The Good Questions Project: Understanding Energy Project Development in Indiana

prepared for:

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5 July 2022

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IUPUI Account No. 47-953-00
IU Award ID: 078375-00002B

1.0 Executive Summary

The Indiana Office of Energy Development (OED) has contracted with a research group under the direction of Prof. Peter Schubert of the Richard G. Lugar Center for Renewable Energy, administratively housed within the Purdue School of Engineering and Technology on the campus of Indiana University-Purdue University Indianapolis (IUPUI) of Indiana, USA as of 17 January 2022 to conduct studies into the issues involved and the possible resolution thereof for energy projects being considered by Indiana counties. Called the "Good Questions Project", the aim is to help community members ask informed questions of developers, and to provide aid and assistance to county elected officials and county economic development professionals. This is the final report of Phase 1 of this two-phase project.

The project team consists of student researchers at IUPUI and IU-Bloomington, plus Mr. Lee Lewellen, the CEO of the Indiana Economic Development Association (IEDA). Four students were engaged and include a SPEA graduate student from IU Bloomington plus Energy Engineering majors from the Purdue School of Engineering & Technology at IUPUI. Additional assistance has been provided by the Association of Indiana Counties (AIC) and the Indiana University Center for Survey Research (CSR) organizations.

Key findings of a survey of county commissioners and economic development professionals include (see section 6.0 for details):

- Most Hoosier communities welcome solar, while wind turbines are more controversial, with a substantial fraction of people viewing wind negatively.
- Favorable factors in wind and solar projects are economic benefits to communities, and environmental stewardship. Detractors focus on aesthetic concerns.
- Policy makers are focused on the economic impact of renewable energy projects.
- Critical factors in considering new energy projects are (1) economic benefits, (2) community outreach, and (3) environmental benefits.

Five specific "qood questions" were researched to discover the underlying science, and to put results in context. These include two related to wind, two related to solar, and one related to agriculture so as to provide a broad starting point for additional studies. One- or two-page information cards were created that can be handed out at public events to help educate citizens about concerns that are commonly raised regarding new projects.

Some citizens favorable to new energy projects feel intimidated and will "self-silence". An appendix on event security is included so that public discourse can be held in a safe space. A glossary of frequently-encountered terms and abbreviations is included.

Several policy recommendations are made, the most urgent of which is a public education campaign across the State of Indiana. This is urgent, because those who peddle misinformation act quickly, and sow seeds of doubt that are very hard to dislodge.

The outlook for Phase 2 of the GQP is presented. Also included are methods used to generate the information contained herein. This may simplify the task of research into future energy topics (e.g. hydrogen, small modular reactors) when they come to Indiana for consideration.

2.0 Introduction

New energy projects can be controversial. A common response is "Not In My BackYard" (NIMBY). Many legacy generation sites are sufficiently removed from population centers that their aesthetics, noise, traffic, odor, and pollution can be overlooked or ignored. The luxury of remoteness is generally in the past.

Cheap electricity is desirable. Currently, the lowest cost generally comes with the largest scale and the oldest equipment. For this reason, large coal-fired power plants have dominated electricity generation for a century. Nuclear power makes a sizeable (19%) contribution to the US generation portfolio [EIA], and in the Pacific Northwest, hydropower is widely available. Notwithstanding environmental control investments, thermal stations that were built 30 to 50 years ago have long been paid off, requiring only fuel, operations and maintenance to "keep the lights on". Yet, these same workhorses of the power grid incur a significant environmental and health cost. A 2010 study cites a conservative estimate of an additional 3.2 cents per kilowatt-hour (kWh) required to offset known and provable public harm from the mining, transport, and burning of coal within the US fleet [National Research Council]. These harms have long been normalized as the "cost of doing business".

Low-cost power requires large installations such that the non-recurring costs are spread out over a greater output. For newly-installed utility-scale generation, the cost per kWh is now lower for wind and for solar compared to coal or natural gas [Lazard]. Indiana is known as the "Crossroads of America", especially when it comes to high-tension electric transmission lines. The density of such grid connections makes the Hoosier State very attractive to new energy projects. Sunlight ("insolation") in Indiana is not as strong as Arizona. Wind in Indiana is not as strong as in Kansas. But with nearby grid ties, solar and wind projects sited in Indiana can generate strong revenues and attractive profits.

A further significant financial benefit of wind and solar relative to coal or natural gas is the absence of fuel costs. Sunlight and wind are free. Maintenance for both is modest. Dramatic reductions in capital expenses to build, install, and connect solar and wind developments over the last ten years now make these very appealing to investors. To reap these benefits, with today's population densities, wind and solar installations need to be closer to, and more visible to, citizens in the rural counties of Indiana. This has caused some consternation, and even in some cases prohibitions against, or severe restrictions upon, such developments. A portion of this study is to understand the sources, motives, and nature of objections, and to provide science-based responses to some of the nightmare scenarios raised by opponents. Some of these, unfortunately, are brought forward by *agents provocateurs* who may live outside the local jurisdiction, and may be acting on ideological or anti-competition motivations. Too often, these outside concerns seek to disrupt and divert the local decision-making process.

"Depending on the specific technology, a utility-scale solar power plant may require between 5 and 10 acres per megawatt (MW) of generating capacity. Like fossil fuel power plants, solar plant development requires some grading of land and clearing of vegetation." [SEIA]. Considering the auxilliary resources around a solar or wind project, such as roads, transmission switchgear, and setbacks, the land required per MW is even higher. A study by Strata [Stevens] published the analysisin Chart 1 of per-MW land use in 2017. Values for wind and solar are likely lower in 2022, but still require significantly more land than coal or natural gas facilities.

Chart 1: Land Use by Electricity Source in Acres/MW Produced

Electricity Source	Acres per Megawatt Produced
Coal	12.21
Natural Gas	12.41
Nuclear	12.71
Solar	43.50
Wind	70.64
Hydro	315.22

The tradeoff of rural land use between energy production and agriculture is important to Indiana farmers and farming communities. Some projects being proposed or started occupy large areas, and reawaken the "food versus fuel" debate that arose when corn-based ethanol production was first being considered. By 2022, approximately half (50%) of corn grown in Indiana goes into fuel production [ICMC].

In contrast, wind mill towers are often co-located with farmland, with each tower occupying about half (0.5) of an acre, so about 95% of a farmer's land is still suitable for cultivation [FB]. For solar installations, traditional row crop farming is not possible, however, the growing field of agrivoltaics is exploring husbandry and vegetable farming that can be co-located with PV panels (see section 8.0). An often-overlooked positive factor in solar installations is that the land is readily converted back to farmland at the end of the project. The soil will have rested for several decades, which may even improve yields compared to when the project was begun.

No form of power generation is completely clean. No source of energy is free of risks. New energy projects involve a spectrum of concerns. These must be considered in balance with each other, and in context with existing risks and harms. Broader considerations such as energy independence and climate change are important factors that may seem remote to individual citizens, but which are vital to our national security and future prosperity. There are no perfect solutions. The Good Questions Project brings science-based analysis of the pros and cons of new energy projects. Concerned citizens are encouraged to ask good questions of developers, and to challenge them to provide good answers (see section 9). It is our belief that public discourse in this fashion will lead to the best overall decision for a given Hoosier community.

References Cited

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3.0 Opportunities and Challenges

Most new energy projects offer generous economic stimulus to counties. Most offer jobs for locals, both limited duration construction work, plus on-going operations and maintenance positions. The tax benefits from energy generation, along with other financial or in-kind contributions by energy developers can address important public and social needs, such as improvements in infrastructure (roads, bridges, power lines), community facilities (schools, hospitals, green spaces, parks, libraries, public buildings), and economic development (attracting new businesses, expanding existing companies, promoting downtowns, creating neighborhoods). Section 5.0 lists subject matter experts who helped our team understand these issues in Indiana.

Such benefits and opportunities must be weighed against concerns, questions, and objections raised by residents of the county. People may take issue with aesthetics (viewscapes, motion), with nuisances (sound, shadows, traffic), or possible disasters (fire, electrocution). In addition, some citizens may object to new types of power generation (wind, solar, biomass, nuclear) because of the familiarity and cultural relevance of legacy technologies (coal, natural gas).

Compared to the political climate of 50 years ago, the internet, social media, cable news, blogs, and streaming video can dramatically amplify the speed and perceived power of citizen opposition. Following the example set by the tobacco industry, corporations and trade groups have learned methods to foment discord, doubt, and anger when their business models are threatened by new information and new technology. Misinformation is a term used to describe claims that are either unsubstantiated ("windmills cause cancer and diabetes") or which contain a germ of truth but are then wildly exaggerated ("solar panels catch fire when birds land on them"). Organized groups, armed with videos, photos, and written materials, can rapidly inject strong doubts and concerns among the lay population of a county that comes under consideration for a new energy project. These dynamics make the introduction of, and discussion about, energy-related developments much more challenging.

An interesting historical record illustrates that concerns over new energy projects are not new. The following is an excerpt from the Congressional Record, dated 1875:

> "A new source of power… called gasoline has been produced. Instead of burning the fuel under a boiler, it is exploded inside the cylinder of an engine… The dangers are obvious. Horseless carriages propelled by gasoline might attain speeds of 14, or even 20 miles per hour. The menace to our people of this type hurtling through our streets and along our roads and poisoning the atmosphere would call for prompt legislative action even if the military and economic implications were not so overwhelming…"

4.0 Methodology

In addition to the direct research findings of this study, this report captures the means by which the research was conducted. This meta-level assessment intends to teach others how to develop their own analyses to address additional factors in considering new energy projects. As one example, there is a burgeoning world-wide interest in hydrogen technologies, but these are not yet widely deployed outside of the commercial and industrial sectors. One day in the not-too-distant future, there may be "blue" or "green" hydrogen generation, storage of such hydrogen, and its use in a fuel cell running a home, a vehicle, an airplane, or even portable electronics. Another example is small modular reactors (SMR), that are fully-sealed nuclear reactors purported to be much safer than existing light-water reactor designs. The methodology presented in this section aims to create a near-universal approach to studying energy systems of the future, while being applied to those of today.

The Research Team

Prof. Peter J. Schubert, Director, Richard G. Lugar Center for Renewable Energy
Mr. Lee Lewellen, President/CEO, Indiana Economic Development Association (IEDA)
Mr. Forrest Levy, Graduate Student, IU – School of Public and Environmental Affairs
Mr. Ben Baker, Student, IUPUI - Energy Engineering
Mr. Nic Parvex, Student, IUPUI – Energy Engineering
Mr. Shalem Poriah, Student, IUPUI – Energy Engineering
Mr. Antwan Khoury, Student, IUPUI – Energy Engineering

Subject Matter Expert Interviews

For the subject matter expert (SME) interviews (see section 5.0), a consistent plan was used to develop 6 to 10 questions per interviewee. First, Mr. Lee Lewellen or Dr. Schubert would find a renewable energy policy expert who was willing to be interviewed for the project. After sending their name to the group, Mr. Forrest Levy would then delve into the interviewee's work background, crafting questions relevant to the project based on their relevant experiences. He would then send the questions to Dr. Schubert and Mr. Ben Baker for editing and suggestions prior to the interview. The workflow used for creating questions can be found in Appendix A.

All interviews for the Good Questions project were conducted over Zoom and typically lasted around 45 minutes. To start, either Dr. Schubert or Forrest would give a brief introduction of the project to the interviewee. Then, Forrest would begin by asking the interviewee questions from his list of questions and communicate with his 'color commentator' Ben in the private chat to plan follow up questions that Ben could ask based on the respondent's answers. Forrest and Ben split question-asking about 80-20. Meanwhile, Antwan or Nic would act as the scribe and transcribe the important points of the interview. Once the interview concluded, the scribe would add any additional touches and send it to the group so that everyone could review the interview.

Survey Development

In order to collect responses from economic developers and county commissioners, a survey was created (see section 6.0). The survey was conducted through Qualtrics™ (Qualtrics, Provo, UT), the survey host that thousands of organizations – including IU – use. The Center for Survey Research at IU helps organize a class on software and surveys, and Forrest was able to audit the class and have access to the class materials. When creating questions for the project, Forrest altered public domain questions from Pew and Gallup to fit the scope of the project and developed additional Indiana-specific questions himself. He coded those questions into Qualtrics to create a rough draft of the survey (see Appendix B for the flow chart of questions). He then sent this to Dr. Schubert and some members of the Indiana Office of Energy Development so that they could review the questions and try to 'break' the survey to probe for shortcomings. Forrest used this feedback to tailor the survey to the final product and used the responses to plan how he will display the data using RawGraphics – a free data visualization software. Finally, the survey was distributed to county officials and economic developers throughout Indiana. The survey instrument developed for Phase 1 will be adapted and used in Phase 2 to gather responses from the general public.

Renewable Energy Groups List

The process of identifying and compiling a list of renewable energy groups was a research-intensive process. The process involved starting with a search engine, in this case Google, and searching phrases using the key words like renewable, energy, and Indiana, such as, "renewable energy groups Indiana" and "anti-renewable energy groups Indiana." Searches using general phrases primarily yielded news articles pertaining to renewable energy in Indiana.
The articles were used as a stepping-off point to begin the process of identifying distinct groups. If an article mentioned a group, the identified group would then be researched and used to identify other groups. New groups that were identified would then undergo the same type of research that the initial group underwent. This method would continue until no new groups were discovered (see Appendix C for a diagram of the research methodology). After hitting a dead end, the research would start over by either searching for a new phrase or by reading different articles. There were some instances when a specific group's page would pop up in the results page after searching a general phrase. The research, in this case, was the same as the research in the case of an article with the only exception being that an article was not relied upon to initially identify the group. The list of groups active in Indiana Energy is presented in Appendix N.

5.0 Subject Matter Expert Interview Findings

In order to gain insight into the issues facing policy makers, over a dozen subject matter experts were interviewed. This included interviews with professors, county commissioners, economic developers, energy professionals, and professional researchers. These interviews were conducted in order to find gaps in the researcher's knowledge and solicit information that otherwise would have remained hidden. Below is a table showing a list of those who have been formally interviewed using the methodology above, their profession, the date of the interview, and a brief summary of the topic discussed.

Name	**Profession**	Date	**Topic**
Corey Murphy	Economic development director in Henry County	3/8/22	Sources of strife in renewable energy projects in Henry County
Randy Mitchell	President White County Economic Development Organization	3/8/22	Renewable energy successes in White County
Connie Neininger	Hoosiers for Renewables	4/7/22	Meadow Lake Wind Farm's relationship with White County
Ben Hoen	Research Scientist at Berkley National Labs	4/25/22	Attitudes towards wind turbines based off individual's characteristics and beliefs
Steve Eberly	Executive Director Hoosiers for Renewables	4/26/22	Renewable energy throughout Indiana and challenges in Warren County
Lisa Dan	Executive Director at Starke County Economic Development Foundation	5/9/22	Mammoth Solar and specific challenges facing PV projects
Dr. David Konisky	Associate Professor at Indiana University O'Neill School of Public and Environmental Affairs	5/9/22	Equitability of renewable energy projects throughout Indiana and how to minimize losses for the 'losers.'
Bennett Fuson	Outreach Associate EDP Renewables	5/12/22	Indiana Electric Cooperatives' relationship with renewable energy projects and procedures EDP Renewables use for new renewable energy projects
Lisa Linowes	Executive Director of Wind Action	6/1/22	Reasons for opposition to wind and solar projects
Dr. Nathan Geiger	Assistant Professor Indiana University Media School	6/8/22	How individuals discuss renewable energy and climate change and how people become motivated to take action on climate change

Although many issues were touched upon in these interviews, some came up more frequently than others. Perhaps the most relevant to the Good Questions project is the repeated insistence on early communication. Many county commissioners and an energy professional from EDP renewables (the company that runs many renewable energy projects in Indiana including the Meadow Lake Wind Farm located on I-65) insisted that the key to broad local support was early and consistent contact with the community. This can be done through town hall meetings with the energy company, booths at local fairs, flyers in prominent locations, and other 'get to know you' events. Although EDP renewables does not have a set timeline for when they like to begin communications with the community, they place "heavy importance" on quickly reaching out and fostering a good relationship with the county. When renewable energy companies can make early contact with a community before *agent provocateurs* can spread misinformation, communities are more likely to have truthful discussions surrounding renewable energy projects, leading to an increased likelihood of project approval.

> "That [early communication] is something we're trying to be more mindful of at the outset so that when we do know we have these opportunities and we can put in that extra layer of early education and early outreach to better set expectations about what these projects are – and more importantly what they're not- that can really be a significant benefit that opens the door for easier conversations as we get further down the line in development." - ***Bennett Fuson of EDP Renewables***

Another important discovery from the case study interviews is the role farmers play in renewable energy projects. Many projects throughout Indiana need support from farmers, as farmers make up a significant portion of a county population as well as provide the land where projects may be sited. Every economic developer interviewed as well as Ben Hoen and Bennett Fuson, mentioned the importance of first getting support from farmers. Steve Eberly, a third-generation farmer and former county commissioner, mentioned that income from renewable energy projects allow farmers to sustain previously non-viable farms and provide futures for their children and grandchildren. Additionally, Bennett Fuson stated that the Farm Bureau was one of the biggest stakeholders that EDP Renewables works with. Randy Mitchell stated that farmers earn $3,000 per turbine on their property from Meadow Lake Wind Farm and adjacent neighbors without turbines are compensated $1,500 per turbine as an 'inconvenience fee' for the shadow flicker. This has led to farmers actively vying for turbines on their property from new projects. Whether it's at the county or state level, getting support from farmers is essential for renewable energy projects to succeed.

The last important insight gleaned from the interviews was the relationship between political persuasion and feelings towards renewable energy projects. Based on stereotypes, one might think that Democrats always support renewable energy projects while Republicans don't; yet this is not the case. Many of the county commissioners that were interviewed come from Republican districts and report generally high levels of support for their local renewable energy projects. On the other hand, we learned that Democrats and Progressives sometimes oppose renewable energy projects due to some environmental harms: for example, wind turbines causing damage to bat populations or solar panels that have non-native plant species underneath them. Ben Hoen from

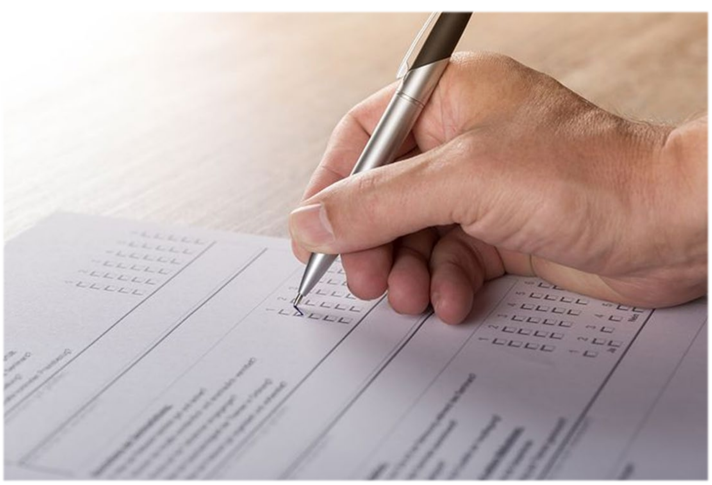
Lawrence Berkeley National Laboratory reported that Republicans who live in Democratic areas tend to support solar panels more than average Republicans. This shows that renewable energy projects don't need to avoid certain areas just because of the generalized political attitude of the area. As long as the company is willing to go out and build early relationships, there is no reason to fear Republican controlled area or assume a Democrat controlled area is an "easy win" for a renewable energy project.

6.0 Survey Results

To uncover attitudes from local policy makers throughout Indiana, a survey was sent to economic developers and county officials. The survey touched on a variety of topics relating to renewable energy, including attitudes toward renewable energy projects, where respondents get their news and other topics. A full list of questions and the purpose for each question can be found in Appendix B. In total, there were 62 responses from economic developers and county commissioners. Some surveys were incomplete, so not every graph displays responses from all 62 respondents.

Figure 1 below shows survey respondent's feelings towards renewable energy projects. The survey respondents were asked to estimate how members of their community feel about four different alternative energy technologies. Phase II of the project will send out a similar survey to a wider range of people and this will be used to compare with the policy maker's answers.

Figure 1 is a box-and-whisker plot. A score of 100 means that community members absolutely need the technology in their community while a score of 0 means that community members do not want the technology in the community. It shows that in general, policy makers who responded to the survey think their constituents feel more positively about solar panels and biofuels while feeling more negatively towards wind turbines. The median for wind turbines, represented by the line in the box- is around 30, and the average – represented by the 'x' – is around 40, signaling that policy makers generally think their community members would be opposed to turbines, especially when compared to solar panels which have a median and mean in the upper 60s and low 70s respectively. Biofuels fall in the middle, with respondents assuming their constituents are lukewarm on the fuel source. This is useful, as it shows that solar panels are generally more acceptable to Hoosiers. Since solar panels can be deployed on a much smaller scale than wind turbines and have less of an aesthetic impact than wind turbines (more on that later in the section), this answer was expected. Biofuels are not as discussed in the media, possibly explaining the moderate, or accepting, feelings towards the biofuel plants.



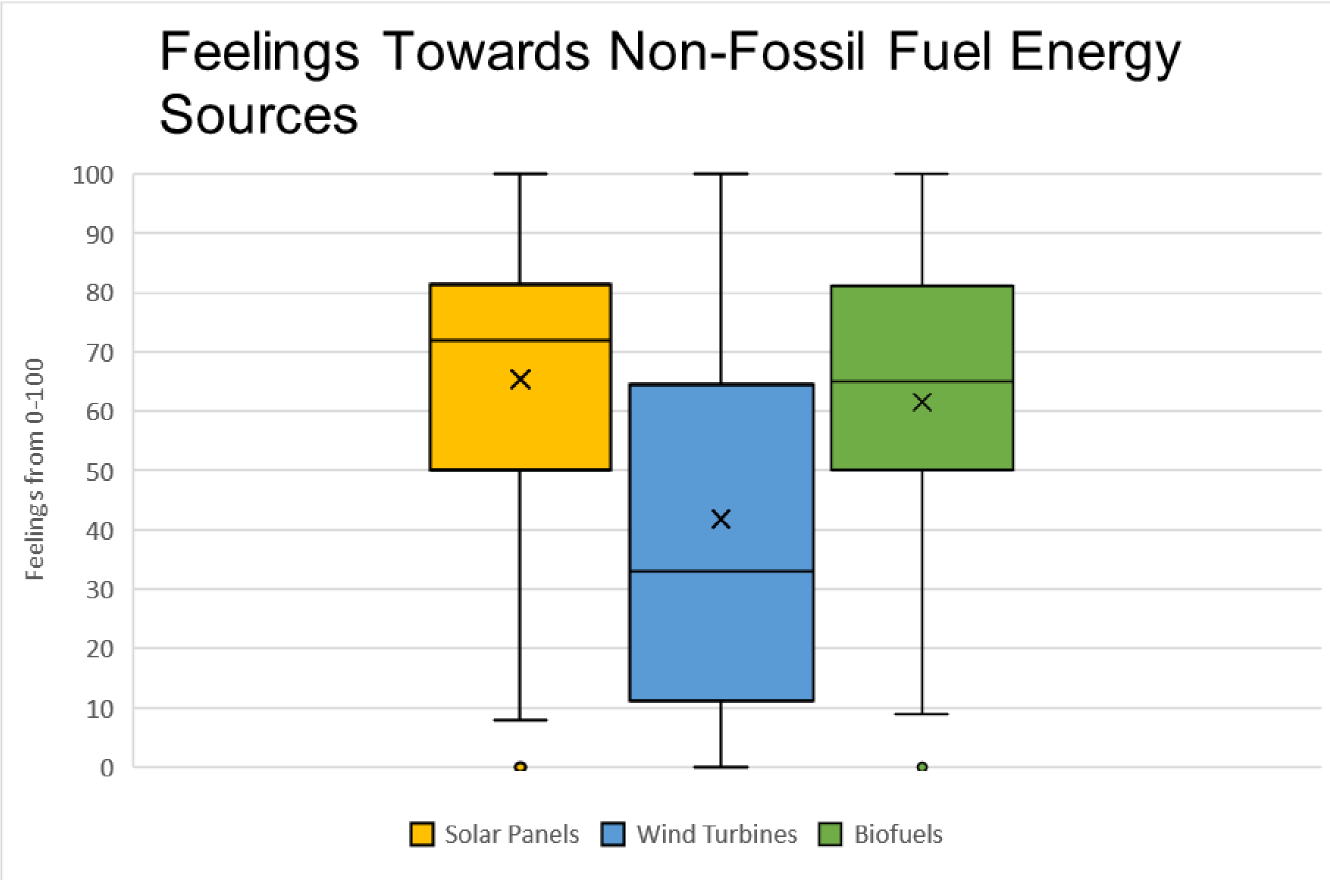


Figure 1 showing the responses from policy makers when asked about community feelings towards different technologies, with a score of 100 being a strong need, and a score of 0 being "do not want". N=30

How to read a box-and-whisker plot: A box-and-whisker plot has four main features. The first are the 'whiskers' extending from the box. These show the maximum and minimum responses. Next are the ends of the box. These show the 75th and 25th percentile of answers. Within the box is the line in the middle, the median, and an 'x' which shows the average response. An average above the median shows that most answers are below the average while an average below the median shows that most answeres are above the answer. Finally, the dots beyond the whiskers represent outliers.

