A review of potential public health impacts related to industrial scale wind and solar energy

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Introduction

Public Health professionals, particularly those in local health departments, are guided in their practice by the Ten Essential Public Health Services Framework, which outlines the services necessary to promote and protect health and well-being. One of the Ten Essential Services[1] is to "create, champion, and implement policies, plans, and laws that impact health" which involves engaging in the key activity of "providing input into policies, plans, and laws to ensure that health impact is considered." Staff from Lawrence-Douglas County Public Health (LDCPH) regularly receive requests to review the potential health impacts of laws, regulations, policies, and practices which may have direct or indirect consequences for health and well-being to people living in its jurisdictions. In accordance with the essential public health services noted above, LDCPH seeks to respond to requests to explore, understand, and describe potential implications to the public's health from pending laws, regulations, policies, and practices.

In November 2023, LDCPH received a request to examine the potential implications of pending local regulations for industrial scale wind and solar energy from the Douglas County Administrator's Office. A brief meeting with staff from the Administrator's Office and a county commissioner further clarified questions and aims of interest. LDCPH agreed to create a product which responded to three overall questions:

1) What does the available peer-reviewed literature suggest about potential adverse public health issues resulting from the use of industrial scale wind and solar energy?
2) What evidence exists that supports constituent-generated public health concerns resulting from the use of industrial scale wind and solar energy?
3) What information exists about potential public health impact of climate change?

Approach

LDCPH partners with the University of Kansas Medical Center-Department of Population Health to support staffing of its Community Health Program. Staff from both organizations worked to complete the assessment of potential impacts. To answer the key questions, staff and an intern conducted a literature search using a widely-used database of peer-reviewed literature, the National Institutes of Health National Library of Medicine, commonly referred to as PubMed (https://pubmed.ncbi.nlm.nih.gov/). Search terms germane to the primary questions, such as "industrial scale," "wind energy," "solar energy," and "health impacts" were used to start the search to answer question one. Targeted search terms were used to answer question two and were derived from a list of concerns described by the County Administrator's Office. Additional, search databases (e.g., Google Scholar), were used to identify journal articles outside the field of public health and medicine. In addition, resources from the Centers for Disease Control and Prevention were used to describe the potential impacts from climate change overall. With each identified potential health impact or factor, staff sought to describe related research findings and indicate the scale and probability of impact. Where applicable and possible, staff noted the mitigation strategies described in published literature. Staff used categories to describe the scale of impact and the probability of impact, following the example of a health impact assessment conducted by Reno County[2]. These are described in table 1 below.

Table 1. Descriptions of terms used to describe scale and probability of impact

Scale of Impact		Probability of Impact	
Individual	Impact is anticipated to be small and limited to small numbers of individual	**Definite**	Demonstrated association in the literature or through expert opinion
Public	Impact may have the potential to affect larger numbers of people and members of the public	**Probable**	Likely to have an impact
Inconclusive	Inadequate information available to describe scale.	**Speculative**	Impact may be possible
Not applicable	Used to describe when issue was related to non-humans (e.g., livestock or property)	**No evidence**	No published evidence exists to assess probability of impact

The findings below describe a review of the available literature.

Potential Health Impacts Connected to Industrial Scale Wind Energy

A number of health impacts are often discussed in the context of industrial scale wind energy. A review of published literature was used to create table 2 below.

Table 2. Assessment of potential health impacts connected to industrial scale wind energy

Potential Health Impact	Scale of Impact (numbers of people)	Probability of Impact	Research Findings	Potential strategies for mitigation
Annoyance	Individual	Definite	Associations between annoyance and wind turbines represented the clearest finding in review. However, these associations were mediated by a number of factors including perceptions	Participation and engagement in siting decisions

