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Perceived Impacts from Wind Farm and Natural Gas Development in Northern Pennsylvania*

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Abstract This study examines the environmental, social, and economic impacts that landowners perceive from the simultaneous development of an industrial-scale wind farm and extensive natural gas drilling in an area of northern Pennsylvania. A mail survey ($N = 1{,}028$) reveals that the types of perceived impact from wind and natural gas are similar overall, although the perceived magnitude of positive and negative impacts is greater from natural gas drilling. Impact perception was found to explain a large portion of residents' overall attitudes toward the energy developments, and residents' place meanings for the area also explain some attitudinal variation. Additionally, factors such as place attachment and length and type of residency were found to have little or no effect on either the perception of impact or resident attitudes toward development.

Introduction

Wind farm and natural gas energy developments represent some of the most extensive and contentious rural land use transitions occurring in the United States today. Technological innovations and high energy prices have spurred the construction of tens of thousands of industrial-sized wind turbines and hundreds of thousands of natural gas wells in the last decade (ORNL 2011; U.S. EIA, 2011). Continued domestic and global growth in both wind farm construction and the development of so-called unconventional gas resources is considered likely (IEA 2012; Paltsev et al. 2011; USDOE 2008).

During the last great energy boom in the United States—during the 1970s and early 1980s—great attention was paid by rural sociologists to the social and community impacts of energy development (Krannich and Greider 1990; Murdock and Leistritz 1979). In recent years, the

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reemergence of widespread oil and natural gas development has led to renewed research interest in the impacts of nonrenewable energy development (Anderson and Theodori 2009; Brasier et al. 2011; Jacquet 2005, 2009; Parkins and Angell 2011; Theodori 2009). In contrast, much less research has been paid to the impacts from renewable energy development, such as wind farms, especially in the United States. Wind farm impacts are often framed as primarily involving aesthetics (Pasqualetti, Gipe, and Righter 2002), as well as aspects such as property values or ambient noise levels (Jobert, Laborgne, and Mimler 2007).

Wind and natural gas projects have caused debate and opposition in many communities across the United States and the world (Food and Water Watch 2013; Phadke 2011; Pociask and Fuhr 2011). Resident attitudes toward change are often viewed as derived from an assessment of the perceived costs and benefits (i.e., impacts) that have accrued or may accrue. Understanding how and why local residents perceive the positive and negative impacts from these energy developments—and, ultimately, support or oppose the projects—will become more critical as these energy projects continue to expand and policymakers engage strategies to manage the permitting and development of diverse energy resources (Warren et al. 2005).

This article uses a 2011 mail survey to explore resident perception of types and magnitudes of social, economic, and environmental impacts associated with industrial-scale wind farm and wide-scale natural gas development in rural northern Pennsylvania. We examine the drivers of these perceived impacts, and the relative contribution of each of these impact perceptions on overall project support or opposition. The survey area has experienced an array of natural gas and wind development since 2009. This article provides an in-depth comparative analysis of the impacts perceived from the construction of these energy installations, based on key elements drawn from rural sociology and environmental psychology that describe how different types of residents respond to environmental and land use change.[1]

Literature Review

Natural Gas Development and Energy-Impacted Communities

Research on impacts of natural gas drilling and other types of fossil fuel development grew to prominence in the late 1970s during a

[1] Results from this survey that focus on attitudinal variation and its relationship to proximity and employment have been published previously (see Jacquet 2012).

period of high energy prices and a boom of energy development in rural and often isolated communities in the western United States. Such "boomtown literature" (Freudenburg 1986a:92) centered on rapid population growth and subsequent changes in social structure and quality of municipal services (Gilmore 1976; Krannich and Greider 1985, 1990; Murdock and Leistritz 1979; Myhra 1980). A number of studies have found that residents in communities experiencing such developments perceived economic impacts to the communities as primarily positive in nature, while social impacts were viewed as mostly negative (Gilmore and Duff 1975; Greider and Krannich 1985; Kohrs 1974). Perceptions of environmental impact were not often the focus of this suite of research (Stedman et al. 2012). Thompson and Blevins (1983) did examine perceptions of environmental impact in their survey work of a community in North Dakota and found that residents largely viewed such impacts as less important than social or economic concerns. Thompson and Blevins (1983) also documented that economic optimism tends to decline with energy development experience. Positive economic impacts were often related to employment opportunities, while negative social aspects commonly included crime, substance abuse, and decreased mental health (Bacigalupi and Freudenberg 1983), a decrease in the number and quality of social relationships (Freudenburg 1986b), and a transformation of social roles in the community (Jobes 1986).