Next is a series of four graphs, showing what self-identified proponents of solar panels bring up most frequently in meetings (figure 2), what those who identify as being unfavorable towards solar panels bring up most frequently in meetings (figure 3), what supporters of wind turbines bring up most frequently in meeting (figure 4), and what those who oppose wind turbines bring up most frequently in meetings (figure 5). The results are displayed using a histogram, which is a bar chart that shows the frequency of each answer.

Comparing the four graphs yields interesting and useful results for solar and wind projects in Indiana. For both solar and wind projects, supporters focus on the economic impact as the most important benefit these projects bring to the community, following it up with the environmental benefits. Renewable energy projects frequently bring jobs to a community, as technicians need to build the project as well maintain it. As for environmental impacts, these projects do not release any greenhouse gases, and may replace power plants that release harmful gases. On the other hand, opponents of both projects set their sights on the aesthetic impacts. As learned through some of the subject matter interviews, many Hoosiers are worried about the shadow flicker caused by wind turbines, as well as the flashing light at the top of the tower. Although solar panels don't have flashing lights or shadow flicker, they do take up a significant amount of land, likely leading to aesthetic concerns. These results also mean that supporters and opponents of these renewable energy projects tend to focus on different things. Community health is not a frequently brought up issue. Figuring out ways to limit these aesthetic concerns, whether ensuring shadow flicker doesn't affect many people or limiting the land impact of solar panels, will likely lead to fewer complaints among Hoosiers about renewable energy projects.

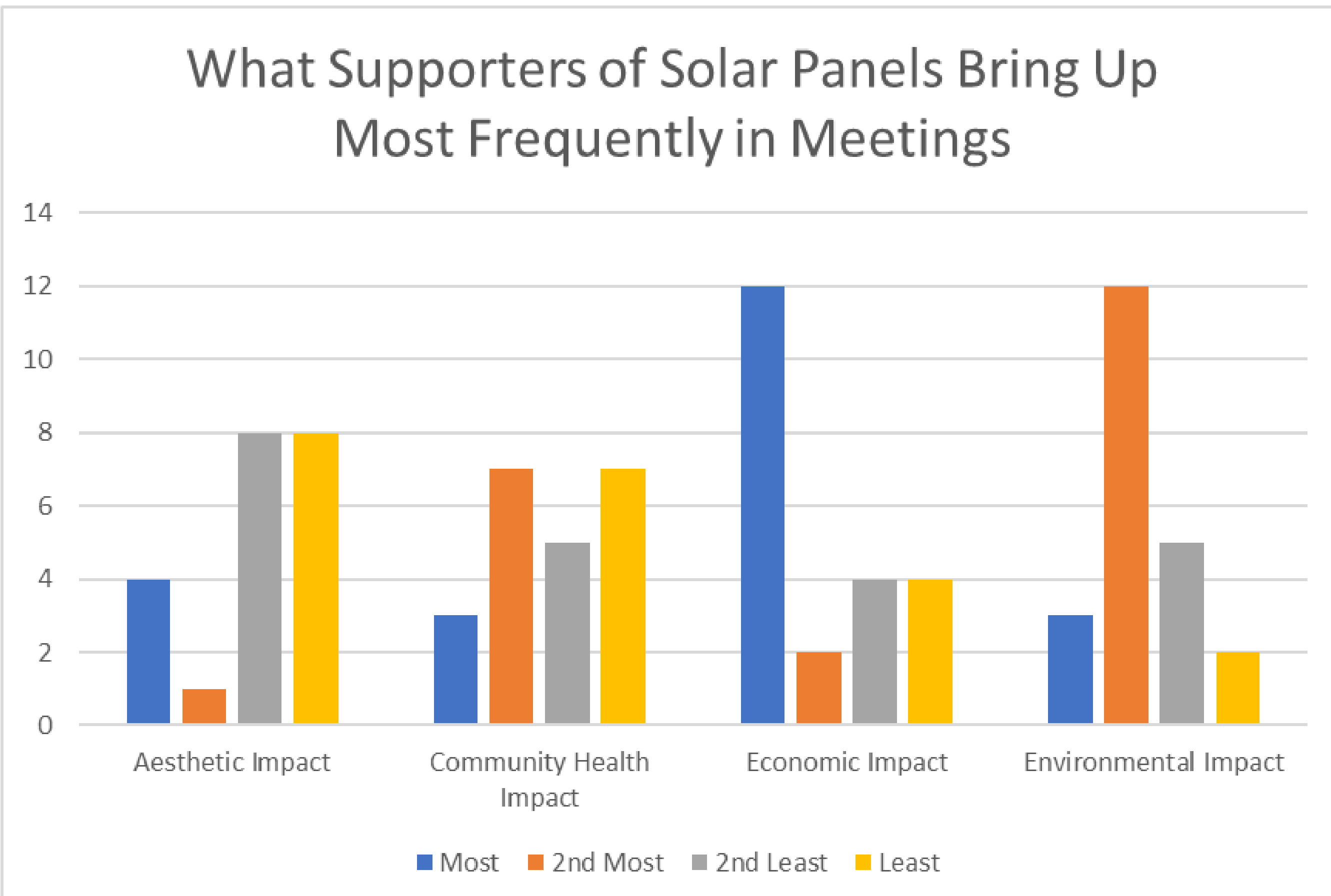


Figure 2. N= 23

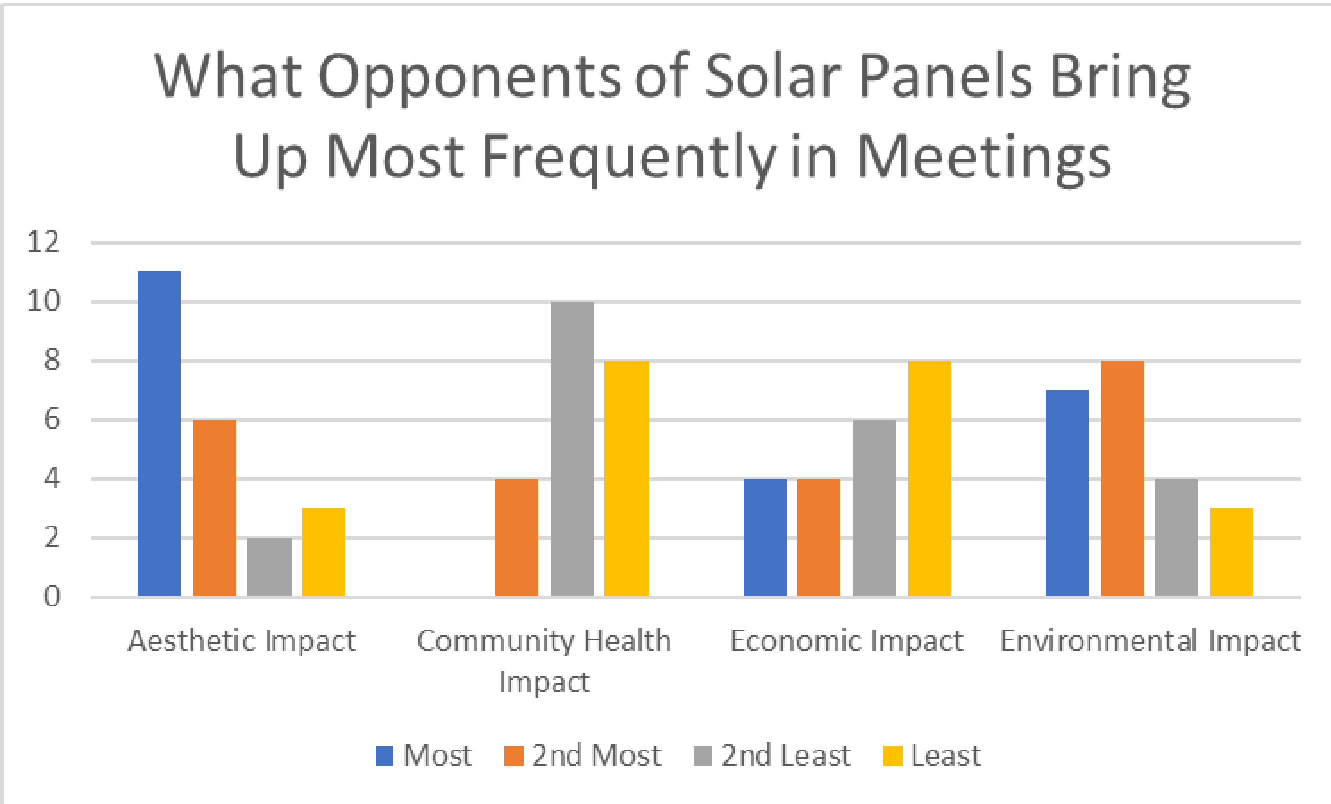


Figure 3. N =23

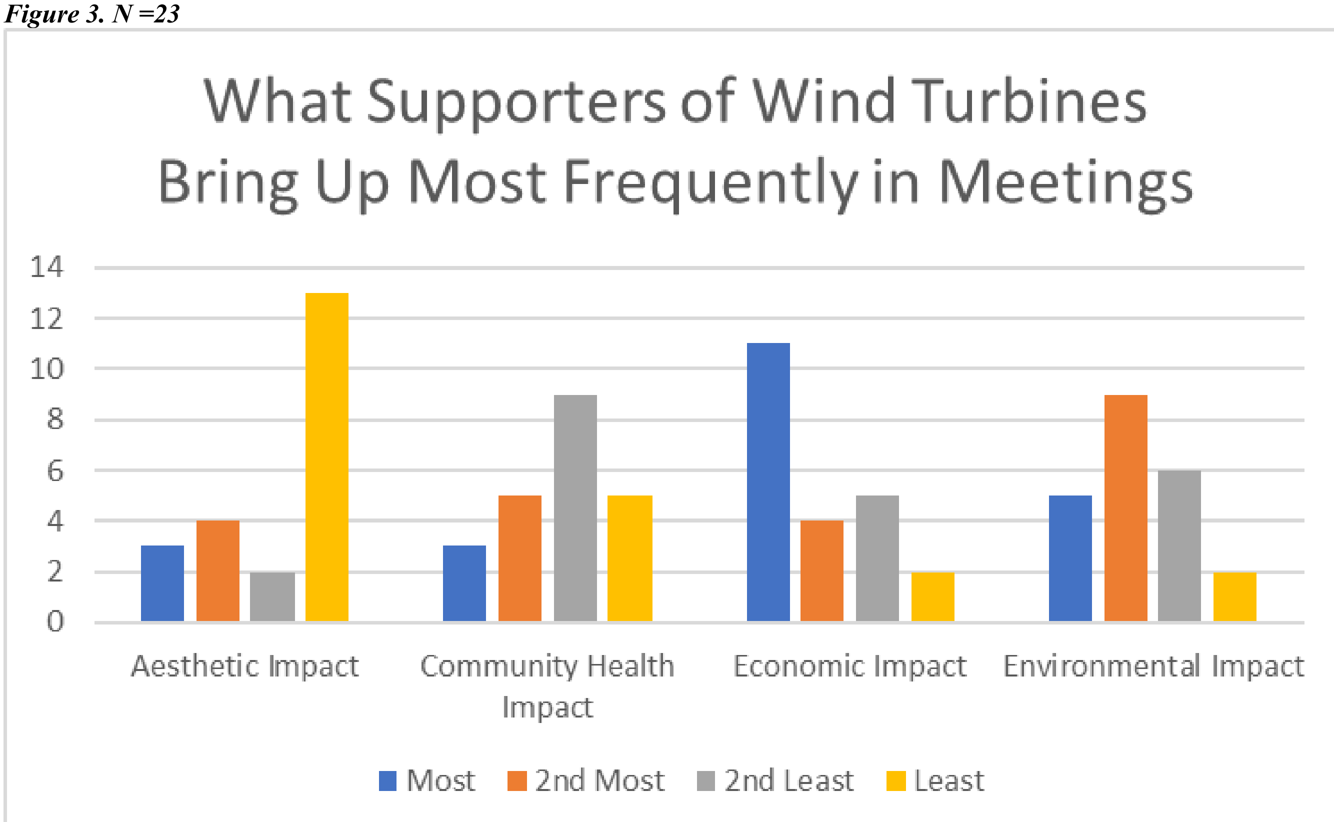


Figure 4. N = 23

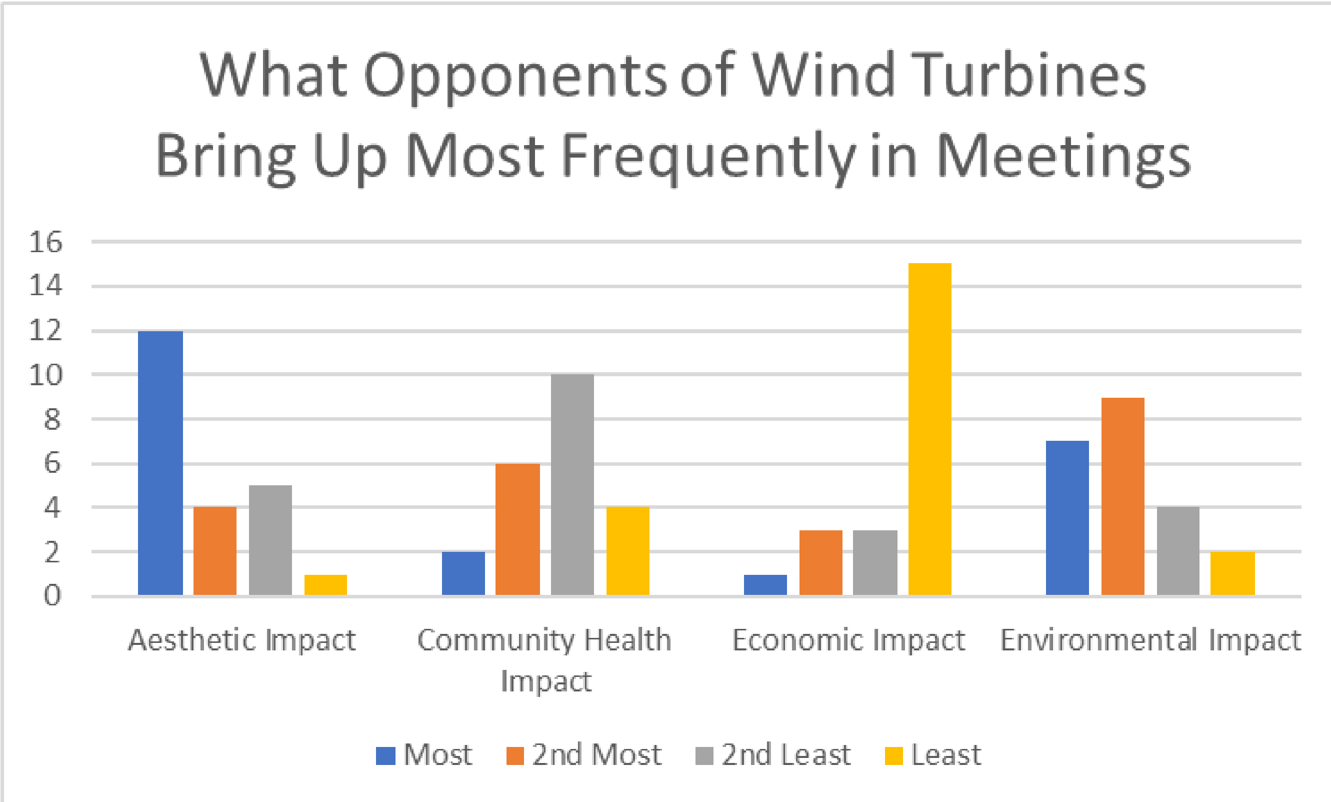


Figure 5. N = 23

The last graph that can be useful for the Indiana Office of Energy Development is figure 6, which shows the issues that local policy makers consider when building energy projects in their communities. It uses the same categories as the previous four graphs. Unsurprisingly for economic developers and county commissioners, economic impact ranks as the most important issue they consider, echoing what supporters of renewable energy projects say. Interestingly, they rank community health impacts as the second most pressing topic, despite neither opponents nor supporters raising the issue. The third interesting item of information from this graph is that aesthetic concern ranks as the least important issue. This is interesting as opponents of renewable energy projects focus on the issue, and since this is something that policy makers don't hold as an important issue, it would suggest renewable energy projects frequently get approved in spite of the issue. However, this may not be the case and should be a topic of further investigation in Phase 2 of the project.

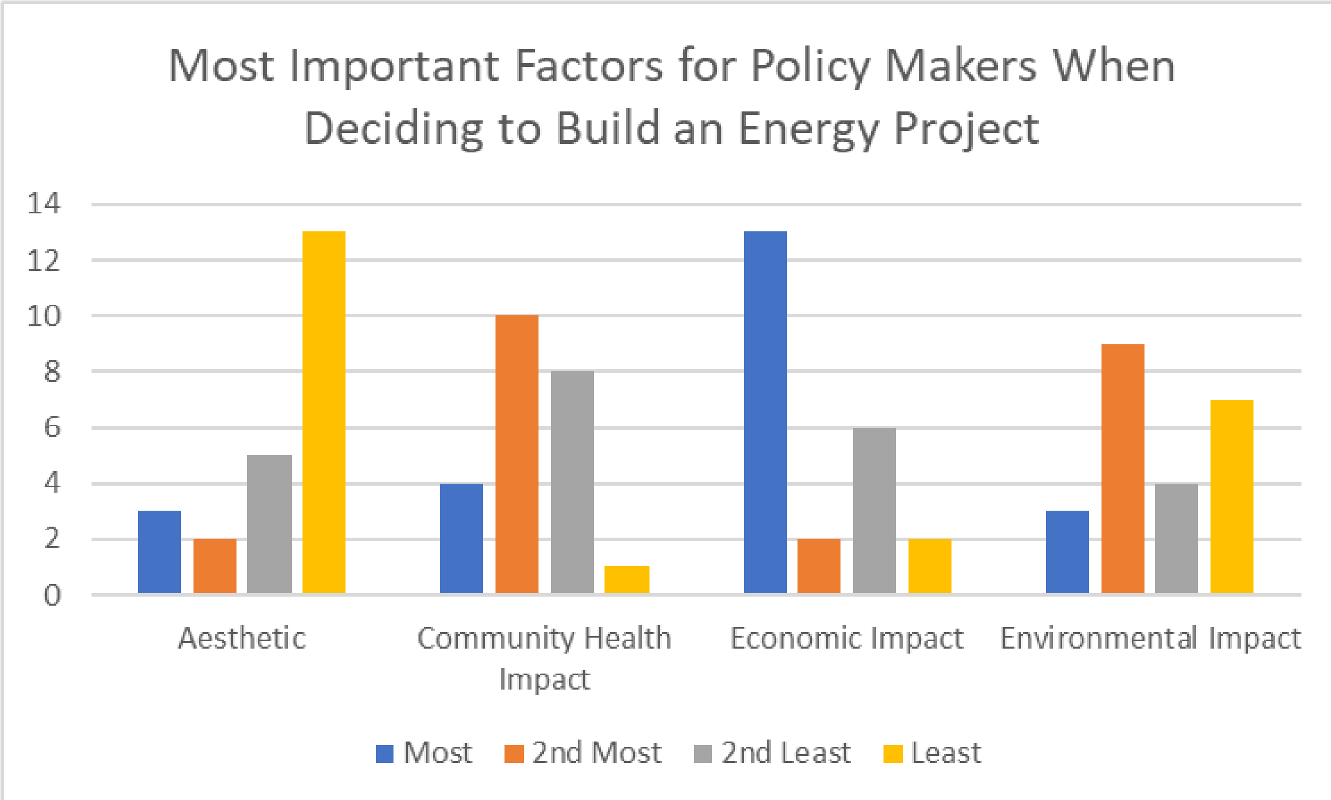


Figure 6 N = 24

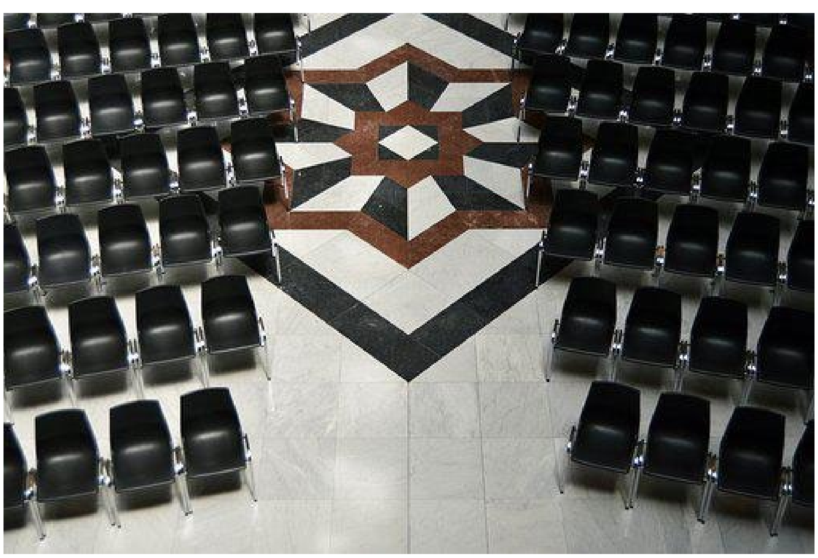
Although text response would be difficult to display graphically, the text responses did generate some intriguing responses. Policy makers were asked for reasons behind some of the answers given. The policy makers overwhelmingly commented that citizens are concerned about wind turbines not fitting in with the landscape of the community, supporting concerns vocalized in the subject matter interviews. Other responses varied as supporters brought up topics such as climate change, more jobs in the community, and lower energy prices. Policy makers were also asked about key decision makers they work with, and local energy companies and the Indiana Municipal Power Agency (IMPA) were almost unanimously identified. Also, when asked where they get their news about energy, policy makers stated they get most of their information from energy professionals (see next paragraph for more on this topic).

Another question asked policy makers about their ‘must haves’ when considering an energy project in the community. There were three main themes in the responses. The first was that the developer must show interest in the community, whether that is coming to county meetings or general community outreach. Next was environmental impact/ location, as the developer needs to show that the project will have both short term and long-term positive environmental impact and be placed in a location beneficial to the whole community. Finally, the developers must outline how the project will benefit the community and include details such as the number of jobs the project will bring and the impact it will have on commodity prices. One respondent summarized it best by saying that, “(the) developer of the energy project must show they have done their own outreach to supporters and opposers of their projects. Developers must show economic and environmental impact studies of their project."

