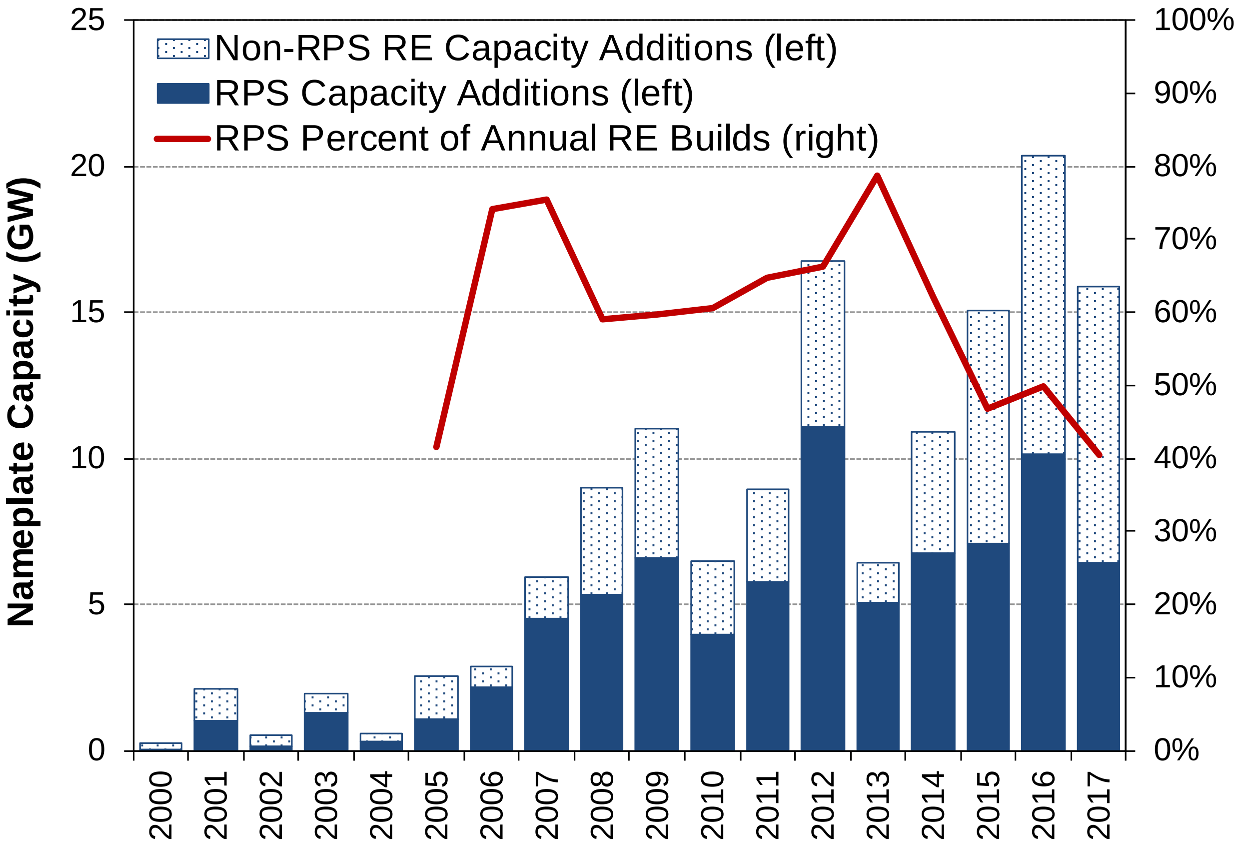
- Negligible RPS demand; just a single RPS state (NC) in the region
- Some RE growth serving PJM needs

