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A change in the wind? US public views on renewable energy and climate compared

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Abstract

Background: Renewable energy development is a necessary step toward climate change mitigation, so these topics have often been linked. In US public discourse, however, they have somewhat different profiles—climate change views are tied closely to partisan identity, whereas renewable energy exhibits more cross-cutting appeal, and sometimes more cross-cutting opposition as well. To what extent are such differences reflected in survey data tracking rates of change, respondent characteristics, and local or regional variations in public opinion on renewable energy and climate?

Methods: We explore similarities and differences in views of renewable energy and climate change using a unique collection of 18 US national or regional surveys totaling more than 14,000 interviews, conducted between 2011 and 2017. Individual surveys varied in context, content, and goals, but all asked two common energy and climate questions, which yield comparable and strikingly consistent results.

Results: Public support for renewable energy appears broader than acceptance of anthropogenic climate change (ACC), especially in a more conservative region. Despite local controversies, support for renewable energy in recent years rose faster than ACC acceptance on two regional surveys. Political divisions remain wide on both topics, but wider regarding climate change—particularly among college-educated respondents. Renewable energy views in counties with proposed or operating wind farms are not systematically different from those in other counties.

Conclusions: Overall, these results provide encouragement for promoting renewable energy in terms of its economic benefits, working around some of the political identity-based resistance to climate change mitigation. That approach could be most important in politically conservative regions where such resistance is strong.

Keywords: Climate change, Renewable energy, Wind, Solar, Survey, Public opinion

Background

Transitioning from fossil fuels to lower-carbon renewable energy sources presents the central challenge and most pressing requirement for mitigation of anthropogenic climate change. Consequently, the issues of renewable energy development and climate change often are linked through scientific, policy, and public discussions. In the USA, however, renewable energy appears to have somewhat broader public appeal [1-3]. That appeal partly reflects immediate economic benefits including jobs, cheaper energy, and income for landowners or managers. Less tangibly, some renewable sources (e.g., rooftop and community solar) promise a sense of self-sufficiency that attracts people of diverse persuasions. Individual incentives include lower prices, growing accessibility, belief that renewable energy is environmentally better, and social modeling as people see their peers or other regions successfully adopting. Broader public acceptance of renewable energy leads to suggestions that renewable energy development should be advocated as a constructive action with or without reference to climate change [4-7].

But how different *are* the social bases of public support for renewable energy and views about climate change? A unique collection of 18 national and regional US surveys, all of which carried the same two energy and climate questions, allows systematic comparison of views on these issues across time, location, and respondent characteristics. We find broad similarities in the background characteristics of people who prioritize renewable

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energy development and those who accept the reality of anthropogenic climate change (ACC). There are some contrasts regarding the two issues as well: renewable energy development has somewhat higher public support, especially in a conservative region, and its support may be rising faster. More subtly, differences in the interaction between education and political party suggest that processes of partisan information-filtering operate less severely with renewable energy than with acceptance of ACC. These results provide qualified encouragement for promoting renewable energy in terms of its economic benefits, working around some of the political identity-based resistance to climate change mitigation.

Solar and wind power currently make up relatively small fractions, around 2.2 and 5.5% respectively, of US electricity generating capacity [8]. However, their importance is rapidly growing. Solar power (both concentrated industrial and distributed photovoltaics) contributed 39% of all new US capacity in 2016; another 26% came from wind power [9]. In terms of employment, solar and wind power industries grew 12 times faster than the US economy as a whole, with employment in both sectors well surpassing the declining coal industry [10]. Dramatic reductions in the cost of solar- and wind-generated electricity have made them economically more competitive, while rising concerns about climate change highlight their importance as low-carbon sources. Other factors including legislation, tax credits, community programs, new enterprises, and wider distribution networks add to renewable energy's consumer appeal—although some of these could be reversed by changes in government policy.

Immediate employment and economic benefits give renewable energy issues a different character from risk-oriented discussions of anthropogenic climate change (ACC), but the two topics often are linked [11]. Reducing greenhouse gas emissions, hence slowing the pace of climate change, forms a major argument in favor of renewable energy development. While new industries or investments build up wind and solar, fossil fuel interests have incentives and means to oppose renewable energy development or else shift emphasis to other fossil fuels such as natural gas instead of coal. Politicians, politicized media, and the public often align their views on both topics according to general left/right orientation: renewable energy and the reality of ACC are more widely accepted among liberals and moderates, whereas fossil fuels and ACC denial have stronger conservative appeal. Thus, perceptions about renewable energy and climate become tied to sociopolitical identity, as dramatized in the 2016 US presidential campaign where the main parties took opposite positions on both [12]. Of course, such left/right alignment is socially constructed; there is nothing inherently liberal or conservative about wind turbines and oil wells, or the Earth's air and water.

Political identity dominates other individual characteristics in predicting climate change views among the US public. Gender and age effects are weaker but generally consistent: women and younger adults more often see ACC as a problem. Such relationships between climate views and individual characteristics have been extensively studied, with new work almost weekly [13-20]. Despite the diverse methods employed, analyzing different questions from samples collected at different times, core findings appear stable. The demographic predictors of climate change concern broadly resemble those of other environment-related topics explored by studies over the decades since Van Liere and Dunlap wrote about "the social bases of environmental concern"—although political divisions are much wider now [21].