The last interesting piece of textual information comes from asking which groups most vocally support or oppose solar and wind projects. When asked who came out to support and oppose solar panels and support and oppose wind turbines, policy makers overwhelmingly listed 'farmers' as the top choice for all four questions. This underscores Bennett Fuson's point from the subject matter interviews that farmers are a key constituency in getting energy projects to pass or fail.

For Phase 2 of the project, the survey will be sent out to more people throughout the state, trying to achieve a broader respondent base. Questions will focus on Hoosier attitudes about various energy projects and will compare those findings to how their local officials estimated their constituents feel about the same technologies. Hoosiers' feelings towards all energy projects, including fossil fuel projects, will be presented in a manner like figure 1 above. Energy professionals will be asked an additional five questions to gauge how they feel about the legislative, economic, and social climate in Indiana and whether that affects their desire to build renewable energy projects in the state.

Lastly, Hoosiers will be asked where they learn about topics related to energy and those responses will be compared to how they feel towards renewable energy projects. These data can be used to identify 'problem sources' of information allowing steps to be proposed to limit disinformation coming from these sources. Policy makers also answered this question, and early results show that energy professionals and local newspapers are the most reliable sources of information. Energy professionals will likely support renewable energy projects, while local newspapers are more likely to have varied opinions. Finding where the local newspapers get their information is another area that the Good Questions project can pursue during Phase 2 of the project.



7.0 White Paper Content Summary

Citizens often have a long list of questions regarding new energy projects proposed for their communities and neighboring lands. Our team views these within a range from 'legitimate' to 'questionable.'

Some questions are legitimate and represent real concerns that should be addressed. Others are pure fabrication. In between are those questions or concerns that contain a grain of truth, but have often been taken out of context, or over-exaggerated. An example of a legitimate concern is the shadow-flicker of wind turbine blades. There is now a technical solution available to address this, by stalling a turbine when the blade's shadow would pass over a nearby homestead. Another example is the obstruction lights on the tops of wind towers, which annoy those who prefer darker skies. A technical solution is available for this issue as well. Our team did not focus on questions that are easily-answered, nor on those that are patently false ("wind turbines cause cancer'). A key task in Phase 1 of the Good Questions Project has been to develop thoughtful and well-researched answers to some of these questions in the middle of the spectrum in order to develop a solid method and approach. The first five white papers covered the three most relevant energy projects: two for wind, two for solar, and one for energy crops. Below is a description of the methodology used to develop "white papers" to address specific concerns, and a list of those topics which have been studied during Phase 1.

Methodology

Of energy crops in Indiana, corn (maize) is nearly ubiquitous, with about 50% of corn grown in our State going into producing over a billon gallons of ethanol each year. Some of Indiana's soy bean (soya) crop goes into the making of biodiesel fuel, up to 100 million gallons per year (https://www.in.gov/oed). Because these two agricultural crops are already well-established, our team selected energy grasses for a white paper study. Energy grasses such as switchgrass or Miscanthus are often promoted as avoiding the "food vs. fuel" debate, because they can potentially be grown on marginal lands. Energy grasses have been used as a feedstock for "second generation" cellulosic ethanol. When dried, such fast-growing biomass can be used as a fuel for direct combustion, or for co-firing with coal, in a thermal power plant. A particular issue from the list of questions presented below in Appendix D included a concern that Miscanthus grown nearby to corn fields could exacerbate the issue of insect pests on food crops.

Research into the topic of Miscanthus and the western corn rootworm (WCR) occurred in two phases. The first phase involved determining if WCR could feed and develop in Miscanthus and the second phase involved researching whether the relationship between WCR and Miscanthus poses a risk to corn crops. To ensure the information gathered was accurate, articles from peer-reviewed journals were relied on for much of the research. The Google Scholar search engine (https://scholar.google.com/) and the IUPUI library database were the primary search tools used for locating scholarly articles. There has been a lot of research into the relationship between WCR and Miscanthus. It was determined early in the research process that WCR could hatch and develop to adulthood in Miscanthus. Searching for studies related to WCR intercrop travel between Miscanthus and corn crops yielded no results. The next step was to identify literature that discussed WCR movement within Miscanthus fields, but this also yielded no results. The lack of literature discussing the topics of WCR travel within Miscanthus and WCR inter-field travel between Miscanthus and corn crops made it impossible to determine to what extent Miscanthus might endanger corn crops. Further research on this topic is clearly warranted. The final research method focused on general information about Miscanthus and WCR, as well as the migratory and inter-field travel of WCR.

The WCR white paper is presented in an Appendix of this report. A list of each of the five questions studied in Phase 1 is presented here:

1. APPENDIX E: Western Corn Rootworm and Miscanthus Biomass Crop
2. APPENDIX F: Infrasound And Wind Turbine
3. APPENDIX H: Solar Panel Fires
4. APPENDIX J: Recycling of Solar Panels at End-of-Life
5. APPENDIX M: Bat Kills by Wind Turbine Blades

An example of a two-page summary of the information gathered regarding Miscanthus and WCR is presented immediately below. This is intended to be printed on card stock for convenient distribution at a public event, or as an information card in a pocket folio. The general outline of an information card is to headline a common question along with a simple and direct answer, followed by a section with a bit more detail, and completed with a deeper description with achivable references listed for further study. This, and other one- or two-page summaries from Phase 1 are deliberately varied in their design. A graphics artist at IUPUI will draw from these examples to prepare a final design format during Phase 2.

Concern: Energy crop Miscanthus will act as a host for the western corn rootworm and, if planted near corn crops, will endanger the corn crops by exposing them to insect pests.

Answer: There has not been research to determine if the relationship between the western corn rootworm and Miscanthus will endanger corn crops.

WESTERN CORN ROOTWORM (WCR)

Diabrotica vergifera vergifera, better known as the western corn rootworm (WCR), is an insect pest that feeds on the root systems of plants as larvae and on pollen, green silks, and leaves of corn crops as adult beetles. WCRs damage plants in both their larval and adult stage, though the most damaging phase in WCRs life is during its larval stage. Extensive damage to the roots caused by WCR larvae can inhibit the crops' ability to retain nutrients and water, facilitates infection, and makes plants more vulnerable to lodging caused by high winds and rain. It has been estimated that WCR causes up to $1 billion dollars a year through precautionary measures and reduction in crop yields.

MISCANTHUS

Miscanthus (*Miscanthus x giganteus*) is a perennial grass (a life cycle that extends beyond a single growing season) that originated from southeastern Asia but can now be found in North America, South America, Europe, and Africa. Miscanthus has been identified as a promising biomass crop due its cold tolerance, long lifespan, high energy output relative to energy input, low nutrition demands, and high yield. **It has been estimated that Miscanthus could provide 260% more ethanol per acre than corn grain**.

MISCANTHUS & WCR

The introduction of WCR in Europe and the growing need of renewable energy sources has sparked a great deal of research into Miscanthus and its relationship with WCR. Many studies have been shown that WCR larvae can feed and develop to adulthood on Miscanthus; however, the emergence of adult WCR on Miscanthus is less than that of corn crops. A study performed in Illinois on the adult activity and oviposition of WCR in Miscanthus, corn, and switchgrass found that:

- **Corn fields contained 3-10 times as many adult WCR as that of Miscanthus and switchgrass**
- **Soil samples showed that female adult WCR laid 10 times as many eggs in corn as they did in Miscanthus and switchgrass**

The direct relationship between WCR, energy crop Miscanthus, and corn crops has not been studied.

CROP DISEASE

One of the leading causes of crop damage every year in Indiana and the United States as a whole, are crop pathogens. The 2021 Plant and Pest Diagnostic Lab Annual Summary Report found that 59% of the plant samples they received, the majority of which were from Indiana, were infected with a disease. In 2021, the most damaging diseases to corn crops in the northern United States were tar spot, Fusarium stalk rot, gray leaf spot, southern rust, and northern corn leaf blight and these diseases caused a combined estimated loss of 639.6 million bushels worth of corn. From 2016-2019, Indiana lost an estimated $2 billion due to corn diseases alone.

CLIMATE CHANGE

Changes to Indiana's climate such as increasing temperatures, changes in precipitation patterns, and rising levels of carbon dioxide in the air will result in direct and indirect impacts to the agricultural industry. More frequent plant stress heat days and reduced precipitation in summer is expected to reduce corn and soybean yields by 16 to 20 percent and 9 to 11 percent respectively by 2050.

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8.0 Policy Recommendations

Many 'good questions' have incomplete answers. Our investigations have revealed the need for further study, analysis, or data gathering. Whether these should be conducted by the State, by the Federal government, or an independent body is an open question. However, the benefit to every community in America argues that the analysis is critical.

1. The Office of Energy Development should consider a massive, state-wide **education campaign** regarding utility-scale energy projects, along with a publicly-available information depository. Opposition groups that act in advance of public notification plant seeds of doubt using extreme forms of misinformation. If a person's first exposure to an energy project is strongly negative, this is nearly impossible to overcome [Rabin]. The conventional wisdom is supported by studies of human psychology: "You never get a second chance to make a first impression."
2. Create small-scale State **grant funding to support public events** or local studies of site-specific citizen's concerns. Have "circuit riders" who can consult with city councils, economic development boards, and be there to answer questions, and be a disinterested third party to provide information and resources. These independent 'circuit riders' can also consult on 'best practices' for developing public input processes and serve as potential facilitators to take some of the pressure off local officials.
3. **Uniformity of standards** across county lines within the State of Indiana would be helpful. Many people do not want the State legislature to overreach local decision-making, so a gentler approach may be an IF-THEN or 'suggested standards' construct. IF a new energy project is planned to proceed, THEN, there should be uniform standards to be followed. One example is uniform setback requirements. Other examples to consider may include end-of-life decommissioning escrow, mitigation of wind turbine blade shadow flicker, and aircraft detection lighting systems (ADLS) to extinguish obstruction lights except when needed [FAA].
4. **Agrivoltaics** is the combination of renewable energy with agricultural production [Pascaris]. Sheep are more compatible with solar panels than cattle (cow rub hard against any surface that can scratch their itches), but mutton is a small market. Low-lying vegetables are an excellent choice, such as cucumbers, melons, onions, and even strawberries. The OED should consider sponsoring experimental projects that can provide further insight and examples of best practices. Consider engaging IEDC to encourage entrepreneurship around agrivoltaics.

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9.0 Some Good Questions

This section presents some good questions to be asked by concerned or interested citizens when their community is being considered for a new energy project.

GENERAL

Do you have a Good Neighbor policy, where adjacent homesteads get partial compensation? (*more common with wind, less common with solar*)

What benefits will come to the community, and what are some examples of how these can improve our lives?

What makes our community attractive to your project? What makes our land better than others around us?

What evironmental impacts are possible that may affect human health? How significant could the risk be? What measures will be used to mitigate those risks?

What is the end-of-life recycling or disposal plan? How will it be paid for?

WIND

What is being done to minimize blinking lights on the top of the towers at night?

How can shadow flicker be minimized or eliminated from my home?

What level of sound can I expect at my house? How does it depend on weather conditions? What if there is a maintenance problem causing a squeak or rattle – who do I contact?

SOLAR

What happens to the soil under the solar panels for the duration of the project? What will be the condition of the soil at the end? Will there be any impact to farming afterwards?

How will the solar panels affect temperature and weather over and around the project?

How will you reduce or eliminate glare and reflections from affecting drivers and passersby?

10.0 Outlook for Phase 2 of the GQP

The second phase of the Good Questions Project has these deliverables:

(a) **Mapping Tool** to illustrate county-by-county opportunities towards new energy project rollout, economics, harm to humans, impact on the environment, and considerations of social justice, equality, and diversity.

(b) **Guidance Tool** for siting per energy technology (this will be at a medium level of detail, as a full study would require more time), with white papers to help guide discussion germain to the intersection of technology and land site.

(c) **Best Practices** stories and data, including successes, projects that did not consumate, as well as epic failures. These can be useful to county assets in guiding their own destiny.

(d) A **Generic Survey** that can be used to update the information presented as circumstances and situations evolve over time in this dynamic field.

The Mapping Tool will integrate the Phase 1 studies of human health impacts with the study done by Purdue Extension on zoning issues, and blend in DEI (diversity, equity, inclusion) considerations relevant to various communities across Indiana.

The Guidance Tool will incorporate general knowledge on site selection, such as north-facing slopes are not suitable for solar, with a map of high voltage transmission lines crisscrossing Indiana. This will also include a study of the cultural milieus within Indiana that may be favorable to new energy projects.

The Best Practices section will expand upon the failures studies included herein, including data from nationwide studies performed by national DOE labs. Additional stakeholders from Indiana will be interviewed, and more investigative research will shed light on what went wrong for projects that fail to reach completion. Success stories are also important, as examples for county economic development professionals and commissioners to follow to benefit their own communities. This will culminate with a **handbook** for these purposes, including a quick reference guide to provide ready answers to a long list of possible concerns and questions.

The Generic Survey will be provided in Qualtrics along with a how-to document to easily adapt it to new situations, issues, sites, and concerns. The analysis tools will also be heavily commented so that a new user can quickly learn how to extract important information from future implementations of surveys on new energy projects in Indiana counties. The Phase 1 survey of professionals will be extended to **general populations** to obtain further insight into the challenges to be faced by new energy project developments.

11.0 Glossary

Acronyms and Abbreviations

1. CRP - Conservation Reserve Program, run by USDA's Farm Service Agency (FSA)
2. CSR – Indiana University Center for Survey Research
3. DOE – US Department of Energy (https://www.energy.gov/)
4. EPA – US Environmental Protection Agency (https://www.epa.gov/)
5. EMF – ElectroMagnetic Field (also EMI for EM Interference)
6. FB - Facebook
7. FMEA – Failure Mode and Effects Analysis
8. GQP – Good Questions Project
9. IACC – Indiana Association of County Commissioners
10. IDEM – Indiana Department of Environmental Management
11. IEDA - Indiana Economic Development Association
12. IUB – Indiana University - Bloomington
13. IUPUI – Indiana University-Purdue University Indianapolis
14. IOED – Indiana Office of Energy Development
15. kW – kilowatt or 1,000 Watts (measure of power, sometimes MW for 1,000,000 Watts)
16. kWh – kilowatt hour (measure of energy, equal to running a hair dryer for 1 hour)
17. LCRE – Lugar Center for Renewable Energy (www.lugarenergycenter.org)
18. LCOE – Levelized Cost of Energy (measured in $/kWh over the lifetime of an asset)
19. MSW – Municipal Solid Waste (garbage or trash collected from a population center)
20. NIMBY – "Not In My Back Yard"
21. O&M – Operations and Maintenance – costs associated with running a facility
22. OSHA – Occupational Safety and Health Administration
23. PV – Photovoltaic (scientific term for solar panel)
24. ROI – Return on Investment
25. SME – Subject Matter Expert
26. SMR – Small Modular Reactor (nuclear)
27. SPEA – School of Public and Environmental Affairs
28. TBD – To Be Determined
29. USDA – United States Department of Agriculture (https://www.usda.gov/)
30. WCR – Western corn rootworm

Frequently-used Terms

Agent Provocateur - a secret agent hired to incite suspected persons to some illegal action, outbreak, etc., that will make them liable to punishment (https://www.dictionary.com/).

Astroturfing - the deceptive practice of presenting an orchestrated marketing or public relations campaign in the guise of unsolicited comments from members of the public (https://www.dictionary.com/).

Biomass – any renewable, or endlessly replenishable carbon-based resource, such as utility trim (of trees), agricultural residues, landscape trimmings, forest slash, and even MSW.

Capacity Factor – the ratio of electrical energy output actually generated divided by the maximum possible output if the asset ran 100% of the time. Wind turbines may be in the 30-45% range, solar in the 25-35% range, and a nuclear power plant may be 90%.

Capital Expense – sometimes appreviated CAPEX, this is the total up-front cost to build, install, and activate a large, expensive project.

Energy – a static quantity, measured in kWh or Joules, that has the potential to do work, or the amount of work that has been done. In equation form: Energy = Power * time.

Externality – an economist's term to describe those harms or loss of value/productivity due to uncosted consequences of doing business. When government regulation requires avoidance, reduction, remediation, or recompense, that become factored into business financial decision-making, these are no longer externalities.

Greenwash - disinformation distributed by an organization so as to present an environmentally responsible public-facing image.

Insolation – the technical term for how much sunlight falls on a given piece of land, often measured in kWh per square meter, sometimes also called "irradiance" or "exposure".

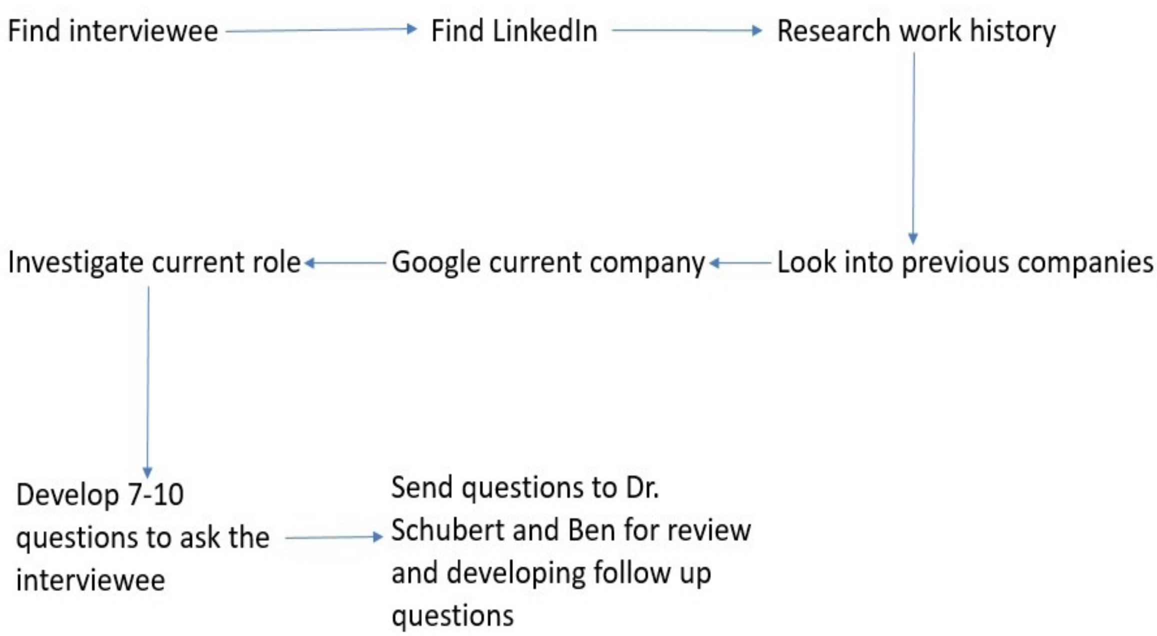
Intermittent – refering to the uncontrollable loss of availability of wind and solar resources; more accurately called "non-dispatchable", because it cannot be turned on at will.

Power – a dynamic quantity, measured in kW, for how fast work is being done. In equation form: Power = Energy/time.

12.0 Appendices

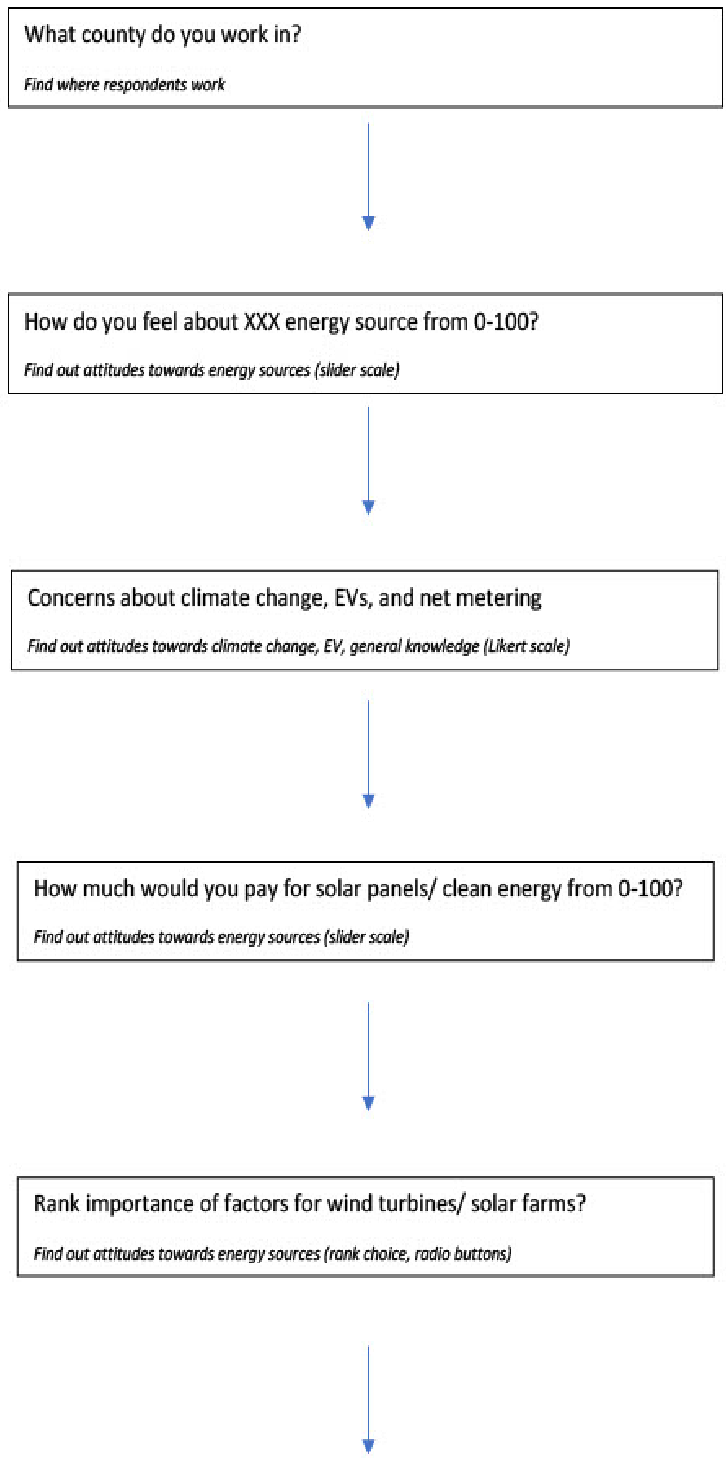
12.1 APPENDIX A – Survey Question Generation Process

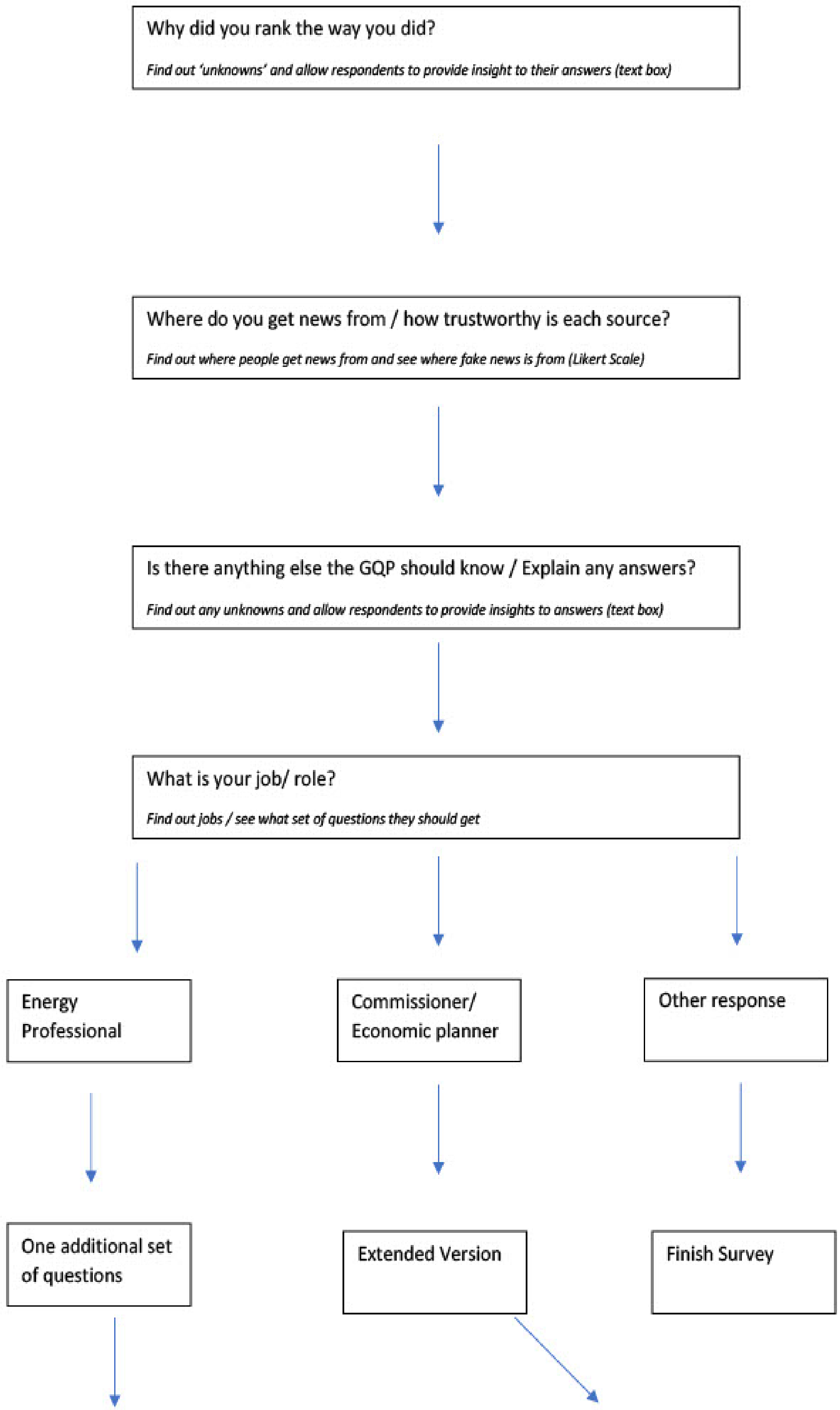
This flow chart shows the process for creating 7-10 questions for the subject matter interviews. It involved internet searches, background research into the person's prior experiences, and investigation into the company the subject works for.

