Technical Appendix

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Wind Ordinance Data Collection

We developed a database of wind ordinances designed explicitly for commercial wind turbines enacted in each of the 99 counties in Iowa to develop a thorough historical record of requirements over time. Our Iowa wind ordinance database is publicly available on the Hawkeye Headwinds project page at https://clearpath.org/hawkeye-state-headwinds/.

Siting control for wind generation projects varies by state.[1] In Iowa, siting control is at the county level for wind projects under 25 MW, with dual state and county siting processes required for projects 25 MW or larger.[2] In Iowa, counties pass wind ordinances to define the parameters wind farms must meet to be approved and built. Wind ordinances aim to protect the interest and safety of participating landowners and non-participating landowners or community members while enabling cost-effective wind development.[3] These ordinances typically include requirements for application and approval processes, setbacks, construction, decommissioning, and safety. Ordinances are neither unique to Iowa nor unique to wind development.

Turbines need unobstructed wind to operate efficiently, leading to site selections that have fewer obstructions, such as buildings. As the best locations for wind tend to be in remote areas, projects are developed closer to people who often have no previous experience or familiarity with wind turbines or other large energy infrastructure projects. As a result, wind ordinances are becoming increasingly prevalent as these technologies deploy at scale across the country.

Setback distances establish the minimum distance between turbines and buildings, roads, property lines, and utility lines. There are several considerations that determine the setback distances, including turbine noise levels, the turbine fall zone, and environmental characteristics such as wildlife areas, airports, or dwellings. In addition to these objective factors, setback distances can also be influenced by subjective factors, such as whether a landowner permits a turbine within a setback or if the entities involved in deciding a setback — county board of supervisors or state legislature — choose to increase the distance beyond what may objectively be determined.

In our Iowa case study, we found that for buildings, setbacks are typically the "greater of" a standard distance, such as 1,250 feet, and the multiplier of total turbine height, defined as the distance from the bottom of the structure to the blade tip at its apex. We found that for roads, a multiplier of total turbine height, such as 1.1 times the total height, is the more common metric for setback distance. However, some counties also included a "greater of" clause for road setbacks, with a standard distance that is typically smaller than the one used for buildings, around 600-800 feet.

We used the maximum allowed turbine height as inputs for counties with height limitations on turbines. While we did document noise and shadow flicker requirements for each wind ordinance, they were not implemented in our analysis. Shadow flicker requirements limit the number of hours per year that the shadow cast from the turbine and its rotating blades falls on buildings or property. Wind turbines' noise levels are measured in A-weighted decibels and recorded at a particular distance from a wind farm. Nearly all noise limitations in place in Iowa fell in the range of 50-60 A-weighted decibels (dBA), which aligns with American Planning Association recommendations.[4]

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[1] (*State Approaches to Wind Facility Siting*, n.d.)
[2] (Greene et al., 2020)
[3] (Johannsen, n.d.)
[4] (Johannsen, n.d.)

It is important to note that some county-level ordinances have different requirements for different zoning districts. In these cases, we applied the most stringent setback requirements specified in any zone across the entire county. Some counties have chosen not to enact ordinances in favor of evaluating wind development on a project-by-project basis. This approach provides counties greater latitude over project selection because they are not required to allow the development of any project that meets all of their ordinance requirements.

Ordinance Stringency Categories

We developed four ordinance categories based on the stringency of their requirements. The definitions for each category were informed by consultations with wind developers and utilities that plan and develop wind projects in Iowa in addition to a literature review. The four categories we utilize are below:

1. No ordinance in place: Some counties don't have a wind ordinance or choose not to adopt a wind ordinance because they prefer to consider wind development on a project-by-project basis.
2. Permissive ordinances: Setbacks less than or equal to 1,600 feet from buildings and 1.5 times the total turbine height from ROWs, and no height limitations.
3. Prohibitive ordinances: Setbacks greater than 1,600 feet from buildings and 1.5 times the total turbine height from ROWs, and height limitations.
4. Moratoriums: Indefinite or temporary prohibitions on development or a cap on the number of turbines that can be built.

