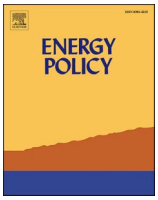
Energy Policy 153 (2021) 112279

Contents lists available at ScienceDirect

Energy Policy

journal homepage: http://www.elsevier.com/locate/enpol



Measuring the impacts of wind energy projects on U.S. rural counties' community services and cost of living

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ARTICLE INFO

Keywords:
Wind energy development
Descriptive statistical
Semi-structured interview
Documents analysis
Rural communities
Community services

ABSTRACT

Wind power development has rapidly expanded in rural areas in the United States. Numerous studies addressing the impacts of wind development on rural communities focus on overall economic, environmental, and social effects (Brown et al., 2012; Kahn, 2013; Mulvaney et al., 2013). This research builds on those to add the impacts of substantial wind power development on community services and the cost of living, focusing on eleven rural counties with wind energy development over 1000 MW in five different states in the U.S. The research uses descriptive statistical analysis to document county-level changes in the population size, employment, and poverty rate before and after hosting substantial wind projects from 1990 to 2015. Qualitative analysis of interviews and county documents identified data on and perceptions of the impacts of the wind projects on tax revenues as well as community services. We find that wind development tax income improved community services without any noticeable increases in required community services or cost of living. From a policy perspective, these results are most relevant for local governors and planners, who seek to balance the cost and benefits of wind farms to the rural community.

1. Introduction

The United States' cumulative installation of wind power capacity increased from 2.6 Gigawatts (GW) in 2000 to 97.6 GW by 2018 (American Wind Energy Association's [AWEA], 2019). Much of this growth occurred in rural areas because of the availability of land and wind speed for wind turbines (Logan and Kaplan, 2008). Rural counties have nearly half of the total wind power capacity in the U.S (Mauritzen, 2020). The development of the wind energy sector is often promoted as a means of supporting rural economies (Phimister and Roberts, 2012; Government Accountability Office [GAO], 2004; Logan and Kaplan, 2008). Turbines undoubtedly bring local tax income, but the net costs to the community are less clear. This paper focuses on the effect of wind development on community services and cost of living in rural communities in the U.S to measure the impact of wind power investment on the community.

The impact of wind power on rural communities has been an active topic of research, in Europe and the U S. Most of the literature in Europe and the U.S estimates the hypothetical economic impacts of wind projects at regional or national level using simulation methods, most commonly input-output based economic impact models (Lehr et al., 2008, 2012; Slattery et al., 2011; Reategui and Hendrickson, 2011; Reategui and Tegen, 2008; Lantz, 2009). These models generally tend to be aggregated, without considering the geographic and spatial distribution of economic effects.

Community services and cost of living research has explored impacts on economic growth, municipal finance and schools' income, housing and property values, transportation and traffic issue during the construction phase of wind projects. Research measuring the ex-post impact at the local level for U.S. rural counties has generally found a strong association between wind power projects and economic growth in rural counties, measured by an increase in personal income, wages, employment, and municipal finance, suggesting that wind projects could be beneficial for rural economies (Brown et al., 2012; William et al., 2008; Kahn, 2013; De Silva et al., 2016; Mauritzen, 2020). Wind energy projects tend to decrease the property tax rate and increase the tax base (Kahn, 2013; De Silva et al., 2016) and provide higher local schools revenues than non-wind-power counties (Kahn, 2013; Castleberry and Greene, 2017; Loomis and Aldeman, 2011). In addition to the expected tax income from wind projects, many developers also allocate funds for

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https://doi.org/10.1016/j.enpol.2021.112279
Received 23 June 2020; Received in revised form 23 March 2021; Accepted 24 March 2021
Available online 8 April 2021

the community to compensate for the project impacts, as well as to build trust with the community. This is a common case in the Scotland and Wales, United Kingdom (Kerr et al., 2017; Bristow et al., 2012; Aitken, 2010; Castleberry and Greene, 2017). For example, Bristow et al. (2012) found that two-thirds of the wind projects in Wales, U.K, provided a benefit fund for community improvement projects.

The effect of wind power projects on housing and property value has been studied extensively, mainly through hedonic econometric models (Hoen et al., 2011, 2015; Lang et al., 2014). Results are mixed. Several recent studies in Europe found that wind farm visibility reduces local house prices (Gibbons, 2015; Jensen et al., 2018; Sunak and Madlener, 2016). In contrast, two studies did not find impacts on home prices surrounding wind facilities in Cornwall, United Kingdom (Sims and Dent 2007; Sims et al., 2008) and no significant impact was also found in United States and Canada (Vyn and McCullough, 2014; Hoen et al., 2015; Lang et al., 2014; Hoen and Atkinson-Palombo, 2016). Timing seems to matter. Two studies in the U.S found that the announcement of wind projects reduced the selling price of property, but they found no effect on the property values near the wind farm after the wind farm entered the operational stage (Laposa and Mueller, 2010; Hinman, 2010). Qualitative work in Brannstrom et al. (2011), which used semi-structured interviews with landowners, government officials, and local businesses and residents, identified a perception of increases in housing rental prices and cost of living prices due to wind projects, which hurt non-landowning residents.

The construction of wind farms requires the transport of very large wind turbine components, creating increased and unexpected loads on rural roads and bridges which are typically not designed for such loads (Astroza et al., 2017, p, 1). Greene and Geisken (2013) stated a local officials' concern about road conditions during the construction phase of wind projects in the City of Weatherford, Oklahoma, and they reported that the developers agreed to take responsibility for any damage. Jacquet and Stedman (2013) reported some residents' concerns about traffic issues during the construction phase of wind projects in two counties in Northern Pennsylvania.

