Interstate Wind: Using New Technology to Enhance Transportation Fuel Investments

Note

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I. INTRODUCTION

The success or failure of any energy project depends on policy and politics, technology, and economics.[1] Policy can influence the development of

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1. Donald N. Zillman, *The Legal Framework*, *in* ENERGY LAW AND POLICY FOR THE 21ST CENTURY 3-1, 3-1 to -2 (2000).

technology to accomplish an energy goal.[2] It can make a project implementing that technology more economical by providing public funds.[3] Also, public policy may reflect society's support for certain energy goals furthered by energy projects.[4] This paper endeavors to identify the law, policy, politics, and financing relating to innovative wind energy systems. Primarily, this paper addresses the possibilities of harnessing the wind created by vehicles on interstate highways to generate electricity through recent technological advances.

Exploring recent technology, policy and political trends, and financial opportunities shows that innovative wind generation projects within or adjacent to ground transportation corridors should be seriously considered as a means of improving the return on continuing investments in transportation fuels.

II. EXPANDING THE WIND RESOURCES PARADIGM

Wind is commonly defined as "air in natural motion, as that moving horizontally at any velocity along the earth's surface" or "any stream of air, as that produced by a bellows or fan."[5] These multiple definitions suggest that wind may exist as a natural phenomenon, or that it may be manufactured. An example of manufactured wind is the air flow produced by vehicles, palpable while standing on a sidewalk as a bus charges by.[6] Highways contain even more dramatic turbulence.[7] And, a "piston effect" is created by air pushed through highway and transit tunnels by automobiles and trains.[8]

2. *See id.*

3. *Id.*

4. *Id.*

5. Dictionary.com, Wind, http://dictionary.reference.com/browse/wind (last visited Jan. 28, 2008).

6. Large vehicles used in mass transit and motor carrier operations are probably the best producers of Interstate Wind. Thus, as wind in transportation corridors is developed as an energy source, the operators of these vehicles should be recognized for their enhanced contributions to the wind supply.

7. Posting of Arizona State University (Joe) to Archinect, http://www.archinect.com /schoolblog/blog.php?id=C0_374_39 (Apr. 10, 2007) [hereinafter De La Ree Project] (finding that "[a]verage vehicle speeds on the . . . highways are approximately 70 mph," and that "the wind stream created over the freeways by our primary mode of transportation will create an average annual wind speed well beyond . . . 10 mph.").

8. *See* FEDERAL HIGHWAY ADMINISTRATION, FEDERAL TRANSIT ADMINISTRATION, HIGHWAY AND RAIL TRANSIT TUNNEL INSPECTION MANUAL 2-15 (March 2003), http://ntl.bts.gov/ lib/23000/23700/23726/inspect.pdf (figure 2.13 within the Manual depicts "air flow" with arrows coinciding with the "flow of traffic"); *see also* Public Art Program, Kinetic Light Air Curtain, http://www.flydenver.com/guide/art/detail.asp?ID=17 (last visited Feb. 2, 2008) (describing Antonette Rosato and William Maxwell's installation containing, "a grouping of 5,280 propellers laid out on a grid system that changes from tight to loose configurations as the train passes. The propellers are made of reflective stainless steel and are 12" in diameter. The work, which includes blue fluorescent lighting,

Indeed, Congress has implicitly recognized this reality by not limiting its definition of "known wind resources" to natural phenomena.[9] However, the wind industry seems sedentary in its thinking about where the wind is: the common paradigm is that wind can only be harnessed where it is created by meteorological effects.[10] The National Renewable Energy Laboratory (NREL) illustrates this through its Wind Energy Resource Atlas of the United States that displays only collected meteorological site data.[11] By ignoring the wind on our ground transportation corridors, however, NREL paints an incomplete picture.

By indulging in the suggestion that wind exists on highways, one opens an additional 160,000 miles of potential wind resources that comprise the National Highway System (NHS).[12] The NHS is also depicted in map form (see Figure 1 below). An interposition of the Wind Energy Resource Atlas of the United States and the NHS provides an enhanced graphical representation of where wind is available.

encompasses the entire mile of the train tunnel journey. The propellers are activated by physical phenomena already existing in the tunnel, including light from the train and wind generated by the movement of the train.").

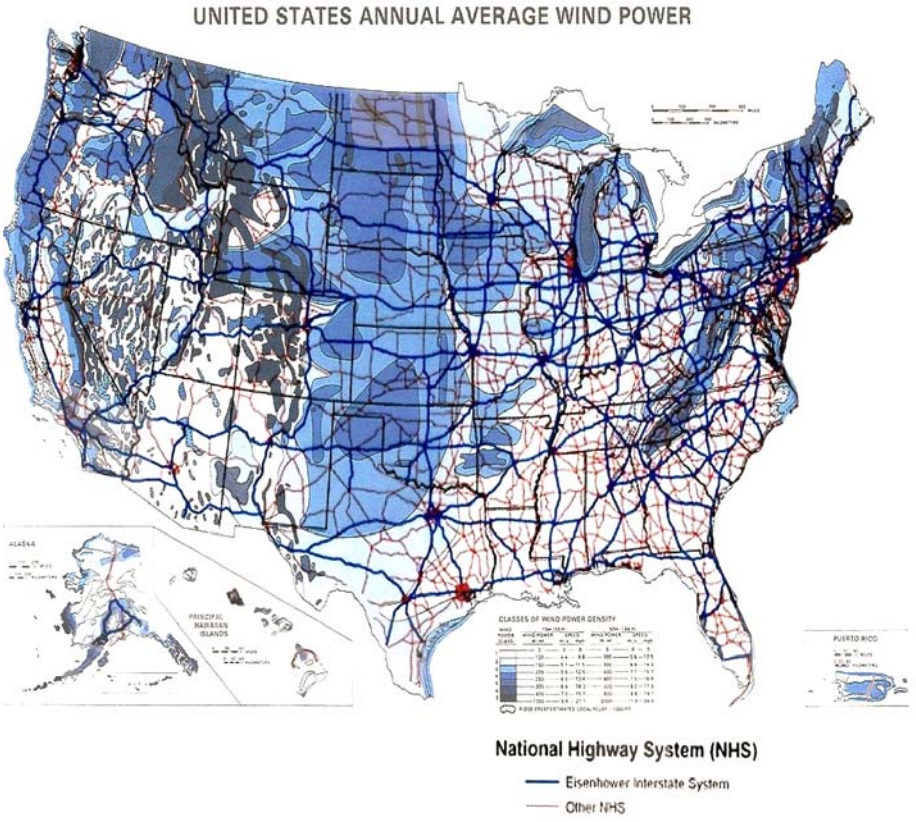
9. 42 U.S.C. § 9202(5) (2008) (defining "known wind resource" as "a site with an estimated average annual wind velocity of at least twelve miles per hour").

