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ASSESSING CITIZEN ATTITUDES TOWARDS CLIMATE CHANGE, RENEWABLE ENERGY, AND SOLAR DEVELOPMENT IN KENTUCKY

By

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A Thesis
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ABSTRACT

ASSESSING CITIZEN ATTITUDES TOWARDS CLIMATE CHANGE, RENEWABLE ENERGY, AND SOLAR DEVELOPMENT IN KENTUCKY

Ryan Patrick Lloyd

April 19th, 2022

This study focuses on public attitudes and perceptions of renewable energy development strategy, solar energy, and climate change using a statewide survey in the 23 counties of Kentucky (KY) where solar developments have been installed or will be installed soon. Results indicate a that the public has a complex view of renewable energy development (RED) and how best an energy transition should be carried out, if at all. Solar RED was generally perceived positively by members of the public, with rooftop or household solar being stated as the preferred model of development. Citizens were most concerned over the visual impact of solar developments on the landscape, as well as its reliability as an energy source. Those who politically identified as Democrats had significantly less variation in response type than did Republican and third-party respondents. Responses from Democratic participants were more amenable to RED in general, whereas a higher level of concern and skepticism was expressed by other political party groups. Policymakers, state institutions, and developers should closely assess concerns at community-scale and adopt a more flexible strategy for design and configuration of developments. The future of RED in KY might benefit from state programs such as Community Choice or other decentralized development options for consumers.

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INTRODUCTION

This study identifies various attitudes and perceptions that citizens across the Commonwealth of Kentucky (KY) have regarding the broad categories of solar energy development for electricity generation, energy systems, and climate change. The results may help inform policymakers, developers, non-governmental organizations, and laypersons develop a better solar energy portfolio for KY. Firstly, as the state begins to transition portions of its energy systems away from fossil fuel sources like coal and natural gas and towards renewables like solar, there is a unique opportunity to collect input from the public and meaningfully incorporate this data into systems design and roll out. Secondly, there is a growing body of literature on renewable energy development as its popularity increases worldwide, yet relatively few studies of this type have been carried out in the United States, much less in KY. It is a valuable addition to the existing literature on the subject that a study of this type be conducted here.

Establishing the Need for an Energy Transition

Relative to the period ranging from 1850 to 1900, the climate on Earth has warmed by over 1 ˚C in 2010-2019 alone, with the main driver of this warming being greenhouse gas (GHG) emissions from human activity (IPCC 2021). If our energy infrastructure continues to operate as it is now, models estimate that a global temperature rise of 1.65 ˚C would be inevitable, which would surpass the 1.5 ˚C threshold projected to cause major disruptions to environments, communities, and economies worldwide (Allen et al. 2018; IEA 2020). Globally, electricity generation is second only to the transportation sector in terms of its carbon intensity, accounting for 25% of total GHG emissions as of 2019. It is estimated that over 60% of the fuel used for electricity generation worldwide comes from the carbon intensive sources of coal and natural gas (EIA 2021; IEA 2019). Therefore, mitigating emissions from the energy sector is a key component of addressing climate change at a broad scale.

A major part of the solution to lowering emissions from the production of energy has been a push for adopting renewable energy in the form of solar and wind. While the direct mitigation of GHG emissions through solar and wind infrastructure development are understood, the best-practices for implementing this infrastructure are only beginning to be studied. The importance of public attitudes and acceptance towards renewable energy projects has become part of the discourse surrounding an energy transition, as policymakers and developers begin to see both opposition and support for renewable energy development (RED) in various contexts. Undoubtedly, part of successfully implementing renewable energy to reduce emissions will require the public to be informed and, to some extent, supportive of such developments. The US is expected to greatly expand electricity production via various renewable energy developments (including solar) to meet goals of net zero emissions by 2050 (Nalley and LaRose 2021). Policy and implementation such as incentives, taxes, and various models of development that satisfy the needs and wants of citizens will be essential not only in quickly and continually expanding renewable energy capacity, but also doing so equitably and with regard to sound economic practices.

Solar in Kentucky

The market for solar energy is growing in KY. There are at least 32 currently planned large-scale merchant solar (>1 mW) projects across 23 counties, with many more proposed or awaiting action down the line (KY Public Service Commission 2021; PJM 2021). While some studies documenting attitudes and perceptions towards RED have been carried out in states like California, where there is a relatively high share of solar energy (14.22% of total) currently in the fuel mix, there is a lack of research in places where the solar energy industry is less developed (CAEC 2019). Kentucky is one such place, and citizen attitudes towards RED have not been a major area of focus for the actors involved in solar development within the Commonwealth. This study will examine the socio-technological and socio-political interfaces that determine level of concern and acceptance surrounding solar developments, and in doing so add to a growing body of literature about public attitudes towards both climate change and solar energy. By exploring the effects of solar development configuration, size, key sociodemographic variables, and perceptions of climate change using a statewide survey, the results from this study hope to better inform all actors involved in the process of developing solar energy in KY.

LITERATURE REVIEW

Part I: The Formation and Role of Public Attitudes in Renewable Energy Development

Attitudes towards renewable energy and strategies for policy and development have been studied since the early 2000s, especially in areas where renewables were adopted and implemented relatively quickly such as the EU. Existing literature has helped in forming the central questions of this study. In this section, some brief historical background regarding renewable energy development (RED) will be discussed, along with information from some of the critical studies on attitude that have been conducted. These studies relate to public formation of attitudes based on economic, geographical, and psychological variables, as well as the role of institutions in the process of development. Important to note is that while the research background done for this study pulls theoretical knowledge from literature on both solar and wind development, solar is the ultimate focus for the state of Kentucky at the moment due to the high volume of those types of developments being planned here.

Themes of International Renewable Development Strategy

Haas et al. (2004) summarize the results of the third Forum of the European Network on Energy Research (ENER), held in 2002 in Budapest, Hungary. This forum was an early example of a collaborative, institutional effort to promote ideas, economic instruments, and types of strategies to help establish a more robust network of renewable energy across Europe. The forum concluded that, without well-defined policy measures to support and maintain renewables, nearly all countries in the EU were destined to fall short of goals in emissions reductions within their energy sectors. They also concluded that larger-scale developments like solar and wind farms were a more efficient option in most cases, citing a lack of existing regulatory mechanisms, authorities, and infrastructure available to support a more decentralized network of smaller installations. Although the authors provide a comprehensive look at existing governance structures and their capacity to regulate the renewable energy market, the role of public opinion is notably absent. The result is a top-down, centralized look at the potential for promoting and expanding renewable energy. While this may be a viable option in some cases, in others there may be misalignments between a community's vision for renewable energy and institutions' plans for development. This type of misalignment can be categorized as an issue of institutional fit*,* and it is a problem that requires proper governance frameworks to solve (DeCaro and Stokes 2013).

Nuance in Public Attitude Towards RED

Potential for misalignment and lack of acceptance for RED can occur when citizens support the idea of renewable energy generally, but do not wish to change place-based characteristics of their immediate environment (Sutterlin and Siegrist 2017). This is sometimes referred to as the "not in my backyard", or NIMBY, effect. It is distinct from outright rejection in that an individual's stated preference is supportive of such development, but their revealed preference in a scenario which would directly impact them is opposing. Two studies based in California and the greater US southwest illustrate other sources of misalignment stemming from personal environmental and political beliefs, lack of trust in institutions and government, lack of trust in developers, and knowledge or lack of knowledge on economic benefits and detriments for various actors involved in the development process (Carlisle et al. 2014; Carlisle et al. 2015). Some studies have concentrated on the effects of political party affiliation as the primary variable correlated with individuals' attitudes towards renewable energy generally (Clulow et al. 2021; Karlstrom and Ryghaug 2014). Such studies normally find affiliation with "progressive" and "conservative" political parties as strongly tied to positive and negative attitudes towards renewable energy, respectively. Schelly (2015) suggests that solar photovoltaic technologies are highly political technological artifacts in that they suggest the possibility of a future based on decentralization, resilience, and redistribution of wealth. Other studies suggest everything from lack of government provided economic incentives, missing social and psychological elements like self-determination and autarky, role of affect or imagery, or some combination of all these as what determines public attitudes (Colasante et al. 2021; Ecker et al. 2017; Huijts et al. 2012). Attitudes also shift depending on the size and type of the renewable energy development in question, and it appears that solar farms and rooftop solar installations seem to be viewed differently both in general and across various sociodemographic variables by members of the public (Cousse 2021). This illustrates the potential importance of configuration of deployment and its effect on the public's level of concern over developments.

Further complicating the formation of attitudes is the fact that some studies have found results contradicting the longstanding not-in-my-backyard (NIMBY) hypothesis (Musall and Kuik 2011; Walter 2014; Wolsink 2007). All of this suggests that a more multi-faceted reasoning process shapes public opinions on renewable energy and developments. In conclusion, a complicated socio-technological, sociopolitical assemblage of interrelated factors may affect one another on different spatiotemporal scales, and to varying degrees depending on the context of the community being examined. Geels (2002) describes the nature of these elements as an unfolding process which can cause newer technologies, like solar and wind energy, to make their way from small, niche uses, to large and stable regimes. Eventually, some new technologies may become culturally ubiquitous in this manner. This nexus is what forms attitudes towards both renewable energy in general, and specific developments. Policymakers and developers in the process of trying to settle on a strategy for implementing renewables in a community may find it difficult to incorporate attitude into their development strategies for this reason. Although the process for assessing attitude can be accomplished using several fairly straightforward techniques such as well-designed surveys or interviews, incorporating such results into policy that addresses the root causes of misalignments is complex due to the number of variables and limitations in the policymaking framework. Actors may have conflicting goals or ideas on best-practices, and in some cases the best-practices themselves may present difficult cost-benefit scenarios for balancing economic, social, and environmental sustainability objectives.

Synthesizing Knowledge for This Study

The relationship that we have with technology can be described as highly complex in that solving problems with technology-based solutions only goes so far as our constantly changing set of social values has prioritized at the time decisions are made

(Smith 2005). The socio-technological framework behind renewable energy is complex and multifaceted, as demonstrated by the various and sometimes contradictory studies on the technology mentioned in the previous section. In many ways the capacities, limitations, and cost-effectiveness of the technology determine level of success. However, the nexus of relationships between developers, policymakers, lobbyists, existing energy industry leaders, the public, the media, and the technology also create conditions which may help or hinder the expansion of renewable energy (Shanahan et al. 2011). In addition to this there are many geographic variables which affect systems' feasibility, and grid infrastructure from utilities that affect site suitability and scale of projects (Brewer et al. 2015; Graabak and Korpus 2016; Lan et al. 2021). This study focuses on a very specific dilemma within the larger context of renewable energy development, which is the role the public's attitude could have in shaping solar energy's development and success in the Commonwealth of Kentucky.

Part II: Conceptual Frameworks and RED in KY

Importance of Theoretical Frameworks

Understanding governance frameworks designed to work in conjunction with public attitudes is equally as important as understanding the attitudes themselves. In this section the theoretical frameworks of governance as they relate to incorporating public attitude into RED strategy will be discussed. The actors present in solar RED in the Commonwealth of Kentucky, and some specific policies, incentives, and other items critical for understanding the situation will also be discussed. Ultimately, it will be demonstrated that it is not always the wants of the community or the needs of the environment that come first in the current policy environment. A study that focuses on gathering public attitudes towards this technology and incorporates this data into suggestions for best practices in development could be highly beneficial to actors involved in the decision-making and development process. Given the relatively recent rise of proposals for RED in the Commonwealth of KY in the form of large-scale, merchant solar farms, these results may be especially beneficial to actors with a high degree of authority and operational capacity who may not have had the chance to collect such data yet. Such governmental and institutional actors are tasked with finding solutions to dilemmas related to solar RED as the industry continues to grow, but they may lack the necessary input from the public to find solutions to dilemmas related to garnering community support and maintaining adaptive capacity in their approach. This chapter aims to elucidate some of the underlying policy mechanisms and relevant stakeholders that create different conditions for RED to evolve at different scales.

Role of Public Attitude in RED

Public attitude as an element that informs strategy is an important component of sustainable RED. Acceptance and support can facilitate continued success and expansion of renewable energy within communities, just as concern and opposition can dismantle it. Given the potential gravity of the climate crisis as discussed in the introduction section, it is crucial that fossil fuel energy sources be phased out and renewable energy be expanded. Yet also imperative is that this transition be achieved holistically, and with sensitivity to social and economic factors, not only environmental. Indeed, the expansion of renewables at the expense of social or economic wellbeing is not preferable at all. Instead, with support from the public in its implementation, the goal is for RED to achieve some degree of improvement in all these areas. Here is where the importance of public attitudes in helping shape RED strategy becomes especially salient. It is essential that these attitudes be considered carefully by institutions and developers and used as tools for co-production and collaborative problem-solving. Co-production and participatory governance can broadly assist in the process of policymaking and environmental management, as well as inform decisions regarding funding, resource use, problem-solving strategy, organization, site selection, infrastructure size, and development type (Alonso et al. 2019; Djenontin and Meadow 2018; O'Connor et al. 2021; Ostrom 1996; Tiller et al. 2021).

Citizen participation in the problem-solving process can be categorized as more or less participatory based on actual redistribution of power and decision-making ability among actors trying to find solutions to a dilemma (Arnstein 1969). Going along with this idea, the role of transdisciplinary knowledge (or knowledge that exists outside the sphere of what is considered traditional expert or academic knowledge) should also be incorporated into any framework that seeks to co-produce results with the general public in the context of environmental decision-making (Ellis 2005). Incorporation of public attitudes into governance and development strategies should be done on a case-by-case basis by developers and institutions, as a one-size-fits-all approach to solving problems within social-ecological systems can lead to unfavorable outcomes even when the intention is to co-produce results supported or partially supported by all actors (Cohen and Wiek 2017).