More recently, unconventional natural gas development that utilizes horizontal drilling and high-volume hydraulic fracturing technologies has rapidly proliferated in areas across the United States, and the boomtown literature has reasserted its relevance. Unlike in the boomtown cases in the 1970s, contemporary public debate over gas drilling has thus far largely centered on the health and environmental risks gas drilling poses, especially as used in the hydraulic fracturing process (Colborn et al. 2011; Wiseman 2011). Theodori (2009) found—in addition to concerns over large truck traffic—that community leaders in affected areas of Texas perceived impacts to drinking water, freshwater consumption, and environmental pollution. A number of studies have found that residents of communities that have undergone natural gas or other kinds of fossil fuel energy development typically temper their overall perceptions of impact magnitude—positive or negative—as development unfolds: perceptions of economic benefits (especially prospects for employment within the industry) become less positive as time goes on (Anderson and Theodori 2009; Brasier et al. 2011; Murdock and Leistritz 1979; Thompson and Blevins 1983), while negative aspects are also often viewed as not as bad with increased

development experience (Brown, Dorius, and Krannich 2005; Jacquet and Stedman 2011).

Wind Energy Development

Modern, industrial-scale wind development has become prevalent only in the past decade or so; accordingly, research on the full range of social, economic, and environmental impacts that are perceived as associated with the construction of wind farm development is less established, especially in the United States. Research in the United States has mostly focused on resident attitudes toward the planning and siting of wind farm development and the types of impacts that residents expect to occur (Nadai 2007; Wüstenhagen, Wolsink, and Bürer 2007). Concerns over aesthetic impacts of wind farm instillations are often invoked: abundant wind resource is often located where large man-made structures are most noticeable (ridgelines, coastlines, etc.) (Jobert et al. 2007; Johansson and Laike 2007; Pasqualetti et al. 2002; Swofford and Slattery 2010). Nearby landowners may express concern over impacts to property values (AGO 2009). This concern appears to be overstated in comparison to actual impacts: while some site-specific studies have found negative impacts on property values, a nationwide study on the sale of 7,500 single family homes within 10 miles (16 km) of wind farm developments found no conclusive evidence of any widespread effect on property values (Hoen et al. 2009, 2011). Similar concerns have been expressed about potential effects of wind farms on local tourism, although evidence of a tourism decline in areas where wind farms have been built is also scant (Landry et al. 2012). Bird and bat mortality related to wind farm development is also listed as a concern among environmentalists (Warren et al. 2005), while actual effects on these is variable, depending on location and species (Drewitt and Langston 2006). Of more prominence lately are effects of low-frequency wind turbine noise that increase stress and disturb sleep, and several scientific studies have found that significant minorities of residents near wind turbines report these problems (Bolin et al. 2011).

A number of studies in Europe have recorded postconstruction perceptions of wind farm development, and attitudes toward wind farms have been found to fluctuate over time, with positive attitudes declining after a specific wind farm is proposed and during its construction, but—in contrast to gas development—becoming much more positive after the facility is constructed (Braunholtz 2003; Devine-Wright 2005; Jobert et al. 2007; Wolsink 2005).

Impacts and Perceived Impacts

Perception of potential change—even if the change does not actually occur—can lead to real changes in quality of life, stress, mental health, and subsequent behavior (Freudenburg and Jones 1991; Hunter, Krannich, and Smith 2002, Jacquet and Stedman forthcoming). Perception of impacts can be better predictors of community change and subsequent behavior than measures of the impacts themselves (Dillman and Tremblay 1977; Gramling and Freudenburg 1992; Lankford 1994; Stedman 1999). Further, resident perception of impacts may be among the only assessments available, as objective information is often difficult to obtain because of the geographic and temporal limitations of available data (Burdge 1994; Greider and Krannich 1985).

Drivers of Concern about Energy Development

Substantial research has explored the emergence of differences in perceived risk to environment and health. Sociodemographic factors such as age, race, and gender are thought to influence perception of health and environmental risks (Slovic 1987). Davidson and Freudenburg (1996) describe women and people of color as often more concerned about numerous environmental risks, particularly those that relate to local issues.

Community attachment (Beggs, Hurlbert, and Haines 1996; Goudy 1990; Kasarda and Janowitz 1972), length and type of residency (i.e., permanent or seasonal) (Girard and Gartner 1993), place attachment (Burdge and Ludtke 1972; Williams et al. 2009), and place meanings (Kaltenborn 1998; Stedman 2003) have all been found to influence resident perceptions of social and environmental change. For example, Brehm, Eisenhauer, and Krannich (2006) found that in the Rocky Mountain West, strong social attachments of residents corresponded with a desire to protect long-standing cultural traditions from development, while environmental attachments corresponded with environmental protectionism, and that resident attachments explained attitudes toward development far better than demographic factors. Devine-Wright (2009) and Devine-Wright and Howes (2010) have found that in the case of wind energy, the place meanings that residents have traditionally held for the impacted area can affect perceptions of impact from development. For example, the authors found that if residents associate meanings of an environmental or restorative nature with the area, they may view the impacts from the development as larger and less acceptable. Conversely, residents who view the area as embodying meanings that

represent opportunities for economic growth, for example, may view the impact from the development as congruent with these meanings, and the impact smaller and more acceptable.