Regarding climate change and other environmental issues, people with more education generally express higher concern. Education effects are complicated, however, by their interaction with politics. Concern increases with education among liberals and moderates, but does not increase and may even decrease with education among the most conservative [22-26]. Similar patterning occurs in analyses with objectively assessed science literacy or numeracy, or with subjectively assessed understanding, taking the place of education [25, 27-29]. Conceptual explanations for this class of interactions invoke information-filtering frameworks such as elite cues, confirmation bias, cultural cognition, biased assimilation, motivated reasoning, reinforcing spirals, and selective exposure [15, 30-39]. These frameworks share a common insight that people preferentially acquire information that reinforces their prejudices and sociopolitical identity. Better-educated individuals more actively filter information and are more cognizant of identity-appropriate positions, so educated partisans are the farthest apart.

The social bases of support for renewable energy development in general terms resemble those for concern about climate change and other environmental issues. Driven by practical interests, however, studies of public support for renewable energy often focus on specific places where development is occurring or proposed. At regional and local scales, different patterns emerge, as people who might be expected to favor renewable energy in general terms based on their values nevertheless oppose a specific development having impacts near where they live [40-42]. Such opposition is often labeled as NIMBY ("not in my backyard"), although some scholars reject that term as pejorative and unfairly simple [43, 44]. Wolsink (2007), for example, notes the importance of feelings about equity and fairness, along with visual impacts on the landscape, in shaping views

toward local wind development [45]. Petrova (2016) distinguishes four broad categories of concern—visual/landscape, environmental, socioeconomic, and procedural [46]. Specific issues include apprehensions about noise, impacts on wildlife, sense of place, engagement in process, and the degree of local vs. distant benefits. Research sometimes aims to identify particular communication or engagement strategies that reduce local opposition [47]. Unsurprisingly, a key factor affecting public support for renewable energy development is perception of local economic benefits [48-50].

In this paper, we examine key questions arising from discourse on renewable energy in the context of climate change. (1) Does the higher public support for renewable energy found in national surveys also occur locally, in places with controversial development? (2) Are views on these topics changing, and with similar directions and rates? (3) Do the same individual characteristics predict views on renewable energy and climate change, or are the former less politicized? (4) Net of individual characteristics, are there detectable differences in renewable energy views of residents in counties that have or have not experienced large-scale wind power development?

Addressing these questions requires broad, comparative data. We analyze a unique collection of 18 surveys with more than 14,000 respondents, conducted under four different projects over 2011 to 2017. Although these surveys differed in content and goals, they carried two common renewable energy and climate change questions—providing a resource for exploring individual, regional, and temporal dimensions of public views on renewable energy and climate change together.

Methods

Of the four survey projects covered, one (Polar, Environment, and Science; POLES) involves nationally representative US samples. The other three are regional, covering the state of New Hampshire, the North Country (a rural four-county region in northern New Hampshire, Vermont, and Maine), and northeast Oregon. Each of the regional studies involves areas that experienced economically significant manifestations of climate change during these years and also saw controversial development of wind power.

Regional survey context

Solar energy, mainly from distributed photovoltaics, contributes less than 1% of New Hampshire's electricity needs. The state's northern latitude and climate are less conducive to solar power than some sunnier locations, but the solar contribution has been rapidly growing. Around 54 MW of installed capacity existed in 2016, and it is projected to pass 260 MW over the next 5 years [9]. The state's solar industry includes almost 80 companies, the majority involved with manufacturing. Demand from individual businesses and homeowners, encouraged by utility rebates, is driving this expansion.

New Hampshire hilltops provide locations favorable for wind turbines. The main sites currently operating are Lempster Mountain (Sullivan County), Granite Reliable Wind Farm (Coös County), and Groton Wind (Grafton County), which have a combined capacity around 170 MW. Additional wind farms have been proposed for Antrim (Hillsborough County) and Spruce Ridge (Grafton County), but these appear stalled after residents of nearby towns voted overwhelmingly against them. Primary concerns raised by opponents include negative impacts on property values, scenery, wildlife, and public health and safety (related to sound and shadow flicker from turbines) [51].

Other significant sources of renewable energy for New Hampshire are hydroelectric power and biomass burning. Together, these have a capacity over 600 MW, although these sources were not mentioned in our survey question. Tidal energy, which is mentioned in the New Hampshire question, is not yet operational in the state apart from the small-scale Living Bridge project in Portsmouth.

Coös and Grafton Counties in New Hampshire, along with Essex County in Vermont, and Oxford County in Maine, comprise our North Country region. This sparsely populated region was the focus of a separate, targeted survey involving 1650 interviews in the summer of 2017. Coös and Grafton wind developments have been mentioned above. Oxford County has about 70 MW of wind capacity operating at two sites (Spruce Mountain and Record Hill), with local support encouraged by the resulting income [52]. Wind farms at large and small scales have been proposed in Essex County, but faced strong local opposition [53]. Thus, all of the North Country counties have experience with proposed or currently operating wind development.

The state of Oregon generates the majority of its own electricity from renewable sources and exports some to other states. Hydroelectric power comprises the largest fraction, but installed wind capacity exceeds 3100 MW. Installed solar capacity is over 260 MW and, as in New Hampshire, has been rising steeply [9]. Northeast Oregon, the site of our Communities and Forests in Oregon (CAFOR) surveys, is a sparsely populated region (fewer than 3 people per km^2) with a relatively dry climate. Substantial wind farms operate at Elkhorn Valley (Union County) and the Vansycle Ridge and Stateline projects in Umatilla County. One smaller project (Chopin, also in Umatilla County) has been approved but not yet completed. A proposal for a larger project at Antelope Ridge in Union County was withdrawn in 2013. Fifty-two percent in a vote among Union county residents went against this project. Local opponents cited wildlife and visual impacts, whereas proponents focused on the

potential for tax revenues and employment—as well as freedom of people to do what they want on their own land, a salient value in this region. The developer described withdrawal as strictly a business decision, resulting from changes in California rules that made it harder to export electricity to that state [54]. An even larger project, Wheatridge Wind (500 MW), has been proposed for Morrow and Umatilla Counties.

