2018

Under the Radar: The Cost and Benefits of Wind Energy Through the Lens of National Security

David N. Cassuto
Elisabeth Haub School of Law at Pace University

UNDER THE RADAR: THE COST AND BENEFITS OF WIND ENERGY THROUGH THE LENS OF NATIONAL SECURITY

David N. Cassuto[*]

2018 MICH. ST. L. REV. 587

TABLE OF CONTENTS

---

* Professor of Law, Elisabeth Haub School of Law at Pace University, Director, Brazil-American Institute for Law & Environment (BAILE), Class of 1946 Distinguished Visiting Professor of Law, Williams College. Fellow, Getulio Vargas Foundation School of Law, Rio de Janeiro; BA, Wesleyan University; PhD, Indiana University; JD, University of California Berkeley, Boalt Hall School of Law. The author is very indebted to Amy O'Brien for her outstanding work helping put this Article together, to Ashley White whose research and writing was instrumental, and to Drew Levinson, who added critical research and thoughtful criticism to the middle phase.

INTRODUCTION

Between climate change and the myriad other environmental hazards associated with fossil fuels, the need for renewable energy grows ever more urgent. For example, wind-energy production has experienced rapid growth in the past few years.[1] In 2016, the United States Department of Energy (DOE) reported wind power to be the third largest source of electric-generating capacity in the United States, trailing behind only solar and natural gas.[2] Furthermore, in the past decade cumulative wind-power capacity in the U.S. increased at an average rate of 30% per year.[3] In 2016, the U.S. added approximately 8,203 megawatts (MW) of new wind capacity for a total capacity of 82,143 MW.[4] Wind energy is clearly a rapidly expanding source of clean energy;[5] however, it is not without its complications. In addition to land use,[6] wildlife,[7] aesthetic,[8] and reliability[9] concerns (among others), wind also presents some unique challenges to air navigation, both civilian and military.[10]

This Article examines wind energy through the lens of national security. The benefit resides with helping the United States become energy independent.[11] National-security concerns also present a cost because wind energy interferes with military radar, posing a potential

---

1. *See* WIND TECHNOLOGIES MARKET REPORT, U.S. DEP'T OF ENERGY 6 (2016) ("Global wind additions equaled roughly 54,600 GW in 2016, 14% below the record of 63,600 MW added in 2015. With its 8.2 GW representing 15% of new global installed capacity in 2016, the United States maintained its second-place position behind China.").

2. *Id.* at 5.

3. *Advantages and Challenges of Wind Energy*, U.S. DEP'T OF ENERGY, https://energy.gov/eere/wind/advantages-and-challenges-wind-energy [https://perma.cc/7W95-V3A4] (last visited Sept. 24, 2018) ("[W]ind now has the largest renewable generation capacity of all renewables in the United States.").

4. RYAN WISER & MARK BOLINGER, U.S. DEP'T OF ENERGY, 2016 WIND TECHNOLOGIES MARKET REPORT 4 (2016), https://www.energy.gov/sites/prod/files/2017/10/f37/2016_Wind_Technologies_Market_Report_101317.pdf [https://perma.cc/H647-X5PK].

5. *See Advantages and Challenges of Wind Energy*, *supra* note 3.

6. *See WINDExchange Slideshows*, U.S. DEP'T OF ENERGY, https://windexchange.energy.gov/slideshows [https://perma.cc/VG3Z-SZJY] (last visited Sept. 24, 2018).

7. *See id.*

8. *See id.*

9. *See The Rise of Wind Energy Raises Questions About its Reliability,* NATIONAL PUBLIC RADIO (June 22, 2017) https://www.npr.org/2017/06/22/532763718/the-rise-of-wind-energy-raises-questions-about-its-reliability [https://perma.cc/C8FM-2H33].

10. *See id.*

11. *See id.*

threat to the systems that monitor possible attacks.[12] This Article attempts to analyze the overall impact of wind energy while noting the inherent difficulties when so much uncertainty is involved in the process.

Part I of this Article discusses the benefits of wind energy.[13] Part II examines its costs, specifically its interference with radar, and what that means for national security.[14] This Part focuses on the fact that wind turbines can cause significant interference with radar, a problem complicated by the disturbing reality that it currently lies beyond the Department of Defense's (DOD's) technological capabilities to determine whether and if such interference occurs.[15] Part III outlines the federal process by which wind energy interference with radar is managed and the mitigation strategies used to reduce the interference.[16] Part IV uses a 2010 wind-energy project in Oregon as a case study to illustrate the uncertainties in calculating the costs of wind energy.[17] Part V discusses the current mitigation strategies employed by federal agencies to reduce the effects of wind development on radar systems.[18] Part VI analyzes the hard and soft uncertainties associated with the effects that wind turbines have on military radars.[19]

Finally, this Article concludes that logic and common sense require a precautionary approach to this problem. Until such time as DOD is able to determine whether and to what extent wind turbines cause interference, no new permits for wind-energy developments should issue for installations in proximity to military radar. In addition, current radar facilities should be retrofitted immediately to the extent possible, and additional resources should be devoted to resolving the interference problem.

I. BENEFITS OF WIND ENERGY

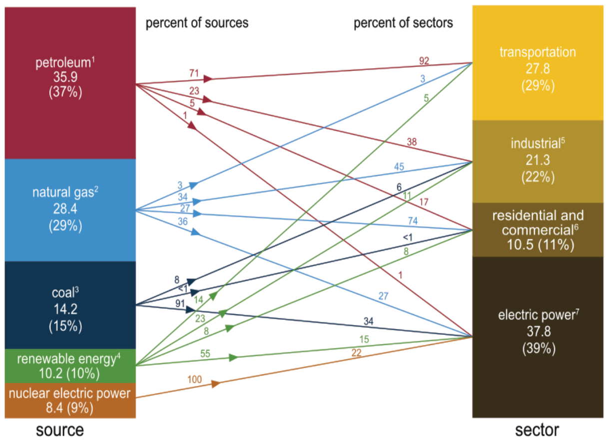
Among the clear benefits of wind energy is its role in combating the effects of climate change. According to the Energy Information Administration's (EIA) 2016 Report, petroleum, natural gas, and coal

12. *See id.*
13. *See infra* Part I.
14. *See infra* Part II.
15. *See infra* Section II.B.
16. *See infra* Part III.
17. *See infra* Part IV.
18. *See infra* Part V.
19. *See infra* Part VI.

constituted 81% of U.S. primary energy consumption[20] and approximately 65% of electricity generation.[21] All three of these sources contribute significantly to climate change.[22] As of 2016, renewable energy sources (including wind) made up approximately 10% of the primary energy consumption[23] and approximately 15% of electricity generation.[24]

U.S. primary energy consumption by source and sector, 2016

Total = 97.4 quadrillion British thermal units (Btu)



This small percentage of renewable energy generation in the United States leaves a large potential for greenhouse gas (GHG) pollution displacement. As a DOE study noted, "[A] single 1.5 MW wind turbine displaces 2,700 tons of CO_2 per year, or the equivalent of planting 4 square kilometers of forest every year."[25] In addition, manufacturing and building wind plants has a much smaller carbon

---

20. *U.S. Energy Facts Explained*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/?page=us_energy_home [https://perma.cc/33MC-NZDC] (last updated May 16, 2018).

21. *FAQs: What is U.S. Electricity Generation by Energy Source?*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/tools/faqs/faq.php?id=427&t=3 [https://perma.cc/UQ4J-KBA5] (last visited Sept. 24, 2018).

22. *Overview of Greenhouse Gases*, EPA, https://www.epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide [https://perma.cc/8F79-8EHL] (last visited Sept. 24, 2018) ("In 2016, CO_2 accounted for about 81.6% of all U.S. greenhouse gas emissions from human activities."). Fossil fuels are the primary source of carbon dioxide. *See id.*

23. *U.S. Energy Facts Explained*, *supra* note 20.

24. *FAQs: What is U.S. Electricity Generation by Energy Source?*, *supra* note 21.

25. 20% WIND ENERGY BY 2030, U.S. DEP'T OF ENERGY 107 (2008), https://www.nrel.gov/docs/fy08osti/41869.pdf [https://perma.cc/48N2-YJ6A].

footprint than that of other types of energy-generation installations.[26] So, from inception to generation, wind power is carbon efficient.

Second, wind energy is domestically sourced, thus aiding in energy independence and security while reducing transportation costs.[27] Furthermore, wind's ability to displace fossil fuels will also help states meet increasingly stringent (state-based) regulatory requirements and programs designed to limit fossil fuel generation.[28] For example, a study in New York observed that if wind energy provided 10% of the state's peak electricity demand, it would displace 65% of the energy generated by natural gas, 15% of the energy produced by coal, and 10% of the energy that comes from oil.[29]

Finally, wind energy does not contribute to other forms of ambient air pollution.[30] It produces none of the commonly regulated pollutants—nitrogen oxides, sulfur dioxides, mercury, and particulate matter—created through the burning of fossil fuels.[31] These pollutants have been linked to a range of health problems including: neurological development in children, decreased lung function, respiratory infection, lung inflammation, and aggravation of respiratory illness.[32] Reducing airborne particulate matter also decreases the number of heart attacks and strokes and the number of hospital visits for asthma and cardiovascular disease.[33] In light of this, the potential savings to both the nation and individuals from lowered health care costs resulting from decreased air pollution are substantial as well.[34]

---

26. *See id.* at 108 (explaining that using wind instead of coal can reduce CO_2 emissions by 99%, and similarly, replacing natural gas with wind reduces CO_2 emissions by 98%).

