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K.K. DuVivier
University of Denver, kkduvivier@law.du.edu

Brendan Mooney

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MOAT MENTALITY: ONSHORE AND OFFSHORE APPROACHES TO WIND WAKING

K.K. DuVivier[*] & Brendan T. Mooney

INTRODUCTION

Wind energy developers are becoming increasingly aware of the damaging impact of wakes from turbines. To deal with the issue on land, many terrestrial developers have adopted a "moat mentality," creating buffer zones around their wind plants[1] to protect them from neighboring wind developments. While these "moats" may protect the investment of a particular wind developer, they render large areas that could be generating electricity into unproductive waste zones. US offshore wind development is in its nascence. This article will explore ways that offshore wind developers are addressing waking issues and whether they can find more collaborative solutions to maximize productivity as this new industry emerges.

I. US WIND ENERGY

By 2017, wind power domestically outranked all other renewable energy resources in terms of installed capacity,[2] and the Energy Information Administration has predicted that in 2019, wind power will exceed hydropower for the amount of electricity it produced.[3] Until recently all of US wind energy production was onshore, but offshore development is poised

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[1] The terminology of "wind plant" was chosen for any wind energy development including a number of turbines. This is the preferred terminology by the Department of Interior. However, many others use the term "wind farm" and the terminology is interchangeable. Some just find the reference to "farms" confusing, especially when referring to offshore wind development. Another alternative would be "offshore wind power project," but that phrasing is a bit more cumbersome than "wind plant."

[2] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEPT. OF ENERGY, 2017 RENEWABLE ENERGY DATA BOOK 10 (2017), https://www.nrel.gov/docs/fy19osti/72170.pdf (listing wind power capacity at 7.5%, hydropower at 6.7%, and solar at 3.8%).

[3] U.S. ENERGY INFO. ADMIN., SHORT-TERM ENERGY OUTLOOK 2 (2019), https://www.eia.gov/outlooks/steo/pdf/steo_full.pdf.

to take off.

A. Onshore

Land-based, or terrestrial, wind energy continues to expand in the United States. From just 2.578 GW of capacity in 2000, terrestrial wind had increased almost 380% by the second quarter of 2019,[4] marking gains of over 65% in some single years.[5] With over 57,000 wind turbines in forty-one states and two US territories, the cumulative installed wind capacity was close to 100 GW at the end of the second quarter of 2019.[6] The regulation of terrestrial wind varies widely in the United States, but most development is on private lands[7] and controlled at the local level.[8]

For the first half of 2019, the US wind industry commissioned 1.577 GW of new capacity, "a 53% increase over the first half of 2018."[9] Eight utility-scale projects were commissioned in Iowa, Texas, Illinois, Michigan, and Minnesota, and current large capacity projects are also slated to come

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[4] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *supra* note 2, at 54 (using the 2000 figure of 2.578 GW in comparison with the second quarter of 2019 figure of 97.969 GW of installed capacity).

[5] *Id.* (using figure of 65.8% increase for 2001).

[6] *See U.S. Wind Indus. Quarterly Mkt. Rep.: Second Quarter 2019*, AM. WIND ENERGY ASSOC.5 (2019), https://www.awea.org/resources/publications-and-reports/market-reports/2019-u-s-wind-industry-market-reports (2019 YTD cumulative installed wind capacity was 97.960 GW).

[7] WIND & WATER POWER TECH. OFFICE, U.S. DEPT. OF ENERGY, WIND VISION: A NEW ERA FOR WIND POWER IN THE U.S. 103 (2015), https://www.energy.gov/sites/prod/files/2015/03/f20/wv_full_report.pdf ("Unlike land-based wind development, which has largely been undertaken on private land, offshore wind development will take place in public waters").

[8] *See* K.K. DuVivier & Thomas Witt, *NIMBY TO NOPE–OR YESS?,* 38 CARDOZO. L. REV. 1453, 1463 (2017); Jesse Heibel & Jocelyn Durkay, *State Legislative Approaches to Wind Energy Siting*, NAT'L CONFERENCE OF STATE LEGISLATURES (2016), http://www.ncsl.org/research/energy/state-wind-energy-siting.aspx; *see also*, Amy Morris et al., *Green Siting for Green Energy*, 5 GEO. WASH. J. ENERGY & ENVTL. L. 17, 20 (2014); Uma Outka, *Environmental Law and Fossil Fuels: Barriers to Renewable Energy*, 65 VAND. L. REV. 1679, 1693 (2012); Uma Outka, *Siting Renewable Energy: Land Use and Regulatory Context*, 37 ECOLOGY L.Q. 1041, 1058 (2010); Alexandra B. Klass, *Property Rights on the New Frontier: Climate Change, Natural Resource Development, and Renewable Energy*, 38 ECOLOGY L.Q. 63, 66 (2011); Hannah Wiseman et al., *Formulating a Law of Sustainable Energy: The Renewables Component*, 28 PACE. ENVTL. L. REV. 827 (2011) (generally discussing legal framework for renewable development); Steven Ferrey, *Restructuring a Green Grid: Legal Challenges to Accommodate New Renewable Energy Infrastructure*, 39 ENVTL. L. 977, 1004 (2009).

[9] AM. WIND ENERGY ASSOC., *supra* note 6, at 3.

online in Texas, Iowa, Illinois, and Oklahoma.[10] Texas currently has the largest onshore pipeline with over 11 GW planned spanning over twenty-nine projects.[11] Last year, projects using turbines over 100 kW accounted for 49 MW of the 50.5 MW installed in 2018.[12]

B. Offshore Wind Resource and Potential in the United States

The gross resource potential capacity for offshore wind power in the United States is 10.800 TW.[13] The actual technical capacity is closer to 2.058 TW,[14] when considering that 80% of the Outer Continental Shelf (OCS) is unsuitable for existing market technologies.[15] While the current actual potential is only about a fifth of the gross potential, it still translates to energy generation of 7,203 terawatt hours per year (TW·h) or nearly double the total electricity consumption of the United States.[16]

Renewable technologies historically have seen considerable cost decreases because of technology advancements, large-scale production, and

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[10] *24GW under construction in the US*, WIND POWER MONTHLY (July 18, 2019), https://www.windpowermonthly.com/article/1591387/24gw-construction-us.

[11] *Id.*

[12] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEPT. OF ENERGY, 2018 DISTRIBUTED WIND MKT. OVERVIEW 1 (2019), https://www.energy.gov/sites/prod/files/2019/05/f62/2018-distributed-wind-market-report-overview.pdf.

[13] U.S. DEPT. OF ENERGY & U.S. DEPT. OF THE INTERIOR, NAT'L OFFSHORE WIND STRATEGY: FACILITATING THE DEV. OF THE OFFSHORE WIND INDUS. IN THE U.S. 7 (2016), https://www.boem.gov/National-Offshore-Wind-Strategy/ (figure does not account for technological and political limitations).

[14] *Id.*

[15] Offshore wind development, at its inception, occurred relatively near to shore in shallow waters, typically between 0 m and 30 m. In 2012, the average water depth of European offshore wind plants was 22 m. Athanasia Arapogianni et al., *Deep Water: The next step for offshore wind energy*, THE EUROPEAN WIND ENERGY ASSOC., 14, 20 (July 2013), http://www.ewea.org/fileadmin/files/library/publications/reports/Deep_Water.pdf. These monopile technologies have dominated the industry; however, as offshore wind turbines get larger, they are developed further offshore, typically between 30 m and 60 m. Una Brosnan & Andrew Thompson *Offshore Wind Handbook* 56 (2018), http://www.klgates.com/files/Upload/2018-08_OG_Offshore-Wind-brochure.pdf. Turbines deployed at these sea-levels are mounted on monopile, fixed-bottom substructures. To access sites in greater water depths, fixed, four-legged foundations with wider footprints are needed, such as jacket structures, and for depths greater than 60 m, floating substructures are necessary. *Id.* at 27. Without accounting for technological limitations, the gross offshore wind resource capacity is 10.800 TW, meaning that roughly 80% of the potential capacity is only available when utilizing floating sub-structure technologies in waters between 60 m and 1 km. Walt Musial et al., 2016 OFFSHORE WIND ENERGY RES. ASSESSMENT FOR THE U.S. vii (2016), https://www.nrel.gov/docs/fy16osti/66599.pdf.

[16] U.S. DEPT. OF ENERGY, *supra* note 13 at 9.

commercialization.[17] Deployment levels grew by a compound annual growth rate of 17% between 2008 and 2014,[18] with costs for land-based wind in the United States decreasing by nearly 40%.[19] Project costs for offshore wind projects, since the construction of the Block Island Wind Farm in 2016, addressed in the next section, already have declined 75%[20] and may decrease further as technology and modeling software advances continue.[21]

Federal tax incentives, like the Renewable Energy Production Tax Credit (PTC)[22] and the Business Energy Investment Tax Credit (ITC),[23] have contributed to growth in domestic renewable energy technologies, as they are after-tax, dollar-for-dollar incentives.[24] Legislation enacted in 2017 created a glide-path off of both tax credits, with the PTC ending in 2020, and

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[17] For instance, between 2014 and 2017, net generation capacity from wind energy increased by an average of nearly 9.8% each year. U.S. ENERGY INFO. ADMIN., U.S. DEPT. OF ENERGY, ELEC. POWER ANNUAL 2017: TABLE 4.2(B) (2019), https://www.eia.gov/electricity/annual/pdf/epa.pdf; *see also 51.3 GW of global wind capacity installed in 2018,* GLOBAL WIND ENERGY COUNCIL (Feb. 26, 2019), https://gwec.net/51-3-gw-of-global-wind-capacity-installed-in-2018/.

[18] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEPT. OF ENERGY, 2014 RENEWABLE ENERGY DATA BOOK 25 (2015), http://www.nrel.gov/docs/fy16osti/64720.pdf.

[19] WIND & WATER POWER TECH. OFFICE, *supra* note 7 at xxxv.

[20] "This rapid cost decline is partially due to breakthroughs in other industries using the same technologies, i.e. onshore wind (blade, generator and pole technologies) and offshore drilling. And the global market is more mature than the U.S. market. . . . with almost 20 GW capacity already installed [in Europe], and some projects are already competitive with wholesale power rates . . . offshore wind's learning curve [a mechanism to explain the relationship between deployment and price] is likely already further along than expected." Mike O'Boyle, *Offshore Wind Prices Have Fallen 75% Since 2014 – Here's How To De-Risk Projects Even Further,* UTILITY DIVE (Dec. 3, 2018), https://www.utilitydive.com/news/offshore-wind-prices-have-fallen-75-since-2014-heres-how-to-de-risk-pro/543384/.

[21] *Id.*; *see also Floating Offshore Wind Vision Statement,* WIND EUROPE 11 (2017), https://windeurope.org/wp-content/uploads/files/about-wind/reports/Floating-offshore-statement.pdf.

[22] The PTC is an inflation-adjusted, per-kilowatt-hour tax credit available only to qualified energy resources. 26 U.S.C. § 45(a) (2019); "Qualified energy resources" include wind, closed-loop biomass, open-loop biomass, geothermal energy, solar energy, small irrigation power, municipal solid waste, qualified hydropower production, and marine and hydrokinetic renewable energy. 26 U.S.C. § 45(c)(1) (2019).

[23] The ITC is a 30% tax credit tied to the dollar amount of the energy investment in question. 26 U.S.C. § 48(2)(a) (2019).

[24] Large wind generation projects, which are eligible for both types of incentives, typically choose to utilize the PTC, likely because they can couple this with the benefit of the Modified Accelerated Cost Recovery System, which provides accelerated depreciation tax offsets. The Modified Accelerated Cost Recovery System is a before-tax incentive, as it provides a reduction in taxable income. NAT'L RENEWABLE ENERGY LAB., U.S. DEPT. OF ENERGY, WIND ENERGY FINANCE IN THE UNITED STATES: CURRENT PRACTICE AND OPPORTUNITIES 11 (2017), https://www.nrel.gov/docs/fy17osti/68227.pdf.

the ITC stepping down to a permanent 10% for commercial solar projects after 2021.[25] In response to the planned phase-outs of the federal tax credits, two pieces of federal legislation have been introduced. The Offshore Wind Incentives for New Development Act,[26] if adopted, would extend the Investment Tax Credit to all offshore wind projects commencing construction before January 1, 2026.[27] Alternatively, the bipartisan Incentivizing Offshore Wind Power Act[28] proposes that the Investment Tax Credit be extended to the first 3 GW of qualifying offshore wind facilities placed into service.[29]

1. State Waters. – Despite significant wind potential and its proximity to load areas,[30] the US offshore wind resource has remained stubbornly untapped. Instead, individual states have taken the lead.

In May of 1953, Congress passed the Submerged Lands Act, which granted individual states rights to the natural resources of submerged lands from the coastline to approximately three nautical miles seaward.[31] Texas and the west coast of Florida were exceptions as the Act extended those state jurisdictions nine nautical miles into the Gulf of Mexico.[32] The Submerged Lands Act defines the "outer continental shelf" as "all the submerged lands lying seaward and outside of the area of lands beneath navigable waters."[33]

Using its authority under the Submerged Lands Act, Rhode Island issued a state lease for state-controlled Submerged Land Act areas off Block Island. The Block Island Wind Farm, which came online in December of 2016, was the US's first offshore wind development.[34] With only five six-megawatt turbines, the Block Island Wind Farm will be dwarfed by higher capacity

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[25] Philip Tingle et al., *Renewable Energy Tax Bill Update: No Change to PTC and ITC and Some BEAT Changes*, THE NAT'L LAW R. (Dec. 21, 2017), https://www.natlawreview.com/article/renewable-energy-tax-bill-update-no-change-to-ptc-and-itc-and-some-beat-changes.

[26] Offshore Wind Incentives for New Development (WIND) Act, S. 3036, 114th Cong. (2016).

[27] *Id.* at § 2(B)(iii).

[28] Incentivizing Offshore Wind Power Act, S. 1672, 115th Cong. (2017).

[29] *Id.* at § 48E(d)(B).

[30] A load area is a region of increased electricity demand. As many of the US's major cities are along coasts, they are areas of increased electricity needs or loads.

[31] Three nautical miles is about 5.6 km.; Submerged Lands Act, Pub. L. No. 83-65, 67 Stat. 29 (1953), (codified as amended at 43 U.S.C. § 1301 *et seq.*).

[32] Nine nautical miles is about 16.2 km. Puerto Rico also has development rights nine miles out.; *Id.* at § 1301(b).

[33] *Id.* at § 1331(a).

[34] *Block Island Wind Farm*, DEEPWATER WIND (2019), http://dwwind.com/project/block-island-wind-farm/.

developments, but it is currently providing reliable,[35] affordable renewable energy to Block Island, Rhode Island.[36]

2. Federal Waters. – Historically, federal lands have not been the site of significant US wind energy development - either onshore or off. As of early 2019, federal lands represented less than 4% of all US wind energy capacity onshore,[37] and not a single US project had been developed in federal waters offshore.[38]

Some of this shortfall can be attributed to a lack of clear statutory authority to allow development. The Federal Land Policy and Management Act (FLPMA)[39] was enacted in 1976 before current wind energy technologies had been developed. When confronted with new wind-to-electricity technologies, federal officials responded on land by forcing the square-peg of

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[35] Molly Seltzer, *On Block Island, offshore wind ushers in a new time- quite literally*, AM. WIND ENERGY ASSOC.: INTO THE WIND (Oct. 24, 2017), https://www.aweablog.org/block-island-offshore-wind-ushers-new-time-quite-literally/ ("The Sea2Shore cable is an underwater line that connects the turbines to the island, and the island to the mainland. That cable is effectively bringing better quality, more secure, and cheaper electricity to Block Island. . . . The connection to the mainland also means that when the wind turbines are not producing power, the island can receive electricity from Rhode Island, and officially retire diesel generators.").

[36] *Block Island Wind Farm*, *supra* note 35; With the island's heavy reliance on diesel for electricity production, budgeting the town's energy expenses when fuel prices were volatile and unpredictable was difficult, and such fuel adjustment prices were reflected in customer's energy bills. Interim Block Island Power Company President Jeffery Wright said in 2017, "Wholesale energy prices are at historic lows right now and to have the opportunity to secure some long-term contracts for our customers provides price stability and allows customers to budget month to month, rather than have their electric bills tied to volatile diesel fuel prices." Cassius Shuman, *Island operating on wind farm power*, BLOCK ISLAND TIMES*,* (May 1, 2017), https://www.blockislandtimes.com/article/island-operating-wind-farm-power/49352; *see also* STATE OF R.I. OFFICE OF ENERGY RES*.,* FINAL REP. ON BLOCK ISLAND SAVES 4 (2018), http://www.energy.ri.gov/documents/archived-reports/Block%20Island%20Saves%20Pilot%20-%20Full%20Report%20-%20April%202018.pdf.

[37] 3.284 GW of the U.S. total of more than 100GW had been developed on BLM lands. OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, DEPT. OF ENERGY, WIND PROJECTS ON PUBLIC LANDS (2019), https://windexchange.energy.gov/projects/public-lands; 43 U.S.C. § 1761 (2019).

[38] *See, e.g.,* Erin K. Benson, *States Will be Big Fans: A State Driven Regulatory Process for Offshore Wind Development off U.S. Coastlines*, 47 U. BALT. L. REV. 111 (2017); Benjamin Fox, *The Offshore Grid: The Future of America's Offshore Wind Energy Potential*, 42 ECOLOGY L. Q. 651 (2015); Lamya Moosa, *The Energy Capital of the East Coast: Lessons Virginia Can Learn from Cape Wind Failure and European Success in Offshore Wind Energy*, 39 WM. & MARY ENVTL. L. & POL'Y REV. 713 (2015); Jacqueline S. Rolleri, *Offshore Wind Energy in the United States: Regulations, Recommendations, and Rhode Island*, 15 ROGER WILLIAMS U. L. REV. 217 (2010); Joseph J. Kalo et al., *Wind Over North Carolina Waters: The State's Preparedness to Address Offshore and Coastal Water-Based Wind Energy Projects*, 87 N.C. L. REV. 1819 (2009).

[39] 43 U.S.C. §§ 1701-1785.

wind development into the round hole of a Title V FLPMA right-of-way.[40]

Before 2005, however, federal agencies had no authority, comparable to the FLPMA right-of-way, to permit wind energy development in US waters offshore.[41] The Outer Continental Shelf Lands Act (OCSLA) was passed in August of 1953 to authorize the Secretary of the Interior to grant any oil, gas, or mineral lease for development, through competitive bidding, on submerged lands of the outer continental shelf.[42] The outer continental shelf specifically refers to 1.7 billion acres of federal submerged lands, subsoil, and seabed generally beginning three nautical miles off the coastline[43] and extending for at least 200 nautical miles to the edge of the Exclusive Economic Zone.[44] The Outer Continental Shelf Land Act stipulates that energy developers operating on the outer continental shelf are required to have a federal lease for their projects.[45]

The Energy Policy Act of 2005 (EP Act 2005) updated some of the provisions of the Energy Policy Act of 1992,[46] to address wind energy production in the United States.[47] Section 388(a) of EP Act 2005 amended Section 8 of the Outer Continental Shelf Lands Act.[48] The amendment authorizes the Secretary of Interior to "lease submerged lands [in] support [of] production, transportation, or transmission of energy from *sources other than oil and gas.*"[49] The Secretary of the Interior delegated the authority to regulate offshore wind activities to the Bureau of Ocean Management (BOEM).[50]

[40] *See, e.g.*, David J. Lazerwitz, *Renewable Energy Development on the Federal Public Lands: Catching Up with the New Land Rush*, 55 ROCKY MTN. MIN. L. INST. 13-1 (2009).

[41] *See, e.g.*, *Alliance to Protect Nantucket Sound, Inc. v. U.S. Dep't of the Army*, 398 F.3d 105 (1st Cir. 2005).

[42] Outer Continental Shelf Lands Act, Pub. L. No. 83-212, 67 Stat. 345 (1953), (codified as amended 43 U.S.C. §§ 1331–1356(b)).

[43] 43 U.S.C. §§ 1301(a), 1331(a) (2019).

[44] Proclamation No. 5030, 97 Stat. 1557, (Mar. 10, 1983); The Economic Exclusive Zone is the zone where the U.S. and other coastal nations have jurisdiction over natural resources. *See* NATIONAL OCEAN SERVICE, U.S. DEP'T. OF COM., WHAT IS THE EEZ? https://oceanservice.noaa.gov/facts/eez.html (last visited May 12, 2019).

[45] 43 U.S.C. § 1337(p)(1)(C).

[46] Energy Policy Act of 1992 Pub. L. No. 102-486, 106 Stat. 2776 (1992), (codified at 16 U.S.C. § 2601 and codified as amended in scattered sections of 42 U.S.C.).

[47] Energy Policy Act of 2005 Pub. L. No. 109-58, 119 Stat. 594 (2005), (codified as amended in scattered sections of 42 U.S.C.).

[48] Energy Policy Act of 2005, Pub. L. No. 109-58 sec. 388(a) 119 Stat. 594 (codified as amended at 43 U.S.C. § 1337(p)(1)(C) (2005)).