The context for renewable energy development in both New England and Oregon involves rapid growth in distributed photovoltaics, although these do not yet make up a large fraction of electricity supply. Both regions also have a recent, high profile recent history of wind farm development, with some sites established but others successfully opposed. Homemade signs and local activism opposing development in Union County, Oregon, were noted by the CAFOR research team during field work in 2011. The controversy inspired placement of our renewable energy question on the first Oregon survey, and subsequently on many others.

Four survey projects

US Polar, Environment, and Science (POLES)

These nationwide US landline and cell telephone surveys were organized by University of New Hampshire and Columbia University researchers. Interviews involved two stages with separate random samples: before the US presidential elections in August 2016 ($n = 704$) and immediately afterwards in November/December 2016 ($n = 707$). Response rates in four subsamples of the POLES survey ranged from 15 to 30% (all response rates are calculated following AAPOR definition 4 [55]). The surveys asked mainly environment- and science-related questions. Preliminary results have been described in two reports [12, 56].

New Hampshire Granite State Poll (GSP)

These landline and cell telephone surveys interview independent random samples of New Hampshire residents four times each year. Along with standard background and political questions, the GSP often carries items about environment or science. New Hampshire responses on the environment/science questions commonly fall close to national benchmarks. Some recent New Hampshire/US data comparisons, and citations to other GSP research, are given by Hamilton [56, 57]. From July 2012 to October 2017, the GSP conducted 7064 interviews that included our renewable energy question. The median response rate over this period was 20%.

Northeast Oregon Communities and Forests in Oregon (CAFOR)

Under the CAFOR project, landline and cell telephone surveys involving separate random samples of northeast Oregon residents were conducted in three stages: September/October 2011 ($n = 1585$ from Baker, Union, and Wallowa Counties), August/October 2014 ($n = 1752$, from the same three counties along with Crook, Grant, Umatilla, and Wheeler Counties), and October/November 2015 ($n = 651$, repeating the seven counties from 2014) [24, 58-61]. Response rates on the three CAFOR surveys range from 30 to 48%.

North Country

This survey in summer 2017 involved random-sample cell phone and landline interviews with 1650 residents of four adjacent counties in northern New England: Coös and Grafton, New Hampshire; Essex, Vermont; and Oxford, Maine. Designed to assess changes in residents' perceptions of their rural communities, the survey (with a response rate of 19%) replicated some questions from earlier surveys [62].

Results

Table 1 lists variables from these surveys that are analyzed here. Although each project had different frameworks and goals, they carried two standard questions on renewable energy and climate. Additionally, the surveys gathered respondent background information such as age, education, and political party.

Renewable energy and climate change views

The renewable energy question asks,

> Which do you think should be a higher priority for the future of this country, increased exploration and drilling for oil, or increased use of renewable energy such as wind or solar?

Figure 1 shows the strong support for renewable energy across the most recent years of each project (2015 for CAFOR, 2016 for POLES, 2017 for GSP and North Country).[1] Seventy-two percent of the national respondents, and 78 or 79% in the recent North Country and New Hampshire surveys, gave renewable energy higher priority. Even in northeast Oregon, which environmentally and politically tends to be much more conservative [60, 63], 61% prioritized renewable energy while only 26% chose increased exploration and drilling.

The surveys also carried a basic question on climate change:

> Which of the following three statements do you think is more accurate? Climate change is happening now, caused mainly by human activities; climate change is happening now, but caused mainly by natural forces; or climate change is not happening now.

The US, New Hampshire, and North Country results are quite similar—64 to 66% agreement with the

Table 1 Definitions of variables, with coding used for logit regression models in Table 2

Dependent variables
Renew—Which do you think should be a higher priority for the future of this country, increased exploration and drilling for oil or increased use of renewable energy such as wind or solar? (Response choices rotated in interviews.)
Increased use of renewable energy such as (NH only: tidal,) wind or solar (1)
Increased exploration and drilling for oil (0)
don't know/no answer (0)
Climate—Which of the following three statements do you think is more accurate? (Response choices rotated in interviews.)
Climate change is happening now, caused mainly by human activities (1)
Climate change is happening now, but caused mainly by natural forces (0)
Climate change is NOT happening now (0)
don't know/no answer (0)
Respondent characteristics
Age—Respondent's age in years, 18–96
Sex—Male (0) or female (1)
Education—High school or less (– 1), some college or technical school (0), college graduate (1), or postgraduate (2)
Party—Democrat (– 1), Independent (0), Republican (1), or Tea Party supporter (2, not asked on 2011 CAFOR survey)
Timing of survey
Election—US POLES survey only: pre-election (0) or post-election (1) 2016
Year—NH GSP and OR CAFOR surveys only: year from 2011 to 2017
Wind power development
Windev distinguishes between counties in the regional surveys that do (1) or do not (0) contain currently operating or proposed wind power developments. In New Hampshire, these are Coös, Grafton, and Sullivan counties; in northeast Oregon, Umatilla, and Union counties. All of the North Country counties (Coös, Grafton, Essex, and Oxford) include such developments.

scientific consensus that climate change is happening now, caused mainly by human activities (Fig. 2). Twenty-five to 29% instead think climate is changing for natural reasons, while just 3 or 4% maintain that climate change is not happening now.[2] Previous studies found that New Hampshire and nationwide responses tend to be similar on this question [16].