10. *See* Suedeen G. Kelly, *Alternative Energy Sources*, *in* ENERGY LAW AND POLICY FOR THE 21ST CENTURY 13-1, 13-6 (2000).

11. NATIONAL RENEWABLE ENERGY LABORATORY, WIND ENERGY RESOURCE ATLAS OF THE UNITED STATES, Map Description, http://rredc.nrel.gov/wind/pubs/atlas/map_descript.html (last visited Jan. 28, 2008) (describing Map 2-1, available online at http://rredc.nrel.gov/wind/pubs/atlas/maps/chap2/2-01m.html, which depicts the annual average wind power in the United States).

12. UNITED STATES DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, The National Highway System, http://www.fhwa.dot.gov/hep10/nhs/ (last visited Jan. 28, 2008) (describing the extent of the NHS and its importance "to the nation's economy, defense and mobility.").

FIGURE 1: INTERSTATE WIND RESOURCES[13]



The locations where the dark and thin lines representing the NHS are most noticeable – the southeastern United States – represent the areas where access to wind technology has not been recognized up to this point. Again, these areas are concentrated in the southern half of the country, and predominantly in the southeast.

By changing our conception of what constitutes a wind energy resource, we can redefine the potency of wind as a source of electricity for our nation's future. Also, thinking of wind as a byproduct of ground transportation will aid society in gaining a better return on its investment in fossil fuels and other transportation fuels. As the ceiling has come off crude oil prices recently, and only continues to skyrocket, Congress feels more pressure to pass more aggressive legislation that addresses the implementation of alternative energy

13. *Id.* (The image may be viewed by following the map link on the right side of the screen.)

systems.[14]

III. THE TECHNOLOGY OF INTERSTATE WIND

Recent technological innovations provide the impetus to rethink the location of wind resources.[15] Their inventors suggest these devices can supplement the existing power grid[16] or facilitate other transportation modes, such as light-rail or subway trains. [17] Viewing wind availability as a function of traffic patterns instead of natural phenomena will therefore increase the predictability of new wind systems over traditional systems reliant on natural wind.[18]

As stated earlier, the piston effect of wind is manifested when vehicles rush through enclosures.[19] Concrete medians, referred to as Jersey barriers, commonly enhance safety on the highways by separating traffic from opposing directions.[20] The *New* Jersey Barrier adds to the safety function of the concrete median by stacking two Darius turbines[21] in a row within the structure.[22] The turbines capture wind produced by a partial piston effect

14. John. M. Broder, *Voter Anger May Free Up Energy Bills*, N.Y. Times, Nov. 13, 2007, *available at* http://www.nytimes.com/2007/11/13/washington/13oil.html (noting that analysts project gasoline prices to continue to rise and that new energy legislation likely will only have long term effects on oil prices).

15. Modern art also inspires the utility of ground transportation as a source of wind energy. *See* Public Art Program, Kinetic Light Air Curtain, http://www.flydenver.com/guide/art/detail.asp?ID=17.

16. Rebecca Cavanaugh, *The New Jersey Barrier*, METROPOLIS MAG., Jan. 10, 2007, http://www.metropolismag.com/cda/story.php?artid=2466.

17. *Id.*, (also commenting,

> 'The technical problems of tying into the grid and managing the flow made me think of putting the power to a different use,' [says Mark Oberholzer]. 'I'm pretty excited about integrating a subway or light-rail train right where the barrier is. I love the idea of siphoning off electricity generated by private transportation to run public transportation.' Using the power where it's generated, rather than redistributing it through the grid, avoids energy losses that occur during transportation and eliminates the cost of adding extra infrastructure.").

18. *See* Kelly, *supra* note 10, at 13-7 (stating the "major challenge" of wind is its "intermittent" nature).

19. *See* HIGHWAY AND RAIL TRANSIT TUNNEL INSPECTION MANUAL, *supra* note 8, at 2-15.

20. Wikipedia, Jersey Barrier, http://en.wikipedia.org/wiki/Jersey_barrier (stating a "Jersey barrier or Jersey wall separates lanes of traffic [often opposing lanes of traffic] with a goal of minimizing vehicle crossover in the case of accidents.").

21. The Darius turbine, or Darrieus turbine was invented by French engineer Georges Jean Marie Darrieus, and is an example of a vertical-axis turbine. Wikipedia, Darrieus Wind Turbine, http://en.wikipedia.org/wiki/Darrieus_wind_turbine. For a discussion of the mechanics of wind turbines generally, *see* Avi Brisman, *The Aesthetics of Wind Energy Systems*, 13 N.Y.U. ENVTL. L. J. 1, 45-46 (2005).

