

**Land Use, Land Conservation, and Wind Energy
Development Outcomes in New England**

by

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CHAPTER I

Introduction

The Research Problem

The search for reliable and clean energy supplies has increasingly become a greater policy and planning priority internationally and within the United States at the state level (EERE, 2008; Jefferson, 2008; Jacobsen, 2009; Rabe, 2006; Wiseman et al., 2011). For the New England region, a combination of high energy import dependency, high electricity prices, aging nuclear and coal-fired power plants, and heightened concern for climate change has created an atmosphere conducive to advancing renewable energy production (EIA, 2010; EIA 2011; Krosnick and Villar, 2010; Leiserowitz et al., 2010). Yet, despite the states' legislative and administrative efforts and a public receptive to climate change response and clean energy development, very few commercial-scale projects have been constructed in New England. This is especially the case with wind power.

Wind power technology currently provides the highest energy return on life-cycle fossil fuel invested (EROI) and the least life-cycle environmental impact of any major source of renewable energy (Ardente, Beccali et al. 2008; Jacobsen, 2009; Wüstenhagen, Wolsink et al. 2007). The land use implications of other renewable electricity resources such as solar photovoltaic, forest biomass, and hydroelectricity require further review beyond the scope of this dissertation.

The main policy drivers for wind power development are the states' individual renewable portfolio standards (RPS), and the primary planning tool has been a series of geographic information system (GIS)-based land area assessments. All of the New England states have enacted and maintained a renewable portfolio standard, although

Vermont's is voluntary and applies to meeting only new electricity demand. Most of the New England states have conducted land area assessments, however each of the reports represent a specific interest such as scenic and recreation values, or a specific landowner such as state or federally-managed forest lands (Navigant, 2009; Publicover, 2004; Zimmerman, 2003). A more comprehensive analysis, one that addresses a broader range of influential factors and accounts for a greater set of spatial land use variables, is needed.

This dissertation provides three original research inquiries. The first examines the impact of inter-governmental policy, site-specific, and social factors on wind energy development outcomes within the three New England states of Massachusetts, New Hampshire, and Vermont. The second identifies the amount of suitable land area for wind power development and the corresponding electricity generation potential for Western Massachusetts, based on three modeling scenarios. The third determines the degree of historical land use and conservation change that occurred from 1985-2009 within the prime wind resource areas of Western Massachusetts.

Wind Power Planning and Siting Scholarship

Although the promotion of renewable energy development, particularly wind power, receives considerable mainstream attention, scholars have only begun to identify and analyze the implications of its widespread deployment across the United States (Davies, 2010; McDonald, 2009; Outka, 2011). A larger collection of wind power planning and siting studies exists in Europe, where several nations adopted wind power policies and subsidies much earlier and more assertively (Wolsink and Wüstenhagen, 2007; Nadaï and van der Horst, 2010). The European studies provide case study methodologies for analyzing the wind power planning and siting process occurring in the United States. They identify inter-governmental policy, site specific, and social/institutional issues as the three main categories of factors influencing commercial wind power project outcomes (Breukers and Wolsink, 2007; Jobert et al, 2007; Wüstenhagen et al, 2007).

Energy and planning scholars have also conducted GIS-based land area assessments to determine the suitability of wind power placement for individual states and for high wind resource regions in other countries. These assessments, along with

state wind power model ordinances, provide an initial set of land use variables and buffer distances to employ in a comprehensive wind power-land use assessment. Another significant, but currently under-studied, aspect of wind power development is how the conversion of rural property from working lands (agricultural and forestry) to exurban (residential and commercial) development will diminish the amount of prime wind resource areas available for electricity generation. The planning literature emphasizes how low-density exurban growth reduces the natural resource base, such as agriculture and forestry production, especially within the U.S. Northeast (Brown, Johnson, et al., 2005; Davis, Nelson, et al., 1994; Daniels, 1998; Nelson, 1990). Further research is needed, however, to determine how this low-density exurban growth will specifically reduce the capacity to extract, transport, and generate power from primary renewable energy resources such as wind, biomass, and solar.

Land use legal scholars have also begun to observe the unintended consequences of the ubiquitous method of employing conservation easements for permanent land conservation (Aaronsen and Manual, 2008; Korngold, 2007; McLaughlin, 2005). Conservation easements may significantly limit, now and in the future, the ability of rural lands to provide other, equally important public benefits and conservation purposes, such as access to wind power resources for low carbon, renewable energy generation.

Research Design and Methodology

This dissertation seeks to answer the following research questions:

- 1.) What are the differences/similarities in the development outcomes between three inland commercial wind power projects in central New England?
- 2.) How much land area exists for wind power development in the prime wind resource areas of Berkshire County, Massachusetts, when comprehensively accounting for current land use composition and development restrictions?
- 3.) To what extent has land use conversion and land conservation reduced the land availability within the prime wind resource areas of Western Massachusetts from 1985 to 2009?

The dissertation consists of three independent research studies that employ both qualitative and quantitative methods. For the first study, forty-five semi-structured stakeholder interviews were conducted for a comparative analysis between three wind power development case studies in central New England. The methodology for this study was informed by recent European and U.S. case studies, which are summarized in chapter two, the Literature Review. The second and third studies employ geographic information system (GIS) spatial analysis modeling for the prime wind resource areas of western Massachusetts. Prime wind resource areas are classified as class 4 (average wind speeds exceeding 6.3 meters/second) by the National Renewable Energy Laboratory (NREL). The models are formed through the geo-processing and management of source data acquired primarily from the Massachusetts Office of Geographic Information Systems (MassGIS).

The second study establishes a comprehensive set of thirty-seven exclusionary variables to determine the amount of suitable land area and the corresponding electricity generation potential for western Massachusetts. The land use variables are incorporated into Boolean raster GIS models which represent two, opposing scenarios towards wind power development in Massachusetts, and a third model that balances the empirical siting criteria used to define these divergent scenarios. The third and final study incorporates historical land use and land conservation variables into Boolean raster GIS models to determine the degree of land use and ownership conversion from 1985 to 2009 that occurred within the prime wind resource areas of Western Massachusetts.

Outline of the Dissertation

This chapter introduced the importance of examining how intergovernmental policy, site-specific, and social factors impact the wind power siting process, establishing a more comprehensive set of land use variables for wind power land use assessments, and determining how land use conversion and land conservation may reduce the area available for wind power generation now and in the future.

The following, second chapter describes the wind power planning, siting, and land use modeling literature. The scope of this literature review is limited to wind power development within inland areas, thus excluding offshore development, and places wind

power within the broader context of energy facility planning and siting in the United States. This follows with a summary of U.S. and European case studies which focus mainly on the regulatory process, public participation, and perception of wind power development. Lastly, the more-empirically based land use models, assessments, and technical ordinances are summarized.

The third chapter describes how inter-governmental policy, site-specific, and social factors influenced wind energy development outcomes in central New England. Three case studies are examined, including the 48 megawatt Glebe Mountain Wind Farm proposal in southern Vermont, the 30 megawatt Hoosac Wind Farm proposal in western Massachusetts, and the operating 24 megawatt Lempster Wind Farm in New Hampshire. These projects represent the largest, grid-connected wind farm proposals within 100 miles of the populous cities of southern New England. To ascertain why the project outcomes varied- from unrealized, to a protracted delay, to construction and operation- a range of stakeholders were interviewed. Interviewees represented wind development firms, utility companies, state regulatory agencies, regional planning commissions, town officials, land conservation organizations, and opposition groups.

The fourth chapter describes a wind power land use siting assessment for Western Massachusetts. Employing a comprehensive set of thirty-seven land use variables, the amount of suitable land area and the corresponding electricity generation potential is identified for a four county region. The empirical variables are incorporated into three raster-based GIS models. The first model represents the scenario that wind power and land conservation cannot coexist, and assumes that enough privately-held, non-scenic, unprotected land remains for wind power development. The second model represents the scenario that wind power development is vital to meeting the state's renewable portfolio standard, mitigating climate change, and improving regional air quality, and therefore is suitable within all prime wind resource areas within both public and unprotected private lands. The third model represents a balance between these two divergent scenarios. While the study includes many of the explanatory variables from previous wind power land use assessments, it also contributes several previously neglected ones that are essential to measure for rural landscapes that have multiple land uses and ownership rights. These newly incorporated variables include municipal preserves, parks, forests,

water supply districts, rare species habitat areas, state areas of critical environmental concern, tele-communication and emergency towers, designated scenic landscapes, conservation restrictions, and agricultural restrictions.

The fifth and sixth chapters describe how not only land use conversion, but also conservation easements, reduces access to prime wind power resources. A historical analysis of land use and land ownership change from 1985 and 2009 of a four-county area of Western Massachusetts, through GIS modeling, determines that exurban residential development and the expanding wildland-urban interface are not the only land use factors impeding access to prime wind resources. The continual aggregation of conserved lands through conservation and agricultural easements also creates significant implications for future wind power development, and thus for states to meet their renewable portfolio standard requirements.

The seventh and concluding chapter describes the overarching observations, limitations, and recommendations from the three research studies on wind power planning and development. The six main observations are: (1) visual aesthetics remain the main reason for the opposition towards specific projects, (2) the Not-in-my Backyard debate for wind power remains unsettled, (3) widespread support exists for regional land use energy plans, (4) the wind resources of Western Massachusetts can significantly contribute to the state's current renewable portfolio standard while balancing the concerns of conservation with renewable energy development, (5) exurban residential development and conservation easements limit wind power development potential, and (6) there is a compelling need to legally define wind as a publicly beneficial resource.