Northeast Oregon is a politically conservative region; in the 2012 presidential election, Barack Obama received only 22 to 34% of the votes from our CAFOR counties (compared with 51% nationwide or 52% in New Hampshire). County-level voting behavior correlates strongly with views on climate change [63], so there is correspondingly low agreement in this region that human activities are changing the climate (42% on our 2015 survey). Many residents concede that climate is changing but attribute it to natural forces [64]. Although our renewable energy and climate change questions are not directly comparable with each other, we note that the *gap between* renewable energy and anthropogenic climate change responses is particularly wide in this conservative region (19 percentage points). The wide gap in Oregon, where majorities prioritize renewable energy but do not think ACC is real, suggests some degree of decoupling from left/right identity—as illustrated anecdotally in Fig. 3.

Earlier papers discussed perceptions and reality of climate changes in northeast Oregon [24, 60] and New Hampshire [63].

Figure 4 tracks results from the 18 surveys synthesized for this study. The two nationwide POLES surveys, conducted just before and after the 2016 election, exhibit a slight uptick in public support for renewable energy following the election of Donald Trump, who strongly promotes fossil fuel use instead. In northeast Oregon, support for renewable energy rose almost linearly by about 10 points through the surveys of 2011, 2014, and 2015. Twelve statewide New Hampshire surveys show a rise of more than 15 points from 2012 to 2017. The North Country results, involving four rural counties of New Hampshire, Maine, and Vermont, provide a single data point that fits with the statewide New Hampshire trend.[3]

Taken together, the regional surveys suggest a gradual rather than event-driven rise in priority for renewable energy, in keeping with national trends [2]. In New Hampshire and Oregon, the rise occurred despite local controversies about wind development. The next section tests whether shifts in demographics or political orientation can account for these trends.

Individual, temporal, and regional effects

Table 2 summarizes results from eight logit regression models predicting support for renewable energy (*renew*) or acceptance of anthropogenic climate change (*climate*) from individual respondent characteristics: *age*, *sex*, *education*, political *party*, and *education*×*party* interaction.[4] Where appropriate, indicators of survey timing are included as predictors too—before/after the 2016 election for POLES or year for the New Hampshire and Oregon surveys. Finally, with New Hampshire and Oregon, we include an indicator for counties that have experienced proposed or accomplished wind developments. Variable definitions and coding are given in Table 1.

Table 2 expresses predictor effects in terms of odds ratios (exponentials of logit coefficients), interpreted as multiplicative effects on the odds favoring renewable energy development, or anthropogenic climate change, per 1-unit increase in each predictor. For example, the odds ratio 1.352 for education in model 1 indicates that the odds of favoring renewable energy increase by about

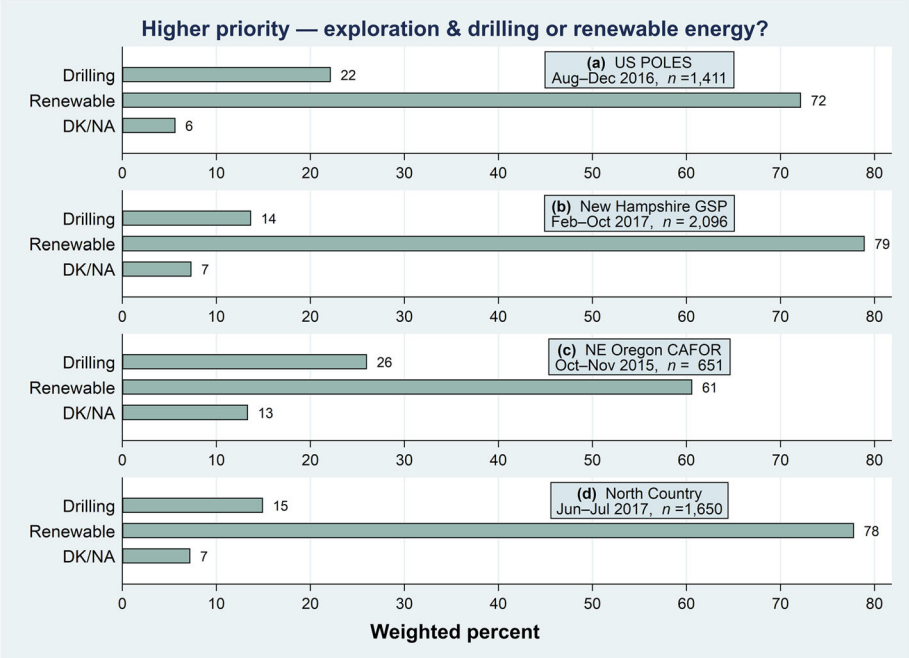

Fig. 1 Should increased exploration and drilling for oil, or increased use of renewable energy such as wind or solar, be a higher priority for the future of this country? Responses from most recent years of US POLES, New Hampshire GSP, NE Oregon CAFOR, and North Country survey projects

