Note

Go, Fly a Kite: The Promises (and Perils) of Airborne Wind-Energy Systems*

Introduction

Commercial wind power generation is still, in many ways, an emerging technology. This may sound surprising for a technology that currently generates 4.4% of all energy produced in the United States,[1] but the first commercial wind farm in the United States was built only thirty-five years ago—a fraction of the history of oil and gas, not to mention coal.[2] These few decades have provided little time to develop the laws, regulations, and judicial decisions that define other sectors of the energy industry. We still lack definitive answers to questions of property rights associated with wind generation[3] and its environmental impacts.[4] Already, those questions are evolving, and advances in technology may radically alter the landscape. This Note discusses some of the legal issues that may be implicated by the introduction of a new technology: airborne wind energy.

Airborne wind-energy systems (AWES),[5] though still in their technological infancy, may one day change the commercial wind-energy sector. Scientists estimate that high-altitude winds contain several times the amount of energy needed to meet current global demand.[6] Airborne systems hold the promise of access to that energy. Access to high-altitude wind would be both tremendously valuable and disruptive. As is often the case, though, in the uncertain legal environment that accompanies disruptive technologies, it is unclear just who will benefit from this valuable resource and how.

---

* I would like to dedicate this Note to my wife, Jenn Langley, for her love, patience, and support. I would like to thank Rod E. Wetsel for introducing me to the world of wind law. Anything of value in this Note is a credit to his instruction. The failings are mine alone.

1. *Frequently Asked Questions: What is U.S. Electricity Generation by Energy Source?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3 [http://perma.cc/F8QV-CCW3]. This is more than ten times the percentage produced by solar energy. *See id.* (reporting that solar energy produces 0.4% of the total U.S. energy).

2. DAVID E. NEWTON, WIND ENERGY: A REFERENCE HANDBOOK 327 (2015).

3. *See infra* Part III.

4. *See infra* Part IV.

5. These go by several names, including high-altitude wind-energy systems (HAWES).

6. *See, e.g.*, Cristina L. Archer & Ken Caldeira, *Global Assessment of High-Altitude Wind Power*, 2 ENERGIES 307, 307–08 (2009) (estimating the total wind energy in the jet streams at "100 times the global energy demand"). *But see* L. M. Miller et al., *Jet Stream Wind Power As a Renewable Energy Resource: Little Power, Big Impacts*, 2 EARTH SYST. DYNAMICS 201, 211 (2011) (estimating the "maximum sustainable extraction of kinetic energy" to be 7.5 terawatts (TW)).

Like other modern energy sources, high-altitude wind raises a number of novel and complex legal issues. Taking wind power into the skies raises new issues for this developing industry—sometimes simplifying and sometimes complicating existing challenges. If wind energy is to become a pillar of global energy production, these questions must be addressed, and there is no time like the present.

This Note will sketch out a number of the more significant legal issues airborne systems raise and propose some ways to begin thinking about how to address those issues. Part I contains a concise history of major developments in wind energy and a summary of the current landscape of land-based wind turbines. In Part II, I discuss the reasons for attempting to harness high-altitude wind along with some of the designs available from aspiring commercial AWES providers. Part III introduces the legal landscape, compares and contrasts AWES with existing wind installations, and presents legal frameworks that might be adapted to deal with AWES. Finally, in Part IV I recommend some measures for facilitating the development of high-altitude wind farming.

I. Historical Development of Wind Energy

Wind energy is an abundant and versatile resource. The earliest known human application of wind power was for sailing vessels at around 5,000 B.C.E.[7] Several millennia later, around 200 B.C.E., the Chinese began converting wind energy into mechanical energy to pump water.[8] The Dutch landscape was famously dotted with windmills in the eighteenth century C.E.[9] Within a few decades of harnessing electricity, wind energy was tapped for electrical power generation. As early as 1887, a Scottish professor experimented with wind-turbine designs to power his home.[10]

Less than a century after that early personal experiment, the world's first wind farm was constructed in New Hampshire in 1980. The twenty-turbine farm was tiny by today's standards and a failure by most measures,[11] but despite that failure, wind-turbine technology rapidly accelerated over the following decades.[12] From 1980 to 2003, the capital cost of wind energy was

---

7. *History of Wind Energy*, WIND ENERGY FOUND., http://www.windenergyfoundation.org/about-wind-energy/history [http://perma.cc/HLE5-U788].

8. *Id.*

9. *See* RICHARD C. DORF, TECHNOLOGY, HUMANS, AND SOCIETY: TOWARD A SUSTAINABLE WORLD 287 (2001) ("In 1750, the Netherlands had 8,000 windmills in operation.").

10. Niki Nixon, *Timeline: The History of Wind Power*, GUARDIAN (Oct. 17, 2008, 10:39 AM), http://www.theguardian.com/environment/2008/oct/17/wind-power-renewable-energy [http://perma.cc/N4V2-6PEK].

11. *Id.*

12. *See* ERIC LANTZ ET AL., NAT'L RENEWABLE ENERGY LAB., IEA WIND TASK 26: THE PAST AND FUTURE OF WIND ENERGY 3–4, 4 fig.1 (2012), http://www.ieawind.org/index_page_postings/WP2_task26.pdf [http://perma.cc/MQP5-2BGW] (depicting the rapid decrease in the capital costs

cut by approximately two-thirds,[13] and by the second quarter of 2014, the United States alone had nearly sixty-two gigawatts (GW) of installed wind-energy capacity—enough to power more than 15 million homes.[14] Global installed capacity by the end of 2014 was nearly 370 GW,[15] with projections of up to 2,000 GW installed by 2030.[16] The United States will be contributing more than its fair share of that capacity if it reaches the goal of obtaining 20% of all energy from wind by 2030.[17]

Modern wind turbines function much like their predecessors, albeit with far greater efficiency. A typical wind turbine using current technology sits on a mostly tubular tower made of steel, with blades of fiberglass-reinforced polyester or wood epoxy.[18] Utility-scale wind turbines for surface-based wind farms range from about 50 meters to about 90 meters and sit on top of towers of roughly the same size.[19] Larger towers have a total height from the tower base to rotor tip of approximately 135 meters (442 feet).[20] A 5 MW turbine, operating at full capacity, can produce enough to power more than 1,400 households.[21]

Traditional wind turbines have advanced significantly in recent decades as their economic potential has developed.[22] Despite concerns about the long-term status of federal tax incentives,[23] the future of wind energy looks

---

associated with wind energy from 1980 to 2005 and explaining some of the technological innovations that occurred during that period).

13. *Id.* at 3.

14. *See U.S. Wind Industry Fast Facts*, WIND ENERGY FOUND., http://www.windenergyfoundation.org/about-wind-energy/us-wind-industry-fast-facts [http://perma.cc/NYG2-Z6C4] (indicating that 60 GW would power 14.7 million American homes).

15. GLOB. WIND ENERGY COUNCIL, GLOBAL WIND REPORT: ANNUAL MARKET UPDATE 6 (2014), http://www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf [http://perma.cc/V2TE-RVR2].

16. GLOB. WIND ENERGY COUNCIL, GLOBAL WIND ENERGY OUTLOOK 10 (2014), http://www.gwec.net/wp-content/uploads/2014/10/GWEO2014_WEB.pdf [http://perma.cc/JT43-P9QM].

17. *See* U.S. DEP'T OF ENERGY, WIND VISION: A NEW ERA FOR WIND POWER IN THE UNITED STATES 1–2 (2015) [hereinafter WIND VISION] (assessing the viability of and updating a 2008 report calling for 20% wind energy by 2030).

18. *Wind Web Tutorial: Wind Energy Basics*, AM. WIND ENERGY ASS'N., http://web.archive.org/web/20100923194211/http://www.awea.org/faq/wwt_basics.html [http://perma.cc/7R4R-4Y2S].

19. *Id.*

20. *Id.*

21. *Id.*

22. *See generally* LANTZ ET AL., *supra* note 12, at 4 (detailing technological innovations that enabled the creation of larger wind turbines at lower costs).