In summary, according to the reviewed literature, wind projects have a positive impact on overall economic growth, municipal finance, and revenues for locally-funded schools. At the same time, research tends to find no permanent significant impact on property value although this issue is less settled. Road traffic occurs during the construction phase, but is temporary. What is less well understood is the net-effect of wind projects on community services and costs of living, taking into account service needs in comparison to revenues generated. From a planning perspective, there are two general kinds of local service: turbine-related (new land use services), and resident services (Spicker, 2009; Ervin, 1978). Turbine-related services are roads, fire protection, and safety, while resident services relate to the needs of new residents – schools, housing, recreation areas, and water and sewer. Turbine-related services are considered to be immediate services as opposed to long-term resident services that happen with any turbine-related population growth. To predict the residential services demands from wind power projects requires an accurate prediction of employment and population growth stemming from the new development. As it pertains to both kinds of services, one must ask: Who will pay for the services, and when? Problems arise when the growth in tax income is surpassed by an increase in service demands, or when there is a mismatch in the timing of revenue flows and costs. While increases in tax base can be expected to improve a town's ability to provide services, in fact, the impact of wind projects on a community's services is related to increases or changes in demanded services. It is also related to the funding and maintenance of those services through the tax and income revenue of such wind projects. As a result, a fuller understanding of the impact on community services requires attention to a broader range of impacts such as impacts on employment, population, and tax base. For this, the paper uses descriptive statistical analysis to measure the impacts of wind projects on the population and employment.

2. Research question

This paper focuses on measuring wind projects' impacts on community or local governmental services. These are the services a municipality provides to its residents and businesses such as road services, police, fire, schools, recreation areas, and water and sewer. To answer this overall main question, What are the impacts of substantial wind power projects on local government services and cost of living?, the research investigates sub-questions including: do wind power expansions increase the local tax revenue?; do wind power projects require any additional public services and how was the cost of these services is covered?; how have the counties used the additional tax income?; was the additional tax income used to improve the public services in the county?; did wind power projects increase the population and did this population growth require more residents' services in addition to turbine-related services?

3. Case selection and analytic method overview

The research questions are answered by comparative case study analysis involving both descriptive statistical analysis and qualitative analysis of data gleaned from interviews and public documents. The strength of studying these cases is the ability to deal with a full variety of contextual evidence beyond what might be available in a conventional historical or econometric study (Yin, 2014, p.12).

3.1. Case selection and description

For this study, the target population is counties with very large wind energy production in the United States and the county is the primary unit of the analysis. There are over four hundred counties in the U.S. with wind power projects ranging from one MW to over 3000 MW. This paper is focused on counties with substantial wind projects, defined here as those with capacity in excess of 1000 MW. According to American Wind Energy Association's (AWEA) 2016 s second quarter wind capacity data, only eleven U.S. counties from five different states have that level of total wind capacity. These eleven counties are the research case studies. Five counties are located in Texas, two in California, two in Oregon, one in Colorado, and one in Washington State (Fig. 1). Some counties, such as Kern County California, have had wind power since the 1980s, while some are new to wind power development, such as Floyd County, Texas which introduced wind power in 2014.

The following table shows the eleven case study counties' population, income, and wind power capacity in 1990 and 2015. The case studies include a variety of small and large counties. For example, Kenedy County has only approximately 400 people, while Kern County has close to 900,000 people. Most of the counties have a wind capacity of around 1000 MW except Kern and Nolan county, which has wind capacity over 3000 MW and over 2000 MW respectively. As shown in Table 1, the per capita income is increasing fast in most of the eleven counties, even after adjusting the income to the 2015 dollar value. For example, Kenedy County's income per capita almost doubled from approximately $35,000 in 1990 to $68,000 in 2015. Population growth is less consistent, increasing in counties like Kern, Solano, and Lincoln while declining in others such as Sherman, Carson, Castro, and Floyd County.

3.2. Analytic method overview

For each case, descriptive statistical analysis is used to document changes in the population size, employment, and poverty rate of counties before and after hosting substantial wind projects. The descriptive statistical includes data about each county for 26 years, starting from 1990 to 2015 and consists of economic and demographic data. Second, a qualitative analysis of interviews and documents was conducted to identify local sources and uses of funds as well as officials'

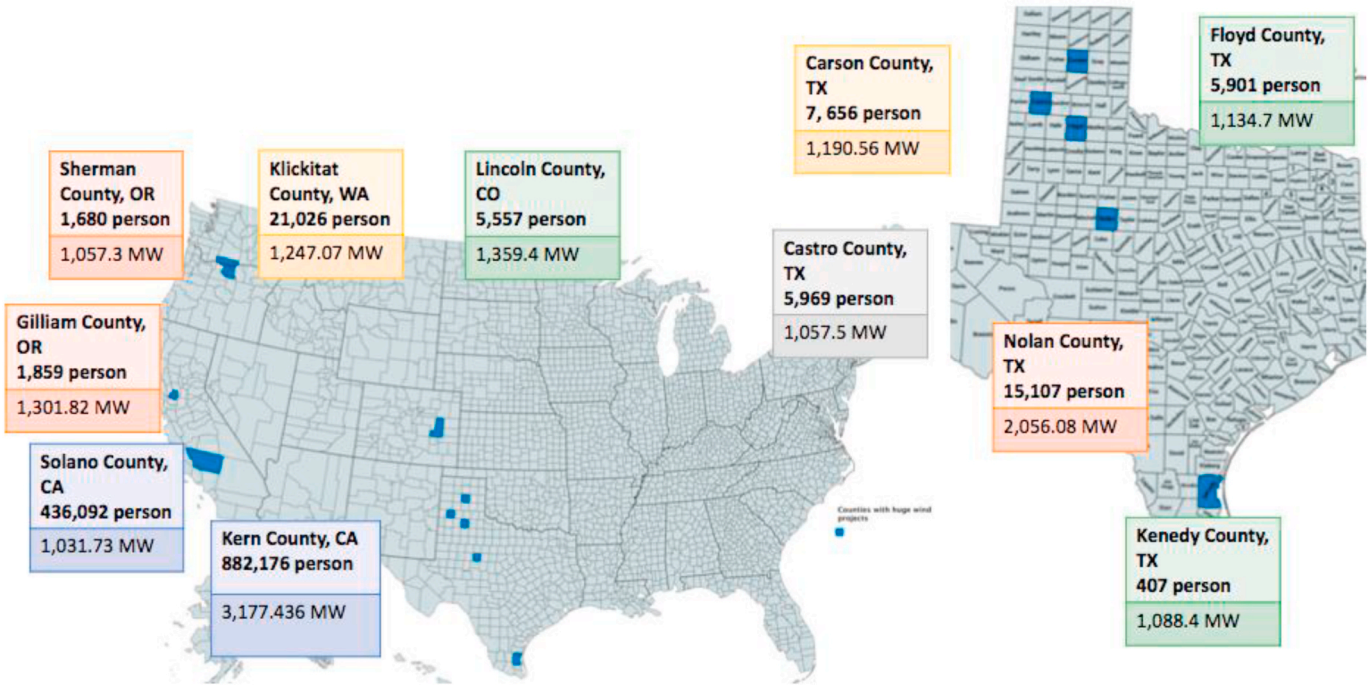

Fig. 1. Case Studies of counties with wind projects over 1000 MW.