22. Cavanaugh, *supra* note16.

created when vehicles pass the median in either direction.[23] Commenting on the effectiveness of vertical-axis turbines in this application, inventor Mark Oberholzer stated, "[o]pposing streams of traffic create really incredible potential in terms of a guaranteed wind source."[24] Oberholzer's invention is "still in the research phase," however.[25]

A similar concept in the research phase is styled a "Parasitic Catalyst"[26] by its inventor Joe De La Ree.[27] It replaces steel support tubes from highway signs with two horizontal-axis wind turbines that collect the wind created by the "turbulence" from cars passing below.[28] De La Ree estimates each Parasitic Catalyst could generate 9,600 kilowatt hours annually.[29]

Another promising technology is the micro-wind turbine jointly developed by the Mechanical Engineering Department at the University of Hong Kong and Motorwave Limited.[30] The micro-wind turbine consists of small plastic gearwheels attached to a small generator.[31] The gears are made of recycled plastic and best receive wind within thirty degrees of perpendicular.[32] These turbines work when moved by wind speeds as low as two meters per second and continue to work at higher speeds, unlike conventional turbines that function less efficiently in variable wind conditions.[33]

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23. *Id.*; *see also* HIGHWAY AND RAIL TRANSIT TUNNEL INSPECTION MANUAL, *supra* note 8, at 2-15.

24. Cavanaugh, *supra* note 16.

25. *Id.*

26. De La Ree Project, *supra* note 7.

27. Linda Stern, *Where It's Always A Windy Day*, NEWSWEEK, Sept. 17, 2007, E02.

28. De La Ree Project, *supra* note 7.

29. *Id*. (commenting on turbine efficiency and power output, De La Ree writes,

> Average vehicle speeds on the valley highways are approximately 70 mph. Using average annual wind speeds of 10 mph as a baseline, each single wind turbine will produce 9,600KwH of energy, annually (enough to fully power my 700 [square foot] apartment). This power production estimate will increase exponentially with an increase in wind turbulence speed. I believe that the wind stream created over the freeways by our primary mode of transportation will create an average annual wind speed well beyond the baseline of 10 mph.).

30. Press Release, The University of Hong Hong, HKU and Motorwave Limited Jointly Developed Micro-Wind Turbine Technology for Crowded Cities (Mar. 15, 2007), http://www.hku.hk/press/news_detail_5535.html [hereinafter HKU].

31. *Id.*

32. Motorwind, Product Description, http://www.motorwavegroup.com/new/motorwind/product.html.

33. HKU, *supra* note 30 (explaining the enhanced performance ability of a micro-turbine: "Conventional small wind turbines only work 20-40% of the time due to variations in wind speed, whereas the micro-wind turbines can operate 80% of the time [in both weak and strong wind conditions]."). The Motorwave home page also notes that all turbines deployed in Hong Kong continued to work during a recent typhoon where wind speeds reached 110 kilometers per hour. *See* Motorwind, http://www.motorwavegroup.com/new/motorwind/index.html.

Lucien Gambarota, the inventor of the micro-wind turbine, stated that the driving philosophy behind this technology was "to make renewable energy accessible in terms of price and technology."[34] Motorwave's primary market is the individual.[35] For example, a typical domestic system, which is rated at 170 watts at wind speeds of ten meters per second, and which consists of twenty micro turbines and a generator with steel supports for deployment, sold for $349.[36] For larger applications, Motorwave sells the turbines in sets of forty turbines and separately sells bundled converters and high-speed wind regulators.[37] The micro-wind turbines can be arranged in a myriad of patterns and span great distances.[38]

Recently, Motorwave demonstrated the commercial viability of the micro-wind turbine when the Hong Kong Sea School deployed an array of 396 turbines on its rooftop to generate electricity and provide advertising.[39] The Sea School project is depicted in Figure 2 below. Given the versatility and commercial viability of the micro-wind turbine, it appears to be the best current technology to harvest wind from the highways. These turbines could be deployed in lengthy stretches along barriers on highways to collect the wind created by vehicles as they pass. By deploying three rows of turbines, for example, chevron patterns could be created in the array to aid highway travelers through turns. Like the aforementioned technologies, the micro-wind turbine could be applied to alleviate general strain on the electric grid and even power new transportation infrastructures,[40] traffic control signals, lighting fixtures, tunnel ventilation systems,[41] and transmission systems.[42]

34. HKU, *supra* note 30.

35. Product Description, *supra* note 32 (cautioning the consumer that a tie grid inverter is required to connect the product to the electric grid, and that inverters are expensive and probably cost prohibitive unless large systems are being used).

36. Motorwind, 20 Micro Turbines with Generator, http://store.motorwavegroup.com/20-turbin.html.

37. Motorwind, Product Description and Prices, http://www.motorwavegroup.com/new/motorwind/catalogue3.html (*see* "Page 2 turbines without mounting frame" for bulk turbine orders and "Page 3 spare parts" for the battery, regulator, inverter bundles).

38. *Id.*

39. *Id.* Available electrical information on the project indicates the turbines charge eight twelve volt batteries and three 0.8 to 1.2 kilowatt inverters. Motorwind, *Product Description available at* http://www.motorwavegroup.com/new/motorwind/hkseaschool.html (last visited January 30, 2008). The daily output of the system is from ten to thirty kilowatts. *Id.* This production capacity fits micro-turbines within the definition of "small wind energy system," as "a wind energy system having a maximum rated capacity of one hundred kilowatts or less." As the number of turbines increases, as would be necessary if deployed along extended stretches of interstate highways, the systems may then constitute "large wind systems" once the one hundred kilowatt threshold is breached.

40. *See* De La Ree Project, *supra* note 7; Cavanaugh, *supra* note 16.

41. *See* HIGHWAY AND RAIL TRANSIT TUNNEL INSPECTION MANUAL, *supra* note 8 at 2-16 – 2-25 (providing descriptions and illustrations of common ventilation, lighting, and traffic signal systems that could be powered by the new technologies discussed, particularly the micro-wind turbines).

42. Dr. George William Sherk is owed credit for suggesting this application of the Interstate Wind

FIGURE 2: COMMERCIAL DEMONSTRATION OF MICRO-WIND TURBINES AT THE HONG KONG SEA SCHOOL[43]

IV. POLICY AND POLITICAL ATTITUDES

As previously mentioned, public policy indicates society's choice to support practices and technologies.[44] Federal law expresses support for wind energy by making the Secretary of Energy responsible for implementing a Comprehensive Program Management Plan for Wind Energy Systems.[45] Congress requires the Secretary to submit plans annually to the House Committee on Science and Technology and the Senate Committee on Energy and Natural Resources with revisions as circumstances make necessary.[46] The Secretary's revisions must address:

> (1) the anticipated research, development, demonstration, and technology application objectives to be achieved by the program;
>
> (2) the program elements, management structure, and activities, including any regional aspects and field responsibilities thereof;
>
> (3) the program strategies and technology applications plans, including detailed mile-stone goals to be achieved during the next fiscal year for all major activities and projects;
>
> (4) any significant economic, environmental, and societal effects which the program may have;

technologies.