23. *See* WIND VISION, *supra* note 17, at 38–39 (explaining that wind development cycles are demonstrably influenced by extensions and expirations of federal tax incentives).

bright.[24] The Obama administration recently announced its goal to have 35% of all energy supplied by wind by 2050.[25]

Nevertheless, there are some significant limitations to the potential of traditional wind farms. First, surface wind is heavily dependent on location. Geographic features, or even manmade obstructions, can interfere with wind, and as with most resources, some areas are wind rich while others are wind poor.[26] This often means that existing grids must be adapted to collect wind energy from sites where that energy is abundant enough to be economically feasible. Energy transmisson from wind-rich areas to the rest of the country depends on an ailing, ever-shrinking, and rapidly obsolescing national electrical grid.[27]

A second, oft-cited limitation on traditional wind energy is intermittency. Just as solar panels are useless at night, wind turbines do not always produce energy. Surface wind has peak hours and off hours.[28] While these may, in many cases, coincide with peak energy consumption, intermittency inherently limits the viability of wind energy as a primary energy source.[29]

A third problem facing traditional wind farms is what I will broadly call interference with other surface activity. This can be in the form of nuisance or environmental impact. Modern wind turbines have a significant footprint.[30] Turbines are up to 450 feet tall and can have blades with a nearly equivalent diameter.[31]

Airborne wind systems offer several advantages over traditional wind turbines in terms of the limitations discussed above. Wind energy has rapidly transitioned in recent years, but the difference between a Dutch windmill circa 1750 and a modern wind turbine pales in comparison to the difference between a land-based wind turbine and an airborne wind-energy system. Airborne systems untether wind power from the ground, allowing energy providers to harness steadier, more robust winds at altitudes of 1,000 meters

24. *See supra* notes 15–16 and accompanying text.

25. David Jackson, *Report: Wind Power Could Be 35% of Supply by 2050*, USA TODAY (Mar. 12, 2015, 10:10 AM), http://www.usatoday.com/story/news/nation/2015/03/12/obama-wind-power-report-energy-department/70160824/ [http://perma.cc/G7KN-7EQA].

26. *See* ERICH HAU, WIND TURBINES: FUNDAMENTALS, TECHNOLOGIES, APPLICATION, ECONOMICS 508 (Horst von Renouard trans., 3d ed. 2013) (describing the factors that cause wind variability globally and explaining why certain areas have more wind than others).

27. *See generally* Chris Martin et al., *Why the U.S. Power Grid's Days Are Numbered*, BLOOMBERG BUSINESSWEEK (Aug. 22, 2013), http://www.businessweek.com/articles/2013-08-22/homegrown-green-energy-is-making-power-utilities-irrelevant [http://perma.cc/KER7-9ZQ6].

28. *See* Cristina L. Archer & Mark Z. Jacobson, *Evaluation of Global Wind Power*, 110 J. GEOPHYSICAL RES., no. D12110, at 10 (2005) (noting a difference in average wind speeds between day and night). However, at an altitude of 80 m, the variations have been described as "sligh[t]." *Id.*

29. *Id.* at 1.

30. *See Wind Web Tutorial: Wind Energy Basics*, *supra* note 18 (explaining that modern wind turbines have "rotor diameters ranging from about 50 meters to about 90 meters").

31. *Id.*

or higher.[32] The next Part of this Note sketches some of the more popular designs for airborne wind and lists some of the advantages and drawbacks of each.

II. Airborne Wind Energy

AWES come in a variety of forms, from kites to balloons to free-floating aircraft. The common element may be what each system lacks. AWES are not mounted on a fixed structure. Instead, as the name suggests, an airborne system, or at least some part of it, is suspended in the air and attached to the ground—in most cases—with one or more tethers. Airborne systems capture wind energy from higher altitudes, taking advantage of the accompanying increase in wind power.

For those unfamiliar with this technology, a brief description of some popular airborne-turbine designs may provide some useful background. Airborne wind systems come in many varieties, but for simplicity, they can be placed into two broad categories: those that carry turbines onboard and those that utilize high-altitude winds to power ground-based turbines.[33] Onboard energy systems can be further subdivided into helium-filled and winged varieties.[34] This is not meant to be an exhaustive list. As with any nascent technology, the future may hold thus far unimagined variants in store. For present purposes, however, these categories will suffice. Examples of each type are given below, accompanied by some of the relevant advantages and drawbacks of each.

Altaeros Energies' Buoyant Airborne Turbine (BAT) may be the most recognizable of the onboard, helium-filled systems, especially after its recent feature in the magazine *Popular Science*.[35] The BAT is essentially a tube-shaped blimp with a fan inside.[36] Since the generator is onboard, the BAT's tethers both secure the inflatable and transmit electricity to the ground.[37] The

32. Archer & Caldeira, *supra* note 6, at 308.

33. Brian MacCleery, *The Advent of Airborne Wind Power*, WIND SYSTEMS, Jan. 2011, at 24, 30.

34. *See Airborne Wind Energy Devices*, ALTERNATIVE ENERGY TUTORIALS, http://www.alternative-energy-tutorials.com/energy-articles/airborne-wind-energy.html [http://perma.cc/YR4U-AWD4] (discussing the general types of airborne onboard energy generators and noting that there are types that resemble planes and others that are helium filled).

35. Erik Sofge, *The Quest to Harness Wind Energy at 2,000 Feet*, POPULAR SCI. (Oct. 6, 2014), http://www.popsci.com/article/science/quest-harness-wind-energy-2000-feet [http://perma.cc/7K4X-MBW8].

36. Press Release, Altaeros Energies, Altaeros Energies Achieves Breakthrough in High Altitude Wind Power (Mar. 27, 2012), http://www.altaerosenergies.com/pressrelease_2012_03.html [http://perma.cc/4TN9-Q4Z5] ("The lifting technology is adapted from aerostats, industrial cousins of passenger blimps that for decades have lifted heavy communications and radar equipment into the air for long periods of time. Aerostats are rated to survive hurricane-level winds and have safety features that ensure a slow descent to the ground.").

37. *Id.*

BAT can take advantage of winds at heights of 500 feet and higher.[38] The company initially intends to target the $17 billion remote power and micro-grid market with customers including "remote and island communities; oil & gas, mining, agriculture, and telecommunication firms; disaster relief organizations; and military bases."[39]

Technology powerhouse Google recently acquired a company named Makani,[40] which is developing a kite-based onboard system.[41] Like the BAT, Makani's energy kite generates electricity onboard and transmits it to a ground station via tether.[42] Unlike the BAT, Makani's kite does not hover passively; instead it "simulates the tip of a wind turbine blade" by flying in wide circles.[43] The 600 kilowatt version of the energy kite operates at altitudes ranging from 140 to 310 meters.[44]

KiteGen's "tethered airfoil" system is an example of a kite-style ground-based system.[45] The airfoil attaches a giant wing to a rotating arm (or track-mounted steering unit in the case of the Carousel design) connected to a generator on the ground.[46] As the kite pulls the arm or steering unit in a circle, the mechanical energy of rotation is converted to electrical energy in the generator.[47] The airfoil in KiteGen's system maintains a consistently higher altitude, has no onboard rotors, and does not use a conductive tether, all of which cut down on wind noise.[48] Mechanical noise is also likely to be

---

38. Press Release, Altaeros Energies, Altaeros Energies Poised to Break World Record with Alaska High Altitude Wind Turbine (Mar. 21, 2014), http://www.altaerosenergies.com/pressrelease_2014_03.html [http://perma.cc/YA5W-3DHF] ("Altaeros successfully tested a BAT prototype in 45 mph winds and at a height of 500 feet at its test site in Maine.").

39. *Id.*

40. *About Us*, MAKANI, http://www.google.com/makani/about/ [http://perma.cc/7HNR-72Y5].

41. *The Technology*, MAKANI, http://www.google.com/makani/technology/ [http://perma.cc/G4QT-453T].

42. *Id.*

43. *Id.*

44. *Id.*

45. *Details*, KITEGEN RES., http://www.kitegen.com/en/technology/details/ [http://perma.cc/5B76-AEJL].