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CHAPTER II

Literature Review

Introduction

The planning and siting process for wind turbines has become the latest iteration of a long continuum of energy facility siting conflicts. While wind power possesses a unique set of market drivers, environmental considerations, and public benefits distinct from conventional fossil fuels and nuclear power, it continues to experience similar siting constraints. This literature review covers the broad range of theories, case studies, guidelines, and land use assessments for wind power planning and siting. The scope is limited to commercial scale inland wind power development and thus excludes smaller community-scale as well as offshore developments.

This chapter begins by providing a brief overview of how wind power falls within the context of the literature on U. S. energy facility planning and siting. For the purpose of maintaining a focused research inquiry, the review of facility siting literature is limited to electricity-generating facilities. Therefore, the extensive work on contested facilities such as hazardous waste depositories (Heiman, 1990; Portney, 1991; Rabe, 1994) and other industrial uses (Schively, 2007) is not reviewed. The review of energy facility siting studies is followed by a review of the two main categories specific to the wind power planning literature: the public process and perception case study comparisons, and the more empirical wind power land use assessments and state wind model ordinances. The chapter concludes with a review of the emerging literature that focuses on how incremental land conservation will impact wind power siting and development.

Energy Facility Planning and Siting Literature

Resistance to new energy facilities arose during the second half of the 20th century. As urban and suburban populations expanded, an increase in energy

consumption, coupled with limited incentives for efficiency measures, led to demand for new facilities and requisite utility infrastructure (Aldrich, 2008; McLaughlin, 2008; Vajjhala and Fischbeck, 2007). Yet the very force that created demand for new facilities, suburban and exurban sprawl, increased the difficulty for developers and utilities to find economically viable locations for power plants, pipelines, transmission lines, and repositories for spent fuel waste such as coal ash and low-level radioactive nuclear fuel rods. This leads to a feedback loop, since the closer people reside to a proposed energy facility, the more likely they are to resist its construction (Thayer and Freeman, 1987; Dear, 1992). More people are now located closer to proposed energy facility sites than ever before. O'Hare and colleagues write, "Public conflict seems to have become the rule rather than the exception. No matter what a developer proposes to build...someone will oppose it. No matter how safe the proposed facility looks to its developer and government officials, someone will oppose it. No matter how badly society's general well being depends on a new development, someone will oppose it" (O'Hare et al, 1983, p. 6). Exurban sprawl, often in the form of secondary vacation home developments along shorelines and scenic mountains, has especially contributed to the resistance to wind power facility siting (Bishop, 2002; Groothuis et al., 2008; Nadai & Labussiere, 2009; Rogers et al., 2008). The most technically and economically suitable locations for wind power generation often overlap with the most appealing recreational and scenic locations (Nadai and van der Horst, 2010).

The main periods of permitting approvals for *new* coal-fired plants (1880-1980) and nuclear reactors (1960-1990) appear to have passed in the United States (EIA, 2011). The new energy facilities (not the re-commissioning of existing facilities) in the 21st century are powered by natural gas (1960 – onward), wind power (2000 – onward), biomass, and other emerging renewable technologies. The policy and market drivers for re-commissioning fossil fuel and nuclear energy facilities include the economic projections of increased energy consumption, the desire to maintain reliable baseload electricity service, and local job creation (EIA 2011; Boudet and Ortolano, 2010). In addition to these same drivers, wind power facilities are separately driven by state renewable portfolio standard mandates, carbon cap and trade proposals, and state and

institutional greenhouse gas emission reduction policies (Alexander, 2011; Bolinger, 2005).

Supportive energy policies and market incentives are not enough to enable the siting of new energy facilities, and developers must adjust to stronger opposition from well-organized and financed interest groups. Beierle and Cayford (2002) and Vajjhala and Fischbeck (2007) describe how developers once relied on a “decide-announce-defend” model for facility siting. Yet an increase in the incidences of public opposition forces a more inclusive participatory process, and projects which follow the older model often lead to “decide-announce-defend-abandon.” While multi-national firms have managed the development process for conventional fossil energy projects from start to completion, many smaller, regional-based firms have initiated the process for wind power. These wind power projects, smaller in terms of generation capacity, are often acquired later in the review process by multi-national energy firms. One reason in the difference in ownership relates to the difference in the siting regulatory framework between conventional, fossil fuel facilities and newer, alternative renewable energy facilities. The authorization for fossil energy-powered facilities typically resides with a state siting commission (O’Hare et al., 1983), whereas the following research, described in chapter 3, found that the authorization for renewably-powered facilities varies by state from whether the local planning board or state siting commission holds the ultimate approval authority. Large, multi-national firms demand a reliable regulatory framework and timeline, whereas smaller, regionally-based firms often make the initial investments and assume greater risks to gain market entry.

During the past forty years, the public perception of new energy facilities has remained an intensely local interest, with episodes of broader societal interest. O’Hare and colleagues (1983) found nuclear power and natural gas plant proposals to be locally undesirable in the 1970s, yet still considered beneficial by the greater public. Wolsink (2000) acknowledged the importance of responding to and mitigating local risk in order to disperse social benefits. Dear (1992) however, observed that several new facility proposals were unwelcome by both the local and a broader general public, regardless of greater societal benefits. Aldrich’s (2008) more recent comparison of nuclear power plant siting equates these facilities to an outright *public bad*, challenging the notion that

any electricity source can be considered a de facto *public good*. As for wind power, the technology is favorably received as a public good by the general public, with localized pockets of assertive opposition to specific facility proposals (Jobert et al. 2007; Nadaï and van der Horst, 2010; Wüstenhagen et al., 2007).

According to Aldrich (2008), public opposition is seen as reflective of civil society, those willing to engage and take a stand against a perceived public bad, whereas earlier studies from O'Hare and colleagues (1983) and Walker (1991) have characterized the opposition as highly rational and efficient in ensuring their own self-interest. Hunter and Leyden (1995) observed the opposition as an assertive, vocal minority that in essence distorts both municipal and state policymakers' notion of local acceptance. McAvoy (1999) found the opposite occurrence, where policymakers saw the public participatory process becoming more of a nuisance than the proposed facility itself. Local interest groups contract their own professional consultants to testify on behalf of their position, countering the findings of consultants contracted by state agencies, or by the developer. This phenomenon is described by Busenburg (1999) as an "adversarial analysis" strategy. Finally, planners and policymakers must recognize the ability of well-financed opposition groups to engage in extensive legal appeals and hiring expert consultants to present contradictory scientific information (O'Hare et al 1983). Walker (1991) and Boudet and Ortolano (2010) emphasize that this resource mobilization is an increasingly influential factor in energy facility siting outcomes, particularly where wealthy property owners may effectively outlast wealthy energy development firms.

A suite of conflict resolution strategies emerged to respond to such facility siting opposition. O'Hare and colleagues describe how mitigation packages to both the host municipality and adjacent residents provide financial compensation for potential or verifiable adverse impacts (1983). Other effective strategies observed by Kasperson (1992), Dear (1992) and Schively (2007) include informal consensus building between the stakeholders (versus a formalized set of hearings) and human services planning. However, these strategies have limited success in resolving the latest incidences of siting conflicts, especially for electricity infrastructure. Vajjhala and Fischbeck (2007) argue that state and regional policy reforms are required to overcome local opposition and meet the demand for new energy facilities and their requisite infrastructure. Wiseman (2011)

calls for a stronger regional energy siting authority to enable the construction of more renewable energy facilities. This holds promise in New England, since the electric grid is managed across several small states that have often worked in concert in establishing regional environmental and natural resource accords. A Northeast regional renewable energy siting authority could mirror the Regional Greenhouse Gas Initiative (RGGI) and other Northeast regional environmental compacts (Rabe, 2009).

Wind Power Planning, Public Process, and Perception Case Studies

The previous section described how wind power siting falls within the greater context of U.S. energy facility siting within the United States. The following section focuses in on and compares the specific case studies of wind power development outcomes within the United States, as well as in Western and Northern Europe.

Wind Power Planning and Siting Process Studies in the United States

Table 2.1 provides ten key U.S.-based studies on the wind power planning and siting process. They address a range of issues- six concentrate on local public responses (Acker, 2003; Thayer and Freeman, 1987; EERE, 2008; Groothuis et al, 2008; TRC, 2009; Swofford and Slattery, 2010), two focus on the planning practitioner's role (Andrews, 2008; APA, 2004), while others focus on the promise of community-ownership (Bolinger, 2005) and analyzing siting difficulty for requisite electricity transmission lines (Vajjhala and Fischbeck, 2007). The chronological table lists each study's research question and methodology and a summary of the main policy, site, and social/institutional factors.