National Level Scenario, Policy, and Incentives

In the United States there is a federal solar investment tax credit (ITC), which was enacted in 2006 and will continue to be in effect until 2023 (SEIA 2021). This ITC is available to both commercial and residential sectors and provides a 26% tax credit across the board for photovoltaic (PV) systems both large and small. For projects that begin construction in 2023 this rate drops to 22%, and after 2023 (when the ITC is set to expire) a 10% permanent ITC for large-scale commercial developments will remain, while the ITC for residential installations will disappear entirely. It is important to note that the federal solar ITC cannot be claimed by homeowners who lease PV systems or enter power-purchase agreements (PPAs), as the ITC will only be eligible to be claimed by the company leasing the system or offering the PPA. This federal incentive favors larger-scale development (likely in an attempt to expand solar energy capacity as rapidly as possible), but other incentives for homeowners at the federal level include residential energy credits and the modified accelerated cost-recovery system (MACRS) (EIA 2021; IRS 2020; IRS 2021).

State Level Scenario, Policy, and Incentives

Large-scale solar energy has been the main form of RED to be pursued by developers in KY, likely because of the larger benefits it receives at the federal and state levels as compared to household systems. Currently, there are about 19 developers operating in the Commonwealth and at least 32 large-scale, merchant solar developments (>1 mW) planned for installation across 23 counties (KY Public Service Commission

2021; PJM 2021; SEIA 2021). These planned developments are just a portion of the many proposals being processed or withdrawn currently (PJM 2021). Merchant solar facilities are solar farms constructed by third-party developers with the express intent to sell the energy they produce to owners and operators of electrical grids, which in the case of KY are the utilities and regional transmission organizations (RTOs) Louisville Gas and Electric and Kentucky Utilities (LG&E/KU) and the Pennsylvania-New Jersey-Maryland Interconnection (PJM). The presence of these large, regional markets means that there are many points of interconnection (POIs) around the state in the form of electrical substations and high voltage power lines that can be line tapped. The further a planned solar development is from a POI means that a longer line connecting the solar array to the grid, known as a generation tie, needs to be built. These dedicated generation ties can cost approximately $1 million USD per mile, meaning there are more and less cost-effective sites for merchant solar farms because of the minimized construction of electrical transportation infrastructure needed to transfer power to the grid when in closer proximity to one of these POIs.

Proposals for developments are submitted to the KY Public Service Commission (PSC) for revision, amendment, and approval. The PSC is a three-member administrative body that straddles a line between legislative and judicial duties regarding intrastate energy, telephone, water, sewage, and natural gas infrastructure (KY Public Service Commission 2021). These members are appointed by the governor of the Commonwealth of Kentucky, and they have four-year term limits. The PSC has a close relationship with solar developers and other actors related to electrical infrastructure as the authority on approval, revision, and denial of structural changes and rate cases. The PSC reviews evidence and data that they are presented with upon receiving proposals for projects, and these data come largely from the developers or project managers themselves. Their status as both a judicial and legislative governmental body that fields requests and evidence for proposals from those submitting them creates potential for dilemmas.

Large-scale solar has perhaps also been a major focus for expansion of solar in KY due to the suitability of previously mined coal lands, which are abundant across the state and are often ideal sites for solar development projects (KYEEC 2021). At the national level the US Environmental Protection Agency has also identified such sites as targets for large-scale RED projects through its RE-Powering program, which may further influence decisions at the state level to pursue this model if sufficient incentive and support is available (US EPA 2021). LG&E & KU's Solar Shares program is also demonstrative of the expanding market for large scale solar. It is a utility-owned and operated solar energy share program being offered across LG&E/KU's service area in which consumers can pay additional fees on their monthly energy bills to subsidize the expansion of this network of large-scale solar infrastructure as a carbon-offset (LG&E and KU 2021).

In KY at the state level there are several incentives available to farm owners and commercial property owners. These include the Kentucky Agricultural Development Fund's (KADF) On-Farm Energy Efficiency Incentives Program, which gives up to a 50% reimbursement for investing in qualified energy saving items including PV systems of up to $10,000 (KADF 2021). For commercial property owners there is Property Assessment Clean Energy (PACE) financing, which is a program operated under the Greater Cincinnati Energy Alliance. It allows commercial properties to partially or fully finance clean energy and water-saving improvements with grants and low-interest loans (Energize KY 2021).

Smaller scale decentralized solar infrastructure such as rooftop and other household installations have been less incentivized by comparison. In 2018, HB227, put forth by several KY state representatives, proposed cuts to credits for net-metering, affecting residential PV owners who produced excess power and sold power back to the utilities for credits (18RS HB227 2018). The bill was heavily contested and defeated, but demonstrated the position that some state representatives had regarding RED strategy. The rationale behind reducing credits to net-meterers was that households who became self-sufficient were no longer paying to maintain the grid, but were benefitting from selling power back to it. This caused some representatives to question the economic viability of a retail-rate net-metering policy and its potential to favor only those homeowners who had the capital to invest in household systems. Of course, large-scale solar development similarly benefits entities with even more capital than individual homeowners, so conflicting goals of actors create a dilemma here.

The current retail-rate on net-metering credits for residents in KY with home PV systems is an incentive for small scale development, but the favored strategy from an institutional standpoint is large-scale systems. Even so, the development of these merchant-scale solar farms has brought a mix of public responses to the forefront. The public interest group and nonprofit *Clark Coalition* has expressed strong opposition to large-scale solar development in Clark County, citing visual impact on the landscape, exploitation of farmland to outside interests, damage to the agricultural industry, public health risks, and damage to the environment as reasons for the lack of acceptance (Clark

Coalition 2021). Similarly, a public interest group in Mason County called *Citizens Voice of Mason County* is opposing large-scale solar development and citing the negative impact to the landscape, agricultural industry, property values, concern over decommissioning, and concern over lack of permanent jobs to the local economy as reasons for disagreement (Citizens Voice of Mason Co. 2021).

Synthesizing Factors Affecting Solar RED

As initial research on the topic of RED suggests, there is a wide variety of factors influencing the rate and effectiveness to which solar is implemented. Many of these factors, such as national policy and incentives, work across large spatiotemporal scales. Others are far more specific, such as state-level incentives and policies, as well as influence from interest groups, NGOs, and district representatives at the community level. It is important to have a basic working understanding of some of these actors' most salient capacities and limitations, and the process through which RED currently takes to go from an initial idea to a realized project. Figure 1 provides a good snapshot of this process in KY. Legislative members of committees such as Natural Resources and Energy, as well as the Agricultural Committee, are also especially pertinent in the case of solar RED. The interests and livelihoods of citizens working in these sectors and making use of resources the Commonwealth currently provides in these areas are highly relevant to the expansion solar RED. Also of note is the relationship between solar developers, utilities, and the Public Service Commission, who all functionally determine the outcome of these projects. These actors have most of the authority and operational resources to facilitate solar development, although the presence of citizen groups and NGOs who are focusing efforts on affecting the outcome of RED in KY suggests that there is a level of interest from other actors not directly involved in the process of implementation as well.

METHODS

Survey Design and Dissemination

This study utilized a survey consisting primarily of Likert scale and multiple-choice items. The instrument was distributed once to approximately 10,000 members of the public in 23 counties across the Commonwealth of KY on December 20, 2021. While a larger potential participant pool existed, this sample size was chosen based on budget limitations. The 23 counties were chosen because they either had previously developed large scale solar projects installed in them, or such projects had been proposed to be constructed there and were in the process of getting revision and approval from the PSC. The contact list for the study was constructed using geographically filtered results from the voter action network (VAN) database America Votes. Cell phone numbers for these potential participants were used as the means of contact, email addresses were unavailable through this VAN database. New York-based company Build the Wave provided large-scale messaging services used to send out the recruitment text for the survey. This text contained a brief introduction to the researchers, the study, and a Google Forms link to the fill out the questions. Responses were stored in the Google Forms network until a cutoff date of 6:00PM on January 20th, at which time responses were no longer accepted and the data was exported for analysis.

The survey consisted of 30 questions. The first four questions were designed to assess basic spatial and sociodemographic information within the sample group, while the rest were aimed specifically at assessing knowledge and attitudes towards climate change and energy-related concerns and opinions (Table 1). Questions in this survey can be grouped into 4 different categories based on the information they attempt to assess. The first group is geographic and sociodemographic, followed by questions assessing prior knowledge of renewables and solar, questions regarding levels of concern over various issues, and finally questions regarding attitudes and opinions on climate change and energy. This last section was by far the largest, necessitated by the myriad of potential factors affecting attitudes towards RED. A single question on respondents' 5-digit zip code of residence provided finer scale spatial information on the geographic distribution of participants than county of residence.

Spatial Distribution of Participants

A map of the location of participants was generated using ArcGIS Pro and the 5-digit ZIP codes they provided in the survey (Figure 3). Few studies on this subject have utilized a mass texting method for disseminating an instrument, so broadly assessing the effectiveness of this method, its potential benefits and drawbacks, was an important element of this study in addition to the responses.

Analysis

Single-factor ANOVA tests and Bonferroni adjusted t-tests were conducted on attitudinal data, utilizing group comparisons derived from the demographic and geographic results of the survey. Political party affiliation was used to split respondents into four groups of Republican, Democrat, Other, and Prefer not to answer. If p values in

ANOVA tests (alpha = 0.05) indicated statistical significance, these tests were followed up with Bonferroni adjusted t-tests on pairs of groups to determine which pairs differed from one another specifically (alpha = 0.0083). The same process was carried out for participants who responded from ZIP codes in Madison Co. and elsewhere in the Commonwealth of KY to rule out skewed results from potential duplicate survey responses.

Principal component analysis (PCA) was done on data using R stock functions and plotting capabilities from the *ggfortify* and *ggbiplot* developer tools package. 24 questions of the survey related to levels of concern and attitudes were plotted using PCA and subsequently grouped according to response on political party affiliation. These were the attitudinal questions five through 30, minus questions seven and 16, which were categorical and not Likert scale responses.

RESULTS

Sample Makeup and Geographic Distribution

There were total of 170 responses to the survey out of approximately 10,000 texts sent, making for a response rate of 1.7%. 68 responses came from ZIP code 40475, which is a postal code located in Madison County. 24 responses came from ZIP code 40403 in Berea, also located in Madison County. Additionally, 22 responses came from ZIP codes 41039, 41041, 41055, and 41093, which are located primarily in Fleming County, KY (Figure 2). The large makeup of responses from Madison County was the reason for t-tests on the group of respondents from Madison and from those elsewhere in the Commonwealth on attitudinal responses. None of the t-tests for the 24 attitudinal questions indicated significantly different results in this case ($p < 0.05$).

Three responses were omitted when assessing demographics, due to demographic fields being left blank, and of the 167 remaining 96% identified as white or Caucasian, while 2% identified as Black and the remaining 2% identified as either multiracial or a race or ethnicity not listed. The age make-up of the sample was less homogenous, with 8% being between 18 and 35, 33% between 36 and 55, 49% between 56 and 74, and 10% 75 and older. The breakdown of political party affiliation of respondents in this sample group were 43% Democrat, 37% Republican, 7% Libertarian or Independent, and 13% declining to answer (Figure 3).

Preferences for Configuration of Solar Development

The preferred configuration of solar development among respondents was for the household or rooftop model. 42% of participants, or 71 individuals, cited this as their desired method of RED (n = 168). The second-most preferred model was for community-owned solar developments, with 48 respondents stating this as their preferred method of RED and making up 29% of participants overall. Utility-scale and None of the Above answers made up 20% and 9% of responses, respectively (Figure 4).

Levels of Concern

Questions on levels of concern were assessed broadly across the sample group. The five levels of concern were chosen based on a combination of commonly studied levels of concern in literature on renewable energy development, and from commonly cited concerns in citizen interest group petitions. The question on concern over visual impact was worded slightly differently than the others, with a response of 5 indicating positive appraisal of solar development's visual impact on the landscape, 1 being negative, and 3 being directly in between as expression of indifference. This question saw about 19% of respondents expressing positive appraisal of solar development's visual impact on the landscape, while about 43% of respondents felt that solar had either a very negative or somewhat negative visual presence (Figure 5). Concern over solar being potentially unreliable as an energy source was found to be the second highest of all the areas, with 20% of respondents expressing a very high degree of concern for this question (Likert scale response 5) and about 13% having a high degree of concern (Likert scale response 4). Concern over wildlife being negatively impacted by solar development was third highest, with a little over 18% of respondents expressing a very high or high level of concern in this area. Concerns over noise associated with solar development were the least, with 61% of respondents being not concerned at all with this aspect, and only about 7% being highly concerned.

Level of Concern and Attitudinal Question Statistical Analysis – Party Affiliation

Questions five, six, 14, 15, 20, 21, and 22 were among the insignificant group comparisons from ANOVA tests on attitudinal data grouped by political party affiliation (Table 2).

Comparisons with ANOVA (alpha = 0.05) and subsequent Bonferroni adjusted T-tests ($p = 0.0083$) on political party groups yielded 17 significantly different responses out of the 24 Likert-measured attitudinal questions. Question eight on concern that solar development might cause pollution yielded significant results between Democrats and Prefer Not to Answer groups ($p = 0.000$). Democrats and Prefer Not to Answer groups had mean responses of 1.8 and 3.1 on pollution concern, respectively (Figure 6). Question nine on concern over noise from solar development yielded significantly different responses from Democrats and Republicans ($p = 0.0045$) and Democrats and Prefer Not to Answer ($p = 0.00081$) (Figure 7). Question 10 on concern over impacts on wildlife from solar development yielded significant results ($p = 0.00025$) between Democrats and Prefer Not to Answer groups (Figure 8). Question 11 on concern that solar energy is an unreliable energy source showed significant differences between Democrats and all other groups, with Democrats having a mean level of concern of 1.9 and Other, Republicans, and Prefer Not to Answer groups showing means of 3.8 (p =

1.205 E-05), 3.1 (p = 1.373 E-06), and 3.2 (p = 7.632 E-05), respectively (Figure 9). Democrats appraised the visual impact of solar on the landscape more positively than other groups, with a mean answer score of 3.04. Republicans, Other, and Prefer Not to Answer responded with mean scores of 2.3, 1.9, and 2.3, respectively. The p-value for group comparisons between Democrats and Republicans was p = 0.00035, for Democrats and Other p = 0.0044, and for Democrats and Prefer Not to Answer p = 0.0082 (Figure 10).

