

RPS Policy Impacts on Bioenergy

IAEE 2019 - Montreal

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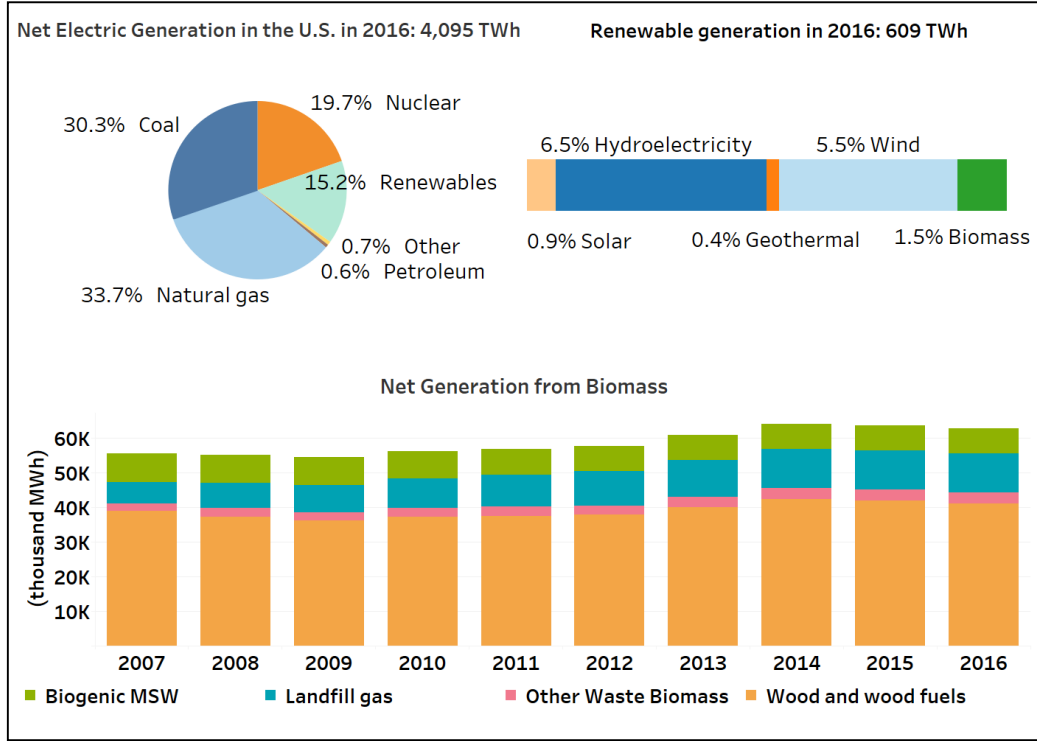
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Summary

- Question: Do RPS policies effect the use of biomass for electricity generation?
- Approach: Estimate a difference-in-differences (DID) model in conjunction with the synthetic control method (SCM).
- Result: On average, RPS policies do not have significant impact on biomass consumption for electricity generation (for six states).
 - Results differ from state to state.

Bioenergy in the U.S.



Source: EIA Form 923

RPS States for IAEE Analysis

- Summary of RPS policies in the US
 - 29 state RPS policies, D.C., and 3 territories.
 - 8 states and 1 territory with renewable energy goals (voluntary)
 - Most targets are less than 50% (CA, HI, MA, NJ, NY, OR, VT >50%)
- In this study, we focus specifically on entities firing primarily biomass in the states listed below (excludes co-firing)

State	RPS Enactment	Revision
Maine (ME)	1997	2009
New Hampshire (NH)	2007	2012
North Carolina (NC)	2007	2011
Oregon (OR)	2007	2009; 2016
Vermont (VT)	2005	-
Washington (WA)	2006	-

- **EIA Form 923**

- Collects information on net generation, fuel consumption, fossil fuel stocks, and receipts at powerplant and prime mover level.
- Window of observation: 2001 to 2016
- Outcome of interest: Fuel consumption for electricity generation:
 - Biomass facilities where biomass is the primary fuel
 - Other renewables

