RESEARCH SUMMARY

# Do Renewable Portfolio Standards Deliver?

*by Michael Greenstone and Ishan Nath*

## KEY TAKEAWAYS

1. Though the United States has had trouble coming to a consensus on broad-reaching climate policy, 29 states and the District of Columbia have been successful in passing Renewable Portfolio Standards (RPS), which require that a percentage of the electricity generation come from renewable sources. These programs currently cover 64 percent of the electricity sold in the United States.

2. Until now, studies have suggested that RPS programs only marginally increase electricity costs, because they have only examined differences in the costs of generation. These studies fail to fully incorporate three key costs that the addition of renewable resources impose on the electricity system: 1) The intermittent nature of renewables means that back-up capacity must be added; 2) Because renewable sources take up a lot of physical space, are geographically dispersed and are frequently located away from population centers, they require the substantial addition of transmission capacity; and 3) In mandating an increase in renewable power, baseload generation is prematurely displaced, which imposes costs on ratepayers and owners of capital.

3. This study compares states with and without RPS policies. It does so using the most comprehensive state-level dataset ever compiled on these outcomes and RPS program characteristics covering the period from 1990 to 2015. The study estimates the impacts of the RPS policies on electricity prices, electricity consumption, renewable penetration, carbon emissions, and economic activity.

4. The study finds that RPS programs significantly increase average retail electricity prices, with prices increasing by 11 percent (1.3 cents per kWh) seven years after the policy's passage into law and 17 percent (2 cents per kWh) twelve years afterward. All in all, seven years after passage, consumers in the 29 states had paid $125.2 billion more for electricity than they would have in the absence of the policy.

5. On the other side of the ledger, RPS programs increase renewable generation. In states with RPS policies, renewables' mandated share of generation increased about 1.8 percentage points seven years after passage into law the start of the program and 4.2 percentage points twelve years after passage. The study finds that that increased renewable generation shares result in reduced carbon intensity of the electricity grid in states with the policy.

6. However, these reduced emissions came at a high cost. The study found that the cost of abating carbon emissions through an RPS policy is more than $130 per metric ton of $CO_2$ and as much as $460 per metric ton of $CO_2$. This is several times higher than conventional estimates of the benefits of reducing a metric ton, or the social cost of carbon (SCC). The Obama Administration's central estimate of the SCC is roughly $50 per ton in today's dollars. A second point of comparison comes from the cost of abating a metric ton of $CO_2$ in current cap-and-trade markets in the US: it is about $5 in the northeast's Regional Greenhouse Gas Initiative (RGGI) and $15 in California's cap-and-trade system.

## Introduction

While the United States has had trouble coming to a consensus on broad-reaching climate policy, states have been successful in passing Renewable Portfolio Standards (RPS), which require that a percentage of electricity generation come from renewable sources. By 2009, 29 states and the District of Columbia had adopted mandatory RPS policies. These programs currently cover 64 percent of the electricity sold in the United States. In recent years, states have greatly ramped up their ambitions for these programs. For example, by 2030, the Massachusetts RPS will require 41 percent of its electricity come from renewable sources; the New York RPS will require half its electricity to come from renewables; and the California RPS will require 60 percent of its electricity to come from renewables.

RPS programs are viewed as having helped to expand the penetration of renewable technologies, with the share of electricity coming from wind and solar increasing by some estimates from 0.1 percent in 1990 to 5.3 percent in 2015. This leads one to believe that they have been successful in reducing carbon emissions. Of course, a raft of other policies, including federal production and investment tax credits along with technological advances have played important roles too.

To date, however, reliable evidence on RPS programs' bang for their buck has not been available. Previous research has only focused on the differences in generation costs and concluded that RPS programs have only marginally increased electricity costs. For example, studies have compared the costs of a renewable plant with the costs of the least expensive source of power that they would have replaced.

However, this approach misses three key ways in which renewables impose costs on the electricity system and impact retail prices:

First, renewables by nature are intermittent sources of electricity. Solar plants cannot provide power when the sun doesn't shine and wind plants cannot provide power when the wind isn't blowing. As a result, any calculation of the costs associated with these sources must take into account the cost of constructing and running back-up power—often natural gas plants that can be quickly and relatively inexpensively switched on and off as needed.