[49] *Id.*

[50] Originally, the Secretary delegated the leasing and management authority to the Minerals Management Service (MMS), which at that time also administered the OCS oil and gas leasing process. However, the federal government grew concerned that MMS, which controlled both leasing and safety as well as revenue generation, had a conflict of

Although the Federal Energy Regulatory Commission (FERC) has also claimed some authority over renewable energy projects offshore, under a Memorandum of Understanding, BOEM has responsibility for leasing and licensing renewable energy projects on the OCS.[51]

According to the Department of Energy, the United States has a total capacity of 25.464 GW in its project queue as of June 2018.[52] This pipeline includes 3.922 GW of project-specific capacity and 21.542 GW of undeveloped lease area potential capacity.[53] As of the close of 2019, no construction had begun on any offshore wind project in federal waters.[54] However, several federal leases have been awarded along Atlantic coastal states.[55]

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interest that may have contributed to the Macondo Well blowout from the Deepwater Horizon oil rig in April 2010. So, the BLM reorganized MMS to separate the two functions. The Office of Natural Resources Revenue controls royalty payments. ABOUT ONRR, https://www.onrr.gov/ (last visited Dec. 2, 2019). A new agency, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) was created to control leasing and safety. BOEMRE was further divided into the Bureau of Ocean Energy Management (BOEM) https://www.boem.gov/ and the Bureau of Safety and Environmental Enforcement (BSEE) https://www.bsee.gov/. HENRY B. HOGUE, CONG. RESEARCH SERV., R41485, REORGANIZATION OF THE MINERALS MANAGEMENT SERVICE IN THE AFTERMATH OF THE DEEPWATER HORIZON OIL SPILL 1-14 (2010); *See also* Secretarial Order 3071 (Jan. 19, 1982) (codified at 30 C.F.R. § 1201 (1982)) (giving MMS authority over offshore leasing); 30 C.F.R. § 585.100 (2019).

[51] Memorandum of Understanding between U.S. DEP'T OF INTERIOR and FERC (Apr. 2009), https://www.boem.gov/Renewable-Energy-Program/DOI_FERC_MOU.aspx (FERC permits marine hydrokinentic (wave and tidal) through its license process, while BOEM issues leases if they are on the OCS. BOEM has exclusive jurisdiction for leasing and permitting wind on the OCS).

[52] U.S. DEP'T. OF ENERGY, 2017 OFFSHORE WIND TECHNOLOGIES MARKET UPDATE 22 (2018), https://www.energy.gov/sites/prod/files/2018/09/f55/71709_V4.pdf (The queue did not include any Pacific Coast projects because none had submitted applications to BOEM by the time of the report).

[53] *Id.*; *see also* U.S. Offshore Wind Industry Status Update, AMERICAN WIND ENERGY ASSOCIATION, https://www.awea.org/Awea/media/About-AWEA/U-S-Offshore-Wind-Fact-Sheet-September-2018-2.pdf (last visited Mar. 26, 2019).

[54] BOEM extended the time for completing its draft Environmental Impact Statement (EIS) for the first in line, the Vineyard Wind project off Massachusetts, to allow for a cumulative analysis of projects. *Vineyard Wind*, BUREAU OF OCEAN ENERGY MGMT., U.S. DEPT. OF INTERIOR, https://www.boem.gov/renewable-energy/state-activities/vineyard-wind (last visited Jan. 18, 2020); *See also*, Phil McKenna and Dan Georino, *Government Delays First Big U.S. Offshore Wind Farm. Is a Double Standard at Play?*, INSIDE CLIMATE NEWS (Aug. 19, 2019), https://insideclimatenews.org/news/19082019/vineyard-wind-offshore-renewable-energy-delay-boem-environmental-cumulative-review-nepa-massachusetts.

[55] *See Lease and Grant Information,* BUREAU OF OCEAN ENERGY MANAGEMENT, https://www.boem.gov/Lease-and-Grant-Information/ (Virginia, Commercial Lease OCS-A-0483: Dominion Energy secured a lease in 2013 for the construction of the Coastal

3. Europe. – In contrast to the United States, Europe has a robust offshore wind industry, with 105 projects constructed as of 2018.[56] The United Kingdom leads the world with about 7 GW of offshore capacity.[57] Germany is next in line with approximately 5 GW.[58] While China is in third place, Denmark, Netherlands, Belgium, Sweden, Finland, Ireland, Spain, Norway, and France are all in the top 18 countries with offshore capacity.[59]

Europe's early success in offshore wind is attributed to several factors, including energy supply and security concerns, a need for investment in electricity infrastructure, and an acceptance and commitment to address climate change.[60] Since 2012, European nations have provided a consistent policy supporting offshore wind energy, which prompted the growth of a reliable commercial industry to facilitate offshore wind materials, construction, and development.[61] This growth increased confidence and investment in offshore wind energy, and as of 2018, there were wind plants

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Virginia Offshore Wind project, also in collaboration with Ørsted, with the goal of being in operation at the beginning of 2022; Maryland, Commercial Lease OCS-A 089: US Wind Inc. was awarded a lease in 2014 for the development of the "Skipjack Wind Farm," in collaboration with Deepwater Wind, with construction planned to begin in 2021; Massachusetts, Commercial Lease OCS-A 051: Offshore MW LLC, a subsidiary of Avangrid Renewables, was awarded a lease for the "Vineyard Wind" project in 2015, and construction is on track to begin in 2019; New Jersey, Commercial Lease OCS-A 0498: RES America Development secured a lease in 2016 for the development of the "Ocean Wind" project, in collaboration with Ørsted, with construction planned to begin early in 2020; New York, Commercial Lease OSC-A 0512: Equinor Wind signed a commercial lease in March 2017 to develop the "Empire Wind Project", which is estimated to begin delivering power in 2025; North Carolina, Commercial Lease OCS-A 0508: Avangrid Renewables signed a commercial lease in November 2017 to develop a project off the coast of Kitty Hawk, and it is in the early stages of site assessment); *See also* OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *supra* note 2, at 59 (chart showing proposed projects).

[56] FLORIAN SELOT, ET AL., OFFSHORE WIND IN EUROPE: KEY TRENDS AND STATISTICS 8 (2019), https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2018.pdf. In addition, European countries have several additional projects in the queue for 2019: The Netherlands is set to have 1 GW of new installations in 2019; Germany plans to have 44 new projects connected in 2019. *Id.* at 11, 25.

[57] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *supra* note 2, at 60.

[58] *Id.*

[59] *Id.*

[60] *See* THE EUROPEAN WIND ENERGY ASSOCIATION, DELIVERING OFFSHORE WIND POWER IN EUROPE 5 (2007), http://www.ewea.org/fileadmin/files/library/publications/reports/Delivering_Offshore_Wind_Power_in_Europe.pdf.

[61] *See, e.g.,* U.K. DEPARTMENT OF ENERGY & CLIMATE CHANGE, NATIONAL RENEWABLE ENERGY ACTION PLAN FOR THE UNITED KINGDOM 6-7 (2010), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment-data/file/47871/25-nat-ren-energy-action-plan.pdf; *see also* Offshore Wind Energy: Oceans of Opportunity, WINDEUROPE, https://windeurope.org/policy/topics/offshore-wind-energy/ (last visited May 12, 2019).

in eleven European countries consisting of 4,543 turbines with a cumulative capacity of 18.5 GW.[62] Many of these wind plants are located in close proximity to one another.[63]

II. WIND WAKES

Wind turbines effect the air downwind of the blades after the wind has gone through the turbine, creating wakes like boat wakes in water.[64] While water makes boat wakes clearly visible, the wind is transparent, so its wakes are less obvious. Section A addresses the science of wind wakes, and Section B explains how developers have gradually gained increased appreciation for the impact of wakes on their wind plants and how they have historically handled the situation.

A. The Science

Wind wakes have two significant negative impacts on projects attempting to harvest wind energy. While some operators do not distinguish between the two, frequently called generically "wake losses" or "wake effects,"[65] the impacts are, in fact, measurably distinct in both the damage they cause and their reach behind a turbine. Although this analysis places wake damage from turbulence first, energy loss is a more serious concern for many wind plant operators because the losses can be in the millions of dollars or more annually and are ones over which an operator may have

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[62] SELOT, ET AL., *supra* note 56, at 8; *see also GWEC Windsights,* GLOBAL WIND ENERGY COUNCIL, https://gwec.net/windsights/ (listing 18.3 GW for Europe in 2018).

[63] *See, e.g.*, 4C OFFSHORE, https://www.4coffshore.com/offshorewind/.

[64] Kimberly E. Diamond & Ellen J. Crivella., *Wind Turbine Wakes, Wake Effect Impacts, and Wind Leases: Using Solar Access Laws as the Model for Capitalizing on Wind Rights During the Evolution of Wind Policy Standards*, 22 DUKE ENVTL. L. & POL'Y F. 195, 199 (2011) (*citing* Christian Melsheimer, *Ship Wakes Observed with ERS and SPOT,* CRISP RESEARCH).

[65] Wake effects are "the reduction in wind speed and increase in turbulence that occurs downstream of a wind turbine." MICHAEL C. BROWER ET AL., WIND RES. ASSESSMENT: A PRACTICAL GUIDE TO DEVELOPING A WIND PROJECT 246 (Michael C. Brower ed., 2012). "Wake losses" reference "energy production changes due to turbine interaction." James Bleeg et al., *Wind Farm Blockage and the Consequences of Neglecting Its Impact on Energy Production*, ENERGIES (June 20, 2018), https://www.mdpi.com/1996-1073/11/6/1609 (arguing that models used to predict a wind project array's efficiency that only consider wake impacts "generally overpredict wind farm energy production" and that a model that considers turbine interaction including blockage as well as wake loss will provide more accurate results even if more complicated and costly to produce).

little or no control.[66]

1. Wake Damage (Turbulence). – There is a "wake damage" or "turbulence" effect in the zone immediately behind a wind turbine. The turbulence from an upwind turbine can strike (or impact) a downwind machine, causing premature fatigue of the turbine blades and electricity generation equipment.

Wind turbines typically have a design lifetime of about 20 to 30 years, which makes "fatigue" a critical factor in wind turbine design, especially blade design.[67] Fatigue loading on the blades can be caused by gravity, wind shear, and partial waking.

While gravity and wind shear are environmental factors that cannot be controlled, partial waking is one that can. Partial wake operation causes uneven load distributions on either side of the turbine blade face, leading to lower efficiency, diminished output, less cost-effective operation, and a shorter service life for the gears and other components of a turbine.[68]

Historically, industrial climbers have been used to regularly inspect the rotor blades on turbines.[69] However, the poor accessibility of offshore wind plants and the unpredictability of maritime weather conditions make it difficult to plan the deployment of maintenance teams, with a corresponding impact on operating costs.[70] Wind plant operators have been looking for alternative structural monitoring methods that are equally as reliable as regular inspections by industrial climbers.[71] One such tested technology among industry operators is mobile thermography through the use of drones. By attaching thermal imaging cameras to drones, it is possible to

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[66] *See, e.g.,* J.K Lundquist, et al., *Costs and Consequences of Wind Turbine Wake Effects Arising from Uncoordinated Wind Energy Development,* 4 NAT. ENERGY 26 (2019) discussed *infra* p. 15.

[67] During that lifetime they can perform up to 10^9 revolutions, but this varies depending on the size and application of a wind turbine. MARTIN O. L. HANSEN, AERODYNAMICS OF WIND TURBINES 91 (2d ed. 2008), https://epdf.tips/aerodynamics-of-wind-turbines.html.

[68] Aaron Walters, *A Fast Way to Find Fatigue Damage on Wind Turbines from Partial Waking,* BRIGHAM YOUNG UNIVERSITY 1, https://www.et.byu.edu/~vps/ME505/AAEM/V4-10.pdf; *See also* Fraunhofer-Gesellschaft, *Inspecting Rotor Blades with Thermography and Acoustic Monitoring,* PHYS (Jan. 12, 2017), https://www.fraunhofer.de/en/press/research-news/2017/december/inspecting-rotor-blades-with-thermography-and-acoustic-monitoring.html.

[69] Ben DuBose, *New Rotor Blade Inspection Methods for Offshore Wind Turbines,* MATERIALS PERFORMANCE (Feb. 1, 2018), http://www.materialsperformance.com/articles/coating-linings/2018/02/new-rotor-blade-inspection-methods-for-offshore-wind-turbines.

[70] Fraunhofer-Gesellschaft, *supra* note 68.

[71] Corten & Brand, *infra* note 377.

detect subsurface defects in composite materials.[72] Under operational load, such defects deep inside the rotor blade, if not detected and dealt with in good time, can provoke more serious structural damage and eventually lead to a total breakdown.[73] With the proliferation of drone technology, coupled with the advancement of wake modeling techniques, developers can become better informed about impending wake effects on their projects with an ability to more closely track turbine damage as it occurs.

The notion of blade fatigue is not new to the industry. Some of the key wake damage models were developed in the 1980s,[74] and in 1999 two Danish scientists conducted a study on the Vindeby offshore wind plant in Denmark and found that wakes increased fatigue loads by 5 to 15% compared to freestream wind.[75] With increased fatigue loads comes the need for additional maintenance measures. Operational and maintenance costs can rise due to frequent unplanned maintenance.[76] In addition to decreasing the life of the turbine, turbulence also can create safety concerns.[77]

This "wake damage" effect is most severe close to the turbine causing it. Three rotor diameters (RD)[78] can be a bare minimum spacing behind the

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[72] Such subsurface defects include delamination (the loss of cohesion between laminate layers), inclusions (presence of foreign bodies in layer resin), faulty bonding in the loadbearing web-flange joints, and shrinkage cavities. *See* Fraunhofer-Gesellschaft, *supra* note 68.

[73] *Id.*

[74] BROWER ET AL., *supra* note 65, at 252 (noting that the "Park" wake model was developed "in the mid-1980s" and the "Eddy Viscosity (EV) Model" came about "around the same time" "in the late 1980s.").

[75] Kenneth Thomsen & Poul Sørensen, *Fatigue Loads for Wind Turbines Operating in Wakes*, 80 J. OF WIND ENG'G & INDUS. AERODYNAMICS 121, 135 (1999).

[76] Patrick I. Muiruri & Oboetswe S. Motsamai, *Fatigue Loads Mitigation on Horizontal Axis Wind Turbines Using Aerodynamic Devices. A Survey,* 10 J. OF ENG'G SCI. AND TECH. REV. 144 (2017); *see also* INT'L RENEWABLE ENERGY AGENCY, *Renewable Energy Technologies: Cost Analysis Series–Wind Power* (Int'l Renewable Energy Agency Working Paper, Vol. 1: Power Sector Issue 5/5, June 2012), https://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-wind_power.pdf.

[77] *See, e.g.*, Waveney District Council v. Next Generation Ltd. [2003] P.A.D. 36 [5.4] (appeal taken from Inspector D. Lavender, MRTPI) (UK) ("The manufacturers say that increased stresses imposed on the turbine due to turbulence in the air has the effect of decreasing the design life of many of the turbine components dramatically and immeasurably, so the safety of the turbine over time cannot be guaranteed.").

[78] The horizontal-axis wind turbine, which is the most commonly used for generating electricity throughout the world, involves a tower or mast with a blade or blades attached. Two common ways of measuring these wind turbines are at hub height or by rotor diameter. The hub is where the turbine drivetrain and the rotors or blades attach to the tower. The rotors at hub height generate electricity when the blades turn. Rotor diameter (or RD) is the diameter of the area swept by the rotor which is equivalent to twice the length of a rotor blade. DESIRE LE GOURIERES, WIND POWER PLANTS: THEORY AND DESIGN 39

upwind turbine to prevent damage,[79] but generally operators still consider that turbulence damage can occur between 5 and 10 RD.[80]

While some argue that the wake damage effect can be mitigated,[81] the International Electrotechnical Commission (IEC) has created a recommendation of at least 5 RD, with 10 RD as the point where there is no more wake damage.[82] Similarly, the UK's Planning Policy Guidance on Renewable

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(1982). In 2017, the average rotor diameter in the United States was 113 meters. OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEP'T OF ENERGY, 2017 WIND TECHNOLOGIES MARKET REPORT vii (Aug. 2018), http://eta-publications.lbl.gov/sites/default/files/2017-wind-technologies-market-report.pdf. *See also*, Eric Lantz et al., *Increasing Wind Turbine Tower Heights: Opportunities and Challenges,* U.S. DEP'T OF ENERGY, NAT'L RENEWABLE ENERGY LABORATORY (MAY 2019) https://www.nrel.gov/docs/fy19osti/73629.pdf. *Tall Towers Tap Greater Wind Potential*, U.S. DEP'T OF ENERGY, NREL (July 11, 2019), https://www.nrel.gov/news/program/2019/tall-towers-tap-greater-wind-resource-potential.html ("Size increases have led to greater output from turbines under ideal conditions–also known as the nameplate capacity–which has gone from 100 kW per turbine in the 1980s to approximately 2.4 MW per turbine in 2018. In that same time frame, the average U.S. commercial wind turbines' hub height increased from 20 meters (m) to 88 m and rotor diameter has expanded from 20 m to 116 m. Taller towers can tap stronger wind resources that exist at higher levels, beyond the reach of today's typical turbines. Higher hubs on wind turbines also reduce interference from trees, buildings, and other topographical features and provide additional clearance needed for longer blades–all of which increases energy capture per turbine.").

[79] BROWER ET AL., *supra* note 65, at 246. *See also*, Fernando Porté-Agel, Majid Bastankhah, & Sina Shamsoddin, *Wind-Turbine and Wind-Farm Flows: A Review*, 174 BOUNDARY-LAYER METEOROLOGY 1, 5-8 (Sept. 20, 2019), https://link.springer.com/article/10.1007/s10546-019-00473-0 (defining impacts between 2 and 4 RD as the "near-wakes" in contrast to the wake effects in contrast to those beyond 4RD classified as "far-wakes."). However, turbulence damage can extend beyond 10 RD in certain atmospheric conditions. Email from Patrick Moriarty, Group Manager III-Systems Engineering, National Renewable Energy Laboratory, to author (Aug. 26, 2019) (on file with author).

[80] Thomsen & Sørensen, *supra* note 75, at 135.

[81] Some active research is looking at manipulating wakes within one plant to ameliorate these damages. *See* Paul Fleming et al., *Initial Results from a Field Campaign of Wake Steering Applied at a Commercial Wind Farm – Part 1*, 4 WIND ENERGY SCI. 273 (2019); Paul Fleming et al. *Simulation Comparison of Wake Mitigation Control Strategies for a Two-Turbine Case.* 18 WIND ENERGY 2135 (2015); *see also* Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, [3.4] (arguing that "cutting edge technology, with the speed of the rotor blades regulated so that the effect on downstream turbines becomes smaller as wind velocity increases" can allow turbines to be "as close together as two rotor diameters" without significant damage).

[82] Patrick Moriarty of NREL cites Appendix D of IEC International Standard 61400-1 (3rd ed. 2005-2008) for the 5 RD to 10 RD figures. IEC 61400-1 Appendix D is based on S. Frandsen (2003) *Turbulence and turbulence generated fatigue in wind turbine clusters,* Risø-R-1188. Moriarty also states that wake damage can extend beyond 10 RD: "A wake will propagate more than 5 RD in stable conditions and if a turbine is in a half wake condition (half in half out) that will be damaging." Emails from Patrick Moriarty, Group Manager III-Systems Engineering, NREL, to author (July and Sept. 2019) (on file with author).

Energy Note 22 (PPG22) also recommends that wind turbines be spaced approximately 5 to 10 RD apart.[83] A study by the National Renewable Energy Laboratory concluded that "turbulent wakes generated from [] upstream turbines have significant impact" even when spaced at 7 RD.[84]

During the summer of 2019, Daniel Thomas Kaffine, Professor at the University of Colorado Boulder, and Fellow at the Renewable & Sustainable Energy Institute (RASEI), calculated the proximity of installed wind turbines in the United States using data from the US Wind turbine database website.[85] Professor Kaffine's calculations indicate that a 5 to 10 RD spacing appears to be a norm within most US terrestrial wind plants.[86] His calculations also indicate that, at an individual turbine level, there seems to be an industry norm of not placing turbines closer than 10 RD to another turbine from a different wind plant.[87] For the average onshore turbine in the United States, this translates to a turbine spacing of between 1800 and 3600 feet, or about 0.5 to 1 km to address the wake damage effect alone.[88]

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[83] *See, e.g.*, Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, [3.4] (Eng.).

[84] S. Lee, et al, *Atmospheric and Wake Turbulence Impacts on Wind Turbine Fatigue Loadings,* U.S. DEP'T OF ENERGY, NAT'L RENEWABLE ENERGY LABORATORY (2011), https://www.nrel.gov/docs/fy12osti/53567.pdf.

[85] Professor Kaffine notes, "Quick note on what a "wind farm" is, I did some data cleaning of the raw USGS data to toss out obvious cases where a wind turbine is clearly from the same plant and is owned by the same company but has slightly different names. For example, if some turbines were assigned to the plant "Windy McWindfarms" and then others were assigned to "Windy McWindfarms (expansion)", I called that the same wind farm. There's some error in this process, and there's likely some cases where turbines belong to the same wind farm (in the sense that they're owned and operated by same company) but I call them different, and some cases where the turbines actually belong to different wind farms, but I call them the same." Email from Daniel Thomas Kaffine, Professor of Economics, University of Colorado Boulder, to author (Aug. 19, 2019) (on file with author) (using THE U.S. WIND TURBINE DATABASE, https://eerscmap.usgs.gov/uswtdb/(using data from July 15, 2019)).

[86] Professor Kaffine stated, "at the individual turbine level, only 20% of wind turbines have no other wind turbines (from any wind farm) within 5 RD, and only 1.6% have no other wind turbines within 10 RD." Email from Daniel Thomas Kaffine, Professor of Economics, University of Colorado Boulder, to author (Aug. 19, 2019) (on file with author). This means that 98.4% are closer than 10 RD to another turbine, and 80% are 5 RD or closer.

[87] Professor Kaffine stated, "at the individual turbine level (~55,000), about 1.3% have a turbine from a different wind farm that's within 5 RD of itself, and about 5.6% have a turbine from a different wind farm within 10 RD." Email from Daniel Thomas Kaffine, *supra* note 86. Seen from the opposite perspective, this means that 94.4% had no turbine from an adjacent wind farm within 10 RD, and 98.7% had no turbine from an adjacent wind plant within 5 RD.