Table 2.1: Wind Power Planning and Siting Process Studies: United States

Geographic Area	Research Question & Methodology	Policy Factors	Site Factors	Social & Institutional Factors
Thayer and Freeman, 1987 California	<i>What is the local public's response to the Altamont Pass, CA Wind Farm?</i> Questionnaire and visual preference survey to 600 subjects	Public perception of wasted public funding	<ul style="list-style-type: none"> • Visual impact • Larger preferred over smaller turbines 	<ul style="list-style-type: none"> • External attributes (non-polluting, safer energy production) • Proximity to wind farm • Unreliability/intermittency of turbines
Acker, 2003 Arizona	<i>What are the specific barriers & opportunities for wind power dev. on Western Tribal lands that will reduce regional haze?</i> 1996-97 survey of 39 U.S. tribes and 2001 assessment of Western tribal attitudes	<ul style="list-style-type: none"> • 1990 Clean Air Act goal of reducing regional haze • 1999 EPA Regional Haze Rule • Tribal renewable portfolio standards 	<ul style="list-style-type: none"> • Sacred sites protection • Mapping & measuring wind velocity on Triballands 	<ul style="list-style-type: none"> • Econ. dev for tribes • Lessen energy import dependency • Increase electricity reliability • Collaboration of Tribe w- wind power developer
American Planning Association, 2004 United States	<i>What is the planner's role in increasing both energy conservation and renewable energy production while significantly reducing use of non-renewable energy sources?</i> Guidelines for including energy in the traditional comprehensive planning and zoning processes	<ul style="list-style-type: none"> • Incorporate energy into the broad range of community-based planning functions (zoning bylaws, master plans, building codes, homeowners association covenants) 	<ul style="list-style-type: none"> • Expedite permitting of renewable energy facilities through reform of zoning regulations 	<ul style="list-style-type: none"> • Most Americans remain unaware of the considerable impact energy has in their daily lives • Energy decisions affect the economy • Energy decisions also affect quality of life
Bolinger, 2005 Minnesota, Iowa, Wisconsin, Massachusetts	<i>Can the European community-owned wind power model work in the U.S.?</i> Comparative policy analysis between European countries and U.S. states	<ul style="list-style-type: none"> • German feed-in tariff • European carbon tax • U.S. annually authorized production tax credit (PTC) • Minnesota 10yr. wind productn. incentive & utility's mandate 	Stronger 3-phase electricity grid in Europe handles interconnection of distributed turbines	<ul style="list-style-type: none"> • Large, grid-connected turbines owned by multiple local investors (DK, DE, SW, NL), not by corporations • U.S. farmers, schools, municips. & local investors as wind turbine owners
Vajjhala and Fischbeck, 2007 United States	<i>How difficult is siting electricity transmission lines, and what makes siting difficult?</i> Empirical analysis of 4 siting difficulty indicators	<ul style="list-style-type: none"> • Energy Policy Act 2005's national interest elec. transm. corridors • Lack of federal site permit standardization 	<ul style="list-style-type: none"> • Distance separating elec. generation from demand load centers • Expected construction of new energy facilities 	<ul style="list-style-type: none"> • Marginal cost of electricity production • Perception of public opposition
Andrews, 2008 United States	<i>Emerging energy technologies with smaller facilities bring planners a new set of siting issues.</i> A conceptual framework that has planners using network models to focus on energy conversion nodes	<ul style="list-style-type: none"> • Planners should identify areas of policy leverage on private sector • Recognize persistent siting issues, especially with disbursed, decentralized facilities 	<ul style="list-style-type: none"> • Planners should focus on how energy conversion takes place • Focus on how smaller, decentralized facilities can support smart grid 	<ul style="list-style-type: none"> • Planners should remain informed of how the public perceives the implementation of evolving energy technologies
EERE, 2008 United States	<i>Can wind power supply 20% of the nation's electricity by 2030?</i> Lit. & case study review	<ul style="list-style-type: none"> • State agencies must expedite approval process • State wind model ordinances to guide state & municip. permittg. agencies 	<ul style="list-style-type: none"> • Visual impact • Coexists w- farm, forestry & ranching • Mitigate avian & bat mortality • Mitigate lightg. & noise 	<ul style="list-style-type: none"> • Developer must engage local leaders & public • Educ. locals on wind P env. Benefits & LCIA w- other elec. gen. options • Surroundg. prop. values • Local ownership • Municipal tax revenue

Groothuis et al, 2008 North Carolina	<i>How much compensation is required for property owners to accept wind farms within their viewshed?</i> Contingent valuation survey and bivariate-probit analysis	Local politicians catering to wind power opposition	<ul style="list-style-type: none"> • Visual impact • Noise • Shadow flicker 	<ul style="list-style-type: none"> • Consumers willing to pay premium for renewable electricity • Property values • Tenure of residents (ancestral vs. transplant)
TRC, Inc., 2009 Massachusetts	<i>Do current state laws and regulations adequately facilitate the siting of wind power facilities?</i> 6 case studies with document review and stakeholder interviews	<ul style="list-style-type: none"> • MA Green Communities Act 2008 • MA Renewable Portfolio Standard • High energy import dependency 	<ul style="list-style-type: none"> • Municipal zoning: height, noise, setback codes prohibit wind power • Environmental impacts (threatened species, water quality, crossings) • Historical & archeol. resources 	<ul style="list-style-type: none"> • Zoning appeals process • State environmental permit appeal process
Swofford & Slattery, 2010 Texas	<i>What are the environmental attitudes of the local community, and does proximity influence attitude and NIMBYism towards an operational wind farm?</i> Mailed survey questionnaire (N=200; 14% response)	• Policy factors not addressed in this study	<ul style="list-style-type: none"> • Majority respondents see turbines while driving • More responded that wind farm is unattractive vs. attractive landscape feature • Allows multiple land uses • NIMBY does not adeq. explain opposition 	<ul style="list-style-type: none"> • Major responses include recognition of wind power as a safe, clean, and renew. resource • Respondents split over elec. reliability of wind • Even split of gen. attitude towards wind farm for residents within 0-5km • Greater positive attitude for residents w-in 10-20km (72%)

Studies focusing on the specific conflicts of wind power siting appeared in the United States with the first modern wind farms built in California in the 1980s (Thayer & Freeman, 1987; Gipe, 1990; Gipe, 1995). Thayer and Freeman (1987) surveyed the local public's response to the Altamont Pass Wind Farm. Survey responses showed neutral public perceptions towards the early forms of wind power technology, with the strongest reaction to the use of public funds for "unreliable and intermittent" electricity generation. Out of a 1 to 5 point Likert scale, respondents (N=200) expressed mixed reactions on aesthetics, whether turbines were perceived as *ugly* (3.1), *unattractive* (3.2), or *conspicuous* (4.4). Yet respondents also recognized that wind turbines symbolize *progress* (4.14), the *use of safe and natural energy* (4.60), and are *appropriate* (3.8). Other findings include a correlation between respondents' proximity to the wind farm and their increased opposition to it, and a visual preference for larger, but fewer turbines versus many, smaller turbines (Thayer & Freeman, 1987).

A fifteen year lapse occurs before considerable wind energy development, and corresponding planning and siting studies, emerge again in the U.S. (Table 2.1). In the early 2000s in Arizona, Acker and colleagues (2003) studied the specific barriers and opportunities for wind power development on Western Tribal lands that would, in turn,

reduce regional haze. The 1990 Clean Air Act and a 1999 EPA regional haze rule were the main policy-based opportunities. Acker (2003) surveyed tribal residents' attitudes toward wind energy facilities and found strong support when sacred sites and local economic benefits were considered. Over 75% of the tribe members surveyed indicated an interest in developing renewable energy systems, if costs were competitive, and an interest in selling renewable electricity through deregulated markets. The authors found the main barrier was a lack of a central utility or authority to manage energy production and distribution within Tribal Lands.

The American Planning Association released an Energy Policy Guide (2004), which addressed the planner's role in increasing renewable energy production, among other objectives. The APA guide (2004) emphasized incorporating renewable energy production into the broad range of community-based planning functions such as zoning bylaws, master plans, and overlay districts. These would theoretically provide renewable energy projects with a locally-defined, legal framework to counter public resistance.

Bolinger (2005) explored whether the European community-owned wind power model could also work in the U.S. (Table 2.1). The study compared policy instruments between European countries and U.S. states. Major differences observed include the number of large commercial turbines owned by multiple local investors, not by corporations, in Denmark, Germany, Sweden, and the Netherlands. The study recommended farmer cooperatives, schools, municipalities, and local investors as wind turbine owners, especially in states such as Minnesota which provide utility mandates and production incentives beyond the intermittent federal production tax credit. The European Union carbon market and the German and French feed-in tariff are also mentioned as policy mechanisms that would support community-owned wind turbines.

Vajjhala and Fischbeck (2007) analyzed the factors for the difficulty in siting interstate transmission lines. Wind power projects rely on transmission expansion and upgrades in order to transport the electricity to the major load centers. Despite the 2005 Energy Policy Act defining the planning and expansion of electricity transmission corridors as a national security interest, strong local public opposition remains the primary barrier. This opposition to power lines parallels instances of public opposition to the siting of new wind energy facilities.

Andrews (2008) described how emerging energy technologies with smaller, more decentralized facilities bring planners a new set of siting challenges. He advocates for planners to focus on how energy conversions take place at specific nodes, how smaller decentralized facilities can support implementation of smart grids and to identify areas where policies can leverage greater private sector activity. Andrews also stresses that planners should remain cognizant of how the public perceives the actual implementation of the several evolving, self-proclaimed clean and renewable energy sources (2008).

In 2008, the U.S. Department of Energy released the *20% Wind by 2030* plan, which announced that the federal goal of supplying 20% of the nation's electricity from wind energy generation could feasibly occur by 2030 (EERE, 2008). The report provides a thorough assessment of the potential for, and the barriers to, wind energy development throughout the U.S. It suggests state agencies expedite the approval process by providing model wind ordinances to guide municipalities, and ensuring adequate mitigation for visual, wildlife, lighting, and noise impacts (EERE, 2008).