Research Objectives

Little data exist on the impacts that residents perceive from the development of wind farms or modern forms of natural gas drilling; no detailed research that we have found has compared perceptions between these two energy sources in the same setting. As these forms of energy development may increasingly be located spatially adjacent to each other, or be considered as alternatives to each other, we believe that such comparative work is crucial. Therefore, the main questions guiding this research are: (1) What are the specific impacts that residents perceive from wind farm and natural gas development? (2) How do these specific impacts relate to overall support or opposition for the developments? (3) What are the attitudinal, experiential, and sociodemographic drivers of these perceptions, and how does impact perception differ systematically among different kinds of people? (4) How do the above differ between natural gas and wind development?

Methods

Study Site

Spanning Tioga and Bradford Counties in northern Pennsylvania, the Armenia Mountain region consists of a highly visible mountain ridge (elevation approximately 2,000 feet above sea level) surrounded by a mix of small towns, agricultural and forested lands, and amenity-rich natural areas (Figure 1). The area was chosen for study because it contains intensive natural gas development and a prominent wind farm facility, and additional gas and wind development have been proposed in the area.

The Armenia Mountain Wind Farm, operated by the international energy firm AES, consists of 67 1.5 megawatt turbines constructed in 2009–10 on top of the mountain ridge, with plans for an additional 57 turbines to be constructed in the coming years. The average tower height is 118 m. The wind farm includes multiple substations, overground and underground transmission lines, meteorological towers, and approximately 25 km of access roads over a total area of about 10,000 acres comprising 117 private parcels under lease by AES (AES 2007).

Several energy firms are conducting natural gas drilling activity in the area, targeting the unconventional Marcellus Shale gas formation, with

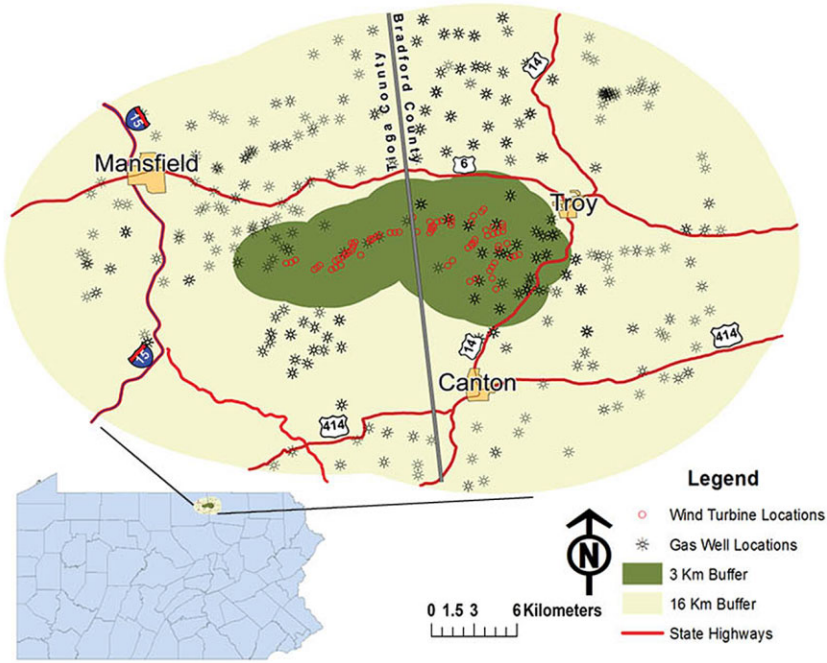

Figure 1. Depiction of the Study Area. The State of Pennsylvania Is Shown in Inset.

934 shale gas wells drilled between January 2009 and September 2011 within 16 km of the Armenia Mountain Wind Farm area. This region of northern Pennsylvania has emerged as much more geologically attractive for development than many other parts of the Marcellus Shale. Of the 934 wells drilled, 96 were drilled on or immediately adjacent to private parcels that also contain wind turbines (PA DEP 2011).

Approximately 10,000 people live year-round within 16 km of the wind farm, including within six small towns (called "boroughs" in Pennsylvania) (U.S. Census Bureau 2011). Armenia Mountain ridge itself is among the most rural areas of Pennsylvania, comprising mostly vacation homes, hunting cabins, and unimproved tracts of land. The total year-round population on Armenia Mountain was 180 in 2010.