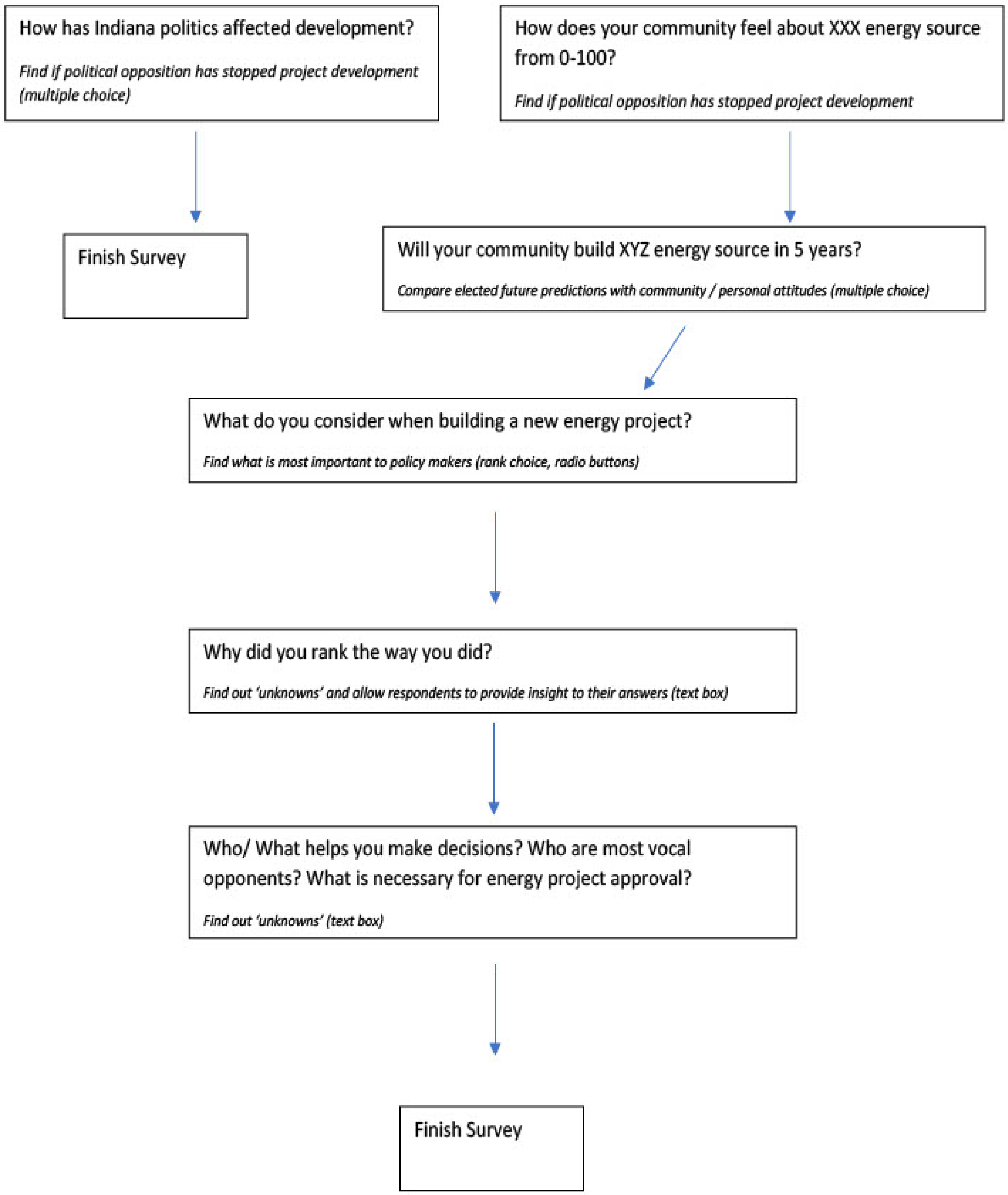


12.2 APPENDIX B – Structure of GQP Survey

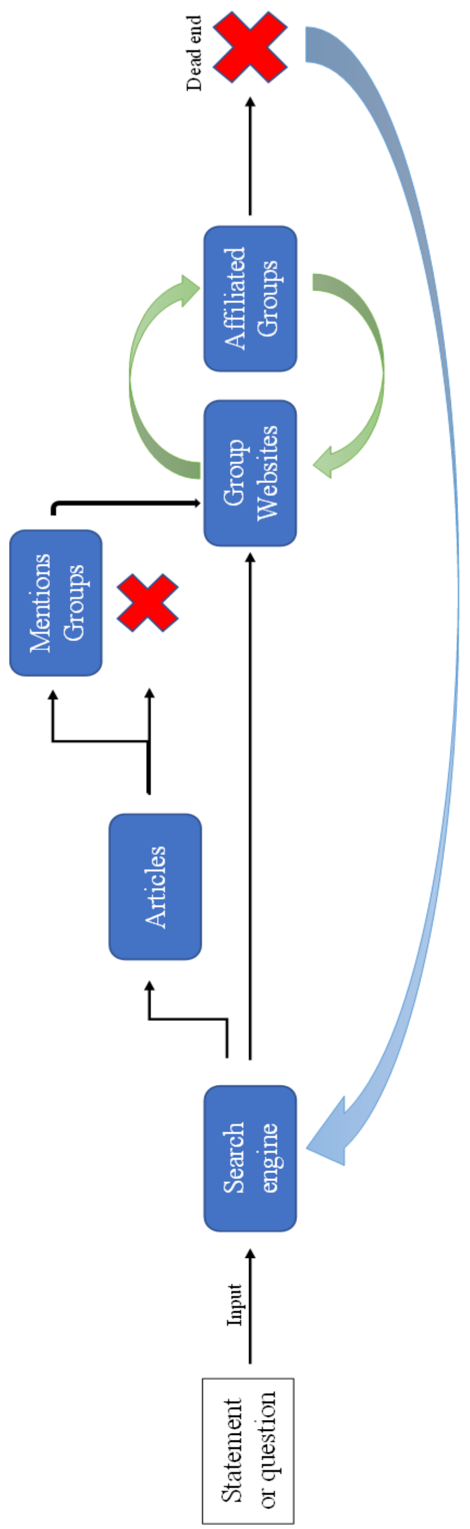
This flow chart shows the thought process used to **generate survey answers** useful to the project. Questions were sourced from a variety of sources and the goal of the question is in the bottom of every box in italics.




Why did you rank the way you did?
Find out 'unknowns' and allow respondents to provide insight to their answers (text box)
Where do you get news from / how trustworthy is each source?
Find out where people get news from and see where fake news is from (Likert Scale)
Is there anything else the GQP should know / Explain any answers?
Find out any unknowns and allow respondents to provide insights to answers (text box)
What is your job/ role?
Find out jobs / see what set of questions they should get
Energy Professional
Commissioner/ Economic planner
Other response
One additional set of questions
Extended Version
Finish Survey


How has Indiana politics affected development?
Find if political opposition has stopped project development (multiple choice)
How does your community feel about XXX energy source from 0-100?
Find if political opposition has stopped project development
Finish Survey
Will your community build XYZ energy source in 5 years?
Compare elected future predictions with community / personal attitudes (multiple choice)
What do you consider when building a new energy project?
Find what is most important to policy makers (rank choice, radio buttons)
Why did you rank the way you did?
Find out 'unknowns' and allow respondents to provide insight to their answers (text box)
Who/ What helps you make decisions? Who are most vocal opponents? What is necessary for energy project approval?
Find out 'unknowns' (text box)
Finish Survey

12.3 APPENDIX C – Methodology for Researching Citizen's Questions



Schematic process flow for the research into finding answers for questions asked by concerned citizens regarding new energy projects. The thin arrows indicate the steps in which research mentioned in the renewable list methodology in section 5.0 occurred. The red Xs symbolize a point where either no new information or no new groups were being identified and the cycle of research would start over.

12.4 APPENDIX D - Citizen Questions and Concerns

The Good Questions Project selected a few topics from the lists below for deeper analysis. These examples are presented as white papers and information cards in this report. Our team petitioned several sources, but so far has received input from only one, to whom we are grateful.

Below are a list of **questions and concerns** captured during a variety of events either hosted or attended by the Center for Energy Education (C4EE, Regional Office at 32 E. Franklin Street, suite 310, Huntington, IN, 46750, https://center4ee.org/) related to concerns about **large scale solar** installations.

- Will or what is the impact to Wi-Fi, cell, wireless signals?
- How many job opportunities will stem from this?
- How does topsoil rebuild itself? (as part of a solar installation)
- Will posts driven go so deep to have impact on ground water?
- How do you plan to (fix?) wifi and cell disruptions? How to (fix?) the raise in temperature? What about the property values of the surrounding area?
- Any change in weather patterns? (due to large scale solar installations)
- Why Indiana? Why solar in Indiana, I get wind farm. Other places have more sunlight than us.
- Farmers setting aside land that is supposed to be fallow is usually low-quality farm. Solar uses high quality land.
- Where are these panels made, what country?
- What natural event has the greatest impact on solar farms?
- CRP (Conservation Reserve Program, https://www.fsa.usda.gov/) ground is placed in CRP for a reason, for low productivity. Indiana is being targeted for solar because two grids go through the state. Are solar companies targeting less productive soils, or are we being targeted because of solar company's purposes? Why not do CRP instead of productive lands?
- There are a few projects that are at old industrial site in Muncie. This is probably good development. Are we looking at any other sites like this? Can't we build something locally that benefits us that doesn't put farming business out of business. Can't we do something productive to begin with? The farmland is sowed to agricultural, in the county plan it says to protect farmland. It seems to go against what we are expected to do.
- How much power does Indiana use compared to other states? Where do we rank?
- All of the electricity that is manufactured is going on to the grid but isn't going to lower or effect our electric bill, correct? So that would make us want to have a smaller farm given we can't pull from large solar farms directly?
- Using land that is not prime farmland, I would like to see that
- You said the fence is there to keep people/animals out. Yet you have people and animals (the dual use) in, how does that work?
- My understanding is that there is cement in the ground? What about cables?

Below is a list of further topics gathered by C4EE from a variety of sources:

- Solar panels contain toxic materials, such as lead, that leach into the soil and ground water when panels are damaged either by weather events or other means. These toxic materials can also be absorbed by rainwater as it passes over the panel.
- Solar panels are hot and catch on fire, often.
- Tornados (and hurricanes) damage solar panels, often.
- Solar installations are harmful to wildlife – disruptions to habitat, travel/migration patterns. Also, water birds such as geese, confuse the panels with water and land on the panels. See fire concern above.
- Farmland cannot be restored back to agricultural use after decommissioning.
- Solar installations create heat effects – heat domes or updrafts above the installation; or increased heat beneath the panels.
- Heat effects described above effect local weather patterns.
- Vegetation cannot grow under the panels.
- Dual use, such as with sheep, is not cost effective, is complicated, and not an effective vegetation management practice.
- Vegetation will be uncontrolled on the solar installation site, full of weeds, and require constant upkeep.
- Solar installations will negatively affect drainage; there will be substantial increased water runoff.
- Flood areas aren't avoided, drain & field tiles will be damaged during construction, extra watershed is a big concern.
- Solar is unreliable and inefficient and therefore doesn't reduce the need for back up nonrenewable energy.
- The electrical grid cannot balance power with demand using renewables.
- Utilities must buy the solar power even if they don't need it and at a higher rate, makes utility bills for the consumer go up. Also, the utilities don't share what price they buy the energy at and must keep redundant fossil fuel-fired electric sources operating constantly.
- Lithium-ion batteries are unsafe and can explode and cause major injury and in worse case paralysis, traumatic brain injuries, or death.
- Desire for energy from solar generation to "stay local" and be used locally.
- Home and property values will decrease.
- Solar installations change ownership, often, and agreements with landowners can become void. Ultimately, sites may be owned by utility companies. Since utility companies have the right to eminent domain, they can take the land away from the farmer/land owner.
- If solar is sold to the utility it becomes tax exempt.
- They say solar panels are recyclable, but they are really not (plus toxicity concerns). Even if they are recyclable, there aren't adequate facilities to recycle them. Like wind turbine blades, solar panels will be filling up landfills (add toxicity concerns.) Obsolete panels are sold to third world countries and disposed of improperly.
- Solar panels emit radiation (EMF) and exposure leads to a wide variety of health problems from cancer to reproductive issues.

12.5 APPENDIX E – WCR and Miscanthus White Paper

Western Corn Rootworm and Miscanthus Biomass Crop

Professor: Dr. Peter Schubert
Student: Nicholas Parvex
Richard G. Lugar Center for Renewable Energy, IUPUI
Good Questions Project

Executive Summary

The purpose of this report is to determine if research supports the claim that the popular biomass crop Miscanthus can serve as a host for the western corn rootworm (WCR) and, if Miscanthus can serve as a host for WCR, to determine if this will have a negative impact on corn fields located in and around Indiana. Multiple experiments have found that Miscanthus can support WCR development; however, it still appears that adult female WCR prefer to oviposit in corn crops relative to other types of perennial grasses. It is currently unknown whether the ability for WCR to develop within Miscanthus is likely to harm commercial corn crops in the Midwest.

Introduction

The Good Questions Project, developed by the Richard G. Lugar Center for Renewable Energy at IUPUI in collaboration with the Indiana Economic Development Association (IEDA), is a venture aimed at answering communities' questions about renewable energy. The purpose of the project is to investigate local concerns and outline facts about the implementation and use of renewable energy systems.

This report will discuss the link between the biomass plant *Miscanthus x giganteus*, Miscanthus hereafter, and *Diabrotica vergifera vergifera*, more commonly known as the western corn rootworm (WCR), which is a prominent pest in North America and Europe.

Power generation using biomass (organic material that comes from plants and animals) works the same way as power generation from fossil fuels, with the only exception being the type of fuel that is used and how the fuel is produced. Power generation from biomass is considered a more environmentally friendly alternative to the burning of fossil fuels because the raw materials can be sustainably produced through farming and the process of planting, processing, and burning biomass leaves a smaller carbon footprint than that of fossil fuels [1].

The potential of biomass for being a sustainable and environmentally friendly alternative to fossil fuels has sparked a large amount of research into identifying crops that could be used for biomass. Miscanthus has arisen as being a very promising plant to be harvested for biomass due to its cold tolerance, long lifespan, high energy output relative to energy input, low nutrition demands, and high yield [2]. When deciding whether a plant should be used for biomass, it is important to determine a viable environment for the crop and to study the prospective impact the crop could have on that environment. The Corn Belt, which consists of Indiana, Illinois, Iowa, Missouri, Nebraska, and Kansas, has been identified as being an environment that Miscanthus would thrive in because of its well-distributed rainfall, which is something that the Miscanthus requires to thrive. This has raised concerns about the interaction between Miscanthus, WCR, and corn crops. The purpose of this paper is to discuss the interaction between Miscanthus and WCR, and to determine if this poses a risk to corn crops.

***Miscanthus x Giganteus* (Miscanthus)**

The *Miscanthus x giganteus* is a C_4 perennial grass (a life cycle that extends beyond a single growing season) that is a sterile hybrid between the *Miscanthus sacchariflorus and the Miscanthus sinensis*. The *Miscanthus* genus is native to southeastern Asia but can now be found in North America, South America, Europe, and Africa [3] [4]. Miscanthus has been studied as a potential biomass crop since 1989 when the European JOULE (Joint Opportunities for Unconventional or Long-term Energy Supply) program established a research project dedicated to studying it [5]. The United States began researching and investing in biomass after the oil embargo in the 1970s; however, Miscanthus wasn't one of the plant species that was being researched at the time for being used as a biomass crop [6]. Research into Miscanthus as a biomass crop in the United States didn't begin until 2000 [2].

One of the main advantages of Miscanthus is its production. "A quantitative review extracted values of annual production from peer-reviewed articles describing the separate trials of these species (97 observations of Miscanthus, 77 observations of switchgrass) and suggested that Miscanthus produced an average annual biomass of 22t ha^{-1} compared with 10t ha^{-1} of switchgrass (Heaton et al., 2004b)." Heaton [7] performed an experiment in Illinois comparing the biomass productivity of switchgrass to Miscanthus and the results showed that Miscanthus produced significantly larger amounts of biomass per unit area than switchgrass. The peak dry biomass production of Miscanthus of 60.8t ha^{-1} was among the highest ever recorded for this species. The same study concluded that Miscanthus could provide 260% more ethanol per hectare than corn grain [7]. This is of particular importance because currently corn is the leading U.S. crop when it comes to ethanol production [8].

Another reason Miscanthus has been identified as a promising plant for biomass is because of its efficient use of nutrients and water, and its resistance to cold climates. Researchers at North Carolina State University studied the biomass yield and water use efficiency (WUE) of switchgrass, Miscanthus, biomass sorghum, silage corn, and tall fescue and found that Miscanthus had the highest average biomass yield and had comparable WUE to that of corn grown for silage and sorghum [9]. Heaton [7] "achieved some of the highest productivity on record of Miscanthus without irrigation and only 24 kg ha^{-1} of N fertilizer applied in one season" [10]. Of the three locations where Miscanthus was planted in Illinois (Northern, Central, and Southern), the Northern site lost 14% if its crop in the first year while the Central and Northern sites no crops die. There were no subsequent losses in the preceding years for any of the sites [7].

Miscanthus' efficient use of nutrients and water paired with its high yield, longevity, and cold tolerance are some of the reasons that this perennial grass has been identified as being a promising crop to be used for biomass.

***Diabrotica vergifera vergifera* (Western Corn Rootworm)**

Diabrotica vergifera vergifera, better known as the western corn rootworm (WCR), is an insect pest that is thought to have originated from Central or South America before making its way up to North America and more recently (mid-1990s) to Europe [11]. It has been estimated that WCR causes roughly $1 billion dollars in preventative treatments and yield losses every year with some years rising above that mark. WCR first arose as a problematic pest in Fort Collins, Colorado in 1909. From 1909 to 1948, the pest managed to travel from Colorado to the Missouri River. Between 1948 and 1954, Nebraska attempted to treat the soil with different insecticides to control the spread of WCR but in 1959 it was noted that the insecticides were no longer effective in controlling the spread. The introduction of insecticides to WCR led to insecticide-resistant strains of WCR and from then on, the pest began to spread at an increased rate. From 1961 to 1968, WCR had spread from Grand Island, Nebraska to Eau Claire, Wisconsin and by 1968 it had reached Indiana. By 1980, WCR had infested the entire corn belt. One of the most interesting factors in the spread of WCR is that the rate of migration increased after being exposed to insecticides. Prior to being exposed, WCR traveled between 12 and 30 miles per year and after being exposed it traveled from 70 to 120 miles per year [12].

WCR lifecycle occurs in three stages: larvae, pupate, and adult. The larval stage has three instars before advancing into the pupate stage. WCR eggs usually hatch in the springtime, between March and early June. After hatching, the larvae migrate to the secondary root system where they begin feeding. As the larvae grow and their food requirements increase, they begin to burrow into the primary root system. After completion of the three larval instars, WCR pupate in the soil, typically at the base of the crop. Adult beetles begin to emerge from the soil between late June and early July. Adult beetles primarily feed on pollen, green silks, and leaves of corn crops. The mating process begins immediately after hatching and females begin laying eggs within 2 weeks of emergence [13]. Females only copulate one time whereas males are capable of mating multiple times. Females lay between 500 and 1000 eggs in the form of clutches at varying locations [14]. Peak egg laying season usually occurs in early to mid-August when pollen levels are at their peak but can continue until autumn. The eggs remain in the soil through winter and hatch the following spring. Adult WCRs last through the first few frosts of winter before dying off.

WCRs damage plants in both their larval and adult stage, though the most damaging phase in WCRs life is during the later stages of the instars. During this period the larvae feed on the primary roots. Extensive damage to the roots can inhibit the crops' ability to retain nutrients and water, facilitates infection, and makes plants more vulnerable to lodging caused by high winds and rain. High populations of adult rootworm may inhibit corn plant pollination by severely clipping silks during pollen shed. However, widespread damage caused by adult rootworms is uncommon, crop damage is typically exclusive to a handful of plants. High populations of adult rootworm beetles could be indicative of high WCR numbers the following year when eggs hatch [13], [15].

The migratory abilities of adult rootworm beetles have been well researched and documented. Coats [16] performed an experiment studying the migratory flight of adult female rootworms and in the population that was studied, the longest single flight distance recorded was 24 km with the farthest distance traveled in a 24-hour period being 39.6 km. Sustained flights, defined as flights lasting considerably longer than 17 minutes, in the range of 45 minutes to 4 hours, only occurred in female WCRs that were between 2 and 9 days old. The average distance covered per day in the first 6 days life was 35 km. If the average flight distance per day is applied over the 6-day period, that would result in 210 km traveled over that period [16]. This study highlights the ability of WCRs to migrate over long distances and paints a picture of the ease with which WCR can perform interfield travel. Isard [17] performed a study to investigate the influence of atmospheric conditions on high elevation flight of WCR. Among dispersing beetles that were collected, 85.4% were found to be female and 99.1% had recently mated [17]. This suggests that following mating, adult female rootworms perform sustained and inter-field flights in search for new host fields. Previous studies have also shown that female WCR beetles make sustained flights prior to oviposition [16], [18], [19].

Western Corn Rootworm Interaction with Miscanthus

The interaction between WCR and Miscanthus and the impact that interaction could have on corn crops is not a well-documented or researched topic. This could be due to the lack of geographical overlap between Miscanthus and WCR. Miscanthus has only been planted and studied in the United States in the past 20 years and WCR has only been in Europe, where majority of research into Miscanthus has occurred, in the past 30 years. With that being said, studies performed in green houses and on research plots have concluded that WCR could develop to adulthood on Miscanthus and with similar success to that of maize [20]- [21]. However, in some cases, the emergence of adult rootworm beetles has been significantly lower among Miscanthus than that of corn [22].