Groothuis and colleagues (2008) conducted a contingent valuation survey in western North Carolina to determine the degree of compensation required for property owners to accept wind farms within their viewshed. They found strong local public opposition to wind development, with the local officials catering to the opposition's concerns. The opposition's primary concern in this case was property devaluation, followed by perceived visual, noise, and shadow flicker impacts. Notably, those residents who expressed a willingness to voluntarily pay a premium for renewable electricity were more accepting of wind power, as were ancestral residents as compared to transplant residents (Groothuis et al., 2008).

The TRC consulting firm (2009) analyzed how state regulations inadequately address wind power development within Massachusetts. The firm performed six wind power project case studies, ranging in size from a 1.5 megawatt turbine community project to a 15 turbine, 30 megawatt capacity commercial project. The study determined that many municipal zoning, height, noise, and setback ordinances limit the siting of commercial-scale turbines. Yet the zoning and environmental permit legal appeals process is the largest barrier to development. Lengthy project delays based on legal

appeals have led to the Wind Siting Reform Act legislation. The Act, in turn, has remained stalled in the Massachusetts state senate since its introduction in 2009.

Lastly for the United States, Swofford and Slattery (2010) measured through a mailed survey questionnaire whether proximity influences individual attitudes and NIMBYism towards an operational North Texas wind farm. More local individuals (N=200) responded that the wind farm is an unattractive, versus attractive, feature (47% to 31%) on the landscape. Respondents recognized that the wind farm enables multiple land uses on the same site (55% to 19%), and most people observed the turbines while driving (90%), more than while in their homes or in other buildings (38%). The results show an even level of acceptance towards the wind farm from residents within 0-5 kilometers, whereas 72% of residents within 10-20 kilometers expressed a positive attitude. Despite the authors' inference that the NIMBY phenomenon does not adequately explain public opposition, their findings appear to prove otherwise. The study upholds the prevailing wind energy siting theory that a not-in-my-backyard-reaction (NIMBYism) is not the sole predictor for opposition (van der Horst, 2007; Wolsink, 2007).

In summary, the U.S. based studies inform us that the public perceives wind power as a clean, appropriate source of electricity (Thayer and Freeman, 1987; Bolinger, 2005; Swofford and Slattery, 2010). Survey responses are mixed in terms of the visual aesthetics of turbines (Thayer and Freeman, 1987; Groothuis et al., Swofford and Slattery, 2010). The proximity to a wind turbine does not necessarily correspond with opposition (Groothuis et al., 2008; Swofford and Slattery, 2010). Regional energy infrastructure planning should be incorporated into existing land use planning processes (Acker et al., 2003; Andrews, 2008; APA, 2004; Vajjhala and Fischbeck, 2007), and more surveys are needed to provide a larger sampling size and to determine public receptiveness in geographic areas other than Arizona, California, Texas, and North Carolina.

Wind Power Planning and Siting Process Studies in Europe

Table 2.2 summarizes fourteen European wind power planning and siting studies from 1988 through 2010. They address similar issues that occur within the United States, yet provided a greater number of case studies, since commercial wind power development projects began much earlier in Europe. Half of the articles compare wind power development policies and outcomes between different European nations (Breukers and Wolsink, 2007; Buen, 2006; Carlman, 1988; Jobert et al., 2007; Nadai and van der Horst, 2010; Wüstenhagen et al., 2007). The other half compare the different municipal or regional approaches to wind development occurring within the same nation and policy framework (Khan, 2003; Moller, 2010; Nadai, 2007; Nadai and Labussiere, 2009; Ohl and Eichhorn, 2010; Rogers et al., 2008; Warren et al., 2005). The methodology and organizational framework of the dissertation's case study comparisons of three wind power project outcomes, described in chapter three, is derived from the Breukers and Wolsink (2007), Jobert (2007), and Wüstenhagen (2007) studies, which identify inter-governmental policy, site-specific, and social/institutional factors as the main factors influencing a project's outcome.

Table 2.2: Wind Power Planning and Siting Process Studies: Europe

Geographic Area	Research Question & Methods	Policy Factors	Site Factors	Social & Institutional Factors
Carlman, 1988 Denmark, Sweden	<i>Have Denmark and Sweden lived up to their reputation of being the leaders in wind energy development?</i> Content analysis and interviews	<ul style="list-style-type: none"> Oil crises of 1973 & 1979 major driver to secure other energy sources- for both countries Denmark exhibited strong political will and promotion Superficial political interest in Sweden 	<ul style="list-style-type: none"> Both Danish and Swedish planners concerned with visual impact Established “residence free” areas based on noise level 	<ul style="list-style-type: none"> Denmark’s accelerated adoption of wind energy attributed to different energy portfolio than Sweden, which has relied on hydro-electric and nuclear Danish public able to work with the utility companies
Bishop, 2002 Victoria, Australia	<i>Determine the relative perceived size and contrast levels of wind turbines at distances up to 30km</i> GIS internet-based visual impact mapping	<ul style="list-style-type: none"> Inform distance buffers in zoning regulations 	<ul style="list-style-type: none"> Site planning, gauging distances of visibility 	<ul style="list-style-type: none"> visual impact of wind turbines within a rural landscape
Khan, 2003 Sweden	<i>How does the municipal planning process influence the outcome of wind power development projects?</i> 3 municipal case studies	<ul style="list-style-type: none"> Stronger national policies needed to ensure greater predictability in local permitting process, while still enabling public participation Poor local plng. can lead to public suspicn. in other municipalities 	<ul style="list-style-type: none"> Distance to houses Landscape & visual impact Noise level Nature conservation Recreation Cultural & historical values 	<ul style="list-style-type: none"> Large difference in how municipalities manage wind power proposals Divergent public opinion from the 3 towns, from substantial to minimal opposition to specific proposals
Warren et al. 2005 Scotland, Ireland	<i>Do locals favor wind farms more after construction, and does acceptance incr. with proximity to them?</i> Case Study review of public attitudinal studies	<ul style="list-style-type: none"> Policy factors not addressed in this study 	<ul style="list-style-type: none"> Aesthetic preference, whether positive or negative, has strongest influence on individual attitude towards wind farms 	<ul style="list-style-type: none"> Theory of global vs. local environmentalism “green vs. green” locals favor wind farms more upon completion of their construction greater public acceptance occurs at closer proximities- counters NIMBY theory
Buen, 2006 Denmark & Norway	<i>Do policies stimulate long-term technological change in the wind industry?</i> Comparative policy analysis	<ul style="list-style-type: none"> Denmark offers broad policies and incentives to both manufacture and site wind turbines Policies much weaker in Norway 	<ul style="list-style-type: none"> Danish tradition of community ownership in turbines enables constant phasing in of new, larger turbines Limited diffusion in Norway 	<ul style="list-style-type: none"> Denmark’s wind industry adapted to unpredictable global energy market Less social support for new power supplies, reliance on incr. existing energy supply (oil)
Breukers & Wolsink 2007 Netherlands, UK, Germany	<i>Why do divergent achievements in wind power implementation exist in Europe?</i> 3 case studies in separate countries (DE, NL, UK) via document review & stakeholder interviews	<ul style="list-style-type: none"> Volatility of national renewable electricity policy 1990’s electricity market liberalization Status of country’s wind turbine manuf. 	<ul style="list-style-type: none"> Local nature protection Cultural historic landscapes 	<ul style="list-style-type: none"> Local financial participation or co-ownership (DE) Local community benefits (UK) Public participation (all) Resistance to change
Jobert et al, 2007 France, Germany	<i>What contributes to the success or failure of a wind power project?</i> Historical reconstruction and stakeholder interviews.	<ul style="list-style-type: none"> Strong national renewable electricity incentives required (French v. German policy differences) 	<ul style="list-style-type: none"> Visibility Former use of site Rural economy & tourism Land ownership 	<ul style="list-style-type: none"> Origins of developer(s) Extent of open, public participation Local, supportive activism & assurance Wind farm ownership