43. Motorwind, *Product Description*, *available at* http://www.motorwavegroup.com/new/motorwind/hksea school.html.

44. *See* Zillman, *supra* note 1.

45. 42 U.S.C. § 9203(a) (2008).

46. *Id.* § 9203(b).

(5) the total estimated cost of individual program items; and

(6) the estimated relative financial contributions of the Federal Government and non-Federal participants in the program.[47]

Concurrently, the Secretary must annually assess "renewable energy resources within the United States, including . . . wind, . . . taking into account changes in market conditions, available technologies, and other relevant factors."[48] Congress also authorized appropriations of $10,000,000 for each fiscal year from 2006 to 2010 to foment this endeavor.[49]

Concerning research, development, and demonstration of wind technologies, the Secretary is required to "accelerate existing research and development" to achieve "widespread utilization of wind energy systems."[50] The Secretary is also charged to "continue an aggressive program for the development of prototypes of advanced wind energy systems."[51] To that end, the Secretary must "solicit and evaluate proposals for research and development of any new or improved technologies."[52] Congress empowers the Secretary "to enter into contracts, grants, and cooperative agreements with public and private entities"[53] providing for, "purchase, fabrication, installation, and testing to obtain scientific, technological, and economic information from the demonstration of a variety of prototypes of advanced wind energy systems under a variety of circumstances and conditions."[54]

Therefore, Congress has set forth a strong policy to move forward with innovative wind technology and has not limited its application to wind produced by nature.[55] The federal government also supports wind energy production through tax incentives, including the Production Tax Credit, and subsidies.[56] But the federal government could be doing more by adopting Renewable Portfolio Standards.[57] Furthermore, the federal government

47. *Id.* § 9203(c).

48. *Id.* § 15851(a).

49. *Id.* § 15851(c).

50. *Id.* § 9204(a).

51. *Id.* § 9204(b)(1).

52. *Id.* § 9204(b).

53. *Id.* § 9202(4) ("[T]he term 'public and private entity' means any individual, corporation, partnership, firm, association, agricultural cooperative, public - or investor-owned utility, public or private institution or group, any State or local government agency, or any other domestic entity.").

54. *Id.* § 9204 (c). Also note that Congress, in its broad grant of discretion to the Secretary of Energy, exempts this section from the rulemaking provisions of 5 U.S.C. § 553 (2008) and 42 U.S.C. § 7191. *Id.* § 9204(d).

55. *Id.* § 9202(5) (defining "known wind resource" as "a site with an estimated average annual wind velocity of at least twelve miles per hour").

56. Brisman, *supra* note 21 at 55-61.

57. *Id.* at 59-60 (noting that the states are taking leadership in this endeavor). Also, the House of

continues to subsidize generation that uses conventional fossil fuels at greater rates than renewable resources.[58] While Congress focused on increasing Corporate Average Fuel Economy Standards in passing the Energy Independence and Security Act of 2007, it failed to consider the benefits of capturing vehicle wind byproducts.[59] The federal government, thus, should redouble its efforts to help American industries bring technologies similar to those discussed above into the domestic and international markets.

Adding to the perceived failure of Congress to make the strong language of the Wind Energy Systems legislation meaningful, individuals can inhibit development of wind energy.[60] Opponents of renewable and alternative energy projects typically invoke aesthetics to oppose development.[61] Wind energy, like other renewable resources, has been criticized for its negative impacts on the visual appeal of the human horizon.[62] In spite of these concerns, microgeneration allows us to rethink where wind resources exist. Micro-turbine technology also allows us to integrate wind generation systems into the environment in ways unobtrusive to the eye: technology may be concealed within highway barriers,[63] or even displayed as an advertising medium.[64] Similarly, opponents citing noise from wind energy generation should be pacified by advances in engineering, in addition to the fact that highways are already noisy places. [65]

Others oppose wind projects for their perceived effects on avian death

Representatives recently agreed to a national "Renewable Electricity Standard" of fifteen per cent after 2020 that was defeated in the Senate. H.R. 6, 110th Cong. § 610(c) (2007) *available at* http://www.thomas.gov (as agreed to by the House, 2007).

58. Brisman, *supra* note 21 at 60-61 (explaining that "any benefit that renewable energies in general, and the wind industry in particular, might have received from federal subsidies is emasculated by the sustained subsidization of fossil fuels.").

59. H.R. 6, 110th Cong. § 102(b)(2) (2007) (amending 49 U.S.C. 32902 (b) to raise the fuel economy standard to thirty-five miles per gallon by 2020).

60. Brisman, *supra* note 21 at 66-67.

61. Brian Dietz, *Comment, Turbines vs. Tallgrass: Law, Policy, and a New Solution to Conflict over Wind Farms in the Kansas Flint Hills*, 54 U. Kan. L. Rev. 1131, 1135-36 (2006) Rule 16 (stating, "the most frequently mentioned objection to the use of wind energy across the world is the perceived aesthetic impact wind turbines have on the rural vista.").

62. Monica Davey, *In Farm Belt, Ethanol Plants Hit Resistance*, New York Times *available at* www.nytimes.com (last visited November 13, 2007).

63. *See* Cavanaugh, *supra* note 16.

64. *See* HKU, *supra* note 30.