An experiment that was performed in Central Illinois from 2010 to 2011 monitored the presence of WCR and the adult activity and oviposition of both WCR and *Diabrotica barberi* (northern corn rootworm) in Miscanthus, switchgrass, and corn. The number of WCR adults captured in the corn fields was 3-10 times as many as in Miscanthus and switchgrass. Soil samples also showed that females laid 10 times as many eggs in corn as they did in Miscanthus and switchgrass [23]. Although WCR larvae can develop to adulthood on Miscanthus, it appears that adult female rootworms prefer to oviposit in corn compared to other perennial grasses.

The impact of Miscanthus on corn fields is still currently unknown and the impact that the relationship between Miscanthus and WCR may have on corn fields is also unknown. Additionally, the ability of adult WCRs to move within Miscanthus is unknown which is an important predictor of the ability for WCR to perform interfield movement between Miscanthus and corn fields.

Other Sources of Corn Crop Losses and Damage

Crop Damage

One of the leading causes of crop damage every year in Indiana and the United States as a whole, are crop pathogens. The 2021 Plant and Pest Diagnostic Lab Annual Summary Report found that 59% of the plant samples they received, the bulk of which were from Indiana, were infected with a disease [24]. Predicting what diseases will be of importance each year is difficult due to the number of factors that influence a diseases ability to thrive. In 2021, the most damaging diseases to corn crops in the northern United States were tar spot, Fusarium stalk rot, gray leaf spot, southern rust, and northern corn leaf blight and these diseases caused a combined estimated loss of 639.6 million bushels worth of corn [25]. From 2016-2019, Indiana lost an estimated $2 billion due to corn diseases alone [26].

Climate Change

Changes to Indiana's climate such as increasing temperatures, changes in precipitation patterns, and rising levels of carbon dioxide in the air will result in direct and indirect impacts to the agricultural industry. More frequent plant stress heat days and reduced precipitation in summer is expected to reduce corn and soybean yields by 16 to 20 percent and 9 to 11 percent respectively by 2050. Increased precipitation in winter and spring is expected to cause signification leaching of soil. Warmer winters, wetter springs and hotter summers are predicted to increase the prevalence of crop pests and diseases which could further impact yields. An additional effect of climate change is an increase in the severity and number of extreme weather patterns. The drought in 2012 that resulted in over $1 billion in crop losses and the flooding in 2015 that lead to $300 million in crop losses will become more normal and will have widespread affects [27].

Conclusion

Multiple studies have concluded that Miscanthus can support WCR development to adulthood; however, some field studies have shown that female adult rootworms prefer to oviposit in corn over Miscanthus. There has not been research to determine whether Miscanthus being able to host WCR will have any impact on corn crops. Any statements made claiming that Miscanthus will negatively impact corn crops are purely speculative at this time.

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12.6 APPENDIX F Wind Turbine Infrasound

Infrasound And Wind Turbine

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Executive Summary

During the operation of wind turbines, they emit sound. This sound has a low frequency, It is at the low end of what humans can hear. This range of sound is called infrasound, it is defined as the range of sound below what the human ears can pick up. Some people worry that this will cause harm.

Living very near to a wind turbine the sound is certainly noticeable, and some people may find this annoying. However, there is little or no evidence that the sound from wind turbines has any physical health effects. Some people may feel anxiety about the sound, perhaps because someone told them to be worried about it.

The sound pressure, or volume, of a wind turbine falls off with distance. At a typical standoff distance, the sound pressure is about 50 dB (decibels). This is similar to a high-end dishwasher. Every +10 dB increase in sound pressure is a doubling of loudness. A conversation is about 60 dB, a car driving on the highway is about 90 db, and a nearby police siren can be 120 dB.

This report is not to diminish the psychological effect. However, if people's anxiety is caused by misinformation, this report is to guide people to the truth by providing scientific evidence.

Introduction

The Richard G. Lugar Center for Renewable Energy at IUPUI in collaboration with Indiana Economic Development Association (IEDA) is working on a project called the Good Question Project. This project seeks to understand common concerns regarding energy projects and help to answer queestions and show the facts about new energy sources.

This report will discuss the wind turbine's infrasound (IS), its potential health impacts, and compare the sound pressure with other sources. This project aims to help everyone seeking information and facts about renewable energy from economic developers to the farmer to the public community.

Wind energy is one source of renewable energy that can produce power at a utility scale ("grid-connected") with a small environmental footprint. The environmental footprint is defined as the effect any person, object, or building has on the environment. Wind turbines use the wind to rotate the blades, which will result in rotational movement. This movement will be used to produce electrical power by connecting a generator to the rotating shaft.

The mentioned movement can result in infrasound, which is defined as pressure waves with frequencies lower than 20 Hz. Humans can only hear pressure waves between 20 Hz to 20,000 Hz. Even though there is not enough evidence of the health impact relating to the infrasound from wind turbines to some health impact, this report will break down each claimed symptom and explain them.

Wind Turbine

Wind energy is the type of energy that converts the wind's kinetic energy to electrical energy by using wind turbines, and it is considered a type of electromechanical energy. Wind energy is a renewable energy that has been widely used as an alternative to fossil fuels, and it is abundant and renewable energy, but its availability varies from one location to another. It is clean renewable energy that does not produce emissions such as greenhouse gases during operation.

Wind energy is one of the fastest-growing energy sources globally, so it offers many advantages, such as low operational cost and job creation. As a local energy source, wind is an abundant and inexhaustible, so it is considered sustainable. Wind energy is classified as a form of solar energy, because winds are produced due to the sun raising the temperature in the atmosphere, in addition to the rotation of the earth and the irregularity of its surface. This means that as long as the sun shines, the wind will blow, and therefore it is sustainable and renewable.

Despite the many advantages of wind energy, there are some negatives or challenges that can appear when relying on wind energy. It is an intermittent source, it is not possible to be sure of wind blowing reliably. Therefore having a large portfolio of wind turbines on the electric power grid will require additional sources of baseload ("always available") power, or energy storage. Wind turbines emit a sound ranging from 50 to 60 decibels, and therefore if the turbine is near a residence, the noise may be annoying to certain occupants. If there is a problem with a particular wind turbine, such as a faulty gearbox, there may be additional noises that require maintenance to address. This report focused on the "shushing" sound, or "ocean waves on the shore" sound, including the sound produced in a range that cannot be picked up the human ear.

It is not recommended to install wind turbines in urban areas due to the presence of obstacles preventing strong and steady wind speeds. Rural areas are much more feasible due to the large areas and small buildings. Locales with nearby transmission lines (also called "high tension" or "high voltage" lines) are also favorable to keep up-front capital costs low. Indiana has a combination of open land and many high voltage lines, making wind power especially attractive.

The design of wind turbines depends on defining the shape and specifications of the wind turbine to extract the maximum amount of kinetic energy from the wind. Taller is better and wider is better for power generation, therefore, the height and blade length of wind turbines has steadily increased over time. The wind turbine consists of the systems necessary to capture the wind and rotate the wind turbine in the direction of the wind, in addition to the processes of converting the kinetic energy of the rotating mechanical parts into electrical energy, in addition to other systems such as take-off, stopping and turbine control operations.

Infrasound

Infrasound (IS) can be defined as the sound lower in frequency than 20 Hz, or cycles per second, this limit of 20 Hz is the lower natural limit of human hearing. For many people, sounds below 70 Hz are inaudible, unless at very high sound intensity. Here is a website to test your own hearing as a function of frequency (https://www.szynalski.com/tone-generator/). The ear is the main organ for sensing sound, but it is possible to feel infrasound vibrations in different parts of the body with higher intensity. As an example, in a TDX-equipped IMAX movie theater, or a Lovesac® "Sactinals StealthTech Sound+Charge", vibrations in the IS range are used to add a rumble to action films or rock music. The Buttkicker® product adds this "haptic" sensation to your couch or video game chair (https://thebuttkicker.com/).

Wind turbines that are used in the production of electrical energy emit sound waves in a range of infrasound frequencies. Infrasound waves originate in particular from the blades made of steel (most modern blades are made of composite). These waves become very weak within a short distance from the rotor of the turbine. Most communities have a setback distance, or standoff zone, established by law or regulation to keep wind turbines from encroaching too close to residential areas.

Compared to other sources of sound such as trucks and airplanes, wind turbines are much quieter. However, some residents who live close to wind turbines complain of difficulty sleeping or headaches. For this reason, many authorities have specified that the minimum distance between a wind farm and the nearest house should at 1000 meters (0.6 miles).

We define the intensity of a sound wave as the energy that the wave carries per second through a unit area perpendicular to the direction of wave propagation. Since intensity is the amount of energy per second, sound intensity is the power that passes through a unit area perpendicular to the direction of wave propagation. This sound pressure, or sound intensity is measured by decibels (dB), named after American inventor Alexander Graham Bell. He recognized that human hearing is logarithmic in nature, so the ear hears a sound **twice as loud** when the sound pressure is **ten times as strong**. The logarithmic scale means that each increase of +10 dB is a times-ten increase in sound pressure, and sounds 2-times as loud to the human ear. As an example, a hovering helicopter emits 100 dB, or 40 dB louder than a normal conversation at 60 dB, and is actually 10-to-the-power-of-4 (10*10*10*10 = 10,000) greater in sound pressure, and sounds 16 times louder to the ear. A typical **wind turbine**, listened to at the setback distance, is 50 dB. Fifty decibels (50 dB) is **half as loud as two people chatting**, or on the other hand, it is **twice the volume of a whispered secret**.

The decibel makes it easy to compare very large numbers with very small numbers, as the sound intensity changes by a very wide range between a whisper and noise that hurts, all of which can be heard by the ear. Regarding the known effects of sound: 120 dB can cause hearing loss with long-term exposure (rock concerts), and 140 dB is immediately painful. Wind turbines are one million to 100 million times smaller than this in actual sound pressure, even though one cannot hear these lower frequencies. You probably know that **dogs** can hear frequencies higher than humans can ("ultrasound"), and it is also true that **elephants** can hear frequencies lower than humans can ("infrasound").

The Health Effects Of Infrasound

Wind Turbine Syndrome

Wind turbine syndrome and wind farm syndrome are terms for the purported adverse effects on human health related to the proximity of wind turbines to humans. Proponents claim that these effects include birth defects, cancer, and death, for which there is no scientific support. However, the distribution of recorded events correlates with media coverage of the wind farm syndrome itself, not with the presence or absence of wind farms. This term is not recognized by any international classification system for diseases, but several articles investigating such claims may be found in the US National Library of Medicine's PubMed database (https://pubmed.ncbi.nlm.nih.gov/). Wind turbine syndrome is often described as a pseudoscience.

Previous Studies And Claims

A panel of experts commissioned by the Massachusetts Department of Environmental Protection concluded in 2012 that "there is no association between wind turbine noise and stress gauges or mental health problems."**[1]**

A 2009 Canadian study found that "a small minority of those exposed reported discomfort and stress related to the perception of noise…" however "nuisance is not a disease." The study group explained that similar irritations result from local vehicles, highways, as well as from industrial processes, and aircraft**[6]**.

A 2011 literature review found that although wind turbines have been associated with some health effects, such as disturbed sleep, the health effects reported by those living near wind turbines may not have been caused by the turbines themselves but rather by the "physical manifestation of the state of being disturbed**[2]**. A 2013 report by the National Health and Medical Research Council (Australia) explained: "There is consistent evidence that wind turbine noise is associated with disturbance and reasonable consistency associated with sleep disturbance and poor sleep quality and quality of life. However, it is unclear whether the associations are observed are caused by wind turbine noise or reasonable confounding factors."**[8]**

A descriptive study published in 2014 reported that, of the best-quality cross-sectional studies, there is no clear or consistent association between wind turbine noise and any reported disease or another indicator of harm to human health. Noise from the turbines played a secondary role compared to other factors in causing people to report discomfort in the context of wind turbines**[5]**.

In late 2019, then-President Trump described the wind turbines as "monsters", and that they do cause the death of a lot of birds and bats. He also cited the carbon footprint required to create wind turbines. He also tweeted about wind turbines on multiple occasions throughout the years.**[4,10]**

Health Impact Of Noise And Vibration

Infrasound can be considered as noise coming out of the wind turbine. Some of the claimed symptoms of wind turbine syndrome are headache, sleep disorders, tinnitus (ringing in the ears), mood swings (such as irritability, anxiety), concentration and memory problems, balance problems, and feeling dizzy and nauseated.

From a scientific standpoint, such anecdotal evidence could also be caused by, or made worse by, other health problems. Chronic lack of sleep, in an urban environment, due to traffic, revelers, horns, sirens, trains, and garbage trucks, can lead to other symptoms such as irritability and dizziness. The much softer sound of a wind turbine in a rural environment can be expected to have a lower impact on rest compared to trying to sleep in a noisy city.

Most studies did not find explicit evidence that an individual's health was affected by exposure to wind turbines. However, to address concerns around wind turbine noise, many manufacturers have developed sound suppression techniques. Newer wind turbines are designed to be considerably quieter than the prototypes of yesteryear. Noise from gears and generators has been reduced, and modern wind farms are generally isolated from residential areas. The blades are also designed to make less noise.

Most experts advise the importance of having a buffer zone around wind farms to protect people from potential impacts. Opinions differ on the minimum buffer zone, or distance to be left between residential areas and wind farms, as regulations vary by country, state, and county. Hopefully, laws regulating housing outside buffer zones and the constant pursuit of noise suppression through the use of sound insulation techniques may eliminate the need to answer our question: Does wind turbines infrasound cause health problems? Most scholars deny that.

The Nocebo Effect

The Nocebo effect occurs due to the patient's negative expectations: if s/he expects negative effects of a particular drug or treatment, s/he may suffer from the symptoms expected, even if the drug is an inert substance. The Nocebo effect is psychological but can still bring about measurable changes to the body. A patient's expectations can have powerful effects on the outcome of the illness, the experience of pain, or even the success of surgery. The patient may be affected by pathological delusion as a result of his/her doubts about whether s/he had a disease that led to the death of a member of his family or heard about it somewhere, where s/he suffers from the same disease despite being healthy and despite visiting a doctor and conducting tests and obtaining negative results**[11].**

The Sources Of Infrasound

Natural Sources

Infrasound sometimes results naturally from extreme weather conditions, surfing, avalanches, earthquakes, volcanoes, bolides, waterfalls, births of icebergs, and thunder from ground-strike lightning and upper-atmospheric lightning. Nonlinear ocean wave interactions in ocean storms result in diffuse subsonic vibrations around 0.2 Hz, known as microbaroms.

Animal Communications

Whales, elephants, hippos, rhinos, giraffes, and crocodiles are known to use vocals for communication across distances- up to hundreds of miles in the case of whales. It has also been suggested that migratory birds use naturally generated infrasound, from sources such as turbulent airflow over mountain ranges, as a navigational aid. Infrasound can also be used for long-range communication, especially well-documented in baleen whales and African elephants. Elephants also produce infrasound waves that travel through solid ground and are sensed by other herds using their feet, although they may be hundreds of miles apart. These calls can be used to coordinate the movement of herds and allow mating elephants to find each other.

Created Human Sources

Acoustic sources can be generated through human processes such as fireworks (for example, a “salute shell” with a deep boom and white flash), vehicles crossing a bridge, motorcycles, gasoline and diesel engines, manufacturing equipment, wind turbines, or the Purdue Big Bass Drum (https://en.wikipedia.org/wiki/Purdue_Big_Bass_Drum). Some specialized loudspeaker designs are also capable of producing infrasound frequencies. These include rotating, wide-range subwoofer models, as well as large trumpet-loaded tweeters, bass-reflex tweeters, sealed woofers, and haptic vibrators.

Comparison Between Infrasonic waves Sources pressure data:

The main reason for this comparison is to give the reader the ability to be able to compare the sound pressure that is being emitted from the wind turbine with a familiar source. Wind turbines emit on average a sound wave of 50 dB. We will start by stating other sources such as the faintest whisper inside a recording studio will have sound pressure around 20 dB. A quiet room or office has 50 dB, while talking could have up to 70 dB. Loud group meetings have 80 dB. When it comes to moving cars, it can get as high as 90 dB. Even higher is air travel, where a turbojet engine can reach 120 dB **[1]**.

Conclusion

There is little or no scientifically validated evidence that wind turbine’s infrasonic waves cause any disease. However, some researchers suggested that more research is required to obtain more data to be able to decide for sure if wind turbine syndrome exists or not. People that live near wind turbines keep reporting some side effects that they believe are because they live near the turbine. Further study is needed to determine if these effects are physically real, or if they are a psychogenic response, or possibly a result of the Nocebo effect due to negative expectations derived from misinformation.

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12.7 APPENDIX G – Data Card for Infrasound from Wind Turbines

IUPUI - INDIANAPOLIS

THE RICHARD G. LUGAR CENTER FOR RENEWABLE ENERGY

Facts about Wind Turbine Noise:

- Setbacks are the distance to a home
- Sounds at setback are about 50 dB
  - **Half as loud** as a conversation
  - **Twice as loud** as a whisper
  - Similar to high-end dishwasher
- Turbine noise falls off quickly with distance
- Infrasound desired in video game chairs
- Many other sources of infrasound exist:
  - Vehicles on bridges, garbage trucks
  - Motorcycles, diesel engines
  - Manufacturing equipment
  - Fireworks, thunder
- Elephants can hear infasound

INFRASOUND (IS)

Wind Turbine Syndrome

There is no scientifically validated evidence to support negative human health impacts from low-frequency noise (infrasound) generated from the turning blades of a wind turbine.

The sound from a wind turbine may annoy some people, if their homes are very close.

Sensitive People

Some people are more sensitive to noise than others. Living near a wind turbine is much less noisy than living in downtown Indianapolis. Road noise from highways can be louder than wind turbine noise.

Modern wind turbines are designed to be quiet. The shussing of turbine blades has been reduced, as has gear noise from the generator nacelle (at the top of the mast). Excess noise can indicate the need for a maintenance call.

Some people expect health problems, which can be a self-fulfilling prophecy. Your expectation of problems can lead to real consequences for your health. It is important to know the facts, rather than the fears of others.

Sound Pressure

Sound is measured in decibels (dB) named after Alexander Graham Bell. Painful sound is 140 dB. The threshold of detection is about 0 dB. Wind turbines are about 50 dB.

12.8 APPENDIX H – Solar Panel Fires

Frequency of Solar PV Fires

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Student: Shalem Poriah
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Good Questions Project

Executive Summary

Solar photovoltaic (PV) devices use the sun's energy to provide useful power on Earth. These devices are exposed to the sun's radiation and heat for extended periods of time. A professionally installed and maintained solar panel will not catch fire, however, there has been some concern that solar photovoltaic devices catch fire often.

It is true that solar photovoltaic devices can cause fires. However, the statistics on photovoltaic fires show that this is a very, very, rare occurrence. In fact, you are more likely to have your car stolen than having a solar panel cause a fire. Also, the causes of these fires are not due to the sun setting them on fire. Instead, these fires are due to poor installation, poor design, and damage to the photovoltaic system.

The purpose of this report is to address the concern that solar panels are a frequent source of fires. They are not. At the same time, this report aims to present information on why such fires do occur on occasion.

Introduction

This paper is a product of the Good Questions Project, a collaboration between the Richard G. Lugar Center for Renewable Energy at IUPUI and the Indiana Economic Development Association (IEDA). The purpose of the Good Questions Project is to address any renewable energy questions that concern the public.

This paper will address the subject of solar photovoltaic fires as well as present why these fires occur and why their occurrence is so rare. It aims to provide clear information so that anyone and everyone can have solid, fundamental knowledge of the subject.

Solar photovoltaic systems are a "green" energy source, that is not only versatile in applications, but is also completely silent with minimal maintenance costs. They are versatile because wherever there is sun, you can produce useful energy, whether it be on rooftops in Indianapolis, or in fields like the Indianapolis International Airport.

Solar panels provide electrical current that can be used to power homes and devices. However, since they are electrical devices, there is a fire risk involved. This risk of electrical fire is extremely small and solar panels are designed to prevent fires from occurring. The rest of this paper will expand on photovoltaics, causes of these fires, and what preventative measures are in place.

Solar PV Systems

Solar photovoltaic systems use the sun's radiation to produce electricity that can be used to power homes and devices. Solar photovoltaic systems are very environmentally friendly because they produce no emissions, no noise, and can be recycled. This makes them a green alternative source of energy to fossil fuel driven generators.

Even though they only work when the sun is out, the solar resource for the U.S. is massive. According to energy.gov "In fact, just one hour of noontime summer sun is equal to the annual U.S. electricity demand" [1]. Not to mention, the sun shines everywhere and is an inexhaustible source of energy. This also allows for solar power to be very versatile in applications. Solar photovoltaic systems are on the cheaper end when compared with other energy sources such as wind or nuclear. Solar panels can also increase the value of your home when installed, all while providing electricity to help cut costs.

Although there are many advantages to solar photovoltaic power, there are also disadvantages and challenges. Energy cannot be produced when there is no sun, therefore, during the fall and winter when the sun shines less, energy production will decrease. It is also dependent on the weather since cloudy days can drastically reduce production. This means that solar panels cannot consistently produce electricity like nuclear or gas.

Solar Farms

Solar farms are a method of harvesting solar energy. They can be used when there is plenty of land available and in the sun can shine uninterrupted. Solar farms come in different sizes and can have the power to supply a community or supply a county. Utility companies make use of solar farms to sell electricity but there are also solar farms to offset large facilities. For instance, the Indianapolis International Airport has used the idea of solar farms to help reduce the cost of the airport. It has reduced its running cost while outputting 17.5 megawatts AC (22.2 megawatts DC) of electricity. It also has not experienced a single solar fire, even though it contains over 76,000 solar panels [2].

Rooftop Solar

Rooftop solar is the installation of solar panels on the roofs of houses or businesses. This can be done to provide solar power in areas where there is less land available such as in cities. Rooftop solar is also a decision that homeowners can consider when trying to establish energy independence. As a sidenote, solar panels can be installed on the ground away from the house of a homeowner as well. The Major General Emmett J. Bean Federal Center uses rooftop solar as well. "The solar roof system generates enough power to save $500,000 in electric utility costs annually" [3]. Another building is Rockville Solar II, a 2.374 MW solar facility with an estimated annual production of over 4 million kWh [4][5].

Solar PV Fire Frequency

There is a claim that solar panels catch fire often. However, the available statistics state otherwise. According to Fraunhofer ISE, a German research group, there has been a recorded 120 PV caused fires out of the 1.3 million solar panels in the country [6]. This was over the course of 20 years. We can solve the number of fires per year by dividing 120 fires by 20 years. This gives us an average of 6 fires annually. Now we can divide 6 by the total number of solar PV systems in the country (1.3 million) and multiply that by 100 to get a percent. This percentage represents the chance of a solar PV fire occurring annually. BRE National Solar Centre, located in the UK, recorded, and investigated 80 fires related to solar panels. During that time there were about 940,000 PV systems in the country [7]. Over the course of the 3-year project, 47 incidents were investigated. Using 47 to solve for the number of fires per year gives us 15 ⅔. Using that we can determine the likelihood of a PV occurring in a year to be .00167%. In Japan, the government reported 13 solar panel related fires. This was over a 10-year period and the number of solar panels in Japan was around 2.4 million [8]. This leads to a .000054% chance of a fire occurring annually. Looking at Table 1. The highest probability of a solar photovoltaic fire occurring is .00167%. Table 2 shows that **you are more likely to be struck by lightning than have your solar panel catch fire**.

Table 1. PV fire risk.

Country	Percentage (annual)
Germany	.00046 %
UK	.00167 %
Japan	.000054 %

Table 2. [9][10] Other risks.

