Do Wind Turbines and Karst Belong Together?

I had the opportunity to meet with some constituents and look at some areas in farm fields in northern Floyd County that would be characterized as having karst topography. One of my constituents Derek Straube, who farms along with his family in this area and who also is an agriculture education teacher and FFA advisor for a local school district, researched the farmland and construction, structure, and operation of wind turbines to determine if northern Floyd County would be a good location for a wind farm. The reason he looked into this is because a wind energy company is considering establishing a wind farm in that area. The information I will present here comes from his research report.

What is Karst?

Karst topography is a distinctive landscape that showcases the remarkable power of water in shaping our planet's surface. Karst is characterized by a complex network of surface and underground structures that create a fascinating and sometimes challenging environment.

Formed gradually by the dissolution of soluble rocks—primarily limestone, dolomite, and gypsum— karst begins when rainwater absorbs carbon dioxide from the atmosphere and soil, forming carbonic acid (H_2CO_3). This mildly acidic water then percolates through cracks and fissures in the rock, slowly dissolving them over time.

As this dissolution continues, several key features of karst are created:

1. Sinkholes, perhaps the most recognizable, are depressions in the ground caused by the collapse of surface layers into underground cavities and channels. Over extended periods, groundwater slowly dissolves rocks, creating these underground cavities and channels. As this process continues, the overlying soil and rock become increasingly unstable. Eventually, when the subsurface void becomes too large to support the weight above it, the ground gradually or even suddenly collapses, forming a sinkhole at the surface. These can range from small, bowl-shaped depressions to large, massive steep-sided

chasms, even up to 100 feet wide and 100 feet deep, that dramatically alter the landscape.
2. Equally significant are the extensive underground cave systems that form as water dissolves rock along fractures and bedding planes, creating vast subterranean worlds ripe for exploration and study.
3. Unlike areas with more typical geology, karst often lacks surface streams. Instead, water quickly infiltrates the ground through cracks and sinkholes, creating complex underground drainage networks.
4. This unique characteristic gives rise to two other notable features: springs and disappearing streams.
    a. Springs occur where underground water resurfaces, manifesting as anything from small seeps to large, powerful outflows.
    b. Conversely, streams in karst areas may suddenly vanish underground, only to reappear elsewhere as springs, creating a mysterious and dynamic hydrological system.

While karst landscapes are undoubtedly beautiful and scientifically valuable, they also present significant environmental implications.

1. The porous nature of these terrains makes groundwater highly susceptible to contamination due to the direct connection between surface and groundwater systems, posing challenges for water resource management and environmental protection.
2. Additionally, the complex underground systems can complicate water resource planning and management, requiring specialized approaches to ensure sustainable use.
3. From a safety perspective, sinkholes and cave collapses pose potential risks to homes, farm buildings, other infrastructure and human activities, necessitating careful consideration in planning and development.

Iowa Homeland Security and Emergency Management (HSEMD) in conjunction with the Iowa Geological Survey (IGS) have identified and mapped karst-prone areas throughout the state. Floyd County has over 1000 documented sinkholes, which indicate there is an underground system of cavities, caves, and drainage areas connected to underground water resources all over that area. Even with HSEMD and IGS advanced technology to identify and map karst areas in Iowa, they still cannot detect

the entire underground system of cavities and caves that make up the karst environment.

Karst and Wind Turbines

The delicate geological features of karst explained above present significant risks when considering the placement of wind turbines in Floyd County or any other place in Iowa with karst topography. Here are the risks:

1. Wind turbines, with their immense weight and dynamic loads, can exert considerable pressure on the underlying geology. A typical utility-scale wind turbine can weigh between 176 to 290 tons, with the nacelle (generator and accompanying components that sit atop a wind turbine tower) alone weighing about 62 to 80 tons. In addition, the concrete base of a wind turbine structure can weigh as much as 1,500 tons and the turbine blades 16-22 tons. This substantial mass, roughly a total of 1800 tons (about the weight of 1000 average size cars), concentrated on a relatively small foundation area, can potentially accelerate the formation of sinkholes and ground instability in karst-prone regions.
2. The danger is further compounded by the constant vibrations and the cyclic force of the wind generated by operational wind turbines. These vibrations, while seemingly minor, can have a cumulative effect on the subsurface over time. In karst landscapes, where the bedrock is composed of soluble rocks like limestone or dolomite, these vibrations may exacerbate the natural process of rock dissolution and erosion. The vibrations can also travel considerable distances, even detected by some researchers up to 6 miles from wind turbines. This could lead to the enlargement of existing underground cavities or the creation of new ones, destabilizing the ground and ultimately increasing the risk of sinkhole formation or sudden ground collapse.
3. The construction phase of wind farm projects introduces additional stressors to karst environments. The transportation of turbine components requires heavy vehicles and equipment, often traversing rural roads not designed for such loads. This increased traffic can cause significant ground vibrations and potentially trigger sinking or settling in areas already prone to sinkhole formation. The weight of these vehicles, sometimes exceeding 100 tons when fully loaded, can

stress the underlying karst structures, potentially leading to localized collapses or accelerating the development of sinkholes.