Counties can change ordinances at any time, so the status and labeling of ordinances in our dataset should be interpreted as a snapshot of siting regulations in Iowa. Some counties have changed Permissive ordinances to Prohibitive ordinances or Moratoriums during development.[5] Other counties adopt temporary moratoriums, also called abeyances, to give the county board of supervisors' time to update or create new wind ordinances. Worth County in Iowa is an example: In 2021, the county adopted a temporary moratorium that sunsets in 2022, with the intent of developing a new wind ordinance in the interim.[6] Ordinances whose requirements overlapped multiple categories were placed in the more restrictive one.

[5] (*RWE Renewable Development LLC vs. Hardin County Board of Supervisors*, 2020)
[6] (Smith, 2021)

Turbine Technical Assumptions

We used turbine size projections from the National Renewable Energy Laboratory's Annual Technology Baseline (ATB) for Land-Based Wind as inputs in our analysis.[7] Table 1 adapts NREL's Wind Turbine and Plant Details by scenario table to display the technical assumptions in this analysis. To represent the range of turbines built between now and 2050, we used estimates for the year 2030 in both cases.

	Conservative - 2030	Advanced - 2030
Hub Height (m)	110	135
Rotor Diameter (m)	150	200
Total Height (m)	185	235
Specific Power (W/m2)	226	223
Turbine Rating (MW)	4	7

Table 1. Adapted from the National Renewable Energy Laboratory's Land-Based Wind Annual Technology Baseline.

We used ATB's Conservative 2030 turbine size projection because these values have greater alignment with the current technology marketplace compared to NREL ATB's 2019 Base turbine specifications. To assess the impact of future turbine size on land availability, we used the Advanced 2030 projections.

[7] (*Annual Technology Baseline: Land-Based Wind*, 2022)

Scenario Development

Using total turbine heights as multipliers for setback distances creates an inverse relationship between technology advancement and land availability, which we explored using the two turbine size assumptions outlined in Table 1. In addition to exploring the impact of technology advancements on land availability, we assessed two ordinance scenarios to quantify the potential effects of increasing ordinance prevalence on future land availability. The first ordinance scenario uses the parameters outlined in existing county-level ordinances only. The second ordinance scenario also utilizes existing ordinances but adds the assumption that counties that currently have no ordinance will adopt setbacks that align with our permissive ordinance level. For those counties, our setback assumptions are the greater of 1,250 feet or 2 times the total turbine height for buildings and 1.5 times the total turbine heights for roads, with no height limitations. Our Conservative Turbines assumptions result in a building setback distance of 1,250 feet, while our Advanced Turbines assumptions used 1,542 feet. Table 2 displays a matrix of the scenario assumptions used in our analysis.

	Conservative Turbines	Advanced Turbines
Existing Ordinances	For counties <u>currently with</u> wind ordinances, we utilized those requirements. We have made <u>no setback assumptions</u> for counties currently without a wind ordinance. ATB Conservative 2030 turbine height of 110 m and a rotor diameter of 150 m for a <u>total turbine height of 185 m</u>.	For counties <u>currently with</u> wind ordinances, we utilized those requirements. We have made <u>no setback assumptions</u> for counties currently without a wind ordinance. ATB Advanced 2030 turbine height of 135 m and a rotor diameter of 200 m for a <u>total turbine height of 235 m.</u>
Ordinances in All Counties	For counties <u>currently with</u> wind ordinances, we utilized those requirements. For counties currently without a wind ordinance or with only one type of setback, the <u>assumed setback requirements are the greater of 1,250 ft. or 2x total height from buildings and/or 1.1x total height to roads.</u> ATB Conservative 2030 turbine height of 110 m and a rotor diameter of 150 m for a <u>total turbine height of 185 m</u>.	For counties <u>currently with</u> wind ordinances, we utilized those requirements. For counties currently without a wind ordinance or with only one type of setback, the <u>assumed setback requirements are the greater of 1,250 ft. or 2x total height from buildings and/or 1.1x total height to roads.</u> ATB Advanced 2030 turbine height of 135 m and a rotor diameter of 200 m for a <u>total turbine height of 235 m.</u>

Table 2. Matrix of scenario assumptions.