46. *KiteGen STEM*, KITEGEN RES., http://www.kitegen.com/en/products/stem/ [http://perma.cc/9UFS-AC5L] (describing the rotating arm system); *KiteGen Carousel*, KITEGEN RES., http://www.kitegen.com/en/products/kite-gen-carousel/ [http://perma.cc/7HT4-PJGE] (describing the Carousel design).

47. Massimo Canale et al., *Power Kites for Wind Energy Generation: Fast Predictive Control of Tethered Airfoils*, IEEE CONTROL SYSTEMS MAGAZINE, Dec. 2007, at 25, 26.

48. *See* HAU, *supra* note 26, at 616 ("In many wind turbines . . . the aerodynamic noise is drowned out by mechanical noise sources."); Mike Barnard, *Airborne Wind Energy: It's All Platypuses Instead of Cheetahs*, CLEANTECHNICA (Mar. 3, 2014), http://cleantechnica.com/2014/03/03/airborne-wind-energy-platypuses-instead-cheetahs/ [http://perma.cc/32ZY-XHPN] (listing increased "tether noise" as one of the downsides to using a conductive tether in an airborne wind-energy system).

reduced with a generator on the ground rather than suspended on top of a tower.[49]

The recent proliferation and future plans of wind farms will require relatively rapid developments in regulation.[50] Ground-based wind farms raise a number of environmental and legal issues with which courts are beginning to grapple.[51] These issues involve both state and federal law, especially when it comes to offshore wind farms.[52] Much has been written, and continues to be written, about the developing regulatory framework of the wind-energy industry.[53] Airborne wind is among the newest and perhaps least developed areas of the wind industry, but development in this area, including the involvement of massive corporations like Google, shows "the huge stimulus for creative engineering which has arisen from . . . the establishment of wind energy technology in the power industry."[54]

Unfortunately, this may not leave legislatures or courts the luxury of time to address a number of the more intricate questions facing them before this new development alters the energy landscape. This Note addresses some of the challenges unique to AWES. For example, whereas ground-based systems have just begun to reach into navigable airspace, AWES can encroach well into portions of the sky typically reserved for air traffic.[55] Additionally, as landowners discover the potential for harvesting wind energy high above their property, they might well assert the priority of their right to use that airspace in connection with the land.[56] This is to say nothing of environmental questions.

The remainder of this Note lays out some of the more pressing issues that will face stakeholders when the first commercially viable AWES take flight in the (very) near future.[57] It is also intended to encourage lawmakers

---

49. *See* HAU, s*upra* note 26, at 616 (noting that "[a] hollow steel tower or the steel walls of the nacelle are just about the ideal resonating bodies").

50. *See generally* Elizabeth Burleson, *Wind Power, National Security, and Sound Energy Policy*, 17 PENN ST. ENVTL. L. REV. 137 (2009) (discussing the relationship between wind-generated electricity and energy policy, including the need for national renewable-energy standards).

51. *See, e.g.*, Stephen Harland Butler, *Headwinds to a Clean Energy Future: Nuisance Suits Against Wind Energy Projects in the United States*, 97 CALIF. L. REV. 1337, 1341–42 (2009) (discussing recent nuisance suits against wind-energy projects).

52. Adam M. Dinnell & Adam J. Russ, *The Legal Hurdles to Developing Wind Power as an Alternative Energy Source in the United States: Creative and Comparative Solutions*, 27 NW. J. INT'L L. & BUS. 535, 545–47 (2007).

53. *See, e.g.*, Burleson, *supra* note 50, at 137–38 (describing the interrelationships and challenges "between wind-generated electricity, national security, and sound energy policy").

54. *See* EUROPEAN WIND ENERGY ASS'N, WIND ENERGY—THE FACTS 91–92 (2009) (describing innovative new system concepts for wind power generation).

55. *See infra* Part III.

56. *See infra* subpart III(A).

57. *See* Katherine Tweed, *World's Highest Wind Turbine Will Hover Above Alaska*, IEEE SPECTRUM (Mar. 25, 2014, 7:48 PM), http://spectrum.ieee.org/energywise/energy/renewables/first-

to address these issues proactively. While AWES designers have faced numerous technical and other challenges on the road to viability, their continued progress, when combined with the untapped potential of high-altitude winds, suggests that full-scale, commercial AWES deployment will be upon us in years rather than decades. The public would be well served by having a thoughtful regulatory framework in place when that time arrives.

III. To the Heavens: AWES and Property

Who owns the sky? Ownership is a fraught concept. First-year law students are often taught to think of property ownership as a bundle of rights.[58] Ownership of land or chattel, while not without its complications and idiosyncrasies, is largely familiar. Most aspects of one's ordinary understanding of ownership can be imported into legal studies. Ownership of intangibles like ideas can be more difficult to grasp. Ownership of wind energy may lie somewhere in-between. While wind can be felt and its effects can be seen, it is not something that can easily be captured or counted. Wind is often associated with freedom, but when wind is harnessed its value ensures that potential beneficiaries will want to establish their rights to it.

Wind may be thought of as transient energy merely passing through the sky. Thus, the question of who owns the wind is tied to who owns the sky. One preliminary complication to any discussion of ownership of the sky is that the sky is a different thing to different people. To a builder, it may represent the space that a building will occupy; to a homebuyer, the scenic backdrop to a dream home; to a pilot, a flight path; and to a wind-farm developer, a vast untapped resource. The obvious problem is that a single portion of sky cannot be all of those things at once. A skyscraper will interfere with flights. A wind turbine will mar the view. The question then is: who can claim which rights when it comes to the sky? The fact that most encounters with this question have arisen in the context of infringement from aviation upon rights associated with the land[59] complicates any attempt to answer this question.

A. Ad Coelum *and the* Causby *Decision*

We begin with the basics: the right to physically occupy the space above the ground. The issue of who owns the sky above (and the earth below) the surface of a piece of property is not a new one. The classic doctrine in this

commercial-floating-wind-turbine-hovers-above-alaska [http://perma.cc/3H3U-N6EF] (reporting on a scheduled Altaeros eighteen-month Alaskan test).

58. *See, e.g.*, *Property*, BLACK'S LAW DICTIONARY (10th ed. 2014) ("It is common to describe property as a 'bundle of rights.'").

59. *See, e.g.*, United States v. Causby, 328 U.S. 256, 266 (1946) (holding that flights over private land do not constitute a taking unless they "interfere with the enjoyment and use of the land"); Andrews v. United States, 108 Fed. Cl. 150, 158–61 (Fed. Cl. 2012) (dismissing plaintiff's claim that Navy Fighter Jets flying directly over plaintiff's property constituted a taking).

area takes its name from a Latin phrase, "*Cujus est solum, ejus est usque ad coelum*," which means "whoever has the land possesses all the space upwards to an indefinite extent."[60] The *ad coelum* doctrine,[61] as it is commonly called, is believed to have originated in either Roman or Hebraic law.[62] It theoretically affirms a cone of ownership that would extend from the center of the earth to the edge of the universe.[63] The *ad coelum* doctrine recognizes the common sense notion that an ownership right that approximates a two-dimensional plane would be of little use. It is difficult to imagine a use for property that does not extend either above or below the soil. The virtually infinite vertical extension of property rights must have seemed a prudent way to preempt disputes about the boundaries of ownership, although it was not literally enforced.[64] Of course, before the advent of flight, perhaps no one imagined the scenario in which one would need to test the upper boundary of ownership.

The ubiquity of flight in the mid-twentieth century put the *ad coelum* doctrine to the test. As mankind's mechanical birds descended from the heavens, they brought with them the upper boundary of property rights. The paradigm case of planes versus property owners is *United States v. Causby*.[65] First-year property students likely remember this case more for its kamikaze chickens than its legal analysis. The landowners in *Causby* brought suit against the federal government because of the alleged taking of airspace over their farm.[66] Planes from a neighboring airbase regularly flew over the farm at low altitudes.[67] The sound of aircraft skimming just over the treetops near the farm and the bright lights from the planes frightened the Causbys' chickens so much that they flew into the walls of their coops in a fatal, failed attempt at escape.[68] The landowners fared better, but the lack of sleep and the deaths of around 150 chickens took their toll.[69] In fact, the frequent flights were so disruptive, they argued, that the farm no longer served its original

---

60. 2 WILLIAM BLACKSTONE, COMMENTARIES *18.