65. Brisman, *supra* note 21 at 74-76 (quoting American Wind Energy Ass'n, The Most Frequently Asked Questions About Wind Energy 14, 16 (2002), which states that only "[a] small amount of noise is generated by the mechanical components of the turbine."); see Brisman's quote from Ari Reeves & Fredric Beck, Wind Energy for Electric Power: A REPP Issue Brief 8, 17 (July 2003), (stating that "wind farm noise will be partly masked by ambient noise, such as that from the wind rustling leaves or grasses. The sound also tends to be spread out across many frequencies, like white noise, further contributing to its unobtrusiveness.").

rates.[66] Hysteria over avian mortality caused by wind turbines piqued public interest when turbines over Altamont Pass in California killed or injured over thirty threatened golden eagles and over seventy raptors in just three years.[67] But, these relatively high numbers pale in comparison to avian deaths wrought by other human activities, such as hunting, ground transportation, and erecting buildings.[68] Despite this comparison, wind turbines maintain the unfortunate moniker of "condor Cuisinarts,"[69] although innovations like painted turbine blades and implementation of sonar systems help mitigate the avian mortality effects.[70]

The recent technological advances discussed above may suffer from concerns for avian mortality, but these concerns should not inhibit their implementation. The aforementioned Parasitic Catalyst, which most resembles an avian meat grinder, probably enhances avian mortality risks more than any technology previously discussed.[71] Protective gratings that house turbines but still allow air to flow into the turbine, as incorporated into the design of the New Jersey Barrier,[72] may alleviate this avian mortality risk. And coloring micro-turbines with reflective paint may also mitigate avian risks while enhancing the safety of the highways.[73]

While micro-turbine arrays in particular can also enhance driver awareness of highway features and hazards, their mere existence within the Interstate right-of-way is subject to federal safety standards.[74] Federal law grants the Secretary of Transportation discretion to "[accommodate] any utility facility" after considering the "environmental and economic effects together with interference or impairment of the use of the highway" and determining that no adverse effects of such use will ensue on "highway and traffic safety."[75] A key strategy in the research and development stage of innovative

66. Brisman, *supra* note 21.

67. *Id.* at 70.

68. *Id.* at 71-72.

69. *Id.* at 73 (quoting Katharine Q. Seelye, *Windmills Sow Dissent For Environmentalists*, N.Y. Times, June 5, 2003, at A28).

70. *Id.* at 72-73.

71. De La Ree Project, *supra* note 7.

72. *See* Cavanaugh, *supra* note 16 (illustrations of protective gratings that house the turbines may be enlarged by clicking on the images on right side of the page).

73. Brisman, *supra* note 21, at 72-73.

74. *E.g.* 23 U.S.C. § 109 (a)(1) (2006) (requiring the Secretary of Transportation to plan highway facilities "in a manner that is conducive to safety."); 23 U.S.C. § 303 (a)(3) (2006) (mandating the issuance of regulations for "State development, establishment, and implementation of a system for managing…[h]ighway safety.").

75. *Id.* § 109(l)(2)(A)-(B) (2006) ("[T]he term 'utility facility' means any privately, publicly, or cooperatively owned line, facility, or system for producing, transmitting, or distributing communications, power electricity, light, heat, gas, oil, crude products, water, steam, waste, storm water not connected with highway drainage, or any other similar commodity, including any fire or police signal system or street lighting system, which directly or indirectly serves the public; and . . . the term

wind technology, therefore, is to take advantage of the categorical exclusion from the National Environmental Policy Act (NEPA)[76] for wind resource investigation.[77] Once highway wind resources are empirically demonstrated, concerns over maintaining highway safety should predominate.

Federal agencies that rent or dispose "real property interests" obtained with federal funds under title 23 of the United States Code are generally bound to get "fair market value" for the interests conveyed and must "use the funds for transportation purposes."[78] Leases can be accomplished by agreements between State transportation departments and lessees that provide for "the safety and integrity of the federally funded facility[,] . . . removal of improvements at no cost to the FHWA [(Federal Highway Administration)], [and governmental] access . . . for inspection, maintenance, and reconstruction."[79] Exceptions apply for uses that promote "the overall public interest for social, environmental, or economic purposes[,]" and public transportation.[80] This indicates that developers seeking to use wind generated from "private transportation to [electrify] public transportation"[81] may be preferred recipients of federal land grants and leases.

Also, interests conveyed for "use by public utilities" are separately

'right-of-way' means any real property, or interest therein, acquired, dedicated, or reserved for the construction, operation, and maintenance of a highway."); 23 U.S.C. § 109 (l)(2) (2006) (regarding state projects, the statute further provides, "[p]rojects (other than highway projects on the National Highway System) shall be designed, constructed, operated, and maintained in accordance with State laws, regulations, directives, safety standards, design standards, and construction standards."); 23 U.S.C. § 109 (o) (2006).

76. 42 U.S.C. § 4321 (2006).

77. 10 C.F.R. § 1021 (subpart D, Appendix B, B3.1 (h)) (2008) ("Onsite and offsite site characterization and environmental monitoring, including siting, construction (or modification), operation, and dismantlement or closing (abandonment) of characterization and monitoring devices and siting, construction, and associated operation of a small scale laboratory building or renovation of a room in an existing building for sample analysis. Activities covered include, but are not limited to, site characterization and environmental monitoring under CERCLA and RCRA. Specific activities include, but are not limited to . . . [i]nstallation and operation of meteorological towers and associated activities, including assessment of potential wind energy resources.").

78. 23 C.F.R. § 710.403 (d) (Subpart D. Real Property Management) (2008).

79. *Id.* § 710.407 (a)-(b) (requiring that changes to facilities "shall be provided without cost to Federal funds unless otherwise specifically agreed to by the [State transportation department] and the FHWA.").

80. *Id.* § 710.403 (d)(1).