For question 13 on what respondents' general opinion of solar development in their community was, Democrats had a significantly more positive opinion than Republicans with mean scores of 4.1 and 3, respectively (p = 3.463 E-06). For Democrats and Prefer Not to Answer, results differed significantly on this question as well, with Prefer Not to Answer having a mean of 3.2 (p = 0.00352) (Figure 11). Question 17 on whether respondents believe that installing solar on their rooftop is a good idea or not, Democrats and Republicans differed significantly with respective means of 4.2 and 3.5 (p = 0.000493) (Figure 12). Question 18 asked respondents whether they agreed or disagreed with the statement that the use of renewable energy in their communities would provide a future for their children. Democrats agreed significantly more with this statement than did the other groups with a mean of 4.5, while Other had a mean of 2.9 (p = 3.512 E-05), Republicans had a mean of 3.4 (p = 5.523 E-06), and Prefer Not to Answer with a mean of 3.4 (p = 0.000164) (Figure 13). Figure 14 shows the mean responses for the question of whether respondents agree or disagree with the statement that solar energy development would provide jobs for their communities. Democrats again agreed significantly more than other groups here with an average response of 4.1 in comparison to Republicans (mean = 2.9, p = 1.776 E-07), Other (mean = 2.9, p = 0.00181), and Prefer Not to Answer (mean = 2.6, p = 8.948 E-07).

The Democrat group had a significantly higher level of agreement with statement that protecting the environment is one of respondents' biggest personal concerns in comparison to other political groups. Mean response for Democrats was 4.6, for Other it was 2.9 (p = 1.627 E-06), for Republicans the mean response was 3.5 (p = 1.627 E-06), and for Prefer Not to Answer the average response was 3.8 (p = 0.000102) (Figure 15). Democrats disagreed significantly more than other groups on question 24, the belief that concerns over climate change are exaggerated. Average response for Democrats on this question was 1.3, while for Other it was 4 (p = 2.049 E-14), Republicans 3.7 (p = 5.965 E-25), and Prefer Not to Answer 3.6 (p = 1.413 E-15) (Figure 16). Question 25 on whether respondents were concerned about high energy consumption or not revealed significant differences in responses between Democrat and Republican groups. Democrats agreed significantly more that high energy consumption is a concern than Republicans, with respective means of 4 and 3.3 and a p-value of 0.00067 (Figure 17). For question 26 regarding whether respondents agreed that fossil fuel usage was harmful to the environment, the Democrat group was significantly different from all other groups and responded with a mean score of 4.5, while Other had an average score of 3.4 (p = 0.00133), Republican with a mean score of 3 (p = 1.88 E-12), and Prefer Not to Answer with a mean of 3 (p = 6.104 E-07) (Figure 18). Similarly, the Democrat group also differed significantly from all other groups in response to the question of whether respondents agreed or disagreed with the statement that fossil fuel usage is harmful to their communities (Figure 19). For this question Democrats had a mean response of 4.2, while Other averaged 2.9 ($p = 0.000635$), Republican averaged 2.7 ($p = 1.831$ E-11), and Prefer Not to Answer averaged 3 ($p = 3.467$ E-05).

Respondents in the Democrat group also responded significantly differently to question 28 on whether participants agreed or disagreed with the statement that we should use more renewable energy in the United States (Figure 20). For this question Democrats averaged a response score of 4.7, while Other had a mean of 4.1 ($p = 0.00646$), Republicans averaged 3.5 ($p = 5.024$ E-10), and Prefer Not to Answer averaged 3.6 ($p = 5.605$ E-07). Question 29 asked participants to respond in agreement or disagreement with the statement that we should use more solar energy in the U.S. (Figure 21). This question also yielded significantly different results in the Democrat response in comparison to the other three groups. Democrats averaged 4.6, while Other had a mean of 3.7 ($p = 0.00146$), Republicans with 3.5 ($p = 7.63$ E-08), and Prefer Not to Answer with 3.6 ($p = 6.731$ E-05). Finally for the party groups, the final 30th question on whether respondents would be willing to pay 2% more for energy from renewable sources revealed significant differences in Democratic responses as compared to the other three groups (Figure 22). For this question the Democrat group had a mean score of 4, and Other, Republican, and Prefer Not to Answer had mean scores of 2.4 ($p = 0.000236$), 2.3 ($p = 5.816$ E-11), and 2.1 ($p = 4.022$ E-08), respectively.

<u>Level of Concern and Attitudinal Question Statistical Analysis – Age Group</u>

Questions five, six, eight through eleven, 14, 15, 17-25, and 27-30 were among the insignificant group comparisons from ANOVA tests on attitudinal data grouped by age (Table 2).

Figure 23 shows means for the four different age groups' responses to question 12 on respondents' appraisal of the visual impact of solar development on the landscape. The 18-35 age group had a significantly more positive appraisal of the visual impact of solar with a mean response of 3.5 as compared to the 36-55 group's average of 2.4 ($p = 0.00164$). Question 13 on respondents' general opinion of solar development in their community revealed significant differences in response between the 18-35 and 56-74 age groups (Figure 24). The 18-35 and 56-74 groups responded with means of 4.6 and 3.4, respectively ($p = 0.00398$). Lastly, question 26 on whether participants believed that fossil fuel usage was harmful to the environment yielded significantly different results for the 18-35 and 36-55 age groups ($p = 0.00736$). Respondents aged 18-35 responded with a mean score of 4.5, while those aged 36-55 responded with an average of 3.3 (Figure 25).

<u>Principal Component Analysis of Attitudinal Data in Political Party Groups</u>

PCA of the 24 attitudinal questions in the survey resulted in PC1 explaining 38.11% of the variation in the data, and PC2 explaining 10.68% of variance. Democrats responded more uniformly to survey questions than others did, as evidenced by the strong clustering of that group in the plot relative to Republican, Other, and Prefer Not to Answer responses, which were much more dispersed by comparison (Figure 26). Specific factors contributing strongly to the observed pattern in this PCA were questions on levels of concern, fossil fuel harm to the environment and community, renewable energy providing a future for children, renewable energy providing jobs to the community, and disagreement that climate change concerns are exaggerated.

DISCUSSION

Results of this study revealed that citizens in the Commonwealth of Kentucky (KY) have a complex set of attitudes and opinions regarding solar renewable energy development (RED). Trends in the spatial distribution of respondents, general attitudes towards preferred models of development, levels of concern, and variation in attitudes across political party and age groups all provided feedback from KY communities and can help to inform policy structure and development design in the future.

Response Rate and Spatial Distribution

Response rates and spatial distribution of respondents within KY are indicators of specific areas where both positive and negative interest in solar development is higher. The high percentage of responses from Madison County and Fleming County likely suggests that either a snowball effect occurred in response patterns, or that the residents of these areas have more of a collective interest in voicing their opinions about RED. However, the relatively low overall response rate for the other targeted 21 counties suggests that these areas have not seen similar spikes in interest on the subject. A possible explanation for this could be the result of hyper-local niche formation for energy transitions within the sociotechnological landscape (Coenen, Raven, & Verbong 2010). Following the logic of niche formation for emerging solar energy development, Fleming County's high interest levels are perhaps the result of the proximity of the large and nearly complete ACCIONA-Tenaska solar development to communities there. This 188 mW photovoltaic development is slated to begin operations in 2022, and has been undergoing permitting and construction since 2020 (ACCIONA-Tenaska n.d.-a). Opinions and attitudes towards RED in this region may be more solidified because of the *in situ* changes taking place. This could help explain why there is a relatively more responsive group of residents in Fleming County. This niche formation seems related to, but not necessarily the same as, the not-in-my-backyard (NIMBY) phenomenon. Relevant communities may either express support, opposition, or indifference to developments at higher rates as developments affect the landscape in closer proximity to the communities in question.

Similarly to Fleming Co., Madison Co. has a large proposed solar development from AEUG Madison Solar LLC, a subsidiary of ACCIONA. This 100 mW, $120 million investment is currently in the construction phase and is slated to be fully operational sometime in 2023 (ACCIONA-Tenaska n.d.-b). This utility-scale solar energy development is the result of Amazon's power purchase agreement to construct four large-scale solar developments in the Kentucky-Illinois-Ohio region by 2024 (Ludt 2020). This power purchase agreement between Amazon and ACCIONA will result in an additional 889 mW of solar photovoltaic energy production in the region and represents an estimated $1 billion investment. This development seems to have drummed up significant interest among residents, some of which have voiced concerns through drafting a petition to send to the Madison County Board of Adjustments, which handles permitting and zoning issues within the area (Rice 2020).

The high proportion of respondents from counties with RED projects closer to completion, especially those which have large and impactful footprints, may unsurprisingly suggest that residents form stronger opinions on the subject when the place-based characteristics of their community undergo change (Esaiasson 2014). In the case of this study the results of analysis of Madison residents' responses did not differ significantly from the rest of the sample. This suggests that although solar RED has potentially created a larger number of residents willing to state their opinions about solar energy in general, their collective attitudes were not very different from residents in other areas of the state.

Citizen Preferences for Configuration of Solar Energy Deployment

Despite the substantial corporate investment in large-scale solar development within the Commonwealth over the last couple years, the proportion of citizens who expressed a preference for utility-scale solar power for their residence was 19.6%. By contrast, 28.6% and 48.3% of respondents in this study said their preferred model for solar energy generation would be community-owned and rooftop systems, respectively. The intended distribution of power from ACCIONA-Tenaska's utility-scale photovoltaic installations is unclear. Whether or not these developments will exclusively supply power to industrial and commercial operations, or if they will partially supply residences, is not discussed in the project proposal. From an environmental standpoint the reduction of GHGs via these developments can be considered a positive, though there are some elements of economic impact analysis and participatory misfit that could be better addressed.

The relatively strong stated preference that respondents in this study had for community solar energy development is also something that could be addressed using a collaborative governance model (Prehoda, Winkler, and Schelly 2019). While this method for development comes at the cost of some additional administrative burden and challenges in community engagement, it is a promising framework for future RED project managers seeking to align their visions closely with the communities that they seek to become a part of.

While the current investment of corporate capital in Kentucky's solar energy future is promising is many respects, there are still misalignments in the design of these developments and the expectations of the communities they are most directly impacting. This is evidenced by citizen preference for models of solar energy development in the Commonwealth of KY and the types of developments that are occurring here.

Levels of Concern

There was a relatively high degree of concern over the reliability of solar as an energy source. Solar developers, policymakers, NGOs, and others with an interest in laying a supportive foundation for renewables in the Commonwealth would do well to focus efforts in addressing concerns over reliability as a matter of priority. Solar has been proven a reliable source of energy given the proper environmental conditions and infrastructure, so educating concerned members of the community on this topic should be achievable for institutions that see a benefit to expanding RED (Billington 2006).

The issue of visual impact on the landscape was also a large area of concern, with about 27% of respondents expressing a strong negative opinion of solar's aesthetic appearance, and an additional 16% having a somewhat negative opinion on its visual impact. Visual impact was also an oft-mentioned topic of conversation in citizen interest group petitions and conversations opposing solar development in the community. It may be that the large degree of support for household and rooftop solar models of configuration in this sample group is connected to this. The more minimized visual impact of residential rooftop systems versus utility-scale arrays may present an opportunity for alternate models of RED that garner more support from the community in some instances (Cousse 2021). This is an area of research worth exploring more since perceptions of place-based characteristics and community members' connection to the land around them can vary based on location and culture – a much more complex set of conditions affecting a community's acceptance of RED than the commonly cited "not in my backyard", or NIMBY, theory (Devine-Wright 2009).

Solar development being a potential threat to wildlife had the third highest level of overall concern, with nearly 27% of respondents expressing high or moderate concern on this subject. Issues of solar development's impact on ecosystems, particularly utility-scale, is understood to be a potential threat to conservation efforts due to its effect on land use and habitat loss from expansion (Hernandez et al 2015; Kim et al 2021). Determining what specific concerns communities have regarding wildlife impacts will be important in determining how solutions to this concern are formulated. Siting solar farms, particularly utility-scale developments, in using a more urban-centric method may help reduce impacts to existing and potential conservation or agricultural lands.

<u>Attitudes, Perceptions, and Political Identity</u>

Results and analysis of the survey responses for this study indicate that political party affiliation, especially identification as a Democrat, is a strong predictor of attitudes and opinions on topics of solar energy development, climate, and energy issues. All significantly different response results for Likert-measured attitudinal questions were found between the Democratic group of participants and one or more of the other political party groups. No significant differences were found between the other groups for any question. PCA analysis supports this pattern as well, showing a strong tendency for those identifying as Democrats to respond very similarly to one another and differently from other groups. This contrasts with the three other political groups, whose responses were highly dispersed and did not display the tight clustering seen in the Democratic group.

Those identifying as Democrats generally had significantly lower levels of concern and a more positive opinion on solar development and its associated environmental and economic benefits than other groups. This was especially apparent in the case of question 24 on whether participants believe that concerns over climate change are exaggerated or not, which displayed the most significant difference between Democrats and other groups of any question in the study. This is consistent with other literature that suggests that environmental awareness and political beliefs can be strong influences on attitudes towards renewable energy and climate change both in the United States and around the world (Carlsson et al 2021; Schwirplies 2018; Ziegler 2017). However, means for responses across all political groups were above three on the five-point Likert scale. This suggests a generally positive attitude towards utilizing more renewable and solar energy in the U.S. across the political spectrum, possibly pointing to a shared vision for an end-goal of decarbonization in the energy sector, but a disagreement in how exactly to achieve this (Miniard, Katenbacher, and Attari 2019).

These results highlight the need for solar developers and policymakers to structure their approach to RED accordingly. The concerns and attitudes of the public on the topic of solar development will likely shift strongly in response to the predominant political ideological makeup of the community. A majority Democratic community in KY will be more likely to agree with one another on issues of RED, concerns, and climate change. Whereas a predominantly Republican or third-party group may have less predictable collective attitudes towards these aspects of RED and the environment. Given this outcome and the heterogenous political landscape of the Commonwealth, it would be beneficial for policymakers and developers to recognize this correlation and work to solve problems of acceptance at the community level if they wish for the continued success of the renewable energy industry and climate change mitigation efforts here.