BERKELEY LAB

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

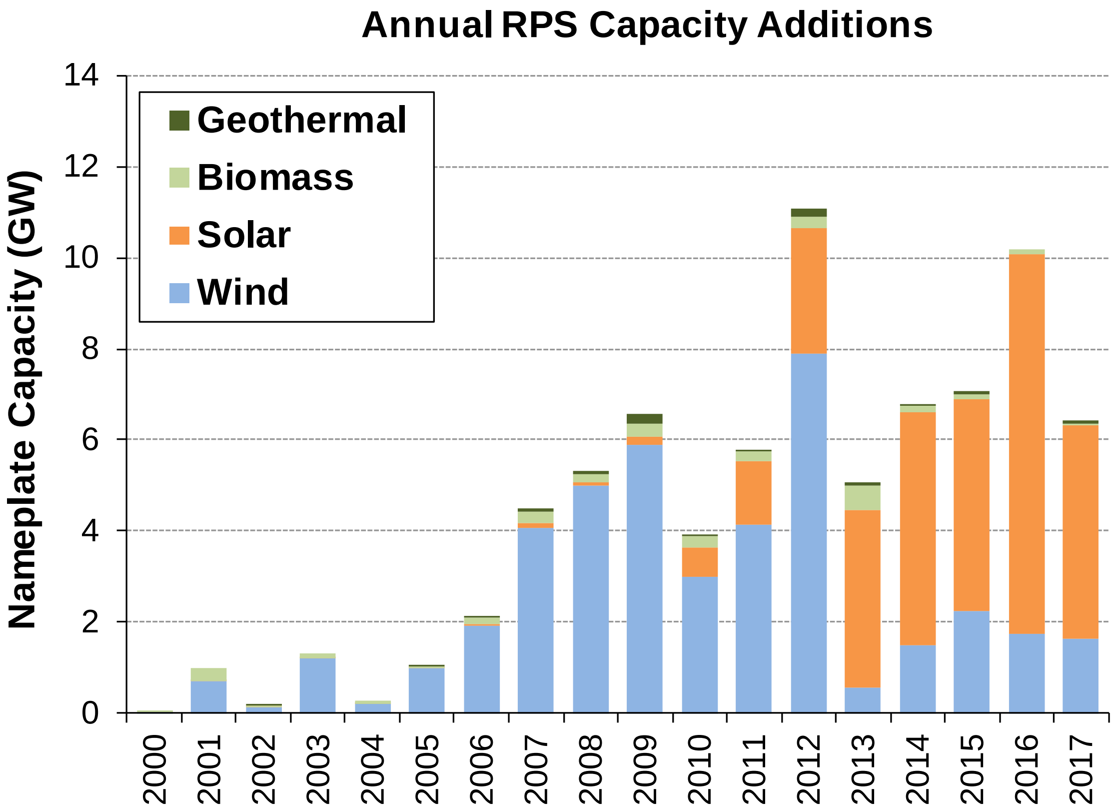


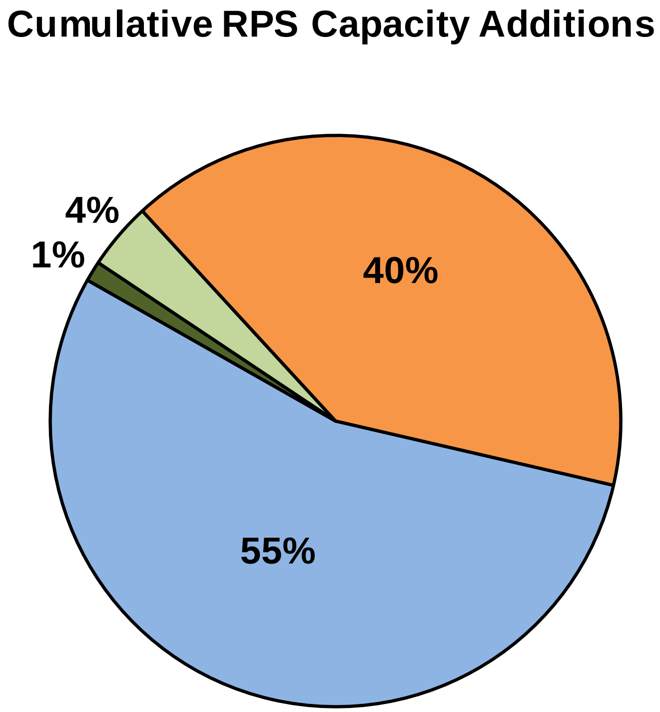
Notes: RPS Capacity Additions consists of RE capacity contracted to entities with active RPS obligations or sold on a merchant basis into regional RPS markets.

- 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

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

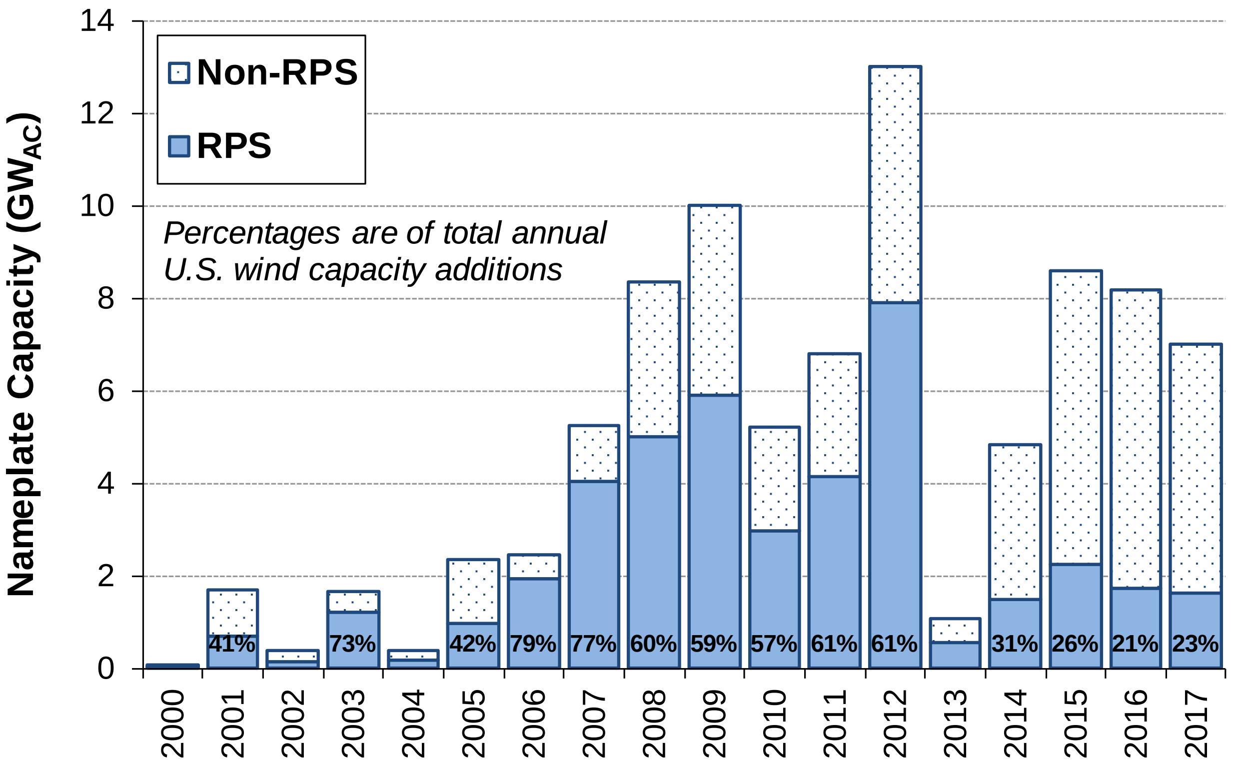
- Prominence of solar among recent RPS builds reflects:
  - Prevalence of solar carve-out requirements
  - Increasing cost-competitiveness of utility-scale solar vis-à-vis wind
- Wind capacity growth still strong, but recent additions primarily not for RPS