81. Cavanaugh, *supra* note 16 (quoting Christine Real de Azua of the American Wind Energy Association as stating,

> [u]sing the power where it's generated, rather than redistributing it through the grid, avoids energy losses that occur during transportation and eliminates the cost of adding extra infrastructure. Certainly having them closer to where you actually use the electricity is very helpful).

provided for, and are excepted from the general fair market value rule.[82] The FHWA has indicated that the policies of accommodating utility facilities on the interstate highways should not conflict with maintaining safety or other laws or regulations, or impair the highway's aesthetic quality.[83] Specifically, a "clear zone" is established "between the traveled way and the right-of-way line" for safe use by errant vehicles.[84] The "clear roadside policy" also mandates that the clear zone be free of "obstacles which are likely to be associated with accident or injury to the highway user" and that "appropriate countermeasures . . . reduce hazards."[85] "Use and occupancy agreements" provide the necessary documentation "by which [State] transportation departments [approve] the use and occupancy of highway right-of-way by utility facilities or private lines."[86] These permits must include:

> (a) [t]he transportation department standards for accommodating utilities[. . .;]
>
> (b) [a] general description of the size, type, nature, and extent of the utility facilities being located within the highway right-of-way[;]
>
> (c) [a]dequate drawings or sketches showing the existing and/or proposed location of the utility facilities within the highway right-of-way with respect to the existing and/or planned highway improvements, the traveled way, the right-of-way lines and, where applicable, the control of access lines and approved access points[;]
>
> (d) [t]he extent of liability and responsibilities associated with future adjustment of the utilities to accommodate highway improvements[;]
>
> (e) [t]he action to be taken in case of noncompliance with the transportation department's requirements[; and]
>
> (f) [o]ther provisions as deemed necessary to comply with laws and regulations.[87]

These agreements must in turn be approved by the FHWA and revised as

82. 23 C.F.R. § 710.403 (d)(2) (2008).

83. *Id.* § 645.203 (c); *Id.* § 645.207 (The FHWA defines aesthetic quality as: "desirable characteristics in the appearance of the highway and its environment, such as harmony between or blending of natural and manufactured objects in the environment, continuity of visual form without distracting interruptions, and simplicity of designs which are desirably functional in shape but without clutter.").

84. *Id.* § 645.207.

85. *Id.*

86. *Id.* (This section further broadens the term "utility facility" by stating, "[t]he term utility shall also mean the utility company inclusive of any substantially owned or controlled subsidiary. For the purposes of this part, the term includes those utility-type facilities which are owned or leased by a government agency for its own use, or otherwise dedicated solely to governmental use.").

87. *Id.* § 645.213.

"deemed necessary."[88]

Recognizing the historical tradition of "accommodating utility facilities within the highway right-of-way," the FHWA advocates that a joint use principle should guide highway right-of-way requirements, and that, "[t]he lack of sufficient right-of-way width to accommodate utilities outside the desirable clear zone, in and of itself, is not a valid reason to preclude utilities from occupying the highway right-of-way."[89] "New above ground installations," such as micro-turbines, are generally prohibited within the clear zone, unless the controlling transportation department[90] "[determines] . . . that placement underground is not technically feasible . . . and there are no feasible alternative locations."[91] Furthermore,

> When it is essential to locate such above ground utility facilities within . . . the clear zone . . . appropriate countermeasures to reduce hazards [may be required] . . . [including] placing utility facilities at locations which protect or minimize exposure to out-of-control vehicles, using breakaway features, using impact attenuation devices, using delineation, or shielding.[92]

Similarly, the FHWA calls for formulation and submission of accommodation plans by State transportation departments concerning "installations within freeways."[93] Therefore, the FHWA regulations do not prevent a utility company from placing micro-turbines in the clear zone, where they are likely to be most effective, because the technology will not work underground. Continued engineering and testing is required to determine the most effective placement strategies and countermeasures to be employed during the siting process for micro-turbine arrays, possibly considering attaching them to crash barriers or noise barriers.[94] And further inquiries into state accommodation plans will be necessary once technology becomes feasible for application in the center median.[95] See Figure 3 below, a photograph taken by the author, depicting micro-turbines installed on the center median of Interstate 25 in

88. *Id.* § 645.215(a).

89. *Id.* § 645.209 (a) (acknowledging that "safety [is] of paramount, but not of sole, importance when accommodating utility facilities within highway right-of-way.").

90. *Id.* § 645.207 ("Transportation department" is defined as, "that department, agency, commission, board, or official of any State or political subdivision thereof, charged by its law with the responsibility for highway administration.").

91. *Id.* § 645.209 (b) (2008).

92. *Id.*

93. *Id.* § 645.209 (c) (2008) (noting that such plans must adhere to the requirements set out in sections 645.211 and 645.215).

94. *See Id.* § 645.207 (2008) (exhorting that, "[i]n all cases full consideration shall be given to sound engineering principles and economic factors.").

95. *See* Cavanaugh, *supra* note 16 (noting that the New Jersey Barrier awaits further research and development).

Denver, Colorado.

FIGURE 3: MICRO-TURBINES DEPICTED AT INTERSTATE 25 AND DRY CREEK IN DENVER, CO

V. FINANCE OPPORTUNITIES AND CHALLENGES

The Energy Policy Act of 2005[96] established a rebate program for consumers who install a "renewable energy system in connection with a dwelling unit or small business," providing the lesser of twenty-five percent of the expenditure or $3,000.[97] Thus, products like Motorwave micro-turbines, which are already modestly priced, [98] can become even more affordable for the individual.

Large scale renewable energy projects, by contrast, are much more expensive, requiring additional public funding.[99] However, project financing can be a favorable option for capital-intensive energy projects.[100] "Non-recourse project financing" is

> A type of financing in capital-intensive industries in which a project's financial backing is based upon the ability of the project's potential cash flow to pay off project debt, rather than relying upon the credit-worthiness of the project

96. Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594.

97. 42 U.S.C. § 15853 (1)-(2) (2006).

98. 20 Micro Turbines with Generator, *supra* note 36.

99. *See* John A. Herrick, Federal Project Financing Incentives for Green Industries: Renewable Energy and Beyond, 43 Nat. Resources J. 77, 79 (2003) (note 9, citing generally Scott L. Hoffman, The Law and Business of International Project Finance 4-11 (1998)).

