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Renewable Portfolio Standards – U.S. Overview

David Mooney

May 6, 2016

ACKNOWLEDGMENTS

Jenny Heeter, Trieu Mai, Lori Bird, Alberta Carpenter, Garvin Heath, David Keyser, Jordan Macknick

Ryan Wiser, Galen Barbose, Mark Bolinger, Andrew Mills, Dev Millstein

References:

Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards - http://www.nrel.gov/docs/fy16osti/65005.pdf

Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards - http://www.nrel.gov/docs/fy14osti/61042.pdf

OUTLINE

1. History and current status of Renewable Portfolio Standards
2. RPS evolution and progress toward targets
3. Impact of RPS implementation on wind and solar deployment in the U.S.
4. Estimates of benefits and impacts of RPS compliance

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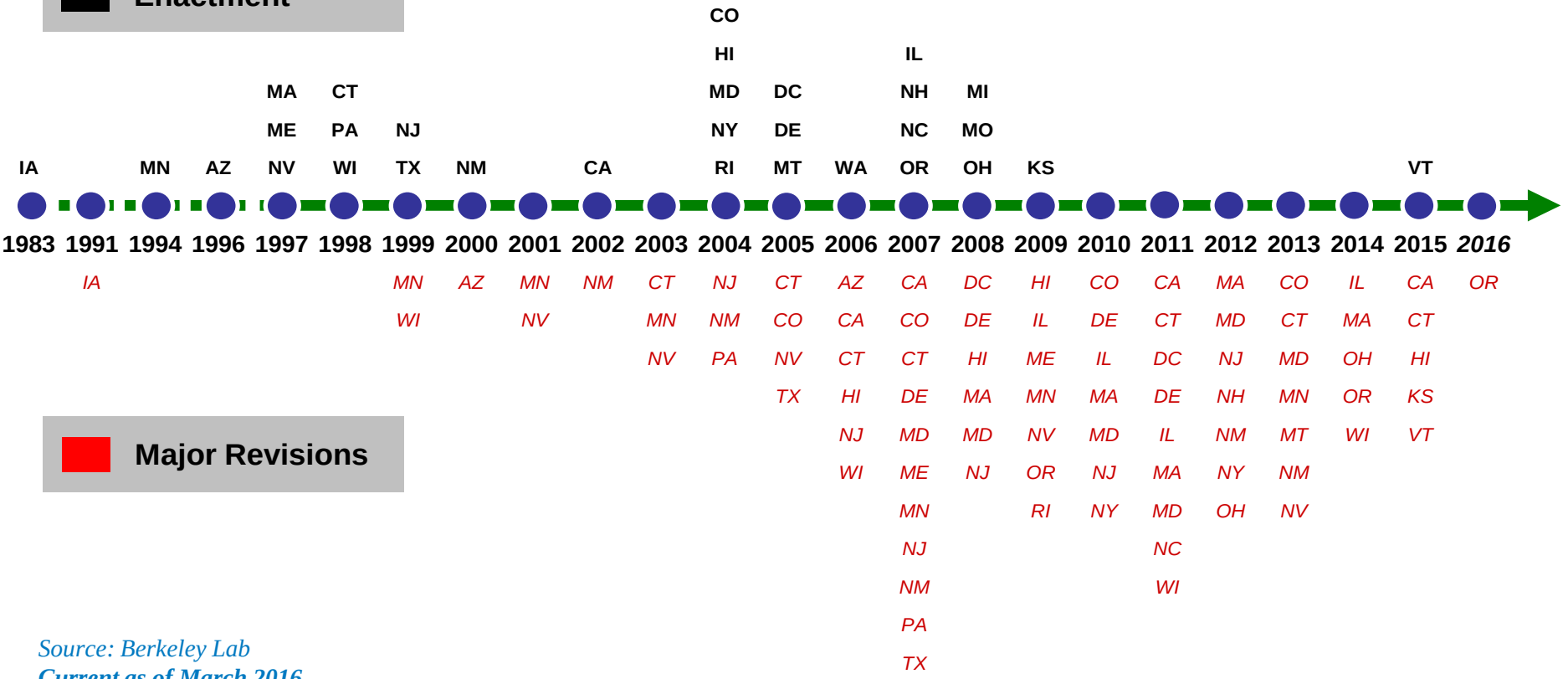
RPS HIGHLIGHTS

- RPS policies collectively apply to 55% of total U.S. retail electricity sales
- Significant recent legislative changes include new or expanded RPS policies in California, Hawaii, Oregon, and Vermont, while Kansas repealed its RPS
- More than half of all growth in renewable electricity (RE) generation (60%) and capacity (56%) since 2000 is associated with state RPS requirements
- Wind energy has been the primary form (65%) of all RPS-driven RE capacity growth to-date, but solar was the largest source (69%) of RPS builds in 2015
- Total RPS demand will double from 215 TWh in 2015 to 431 TWh in 2030
- RPS demand will require an additional 60 GW of RE capacity by 2030, roughly a 50% increase from current non-hydro RE capacity
- Achievement of RPS requirements has thus far been high, with states collectively meeting roughly 95% of their interim RPS targets in recent years
- RPS compliance costs totaled $2.7 billion in 2014, averaging $12/MWh-RE across all RPS resource tiers and equivalent to 1.3% of average retail electricity bills; cost growth is capped by cost containment mechanisms in most RPS states

RPS TIMELINE

Enactment

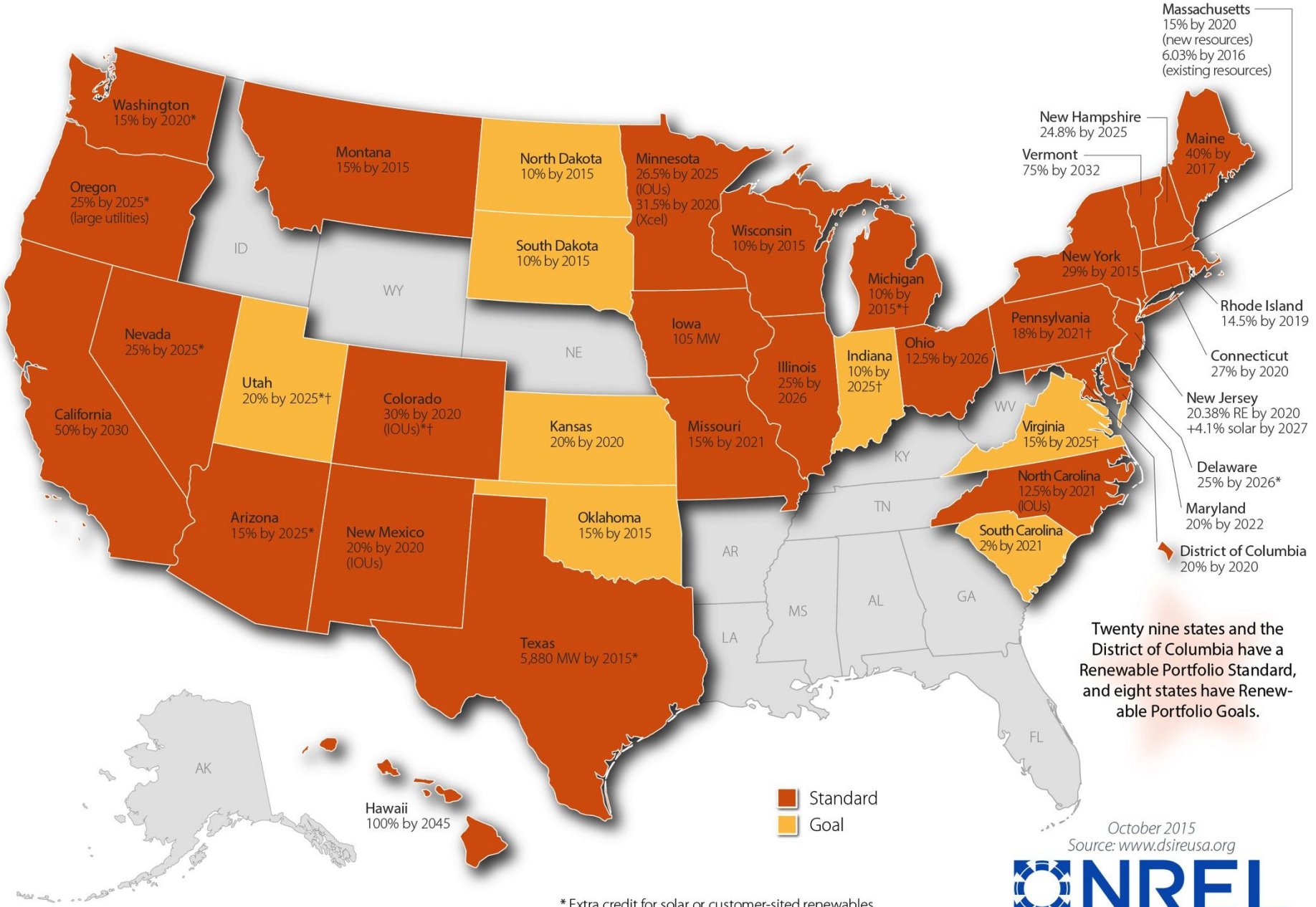
Major Revisions



Source: Berkeley Lab

Current as of March 2016

Renewable Portfolio Standard Policies



Twenty nine states and the District of Columbia have a Renewable Portfolio Standard, and eight states have Renewable Portfolio Goals.