Like many rural and agricultural areas of the United States, this portion of the mid-Atlantic region has shown economic underperformance during the past several decades (Thomas and Smith 2009). The population of Tioga and Bradford Counties decreased by 0.6 percent between 1980 and 2010 (U.S. Census Bureau 2011). Tourism, especially hunting and fishing, remains important to the local economy, although

natural gas drilling activity is putting pressure on the availability of vacant motel rooms and there are concerns over negative impacts to the tourism industry (Rumbach 2011).

Survey Sample

We utilized public property tax databases to obtain landowner mailing information, land use characteristics, and geospatial information for all parcels within a 10-mile (16-km) region around the Armenia Mountain Wind Farm in Tioga and Bradford Counties. Searches of databases identified approximately 8,000 separate property owners owning parcels classified as residential, agricultural, and recreational, and selected a survey sample of 1,800 property owners. Using ArcGIS software, we selected all property owners ($N = 570$) within approximately 3 km of a wind turbine as part of the survey sample, and randomly selected the remainder of landowners ($N = 1,230$) from between 3 km and 16 km from the nearest wind turbine.

In April 2011, we mailed an initial copy of the survey to respondents, followed by two reminder letters and an additional copy of the survey. Of the 1,800 surveys, 49 were returned as undeliverable; 1,028 of the remaining 1,751 surveys were completed, resulting in a response rate of 58.7 percent. Respondents within 3 km of the wind farm had a higher response rate (359 responses, or 63.0 percent returned) than those outside this area (669 responses, or 54.4 percent returned), and we weighted the results to ensure that respondents from beyond 3 km of the wind farm were not underrepresented.

Questionnaire Items

Perceived impacts of wind and gas development. We asked all survey respondents to complete similar 23-variable impact matrices for both wind farm development and natural gas drilling. We chose these variables to reflect the array of economic, social, and environmental concerns identified in the historical and contemporary sociological literature on energy-impacted communities, as well as other concerns (i.e., health impacts, water quality) that emerged through interviews and informal discussions with residents of the affected area. For each of the 23 variables, the survey asked respondents "how the [energy source] has changed certain facets of the study area," to which they could respond by marking one of five boxes for each variable: "very negative," "negative," "neither negative nor positive," "positive," and "very positive" (researchers subsequently coded responses with values 1 through 5, respectively).

Table 1. Scales of Resident Attitude toward Energy Development.

	Mean		Standard Deviation		Cronbach's Alpha	
	Wind Farm	Gas Drilling	Wind Farm	Gas Drilling	Wind Farm	Gas Drilling
Attitude Scale	3.10	2.77	1.123	1.327	.917	.939
Attitude toward existing development	3.01	2.78	1.161	1.384		
Attitude toward additional development	2.93	2.79	1.262	1.431		
Effect on view of energy source in general	3.33	2.89	1.306	1.480		
How attitudes to development changed	3.17	2.66	1.285	1.471		

1 = very negative; 2 = negative; 3 = neither negative nor positive; 4 = positive; 5 = very positive.

We performed a factor analysis (principal components extraction with varimax rotation) on the impact variables for both energy sources, and in both cases loaded the variables onto four separate components, interpreted to represent environmental impacts, sociocommunity impacts, personal impacts, and economic impacts (we show these components in Table 2, discussed later). For both wind and natural gas, the amount of variance in the item pool explained by the factor loadings was greatest for the environmental impact category (36.1 percent for the wind farm; 45.8 percent for gas drilling) and much lower for the other categories (in the 4–8 percent range). All factors demonstrated acceptable reliability, with the lowest Cronbach's alpha value at .720 (see Table 2).

Attitudes toward development. Four questions for each energy source measured attitudes toward each form of energy development; these questions asked respondents to rank, on a five-point scale, how positively or negatively they viewed current development levels and future development, how their attitudes changed during the development, and how the development changed their attitudes toward the use of the energy source in general (Table 1). We combined the attitudes in a composite scale to create an overall measure of attitude toward each of the two developments. The scale achieved high Cronbach's alphas of .917 for attitudes toward the wind farm and .939 for attitudes toward gas drilling, suggesting that respondents were generally negative or positive about a given form of energy development across all items in the scale, rather than (for example) viewing current levels positively, but being more negative about increased future development.

Place meanings. Building from previous studies on place-meaning research (Kudryavtsev, Stedman, and Krasny 2012; Stedman 2008), we

devised 13 different place meanings (e.g., "tourist destination," "wilderness qualities," "close-knit"). As with the impact measurement, the "environment" category of place meanings achieved the greatest explained variance and highest Cronbach's alpha measure of reliability (30 percent and .800, respectively) (see Table 3). The "integrated" category, comprising two place meanings, "tourist destination" and "industrial area," achieved a poor Cronbach's alpha score of only .317.