27. *See* WIND TECHNOLOGIES MARKET REPORT, *supra* note 1, at 6.

28. *See The Regional Greenhouse Gas Initiative (RGGI) Carbon Budget Training Program*, N.Y. STATE DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/energy/rggi.html [https://perma.cc/8J7C-ME2J] (last visited Sept. 24, 2018). For example, New York, along with eight eastern states, developed the Regional Greenhouse Gas Initiative as a "market-based emissions trading program" to promote a "clean-energy" future. *Id.* This initiative set a cap for greenhouse gas emissions from electric generating facilities that will decline over time and thereby slowly tighten the standards for carbon emissions. *See id.*

29. 20% WIND ENERGY BY 2030, *supra* note 25, at 108.

30. *See id.* at 13.

31. *See The Regional Greenhouse Gas Initiative*, *supra* note 28; *see also* 42 U.S.C. § 7412 (2012) (listing the hazardous air pollutants regulated by the Clean Air Act).

32. *See Fast Facts about Health Effects of Air Pollution*, CTR. FOR ECOGENETICS & ENVTL. HEALTH (Univ. of Wash.), May 2012, at 1, https://deohs.washington.edu/sites/default/files/FastFacts_AirPollution_12MAY10.pdf [https://perma.cc/JYR9-AMZJ].

33. *See id.*

34. *See Death in the Air: Air Pollution Costs Money and Lives*, WORLD BANK (Sept. 8, 2016), http://www.worldbank.org/en/news/infographic/2016/09/

Nevertheless, wind energy presents a major risk to national security. Wind turbines interfere with radar, including DOD military radar systems.[35] Perhaps more troubling still is the fact that there is currently no accurate means of measuring the amount of interference these turbines cause nor indeed when and if it occurs.[36] This threat impacts risk assessment and must be part of any analysis as to whether and how much of a role wind energy should play in our national energy strategy.

II. COSTS ASSOCIATED WITH WIND ENERGY

Wind turbines vary in size and are grouped into classes based on generating capacity: residential-scale onsite energy use (<10 kilowatts (kW)), small commercial-scale onsite energy use (10–50 kW), commercial onsite energy use (50–250 kW), large commercial or industrial energy use (500 kW–1.5 megawatts (MW)), and utility-scale energy use (1.5–7.5 MW).[37] The amount of regulatory involvement necessary to install wind turbines depends on the scale of the project. Turbines above 200 feet require approval from all government levels: federal, state, and local. Federal regulation requires turbines over 200 feet to go through a specific approval process[38] before undergoing state and local approval processes, which vary by jurisdiction.[39]

The federal government has jurisdiction over large commercial turbines and utility-scale turbines. Large commercial turbines can exceed 200 feet in height, and utility-scale turbines always exceed 200 feet in height.[40] Utility-scale turbines, the largest class and the type used for large wind farms, can have rotors exceeding 250 feet in

08/death-in-the-air-air-pollution-costs-money-and-lives [https://perma.cc/4HFK-D3MF] (stating that air pollution is now the fourth leading risk factor for death worldwide).

35. *See* MICHAEL BRENNER, MITRE CORP., WIND FARMS AND RADAR 1 (Jan. 2008), http://users.ece.utexas.edu/~ling/US1_Wind_Farms_and_Radar_Brenner_USA.pdf [https://perma.cc/3UZ2-9YJ6].

36. *See id.*

37. *What is Wind Power?*, U.S. DEP'T OF ENERGY, https://windexchange.energy.gov/what-is-wind [https://perma.cc/X8UK-56G2] (last visited Sept. 24, 2018).

38. *See infra* Part III.

39. *See, e.g.*, *Wind Power*, N.Y. STATE DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/energy/40966.html [https://perma.cc/XUC5-Y75X] (last visited Sept. 24, 2018). For example, New York law defines large wind projects as those of 25 MW or greater and requires developers of such projects to undertake a unified state and local permitting process. *Id.*

40. *See What is Wind Power?*, *supra* note 37.

diameter.[41] In 2016, the average generating capacity of newly installed turbines was 2.15 MW, an increase of approximately 11% from the years 2011-2015.[42] Furthermore, the diameter of the turbine rotors also saw a significant increase in 2016, jumping 13% to an average diameter of 108 meters.[43]

Many wind turbines, especially utility-size aggregations (or "farms"), can impact all forms of radar—military, weather, and air traffic control.[44] This Article focuses on the impacts to military radar systems. DOD notes that "[m]any governmental agencies . . . study[] wind turbine impacts on radar systems; however, no agency has successfully been able to relate impacts to quantifiable mission degradation."[45] DOD knows the potential for and the type of interference caused by wind turbines but not the amount of interference each turbine causes.[46] As such, decisions by DOD regarding whether wind farms will cause undo interference with particular radar stations is closer to guesswork than precise forecasting. In a congressional hearing before the House Armed Services Subcommittee, Dr. Dorothy Robyn, Deputy Under Secretary of Defense, Installations and Environment, U.S. Department of Defense noted that:

> [K]ey factors aggravate what would otherwise be a much more limited problem. First, is the aging nature of our radar infrastructure. Our long-range radar is particularly old, decades old. Many still use analog technology, which has limited ability to filter out wind turbine clutter. Second, the FAA's [Federal Aviation Administration's] citing review . . . is itself a kind of a legacy system. It . . . has not been updated to take account of current national security needs and operations. Most significant, a developer only has to give the FAA 30 days notice of the start of construction . . . . This is generally adequate for the FAA's purposes, but if we raise a concern at that late stage . . . we can create serious financial and execution challenges for the developer.[47]

---

41. *See id.*
42. *See* WIND TECHNOLOGIES MARKET REPORT, *supra* note 1, at 26.
43. *See id.*
44. OFFICE OF THE DIR. OF DEF. RESEARCH & ENG'G, REPORT TO THE CONGRESSIONAL DEFENSE COMMITTEES: THE EFFECT OF WINDMILL FARMS ON MILITARY READINESS, U.S. DEP'T OF DEF. 52-56 (2006).
45. Information Paper On: NORAD Radar System Interference Caused by Wind Turbines, U.S. DOD (onsite research conducted under the direction of the author).
46. *See id.*
47. *Wind Farms: Compatible with Military Readiness?: Hearing Before the Subcommittee on Readiness of the Committee on Armed Services*, 111th Cong. 6 (2010) (statement of Dr. Dorothy Robyn, Deputy under Sec'y of Def., Installations & Env't, U.S. Dept. of Def.). The process issue will be discussed more fully below. *See infra* Part III.

Radar technology has improved greatly since the majority of DOD's radar systems went online.[48] Newer radars can, in theory, handle more interference, which would create an enhanced ability to deal with interference from wind farms. However, until such improvements are integrated into the national security grid, they remain irrelevant to the current threat assessment. Furthermore, even the most modern technology remains inadequate to the task of accurately measuring interference.[49]

A. How Radars Function

Understanding how wind power generation can interfere with radar systems requires some basic familiarity with how radar works. The process begins when an emitter pulses energy outward in the form of radio frequency (rf) waves between three megahertz and 100 gigahertz.[50] Any object struck by the pulse reflects some of that energy back.[51] That reflected energy is then collected by the emitter's antenna and analyzed.[52] The weaker the energy reflected back to the antenna, the more difficult the information is to process.[53] The signal's strength depends on the power of the transmitter, its distance to the target, atmospheric effects, the radar cross-section[54] of the target, and interference caused by other objects and the antenna geometry.[55]

Unwanted reflected signals are called "clutter."[56] Objects within the path of the radar can affect the wave's propagation characteristics, or how the waves travel. This can include actual blockage of the

---

48. *See, e.g.*, *Air Force Tech Report: Ground Based Radar Early Warning System*, U.S. AIR FORCE (Apr. 25, 2018), https://www.af.mil/News/Article-Display/Article/1503094/air-force-tech-report-ground-based-radar-early-warning-system/ [https://perma.cc/25D3-HLR4].

49. *See Wind Turbine Radar Interference Mitigation (WTRIM)*, SANDIA NAT'L LABS., https://energy.sandia.gov/energy/renewable-energy/wind-power/wind-turbine-siting-and-barrier-mitigation/wtrim/ [https://perma.cc/4L29-59PE] (last visited Sept. 24, 2018) (recognizing that models and mitigation strategies still need to be done to fully understand the level of interference and technology required to combat interference).

50. *See* DEP'T OF DEF., THE EFFECT OF WINDMILL FARMS ON MILITARY READINESS 10 (2006).

51. *See id.*

52. *See id.*

53. *See id.*

54. *See* OFFICE OF THE DIR. OF DEF. RESEARCH & ENG'G, *supra* note 44, at 10. The radar cross section (RCS) is the "size" of the object, or in other words how much radar energy that object will reflect back. *See id.* The larger the object, the larger its RCS. *See id.*

55. *See id.* at 10-11.