October 2015
Source: www.dsireusa.org

* Extra credit for solar or customer-sited renewables
† Includes non-renewable alternative resources

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GENERAL TRENDS IN RPS REVISIONS

- Creation of resource-specific carve-outs: Solar and DG carve-outs are most common (18 states + D.C.), often added onto an existing RPS
- Increase and extension of RPS targets: Roughly half of all RPS states have raised their overall RPS targets or carve-outs since initial RPS adoption
- Long-term contracting programs: Often aimed at regulated distribution utilities in competitive retail markets; sometimes target solar/DG specifically
- Refining resource eligibility rules: Particularly for hydro and biomass, e.g., related to project size, 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, many bills have been proposed to repeal, reduce, or freeze RPS programs, though only two (OH, KS) have thus far been enacted

RECENT LEGISLATIVE ACTIVITY

RPS-Related Bills Introduced (Enacted) in 2015 and 2016-to-date

	Strengthen	Weaken	Neutral	Total
2015	44 (5)	52 (3)	44 (7)	140 (15)
2016 (Jan-Feb)	22 (1)	4 (0)	19 (0)	45 (1)

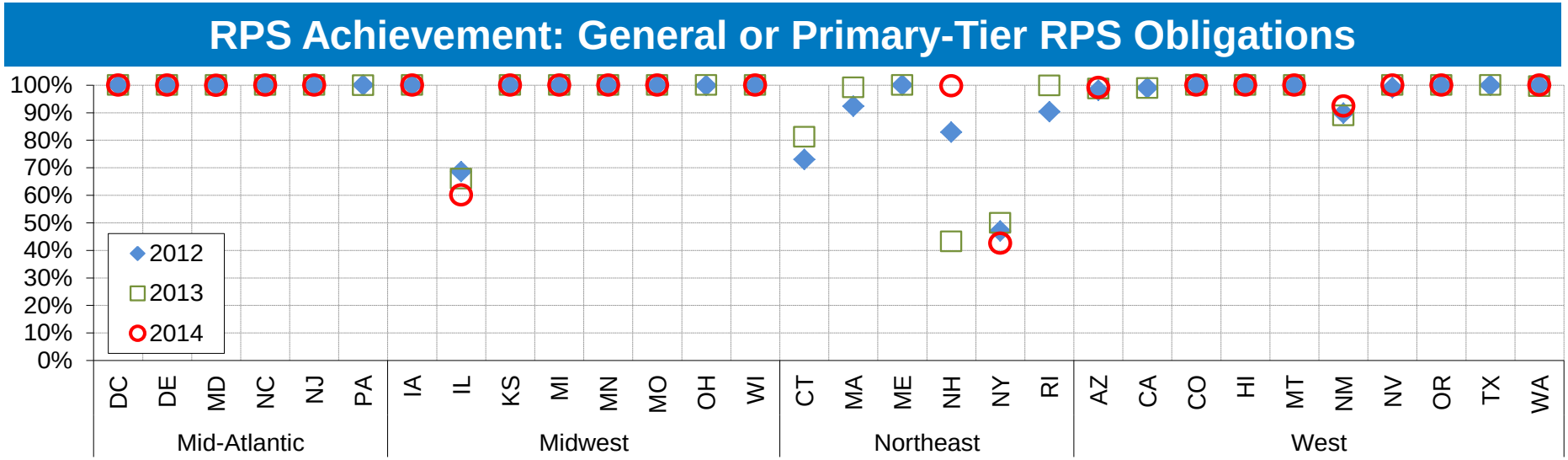
Data Source: EQ Research

Notes: Companion bills introduced in both chambers are counted as a single bill. Numbers in parentheses refer to bills enacted.

Significant recent legislative actions include:

- **CA:** Increased RPS to 50% by 2030
- **CT:** Created residential solar program funded through RPS (300 MW by 2022)
- **HI:** Increased RPS to 100% by 2045
- **KS:** Repealed RPS and replaced with voluntary RE goal
- **OR:** Increased RPS to 50% by 2040 for large IOUs
- **VT:** Created a new RPS (75% by 2032) with a DG carve-out (10% by 2032)

MOST STATES HAVE FULLY MET RECENT TARGETS



Notes: The values represent the percentage of annual RPS targets met with RE or RECs retired for RPS compliance each year, focusing on general or primary-tier (new, Class I, or Tier I) RPS obligations—i.e., excluding technology carve-outs or secondary (existing, Class II or Tier II) resource tiers. For states with compliance years beginning in the middle of calendar years, compliance years are mapped to the chart based on their start date.

The vast majority of states fully met their RPS targets over the three-year period shown; exceptions include:

- IL: Alternative retail suppliers are required to meet 50% of RPS with ACPs
- Northeast: Growth in regional RE supplies lagged behind RPS demand growth
- NM: RPS cost caps led to reduced procurement for one utility

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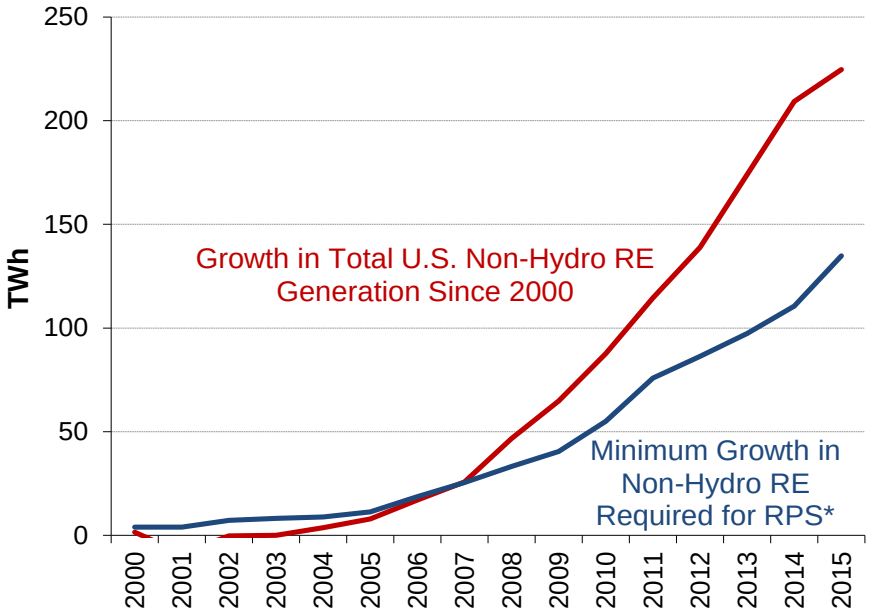
RPS Demand a Key Driver for RE Growth:
60% of growth in RE generation since 2000 required by RPS

RE growth has been driven by multiple factors, but several benchmarks can help to gauge the impact of RPS programs

- RPS programs required 135 TWh growth in renewable electricity (RE) generation since 2000
- Represents 60% of growth in total U.S. non-hydro RE generation (though some of that growth may have occurred in the absence of RPS)
- Additional RE growth associated with voluntary green power markets, accelerated RPS procurement, and economic purchases