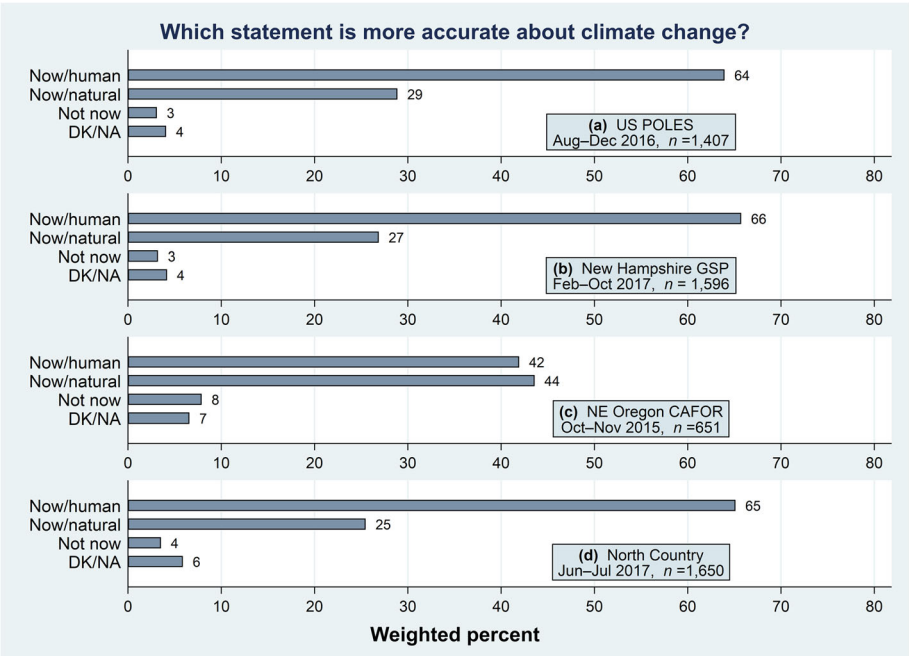

Fig. 2 Is climate change happening now, caused mainly by human activities? Is it happening now, but caused mainly by natural forces? Or is climate change not happening now? Responses from most recent years of US POLES, New Hampshire GSP, NE Oregon CAFOR, and North Country survey projects

Fig. 3 Billboard with "I didn't vote Obama" sticker signals the political orientation of a wind power supporter in Oregon (L. Hamilton photo, July 2013)

35% (multiplied by 1.352) with each 1-step increase in respondent education, other things being equal. This *education* effect is statistically significant at $p < 0.01$, as determined by an adjusted Wald test. Probabilities from these tests are summarized by one to three stars (for $p < 0.05$ to $p < 0.001$) for each individual odds ratio in Table 2. Similar notation in the row of F statistics (likewise based on adjusted Wald tests) indicates that for all of these models, overall tests of the fitted model against a constant-only model yield p values below 0.001. Descriptively, each model's fit is summarized by count R^2 and adjusted count R^2 statistics, adapted for these probability-weighted models [65].

The eight models in Table 2 describe four sets of data. The first two models involve the nationwide POLES survey, with an estimation sample of 1209 interviews. The dummy variable *election* is coded 0 for the pre-election August stage and 1 for the post-election November/December stage, but this timing makes no difference in predicting either *renew* or *climate*. *Age*, *education*, and *party*, on the other hand, do affect *renew* and *climate*, and in similar directions for both dependent variables. Odds ratios greater than 1.0 correspond to "positive" effects, while those below 1.0 correspond to "negative" effects. Older respondents less often prioritize renewable energy or think anthropogenic climate change is real. Odds of prioritizing renewable energy or accepting ACC tend to be higher among respondents with more education and lower among those with more conservative political identities.

The *education*×*party* interaction effect on *renew* falls short of statistical significance ($p = 0.09$), although this interaction does significantly affect *climate* ($p < 0.001$). The interactions have a similar character for both *renew* and *climate*. Support for renewable energy, or acceptance of ACC, both tend to increase with education among Democratic and Independent respondents. Among Tea Party supporters, on the other hand, support for renewable energy does not rise with education, and acceptance of ACC actually declines (Fig. 5). Similar interactions have