61. "*Ad coelum*," as the Latin suggests, applies to questions of ownership regarding airspace, whereas "*ad inferos*" would apply to areas such as subsurface mineral rights. *Ad coelum doctrine*, BLACK'S LAW DICTIONARY (10th ed. 2014); *ad inferos*, BLACK'S LAW DICTIONARY (10th ed. 2014).

62. Michael M. Bernard, *Transformation of Property Rights in the "Space Age,"* AIR & SPACE L., Spring 1993, at 6, 6.

63. K.K. DuVivier, *Animal, Vegetable, Mineral—Wind? The Severed Wind Power Rights Conundrum*, 49 WASHBURN L.J. 69, 76 (2009).

64. Troy A. Rule, *Property Rights and Modern Energy*, 20 GEO. MASON L. REV. 803, 806 (2013).

65. 328 U.S. 256 (1946).

66. *Id.* at 258.

67. *Id.*

68. *Id.* at 259.

69. *Id.*

purpose.[70] They claimed that the government's activity thus constituted a taking.[71]

For present purposes, the holding of *Causby* is less important than the reasoning—and lack thereof—provided in the case. The Supreme Court eventually held that the government's activity imposed a servitude on the land below and remanded the case for a determination of the extent of the taking.[72] Both the majority and the dissent, despite not espousing a particular theory of airspace ownership,[73] set the stage for future conflicts between pilots and property owners.

The Supreme Court began its analysis by declaring that the ancient *ad coelum* doctrine "ha[d] no place in the modern world."[74] The Court noted, without question, that Congress had declared the air to be a "public highway."[75] To recognize trespass claims on the basis of overflight "would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim."[76]

The Court qualified those statements by recognizing that "it is obvious that if the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere."[77] Without that exclusive control, the land would be of little use to its owner. Hinting at a more extensive right, the Court stated that "[t]he landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land."[78]

In his dissenting opinion, Justice Black disagreed with even this minor concession.[79] Justice Black found it "inconceivable . . . that the Constitution guarantees that the airspace of this Nation needed for air navigation is owned by the particular persons who happen to own the land beneath to the same degree as they own the surface below."[80] He contended, saying that "the Constitution entrusts Congress with full power to control all navigable airspace" under the Commerce Clause.[81] And Justice Black noted that

---

70. *Id.*

71. *Id.* at 258.

72. *Id.* at 267–68.

73. *See id.* at 266 (explaining why the court declined to impose precise limitations on airspace); *id.* at 271–72 (Black, J., dissenting) (discussing at length the power of Congress to control airspace without defining a theory of airspace ownership).

74. *Id.* at 260–61 (majority opinion).

75. *Id.* at 261.

76. *Id.*

77. *Id.* at 264.

78. *Id.*

79. *Id.* at 268–71 (Black, J., dissenting).

80. *Id.* at 271.

81. *Id.* at 271–72.

Congress had laid claim to that power.[82] From his perspective, the fact that "Congress thus declared that the air is free, not subject to private ownership, and not subject to delimitation by the courts" was a settled matter.[83]

It is perhaps unsurprising that a mid-twentieth century Supreme Court took the opportunity presented in *Causby* to reconsider the ancient *ad coelum* principle. Historically, most activity associated with land took place on the surface, whether it be farming or travel or merely going about one's day-to-day business. However, since nothing takes place on a true two-dimensional plane, the use of the land requires the use of space above the land.[84] Then once people began to use airspace regularly, the value of the air above a piece of property arguably became more valuable to those who traveled through it than to those who lived under it. The *ad coelum* doctrine no longer made sense in its strictest form.

Both before the decision in *Causby* and since, courts have introduced but not settled upon various principles of superadjacent-airspace ownership. This may be because few outside of major cities have been able to "occupy or use" enough airspace to interfere with most air traffic, but that may be about to change. So, what happens when landowners can benefit from the use of the wind thousands of feet above their properties?

At least one commentator has recognized six distinct approaches courts have applied to cases in this area.[85] While each of those principles has been applied at least once, none has been adopted as a definitive approach. The first principle is just the classic *ad coelum* principle.[86] The next theory also recognizes the surface owner's property rights to her airspace but subjects that right to a public easement.[87] A third, tort-based approach provides a cause of action only when a presupposed privilege for overflight has been abused or exceeded.[88] Two more theories fall under what may be termed "zone" approaches. The first of these zone theories, the "fixed height" theory, divides airspace into private and public zones, typically marked by the Congressional definition of "navigable airspace."[89] The second zone theory fixes the height of a landowner's airspace on a case-by-case basis depending on the property's use.[90] Finally, at least one decision limited the landowner's airspace to that which was actually occupied, thereby limiting

---

82. *Id.* at 272.

83. *Id.*

84. And below the land (e.g., planting crops).

85. Colin Cahoon, *Low Altitude Airspace: A Property Rights No-Man's Land*, 56 J. AIR L. & COM. 157, 163–66 (1990).

86. *Id.* at 163.

87. *Id.* at 164.

88. *Id.* at 164–65.

89. *Id.* at 165.

90. *Id.* at 165–66.

claims to those involving actual physical damage.[91] Several of these theories were in play prior to the Court's decision in *Causby*, leaving landowners and aviators in a state of confusion.[92]

Unfortunately, *Causby* did not eliminate the confusion entirely. The Court left several theories in play. In fact, it seemed to draw from virtually all theories in its analysis.[93] One possible interpretation of the decision is a partial restoration of the *ad coelum* principle. If navigable airspace is suddenly valuable to surface owners, perhaps their presumed right to that airspace should be restored. This might not apply exclusively to landowners who actually intend to install an AWES. The issue on this theory is what the landowner *can* put to valuable use, not what she actually uses. After all, one should not be allowed to build a bridge just a few feet over a neighbor's property on the theory that the neighbor has not yet made use of the space directly above the land.[94]

Another possibility is to focus on the phrase "in connection with the land."[95] This might entail something like a zone theory. Perhaps an analogy would help here. The relationship between one's land and the airspace above one's land can be likened to the relationship between the ocean and a beachfront property. Ownership of land adjacent to the ocean comes with certain rights to use the water in connection with the land. Those rights do not, however, extend indefinitely. International shipping traffic in the Pacific does not have to seek permission to cross in front of the beachfront property of wealthy Angeleños. In the same way, airspace that can be used in connection with the land might extend only a certain distance.

So, what happens to the remaining airspace? Extending the analogy a bit, the airspace above but not "connected" to the land might be treated as a public trust resource.[96] That approach would resemble the approach currently taken with deep offshore wind projects.[97] Many of the same concerns arise with high-altitude wind projects. The similarities and differences between offshore and airborne wind systems are the subjects of the next subpart.

91. *Id.* at 166.

92. *Id.* at 166–67.

93. *Id.* at 170.

94. *See* United States v. Causby, 328 U.S. 256, 264–65 (1946) (explaining that encroachment into the airspace directly above land may constitute an invasion because landowners have incidental property rights to the airspace over their property).

95. *Id.* at 264.

96. For a discussion of the relationship between the public trust doctrine and renewable energy, see Alexandra B. Klass, *Renewable Energy and the Public Trust Doctrine*, 45 U.C. DAVIS L. REV. 1021, 1023–24 (2012) (contrasting renewable-energy projects with other development projects based on the fact that the former are intended to favorably impact public trust resources).

97. *See id.* at 1051–58 (noting that offshore wind projects can increase public trust resources and analyzing the Massachusetts Supreme Court's opinions regarding an offshore wind project in Massachusetts).

While both systems are in their infancy, some of the progress that has been made in offshore wind as well as the resistance encountered by those projects can provide insight into the potential future of AWES.

B. Navigable Waterways and Flight Paths

The federal government, as the dissent noted in *Causby*, has long held near absolute sway over navigable waterways.[98] This power stems from the Commerce Clause, which gives Congress the power to regulate "[c]ommerce . . . among the several States."[99] As early as 1824, the Supreme Court held that this power extended to navigable waterways insofar as these were the original interstate highways, essential to early commerce.[100] In several decisions over the years, the Court has held that this power trumps the riparian owner's limited title to land beyond the high-water mark.