100. *Id.*

> sponsors. Under this type of project financing, the debt, equity, and credit enhancement are combined for the construction and operation of a facility. The assets of the facility, including the long-term revenue producing contracts, become the collateral for the lenders.[101]

To ease high project costs, Congress has authorized the Secretary of Energy to "solicit and evaluate proposals for Federal assistance" in the form of "(1) contracts and cooperative agreements; (2) grants; [and] (3) loans" made by "public or private entities wishing to utilize wind energy systems."[102]

Cost-sharing cooperative agreements have been employed by the Department of Energy (DOE) since the late 1980s to "[provide] financial assistance to a project sponsor, on a cost-sharing basis, without taking an equity or security interest in the venture."[103] The government's return on investment is its quality-control role in the project.[104] By involving itself in these agreements, DOE usually "attract[s] new financial support for the project from traditional project-financ[iers]."[105] The federal government usually bears most of the project costs, (up to eighty percent) for technologies in research and development.[106]

Cooperative research and development agreements also assist research and development of new technologies at "government-owned, contractor-operated national laboratories."[107] These agreements generally foment new technology toward the commercialization stage.[108] The national laboratories are ideal environments for developing the nascent technologies discussed previously, [109] as well as for testing commercially viable technologies, e.g., Motorwave micro-turbines, [110] in novel applications.

"[D]irect grants for large systems"[111] are available to cover the costs of purchase and installation, not to exceed "50 per centum . . . [in] the first six years . . . [and] 25 per centum . . . during the seventh or eighth year."[112] Loans are made available for small and large wind energy systems to cover "up to 75 per centum of the total purchase and installation costs of wind energy systems

101. *Id.*

102. 42 U.S.C. § 9205 (a)-(c) (2006).

103. Herrick, *supra* note 99, at 84.

104. *Id.*

105. *Id.*

106. *Id.* at 89.

107. *Id.* at 98.

108. *Id.* at 99.

109. *See* De La Ree Project, *supra* note 7; Cavanaugh, *supra* note 16.

110. *See* HKU, *supra* note 30; Product Description, *supra* note 32.

111. 42 U.S.C. § 9202(2)-(3) (2000) (defined as systems that exceed one hundred kilowatts generating capacity).

112. *Id.* § 9205(e).

providing in the aggregate up to three hundred and twenty megawatts peak generating capacity involving at a minimum four projects."[113] Loan terms are not to last more than twenty years beyond the operational capacity of the system, and interest is fixed at the same rate used for "water resource planning projects."[114]

The Secretary of Energy is also "authorized to provide funds for the accelerated procurement and installation of small and large wind energy systems by Federal agencies" and "to enter into arrangements with appropriate Federal agencies, including the Water and Power Resources Services and the Federal power marketing agencies for large wind energy systems, to carry out such projects and activities as may be appropriate for the broad technology applications."[115]

The Department of Agriculture (DOA) also provides grants and loans as "financial assistance to agricultural producers and rural small businesses for the purpose of purchasing and installing renewable energy systems and energy efficiency improvements in rural areas."[116] Beyond limiting applicants to rural[117] agricultural producers[118] and small businesses [119] that are, or are more than half owned by U.S. citizens,[120] DOA limits assistance to eligible projects with "technical merit[;]" involving "pre-commercial or commercially available, and replicable technology . . . located in a rural area . . . controlled

113. *Id.* § 9205(f)(1).

114. *Id.* § 9205(f)(2)-(3).

115. *Id.* § 9205(c)(4), (g).

116. Rural Business-Cooperative Service and Rural Utilities Service, Department of Agriculture, 7 C.F.R. § 4280.101(a) (2007).

117. *Id.* § 4280.103 ("Rural" is defined as "[a]ny area other than a city or town that has a population of greater than 50,000 inhabitants and the urbanized area contiguous and adjacent to such a city or town according to the latest decennial census of the United States.").

118. An "[a]gricultural producer" is "[a]n individual or entity directly engaged in the production of agricultural products, including crops (including farming); livestock (including ranching); forestry products; hydroponics; nursery stock; or aquaculture, whereby 50 percent or greater of their gross income is derived from the operations." *Id.*

119. A "[s]mall business" is:

> An entity . . . in accordance with the Small Business Administration's (SBA) small business size standards by the North American Industry Classification System (NAICS) found in Title 13 CFR part 121. A private entity, including a sole proprietorship, partnership, corporation, cooperative (including a cooperative qualified under section 501(c)(12) of the Internal Revenue Code), and an electric utility, including a Tribal or governmental electric utility, that provides service to rural consumers on a cost-of-service basis without support from public funds or subsidy from the Government authority establishing the district, provided such utilities meet SBA's definition of small business. These entities must operate independent of direct Government control. With the exception of the entities described above, all other non-profit entities are excluded.

Id.

120. 7 C.F.R. § 4280.107(a)(1)-(3).

by the agricultural producer or small business for the financing term of . . . [the federal assistance]."[121] This control element heightens the importance that an eligible applicant gains a real property interest in the portion of rural Interstate highway where a wind system will be deployed for the term to be covered by federal assistance before applying.[122]

Grants are not to exceed "25 percent of total eligible project costs"[123] and total grant funding is not to exceed $750,000 per individual per fiscal year, $500,000 of which can fund renewable energy systems.[124] A simplified application, involving less onerous technical data requirements, applies to grant applications with total eligible project costs less than $200,000.[125] Guaranteed loans from eligible lenders[126] may be used to plan and construct renewable energy systems or to improve existing renewable energy systems.[127] Guaranteed loans are available in amounts from $5,000 to $10,000, not to exceed "50 percent of total eligible project costs" with reductions in the cost percentage guaranteed as the loan amount increases.[128] Interest rates are negotiable.[129] Direct loans are available according to a "Notice of Funds Availability" publication each year that DOA decides direct loans will be available.[130] Eligible applicants pursuing eligible projects may combine these funding opportunities.[131]

While the foregoing suggests an abundance of federal assistance options for renewable energy project financing, the glut in generation capacity within

121. *Id.* § 4280.108(b), (d), (f).

122. *See generally Id.* § 4280.108.

123. *Id.* § 4280.110(a).

124. *Id.* § 4280.110(d)-(e).

125. *Id.* § 4280.109(a)(3).