Table 1
The summary of the changes in case study counties.

County	Year	Population person	Per capita Income Dollar	Accumulated wind power capacity MW
Kern County, CA	1990	549,535	30,334	406
	2015	882,176	37,355	3,177
Solano County, CA	1990	343,463	36,404	49
	2015	436,092	44,504	1,032
Lincoln County, CO	1990	4,552	29,585	0
	2015	5,557	33,968	1,359
Gilliam County, OR	1990	1,719	28,310	0
	2015	1,859	43,694	1,302
Sherman County, OR	1990	1,924	33,229	0
	2015	1,680	57,526	1,057
Carson County, TX	1990	6,553	31,243	0
	2015	5,969	45,244	1,191
Castro County, TX	1990	9,007	37,232	0
	1990	7,656	63,583	1,058
Floyd County, TX	1990	8,460	35,000	0
	2015	5,901	45,346	1,135
Kenedy County, TX	1990	454	34,542	0
	2015	407	67,830	1,088
Nolan County, TX	1990	16,530	25,414	0
	2015	15,107	37,222	2,056
Klickitat County, WA	1990	16,665	28,108	0
	2015	21,026	43,290	1,247

perceptions of wind projects impacts on tax revenues and community services.

The qualitative data was collected through semi-structured interviews, municipal and project documents, and editorial articles. A dozen telephone interviews were conducted with local officials of the eleven counties.[1] Each county was contacted by emails and phone calls to identify the best person to talk about the wind projects on the county. The research targeted people who witnessed wind power development projects within their county and contributed to wind development's permitting. Most of the interviews lasted for 45 to 60 min. The interview included nine main questions, as shown in Table 2 below. Under each main question, there were some sub-questions.

We collected official documents, plans, and editorial articles about wind projects in each county. Some of the governmental plans and documents were available on the counties' website, and some were provided by the counties' representatives after asking them about any plans in the interview, especially the recent plans that were not yet available online. The documents analysis consisted of 25 official reports included: comprehensive plans, economic strategies, strategic plans, economic policies, renewable energy policies, economic diversification studies, and energy cluster studies. For the newspaper articles, we focused on those reporting the socioeconomic side of wind projects within the counties studied. The analysis included twenty-six newspaper articles on the eleven rural communities.

Qualitative data was coding in N*Vivo. Most of the coding themes were taken from the literature, with the main themes related to the main questions group. All the main coding themes were expected and shaped before the analysis. Only a few branching coding ideas came from the data itself. For example, the literature shows that rural communities may face some problems when they host substantial energy projects. The interviews included a question about the challenges that the county met with wind power projects. The coding came out with different themes pertaining to the challenges such as road access, environmental protection, conflict with other developments (like a military base), and legal code.

All the documents including interviews transcripts, plans and reports, and editorial articles were analyzed followed the same coding scheme. Looking for the answers to the same questions in different

[1] All research procedures were approved by the IRB (Institution Review Board) at the University of Massachusetts Amherst (the approval number 2018-4947).

Table 2
The main interview questions and coding themes.

	Main questions topic	Main coding themes
Q1	**Describe the county:** How would you describe the county?	**Local economy:** Lack of amenity (gas station, food store) Economic crisis (closing plant, oil field)
Q2	**Experience with wind development:** Did you witness the wind projects planning process? What is the role that you have taken as part of the county's wind power planning process? Did the county's planning team face any challenges during wind power development? What are the challenges the planning team face?	**Challenges faced by the county:** Road access Protected species Conflict with other developments Transmission lines Housing the construction crew Agriculture law code
Q3	**The impacts on population:** Do you think the wind projects brought more population to the area or helped people to stay here? What do you think about wind project workers? Where do they live? From, where are they?	**Population:** Attracting the new employment New employee residential location
Q4	**The impacts on employment:** Do you think wind power projects brought new employment to the county?	**Employment:** Construction employment Permanent employment Training programs Recommended to hire local people.
Q5	**The impacts on tax revenue.** How the county spends the tax income from wind development? Did wind developers ask for tax abatement? What is the county's plan to use the wind power project tax revenue?	**Tax:** Tax revenue from wind development Tax abatement Tax relief Tax rate Compensation programs
Q6	**Donation:** Did the county receive any donation from wind developers? Did the county or the community receive any fund from wind developers other than the tax income? Maybe under donation, or community trust fund?	**Donation:** Donation to improve public services like school, fire station, and emergency Community fund Involvement with the community Inviting the developers to community events
Q7	**Public services:** Did the county have a public services demand related to wind power development? Did the wind developers ask for any services to help set their projects? Who pay for these services? Did the county have a public services deficit before wind power projects? Did the county plan to add more public services due to wind power projects?	**Public services:** The required turbine-related services: • Road access • Fire training, special fire protection material • Safety • Who pay the cost of the road?
Q8	**Housing:** Depend on the county numbers, Do you think there is an increase or decrease on the average house prices and rental prices? Do you think that this change related to jobs provided by wind projects?	**Housing:** The effect on rental prices The effect on the median house sales Housing the construction crews.
Q9	**Future plans of the county & Community changes:** How did wind development affect the county's future plans?	**Future & Community changes:** Community changes County benefits Looking for more wind development What will happen after wind projects?

sources, and in different places – in other words, triangulation - increased the validity of the results (Yin, 2014). The analysis found a confirmation of the facts from the interviews in the governmental documents and vice versa.