Event	Percentage (annual)
Struck by lightning	.0065 %
Home catching Fire	.24 %
Dying to a home fire	.18 %

Causes of Solar PV Fires

The causes of solar PV fires mostly stem from poor installation and maintenance practices. Practices such as improper grounding, leaving wires near abrasive edges, and taping hotspots during maintenance. These practices are what led to the infamous Walmart roof fires. They also allow for damage to the electrical components of the system. Cheap components or components that are not compatible will increase the likelihood of fires. BRE National Solar Centre reported that the components most responsible for the incidents they investigated were DC isolators, DC connectors, and inverters. Connectors in general as well as the optimizers are areas that can catch fire.

Isolators

Electrical isolators are a type of switch that can disconnect a part of a circuit. In solar PV applications, they are used to disconnect the solar panels from the inverter. This isolates the solar panels so that they can be worked on safely.

Isolators are also an area where arcing can occur. Electrical arcing is when electricity jumps from one connection to another, not through the expected way, but through another medium like air. For instance, if you hold two live wires close enough to each other, you will see the electricity flow through the air (a spark) to complete the circuit from one wire to another. Arcing can lead to fires in solar PV systems, especially with DC isolators.

Improper installation, water intrusion, or damage to the isolator can result in arcing. During installation, a qualified DC switch must be used that can handle the voltage of the system. A DC switch must be used since solar panels produce DC current. If an AC isolator switch is installed instead, this can lead to the switch overheating and fire. Improper installation can also allow for water intrusion. As always, the environment the isolator switch will be placed in must be considered. Plastic housing can be prone to corrosion and the seals for them could then be compromised leading to arcing. This is especially an issue with home solar panels in

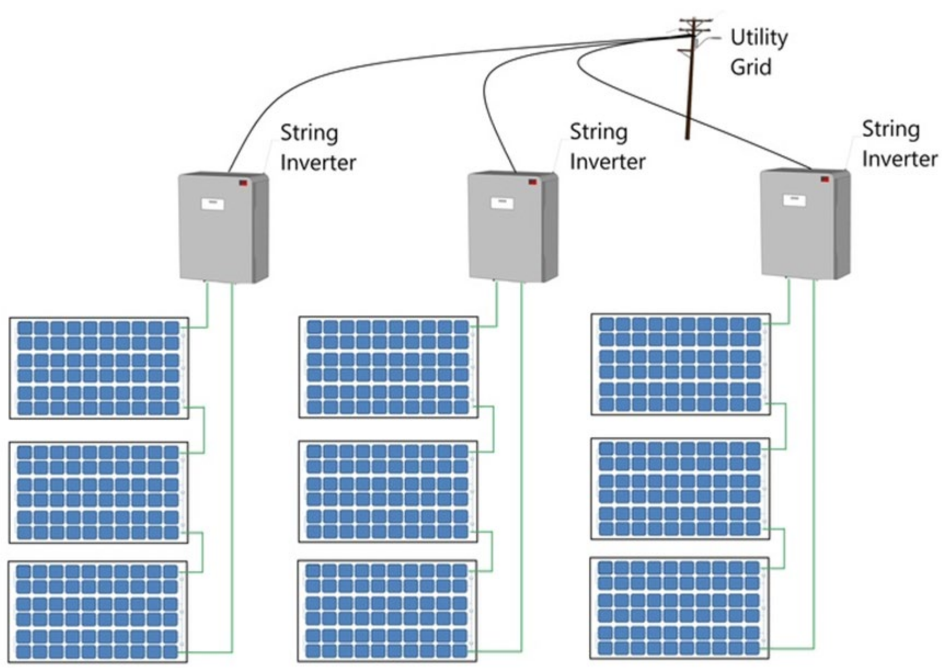
Australia. Therefore, it is important to have quality isolators installed. For example, the Australian Competition and Consumer Commission (ACCC) had to issue a recall on a DC isolating switch supplied by Origin Energy. They stated that these isolators had an internal fault causing them to fail, resulting in excessive heat. They also stated that there is a potential fire risk from faulty contacts within the switch [11].

Inverters

Inverters are used to convert the DC current produced by solar panels to AC current that is used in homes. This DC to AC conversion is accomplished by switching the direction of DC current very rapidly. Inverter boxes are not limited to DC to AC conversion, they can also monitor solar PV systems and communicate with external devices to relay information about the system. Solar panels can use various kinds of inverters, string inverters, central inverters, and microinverters.

String inverters connect a set of panels to one inverter. A set of connected panels are referred to as a “string,” hence the name string inverters (fig. 1). This set up is cost effective, but the power produced will be reduced if any panel along the string undergoes shading or reduced production. This is an economical option for homeowners interested in solar panels on their roof.

Figure 1. String Inverters [12]



Central inverters refer to a main inverter that all solar panels connect to. Therefore, all the DC current produced is converted to AC all in one place (fig. 2). Multiple strings can be run through a central inverter, and there can be multiple central inverters. This is useful for cutting costs on large project, especially when there are many solar panels in a system. For example, the solar farm at the Indianapolis International Airport initially had 41,000 solar panels with 20 inverters [13]. This can be done using central inverters**.**

Microinverters (fig. 3) can be placed on each solar panel. Since each panel will have an inverter, this setup is more expensive than having string inverters. However, since there is an inverter on each panel, if one panel has reduced output, it will not affect the power that can be drawn from the other panels. Microinverters can also act as smart modules, which is useful for examining what each panel is producing.

Figure 2. Central Inverter [12]

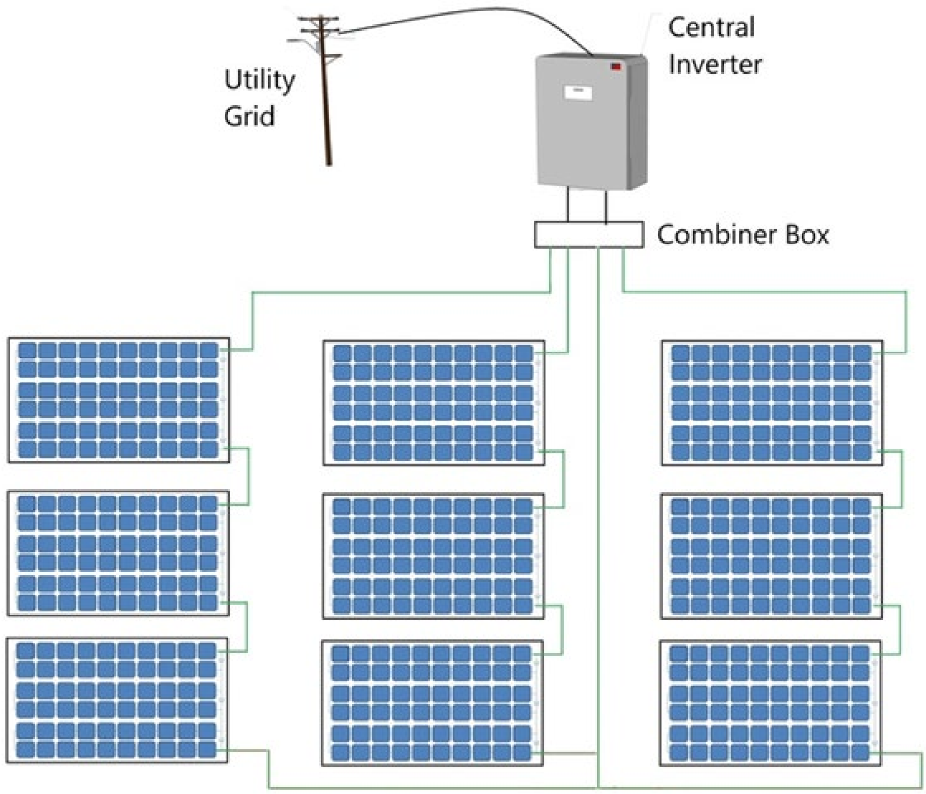
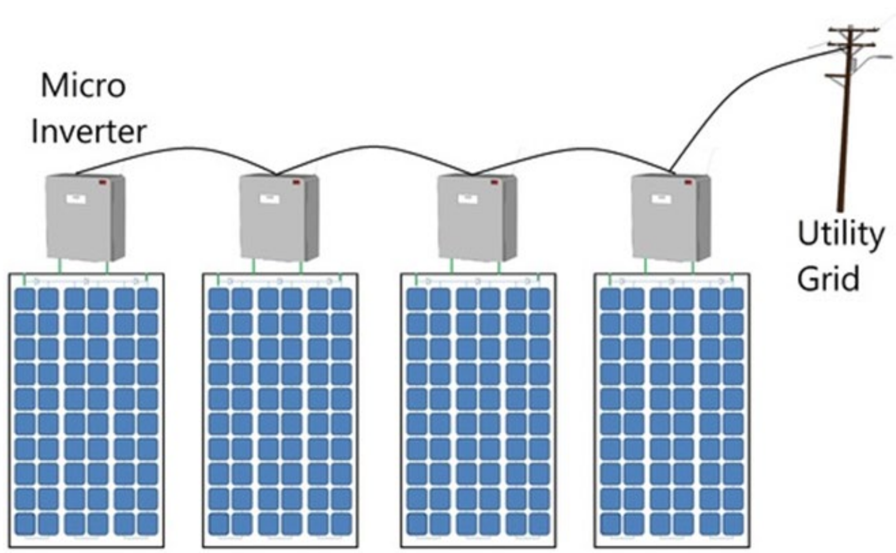


Figure 3. Microinverters [12]



When not installed properly, inverters can cause a fire. The environment is to be considered. A faulty, or poorly-installed inverter may overheat in the summer. It is also important to use quality inverters. The United States Consumer Product Safety Commission (CPSC) recalled Delta Electronics inverters because of capacitors failing and allowing heat buildup. In some cases, the cover would forcibly fly off [14].

Optimizers

In solar PV systems, optimizers are used to increase the efficiency of the system. Optimizers achieve this by "optimizing" the voltage before the current reaches the inverter. Without optimizers, solar panels can only produce electricity equal to the lowest-performing panel on that string. This is especially useful if the solar panels are installed on a north facing roof, or when it is under heavy shade. Another scenario is if there are many solar panels facing different directions and at different angles along a string. Optimizers would allow make sure to maximize the electricity sent to the inverter in complex installations.

In general, optimizers are another break in the system where fires can occur. This allows for an increased chance of strong electrical arcing occurring, especially since optimizers are running on DC portion of the solar PV system. After the infamous Walmart fires, Tesla secretly started Project Titan. Tesla went around to its solar PV systems to replace connectors and optimizers that were not industry standard [15].

Connectors

Connectors are used to connect circuits or disconnect from circuits. For example, a USB connector can be found at the end of mouses so you can connect to the circuit in your computer and power your mouse. With solar PV systems, connectors are used to connect solar panels to each other, inverters, optimizers, or other devices. There will be a male connector a plug and a female connector socket. The connectors allow for these solar modules to be connected in series or parallel depending on what is needed. In most solar PV systems, the MC4 connectors are used, once locked a special tool is needed to disconnect them.

In general, connectors can catch fire when damaged, or poorly connected. During installation, connectors can be incorrectly installed, leading to poor connections. These loose connections will allow for water intrusion which will then lead to water corrosion. Water corrosion can then lead to even looser connections and more severe damage. Poor connections can also occur when the connectors are incorrectly crimped during installation, or during maintenance. Incorrectly crimped connectors as well as loose connections can lead to electrical hotspots. Electrical hotspots occur when the current running through the circuit starts to dissipate a lot of its energy as heat. In the Walmart solar fires, it was once observed that a Tesla employee put tape on a solar panel to mark its hotspot [16]. This poor practice would increase the resistance at the hotspot and only increase the heat dissipation.

Another way they can catch fire is if they are cross-mated. Cross-mating is when connectors from two different manufacturers are used to connect components. This not only can result in inefficiencies but also fires, since each connector has different specifications. Additionally, this may result in cracks or leakage as well. Initially, cross-mating may not produce any visible downsides. However, internally the lack of uniformity may result in damage and a shorter component life. Even small imperfections can lead to damage and fire. According to the CPSC, SolarWorld had to recall its connectors since "The connectors that are attached to the solar panels can develop microscopic cracks that allow moisture to leak into them while the system is producing electricity, posing an electrical shock hazard." [17]. Also, solar connectors played a part in the Walmart fires, and the H4 connectors from Amphenol were not industry standard and had to be replaced [18].

Industry Standards

Industry standards are updated to maximize efficiency and safety. The Institute of Electrical and Electronics Engineers (IEEE) gives guidelines on how a solar PV system can be tested for adequacy before being installed. To run these tests, proper sensors with a range that can handle the circuits maximum voltage and current [19]. These maximum current and voltage values can be calculated properly from the National Fire Protection Association (NFPA) 70. Article 690.8 in NFPA 70 grants flexibility by allowing a licensed professional engineer to calculate the maximum current using an industry standard method rather than the method given by NFPA [20]. Indiana's electrical codes are based off NFPA 70, and its fire codes are based off the 2014 Indiana Fire Code. The Indiana Fire Code calls for PV systems to be properly marked and have their DC wiring in such a manner to reduce trip hazards as well as maximize ventilation [21]. The DC combiner boxes should also minimize the connection lengths between arrays. Residential structures are limited so that a PV array cannot exceed a 150 ft x 150 ft area [21].

Conclusion

In summary, solar PV systems can catch fire, however the chance of this happening is quite low when proper equipment and installation practices are followed. These rare instances occur when solar PV systems are poorly installed, maintained, or contain faulty components. To minimize the chances even further, solar panel installations must be done professionally and maintained professionally. Industry standards must be followed to avoid incidents such as the Walmart fires. When choosing components for a PV system, it is important to not sacrifice quality for the sake of saving money during installation. Money will be saved over time, and to maximize value, quality components are vital. Scale and location of a PV system affects how these systems are set up and operated. Industry standard PV systems are not significant fire hazards. A trusted, professional company will allow for a safe system to be built and operated. Regardless of whether the PV system is on the roof of a house, or the Indianapolis International Airport's solar farm, standards, regulations, and building codes exist to make PV fires a very small risk.

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12.9 APPENDIX I – Solar PV Fires Data Card

How Often Do Solar PV Fires Occur?

Answer: Very rarely

According to Fraunhofer ISE, a German research group, there's been a recorded 120 fires out of the 1.3 million solar panels in the country. This was over the course of 20 years. We can solve for the number of fires per year by dividing 120 fires by 20 years. This gives us an average of 6 fires annually. Now we can divide 6 by the total number of solar PV systems in the country (1.3 million) and multiply that by 100 to get a percent. This percent represents the chance of a solar PV fire occurring annually. BRE National Solar Centre, located in the UK, recorded 80 fires related to solar panels out of 940,000 PV systems. The Japanese government reported 13 solar panel related fires over a 9-year period when 2.4 million solar panels were operating. The highest probability of a solar photovoltaic (PV) fire occurring is 0.00167% as shown by Table 1 below. The same operation was used to determine the chance of getting struck by lightning. Below, Table 2 shows that you are more likely to be struck by lightning than have your solar panel catch fire.

Statistics

Table 1.
Yearly Probability of Solar Fire

Country	Probability of Solar Fire
Germany	0.00046%
UK	0.00167%
Japan	0.00006%

Table 2.
Yearly Probability of Select Events

Event	Probability of Occurrence
Struck by lightning	0.0065%
Home catching Fire	0.24%
Dying to a home fire	0.1812%

Why do PV fires occur?

Solar fires are mostly due to poor installation, maintenance, and component damage. For instance, the infamous Walmart solar panel fires occurred because of Tesla not following proper industry protocol and standards. Also, as with all electrical devices, there is a chance of a fire occurring due to arcing and hotspots.

Industry Standards

Industry standards are updated to maximize efficiency and safety. The Institute of Electrical and Electronics Engineers (IEEE) gives guidelines on how a solar PV system can be tested for adequacy before being installed. In order to run these tests, proper sensors with a range that can handle the circuits maximum voltage and current [4]. These maximum current and voltage values can be calculated properly from the National Fire Protection Association (NFPA) 70. Article 690.8 in NFPA 70 grants flexibility by allowing a licensed professional engineer to calculate the maximum current using an industry standard method rather than the method given by NFPA [5]. Indiana's electrical codes are based off NFPA 70 and its fire codes are based off the 2014 Indiana Fire Code. The Indiana Fire Code calls for PV systems to be properly marked and have its DC wiring in such a manner to reduce trip hazards as well as maximize ventilation [6]. The DC combiner boxes should also minimize the connection lengths between arrays. Residential structures are limited so that a PV array cannot exceed a 150 ft x 150ft area [6].

Solar PV Applications

Solar Farms

Figure 1. shows an example of a solar farm in Minnesota. In Indiana, the Indianapolis International Airport has used the idea of solar farms to help reduce the cost of the airport. It has reduced its running cost while outputting 17.5 megawatts AC (22.2 megawatts DC) of electricity. It also has not experienced a single solar fire, even though it contains over 76,000 solar panels [1].

Rooftop Solar

Grounded solar farms aren't the only way PV systems can be set up. Figure 2. shows a common use of rooftop solar. The Rockville Solar II Project in Indiana can produce over 4 million kWh annually [2]. The Major General Emmett J. Bean Federal Center also uses solar panels to offset cost of operation. In fact, it can save $500,000 annually [3].

Figure 1.
Solar Farm at Red Wing Minnesota

Figure 2.
House with Solar Panels at Blue Knob Australia

Conclusion

Solar PV fires are an extremely rare occurrence. The causes for those rare occurrences boil down to poor installation, maintenance, and components. Quality installation and maintenance that adheres to industry standards is the best prevention to solar fires that both businesses and homeowners can have. A professional, trusted company that follows industry standards is paramount. A PV system is safe when installed and maintained correctly with quality parts, regardless of size or location.

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12.10 APPENDIX J – Solar Panel Recyling

Abstract

Solar energy is one of the fastest growing energy sources in the United States and is only expected to provide more clean energy as time goes on. Solar panels harvest the energy and can typically last around 20-30 years. However, solar panels have some toxic chemicals in them and many worry about what happens to solar panels once they need to be decommissioned. Research from the Environmental Protection Agency, the Department of Energy, the International Renewable Energy Agency (IRENA) and academic works show that if they are disposed of properly, about 95% of a solar panel can be recycled. Not only that, but by 2050 it is estimated that over 2 billion solar panels can be created solely from recycled solar panels. As research and development around the world continues to progress, a higher percentage of solar panel parts are expected to be recyclable by the time a majority of recently installed solar panels are decommissioned in the mid-2030s and 2040s.

Introduction

Perhaps one of the most common questions people have about solar panels is what happens to them once they run their use. Solar panel deployment is rapidly growing, as more than 2/3 of solar panel installations in the United States have been built in the last five years (Department of Energy). In Indiana specifically, thousands of homes are installing solar panels on their roofs (small scale deployment) while the country's largest solar farm – Mammoth Solar- is under construction between Starke and Pulaski County (large/ utility scale). Solar panels are typically insured for 20-30 years, so the issue of what to do with individual panels is not an immediately pressing issue. However, there is significant concern surrounding the materials used to make panels, as some of the material within the panel is considered toxic. Fortunately, there are federal regulations in place for what to do with solar panels once they have run their course, and much of the material inside can be recycled, significantly reducing waste and potential for harmful seepage into the environment.

Solar Panel Makeup

There are two types of solar panels in the market: silicon-based PV panels and thin-film based PV panels. Silicon based PV panels are more common in the United States, making up a large majority of the panels currently in use, although there is a significant number of thin film-based PV panels in use as well. Also, silicon-based PV are more efficient, but also slightly more expensive. Thin-film based PV panels are in the early stages of development compared to silicon-based panels, explaining the difference in deployment. The majority of both panels are glass based, although the difference in materials inside the glass leads to different recycling methods. In general, silicon-based PV panels are made up of 76% glass- the casing that holds the solar cells- 10% plastic, 8% aluminum, 5% silicon, and 1% copper and other metals (IRENA). On the other hand, thin film-based PV panels are much more heavily glass based: 89% of the panels are glass, 4% plastic, 6% aluminum, and 1% copper and other metals. Glass is one of the most commonly and easily recycled materials, Fortunately, for both types more than 80% of the materials can be reused (Solar Energy Industries Association). However, some of the materials within the glass, such as lead and cadmium, can seep into the soil and harm the environment if not properly disposed of, meaning that for both types of panels proper disposal are essential.

Future Waste Projections

To build the infrastructure needed to properly dispose of solar panels, it is important to get a general estimate for how much waste solar panels are projected to produce. Solar panels are generally insured for 20-30 years, but after about 10 years they start to lose some of their efficacy (IRENA). This efficiency loss could lead to some stakeholders disposing of their panels before their life span is up, so all projections are general estimates. At the moment, the EPA is projecting between .17 and 1 million tons of waste from solar panels by 2030 (Environmental Protection Agency). In comparison, there is over 200 million tons of solid waste produced each year in the United States. The International Renewable Energy Agency (IRENA) created model projections for 2050 based off early loss- disposing of solar panels before their 20-30 year lifespan is up- and regular loss projections, assuming the disposal of solar panels 20-30 years after deployment. Under early loss projections, the United States is expected to dispose of about 11 million tons per year while the under regular loss models it would be about 8 million tons (IRNEA). In comparison, China would dispose of about 22 million tons under the regular loss model.

Resource Conservation and Recovery Act

At the moment, there is currently no specific solar panel disposal regulation in the United States – although some states do have their own regulations. This means that the Resource Conservation and Recovery Act (RCRA) is the guiding legal principle for solar panel disposal. Different producers include different quantities of toxic metals in their solar panels, so solar panels need to be tested for their toxicity (Environmental Protection Agency). The RCRA sets up sites where these hazardous materials can be dropped off for proper disposal, where they will then be tested and disposed of according to the metals inside. Although the RCRA technically allows for the export of hazardous materials to other countries to be disposed of in landfills, this practice is rapidly falling out of favorability.

Recycling

Although federal regulation only requires that solar panels are disposed of at the proper locations, those locations do have the opportunity to recycle the panels. Since silicon-based panels and thin-film based panels are constructed from different materials, the recycling mechanism varies depending on the panel. However, due to the high use of glass and other recyclable materials, between 90-96% of the material within a solar panel can be recycled depending on the construction process.

Silicon Based Panel Recycling

The first step in silicon-based solar panel recycling is to disassemble the aluminum and glass from the panel. The glass and aluminum are then recycled in their proper recycling mechanism, leading to 95% of glass and near 100% of the aluminum to be recycled. From there, the plastic and other metals get melted, and the plastic can then be used as a heat source for other projects. The solar cells are then separated from the module – which can usually be reused- and the wafers (the individual pieces within a cell) are then melted and about 85% of the silicon can be reused. All in all, about 95% of the silicon-based solar panels can be repurposed in new solar panels or other materials (Vekony).

Thin-film Based Recycling

Once thin-film based panels are collected, the first step is to shred the panels into thin strips. The solids and liquids are then separated, and the liquids have water and metals pulled out, resulting in 95% of semiconductor materials being recycled. The glass is then rinsed and recycled, meaning 90% of the glass can be recycled. This means just over 90% of materials in thin film-based solar panels are reusable, but newer models have a higher rate of recyclability (*Matthews)* Figure 1 from Greenmatch.com -using information from IRENA and Brookhaven National Laboratory- shows the process used for recycling each type of solar panel (Vakony).