56. *See id.* at 11.

waves, causing shadowing behind the object.[57] Objects in areas of complete shadow are invisible to radar while objects in partial shadow are detectable, albeit with difficulty.[58] A third form of shadowing, known as diffraction, arises when a radar signal hits a line of objects.[59] When this occurs, the waves are altered, making it difficult to detect objects of interest.[60] The spacing of the turbines on wind farms makes diffraction the most common form of interference caused by wind-power generation.[61] Clutter also causes difficulty when a receiver picks up two different signals simultaneously as a result of the obstruction, rendering the primary signal undetectable.[62] The varied effects of reflected and diffracted signals make the interference capability of large wind turbines hard to quantify.

B. Challenges to National Security

From a national security perspective, clutter and interference caused by wind farms pose significant concerns.[63]

> As wind turbines continue to be installed, and as advances in wind energy technology enable wind farms to be deployed in new regions of the country, the probability for wind development to present conflicts with radar missions related to air traffic control, weather forecasting, homeland security, and national defense is also likely to increase, as is the potential severity of those conflicts.[64]

This statement is cause for significant concern. Wind-energy construction will cause more and more severe instances of radar interference.

Wind farms are often developed in agricultural areas with expansive, available land.[65] Accordingly, large-scale farms have been

---

57. *See id.* at 13.
58. *See id.*
59. *See id.*
60. *See id.*
61. *See id.*
62. *See* Florian Krug & Bastian Lewke, *Electromagnetic Interference on Large Wind Turbines*, 2 ENERGIES 1118 (2009).
63. *See* FEDERAL INTERAGENCY WIND TURBINE RADAR INTERFERENCE MITIGATION STRATEGY, U.S. DEP'T OF ENERGY 1 (2016), https://www.energy.gov/sites/prod/files/2016/06/f32/Federal-Interagency-Wind-Turbine-Radar-Interference-Mitigation-Strategy-02092016rev.pdf [https://perma.cc/SWK2-78AD] [hereinafter FEDERAL INTERAGENCY REPORT].
64. *See id.* at vii.
65. *See Wind Energy*, NAT'L GEOGRAPHIC, https://www.nationalgeographic.org/encyclopedia/wind-energy/ [https://perma.cc/ZXU2-MCVG] (last visited Sept. 24, 2018).

built across the country from California to New England.[66] Similarly, the United States has radar stations (early-warning stations and air-traffic control stations) located from coast to coast:

The picture on the left depicts all of the major airports in the United States (a section of air-traffic control radars), and on the right are the early-warning radar locations.[67] The early-warning radars are a joint effort with Canada and were put in place in the 1980s, replacing the Distance Early Line Radars.[68] Of those radars that remain operational, remedial work for many was completed in the early 1990s and for a few more in 2005.[69] Also in 2005, budgetary concerns led to the deactivation of others.[70] By 2015, more than twenty-five long-range radars were updated to full operational capability.[71] The upgrades have increased the surveillance, advanced warning, and troubleshooting capabilities of the long-range radars; however, many upgrades are still to come.[72]

66. *See* Paul Rogers, *New Map Shows Wind Farms Spreading Rapidly Across the US*, MERCURY NEWS (Aug. 11, 2017, 6:35 AM), https://www.mercurynews.com/2017/08/10/NEW-MAP-SHOWS-WIND-FARMS-SPREADING-RAPIDLY-ACROSS-US/ [https://perma.cc/3UG6-L8BQ].

67. *See North Warning System*, WIKIPEDIA, http://en.wikipedia.org/wiki/North_Warning_System [https://perma.cc/XHH7-8C5B] (last visited Sept. 24, 2018). Northern Command, a branch of DOD in charge of the long-range radars, directed us to the cited Wikipedia page for information on the age and locations of their radar. *See id.*

68. *See* James E. Bollinger, *North Warning System*, http://www.radomes.org/museum/NorthWarningSystem.php [https://perma.cc/J9RZ-MQMK] (last visited Sept. 24, 2018).

69. *See North Warning System*, *supra* note 67.

70. *See id.*

71. *See* Patty Welsh, *Radar Upgrades Ensure Situation Awareness*, U.S. A.F. (Oct. 21, 2015), https://www.af.mil/NEWS/ARTICLE-DISPLAY/ARTICLE/625117/RADAR-UPGRADES-ENSURE-SITUATION-AWARENESS/ [https://perma.cc/U7QN-MPTE].

72. *See* Elwood Brehmer, *DOD to Spend $325M on Clear Missile Defense Radar*, ALA. J. OF COM. (Mar. 2, 2016, 3:10 PM), http://www.alaskajournal.com

The federal government knows how turbines can affect the radar stations, but to date, the effects have not been quantified.[73] DOD expects radars to at least run at 80% efficiency; this means that some interference is expected and filtered out, and the radar is still functional.[74] However, as mentioned above, DOD and other agencies have not been able to quantify when another turbine will push the amount of interference over the 20% allowable amount and cause the system to run at less than 80% efficiency. This means that DOD *does not know when its radar is functioning effectively or when it is experiencing crippling interference*.

III. FEDERAL SITING PROCESS FOR WIND FARMS

When a proposed wind farm reaches the threshold at which it needs federal approval,[75] the FAA has exclusive authority to make determinations that will either allow the project to move forward or stop the project.[76] This jurisdiction includes objects that could impact air navigation or DOD operations.[77] The height requirement includes all wind turbines in the utility-scale group and some in the large commercial group discussed above.[78]

Each wind turbine and project above 200 feet must receive FAA approval as part of its preconstruction commitments.[79] This FAA process provides the only formal venue for DOD to contest the construction parameters of a wind-energy project.[80] In the past, DOD was invited to consult only late in the process.[81] DOD's late entry into the process slowed the decision making because the FAA had to wait

---

/2016-03-02/dod-spend-325m-clear-missile-defense-radar#.WnJHq5Oplo4 [https://perma.cc/M2EH-VR4T].

73. Presentation: Energy, Urban Development and Aerospace Capabilities Deconfliction Branch, NORAD J36R, (Feb. 21, 2012).

74. *See* Colonel Felix A. Losco & Major Thomas F. Collick, *When Wind, Wind Turbines, and Radar Mix – A Case Study*, 68 A.F. L. REV. 235, 242 (2012).

75. The FAA has jurisdiction over construction and alteration of objects exceeding 200 feet in height. 14 C.F.R. § 77.9 (2018).

76. *See id.* § 77.31.

77. *See* 20% WIND ENERGY BY 2030, *supra* note 25.

78. *See id.*

79. *See* § 77.9.

80. DOD can hold up wind farms when they are in the FAA process, but the DOD determination is still part of the FAA process. *See infra* Section III.B. DOD does not have a separate process of its own in which it gives the public determinations. *See id.*

81. *See* Juliet Eilperin, *Pentagon Objections Hold Up Oregon Wind Farm*, WASH. POST (Apr. 15, 2010, 9:09 PM), http://www.washingtonpost.com/wp-dyn/content/article/2010/04/15/AR2010041503120.html [https://perma.cc/BK2C-99JZ].

for DOD input before issuing a formal decision.[82] The process has since streamlined.[83] However, it seems counterintuitive that the FAA retains exclusive jurisdiction over a process with potentially significant impacts on national security. It is therefore worth examining this process in detail.

A. The FAA Approval Process

Although wind farms require federal approval, an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) is not required.[84] NEPA requires that any major federal action with potentially significant environmental impact be preceded by an analysis of environmental impacts and a discussion of possible alternatives.[85] Federal actions of an advisory nature, however, are excluded from NEPA requirements.[86] Determinations by the FAA dealing with obstruction of air space are considered to be advisory and therefore not a major federal action under NEPA.[87] This means that the only federal requirement for the approval of a wind farm is a determination by the FAA as to whether the object unduly obstructs air space.[88]

The FAA approval process is straightforward. If a proposed project is under the FAA's jurisdiction, then a Notice of Proposed Construction is required.[89] After the Notice is issued, the FAA must study the proposed project or object and make a determination.[90] Following an initial aeronautical study, the FAA will issue one of the following: Determination of No Hazard to Air Navigation (DNH) or Notice of Presumed Hazard (NPH).[91] During the hazard-evaluation process, DOD can offer input and analysis on the potential effects on

---

82. *See infra* Part IV (exemplifying the delay in the siting process).

83. *See* Losco & Collick*, supra* note 74, at 243-44.

84. U.S. DEP'T OF TRANSP., ORDER 1051.1E, SUBJ: ENVIRONMENTAL IMPACTS: POLICIES AND PROCEDURES 2-2, 3-1 (2006).

85. *See* 42 U.S.C. § 4321 (2012).

86. *See* U.S. DEP'T OF TRANSP., *supra* note 84, at 3-1.

87. *See id.*

88. *See id.*

89. *See* 14 C.F.R. § 77.7 (2011); *see also* Dawn Meyers & Paul Figg, *Don't Get Your Construction Project Grounded: Navigating the FAA's Hazard Determination Process*, Air & Space Lawyer (ABA), 2015, https://www.americanbar.org/content/dam/aba/publications/air_space_lawyer/Fall%202015/A%26SL_v28n3_Sept2015_MeyersFigg.pdf [https://perma.cc/J9XW-YUF6].