Data Sources

Princeton University's Net-Zero America Project (NZAP) delivers a high-resolution depiction of five technologically and economically plausible pathways to a net-zero national economy by 2050. While Princeton developed five technology pathways for their report, only spatially explicit datasets for three pathways were published, and only one of these pathways was assessed using both land-use assumptions. Figure 1 below defines the four net-zero pathways with spatially explicit datasets published by Princeton used in this study.

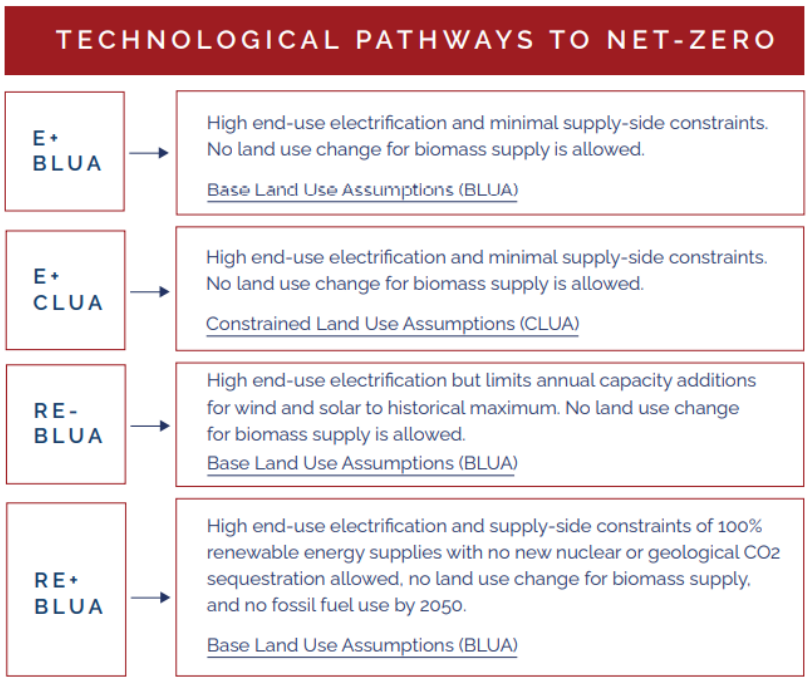

Figure 1. Four pathways to a net-zero national economy by 2050, developed by Princeton University and used in this study.

NZAP developed a least-cost siting optimization methodology that provides a spatially explicit downscaling for the energy infrastructure deployments necessary to reach net-zero within the parameters established by each pathway. Potential renewable deployment sites are passed through a land-use screening process that employs over 60 GIS layers, which represent the "techno-economic, geological, and environmental land-use exclusions" that constitute their Base Land Use Assumptions (BLUA).[8] The resulting Candidate Project Areas (CPAs) are a 4 km by 4 km grid with cells characterized by location-specific resource quality — such as wind speed, capital cost, and transmission cost — and then selected through a macro-energy systems optimization model to meet specific wind energy supply levels while minimizing costs.[9] Additional restrictions aimed at preserving intact landscapes and prime farmland applied for the Constrained Land Use Assumptions but are not reflected in the CPA data published by

[8] (Leslie et al., 2021)
[9] (Leslie et al., 2021)

Princeton. Therefore, our study assesses Princeton's CPAs that reflect Base Land Use Assumptions in addition to the four net-zero pathways with publicly available datasets.

CPAs represent the indirect land impact of wind development, which is much greater than the direct land impact of turbines. We separately calculate the direct land impact of wind turbines assuming 0.74 acres/MW, which is the amount of land permanently used during their operation, according to the Department of Energy's 2015 Wind Vision Report.[10] The NZAP analysis assumes a turbine hub height of 100 meters, which corresponds to a 3-MW turbine approximately.[11] We used the 2050 projections of wind capacity in Iowa across each net-zero pathway to determine the number of 3-MW turbines needed to reach that goal. We used our determined number of turbines to calculate the direct land impact.

Neither building nor road footprints were included in their land-use screening process, and nor were subnational legal frameworks, such as wind ordinances. Our study aimed to fill this gap by quantifying the impact on land available for wind development when the built environment — buildings and roads — and regulations on wind turbine placement were considered.