BERKELEY LAB

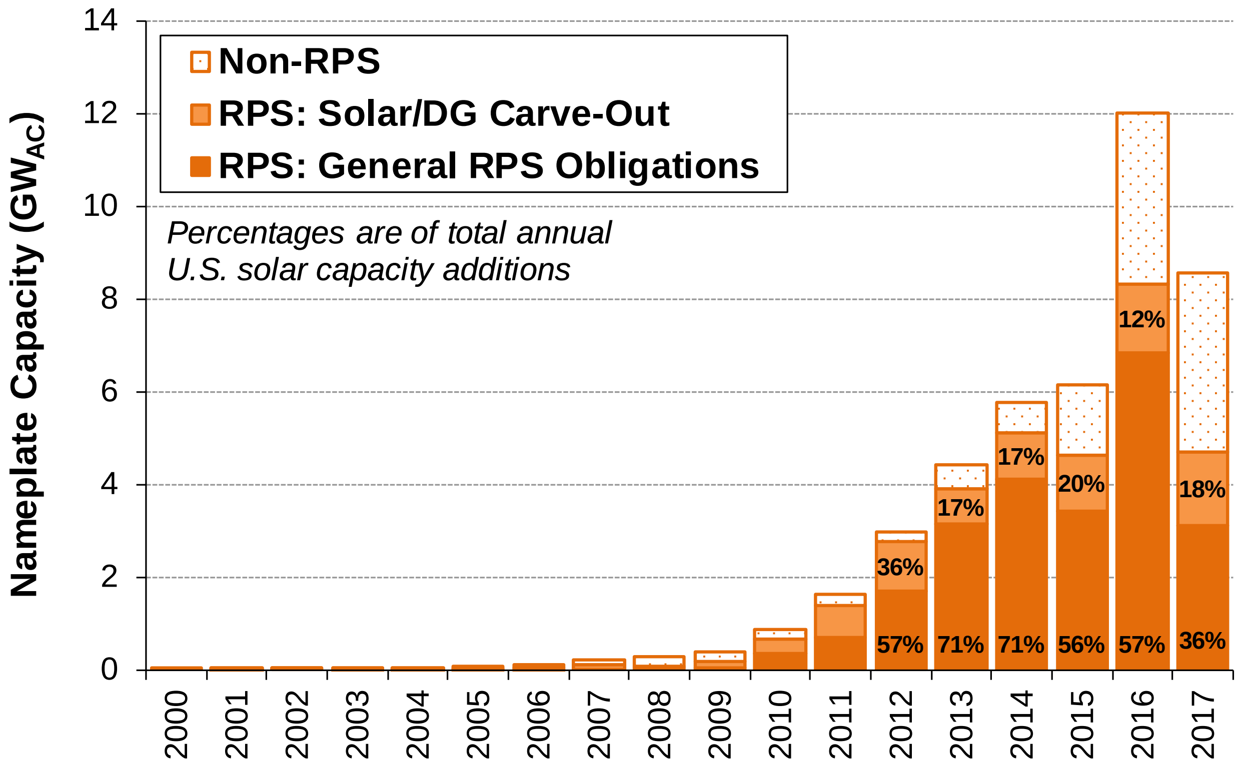
Recent Wind Additions Built Primarily Outside of RPS Requirements, While Solar is More-Concentrated in RPS States

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



BERKELEY LAB

Table of Contents

- Evolution of state RPS programs
- Historical impacts on renewables development
- **Future RPS demand and incremental needs**
- REC pricing trends
- RPS compliance costs
- Outlook

Some States Are Nearing their Final RPS Target Year, While Others Have a Decade or More of Demand Growth Remaining

Year of Maximum RPS Percentage Target

5 states have passed their terminal RPS target year; **8** others will do so within the next few years

7 states will hit their terminal RPS target year in 2025/26

10 states have targets extending to 2030 or beyond (incl. MA, which has no final target year)

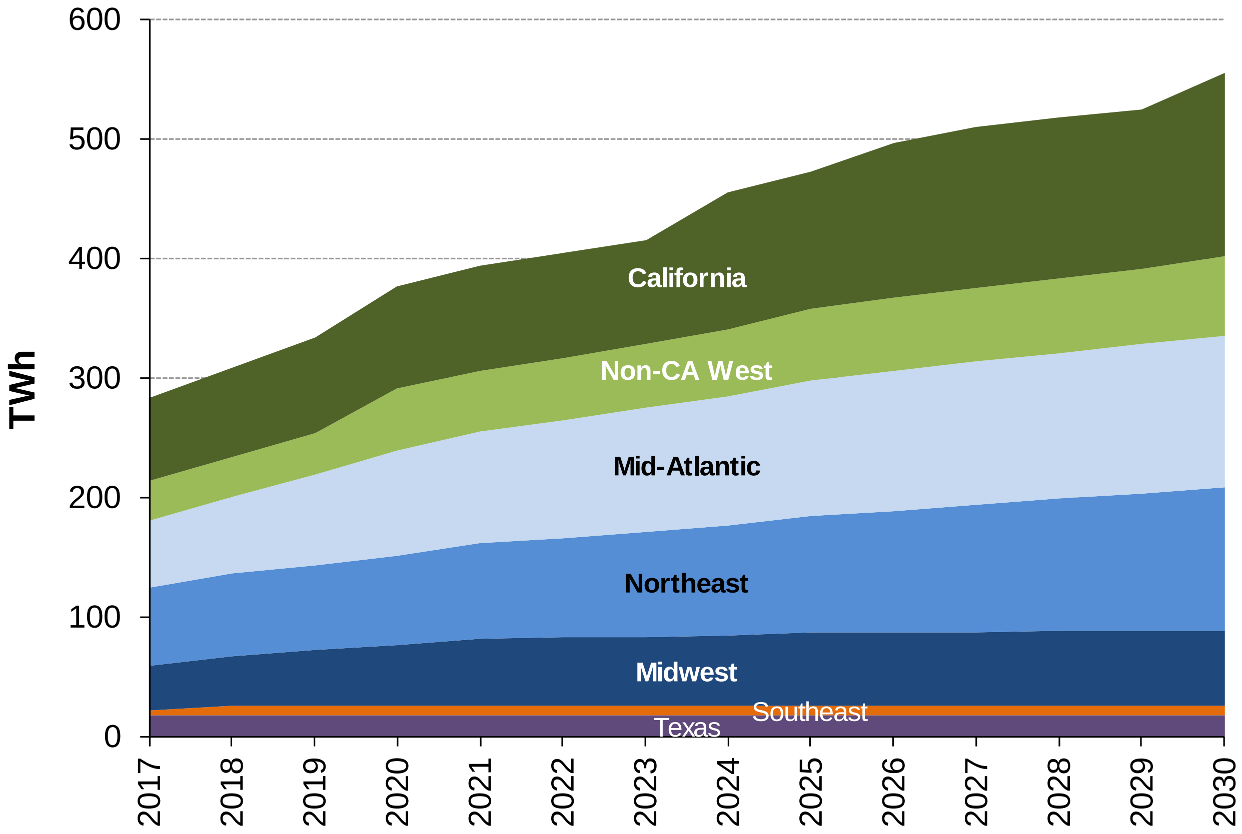
1999	IA
2015	MT, TX, WI
2016	
2017	ME
2018	NC (POUs)
2019	
2020	CO, MD, MN (Xcel), NM, PA, WA
2021	MI, MO, NC (IOUs)
2022	
2023	
2024	
2025	AZ, DE, IL, MN, NH, NV
2026	OH
2030	CA, CT, NJ, NY
2032	DC, VT
2035	RI
2040	OR
2045	HI
→	MA

