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The determinants of wind energy growth in the United States: Drivers and barriers to state-level development

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ABSTRACT

The focus of this paper is to analyse the determinants of wind energy development in the United States and how procedural and regulatory frameworks influence the deployment of wind power facilities. The empirical analysis uses statistical regression models integrating geospatial, macroeconomic and socio-environmental control variables. Using wind penetration as well as wind capacity additions as dependent variable permits a more differentiated analysis of both absolute and relative growth factors. This enables a precise assessment of state-to-state variations in permitting, zoning and siting procedures that wind developers have to clear before being authorised to start construction. Quantifying the number of state-level financial support measures and various permitting and regulatory process stages allowed for a more comprehensive assessment of administrative barriers to wind energy development than prior research studies. The results indicate a partial reversal of previous findings that showed that a high quantity of state-level regulations negatively affects wind capacity additions. Exogenous factors such as the ratio of in-state federal lands, population density, and especially wind energy potential, as well as federal statutes and incentives remain the main drivers of wind capacity additions and overall wind energy penetration. Contrasting prior literature, the influence of localised financial incentives or regulatory approval procedures appears to be minor; therefore streamlining national policies and incentives at the federal level might prove more effective than promoting wind development at the state level. We point out that future research should also examine the role of quality of state-level regulations in addition to quantity.

1. Introduction

Renewable energy (RE) development has experienced significant growth in recent years in the United States. The majority of this came from the expansion of wind energy, with onshore capacity additions amounting to a 48% increase from 60,005 MW to 89,078 MW between 2012 and 2017 [1]. Congress has been supporting the transition towards clean and less carbon-intensive energy solutions with several federal measures. Most notably through an industry-wide federal renewable electricity production tax credit (PTC), which has led to a dramatic increase in private-investment driven growth in the wind energy sector [2,3]. In light of increasingly deteriorating climate change indicators, RE development has become a core component of most comprehensive greenhouse gas (GHG) emission mitigation scenarios [4].

2016 gained notoriety in recent history as the warmest year on record, accompanied by multiplying indicators of intensifying climatic upheavals, including observations of sharp drops of Arctic ice cover [4]. Therefore RE support is considered one of the most effective and efficient strategies against anthropogenic climate change, which threatens numerous ecosystems and vulnerable communities [5]. It represents a strong mitigation tool to lower energy-related output of carbon dioxide and other GHGs into the atmosphere [5]. The 5th Intergovernmental Panel on Climate Change (IPCC) Assessment Report, the Sustainable Development Goals (SDGs) as well as the Paris Climate Agreement have further solidified the importance of shifting away from fossil fuel-based carbon-intensive forms of energy generation towards carbon-neutral RE solutions [5,6].

Abbreviations: BGEPA, Bald and Golden Eagle Protection Act; CREZ, Competitive Renewable Energy Zones; DEM, Majority Democratic Representation; ESA, Endangered Species Act; EPACT, Energy Policy Act; ER, Environmental Regulations; FEVD, Fixed Effects Vector Decomposition; FI, Nr. of State-level Financial Incentives; FLR, Ratio of Federal Land Area; LA, Total State Land Area; MBTA, Migratory Bird Treaty Act; ORD, Nr. of State-level Wind Ordinances; PD, Population Density; PPA, Power Purchase Agreements; REP, Majority Republican Representation; RM, Nr. of State-level Regulatory Measures; TD, Average Distance of State-level wind power capacities to Transmission Lines; WC, Wind Capacities; WDI, Wind Development Indices; WP, Wind Penetration; WPT, Wind Potential

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However, the expansion of RE projects has been facing re-emerging obstacles in some regions, most notably the United States under the revised environmental priorities of the Trump administration [7–9]. This will render efforts to maintain the increase of global temperatures below 2 °C more challenging [10]. Previous commentators have discussed the prospect of alleviating confrontational trends such as local stakeholder opposition by reducing the number of administrative burdens and barriers, hence allowing the approval and development processes to be sped up and become less costly [11,12]. This 'green v. green' issue between advocates of GHG emission reductions and those concerned about local environmental impacts, such as bat and bird deaths or public health threats like low-frequency noise, is at the heart of the ongoing policy debates on what instruments are most suited to expand wind energy while at the same time addressing public concerns [11,12]. As a consequence, the enactment of environmental regulations has become a point of contention of both wind energy development proponents and opponents. The former argue that a panoply of environmental rules and regulations affecting wind will hinder further expansions while the latter contend that these are necessary in light of the potential environmental and socio-economic risks emanating from wind turbines [11,12]. This paper will contribute to this discussion by providing the most comprehensive analysis to date of whether the quantity of regulations affecting wind, primarily at the state-level, and to some extent at the county level, significantly influences state-level wind energy growth.