Place attachment and residency status. The survey utilized a six-item scale (a reduced form of that in Stedman 2003) to measure resident place attachment. We asked respondents to indicate whether they strongly disagree, disagree, neither disagree nor agree, agree, or strongly agree with statements about the local area such as "It is my favorite place to be," "For the things I enjoy most, no other place can compare," "Everything about it is a reflection of me," "I feel happiest when I am there," "It is the best place to do the things I enjoy," and "I feel I can really be myself there." The combined composite scale produced a high degree of reliability, achieving a Cronbach's alpha of .940.

The survey also asked respondents if their property was a permanent residence, a seasonal residence, or land without a residence. In addition, we asked how long they have owned property in the area and how many acres they owned.

Demographics. We asked respondents about their gender, age, and level of education. For gender, 69.0 percent (709) of respondents were male, 27.7 percent (285) were female, and 3.3 percent (34) did not indicate gender, reflecting both the high proportion of male names in the tax database, and also problems with gender disparity in survey research that is common to rural areas (Jacobson, Brown, and Scheufele 2007). The median age of the survey respondents was 52 years old, while the census reported that the average age of people aged older than 18 in the survey area was 58 (U.S. Census Bureau 2011). In regard to education, 32.4 percent of the survey respondents reported a college degree, which is much higher than the 10 percent of population with a college degree reported by the U.S. Census Bureau (2011). The survey did not ask about income.

Results

Overall, residents were relatively neutral in their attitudes toward construction of the wind farm (with nearly 40 percent reporting that it had neither a positive nor negative effect on the area). In contrast, attitudes toward natural gas drilling were more polarized and became much more negative as development unfolded (Table 1). For gas drilling the attitude mean was 2.77 for gas drilling compared with 3.10 for the wind

farm. For the question on whether attitudes had changed since development occurred, the mean for gas drilling was 2.66 (became slightly more negative) compared to 3.17 (became slightly more positive) for the wind farm. For detailed results on attitudinal variation based on factors such as proximity, employment, and environmentalism, see Jacquet (2012).

Perceived Impacts

A main objective of this survey was to measure the types of impacts perceived from both wind and natural gas development (Table 2). The results show a number of similarities in the types of impacts perceived as respondents indicated that negative community impacts, personal impacts, and environmental impacts were experienced as a result of both wind and gas development (Table 2). They perceived the impacts as more negative for natural gas drilling (Table 2), and we measured the differences between energy developments by the Games-Howell post-hoc test to be significant at $p < .01$. In direct contrast to other categories of impacts, the perceived economic impacts were largely neutral for wind farm development (mean = 2.98), while they were quite positive for natural gas drilling (mean = 3.64).

"Area employment" was considered the most positive impact from both wind and natural gas, while "effect on area scenic beauty" and "amount of traffic" were the most negatively affected variables for both energy sources, although the magnitude of impact was reported as greater for gas drilling (both positively and negatively).

Bivariate correlations between the types of impacts perceived and attitudes toward energy development indicate strong bivariate relationships between impact perception in the environmental and community domains and attitudes toward development. Environmental and community impacts correlated most strongly with attitudes toward both wind and natural gas, with correlation coefficients equaling .714*** and .704***, respectively, for natural gas and .633** and .673***, respectively, for wind, demonstrating that the more negative the perceived impact on these aspects, the more negative the attitude toward energy development. Correlations between overall attitude and the "economic" and "personal" impact categories were .692*** and .555*** (respectively) for gas, and much lower (.194*** and .233***) for wind.

Place Meanings

Respondents most agreed with statements about the community that corresponded with environmental or restorative meanings, followed by

Table 2. Perceived Impacts (Grouped by Factor).

	Wind Farm				Gas Drilling			
	Mean	Standard Deviation	Cronbach's Alpha	Variance Explained (Factor Analysis)	Mean	Standard Deviation	Cronbach's Alpha	Variance Explained (Factor Analysis)
Environmental impacts	2.63	.660	.845	36.17%	2.30	.809	.911	45.82%
Hunting/fishing	2.55	.787			2.37	.913		
Outdoor recreation	2.63	.767			2.42	.903		
Scenic beauty	2.42	.984			2.11	.913		
Environmental health	2.93	.676			2.28	.913		
Community impacts	2.88	.716	.824	8.14%	2.67	.679	.887	6.97%
Sense of community	2.90	.639			2.94	.832		
Attachment	2.97	.790			2.68	.882		
Social relations	2.96	.547			2.79	.747		
Trust in local government	2.65	.790			2.40	.901		
Trust in the energy developer	2.72	.912			2.30	1.035		
Pride in the community	3.15	.777			2.99	.910		
Quality of government services	2.80	.610			2.59	.823		
Personal impacts	2.71	.485	.725	6.55%	2.31	.696	.846	5.70%
Noise	2.58	.795			2.14	.973		
Crime	2.89	.563			2.37	.870		
Traffic	2.51	.967			1.80	1.208		
Quality of the water	—	—			2.27	.926		
Local energy prices	2.59	.826			2.53	.921		
Cost of living	2.77	.740			2.44	1.009		
Resident health	2.97	.495			2.63	.797		
Economic impacts	2.988	.471	.740	5.69%	3.64	.802	.759	4.40%
Property values	2.81	.740			3.46	1.194		
Area employment	3.25	.678			4.04	.810		
Economic health	3.16	.622			3.42	1.015		
Agriculture industry health								
Tourism industry health	2.89	.599			2.57	.945		
	2.84	.710			2.62	.850		
Nonloading impacts								
Quality of Life	2.89	.640			2.65	.924		