Their results demonstrate one possible projection of least-cost wind development that achieves net-zero by 2050. No pathway utilizes the total available land identified as CPAs, indicating that less optimal configurations of wind development could keep net-zero within reach for each pathway.

Princeton University's Net Zero America Project published annexes that comprehensively detail their methodology and made their underlying datasets publicly available on their website.
Source link: https://netzeroamerica.princeton.edu

We use the Energy Information Administration's United States Wind Turbine Database, updated through January 2021, to screen out land with existing projects not represented in Princeton's datasets. We apply 381-meter (1,250-foot) buffers to each turbine to give them a spatial footprint that conservatively accounts for indirect land impacts.
Source link: https://atlas.eia.gov/datasets/eia::united-states-wind-turbine-database-uswtdb/about

We used a spatial database of building footprints in the United States, developed by Microsoft, to account for the structure footprints that function as the reference point for our building setbacks. Setback requirements often vary between occupied and non-occupied buildings and participating and non-participating landowners. Participating landowners are individuals who sign contracts with and receive compensation from developers for hosting a turbine or project infrastructure. Because we do not know the characteristics of each building and make no assumptions about participating landowners, we use the maximum setback distances and multipliers that apply to buildings in each ordinance. Additionally, in the cases where property line setbacks were used without building setbacks, those requirements were treated as building setbacks. This captures the ordinance's intent — to create a buffer between turbines and buildings — in the absence of available property-line spatial datasets.
Source link: https://github.com/microsoft/USBuildingFootprints

We use the Iowa Department of Transportation's road network dataset to account for road footprints in Iowa, which function as our point of reference for road setback distances. This dataset provides surface width and lane information, enabling us to accurately account for the variable footprint of roads across

[10] (*Wind Vision: A New Era for Wind Power in the United States*, 2015)
[11] (*Wind Turbines: The Bigger, the Better*, n.d.)

Iowa. For roads without a provided width or number of lanes, we assumed them to be two-lane roads with lane widths of 3.6 meters, as the Federal Highway Administration recommends.[12]

Source link: https://public-iowadot.opendata.arcgis.com/datasets/IowaDOT::road-network-portal/about

The Iowa Counties spatial dataset was created by the Iowa Department of Natural Resources and retrieved from ArcGIS.

Source Link: https://www.arcgis.com/home/item.html?id=8a1c2d500d8847d79aa47d45d44eb133

[12] (*Federal Highway Administration*, n.d.)

Geospatial Downscaling Methodology

The following methodology was the same for each of the four net-zero pathways and CPA datasets and was conducted using QGIS 3.16.14 and Python 3.10.

We used the Clip tool to create Iowa specific shapefiles for all datasets, using the Iowa Counties shapefile as the overlay file. We then calculated the area of each feature in the NZAP shapefiles to account for changes to feature footprints that may have extended beyond Iowa into neighboring states. We then used the ratio between the previous feature area and recalculated area to reassess the capacity (MW) and annual generation (MWh) values for each feature. These recalculated values are the baseline values for our percent change calculations.

Existing and planned windfarm features identified by NZAP as well as the buffered turbine sources from EIA (see Data Sources on EIA turbine buffering methodology) were removed from each NZAP dataset. This ensured that our analysis only reflected differences in potential wind development areas. For each of the NZAP shapefiles, features representing solar technology were also removed.

Setback distances for each of the four ordinance and turbine scenarios were calculated for buildings and roads respectively, according to the regulations in the county, if applicable. This Excel file was joined with the Iowa Counties shapefile. We then intersected this Iowa Counties-with-setbacks file with the building and road shapefiles to attribute each feature (road or building) to the county it is located within or intersects with. The setback distances for roads in each county were added to road width values in the Iowa DOT road shapefile to reflect the footprint of the road and the setback distances for each county. Next, we used the setback distance values for each feature across all four of our scenarios to create building and road buffer shapefiles.