Of course, such a sweeping grant of authority was bound to run up against the rights of riparian owners who also depended on navigable waterways. In *Scranton v. Wheeler*,[101] a government-constructed pier cut off a riparian owner's access to deep water.[102] The owner sued under the Fifth Amendment, arguing that the government's action constituted a "taking."[103] The Court responded with the following reasoning:

> Whatever the nature of the interest of a riparian owner in the submerged lands in front of his upland bordering on a public navigable water, his title is not as full and complete as his title to fast land which has no direct connection with the navigation of such water. It is a qualified title, a bare technical title, not at his absolute disposal, as is his upland, but to be held at all times subordinate to such use of the submerged lands and of the waters flowing over them as may be consistent with or demanded by the public right of navigation.[104]

In terms of federal preemption over navigable waterways, the Court has addressed the renewable-energy context more than once. In *United States v. Chandler-Dunbar Water Power Co.*,[105] a more tangential ruling, the Court held that the potential value of hydroelectric power generation did not warrant more money for property acquired via eminent domain in an outlet of Lake Superior.[106]

---

98. *See Causby*, 328 U.S. at 272 (Black, J., dissenting) (mentioning Congress's plenary power over navigable waters).

99. U.S. CONST. art. I, § 8, cl. 3.

100. Gibbons v. Ogden, 22 U.S. (9 Wheat.) 1, 197 (1824).

101. 179 U.S. 141 (1900).

102. *Id.* at 143.

103. *Id.* at 147.

104. *Id.* at 163.

105. 229 U.S. 53 (1913).

106. *Id.* at 75–76.

> This title of the owner of fast land upon the shore of a navigable river to the bed of the river, is at best a qualified one. It is a title which inheres in the ownership of the shore and, unless reserved or excluded by implication, passed with it as a shadow follows a substance, although capable of distinct ownership. It is subordinate to the public right of navigation, and however helpful in protecting the owner against the acts of third parties, is of no avail against the exercise of the great and absolute power of Congress over the improvement of navigable rivers. . . . If, in the judgment of Congress, the use of the bottom of the river is proper for the purpose of placing therein structures in aid of navigation, it is not thereby taking private property for a public use, for the owner's title was in its very nature subject to that use in the interest of public navigation. . . . So, also, it may permit the construction and maintenance of tunnels under or bridges over the river, and may require the removal of every such structure placed there with or without its license, the element of contract out of the way, which it shall require to be removed or altered as an obstruction to navigation.[107]

Navigable airspace may seem comparable to navigable waterways in several respects. First, title to navigable airspace is, at best, a qualified title. The ordinary uses to which land is put do not impinge on navigable airspace. Second, navigable airspace is essential to interstate commerce in much the same way as navigable waterways have been and continue to be. People and packages constantly crisscross the skies. However, navigable airspace is different from navigable waterways in some important respects as well.

First, navigable airspace does not have a clear demarcation analogous to the high-water mark used to define the boundaries of waterways. *Causby* and cases like it have dealt with low-flying planes in the vicinity of airports, but the average cruising altitude of a commercial jetliner is over 30,000 feet above sea level.[108] The typical standard used for demarcating navigable airspace is the Minimum Safe Altitude (MSA) set by the Federal Aviation Administration (FAA).[109] Of course, the MSA guidelines reference distance from "any person, vessel, vehicle, or structure."[110]

Another important difference is the sheer size of navigable airspace. The United States contains approximately 12,000 miles of commercially navigable channels.[111] In contrast, the navigable airspace includes everything

---

107. *Id.* at 62–63.

108. Monica Wachman, *What is the Altitude of a Plane in Flight?*, USA TODAY, http://traveltips.usatoday.com/altitude-plane-flight-100359.html [http://perma.cc/5Z6A-458C].

109. *See* United States v. Causby, 328 U.S. 256, 260 (1946) (referring to the standards set by the Civil Aeronautics Board, the predecessor to the FAA).

110. 14 C.F.R. § 91.119(c) (2015).

111. U.S. MAR. ADMIN. ET AL., WATERWAYS: WORKING FOR AMERICA 1, http://www.marad.dot.gov/documents/water_works_REV.pdf [http://perma.cc/8CHT-78CQ].

above the approximately 3.7 million square miles of total land area.[112] It is not clear exactly what the legal or policy implications of this difference might be. Certainly, regularly traveled flight paths would take precedent. In addition, the continued expansion of the country's aviation network in the form of new airports would necessitate future invasion of airspace at and below the heights of airborne systems. Finally, airborne systems run the risk of interfering with outmoded military radar installations.[113] Traditional wind farms, too, have encountered resistance from the military.[114] Airborne systems, with their incursion into navigable airspace, may pose a greater threat of interference. That threat may counterbalance the wider range of viable locations for high-altitude wind systems.

In light of the relevant differences between airspace and navigable waterways, a modified zone theory seems like a reasonable compromise. A fully developed theory of this sort is beyond the scope of this Note. The basic idea, though, would be to open up some portion of the airspace between 500 feet and the cruising altitude of commercial aircraft. Of course, approach paths for existing commercial air traffic would need to be protected. Since most busy commercial airports are in or near cities, plenty of rural space would be left for AWES deployment. The FAA's ubiquitous involvement in the regulation of navigable airspace may make the agency uniquely suited to creating and instituting a national plan.

The extensive space available to air traffic would mitigate any cost associated with recognizing a landowner's rights to a portion of the airspace between 500 feet and the cruising altitude of commercial aircraft. Acknowledging the value associated with that airspace would encourage investment in and use of this valuable resource. Of course, not everyone would likely be thrilled with an increase in investment in wind energy.

IV. Interference: Environmental and Other Impacts

The development of commercial wind energy, often in the form of wind farms, has resulted in an uneasy tension within the environmentalist community. Increased investment in renewable energy may be motivated in large part by environmental concerns associated with the burning of fossil fuels and other nonrenewable resources.[115] Yet renewable projects are not without

---

112. *State Area Measurements and Internal Point Coordinates*, U.S. CENSUS BUREAU, https://www.census.gov/geo/reference/state-area.html [https://perma.cc/NF6N-46MG].

113. *See* Rule, *supra* note 64, at 829–30 (discussing the FAA's decision to exercise its regulatory power to prevent wind-energy development out of concern for potential interference with outmoded military radar systems).

114. *Id.*

115. *See, e.g.*, U.S. ENVTL. PROT. AGENCY, ASSESSING THE MULTIPLE BENEFITS OF CLEAN ENERGY: A RESOURCE FOR STATES § 1.1.3, at 5–6 (2011), http://epa.gov/statelocalclimate/documents/pdf/epa_assessing_benefits.pdf [http://perma.cc/B4DG-4TSB] (addressing the environmental and health concerns associated with fossil-fuel-based electricity).

environmental impact. Traditional wind projects often face resistance from environmentalists and may even run afoul of federal environmental regulation.[116] AWES may have less of a negative environmental impact than traditional wind farms.[117] The three most prevalent impacts of existing wind farms are noise pollution, visual interference, and impact on wildlife.[118]

A. Noise Pollution

Noise pollution and visual interference have given rise to frequent, if typically unsuccessful, nuisance suits from the neighbors of wind projects of all sizes.[119] The noise from a neighboring wind turbine 300 meters away may average between thirty and forty decibels.[120] This means that a nearby wind turbine may typically be as loud as a refrigerator or window air-conditioning unit and occasionally as loud as a vacuum cleaner if it is closer.[121]

Airborne turbines can reduce some of the environmental impacts of wind power generation. First, consider turbine noise. Each of the several types of AWES lessens the noise pollution associated with existing surface turbines.

First, and perhaps most significant, are the kite-based systems. Consider, for example, the Makani kite system.[122] There, a large kite "simulates the tip of a wind turbine blade."[123] The kite is launched from the ground via the rotors like a helicopter.[124] Once in the air, the kite flies in circles while "air moving across the rotors forces them to rotate, driving a generator to produce electricity," which is transmitted to the ground station by a conductive tether.[125] In the Makani case, the movement of the kite

---

116. *See* Dinnell & Russ, *supra* note 52, at 535 (discussing "how parties have used current domestic environmental laws to curb the development of . . . wind power").