Nadai, 2007 France	<i>Does national wind energy policy enable the right balance between top-down rational planning and the local siting process?</i> Analysis of national policy proposals	<ul style="list-style-type: none"> •Rational planning arose from political fight over energy decentralization •Municipalities devise wind power zones •Yet feed-in tariff rates and final permitting remains w- federal agencies 	<ul style="list-style-type: none"> •Policy reform provides incentives for constructing larger, commercial wind farms within locally-defined wind power zones 	<ul style="list-style-type: none"> •Mitigating landscape impacts and achieving local acceptance were main argument of proponents for greater local control •Policy reform results in “flexible decentralized planning”
Wustenhagen et al, 2007 Western Europe	<i>How do socio-political, community, and market factors influence social acceptance of wind power projects?</i> Review of case study surveys	<ul style="list-style-type: none"> •European nations have ambitious targets to increase share of renewable energy to produce electricity •A national policy/local process divide exists 	<ul style="list-style-type: none"> •Visual impact on landscape •Local acceptance follows U curve- from greater acceptance pre-announcement, low acceptance during construction, then higher acceptance post-construction 	<ul style="list-style-type: none"> •Social acceptance constrains achieving national renewable energy production targets •Debate over NIMBY as cause of local opposition
Rogers et al., 2008 United Kingdom	<i>What are residents’ attitudes towards and expectations of a community energy project. Would they become involved in both planning and implementation?</i> Questionnaire survey (N =38) and semi-structured interviews	<ul style="list-style-type: none"> •Greater gov’t support needed to implement wind power project (locality accepts concept but unlikely to lead development) 	<ul style="list-style-type: none"> •Main concern is visual impact on rural character (8) •Very few survey respondents listed environmental harm (1) and noise pollution (1) as concerns (N =38) 	<ul style="list-style-type: none"> •Considerable support for a comm. group to dev. renew. energy facility •Local public willing to participate in planning process, but not in actual development •Local control of projects not realistic for many rural communities
Nadai & Labussiere, 2009 Aveyron, France	<i>Why does the installed capacity of wind power remain low in France after seven years of high feed-in tariffs?</i> Document review and interviews	<ul style="list-style-type: none"> •Government agencies should involve public in decisions which directly effect their community •Decentralization of wind power regulation remains incipient 	<ul style="list-style-type: none"> •National landscape protection mechanisms work against national wind policy objectives by halting projects based on visual impact and sensitive ridgelines 	<ul style="list-style-type: none"> •The conflict is more between two national government agencies, rather than local concerns pitted against top-down mandates
Moller, 2010 Northern Jutland, Denmark	<i>How did the wind power planning regime fail and what impact did planning have on the landscape effect?</i> GIS spatial analysis of proximity, density, and visibility of wind turbines from 1982-2007	<ul style="list-style-type: none"> •Munic & regional zones permit wind power •Larger turbines began to fail EIS •Economics of wind power dev. worsen w-removal of feed-in tariff in 2000 	<ul style="list-style-type: none"> •Visibility of turbines increased over time w- installation of more (up to year 2000) & larger turbines (especially w-replacements) •Proximity to settlements •Density of turbines 	<ul style="list-style-type: none"> •Certain populations suffer from wind turbine visibility more than others •Clustering of turbines into wind parks cause higher visibility, but are economically advantageous
Nadai & Van der Horst, 2010 European Union	<i>How do the efforts to achieve national renewable energy targets impact the appearance of the physical landscape, as well as spatial planning?</i> Review of wind power planning case studies	<ul style="list-style-type: none"> •Top-down streamlined decision process risks alienating stakeholders and local public •Forced to arbitrate between globalised public good (less CO2) and localized public bad (landscape impact) 	<ul style="list-style-type: none"> •Major concern is impact on the landscape- which is a broad term insufficiently unpacked 	<ul style="list-style-type: none"> •Considerable gap exists between generic and qualified public acceptance •Conflict is not based on technical aspects, but is highly contextual-unsuitability is perceived & narrated differently by stakeholders
Ohl & Eichhorn, 2010 West Saxony, Germany	<i>Does regional wind power planning conform to revised national policy standards?</i> Case study of West Saxony region analyzing how new federal siting standards & the decision making for priority areas in the regional plan restrict wind P dev potential	<ul style="list-style-type: none"> •Renew E Sources Act requires 30% elec. from RE by 2030 (formerly 15%) •Modified in 2009, feed in tariff only applies to elec. gen yields 60%+ performance standard, but raised by 20%+ per kWh 	<ul style="list-style-type: none"> •Renew E Sources Act places higher standards on suitable wind P dev areas •New height limitations of 100m reduce dev. potential w-in priority areas by 50% 	<ul style="list-style-type: none"> •Regional particip. planning process currently hampers siting of larger, more efficient turbines

Carlman (1988) provides the first studies of modern wind power in Europe, comparing through content analysis and interviews how Denmark and Sweden promote the industry. Interestingly, both countries established “residence free” zones within prime wind resource areas, the opposite of many municipal zoning laws in the U.S. that in essence establish wind turbine free areas (Table 2.2).

Khan (2003) found, through three municipal case studies in Sweden, that visual aesthetics was the major factor in opposition. Large differences existed in how municipalities handled proposals and there was divergent public opinion from the three towns (Khan, 2003).

Warren and colleagues (2005), through public attitudinal studies, examined how locals in Ireland and Scotland react to wind farms before and after construction and whether proximity influenced acceptance. They found local acceptance to increase upon the completion of a project. Visual aesthetics, whether viewed positively or negatively, had the strongest influence on attitudes towards wind farms, which supported Khan’s findings. They also found that greater public acceptance occurred at closer proximity, within 5 kilometers, than at distances between 5-10 and 10-20 kilometers, countering the NIMBY theory (Warren et al., 2005). The personal experience living near operating wind turbines contributed to an appreciation and support for the technology. However, the authors do not include viewshed analysis with their surveys, as Bishop (2002) and Thayer and Freeman (1987) employed, in order to determine which populations are most affected visually. Proximity does not necessarily correlate with visual exposure to a wind turbine.

Buen (2006) compared Danish and Norwegian energy policies to determine if they stimulate technological advances in the wind power industry. The study found Denmark’s policies strongly incentivized both the manufacturing and the siting of wind turbines. The Danish approach of community ownership in wind turbines also enabled a constant phasing in of larger, more efficient and productive turbines. For Norway, the reliance on increasing the supply of domestic oil lessened public support for investing in wind power.

Breukers and Wolsink (2007) interviewed stakeholders from three case studies in separate countries (Germany, Netherlands, and the United Kingdom) to analyze why

wind power outcomes differ throughout Europe. They found a country's manufacturing of turbines and local financial ownership influenced successful outcomes in Germany and Netherlands, while the protection of natural and historical landscapes and resistance to change impeded development within the United Kingdom.

Jobert and colleagues (2007) interviewed wind power stakeholders in France and Germany to determine what factors contribute to the success of wind power projects (2007). They determined that there are three categories of influential factors: policy, site-specific, and local/institutional responses. For policy factors they found stronger national renewable energy incentives to be essential, as observed in Germany. The main site-specific factors include the former use, land ownership structure, and the makeup of the rural economy and tourism. Local and institutional factors include perception of local versus "outside" developer, the extent of open, public participation, active support from local leaders, and co-ownership by locals (Jobert et al., 2007).

Nadaï (2007) also examined wind power development in France, analyzing federal policy proposals to determine whether they enable a balance between top-down rational planning and the local siting process. He found a tenuous balance exists, where the municipalities devise the specific wind power zones while feed-in tariff rates and final permitting remains with federal agencies. Policy reforms in the 2000s enabled more flexible decentralized planning, yet proponents for greater local control sought stronger mitigation of landscape impacts (Nadaï, 2007).

Wüstenhagen and colleagues (2007), through a review of case study surveys, researched how socio-political, community, and market factors influence acceptance of specific wind projects throughout Western Europe. The demand for more thorough local process stifles ambitious national renewable energy targets. Local acceptance follows a U-curve pattern- higher pre-announcement of a specific projects, lowest during construction, then higher again post-construction. They found visual aesthetics to be the main factor for opposition, thus inferring that the NIMBY phenomenon does influence wind power siting. Those living within the viewshed of wind turbines, in their distant "backyard," oppose the projects more than others located outside of the viewshed (Wüstenhagen, et al., 2007).

Nadaï and Labussiere (2009) examined, through document review and interviews, why the installed capacity of wind power remains low in France after seven years of feed-in tariffs and strong federal policy support. They determined that conflicts occurred more among national governmental agencies, rather than local concerns pitted against top-down mandates. National landscape protection mechanisms counter national wind policy objectives by limiting projects based on visual impact and sensitive ridgelines (Nadaï and Labussiere, 2009).

Ohl and Eichhorn (2010) provide a case study of West Saxony, Germany to determine if regional wind power planning conforms to revised national energy policy standards. An increase from 15% to 30% of electricity from renewable sources and a higher feed-in tariff places pressure to increase wind power development. At the same time, they note that energy policy also places stricter standards on suitable development areas while regional plans' height limitation of 100 meters reduce potential within priority areas by 50%. Ohl and Eichhorn (2010) determined that the regional participatory planning process hampers the siting of the larger and more efficient turbines.

Lastly, Nadaï and van der Horst (2010) reviewed a broad set of case studies throughout the European Union to observe how efforts to achieve national renewable energy targets impact spatial planning and the physical landscape. They determined that top-down decision-making is risking the alienation of the local public. They perceive the main tension to be between arbitrating a globalised public good (reduction of greenhouse gas emissions) and a localized public bad in the form of landscape impact. A considerable gap exists between general and qualified public acceptance, and where conflicts exist, they are based not on technical but rather contextual aspects, which are perceived differently by stakeholders (Nadaï and van der Horst, 2010).

In summary, the European case studies provide a more comprehensive picture of the opportunities and barriers to wind power development, based on an earlier inception of policies and incentives. A wide range of inter-governmental cohesion and support exists between European nations. Denmark and Germany are seen as wind energy pioneers, while the United Kingdom, France, and Sweden struggle to develop wind power, despite strong national renewable energy policies and incentives (Breukers and

Wolsink, 2007; Buen, 2006; Carlman, 1988; Jobert et al, 2007; Wüstenhagen et al., 2007). Many of the groundbreaking European nations are now reaching the build-out of the most politically and socially viable locations for wind power generation (Nadai and van der Horst, 2010; Ohl and Eichhorn, 2010). In the United Kingdom (Rogers et al., 2008), France (Nadai and Labussiere, 2009), and Germany (Moller, 2010) there is increasing public resistance to the expansion of wind power development on landscapes of cultural, recreational, and historic significance.