4. Results and discussion

Findings presented below are the integration of results from the descriptive statistical analysis and qualitative analysis based on a deductive research approach. The results are presented as followed: population and employment, rural economy, public services, and cost of living.

4.1. Population and employment

Population growth and related employment can be divided into the period while the turbines were under construction, and the long-term period of operations. The descriptive statistical analysis found a relationship between the construction phase of wind projects and local unemployment rates, but no strong relationship once operations commenced. As shown in Fig. 2, unemployment tended to dip during construction but rise again post-construction in the sample counties. As an example, Nolan County's unemployment rate was around 6% before wind development and dropped to be approximately 3.5% in the construction period, but back again to 6% after the construction ended. Small counties' populations were declining before wind power development and still declining after wind projects, as evidenced by Sherman, Nolan, Castro, and Carson Counties. Larger counties' populations, such as Kern and Solano County were growing before wind projects and continued growing after wind projects. A Lincoln County representative explains the spillover effects his county experiences:

It (wind farm development) brought permanent wind technician jobs in the county, with probably up to 35 to 40 of those wind technician jobs that are working here. So, it brought people here working in the county. However, we do not have all of those technicians living in Lincoln County. Many of them are commuting back into Denver for the weekend or back to their home in Colorado Springs.

Pure counts of added employment did not fully capture interviewees' perspectives, though. Most counties' representatives agree that wind development helped some residents to stay in the community who might otherwise have to leave (Klickitat, Nolan, Sherman, and Carson County). For example, Klickitat County's representative said: "There are people in the local community, and they were saying, their children were able to stay in the county because of the jobs that wind projects provide."

One way that states or counties attempted to build in community benefit was by requiring wind developers to do local hiring, training residents to fill wind-energy jobs, and buying local when possible. For example, the State of Texas offers wind developers tax abatements conditional upon hiring local workers. Carson County required the wind farm developer to hold a local job fair and seek purchasing contracts from county businesses, and Kenedy County was negotiating with the developers for an apprentice program and scholarship to increase local hiring.

There are barriers to maximizing local benefits in employment. Among the issues mentioned were lack of skills and experience by locals for the high-tech needs of the turbines, which is a particular problem for small counties. For example, Kenedy County representatives reported "with our small population we don't have enough workforce to take care of the needs that they (employers) (already) have." There can be other challenges as well. One Kern County official stated: "They try to hire locally. There were two problems here in California; one is the training that we fit. But the second was passing the drug test."

To summarize, for small and mid-sized counties wind development had zero or minimum impact on the population growth even with large projects because of the small number of permanent jobs, the spillover of the jobs, and the choice of the workers where to live, although interview respondents believed the project aided in retention of population. In larger counties, there was more local employment.

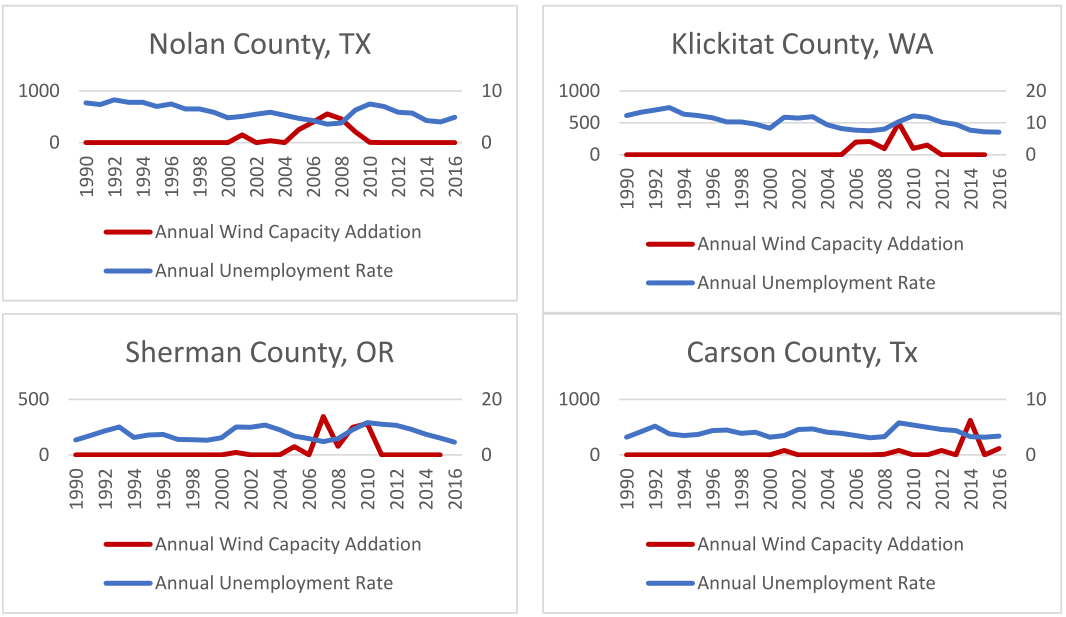

Fig. 2. The relationship between the added wind power capacity (the construction phase) and the unemployment rate (Results from other sample counties are similar).

4.2. Rural economy

Rural governments considered renewable energy like wind development and solar as a suitable way to diversify their economic base. Many rural plans aim to diversify the local economy through renewable energy projects. Lincoln County, Kern County, and Nolan County are examples of this. Kern County's plan stated that "agriculture and energy are solid pillars upon which Kern County can build its future economic base" (Hamilton et al., 2015, p. 2).

This diversification can be particularly helpful for counties with highly concentrated or volatile employment bases. For example, Klickitat County's aluminum plant closed during the recession, but with the advent of wind power "They saved us during the recession," according to a representative. Kenedy County's oil production dropped right before the wind projects started, but a representative mentioned, "they help maintain jobs in areas that would have been lost because the oilfield left", and Kern County reported a similar experience "we went from 23% unemployment to 9% during the recession. Fig. 3 shows this for Nolan County, where tax rolls dipped in the 2008–2010 recession but wind power proceeds provided support.