Second, renewable sources—solar and wind power in particular—take up a lot of physical space, are geographically dispersed, and are frequently located away from population centers. These factors raise transmission costs—possibly by about $300 per kW, according to one study by the Lawrence Berkeley National Laboratory, or 1.5 cents per kWh. Further, a 2011 analysis by the Edison Electric Institute found that 65 percent of planned transmission investments over a ten-year period, totaling almost $40 billion for 11,400 miles of new transmission lines, were primarily directed toward integrating renewable generation.

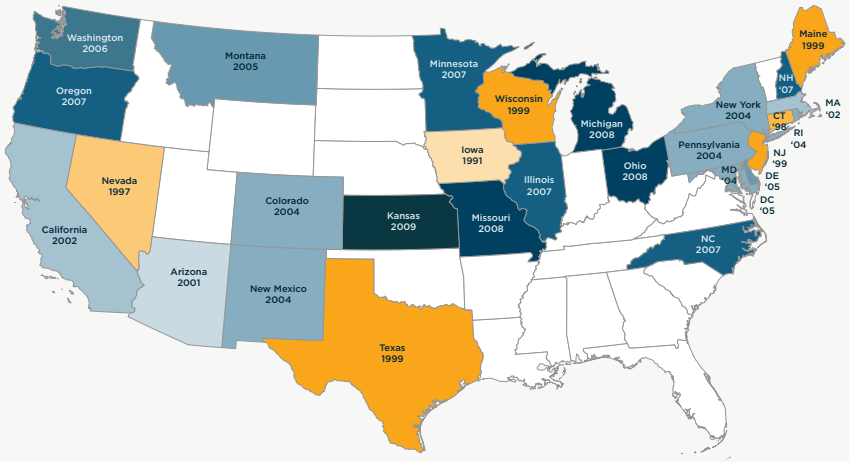
Third, in forcing an increase in renewable power, an RPS program can prematurely displace existing baseload generation. Though this is an intended effect of RPS policies in that it 'replaces dirtier fuels with cleaner ones, the costs of these early retirements or decreased utilization—so called "stranded assets"—do not disappear and are borne by some combination of ratepayers and owners of capital.

## Research Design

This study compares states with and without RPS policies. It does so using the most comprehensive state-level data ever compiled on these outcomes and RPS program characteristics, covering the period from 1990 to 2015. The study estimates the impacts of the RPS policies on electricity prices, electricity consumption, renewable penetration, carbon emissions, and economic activity. It uses data from all 29 states and the District of Columbia that have initiated programs since 1990. Importantly, it takes into account variation in when the programs were adopted. This allows the authors to account for pre-existing trends between adopting and non-adopting states. Additionally, the study uses data on electricity generation by state and fuel source, along with average fossil fuel cost and compiles a yearly panel of state emissions from electricity generation.

The focus on electricity prices is a solution to the problem that it is nearly impossible to directly measure each of the mechanisms by which RPS policies influence costs. That is, prices should reflect all costs. A limitation is that this approach does not provide any evidence on the share of the costs that are borne by owners of capital.

**Figure 1** · RPS Passage by State




States that have adopted any RPS policy are colored according to the year in which the RPS legislation was first passed.
Sources: US Department of Energy and state government websites.

# Findings

**1. RPS programs significantly increase retail electricity prices.**

Seven years after legislation creating an RPS program, retail electricity prices are 11 percent higher on average (1.3 cents per kWh), or about $30 billion annually across the 29 states. Twelve years afterward, prices are 17 percent higher on average (2 cents per kWh). In total, seven years after the start of the programs, consumers in the 29 RPS states paid $125.2 billion more for electricity than they would have in its absence.