90. *See FAA Determinations*, FAA, https://oeaaa.faa.gov/oeaaa/external/content/faaDeterminations.jsp_[https://perma.cc/9469-U8EH] (last visited Sept. 24, 2018).

91. *See id.*

national security, including interference with military radar systems.[92] However, the FAA has final authority when issuing a determination on proposed projects and can override any DOD objections.[93]

If the project receives a DNH, the project can proceed as planned, and no further agency action is required.[94] If the project receives an NPH, the FAA conducts an in-depth technical analysis to explain the cause of the NPH and evaluate the impacts.[95] The FAA then negotiates with the regulated entity to change the parameters of the project to allow the project to continue.[96] If no agreement on modifications emerges, the FAA issues a Determination of Hazard.[97] A Determination of Hazard halts construction of the project with no further consideration by the FAA.[98]

B. The DOD Process

Wind interference with military radar has become a serious policy concern only in the last decade. In 2005, Congress attached a rider to an appropriations bill requiring DOD to study the impacts of wind energy on military radars and issue a report.[99] In March 2006, DOD, along with the Department of Homeland Security (DHS), issued a temporary ruling, which prevented the construction of wind energy plants within the sightlines of military radar facilities.[100] Once the study was complete, DOD revoked the ruling and decided

---

92. *See DoD Preliminary Screening Tool*, FAA, https://oeaaa.faa.gov/oeaaa/external/gisTools /gisAction.jsp?action=showLongRangeRadarToolForm [https://perma.cc/387W-AN7T] (last visited Sept. 24, 2018); *see also DoD Siting Clearinghouse Reviews*, OFF. ASSISTANT SECRETARY DEF., https://www.acq.osd.mil/dodsc/contact/dod-review-process.html [https://perma.cc/8CQG-WC9R].

93. Informational Paper on: NORAD Radar System Interference Caused by Wind Turbines, NORAD J36R/554-5265 (Apr. 17, 2012).

94. *See* 14 C.F.R. § 77.31(d) (2011).

95. *See* U.S. DEP'T OF TRANSP. FED. AVIATION ADMIN., ORDER JO 7400.2K, PROCEDURES FOR HANDLING AIRSPACE MATTERS 7-1-1 (Apr. 3, 2014), https://www.faa.gov/documentLibrary/media/Order/7400.2K_w_ Chg1_dtd_7-24-14.pdf [https://perma.cc/6UCU-W5YD].

96. *See id.* at 7-1-2.

97. *See FAA Determinations*, *supra* note 90. The FAA can also issue a Determination of No Hazard with Conditions that allows the project to continue subject to mitigating measures such as lighting or marking. *See id.*

98. Regardless of the determination, the FAA determinations are appealable. *See id.*

99. *See* DEP'T OF DEF., *supra* note 50.

100. JEFFREY LOGAN & STAN MARK KAPLAN, CONG. RESEARCH SERV., RL34546, WIND POWER IN THE UNITED STATES: TECHNOLOGY, ECONOMIC, AND POLICY ISSUES 35 (2008).

determinations were to be made on a case-by-case basis.[101] DOD recognized the need to develop mitigation strategies beyond merely preventing the development of wind turbines in the line of sight.[102] Accordingly, DOD initiated research to determine future mitigation strategies.[103]

In addition to independent determinations made by DOD, a number of sub-agencies also participate in the permitting process. The North American Aerospace Defense Command (NORAD) is an American-Canadian bilateral organization charged with maintaining and using the early-warning air defense radars.[104] The United States Northern Command (US NORTHCOM) is the body within DOD that coordinates homeland security efforts.[105] Different branches of the military also have radar systems under their control, which could be affected by wind turbines.[106] It bears stressing that neither DOD nor any of its branches have any independent regulatory authority.[107] FAA makes the final determination regarding proposed wind projects and can green-light proposed projects even over DOD objections.[108]

Prior to Congress' adoption of the Ike Skelton National Defense Authorization Act of 2011 (ISNDA),[109] DOD was not responding to wind power projects in a timely and coherent manner.[110] One of the objectives of ISNDA was to develop a process through which DOD would aid in the development of renewable resources while minimizing any adverse effects on military readiness.[111] This

---

101. *See id.*

102. *See id.*

103. *See id.*

104. *About NORAD*, N. AM. AEROSPACE DEF. COMMAND, http://www.norad.mil/About-NORAD/ [https://perma.cc/PCP9-KU5Q] (last visited Sept. 24, 2018).

105. *About USNORTHCOM*, U.S. N. COMMAND, http://www.northcom.mil/About-USNORTHCOM/ [https://perma.cc/P64Y-BNE5] (last visited Sept. 24, 2018).

106. *See* JOSEPH P. CAMACHO, U.S. DEP'T OF COMMERCE, FEDERAL RADAR SPECTRUM REQUIREMENTS 4-7 (May 2000), https://www.ntia.doc.gov/files/ntia/publications/ntia00-40.pdf [https://perma.cc/VN9B-8LVL].

107. *See supra* Section III.A (discussing the FAA's regulatory authority over siting wind farms).

108. *See* 49 U.S.C. § 44718 (2012). Under this statute the Secretary of Transportation has final authority over structures that may interfere with air commerce. That authority has been delegated to the FAA.

109. Ike Skelton National Defense Authorization Act for Fiscal Year 2011, Pub. L. No. 111-383, 124 Stat. 4137 (2011).

110. Multiple diverse bodies within DOD could be affected by projects as mentioned above. *See infra* Part IV (exemplifying the delay in DOD coming to the table to discuss an Oregon wind farm project).

111. *See* Ike Skelton National Defense Authorization Act *supra* note 109, § 358 (explaining the objective of ISNDA).

legislation changed how DOD responds to projects internally and aimed to foster coordination between all stakeholders within DOD.[112] Section 358 of ISNDA discusses fostering wind-energy development and improving DOD responses to the FAA during the permitting process.[113] These measures in theory allow NORAD, US NORTHCOM, the Air Force, and others to efficiently respond to projects pending before the FAA by implementing a formal procedure for the agencies to follow.

The first step in the retooled DOD internal procedure is Triage, during which DOD performs a preliminary assessment with the FAA's raw data.[114] The next step is an 84 RADES assessment.[115] The 84th Radar Evaluation Squadron, the entity tasked with assessing impacts on radar systems, performs an 84 RADES assessment.[116] If the 84th Radar Evaluation Squadron finds that a project will have a moderate to severe impact on radar systems, the analysis shifts to the Operational Risk Assessment (ORA) team for a more in-depth assessment.

This revised process mitigates earlier problems arising from late DOD involvement in the FAA approval process.[117] ORA considers technical and operational mitigation options and can take one of two actions: (1) approve the project and accept the risk, or (2) request DOD coordination with the FAA in issuing a Determination of Hazard.[118] Requesting coordination with FAA personnel on a particular case allows more DOD involvement in FAA's process and a greater say in the outcome of a hazard determination. DOD is likely to ask to coordinate with FAA only in circumstances where the risk to a radar station is deemed substantial.[119]

In sum, the responsibility for approving or denying a wind energy facility permit rests solely with the FAA.[120] This remains true despite the acknowledged threat that wind-energy constructions can pose to military radars.[121] Furthermore, and perhaps more concerning, is the fact that the threat wind turbines pose to aviation radars has not been fully quantified and indeed may be impossible to accurately

---

112. *See id.*
113. *See id.*
114. *Presentation*, *supra* note 73.
115. *See id.*
116. *See generally id.*
117. *See id.*
118. *See id.*
119. *See id.*
120. *See supra* notes 75-83.
121. *See supra* notes 63-73.

measure.[122] Even with the new procedures in place, DOD's role remains strictly advisory.[123] Without the regulatory authority to deny wind farm developers the ability to develop, DOD is at the mercy of the FAA decision-making process.

A wind farm operating in Boardman, Oregon offers a useful illustration of the interplay between DOD and the FAA.[124] A case study of this facility, known as Shepherds Flat, illustrates how both agencies must make determinations in the absence of crucially relevant data.[125] As shown below, the federal government knows the type of interference wind turbines cause and that radar systems can deal with a certain amount of interference and still perform adequately. However, no one knows how to predict when one turbine will produce an amount of interference that will cause radar systems to perform inadequately.[126]

IV. Uncertainties in Calculating the Cost of Wind Energy: A Case Study of Boardman, Oregon—Shepherds Flat

Assessing the value of a wind-energy facility can be challenging. The benefits (clean, renewable energy) are obvious. But when a facility can pose an immeasurable potential threat to air defense systems, the cost-benefit analysis becomes more complicated.