Land Use Assessments, Model Ordinances, and Empirical Variables for Wind Power Siting

The previous section described the main U.S. and European case studies of wind power planning and siting. This section reviews the more empirical-based studies on siting suitability, as well as state-level model ordinances. State and municipal governments increasingly rely on GIS land use assessments and model zoning ordinances to analyze and determine specific setback thresholds for wind farm placement. This section reviews the range of empirical wind farm siting criteria being employed. From nine sources, 29 quantitative variables were selected. These variables can be divided into four distinct categories: physical and technical; environmental and historic resources; visual, noise, and communication; and land use and land ownership. This section of the review uncovered a need to incorporate several siting criteria from land use assessments into state model wind ordinances and vice-versa. Secondly, multi-county, regional-scale assessments provide more accurate GIS modeling results. Finally, the review recognizes the need for a new, fifth category of wind farm siting variables that will encompass conservation easements, development restrictions, and other legal land protection designations.

Land Use Assessments for Wind Power Siting

Wind power *land use* assessments differ from wind power *resource* assessments. Resource assessments measure the wind power velocity at specific heights above the ground surface using anemometers mounted to meteorological towers, ideally at the same

height of a proposed wind turbine hub (Landberg et al., 2003). A wind power resource assessment is a prerequisite for conducting a land use assessment, as it establishes the primary, dependent variable of mapping the land areas with prime wind power density. Land use assessments typically measure the amount of land coverage suitable for the placement of wind turbines after accounting for several exclusionary variables (e.g. proximity to transmission lines, steep slopes, wetlands), and employ either a weighted suitability or boolean GIS model.

Wind power land use assessments developed incrementally once resource assessments had identified the land areas with potentially significant average wind power velocities (Elliott et al., 1987). U.S. Department of Energy studies established initial siting criteria in 1991 with a series of land exclusion scenarios that refined the estimates of wind resources available for electricity generation in each U.S. state (Elliott, Wendell, & Gower, 1991). The moderate scenario excludes 100% of environmental and urban areas, 50% forest, 30% agricultural, and 10% range land coverage (Figure 2.1). This moderate scenario established the base land use criteria for subsequent state-level land area availability assessments conducted by NREL (MREP-NREL, 2005; Acker, 2007).

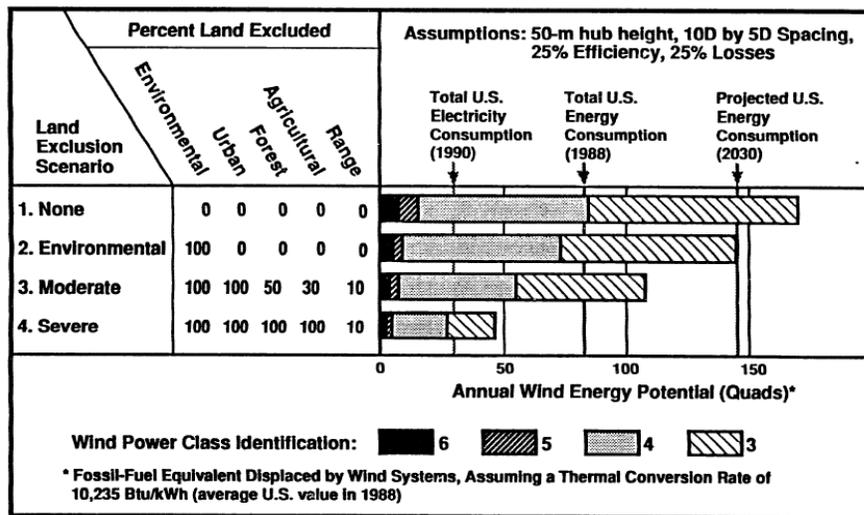


Figure 2.1: Original Wind Power Siting Assessment Land Exclusion Scenarios, U.S. DOE, 1991.

However, this initial wind power siting assessment lacked physical and technical variables that affect economic viability, such as slope gradient, proximity to existing

paved roads, and existing transmission lines. It also lacked environmental resource variables that would account for the variability in ecological value. Lastly, it lacked variables accounting for potential conflicts with infrastructure (such as telecommunications and airports) and adequate buffer distances for residential, institutional, and recreational land uses. As mapping resolution improved and geographic information systems (GIS) land use data became more available, subsequent studies incorporated these missing variables (Short, 1999; Heimiller, 2001).

Several wind power land use assessments calculate suitable land area for wind farms within specific land holdings or land management designations, such as exclusively within Bureau of Land Management, U.S. Forest Service, and state-owned and managed lands (Kirby et al., 2003; Zimmerman, 2003; Karsteadt et al., 2005). Because they limit the geographic area to within a single property owner's holdings, they are not included in this review. The following section describes six peer-reviewed wind power land use assessments from Europe and the United States.

Baban and Parry (2001) assess the suitability of locating wind farms within Lancashire, United Kingdom using two GIS models: a criteria-based boolean model, and a weighted model based on public survey responses. Publicover (2004) employs a weighted suitability GIS model to assess potential conflicts between wind power and four land use categories: existing conservation status and ecological, recreational, and scenic factors. The Michigan Renewable Energy Program (MREP) utilizes the National Renewable Energy Laboratory's (NREL) land use criteria to establish a 2006-2020 assessment of wind power capacity potential for the state of Michigan (Schwartz, 2003; MREP, 2005). Rodman and Meentmeyer (2006) assess the suitable land area for wind turbine placement within the nine-county Central California region by employing a rule-based, weighted GIS suitability model. Acker and colleagues (2007) also incorporate the NREL land use criteria to assess the wind power capacity potential within the state of Arizona using a boolean GIS model. In Spain, Bravo and colleagues (2007) assess the generation capacity potential for six renewable energy technologies, including wind power within onshore flatlands and complex terrain. The lack of data and divergent criteria from the assessments show a need to analyze and compare land use variables and

buffer distances from other sources as well, such as state wind model ordinances, in order to establish a more comprehensive set of explanatory variables (Figures 2.2-2.5).

State Model Ordinances for Wind Power Siting

While wind resources and the underlying land uses were being assessed, states began to confront land use conflicts and opposition to wind power proposals. In response, many states drafted wind energy model ordinances, and nationwide several municipalities adopted either enabling or restrictive bylaws. Oteri's overview (2008) of municipal wind power ordinances, predominantly from the Midwest, includes summary charts for 25 individual municipal ordinances. He identifies themes in the ordinances—which are designed to regulate large commercial-scale wind power facilities—such as access, appearance, height, lighting, noise, site restoration, minimum setbacks, shadow flicker, spacing, and zoning (Oteri, 2008). Although hundreds of municipal wind power ordinances presently exist, this review concentrates on the empirical variables included in four state model ordinances. The ordinances are from the Northeast U. S., the most densely-populated region with wind resources in the nation. The first model ordinance, New York's *Wind Energy Model Ordinance Options*, offers the most comprehensive set of wind power siting variables (New York, 2005). The *Model Ordinance for Wind Energy Facilities* in Pennsylvania employs similar variables (Pennsylvania, 2006). The Massachusetts *Model Amendment to a Zoning Ordinance or By-law: Allowing Wind Facilities by Special Permit* provides a regulatory framework for both large, utility scale and smaller, residential scale wind turbines (Massachusetts, 2007). The final and most recent model ordinance is the Maine State Planning Office's *Model Wind Energy Facility Ordinance* (Maine, 2009).

The Four Categories of Empirical Wind Power Land Use Variables

Combined, the wind power land use assessments and the state wind model ordinances provide 29 explanatory variables for determining wind power siting suitability. Not all wind siting variables are measurable at the regional, landscape scale. Variables such as shadow flicker, noise level, and radio, television, and microwave signal paths are heavily site dependent and require an assessment of the site's surroundings in a

more complex, site-specific three-dimensional model. The variables are arranged into four defining categories, based on how the wind power siting and planning literature has distinguished them:

1. Physical and Technical
2. Environmental and Historical Resources
3. Visual, Communication, and Noise
4. Land Use and Land Ownership

The first category of wind power siting variables accounts for the four physical and technical aspects found within wind power land use assessments and state model wind ordinances. This category includes the variables essential for economically viable wind power development: wind resource/wind power density, slope gradient, proximity to existing electricity transmission infrastructure, and proximity to major graded roads. A minimum wind resource value and a maximum slope gradient are conspicuously absent in the model ordinances (figure 2.2). A minimum wind resource requirement would guide large wind power projects to the areas in a municipality with the most optimal wind resources, maximizing the use of state and federal technical and financial assistance. A defined maximum slope gradient ensures the identification and exclusion of steep slope areas when constructing access roads and siting individual wind turbines.

Surprisingly, few siting assessments or model ordinances account for distance from existing electricity transmission lines as a constraining physical variable. Public utility and energy company representatives mention close proximity to existing or proposed transmission infrastructure as a requisite variable for wind farm placement. Two model ordinances recommend a minimum turbine setback buffer to transmission lines, and all provide a minimum buffer from major roads. The model ordinances focus on maintaining a minimum safe distance (i.e., 1.5x the total turbine height) away from infrastructure, whereas the siting assessments focus on the maximum plausible distance to infrastructure (i.e., within 10,000 meters).