It has already been documented that policies at the federal level act as a major catalyst of comprehensive RE development. A particularly impactful example is the federal production tax credit (PTC) [13]. The latter was originally adopted in 1992 through the Energy Policy Act (EPACT) and is currently set at $0.023/kWh for wind, geothermal, and closed-loop biomass, $0.012/kWh for other eligible technologies, and applies to the first ten years of operation [13]. Previous studies have outlined in detail the preeminent role and influence of this policy tool in increasing deployment of wind energy [2,14]. This also inadvertently led to boom-bust cycles that coincided with the respective PTC extensions and expirations [2,3,15]

However, federal support measures such as the PTC remain the exception and are highly volatile in terms of implementation, with the latter and other federal financial or regulatory measures such as the Clean Power Plan (CPP) either being on halt or subject to revisions. Given the political shifts under the conservative-leaning Congress, the White House, and government agencies, the focus on future state-level wind energy barriers and incentives will become more accentuated [11,12]. The absence of comprehensive federal regulatory frameworks is partially offset by state-level rules. However, they do not always define local government powers, which at times results in the development of wind facility projects being stifled due to an unintended regulatory maze created by a lack of uniform procedures and standards [16]. State policies affecting wind energy development show significant variances regarding the structuring of energy policy frameworks and permitting procedures. With many determinants influencing overall RE growth, the objective of this paper is to analyse some of those that face the most criticism among developers. One of these is the number of environmental regulations in the permitting process and siting procedural frameworks such as ordinances [17,18]. Regulations mandating environmental impact statements or imposing stringent rules with regards to rare species protection, environmental health impact considerations, land use or procedural justice can act as barriers to wind energy development [19–22]. Henceforth, they bear the potential to stifle both RE growth and GHG mitigation efforts [19–22].

Therefore, analysing to what extent state-to-state variances in wind energy growth and overall electricity generation share can be attributed to the presence or absence of environmental regulations will permit a deeper understanding of the exogenous factors that impact wind energy development – more specifically large-scale installations – the most and whether or not procedural streamlining reforms of environmental provisions or reductions of regulations could act as a RE support mechanism. In the United States, local zoning laws are one of the primary planning and siting vehicles that determine where installations can be placed [24]. In part to address the public opposition to wind farms, largely due to their proximity to residential areas and to provide clarity to developers, numerous states established clear and uniform wind siting requirements or guidelines instead of delegating it to local authorities [16,24]. States thereby adopted two main approaches, falling either into the "Dillon rule" or the "home rule" groups. The "Dillon rule" generally delegates siting authority to state agencies (e.g. public utility commissions or siting councils and boards) often in conjunction with local authorities. A majority of states that adopt this approach may limit local authority through state law, such as setting generating capacity thresholds before state regulatory involvement is authorised, for example Washington State [16,24]. In 25 states, the siting of wind facilities requires approval by state or local government bodies depending on size while five states reserve the power to regulate the siting of all wind facilities, regardless of size [16]. The second approach, most often found in "home rule" or "local control" states, cedes siting authority to local governments. In these states, local governments have substantial autonomy to regulate the siting of most wind facilities through their traditional land use authority. 20 states adhere to the "home rule", with 15 of those states, including Texas, having no process or legislation specifically addressing wind facilities [16].

Regulatory requirements in the forms of zoning, planning, siting rules constitute fundamental components of wind energy project development. Whether they are performed at the state or county level, several states have begun implementing structured streamlining measures for these procedural steps and centralise them at the state-level [25]. Permitting, zoning, planning and siting are essential elements in assuring that a wind energy project takes account of not only environmental but socio-economic factors as well. This will guarantee that the construction, operation, and the decommissioning of projects occur in the least intrusive manner possible and respect local requirements [25]. With wind resources varying as much within a state as they do across states and zoning laws often being set at the county level, we are attempting to also weigh county-level factors by taking into account these differences through the integration of local ordinances [23]. Ordinances include provisions concerning permits, approvals, operation, and oversight of wind energy installations [26]. We opted for a primarily state-level analysis because under the Trump administration, the importance of state-level action has progressively been increasing especially as tax credits have been reformed and environmental regulatory interventions through federal agencies, most notably the Environmental Protection Agency (EPA) under Scott Pruitt, have decreased [27,28].

This paper addresses these questions through econometric analysis taking into consideration that numerous factors influence state-level installed wind capacity (WC) and wind energy penetration (WP) figures. Therefore a comprehensive overall assessment, of how the number of specific environmental regulatory requirements in state-level wind energy permitting and siting processes contributes to the deployment of large-scale wind energy facilities, will allow us to identify any potential correlations between WC/WP[1] and environmental regulations. Most of the existing literature (see Table 1) deals with the effects of RE policies in general, without any specific focus on wind energy [31,36].

Moreover, most of the existing empirical studies concentrate in large parts on individual policies such as renewable portfolio standards (RPS) [34–39] or electricity market regulation elements such as Mandatory Green Power Options (MGPO) [40]. Hitaj [31] does cover a considerable number of policies at the state and county levels, however environmental components or permitting procedural steps are excluded

[1] Throughout the text WC/WP signifies 'WC and WP', not 'WC divided by WP'.