It is helpful to separate out direct impacts such as tax revenue and lease payments to farmers, from indirect effects like effects on the local business and encouraging new development. These are discussed separately below.

4.2.1. Direct impacts - tax revenue

All the interviewees mentioned an increase in their tax base after hosting wind development as a main benefit of wind projects, consistent with the findings of Kahn (2013) and De Silva et al. (2016). This increase in the tax base, while small in most cases, is still significant to small counties with limited resources. For large counties with more resources, it can help augment their revenue but is not one of the primary sources. For example, a Kern County, California representative mentioned, "there are millions and millions of dollars tax revenue, and in reality, wind projects do not generate that many public services." For small counties, the tax revenue of wind projects represents a large percentage of the county tax base. For example, the local official of Klickitat County Washington said: "It [tax revenue from wind energy] is significant. Wind projects when they first were built comprise about one-third of the county's tax base. Now with some depreciation, I think it's around 28 percent, which is still significant." In some counties like Nolan County, the county's tax base increased after hosting wind projects as mentioned on the county tax documents. Fig. 3 above shows that Nolan County's percentage of tax roll paid by wind farms, even post-construction, was approximately 23% of total tax roll.

The amount of the tax revenue depends on the county law and tax rate on the county, if the county offers tax abatement or not, and if there are additional fees in addition to the tax. The tax rate is a county policy, but the tax abatement and the extra fees may either be set by state or county policy. Depending on the state's law, the county can offer some tax abatement or add some fees for the community fund. The community fund fees appear clearly in the State of Oregon. Oregon has a strategic investment program where, during the negotiation process with the developers, the county can ask for what they call a local improvement fee.

In contrast, many states, including Texas, Colorado, and Oregon have tax abatement policies, although they differ from one place to another. The interviewees reported that tax abatement decision is a local decision based on many reasons like the county financial situation and how the negotiation was managed and varied based on time and place. For example, Lincoln County Colorado offered tax abatements for some of its earlier wind projects, but they refused to provide tax abatements for more recent wind projects. Nolan County Texas refused to allow tax abatement to repower wind farms as the local official said: "Wind farms are coming back asking for tax abatement and again when they are repowering, and so far the county has declined that opportunity."

Texas' property tax code allows counties to give developers tax abatement for up to ten years. After ten years, developers pay the full property taxes. Each county in Texas worked out an arrangement with wind developers to pay only a percentage of the actual taxes under the name of community fund or in lieu of tax. The amount of the community fund and how the county will spend the money depends on the county and how the agreement goes between the county and the developers. A Carson County local official stated:

All [wind projects] have some sort of tax abatement agreement. Since 2012, the tax abatements were for ten years with a PILOT payment for the first ten years of production". [PILOT stands for 'Payment In Lieu Of Taxes']. This payment was negotiated with the developers and was based on generating capacities. This was cheaper for them than the property taxes would have been, plus lent the county some flexibility of

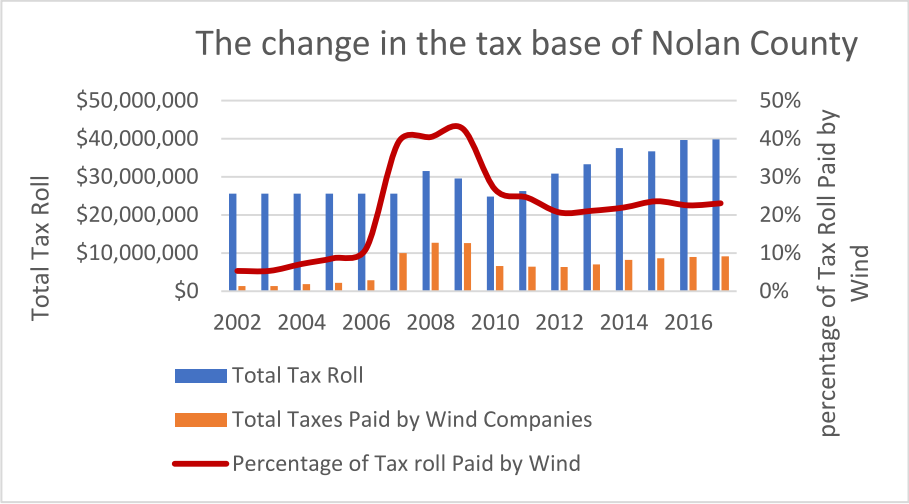

Fig. 3. The change in the tax base of Nolan County (data provided by the county economic development). Nolan county local official send me the actual number of the county tax revenue on excel file.

this income in our budgets.

Sherman County, Oregon followed the same idea as Texas Counties, using PILOT payments rather than direct taxation. The following examples show different agreements for community fund:

- Pattern Energy Group announced it had begun construction of a $400 million wind farm in Carson County that will result in an $800,000 payment to establish a community fund for civic and educational causes (Welch, 2013, Aug20).
- Carson County Judge Lewis Powers said in a newspaper speech "We provided a tax abatement agreement with EON to abate the taxes for ten years. In exchange, we get an annual payment for $316,500 on an annual basis. That's $1500 a megawatt" (Media agent, 2015 April, 22).
- Kenedy County, Texas representative said in the interview "Right now, we are taking payment in lieu of taxes for the first ten years and then they go back to whatever the value of it is then. Every October, we get a check for $440,000 for the first five years, and then that will almost double for the second five years, and then we'd go back to what the retail value."

4.2.1.1. How counties spend the extra tax money. The important point of the wind tax revenue is how tax revenues and the community fund affect the public services and the rural communities. The interviews included a direct question of how the county spent the tax revenue of wind development and how this increase in the tax base affects the level of the public services on the county. Most of the counties incorporated the additional tax funds from wind projects into the county budget and they used these funds to cover some services that the county needed but could not afford before. For example, Sherman County Comprehensive plan stated:

The property tax income stream, created by over 700 wind machines, at over 1.25 million dollars in value each, created a sizable annual revenue stream for public use and improvements in the County. The second phase is the direct benefit to Sherman County of an enhanced property tax revenue stream, which will significantly increase the ability of the County to solve its own problems without relying upon state or federal government assistance (Sherman County, 1994,p. 37).