117. This Part contains only a sample of the wide range of potential environmental impacts of wind-power development for the purpose of illustrating some of the possible advantages of AWES. Depending on the project, both ground-based and airborne projects may interact with other laws or regulations not discussed here. For example, if federal funding is involved, the National Environmental Policy Act would require environmental impact studies. 42 U.S.C. § 4332 (2012).

118. R. Saidur et al., *Environmental Impact of Wind Energy*, 15 RENEWABLE & SUSTAINABLE ENERGY REV. 2423, 2426 (2011).

119. *See, e.g.*, Dinnell & Russ, *supra* note 52, at 545–55 (recounting the challenges of the Cape Wind project); Dwight H. Merriam, *Regulating Backyard Wind Turbines*, 10 VT. J. ENVTL. L. 291, 302–03 (2009) (discussing the pros and cons of residential wind-turbine installation).

120. Saidur et al., *supra* note 118, at 2428.

121. Tomas Kellner, *How Loud is a Wind Turbine?*, GE REPORTS (Aug. 2, 2014), http://www.gereports.com/post/92442325225/how-loud-is-a-wind-turbine [http://perma.cc/P3BS-F6FZ].

122. *Energy Kites*, MAKANI, http://www.google.com/makani [http://perma.cc/2UN2-3R5F].

123. *The Technology*, *supra* note 41.

124. *Id.*

125. *Id.*

substitutes for large rotors, thereby potentially reducing mechanical noise.[126] In addition, the rotors and generators are rarely below 100 meters and spend most of their arc above 200 meters,[127] increasing the distance between the source of the noise and the potential hearer.

Perhaps better still is a model like that of KiteGen Research.[128] KiteGen's "tethered airfoil" system, recall, attaches a giant wing to a rotating arm on a ground-based generator.[129] The airfoil in KiteGen's system maintains a consistently higher altitude, has no onboard rotors, and does not use a conductive tether,[130] all of which could cut down on wind-related noise. Mechanical noise is also likely to be reduced with a generator on the ground rather than suspended on top of a tower.[131]

Other AWES designs, such as Altaeros's BAT, may reduce noise pollution as well.[132] The BAT is designed to capture wind at altitudes of over 300 meters.[133] The BAT, like the Makani kite, has an airborne turbine and conductive tethers, but its turbine maintains a more consistent altitude.[134] Thus, the BAT keeps potential rotor and mechanical noise farther away than do existing surface turbines. The BAT also uses a smaller turbine than those on conventional wind towers, and the turbine is located within the inflatable, which also blocks some of the rotor noise.[135]

The variety of airborne system designs makes it difficult to consistently compare noise pollution across the board, but the above options demonstrate that airborne systems are not likely to increase noise pollution and may even reduce it in many cases. The one extra consideration to account for with most airborne systems is the tether. The larger, conductive tethers may generate some wind noise. However, that noise is likely to be substantially less than standard rotor noise.

B. Visual Interference

The next challenge facing today's standard large wind turbines is visual interference. The visual impact of a large wind farm can be even more dramatic and far-reaching than noise pollution. Visual interference can take

---

126. *Cf.* Saidur et al., *supra* note 118, at 2428 (describing mechanical noise generated from conventional turbines).

127. *See The Technology*, *supra* note 41 (indicating that the operational altitude range is between 140 meters and 310 meters).

128. *See supra* notes 45–49 and accompanying text.

129. *Details*, *supra* note 45.

130. *Id.*

131. *KiteGen STEM*, *supra* note 46.

132. *See supra* notes 35–36 and accompanying text.

133. Press Release, Altaeros Energies, *supra* note 36.

134. *BAT: The Buoyant Airborne Turbine*, ALTAEROS ENERGIES, http://www.altaerosenergies .com/bat.html [http://perma.cc/M8P3-2PAB].

135. Press Release, Altaeros Energies, *supra* note 36.

several forms. Large wind turbines are visible against the skyline for several kilometers.[136] Worse for some than this static visual impact, though, is the effect of the blades in motion. Large wind turbines can create what is known as a "flicker effect," where moving shadows can cause a pulsating effect similar to flicking a light switch on and off.[137]

A frequent complaint against large wind farms is the loss of scenic vistas.[138] For instance, one Texas landowner organized his neighbors and sought a temporary injunction against and damages for nuisance from a wind developer and neighboring landowners for the loss of property value and decreased enjoyment of his "dream home" in Taylor County.[139] They worried that the once-pristine land that had drawn them to the area would soon be filled with large, industrial turbines.[140] The claimants lost an "emotionally charged trial" and subsequent appeal.[141]

Another oft-cited impact of wind turbines is the flicker effect.[142] In larger installations, at certain times of the day there can be a "visually disturbing" shadow flicker when the blades are turning.[143] Despite being limited to certain seasons and times of the day, neighbors have found this effect disturbing.[144] While there are no comprehensive standards regarding flicker effects,[145] the likelihood of flicker "is very low once you get beyond ten rotor diameters from the turbine, so it is unlikely to be a serious problem with the small rotors in typical homeowner installations."[146]

Again, the variety of AWES designs precludes a blanket statement on the comparison of typical turbines to airborne systems. However, there are reasons to think that airborne systems may have an advantage here as well. First, airborne systems can be made smaller due to the increased efficiency

---

136. Saidur et al., *supra* note 118, at 2428–29.

137. *Id.* at 2429. For a video showing the flicker effect, see betterplanWI, *Industrial Wind Turbine Shadow Flicker in Wisconsin 2008*, YOUTUBE (Dec. 21, 2008) https://www.youtube.com/watch?v=MbIe0iUtelQ [https://perma.cc/73XQ-AKPZ].

138. For some examples, see ERNEST E. SMITH ET AL., WIND LAW § 6.01 (5th ed. 2015) (explaining common law nuisance and providing samples of nuisance suits). A website devoted to combating wind development in the Texas Hill Country can be found at SAVE OUR SCENIC HILL COUNTRY ENV'T, http://www.soshillcountry.org/ [https://perma.cc/6699-PBNX?type=source].

139. Rod E. Wetsel & Steven K. DeWolf, *Ride Like the Wind: Selected Issues in Multi-Party Wind Lease Negotiations*, 1 TEX. A&M J. REAL PROP. L., 447, 463 (2014).

140. *Id.*

141. *Id.*

142. Dwight H. Merriam, *Regulating Backyard Wind Turbines*, 10 VT. J. ENVTL. L. 291, 302–03 (2009).

143. *Id.* at 302.

144. *See id.*

145. *See id.* at 302–03 (asserting the importance of local standards that account for varying conditions in the absence of generally acceptable standards).

146. *Id.* at 303.

produced by stronger, steadier winds.[147] Thus, the visual interference is less to begin with for a comparable amount of power generation. Also, airborne systems do not fill the horizon with large towers. They do not need large structural supports, and since they tend to remain at altitude they appear smaller. Their size and design also virtually eliminates the flicker effect, one of the more maddening effects of a neighboring wind turbine.[148] Finally, as a minor point, airborne systems could easily be designed to be more aesthetically pleasing. If instead of a sterile line of stark, white towers neighbors were treated to an array of colorful dancing kites or balloons—think of New Mexico's annual hot air balloon festival—wind installations might not be such an eyesore. They might even make for desirable neighbors. They might even *increase* property values.[149]

Of course, airborne systems are not likely to please everyone aesthetically. Some neighbors will probably find them ugly or distracting despite designers' best efforts. While airborne systems would seem to be an improvement over the visual interference of existing turbines and towers, some points may yet count against them. First, although smaller turbines and greater distances makes for less visual impact, the height of an AWES would likely make it visible over greater distances. For example, a high-altitude wind farm would affect not only the neighbors with views of the adjacent ridgeline but all neighbors within a certain radius. Another factor to consider is motion. Spinning wind turbines might catch the eye at first, but familiarity with the constant, uniform motion of a wind farm may allow them to fade into the background to some degree. Not so with Makani's rotor-driven kite or KiteGen's airfoil.[150] The aerial acrobatics of these devices may well distract drivers or other passersby. Airborne wind farms would likely be an improvement over existing wind farms in terms of visual interference, but they would still be visible.