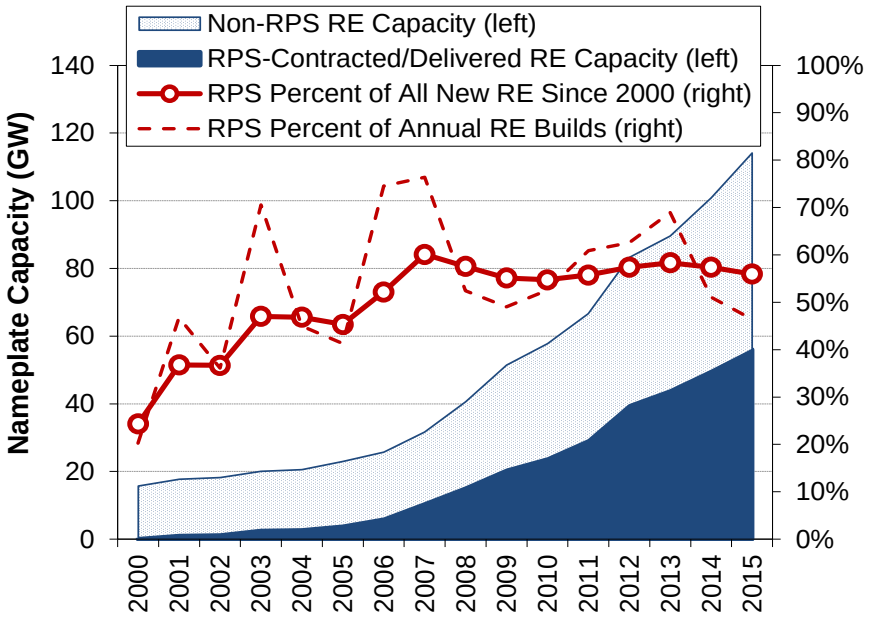
Growth in U.S. Non-Hydro Renewable Generation (TWh)



Notes: Minimum Growth in Non-Hydro RE Required for RPS excludes contributions to RPS compliance from pre-2000 vintage facilities, and from hydro, municipal solid waste, and non-RE technologies. Growth in Total U.S. Non-Hydro RE Generation is based on data from EIA's Electric Power Annual.

RPS Demand a Key Driver for RE Growth:
56% of new RE capacity delivered to RPS-obligated LSEs

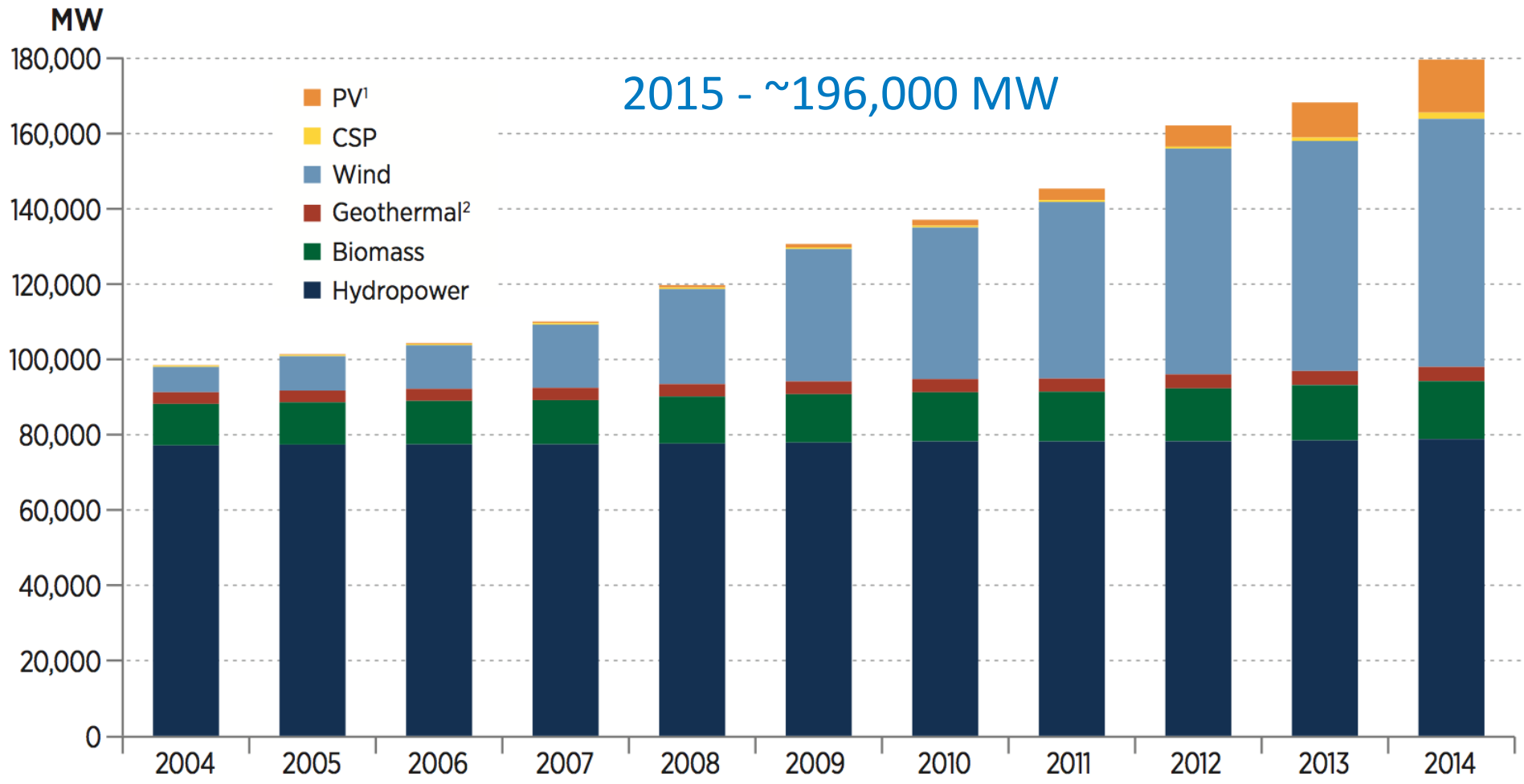
Total U.S. Non-Hydro Renewable Generation Capacity (GW)



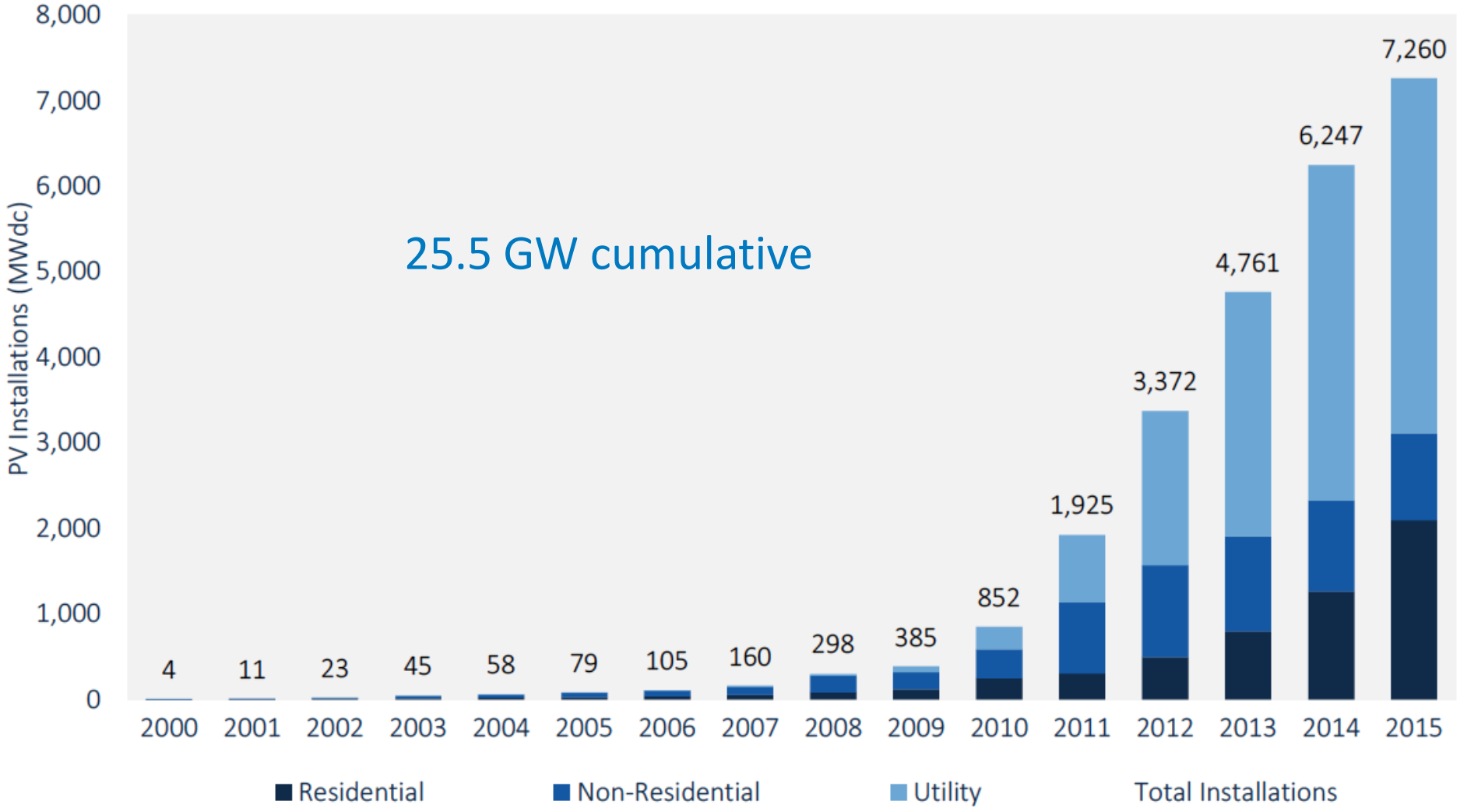
Notes: RPS-Contracted/Delivered capacity consists of RE capacity contracted to entities subject to an RPS or sold on a merchant basis into regional RPS markets, subject to additional constraints (see Supplementary Notes). Lines represent RPS-Contracted/Delivered capacity as a percent of all RE capacity additions (RPS+Non-RPS) on annual and cumulative bases.