Questions on whether renewable energy provided a future for our children and whether people would be willing to pay more revealed that Democrats were also more inclined to believe that renewables would result in better health outcomes for future generations, and that they were more willing to pay additional costs for energy that came from renewable sources than other political party groups. These attitudinal variables are potentially closely connected. Graham et al (2019) found that those who viewed climate change as a more serious public health crisis were more willing to pay additional costs for renewable energy. Researchers in that study also found that those who believed climate change was generally serious also believed it to be a major public health crisis for future generations. Results from this study here in the Commonwealth of KY strongly echo these correlations.

Republican, Other, and Prefer Not to Answer attitudes were far less uniform than the Democrat group was, displaying a high degree of variation in responses. This non-uniform response suggests that Republican and third-party political ideology may be less of a factor in attitude formation on issues of climate change and renewable energy development than Democratic political ideology is. This is a topic worth exploring in future studies

Attitudes, Perceptions, and Age

There were far fewer significant differences in age groups than there were in political groups in this study. However, the significant differences between age groups that did occur were all between the youngest age group of 18-35 and the 36-55 and 56-74 age groups. Respondents in the youngest age group appraised the visual impact of solar on the landscape significantly more positively than the 36-55 age group did, and the 18-35 age group also agreed significantly more that fossil fuels were harmful to the environment than did the 36-55 group. The youngest age group also had the most positive opinion on solar development in their communities of any group, responding with a mean 4.6 to question 13. This response was also significantly more positive than that of the 56-74 group. These trends could potentially be the result of a growing number of young adults afflicted with climate anxiety around the world, who believe that institutions must take action to mitigate the effects of climate change more so than older people (Hickman et al 2021). However, this nuance would require more specific study as the youngest and oldest age groups in this study had a comparatively small number of respondents than the middle two age groups.

Recommendations

Results of this study highlight an opportunity for the incorporation of transdisciplinary knowledge and holistic sustainability into solar energy development policy in Kentucky (Staples et al 2021). Were Kentucky to adopt a state policy measure such as Community Choice Aggregation (CCA), the ability of consumers and municipalities to negotiate for better fitting development options to supply power to their communities in the long-term could be greatly enhanced (Farrell 2020). CCA gives municipalities the ability to purchase power on behalf of the citizens in their communities, without having to carry the economic burden of taking over an investor-owned utility's power generation and infrastructure. This policy structure strikes a balance between the fully investor-owned and operated utility model currently in effect in Kentucky, and the model of municipalization that many cities and towns switched to in the early 20th century. Another potential option for addressing citizens' desire for a more distributed model for renewable energy production would be the adoption of utility-owned rooftop installations. The model for this hybrid development format is explained exhaustively in a U.S. Department of Energy study on this development strategy (Inskeep et al 2015). This hybrid model works to expand the flexibility of development and financing options for consumers, without necessarily requiring a full transition of utility-owned energy infrastructure and decentralization to occur.

Conclusion

The results of this study reveal a misfit in preferences for solar development among citizens and the current state-level strategy for its expansion. Additionally, there appears to be a high degree of variation in attitude correlated with political beliefs, as well as age difference. Despite these correlations and apparent differences, there seems to be a strong preference for decentralized energy across-the-board for this study group. Key actors with a high level of operational capacity and authoritative power should consider these facets carefully and work to establish an adaptive framework for governing solar energy development that can effectively respond to the needs of the community. Responses to questions regarding whether respondents felt their opinions were able to be voiced and were valued would suggest that community outreach on the part of developers and state officials could be improved.

A larger sample size would have been generally beneficial for results. Additionally, a more even geographic spread of participants would have provided a wider scope in attitudes and opinions on energy issues and climate change across KY. However, the hot spots of high response rates also made it easy to identify communities where interest in solar RED is highest. Future study on this subject in KY could benefit from analysis of both urban and rural populations, as well as expanding on nuances within Republican and third-party attitudes towards renewable energy and climate change, as these responses were highly variable as compared to those of Democrats.

At present there is very little known about local attitudes and acceptance of RED in KY, and while some of the trends seen in this study echo trends seen in other studies conducted around the U.S. and the world, the voices of communities here must take precedent in development plans (Johansen 2019; Karlstrom and Ryghaug 2014). Despite a present lack of knowledge, the underdeveloped nature of the Commonwealth's policy framework for renewable energy development also offers exciting opportunities for niche experimentation and incorporation of grassroots ideas. Alternative models for RED such as decentralized networks and equity ownership show promise as means of diversifying RED strategy and expanding the ways that this sector can provide energy for communities and improve economic and social conditions in the process

(Hoicka, Savic, and Campney 2021).There may be opportunity for policy measures such as Community Choice and incentive or tax structures that could make the landscape for RED in KY more equitable as well. The prospect of an all-out transition to renewables could work to make KY's economic landscape more inequitable in some ways, or more equitable in others, posing other imminent challenges for policymakers and citizens alike as RED becomes more prevalent (Henry et al 2021; Patrizio, Pratama, and Mac Dowell 2020). Creating amenable economic conditions for citizen acceptance of renewables in KY will likely be paramount to making RED sustainable in the long-term, as economic factors have been found to be more prevalent in citizens' willingness to pay than environmental beliefs alone (Hast and Syri 2015).

As communities around the globe begin to look to renewable energy sources for solutions to energy issues, more dilemmas associated with development of solar installations are sure to arise. This study attempts to take a holistic look at some of these dilemmas and their potential solutions within the Commonwealth of Kentucky, and asks members of Kentucky's communities for their valuable insight into this growing industry. The attitudes and perceptions of the solar industry in KY are highly complex at present, and as the energy mix for a state that has historically been invested in the promise of coal for its energy, economic production, and social benefits begins to look to renewables, I hope that the citizens and institutions with interest in making this transition do so with some of the aspects revealed in this study in mind.

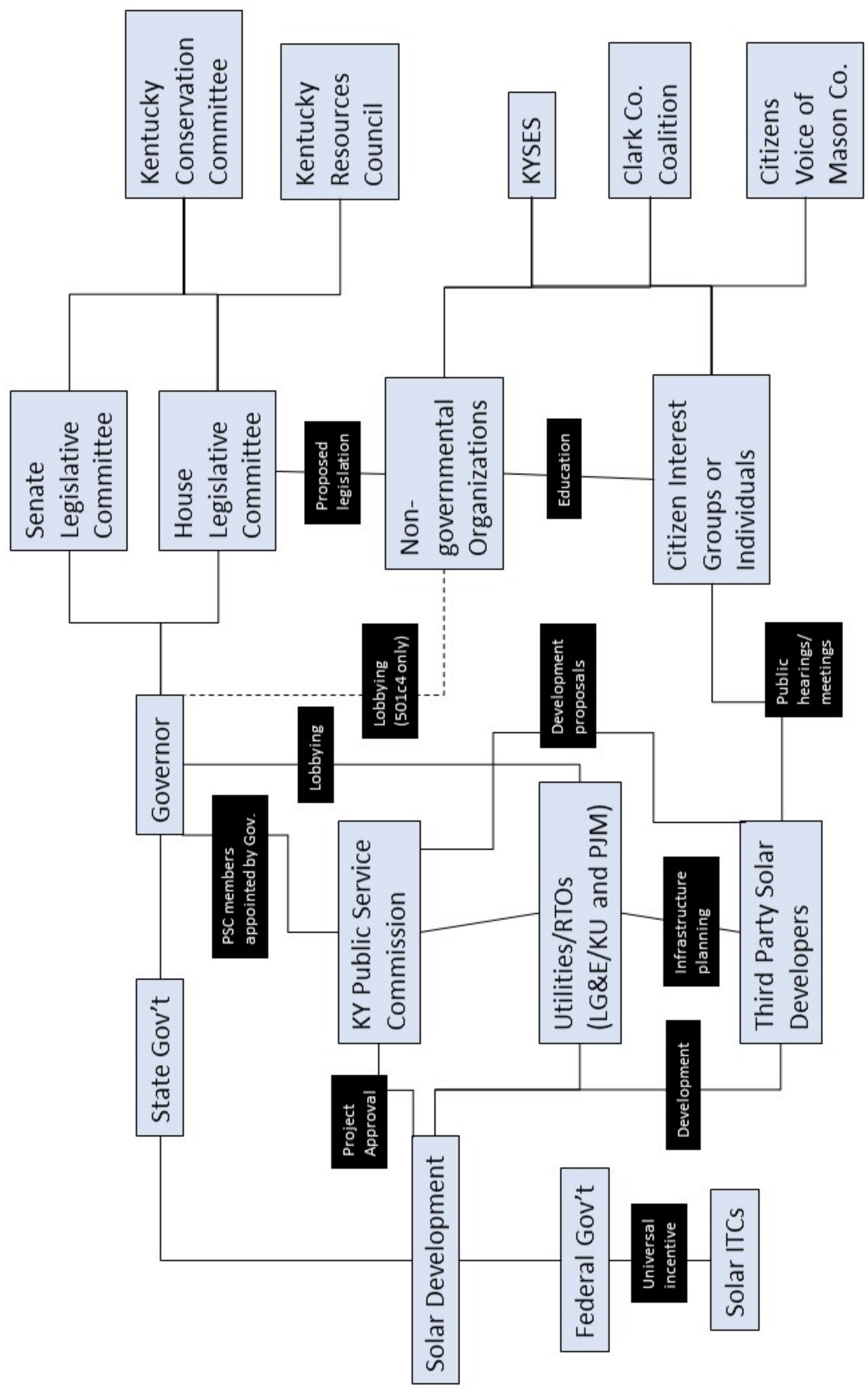

Figure 1. Organization chart displaying the flow of decision-making and operational capacities for actors related to solar development and policy in the Commonwealth of Kentucky. Acronyms; ITC - income tax credit, RTO - regional transmission organization, KYSES – Kentucky Solar Energy Society.

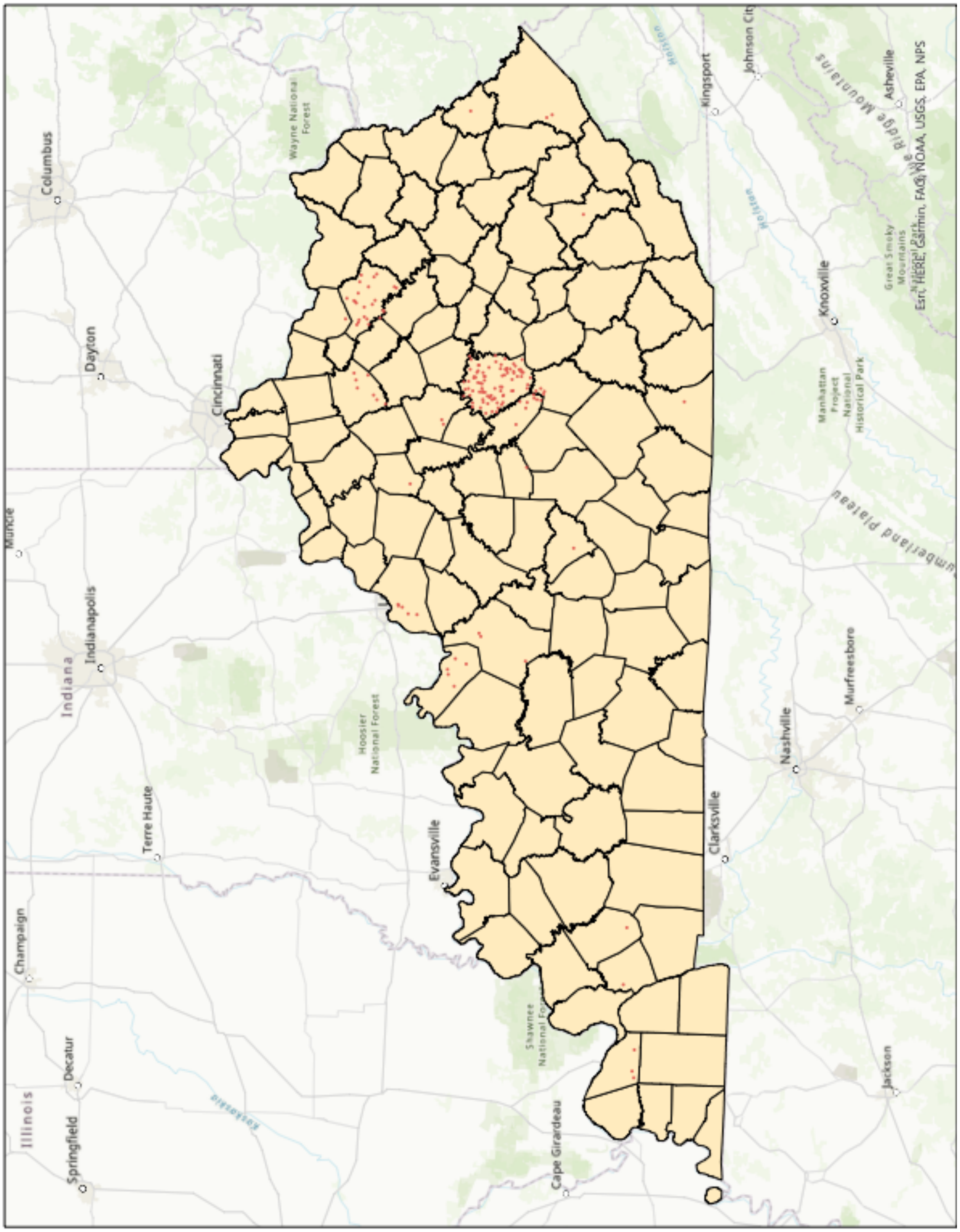

Figure 2. Dot density map displaying the geographic distribution of respondents to the survey used for this study. Each dot is one respondent, and the location of dot does not indicate exact location of respondent. Dots generally represent in which counties respondents home addresses were listed (n = 161).