[88] With an average rotor diameter of 110 m or 361 feet. OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *supra* note 78, at ix.

The world's current largest offshore wind turbine is 12 MW with a rotor diameter of 214 m.[89] Consequently if one of these turbines is spaced 5 RD to avoid causing turbulence wake damage to an adjacent turbine, the two turbines would have to be over 1 km or more than half a mile apart.[90]

2. Energy Loss. – Another, and often more serious, wake effect is "energy loss."[91] The goal of a wind plant is to extract energy from wind. Consequently, the wind speed is reduced and the amount of energy in it diminished after it passes through an upwind turbine.[92] A couple of rotor diameters upstream from a wind turbine, the air that is traveling unaffected by wake is the "freestream."[93] Because the diminished wind from an upwind turbine reduces the energy entering downwind turbines, it similarly decreases the downwind turbines' overall energy output.[94]

While energy loss has been recognized as a concern for some time,[95]

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[89] The GE Haliade-X is 12 MW. While manufacturing has begun, it is not yet commercially used. Anmar Frangoul, *Installation of GE's Huge 12-Megawatt Wind Turbine Prototype 'On Schedule'*, CNBC (Apr. 1, 2019), https://www.cnbc.com/2019/04/01/installation-of-ges-12-megawatt-wind-turbine-prototype-on-schedule.html; Betsy Lillian, *GE Reveals First Manufactured Part of Haliade-X 12 MW*, NORTH AMERICAN WINDPOWER (July 22, 2019), https://nawindpower.com/ge-reveals-first-manufactured-part-of-haliade-x-12-mw.

[90] The rotor diameter is roughly the equivalent of two blades, so 214 m or equivalent to about 702 feet per RD and 3510 feet of turbulence impact.

[91] This also is sometimes called "wind shadow." *See, e.g.*, Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, [7.6] (Eng.).

[92] Jeffrey Mirocha et al., *Investigating Wind Turbine Impacts on Near-Wake Flow Using Profiling Lidar Data and Large-Eddy Simulations with an Actuator Disk Model,* 7 J. OF RENEWABLE & SUSTAINABLE ENERGY 1, 1–2 (2015).

[93] Diamond & Crivella, *supra* note 64, at 199.

[94] Pedro A. Jiménez et al., *Mesoscale Modeling of Offshore Wind Turbine Wakes at the Wind Farm Resolving Scale: a Composite-Based Analysis with the Weather Research and Forecasting Model Over Horns Rev*, 18 WIND ENERGY 559, 559 (2015); *see also* Clara M. St Martin et al., *Wind Turbine Power Production and Annual Energy Production Depend on Atmospheric Stability and Turbulence,* 1 WIND ENERGY SCI. 221 (2016); Nicolai Gayle Nygaard & Sidse Damgaard Hansen*, Wake Effects Between Two Neighbouring Wind Farms,* 2016 J. OF PHYSICS: CONF. SERIES 753 032020, 6–10 (2016); Nicolai Gayle Nygaard, *Wakes in Very Large Wind Farms and the Effect of Neighbouring Wind Farms*, 2014 J. OF PHYSICS: CONF. SERIES 524 012162 (2014) (research about the impact of the Rødsand II wind project on the efficiency of the Nysted project in the North Sea (efficiency dropped by 21%)).

[95] *See, e.g.*, MANWELL ET. AL., WIND ENERGY EXPLAINED: THEORY DESIGN AND APPLICATION 423 (2010) ("Studies have shown that, for turbines that are spaced 8 to 10 rotor diameters, RD, apart in the prevailing downwind direction and five rotor diameters apart in the crosswind direction, array losses are typically less than 10%." (citing PBS LISSAMAN ET AL., NUMERIC MODELING SENSITIVITY ANALYSIS OF THE PERFORMANCE OF WIND TURBINE ARRAYS (1982)). Department of Energy/Pacific Northwest Laboratory Contractor Report, D. E. 82027570. PNL-4183). The 8-10 RD distance is also referenced in Rafiee, Van der Male, Scholten,

research continues with more sophisticated measurements and modeling.[96] Experts have begun to quantify the degree of energy loss between wind plant clusters and to verify whether there is an "underestimation of the wake losses inside large arrays."[97]

The distance that a wake effect extends is still being researched by the scientific community. As discussed above, the wake damage or turbulence effect damage from an individual commercial wind turbine can persist downwind for eight to 10 times the turbine's rotor diameter or over 1 km.[98] While several terrestrial wind developers also cited 10 RD as the rule of thumb or industry standard for full wake effect protection from both turbulence and energy loss, the scientific community is warning that energy loss impacts can be significant well beyond 10 RD.

Energy loss wake effects have been studied for over 15 years, and the extent of their impacts continues to be better understood.[99] One study in 2004 used satellite imaging to determine wake effects between two large wind plants, Horns Rev and Nysted, off the coast of Denmark.[100] The images show a trail downwind of the plant that propagates for 20 km or about 12.5 miles before near-neutral conditions are reached.[101]

Interactive 3D Geodesign Tool for Multidisciplinary Wind Turbine Planning, J. ENVTL. MGMT. 107, 119 (2018) (based on the LISSAMAN model again). *See also* The Queen on the Application of Coronation Power Limited v. Secretary of State for Communities and Local Government, [2011] EWHC 2216 (Admin), 2011 WL 2748278 (July 22, 2011) (Noting that paragraph 1.32 of the environmental statement says the turbines of the proposed wind plant "have been positioned so as to: Allow a balanced layout and *avoid wake effects and interference between turbines which may lead to a 'reduction of energy generation.'*") (emphasis added).

[96] BROWER ET AL., *supra* note 65, at 250 ("Wake modeling remains an area of active research because of the great complexity and wide range of scales of turbine-atmosphere interactions.").

[97] Nygaard, *Wakes in Very Large Wind Farms and the Effect of Neighbouring Wind Farms*, *supra* note 94. *See also* Bleeg, *supra* note 66 (noting that wake-only models that do not consider "extra-wake turbine interaction" have a bias for overpredicting production. Also noting that some researchers have shown increased production from tightly spaced rows–hub-to-hub distance of 1.5 RD–perpendicular to the flow.).

[98] Diamond & Crivella, *supra* note 64, at 204. *See also* Bleeg, *supra* note 66 (Measuring wind slowdown at 3.4% at 2 RD and an average of 1.9% between 7-10 RD).

[99] Email from Julie Lundquist, Associate Professor, University of Colorado (July 28, 2019) (on file with author).

[100] Merete Bruun Christiansen & Charlotte B. Hasager, *Wake Effects of Large Offshore Wind Farms Identified from Satellite SAR*, 98 REMOTE SENSING OF ENVIRONMENT 251 (2005); *see also* Nygaard, *Wakes in Very Large Wind Farms and the Effect of Neighbouring Wind Farms*, *supra* note 94, at 1-10.

[101] *See* Christiansen and Hasager, *supra* note 100, at 259; *See also* Charlotte B. Hasager, et al., *Using Satellite SAR to Characterize the Wind Flow around Offshore Wind Farms,* ENERGIES (June 2015), https://www.mdpi.com/1996-1073/8/6/5413. Julie

A study published approximately 10 years later modeled the impacts of a new wind plant that was constructed about 3 km upwind of Nysted.[102] This study concluded that "the external wake losses can be significant for wind directions, where the neighbouring wind plant is directly upstream. This additional wake loss is accompanied by an increase in the turbulence intensity on the order of a few percent."[103]

Some studies have estimated the energy loss effect to dissipate after 15 RD (or 1.2 km),[104] but more recent work shows the energy loss effect extending further. One study, using dual-Doppler radar tracking wakes for 17 km behind a wind plant, noted that 17 km was "the limiting range of the radars given the experimental setup. For production estimate calculations the influence of neighbouring wind plants therefore needs to be included at least to this distance, but *probably further*."[105]

A German study found that for offshore wind plants located several tens of kilometers downwind of neighboring wind plants along the main wind direction, the productivity of the downwind plants may be reduced during periods of stable atmospheric stratification.[106] This study provided the first *in situ,* or on-site, confirmation of the existence of far wakes extending at

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Lundquist also noted, "There is a large body of work now assessing SAR images of wind farm wakes. Platis, Siedersleben, etc. all include them." Lundquist Email, *supra* note 100.

[102] Nygaard, *Wakes in Very Large Wind Farms and the Effect of Neighboring Wind Farms*, *supra* note 94.

[103] *Id.* at 10. *See also* Interview with Julie Lundquist, *supra* note 99 ("Anyway, the percentage of capacity factor before the upwind farm (for specific wind speeds and specific wind directions) was taken from digitizing Fig 9a and looking at the 270 deg wind direction differences. 88% vs 67%.").

[104] Mark A. Harral, et al., *The Wake Effect: Impacting Turbine Siting Agreements*, NORTH AM. CLEAN ENERGY (2013) http://www.nacleanenergy.com/articles/15348/the-wake-effect-impacting-turbine-siting-agreements (citing Brian D. Hirth & John L. Schroeder, *Documenting Wind Speed and Power Deficits Behind a Utility-Scale Wind Turbine*, 52 J. APPLIED METEOROLOGY AND CLIMATOLOGY 41–42 (2013)).

[105] Nicolai Gayle Nygaard & Alexander Christian Newcombe, *Wake Behind an Offshore Wind Farm Observed with Dual-Doppler Radars*, J. PHYSICS: CONF. SERIES 1037 072008 (2018) (emphasis added).

[106] "Stratification" in this context is the division of Earth's atmosphere into layers. H. Flohn & R. Penndorf, *The Stratification of the Atmosphere,* 31 BULLETIN OF THE AM. METEOROLOGICAL SOC'Y 71, (1950). https://journals.ametsoc.org/doi/pdf/10.1175/1520-0477-31.3.71; *See also*, Andreas Platis et al., *First* in situ *Evidence of Wakes in the Far Field Behind Offshore Wind Farms*, NATURE: SCI. REPORTS (Feb. 1, 2018), https://www.nature.com/articles/s41598-018-20389-y#ref-CR55 ("For wind plants located several tens of kilometres downwind of neighbouring wind plants along the main wind direction, the productivity of the downwind plants may be reduced during periods with stable stratification.").

least 45 km (28 miles) downwind from wind plants.[107] Additional modeling shows that in certain conditions, one wind plant can reduce downwind speeds by 10 % up to 60 km (35 miles) away.[108]

Scientists have described wind turbines as "greedy" because they will extract as much energy from the wind as possible[109] without consideration for other turbines in the wind plant network.[110] Much modelling initially focused on impact behind a single turbine. However, as time went on, the science expanded to consider the more complicated impact of multiple turbines and "deep arrays" of turbines.[111]

The ultimate goal of most developers may be to optimize profits rather than to maximize the number of gigawatt hours a wind plant produces. Thus, tradeoffs with spacing might be outweighed by efforts to address other costs such as bonus payments, rents, royalties, cable costs, cable losses, costs per turbine (deep borings, purchase, foundation, install), production per turbine, site investigation costs, and operation and maintenance or O&M costs.[112] Yet maximizing production and minimizing losses or O&M costs would seem to be key factors in the equation.

Knowledge of the turbulence effect and energy loss impacts create a fundamental dilemma for a wind developer. As a general rule, more turbines might mean more opportunities to produce electricity translating to more income for the project. So, developers want to site as many turbines as they can in prime locations where they control the land, thus narrowing the spacing. But they also need to space turbines far enough apart to minimize wake losses and turbulence damage.[113] Closer spacing of wind turbines

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[107] Andreas Platis et al., *First* in situ *Evidence of Wakes in the Far Field Behind Offshore Wind Farms* NATURE: SCI. REPORTS (Feb. 1, 2018), https://www.nature.com/articles/s41598-018-20389-y#ref-CR55; See *also,* Simon K. Siedersleben et al., *Micrometeorological Impacts of Offshore Wind Farms as seen in Observations and Simulations*, 2018 ENVTL. RES. LETTERS 13 124012 (2018); Simon K. Siedersleben, et al., *Evaluation of a Wind Farm Parametrization for Mesoscale Atmospheric Flow Models with Aircraft Measurements*, 27 METEROLOGISCHE ZEITSCHRIFT 401 (2018).

[108] Anna C. Fitch, et al., *Mesoscale Influences of Wind Farms Throughout a Diurnal Cycle*. 141 MONTHLY WEATHER REVIEW 2173, 2182 (2013).

[109] Only about 59.3% of the kinetic energy from a wind turbine can be used to spin the turbine for electricity generation according to Betz's Limit, a theory proposed by German physicist Albert Betz in 1919. *See, e.g.*, *Reference Manual: Proof of Betz law*, http://mstudioblackboard.tudelft.nl/duwind/Wind%20energy%20online%20reader/Static-pages/betz-law.htm.

[110] David Glickson, *High-Tech Tools Tackle Wind Farm Performance*, U.S. DEP'T OF ENERGY: THE NAT'L RENEWABLE ENERGY LABORATORY (Sept. 20, 2012), https://www.nrel.gov/news/features/2012/1995.html.

[111] *See, e.g.*, BROWER, ET AL., *supra* note 65, at 253.

[112] E-mail from Jeremy Firestone, Director, Center for Research in Wind, University of Delaware, to author (Aug. 21, 2019) (on file with author).

[113] BROWER, ET AL., *supra* note 65, at 234.

may allow more wind turbines on the site, but will reduce the average energy capture from each turbine in the wind plant.[114] So, while models have provided some insight into how to operate a wind plant to optimize the energy capture of the entire plant instead of just looking at individual turbines,[115] some operators have been more successful than others at avoiding underperformance due to waking. As one author notes: "The average underperformance is about 10%, with some seeing underperformance as high as 30 to 40%. This adds up to a lot of lost energy and high cost for the industry over the life of a wind plant and presents us with a big opportunity to improve wind plant efficiencies."[116]

Wake losses can add up to significant financial losses. In a 2018 article in *Nature Energy,* the author and collaborators examined the impact of the construction of a new plant upwind of an existing one in West Texas.[117] Over the six-year term of the study, the economist on the team calculated that the downwind plant appeared to have experienced several million dollars of losses as a result of reduced generation of about 5% on average.[118]

It should be noted that wind patterns vary around the country and the world. At some locations, the wind rose, or graphic measurement of the direction of wind volume and speed over time, shows the wind blowing in a widely varying or bimodal pattern. A bimodal wind rose suggests that one wind plant might be upwind for part of the time, waking a downwind plant. But when the wind direction changes, that wind plant may then become the downwind plant, which is now waked by the plant that it previously impacted. Cooperative development might be able to minimize the impact of these two wind developments on each other, but the effects also might cancel each other out, with one wind plant experiencing energy losses at a particular wind direction and then having the advantage of capturing more wind than its neighbor when the wind changes. The mid-Atlantic states experience "more bimodal [offshore] wind direction distributions" resulting in "projects [that] may experience relatively higher wake losses and more

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[114] MANWELL, ET AL., *supra* note 95, at 424.

[115] *Wake Effect*, WIND ENERGY THE FACTS, https://www.wind-energy-the-facts.org/wake-effect.html; *See e.g.,* Michael F. Howland, et al., *Wind Farm Power Optimization Through Wake Steering,* 116 PROCEEDINGS OF THE NAT'L ACADEMY OF SCI. OF THE U.S. OF AM. 14495 (2019); Glickson, *supra* note 110.

[116] Glickson, *supra* note 110; Matthew J. Churchfield et al., *A Large-Eddy Simulation of Wind-Plant Aerodynamics,* 50TH AIAA AEROSPACE SCI. MEETING INCLUDING THE NEW HORIZONS FORUM AND AEROSPACE EXPOSITION 1 (2012).

[117] J.K Lundquist, et al., *Costs and Consequences of Wind Turbine Wake Effects Arising from Uncoordinated Wind Energy Development,* 4 NATURE ENERGY 26 (2019) (Analyzing the impact of the 2008-2009 construction of the Loraine wind project on the existing Roscoe project in Texas).

[118] *Id.* The impacted windplant, Roscoe I, has a nameplate capacity of only 209 MW.

difficultly in optimizing array layouts for power production."[119]

Locations that have a dominant wind direction can create a more problematic situation for waking. In those cases, one plant may be persistently downwind and suffer serious wake impacts from a development upwind. Because of prevailing winds in many ocean environments, this predominant wake effect may have more of an impact in offshore wind development. Furthermore, wakes from wind plants over the sea are expected to extend further downwind than those over land,[120] especially under a more stable flow, which inhibits thermally produced turbulence.[121] Fortunately, "having a high percentage of the winds from a single prevailing direction sector [also can] simplify the siting and layout optimization"[122] if it is addressed at the assessment stage in determining lease configurations.

Wind developers have an obvious incentive to pay attention to the impacts of wind wakes within their own projects.[123] Developers have less motivation to be concerned about how the wakes from their wind plant might impact a neighboring plant. In fact, the projects are developed in fierce competition, and if a developer can extract more wind from a neighbor, that might provide it with a competitive advantage.

Yet the urgency of climate change creates a general public benefit in minimizing energy losses both within one wind plant and among different wind plants.[124] Furthermore, if the wind plants are on public lands with a single owner, such as they will be offshore in the United States, there should also be an incentive by the lessor to optimize production from the properties and to maximize royalty payments to the American people.

B. Historic Treatment of Wind Wakes

Wind plant development first became commercially viable in the United

[119] NAT'L RENEWABLE ENERGY LABORATORY, ASSESSMENT OF OFFSHORE WIND ENERGY LEASING AREAS FOR THE BOEM MASSACHUSETTS WIND ENERGY AREA 23 (2013), https://www.nrel.gov/docs/fy14osti/60942.pdf.

[120] *See, e.g.*, Nicola Bodini et al., *U.S. East Coast Lidar Measurements Show Offshore Wind Turbines Will Encounter Very Low Atmospheric Turbulence*, 46 GEOPHYSICAL RESEARCH LETTERS 5582 (2019), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL082636; *see also id.*

[121] Martin Dörenkämper et al., *On the Offshore Advection of Boundary-Layer Structures and the Influence on Offshore Wind Conditions*, 155 BOUNDARY-LAYER METEOROLOGY, 459, 459–50 (2015).

[122] NAT'L RENEWABLE ENERGY LABORATORY, *supra* note 119, at 23.

[123] Churchfield, *supra* note 116, *construed in* Glickson, *supra* note 110 (warning that ignoring wakes during the planning phases is not an optimal way to operate a wind plant as a whole).

[124] Howland, *supra* note 115.

States in the 1980s.[125] Some of the first were in California, not because the state has the best resources in the country, but because the state of California provided appealing tax and other financial incentives for development.[126] Two of the first areas were Altamont Pass and San Gorgonio Pass because the wind was concentrated there when the air funneled through these mountain passes.[127]

Early developers were not yet experienced with wind turbine dynamics, and as a consequence, the turbines were located in close proximity to one another. As just one example, the National Renewable Energy Laboratory studied wake impacts within a 41-row wind plant with almost 1000 turbines built in San Gorgonio Pass, California in 1989 to 1990.[128] The plant experienced frequent failures and significant damage to turbine components. Soon developers realized that the turbines were waking other turbines within their own projects and causing premature fatigue.[129]

Wind developers have come a long way toward recognizing wakes in developing a project. While few thought about buffers before about 2010, "now everybody does."[130] They are addressed at three stages of development on private lands. First, a developer considers turbine production and waking in creating a project layout.[131] This internal wake analysis is done either by independent contractors for smaller companies or by in-house staff for larger developers.[132]

Next, the manufacturer of the turbines that will be used on a project performs a "site suitability" study.[133] This involves reviewing the layout proposed by the developer and determining whether any of the turbines are proposed to be placed in locations that might compromise the

[125] Alan J. Alexander, *The Texas Wind Estate: Wind as a Natural Resource and a Severable Property Interest*, 44 U. MICH. J. L. REFORM 429, 436 (2011).

[126] PAUL GIPE, WIND ENERGY COMES OF AGE 30–36 (1995).

[127] *Id.* at 34.

[128] Neil D. Kelley, *Boundary Layer Turbulence and Turbine Interactions with a Historical Perspective,* NAT'L RENEWABLE ENERGY LABORATORY (Aug. 1, 2010), in slideshow at slides 18-19; also citing the following research papers by Kelley NREL/TP-442-6008; NREL/TP-442-7035; NREL/CP-500-26829; NREL/CP-500-30917; NREL/CP-500-38074; NREL/TP-500-41137; *see also* Neil D. Kelley et al., *Using Wavelet Analysis to Assess Turbulence-Rotor Interactions*, 3 WIND ENERGY 121 (2000).

[129] Interview with Steve Drouhilet, Founder & CEO, Sustainable Power Systems, in Boulder, Colorado, 227-228 (Apr. 29, 2016) (fatigue after 6 months of operation–blades fly off, failures).

[130] Interview with anonymous industry source in Colorado, #14 1. 742 (May 18, 2017).

[131] Telephone Interview with Dan Boyd, Vice President of Development in North Region, Renewable Energy Systems Americas Inc. (June 10, 2019).