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 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 roughly 280 TWh in 2017 to 560 TWh in 2030
  - Represents the total RE 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 ahead of schedule, others are behind
  - Some growth in demand will likely be met with banked RECs

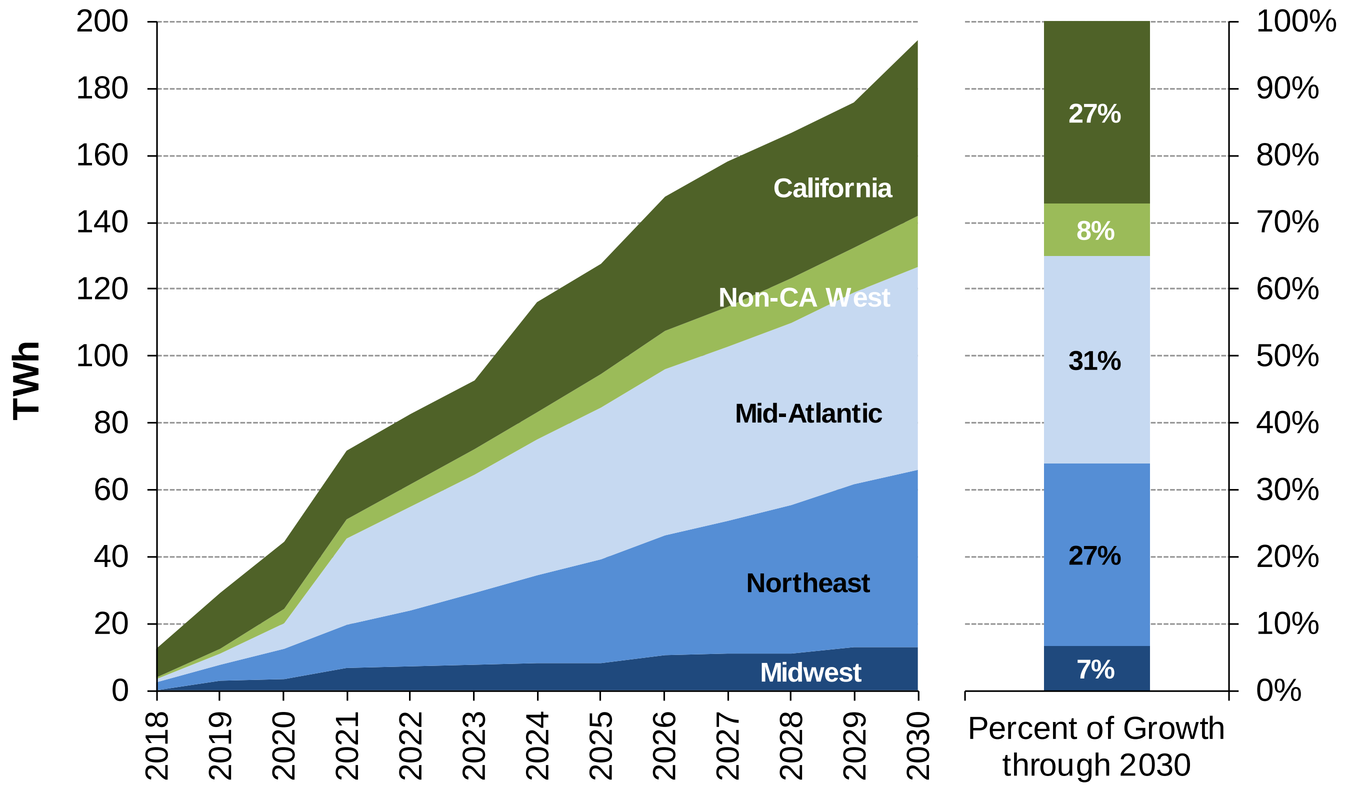
State-level RPS demand projections available for download at: rps.lbl.gov

BERKELEY LAB

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 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 2017 (see figure notes for further details)
- Accounting for REC banking over the forecast period, per each state's rules