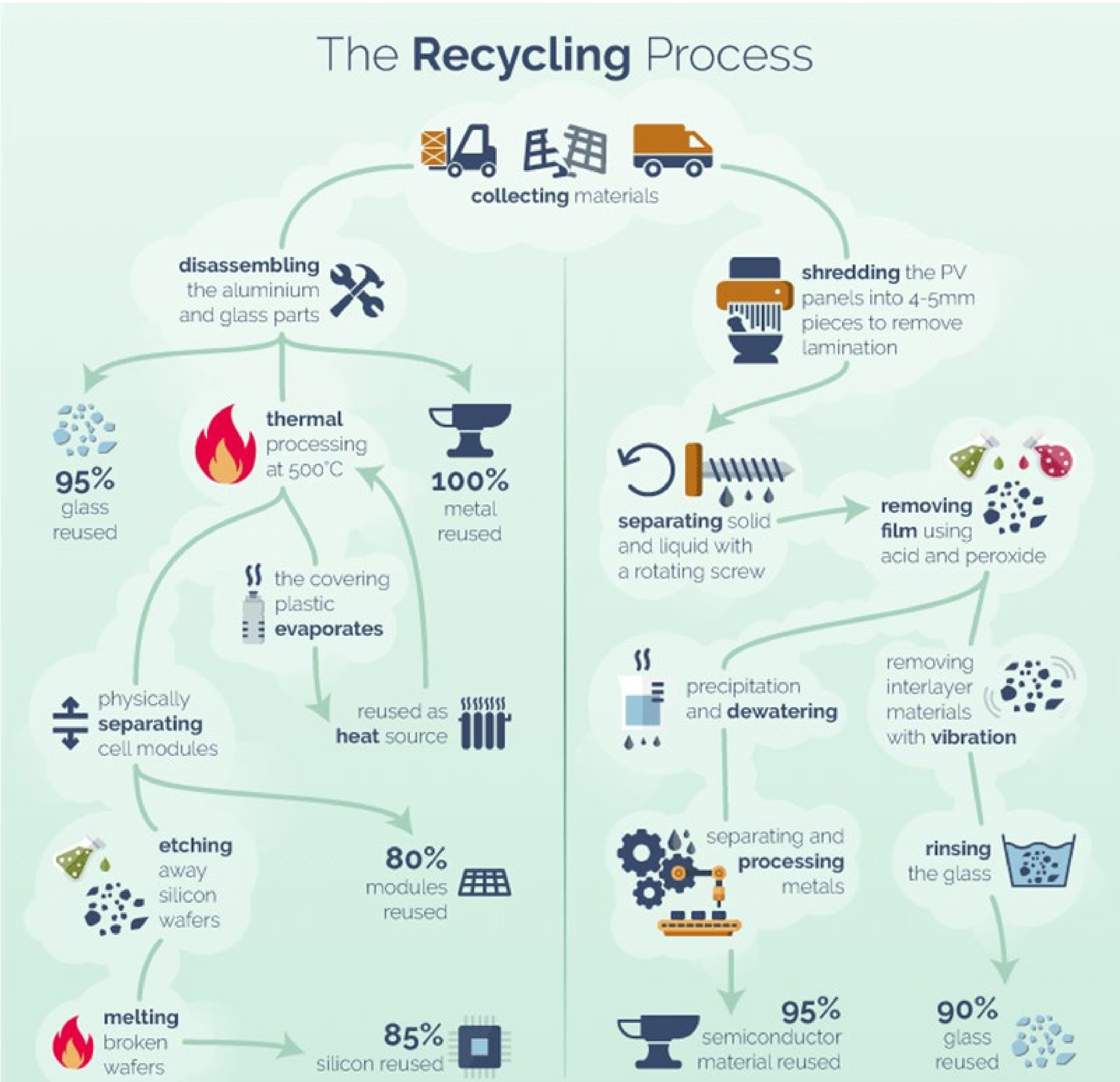

Figure 1. Recycling process for different types of solar panels from greenmatch.com

Indiana Specific Recycling

Only four states in the United States have specific regulations regarding solar panel disposal, and Indiana is not one of them. This means that solar panels in Indiana only need to comply with the RCRA. IDEM helps coordinate disposal and there is an RCRA site that can help coordinate drop off by closest location and disposal, with over 17,000 locations in the state. However, many individual solar sites- both in Indiana and around the country- require decommissioning plans. For example, the Mammoth Solar site application required a concise decommissioning plan explaining what would happen to solar panels once they needed to be retired (although the information is not publicly available at time of publishing) (Parzyck).

Solar Panel Disposal Around the World

Different countries / regional organizations have different regulations regarding solar panel disposal. IRENA has compiled the regulations for a handful of countries for a handful of countries which will be detailed below (IRENA). Only the EU has specific regulations surrounding solar panel disposal, but most other countries are heavily funding research and development regarding solar panel recycling.

European Union

In 2014, a specific law regarding the disposal of solar panels went into effect. The policy has three main pillars. The first is that the solar panel producers are financially responsible for the recovery and recycling of solar panels used by private households and come up with a compliance scheme for solar panel renewal. The second and third pillars state that producers have to report the number of panels sold and recovered and the proper labeling of panels. Individual countries are tasked with detailing how the recovery and recycling are carried out. In general, countries recycle the materials in panels to be either reused in other panels or other goods.

Japan

Like the United States, Japan has no specific laws surrounding solar panels. They also classify solar panels as a hazardous material and dispose of them in their national hazardous waste law. However, Japan is considering adding an amendment to the law outlining specific practices for solar panel recycling. They have funded a project aiming to slash the cost of recycling by streamlining the recycling process.

China

At the time of writing, China has deployed the most solar panels of any country in the world. However, they also do not have specific regulations surrounding solar panel disposal. They recycle about 90% of the solar panels that they use but the low-grade silicon used in the panels make most of the silicon non-reusable.

Future Options

Like many of the countries mentioned in the previous section, the United States is funding research and development into new ways to recycle solar panels. The Department of Energy Solar Energy Technologies Office has funded several projects with this aim. They work with the National Renewable Energy Laboratory (NREL) to run life-cycle analysis of solar systems as well as research on recycling of these systems (Environmental Protection Agency). Based on projections on increases in solar panel recycling and IRENA's solar panel waste projections, the Department of Energy suggests that by 2030, $450 million worth of raw materials can be recovered from solar panels which can be reused into 60 million solar panels, and by 2050 $15 billion worth of raw materials can be recovered from solar panels to be used in 2 billion solar panels around the world (Department of Energy). Many non-NREL researchers are also looking for ways to recycle solar panels, including filtering out impurities in silicon wafers and using the high-quality silicon to remake panels (Heath et al.) At the moment this is an expensive practice, but with enough research and development, it is possible that this becomes cost effective by the time many solar panels start to approach the end of their use. Another recently published article investigated three methods for recycling solar panels and discovered that reusing the solar module was the most cost-effective recycling technique, while chemical processes could be used to recover the lead and silver in the panels and prevent any potential environmental harm (Tao et al.). By and large, solar panel recycling is a heavily funded area of study, with national agencies and academics alike looking to increase the 95% recyclability rate of solar panels to a near 100% reusability.

Conclusion

To sum up if solar panels are recyclable, the answer is yes- as long as they are disposed of properly. Both silicon-based and thin film-based solar panels are largely glass – an easily recyclable material- and many of the metals within the solar panel can be recycled to use in future solar panels. If improperly disposed of, the toxic metals can leak into the ground and cause environmental harm. For new solar farms, it is important to have a pre-paid escrow for proper solar panel removal and disposal at the end of its service life.

Both in the United States and around the world, countries are heavily investing in solar panel recycling research and development to increase the current rate of recyclability of solar panels- about 95%- to an even higher rate of 98 or 99%. By making solar panels almost entirely recyclable, that would reduce the environmental harm caused by solar panel mining and waste as well as be economically efficient as it would save on mining cost. Many already-installed solar panels still have 15 or 20 years left of use and recyclability is only expected to improve as time goes on. Therefore, although solar panels do have some toxic materials within them, they are still harmless as long as they are disposed of properly.

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12.11 APPENDIX K – Solar Panel Recyling Data Card

Can Solar Panels be Recycled?

As long as they are properly disposed of, **Yes**! About 95% of a solar panel can be recycled

More Detailed Answer:

Solar energy is one of the fastest growing energy sources in the United States and is only expected to provide more energy as time goes on. Solar panels harvest the energy and can typically last around 20-30 years. However, solar panels have some toxic chemicals in them and many worry about what happens to solar panels once they need to be decommissioned. There are two main types of solar panels on the market: silicon-based PV panels and thin-film based PV panels. Silicon-based panels are 76% glass while thin-film based PV panels are 89% glass. Since glass is easily recyclable, that means a majority of solar panels are recyclable. Many of the materials within the solar panels, like plastic, silicon, and copper, can be recycled as well. There are some toxic chemicals within solar panels – like lead and silver- that can be harmful if they spill into the environment, but as long as solar panels are properly disposed of that should not be a problem. There is no specific solar panel recycling law, but the Resource Conservation and Recovery Act – a piece of federal legislation that covers hazardous waste disposal- governs solar panel recycling. There are over 17,000 RCRA compliant disposal centers in Indiana.

By 2030, the EPA projects that there will be between .17 and 1 million tons of waste from solar panels. For comparison, there is over 200 million tons of solid waste in the United States produced each year. By 2050, the United States is estimated to generate about 8 million tons of waste from solar panels, the second most in the world behind China which is estimated to dispose of 22 million tons. However, if properly recycled, those numbers can be dramatically slashed. Not only that, but if solar panels are recycled, then the International Renewable Energy Agency (IRENA) estimates that over 2 billion solar panels can be created from recycled solar panels in the United States by 2050.

Currently, about 95% of a solar panel can be recycled depending on the make and components of a solar panel. Around the world, only the EU has a solar panel specific recycling system, while many other players, like Japan and China have a system similar to the United States. China and Japan both heavily fund research into solar panel recycling. In the United States, the Department of Energy funds many projects with the National Renewable Energy Laboratory to make solar panel recycling more efficient and allow for more solar panel materials to be recycled. Additionally, many academics (see below) also do research into making solar panel recycling more streamlined. By the time many solar panels need to be decommissioned in the 2030s and 2040s, solar panel recycling will be even more efficient and commonplace than it is now.

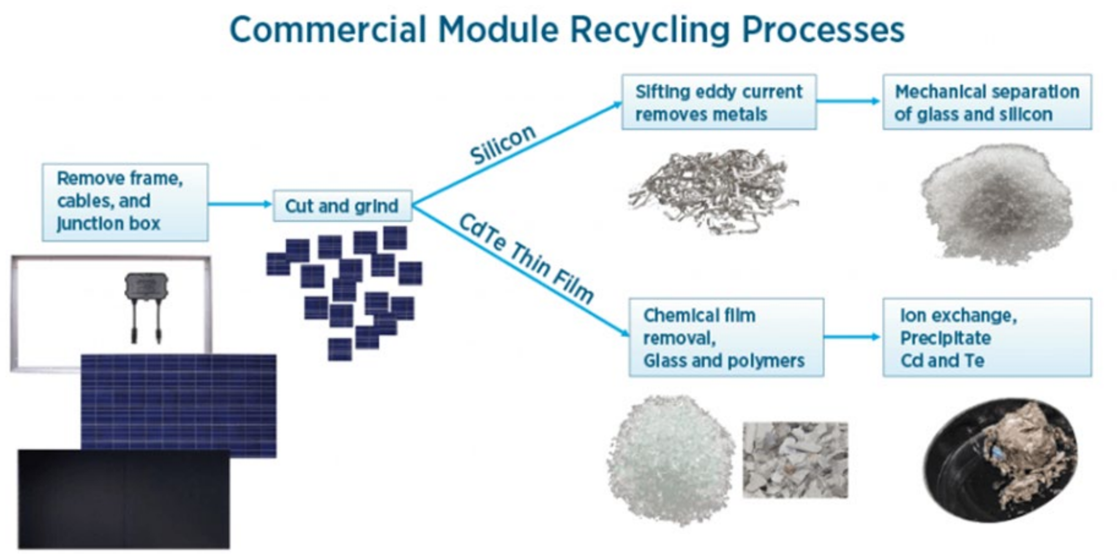

Figure 1 Figure from Department of Energy showing process for recycling silicon-based solar panels

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[1] Many academic sources charge to read their articles, so beware that some free sources are trying to push an agenda- either pro or anti solar

12.12 APPENDIX L – Bat Kills by Wind Turbines

Wind Turbines and Bat Fatalities in Indiana

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Student: Nicholas Parvex

Richard G. Lugar Center for Renewable Energy, IUPUI

Good Questions Project

Executive Summary

Bat fatalities caused by collisions with wind turbines is a well-researched and documented phenomenon. Wind turbine collisions and white-nose syndrome (WNS) are widely considered the leading causes of bat deaths both nationally and globally. However, wind farms and WNS tend to impact different types of bats. Wind turbine collisions disproportionally kill migratory tree bats, specifically the eastern red bat (*Lasiurus borealis*), silver-haired bat (*Lasionycteris noctivagans*), and the hoary bat (*Lasiurus cinereus*), whereas WNS tends to infect cave dwelling bats like the Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*). Post-construction mortality reports at wind facilities in Indiana support research that migratory tree bats are killed by wind turbines with more frequency than other types of bats. Populations of cave-dwelling bats in Indiana have dropped significantly since 2009 because of WNS and is currently the biggest threat to the Indiana bat and the northern long-eared bat. Methods such as feathering wind turbines below cut-in speeds of up to 5.5 m/s during specific times of the day and year have been shown to reduce bat mortality at wind facilities by over 70%. Studies into acoustic deterrents have also shown promise in reducing bat mortality at wind facilities although more large-scale research is needed.

Introduction

The Good Questions Project, developed by the Richard G. Lugar Center for Renewable Energy at IUPUI in collaboration with the Indiana Economic Development Association (IEDA), is a venture aimed at answering communities' questions about renewable energy. The purpose of the project is to investigate local concerns and outline facts about the implementation and use of renewable energy systems.

This report will examine bat fatalities caused by wind turbines in Indiana, preventative measures that are currently being taken to mitigate fatalities and provide contextual references regarding bat fatalities. The goal of this report is to inform the public and policy makers and to propose potential legislation that can be instituted to prevent further damage to bat populations in Indiana.

As the climate situation becomes more dire, the need for renewable and sustainable energy sources also increases. In Indiana, wind energy has been identified as having the potential to produce massive quantities of electricity for not only Hoosiers but also for populations in the surrounding states. This has resulted in a lot of interest and development of large-scale wind farms in Indiana.

The increase in development of large-scale wind farms raises concerns regarding the potential impact these wind farms could have on the surrounding ecosystems. The negative impact of wind turbines on various species of bats in Indiana and across the country has been of particular focus and used as ammunition in opposing the development of wind farms. Although wind turbines do cause bat fatalities, this argument is not often discussed relative to other causes of bat deaths. This report will present research pertaining to bat fatalities at wind facilities in Indiana and North.

Bats

Bats are mammals belonging to the order *Chiroptera*. They exist in almost every environment in the world, with the exception being some oceanic islands, the Arctic, and Antarctica. There are over 40 distinct species of bats that live in the United States. Most bats are nocturnal, and hunt for food at night. During the daytime, bats roost in dark, secluded places including caves, rock crevices, under bridges, tree canopies, and abandoned buildings. Most bats in the United States are insectivores, meaning they feed exclusively on insects. Many of these insects are considered pests, such as mosquitos, beetles, and moths. Estimates place the agricultural impact of bats to be between $3.7 and $53 billion annually **[1]**. Bats use echolocation to find and capture flying insects at night. Most bat species in North America have single litters and single young. This makes them vulnerable to endangerment and poses additional barriers to population recovery.

Bat species in the U.S. can be divided into two groups based on behavior during cold temperatures and food availability: cave-hibernating bats and migratory tree bats. Cave-hibernating bats overwinter in shelters that maintain stable temperatures, such as caves and mines. Over-wintering typically occurs from late fall-early winter to spring of the following year; however, there are a multitude of factors that can influence when hibernation starts and ends. After waking from hibernation, female cave-hibernating bats start identifying and moving between roosting sites and forming maternity colonies. Cave-hibernating bats begin swarming and mating late summer-early fall. They typically do this near their hibernacula (location of hibernation). Migratory tree bats have similar life cycles to that of the cave-hibernating bats, with the main difference being that they spend August to October migrating latitudinally to warmer climates. They may spend parts of winter in a temporary torpor but are still much more active than their cave-hibernating cousins and will spend large parts of their time feeding. After winter ends and insect prey returns, they migrate back to their summer habitats **[2]**.

Monitoring bat populations has proven to be a challenging task for the science community. Their reclusive nature and nocturnal behavior are only a few of the barriers that make it difficult to track bat populations. Other obstacles include hibernation locations and roosts being well hidden and/or inaccessible, large variances in bat behavior across different species, and the wide geographical range that bats can be found inhabiting **[3]**. Lack of population knowledge attributes to difficulties determining when species are in danger of extinction.

Thirteen distinct species of bats have been identified in Indiana. Six (big brown bat, gray bat, Indiana bat, little brown bat, northern long-eared bat, eastern pipistrelle) of which use sites such as caves, mines, or tunnels for hibernacula during winter months and trees, caves, and/or other structures for summer roosts. Four species (eastern red bat, evening bat, hoary bat, and silver-haired bat) are found either during summer reproductive months or spring and fall migrations. Three of the thirteen species are exceptionally rare in Indiana. All bats that occur in Indiana are insectivores and provide an extremely important service to the agricultural industry by feeding on pests **[4]**.

Wind Turbines & Bats

Bat fatalities caused by collisions with wind turbines is a well-researched topic. However, the exact annual number of wind turbine-related bat fatalities is unknown, as is the impact that these fatalities have on bat populations. This is in part due to intrinsic biases in the methodology of tracking bat fatalities, along with the lack of knowledge regarding the populations of different species of bats **[5]**. Wind turbine facilities failing to track bat deaths and/or refusing to make bat mortality reports public also serve as a barrier in determining the number of bat deaths at wind facilities. There is currently no single way in which bat fatality models are created, this has led to some variance in terms of the projections of bats dying at wind facilities. It is estimated that over 500,000 bats are killed annually at wind facilities **[6], [7]**. Wind turbine collisions and white-nose syndrome (WNS) are widely considered the leading causes of bat deaths both nationally and globally **[8]**.

Multiple studies have found that the majority (>90%) of bats that die at wind facilities are migratory tree bats, specifically the eastern red bat (*Lasiurus borealis*), silver-haired bat (*Lasionycteris noctivagans*), and the hoary bat (*Lasiurus cinereus*) **[2], [5], [6], [9]**. This appears to be true in Indiana as well. Over 80% of the bat carcasses collected from Fowler Ridge Wind Farm in Benton County in 2017 and Wildcat Wind Farm in Madison and Tipton Counties in 2016 were composed of the eastern red bat, silver-haired bat, and the hoary bat. In both cases, there were no Indiana bat carcasses collected **[10], [11]**. To date there have only been 29 recorded deaths of Indiana bats at wind facilities and 15 of those have occurred in Indiana **[12]**. There are no statewide Indiana specific studies pertaining to bat fatalities at wind facilities. Fowler Ridge Wind Farm and Wildcat Wind Farm are the only wind facilities that have performed and made public post-construction fatality reports. These facilities make up a minority of wind farms in Indiana.

Mitigation Efforts

The awareness of the negative impact that wind farms have on bats has caused a lot of research and development into mitigating bat fatalities. In 2011, an experiment was performed at the Fowler Ridge Wind Farm to determine the effectiveness of feathering turbine blades below multiple different cut-in speeds for reducing bat fatalities. The experiment was performed at night during spring (April 1 - May 15) and fall (July 15 – October 29) when bat migrations are most common. Feathering below 3.5, 4.5, and 5.5 m/s cut-in speed corresponded to a 36.3%, 56.7%, and 73.3% reduction in fatality rates respectively **[13]**. Many similar studies that have been performed at wind facilities across the United States and Canada have come to a similar conclusion **[14]**. A meta-analysis published in 2021 that checked the effectiveness of curtailing wind turbine speeds to reduce bat mortality also concluded that wind facilities that implemented this practice saw reductions in bat mortalities in the range of 50% **[15]**. In 2015, the wind industry endorsed this practice to reduce bat fatalities, specifically during periods where bat migration is more frequent **[12]**. Using acoustic deterrents at wind farms is another method that has been studied to decrease bat fatalities at wind farms. Results have shown that the implementation of such technologies could greatly reduce bat mortality at wind facilities **[16], [17], [18]**.

Context

White Nose Syndrome (WNS)

White-nose syndrome (WNS) is a disease caused by the fungus, *Pseudogymnoascus destructans* (Pd). The disease got its name because it can sometimes appear as white fuzz on bats' faces. It grows in cold, dark, and damp places which is why it primarily affects cave hibernating bats. Twelve different bat species in Indiana have been affected by WNS. An estimated 6.7 million bats have died since 2006 because of WNS with some caves exceeding 90% mortality rates. There are 21 WNS-affected hibernacula in Indiana that host long-term winter bats. A comparison of bat populations in Indiana from 2017-2018 to 2009, pre-WNS prevalence in Indiana, has shown a decline of 17% in bat populations. The disease has negatively impacted tri-colored bats, big brown bats, and Indiana bats more than other bat species in Indiana **[19]**.

Habitat Loss

Cave disturbances and habitat loss were considered the most imminent danger to bats prior to WNS and the advent of commercial wind farms. Bats are very sensitive to disturbances when hibernating and roosting and the commercialization of caves has resulted in some bats having to relocate their hibernacula. Disturbances during hibernation has been shown to negatively impact the health of bats. Loss of forest cover due to land-use changes has contributed to declines in bat numbers, especially among bats that roost in trees **[20]**. Changes in forest habitats have also raised concerns regarding the abundance of insect prey **[2]**.

Efforts have been made in Indiana to mitigate habitat loss and damage. The Nature Conservancy's (TNC) Indiana Chapter established the Bat Conservation Bank of Indiana, which protects two caves and 673 acres of surrounding habitat that are critical for the Indiana bat and the northern long-eared bat **[21]**.

Conclusion

On a national scale, the negative impact of wind facilities on bat populations is a known fact and the more wind facilities that are developed the greater the concern becomes. The impact that wind facilities in Indiana are having on bat populations is unknown due to the lack of research and documentation by wind energy companies that function within the state. Research and experiments performed in Indiana and other parts of the United States have proven that feathering wind turbines decreases bat fatalities.

Proposal

The first step that could be taken in Indiana to reduce animal fatalities in general at wind farms is to require that wind energy companies create a habitat conservation plan prior to erecting wind farms. Doing so would determine the impact that said wind farm would have on the local ecosystem and provide solutions to minimize any negative impacts that could entail. Legislation could also be passed requiring that wind facilities track bat/bird fatalities and require that if the fatalities per megawatt are above some predetermined mark, the wind energy company is required to implement fatality mitigation measures.

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12.13 APPENDIX M – Wind Turbines and Bat Fatalities Summary

Richard G. Lugar Center for Renewable Energy

Concern: Wind farms are endangering populations of bats that hibernate and roost in Indiana.

Answer: Bat fatalities caused by wind turbines does occur and is a concern of both the scientific community and of wind energy companies. Indiana bats and the northern long-eared bat make up less than 1% of bat fatalities at wind facilities. Methods of mitigation such as turbine feathering, and acoustic deterrents has shown to reduce fatalities by as much as 73%.

BATS

Bat species in the U.S. can be divided into two groups based on behavior during cold temperatures and low food availability: cave-hibernating bats and migratory tree bats. Monitoring bat populations has proven to be a difficult task. Their reclusive nature and nocturnal behavior are only a few of the barriers that make it difficult to monitor bat populations. Other obstacles include hibernation locations and roosts being well hidden and/or inaccessible, large variances in bat behavior across different species, and the wide geographical range that bats can be found inhabiting.

Thirteen different species of bats have been identified in Indiana. Six (big brown bat, gray bat, Indiana bat, little brown bat, northern long-eared bat, eastern pipistrelle) of which use sites such as caves, mines, or tunnels for hibernating during winter months and trees, caves, and/or other structures for summer roosts. Four species (eastern red bat, evening bat, hoary bat, and silver-haired bat) are found either during summer reproductive months or spring and fall migrations. Three of the thirteen species are exceptionally rare in Indiana

WIND TURBINES & BATS

Bat fatalities caused by collisions with wind turbines is a well-researched phenomenon. The exact annual number of wind turbine related bat fatalities is unknown as is the impact that these fatalities have on bat populations. There is currently no single way in which bat fatality models are created, this has led to some variance in terms of the projections of bats dying at wind facilities. However, many studies estimate that over 500,000 bats are killed annually at wind facilities.