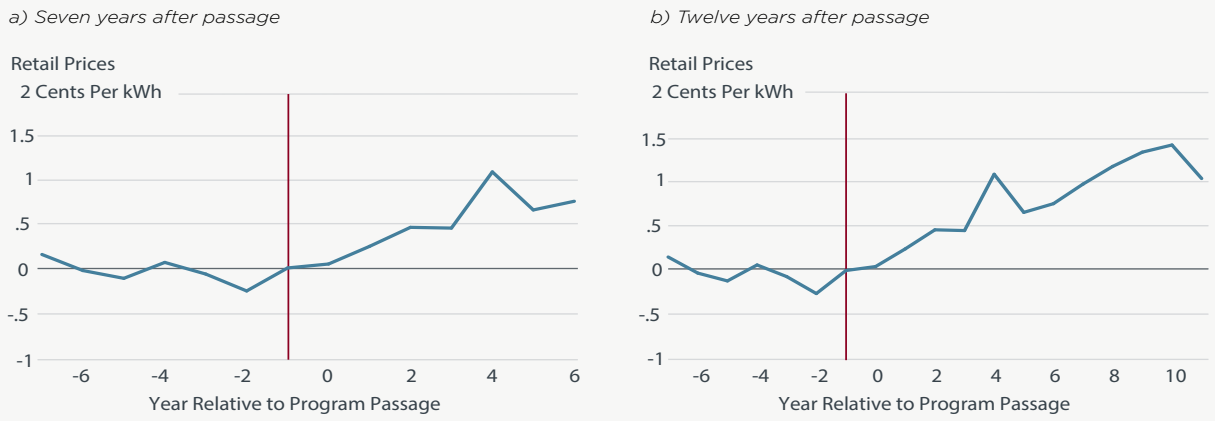
The residential sector saw the largest increases, though prices also rose in the commercial and industrial sectors. The increases in price don't have an impact on electricity consumption or state-level employment.

**2. RPS programs mandate increases in renewables' share of electricity generation.**

In states with RPS policies, renewables' share of generation increased about 1.8 percent seven years after passage, and 4.2 percent twelve years afterwards. These figures are net of renewable generation that was already in place at the time an RPS was implemented.

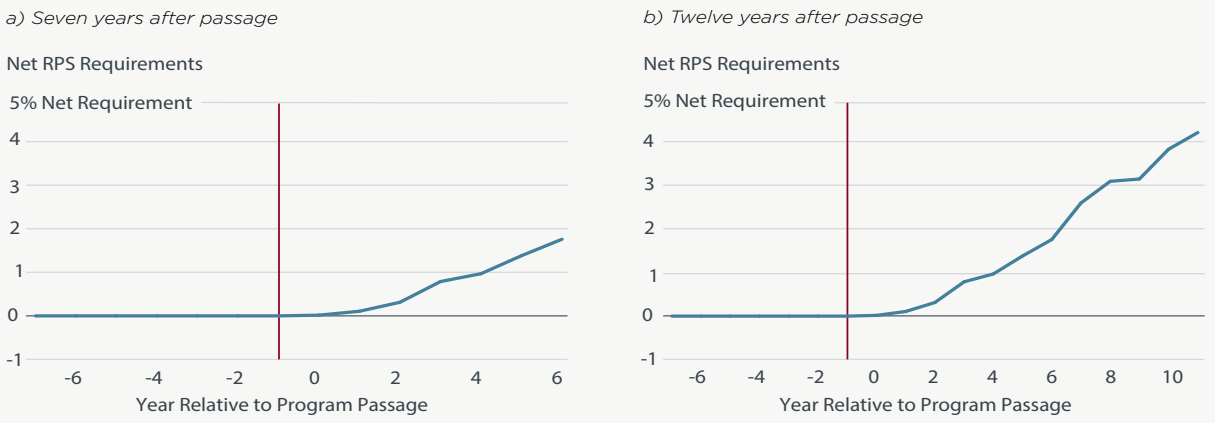
This analysis focuses on net generation in order to accurately account for the direct effects of RPS policies. That is, RPS policies frequently overstate their impact on renewable penetration by including generation that existed at the time of the policy's passage. For example, six years after Minnesota adopted its RPS policy, its total requirement was that renewables account for 14.2 percent of generation. Yet, at the time of adoption, renewables already accounted for 5.3 percent of generation. So, its net requirement in this year was 8.9 percent.

**Figure 2 ·** Estimated Effect of RPS Programs on Retail Electricity Prices




The cost per kWh for electricity in the (a) seven and (b) twelve years before and after the passage of legislation enacting an RPS policy, with the vertical line marking the time of passage.
Sources: EIA; LBNL; Department of Energy and state government websites.