PHYSICAL & TECHNICAL VARIABLES	WIND POWER SITING LAND ASSESSMENTS					STATE WIND MODEL ORDINANCES			
	BABAN (2001) U.K.	MREP-NREL (2005) Michigan	RODMAN (2006) Central CA	ACKER (2007) Arizona	BRAVO (2007) Spain	NEW YORK (2005)	PENN. (2006)	MASS. (2007)	MAINE (2009)
1. Wind Resource/ PowerDensity	> 5 meters/ sec	> 6.3 meters/ sec @ 50m height	> 7 meters/ sec @ 50m height	> 6.3 meters/ sec @ 50m height	> 8 meters/ sec				
2. Slope Gradient	less than 10%	less than 20%	0-7°, 7-16°, 16-30°, 30-40°, 40°+	less than 20%	less than 10%				
3. Proximity to Existing Elec. Transm. Lines	w/in 10,000m			w/in 10 miles		1.1x total turbine height buffer			1.5x total turbine height buffer
4. Proximity to Major Roads	w/in 10,000m			w/in 10 miles		1.0x total turbine height + 50' buffer	1.1x total turbine height buffer	100' buffer	1.5x total turbine height buffer

Figure 2.2: Comparison of Physical and Technical Wind Power Siting Variables

The second category of wind power siting variables describes environmental and historical resources. Environmental resource impacts are the primary concern of conservation organizations opposed to wind power development (Publicover, 2004, Allison et al., 2006; BNRC, 2005; Bodin, 2009; TTOR, 2009). The siting assessments thoroughly account for environmental resources, but they surprisingly remain absent within the state model ordinances. Two of the four model ordinances incorporate no environmental variables (Figure 2.3; Pennsylvania, 2006; Massachusetts, 2007). The New York model ordinance recommends buffers for important bird areas and wetlands, and well as site maps demarcating historical sites. The model ordinances provide no guidance for prioritizing or buffering certain types of land cover or vegetative cover beyond non-forest wetlands. For historic and archeological resources, only one siting assessment (Baban, 2001) and one model ordinance (Maine, 2009) provide an exclusionary variable.

Variables accounting for avian and chiroptera habitat and migratory routes remain absent from both the siting assessments and the model ordinances, despite the broader wind power literature citing avian and chiroptera mortality rates as important environmental considerations (Figure 2.3; Andrews, 2008; Baerwald et al., 2008; Devereux et al., 2008). Studies in Texas predict mortality risk to avian and chiroptera populations from newly operating wind farms (Hale and Karsten, 2010; Swofford and Slattery, 2010). A lack of GIS data may contribute to the absence of siting variables specifically designated for avian and chiroptera habitat and migration.

Most siting assessments include distinct variables for rare species, wildlife habitat, federal wildlife refuges, preserves, and wilderness areas and/or state-designated ecologically sensitive areas. Only one siting assessment, the Rodman (2006) study, includes endangered plant species sites as a separate variable.

ENVIRONMENTAL & HISTORICAL VARIABLES	WIND POWER SITING LAND ASSESSMENTS						STATE WIND MODEL ORDINANCES			
	BABAN (2001) U.K.	PUBLICCOVER (2004) Berkshires MA	MREP-NREL (2005) Michigan	RODMAN (2006) Central CA	ACKER (2007) Arizona	BRAVO (2007) Spain	NEW YORK (2005)	PENN. (2006)	MASS. (2007)	MAINE (2009)
Endangered Plant Species Sites				excluded						municip. considers ME agency
Rare Species/ Wildlife Habitat		excluded								municip. considers ME agency
Federal Wildlife Refuges, Preserves, & Wilderness	1,000m buffer	excluded	3,000m buffer	excluded	excluded					153m buffer
State Desig. Ecologically Sensitive Areas	1,000m buffer	excluded	3,000m buffer			special & natural protn. areas excl'd	763m buffer from impo. bird areas			
Forest Density	500m buffer from forests	old growth + unfrag. areas excluded		low=suitable high = unsuitable		all forests excluded				
Wetlands	1,000m buffer		3,000m buffer	excluded	excluded	excluded	453m buffer			153m buffer
Lakes, Rivers & Streams	400m buffer		3,000m buffer			excluded				153m buffer
Historical & Archeological Resources	1,000m buffer						show historical sites on site map			763m buffer

Figure 2.3: Comparison of Environmental & Historical Resources Wind Power Siting Variables

The third category of wind power siting variables addresses the mitigation of human-related nuisances associated with wind farms. Noise level and shadow flicker are the most commonly addressed variables in the visual, noise, and communication category. In this category, the siting assessments contain a paucity of variables compared to the model ordinances (Figure 2.4). Certain variables in this category such as shadow flicker, noise level, and radio, television, and microwave signal paths are not yet measured for GIS modeling purposes. However, several wind farm review processes measure municipally designated scenic vistas and residential viewsheds, and therefore they may plausibly be incorporated into wind power land use assessments that cover smaller geographical areas.

VISUAL, NOISE, & COMMUNICATION VARIABLES	WIND POWER SITING LAND ASSESSMENTS						STATE WIND MODEL ORDINANCES			
	BABAN (2001) U.K.	PUBLICCOVER (2004) Berkshires MA	MREP-NREL (2005) Michigan	RODMAN (2006) Central CA	ACKER (2007) Arizona	BRAVO (2007) Spain	NEW YORK (2005)	PENN. (2006)	MASS. (2007)	MAINE (2009)
Total Height Limitation									max. 122m	
Ridgelines	avoid summits	ridgelines w- recr. trails excluded		most suitable			ridgeline buffer, when applic.			
Municipally Designated Scenic Vistas							exclude		visual repr. if w/in scenic vista	visual impact assesmt w-in 4.8 km
Public and Residential Viewshed		3.2 km buffer from trail vistas					visual represtns w/in 4.8 km		3 visual repr. (pop. areas w/in 3.2 km)	mitigate through native tree planting
Shadow Flicker	500m						mitigate on adj. occup. buildings	mitigate on adj. occup. buildings		avoid adverse effects
Noise Level	500m						max. 55 dBa from prop. Lines	max. 55 dBa from adj. resid. bldg.	max. 10 dBa above avg. ambient level	max. 55 dBa from adj. resid. bldg.
Radio, TV, Microwave Signal Paths							mitigate signal disruptions	mitigate signal disruptions		

Figure 2.4: Comparison of Visual, Noise & Communication Wind Power Siting Variables

The fourth and final category of variables accounts for land use and land ownership, with ten empirical variables found to measure suitable land areas for wind power siting (Figure 2.5). The siting assessments unexpectedly contain more land use and ownership variables than the model ordinances. The siting assessments incorporate eight out of the ten total land use variables whereas the model ordinances incorporate only four. The model ordinances address specific building and property line setbacks, whereas the siting assessments address the unsuitability of specific land uses such as urbanized areas, airports, public parks, and conservation and recreational areas. The Acker (2007) study incorporates Tribal Reservation lands, yet no siting assessment or model ordinance includes municipal parks, municipal forests, or other municipally held property. Many rural areas with high wind resources comprise significant tracts of municipally owned and managed properties (Publicover, 2004). Lastly, it is important to note that secondary land ownership rights such as conservation, agricultural, and historical preservation easements are also absent in the siting assessments and model ordinances.

LAND USE & OWNERSHIP VARIABLES	WIND POWER SITING LAND ASSESSMENTS						STATE WIND MODEL ORDINANCES			
	BABAN (2001) U.K.	PUBLICCOVER (2004) Berkshires MA	MREP-NREL (2005) Michigan	RODMAN (2006) Central CA	ACKER (2007) Arizona	BRAVO (2007) Spain	NEW YORK (2005)	PENN. (2006)	MASS. (2007)	MAINE (2009)
Zoning							est. wind facility overlay district		est. wind facility overlay district	
Urban / Settled Areas	2,000m buffer		3,000m buffer	excluded	excluded	excluded				
Airports			3,000m buffer		3,000m buffer					
Proximity to Occupied Buildings	500m buffer						453m buffer	buffer 5x total turbine height	buffer 1.5x total turbine height	153m buffer
Property Line Setback							1.5x total turbine height buffer	1.1x total turbine height buffer	30m buffer	1.5x total turbine height buffer
Conservation Land Trust Property			3,000m buffer		excluded					1.5x total turbine height buffer
Farmland	exclude prime soils			most suitable veget. cover						
State Parks & Forests		conservatn & recr. areas excluded	50% excluded	excluded			show state lands on site map			
Federal Parkland & Recr. Areas	1,000m buffer	305m buffer from desig. recr. trails	3,000m buffer	excluded	excluded					
Federal Forests (USFS)		conservatn & recr. areas excluded	50% excluded		50% excluded					

Figure 2.5: Comparison of Land Use & Ownership Wind Power Siting Variable

This comparative review of the empirical variables used in both wind power land use assessments and model ordinances finds a lack of uniformity for exclusion standards. A conspicuous gap exists between how energy and land use researchers and state energy officials determine which exclusionary variables to include and the specific metrics used for each variable, and they often acquire their criteria from different sources. Only half the variables, 15 out of 29, exist in both siting assessments and model ordinances, and only 2 out of the 10 land use and ownership variables (proximity to occupied buildings and land trust property) are found in both. Even the MREP and Acker studies, which both incorporate NREL’s original land use guidelines, employ separate buffer distances. The New York and Maine model ordinances account for more overlap, 15 out of 29 siting variables, than the other model ordinances examined. For the Maine ordinance, this may be attributable to its later release, allowing the authors to build from previously published state and municipal ordinances.