C. *Wildlife Impact*

The final environmental impact to consider is the effect of wind farms on wildlife. This impact can largely be divided into two categories: birds and bats, and endangered species. Given the nature of wind turbines, the former is the more obvious category, but the installation of large towers and transmission lines can have a serious impact on surface wildlife as well.[151] In the

---

147. *See* Archer & Caldeira, *supra* note 6, at 308 (explaining how an aircraft can be lofted to a high altitude to achieve greater electricity generation).

148. *See* Saidur et al., *supra* note 118, at 2429 (explaining that shadow flickering intensity is diminished by increased distance from residents).

149. This may seem like farfetched wishful thinking, but it is not beyond the realm of possibility.

150. *See supra* Part II.

151. In this subpart, I focus on land-based versus airborne wind-energy systems. The environmental impacts on wildlife of offshore wind is a contentious subject, and there is little in the

following sections, I briefly outline the relevant federal laws concerning wildlife and then compare the impacts of traditional wind farms to those of airborne systems.

1. The Endangered Species Act.—The Endangered Species Act (ESA), which protects fish, wildlife, and plants,[152] is among the broadest of federal wildlife laws. The ESA prohibits the unauthorized taking of designated species.[153] To "take" is defined broadly as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."[154] Takings, in the form of harm, can also include habitat destruction.[155] In addition to standard enforcement mechanisms, the ESA also provides for a private cause of action that can be brought by vigilant environmentalist citizens.[156] With such a broad range of potential violations—both during installation and operation—developers often undertake extended, expensive impact studies to avoid penalties for unauthorized takings later.[157] If these impact studies indicate a possible taking, developers can apply for incidental take permits, which will protect them from enforcement actions for the taking of specified species.[158]

2. The Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.—Whereas the ESA applies to a wide variety of species, the Bald and Golden Eagle Protection Act (BGEPA) is specifically targeted at "pursu[ing], shoot[ing], shoot[ing] at, poison[ing], wound[ing], kill[ing], captur[ing], trap[ping], collect[ing], molest[ing], or disturb[ing]" Bald or Golden Eagles.[159] The BGEPA differs from ESA in some ways. First, the BGEPA does not include habitat damage.[160] Second, it provides civil and criminal penalties but restricts criminal penalties to causing the death of an eagle "knowingly" or with "wanton disregard" for the consequences of some

way of consensus on the topic; for an in-depth discussion of the advantages and criticisms of offshore wind power, see Brian Snyder & Mark Kaiser, *Ecological and Economic Cost-Benefit Analysis of Offshore Wind Energy*, 34 RENEWABLE ENERGY 1567, 1567–68 (2009).

152. 16 U.S.C. §§ 1531–1543 (2012).

153. *Id.* § 1538.

154. *Id.* § 1532.

155. San Carlos Apache Tribe v. United States, 272 F. Supp. 2d 860, 873–74 (D. Ariz. 2003), *aff'd*, 417 F.3d 1091 (9th Cir. 2005).

156. Defs. of Wildlife v. EPA, 882 F.2d 1294, 1298 (8th Cir. 1989) (citing 16 U.S.C. § 540(g)(1) (1982)).

157. John Arnold McKinsey, *Regulating Avian Impacts Under the Migratory Bird Treaty Act and Other Laws: The Wind Industry Collides with One of Its Own, the Environmental Protection Movement*, 28 ENERGY L.J. 71, 82–83 (2007).

158. *Id.* at 76.

159. 16 U.S.C. § 668c (2012).

160. McKinsey, *supra* note 157, at 77.

activity.[161] However, like the ESA, the BGEPA allows for the acquisition of take permits for projects that may harm Bald or Golden Eagles.[162]

The Migratory Bird Treaty Act (MBTA), enacted in 1918, in very broad language, makes it "unlawful at any time, by any means or in any manner, to pursue, hunt, take, capture, [or] kill . . . any migratory bird."[163] The MBTA is distinct from the previous laws in two important respects. First, it makes no mention of intent and even provides penalties for unknowing violations.[164] Second, the MBTA does not authorize permits for incidental takings.[165] This means that developers who risk violating the MBTA by taking any of the more than 800 covered species[166] have no way to mitigate that risk. Thus, widespread enforcement of the MBTA against wind-farm developers could be fatal to the wind industry. Fortunately for developers, the United States Fish and Wildlife Services, the agency responsible for enforcing the MBTA, has typically enforced it selectively.[167]

3. Airborne vs. Conventional Wind Systems.—Airborne systems may offer some benefits to wind-farm developers when it comes to wildlife impacts. The most direct benefit of an AWES is that it is out of the flight path of most birds and bats.[168] When not in migration, most birds tend to stay below 500 feet above mean sea level (AMSL).[169] This puts them in the path of conventional industrial turbines.[170] Airborne systems are well above this height. Yet, they remain well below the average altitude of migratory species, which tend to maintain heights of 5,000 feet AMSL or above.[171]

While other state and federal laws may also impact wind-farm development,[172] the laws discussed above provide some examples of the uncertainty and potential expense associated with the wildlife impacts of wind farms. In the area of avian protection laws, at least, developers can hope for

161. 16 U.S.C. § 668(a)–(b).

162. *Id.* § 668a. *But see* McKinsey, *supra* note 157, at 77 (noting that the BGEPA does not, however, allow for incidental take permits).

163. 16 U.S.C. § 703(a) (2012).

164. *Id.*

165. *Id.* § 705.

166. *See* McKinsey, *supra* note 157, at 77 (citing 50 C.F.R. § 10.13 (2005)) (noting that the incidental, unauthorized killing of any one of over 800 species of birds would constitute a violation of the MBTA).

167. *Id.* at 78.

168. *See* Paul R. Ehrlich et al., *How Fast and High Do Birds Fly?*, (1988), https://web.stanford.edu/group/stanfordbirds/text/essays/How_Fast.html [https://perma.cc/W4XK-QWLE] (stating that the typical flight altitudes of most birds is below 500 feet).

169. *Id.*

170. *See supra* note 20 and accompanying text (noting that towers can have a total height of 442 feet).

171. Ehrlich et al., *supra* note 168.

172. *See, e.g.*, 42 U.S.C. §§ 4321–4347 (2012) (requiring the government to follow certain procedures when its actions may affect the environment).

clarification in the form of proposed legislation to harmonize these laws with current energy policy.[173]

Even if such legislation passes, developers face plenty of other environmental challenges, as discussed above. For example, the embattled Cape Wind project has become a cautionary tale for would-be offshore wind developers.[174] And even failed nuisance suits can tie up developments.[175] There is a certain irony to environmental complaints against wind farms. While many, if not most, environmentalists would prefer wind power generation to fossil-fuel-based options, they may oppose particular developments in light of the aforementioned impacts.

D. Other Impacts

Although environmental impacts have generated resistance, some of the most substantial obstacles to wind-farm development have come in the form of airports and military bases.[176] In Part II, I discussed this conflict from the perspective of the property rights of landowners and the potential taking of airspace as a result of air traffic. Here, I address the impact from the perspective of airports and airbases and the potential interference with not only flight paths but radar and other activities essential to modern aviation. Both the mechanical and electromagnetic properties of wind turbines can adversely affect military installations and activities.[177]

The federal government commissioned a study, completed in 2006,[178] which ultimately contributed to legislation instructing the Department of Defense "to ensure that the robust development of renewable energy sources and the increased resiliency of the commercial electrical grid may move forward in the United States, while minimizing or mitigating any adverse impacts on military operations and readiness."[179] This led to the creation of a special office, the Office of the Deputy Under Secretary of Defense for Installations and Environment, to help carry out this mandate.[180]

---

173. *See, e.g.*, Clarification of Legal Enforcement Against Non-Criminal Energy Producers Act of 2015, H.R. 493, 114th Cong. (2015) (amending the BGEPA to incorporate incidental take permits and the MBTA to require intent).