Questions were formulated as: "Please identify how the (energy development) has changed certain facets of the study area?" (1 = very negative; 2 = negative; 3 = neither negative nor positive; 4 = positive; 5 = very positive).

Table 3. Categories of Place Meaning.

	Mean	Standard Deviation	Cronbach's Alpha	Variance Explained
Environment/restorative	4.27	.596	.804	30.18%
Wilderness qualities	4.30	.694		
Good place to get away	4.22	.800		
Outstanding natural beauty	4.47	.663		
Great recreational opportunities	4.11	.836		
Community	3.77	.663	.742	13.43%
Very friendly	4.02	.780		
Close-knit	3.82	.820		
Newcomers welcome	3.48	.848		
Vertical integration	2.59	.789	.317	11.64%
Tourist destination	2.95	1.105		
Industrial area	2.24	.936		
Threatened	3.02	.768	.768	9.47%
Poor environmental health	2.32	1.03		
Economic decline	3.73	1.02		

Questions were formulated as: "To what extent do you agree or disagree with the following statements about the study area?" (1 = strongly disagree; 2 = disagree; 3 = neither disagree or agree; 4 = agree; 5 = strongly agree).

statements that stressed community cohesion, economic linkages with larger society, and finally with environmental and economic threats (Table 3). One might presume that the type of perceived impact would be strongly related to the associated place meaning category (e.g., environmental impacts from energy would be most strongly perceived among those who agree with environmental place meanings); however, the empirical relationship between level of agreement with particular place meanings and the types of perceived impacts was relatively small and not statistically significant in many cases. An exception was that respondents who had a strong affinity for the "threatened" place meaning (comprising "poor environmental health" and "economic decline") were more likely to view the impacts of both wind and gas development as negative across all impact categories, with correlation coefficients ranging from –.097*** to –.219***.

Place Attachment and Residency Status

The bivariate results suggest that place attachment and residency status (seasonal vs. year-round) appear to play a very marginal role in resident attitudes toward energy development, counter to some previously published research that has emphasized the importance of these variables. Residency type did correlate with attitudes toward the wind farm (r = –.125***), as seasonal residents tended to have more negative attitudes

toward wind farm development than persons with permanent residences, perhaps suggesting harm to amenity or environmentally related values. Stronger place attachment showed a weak positive correlation with attitudes toward gas drilling ($r = .065$**). Length of residency was weakly correlated with attitudes toward natural gas drilling ($r = .105$***) and wind development ($r = .078$**); those with a longer history of residency were somewhat more likely to support development.

Demographic Variables

The variables of age, gender, and education did exhibit some correlation with attitudes toward both wind and especially natural gas development, as women, those with more education, and those who were older were more likely to view the developments as negative. The correlations with natural gas attitudes were stronger for gender ($r = -.179$***; male = 1, female = 2), than for age ($r = -.130$***) or education ($r = -.147$***). The correlations for wind farm attitudes and gender were nonsignificant, and were weaker for age ($r = -.096$**) and education ($r = -.089$*).

Stronger were the correlations between the age and education variables and impact perception. Increased age was correlated with more negative perceptions of community impact ($r = -.134$***), environmental impact ($r = -.189$***), personal impacts ($r = -.198$***) from natural gas drilling, with no significant correlation with economic impacts. Increased education was correlated with more negative perceptions of impacts on community ($r = -.198$***), environmental impacts ($r = -.187$***), personal impacts ($r = -.234$***), and economic impacts ($r = -.143$***) from gas drilling. Gender was only correlated ($r = -.134$***) with economic impacts from natural gas drilling, showing that women were less likely to perceive economic impacts as positive. Correlations with wind farm impacts were weaker. Age was correlated with environmental impacts ($r = -.099$**) and personal impacts ($r = -.088$**) and education was correlated with community impacts ($r = -.086$**), while other correlations were negligible or not statistically significant.