We iteratively used the Difference tool to remove potential wind development areas that overlapped with building and road buffers for each of the four scenarios we assessed, for both the Candidate Project Areas and each of the four pathways we examined: E+BLUA, E+CLUA, RE-BLUA, and RE+BLUA. After removing unavailable areas, we then recalculated the area of each feature. We used the ratio between the baseline area and post-analysis area to reassess the annual generation (MWh) and capacity (MW) of each feature.

Viewshed Analysis

We used the Viewshed Analysis tool in ArcGIS Pro 2.9.0 to assess wind turbine visual extent.

We used randomly selected points within Princeton's Reference, Base Land Use Wind Development Areas as turbine locations for demonstration purposes only (see Diagram 2). We assessed the visual extent of various turbine sizes for a person of average height — 5 feet, 7 inches — using a digital elevation model (DEM) to account for the topography of Iowa. Surface features that could obscure line of sight were not considered in this analysis, only elevation. The maximum extent was set to 50 kilometers and the DEM resolution was 90 meters.

We quantified the visual extent for total turbine heights of 152 meters, which was the typical turbine height in 2019, when many of the Iowa's Prohibitive ordinances and Moratoriums were enacted. We then quantified the visual extent for the total turbine heights used in our analysis: Conservative and Advanced projections for turbine heights in 2030, which were 185 meters and 235 meters, respectively. Visual extent increased 13% from 152-meter to 185-meter turbines and increased 29% from 152-meter to 235-meter turbines.

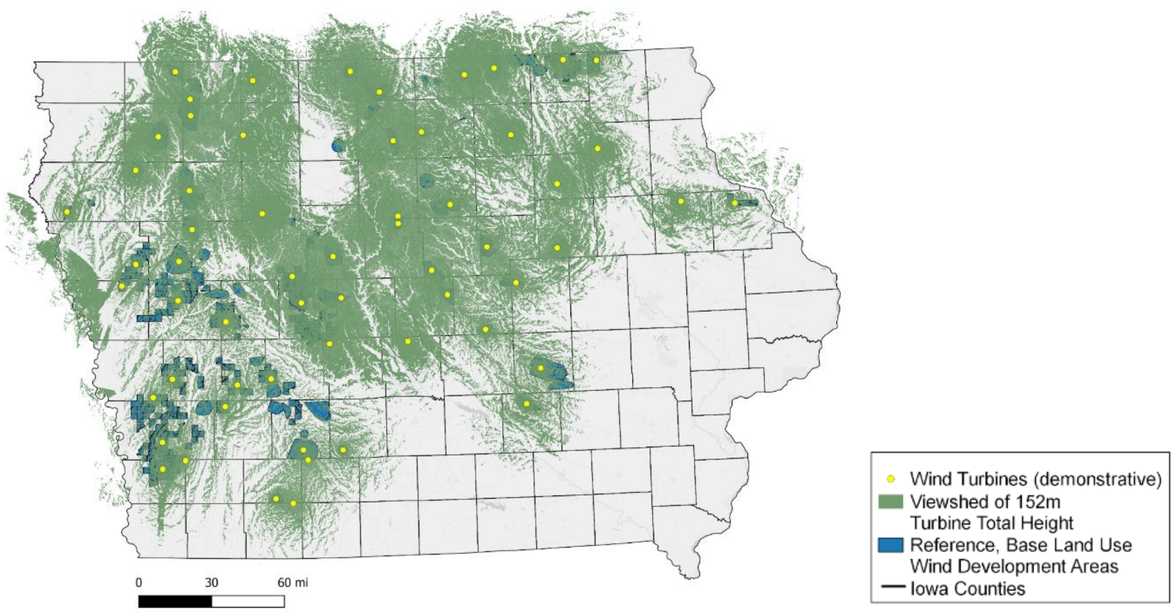

Figure 2. Viewshed analysis results for randomly selected locations in Princeton's Reference Base Land Use to exemplify 152-meter-tall turbines. Sources: NZAP (2021); Iowa DNR (2020)

Influential Factors and Dynamics in Attitude Formation

All net-zero pathways identified by NZAP require large-scale deployments of energy infrastructure, which have the potential to transform the landscape in varying degrees across the country. North American surveys on wind energy acceptance to date have found that 70-90% of the population has positive attitudes toward and supports wind energy generally and specifically,[13] but our research revealed that the prevalence of wind projects facing local opposition is increasing across Iowa and mirrors observations across the rest of the country.