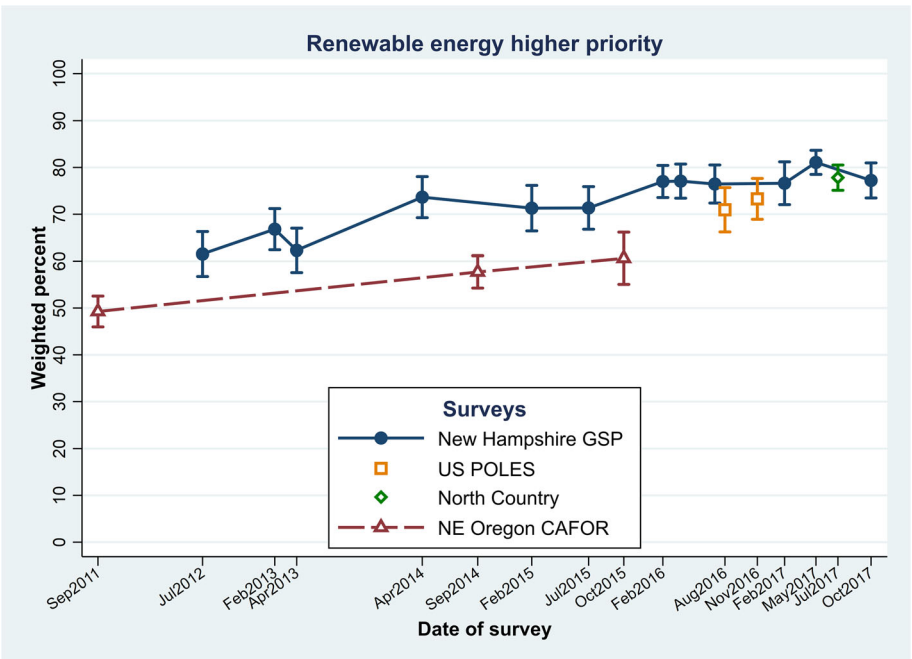

Fig. 4 Weighted percentages and 95% confidence intervals for renewable energy higher priority, on two US and 16 regional surveys (combined $n = 14{,}113$)

Table 2 Respondent characteristics and survey timing as predictors of high priority for renewable energy (*renew*), or think climate change is happening now, caused mainly by humans (*climate*). Values shown are odds ratios (e^b) from weighted logit regressions with four survey datasets

	Surveys and dependent variable							
	US POLES		NH GSP		OR CAFOR		North Country	
	2016 (nationwide)		2012–17 (10 counties)		2011–15 (3 counties)		2017 (4 counties)	
Predictor	1. *Renew*	2. *Climate*	3. *Renew*	4. *Climate*	5. *Renew*	6. *Climate*	7. *Renew*	8. *Climate*
Age	0.978***	0.977***	0.978***	0.985***	0.981***	0.984***	0.984**	0.982***
Sex (female)	0.984	1.300	1.001	1.292**	0.992	1.004	1.537*	1.218
Education	1.352**	1.514***	1.174***	1.277***	1.187**	1.230**	1.073	0.931
Party	0.480***	0.460***	0.437***	0.437***	0.364***	0.387***	0.498***	0.436***
Ed × party	0.873	0.676***	0.865***	0.785***	0.940	0.723***	0.901	0.781**
Election	1.083	0.896						
Year			1.160***	1.116***	1.125**	1.100*		
Windev			0.959	1.094	0.743*	0.776		
Est sample	1209	1209	6143	4162	2357	2357	1451	1451
F statistic	17.35***	23.17***	111.32***	95.36***	32.09***	33.15***	19.86***	31.78***
Count R^2	0.77	0.75	0.79	0.73	0.70	0.73	0.78	0.71
Adj count R^2	0.18	0.32	0.20	0.34	0.38	0.58	0.02	0.18

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

been found in many other datasets across a wide range of environmental or science-related dependent variables [66].

Models 3 and 4 analyze the statewide New Hampshire surveys. *Age*, *education*, and *party* effects resemble those seen with the nationwide POLES data. *Education×party* interactions significantly affect both dependent variables in the New Hampshire data. Among self-identified Democrats and Independents, the probability of prioritizing renewable energy rises with education. Among non-Tea Party Republicans, education has no net effect. Among Tea Party supporters, however, higher education is associated with lower odds of supporting renewable

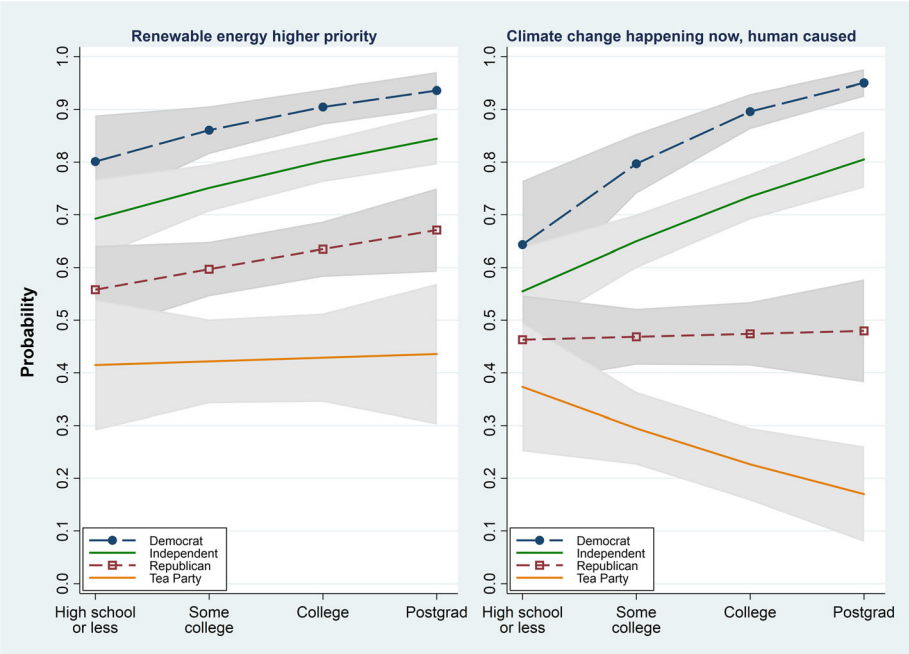

Fig. 5 Adjusted margins plots of *education×party* interaction effects on renewable energy priority (left) and anthropogenic climate change acceptance (right), from US survey models 1 and 2 in Table 2. Shading depicts 95% confidence intervals

energy, or accepting the reality of ACC. Significant main effects for *education* and *party* in models 3 and 4 (as elsewhere in Table 2) represent the effects of those variables when the other term equals zero—that is, the effect of *education* among political Independents (*party* = 0) or the effect of political *party* among respondents with some college education (*education* = 0).