[132] *Id.*

[133] *Id.*

manufacturer's warranty when mechanical wake damage occurs.[134] If the manufacturer anticipates damage, then it will notify the developer, and either a new layout will be proposed or the parties will reach an agreement on a modified warrantee for the turbine.[135]

Finally, wind projects are financed by outside parties, so these financiers will require a third-party review.[136] These third parties are independent engineers creating a report for the benefit of the bank.[137] The third-party reviewers must consider all factors that may impact the feasibility and energy production for a project. They consider wake effects both from the turbulence mechanical damage and from the energy loss damage perspective.[138] These reviewers often conduct an external wake analysis and a future wake analysis considering both existing factors and potential waking to determine buffer zone calculations.[139]

There can be some tension between these reviewers and the project developers. The reviewers have found that wake losses often represent the largest loss factor in their analysis–from 2 to 15%.[140] The developers want the calculation to minimize these potential losses because they would like to maximize production projections for purposes of getting better funding. However, the reviewers want to be conservative to avoid any possible liability to the banks for overestimating a project's potential if for any reason the asset should underperform.[141]

While a single developer can make adjustments to the location of turbines within its own project to avoid waking issues, there can be significant

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[134] *See, e.g.*, Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, [5.4] (Eng.) ("Correspondence from the turbine supplier (Enron Wind, now GE Wind Energy) indicates that an absolute minimum spacing of 300 m is required between turbines in order to validate warranty conditions.").

[135] Telephone Interview with Dan Boyd, *supra* note 132.

[136] *Id.* (listing the two most reputable third party reviewers in the United States as DNV GL and AWS (now UL) as they can create a "bankable report" to support financing); *See also* Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, [5.3] (Eng.) ("[The] scheme must generate sufficient power for it to be economically viable to construct and operate. If this is not the case, commercial investors will not support construction of the prototype and it will thus be impossible to finance.") ("[A] 1 percent decrease in output would result in a 15 per cent reduction in profit from revenue, and a 25 percent decrease in net present value of the installation…thus becom[ing] unviable in financing terms.").

[137] Telephone Interview with Dan Boyd, *supra* note 132; Telephone Interview with Scott Eichelberger,

Business Development Manager, Renewable Energy, Vaisala (June 17, 2016).

[138] *Id.*

[139] Telephone Interview with Eichelberger, *supra* note 138.

[140] *Id.*

[141] Telephone Interview with Dan Boyd, *supra* note 132; Telephone Interview with Eichelberg, *supra* note 138.

problems when an existing wind plant is threatened by development upwind.[142]

Historically, wind energy has been a "cutthroat business."[143] With Production Tax Credits creating looming deadlines, developers, who may be "arch rivals"[144] have competed fiercely for sites that combine the best wind potential along with proximity to transmission and to load demand.[145] Like Wild West prospectors, they "rush[ed] to acquire wind rights" before a competing claim jumper could elbow in.[146] Some developers even have risked the lives of crop-dusting pilots by placing their meteorological testing or "met" towers just below the height that the FAA mandates for warning markings so that other developers would not know they were considering leasing in that area.[147]

There is some incentive to avoid density of offshore wind projects to address criticisms such as "curtailment of the offshore horizon by wind turbines" (seascapes) and calls to "reduce the overlap of wind plants so that they appear more discrete and isolated."[148] Furthermore, fishers want the spacing to be as wide as possible to allow catch within the wind plants and turbine rows.[149] Yet the cost of being further from transmission or load are powerful considerations that encourage closer turbine spacings and colocation of plants as is the case on land. And even if the offshore sites are not extensively crowded, the extent of energy loss wakes (up to 35 miles) mean a developer must "always consider existing and potential future

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[142] Telephone Interview with Dan Boyd, *supra* note 131 (mentioned an impending or new clash in upstate NY where a new wind plant with bigger turbines will be significantly waking an existing plant).

[143] Telephone Interview with anonymous attorney at Minneapolis, MN law firm # 18 1. 213-224 (Mar. 19, 2018).

[144] TROY A. RULE, SOLAR, WIND AND LAND 50 (2014).

[145] K.K. DuVivier et al., *Transmission and Transport of Energy in the Western U.S. and Canada: A Law and Policy Road Map*, 52 IDAHO L. REV. 387, 397 (2016); *see also* Marc Sydnor, *Determinants of Wind Energy Deployment: Infrastructures, Policies, Resources or Economics?* (Jan. 1, 2015) (unpublished Ph.D. dissertation, University of Denver), http://digitalcommons.du.edu/etd/1065.

[146] Telephone Interview with Gary Leak, Senior Project Manager, Atwell, LLC. (July 5, 2016).

[147] K.K. DuVivier, *Wind Power Growing Pains,* 21 NEX. J. OP. 1, 10 (2016).

[148] Gero Vella notes that the Town and Country Planning Act 1990 CITE allows consideration of the "character and appearance" of wind turbines and allows denials of permits on those ground. *See, e.g.,* Coronation Power Ltd. v. Secretary of State for Communities and Local Government and others, [2011] All ER (D) 212 (Jul.) [2011] EWHC 2216 (Admin).

[149] Bruce Mohl, *Vineyard Wind Layout Tough Issue for Regulators*, NAT'L WIND WATCH (Aug. 11, 2019), https://www.wind-watch.org/news/2019/08/12/vineyard-wind-layout-tough-issue-for-regulators/.

neighbouring wind plants in [their] design process."[150]

Some developers have confessed to being the victims of, or hearing of, "extortion" tactics by competing developers.[151] Such tactics can include threatening to build an upwind project that would "cannibalize" the wind productivity from the first unless the existing plant buys a developer out with "go away" money.[152] Another tactic is to participate in opposition efforts to delay or derail another company's approval[153] or to block the competitor from access to the grid by leasing up land around transmission access points.

III. Moat Mentality

Wind developers currently have few options against adjacent-plant wake effects. Subsection A discusses the evolution of the Medieval moat mentality of protection and how it has evolved to become a best practice for terrestrial wind development in the United States. Subsections B and C address the lack of legal protections and how the US compares to Europe with respect to these protections in the offshore wind context.

A. Evolution of Moats

Some attorneys who represent wind developers see no problem with the current state of the law with respect to wind wakes. They simply employ a *caveat emptor* approach and recommend their clients use "best practices,"[154] saying "shame on you for not getting a buffer zone."[155]

Fortunately, the extortion tactics described in Section II.B above are the exception rather than the rule. However, the general rule is that companies in the United States do not compensate downstream landowners for loss of wind[156] and sometimes are not cooperative with downwind

[150] E-mail from Nicolai Gayle Nygaard, Lead Wind Energy Specialist, Energy Yield Assessment, Wind Power, Ørsted, to author (July 9, 2019) (on file with author).

[151] Telephone Interview with Dan Boyd, *supra* note 132, agreeing with "extortion" term.

[152] Interview with anonymous industry source # 14, *supra* note 131.

[153] Although one interviewee noted, "It would not be in either of our interests [to] have mom and dad fighting in front of the crowd." Telephone Interview with anonymous industry source # 12 l. 90-91 (July 11, 2016).

[154] Telephone Interview with Dan Boyd, *supra* note 131.

[155] Telephone Interview with anonymous attorney source # 18 l. 114-15, *supra* note 143.

[156] Telephone Interview with anonymous industry source # 12 l., *supra* note 153. Note the perspective is from a landowner who loses out on royalties. They are the biggest losers because they basically have no leverage under the current legal or negotiation regime.

developers. The only way to acquire some control of upwind development is to avoid putting oneself into a compromised position and instead to tie up significant leases around a development property to provide leverage for negotiation with competitors.

Without incentives to work together, the companies usually develop without consideration of their impact on neighboring projects.[157] Professor Kaffine's review of the US Wind Turbine Database website showed that from the perspective of an entire wind plant, infringement is relatively common: almost 22% of wind plants are within five RD of a turbine in an adjacent plant, and almost 38% have one within 10 RD.[158]

One best practice is to avoid being compromised by not entering a lease or "signing" land if a competitor holds property between that land and a necessary substation or transmission line.[159] Instead, the best practice is to acquire all the land around an interconnection point or substation, even if the developer does not intend to construct turbines on that land itself. The leased area can become a negotiation tool. If another wind developer enters an area, it would need access to the grid and be required to negotiate with the first company that tied up those areas before building a project that might have a negative impact on the first.[160]

Another best practice is to lease as much property as a company can afford in the development area. While the industry rule of thumb for wake protection currently appears to be about 10 RD, it is possible the analysis for the bank might require a larger setback. By having more leases, the developer can meet the financier's needs.

Buffer zones are "insurance."[161] A developer must look at the cost to them, but if they can get more land, then it is best to do so. Later if the

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[157] Some in the industry say that the competition has diminished in the last decade or so because acquiring financing and permits is harder for smaller competing projects. As a result, larger companies are buying out competitors of nearby projects. Once they are under a uniform ownership, it is easier to get financing and permits; *See* Telephone Interview with Dan Boyd, *supra* note 131.

[158] E-mail from Daniel Thomas Kaffine, *supra* note 86 ("at the wind farm level (~1100), about 21.9% of wind farms have at least one turbine that is within five RD of another wind farm's turbine, and about 37.7% of wind farms have at least one turbine within 10 RD of another wind farm's turbine"). This may be consistent, however, with the industry impression that there are no negative impacts from a wake after 10 RD. On their own wind plants, operators place 98.4% of their turbines closer than 10 RD to another turbine, and 80% are five RD or closer. ("[A]t the individual turbine level, only 20% of wind turbines have no other wind turbines (from any wind farm) within five RD, and only 1.6% have no other wind turbines within 10 RD").

[159] Telephone Interview with Dan Boyd, *supra* note 131.

[160] *Id.*

[161] Telephone Interview with anonymous industry source # 13 l. 99-112 (June 17, 2016).

developer has more leased area than needed, it can "shrink wrap" the project by releasing some of the leases.[162] As a condition for the release, the original lessee can create a non-obstruction easement[163] or other contractual obligation on the part of the lessor to protect the original lessee from wake impacts from anyone to whom the lessor later grants permission to develop.

Similarly, if a developer holds land that another company might want to consolidate its holdings, the developer can reach an agreement to trade the leases in exchange for waking protections such as setback concessions or payments to compensate for losses to another wind plant.[164] If one company acquires a property from another, then potential wake impacts are often addressed in a separate wind indemnity agreement or some other compensation clause in the original contract.[165] The ones made available to this author provided much more protection than any setback requirements, for example compensation for any losses greater than .025% using a set formula.

Even if a developer only acquires enough land for its own project, it generally is required by its financiers to have some form of buffer zone. A best practice that developers like to employ in areas that require multiple lessors[166] is to have a standard lease for everyone in the project area. This is an advantage for acquiring financing. Sometimes lessors are resistant to enter a buffer zone lease as they can receive additional payments if a turbine

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[162] Interview with anonymous industry source in Colorado, # 14 l. 359, *supra* note 130.

[163] Diamond & Crivella, *supra* note 64, at 233-35. In the case of a non-obstruction easement, which generally has a duration of approximately 30 years (a period of time long enough to cover the life of the turbines), the right granted to the developer from the land-owner is the right of unobstructed access to wind flow across such landowner's land. If such an easement is included, however, a specific definition of "unobstructed access" must be incorporated. One potential resolution would be to determine an average percentage of wind speed reduction caused by upstream wind turbines that must be avoided in a given area, which would be extrapolated from empirical studies. The developer could then, with a non-obstruction easement, require that their access to wind must not be restricted by neighboring wind plants in some reasonable radius of influence, potentially in relation to set-back limits if in place.

[164] Telephone Interview with Dan Boyd, *supra* note 131.

[165] E-mail from Mark Safety, Wirth Chair in Sustainable Development, University of Colorado (July 27, 2019) (on file with author). In the wind indemnity agreement that Mr. Safty shared, the upwind developer agreed to compensate the downwind developer for Projected Energy Losses of greater than 0.025% using a predetermined equation. The agreement stipulated that this was the only recovery that the downwind developer could seek.

[166] Development in Texas is easier because many landowners have huge ranches with enough acreage for one wind plant. Multiple lessors are more commonly needed for Midwestern state developments in Iowa, Wisconsin, Minnesota, and Illinois.

or other infrastructure is located on their property. In a few situations, developers have created community leases so that even those who do not have any development on their property still receive a percentage of the royalties. While lessors like to try to control what happens with their property, generally lessees attempt to dictate that turbine locations are at the discretion of the lessee.

Most wake conflict situations have been resolved through taking the financial hit on decreased generation or through bilateral agreements. However, buffer zones have become the norm both to create some incentive for an upwind developer to cooperate with or compensate the downwind developer for any wake damage or energy losses and to attempt to provide some protection against neighboring plant wakes. As will be discussed below, the buffers may be necessary under the current legal regime, but they are creating large swaths of unproductive moat-like zones and tying up acreage that potentially could be generating electricity.

B. Common Law

In the absence of codified regulation, a downwind developer would have to look to the common law for any remedy for losses incurred by upwind waking. Two possible theories for recovery include (1) negligence and (2) nuisance.[167]

1. Negligence. – Negligence allows a plaintiff to recover damages if a defendant breaches a duty of care and, as a result, causes injury to the plaintiff. In the context of wake effects, there are two problems with recovering under common law negligence: both the duty of care and the injury elements may be difficult to prove.

a) Duty. – With respect to the duty element, a reasonable person might conclude that a plaintiff's wind plant should recover for wake turbulence damage. Courts have been required to make difficult determinations about what constitutes a duty and have turned their attention to an examination of social perceptions and attitudes in making their choices, formally known as the "Reasonable Person Standard."[168] This standard is evident when courts employ ordinary bystander tests, which focus on whether a reasonable person would consider it appropriate or not to award damages.[169] This is justified on the basis that the real wrong in negligence is the failure to

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[167] Some have discussed a "non-nuisance" standard for resolving wind development conflicts. *See, e.g.*, RULE*, supra* note 144 at 63.

[168] *Id.* at 206.

[169] *Id.*

take care, given the context within which the failure takes place.[170]

In corporate situations, however, a business practice or "mode of operation" standard is often substituted for the "reasonable person" standard for determining whether to impose liability.[171] Arguably, there may be a duty to protect other operators' turbines from turbulence damage from wakes. The IEC standard of 5 RD for wake damage or the 10 RD best practice that several developers referenced could create an industry standard of care that is breached if an upwind operator places its turbines near existing downwind turbines at a spacing closer than the standard. However, Professor Kaffine's analysis of US Wind turbine database website shows that actual practice does not mirror these best practice guidelines.[172] Professor Kaffine states, "At the individual turbine level, only 20% of wind turbines have no other wind turbines (from any wind farm) within 5 RD, and only 1.6% have no other wind turbines within 10 RD."[173] This means that 98.4% are closer than 10 RD to another turbine, and 80% are 5 RD or closer.

With respect to energy loss impacts from wakes that extend beyond 10 RD, there is no US industry standard. This may reflect the law's lagging behind the science. It may also be because parties are less aware of those impacts or perhaps because they vary depending on the atmospheric conditions and can extend for miles. Without such a standard, the duty of care element might be lacking in trying to recover for lost energy under a negligence theory.

b) Injury. – Proving the injury element will be more difficult for energy loss but should be relatively easy for wake turbulence damage. "Physical damage" for the purposes of negligence law most often involves deleterious changes in the physical state or structure of persons or property.[174] These changes impair or destroy the functional characteristics of persons or property. They also ordinarily are apparent in nature and easily perceptible by the human eye.[175] For the wake turbulence effect, the downwind operator should be able to document or model the fatigue damage caused by the upwind turbine's turbulence.

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[170] *Id.*; *See generally* Christian Witting, *Distinguishing Between Property Damage and Pure Economic Loss in Negligence: A Personality Thesis*, 21 LEGAL STUD. 481, 514 (2001).

[171] Lynn Rivera & Paul Caleo, *The Cost of Doing Business as a Self-Service Establishment: A Survey of the Applicability of the Mode of Operation Approach*, 12 No. 4 IN-HOUSE DEF. Q. 53 (2017).

[172] THE U.S. WIND TURBINE DATABASE, https://eerscmap.usgs.gov/uswtdb/ (July 15, 2019).

[173] E-mail from Daniel Thomas Kaffine, *supra* note 85.

[174] Christian Witting, *Physical Damage in Negligence*, 61 CAMBRIDGE L.J. 189, 190 (2002).

[175] *Id.*

For a plaintiff seeking recovery for energy loss impacts of wakes, the injury element is more problematic than the duty element, at least in the United States, because there appears to be no recognized property interest in wind in the United States.

(i) Under European Law*.* – Some European countries have different property law regimes that might make recovery for injury clearer. Denmark was the first country to create a statutory scheme to compensate property owners for any loss of value due to wind plant developments.[176] The Law to Promote Renewable Energy, passed in 2009,[177] created a special tribunal[178] ("the Danish Valuation Authority" or "Authority")[179] to make decisions about what type of compensation might be appropriate.[180] Although parties are allowed to reach settlements without involving the Authority,[181] the tribunal had awarded compensation in over 550 cases by 2013.[182]

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[176] Navraj Singh Ghaleigh, *Legal Compensation Frameworks for Wind Farm Disturbance - Technical Report*, CLIMATEXCHANGE (June 2013), https://www.climatexchange.org.uk/media/1766/cxc_report_-_legal_compensation_frameworks_for_wind_farm_disturbance_.pdf.

[177] BEKENDTGØRELSE AF LOV OM FREMME AF VEDVARENDE ENERGY 2009, https://www.retsinformation.dk/Forms/r0710.aspx?id=139075 (cited in Ghaleigh, *supra* note 176, at 2 ("At Chapter 2 §6 it provides that installers of turbines larger than 25 metres must compensate property owners for any loss of value if the loss is more than one per cent of the property value.").

[178] In Danish, the tribunal is called the "Taksationsmyndigheden" https://taksationsmyndigheden.dk/da/Sider/default.aspx. The "'Taksationsmyndigheden' is chaired by a person who is qualified to sit as a judge and an 'expert' (the equivalent of a surveyor)." Ghaleigh, *supra* note 176, at 3 ("Evaluations are done independently and on a case-by-case basis, taking into account the distance to the turbines, visual aspect, noise, shade, the character of the property and the market evaluation of the area."); Ghaleigh, *supra* note 176 at 2-3 (citing *Wind Turbine Compensation Stirring Discontent*, THE COPENHAGEN POST (Nov. 12, 2012), http://cphpost.dk/news/national/wind-turbine-compensation-stirring-discontent.html).

[179] The Danish Valuation Authority falls under Skatteforvaltningen (meaning Tax Administration in English), which became the overarching tax and property value authority on July 1, 2018. This authority reigns over the settlement of debts as well. *See generally,* DANISH TAX AGENCY*,* https://www.sktst.dk/english/.

[180] Ghaleigh, *supra* note 176 at 2 (citing BEKENDTGØRELSE AF LOV OM FREMME AF VEDVARENDE ENERGY (2009), https://www.retsinformation.dk/Forms/r0710.aspx?id=139075).

[181] *Id.*

[182] *Id.* (citing *Wind Turbine Compensation Stirring Discontent*, THE COPENHAGEN POST, (Nov. 12, 2012) http://cphpost.dk/news/national/wind-turbine-compensation-stirring-discontent.html (stating that an evaluation of the 551 compensation payments indicates that the average award was 57,000 kroner (c.£5,500) per household and that recipients did not feel that the amount of compensation came close to reflecting the actual value of their loss. Being managed by the Ministry for Energy, there are also complaints that the scheme suffers from an inherent conflict of interests and ought to be managed by the Ministry for Justice).

Most of the Danish Valuation Authority's cases involve private property owners seeking recovery for loss of value to their land due to noise or aesthetic concerns about neighboring wind development. However, the Authority awarded damages in a developer v. developer dispute for the first time in 2011.[183] The Authority ruled in favor of the plaintiff, a downwind wind turbine owner who experienced both increased maintenance costs (turbulence damage losses) and lost production revenues (energy losses) as a result of defendant neighbor's re-powering project.[184] In this case, the defendant's nearest turbines were located approximately 561 feet, or only about 1.1 rotor diameters, away from the plaintiff's existing downwind turbines.[185] The plaintiff claimed his turbines would be affected by wind shadow and hence experience production losses and that his turbines would be exposed to tremendous turbulence, causing increased wear and multiple stoppages and reducing the life span of the existing turbines.[186]

In this 2011 Danish case, the defendant contested the fact that wind turbines can be regarded as real estate – a designation that is required for them to qualify for compensation – and therefore suggested the claim should be rejected.[187] A third party appraiser conducted an analysis of the losses. This appraiser determined that increased repair costs were DKK 690,000 (US $130,885) and awarded the plaintiff DKK 650,000 (US $121,996) in compensation for these costs.[188] Most significantly, the Authority not only recognized the turbulence damage losses but also the energy losses in calculating compensation for the plaintiff in this case. The actual production loss was determined to be DKK 300,000 (US $56,430).[189] This brought plaintiff's recovery up to a total of DKK 750,000 (US $140,765).[190]

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[183] The Danish Valuation Authority denied recovery in a previous case concerning wake losses. However, it wasn't because the rights were not compensable losses, but instead the denial was based on the plaintiff's acceptance of the risk of upwind development. Torgny Møller*, First Danish Ruling on Who Owns the Wind*, 33 NATURALIG ENERGI (2011), http://www.sindal-lundsberg.com/cms/from-my-desk/51-first-danish-ruling-on-who-owns-the-wind.

[184] Repowering is the process of upgrading the turbines on an existing wind plant with newer models or components to improve efficiency and power capture. Suparna Ray, *Repowering Wind Turbines Adds Generating Capacity at Existing Sites*, U.S. ENERGY INFO. ADMIN. (Nov. 6, 2017), https://www.eia.gov/todayinenergy/detail.php?id=33632.

[185] Torgny Møller, *Who Owns the Wind?*, 33 NATURLIG ENERGI (2011), http://www.sindal-lundsberg.com/cms/the-sindal-report/from-my-desk/51-from-my-desk-older/50-who-own-the-wind-turbine-owner-receives-compensation-of-dkk-750000.

[186] *Id.*

[187] *Id.*

[188] *Id.*

[189] *Id.*

[190] *Id.*

While this Danish case appears to validate a legal right to recover for energy loss damages, that result is not completely clear. The Danish Valuation Authority has not addressed another developer v. developer claim since 2011.