174. For an extended discussion of the resistance to the Cape Wind project, see Dinnell & Russ, *supra* note 52, at 547–53.

175. *See* SMITH ET AL., *supra* note 138, at § 6.01 (discussing nuisance claims against wind-farm developers).

176. *See, e.g.*, H. Brendan Burke, *Dynamic Federalism and Wind Farm Siting*, 16 N.C. J.L. & TECH. 1, 30–36 (2014) (explaining the formal and informal processes of reviewing wind-farm projects, including project comments, recommendations, and, if necessary, discussions to mitigate adverse impacts on the Department of Defense's activities).

177. *Id.* at 6.

178. *Id.* at 6 n.24.

179. *Id.* at 30.

180. *Id.*

The federal government is evidently concerned with the potential effects of wind turbines siting on airports and airbases, but what exactly are the potential effects? The first is direct physical interference. Turbines take up space, and there is the potential, however unlikely, for low-altitude maneuvers to result in a deadly collision between plane and turbine.[181] Another potential dangerous effect is interference with radar detection.[182] While not the same level of immediate threat, radar interference can lead to a number of dangers and distractions.[183] A third threat is electromagnetic interference with surveillance systems.[184] Unfettered communication between air traffic controllers and pilots is vital as well. Finally, the radar noise created by airborne systems could be a threat to national security if it interferes with the detection of real threats.

Technological advances may mitigate some of the risks created by airborne wind systems, but the physical interference is another matter. The best approach in the case of physical interference with air traffic may be to avoid heavily trafficked areas and to make airborne systems highly visible to pilots. While this could initially limit the deployment of airborne systems, their use in off-grid and micro-grid applications could sustain them while this conflict is sorted out. Some of the reasons to hope that the process will continue to move forward are discussed in the next Part.

IV. Present and Near-Future Prospects

As noted above, private actors have begun to recognize the potential of high-altitude wind farming.[185] With large investments, airborne wind system technology is likely to advance rapidly. If this trend continues, it will be vital to have laws in place to ensure that potential developers can bring airborne wind systems to whatever markets can ultimately benefit from them. Some projects are already in process, but more will be needed.

One such experiment in the works is the Altaeros launch scheduled for later this year in Alaska.[186] Altaeros, the MIT-based wind-energy company founded in 2010, is in the process of launching its Buoyant Air Turbine south of Fairbanks, Alaska.[187] This $1.3 million project will extend for eighteen months and involve the deployment of Altaeros' helium-filled turbine at a

---

181. *Id.* at 18–19, 18 n.111.

182. *Id.* at 6.

183. *See id.* at 8–20 (examining the physical characteristics of wind turbines and explaining how they affect air traffic control and military activities).

184. *Id.* at 18.

185. *See supra* Part II.

186. Katie Fehrenbacher, *SoftBank Backs High-Altitude Wind Startup Altaeros*, GIGAOM (Dec. 4, 2014, 9:00 AM), https://gigaom.com/2014/12/04/softbank-backs-high-altitude-wind-startup-altaeros/ [http://perma.cc/YL4E-Z8FQ].

187. Press Release, Altaeros Energies, *supra* note 38.

height of 1,000 feet above the ground.[188] If successful, the project will break the world record for the highest wind turbine by over 275 feet[189] and mark the first long-term demonstration of airborne wind-turbine technology.[190] Instead of connecting to the grid, Altaeros' BAT is designed for remote power and micro grids like those typically found on remote construction projects.[191] Altaeros estimates the total market for this sort of power generation at $17 billion.[192] Many of those projects currently run on diesel generators, so the environmental benefit could be significant.[193] While the remote power market could benefit from airborne wind and represents a legitimate market, the role of such projects as a proof of concept for on-grid production is potentially much larger. It will be important to fast-track projects like Altaeros' moving forward to get the fledgling airborne wind sector going.

Small experiments like the one outside of Fairbanks provide valuable data for future projects, but as the above discussion illustrates, if airborne wind is to become a major contributor on a national level, the federal government will play a central role. The FAA has already taken a step in the right direction for high-altitude wind generation. In December of 2011, the FAA sent out a "Notification for Airborne Wind Energy Systems (AWES)."[194] The notification served several purposes. First, the notice expressed the agency's interest in "allow[ing] for the continued development" of airborne wind-energy systems.[195] It also identified some of the holes in the existing regulatory framework.[196] Finally, it called for input from stakeholders regarding outstanding issues.[197] The FAA ultimately published only nineteen responses submitted within the time allotted for comments—eleven in favor of regulations promoting AWES testing and

188. Tweed, *supra* note 57.

189. *See* Press Release, Altaeros Energies, *supra* note 38.

190. *Id.*

191. Tweed, *supra* note 57.

192. *Id.*

193. *Id.*

194. Notification for Airborne Wind Energy Systems (AWES), 76 Fed. Reg. 76,333 (Dec. 7, 2011) (to be codified at 14 C.F.R. pt. 77).

195. *Id.* at 76,334.

196. *Id.*

197. *See id.* (articulating the issues as "(1) Impact(s) to various surveillance systems (radars); (2) Conspicuity to aircraft (marking and lighting); (3) Overall safety—safety to other airspace users, safety to persons and property on the ground, safety to the efficient and effective use of NAS facilities, safety to airports, safety to air commerce, and safety to the efficient operations and managing of the NAS; (4) AWES fly-away protection (mooring cable is severed); (5) AWES physical dimensions per unit and per farm; (6) AWES operating dimensions per unit and per farm (amt. of airspace it may require); (7) AWES mobility (potential for AWES to relocate from physical ground location to a different ground location); and (8) Wake turbulence or vortices of wind capturing component(s)").

development and eight against.[198] As of the time of this writing, the FAA has yet to publish any official policy revisions or to incorporate AWES into § 77 of Title 14 of the Code of Federal Regulations concerning the "Safe, Efficient Use, and Preservation of the Navigable Airspace."[199] Perhaps the most important step taken by the FAA, though, has been allowing for single-turbine airborne projects for research purposes on a case-by-case basis.[200] This is exactly the sort of encouragement that is needed from the federal government, and the language of the notification bodes well for the future of airborne wind energy. Of course, the FAA also noted the difficulties of classifying airborne systems as a result of the design variety.[201] This could indicate an obstacle on the path to widespread approval for larger projects. Overall, though, the FAA, under the direction of the current administration, seems committed to exploring a variety of paths to renewable energy development. This is exactly the sort of commitment that will be needed to take high-altitude wind systems into the mainstream.

Conclusion

As we have seen, the relatively young sector of commercial wind power generation is poised to add a transformative new technology. High-altitude wind systems may reach previously inaccessible resources. However, by their very nature, they challenge our existing legal framework. If these systems are put to widespread use, they will challenge our present understanding of property laws and implicate current environmental regulations. In light of the rapid technological advancements in airborne wind technology and the climate impacts from conventional energy sources, any delay in regulation or legislation may be quite costly.

Prospective legislators would be well served by the existence of an ongoing conversation in the academic literature regarding the legal issues unique to airborne wind-energy systems. Previous commentators have taken

---

198. *Notification for Airborne Wind Energy Systems: Docket Folder Summary*, REGULATIONS.GOV, http://www.regulations.gov/#!docketDetail;D=FAA-2011-1279 [http://perma.cc/T8FW-Z3RW].

199. 14 C.F.R. §§ 77.1–.41 (2015).

200. *See* Notification for Airborne Wind Energy Systems (AWES), 76 Fed. Reg. at 76,334 ("Given the altitudes that these structures can operate and their operating characteristics, the FAA concludes that they should be studied and the potential impacts to the navigable airspace must be identified and addressed.").

201. *See id.* at 76,333 ("[S]ome conceptual designs include hybrid concepts or utilize new innovative techniques that are not as easily classifiable.").

note of AWES but most of them only tangentially. It is the goal of this Note to spark further dialogue directed specifically at airborne wind and to offer some preliminary talking points to that effect. High-altitude wind is a powerful resource, and with the right support, it may become a central part of our energy portfolio. It is my hope that this Note will help to generate that support.

—William R. Langley