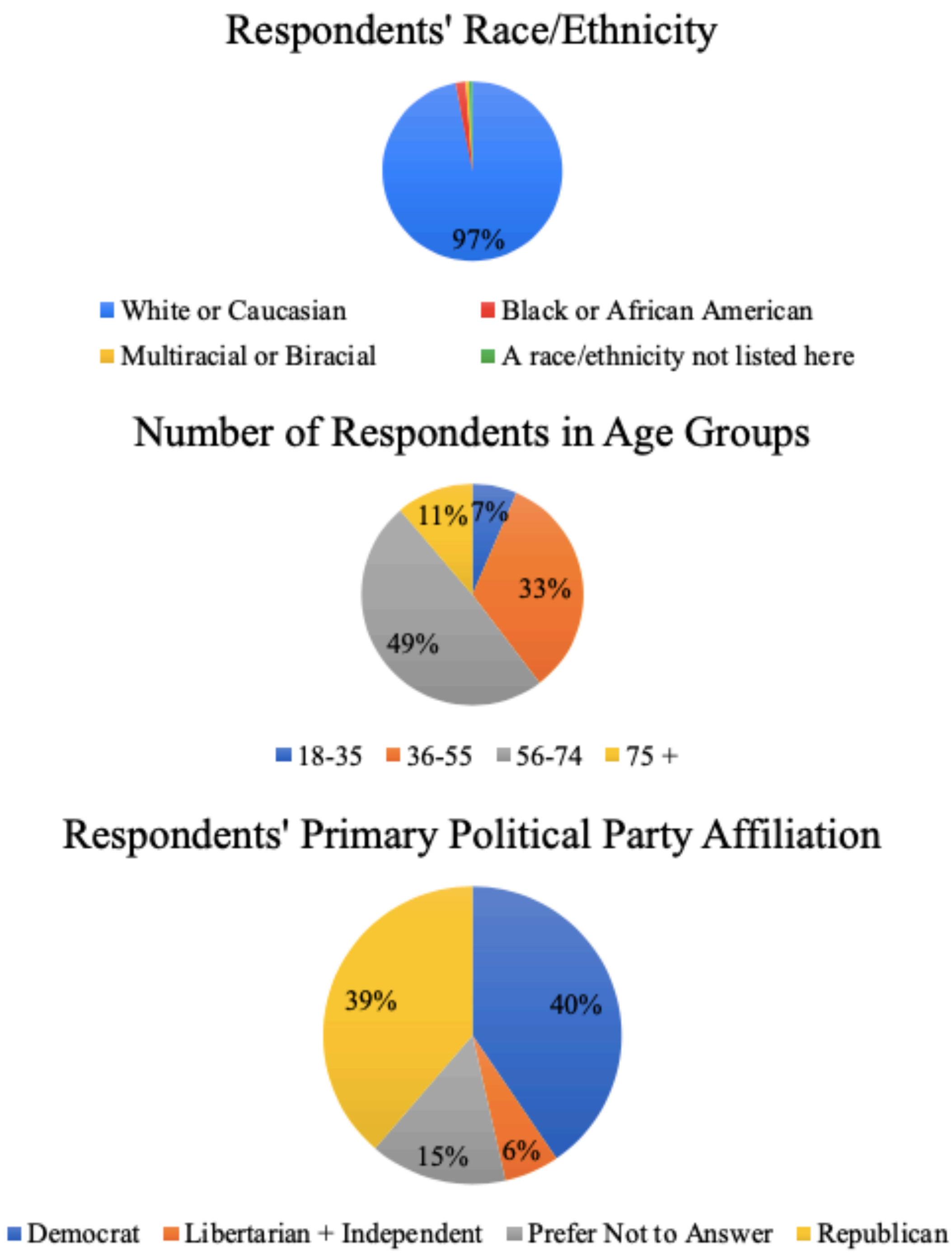

Figure 3. Count of respondents' demographic makeup within the study group. 162 identified as White or Caucasian, 3 as Black or African American, 1 as Multiracial or Biracial, and 1 as a race or ethnicity not listed (n = 167). 11 respondents were between the ages of 18 and 35, 56 were between 36 and 55, 83 between 56 and 74, and 19 were 75 and up (n = 169). Lastly, 68 identified as Democrats, 10 as Other, 25 preferred not to answer, and 65 identified as Republican (n = 168).

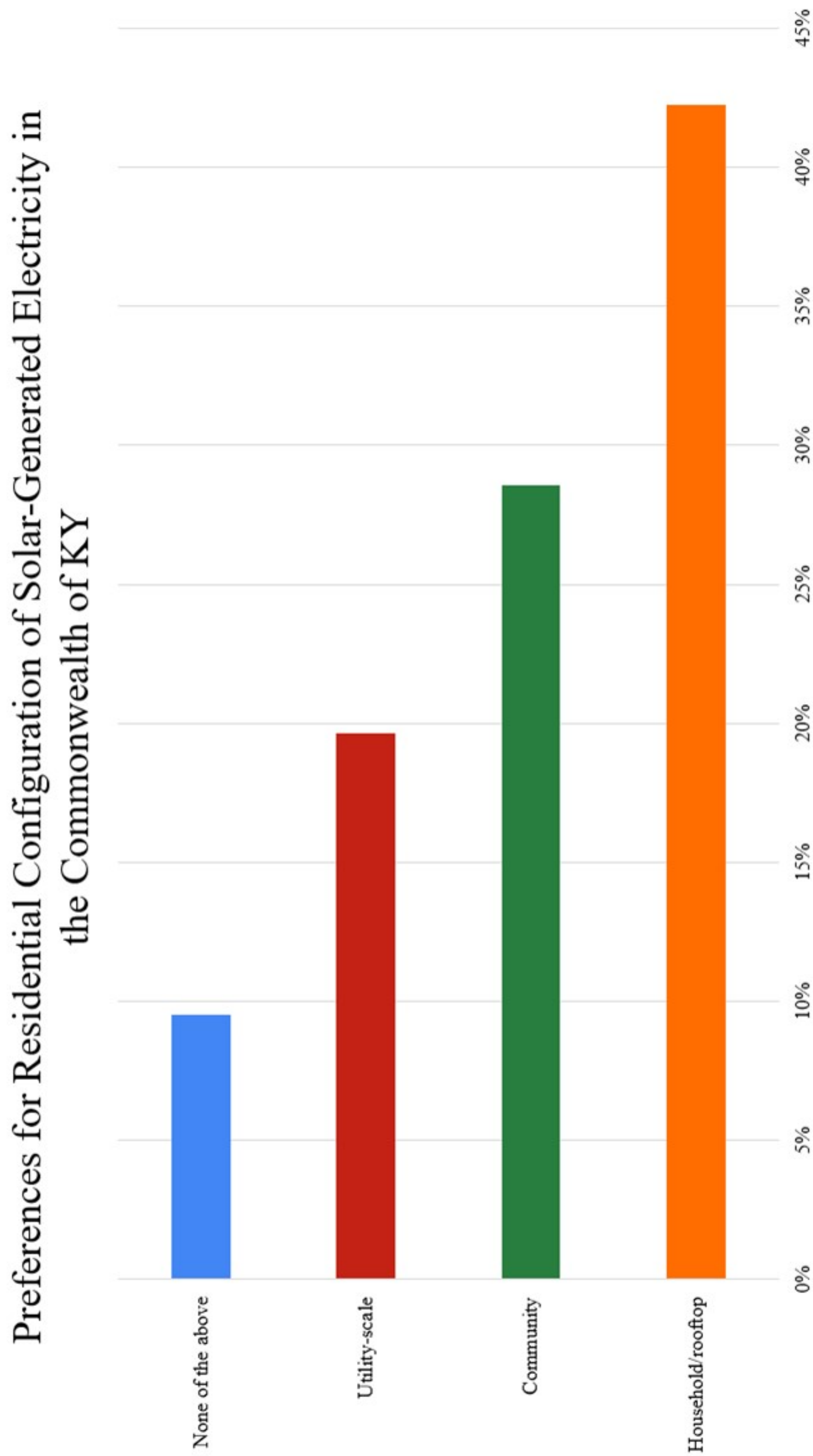

Figure 4. Percentage of total respondents expressing preference for various models of residential solar energy generation (n = 168).

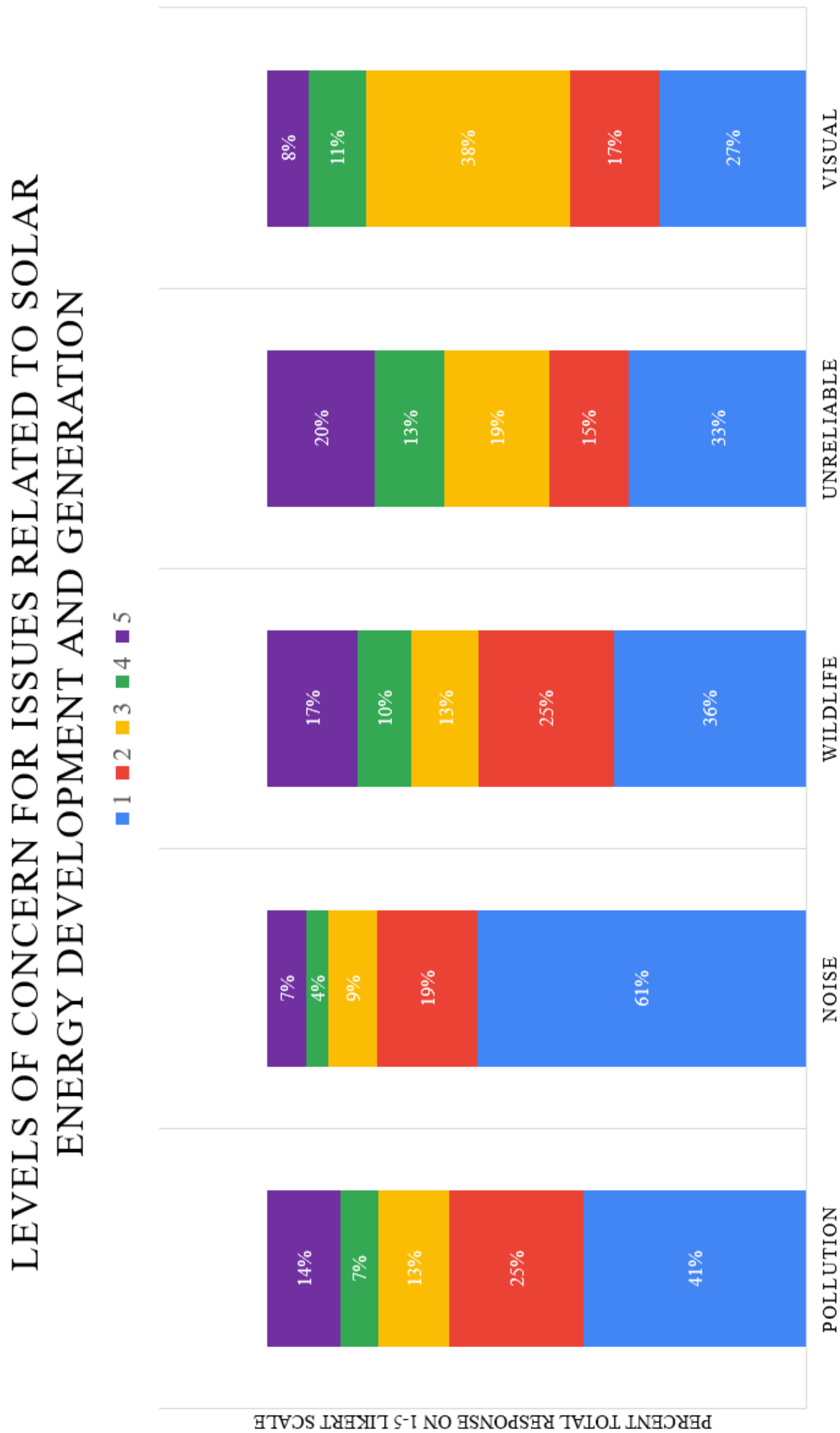

Figure 5. Stacked column graph representing the breakdown of 1-5 Likert scale responses for the five different questions in this survey related to levels of concern on various aspects of solar energy development and generation. All questions on levels of concern were rated 1-5 (1 of no concern, 5 of great concern) except the question on visual impact of solar development on the landscape, which used a 1-5 Likert scale in which 1 was negative appraisal and 5 was positive appraisal (n =138).