The Shepherds Flat wind farm in northeastern Oregon is the third largest operational wind farm in the country and one of the largest onshore wind farms in the world.[127] In 2010, Caithness Energy proposed the addition of 338 new turbines across 32,100 acres of land.[128] The proposed construction promised a generating capacity of 845 MW, enough to power 227,000 households.[129]

---

122. *See Presentation*, *supra* note 73.
123. *See Informational Paper*, *supra* note 93.
124. *See infra* Part IV.
125. *See id.*
126. *See Presentation*, *supra* note 73.
127. *See* Tom Wadlow, *Top 10 Onshore Wind Farms*, Energy Digital (Jan. 5, 2017), https://www.energydigital.com/top-10/top-10-onshore-wind-farms [https://perma.cc/8MHP-6GUM]; *see also* Eilperin, *supra* note 81.
128. *Caithness Shepherds Flat Facts*, CAITHNESS SHEPHERDS FLAT WIND FARM, https://www.caithnessshepherdsflat.com/project-facts/ [https://perma.cc/NM9S-VN9D] (last visited Sept. 24, 2018).
129. *See* Erik Siemers, *Shepherds Flat, One of the World's Biggest Windfarms, Up and Running in Oregon*, PORTLAND BUS. J. (Sept. 24, 2012, 6:42 AM), https://www.bizjournals.com/portland/morning_call/2012/09/shepherds-flat-one-of-worlds-biggest.html [https://perma.cc/WP6C-NTJZ]; *see also Caithness Shepherds Flat Facts*, *supra* note 128.

The Pentagon threatened to derail the project and other renewable energy projects in the area.[130] This project and seven others were temporarily suspended because of potential interference with a long-range air defense radar system near Fossil, Oregon.[131] In March 2010, the FAA rejected the project and issued an NPH based on concerns from the Air Force, NORAD, and US NORTHCOM that the turbines could detrimentally affect nearby radars.[132] Specifically, the NPH stated that the proposed turbines would be located within the radar line-of-sight of the Fossil station and could "seriously impair the ability of the [DOD] to detect, monitor[,] and safely conduct air operations in this region."[133]

FAA's rejection came two months before the project was to break ground. Unsurprisingly, the decision engendered considerable criticism.[134] Caithness Executive Vice President Ross Ain declared: "We're extremely disappointed that the concerns raised by the Air Force at the 25th hour threatens [sic] to crater literally billions of dollars of renewable energy in the United States and tens of thousands of jobs in renewable energy."[135] Ain's frustration was understandable. At the time DOD became involved with the Shepherds Flat proposal, the project had already been in the works for nine years,[136] and the ISNDA had not yet been enacted. Consequently, DOD was asked to consult with the FAA very late in the process.[137]

DOD eventually concurred with the issuance of a DNH by FAA for Shepherds Flat.[138] However, it retained serious concerns about the project because it remained unable to determine the impact individual wind turbines would have on the radar station.[139] In February 2010,

130. *See* Eilperin, *supra* note 81.

131. *Wind Farms to Bloom Across Eastern Oregon*, NAT'L WIND WATCH (Oct. 10, 2010), https://www.wind-watch.org/news/2010/10/03/wind-farms-to-bloom-across-eastern-oregon/ [https://perma.cc/A9D4-QFNG].

132. Scott Lear, *Air Force Concerns About Radar Interference Stall Huge Oregon Wind Energy Farm*, OREGONIAN (Apr. 14, 2010), http://www.oregonlive.com/environment/index.ssf/2010/04/air_force_concerns_about_radar.html [https://perma.cc/P4PA-UR2T].

133. *Id.*

134. *See* Eilperin, *supra* note 81.

135. *Id.*

136. *Id.*

137. *Id.*

138. *See* Press Release, Jeff Merkley, Shepherds Flat Wind Farm Will Move Forward, U.S. Senate (Apr. 30, 2010), https://www.merkley.senate.gov/news/press-releases/-shepherds-flat-wind-farm-will-move-forward [https://perma.cc/7DQB-DHUF].

139. *See* Scott Learn, *Pentagon Drops Opposition to Big Oregon Wind Farm*, OREGONIAN (Apr. 30, 2010), https://www.oregonlive.com/environment/

DOD recommended that FAA consider the project a hazard.[140] It determined that the proposed project "as planned, [would] cause loss of radar coverage to a level that increases operational risk to an unacceptable level."[141] NORAD and US NORTHCOM then evaluated the operational impact of the project and recommended mitigation strategies "that *may* eliminate the interference or reduce it to the maximum extent possible."[142] Among the mitigation strategies were two recommended alternate areas for the proposed turbines.[143] DOD also proposed masking the turbines.[144] Without masking, DOD feared that the project would:

> [D]rive the radar processing constraints to such a high level that it [would] provide questionable coverage throughout the entire radar coverage volume. This reduction in capability comes in the form of erroneous aircraft returns and/or suppressed aircraft returns. Unreliable coverage directly impacts flight safety, intercept operations, and may prevent detection of new targets.[145]

If the Fossil, Oregon radar station became unreliable, the next closest radar station was in Salem, Oregon, over 200 miles away.[146] DOD further explained that if a security threat was in the area and the military became unable to launch a counter attack from Fossil due to a threat assessment failure, the next closest base lay over 500 miles away.[147] Of main concern was the potential inability of the radars to provide targeting information that would signal NORAD to launch fighter aircrafts in response to a threat.[148]

In April 2010, following the Air Force's objections and FAA's rejection of the project, DOD conducted a study with the Massachusetts Institute of Technology to develop mitigation measures.[149] The results suggested that the project would be less

---

index.ssf/2010/04/air_forces_drops_opposition_to.html [https://perma.cc/B5CQ-VGHY].

140. Operational Impact of the Shepherds Flat Wind Farm Proposal, U.S. Dep't of Def., U.S. Northern Command, Congressional Fact Sheet.

141. *Id.*

142. *Id.*

143. *Id.*

144. Masking turbines involves drowning out the noise of the turbines to reduce the impact of noise interference. *See id.*; *see also* Brian F. Keane, *Let's Get Real on Wind Turbine Noise,* HUFFINGTON POST (Oct. 8, 2010), https://www.huffingtonpost.com/brian-keane/lets-get-real-on-wind-tur_b_754584.html [https://perma.cc/JLY7-BHTB].

145. Congressional Fact Sheet, *supra* note 140.

146. *Id.*

147. *Id.*

148. *Id.*

149. *See Wind Farms*, *supra* note 47, at 6.

detrimental to the Fossil station than previously thought, and that certain software could be incorporated at the Fossil station to differentiate between real and false targets.[150] There are "options, based on . . . experiments they ran . . . from adjusting the settings to optimiz[ing] the existing technology to inserting new technology, such as an adaptive clutter map that can edit out false targets."[151] On April 30, 2012, after years of evaluating the project, the Air Force withdrew its initial objections, deciding instead to implement the upgrades recommended by the study.[152]

Although DOD withdrew its objections, concerns remained.[153] For example, the Navy submitted the following statement:

> [W]hile the evaluation determined the structures do not meet the FAA standards for an adverse aeronautical effect; construction of wind turbines does pose a high risk of unacceptable impact to national security and operation impact to the Department of the Navy in conducting low altitude tactical and surface to air counter-tactics training. As such, request the FAA include a statement in the Aeronautical Study requesting the developer coordinate with the Executive Director, Department of Defense Siting Clearinghouse.[154]

As mentioned, these objections were included in the notice that approved the project.[155] That means the FAA issued a DNH even though divisions of DOD still objected to the project.

The problem from DOD's perspective was not just this particular project, but rather what could happen when other developers or the current developer wished to develop even more turbines in the same location. The real gap in knowledge lies in the inability to determine how much degradation a particular radar station will experience from any given turbine or turbines.[156] Thus, even though DOD updated the radar system in this particular instance, it still cannot definitively state that these wind turbines will not affect its radar in an unacceptable way. Phrased differently, DOD knows the facility poses a threat but it cannot accurately assess the severity of the threat. Nevertheless, it withdrew its objections to the project.

---

150. *See id.*

151. *Id.*

152. *See id.* at 26.

153. *See* FAA, Division Responses, Case Overview, ASN: 2010-WTW-2670-OE.

154. *Id.*

155. *See id.* In the Case Overview section of the Division Responses, the document goes through all of the following divisions and their objections: (1) Air Force, (2) Airports, (3) Army, (4) Flight Procedures, (5) Flight Standards, (6) Frequency Management, (7) Navy, (8) Tech Ops, and (9) subdivisions of Tech Ops. *Id.*

156. *See* Informational Paper, *supra* note 93.