Because these New Hampshire surveys occurred over a period from 2012 to 2017, we also include survey *year* among the predictors. *Year* exhibits significant and positive effects on both *renew* and *climate*. Thus, support for renewable energy and acceptance of anthropogenic climate change both increased over this period, and this increase is not explained by individual demographic and political factors. The rate of increase for renewable energy is steeper: odds rising by about 16% per year (multiplied by 1.160), compared with 12% per year (multiplied by 1.116) for acceptance of ACC.

The final predictor in the New Hampshire models of Table 2 is a variable indicating whether the respondent's county has large-scale wind power development. This distinction makes no detectable difference in support for renewable energy, or acceptance of anthropogenic climate change.

Models 5 and 6 describe northeast Oregon CAFOR surveys. For comparability, we restrict this analysis to a subset of the CAFOR data involving Baker, Union, and Wallowa counties. (Four other counties were surveyed, in addition to these three, in 2014 and 2015 only.) Also, the 2011 CAFOR survey permits only a three-party political coding, so that is used in models 5 and 6 unlike the others in Table 2 which employ 4-party coding.[5] *Age* effects and the main effects of *education* and *party* are similar to those in US and New Hampshire surveys. After controlling for *age*, *sex*, *education*, and *party*, we still see significant *year* effects, meaning a rise in the odds of prioritizing renewable energy and accepting ACC. As in New Hampshire, the rise for renewable energy is somewhat steeper—odds increased by about 13% yearly, compared with 10% for ACC.

The Oregon models in Table 2 also include an indicator for counties with substantial wind development. This has a significant negative effect (odds ratio below 1.0), mainly reflecting lower support in Union county—site of an operating wind farm at Elkhorn Valley, but also the controversial Antelope Ridge proposal that was a focus of local opposition and withdrawn in 2013.[6]

The final two models in Table 2 describe the North Country survey conducted in summer 2017 in four adjacent counties of northern New Hampshire, Vermont, and Maine. *Age* and *party* effects closely resemble those of other datasets. *Education×party* interactions affect views on climate change but not renewable energy, similar to the POLES and CAFOR results.

Discussion

Previous nationwide US surveys have noted rising public support for renewable energy development, with political divisions that are substantial but somewhat narrower than for climate change [66]. Given these realities, renewable energy development seemingly offers hope for working around some of the political resistance to climate change mitigation [5]. Development becomes most controversial, however, at local scales where impacts and benefits become more immediate [40, 45]. Our analysis placed regional and national survey data in a side-by-side comparison, addressing four questions.

Does the higher public support for renewable energy found in national surveys also occur locally, in places with controversial developments? In each of the regional surveys, and also nationwide, the proportion of respondents who prioritize renewable energy exceeds those who accept the reality of anthropogenic climate change (Figs. 1 and 2). The gap between these proportions is wider on regional than national surveys and widest in the most conservative region.

Are views on these topics changing, and with similar directions and rates? In two regional time series, renewable energy support and ACC acceptance significantly increased over the years covered (2011–2015 or 2012–2017). In both cases, the trends are steeper for renewable energy than for ACC. Two nationwide and one single-shot regional survey yield data points consistent with these trends (Fig. 4).

Do the same individual characteristics predict views on renewable energy and climate change, or are the former less politicized? Renewable energy support and anthropogenic climate change acceptance are both predicted by age and (in all but the North Country survey) education. Both also are substantially politicized, as shown by strong *party* effects across all models in Table 2.[7] These issues differ most notably in terms of their *education×party* interactions. Odds ratios for the interaction effects are less than 1.0 across all eight models in Table 2, indicating that all point in the same direction: partisan divisions widen with education, so information elites stand the farthest apart. Within the pair of models for each survey, however, the *education×party* effects are weaker (closer to 1.0) for *renew* than for *climate*.

Explanations for this general class of interactions commonly invoke information-filtering processes, whether top-down as with elite cues (educated partisans more aware of positions taken by their political or media leaders) or bottom-up as with biased assimilation or motivated reasoning (educated partisans more actively acquire/reject information according to their prejudices). Information filtering could be a good thing if, for example, people preferentially favor scientific over non-scientific sources and understand which is which. Information

filtering could also be a bad thing, if it involves rejection of scientific or otherwise well-grounded information that conflicts with political beliefs. Previous studies established what Table 2 confirms, that information filtering is particularly acute with regard to climate change. Our analysis shows that it occurs regarding renewable energy too, but less strongly. On that topic, people may be open to a wider range of information and less constrained by their political identity.

Net of background characteristics, are there detectable differences in renewable energy views of residents in counties that have or have not experienced large-scale wind power development? We find no systematic pattern of higher or lower support in counties with wind power development. The significant negative effect of the *windev* indicator in model 5 of Table 2 reflects a single county: Union County, Oregon, site of one successful development but another that was hotly contested and withdrawn. If we expand the Oregon analysis to include the four counties that were surveyed only in 2014 and 2015, instead of just the three counties surveyed in all 3 years (and thereby gain about 1200 observations), this *windev* odds ratio moves closer to 1.0 (going from to 0.72 to 0.83) and is no longer statistically significant.