Although most counties did not have any special plan for wind projects tax income, there are two exceptional examples: one in Kern County, and one in Sherman and Gilliam County. Kern County, California created a special program funded by property tax from wind projects to improve the infrastructure and public services in the county:

Renewable Energy Neighborhood Enhancement Wind Business Investment Zone, RENEWBIZ, a grant program funded by property taxes from wind farms in East Kern County. It provides small matching grants to private businesses and non-profits in unincorporated communities to improve facades, landscaping, public spaces, infrastructure, and other amenities to make them more attractive places to live and work (Hamilton et al., 2015, p.3).

Both Sherman County and Gilliam County in Oregon created compensation programs after the increase in their tax base from wind projects following Alaska's sharing oil revenue idea. Residents are paid $590 per year each as a means of equitably sharing surplus revenue and encouraging a positive outlook on new development.

4.2.2. Direct impacts- lease payments from wind power developers to farmers and ranchers

Farmers and ranchers receive payments from wind developers for leasing land to wind turbines. Lease payments were emphasized as a great benefit of wind power development in the qualitative analysis. All the counties' local officials believed that lease payments helped farmers and ranchers to continue farming and keep their land, as they received a sustained income annually from leasing land to wind turbines. Several newspaper articles reported on farmers who were leasing land to wind power developers, emphasizing how this income helped them to improve their farm and life.

Hilderbran, the first in Sherman County to allow turbines on his land, reaps about $30,000 a year in lease payments. And the checks come without fail, he says, unlike the income from his wheat operation, which is squirrelly as the weather (Cleveland, 2008, Nov 11).

For small isolated counties, there is a significant change in the income per capita after wind development, presumably from lease payments. As shown in Fig. 4, there is a real jump in 2006 in Sherman County and Gilliam County when wind projects started, and both counties at this time had a wind capacity of around 100 MW. For Kenedy County, wind development started late in 2010 and was followed by a clear change in the income per capita of the county.

4.2.3. Indirect impact-encouraging new development

Wind development encouraged new business and development in some of the rural counties. Most of this development is related to housing or providing services to wind employees such as hotels and restaurants. For example:

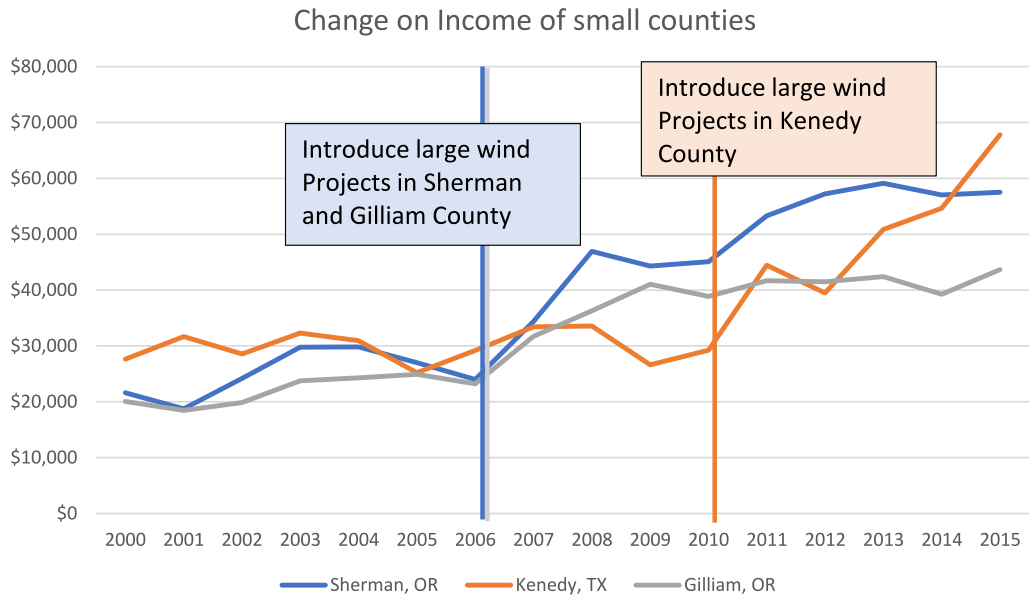

Fig. 4. Change on per capita income after wind development.

- Lincoln County comprehensive plan stated that: "the community experienced a pop up of the small business of bed and breakfast in the town. Some local businesses who closed before reopened for rental" (Lincoln County Economic Development Corp [LCEDC], 2018, p. 14): "one of the residential communities [in] Genoa has recently restored an old town café as well as made a Camp park to attract business from the wind farm technicians" (LCEDC, 2018, p. 6).
- Kern County has a new hardware store for wind turbines maintenance materials.
- A closed restaurant in Sherman County is reopening, according to an interviewee.

Despite the anecdotal evidence of new businesses in Lincoln, Sherman, and Kern Counties, there were insufficient jobs generated to make a notable change in the employment structure. Nolan County, in contrast, experienced changes in employment structure and noticeable increases in related industries in the county. One local official mentioned that: "We have got new business, new hotels, new restaurants, lots of above of the new improvements to our way of living that we didn't have before." Local representatives claimed that before the wind farms were built: "there was three to four percent manufacturing of all kinds, was the highest percentage. Now, we have about 12 percent of our working population worked in the manufacturing sector", which was supported in the County's plan (New Amsterdan Wind Source LIC [NAWSLIC], 2008). Nolan County had three new industrial companies related to wind turbines such as a producer of raw cement and sheet rock used in construction, a company for electrical components for wind turbines, and recycling business for wind blades which was just in permitting.

Nolan County is a unique case. Its location on Interstate 20, a major local connector, appears to have played a major role in Nolan County becoming the center of wind energy development in Texas. The Case Study of Wind Energy Economic Impacts in Texas report mentioned that:

Together [Nolan County] with the adjacent counties of Scurry, Taylor, Mitchell, and Coke, the Sweetwater region is home to well over half of all operational wind energy in Texas and approximately 15 percent of all the United States wind energy operations (NAWSLIC, 2008, p. 4).