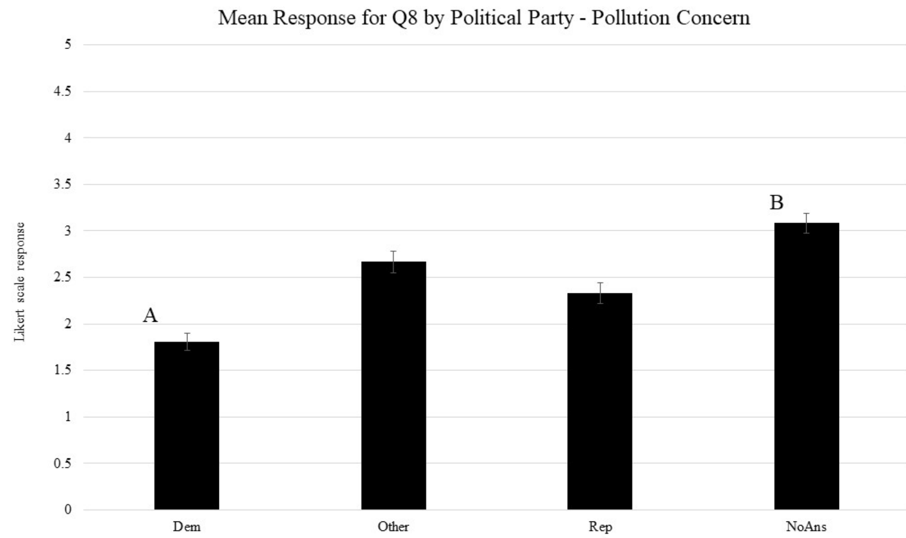

Figure 6. Question 8 on concern that solar development and energy may cause pollution. 1-5 Likert scale, 1 being no concern and 5 being very concerned (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

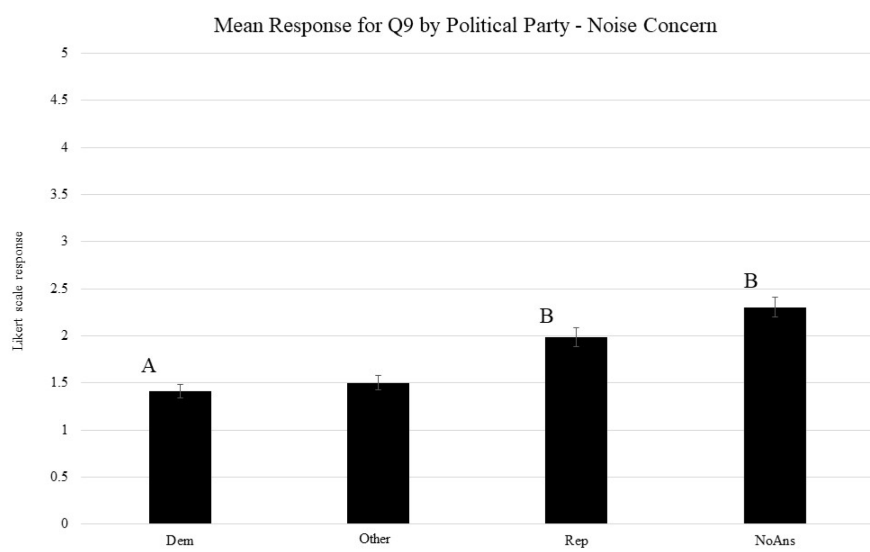

Figure 7. Question 9 on concern that solar development and energy may cause noise. 1-5 Likert scale, 1 being no concern and 5 being very concerned (n = 166). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

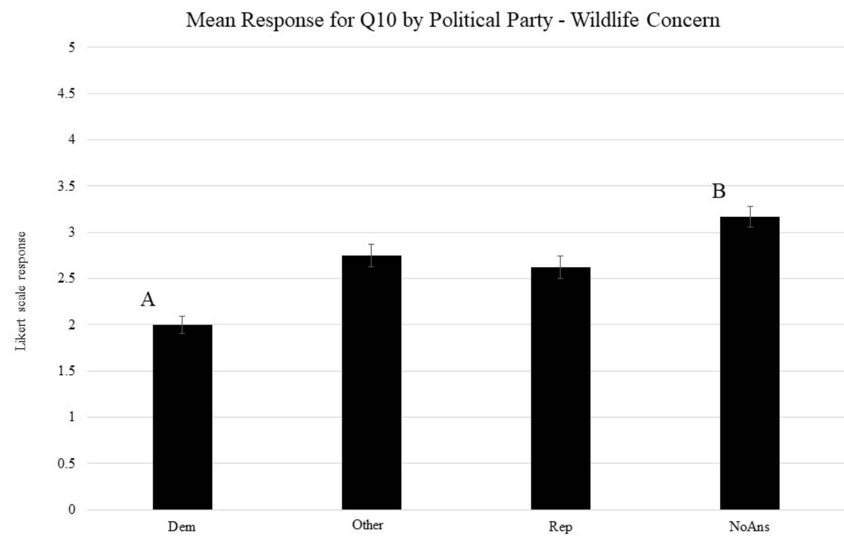

Figure 8. Question 10 on concern that solar development and energy may cause harm to wildlife. 1-5 Likert scale, 1 being no concern and 5 being very concerned (n = 167). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

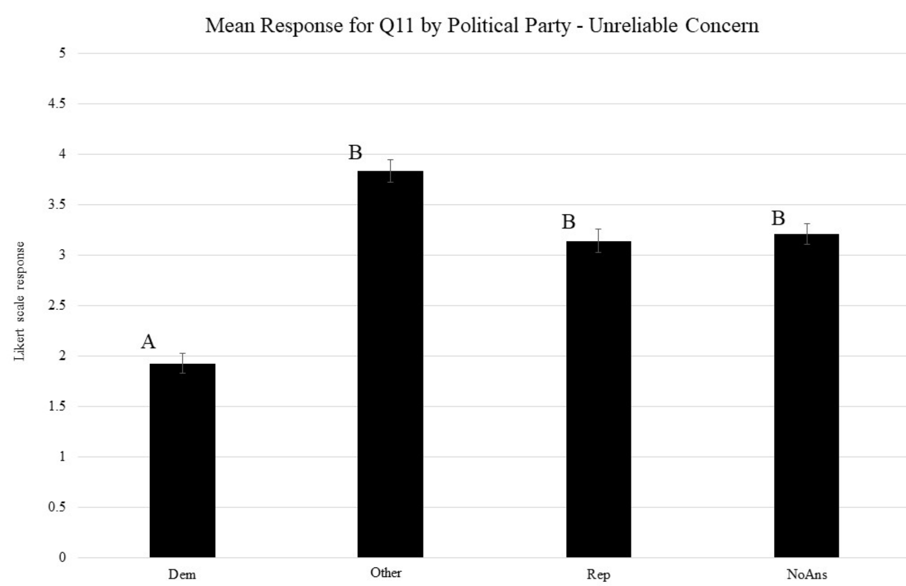

Figure 9. Question 11 on concern that solar development and energy may be unreliable. 1-5 Likert scale, 1 being no concern and 5 being very concerned (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

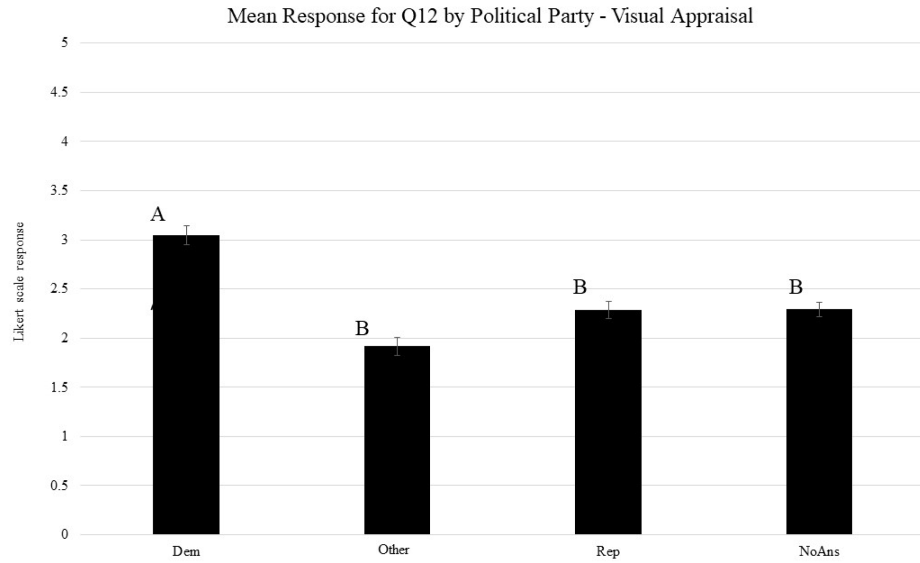

Figure 10. Question 12 on positive or negative appraisal of visual aspect of solar developments on the landscape. 1-5 Likert scale, 1 being negative and 5 being positive (n = 167). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

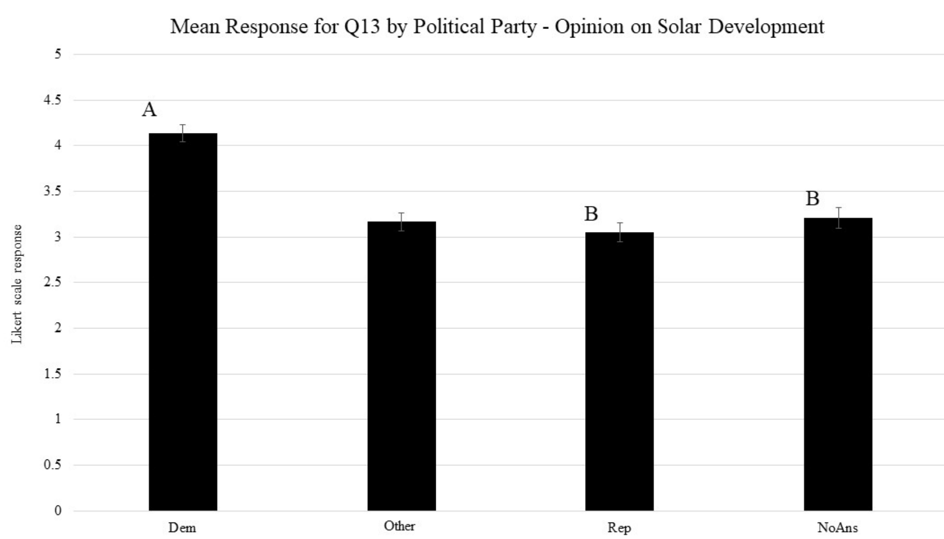

Figure 11. Question 13 on what respondents' general opinion of solar development in their community is. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

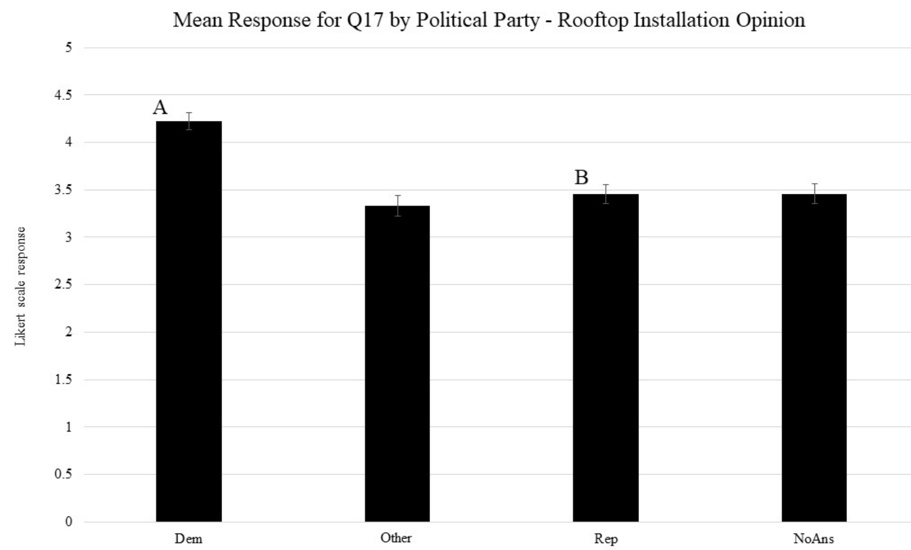

Figure 12. Question 17 on whether respondents believe that the installation of solar on one's roof is a good idea. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

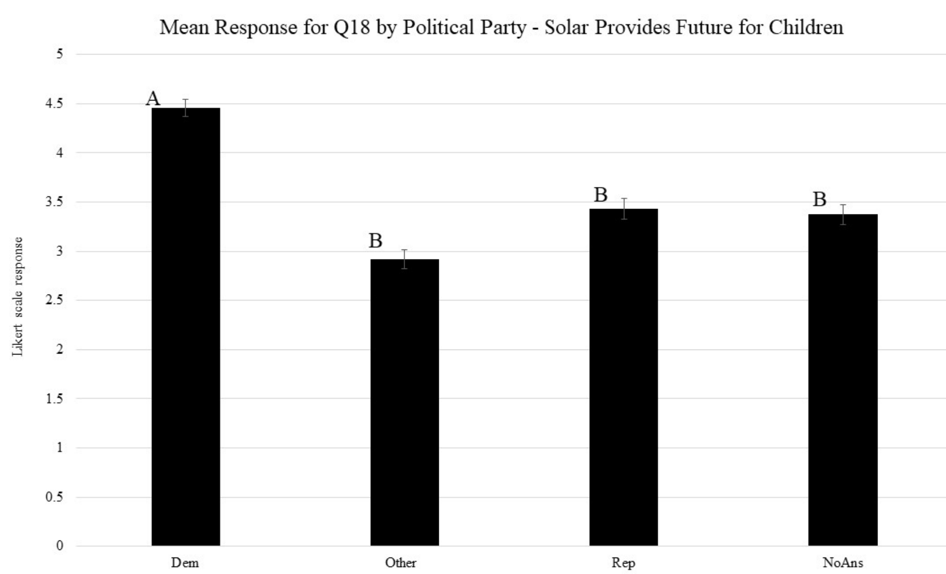

Figure 13. Question 18 on whether respondents believe that use of renewable energy in their community provides a future for our children. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 166). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

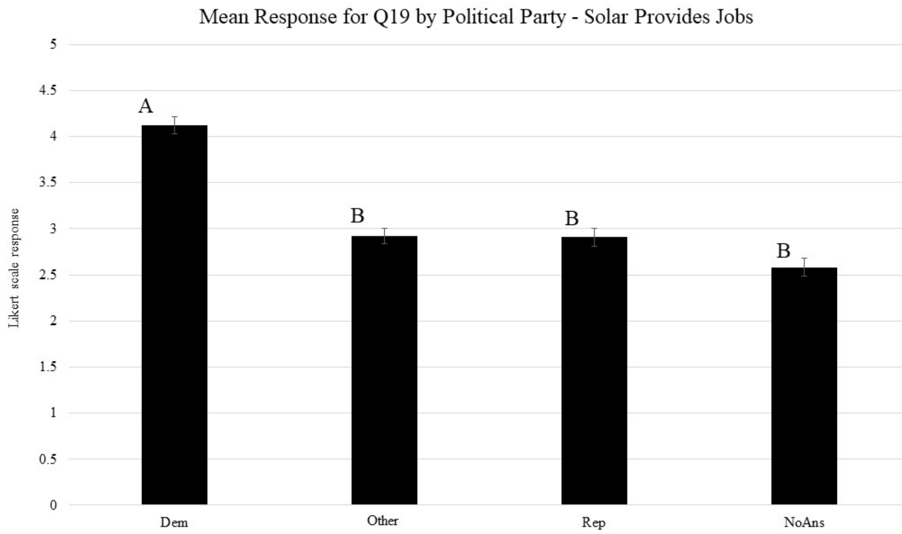

Figure 14. Question 19 on whether respondents believe that the development of solar in their communities will provide jobs. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