This decision is particularly concerning since radar upgrades can sometimes exacerbate problems.[157] For example, in 2006 the Air Force temporarily upgraded its air traffic control radar at the Travis Air Force Base in Solano County, California only to find that the upgrade led to more interference.[158] In that instance, the Air Force upgraded from an analog to a digital system; this led to random weather cells causing operators to lose track of planes they were following.[159] The simple truth is DOD does not know when a turbine will cause too much interference even for an updated radar system. It makes educated guesses, which may or may not be accurate. This seems a heady gamble to make with national security.[160]

V. CURRENT MITIGATION STRATEGIES

Though DOD's role remains advisory, the federal government as a whole has recently started taking the issue more seriously. In January 2016, the Energy Efficiency and Renewable Energy Division of the DOE released a report offering ideas for mitigating radar interference from wind technology.[161] In this report, DOE acknowledged the detrimental effects that wind technology can exert on air-traffic control, weather forecasting, homeland security, and national defense, and created a working group to focus on potential mitigation strategies.[162] The working group is comprised of multiple federal agencies including the DOE, DOD, FAA, and the National Oceanic and Atmospheric Administration (NOAA).[163]

By 2025, the working group intends to "fully address wind turbine radar interference as an impact to critical radar missions, ensure the long-term resilience of radar operations in the presence of wind turbines, and remove radar interference as an impediment to future wind energy development."[164] In order to accomplish these objectives, the working group developed three strategic themes:

1. Improving the capacity of government and industry to evaluate the impacts of existing and planned wind energy installations on sensitive radar systems[;]

---

157. *See* Losco & Collick, *supra* note 74, at 236
158. *See id.*
159. *See id.*
160. Energy, Urban Development and Aerospace Capabilities Deconfliction Branch, Presentation, NORAD J36R, (Feb. 21, 2012).
161. *See generally* FEDERAL INTERAGENCY REPORT, *supra* note 63.
162. *See id.* at vii.
163. *See id.*
164. *Id.*

2. Developing and facilitating the deployment of hardware and software mitigation measures to increase the resilience of existing radar systems to wind turbines[; and]
3. Encouraging the development of next-generation radar systems that are resistant to wind turbine radar interference. [165]

The working group seeks to develop new tools and improve the capabilities of existing tools so as to more effectively identify the impacts of wind technology on military radar systems.[166] Through modeling and simulation tools, wind developers and government entities can then mitigate any negative impacts prior to construction.[167]

Among the existing pre-construction mitigation strategies is DOD's Preliminary Screening Tool.[168] This tool allows wind developers to obtain a preliminary review of potential effects of their proposed development on long-range air defense and national security radars, military training routes, and special airspaces.[169] This tool operates by identifying the longitude and latitude of the proposed development and the type of radar to be affected—long-range, military training, or special airspace, for example.[170] Once these factors are identified, the tool uses a color-coded system to rate the project. Green means no impact, yellow is likely impact, and red denotes a high likelihood of impact.[171]

A second interference mitigation strategy—Tools for Siting, Planning, and Encroachment Analysis of Renewables—was developed in collaboration with five government entities (DOE, DOD, DHS, FAA at the Department of Transportation, and NOAA) and Sandia National Laboratories.[172] It aims to identify barriers to renewable energy development (e.g., radar interference) and develop appropriate mitigation strategies.[173] This tool models the potential impacts of the wind development and creates a scorecard of the estimated impact on radar systems.[174] As of this writing, both tools were available for developers' use but not required.[175]

---

165. *Id.*
166. *See id.* at 5.
167. *See id.*
168. *See id.*; *see also DoD Preliminary Screening Tool*, *supra* note 92.
169. *See DoD Preliminary Screening Tool*, *supra* note 92.
170. *See id.*
171. *See id.*
172. *See Wind Turbine Radar Interference Mitigation (WTRIM)*, *supra* note 49.
173. *See id.*
174. *See id.*
175. *See id.*

The objectives of the second phase of the working group strategy include: (1) facilitating the deployment of current existing mitigation measures, (2) deploying hardware and software upgrades to make existing radars more resilient, (3) improving the capacity of existing automation and command and control systems, and (4) exploring at-the-turbine mitigation methods to reduce radar impacts.[176] The final strategic objective involves ensuring that new radar developments address wind-turbine interference during the design development process.[177] This will require collaboration with radar developers to build "radars that are more robust to wind turbines [as] a long-term solution to wind turbine radar interference."[178] Many such radars have already been developed (e.g., Multi-Function Phased Array Radar, Three-Dimensional Expeditionary Long-Range Radar) and provide models from which future developers will work.[179]

In sum, the objectives of the working group—including simulation models, upgraded software, and design development initiatives—will theoretically aid in the recognition of radar interference prior to the construction of wind energy projects.[180] However, the seven-year time horizon for implementing these strategies leaves a sizeable gap during which the ever-expanding development of wind could detrimentally interfere with national security. And that interference may not be measured or even noticed because DOD cannot measure interference if it lacks a functioning method of determining whether such interference exists.

While this knowledge gap is neither surprising nor an insurmountable challenge, it does underscore a serious flaw in the federal response to uncertainty. Because the government has been slow to recognize the severity and breadth of the problem, the United States faces acknowledged gaps in its air defense systems without knowing exactly where and how severe those gaps are or how to effectively remedy them. While all complex systems contain uncertainty,[181] and addressing and allowing for the unknown factors forms part of any functional risk management strategy,[182] the wind-turbine and radar-interference problem projects an untenable level of uncertainty into a highly volatile and already risk-laden environment.

---

176. *See* FEDERAL INTERAGENCY REPORT, *supra* note 63, at vii, 10.

177. *See* Krug & Lewke, *supra* note 62, at 1121.

178. FEDERAL INTERAGENCY REPORT, *supra* note 63, at 10.

179. *See id.*

180. *See generally id.*

181. *See* David N. Cassuto & Romulo S. R. Sampaio, *Keeping it Legal: Transboundary Management Challenges Facing Brazil and the Guarani*, 36 WATER INT'L 661, 667 (2011).

182. *See id.* at 668.

VI. UNCERTAINTY AS A POLICY ISSUE AND TOOL

Uncertainty plays an important role in policymaking and stems from either a lack of information, lack of access to information, or both.[183] When the lack of information is measurable, we call it risk. When the information deficit cannot be measured (i.e., it is unknown or unquantifiable), that "raw" uncertainty lies outside the bounds of ascertainable risk and cannot be integrated into a risk assessment. Elsewhere Romulo Sampaio and I have divided these two distinct stages into "hard" and "soft" uncertainty.[184]

Hard uncertainty refers to when the triggering event or circumstances are known but the probabilities of possible outcomes or even the outcomes themselves defy prediction.[185] Soft uncertainty applies to circumstances where potential outcomes and their probabilities can be projected.[186] In such cases, risks can be assessed.[187] Consequently, soft uncertainty scenarios are subject to cost-benefit analysis whereas instances of hard uncertainty are not. As noted earlier and discussed in more detail below, both hard and soft uncertainty present themselves in the interaction between wind turbines and military radars.

Uncertainty necessarily complicates decision making. Accurate risk assessment (upon which sound decision-making relies) requires the best available information and technology, both of which vary widely depending on region and circumstances. It also bears emphasizing that risk assessment is inherently subjective and region specific.[188] Policy decisions can never equally favor all parties. They necessarily generate social costs that must be allocated amongst stakeholders (and sometimes among those without any definable interest). Sound policy making therefore involves choices that create different impacts across demographically and geographically distinct communities, even while seeking to minimize global risk.

Perceptions of risk and the advisability of potential responses can also vary widely.[189] For example, some nations might accept the risks of genetically modified organisms (GMOs) in light of the boost it could provide to their agricultural sectors, while others reject such

183. *See id.* at 667.
184. *See id.*
185. *See id.*
186. *See id.*
187. *See id.*
188. Ralph Strauch, Risk Assessment as a Subjective Process, 44th Military Operations Research Symposium (Dec. 5. 1979).
189. *See generally* Kym Anderson & Lee A. Jackson, *Why Are US and EU Policies Toward GMOs So Different?*, 6 AGBIOFORUM 95 (2003).

risks because the dangers of GMOs outweigh any potential gains.[190] Or, on a more micro level, a town might close a beach because of rip currents, to the consternation of many vacationers willing (and in many cases able) to assess and address the risks of swimming under such conditions.

A. Utilizing a Precautionary Principle

The law imposes regulatory demands that create opportunity through restraint. The nature of hard uncertainty requires policymakers to act in the face of unknown and unknowable risk.[191] This seemingly precludes rational policymaking since reasoned analysis is impossible in the absence of information.[192] Yet, even as the nature of the uncertainty (or even its existence) cannot be known, reducing asymmetric information can reveal previously unknown risks by, for example, bringing local knowledge to bear on a problem about whose existence the larger community was unaware.[193] This process can shift previously unknown unknowns (hard uncertainty) into the realm of known unknowns (soft uncertainty), thereby enabling rational risk assessment and creating opportunity.[194] This approach undergirds the Precautionary Principle and could prove particularly useful in assessing the viability of particular wind-energy projects amidst uncertainty about radar interference.

B. Degree of Risk & Probability Neglect

Simply stated, the Precautionary Principle signifies that an information deficit cannot justify decisions that put people or the environment at risk.[195] In this sense, precaution need not (and does not) mean risk aversion.[196] It rather means that functional risk assessment accounts for the equitable distribution of as yet unknown harms and

---

190. *See id.* at 99.
191. *See* Cassuto & Sampaio, *supra* note 181, at 667.
192. *See id.*
193. *See id.*
194. *See id.* at 667-68.
195. *See* David Kriebel et al., *The Precautionary Principle in Environmental Science,* 109 ENVTL. HEALTH PERSPS. 871, 871 (2001) ("The precautionary principle encourages policies that protect human health and the environment in the face of uncertain risks.").
196. *See generally id.*

impacts.[197] It offers a framework for rational decision making in a context of uncertainty.[198]

The degree of openness to risk may be expressed in terms of the ratio of soft to hard uncertainty.[199] When soft uncertainties (known unknowns) predominate, cost-benefit analyses gain coherence and risk assessment becomes a tool for mitigating harm and alleviating concern. While uncertainty remains, likelihoods of potential outcomes become measurable.