126. Eligible lenders are listed in 7 C.F.R. § 4279.29, and exclude mortgage companies comprising bank-holding companies. *Id.* § 4280.130.

127. *Id.* §§ 4280.112, 4280.123(e).

128. *Id.* § 4280.123(a)-(c) ("The maximum percentage of guarantee is 85 percent for loans of $600,000 or less; 80 percent for loans greater than $600,000 up to and including $5 million; and 70 percent for loans greater than $5 million up to and including $10 million.").

129. *Id.* § 4280.124(a).

130. *Id.* 4280.161(a).

131. *Id.* § 4280.193(a)-(b). Funding limitations are:

> (1) The amount of any combined grant and guaranteed loan must not exceed 50 percent of total eligible project costs. For purposes of combined funding requests, total eligible project costs are based on the total costs associated with those items specified in §§ 4280.110(c) and 4280.123(e). The applicant must provide the remaining total funds needed to complete the project. (2) Third-party, in-kind contributions will be limited to 10 percent of the matching fund requirement of any financial assistance provided to the applicant. (3) The minimum combined funding request allowed is $5,000, with the grant portion of the funding request being at least $1,500.

Id. § 4280.193(b).

the "merchant power plant[]" industry makes obtaining funds more difficult.[132] An increasing problem in renewable energy project financing, therefore, remains in attracting traditional private investors.[133] Especially because of the frontloading of public investment, typically reserved for research and development of new technology, private investment later in the game literally can make or break businesses relying on project financing.[134] Although public investment can provide leadership for the private sector to support new technologies, profit gratification motivating private investment may not immediately materialize because of technological risks.[135] Thus, planning for later stages of project development, and adequately allocating risks through creative contracting is essential.[136] In short, preparing a dynamic business, as well as an innovative technology, is necessary for private venture financing.[137]

VI. CONCLUSION

Pressure is mounting on the United States, both from the international community and from within, to shift our reliance on fossil fuels to renewable energy resources.[138] Current national goals provide a "20% Wind Energy Vision" as a national power source in 2020 based on conventional assessments of available wind resources.[139] Meanwhile, the Environmental Protection Agency touts micro-turbine technology as the "cutting edge . . . cornerstone in the distributed generation field."[140] Returning to Figure 1, depicting a

132. D.P. GOLDMAN ET AL., FINANCING PROJECTS THAT USE CLEAN-ENERGY TECHNOLOGIES: AN OVERVIEW OF BARRIERS AND OPPORTUNITIES 2 (National Renewable Energy Laboratory) (2005).

133. *See generally* L.M. MURPHY & P.L. EDWARDS, BRIDGING THE VALLEY OF DEATH: TRANSITIONING FROM PUBLIC TO PRIVATE SECTOR FINANCING 21-24 (National Renewable Energy Laboratory) (2003).

134. *Id.* at 1.

135. *Id.* at 2 tbl.2. *See also* GOLDMAN ET AL., *supra* note 132, at 3.

136. *See* GOLDMAN, *supra* note 132, at 3.

137. MURPHY, *supra* note 133, at 14, 15 (explaining that developing leadership in company management positions, analyzing market conditions, providing liquidity in the form of public offerings or securities, and maintaining an appropriate corporate structure are crucial to attract venture financing because "investors are interested in businesses (not technologies) that are strongly market focuses with products that reflect that focus.").

138. *See* Elisabeth Rosenthal, *U.N. Chief Seeks More Leadership on Climate Change*, N.Y. TIMES, Nov. 18, 2007, § 1, at 1 (describing United Nations Secretary General Ban Ki-moon's exhortation of "the world's greatest greenhouse gas emitters," the U.S. and China, to take "a more constructive role" heading into an energy ministers' meeting in Bali, Indonesia); Power Shift 2007, *Power Shift 2007 Lobby Day Talking Points*, http://smnr.us/lobbyday/talkingpoints.html (last visited Jan. 26, 2008) (advocating that the U.S. achieve 80% reliance on renewable energies by 2050). *See generally* Power Shift 2007, *About Power Shift 2007*, http://powershift07.org/about (last visited Feb. 1, 2008).

139. Utility Wind Integration Group, *The 20% Wind Energy Vision: System Operation and Transmission Needs*, http://www.eere.energy.gov/windandhydro/windpoweringamerica/filter_detail.asp?itemid=746 (last visited Feb. 1, 2008).

140. Environmental Protection Agency, *Local Action Plan Recommendations Denver, Colorado*,

dramatic enhancement of what constitutes an available wind resource in the southeastern portions of this country, the future of wind seems even brighter.

While technology is now developing to make our ground transportation systems more sustainable and cost-effective, businesses should be preparing to embrace the challenge of converting our highways into wind resources.[141] Doing so will alleviate strain on the electric grid and power new transportation modes for our growing communities. If entrepreneurs and utilities in the south and southeastern United States use federal assistance to take the lead in implementing this technology, the crucial private investment sector may become more willing to bear the costs of expanding this vision into reality.[142] Federal agencies can also move this technology into the mainstream through demonstration deployments. By acting now, future generations may be more apt to applaud our efforts to shape an innovative and secure energy economy than to criticize our unwillingness to change.

http://yosemite.epa.gov/gw/StatePolicyActions.nsf/LookupLocalExhibits/Colorado+:+Denver (last visited Feb. 1, 2008); Denver, *Sustainable Initiatives*, http://www.denvergov.org/ES/SustainableInitiatives/tabid/386886/Default.aspx (last visited Feb. 1, 2008).

141. After expanding the wind resources paradigm, NASCAR tracks also become potential energy supplies. *See* Stern, *supra* note 26. Similarly, rail corridors can become potential wind resources. And, the effectiveness of more traditional micro turbine deployment on urban rooftops, for both electric generation and advertising, should not be discounted. *See* Motorwind, *supra* note 42.

142. The mild climate of the South may be best suited for permanent deployments, as snowplowing and other winter roadway maintenance may very well hinder micro turbine operations. Seasonal operations could be useful in other regions, however, to alleviate the strain on electric grids during summer heat waves.