**Figure 3 ·** Estimated Effect of RPS Programs on Net Renewable Requirements



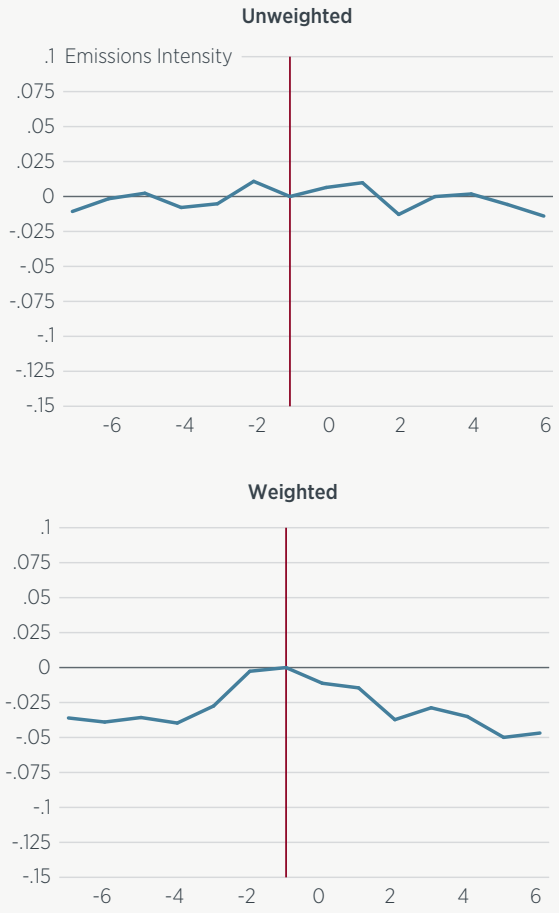

The change in net renewable generation in the (a) seven an (b) twelve years before and after the passage of legislation enacting an RPS policy, with the vertical line marking the time of passage.
Sources: EIA; LBNL; Department of Energy and state government websites.

**3. RPS programs do reduce emissions, but at a high cost.**

In increasing the share of renewable generation, the states with an RPS policy saved 95 to 175 million tons of carbon emissions seven years after the start of the programs. This was driven by a decrease in the carbon intensity of electricity supply in RPS states.

However, this study finds that the cost of reducing carbon emissions through an RPS policy is more than $130 per ton of carbon abated and as much as $460 per ton of carbon abated—significantly higher than conventional estimates of the social and economic costs of carbon emissions. For example, the central estimate of the Social Cost of Carbon (SCC) tallied by the Obama Administration is approximately $50 per ton in today's dollars. A second point of comparison comes from the cost of abating a metric ton of CO2 in current cap-and-trade markets in the US: it is about $5 in the northeast's Regional Greenhouse Gas Initiative (RGGI) and $15 in California's cap-and-trade system.

**Figure 4 ·** $CO_2$ Emissions Intensity Before and After RPS Passage




The intensity of $CO_2$ emissions in the seven years before and after the passage of legislation enacting an RPS policy, with the vertical line marking the time of passage.
Sources: EIA; LBNL; Department of Energy and state government websites.

It is important to note that ongoing research is currently seeking to update the social cost of carbon based on the explosion in scientific and economic literature that has occurred in recent years (See impactlab.org). This is important, because future updates to these estimates will provide additional opportunities to evaluate the cost effectiveness of all climate policies, including RPS programs.

> "The increasing urgency of climate challenge means that the case for ruthlessly seeking out the least expensive reductions in carbon emissions is rapidly strengthening. This study joins a growing body of evidence that demonstrates that when climate policies favor particular technologies or target something other than the real enemy—carbon emissions—the result is less effective and more expensive than is necessary. In contrast, the global experiences from carbon markets and taxes make clear that much less expensive ways to reduce CO2 are available right now."
>
> **MICHAEL GREENSTONE**
> **MILTON FRIEDMAN DISTINGUISHED SERVICE PROFESSOR IN ECONOMICS**

## Policy Implications

These results suggest that while RPS programs are successful in reducing carbon emissions, they do so at a higher cost than is necessary. The available evidence indicates that alternative technology neutral policies, like carbon taxes and cap-and-trade systems, can deliver much larger reductions in carbon per dollar of cost. Cost effectiveness is important, because the appetite for devoting resources to reducing carbon emissions is limited, especially in today's developing countries where future growth in energy consumption is projected to occur.

RPS policies have goals beyond reducing carbon emissions, such as spurring improvements in renewable technologies and improving the growth of these sectors of the economy. The study did not analyze the extent to which RPS policies have succeeded in meeting these goals. The authors note, however, that if RPS policies reduce renewable costs industrywide, then this would alter any cost-benefit analysis. The analysis also does not assess the impact of RPS policies on criteria pollutants. However, these pollutants are subject to national limits, which are enforced at the county level by the Environmental Protection Agency.

For an evalutation of an energy efficiency policy, read: *"Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program."*

### About EPIC

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