- Total U.S. non-hydro RE capacity additions equal 100 GW since 2000
- Of that, 56 GW (56%) is contracted to load-serving entities (LSEs) with active RPS obligations or is otherwise sold into RPS markets
- Non-RPS RE capacity growth is mostly wind energy in Texas and the Midwest (in excess of state/regional RPS requirements), much of it selling into voluntary green power markets
- The relative contribution of RPS to RE growth has declined in recent years (from 69% of Annual RE Builds in 2013 to 46% in 2015), as other drivers have become more significant

U.S RENEWABLE ELECTRICITY CAPACITY – CUMULATIVE



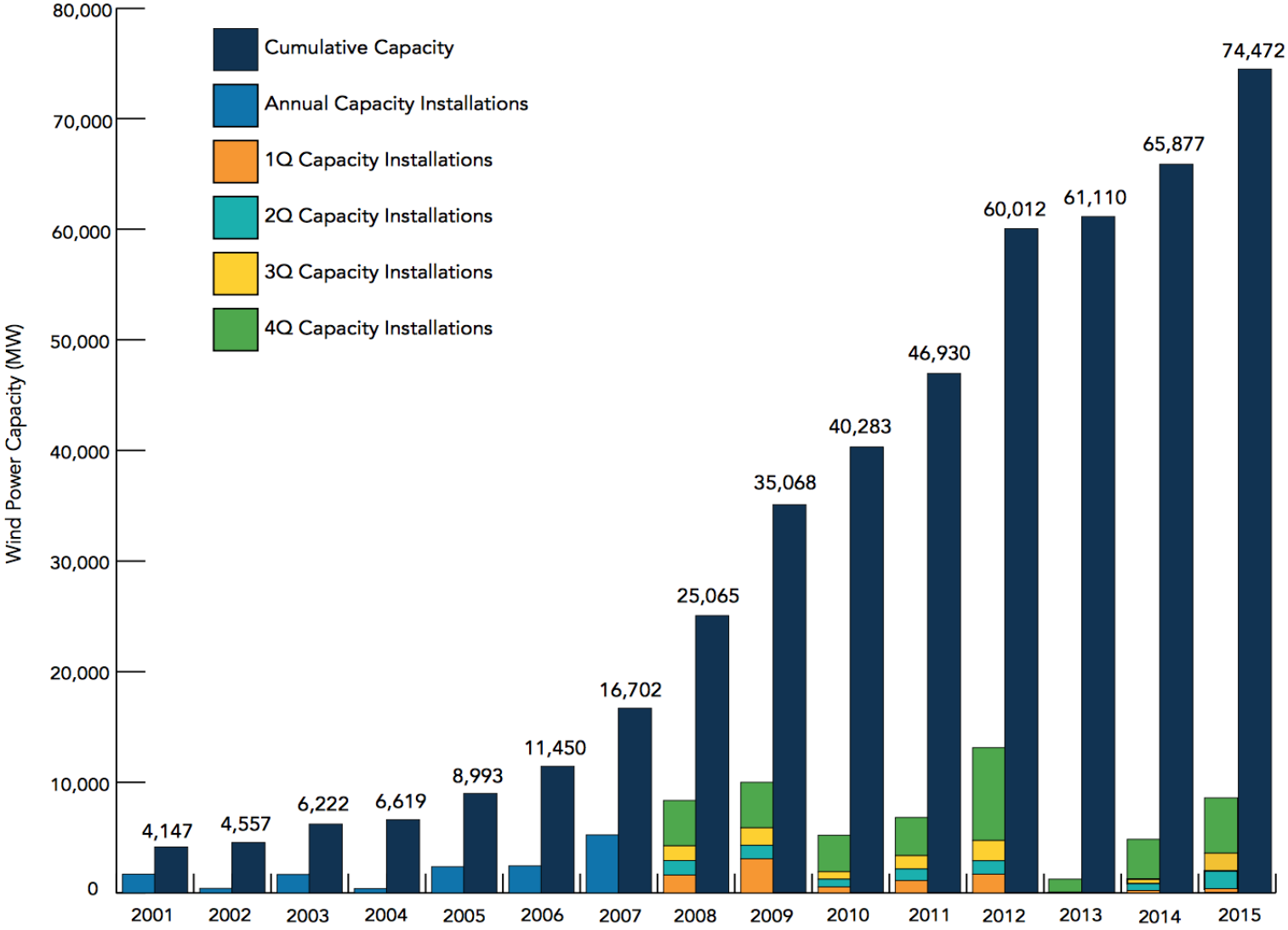
U.S. ANNUAL CAPACITY ADDITIONS



GTM RESEARCH A Greentech Media Company

SEIA Solar Energy Industries Association

U.S. WIND CAPACITY – ANNUAL AND CUMULATIVE



Note: Utility-scale wind capacity includes installations of wind turbines larger than 100-kW for the purpose of the AWEA U.S. Wind Industry Quarterly Market Reports. Annual capacity additions cumulative capacity may not always add up due to decommissioned, uprated and repowered wind turbines. Wind capacity data for each year is continuously updated as information changes.

American Wind Energy Association | **U.S. Wind Industry Fourth Quarter 2015 Market Report** | AWEA Public Version

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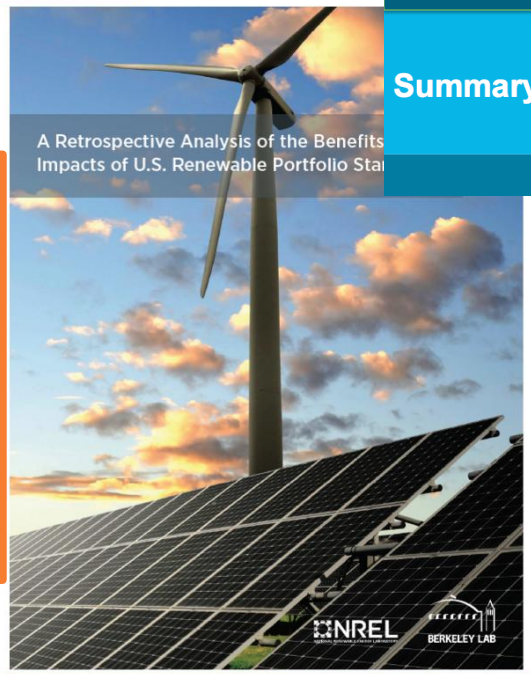
NATIONAL LEVEL BENEFITS AND IMPACTS

Presentation Overview

- Overview, background, scope
- Foundational data and analysis
- Greenhouse gas emissions
- Air pollution emissions
- Water use
- Gross jobs & econ. development
- Wholesale electricity prices
- Natural gas prices
- Conclusions



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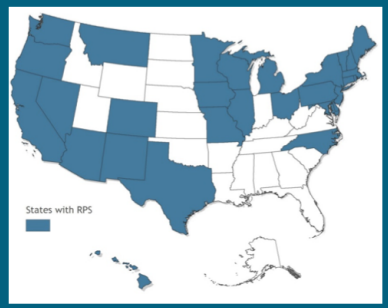
A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards



Summary Briefing of Report

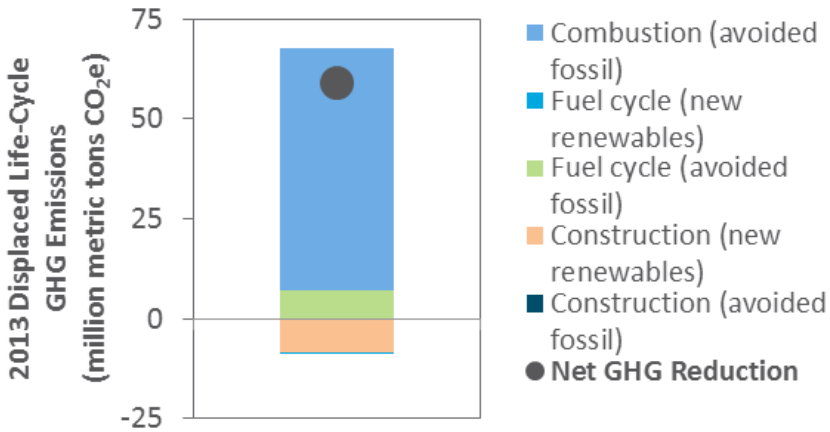
January 2016

CO2 EMISSION REDUCTIONS: PHYSICAL IMPACTS

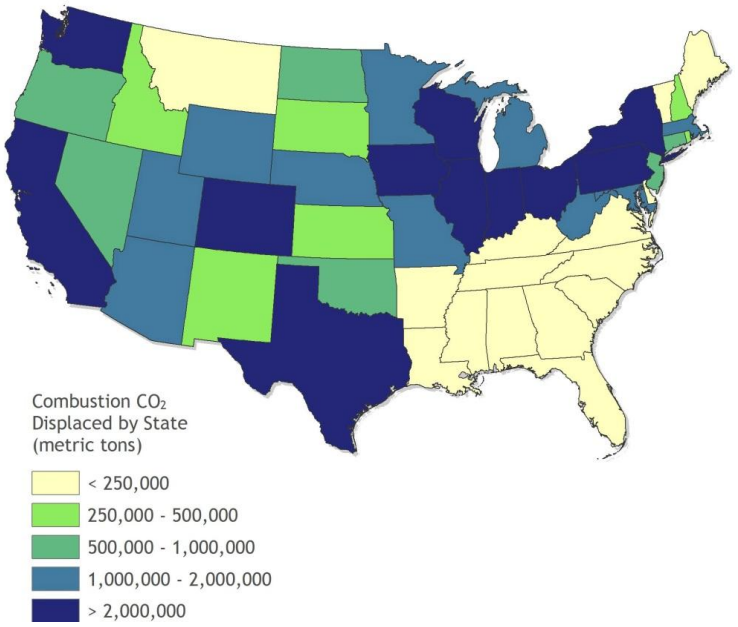
Net displaced CO_2e emissions in 2013: 59 million metric tons

- *Displaced combustion at fossil fuel plants: 61 million metric tons (3% power sector emissions)*
- *Displaced life cycle-related emissions (net of construction and fuel cycle): -2 million metric tons*

Life Cycle GHG Emissions Impacts



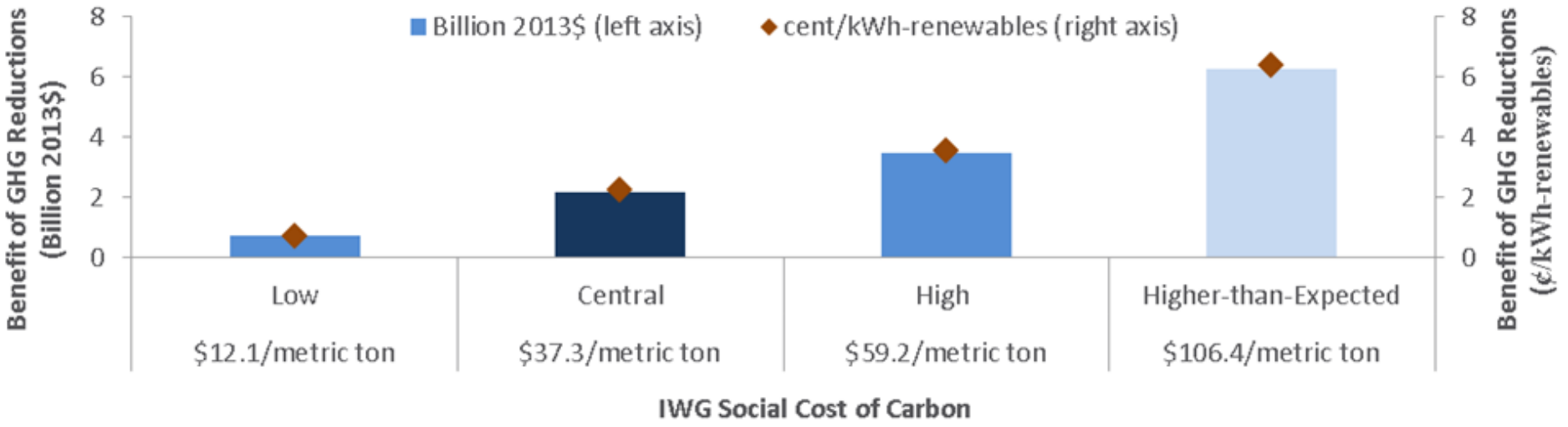
Combustion-Related CO_2 Emissions Reductions



Combustion-related emissions reductions are somewhat concentrated in portions of the Great Lakes, Mid-Atlantic, TX, CA, CO, WA

CO2 EMISSION REDUCTIONS: MONETARY BENEFITS

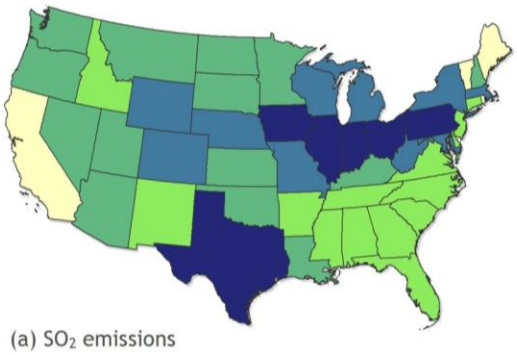
RPS provided between $0.7 and $6.3 billion in reduced global climate change damages in 2013: **central estimate = $2.2 billion**

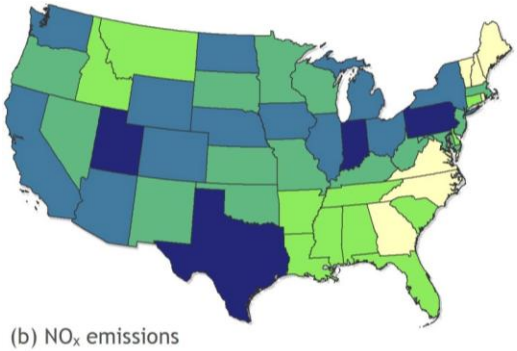


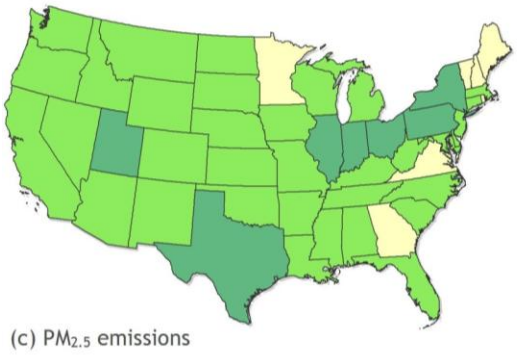
GHG benefits are equivalent to:

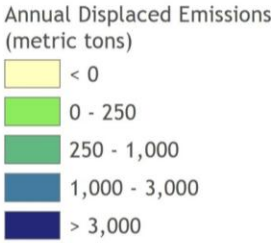
- Central estimate = 2.2¢/kWh-renewable
- Full range: 0.7-6.4¢/kWh-renewable