Multiple Regression Analyses

Perceived impacts and attitudes toward energy development. We determined the direct, linear effect of all variables on attitudes toward development using multiple regression analysis, and showed that it explains a large amount of variation in resident attitudes toward both gas and wind (Table 4). For attitudes toward natural gas drilling, the variables predicted over 60 percent of the variation (adjusted $R^2 = .620$***); while for

Table 4. Multiple Regression Analysis.

Independent Variables	Unstandardized Coefficients B	Standard Error	Standardized Coefficients	*t*	Significance
Attitudes towards gas[a] drilling					
(Constant)	−6.980	.530		−13.163	.000
Community impacts	2.153	.297	.273	7.252	.000
Environmental impacts	1.623	.233	.248	6.950	.000
Personal impacts	.287	.230	.037	1.245	.213
Economic impacts	2.531	.232	.330	10.893	.000
Environmental place meaning	.043	.234	.005	.183	.855
Community place meaning	−.157	.190	−.020	−.825	.410
Integration place meaning	−.341	.146	−.050	−2.336	.020
Threatened place meaning	−.079	.156	−.012	−.509	.611
Place attachment	.032	.029	.028	1.108	.268
Residency status (0 = permanent/1 = seasonal)	.105	.308	.007	.341	.733
Length of ownership	.011	.007	.033	1.505	.133
Acres owned	1.107E-5	.000	.012	.574	.566
Gender (1 = female; 2 = male)	−.796	.255	−.069	−3.122	.002
Age	−.018	.011	−.045	−1.647	.100
Education	.141	.103	.031	1.373	.170
Attitudes toward the wind farm[b]					
(Constant)	−11.218	1.399		−8.017	.000
Community impacts	2.390	.318	.262	7.505	.000
Environmental impacts	2.749	.254	.397	10.841	.000
Personal impacts	0.351	.280	.037	1.256	.209
Economic impacts	1.599	.329	.163	4.860	.000
Environmental place meaning	0.357	.218	.047	1.632	.102
Community place meaning	−0.088	.180	−.013	−.489	.624
Integration place meaning	0.148	.134	.026	1.099	.271
Threatened place meaning	0.510	.149	.086	3.418	.001
Place attachment	0.029	.027	.030	1.075	.282
Residency status (0 = permanent/1 = seasonal)	−0.888	.290	−.074	−3.058	.002
Length of ownership	0.001	.007	.004	.188	.850
Acres owned	1.225E-5	.000	.011	.500	.616
Gender (1 = female, 2 = male)	−.163	.246	−.016	−.664	.507
Age	.006	.010	.018	.607	.544
Education	.083	.097	.021	.854	.393

[a] Model summary: *R* square = .627; adjusted *R* square = 0.620; standard error of the estimate = 3.254.

[b] Model summary: *R* square = 0.569; adjusted *R* square = 0.560; standard error of the estimate = 2.959.

attitudes toward the wind farm, the variables predicted over 55 percent (adjusted R^2 = .560***). In both cases, the vast majority of this variation is explained by perceived environmental, community, and economic impacts, with beta values that remain largely similar to correlations at the bivariate level. The influence of other variables such as place meanings or place attachment was much lower (Table 4). The models show that resident attitudes toward the wind farm were most strongly related to perceived environmental impacts (beta = .397***), meaning that the more negative the environmental impacts were perceived to be, the more negative attitudes were toward the development. Other significant, though weaker, predictors were perceived community impacts (beta = .262***) and economic impacts (beta = .163***). In terms of gas drilling, the model showed that perception of economic impacts (beta = .330***) had the largest effect on attitudes toward gas drilling, followed by environmental impacts (beta =.248***) and community impacts (beta = .273***).

While bivariate correlations were present in some cases, the demographic and place meaning variables lost nearly all predictive qualities once integrated into the multiple regression model. Additionally, the "personal cost category" of perceived impacts, comprising variables such as "water quality," "amount of traffic," "noise," and so on, did not show a relationship with attitudes toward either gas or wind, even though respondents reported these types of impacts to be among the most severe. It appears that both residents who are for and those who are against the development of these energy sources can agree that these impacts are largely negative, thus decreasing their predictive ability.

Discussion

This research demonstrates that the perception of specific impacts from energy development is a key driver of overall attitudes toward the energy projects. The relationship between the types of perceived impacts and overall attitudes toward development are similar between wind and gas in that environmental, economic, and community concerns explained a large amount of variation in resident attitudes toward the energy facilities. The strongest relationship was between perceived economic impact and attitudes toward gas drilling. Respondents who perceived that variables such as "area employment," "property values," and "economic health" were enhanced by development were much more likely to have positive attitudes toward gas drilling. Historical and contemporary research has found economic impacts perceived as the most positive aspects of natural gas drilling (Murdock and Leistritz 1979; Stedman

et al. 2011), and this research suggests that these perceptions will result in positive attitudes toward development.