4.3. Public services

Wind development can affect public services in three ways: increase the population which requires more public services; create extraordinary turbine-related service requirements; or provide additional income to improve public services. As noted above, the analysis of the descriptive data, as well as the qualitative analysis, did not find any increase in the permanent resident population due to wind power development. There were some costs for turbine-related requirements, but these were largely covered by developers contributing needed equipment or training, but it did require some cooperation and adoption of new practices to deal with the safety of the wind turbines. For example, the fire department in most of the counties used to deal with single or two-story buildings and required training to adapt to the tall wind turbines. In this case, the fire and the police department worked with the wind developers to come up with a map of the wind turbines and a unique code and location for an emergency. In some cases, like Kern County, California, wind farms required special equipment like a water tank and foam for wildfires. The wind developers covered the expenses for the fire department equipment and training. The local official of Kern County California said.

The wind company has built and fund water tanks and they are also responsible for water and having water available. The fire department told the wind company through our environmental process that they need a certain type of foam, there is a foam they can use in wildfire so they funded an 890,000-dollar fire truck and provided foam so it can be more efficient wildfire.

The road conditions are a common issue with all the counties, as turbine-construction traffic usually destroyed the roads, but all the local governments had an agreement with the wind developers to return the roads to the way they were before the construction. In all of the counties, the developers paid for all the road work, except Lincoln County, Colorado, where the county helped pay for the road work.

Counties used funds from PILOT, community fund donations or property taxes for a range of benefits. Table 3 shows that communities have used new funding in a variety of ways, including new schools, jails, infrastructure and health care facilities as well as community programming (Table 3).

Table 3
The community services improvement, due to wind projects.

County	Donation and community fund	County tax money
Solano County	Some donation happened when the projects are relatively new, but the interviewee did not remember what the donation for, and the county's plans did not mention the donation.	The tax income helped the county to improve its service in general.
Kern County	Donate money for solar street lights for the community, and give an electronic headboard to the high school.	The county used half of the wind projects tax money to create a special fund to cover community projects and services like paving roads and put restaurants in the park.
Lincoln County	A scholarship donation for healthcare.	Helped to build a new fairground facility, as additional monies became available, they were able to provide a higher level of service.
Castro County	Fund charitable things for fire departments, fundraisers to civic organizations, support the school sports organizations.	Built a new jail that has been needed for a long time, built a new elementary school, the hospital was able to build a nursing home because of the wind farm.
Floyd County	Supporting several local events and activities. The wind projects have just recently offered to pay for some road base material to assist in rebuilding the roads that they use the most.	The County uses the income from the wind projects to maintain and operate the County, and a lot of the tax money goes back into repairing of the roads.
Carson County	The wind developers made generous donations to local charities and non-profit organizations. Donation to the food bank, charities, and volunteer fire departments.	Built a jail, one small community in the county used funds to buy a much-needed new ambulance.
Nolan County	Community fund to school in lieu of taxes: Built brand new school buildings; built sports stadiums, bought new school buses, bought fire trucks, and all the students got a laptop.	The county built a new jail facility and police department, a brand new law enforcement center, and renovations to the parks.
Klickitat County	Provided signs on the baseball court.	Some of the rural fire districts more than tripled their annual budgets because of the wind farms. The community of Bickleton built a new school and bought a new $160,000 ambulance, and plans are underway for a new fire hall.
	The energy companies built a network of new and improved roads to haul their turbines to remote sites.	Property taxes from Iberdrola Renewables and other energy companies with wind farms in the school district will pay 97 percent of the school's cost.
Sherman County	Wind money paid for new computers, musical instruments, robotics equipment, portions of a greenhouse and a new teacher to instruct the most gifted of its 124 students last year.	Translates to meeting essential community needs like fire departments and health services, new supplies for students, and capital projects like construction of a new school, library and city hall." It's also paid down debt for wastewater systems in three towns and launched a renewable energy technician program at Columbia Gorge Community College.
Gilliam County	Scholarships are given out to students, and college students.	Improve health care facilities, replacing the broken fire truck, completely revamped the towns' downtown.
Kenedy County	Kenedy Memorial Foundation lease 9,600 acres to wind developer and used all the lease monies to support its charitable causes to fight poverty, boost education, and build stronger communities. The county negotiates a scholarship donation for its upcoming projects.	Built industrial park, a brand-new library, a new fire hall, a new community center in Arlington. Helped on acquiring, an emergency service 24/7. Improved parks and drainage, paved all the roads.

4.4. Cost of living

Wind power development can affect the cost of living in three ways: through changes to the tax rate, energy prices,[2] or home prices. Exploring these effects can answer the question: Did wind power development increase the cost of living in the rural counties, or not? The interview included a direct question about the effect of wind power development on tax rate and housing prices.

4.4.1. Tax rate

Interviewees confirmed that wind projects increased the tax base and were expected to reduce the tax rate. The effect on the tax rate, however, depends on the county's finances and policy. The tax revenue of wind power development helped the case study counties stabilize, reduce, or prevent a dramatic increase in the tax rate or caused a tax rebate or tax relief for residents, according to interviews and documents. For example, wind development decreased the tax rate in Klickitat County, WA according to the interview and editorial articles. "The tax rate for the Goldendale School District dropped from $15.50 per $1,000 in 2001 to $9.17 this year because of property tax revenue paid by wind energy companies" (Durbin, 2010, Oct 10).

4.4.2. Housing

Any effects on housing were expected to come from the wind power employment and the increased population. However, the descriptive analysis and qualitative analysis proved that there is no noticeable effect on permanent population size. Temporary employment was a bigger problem. Most of the counties stated that it was challenging to house the construction crew of wind farms. In the construction phase, all local rental units were rented, and the hotels were full. Small counties with less available rental units used RV parks. Many of the construction crews brought their trailer houses, and local government worked with the wind construction team to assign a place to serve as an RV park for these trailers. Gilliam County, for example, has an RV park for the first time due wind projects.