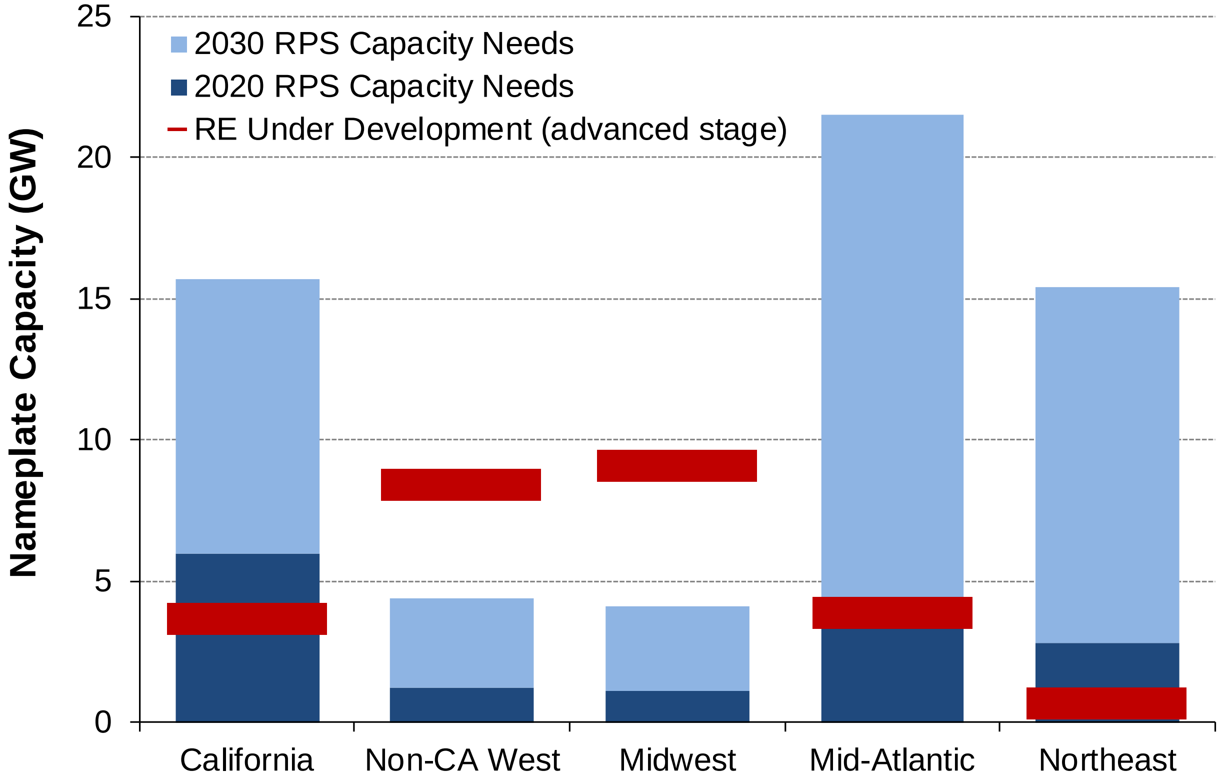
- 200 TWh increase in RPS resources needed to meet RPS demand growth through 2030
  - By comparison, current U.S. RE = ~400 TWh
- Greatest incremental needs in:
  - **California** (60% statewide RPS by 2030)
  - **Mid-Atlantic** (boosted by recent legislation in NJ and IL, but also significant needs for OH)
  - **Northeast** (mostly NY's 50%-by-2030 CES)

Required RE Capacity Builds for RPS

Roughly 15 GW needed by 2020, 60 GW by 2030

- Equivalent to 40% of current U.S. RE capacity
- Requires an average build-rate of 4 GW/yr
  - Below historical rate (7 GW/yr for RPS-related capacity additions, 12 GW/yr for all RE capacity additions)
- RE already under development (at an advanced stage) will meet some of these incremental needs
  - Especially in Non-CA West and Midwest (and potentially in neighboring regions)
  - Not all of that capacity will be available for RPS needs
  - At the same time, ~130 GW of additional capacity at earlier stages of development not counted here
- Retirement of existing RPS capacity is not accounted for here, but will require new RE capacity over time

Required Increase in RPS Capacity (GW)



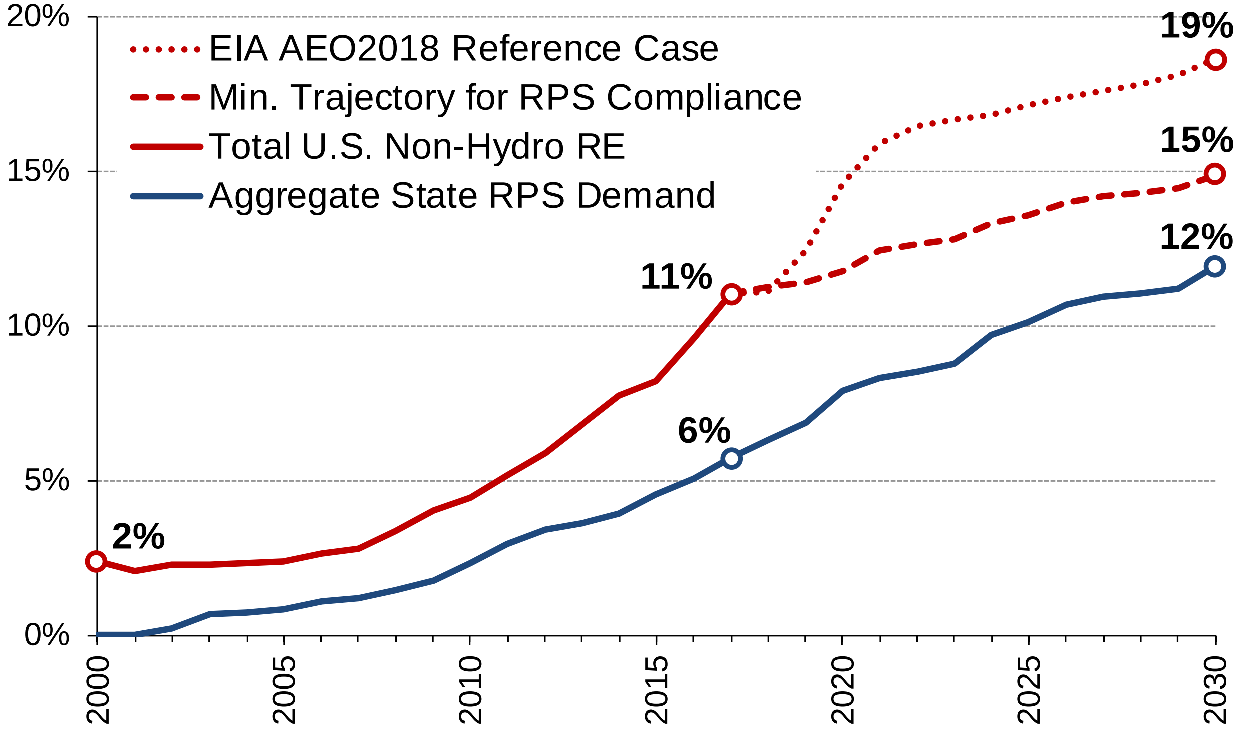
Notes: Calculated from estimated incremental generation needed to meet RPS demand, based on state-specific assumptions about the mix and capacity factor of new RPS supply. RE Under Development consists of units permitted or under construction, site preparation, or testing as of October 2018, plus units that entered commercial operation in 2018, based on data from ABB-Ventyx Velocity Suite.