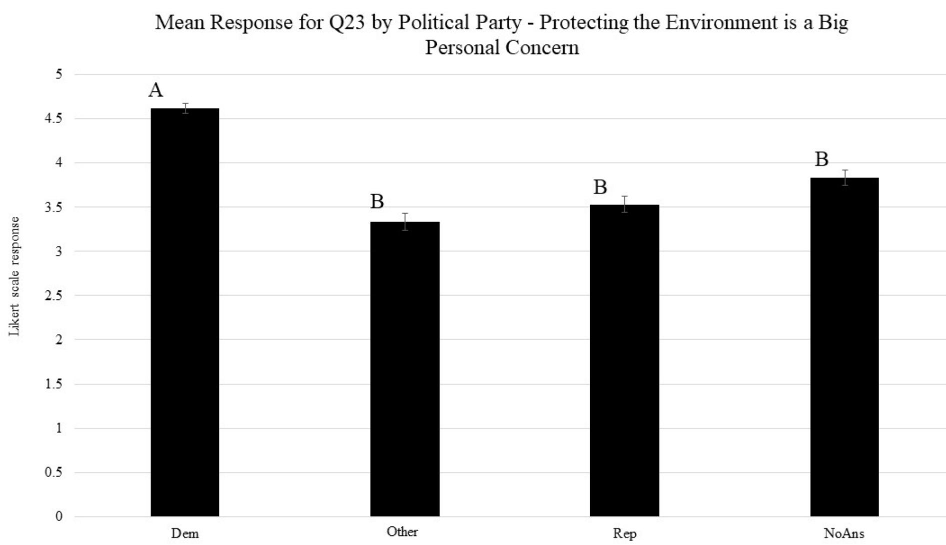

Figure 15. Question 23 on whether protecting the environment is one of respondents' biggest concerns. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

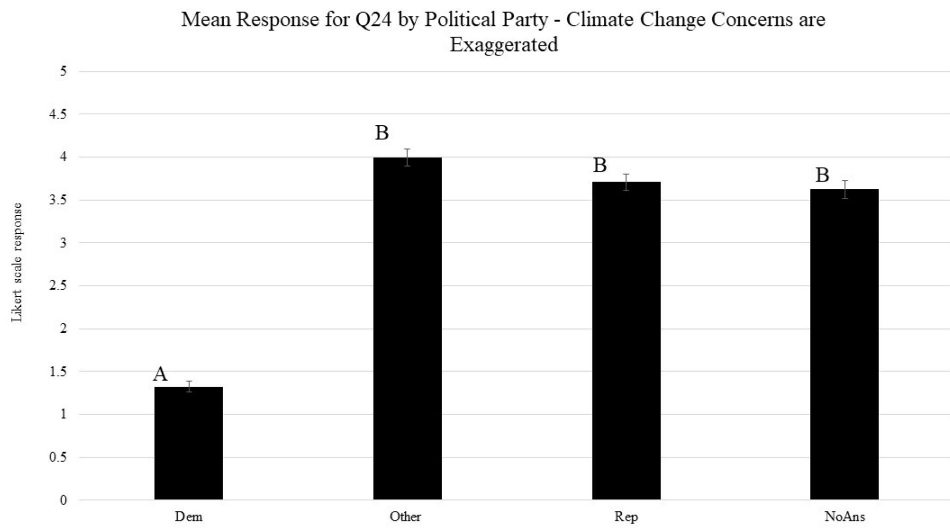

Figure 16. Question 24 on whether respondents believe that concerns about climate change are exaggerated. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 166). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

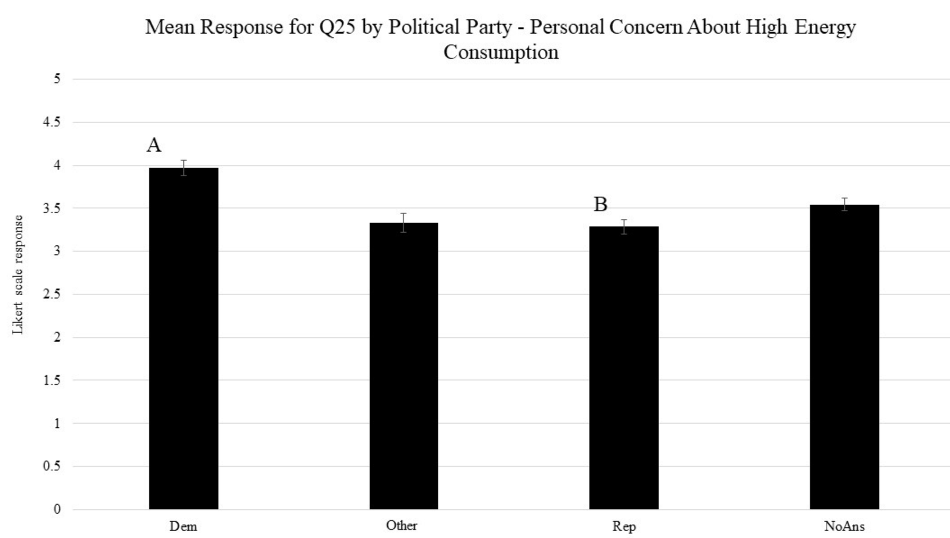

Figure 17. Question 25 on whether respondents are concerned about high energy consumption. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 167). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests ($p<0.0083$).

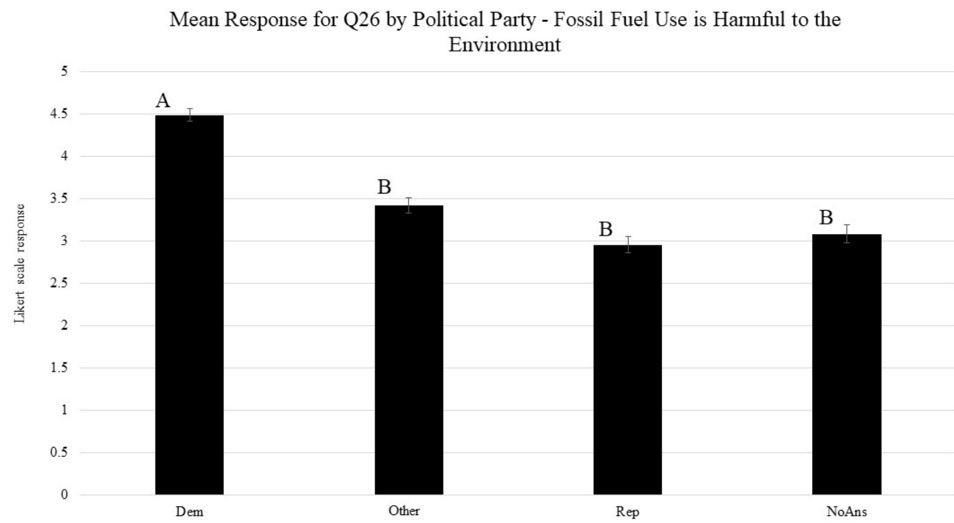

Figure 18. Question 26 on whether respondents believe that fossil fuel use is harmful to the environment. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

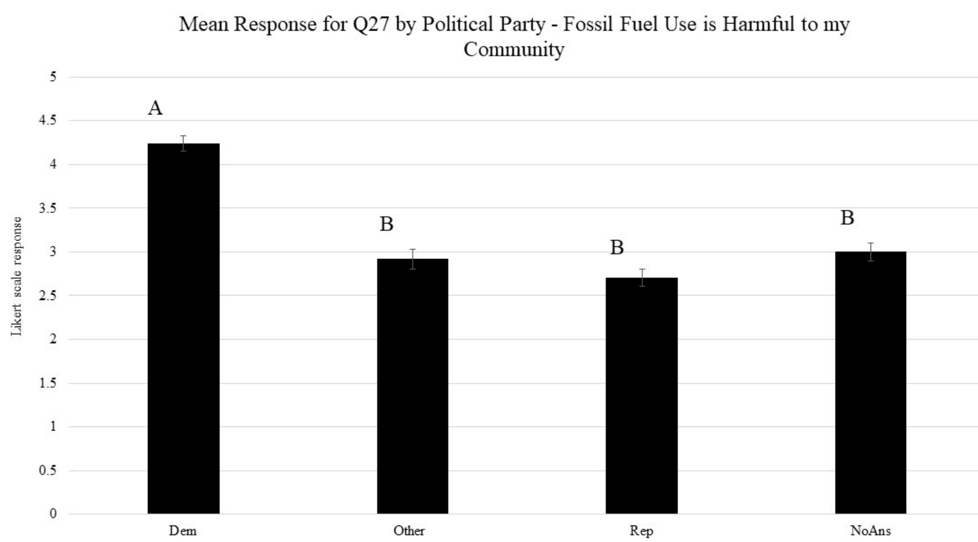

Figure 19. Question 27 on whether respondents believe that fossil fuel use is harmful to their community. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

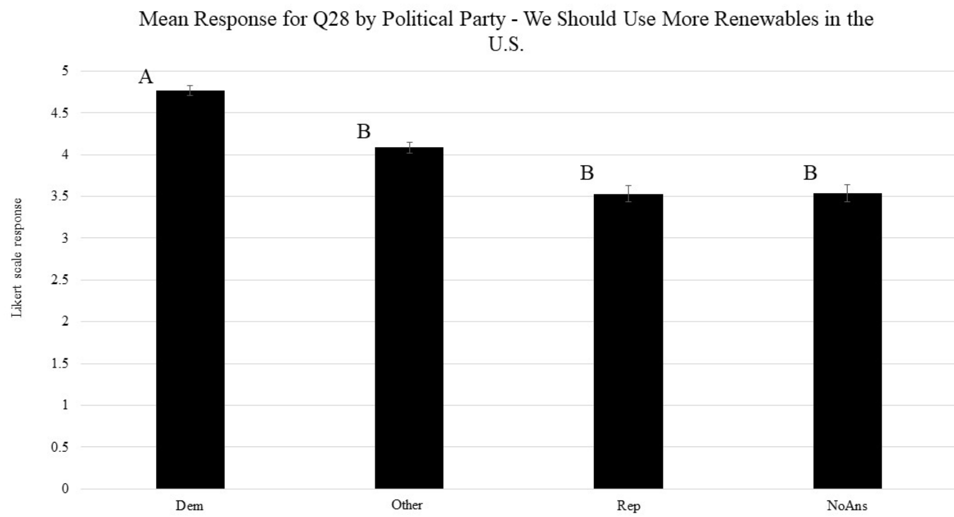

Figure 20. Question 28 on whether respondents believe that we should use more renewable energy in the U.S. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

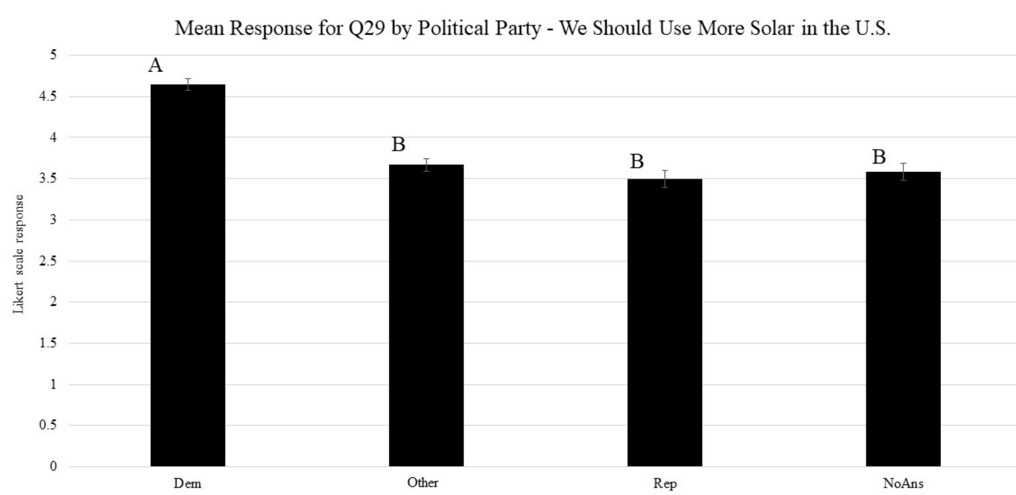

Figure 21. Question 29 on whether respondents believe that we should use more solar energy in the U.S. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

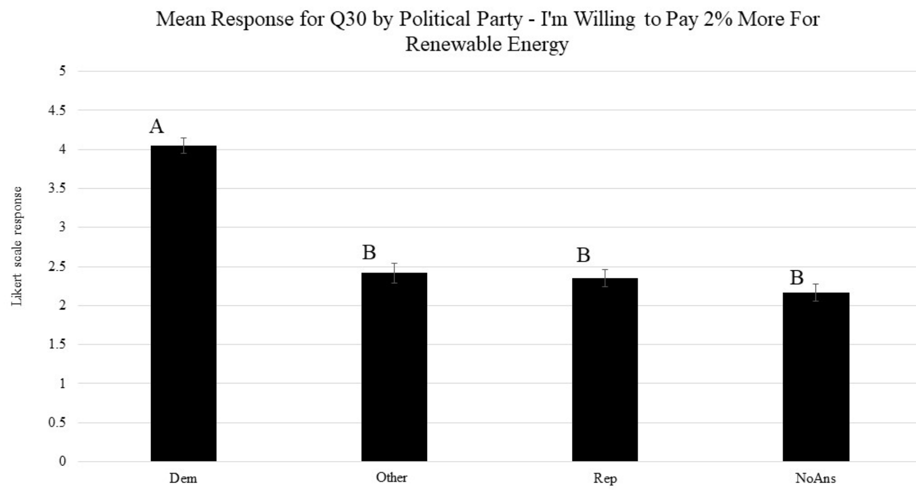

Figure 22. Question 30 on whether respondents would be willing to pay 2% more for energy from renewable sources. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 167). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