In hard-uncertainty scenarios, policymakers do not know what they do not know and act out of ignorance. Such actions are necessarily rash and can involve reactions to the specter of risk rather than the risk itself. A feedback loop results that diverts resources away from risk assessment and toward rearguard measures aimed at safeguarding the status quo.[200] Rather than examine the implications of a situation, people try and think of comparable examples.[201] If an example comes readily forward, it can form the basis for the societal response even if its incidence is statistically rare.[202]

For instance, the federal government devotes enormous time and resources to deterring and deporting undocumented immigrants, citing a danger to national security.[203] Yet, the statistical correlation between illegal immigration and domestic terrorism is remarkably low.[204] This tendency to focus on areas of low risk but heightened fear leads to what Kuran and Sunstein have labeled an "availability cascade,"

---

197. *See generally id.*

198. *See id.* at 875.

199. *See* Cassuto & Sampaio, *supra* note 181.

200. *See* Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law*, 112 YALE L.J. 61, 98-100 (2002).

201. *See id.* at 85-86.

202. *See id.*

203. *See* Emmarie Huetteman & Caitlin Dickerson, *With His Guests, Trump to Highlight Illegal Immigration as a Security Issue*, N.Y. TIMES (Feb. 28, 2017), https://www.nytimes.com/2017/02/28/us/politics/first-ladys-box-guest-list.html [https://perma.cc/G2ZP-M5JL].

204. Dave Bobkoff, Dave Mosher, & Skye Gould, *Trump's Speech Highlighted Victims of Crimes by Immigrants – But a Look at the Data Shows It's Incredibly Rare*, BUS. INSIDER (Mar. 1, 2017, 11:15 AM), https://www.businessinsider.com/trump-voice-office-for-victims-of-immigrant-crime-numbers-not-necessary-2017-3 [https://perma.cc/U2RV-97MZ] (noting data explains that the likelihood of an American being murdered by an undocumented immigrant terrorist is 1 in 10.9 billion). It also bears noting that U.S. nationals commit the majority of domestic terrorism with weapons obtained legally. *See id.* Yet, there, the federal government has shown no willingness to stop the proliferation of firearms. *See* Elizabeth Chuck, *More than 80 Percent of Guns in Mass Shootings Obtained Legally*, NBC NEWS (Dec. 5, 2015, 12:02 PM), https://www.nbcnews.com/storyline/san-bernardino-shooting/more-80-percent-guns-used-mass-shootings-obtained-legally-n474441 [https://perma.cc/3QZ2-EYTU].

wherein the ensuing abundance of information about the perceived low-risk action makes it increasingly difficult to obtain information about other more serious threats.[205] Those who doubt the perceived risk begin doubting themselves, thereby silencing an important constituency whose opinions might lead to more rational behavior.[206]

The result of these linked phenomena is "probability neglect," wherein feelings of fear cause people to ignore probabilities and focus instead on the worst case irrespective of the greater danger from other causes.[207] Probability neglect diverts resources away from serious dangers and concentrates them instead on palliating social unease.[208] The result is increased hard uncertainty, which in turn leads to greater probability neglect. This poorly conceived precautionary approach has led to significant societal dysfunction and mismanagement of resources.[209]

Not all precautionary approaches to hard uncertainty are irrational, however. Postponing projects or regulatory action until information can be gathered and analyzed is itself a form of cost-benefit analysis.[210] It posits that the benefits of immediate action or regulation are outweighed by those gained through information gathering.[211] That is the case with respect to interactions between wind turbines and military radars.

1. *Interference Presents a Hard Uncertainty Scenario*

As earlier noted, hard uncertainty refers to situations where the triggering event is known but possible outcomes cannot be predicted or even known.[212] Wind turbines interfering with radars fit within this definition. The triggering event (turbine construction within territory

205. *See* Timur Kuran & Cass R. Sunstein, *Availability Cascades and Risk Regulation* 685 (Univ. of Chi. Pub. Law & Legal Theory, Working Paper No. 181, 2007).

206. *See id.* at 868-87.

207. *See* Sunstein, *supra* note 200, at 63.

208. *See id.* at 98-100.

209. *See id.* at 102.

210. *See* Nicholas A. Ashford, *The Legacy of the Precautionary Principle in US Law: The Rise of Cost-Benefit Analysis and Risk Assessment as Undermining Factors in Health, Safety and Environmental Protection*, *in* IMPLEMENTING THE PRECAUTIONARY PRINCIPLE: APPROACHES FROM THE NORDIC COUNTRIES, THE EU AND THE UNITED STATES 352, 355 (Nicolas de Sadeleer ed., 2007).

211. *See id.*

212. *See* Cassuto & Sampaio, *supra* note 181, at 667.

surveilled by aviation radar) is known. Possible outcomes (interference or lack thereof) are also known.[213]

However, the limitations of existing technology make calculating the probabilities of possible outcomes impossible. We cannot know if a given project causes interference, whether expanding it will cause interference, or whether the interference, if known, could be successfully mitigated. This inability to determine whether a threat even exists makes calculating possible outcomes impossible—a textbook example of hard uncertainty.[214]

2. *Compromised Radar Presents a Significant Risk, But So Too Does a Failure to Develop Renewable Energy Sources*

If military radar fails to function, incoming threats—from ballistic missiles to hostile aircraft—could escape notice and cause horrific damage. This risk is heightened by the nature of the hard uncertainty that potential interference causes. If DOD does not know if and how the air defense system might be compromised, it cannot know of a threat's existence or its dimensions. It therefore cannot take any steps to mitigate the danger. Thus, the military currently faces the possibility of a compromised air defense system while lacking the ability to determine whether the problem actually exists, its extent, or how to mitigate it.

Failing to develop wind energy also presents risks and hard uncertainty. Should the United States continue its reliance on fossil fuels, it faces continued degradation of the air, soil, and water, expanding human health threats, as well as species and habitat loss.[215] In addition, the dangers of a disrupted climate grow daily more severe. Without a drastically lowered global carbon output, which will necessitate immediate action by the U.S. to lower its emissions, the impacts of climate change will worsen in ways that models are not yet adequate to predict.[216]

---

213. It bears mentioning, however, that the possible consequences of interference are not known. They could range from negligible through disastrous (severe aviation mishap) to globally catastrophic (nuclear war).

214. *See* Cassuto & Sampaio, *supra* note 181, at 667.

215. *See The Localized Health Impacts of Fossil Fuels*, CLIMATE NEXUS, https://climatenexus.org/climate-issues/health/the-localized-health-impacts-of-fossil-fuels/ [https://perma.cc/CP78-D55S] ("[A]ir pollution from power generation causes 52,000 premature deaths per year . . . ."); *See also The Sources and Solutions: Fossil Fuels,* EPA, https://www.epa.gov/nutrientpollution/sources-and-solutions-fossil-fuels [https://perma.cc/ART2-BSWA] (last visited Sept. 24, 2018) (stating the impact that nitrogen pollution from fossil fuels has on plant and animal life).

216. *See How Climate is Changing*, NASA, https://climate.nasa.gov/effects/ [https://perma.cc/MM7L-WJA8] (last visited Sept. 24, 2018) ("Effects that scientists

By contrast, both military radar and wind energy installations offer significant (and obvious) benefits.[217] Radar is essential for maintaining homeland security while wind energy forms part of the suite of renewable alternatives that are also vital for national security.[218] The question is not whether the respective costs of military radar and wind energy outweigh their benefits.[219] The question rather is whether the risks of developing wind energy in proximity to radar installations outweigh the benefits they respectively and collectively offer.

Since it is impossible to determine the extent of the risk, the analysis must focus instead on whether the Precautionary Principle should apply. As elaborated below, I argue that the answer is "yes."[220] The permitting process for wind-energy facilities must be modified to address the information deficit and every effort made to retrofit existing facilities where wind turbines pose a potential hazard.

3. *The Danger of Availability Cascade & Probability Neglect*

Availability cascades occur when either the state, media, or both focus on issues that capture the popular imagination to the exclusion of other phenomena that require attention.[221] One need only glance at the news to see any number of candidates competing to occupy the field to the exclusion of other important issues. One relevant and related example is the North Korean nuclear threat.[222]

---

had predicted in the past would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise and longer, more intense heat waves.").

217. *See* FEDERAL INTERAGENCY REPORT, *supra* note 63, at vii.

218. *See* C.N.A. MILITARY ADVISORY BOARD, ADVANCED ENERGY AND U.S. NATIONAL SECURITY I (2017), https://www.cna.org/CNA_files/PDF/IRM-2017-U-015512.pdf [https://perma.cc/K5XM-4KVH] ("U.S. leadership in advanced energy development and deployment can yield domestic and international opportunities across our national security spectrum. Should America embrace and accelerate the use of advanced energy sources, it can open new markets for a wide range of goods and services, promote prosperity in emerging economies, and establish new energy tethers and political influence.").

219. *Cf., e.g.*, Maeve White, *Effect of Wind Turbines on Bird Mortality*, http://large.stanford.edu/courses/2016/ph240/white1/ [https://perma.cc/H66H-VNFG]; Brian F. Keane, *Let's Get Real on Wind Turbine Noise*, HUFFINGTON POST (May 25, 2011), https://www.huffingtonpost.com/brian-keane/lets-get-real-on-wind-tur_b_754584.html [https://perma.cc/UKZ2-VSHM]. This is not to say that no costs exist. *See* White, *supra* note 219; Keane, *supra* note 219.