North American wind acceptance research extends back as far as the 1980s and has identified numerous variables that explain and predict wind acceptance.[14] For the purposes of our study, we narrowed the scope of this section to two sets of factors that consistently and significantly influence acceptance and are directly or indirectly tied to technology advancements. One is perceptions of visual aesthetics and noise annoyance and the second is perceptions of procedural and distributive fairness, as outlined in Diagram 1.

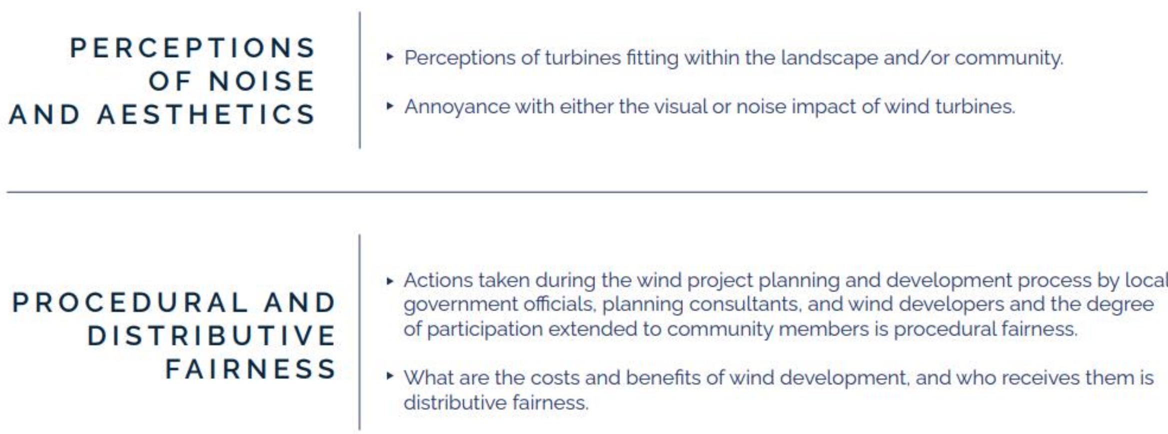

Figure 3. Influential Factors for Wind Development Acceptance were qualitatively assessed in this study.

Visual perception of turbines is a stronger predictor of attitude than the proximity of turbines to one's home and turbine characteristics.[15] Similarly, perceptions of turbines fitting within one's idea of community or landscape is predictive of acceptance, with those finding turbines to be out-of-place or unattractive having lower acceptance.[16]

Academic literature has consistently determined turbine noise annoyance as primarily an expression of personal experience and visual perceptions rather than an objective response to wind turbine sound level.[17] However, the direction of the causal relationship between perception of aesthetics and noise annoyance was not determined in this analysis. Related to perceptions of noise annoyance and visual aesthetics are health and safety concerns over living in close proximity to turbines. While epidemiological research has not found turbine sound to directly and adversely affect human health or sleep quality, the

[13] (Rand & Hoen, 2017)
[14] (Rand & Hoen, 2017)
[15] (Haac et al., 2019)
[16] (Hoen et al., 2019; Pasqualetti, 2019)
[17] (Haac et al., 2019; Hübner et al., 2019)

expectation of negative effects, perception of turbines and their noise as a health risk, or misinformation on their potential health risks contribute to reduced support.[18] Finally, Community Level Tolerance assessments of U.S. communities aligned with the results from international assessments: There is less tolerance of wind turbine noise compared to other common environmental noises at equivalent sound levels.[19]

This estimated increase in the visual extent of turbines on a simple technology-advancement basis does not include the impact on visual extent from the increasing scale of deployment that's projected across net-zero scenarios. These compounding factors, increasing height and deployment, will widen the pool of individuals and communities that are visually impacted by wind turbines and may differentially alter the landscape for individuals and communities.[20] Perception of community fit is likewise not homogenous across individuals or communities, so an exclusive or one-size-fits-all approach to siting and planning could alienate individuals or communities writ large.[21]

Combined with the broader literature's consistent finding and agreement on the influence turbine perceptions have on acceptance, our observations of the increasing prevalence of height limitations suggest that the increasing size of the turbines may have a negative impact on attitudes toward wind development. Conversely, fewer larger turbines may be favorable to some communities and result in greater acceptance and support for future development. Understanding community preferences in terms of fewer larger turbines versus more smaller turbines will be an important consideration during project development.