OTHER EMISSIONS REDUCTIONS: PHYSICAL IMPACTS


(a) SO_2 emissions


(b) NO_x emissions


(c) $PM_{2.5}$ emissions



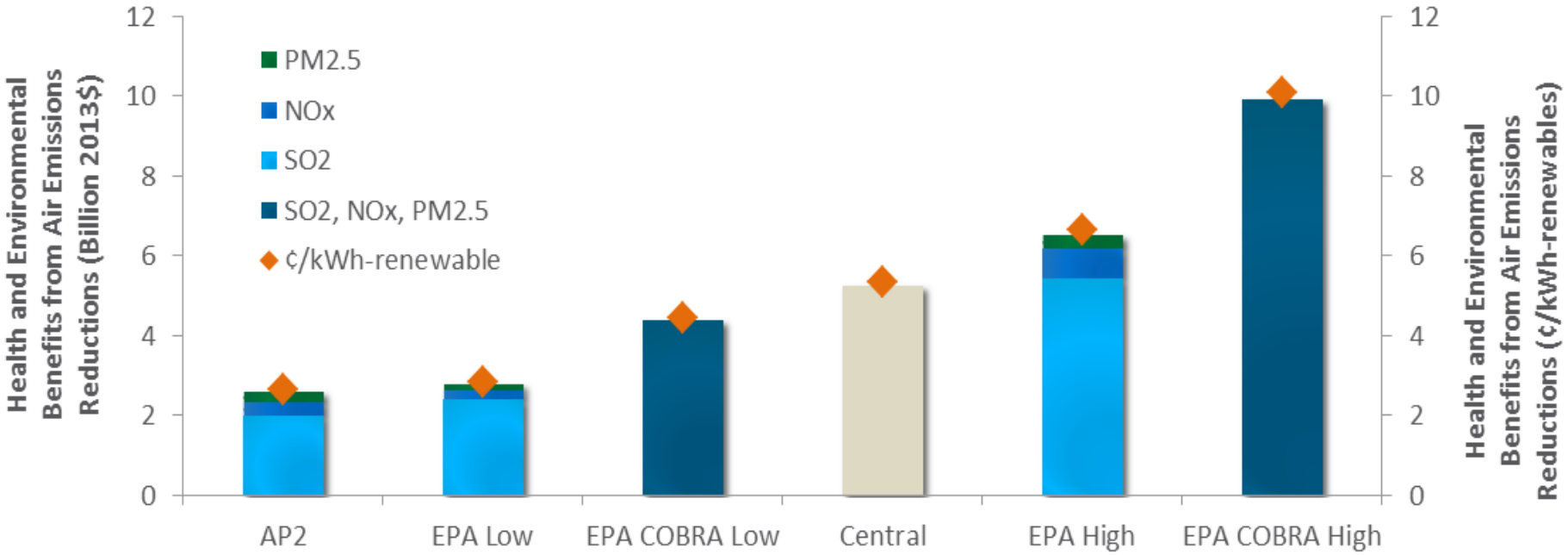
Displaced SO_2, NO_x and $PM_{2.5}$ emissions of 77,400 (2% of power sector), 43,900 (2%), and 4,800 (2%) metric tons, respectively

Emissions reductions are concentrated in Midwest, Mid-Atlantic, Great Lakes, and Texas

Note: A few states with biomass plants serving RPS compliance are estimated to have had small (relative to emission reductions in other states) emission increases

OTHER EMISSIONS REDUCTIONS: MONETARY BENEFITS

RPS provided between $2.6 and $9.9 billion in health & environ. benefits in 2013: **central (average) estimate = $5.2 billion**



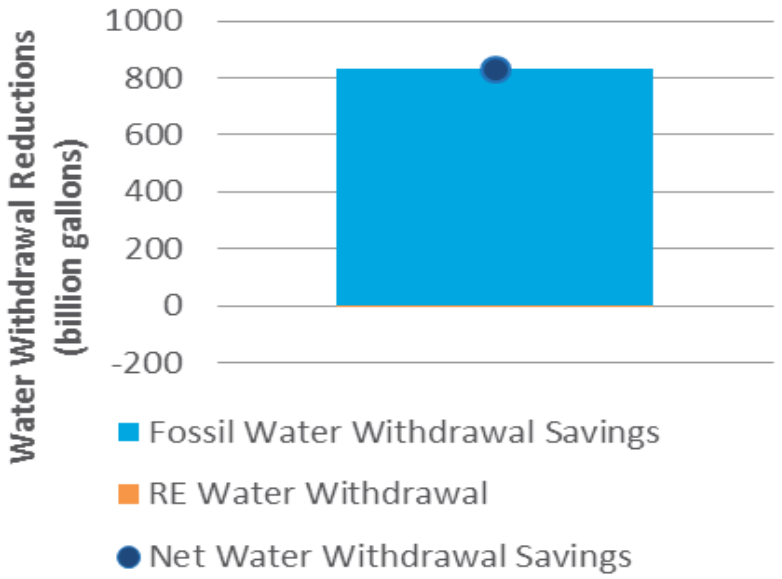
Air emissions reduction benefits are equivalent to:

- Central estimate = 5.3¢/kWh-renewable
- Full range: 2.6-10.1¢/kWh-renewable

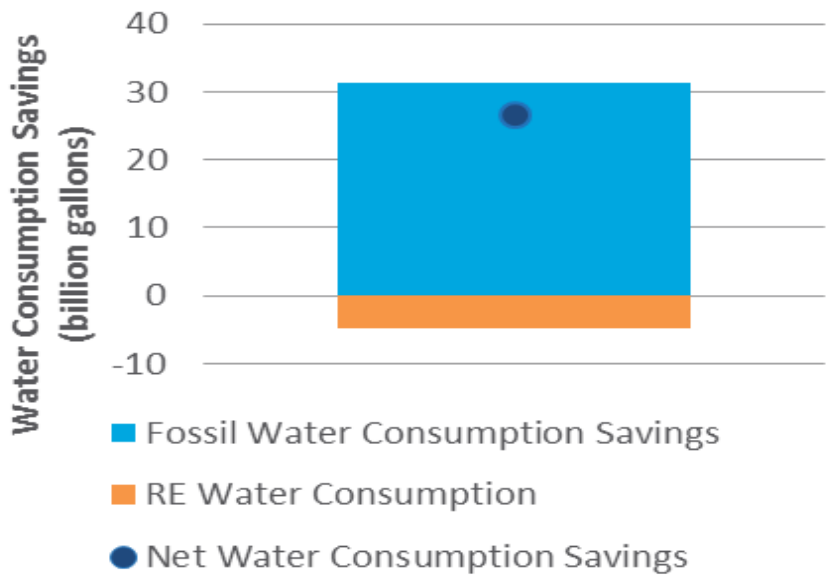
WATER USAGE: PHYSICAL IMPACTS

Reduced net national water withdrawals by 830 billion gallons and net national water consumption by 27 billion gallons

Withdrawal



Consumption



Reductions = 2% of power sector water withdrawals and consumption

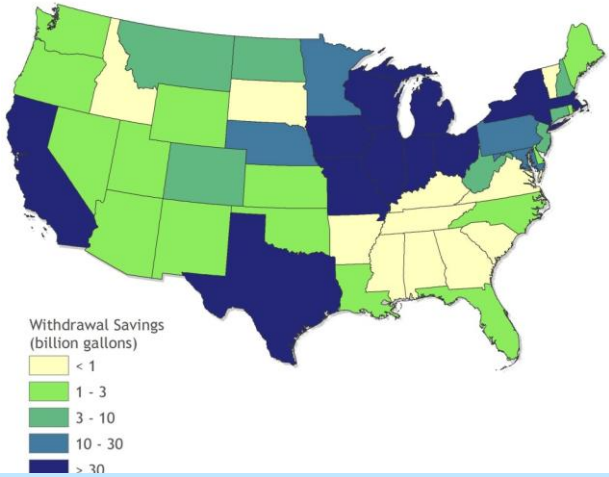
Each MWh of RE serving RPS represents average savings of 8,420 gallons of water withdrawal and 270 gallons of consumption

WATER USAGE: ADDITIONAL DETAILS

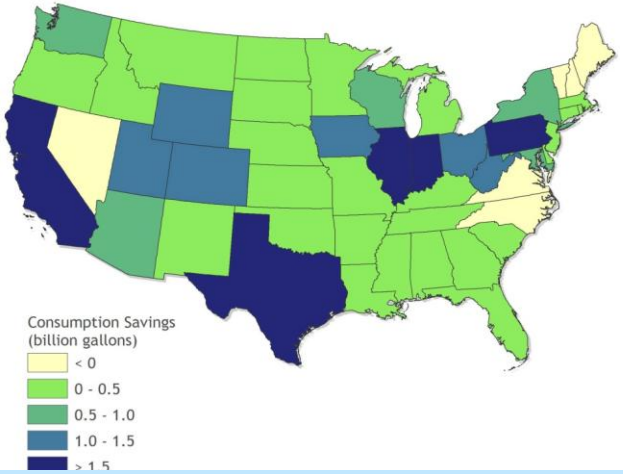
Water savings lower in summer because RE displaces less water-intensive technologies and because some RE with higher water use produce more electricity; water savings predominantly from freshwater sources

Regional water savings are not uniform: impacted by amount, location, and type of RE generation, and by location and type of fossil displacement

Withdrawal



Consumption



There are reductions in water use in many drought-prone regions, with the largest withdrawal savings in California, and the largest consumption savings in Texas