Similarly, efforts to recover for a property right in wind have not been as successful in other European countries. The United Kingdom appears to have some precedent for providing compensation under Section 152 of the 2008 Planning Act, but the scope of that power and whether it would be recognized in a common lawsuit is unclear.[191]

A Norwegian court held that private individuals do not have property rights to the wind and consequently there should not be any recovery for reduction of the wind flowing across one's land.[192] Likewise, in Scotland and the United Kingdom, there are no statutory frameworks or tribunals such as Denmark's that address compensation for "householders/house owners" impacted by wind developments.[193] Instead, companies have set up voluntary "goodwill payment mechanisms"[194] to help garner public support or "social license to operate."[195]

The property status of wind rights in the United States has been debated for over a century.[196] In most other countries in the world, natural

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[191] *See* discussion of §152 of the 2008 PLANNING ACT *infra* Section III.C.2.a.

[192] Torgny Møller, *First Norwegian Ruling on the Question of Who Owns the Wind . . . Nobody Owns the Wind*, 33 NATURALIG ENERGI (2011) [hereinafter First Norwegian Case], http://www.sindal-lundsberg.com/cms/from-my-desk/49-first-norwegian-ruling-on-the-question-of-who-owns-the-wind-nobody-owns-the-wind.

[193] Ghaleigh, *supra* note 176, at 2.

[194] *Id.* at 3.

[195] *See, e.g.,* Geert Demuijnck & Björn Fasterling, *The Social License to Operate*, 136 J. BUS. ETHICS 675 (2016), https://link.springer.com/article/10.1007/s10551-015-2976-7; Jason Prno & D. Scott Slocombe, *Exploring the Origins of 'Social License to Operate' in the Mining Sector: Perspectives from Governance and Sustainability Theories,* 37 RESOURCES POL'Y 346 (2012).

[196] *See, e.g.,* Kimberly E. Diamond, *Wake Effects, Wind Rights, and Wind Turbines: Why Science, Constitutional Rights, and Public Policy Issues Play a Crucial Role*, 40 WM. & MARY ENVTL. L. & POL'Y REV. 813, 822-23 (2016); Yael Lifshitz, *Rethinking Original Ownership*, 66 U. TORONTO L.J. 515 (2016); Yael Lifshitz, *Winds of Change: Drawing on Water Law Doctrines to Establish Wind Law*, 23 N.Y.U. ENVTL. L. J. 434 (2015); Diamond & Crivella, *supra* note 64, at 199; Ernest E. Smith & Becky Diffen, *Winds of Change: The Creation of Wind Law*, 5 TEX. J. OIL GAS & ENERGY L. 165 (2010); Troy Rule, *Sharing the Wind*, 27 THE ENVIRONMENTAL FORUM, 30-33 (Sept. – Oct. 2010); Yael Lifshitz, *Gone with the Wind? The Potential Tragedy of the Common Wind*, 28 UCLA J. ENVTL. L. & POL'Y 435 (2010); K.K. DuVivier, *Animal, Vegetable, Mineral–Wind? The Severed Wind Power Rights Conundrum*, 49 WASHBURN L. J. 69 (2009); K.K. DuVivier & Roderick E. Wetsel, *Jousting at Windmills: When Wind Power Development Collides with Oil, Gas, and Mineral Development*, 55 ROCKY MTN. MIN. L. INST. PAPER NO. 9-1 (2009); Troy Rule, *A Downwind View of the Cathedral: Using Rule Four to Allocate Wind Rights*, 46 SAN DIEGO L. REV.

resources–including minerals and wind–are owned by the state.[197] However, in the United States, these resources, including wind, are privately owned when associated with private lands.[198]

(ii) Under US Law. – Under traditional theories of U.S. property law, including the *ad coelum* doctrine,[199] owners of surface estates have a property right in the wind flowing over and above their lands.[200] The ownership issue is complicated, however, because property law in the United States is governed by each of the states or territories and each may have separate rules.

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207 (2009); Lisa Chavarria, *The Severance of Wind Rights in Texas*, Presentation at the Review of Oil and Gas XXIII, sponsored by the Dallas Bar Association (Sept. 2008) (revision of a manuscript originally published as Lisa Chavarria, *Undertaking the Severance of Wind Rights*, ST. B. TEX.: OIL, GAS AND ENERGY RES. L. SEC. REP., VOL. 32 NO. 2, Dec. 2007); Lisa Chavarria, *Wind Power Prospective: Issues*, 68 TEX. B. J. 832, 834-35 (Oct. 2005) (stating that Chavarria does not support or oppose the practice of severance but recognizes that it is common among Texas landowners); Terry E. Hogwood, *Against the Wind*, 26 STATE BAR OF TEX.: OIL, GAS AND ENERGY RES. L. SEC. REP., NO. 2, Dec. 2004; Ernest Smith, *Wind Energy: Siting Controversies and Rights in Wind*, 1 ENVTL & ENERGY L. & POL'Y J. 281, 300-03 (2007) ("Wind does not share the physical characteristics of solid minerals or of water. It can hardly be deemed part of the fee simple or owned 'in place' by a landowner." Smith also cites Hogwood to say wind ownership may be comparable to the "capture" theory used for wild animals or the law of percolating water and Contra Costa for noting that states may alternatively "look to oil and gas law for an analogy."); Joseph O. Wilson, *The Answer, My Friends, Is in the Wind Rights Contract Act: Proposed Legislation Governing Wind Rights Contracts,* 89 IOWA L. REV. 1775, 1784 (2004); Choctaw, O. & T. R. Co. v. True, 80 S.W. 120, 121 (Tex. Civ. App.–Fort Worth 1904, no writ). For other valuable articles addressing wind rights, without as much emphasis on the categorization of the right, *see* Helle Tegner Anker, et al., *Wind Energy and the Law: A Comparative Analysis*, 27 J. ENERGY & NAT. RESOURCES L. 145 (2009); Elizabeth Burleson, *Wind Power, National Security, and Sound Energy Policy*, 17 PENN ST. ENVTL. L. REV. 137 (2009); Bent Ole Gram Mortenson, *International Experiences of Wind Energy*, 2 ENVTL & ENERGY L. & POL'Y J. 179 (2008); K. Shawn Smallwood, *Wind Power Company Compliance with Mitigation Plans in the Altamont Pass Wind Resource Area*, 2 ENVTL & ENERGY L. & POL'Y J. 229 (2008); Roderick E. Wetsel & H. Alan Carmichael, *Current Issues in Wind Energy Law 2009*, Presentation at 20th Annual Advanced Real Estate Drafting Course sponsored by the State Bar of Texas (Mar. 5-6, 2009). *See also* RULE, *supra* note 144, at 60; Ernest E. Smith, Roderick E Wetsel, Becky H. Diffen, and Melissa Powers, WIND LAW (LexisNexis Matthew Bender 2019).

[197] *See, e.g.,* Marc Howe, *Chinese Regional Government Claims Wind Energy is "State-Owned"*, WINDPOWER MONTHLY (June 19, 2012) (Article 9 of China's constitution, which has been interpreted to say that wind and solar energy are state-owned resources).

[198] K.K. DuVivier, *Sins of the Father*, 1 TEX. A&M J. REAL PROP. L. 391, 412 (2014).

[199] *See* DUKEMINIER ET. AL., PROPERTY CONCISE EDITION 140 (2d ed. 2017). The *ad coelum* doctrine: Cujus est solum, ejus est usque ad coelum et ad infernos ("to whomsoever the soil belongs, he owns also to the sky and to the depths").

[200] *See, e.g.*, TEX. HOUSE OF REPRESENTATIVES HOUSE RESEARCH ORG., CAPTURING THE WIND: THE CHALLENGES OF A NEW ENERGY SOURCE IN TEXAS, No. 80-9, at 17 (2008).

Texas, which has been the number one producer of wind power for the last few decades, seemed to recognize a right to wind access as early as 1904.[201] Although the court did not expressly state that there was such a right, it found that a plaintiff could properly allow evidence to support his claim for damages resulting from the construction of an embankment that blocked wind flows to the plaintiff's windmill.[202]

Wyoming and Montana set out the wind right most explicitly by statute. Wyoming law defines a "wind energy right" as "a property right in the development of wind powered energy generation"[203] and goes on to declare that "[w]ind energy rights shall be regarded as an interest in real property and appurtenant to the surface estate."[204] Montana defines "wind easement" as "the right granted by the owner of real property to a wind energy developer guaranteeing the developer the right to use the real property legally described in a wind energy agreement and the wind resource located on and flowing over its surface to develop a wind energy project."[205] The statute concludes with this explicit declaration: "A wind easement is an interest in real property."[206]

Severance means that an estate can be owned and transferred separately from the surface of the land where it is located. Although it is most often encountered in the context of oil and gas or mineral severance, wind rights are severable in Texas. Several states have enacted statutes that ban severance of the wind from the surface estate.[207] The Colorado General Assembly did so in 2012.[208] The original version of the non-severance statute stated, "A wind energy agreement is an interest in real property."[209] Although the Colorado statute eliminated this language when it was amended in 2015, it still seems to recognize the potential for a separate property interest in the wind.[210] While the language of the statute characterizes wind

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[201] *See Choctaw, O. & T. R. Co.*, 80 S.W. 120, 121.

[202] *See id.*

[203] WYO. STAT. ANN. § 34-27-102(iii) (2019).

[204] *Id.* § 34-27-103(a).

[205] MONT. CODE ANN. § 70-17-402(1) (2019).

[206] *Id.*

[207] *See, e.g.,* COLO. REV. STAT. ANN. § 38-30.7-103 (2015); MONT. CODE ANN. § 70-17-404(1) (2019); 2011 Mont. Laws 976; WYO. STAT. ANN. § 34-27-103(b) (2019); 2011 Wyo. Sess. Laws 17; KAN. STAT. ANN. § 58- 2272(b) (2019); 2011 Kan. Sess. Laws 692; 2009 Neb. Laws 997; 2012 Neb. Laws 497; NEB. REV. STAT. § 76-3004 (2019); S.D. CODIFIED LAWS § 43-13-17 (2019); 2005 N.D. Laws 1572; N.D. CENT. CODE § 17-04-04 (2019).

[208] 2012 Colo. Legis. Serv. Ch. 230 (H.B. 12-1105) (West), at § 38-30.7-103(1): "A wind energy right is not severable from the surface estate; except that wind energy may be developed pursuant to a wind energy agreement."

[209] *Id.* at § 38-30.7-103(2).

[210] COLO. REV. STAT. ANN. § 38-30.7-103.

as a usufructuary right,[211] it also states that agreements to exploit wind are "subject to statutory and other rules of law to the same extent as other agreements creating interests in or rights to use real property."[212] South Dakota and North Dakota statutes both have similar language about an interest in wind having the "same effect as a conveyance of an interest in real property."[213]

Because there are no reported cases interpreting the language of these state statutes, there appears to be no precedent for determining the extent of the wind property right and whether it would include a right to the energy in the wind sufficient to support recovery for production losses. And it remains unlikely that the issue will be resolved by litigation. When a situation gets to the litigation stage, it is generally settled out of court because it is simply a matter of calculating damages, and that amount can be ascertained through wake modeling.[214]

Aside from interpreting statutes that appear to recognize wind as a property right, there have been a handful of cases that have alleged injury or nuisance for waking, but the outcomes did not address the wind as a property right issue. For example, a wind operator near Palm Springs, California, alleged that approval of a repowering project would result in a nuisance.[215] Without using the term "wake," the complaint alleged damages of over $2 million in lost revenues due to energy losses downwind and the depreciation in the value of the existing turbines due to increased wear and tear from turbulence from the upwind plant.[216] The judge resolved the case

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[211] *Id.* § 38-30.7-103(1) ("A wind energy right is not severable from the surface estate but, like other *rights to use* the surface estate, may be created, transferred, encumbered, or modified by agreement.") (emphasis added).

[212] *Id.* § 38-30.7-103(2).

[213] S.D. CODIFIED LAWS § 43-13-17; N.D. CENT. CODE § 17-04-04. Kansas and Nebraska also have nonseverance statutes, but they are more cryptic about what the extent of a wind right might be recognized. *See* KAN. STAT. ANN. § 58- 2272(b); NEB. REV. STAT. § 76-3004.

[214] *See*, Zilong Ti, Xiao Wei Deng & Hongxing Yang, *Wake Modeling of Wind Turbines Using Machine Learning*, 257 APPLIED ENERGY 114025 (Jan. 1, 2020), https://doi.org/10.1016/j.apenergy.2019.114025, https://www.sciencedirect.com/science/article/pii/S030626191931712X?via%3Dihub ("A good understanding and accurate prediction of turbine wakes can remarkably improve the efficiency of wind energy conversion in a large-scale wind farm and achieve a better turbine layout scheme. . . . . Analytical models are still widely used in practice for wake prediction due to their low cost."); *See also,* discussion about how the Calebresi formula can resolve property and tort disputes through economic theory. Telephone Interview with anonymous attorney #18 l. 104-109, *supra* note 143.

[215] Defendants' NextEra Energy Resources, LLC and Wind Power Partners 199s, LLC's Notice of Removal Pursuant to 28 U.S.C. § 1441(b) (Federal Question), Wind Energy Partnership v. NextEra Energy Resources LLC, No. 11-02050 (C.D. Cal. Filed Dec. 27, 2011).

[216] *Id.*

on procedural grounds related to due process and whether there was a failure to provide adequate notice.[217]

Another case involved a wind-power opponent and owner of agricultural land in Illinois who sued to stop some county ordinances in Wisconsin that would make it easier to obtain permits for wind plants near her lands.[218] One of her primary claims was that allowing a wind plant adjacent to her property would deprive her "of the full extent of the kinetic energy of the wind and air as it enters [her property]."[219] In affirming a dismissal of her case,[220] the court opined that nuisance "is a more sensible conceptualization of her claim" scoffing at the theory that "she has a property right in her neighbors' use of their lands."[221]

Thus, it seems likely that it would be difficult to make a case for negligence liability for energy loss impacts. The US Supreme Court has said that "property" is more than an abstract need or desire for something; it must be a "legitimate claim of entitlement" to a particular benefit.[222] Because there is no precedent for a property right in the energy in wind in the United States, it will be difficult for the downwind plaintiff to prove the injury element of a negligence claim for energy loss damages even if the upwind plant caused reduced power production and thus lost revenues for royalty beneficiaries.

2. Nuisance. – As the Wisconsin court opined in the previous section of this paper, nuisance may be a better common law remedy to address the damaging effects of wind wakes.

a) Nuisance in General. – Nuisance allows "lawful occupiers of land [to] be protected against interferences which inhibit their full use of their land for normal purposes."[223] Private nuisance requires a plaintiff to show that

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[217] Wind Energy Partnership, Case No. 5:11-cv-02050-R-OP, slip op. (C.D. Cal. June 11, 2012); *See also,* Kimberly E. Diamond, *Wake Effects, Wind Rights, and Wind Turbines: Why Science, Constitutional Rights, and Public Policy Issues Play a Crucial Role*, 40 WM. & MARY ENVTL. L. & POL'Y REV. 813, 822-23 (2016).

[218] Muscarello v. Winnebago County Board, 702 F.3d 909 (7th Cir. 2012); *See also*, Muscarello v. Ogle County Board of Commissioners, 610 F.3d 416 (7th Cir. 2010).

[219] Muscarello, 702 F.3d at 911 ("A reduction in wind speed downwind is an especially common effect of a wind turbine . . . and that is the harm the plaintiff emphasizes – which is odd. For the only possible harm the wind farm could do to her would be to reduce the amount of wind energy otherwise available to her, and the only value of that energy would be to power a wind farm on her property – and she is opposed to wind farming.").

[220] *Id.* The 7th Circuit noted that "The district court dismissed the suit, a blunderbuss of federal and state claims, on the ground that the complaint fails to state any claim on which the plaintiff would be entitled to relief. Fed. R. Civ. P. 12(b)(6)."

[221] *Id.* at 914.

[222] Board of Regents of State Colleges v. Roth, 408 U.S. 564, 577 (1972).

[223] Ghaleigh, *supra* note 176 at 4.

(1) "the unreasonable, unwarranted, or unlawful use" of the defendant's property (2) "substantially interferes with the enjoyment of the plaintiff's property," without an actual trespass or physical invasion.[224]

Furthermore, nuisance "involves a balancing of the costs and benefits of the land use claimed to have caused a nuisance."[225] Law and economic theories have been wedded to create a conceptual framework for resolving the combined tort law and property law issues raised by nuisance cases.[226] This theory has been expanded to suggest that the choice should be based on the most economically efficient transaction-cost-based option.[227] Applying these frameworks to wind energy disputes suggests that the economics of each situation will drive resolution of any conflicts.[228]

Sometimes "authorization for an activity," such as receiving a permit from a governmental authority may be a defense to nuisance.[229] A wind developer in England argued that compliance with the ETSU and planning conditions would bar a claim brought by Mr. and Mrs. Davis of Gray's Farm, which suffered from a wind turbine 1000 m from their home.[230] Although the *Davis v. Tinsley* case settled, the result in another British case, *Barr v. Biffa*, suggests that authorization does not tip the scales in all cases and may not be a complete defense.[231] As Lord Justice Carnwath, one of the judges

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[224] RESTATEMENT (SECOND) OF TORTS §§ 821D-812E (1979); Robert D. Dodson, *Rethinking Private Nuisance Law: Recognizing Aesthetic Nuisances in the New Millennium*, 10 S. C. ENVTL. L. J., 1, 1 (2002).

[225] Muscarello, 702 F.3d at 915 (citing Village of Wilsonville v. SCA Services, Inc., 426 N.E.2d 824, 834–36 (Ill. 1981); Dobbs v. Wiggins, 929 N.E.2d 30, 38–39 (Ill. App. Ct. 2010); Pasulka v. Koob, 524 N.E.2d 1227, 1238–39 (Ill. App. 1988); RESTATEMENT (SECOND) OF TORTS § 826 (1979); W. Page Keeton et al., *Prosser & Keeton on the Law of Torts* §§ 88, p. 629-30 (5th ed. 1984).

[226] Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972).

[227] James E. Krier & Steward J. Schwab, *Property Rules and Liability Rules: The Cathedral in Another Light*, 70 N.Y.U. L. REV. 440 (1995).

[228] Rule, *A Downwind View of the Cathedral*, *supra* note 196; *See also* Rule, *Sharing the Wind*, *supra* note 196, at 30-33.

[229] Ghaleigh, *supra* note 176, at 6 ("The DECC position is that where the correct methodology has been followed and a wind farm is shown to comply with ETSUR-97 recommended noise limits, the Infrastructure Planning Commission may conclude that it will give little or no weight to adverse noise impacts from the operation of the wind turbines. DECC. July 2011. National Policy Statement for Renewable Energy Infrastructure (EN-3): ¶2.7.58."); U.S. DEPT. OF ENERGY, *supra* note 18.

[230] *Couple Settle with Wind Farm Operators Over 'Unbearable Hum'*, THE DAILY TELEGRAPH, (Nov. 30, 2011), http://www.telegraph.co.uk/earth/environment/8925467/Couple-settle-with-wind-farm-operators-over-unbearablehum.html.

[231] Ghaleigh *supra* note 176, at 4 ("In the recent case of *Barr v Biffa* which related to odours from a waste disposal site, the Court of Appeal did not accept that compliance with regulatory controls such as a permit provided an absolute defence." (citing The Law Reports. [2012] EWCA Civ. 312 (Eng.))).

in *Barr* noted, "[a]n activity which is conducted in contravention of planning or environmental controls is unlikely to be reasonable. But the converse does not follow. Sticking to the rules is an aspect of good neighbourliness but it is far from the whole story–in law as in life."[232]

The burden of proof for either nuisance or negligence would typically fall as it does in any civil action–upon the plaintiff to prove by a preponderance of the evidence.[233] Codified law can either expand or reduce a plaintiff's burden. For example, the burden is expanded in favor of defendants under Section 158 of the British Planning Act 2008, which addresses approval for nationally significant infrastructure projects. Proof of approval under Section 158 can create an absolute defense to a nuisance claim.[234]

In contrast, California has reduced the burden of proof for a plaintiff by scientifically describing private nuisance in the context of obstruction of the sun on a solar panel. The California Solar Shade Control Act provides that "[a] tree or shrub that is maintained in violation of Section 25982 is a private nuisance . . ."[235] And Section 25982 also says:

After the installation of a solar collector, a person owning or in control of another property shall not allow a tree or shrub to be placed or, if placed, to grow on that property so as to cast a shadow greater than 10 percent of the collector absorption area upon that solar collector surface at any one time between the hours of 10 a.m. and 2 p.m., local standard time.[236]

Recovering for either damage losses or energy loss from wakes may be difficult under the traditional nuisance standard. First, setting up wind turbines on an adjacent property is not generally considered an "unreasonable, unwarranted, or unlawful use."[237] In fact, that is what an operator would be expected to do under a wind lease agreement.

Second, the burden would be on the plaintiff, downwind operator, to show that the upwind operator's actions "substantially interfered" with those downwind.[238] It is unclear what the threshold is for "substantially interfered" but unless a statute clarified and narrowed the burden of proof in a way that is similar to California's Solar Shade Control Act, it could be an

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[232] Barr & Ors v. Biffa Waste Services, EWCA Civ 312, para. 47 (Eng.) (Court of Appeals, Civil Division, Mar. 19, 2012) (appeal allowed; cross-appeal dismissed).

[233] *See, e.g.*, Velasquez v. U.S. Postal Service, 155 F. Supp. 3d 218, 227 (E.D.N.Y. 2016) (citing Brown v. Lindsay, Nos. 08-CV-351, 08-CV-2182, 2010 WL 1049571, at *12 (E.D.N.Y. Mar. 19, 2010) ("In a civil case, the plaintiff bears the burden of proving the elements of his claim by a preponderance of the evidence.")).