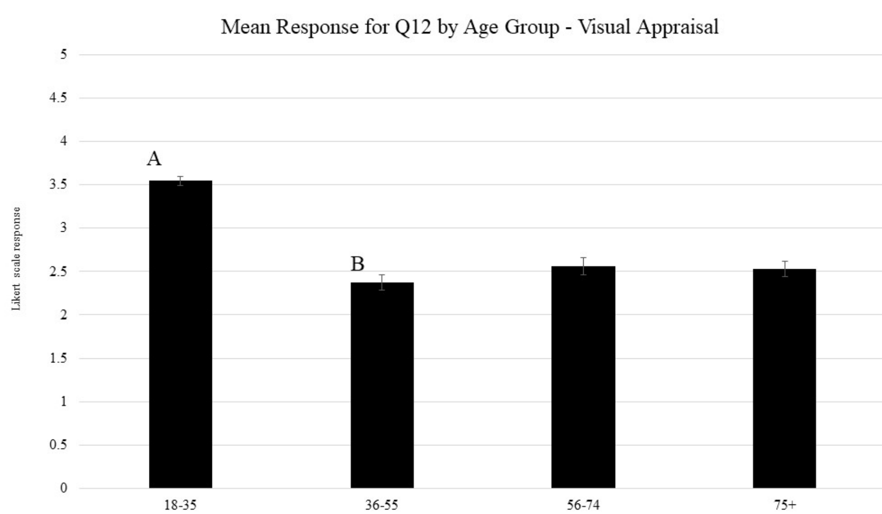

Figure 23. Question 12 on positive or negative appraisal of solar developments on landscape. 1-5 Likert scale, 1 being negative and 5 being positive (n = 168). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

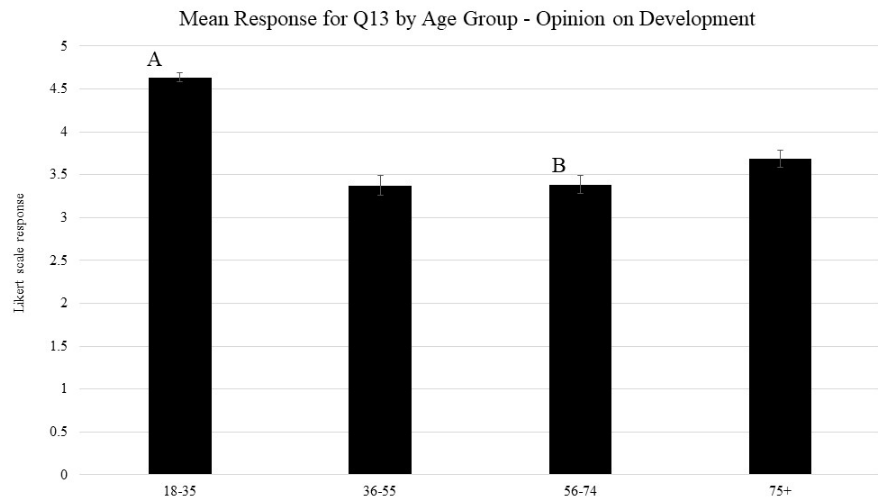

Figure 24. Question 13 on what respondents' general opinion of solar development in their community is. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 169). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

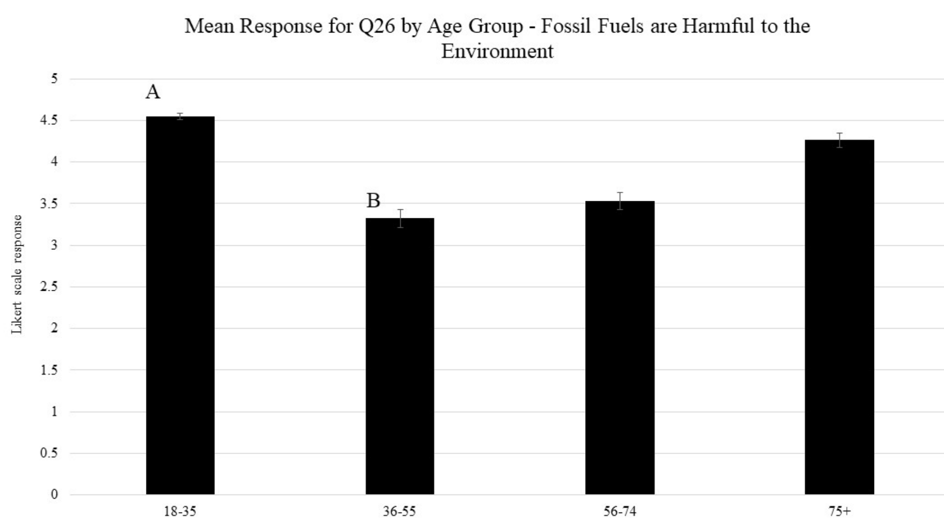

Figure 25. Question 26 on whether respondents believe that fossil fuel use is harmful to the environment. 1-5 Likert scale, 1 being disagree and 5 being agree (n = 169). A and B indicate significant differences between groups based on single factor ANOVA and Bonferroni adjusted T-tests (p<0.0083).

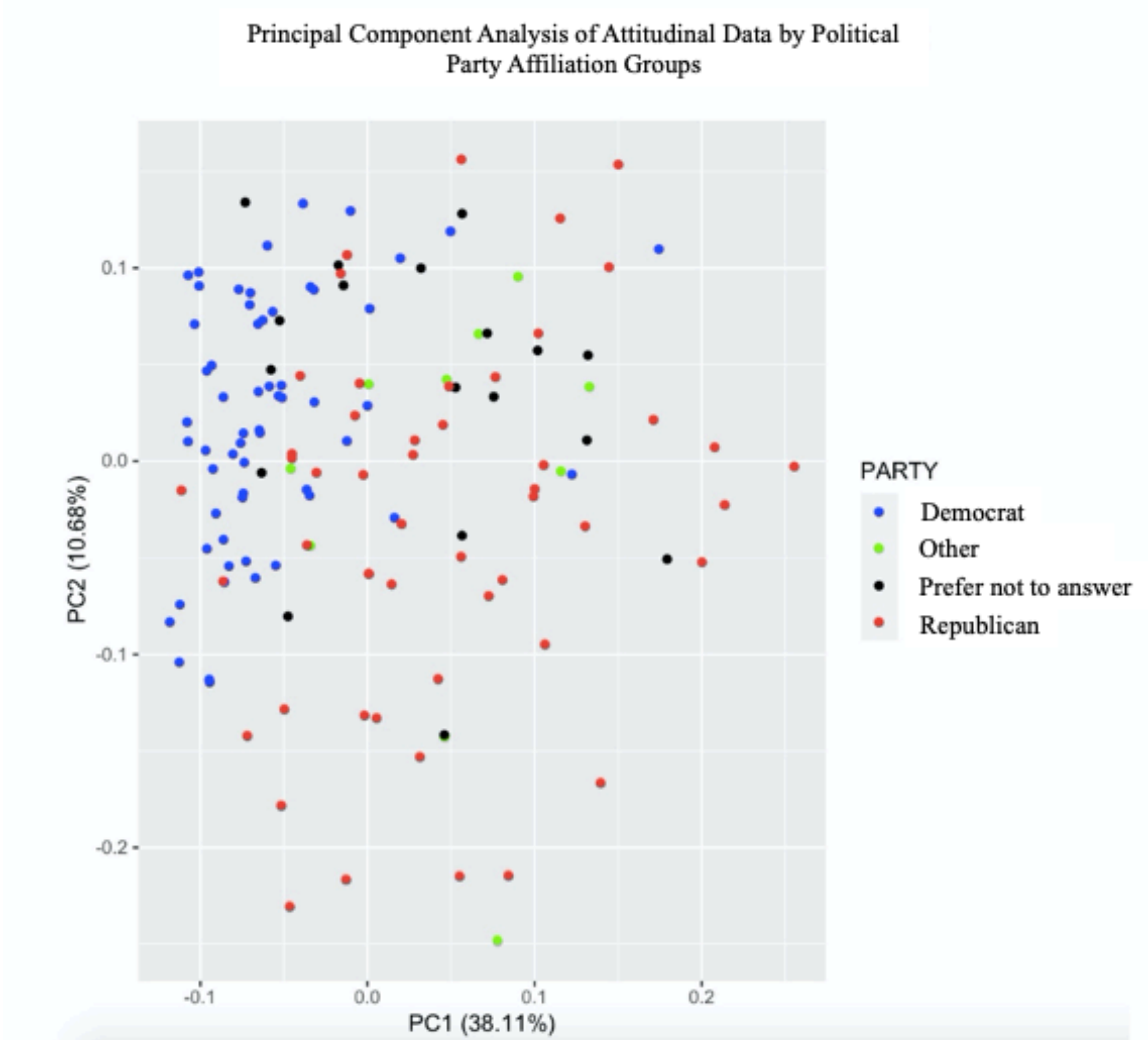

Figure 26. PCA displaying variance within responses to the 24 attitudinal questions in the study survey with data grouped by political party affiliation (n = 138).

Survey Format Pt. 1

	Geographical and Sociodemographic	
Q1	What is your 5 digit ZIP code?	(fill in the blank)
Q2	In which age range do you fall?	18-35, 36-55, 56-74, 75 and older (multiple choice)
Q3	Which of the following best describes you?	Asian or Pacific Islander, Black or African American, Hispanic or Latino, Native American or Alaskan Native, White or Caucasian, Multiracial or Biracial, A race/ethnicity not listed here (multiple choice)
Q4	What do you consider your primary political party affiliation?	Republican, Democrat, Libertarian, Prefer not to answer, Other (multiple choice)
	Prior Knowledge	
Q5	How knowledgeable do you consider yourself on renewable energy?	1 (not at all) - 5 (very) (Likert)
Q6	How knowledgeable do you consider yourself on solar energy?	1 (not at all) - 5 (very) (Likert)
Q7	The energy source for power generation in my community is mainly:	Natural gas, Oil, Coal, Solar, Wind, Don't know, Other (multiple choice)
	Levels of Concern	
Q8	How concerned are you that solar energy/development might cause pollution?	1 (not concerned at all) - 5 (very concerned) (Likert)
Q9	How concerned are you that solar energy/development might create noise?	1 (not concerned at all) - 5 (very concerned) (Likert)
Q10	How concerned are you that solar energy/development is a potential danger to wildlife?	1 (not concerned at all) - 5 (very concerned) (Likert)
Q11	How concerned are you that solar energy is an unreliable energy source	1 (not concerned at all) - 5 (very concerned) (Likert)
Q12	How do you appraise the visual impact of solar panels on the landscape?	1 (negative) - 5 (positive) (Likert)
	Attitudes/Opinions on Climate Change and Solar Energy Development	
Q13	What is your opinion on solar development in your community?	1 (negative) - 5 (positive) (Likert)
Q14	My opinion on solar development in my town would be more positive if it were to be owned or partly owned by the community.	1 (disagree) - 5 (agree) (Likert)

Table 1. Part 1 of Table 1, which contains all of the questions used in the survey for this study along with the format for their responses.

Survey Format Pt. 2

Q15	My opinion on solar development would be more positive if my household or community was given the option to generate our own solar energy.	1 (disagree) - 5 (agree) (Likert)
Q16	There are different models for solar energy production. Three of the most common are: large-scale (utility/municipal run), community-owned, and household/building-owned (rooftop solar). Given an option, which of the following models of solar energy production would be your preferred model for getting energy at your residence?	Large scale (utility/municipal run), Community-owned, Household/building owned (rooftop solar), None of the above (multiple choice)
Q17	The installation of solar on one's roof is a good idea.	1 (disagree) - 5 (agree) (Likert)
Q18	The use of renewable energy in my community provides a future for our children.	1 (disagree) - 5 (agree) (Likert)
Q19	The development of solar in my community will provide jobs.	1 (disagree) - 5 (agree) (Likert)
Q20	The planning of solar developments in my community has been transparent.	1 (disagree) - 5 (agree) (Likert)
Q21	I had/have ample opportunity to state my opinion on solar developments to companies planning them and/or to my political representatives.	1 (disagree) - 5 (agree) (Likert)
Q22	My opinion was taken into account.	1 (disagree) - 5 (agree) (Likert)
Q23	Protecting the environment is one of my biggest concerns.	1 (disagree) - 5 (agree) (Likert)
Q24	The concerns about climate change are exaggerated.	1 (disagree) - 5 (agree) (Likert)
Q25	I am concerned about high energy consumption.	1 (disagree) - 5 (agree) (Likert)
Q26	The use of fossil fuels (oil, natural gas, coal) is harmful to the environment.	1 (disagree) - 5 (agree) (Likert)
Q27	The use of fossil fuels (oil, natural gas, coal) is harmful to my community.	1 (disagree) - 5 (agree) (Likert)
Q28	We should use more renewable energy in the U.S.	1 (disagree) - 5 (agree) (Likert)
Q29	We should use more solar energy in the U.S.	1 (disagree) - 5 (agree) (Likert)
Q30	I would be willing to pay 2% more for energy from renewable sources.	1 (disagree) - 5 (agree) (Likert)

Table 1. Part 2 of Table 1, which contains all of the questions used in the survey for this study along with the format for their responses.

Table of Insignificant ANOVA P-Values for Political Party and Age Groups

Q#	Political Party	Age Group
Q1		
Q2		
Q3		
Q4		
Q5	0.765	0.531
Q6	0.622	0.548
Q7		
Q8		0.418
Q9		0.267
Q10		0.140
Q11		0.796
Q12		
Q13		
Q14	0.070	0.073
Q15	0.066	0.075
Q16		
Q17		0.068
Q18		0.268
Q19		0.134
Q20	0.394	0.673
Q21	0.773	0.063
Q22	0.211	0.288
Q23		0.413
Q24		0.169
Q25		0.285
Q26		
Q27		0.016
Q28		0.106
Q29		0.226
Q30		0.075

Table 2. Table showing the p-values for single factor ANOVA tests on questions grouped by respondents' political party affiliation and age group. Questions without p-values populated indicate either significance a demographic question, or a categorical question.

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