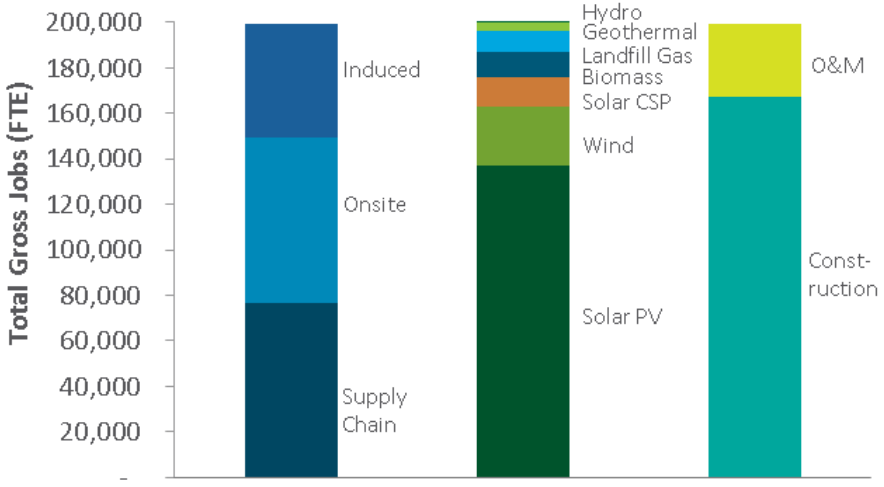
Small number of states see small increases in water withdrawal or consumption

JOBS AND ECONOMIC DEVELOPMENT

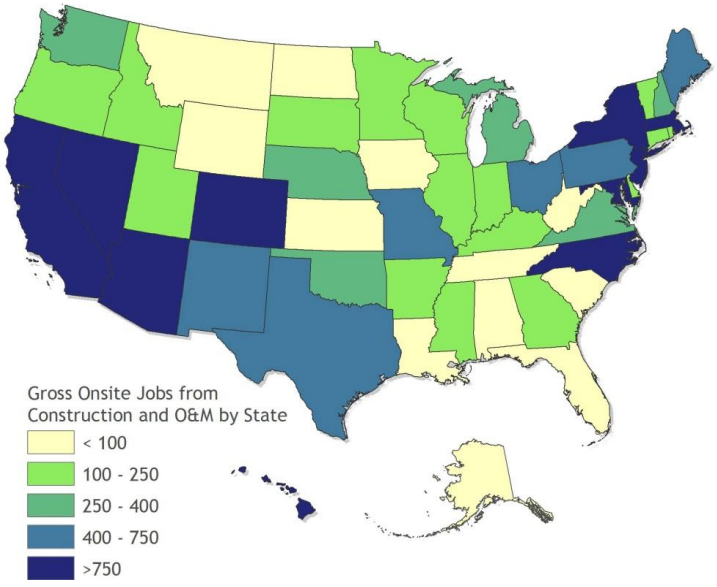
Supported nearly 200,000 gross domestic jobs in 2013, each earning an average annual salary of $60,000, with RE expenditures driving over $20 billion in gross GDP

Location of onsite jobs greatly impacted by new build in 2013-2014 (dominated by PV in California, but including a number of other prominent states noted in map below)

Gross Total Jobs



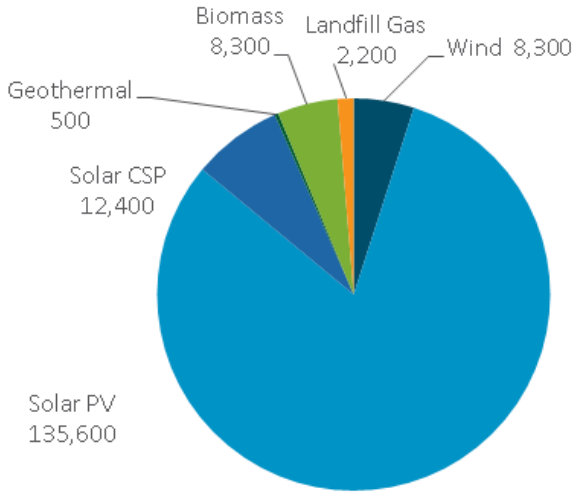
Gross Onsite Jobs



JOBS AND ECONOMIC DEVELOPMENT: DETAILS ON IMPACTS

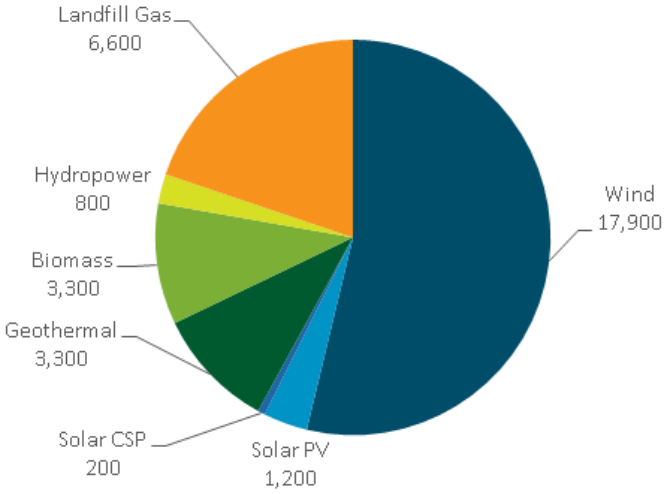
Distribution of jobs among RE technologies reflects the contribution of each technology to RPS generation and capacity additions, as well as its labor-intensiveness within the construction and operation phases

Construction



Gross Jobs Supported by RPS by Technology

O&M



ELECTRICITY PRICE IMPACTS: BACKGROUND

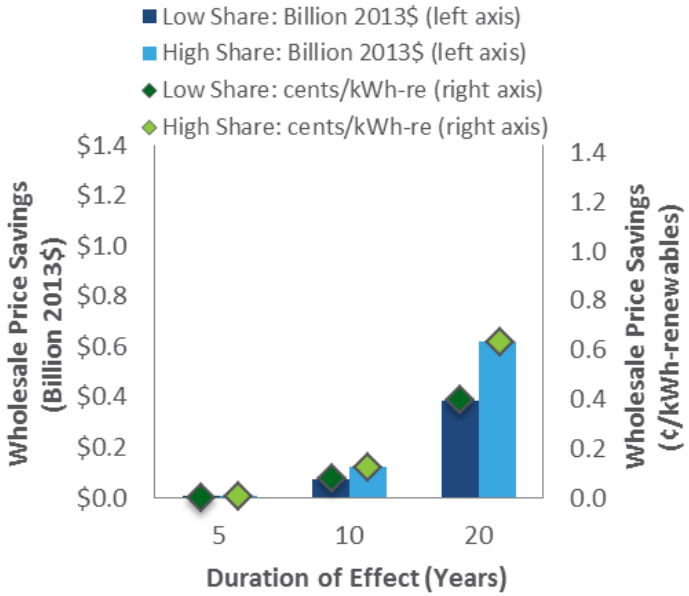
- RE (with a low marginal cost of energy) "pushes out" the wholesale power supply curve, an impact referred to as the merit-order effect
- In the short run—within the time it takes generation to be built or retire—this shift of the supply curve reduces market clearing prices (in the longer term, effect decays towards zero)
- Lower wholesale market prices can also lead to lower consumer electricity bills to the extent that utilities purchase at these prices
- We quantify the potential effects of RPS' on wholesale electricity prices and estimate the associated cost savings to consumers
- It is important to recognize, however, that these savings to electricity consumers come at the expense of electricity generators: *the RPS-induced reduction in wholesale prices represents a transfer of wealth from generators to consumers rather than a net societal benefit*

ELECTRICITY PRICE IMPACTS

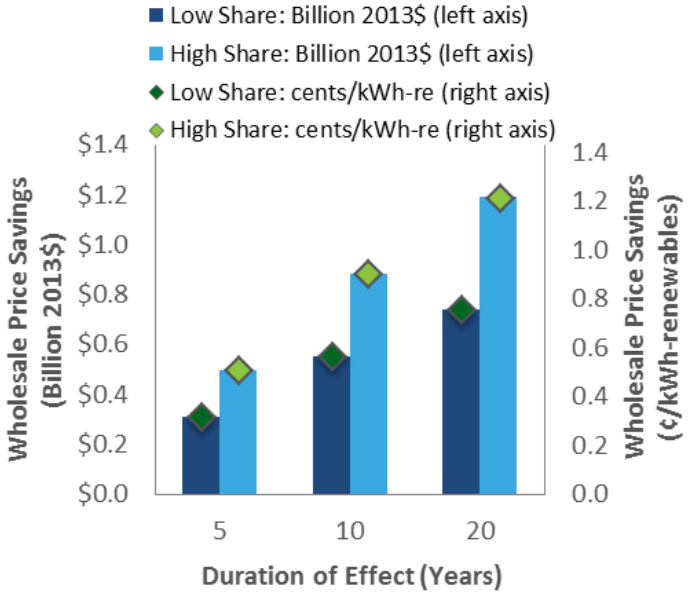
Aggregate, national consumer savings resulting from wholesale price reductions are estimated to range from $0.0 to $1.2 billion