			regarding wind energy[3]. Specifically, the construct of annoyance is related to negative views and attitudes (the nocebo effect)[4].	
Infrasound (def. sound below the level of human hearing)	Individual	Probable	Studies acknowledge wind turbines produce sound and infrasound. Meta-analysis and other studies[3,5,6] suggest that properly sited wind turbines which maintain standards for distance from residences effectively minimize concerns about sound or infrasound produced by wind turbines.	Compliance with industry standards regarding distance from residential areas and monitoring and restrictions on produced sound (e.g., WHO recommends a maximum noise level of 45 decibels from wind farms in residential areas).
Sleep disturbance	Individual	Speculative	Research consists largely of small studies, which often rely on self-reported sleep behavior. Such studies find relationship between sleep disturbance is often related to annoyance. A small study[7] and meta-analysis[8] of objectively measured studies (e.g., sleep latency, efficiency) found no relationship to presence of wind turbines and sleep disturbance.	Participation and engagement in siting decisions
Shadow flicker (def. the effect of the sun (low on the horizon) shining through the rotating blades of a wind turbine, casting a moving shadow)	Individual	Speculative	Existing research suggests that higher levels of exposure to shadow flicker was not associated with greater annoyance with shadow flicker[9]. However, subjective perceptions, such as attitude to the wind project overall, were associated with greater annoyance. Shadow flicker speeds are lower than the known threshold for triggering epileptic seizures[10].	Use of modeling to influence siting to minimize shadow flicker

Quality of life	Individual	Speculative	Some studies note small effects on quality-of-life measures among small numbers of people, which is mediated by annoyance. Conversely, a robust study[11] using a standardized tool for measuring quality of life found no associations between perceived quality of life among 1,200 people living at varying distances from wind turbines.	Participation and engagement in siting decisions
Air Pollution (both wind and solar)	Public	Probable	Use of wind and solar are intended to supplement or replace coal powered energy. A recent study[12] suggested "exposure to coal [*particulate matter]* $PM_{2.5}$ was associated with 2.1 greater mortality risk than exposure to all other $PM_{2.5}$." Further it estimated the loss of 650 million person years due to mortality attributable to coal $PM_{2.5.}$	
Wind Turbine Syndrome	Individual	No evidence	In the grey literature, there exists examination of a medical condition called wind turbine syndrome which may include symptoms, such as vision issues, vertigo, nausea, fatigue, migraines, and sleep deprivation. In the peer-review published literature, the syndrome is not recognized and it is noted that several other factors may influence perceptions of self-reported symptoms[13].	

In summary, the likelihood of negative public health impacts due to industrial scale wind energy seems limited. Across studies, the more likely impact of industrial scale wind energy is an increase in annoyance, particularly among people whose person attitudes and views about wind energy or the presence of industrial scale wind energy are negative.

Potential Health Impacts Connected to Industrial Scale Solar Energy

A number of health impacts are often discussed in the context of industrial scale solar energy. A review of published literature was used to create table 3 below.

Table 3. Assessment of potential health impacts connected to industrial scale solar energy

Potential Health Impact	Scale of Impact (numbers of people)	Probability of Impact	Research Findings	Potential strategies for mitigation
Exposure to hazardous chemicals	Individual – specific to industry workers	Speculative	Materials used in construction of solar panels can include toxic or hazardous chemicals[14]. Implications were noted exclusively for industry and occupational settings, not community settings.	Adoption of industry safety standards for production, construction, and removal (recycling and disposal) of panels
Gentrification	Public	Speculative	Utilization of land and availability of solar power may increase demands for land, as well as price of land[15]. This impact would be expected to have greater impact on vulnerable populations. This may exacerbate inequities experienced by historically marginalized populations.	
Exposure to electromagnetic fields	Individual	Speculative	Researchers noted exposure to electromagnetic fields is likely similar to devices (e.g., cellular phones) which are omnipresent in everyday life[16].	.
Soil-related exposures and illness	Individual – specific to industry workers	Speculative	Several cases of fungal infections related to soil disruptions occurring during installation among solar panel industry workers in California were documented[17]. It is unclear if experiences generalize to different regions with different soil composites.	Appropriate monitoring of workers and soil disruption
Exposure to chemicals in fires	Public	Speculative	Some studies[18,19] document the possibility that human exposure to hazardous	Positioning of panels to avoid hotspots, use of

			chemicals is possible through fires. However, they noted that fires are a low probability event.	monitoring in the network to detect malfunctions or hotspots, and public health communications in the case of emergencies.

In summary, the likelihood of negative public health impacts due to industrial solar energy seems limited. Evidence suggests there are potential impacts to health for small numbers of individuals, much of which can be minimized through appropriate mitigation strategies.

