Corporate Power Purchase Agreements and Renewable Energy Growth

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Overview

The electricity generation portfolio in the U.S. contains a mix of resources that are renewable and nonrenewable. From at least 1950 onward, most of the electricity production has been through means of combustion of fossil fuels, which emit greenhouse gases (GHGs) that have a well-established connection to a warming global climate and a myriad of associated adverse human outcomes. Policymakers have since focused on identifying cost effective mechanisms, both voluntary and involuntary in nature, to reduce the amount of emissions produced by the electricity generation portfolio.

In recent decades, many corporations have responded to investor calls for "environmental, social, and governance" (ESG), and adopted strategies to reduce previously ignored externalities, such as GHG emissions, during normal operating activities. One ESG strategy includes firms entering contractual arrangements for renewable energy (RE). However, existing empirical evidence shows that corporate purchasing of RE certificates (RECs), the dominant type of contractual arrangement, is unlikely to increase the deployment of renewables or reduce GHG emissions.

A power purchase agreement (PPA) is an alternative contractual arrangement that has become increasingly popular in recent years. Although it is frequently asserted that non-utility PPAs accelerate the rate of RE deployment, at present there is a paucity of empirical evidence to back this claim. In this paper, we address this gap in the literature by investigating whether PPAs have had an empirically discernible effect on the amount of RE generation capacity in the electricity grid, including where and in what contexts non-utility and utility PPAs influence RE development.

Methods

Using data on county-level electricity generation capacity over 1990-2021 in the U.S., we use a two-way fixed effects strategy that leverages the spatially and temporarily varying nature of new capacity from RE projects associated with PPAs (PPA capacity, hereafter) to estimate their effects on additions to RE capacity. The primary outcomes of interest include total RE generation capacity, total RE capacity share, and wind and solar generation capacity separately (note that we define RE capacity as capacity from solar, wind, hydro, geothermal, and biomass sources). For RE capacity outcome y in county i and year t, our baseline estimating equation is:

$$y_{it} = \beta_1 Cap_{NonUtil\ PPAs_{it}} + \beta_2 Cap_{Util\ PPAs_{it}} + \beta_3 Cap_{Joint\ PPAs_{it}} + \boldsymbol{X\delta} + \gamma_i + \lambda_t + \epsilon_{it}. \quad (1)$$

The variables of interest are the PPA capacity terms (Cap), which reflect the total capacity from new PPAs by power purchaser type and include solar and wind projects. We also include a rich set of control terms, $\boldsymbol{X}$, which reflect county-level demographic conditions, state-level energy regulations, and local access to competing fuels for electricity generation. Lastly, we include county and year fixed effects, γ_i and λ_t, to control for average differences in RE investment and other factors affecting RE investment across space, and time-specific confounders common to all counties. The PPA capacity coefficients estimate the effect of an additional MW of PPA capacity from non-utility, utility, and joint (non-utility and utility) power purchasers on the RE capacity outcome of interest.

We also disaggregate the PPA capacity terms based on the nature of the RE project (i.e., solar and wind), and estimate separate specifications for solar and wind outcomes, respectively. Hence, $\forall g \in \{solar, wind\}$, we estimate:

$$y_{git} = \beta_1 Cap_{NonUtil\ PPAs_{git}} + \beta_2 Cap_{Util\ PPAs_{git}} + \beta_3 Cap_{Joint\ PPAs_{git}} + \boldsymbol{X\delta} + \gamma_i + \lambda_t + \epsilon_{it}. \quad (2)$$

The coefficients on these terms provide estimates of the effects from an additional MW of solar (wind) PPA capacity by power purchaser type on the solar (wind) capacity outcome of interest.

Results

The first effects of interest relate to total new PPA capacity disaggregated by power purchaser entity type on total RE capacity. We estimate that an additional MW of new PPA capacity, irrespective of generation technology, is associated with increases of 1.569, 1.394, and 1.348 MW in total RE capacity for non-utility, utility, and joint PPAs, respectively (each $p < .01$). Only the effect for non-utility PPAs is statistically larger than one ($p < .05$), which suggests that only non-utility PPAs are associated with additionality (i.e., RE investment spillovers on total RE capacity) in aggregate.