Uncertainty consistent with range of assumptions used for decay of price effects and portion of retail electricity purchased at spot market

RPS Vintage



RE Project Vintage

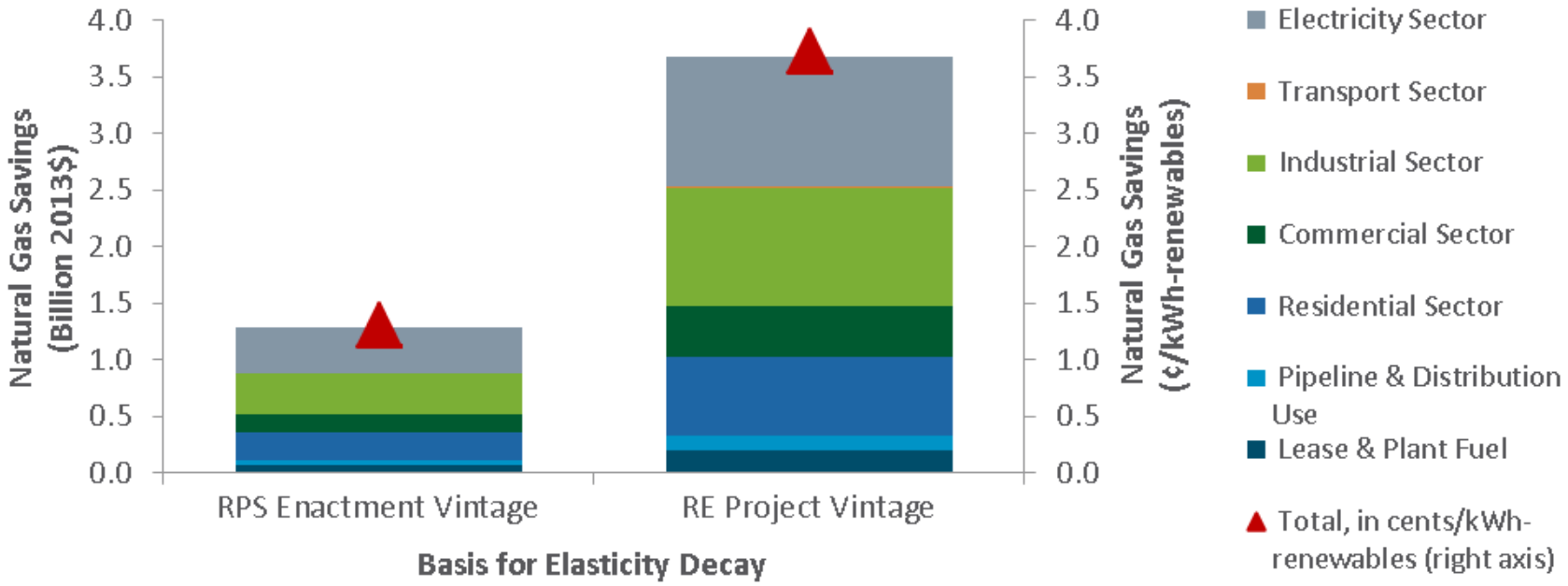


Consumer savings are equivalent to: 0.0-1.2¢/kWh-renewable

NATURAL GAS PRICE IMPACTS

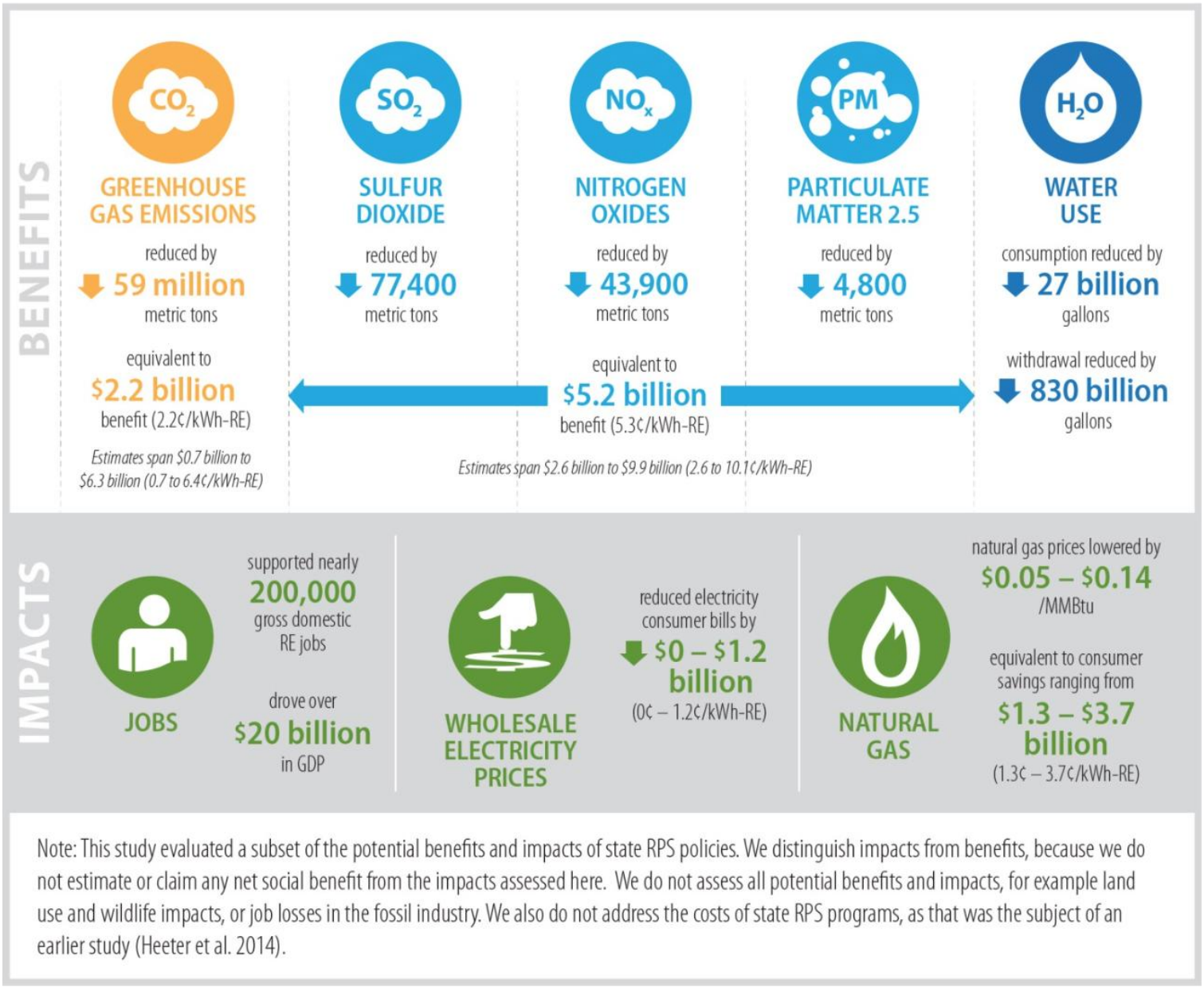
Reduced demand for natural gas by 0.42 quads, representing 1.6% of total consumption in U.S.: lowered gas prices by $0.05 to $0.14/MMBtu, depending on when decay begins

When applied to all gas-consuming sectors of the economy, aggregate consumer savings in 2013 range from $1.3 billion to $3.7 billion



Consumer savings are equivalent to: 1.3-3.7¢/kWh-renewable

SUMMARY OF BENEFITS AND IMPACTS



Note: This study evaluated a subset of the potential benefits and impacts of state RPS policies. We distinguish impacts from benefits, because we do not estimate or claim any net social benefit from the impacts assessed here. We do not assess all potential benefits and impacts, for example land use and wildlife impacts, or job losses in the fossil industry. We also do not address the costs of state RPS programs, as that was the subject of an earlier study (Heeter et al. 2014).

Thank you!

david.mooney@nrel.gov

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NATIONAL RENEWABLE ENERGY LABORATORY

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