We may therefore expect noise concerns and related opposition to increase in response to turbine size, whose impact on sound levels is itself an important area of future research. The larger setback distances that result from increased turbine height may reduce turbine audibility, but studies suggest that noise concerns extend beyond what sound propagation models predict, reflecting the significance of other factors, namely perception of turbine appearance.[22]

Perceptions of procedural fairness are influenced by the actions taken during the wind project planning and development process by local government officials, planning consultants, and wind developers and the degree of participation extended to community members. Longitudinal studies suggest that the perceived fairness of wind planning processes has long-term impacts on attitudes and support, which will play a pivotal role in sustaining "support for adding new and repowering old turbines."[23]

Perceptions of distributive fairness are shaped by the costs and benefits of wind development and who receives them. Fewer larger turbines mean fewer participating landowners compensated by the developers, most commonly for hosting turbines or related infrastructure. These landowners often have more opportunities to provide input on the development process than non-compensated members of their community.[24] This may exacerbate an observed tendency for wind development to divide communities and widen socioeconomic disparities between community members.[25]

[18] (Haac et al., 2019; Knopper et al., 2014)
[19] (Haac et al., 2019; Michaud et al., 2016)
[20] (Fast et al., 2016)
[21] (Bessette & Mills, 2021; Devine-Wright & Howes, 2010)
[22] (Dällenbach & Wüstenhagen, 2022)
[23] (Elmallah & Rand, 2022; Mills et al., 2019)
[24] (Elmallah & Rand, 2022; Hoen et al., 2018; Rand & Hoen, 2017)
[25] (Elmallah & Rand, 2022; Firestone et al., 2017; Rand & Hoen, 2017)

The question of who participates, who is compensated, and to what extent will need to adapt as the compounding and cumulative impacts of increasing turbine size and deployment cross property lines and political boundaries. The decoupling of audibility and noise annoyance, and by extension, negative attitudes and opposition, suggests that technology advancements absent procedural and distributive justice reform may not ameliorate individual or community concerns.

Understanding and acknowledging individual and community concerns, proactively providing resources and tools for communities and decision-makers, and developer implementation of best practices with respect to procedural and distributive fairness will be essential to consent-based siting that balances community autonomy and decarbonization. Developer best practices identified in (Elmallah & Rand, 2022) and amplified in the broader literature include:

- Affording non-participants similar information and opportunities to provide input and voice concerns as participating landowners;
- Providing resources for and knowledge-sharing opportunities among local governments;
- Creating structures for participation, information provision, and decision-making throughout the wind development process; and
- Considering local contexts of historical power generation and resident connections to the land.

However, it is unrealistic to expect that implementation of developer best practices will eliminate negative attitudes or public opposition to wind acceptance. Apex Clean Energy's Exploring Wind Vermillion campaign incorporated many of these best practices, yet Vermillion County in Indiana adopted a wind ordinance whose prohibitive requirements effectively canceled the project.[26] This example underscores the importance of maintaining a tech-neutral approach to decarbonization that implements policies and best practices to maximize wind deployment in communities that welcome development in addition to policies and programs that support other low-carbon resources

[26] (Tomich, 2022)

Transmission and Interconnection Methodology

Transmission is the backbone of the electric grid and is essential to providing reliable, low-cost, low-carbon electricity through the transport of electricity, especially over long distances. Understanding the transmission landscape is critical to evaluating the feasibility of developing the wind capacity suggested in the NZAP study.