Constituent Identified Concerns

People living in Douglas County reached out to commissioners or Douglas County Administrative offices to convey potential public health concerns related to industrial wind or solar energy installations. The table below describes the concerns and the evidence available.

Potential Health Impact	Scale of Impact (numbers of people)	Probability of Impact	Research Findings	Mitigation Strategies
Leaching chemicals into groundwater (solar)	Inconclusive	Speculative	A meta-analysis[20] of studies examining disposal of solar panels in landfills found supported a modeled Health Hazard Risk Assessment which found non-significant amounts of lead into groundwater. However, authors noted that exposures to carcinogens was unknown.	Glass encapsulation and advance recycling were noted as potential strategies for mitigation[21].
Effects to livestock, including spontaneous miscarriage and birth deformities (wind)	Not applicable	No evidence	There are exceedingly few cases[22,23] of this (e.g., deformities in horses) documented in peer-reviewed literature. A few cases (e.g., spontaneous miscarriages among farmed minks) are noted in the grey literature with no additional verification.	
Ice Throws (i.e., ice detaches from a moving blade or rotor) or Ice Falls	Inconclusive	Speculative	No studies identified the extent to which ice throws or ice falls has resulted in injury to humans (or livestock).	Some studies[24,25] proposed the use of models which could be used to estimate

(i.e., ice detaches from a stationary blade or part of a turbine) causing injury (wind)			However, several studies acknowledged that ice throws or falls could result in injury and is a risk which should be acknowledged.	distance from residential area and sites for industrial scale wind energy.
Lightning strikes causing injury (wind)	Inconclusive	No evidence	No studies identified the risk to humans when lightning strikes wind turbines. However, several studies exist examining the risk of damage to turbines.	Considerable research exists describing efforts to reduce the impact of lightning strikes on wind turbines.
Flicker shadow impacts for neurodivergent individuals (wind)	Inconclusive	No evidence	As noted above, shadow flicker has been studied. Further, studies have examined any potential impacts for people with epilepsy. However, no studies noted any focus or concerns for people who are neurodivergent.	

In summary, the review of constituent-identified potential health impacts did not yield any findings which suggest industrial scale wind or solar energy pose a risk to the public's health.

Impacts of Climate Change on Public Health

The Centers for Disease Control and Prevention[26] provide an indication of potential public health impacts from climate change. These potential implications are provided for different regions of the United States. For the region in which Kansas is assigned, the following are listed as potential implications:

- Temperature-related death and illness
- Extreme events
- Vector-borne diseases
- Tropical disease growing impact (via mosquitoes)
- Water-borne Illness
- Food safety, nutrition, and distribution
- Anxiety and mental well-being
- Air Quality

It is important to note that some of the impacts described in this list are already present. LDCPH's Informatics Team describe several vector borne illnesses as endemic to our county, including hantavirus, Rocky Mountain spotted fever, leptospirosis, West Nile virus, and Lone Star ticks. Further, air quality is an ongoing issue in our region. Although data is not available for Douglas County, the American Lung

Association[27] noted that nearby counties (Johnson, Wyandotte, and Shawnee) have middling grades when it comes to high ozone days and particulate pollution. Additionally, the Mid-America Regional Council[28] reported high ozone days (n=16) were higher in 2023 than any other year since 2013. In addition, MARC reported more moderate days (n=87) than in 2022 (n=61) and 2021 (n=46). These air quality observations may be related to wildfires in areas north of Kansas. Lastly, heat-related illness is an anticipated impact of climate change. The Centers for Disease Control and Prevention' s Heat and Health Tracker[29] reported that emergency department visits for heat-related illness in 11 weeks of 2023, the rate of heat related illness at emergency departments in Region VII of the United States (which includes Kansas, Missouri, Nebraska, and Iowa) exceeded the 95th percentile for utilization, and peaked in August with a rate of 2,432 per 100,000 emergency department visits.

It should be noted that this report provides a glimpse of available research, which changes over time. In many cases, cited research noted that more research would clarify or further verify findings. Further, it is difficult to characterize the actual impacts to climate change Douglas County will definitively experience, and available information helps anticipate potential impacts. This review found no information which suggests that industrial scale wind or solar energy poses risks to the public health.

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