Local opposition to wind farms probably operates at scales smaller than counties (or may cross county lines) and can depend on particularities of landscape and soundscape impacts, as well as the distribution of benefits. If wind projects are located in rural regions, while their energy and greatest economic benefits go somewhere else, this creates a sense of inequity and undermines some arguments for permitting local development. Our surveys do not resolve finer-scale geography or the perceptions about benefits, topics that could be pursued in future research.

Conclusions

Analysis of data from 18 surveys robustly confirms that support for renewable energy and acceptance of anthropogenic climate change have similar social bases with respect to age and education. Party divisions also are wide for both issues. Regarding climate change, the partisan gap widens with education. A similar widening pattern occurs with renewable energy but there it is milder and often not significant.

In two regions for which we have time series, and where development controversies have occurred, public support for renewable energy appears to be rising somewhat faster than acceptance of anthropogenic climate change. Renewable energy enjoys higher support overall, and the contrast between energy and climate views is greater in a more conservative region. This finding calls for replication and could have practical implications for renewable energy proponents in conservative regions.

The studied regions in the Intermountain West and northern New England have both have experienced harmful impacts related to climate change—including more frequent drought and wildfires (Oregon) or flooding (New England) and insect infestations affecting forests or human health [67-69]. Despite physical impacts, individual perceptions about climate change in those regions as elsewhere in the USA depend largely on politics [60, 63]. Political opposition keeps agreement on meaningful greenhouse mitigation out of reach, despite growing risks. Renewable energy development, however, can to some degree be motivated without reference to climate change. Economic benefits to landowners or the local tax base appeal to some who reject global warming, even as others see the mitigation value. Local opposition to large-scale solar or wind developments can also be cross-cutting, however, driven partly by concern for landscapes that are central to rural life regardless of politics.

Any prospect for climate change mitigation requires rapid and substantial growth in low-carbon renewable sources of energy (such as wind and solar), while adapting the power grid to these sources and minimizing their manufacturing and waste footprints. US public acceptance of the reality of anthropogenic climate change has advanced only gradually, however, and the currently dominant political narrative at the federal level goes against this. In this context, promoting renewable energy in terms of practical benefits such as jobs and cheaper energy, independent of climate considerations, provides a valuable first step that is by no means sufficient, but in the near term may be necessary—particularly in conservative regions where much of the population rejects ACC. The similar social bases of renewable energy and climate change views place limitations on this strategy, but our findings give encouragement that it has some room to succeed.

Endnotes

[1]Probability weights calculated from each survey's sample characteristics and sampling design have been applied in Fig. 1 and all other analyses in this paper, to achieve more representative results.

[2]Fewer New Hampshire responses appear in Fig. 2b than in Fig. 1b because some GSP surveys with the renewables question did not also ask about climate. Results are similar but have wider confidence intervals if we restrict Figs. 1c and 2c to only the interviews that asked both.

[3]Coös and Grafton counties, which are represented (by different respondents and surveys) in both the New Hampshire and North Country datasets, together comprise only 9% of the state's population, and correspondingly 9% of the New Hampshire statewide sample. The economy and landscapes of these two northern counties differ from those of the state's populous southern tier. Consequently,

there is limited redundancy between the coverage of New Hampshire and North Country projects.

[4]Political party is treated as a four-category ordinal variable, coded from − 1 (Democrat) to + 2 (Tea Party), for these regression models. An alternative approach, instead using a set of {0,1} dummy variables, produces more complicated models with larger standard errors, while reaching substantially similar conclusions. For examples testing dummy-variable party indicators with 12 different dependent variables, see Figure 3 and Table 2 in Hamilton and Saito (2015).

[5]Analysis of the 2014 and 2015 CAFOR surveys only, based on all seven counties and with 4-party political coding (not shown), yields substantially similar conclusions to the 2011–2015, 3-county and 3-party analysis in models 5 and 6 of Table 2. We prefer the 2011–2015 3-county analysis for a more definitive test of change over time.

[6]Two alternative specifications were tested in the New Hampshire and Oregon analyses: indicators for counties where wind power development had been halted in the face of active opposition and indicators treating each county individually. Either alternative yields similarly weak county effects, while leaving the effects of other predictors almost unchanged.

[7]A simpler analysis, not described in the paper, confirms that although partisan gaps on both climate change and renewable energy are quite wide, they are wider for climate change across the most recent years of all four datasets. For example, in the 2016 US POLES surveys, the Democrat/Tea Party gap on climate change is 59 points, compared with 48 points on renewable energy. Corresponding gaps are 66/45 in the 2017 New Hampshire surveys, 56/51 in the 2015 Oregon survey, and 48/31 in the 2017 North Country survey.

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Availability of data and materials
The nationwide US POLES survey data analyzed for this paper (Figs. 1, 2, and 5 and Table 2) will be made available with publication. Time series summarizing results and confidence intervals from all 18 surveys (Fig. 4) will also be published. Individual-level data from the regional surveys is not publishable under human-subjects agreements, given the small populations of some rural counties involved. Stata do-files accomplishing the statistical analysis for these datasets will also be published, so other researchers can replicate our calculations for the POLES models.

Authors' contributions
JH, EB, and LCH designed projects and questions for the regional surveys. LCH supervised all surveys, analyzed data, and drafted the rough version of this paper. LCH, JH, EB, and JDS contributed to writing and editing of the manuscript, and approved its final content.

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Ethics approval and consent to participate
Research protocols for informed consent and the protection of human subjects on the 18 surveys described were individually reviewed and approved by the Institutional Review Board (IRB) at the University of New Hampshire.

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Competing interests
The authors declare that they have no competing interests.

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