220. *See infra* Subsection VI.B.4 and accompanying text.

221. *See* Kuran & Sunstein, *supra* note 205, at 686.

222. *See North Korea's Nuclear Weapons: What We Know*, ALJAZEERA (Feb. 20, 2018), http://www.aljazeera.com/news/2017/05/north-korea-testing-nuclear-weapons-170504072226461.html [https://perma.cc/TN6E-969Q].

In this instance, North Korea's nuclear posturing and the Trump Administration's saber rattling provide genuine cause for concern.[223] North Korea has developed both the weapons and the delivery system to potentially target the United States mainland,[224] and it has stated its desire to use them.[225] The American diplomatic response has consisted—at least in part—of incendiary tweeting.[226] One might think this and the many other regimes and non-state actors who have expressed a desire to harm the United States would spur increased interest in, and attention to, the military's threat detection apparatus. This has not occurred.

Instead, the availability cascade has spiraled into probability neglect. The Trump Administration has ignored expert advice and called for expanding the U.S. nuclear arsenal.[227] Those calls come despite the fact that the U.S. already possess more nuclear weapons than every other country in the world excepting Russia[228] The focus on building up the nation's already superior nuclear capability has diverted attention and likely will divert resources away from upgrading the nation's radar systems. This is despite the reality that the problem of interference and outdated technology presents a recognized, urgent, and ongoing threat to national security.[229]

---

223. *See id.*

224. *Id.* ("'The entire mainland of the US is within the range of our nuclear weapons and the nuclear button is always on the desk of my office,' said North Korean leader Kim Jong-un during his 2018 New Year's address.").

225. *See id.*

226. *See* @realDonaldTrump, TWITTER (Jan. 2, 2018, 4:49 PM), https://twitter.com/realDonaldTrump/status/948355557022420992 [https://perma.cc/2UDB-LC39] ("North Korean Leader Kim Jong Un just stated that the 'Nuclear Button is on his desk at all times.' Will someone from his depleted and food starved regime please inform him that I too have a Nuclear Button, but it is a much bigger & more powerful one than his, and my Button works!").

227. *See* William J. Broad & David E. Sanger, *Trump Plans for Nuclear Arsenal Require $1.2 Trillion, Congressional Review States*, N.Y. TIMES (Oct. 31, 2017), https://www.nytimes.com/2017/10/31/us/politics/trump-nuclear-weapons-arsenal-congressional-budget.html [https://perma.cc/6XPH-D747].

228. *See* Michal Kranz, *A Leaked Pentagon Document Shows that the Trump Administration Wants to Expand the US Nuclear Arsenal*, BUS. INSIDER (Jan. 12, 2018, 6:48 PM), http://www.businessinsider.com/trump-wants-to-expand-the-us-nuclear-arsenal-2018-1 [https://perma.cc/C9K4-V56K].

229. *See* OFFICE OF THE DIR. OF DEF. RESEARCH & ENG'G, *supra* note 44, at 2-5, 56-57.

4. *A Way Forward: The Precautionary Principle*

The status quo with respect to wind turbines interfering with military radar is untenable and dangerous.[230] Yet, both wind energy and radar are necessary to national security.[231] Any solution must therefore acknowledge the role that they respectively play while offering a blueprint for a sustainable future. In short, despite entrenched antipathy in U.S. law and policy toward the Precautionary Principle,[232] the conflict between wind and radar and the potentially disastrous consequences arising therefrom militate for a precautionary approach.[233]

When absence of information creates or masks a threat, that incalculable risk must factor into sound decision making. This is the essence of the Precautionary Principle.[234] Unlike, for example, the GMO dispute, where disagreement exists over whether GMOs pose any significant risk to humans or ecosystems,[235] no one disputes the fact that wind turbines interfere with military radar. That potential interference represents a clear threat to national security.[236] What is not known is the extent of the interference and the resulting dimension of the threat. Continuing to permit and build wind energy installations in proximity to military radar therefore seems foolhardy and unnecessary.

Instead, caution is called for while the information deficit is addressed.[237] Specifically, I propose the following:

1. Suspend outstanding permit applications seeking to site wind turbines near radar facilities. Until the FAA and DOD possess the technological means to evaluate the potential threat, there should be no new construction that risks compromising the nation's air defense capability.
2. To the extent that more resources can expedite the timetable for DOD to complete its analysis on how best to

230. *See id.*

231. *See id.* at 2.

232. *See* Ashford, *supra* note 210, at 352-53.

233. *See* OFFICE OF THE DIR. OF DEF. RESEARCH & ENG'G, *supra* note 44, at 2.

234. *See generally* Katie Steele, *The Precautionary Principle: A New Approach to Public Decision-Making,* 5 L., PROBABILITY & RISK 19 (2006).

235. *See* M.J. Peterson, *The EU-US Dispute over Regulation of Genetically Modified Organisms, Plants, Feeds, and Foods – Case Summary*, INT'L DIMENSIONS OF ETHICS EDUC. IN SCI. & ENG'G 1, 3 (2010), https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1007&context=edethicsinscience [https://perma.cc/B3HR-URKW].

236. *See* OFFICE OF THE DIR. OF DEF. RESEARCH & ENG'G, *supra* note 44, at 2, 4, 56-57.

237. *See* Kriebel et al., *supra* note 195, at 871.

solve the interference problem, those resources should be made available. Easy conclusions stemming from availability cascades should be resisted. Instead, the focus must be on solving this under-publicized but urgent national security dilemma. The United States faces a clear and pressing problem with its national security infrastructure. To quote Arthur Miller in *Death of a Salesman*, "[a]ttention must be paid[!]"[238]

3. If remedial measures with quantifiable and significant impact are possible now, they should be implemented immediately wherever wind turbines pose a potential hazard. This again may require diverting resources from more popular but less urgent or necessary projects.[239] If no remedial measures are sufficient in the short term, then DOD should take whatever steps are necessary to make sure that there is working military radar in the region.
4. Once the study is complete, DOD should move immediately to upgrade its radar systems. Permit applications for wind turbine installations can be unfrozen with construction contingent on a successful radar retrofit. This shared interest between the DOD and the energy sector in the rapid upgrade of the radar systems may offer a fruitful opportunity for cost-sharing.[240]

These recommendations are not ideal. In a time of increasing climate disruption due to (among other things) carbon emissions from the energy sector, suspending new construction of wind energy facilities represents an unfortunate setback. However, renewable energy should be a boon to national security rather than a threat. Furthermore, these recommendations do not call for a moratorium on wind energy construction but just a suspension of new construction that lies in proximity to military radar. The renewable sector can weather this temporary setback.

---

238. ARTHUR MILLER, DEATH OF A SALESMAN 39 (Heinemann Educ. Publishers 1994) (1949).

239. *See, e.g.*, Noah Friedman & Michelle Mark, *One of These Prototypes Could Become Trumps Border Wall*, BUS. INSIDER (Oct. 20, 2017, 9:11 AM), https://www.businessinsider.com/eight-prototypes-trump-border-wall-finished-in-san-diego-mexico-politics-patrol-customs-budget-congress-2017-10 [https://perma.cc/Z6UH-WYGM] ("Estimated cost for the prototypes [of the U.S./Mexico border wall] was between $2.4 and 4M.").

240. *See* Tom Swanson, *U.S. Military Could Save Over $1 Billion and Boost Energy Security, New Research Finds*, PEW CHARITABLE TRUSTS (Jan. 12, 2017), http://www.pewtrusts.org/en/research-and-analysis/articles/2017/01/12/us-military-could-save-over-1-billion-and-boost-energy-security-new-research-finds [https://perma.cc/386Q-8MHS].

CONCLUSION

In sum, the nation's radar systems are inadequate and unable to meet the challenge presented by increased demand for renewable energy. For too long the problem of wind-turbine interference was overlooked and underemphasized amid a ponderous permitting system that did not adequately allow for input from DOD and other stakeholders.[241] The permitting process has been improved,[242] the threat to national security recognized, and preliminary measures taken to address the problem.[243] However, the problem remains for the foreseeable future and simply having a plan in place will not resolve interference problems that DOD cannot yet determine exist.[244]

Consequently, the FAA must take immediate measures to safeguard the nation's radar systems and delay any new potentially problematic wind energy construction until such time as they no longer pose a threat to national security. In the short term, siting wind turbines near military radar facilities deliberately creates hard uncertainty in a realm where the world is already uncertain enough. There is another path, however. And, unlike Yogi Berra's proverbial fork in the road, the way forward is clear.[245]

---

241. *See supra* Part III (discussing the late consultation of DOD in the process).

242. *See supra* Section III.B.

243. *See supra* Part IV.

244. *See supra* Part V.

245. *When You Come to a Fork in the Road, Take It*, QUOTE INVESTIGATOR (July 25, 2013), https://quoteinvestigator.com/2013/07/25/fork-road/ [https://perma.cc/7CMC-BSQV] (noting that one of the many sayings attributed to the legendary Yankees catcher Yogi Berra was, "When you come to a fork in the road, take it.").