[234] Ghaleigh, *supra* note 176 at 4-5. (describes a statutory scheme that allowed the Highland Council, a local authority, to abate a nuisance in June of 2011 by issuing a stop notice for activities to cease until a developer complied).

[235] CAL. PUB. RES. CODE § 25983 (West 2009).

[236] *Id.* § 25982.

[237] *Cf.* standards at *supra* note 224.

[238] *Id.*

insurmountable burden for plaintiff.[239]

Finally, plaintiff's burden is further complicated by the balancing of the costs and benefits of wind turbines including that "the energy they produce is clean and also reduces consumption of fossil fuels and so contributes to US independence from foreign oil supplies."[240]

b) Nuisance in the offshore wind context. – With respect to offshore wind in the United States, several federal leases have been awarded to developers.[241] The main body of US commercial wind leases is quite short: a majority of the provisions state that the lessee must act in accordance with either the approved Site Assessment Plans (SAPs), Construction and Operations Plans (COPs), or 30 C.F.R. Part 585,[242] all of which will be discussed below.

Section 7 of the commercial leases of submerged lands for renewable energy development on the OCS state, "[The conduct of] all activities in the leased area [shall be] in accordance with an approved SAP or COP" to be agreed upon.[243] One distinction in the language of these leases separate from the C.F.R is that the lessee must agree that no activities will be carried out in a manner that "could *unreasonably interfere* with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the [Outer Continental Shelf Lands Act] . . . ."[244]

The language in the SAP and COP requirements[245] and in the leases

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[239] *See, e.g.,* Matteliano et al. v. Skitkzi, 85 A.D.3d 1552, 1553 (2011) ("Interference 'must not be fanciful, slight, or theoretical, but certain and substantial, and must interfere with physical comfort of the ordinarily reasonably person'" (citing Bove v. Donner-Hanna Coke 236 A.D.3d 37, 40 (1932))).

[240] Muscarello, 702 F.3d at 914 ("The fact that the County Board has zoned agricultural property to allow wind farms would complicate her effort to establish that it was a nuisance, but not defeat it.").

[241] As each lease currently available to the public utilizes the same format and language, one specific lease is cited as a reference to all leases in general.

[242] BUREAU OF OCEAN ENERGY MGMT., U.S. DEPT. OF INTERIOR, *Lease OCS-A 0501* (2015), https://www.boem.gov/Lease-OCS-A-0501/.

[243] *Id.* at § 7.

[244] *Id.* at § 7(a). Additionally, a provision in Section 7 nearly mimics that of both the SAP and COP: the lessee agrees that "no activities . . . will be carried out in a manner that . . . could adversely affect sites, structures, or objects of historical, cultural, or archaeological significance." *Id.* at § 7(d). Although this lease section does not discuss the need to avoid damage to property as accentuated in the planning requirements, such specific language is not necessarily required as the lessee must already adhere to their approved SAPs and COPs.

[245] One additional requirement is in Subpart G: The Facility Design Report. This Subpart G report provides specific details about the design of any facilities that were outlined in the SAP and COP. The important features of this report with respect to the necessity of wake analyses are the location plat and summary of environmental data used for design.

themselves mirrors the common law nuisance standard prohibiting "the unreasonable, unwarranted, or unlawful use" of a potential defendant's property. As was discussed above, it appears that a downwind operator would have a difficult time proving that placement of wind turbines on the upwind operator's lease was unreasonable. Similarly, a downwind operator might have a case for compensation for premature fatigue of its turbines ("adverse effect [on] structures") if competing turbines are placed too close, but it would probably be based on an industry standard of care.

C. Codified Law

Although regulation is minimal, sometimes regulators try to ameliorate the wild west competitive approach of wind development by codifying some protections for neighboring wind plants or other impacted parties. The two main mechanisms employed are: (1) setbacks and (2) formal planning processes.

1. Regulated Setbacks. – In the context of project boundaries, a setback is a distance established between: (1) the shared property line between an upwind landowner and a downwind landowner and (2) the closest distance the upwind landowner can site a commercial wind turbine on its property.[246] In the United States, setback distances are primarily focused on public safety and property protection[247] providing a remedy for lessors or adjacent properties for ice throw,[248] blade failure,[249] or a downed turbine

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30 C.F.R. § 585.701(a); *Id.* § 2, § 5. For the summary of environmental data, a wake analysis would be useful in regard to the potential effects of wakes from neighboring faculties on the facility in review, in addition to a wake analysis of the proposed project on other project areas to be leased in the future, in order to be applied to the determination of the location plat. Although it is not currently the responsibility of the developer to determine the potential wake effects from upwind wind plants, such wake analyses are vital for them to know in consideration of an optimal site plan. Ideally, every project developer would be required to conduct its own wake analyses, and such information would be available to the public so these could be analyzed during the review phases discussed above, as is required in the European Union. Commission Regulation (EU) No. 543/2013.

[246] Diamond & Crivella, *supra* note 64, at 195-96.

[247] *Siting Wind Energy Facilities - What Do Local Elected Officials Need to Know*, ENVTL. L. INST., 6 (2013).

[248] Patrick S. Ottinger, *Is There a Future for Wind Energy in the Bayou State: The Answer, My Friend, Is Blowin' in the Wind*, 7 LSU J. ENERGY L. & RES. 1, 28 (2019) ("'Ice throw' [is] . . . the forceful shedding of ice from the blades of a turbine as they rotate.").

[249] *See generally* Samet Ozturk et al., *Failure Modes, Effects and Criticality Analysis for Wind Turbines Considering Climatic Regions and Comparing Geared and Direct Drive Wind Turbines*, 11 ENERGIES 2317 (2018); Jui-Sheng Chou et al., *Failure Analysis of Wind Turbine Blade Under Critical Wind Loads*, 27 ENG'G. FAILURE ANALYSIS 99 (2013).

mast.[250] Only a handful of setbacks have been codified to address wake impacts.

As most terrestrial US wind regulation is at the state and local level,[251] this section will begin first with that analysis. Second, it will address mandatory setbacks in offshore "Crown Estate" leases in the United Kingdom. Finally, US federal leases, both onshore and offshore, will be examined and compared to the setback practices in some states and the UK to determine the benefits and detriments to having similar arrangements in the US government leases.

a) State. – Different states have their own rules on prescribed setback limits. They typically can be described by two general approaches.[252] First is the minority position of statewide control. Only four states reserve all siting authority for wind projects to state government.[253] Twenty-four states have both state and local siting provisions.[254] The second alternative–local control–is by far the most common. Of the 20 states with substantial local autonomy, only two states have an established statewide setback, and 15 of those states have no such statewide process specifically addressing wind energy siting.[255] Below is a discussion of how these protections and a lack of them have played out and how states are considering them in the offshore context.

(i) No Protection–North Dakota. – One scenario where the lack of a setback limit proved to be problematic occurred in 2008 when a downwind developer voiced concern about the potential wake effect that a

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[250] Lisa Linowes, *Wind Setbacks: Safety First (Unless You're a Wind Developer)*, WIND ACTION (July 1, 2014), http://www.windaction.org/posts/40729-wind-setbacks-safety-first-unless-you-re-a-wind-developer#.XVJPgZNKhTY.

[251] It is beyond the scope of this article to address all possible local regulations related to wind. Texas, which has been the largest wind producing state in the United States for decades, has 1,472 general purpose jurisdictions alone. *See Number of Local Governments by State*, GOVERNING (2019), https://www.governing.com/gov-data/number-of-governments-by-state.html (citing U.S. Census Bureau, 2017 Census of Governments).

[252] The first approach designates siting authority to state agencies, including public utilities commissions or siting councils and boards in conjunction with local authorities. The second approach typically gives local government substantial authority in regulating the siting of most wind facilities. *See* Jesse Heibel & Jocelyn Durkay, *State Legislative Approaches to Wind Energy Facility Siting*, NATIONAL CONFERENCE OF STATE LEGISLATORS (Nov. 11, 2016), http://www.ncsl.org/research/energy/state-wind-energy-siting.aspx.

[253] *Id.* These states include North Carolina, Virginia, West Virginia and Connecticut.

[254] *Id.* Of the twenty-four states with both state and local siting provisions, twelve of those states have statewide setback requirements.

[255] *Id.*

neighboring upwind developer would have on its project.[256] Peak Wind and Florida Power and Light (FPL) both announced their plans to construct wind plants on a glacial ridge in North Dakota. At the time, North Dakota did not have statewide or local setback guidelines in place.

Peak Wind requested the use of a setback standard of three to five times the diameter of the rotor blade away from the property line.[257] FPL's siting of their turbines closer to the property in the absence of setback limits would force Peak Wind to either construct fewer turbines than planned to minimize effects due to wakes, or to continue with their construction as planned at the expense of turbulence damage and less energy production.[258]

As is somewhat typical for local authorities that do not have expertise in wind development, the zoning commissioners reverted to a standard that reflected safety and not wind wake concerns. The zoning commissioners simply required a setback of "one fallen turbine," which is effectively a set-back limit of the length of one turbine or one hub height.[259]

One hub height is less than 1 RD,[260] so this setback limit does not come near the 5 to 10 RD recommended to prevent turbulence damage nor the larger setback that would be required to address possible energy losses to the downwind turbines. Consequently, Peak Wind did not receive any protection for wake effects from this zoning ruling.[261]

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[256] Lauren Donovan, *Two Energy Projects Competing for the Wind*, BISMARCK TRIBUNE, (Feb. 22, 2008), http://bismarcktribune.com/news/local/article_4bd1f0d6-6616-512b-970f-b4301800f774.html?print=1.

[257] *Id.* This request was based on the Minnesota Public Utilities Commission setback standard discussed *infra* note 258 and is consistent with the 5 RD setback to prevent turbulence damage discussed *supra* note 256.

[258] Diamond & Crivella, *supra* note 64, at 212; *see also* Donovan, *supra* note 256.

[259] *See generally* Diamond, *supra* note 196, at 822-23 (discussing the safety precautions of 1 to 1.5 turbine height).

[260] Hub heights are generally less than rotor diameters. *See* Ryan Wass, *Design of Wind Turbine Tower Height and Blade Length: An Optimization Approach*, MECHANICAL ENG'G. UNDERGRADUATE HONORS THESES 1 (2018), https://pdfs.semanticscholar.org/25fa/0c1ad17031c785fb42d5ddf1ec7c472c21a7.pdf ("Current design standards set a fixed rate of 1-1.3 for the height to diameter ratio as this is the estimated best ratio to receive the most power output for the least cost.").

[261] Diamond & Crivella, *supra* note 64, at 213; *see also*, Donovan, *supra* note 256. It is perhaps poetic justice that FPL prevailed in this dispute as it failed in an earlier one also in North Dakota. In that case, the existing wind plant owned by EnXco asked Dickey County to impose a 5 RD setback to protect EnXco's project from the one FPL proposed. The county did impose the 5 RD buffer, so FPL abandoned its plans to develop the project. *See also* Charles Read & Daniel Lynch, *The Fight for Downstream Wind Flow,* LAW 360 (May 25, 2011) https://www.law360.com/articles/247122/the-fight-for-downstream-wind-flow. This article also describes efforts of developers to address the impact of competing development through an environmental impact report in Alta-Oak Creek Mojave in California and through litigation concerning projects in Umatilla County in Oregon.

(ii) Protection–Minnesota. – Only one US state, Minnesota, has administrative requirements that specifically mandate setbacks to address wake impacts for terrestrial wind plants. The state statute and administrative regulations do not mention the word "wake."[262] However, a Minnesota PUC opinion recognized wake protection as one of its goals:

The wind access buffer setback standards, as established in the Commission's 2008 Wind Permit Standards Order, are designed to protect wind rights and future development options of adjacent landowners who are not participating in the wind project under consideration.[263]

The Minnesota 2008 Wind Permit Standards Order, referenced by the Minnesota PUC in the excerpt above, used authority from the legislature to establish "property line set-backs"[264] so that projects subject to Minnesota PUC permits are "designed and sited in a manner that ensures efficient use of the wind resources, long term energy production, and reliability."[265] In addition to including "wake loss studies" in some permit applications, the Minnesota PUC is primarily attempting to achieve its efficient-use goals through presuming a required 3 RD by 5 RD spacing for turbines.[266] This presumption may not be enough considering that the IEC recommendation is for at least 5 RD to prevent wake damage and would need to be a greater distance to address energy losses due to wakes.[267]

(iii) Protections Offshore–New York. – With respect to offshore wind, again states are taking the lead. For example, in considering wind turbine spacing and the impacts of wakes in the context of offshore leases for state waters off New York, a report from NYSERDA ran several resource scenarios and model layouts. The lowest setback was 5.5 RD for the Areas of

[262] *See, e.g.,* MINN. STAT. § 216F.03 (2019) ("[It is the] policy of state to site LWECS in an orderly manner compatible with environmental preservation, sustainable development, and the efficient use of resources."). The Wind statute was passed in 1995, and this language seems to be modeled closely after the language in the Minnesota power plant siting statute, which states, "[It is the]"policy of state to locate large electric power facilities in an orderly manner compatible with environmental preservation and the efficient use of resources."); *Id.* § 216E.02(1) (1977).

[263] In re Application of New Ulm Public Utilities Commission for a Large Wind Energy Conversion System Site Permit for the New Ulm Wind Project in Nicollet County, E-282/WS-09-178, 2010 WL 239236 *1, *5 (Minn. P.U.C. Jan. 19, 2010).

[264] MINN. STAT. § 216F.08(c) (2019).

[265] Order Establishing General Wind Permit Standards, In the Matter of Establishment of General Permit Standards for the Siting of Wind Generation Projects Less than 25 Megawatts, No. E,G-999/M-07-1102 (Minn. P.U.C. Jan. 11, 2008).

[266] *Id.* at 8, (3 RD (on secondary) & 5 RD (.5 km on predominant axis) as the standard buffer for internal and external spacing).

[267] IEC INTERNATIONAL STANDARD 61400-1 app. D (3rd ed. 2005-2008).

Consideration, and the widest was 13 RD.[268] The report author, the Renewables Consulting Group LLC, notes that their 13 RD X 10R D layout was generous, given that the 27 European wind plants reviewed for the study had an average downwind and crosswind spacing of 7.5 RD and 5.9 RD, respectively. This is because there is no agreed-upon limit for the distance between neighboring wind plants in Europe; the distances are governed by the leasing and permitting processes in each country.[269]

Even with a 13 RD X 10 RD layout, each individual wind plant in the models still experienced wake losses between 4% and 5%.[270] As discussed above, such percentages can represent several million dollars in lost revenues. Further, the study anticipates "that to reduce wake loss impacts on the downwind site to less than 1%, an inter-site distance of four nautical miles would be required."[271] The study goes on to say, "despite the generous inter-site distances applied in the design (driven by the recommended minimum distance for navigational purposes), the cumulative wake losses are significant in some cases and may warrant some form of wake compensation agreement or negotiated [sic] by the project sponsors."[272]

b) European. – In Germany, each federal state has different rules with respect to ordinances governing the mandatory setback distances from two adjacent landowners' shared property line.[273] In the federal state Schleswig-Holstein, there is a mandatory setback limit of 5 RD, whereas in the federal state North Rhine-Westphalia, there is an 8 RD setback distance.[274] Bavaria has a "10 H rule," meaning the minimum distance between a wind turbine and the nearest building must be ten times the hub height of the turbine.[275]

Bavaria's regulation received opposition from other German states, because they felt the setback was so extensive that it is "destructive to [their]

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[268] N.Y. STATE ENERGY RESEARCH & DEV. AUTH., ANALYSIS OF TURBINE LAYOUTS AND SPACING BETWEEN WIND FARMS FOR POTENTIAL NEW YORK STATE OFFSHORE WIND DEVELOPMENT 23 (2018).

[269] *Id.* at 11.

[270] *Id.* at 29 (With an inter-plant distance of 3.8 nautical miles, wake losses with all sites included increased between 1% and 2%).

[271] *Id.* at 17.

[272] *Id.* at 30.

[273] Sebastian Knauer, *Legal Turbulence in Germany: Who Owns the Wind?,* SPIEGEL ONLINE INT'L, (May 4, 2007), http://www.spiegel.de/international/germany/legal-turbulence-in-germany-who-owns-the-wind-a-480327.html.

[274] *Id.*

[275] Craig Richard, *Reintroduction of German Setback Rules Proposed*, WIND POWER MONTHLY (Oct. 22, 2018), https://www.windpowermonthly.com/article/1496776/reintroduction-german-setback-rules-proposed. Because rotor diameter sizes are greater than hub heights, a 10 H rule may not be any greater than the 8 RD set by North Rhine-Westphalia.

energy policy"[276] by "threaten[ing] Germany's target of sourcing 65% of its energy from renewable sources by 2030."[277] However, the Bavarian Energy Minister defended it, maintaining this setback meant "'legal certainty' and a 'common good, sound balance between [their] energy policy goals and local interests.'"[278]

With respect to offshore wind installed capacity, the United Kingdom is the world leader.[279] The United Kingdom had 8.2 GW of installed offshore capacity as of 2018[280] and anticipates 14 GW by 2023.[281] In 2018, the United Kingdom generated 8% of its electricity from offshore turbines,[282] and it predicts that percentage will be greater than 10% by 2020.[283] The UK's offshore leasing is regulated by the "Crown Estate," an independent, commercial business created by an Act of Parliament.[284]

Offshore Crown leases in the United Kingdom contain a required setback provision for addressing wind wake issues that is not available in US offshore leases. This Crown lease provision is a formalized 5 km setback or buffer zone for all boundaries of the lease.[285] This Crown lease 5 km "buffer

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[276] Lorenz Storch & Max Muth, *Constitutional Court Confirms 10H Turbine Setback Law,* WIND ACTION (May 9, 2016), http://www.windaction.org/posts/45003-constitutional-court-confirms-10h-turbine-setback-law#.XNmx7S-ZORs.

[277] Richard, *supra* note 275.

[278] Storch & Muth, *supra* note 276; *See also* Diamond, *supra* note 196, at 822 (discussing the German rules).

[279] OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *supra* note 2.

[280] Craig Richard, *Record Year for UK Wind*, WINDPOWER MONTHLY (Mar. 28, 2019), https://www.windpowermonthly.com/article/1580446/record-year-uk-wind ("Last year 700MW of onshore wind capacity was added to the grid, bringing the cumulative total to 13.5GW, and 1.2GW of offshore wind was brought online, raising the total to 8.2GW.").

[281] *Offshore Wind New Leasing Market Engagement Event*, THE CROWN ESTATE 7 (Nov. 26, 2018), https://www.thecrownestate.co.uk/media/2797/20181126-new-leasing-engagement-event-slides-published.pdf.

[282] Richard, *supra* note 280 (also noting that "[o]n shore wind accounted for 9.1% and offshore wind 8% of total production in 2018 – both new records, according to the UK's department for energy and industrial strategy (BEIS).").

[283] THE CROWN ESTATE, *supra* note 281, at 7.

[284] *Id.*

[285] *Id.* at 70, 79 ("5. Landlord Covenants 5.1 Subject to clause 5.2 (below) the Landlord covenants with the Project Company that the Landlord shall not without the Project Company's consent (such consent not to be unreasonably withheld or delayed): … (c) grant any agreement for lease or lease for the installation of any windplant (which shall exclude for the avoidance of doubt the grant of any agreement for lease or lease to a Transmission Entity) within a distance of five (5) kilometres from the boundary of the [Site/Premises/REZ Site].); E-mail from Ben Barton, Senior Commercial Managers for the Crown Estate to Karina Condra, Reference Librarian, University of Denver (July 12, 2019) (on file with author).

zone" requirement[286] effectively shifts the "best practice" of creating a "moat" around one's project into a codified contractual obligation. This 5 km buffer may be waived upon written consent of a new tenant and any existing wind plant within that proximity.[287] In fact, Ørsted has several sites where no buffer has been included between wind plants.[288]

It is important to note that the 5 km distance in each lease, which translates to a total of 10 km when two adjacent leases both apply their 5 km obligation, is significantly larger than what would be required simply to address wake damage losses, which the IEC has set at 5 to 10 RD (a distance of only about 1 km),[289] so this protection in UK Crown leases is included specifically to address the second impact of wind wakes–energy loss.[290]

There does not appear to be any recorded history of when or why this 5 km buffer was added to Crown leases,[291] but in a recent presentation, representatives of the Crown Estate said its purpose was "to provide certainty around the closest proximity of future projects"[292] In addition, there is discussion that lessees would prefer that the mandated buffer be wider, between 7.5 and 10 km, to address wake effects.[293]

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[286] E-mail from Gero Vella, Project Development Manager, RES Offshore, to author (June 10, 2019) (on file with author) (noting that the Crown Estate may be increasing the width of this buffer to 10km). See also, E-mail from Nicolai Gayle Nygaard to author (July 9, 2019) (on file with author).

[287] THE CROWN ESTATE, *supra* note 281, at 79.

[288] E-mail from Nicolai Gayle Nygaard, Lead Wind Energy Specialist, Energy Yield Assessment, Wind Power, Ørsted, to author (July 9, 2019) (on file with author) (listing Walney 1&2, Walney Extension and West of Duddon Sands, Burbo Banks, and Burbo Banks Extension).

[289] The fact that developers recommend at least 7 RD and more commonly prefer 10 RD is recognition that the IEC standard is probably a minimum for avoiding turbulence damage. Furthermore, some research is showing that the wake distances and farm-effect, instead of turbine-effect, wakes do not necessarily scale with wind turbine rotor diameter. E-mail from Julie Lundquist, Associate Professor, University of Colorado, to author (July 28, 2019)(on file with author).