BERKELEY LAB

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)



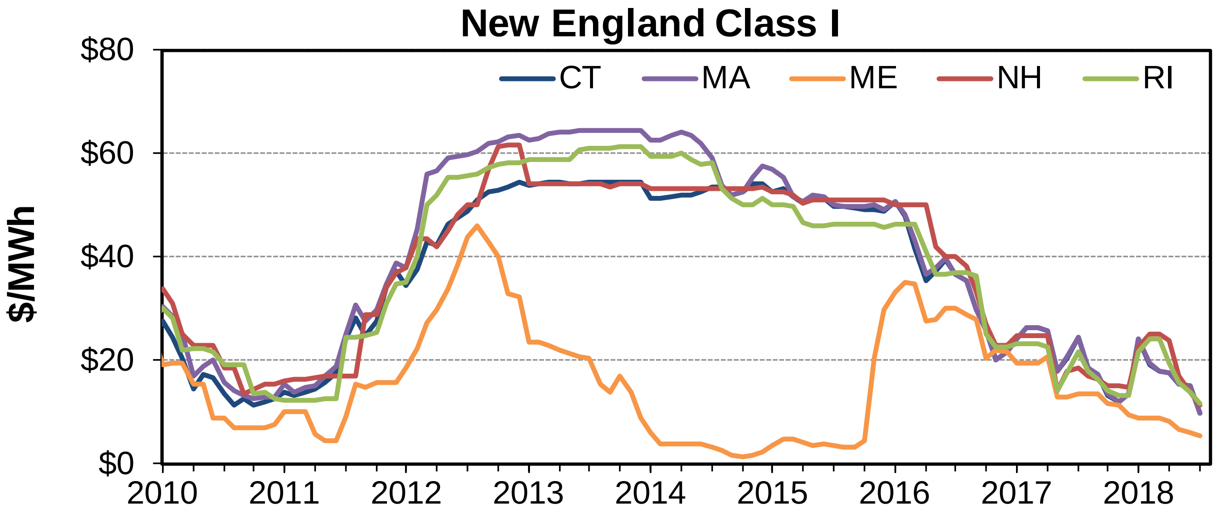
Notes: The figure focuses on non-hydro RE, given the limited eligibility of hydro for state RPS obligations. Accordingly, the Aggregate State RPS Demand excludes historical and projected contributions by hydro as well as by municipal solid waste, demand-side management, and other non-RE technologies.

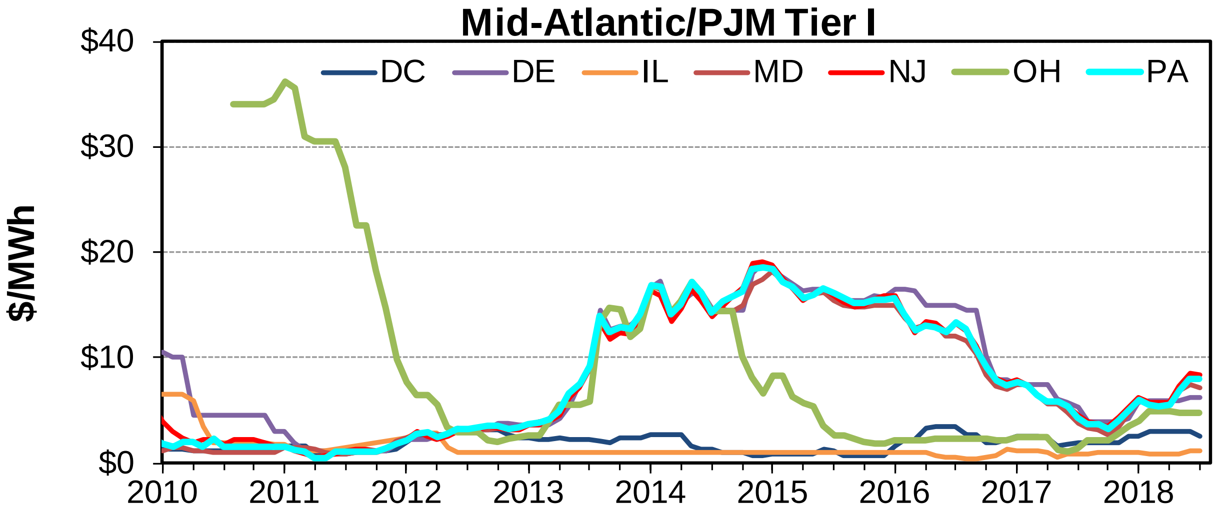
- In aggregate, state RPS targets equate to 12% of U.S. retail electricity sales by 2030
- To meet those targets, total U.S. RE supply will need to reach 15% of retail sales
  - Accounts for the fact that not all existing RE supplies are available for future RPS demand
- EIA projects much greater RE 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

Table of Contents

REC Pricing Trends for “Primary Tier” RPS Obligations

Prices in 2018 continuing to slide in New England, rebounding upward 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 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 all time lows (~$10/MWh, compared to $55-65 ACP levels)