To illustrate the historic high-voltage transmission build rates, existing capacity using 161-kV and 345-kV lines only, and forecasted build rates, Lucid Catalyst reviewed all Iowa Utilities Board dockets on proposed lines from 2010 to 2020. They harvested information on voltage, line length, initial franchise submission date, construction completion date, instances of public opposition during the process (i.e., written or verbal comments during hearings), and the use of eminent domain.

The operation of Iowa's grid is divided between two organizations: Midcontinent Independent System Operator (MISO) and Southwest Power Pool (SPP). States and local utilities are responsible for the siting of regional and interregional transmission projects planned by and located in MISO and SPP. Utilities are also responsible for transmission and distribution infrastructure within their service footprint to meet reliability and economic needs.

We focus on MISO because it operates the majority of the grid in Iowa and served roughly 93% of load through its wholesale electricity markets in 2020 according to EIA Form-861 data. The MISO Transmission Expansion Plan has been on the forefront of designing and implementing an innovative, transparent, and forward-looking transmission planning process. Implemented in 2011, this process identified Multi-Value Projects (MVP) that address "reliability, economic and public drivers in the development of transmission solutions that provide benefits in excess of its cost" across the service footprint.[27] The first MVP portfolio included 17 transmission projects covering over 2,000 miles of 345-kV or 765-kV lines that are nearly all in service today. The benefit-cost ratio of these projects over the next two decades is between 2.4 and 10.4.[28]

Transmission investment returned to historic levels in the years following the approval of the MVP portfolio and did not meet or exceed that level of investment despite the introduction of the South Sub-region to MISO's footprint that began in 2012.[29]

The growing challenges introduced by the rapidly evolving resource mix and electrification of end-uses spurred MISO's Long Range Transmission Planning (LRTP) initiative. This initiative builds on the MVP framework and incorporates 3-Future Scenarios into the transmission planning process.[30] MISO recently published the first tranche of projects, which has a total cost of $10.4 billion and achieves a benefit-cost ratio of 2.6, comparable to the MVP portfolio.[31]

However, the shared boundaries along SPP and MISO — known as seams — compound existing difficulties in connecting new generation to the grid.[32] Seam areas, in particular, introduce additional temporal and cost uncertainty because they are more likely to necessitate the evaluation of a project's

[27] (*Multi-Value Projects (MVPs)*, n.d.)
[28] (*Proposed Revisions to MISO Tariff to Modify Cost Allocation for Multi-Value Projects*, 2022)
[29] (*MTEP21 Report Addendum: Long Range Transmission Planning Tranche 1 Portfolio Report*, 2022)
[30] (*MTEP21 Report Addendum: Long Range Transmission Planning Tranche 1 Portfolio Report*, 2022)
[31] (*LRTP Tranche 1 Portfolio Detailed Business Case*, 2022)
[32] (*Joint Targeted Interconnection Queue Executive Summary*, 2022)

impact on the neighboring systems grid, known as affected system studies. The procedure and timing of these studies are not standardized and have the potential to introduce significant costs to an interconnection customer late into the process.[33]

Seam areas, such as those in Iowa, offer ample opportunities for coordinating interregional transmission investments to cost-effectively improve the integration of new resources, level market prices, and improve system reliability and resilience.

The MISO-SPP Joint Targeted Interconnection Queue study published in 2022 identified several transmission projects that provided significant reliability and economic benefits across both SPP and MISO, including enabling generator interconnections in the range of 28 GW to 53 GW, 48 reliability constraints resolved, and economic benefits of $724 million in the MISO footprint and $247 million in the SPP region.[34]

Identification and agreement on a cost-allocation methodology for the estimated $1.65 billion in transmission investment is the next step in this process and has historically been a barrier for interregional projects.[35]

At the federal level, the Federal Energy Regulatory Commission is prioritizing reforms for interconnection queue procedures and agreements in addition to regional and interregional transmission planning and cost-allocation procedures. Despite the procedural improvements that may manifest from these proposed rulemakings, the development and siting of high-voltage lines and generation resources still require several layers of state and local approvals.

[33] (vander Vorst & Stern, n.d.; EDF v. MISO, 168 FERC ¶ 61,173., 2020)
[34] (*Joint-Targeted Interconnection Queue Executive Summary*, 2022)
[35] (Lieberman, 2021)

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