The second effects of interest relate to new PPA capacity disaggregated by generation technology and power purchaser entity type. For solar, we estimate that an additional MW of solar PPA capacity is associated with increases of 1.583, 2.285, and 1.888 MW in total solar capacity for non-utility, utility, and joint PPAs, respectively (each $p < .01$). For wind, we estimate that an additional MW of wind PPA capacity leads to increases of 1.1, 0.919, and 0.911 MW in total wind capacity for non-utility, utility, and joint PPAs, respectively (each $p < .01$). However, only the effects for solar PPAs are statistically larger than one ($p < .01$), which suggests that all solar PPAs are associated with some degree of additionality in solar capacity (i.e., RE investment spillovers), whereas the relationship between wind PPAs and new wind capacity is mechanical (i.e., proportional) in nature.

Lastly, we conduct heterogeneity analyses to further understand the relationship between PPAs from each entity type and changes to the U.S. RE portfolio. To do this, we estimate the same general specifications as in equation (2) but include interactions between the PPA capacity terms for each entity type with terms that indicate whether the county the project is in has above (below) median solar and wind resource potential, respectively.

For solar PPA capacity, we find that the influence of PPAs varies by power purchaser entity type across the distribution of resource potential. For PPAs in counties with below median resource potential, an additional MW of non-utility solar PPA capacity is associated with a 1.233 MW increase in total solar capacity ($p < .01$, an effect that is not significantly different than one, $p = .106$). For PPAs in counties with above-median resource potential, we find they are associated with an increase of 1.598 MW in solar capacity, an effect that is statistically larger than one ($p < .01$). These findings suggest a mechanical relationship exists between non-utility PPAs and solar capacity in areas with lower resource potential, and the additional benefits of non-utility solar PPAs are driven by those signed in areas with greater resource potential.

For utility solar PPAs, we find that the effects vary more considerably based on the resource potential of the county. In column 4, we find that an additional MW of utility solar PPA capacity in counties with below median resource potential is associated with a 0.533 MW increase in solar capacity ($p < .01$), an effect that is statistically less than one ($p < .01$). For counties with above median resource potential, we find a much larger effect. We estimate an additional MW of utility solar PPA capacity in these counties is associated with a 2.332 MW increase in solar capacity, an effect that is statistically different than one ($p < .01$). These results suggest that the influence of utility solar PPAs is almost entirely driven by those signed in areas with greater solar resource potential.

For wind PPA capacity, we find that an additional MW of non-utility wind PPA capacity in counties with below median resource potential is associated with a 1.311 MW increase in total wind capacity (an effect that is marginally statistically larger than one, $p < .10$). However, we find no differential effect of such PPAs in counties with above median resource potential. For utility PPAs, we find the effects are more limited in nature, and are not associated with any degree of additionality, likely due to the more limited number of wind PPAs signed for utility-scale projects.

Conclusions

Collectively, our results suggest that PPAs are associated with an aggregate increase in the deployment of RE capacity, compared to counties absent such PPA activity. However, the effects are heterogeneous in three important ways. First, the effects of PPAs vary based on the power purchaser entity type. Second, the effects vary based on whether the PPAs are signed for solar or wind projects. Third, the effects of PPAs across both entity and RE project type are sensitive to the renewable resource endowment of the area. These findings offer valuable insights into the efficacy of PPAs in providing public good benefits and may serve as an aid for the decision making of governmental policymakers and non-governmental initiatives seeking to accelerate investment in RE. For example, given that non-utility PPAs demonstrate greater flexibility in their usage, incentivizing investment in non-utility PPAs might be conducive to enhancing the expansion of RE into areas where it may otherwise take longer to develop. Lastly, we provide directions for future research on PPAs.