4. The alteration of natural drainage patterns during wind farm construction is another critical concern. The creation of access roads, excavation, turbine foundation installation, and other infrastructure can modify how water flows across and into the karst landscape. This change in hydrology can lead to increased water infiltration in certain areas, causing erosion or potentially accelerating the dissolution of subsurface rocks and the formation of new underground cavities. It can also disrupt natural groundwater flow paths, potentially altering the local water table.
5. All of this could lead to:
    a. Uneven settling of and increased stress on the turbine foundation
    b. Tilting of the turbine tower
    c. Increased stress on, misalignment of, and accelerated wear on the structural components
    d. Reduced operational efficiency of the turbine
    e. In extreme cases, the collapse of the turbine
    f. Long-term instability or structural damage or even collapse or destruction of homes and farm buildings and other farm structures, even if not in the immediate vicinity of the turbine
    g. Water well replacement or water treatment systems. Any contaminants from the turbine construction or operation, such as lubricants or fuel spills, or microplastic or fiberglass particles due to blade erosion, could rapidly enter the groundwater system through sinkholes or fractures. In addition, there is concern regarding the disruption or alteration of the natural drainage and groundwater paths. All of this poses a risk to the quantity and quality of the water supply of nearby residences, particularly those relying on well water.
    h. Home or farm building repairs due to the construction and operation of wind turbines, such as foundation issues, wall cracks, or other structural damage
    i. Road repairs due to transportation of turbine components by heavy vehicles and equipment on rural roads not designed for those heavy loads. These repairs would be a county expense.

j. Possible insurance cost increases for local homeowners and farm owners due to the heightened risk of property damage associated with wind turbine construction and operation on karst terrain
k. A follow-on risk of property value depreciation

Does Iowa Have Guidance for Building on Karst?

It is interesting to note that Floyd County already hosts a wind farm. The majority of existing turbines are situated on non-karst forming bedrock. This bedrock is composed primarily of strong sandstone and shale, providing a stable foundation for the massive turbine structures.

The wind farm currently being considered calls for its placement on the karst ground in northern Floyd County. This brings up a whole new set of considerations.

HSEMD has developed a comprehensive set of standards and guidelines that include recommendations for construction practices in karst-prone areas, such as conducting thorough geotechnical surveys before initiating any major building projects. The agency also advises on appropriate foundation designs that can withstand the unique challenges posed by karst terrain, including the potential for sudden ground collapse or sinking and settling ground. But, wind turbines are a very specialized type of building project that exert enormous and unusual pressures on the land it sits on.

HSEMD emphasizes the importance of stormwater management in karst areas and provides guidance on the implementation of best management practices, recognizing that improper drainage can exacerbate sinkhole formation and groundwater contamination.

HSEMD also collaborates with other state agencies, such as the Department of Natural Resources and the Department of Transportation, to ensure a coordinated approach to karst and sinkhole management across various sectors. This inter-agency cooperation is crucial for addressing the complex challenges posed by karst landscapes, which can affect everything from water quality to infrastructure stability.

Concluding Thoughts

Given these observations and research, it is troubling that a company is considering building a wind farm on karst terrain. Currently, there are no regulations specifying safe distances between wind turbines and sinkholes, let alone whether or not wind turbines should even be built on karst terrain.

The installation of wind turbines in karst landscapes demands exceptional caution and thorough geological assessment, including the long-term impact, to ensure stability and safety of both the turbines and surrounding landscape, homes, farm fields, and farm structures. It also requires ongoing monitoring of the karst landscape to ensure continued stability of the turbines and safety for residents and surrounding areas.

Perhaps if a thorough geological assessment found a wind farm could be safely established on karst terrain, then that assessment could perhaps give a better idea of what would be a safe setback distance between wind turbines and sinkholes.

At the very least until these surveys and assessments are done, I do not think it is wise to build wind turbines on karst landscape.

Feel free to contact me with ideas, thoughts, and concerns. My phone is 319-987-3021 or you can email me at sandy.salmon@legis.iowa.gov . I want to hear what you are thinking and will listen to your input. Together we will work to make a difference for the future of Iowa. Thank you very much for the honor of representing you!

Sincerely,

Sandy