Meanwhile, some of the impacts of greatest perceived magnitude (constituting the "personal cost" category, variables such as traffic, crime, noise, and water) seemed to have little effect on resident attitudes toward the gas and wind development. Residents both for and against the energy development seemed to agree that these impacts are largely negative. For example, impacts on water quality (which have been much publicized both locally and nationally in the political debate around natural gas drilling) were perceived as among the largest and most negative impacts from gas drilling, yet did not appear to influence attitudes toward development, suggesting, perhaps, that impacts to water quality are largely beyond debate among supporters and opponents.

The specific impacts measured here mirror previous literature in some ways (i.e., impacts on scenic beauty from wind energy as paramount; traffic from natural gas drilling as its largest negative effect) while disclosing new types of impacts typically not documented (i.e., impacts on traffic from wind energy, and impacts to scenic beauty from gas drilling). The impact of natural gas drilling and the associated infrastructures on scenic beauty has been noted by some researchers (Upadhyay and Bu 2010); however, overall the subject of aesthetic impact from natural gas drilling represents a neglected area of academic inquiry, especially in contexts of multiple energy sources and in regions that are relatively close to population centers.

The results of this survey show that respondents view the impacts (both positive and negative) from natural gas drilling to be greater, and that the types of perceived impacts that seem to influence attitudes are more diverse compared to wind farm development. However, in many ways, landowners in the Armenia Mountain area perceive wind and natural gas development relatively similarly: they perceive the same types of impacts from both projects. Despite a survey design that clearly separated the questions regarding the two energy sources, part of this result may in part be due to respondent difficulty in delineating impacts from one energy source from those of the other, especially in an area that has seen the rapid, simultaneous growth in development of these sources. For example, while it is certain that the development of the wind farm increased traffic in the local area, it is also certain that the amount of traffic related to natural gas drilling is much higher. How survey respondents delineate the cumulative effect on traffic according to each energy source is not well understood. However, regardless of the methods, these results clearly show traffic as perceived to be among the most adverse impact from both wind farm and natural gas development.

We can discern that, examined independently, the meanings residents attribute to their community can influence their attitudes toward natural gas development, and to some degree the perception of energy development impacts for both energy sources. We found that place meanings that are environmental, restorative, or threatened are associated with opposition to natural gas development. These results echo other studies that have examined these types of meanings in other types of land-use cases (Devine-Wright 2009; Devine-Wright and Howes 2010; Kaltenborn 1998; Stedman 2003). However, the place meanings seemed to have little or no association with wind farm development, which conflicts in this instance with studies by Devine-Wright that have looked specifically at the wind farm context. Community-based place meanings (such as friendly, close-knit, welcoming) were positively correlated with natural gas development attitudes, as persons who felt their community exhibited these traits were more likely to support gas development. However, once the impact variables are included in the final model, the effect of place meanings on resident attitudes dissipates. Finally, demographic variables do appear to influence the range and types of impacts that residents perceive to some degree. Men are more likely to view the economic impacts of energy development as positive, for example, while increased age and education was associated with a perception of more negative impacts across nearly all categories.

Conclusion

In general, the results show that residents perceive many of the same kinds of positive and negative impacts from both wind and natural gas, although they view the magnitude of positive and negative impact to be greater for natural gas drilling. The results also show that certain types of perceived impacts play consistently larger roles than others in influencing overall support or opposition. It is often assumed in the social sciences that an individual's perception of local impacts of a development will influence his or her attitudes toward that development, and while this assumption is strongly affirmed with results of this research, little research has examined resident impact perception of already constructed facilities. Why certain impacts are more salient in the formation of attitudes than others is promising for future study and can be used to implement more effective impact assessment in the planning and siting of future projects. Is it the case that variables found to not influence resident perceptions in this instance (such as crime, water quality, traffic, etc.) generally do not influence attitudes toward development in other instances of land-use change?

This survey represents only a snapshot in time, measures perceptions and attitudes of landowners only, and is relatively early in the process of energy development. Natural gas drilling will likely continue in this area for many years, and plans for the construction of another 57 wind turbines on Armenia Mountain have been approved. Research on energy-related social impact assessment and perceptions has been criticized for lacking a longitudinal perspective (Brown, Geertsen, and Krannich 1989; Brown et al. 2005; Thompson 1979; Wilkinson et al. 1982), and previous research has shown that perception of impact can change over time (Brown et al. 2005; Devine-Wright 2005; Thompson and Blevins 1983).

Energy development such as natural gas and wind will continue to expand in the coming years and decades, and local conflict over the siting of these projects can be expected to expand as well. It is increasingly likely that areas will experience multiple forms of energy development, and these results imply that the development of these energy sources in close proximity have additive and cumulative effects, at least in the minds of residents, and more comprehensive strategies for managing and mitigating these effects should be considered.

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