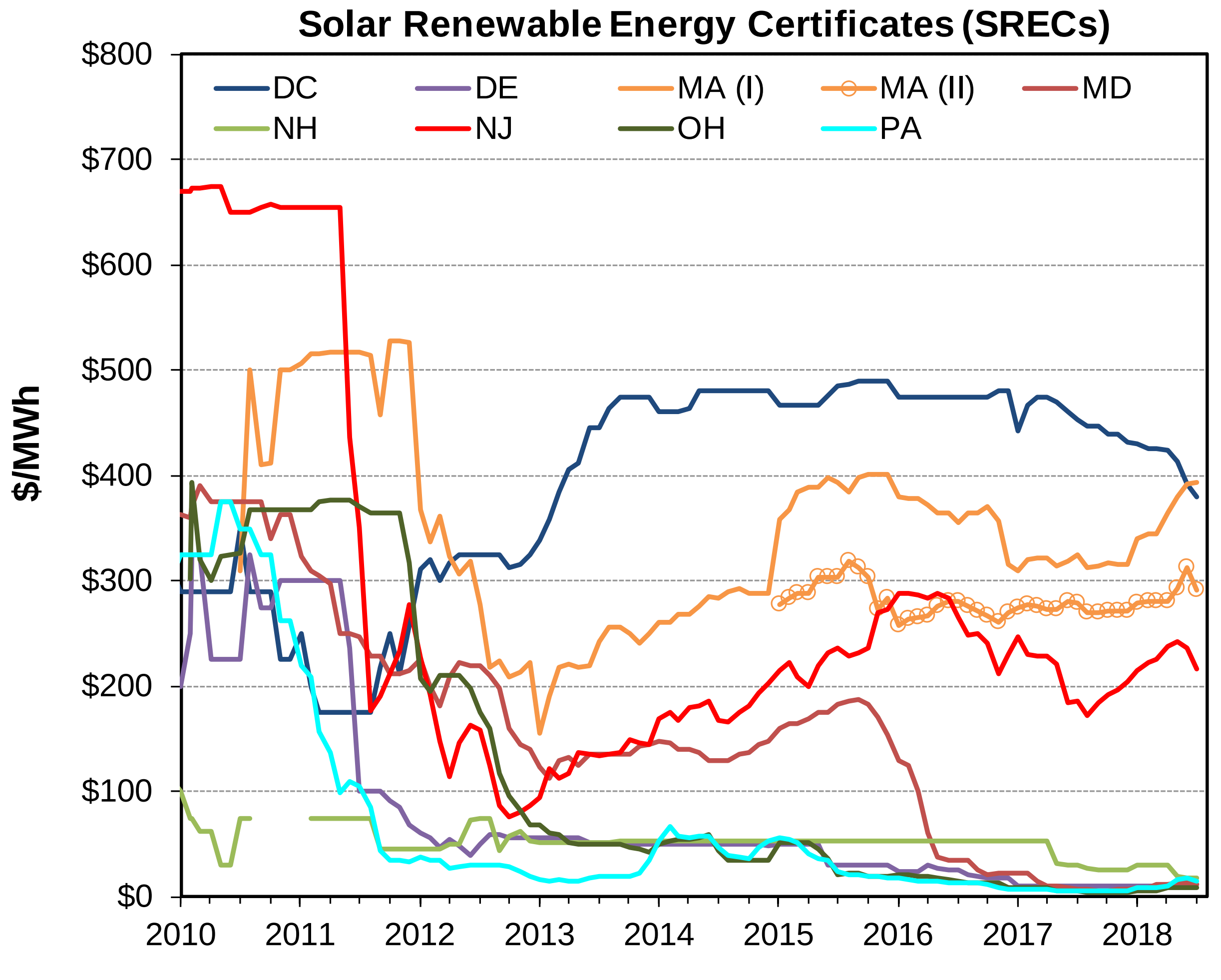
Mid-Atlantic/PJM:

- 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

BERKELEY LAB

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

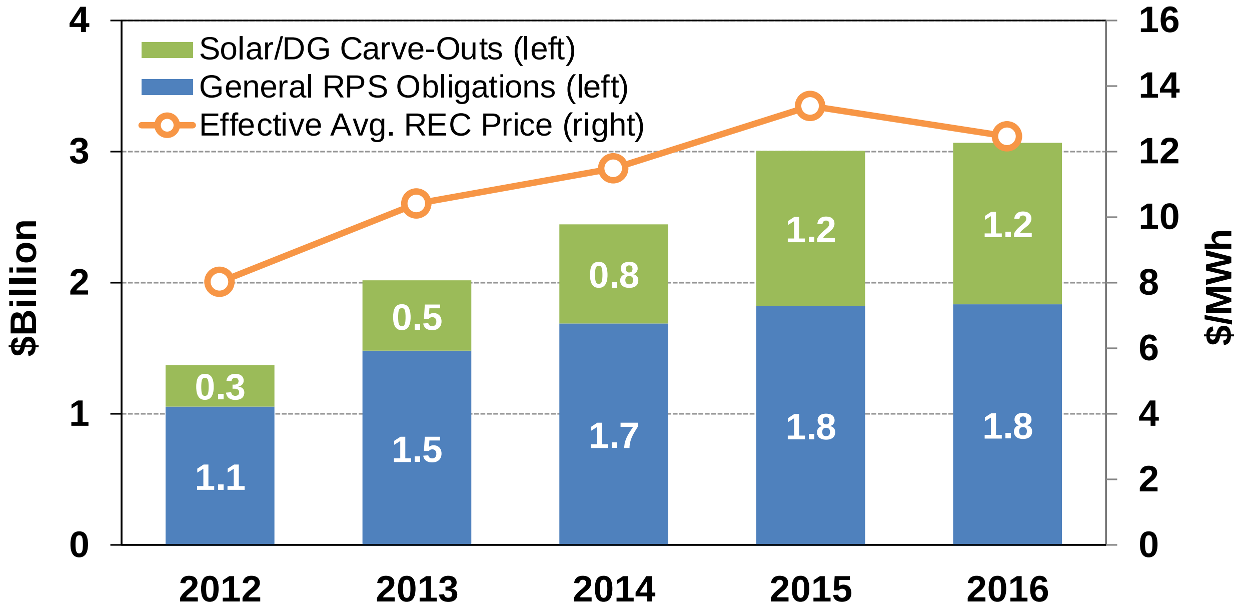
- **DC:** Acute undersupply due to in-district requirements and limited market footprint; 2018 saw first downward trend
- **MA:** Price movements bounded by clearinghouse floor and SACP
- **NJ:** Fairly well-balanced market; looming oversupplies averted by recent legislation
- **MD:** Substantial over-supply emerged in 2015-2016 causing prices to bottom out, 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)

Table of Contents

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 <u>rough</u> one:

– Some impacts (merit order effect, integration costs) not fully captured

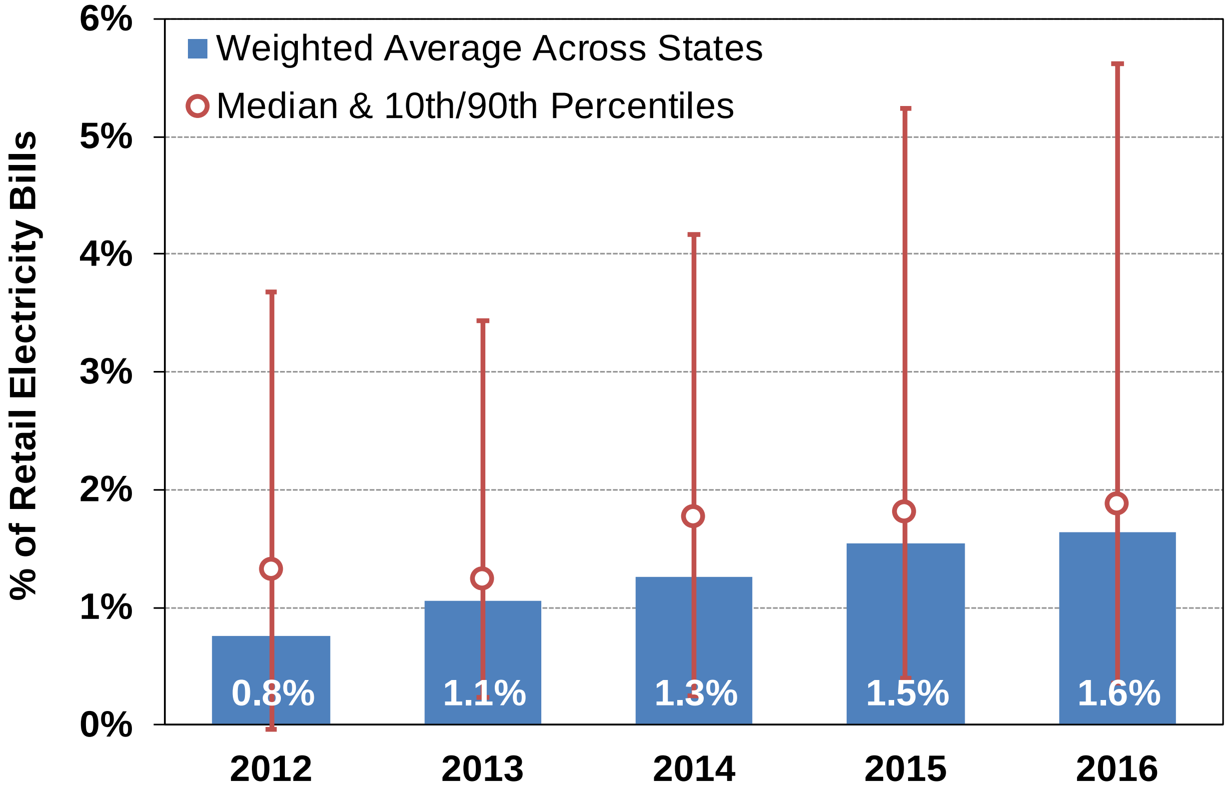
– Compliance costs borne by LSE not always fully or immediately passed through to ratepayers

– 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



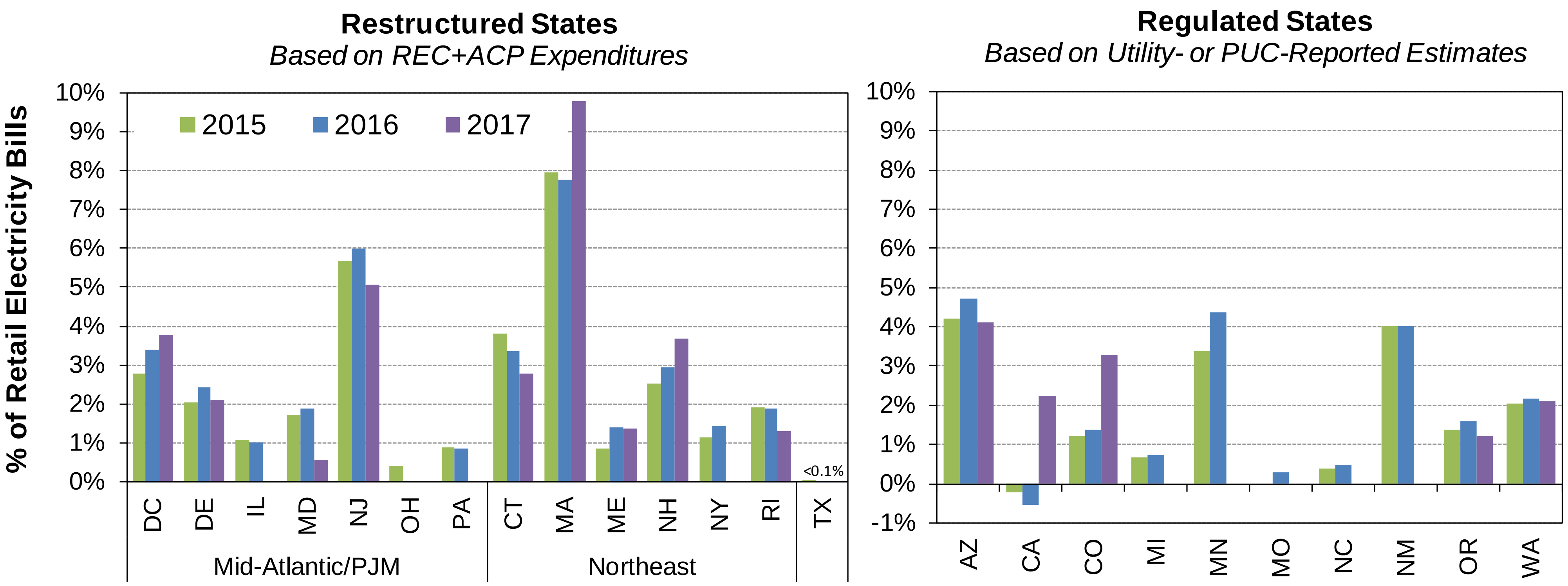
Notes: Annual averages are weighted based on each state's total revenues from retail electricity sales. Using IOU avoided cost estimates for CA, rather than the CPUC's estimates, would raise the U.S. weighted average costs substantially (e.g., to 3.4% of retail electricity bills in 2016).

BERKELEY LAB

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 CA values are based on the CPUC's 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

BERKELEY LAB

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

Follow the Electricity Markets & Policy Group on Twitter

@BerkeleyLabEMP

Contact information:

Galen Barbose, *glbarbose@lbl.gov*, 510-495-2593

Acknowledgements

This analysis was funded by the Office of Electricity Delivery and Energy Reliability (Transmission Permitting & Technical Assistance Division) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. We also thank the many state RPS administrators that graciously offered their time and assistance in providing and clarifying information contained in this report.