The interview had a direct question about the effect of wind

[2] A 2014 study found that residents believed that wind farms caused an increase in the energy prices in their community (Groth and Vogt, 2014). The interview of this research included a direct question about the effect of wind development on energy prices. All the counties' representatives disagreed that the wind energy affects their energy prices. None of the eleven counties use any of the wind energy they provide, and their local energy prices depend on the utility they belong to and what kind of power this utility uses. Only Kern County, California's representative believed that energy prices in the county increased due to the renewable energy, not just wind. Kern County agrees with Borenstein et al. (2018) who found that renewable energy tax incentive offered by the state increased the energy price rate in the state. It is an indirect impact of adopting renewable energy on the energy prices which differs depending on the state policy.

development on rental prices and median house sales prices. The effects on the housing depended on the county size and the housing capacity of the county. For bigger counties, new wind projects had no discernible effect at all on rental prices or median home sales prices. For small counties that did not have any housing to offer (rental units or housing for sale) to start with, there was no discernible effect on prices. For medium-sized counties (Castro, Nolan, and Lincoln Counties with populations ranging from 5,000 to 15,000, despite the short time of the construction phase, rental prices increased. In Castro County and Nolan County prices returned to pre-wind levels after the construction period, while in Lincoln County, the increase in rental prices continued after the construction. Nolan County and Lincoln County had some new businesses for renting furnished houses.

Usually, there are no effects on home sales prices, although in Lincoln County there are mixed perceptions of a price and availability impact. The Lincoln County plan reported that Hugo Town "is experiencing a shortage of available housing since the flood of wind farm technicians purchasing and/or renting much of what was available" (LCEDC, 2018, p. 5). Also, the county plan mentioned that wind power employees affected the availability of houses. This was not necessarily connected to home sales prices, however. For home sales prices, both the interview and the county plan agreed that the current increase of county home sales prices is not related to wind power development and instead reflects an ongoing housing problem in the county and the collective increase of house sales prices in all of Colorado.

5.5. Impacts on the community

Impacts experienced at the county level varied a good deal based on county size. Bigger counties like Sloan and Kern California contain populous urban/suburban areas and as such wind power development was not of a scale to change the community. In isolated small rural counties like Kenedy County, Texas, and Gilliam and Sherman Counties in Oregon, wind development introduced new industry and opened the world for the rural communities. For example, corporate wind farm development encouraged the local residents to start their own community wind projects in Sherman County. Community wind farms may put the rural communities towards more economic and social sustainability (Seyfang et al., 2013; Haf and Parkhill, 2017; Bolinger and Wiser, 2006). The interview analysis found that local officials in small counties felt that wind power development put their communities 'on the map', provide a stable and sustainable economic development source as well stability to local framers. Interview analysis found that the experience of the eleven counties with wind power encouraged them to look for more renewable energy like a solar panel, and some of them already started on a path toward their solar power, like Kern County.

Carson County local representative stated that:

One of the main benefits that I believe is to open the minds of the rural community of worldly affairs and issues. Too often in a rural setting, we believe that the world just passes us by and we are not affected or even that we cannot change from doing things as they have always been done. I personally know of local high school graduates that went on to college and received degrees in wind generation and now work for large developers around the United States. History has shown us that progress has been difficult to accept at times. And it is no different here.

A Nolan County public representative likewise mentioned that "There's just no comparison between living here 25 years ago. Today, … you can have a nice dinner, and there are nice places for people to stay. They now have alcohol retail businesses that have moved here. So, there are lots of good economic spin-offs that have resulted from wind development".

5. Conclusion and policy implication

Wind development benefitted small rural counties economically, especially in Sherman County, Gilliam County, and Kenedy County. Before wind development, these counties faced a common fate of many small rural United States communities with only an agricultural base. They had a declining population, very few employment opportunities, and low income. Although wind development did not provide many permanent jobs, it did offer a sustainable source of tax income to the county, as well as lease income to farmers and ranchers. When wind development blows in, these counties earned additional tax revenue to cover their needs and improve their community services. Some counties like Sherman and Gilliam Counties, Oregon shared the wind revenue through a compensation program, which pays residents yearly dividends as a means of sharing surplus revenue and encouraging a positive outlook on new development. This program follows Alaska's sharing oil revenue idea. Even with small counties, the landowners who benefit the most of leasing their land to wind companies are few. The purpose of the compensation program is to have an equitable distribution of the benefits.

Wind development provides good tax revenue for rural counties, with no reported increase in public services nor any sudden increase in the permanent population. Rural counties with good wind resources are looking for renewable energy to diversify their economic base with a less volatile market as compared to farming. We do not find that wind farms increase long-term population, but they are reported to create opportunities for some residents who want to stay in the community to find a job other than farming, especially with the training programs and the recommendation of hiring local people. Wind development positively affects local businesses during the construction phase and the operation, too. In one exceptional county, Nolan County, Texas, it created a new economic sector and encouraged new development and industry related to wind turbines. Wind development has some negative indirect effects on the living standard during the construction period by bringing some temporary increases in the rent prices in some counties and a bit of 'boom town' feel for a short period. But for the longer term, there was little to no impact on housing rental or purchase prices. Most notably, taxes or payments in lieu of taxes clearly benefitted living standards by funding investment in schools and other public services. In one county, a community wind farms was developed as well as a result of experience with for-profit firms.

Finally, interviewees felt that these large wind power developments changed the rural community in less tangible ways as well. Development may bring a more open view of the world and new industry. Wind power development increased the knowledge of the rural community about renewable energy and made them look for more renewable energy sources like solar, and encouraged the notion of community wind projects. As a result, rural governments understand the benefits of sustainable development like wind. The lessons of COVID-19 show the need for diversified economies, and in rural counties, wind farm development seems to fill an important need.

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CRediT authorship contribution statement

Eman Ahmed Hamed Shoeib: Conceptualization, Methodology, Software, Resources, collecting data and interviews, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Elisabeth Hamin Infield:** Supervision, Writing – original draft, Writing – review & editing, helping to shape the interviews questions and IRB (Institution Review Board) at the University of Massachusetts, reviewing the draft and editing. **Henry C. Renski:** Supervision, especially the descriptive statistical analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2021.112279.

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