- **Difference-in-Differences (DID):**

- First Difference: Before vs. After RPS
- Second Difference: RPS vs. non-RPS plants or states
- DID with only biomass:

$$Y_{it} = \beta_0 + \beta_1 RPS_i + \beta_2 Post_t + \beta_3 RPS_i * Post_t + \varepsilon_{it}$$

- DID with biomass and other renewables:

$$Y_{it} = \beta_0 + \beta_1 Post_t + \beta_2 RPS_i * Bio_i + \beta_3 RPS_i * OthRenew_i + \beta_4 RPS_i * Bio_i * Post_t + \beta_5 RPS_i * OthRenew_i * Post_t + \varepsilon_{it}.$$

- **Synthetic Control Method (SCM)**: Use pre-RPS observations to estimate a weight matrix for the control group that minimizes the “distance” between the RPS and non-RPS observations.
 - Examples: (Abadie & Gardeazabal, 2003) and (Abadie et al., 2010)
- **Advantages of Synthetic DID empirical strategy**:
 - Data-driven approach to control group selection
 - Time-varying unobserved heterogeneity is controlled if a long pre-treatment period can be fitted with the model
 - Estimates a counterfactual
 - (Arkhangelsky et al., 2018)

Results: State-Level DID

State-level	Fuel Consumption for Electricity Generation (mmBTU)			
	(1)	(2)	(3)	(4)
RPS	3.682*		4.467*	
	(1.934)		(2.437)	
RPS*Bioenergy	8.382**	8.394*		
	(3.982)	(4.040)		
RPS*Other Renewables	-1.345	-1.326		
	(2.222)	(2.260)		
RPS*Bioenergy*Post	-1.625	-1.509	-2.411	-2.517
	(2.546)	(2.608)	(2.945)	(3.024)
RPS*Oth. Renew.*Post	13.39	13.38	26.11*	25.99*
	(8.751)	(8.922)	(13.04)	(13.23)
Observations	463	463	463	463
R-squared	0.128	0.155	0.304	0.397
Year FE	No	Yes	No	Yes
State FE	No	No	Yes	Yes
Number of sid			36	36

Results: Plant-Level DID

Plant-Level	Fuel Consumption for Electricity Generation (mmBTU)			
	(1)	(2)	(3)	(4)
RPS	-0.0630 (0.187)		-0.186** (0.0815)	
Post-2007	0.421** (0.155)	0.417** (0.154)		
RPS*Post	-0.146 (0.223)	-0.142 (0.223)	0.0606 (0.0957)	0.0624 (0.0925)
Observations	3,145	3,145	3,145	3,145
R-squared	0.020	0.026	0.014	0.043
Year FE	No	Yes	No	Yes
State FE	No	No	Yes	Yes

Results: Synthetic DID

- Weighting reduces magnitude and significance of the coefficient on **RPS**
- Insignificant effects across five of the six states
- Negative and significant effect in Maine

State	Estimated RPS Effect (mmBTUs / Plant)
Maine	-4.100**
North Carolina	0.0634
New Hampshire	-1.535
Oregon	0.491
Vermont	-2.148
Washington	-2.388

Conclusion

- On average RPS policies do not have a significant effect on bioenergy.
 - RPS policies have a significant and positive effect on generation from other renewables (e.g. wind and solar)
 - State-specific effects vary
 - There may be source-specific effects (i.e. landfill gas), this analysis does not make any conclusions on sector-specific impacts
- **Next Steps:**
 - Expanding analysis to all states with RPS policies
 - Analyzing the “intensive vs. extensive” margins question.
 - Co-firing vs additional capacity where biomass is primary fuel
 - Preliminary analysis hints towards an uptick in co-firing in response to RPS policies

Thank you!