Most fatalities at wind facilities are migratory tree bats, specifically the eastern red bat, silver-haired bat, and the hoary bat. Over 80% of the bat carcasses collected from Fowler Ridge Wind Farm in Benton County in 2017 and Wildcat Wind Farm in Madison and Tipton Counties in 2016 were composed of the eastern red bat, silver-haired bat, and the hoary bat. In both cases, there were no Indiana bat carcasses collected. To date there have only been 29 recorded deaths of Indiana bats at wind facilities and 15 of those have occurred in Indiana (Pruitt and Reed, 2022).

TUBINE FATALITY MITIGATION EFFORTS

An experiment performed at Fowler Ridge Wind Farm in 2011 found that feathering wind turbines in the evenings of spring and fall reduced bat mortality rates by 73% (Good et al. 2018). Similar studies performed at wind facilities across the United State have yielded the same results. The use of acoustic deterrents has also been found to decrease bat mortality at wind facilities; however, more large-scale experiments are needed before implementation.

WHITE-NOSE SYNDROME (WNS)

White-nose syndrome (WNS) is a disease caused by the fungus, *Pseudogymnoascus destructans* (Pd). The disease got its name because it can sometimes appear as white fuzz on bats' faces. It grows in cold, dark, and damp places which is why it primarily affects cave-hibernating bats. An estimated 6.7 million bats have died since 2006 because of WNS with some caves exceeding 90% mortality rates.

There are 21 WNS-affected hibernacula in Indiana that host long-term winter bats. A comparison of bat populations in Indiana in 2017-2018 to 2009 shown a decline of 17% in bat populations. The disease has negatively impacted tri-colored bats, big brown bats, and Indiana bats more than other bat species in Indiana. In the past 10 years, some populations of cave-hibernating bats are thought to have declined by as much as 95%.

HABITAT LOSS

Habitat loss and cave disturbances were once considered the most serious threat to bats. The commercialization of caves has negatively impacted bat species that depend on these unique structures for hibernating and roosting. Degradation of forest habitats have resulted in a decrease in the abundance of insect prey and destruction of tree roosts that serve as shelters for tree bats.

Efforts have been made in Indiana to mitigate habitat loss and damage. The Nature Conservancy's (TNC) Indiana Chapter established the Bat Conservation Bank of Indiana, which protect two caves and 673 acres of surrounding habitat that are critical for the Indiana bat and the northern long-eared bat

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12.14 APPENDIX N – List of Energy Groups Active in Indiana

Presented here is a list of organizations involved in new energy project developments and the considerations and planning of them. This list was compiled from multiple sources, and shared with the State to ask if any had been overlooked as of 31 May 2022. Note that new groups can form quickly, and some groups gradually dissolve, so this list will become increasingly outdated as time goes on. Please see the methodology sections listed above for the means by which this original list was developed, so that you may create an up-to-date version.

Sources of Anti-Renewable Energy Information

- Institute for Energy Research (IER)[1]
- National Wind Watch[1]
- Stop These Things: The Truth about the Great Wind Power Fraud[2]
- Stop-Solar: Stop Solar Farms in Residential Areas[3]
- Wildlife Energy and Community Coalition[4]
- WindAction Group[5]

Anti-Renewable Energy Groups

- Adams County Concerned Citizens[6]
- Boone County – Union Marion Citizens for Responsible Development[7]
- Cass County Indiana Property Rights[8]
- Fulton County Indiana Property Rights[8]
- Henry County, IN Solar Awareness[9]
- Hoosiers for Reliable Energy[10]
- Huntington County Concerned Citizens[8]
- Miami County Indiana Property Rights[8]
- No Wind Farm Henry County[8]
- No Wind Farm Montgomery County, IN[1]
- No Wind Farms in Dekalb County[1]
- NO WIND FARMS IN DEKALB COUNTY!!!![11]
- Posey County Citizens for Property Rights[12]
- Pulaski County Against Solar Project[13]
- Save Jasper County[14]
- Stop Jay County Wind Farms[8]
- Warren County Concerned Citizens[8]
- Wayne County Indiana Against Industrial Wind Turbines[1]
- Wells County Wind Turbine's Fact and Opinions[15]

Pro-Renewable Energy Groups

- American Clean Power Association[16]
- Citizens Action Coalition[18]
- Clean Grid Alliance[18]
- Energy Matters Community Coalition

- Environmental Law and Policy Center[27]
- Hoosier Environmental Council[18]
- Hoosier Interfaith Power and Light (IPL)[19]
- Hoosier Solar[20]
- Hoosiers for Renewables
- Indiana Agricultural Coalition for Renewable Energy (IN-ACRE)[21]
- Indiana Conservative Alliance for Energy[22]
- Indiana Distributed Energy Alliance (Indiana DG)[23]
- Land and Liberty Coalition (Indiana Chapter)[24]
- RPG Energy Group[25]
- Sierra Club Hoosier Chapter – Indiana Beyond Coal[26]
- Solar United Neighbors (Indiana)[27]
- Solarize Indiana[23]
- Vote Solar[27]

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[2] https://stopthesethings.com/
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12.15 APPENDIX O - Strategies for Security

Goal—*The purpose of this section is to provide insight into the security measures necessary for providing a safe space for the discussion of renewable energy projects and the information concerning them.*

Security Basics

Having security professionals at community events is an established practice. It may be common to have between two-and-four armed security officers to be present, generally covering the corners, or exits, of the venue[1]. The presence of security gives the community members peace of mind in knowing that they are free to express their opinions with minimal fear of intimidation or harmful confrontation. The security officers should be informed of the location/event at least one week in advance, to allow them to determine the proper number of officers to send to a given location, as well as the proper strategy for providing the best possible security. Security is provided through either the local police or sheriff's department, or a private security company licensed by the local police. It is generally a simpler process to have event security provided by the local police or sheriff's department. The Indiana Department of Homeland Security provides a document with safety tips for large events, and the first tip is about researching the event and lists the following scenarios to consider [2]:

- How many people are expected at the event?
- Where are the venue's exits?
- What are the emergency evacuation protocols for the venue?
- What is the contact information for security, first aid and lost property?
- What items are allowed, and what is prohibited?
- How might the day's weather (heat, cold, wind, storms) affect people at the event or driving to/from the event?
- What safety or security issues have been reported at similar events?

Police Security

The standard for security at county town hall meetings is to have multiple members of the local police department present, in order to dissuade and resolve conflict in a safe manner. Generally, two to four police officers will be present to provide security. There are often already procedures in place for such events, and local police departments are a viable option for security within their given jurisdiction. Oftentimes, security at community events is included within the pay structure of the local police department, however, in cases that it is not, a base hourly payment may be required (average $20-$50 per hour, per officer). For example, Chief Charles Ramsey, of the Washington D.C. Police Department, states that when hiring security for a public event it is always best to "err on the side of having too many rather than not enough [officers]".

Private Security

The second most common option is to hire private security for community events. The cost for each (unarmed) private security officer can range from $18-$50 per hour [3]. Hiring an armed security officer incurs a higher hourly rate, as additional certifications and licenses are required of the officer. The necessary licenses, permits, and event applications are all still necessary, even if the plan is to hire private security. Local police recommendations supersede private security recommendations.

Police Restrictions

There are duties that a police officer is prohibited from performing while at community events, and therefore volunteers or additional event employees may be required [1]. An officer is prohibited from:

1. Ticket taking, or ushering.
2. Carding individuals, or determining one's right to attend given event.
3. Collection of any money.
4. Parking assistance.
5. Enforcement of facility or management rules.

Hiring Security

The estimated number of attendees is the single most important factor in determining the extent of security necessary for an event. Generally, events with fewer than 200 attendees are considered lower for security risks. However, in recent years it has become common practice for at least two officers to be present at community events. The Department of Justice created a report for Planning and Managing Major Special Event Security [4], in which they provide the chart below for suggested risk levels at public events:

Exhibit 2. IAAM's Suggested Risk Levels at Special Events

DHS Rating	Risk Level	Venue Threat	Security Measures	Action Steps
Severe	5	Cancel	Secured	"Lock down" patrol perimeters restricting access
High	4	Maximum	Government Control	National law officials or security agencies screen public and take control
Elevated	3	Elevated	Restrictive	May involve regional or local law officials with "pat down" measures
Guarded	2	Moderate	Protective	Limited access to venue with screening precautions implemented
Low	1	Minimum	Routine	No primary factors of concern exist outside normal routine measures

Below this chart is a more specific list assessing factors that may increase or decrease risk at a public event, this list is provided by the police department of Peach Tree City, Georgia[5]. Peach Tree City is a town with a population of 34,000, which is typical of rural Indiana.

Factors that increase risk levels for any event	Factors that may decrease risk levels for any event
• The need for personal protection for speakers, performers or guests • Guest(s) will be at multiple locations • Non-city residents are invited to the event • Cash protection/deliveries • Anticipation of large ticket sales (or oversell) • Night time event • Outdoor venue • Live/amplified entertainment • Multiple events on the same day • Venues with multiple entrances • Traffic control needs • Sales of alcoholic beverages • Lack of timely notification to the Peachtree City Police to prepare • Other factors determined by the Peachtree City Police	• Guest(s) will at one general location • Events limited to invitation only • Competing event elsewhere will affect attendance • Patrons are screened for weapons at the entrance • Prior events of similar nature with no history of safety problems or required police actions • Day time event • Indoor Venue • Shorter duration of event • Historically poor ticket sales

After the preliminary permits and licenses required to hold a community event are obtained, an application for event security is then sent to the necessary police department (this is sent even if the plan is to hire private security). The police department may evaluate the application and the event specifications (attendees, size of venue, money exchanged, etc.), determine the number of security officials required, and make any changes to the event structure that it finds necessary to mitigate risk. Below is a useful chart provided by the police department of Peachtree City, Georgia [6] that outlines the recommended number of officers depending on event population:

	Low Risk		Medium Risk		High Risk		
Estimate # of Attendance	0-100	101-200	201-500	501-1000	1001-2000	2001-3000	3000+
Any public gathering	0	0	2 officers	3 officers 1 Supervisor	5 officers 1 sergeant Auxiliary Police	6 officers 1 Supervisor Auxiliary Police	for each 500 attendees 2 additional officers
Road Races & Walks (number will increase on the number of street crossings and the types of streets utilized)	Auxiliary Police	Auxiliary Police	2 officers	2 officers Auxiliary Police	5 officers 1 supervisor Auxiliary Police	6 officers 1 supervisor Auxiliary Police	For each 500 attendees 2 additional officers.
Live Concerts (the serving of alcohol may increase the number of officers required)	2 Officers	2 Officers Auxiliary Police	2 Officers Auxiliary Police	3 officers 1 sergeant Auxiliary Police	5 officers 1 sergeant Auxiliary Police	8 officers 2 sergeant Auxiliary Police	for each 500 attendees 2 additional officers Auxiliary Police

Police security typically requires a minimum number of hours for providing paid security. This is usually three hours, at a rate of $35-$50 per hour [3]. Once again, it is common for police security to be paid for by the state, or local government, making it less costly for event organizers.

While direct contact with County Sheriff's offices was hard to come by, I was able to speak with the Hamilton County Sheriff's office who provided some useful information. It is standard that only off-duty officers are hired out for event security, therefore it is crucial to make a Special Events and Off-Duty Employment Request at least 1 week in advance [8]. Hamilton County, like most other counties in the state, has a page on its website dedicated to security requests which has contact information for Sgt. Mark Barker (email and telephone) [7]. The Special Events and Off-Duty Employment Requests page may also be used to request risk assessments during which security measures are reviewed to enhance the safety of the event [7].

Communication

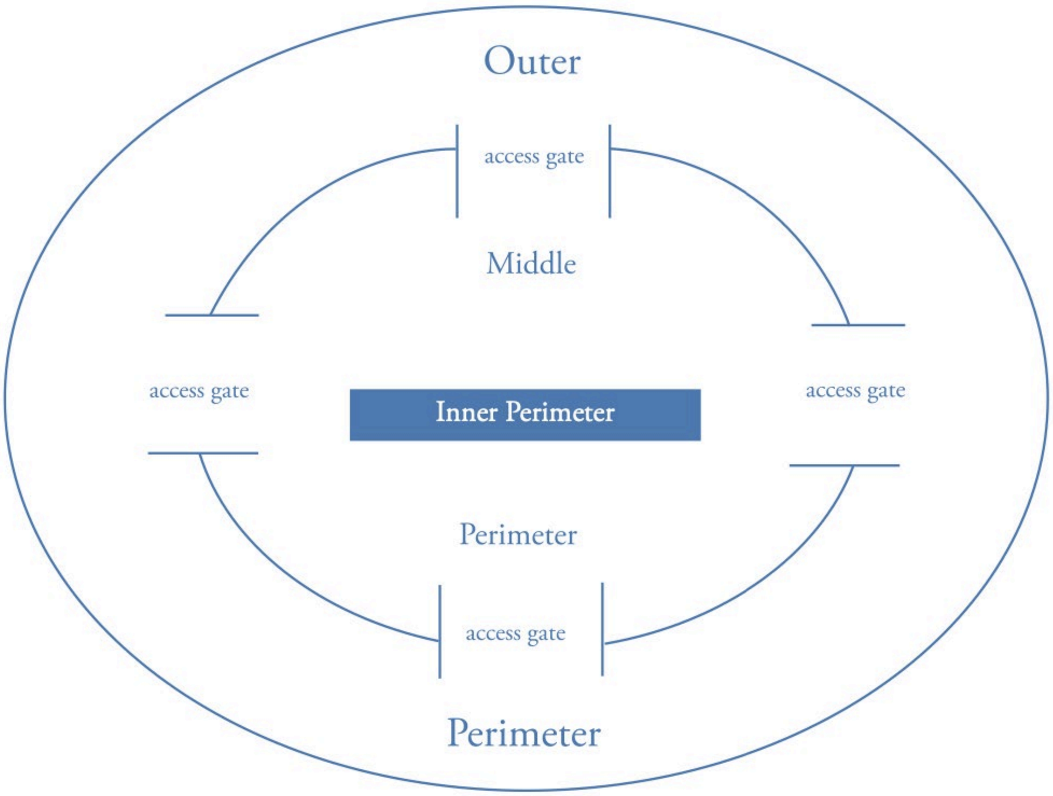
There are many important factors in providing adequate security, but none come before communication. According to the DOJ (Department of Justice), quick and accurate communication between security officers and event staff is the most important factor in ensuring safety at events. Often, officers from one location within an event may need to assist another officer at a different location. In an instance such as this, quick and accurate communications are absolutely crucial, so that officers are able to be present in the most important areas of the event, and quell any sort of trouble that may arise. As indicated above, for larger venues or higher perceived risk, the security force will include a sergeant trained in such communications. The DOJ provides this list of key questions regarding security communication at events [4]:

Key Questions to Ask:

1. Do we have a process in place to communicate regularly with all key partners?
2. Do we have adequate communications technology and equipment?
3. Do we have adequate communications backup?
4. Can we integrate radio communication among many different agencies involved in the event?
5. Are communications command center facilities adequate in size and scope?

Perimeter

When providing security, it is important to establish and secure clear perimeters (boundaries) for entry to the event. The DOJ suggests three theoretical perimeters for event security: an outer perimeter, a middle perimeter, and an inner perimeter [4]. The outer perimeter is where tickets/IDs/permits/event certification is checked and admission is granted. The middle perimeter is where the event attendees can gather, sit, or generally convene. The inner perimeter is then reserved for event hosts, speakers, or performers. The outer perimeter provides a barrier to check for weapons, as well as event admission. The middle perimeter gives the attendees a place to gather and be admitted, without encroaching on the space and privacy of the event hosts. The inner perimeter provides the event hosts peace of mind, as there is one more level of security between them and the attendees, providing them safety if needed. Below is an illustration of this concept [4]:



Physical Facilities

It is imperative that the venue itself is inspected prior to the event to ensure that all necessary aspects are functioning properly. The venue should be cleared of all objects that could be used as weapons, and the site should be properly cleared, cleaned, and inspected. It is best if the inspection is performed by a licensed Fire Marshall, or city/county building inspector. Below is a list of inspection areas provided by the DOJ [4].

Physical facilities inspection areas:

- Are all alarms in working order?
- Are security doors and gates alarmed?
- In case of fire evacuation, do doors automatically unlock?
- How are alarms monitored?
- Are emergency plans up to date?
- Do security planners have a floor plan?
- Are HVAC (heating, ventilation, and air conditioning), mechanical, gas, and other critical systems up to date?

Volunteers

Depending on the number of event attendees, the tasks required, and the structure of the venue, the local police department may require that a certain number of volunteers be present, in addition to the provided security [4]. If the required number of volunteers is not provided by the event organizer(s), the police department has the right to shut down the event, and/or revoke the organizer's right to plan and hold future events in that department's jurisdiction. Volunteers are most often required to perform the duties that police officers are prohibited from providing, see Police Restrictions section.

Handling Protests and Managing Demonstrations

Protests are a possible occurrence at events discussing energy policy and it is important to have a detailed plan in place for handling such an occurrence. Researching the groups likely to arrive and protest is helpful in determining the proper plan for managing the situation. Law enforcement must balance between protecting First Amendment rights and providing a safe and secure environment. Therefore, it is crucial that a discussion takes place prior to the event so that all security officers handle protests in the same fashion; consistency and fair treatment are of the utmost importance. Some key questions to ask when planning to handle protests and manage demonstrations are [4]:

<u>Key Questions to Ask</u>:

1. Have we received useful intelligence information to advise the security plan on anticipated protest movements at the event?
2. Do we have adequate support from police legal advisors?
3. Do we have sufficient numbers of trained mobile field forces to make mass arrests if necessary?
4. Have we issued rules of engagement to all field forces involved in event security?

There are a number of different tactics that a protestor may take advantage of, and it is important to understand the differences in the necessary responses to these tactics. Making arrests based on noisy outbursts is inadvisable, however, damage to property, or threats, requires a more serious response. It is advantageous to discuss possible protest tactics prior to an event so that security is prepared and consistent when responding. Below is a list of common protest tactics, provided by the DOJ [4]:

<u>Some of the common protestor tactics have included the following</u>:

- Stealing security fencing and erecting it to block streets
- Setting fires in the street
- Chaining themselves to objects (sewer gates, light poles) and each other to make it difficult to arrest them
- Locking their arms into concrete sleeves to make it difficult for police to place handcuffs on their wrists

- Moving dumpsters in the street or rolling them toward officers
- Bringing other large objects into the street
- Trying to “lockdown” an intersection by lying down in the street
- Erecting platforms and stages in the street
- Putting chains across an intersection
- Trying to disable police vehicles by flattening tires
- Using chemical irritants against officers
- Throwing hard objects (rocks, bottles) at police
- Using bicycles to lookout and report on police locations and tactics
- Using bicycles to block street traffic
- Communicating by cell phone
- Wearing gas masks, bandanas, and protective equipment to block the effect of chemical irritants
- Using baiting tactics including shouting insults, passive resistance, and videotaping officers

Event Checklist

Having a list of important areas, tasks, and processes integral to providing safety is a must when it comes to community events. The checklist is subject to change depending on the venue, time, and size of the event, as missing one step could result in a massive security failure. As a guideline for creating a more specific checklist, here is a general list provided by the DOJ [4]:

Illustrations of Event Security Management Checklist/To-Do’ Lists

- List of contact information (cell phone, pager, radio call sign, PDA, etc.) for main contacts (on-scene commanders, supervisors, etc.) of all other cooperating/involved agencies. This should be in alphabetical order by name
- Same list of key contact information but ordered by type of assignment or post (for example, supervisor on Access Gate A, supervisor in charge of SWAT team, etc.)
- List of contacts for key outside agencies that may be called in for support if not already involved in security of event
- Annotated summaries of security operational plan (full plan accessible)
- Annotated agenda of the event – what happens when and where – with key security notes added in
- Maps and geographic layouts showing codes for response locations (for example, Gate A, Blue parking lot, etc.)
- Contact all supervisors to determine if all personnel have checked in
- Check with all resources that have been placed on alert and on-call status – for example, K-9 team – bomb dog, bomb experts, helicopter access, etc.

Private Security Companies

Here is a list of private security companies in Indiana, with contact information.

1. Securitas- Phone: (317)568-1790, Address: 9101 Wesleyan Road #200, Indianapolis
2. Genesis Security- Phone: (317)620-1489, Address: 55 S State Ave #104, Indianapolis
3. Trinity Executive Services, Inc.- Phone: (317)890-1169, Address: 7009 56th Street, Suite F, Indianapolis
4. ESG Security- Phone: (317)261-0866, Address: 1060 N. Capitol Avenue, Suite E210, Indianapolis

References

[1] *Indy.gov*, IMPD, 2022, https://www.indy.gov/activity/request-an-impd-community-appearance.

[2] "Large Event Safety." *Indy.gov*, Indiana Department of Homeland Security, 2020, https://www.in.gov/dhs/files/Large-Event-Safety-Tips.pdf.

[3] "How Much Does a Security Guard Cost." *DMAC Security*, DMAC Security, 22 Feb. 2022, https://dmacstrategic.com/how-much-does-a-security-guard-cost/.

[4] Connors, Edward. "Planning and Managing Security for Major Special Events." *US Department of Justice*, USDOJ, 2020, https://cops.usdoj.gov/RIC/Publications/cops-w0703-pub.pdf.

[5] "Police Department." *Police Department | Peachtree City, GA - Official Website*, Peachtree City, 2020, https://www.peachtree-city.org/117/Police.

[6] "'I Need to Hire a Police Officer for Security or Traffic Control.'" *"I Need to Hire a Police Officer for Security or Traffic Control" | Peachtree City, GA - Official Website*, Peachtree City, 2020, https://peachtree-city.org/1171/Hire-a-Police-Officer-for-Security-or-Tr.

[7] "Special Events and off-Duty Employment Requests." *Special Events and Off-Duty Employment Requests | Hamilton County, IN*, Hamilton County, 2022, https://www.hamiltoncounty.in.gov/1322/Special-Events.

[8] Cold call to Hamilton County Sheriff's Office

*several local police and country sheriff's departments were contacted for information on event security however, most did not respond. Those that did respond were unable to share information due to security reasons.

14.0 Revision Log

Revision Date	Revision Description	Paragraphs Affected	Editor
26May22	Create outline and format	All	P. Schubert
28 May 22	Write my part for section 5 and part of section 6	5 and 6	F. Levy
9 June 22	Added info card to appendix 15.2	Appendix	P. Schubert
10 June 22	Added to Appendix and Finished part 6	6 and Appendix	F. Levy
11 June 22	Write part 7	7	F. Levy
13 June 22	Add C4EE questions	App E	P. Schubert
13 June 22	Added white paper summary 9.0 and Appendix F	Appendix F	N. Parvex
15 June 22	Uploaded diagram to Appendix C	Appendix C	N. Parvex
15 June 22	Added Infrasound white paper. Also modified Heading 2 style for 0.5 indent.	Appendix G	P.Schubert
20 June 22	Additional Introductory material. Formatting updates	Section 3.0	P. Schubert
20 June 22	Added List of Active Energy Groups	Appendix N	N. Parvex
21 June 22	Added White Paper to Appendix H	Appendix H	S. Poriah
21 June 22	Added Solar Turbine and Bats White Paper	Appendix M	N. Parvex
23 June 22	Final edits and revisions	All	P. Schubert and L. Lewellen
24 June 22	Move Security document to Appendix O; renumber all.	Former section 9	P. Schubert
4 July 22	Extract study of failed projects for Phase 2	Former section 7	P. Schubert
5 July 22	Address OED feedback	ALL	P. Schubert