[290] E-mail from Nicolai Gayle Nygaard, Lead Wind Energy Specialist, Energy Yield Assessment, Wind Power, Ørsted, to author (July 9, 2019) (on file with author).

[291] E-mail from Barnaby Wharton, Director of Future Electricity Systems, Renewable UK, to Karina Condra (Aug. 12, 2019) (on file with author) ("I have had a look through our records and cannot find any report where we recommended the 5KM buffer.").

[292] *Slideshow at Offshore Wind New Leasing Market Engagement Event 26th November 2018*, THE CROWN ESTATE, (slide 70-71, 79) (A 10 km corridor between projects might also serve shipping and fishing needs, but that was not discussed as a rationale in the slideshow).

[293] E-mail from Barnaby Wharton, Director of Future Electricity Systems, Renewable UK, to Karina Condra (Aug. 12, 2019) (on file with author) ("Offshore wind turbines have become much taller in recent years, and we are now recommending a wider zone between wind farms. The Crown Estate's latest leasing round proposed 7.5km, and this

c) Federal. – In the United States, there are no federal regulations about turbine spacing or setbacks on private lands.[294] However, at times there have been federal regulations about setbacks for wind development grants for Bureau of Land Management lands. A 2008 guidance memorandum recommends a 1.5 mast height setback from the right-of-way boundary in all directions "for safety reasons."[295] Significantly, the BLM guidance also addresses setbacks to address "potential wind turbulence interference issues with adjacent wind energy facilities wake effects."[296] According to Section 3: Development Grant, the BLM guidance created a presumption for a 5 RD setback from the boundary of the right-of-way in the dominant upwind or downwind direction.[297] However, this guidance expired on September 30, 2014.

US federal offshore leases now have mandatory setback requirements as in the UK Crown leases and in the recommendations as with the 2008 BLM guidance memorandum.[298] While mandatory setbacks are perhaps a good start for considering wake impacts, they are problematic.

First, they can be overinclusive in some circumstances where technology and ground conditions might allow a closer spacing. Thus, a rule of thumb that creates a moat or buffer zone can put favorable areas out of production. Based on possible development scenarios set out in his book, *Solar, Wind and Land*, Troy Rule calculates that just a 5 RD setback resulted in

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should be a minimum – many of our members would prefer 10km to address wake effects.").

[294] *See* OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEPT. OF ENERGY, *Frequently Asked Questions about Wind Energy* (2019), https://www.energy.gov/eere/wind/frequently-asked-questions-about-wind-energy. ("[T]here are no national or international defined standards for wind turbine setbacks"); *See also* Diamond, *supra* note 196, at 819 ("Currently, in the United States, there is no Supreme Court ruling, national standard, federal guidelines, legislation, regulatory framework, or other measure that has established a federally protected property right to wind flowing over one's property, including non-interference with this wind flow by an immediately adjacent neighbor.").

[295] Instruction Memorandum No. 2009-043 re Wind Energy Development Policy Program Area: Right-of-Way Management, Wind Energy, page 4 of 7 (Dec. 18, 2008) ("[F]or safety reasons, no turbine on public land will be positioned closer than 1.5 times the total height of the wind turbine to the right-of-way boundary."), https://www.blm.gov/download/file/fid/115.

[296] *Id.* ("In the absence of any specific local zoning and management issues, no turbine will be positioned closer than 5 rotor-diameters from the center of the wind turbine to the right-of-way boundary in the dominant upwind or downwind direction to avoid potential wind turbulence interference issues with adjacent wind energy facilities unless it can be demonstrated that site conditions, such as topography, natural features, or other conditions such as offsets of turbine locations, warrant a lesser distance.").

[297] *Id.*; EMS TRANSMISSION (Dec. 22, 2008).

[298] *See, infra* at note 389 (the most recent leases provide for mandatory setbacks of 750 meters).

"a 50 percent aggregate reduction in the aggregate wind energy generating capacity from what would have been possible" if the same area had been owned by a single operator and no setbacks mandated.[299] Consequently, they do not economically or efficiently utilize the wind resource.

Second, mandatory setbacks are underinclusive. Research shows that in some situations, turbulence damage might extend more than 5 RD and energy losses can be up to 35 miles, so a rigid 5 RD setback, for instance, would not provide sufficient protection for either turbulence or energy loss impacts.

Finally, a rigid setback requirement to protect future wind development may not make sense because it is uncertain what future development will look like. Even within different plants or developments owned by a single producer, there may be energy loss wake impacts that reduce the electricity production of an existing plant. While collaborative development of adjacent lease areas by a single developer may make sense, it may not be possible to optimize across different projects because they are typically developed in phases at different times. In the first auction there is no guarantee that the second project will be awarded. Furthermore, technologies are changing quickly and can vary the calculations. Consequently, it is generally the best strategy to optimize the first project without considering coordination or impacts on future phases.[300]

Despite these drawbacks, it may be advisable for a governmental entity to establish some sort of setback guidelines that might be waivable. First, through the existence of a setback rule, "arguably, the government has recognized there is some property right or entitlement the downwind landowner possesses with respect to wind flow over its property that should be accorded legal protection."[301] Second, by starting with a setback rule, the downwind landowner is given some leverage to get the upwind operator to the negotiating table in the context of litigation or the planning processes discussed in the following section.

2. Planning Process. – Both the United States and United Kingdom have planning processes that might currently provide some of the best protections for wake impacts.

a) The UK Consultation Process. – Offshore wind development in UK waters involves a consenting process. The rules for consent vary according to the size of the project and whether it is located offshore in England, Wales, or Scotland. For offshore wind plants in England and Wales with 1 to 100 MW of capacity, consent is given according to Section 36 of the Electricity

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[299] RULE, *supra* note 144, at 60.

[300] Email from Nicolai Gayle Nygaard, Lead Wind Energy Specialist, Energy Yield Assessment, Wind Power, Ørsted, to author (July 9, 2019).

[301] Diamond, *supra* note 196, at 827.

Act of 1989.[302] In England, section 36 consent is given by the Marine Management Organisation.[303] In Scotland, offshore wind plants require section 36 consent from the Scottish Ministers.

In England and Wales, projects with capacity above 100 MW are considered Nationally Significant Infrastructure Projects (NSIPs) under the 2008 Planning Act (HM Parliament, 2008b).[304] The goal of the Planning Act was to provide a mechanism for "a more efficient, accessible and transparent planning system for [large] projects,"[305] shifting "planning decision-making from local level to national level, and hence reduc[ing] time and costs associated with obtaining development consent."[306] Because offshore wind turbines have large nameplate capacities of up to 10 MW per turbine, the 100 MW trigger encompasses almost all wind plant developments.[307]

Under Planning Act Section 31, NSIP projects require Development Consent Orders (DCO).[308] In England, the Secretary of State grants the DCO, and in Wales, it is the Welsh Ministers.[309] One of the goals of the Planning Act was to reduce the number of consents required for approval of a project.[310] While the number of consents may be reduced, there is still a rigorous consulting process and the consent mechanism gives parties who are included

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[302] Electricity Act of 1989, 1989 c. 29, §36(2) (Eng.).

[303] NAVRAJ SINGH GHALEIGH, *Legal Framework to Develop Offshore Wind Power in United Kingdom*, in THE DEVELOPMENT OF A COMPREHENSIVE LEGAL FRAMEWORK FOR THE PROMOTION OF OFFSHORE WIND POWER: THE LESSONS FROM EUROPEAN AND PACIFIC ASIA 39 (Anton Ming-Zhi Gao & Chien-Te Fan eds. 2017).

[304] Planning Act 2008, 2008 c. 29 § (3).

[305] Emma Gibson & Peter Hausam, *The Legal Framework for Offshore Wind-Farms: A Critical Analysis of the Consent Process*, 38 ENERGY POLICY 1, 15 (2010); K.K. DuVivier, *The Superagency Solution*, 46 MCGEORGE L. REV. 189 (2014) (as California did by consolidating thermal energy permitting in its "superagency.").

[306] Gibson & Hausam, *supra* note 305.

[307] *Id.* (noting that according to Wilson and Triggs 2008, "The majority of Round 3 projects will have capacity greater than 100MW.").

[308] Planning Act 2008, 2008 c. 29 §15(1), (3), §5. *See also* Ghaleigh, *supra* note 303, at 39.

[309] The Secretary of State's role in the DCO process is outlined in Section 37 of the 2008 Planning Act. 2008 Planning Act 2008, 2008 c. 29 §37 (Eng.); While the role of the Welsh Ministers looks to be outlined in section 39 of the Wales Act 2017 (as far as generating stations with 350 MW capacity or less). Wales Act 2017, 2017 c. 4 §39 (Wales).

[310] Gibson & Hausam, *supra* note 305 at 15. ("Part 1 of the Act establishes a new body, the Infrastructure Planning Commission (IPC), with responsibility for making planning decisions for NSIP. The IPC will be independent of government and able to make "transparent, expert, accountable and ethical decisions" (Pitt, 2009). The IPC will be guided by National Policy Statements (NPS) (HM Parliament, 2008b) part 2), which set the policy framework for planning decisions in specified fields of development, namely: energy, transport, water, waste water and waste (section 14(6)).").

some leverage.[311] For example, the Infrastructure Planning Regulations of 2011[312] apply to offshore wind plants. They require both the governmental authority involved[313] and the applicant for a change[314] to consult with "each person for whose benefit the development consent order . . . has effect."[315] This includes individuals and local governmental authorities, as well as competing wind projects. Not only may neighboring projects weigh in, but they also may seek compensation.[316]

(i) Consultation Process on Land Projects. – Section 152 of the 2008 Planning Act provides for compensation in cases where there is no right to claim nuisance.[317] Although it applies to the compensation for "land . . .

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[311] Gibson & Hausam, *supra* note 305 at 15-16 ("NPSs will be prepared by the Secretary of State with responsibility for the field of development and must take into consideration the requirement to achieve sustainable development. In defining the NPS, there is a duty on the Secretary of State to carry out appropriate consultation and publicity (section 7). In defining the consultation requirements, the Secretary of State must consult with local authorities affected by the NPS (section 8). With respect to offshore wind farm development, however, it is unclear which local authorities will be consulted. The Act refers to local authorities where development is to be made, and those neighbouring them, however local authority jurisdiction does not extend offshore (Jay, 2008). There is potential that all local authorities along the coast could be affected by offshore wind farm developments, which represents a vast constituency for consultation in preparing the NPS.").

[312] Infrastructure Planning (Changes to, and Revocation of Development Consent Orders) Regulations 2011, SI 2011/2055, Part 1, Regulation 7

[313] UK Statutory Instruments, 2011 No. 2055, Part 1, Regulation 7.

[314] *Id.* at Part 2, Regulation 10.

[315] *Id.* at Part 1, Regulation 7(2)(a).

[316] *Id.* at Part 4, Regulation 61.

[317] Planning Act 2008, 2008 c. 29 §152 (Eng.): Compensation in case where no right to claim in nuisance

(1) This section applies if, by virtue of section 158 or an order granting development consent, there is a defence of statutory authority in civil or criminal proceedings for nuisance in respect of any authorised works.

(2) "Authorised works" are–
   (a) development for which consent is granted by an order granting development consent;
   (b) anything else authorised by an order granting development consent.

(3) A person by whom or on whose behalf any authorised works are carried out must pay compensation to any person whose land is injuriously affected by the carrying out of the works.

(4) A dispute as to whether compensation under subsection (3) is payable, or as to the amount of the compensation, must be referred to the [F1Upper Tribunal].

(5) Subsection (2) of section 10 of the Compulsory Purchase Act 1965 (c. 56) (limitation on compensation) applies to subsection (3) of this section as it applies to that section.

(6) Any rule or principle applied to the construction of section 10 of that Act must be applied to the construction of subsection (3) of this section (with any

injuriously affected" by a public work, developers have said that compensation has been paid from one wind plant to another under this consultation process.[318]

As an example of how the planning process might apply to wind development, we can look to a 2002 case: *Waveney District Council & Next Generation Ltd.*[319] In this case, the district council refused planning permission for Next Generation Ltd to erect a single wind turbine on land. The Next Generation turbine was to be sited within 160 m of a turbine that a competing company, SLP Energy, was planning to erect.[320] Among the concerns raised by the District and SLP, one related to turbulence damage: SLP's warrantee might be invalidated by the close proximity of the proposed Next Genertion turbine. This warrantee would be required for SLP's turbine to be financed.[321] The inspector concluded that the 5 to 10 rotor diameter guidelines should "be treated with caution" as the "advanced technology" of the turbines in question may allow closer spacing.[322]

Second was concern for "energy loss through wind shadowing from upstream machines."[323] The inspector recognized that SLP Energy's turbine might suffer some electricity production losses. However, he took an

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necessary modifications).

(7) Part 1 of the Land Compensation Act 1973 (c. 26) (compensation for depreciation of land value by physical factors caused by use of public works) applies in relation to authorised works as if–
   (a) references in that Part to any public works were to any authorised works;
   (b) references in that Part to the responsible authority were to the person for whose benefit the order granting development consent has effect for the time being;
   (c) sections 1(6) and 17 were omitted.

(8) An order granting development consent may not include provision the effect of which is to remove or modify the application of any of subsections (1) to (7).

[318] Robert Fradley RES 7-8-2019. Although not an offshore project, the following is an example of analysis prepared by RWE npower renewables as the "Applicant's Response to Munich Ergo Asset Management GmbH (MEAG) Claims on Energy Yield" as part of the Application for a Development Consent Order by RWE npower renewables for the Clocaenog Forest wind farm" as part of the Planning Act 2008 Infrastructure Planning (Examination Procedure) Rules 2010. Document reference: PD/RWE/014/response to MEAG energy yield claims (Nov. 2013) (The existing wind plant apparently claimed the proposed wind plant would cause 2.4% loss, while the proposed wind plant claimed the losses would be in the range of 1.4 to 1.6%. The document doesn't discuss compensation (though one might speculate that is the next step after establishing the wake loss %). Thomas Spalton, *Applicant's Response to MUNICH ERGO Asset Management GmbH (MEAG) Claims on Energy Yield,* RWE NPOWER RENEWABLES (2013).

[319] Waveney District Council & Next Generation Ltd. [2003] P.A.D. 36, (Eng.)

[320] *Id.* at 345.

[321] *Id.* at 351-52.

[322] *Id.* at 354.

[323] *Id.* 36, at 354, 351.

interesting holistic approach in refusing to compensate SLP Energy for its losses. The inspector concluded that the added generation from building the competing Next Generation turbine would most likely offset the losses to one particular operator: "The fact that one generator may impact adversely on another, or prevent the efficient operation of both, is in that context of less importance than securing an overall increase in renewable output."[324] This conclusion might be appropriate if wind is considered a communal resource, but might not be supportable in US terrestrial contexts where each wind right is separately owned and the lessee and operator have an obligation to lessors and investors to maximize production from their property without consideration of neighboring properties or a national or global goal of increasing the renewable energy output overall.

Finally, the inspector's opinion referenced national planning guidance in the Annex on Wind Energy to Planning Policy Guidance on Renewable Energy note 22 (PPG22). This guideline creates a sort of prior appropriation or first-in-time right for wind operators that does not exist in the United States. PPG22 says "that where planning permission for a turbine has been implemented, Local Planning Authorities should safeguard the installation as an electricity generation plant by controlling subsequent development which may impair its operation."[325]

Generally, PPG22 might have prevented development of the Next Generation turbine. However, the situation in the *Waveney* case was somewhat unique. Although the SLP Energy generator had been approved first, neither turbine had yet been built. Consequently, the inspector concluded that PPG22 did not apply because "the SLP Energy generator has not yet been constructed, [and] it would be wrong . . . to apply safeguarding in these circumstances because there can be no certainty that any permission for it will necessarily be implemented. In that eventuality, any contribution to renewable energy from either of the Ness Point sites would be foregone."[326]

(ii) Consultation Processes in the North Sea. – Sometimes cooperation is mandated in addition to, or as an alternative to, compensation. Following a political declaration in 2009,[327] the Ministers of the North Sea

[324] *Id.* at 356 (Also noting that "the estimated reduction in electricity generating potential (rather than profit) is not so great that both generators could not be operated together.").

[325] *Id.* at 354.

[326] *Id.* at 356.

[327] N. SEAS COUNTRIES OFFSHORE GRID INITIATIVE, POLITICAL DECLARATION ON THE NORTH SEAS COUNTRIES OFFSHORE GRID INITIATIVE (Dec. 7, 2009), http://www.benelux.int/files/2714/0921/0355/Political-declaration-on-the-North-Seas-Countries-Offshore-Grid-Initiative.pdf.

Countries,[328] established an initiative that recognizes "the crucial role which offshore wind energy is bound to play in order for Europe to meet the EU's 20- 20-20 targets."[329] The initiative further recognized the enormous costs and other barriers to wind energy development[330] and proposed to work collaboratively. Three working groups were created to separate the overarching goal into deliverable objects, including: Working Group 1-grid implementation, Working Group 2- market regulation, and Working Group 3- permissions and planning.[331]

In 2016, the same countries in the North Seas region,[332] signed a new political declaration[333] to reaffirm their commitment to cooperation, effectively calling themselves "The North Seas Energy Cooperation (NSEC)." One key recognition in the forming of this group is "the importance of developing concepts for joint offshore wind investment (pilot) projects at regional and/or sub-regional level, aiming at win-win situations for all participating countries, e.g. by making use of benefits of scale, as key drivers for further concrete cooperation."[334] In a Scoping Paper titled, "North Seas Energy Clusters,"[335] the NSEC outlines "the scope for cost savings and identif[ies] some of the challenges which may arise from the development of concrete coordinated/combined/hybrid projects in four regions in the North Seas area where a coordinated approach appears to have the highest potential."[336] Examples of where the NSEC believes savings and efficiencies can accrue include "the shared use of infrastructure, for example by combining generation, transmission, and interconnection or infrastructure that facilitates their construction" and "coordinated lay-out to facilitate

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[328] *Id.* (referring to Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden, and the United Kingdom).

[329] *Id.*; *see also* Council Directive 2009/28/EC, 2009 O.J. (L 140) 16 (EC) (Apr. 23, 2009).

[330] N. SEAS COUNTRIES OFFSHORE GRID INITIATIVE, *supra* note 327 ("[T]he costs, associated with the development of electricity (inter)connector infrastructure are enormous and various barriers still exist (technical, market, regulatory, and policy). These are shared challenges for all the countries concerned.").

[331] *The North Seas Countries' Offshore Grid Initiative (NSCOGI)* EUROPEAN NETWORK OF TRANSMISSION SYSTEM OPERATORS https://www.entsoe.eu/about/system-development/#the-north-seas-countries-offshore-grid-initiative-nscogi (last visited May 13, 2019).

[332] N. SEAS COUNTRIES OFFSHORE GRID INITIATIVE, *supra* note 327.

[333] N. SEAS ENERGY COOPERATION, POLITICAL DECLARATION ON ENERGY COOPERATION BETWEEN THE NORTH SEAS COUNTRIES, (2016), https://ec.europa.eu/energy/sites/ener/files/documents/Political%20Declaration%20on%20Energy%20Cooperation%20between%20the%20North%20Seas%20Countries%20FINAL.pdf.

[334] *Id.*

[335] N. SEAS ENERGY COOPERATION, NORTH SEAS ENERGY CLUSTERS: SCOPING PAPER (Sept. 2017), https://ec.europa.eu/energy/sites/ener/files/documents/energy-cluster_paper_-_final_with_date.pdf.

[336] *Id.* at 1.

other uses in the neighborhood of projects (ferry routes, recreational shipping)."[337] Initiatives such as these[338] have driven the expansion of the offshore wind industry in Europe through an early recognition of the necessities of Member State cooperation in tackling the impending challenges associated with offshore wind.[339]

Zooming down to the country level, in the United Kingdom, the Crown sometimes includes mandates for cooperation between wind plants in its orders when co-development is allowed. For example, The Infrastructure Planning for the East Anglia THREE Offshore Wind Farm Order 2017 contains this language:

> SCHEDULE 8, PART 6–Protection for East Anglia ONE Offshore Wind Farm
>
> Co-operation 72. Where in consequence of the proposed construction of any of the authorised development, the undertaker [East Anglia THREE Limited] or the statutory undertaker [East Anglia ONE Offshore Wind Farm] requires the removal of apparatus under paragraph 66(2) or a statutory undertaker makes requirements for the protection or alteration of apparatus under paragraph 68 the undertaker must use its best endeavours to co-ordinate the execution of the works in the interests of safety and the efficient and economic execution of the authorised development and taking into account the need to ensure the safe and efficient operation of the statutory undertaker's undertaking and the statutory undertaker must use its best endeavours to co-

[337] *Id.* at 3.

[338] N. SEAS COUNTRIES OFFSHORE GRID INITIATIVE, *supra* note 327; *see* N. SEAS ENERGY COOPERATION, *supra* note 333. *See also The CPMR North Sea Commission*, THE CPMR NORTH SEA COMMISSION, https://cpmr-northsea.org/who-we-are/ (last visited Oct. 4, 2019) ("Our mission is to strengthen partnerships between regional authorities which face the challenges and opportunities presented by the North Sea,").