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Results: Maine DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	4.667*** (0.591)	4.632*** (0.557)		
	Post-2009	-0.0419 (0.437)		0.0800 (0.479)	
	RPS*Post	-1.539*** (0.437)	-1.505*** (0.486)	-1.661*** (0.479)	-1.644** (0.535)
	Observations	743	743	743	743
	R-squared	0.044	0.048	0.157	0.160
	Weighted	RPS	2.039** (0.443)	2.142** (0.354)	
Weighted	Post-2009	2.572*** (0.198)		2.424** (0.403)	
	RPS*Post	-4.153*** (0.198)	-4.244*** (0.331)	-4.005*** (0.403)	-4.100** (0.533)
	Observations	226	226	226	226
	R-squared	0.013	0.023	0.018	0.028
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes

Results: New Hampshire DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	2.544*** (0.503)	2.477*** (0.495)		
	Post-2007	-0.112 (0.603)		0.00121 (0.630)	
	RPS*Post	0.760 (0.603)	0.824 (0.633)	0.646 (0.630)	0.696 (0.665)
	Observations	717	717	717	717
	R-squared	0.025	0.031	0.179	0.183
	Weighted	RPS	0.831 (0.453)	0.871 (0.476)	
	Post-2007	0.332 (1.823)		0.524 (1.836)	
	RPS*Post	0.315 (1.823)	0.273 (1.846)	0.123 (1.836)	0.0634 (1.867)
	Observations	244	244	244	244
	R-squared	0.007	0.013	0.055	0.060
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes

Results: North Carolina DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	1.596*** (0.503)	1.568*** (0.486)		
	Post-2007	-0.112 (0.603)		0.00121 (0.630)	
	RPS*Post	-0.742 (0.603)	-0.703 (0.622)	-0.856 (0.630)	-0.824 (0.653)
	Observations	736	736	736	736
	R-squared	0.005	0.012	0.171	0.177
	Weighted	RPS	0.818* (0.372)	0.844 (0.415)	
	Post-2007	0.577 (1.069)		0.733 (0.896)	
	RPS*Post	-1.432 (1.069)	-1.387 (1.070)	-1.588 (0.896)	-1.535 (0.905)
	Observations	332	332	332	332
	R-squared	0.005	0.017	0.064	0.078
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes

Results: Oregon DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	-0.365 (0.503)	-0.320 (0.507)		
	Post-2007	-0.112 (0.603)		0.00121 (0.630)	
	RPS*Post	0.821 (0.603)	0.754 (0.583)	0.707 (0.630)	0.647 (0.616)
	Observations	727	727	727	727
	R-squared	0.001	0.007	0.177	0.182
Weighted	RPS	-0.629 (0.771)	-0.597 (0.759)		
	Post-2007	0.0395 (0.767)		0.217 (0.697)	
	RPS*Post	0.669 (0.767)	0.665 (0.727)	0.492 (0.697)	0.491 (0.671)
	Observations	337	337	337	337
	R-squared	0.005	0.020	0.129	0.137
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes

Results: Vermont DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	5.044*** (0.483)	5.018*** (0.460)		
	Post-2007	-0.358 (0.769)		-0.156 (0.812)	
	RPS*Post	-3.558*** (0.769)	-3.534*** (0.797)	-3.761*** (0.812)	-3.756** (0.848)
	Observations	690	690	690	690
	R-squared	0.011	0.016	0.188	0.193
	Weighted	RPS	3.674** (1.090)	3.562** (1.083)	
	Post-2005	-1.651 (0.929)		-1.625 (0.932)	
	RPS*Post	-2.266* (0.929)	-2.124 (0.996)	-2.292* (0.932)	-2.148 (0.995)
	Observations	217	217	217	217
	R-squared	0.120	0.162	0.165	0.201
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes

Results: Washington DID with SCM

Plant-Level		Fuel Consumption for Electricity Generation (mmBTU)			
		(1)	(2)	(3)	(4)
Unweighted	RPS	-0.0251 (0.451)	-0.0226 (0.434)		
	Post-2007	-0.122 (0.761)		0.0338 (0.799)	
	RPS*Post	0.370 (0.761)	0.357 (0.778)	0.214 (0.799)	0.182 (0.828)
	Observations	755	755	755	755
	R-squared	0.000	0.005	0.169	0.173
	Weighted	RPS	-1.087*** (0.165)	-1.114*** (0.148)	
	Post-2006	2.541 (1.847)		2.661 (1.764)	
	RPS*Post	-2.294 (1.847)	-2.239 (1.946)	-2.414 (1.764)	-2.388 (1.865)
	Observations	282	282	282	282
	R-squared	0.065	0.068	0.114	0.116
	Year FE	No	Yes	No	Yes
	State FE	No	No	Yes	Yes