[339] N. SEAS ENERGY COOPERATION, *supra* note 335. One of the overarching regulatory measures addressing offshore wind energy instituted by the EU is the MSP Directive, which obliges 23 coastal Member States to develop a national maritime spatial plan by March 31, 2021. The MSP places a strong focus on the need for consulting and coordinating their respective plans with relevant Member States. More specifically, Article 11 requires that "as part of the planning and management process, Member States bordering marine waters shall cooperate with the aim of ensuring that maritime spatial plans are coherent and coordinated across the marine region concerned." The Directive also makes an allusion to considering wake effect impacts on current and existing projects: "when establishing maritime spatial planning, Member States shall have due regard to the particularities of the marine regions, relevant existing and future activities and uses and their impacts on the environment, as well as to natural resources, and shall also take into account land-sea interactions." In support of reaching these requirements, an EU MSP Platform is available for Member States to share relevant knowledge and experiences, designed to offer support with the implementation of MSP. Council Directive 2014/89/EU of The European Parliament and of the Council on Establishing a Framework for Maritime Spatial Planning, 2014 O.J. (L 257) 135, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L-.2014.257.01.0135.01.ENG; *See also* European Commission, *Introduction to MSP*, EUROPEAN MSP PLATFORM, https://www.msp-platform.eu/msp-eu/introduction-msp (last visited May 13, 2019).

operate with the undertaker for that purpose.[340]

While this language suggests cooperation for infrastructure development, it may be paving a pathway for cooperation in turbine siting to optimize wind production in a region and to minimize the destructive impact of both turbulence and energy loss waking.

b) United States. – The leasing structure for energy development in US federal waters is competitive in nature, and it incentivizes developers to focus on the maximization of resources within their allotted areas. Because of this, developers may not focus attention on potential adverse effects that their projects have on others.

BOEM's offshore wind development process is governed by the regulations set forth in 30 C.F.R. Part 585.[341] The purpose of these regulations is to "establish procedures for issuance and administration of leases, right-of-way (ROW) grants, and right-of-use and easement (RUE) grants for renewable energy production on the OCS."[342] BOEM must ensure that "renewable energy activities on the OCS and activities involving the alternate use of OCS facilities for energy or marine-related purposes are conducted in a safe and environmentally sound manner, in conformance with the requirements of subsection 8(p) of the OCS Lands Act."[343]

With enough interest from commercial developers and after public comment, BOEM designates some or all of a call area with sufficient potential for wind development as a "wind energy area,"[344] where BOEM can then hold a future lease sale.[345]

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[340] UK Statutory Instruments, 2017 No. 826, sch. 8, ¶¶ 63, 68 (referencing electric lines and electrical plant [¶ 63] and giving the first wind plant development the right to approve any changes [¶ 68]), https://www.legislation.gov.uk/uksi/2017/826/contents/made.

[341] 30 C.F.R. §§ 585.100–585.118 (2019).

[342] *Id.* § 585.101(a).

[343] *Id.* § 585.101(c).

[344] *Id.* §§ 585.204-206.

[345] *Id.* § 585.211(d); Fisheries Survival Fund v. Jewell, 236 F.Supp.3d 332 (D.D.C. 2017) ("The commercial leasing process may be initiated by both solicited and unsolicited applications. A solicited application is one in which BOEM itself identifies the potential development site and initiates the leasing process by publishing a notice of Request for Interest ("RFI") or a Call for Information and Nominations in the Federal Register.); *See id.* §§ 585.210, 585.211(a) . . . An unsolicited application is one in which a potential developer applies for a site not otherwise under consideration by BOEM. *See* 30 C.F.R. § 585.230. Upon receiving an unsolicited request, BOEM publishes an RFI to seek public comment and determine whether there is competitive interest from other developers.); *Id.* § 585.231(b). If there is competitive interest, BOEM proceeds with the competitive process. *Id.* § 585.231(c)(1). Otherwise, it publishes a notice of Determination of No Competitive Interest and follows a separate procedure. *Id.* § 585.231(d)-(i). Regardless

Under subpart B, the competitive lease process for OCS Renewable Energy Leases begins with BOEM publishing "Calls for Information and Nominations" in the Federal Register,[346] where respondents may "request comments on areas which should receive special consideration and analysis"[347] or respondents may "suggest areas to be considered for leasing."[348] BOEM may also identify its own areas for environmental analysis and consideration for leasing.[349]

BOEM then publishes a Proposed Sale Notice for a lease area including the terms and conditions developed though the environmental assessment[350] and stakeholder consultation process.[351] The Proposed Sale Notice has a 60-day comment period during which the interested applicants submit their qualifications to BOEM including evidence that they are eligible to hold a lease and demonstrating their technical and financial capability to conduct the authorized lease area activities.[352]

BOEM then publishes a Final Sale Notice and identifies qualified bidders who must then submit the bid deposit as specified in the Final Sale Notice.[353] An auction is held to identify the winning bidder who is then eligible to pay the balance of its bid and execute the lease with BOEM.[354] The lease does not grant the lessee the right to construct any facilities, but instead grants the right to prepare plans for lease development that must be approved by BOEM in subsequent phases.[355]

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of the procedure adopted in any case, BOEM must consult throughout the leasing process with state task forces, other state and local representatives, and with representatives of Indian Tribes whose interests may be affected.").

[346] 30 C.F.R. § 585.211(a) (2019).

[347] *Id.* § 585.211(a)(1).

[348] *Id.* § 585.211(a)(3). If BOEM determines there is no competitive interest in a requested potential lease area, then after the completion of necessary environmental reviews, BOEM may, if deemed appropriate, begin negotiating the terms of a lease with the interested developer prior to issuing a lease. U.S. DEPT. OF ENERGY, *supra* note 7, at U.S. 36.

[349] *Id.* § 585.211(b).

[350] *Id.* § 585.211(b)(2).

[351] *Id.* § 585.211(b)(3).

[352] *Id.* § 585.211(c).

[353] *Id.* §§ 585.211(d), 585.220(b).

[354] *Id.* § 585.224(a)(3).

[355] *Id.* § 585.235(a)(1); Fisheries Survival Fund, 236 F.Supp.3d at 332 ("Before issuing a lease, BOEM follows a four-step procedure, issuing a Call for Information and Nominations, completing the Area Identification process, publishing a Proposed Sale Notice, and publishing a Final Sale Notice. *Id.* § 585.211(a)-(d). Once BOEM has issued a lease, the lessee must submit a Site Assessment Plan for review before any assessment activity takes place. *Id.* §§ 585.601, 585.605. Even after completing a site assessment, a lessee may not begin construction until it has submitted, and BOEM has approved, a

Subpart F discusses the required "Plans and Information Requirements" that a prospective developer must submit to BOEM subsequent to the awarding of a lease: (1) a Site Assessment Plan (SAP),[356] (2) a Construction and Operations Plan (COP),[357] and (3) a General Activities Plan (GAP).[358]

In the SAP, the developer outlines the methodology and means by which it intends to assess the meteorological and oceanic conditions of the leasing area.[359] The regulations require the SAP to demonstrate that the project "does not unreasonably interfere with other uses of the OCS."[360] Similarly, the SAP must demonstrate that the project will not "cause undue harm to natural resources; life; property; the marine, coastal, or human environment; or sites, structures, or objects of historical or archaeological significance."[361]

While the SAP primarily relates to initial preparations for a site, the COP is the primary document that will control development of an offshore wind plant. For the COP, the applicant must (a) describe all planned facilities that it will construct and use for the project, including onshore and support facilities and all anticipated project easements and (b) describe all proposed activities including proposed construction activities, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities.[362] Because an applicant must receive BOEM approval of the COP before beginning any of the approved activities on the lease, this is the opportunity for BOEM to thoroughly review the

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Construction and Operations Plan. *Id.* § 585.620(c). BOEM can accept, reject, or accept with modifications a lessee's Site Assessment or Construction and Operations Plan, *Id.* §§ 585.613, 585.628, and must analyze the potential environmental impacts of the plans. *See id.* §§ 585.613, 585.620(c).").

[356] Provided here is an example of a submitted and approved SAP; this is included only for reference. Vineyard Wind LLC, "Site Assessment Plan- Lease OCS-A 0501", (Nov. 22, 2017), https://www.boem.gov/Vineyard-Wind-Site-Assessment-Plan-0501/.

[357] Provided here is an example of a recently submitted COP for the same project: Vineyard Wind LLC (Oct. 22, 2018), available at https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Vineyard-Wind/Vineyard-Wind-COP-VolumeII-Combined.pdf (vol. 2), https://www.boem.gov/renewable-energy/state-activities/vineyard-wind-construction-and-operations-plan-volume-iii (vol. 3).

[358] 30 C.F.R. §§ 585.600-585.659 (2019). The GAP is only required for limited leases and grants, whereas the SAP and COP are used for commercial leases. STOEL RIVES, LLP., THE LAW OF WIND: A GUIDE TO BUSINESS AND LEGAL ISSUES, Ch. 4. p. 2 (8th ed. 2018), https://files.stoel.com/files/books/LawofWind.PDF.

[359] "Meteorological" and "oceanic" conditions are referred to collectively as "metocean" conditions. 30 C.F.R. § 585.605(a)(1) (2019).

[360] *Id.* § 585.606(a)(3).

[361] *Id.* § 585.606(a)(4).

[362] Vineyard Wind LLC, *supra* note 357 at § 1.2. Specifically, the COP also requires a (1) Fabrication and Installation Report and a (2) Facility Design Report.

applicant's plans prior to approval.[363]

Section 8(p) of the OCS Lands Act provides some of the criteria BOEM must consider in deciding whether to approve a COP including safety, protection of the environment, and protection of national security interests.[364] Although there is nothing that explicitly gives other parties consent authority or an opportunity to seek compensation for impacts of one wind plant on another, there is an opportunity for public notice and comment,[365] and the Secretary of Interior must both consider the protection of correlative rights in the outer Continental Shelf and prevent waste as well as the interference with reasonable uses.[366]

Similarly the regulations state that for approval of the COP, a developer must demonstrate that the project will address the same responsibilities set out for the SAP: (1) not "unreasonably interfer[ing] with other uses of the OCS"[367] and (2) not "caus[ing] undue harm to natural resources; life; property; the marine, coastal, or human environment; or sites, structures, or objects of historical or archaeological significance."[368] In addition, though, the COP requires the submission of a variety of surveys for the proposed sites of facilities.[369] Yet, the regulations do not explicitly require the COP to include a wake modeling analysis in conjunction with site planning.[370]

Thus, there are at least two stages of the federal planning process that can provide opportunities to incorporate more extensive wake analyses,

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[363] 30 C.F.R. § 585.629(c) (2019).

[364] 43 U.S.C. § 1337(p)(4) (2019) ("Requirements--The Secretary shall ensure that any activity under this subsection is carried out in a manner that provides for--(A) safety;(B) protection of the environment;(C) prevention of waste;(D) conservation of the natural resources of the outer Continental Shelf;(E) coordination with relevant Federal agencies;(F) protection of national security interests of the United States;(G) protection of correlative rights in the outer Continental Shelf;(H) a fair return to the United States for any lease, easement, or right-of-way under this subsection;(I) prevention of interference with reasonable uses (as determined by the Secretary) of the exclusive economic zone, the high seas, and the territorial seas;(J) consideration of--(i) the location of, and any schedule relating to, a lease, easement, or right-of-way for an area of the outer Continental Shelf; and (ii) any other use of the sea or seabed, including use for a fishery, a sealane, a potential site of a deepwater port, or navigation; (K) public notice and comment on any proposal submitted for a lease, easement, or right-of-way under this subsection; and (L) oversight, inspection, research, monitoring, and enforcement relating to a lease, easement, or right-of-way under this subsection.").

[365] *Id.* § 1337(p)(4)(K).

[366] *Id.* §§ 1337(p)(4)(C), (G), (I).

[367] 30 C.F.R. § 585.621(c) (2019).

[368] *Id.* §§ 585.621(a)-(g).

[369] *Id.* § 585.626(a).

[370] 43 U.S.C. § 1337(p)(4) (2019). The author anticipates writing a future article about whether the language in 43 U.S.C. § 1337(p)(4) related to correlative rights and preventing waste might be interpreted as requiring wake studies.

discussion of impacts on and from adjacent projects, and possible compensation schemes to cooperatively develop to optimize generation and minimize the negative impacts of waking. First, wakes can be considered, both internally within a single wind plant and externally from neighboring projects, during the lease delineation and auction stage. BOEM has done this on at least one occasion. NREL conducted a study to assess the offshore leasing areas for the Massachusetts Wind Energy Area,[371] the largest BOEM Wind Energy Area (WEA) under consideration in 2013.[372] The goal was to create lease areas and evaluate the effect of different turbine spacing configurations (8 D x 8 D, 8 D x 12 D, and 8 D x 15 D) on wake losses, energy production, and development challenges.[373]

The Massachusetts WEA has prevailing winds coming from the southwest.[374] Consequently, the NREL study recommended leasing areas with "approximately a 45 degree southwest-to-northeast diagonal to be approximately parallel to the prevailing southwest wind direction . . . . This strategy was developed to minimize potential conflicts between neighboring wind projects and to give the lessees the maximum control over their own area."[375]

Furthermore, the NREL study modeled turbine layouts to address wake loss. In a remote array, one might expect a trend where wider spacing results in lower losses or conversely greater array efficiencies. However, the NREL study showed this trend is not as evident in the presence of multiple wind plants. The difference in efficiencies between scenarios ranged from approximately 89 to 92%.[376] This result suggests that the benefits of additional spacing may have diminishing returns when multiple large arrays are sited near each other.[377] The NREL study also noted that "most developers (especially when responding to the RFI and Call) did not consider that their

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[371] NAT'L RENEWABLE ENERGY LABORATORY, *supra* note 119.

[372] *Id.* The Massachusetts WEA included 3,006.7 km^2 and could accommodate at least ten 500-MW wind projects (5,000 MW) under a phased development scenario using up to five leasing areas.

[373] *Id.* (Because the size of the leasing areas are held constant, the phased development analysis examines the tradeoff between turbine spacing and intra-array buffer zones; as the spacing increases, the size of the buffers gets smaller).

[374] *Id.* at 24.

[375] *Id.* at 25.

[376] *Id.* at 46.

[377] Another study in 2004 modeled an installation of 25 wind plants off the coast of the Netherlands totaling 6 GW of capacity within a 10,000 square kilometer area. By calculating the reduction of wind speed in the given area, Corten concluded that an inter-plant loss of 5-14% was probable. G.P. Corten & A.J. Brand, *Resource Decrease by Large Scale Wind Farming,* EUROPEAN WIND ENERGY CONF. (Nov. 2004), https://www.researchgate.net/publication/228794502-Resource-decrease-by-large-scale-wind-farming.

project would be next to another project and could experience diminished capacity as a result of wakes from those adjacent projects."[378]

Finally, the NREL study assumed "that developers would self-impose an internal setback buffer of 8 [R]D from the delineation line . . . ."[379] Yet, as noted above, the NREL study points out that developers did not consider impacts from adjacent wind plant wakes when responding to the RFI and Call,[380] and there is no evidence in terrestrial situations of an industry norm of wind operators creating 8 RD buffers, or even smaller ones, to protect competitors.

While developers may not have any interest in protecting competitors' wind rights, the NREL study may be correct in suggesting that developers would include a setback for self-protection purposes. Thus, offshore operators may follow a moat mentality, as seen with terrestrial wind, creating buffer zones "anticipating that neighboring developers could feasibly place turbines near the delineation boundary."[381]

Furthermore, in the Massachusetts lease sale, BOEM solicited comments concerning the timing for determining buffers.[382] There was wide disagreement from industry commentators about the timing, with most agreeing that the initial leasing stage was too early.[383]

In addition, or in the alternative, to considering wakes during the leasing stage, BOEM could address wake impacts and compensation schemes in the Construction and Operations Plan (COP), giving competing interests an opportunity to be heard, as with the UK system, and conditioning approval on an agreement between all affected parties or a government-imposed resolution.[384] The BOEM comment solicitation for the Massachusetts lease sale, mentioned above, also polled potential leasees: (1) "regarding the imposition of buffer zones between adjacent leases" and (2) "the appropriate

[378] NAT'L RENEWABLE ENERGY LABORATORY, *supra* note 119 at 45-46.

[379] *Id.* at 40.

[380] *Id.* at 45-46.

[381] *Id.* at 40.

[382] *Response to Comments: Proposed Sale Notice – Massachusetts Lease Sale ATLW-4A*, BOEM, at 1, 4 (Oct. 10, 2018), https://www.boem.gov/MA-ATLW-4A-Responses-to-Comments/.

[383] *Id.* ("Two industry representatives oppose implementing lease buffers during the leasing stage, with one of those representatives asserting that bidders take potential buffers into account in valuing the lease areas–and that the need for actual buffers is difficult to predict at the lease sale stage. The other industry representative argued that buffers are a good idea, but should be implemented later during the plan submittal phase. Two other industry representatives agreed buffers are a good idea and indicated that any buffer areas should not be considered part of the leases, rather considered a "separation zone." One of those representatives stated that any buffer should be identified in the Final Sale Notice (FSN) for additional comment.").

[384] BOEM also has a certified verification process, so wakes might be addressed there.

distance for those buffers."[385] The majority of industry responses were supportive of implementing lease buffers, but they could not agree on the appropriate distance.[386]

Rigid setbacks can be problematic as discussed above. However, setbacks are an issue, and having setback guidance in the regulations beyond just mentions of their impacts or assumptions about self-imposed setbacks could be a starting point for more effectively addressing wake impacts.[387] Having codified rules could give a downwind developer some leverage other than nuisance litigation to begin discussions about the most economically efficient layouts.[388] Alternatively, wake guidelines would be less rigid and time-consuming to create than formal rules.

Whether in the form of a rule or a guideline, some articulated setback would be a valuable starting point for addressing the impacts of wakes. BOEM may be moving in this direction. In its response to the request for comments in the Massachusetts lease sale, BOEM noted:

BOEM recognizes the potential for projects on adjacent leases to significantly affect one another. For example, a project that sites turbines very close to the edge of an adjacent lease area may impose wake, navigation, and other safety effects on a neighboring project. In order to balance the rights of lessees and their neighbors to insure the full enjoyment of their respective leases while preserving lessees' flexibility in designing their projects, BOEM has incorporated a stipulation in the leases barring lessees from proposing turbines within 750 m of adjoining lease boundaries unless both lessees agree to a smaller setback between the turbine and the edge of the lease. This decision eliminates uncertainty regarding when lessees should address setbacks between projects, and clearly identifies the default

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[385] *Id.*

[386] *Id.* ("Five industry representatives were supportive of implementing lease buffers ranging from 100 m to 1,000 m, or based on rotor diameter or turbine tip height.").

[387] There is no mention of "wakes" in the 62 pages of the current COP guidelines, but there is a section addressing setbacks from telecommunications cables and negotiations to address those. *See* U.S. DEPT. OF THE INTERIOR, GUIDELINES FOR INFORMATION REQUIREMENTS FOR A RENEWABLE ENERGY CONSTRUCTION AND OPERATIONS PLAN (2016), https://www.boem.gov/COP-Guidelines/.

[388] NAT'L RENEWABLE ENERGY LABORATORY, *supra* note 119 at 40. The report goes on to say, "This is consistent with NREL's analysis for the Rhode Island/Massachusetts, Maryland, and New Jersey WEAs (Musial et al. 2013a, Musial et al. 2013b, and Musial et al. 2013c)." *See, e.g.*, *id.* This solution is somewhat similar to the "use of waivable wake setbacks" discussed by Troy Rule. Rule recommends that an upwind developer should be required to provide notice and then an option to purchase portions of the upwind site that might impact the downwind developer. RULE, *supra* note 144, at 70.

spacing prior to lease sale (~1,500 m).[389]

This solution is somewhat similar to that used by the Crown Leases although the distance is significantly shorter and will barely address turbulence damage, much less energy loss. While this solution does not go as far as one proposed by Professor Troy Rule that recommends an upwind developer should be required to provide notice, and then the downwind developer would have an option to purchase portions of the upwind site that might impact the downwind energy development,[390] it still could help make calculations for compensating a downwind development straightforward, perhaps creating a formula similar to California's Solar Shade Protection Act.

CONCLUSION

There are many reasons why US offshore wind should be developed in a way that optimizes energy recovery. The wind asset is owned collectively by the American people who would be most served by generating maximum amounts of non-carbon electricity from this resource both for climate reasons and for the highest royalties. There is uniformity of ownership, so consistent, cooperative development is possible in a way it is not with competing owners on land. Finally, a great deal more is known about wakes and their effects than there was at the time many terrestrial wind plants were laid out and developed, and consequently, the industry should be able to learn from prior mistakes.

Yet, given the competitive nature of the US offshore leasing process and the awarding of leases based on the highest bid, there is no incentive for bid winners to give regard to currently developed neighboring projects or other adjacent lease areas that are soon to be awarded. It is in the interest of the bid winners to utilize their lease area to optimize power production for their individual project. Based on this system, developers may not feel inclined to take into account the effect that other projects may have on their system, or vice versa.

Furthermore, there is a general assumption that offshore wind development is going forward in a competitive way and offshore developers are applying the same moat mentality used by terrestrial wind developers to

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[389] BOEM, *supra* note 382. *See also,* Paragraph 5.2, page C-17 of OCS-A 520, 521, 522 (incorporating language setting out a standard 750m setback in these spring 2019 leases), https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Lease-OCS-A-0520.pdf; https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Lease-OCS-A-0521.pdf; https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Lease-OCS-A-0522.pdf

[390] RULE, *supra* note 144, at 70.

provide protection from neighboring plant wakes. This moat mentality approach is not the best. First, the rules of thumb used by developers on land (5 to 10 RD) are most likely not sufficient to fully protect the equipment from turbulence damage and still may result in millions of dollars in lost energy production. In addition, if applied rigidly, a 10 RD setback may unnecessarily put productive acreage out of service. Litigation is not a good remedy for dealing with wakes because of the costs and uncertainty of outcomes. So, it appears that the best opportunity for addressing wake concerns offshore is through the BOEM planning process. Whether at the early leasing stages or formalized in a final COP approval, BOEM should require wake studies, coordination, and compensation of neighboring projects to optimize power production across leases, thus maximizing the benefits to developers and to all US citizens who are the royalty beneficiaries.