The findings also illustrate a need for greater coordination between state energy departments and state, regional planning, and conservation group GIS offices. GIS data

layers already exist for variables relevant to wind power siting considerations. For example, the State of Massachusetts GIS office (MassGIS) frequently updates and offers public access to environmental data layers. These GIS data layers include areas of critical environmental concern, rare species habitat, and forest land of statewide significance. However, the Massachusetts Department of Energy Resources has not included these variables in the *Massachusetts Model Amendment to a Zoning Ordinance or By-law: Allowing Wind Facilities by Special Permit*.

In terms of an appropriate geographic scale, multi-county-level wind power land use assessments provide greater resolution, more accurate calculations, and may assist in establishing wind overlay districts within the most suitable areas within a state. A multi-county focus enables the incorporation of higher resolution raster data and often illustrates flaws in variable criteria selection. For example, Rodman's nine-county study employed a 30 meter cell-size resolution versus the MREP and Acker state-level 200 meter cell-size resolution. Wind power land use assessments counties at the sub-state regional scale are now possible at resolutions of 10 meter cell size or less, further improving the accuracy of measuring suitable land areas.

GIS modeling advancements enable future wind power land use assessments to account for the land area and road frontage required for access and electricity transmission interconnection. This will be increasingly important to study, since wind farm projects may stall in the permitting stage because of environmental impact issues associated with road access easements outside the defined boundary of the wind farm. Such is the case with the Hoosac Wind Farm in the Berkshires of Massachusetts.

This review uncovers the need for a fifth category of wind power siting variables. The fifth category incorporates specific land ownership variables not yet covered in siting assessments and model ordinances. These empirical variables measure the extent of land coverage held in conservation easements or that possess specific municipal or state land purpose designation beyond a primary designation as public lands, parks, or forests. In many regions, and especially in New England, a considerable amount of private property within prime wind resource areas already possess conservation easements with restrictions prohibiting all forms of development, including wind turbines. This land use pattern is described in greater detail in chapters six and seven. Within the public park and

forest designations lies a potential mosaic of secondary and even tertiary conservation ownership patterns and/or municipal, state, or federal legislative intentions for certain public lands. Therefore, land use researchers must closely examine secondary ownership and development restrictions when conducting wind power land use assessments and establish new siting variables for them. These new wind power siting variables may include:

- U.S. Forest Service Land with Conservation Restrictions
- State and Municipal Forest Land with Conservation Restrictions
- Private Land with Conservation Restrictions
- State and Municipal Land with Historic Preservation Restrictions
- Private Land with Historic Preservation Restrictions
- State and Municipal Land with Agricultural Preservation Restrictions
- Private Land with Agricultural Preservation Restrictions

Considering these potential variables when conducting wind power land use assessments will familiarize researchers with an underlying mosaic of land ownership and land intent, and encourage them to seek GIS data sources that will enable a more comprehensive land use assessment than those previously conducted.

Emerging Issue: Land Conservation and Wind Power Potential

A surging demand for renewable energy now places greater stress on rural landscapes, as ethanol from corn, biodiesel from soybeans, and electricity from woody biomass and wind power bolster the treatment of land as commodity (McDonald, 2009). Energy joins forestry, farming, recreation, and wildlife conservation as another competing, but potentially complimentary, rural land use (Davies, 2010; Outka, 2011). Yet while many environmental scholars concern themselves with energy sprawl or a

renewable energy footprint (McDonald, 2009; Outka, 2011), this review outlines the studies that support the assertion that a continual increase in private conservation lands will limit development within those areas with the best primary renewable energy resources.

During the past twenty-five years the main land conservation strategy shifted from public land acquisition to quasi-private land trusts acquiring and managing conservation easements. Several land use legal scholars, such as Aaronson and Manuel (2008), Korngold (2007), McLaughlin (2005), and Thompson (2004), are noticing this shifting strategy, and are critiquing the merits of permanently restricting private lands through perpetual conservation easements.

A conservation easement is a deed restriction that follows the title of the property, and all residential, commercial, industrial, or other uses are prohibited unless expressly stated within the deed (Daniels and Lapping, 2005; Schmidt, 2008). The federal tax code, in section 170(h), currently recognizes four conservation purposes for establishing a conservation easement: the land must be preserved for recreation, significant wildlife habitat, scenic open space, or areas and structures of historic importance (Aaronson and Manuel, 2008; McLaughlin, 2010).

Conservation easements are typically held by either state governments, or more typically, by private, non-profit land trusts. Land trusts, also known alternatively as conservation organizations, grew exponentially in the 1980s and 1990s as a response to the limited federal funding and management of natural and ecological areas (Cheever, 1995; Brewer, 2003; Myers, 1993). They were successful in navigating a politically unbiased, non-controversial, free-market approach to land conservation- the voluntary placement of limited restrictions on private property in return for financial compensation (Cheever, 1995; Mahoney, 2002). The land in the U.S. protected by conservation easements held by land trusts increased from 450,000 acres in 1990 to 2.6 million acres in 2000 (Mahoney, 2002). The overarching concept is that the private landowner benefits through a one-time compensation while the general public benefits now and in the future with more scenic open space, recreational opportunities, wildlife habitat, and historically preserved landmarks.

Some consider land trusts invaluable for achieving smart growth objectives that the land use and regional planning process were unable to because of the more contentious nature of down zoning, aversion to local regulation, as well as regional governance (Daniels and Lapping, 2005; Hamill and Sturm, 2003; Korngold, 2007; Schmidt, 2008). In many communities land trusts are often the only institutions capable of protecting threatened landscapes and natural resources considered vitally important by the public.

However, a main criticism has been the inability of conservation organizations to quantify how specific protected parcels hold significant conservation values for the greater benefit of the public (Aaronson and Manuel, 2008; McLaughlin, 2005; Steward and Duane, 2009; Thompson, 2004). According to many land use scholars, the genuine intent of a conservation easement remains questionable for hundreds of properties (Aaronson and Manuel, 2008; Cheever, 1995; Korngold, 2007; McLaughlin, 2010). One of the most frequently used conservation purposes- the scenic open space provision- remains ambiguous and difficult to measure (Aaronson and Manuel, 2008). Most of a land trust's financial resources are applied towards easement acquisition while the requisite stewardship of existing held properties and easements is often short-changed. Another criticism is that conservation easements are not able to accommodate emerging and unforeseen social needs and technologies- the restrictions remain static while society, and the land itself, dynamically change over time (Korngold, 2007; Mahoney, 2002; McLaughlin, 2005; Thompson, 2004). Mahoney (2002) stresses that "unless the original parties to the easement are able to predict with astonishing accuracy the needs and preferences of the next and subsequent generations, substantial amendments and extinguishment of conservation easements will be necessary...the extensive use of conservation easements as an anti-development tactic may create ecological, legal, and institutional problems for later generations."

Land use planners are equally concerned that land conservation could remain an ad hoc movement that does not integrate with the comprehensive planning process (Daniels and Lapping, 2005; Schmidt, 2008). According to Korngold (2007), "there is a risk to effective policy making and democratic principles when local public land use decisions are delegated to non-representative, non-accountable private organizations."

Therefore, an ongoing reliance on conservation easements may undermine the viability of the regulatory and zoning approach by making environmental protection increasingly, and unnecessarily, too expensive (Echeverria, 2005).

At the same time, municipal planners and attorneys have not collaborated with conservation organizations in using conservation easements as an effective planning tool (Brewer, 2003; Daniels and Lapping, 2005; Echeverria, 2005; Schmidt, 2008). This could arise from the differences in land trust and land use planning frameworks. Land trust projects tend to react to immediate threats of locally undesirable development, whereas planning is more proactive as it incrementally guides real estate development in long-term phases over a more expansive geographical area. Despite the shortcomings of conservation easements, their use has protected an impressive amount of threatened farmland, forests, and historical sites during the past forty years. The overall consensus is not to refrain from employing easements, which effectively reduce long-term transaction costs and halt many “tragedy of the commons,” but to make them more flexible in order to adapt to future public needs (Korngold, 2007; Thompson, 2004).

Observations and Further Research

This literature review covers the broad range of theories, case studies, guidelines, and land use assessments for wind power planning and siting. It reveals that the U.S.-based wind energy planning and siting literature remains a limited and loose patchwork of studies, with many regions remaining unexamined. The planning and siting literature from Europe is more extensive, attributable to the earlier deployment of wind power in countries such as Denmark, France, Germany, Netherlands, and Sweden, as well its greater funding for planning and siting research. Since market drivers and state policies for renewable energy continue to expand in the U.S., we can expect ongoing occurrences of wind power siting difficulties to arise in the near future and thus greater opportunities to examine these conflicts and offer informed solutions.

From comparing the wind power siting literature within an overall energy facility siting context, it appears that the not-in-my-backyard form of opposition is not as prevalent for wind power as it is for other energy sources such as nuclear reactors, liquefied natural gas storage centers, and urban coal-fired power plants (American Lung

Association, 2011; O'Hare, Bacow, Sanderson, 1983; Dear, 1992; Schively, 2007; Wüstenhagen, 2007; Boudet and Ortolano, 2010; Swofford and Slattery, 2010).

Interestingly, the main rationale for public opposition to wind power in both the U.S. and Europe does not relate to public health or ecological impacts. Several of the studies found that visual aesthetics, and the impact on rural landscapes, was the prevalent factor (Bishop, 2002; Warren et al, 2005; Groothuis et al., 2008; Nadaï and Labussiere, 2009; Nadaï and van der Horst, 2010; Swofford and Slattery, 2010). This concern arose in the 1980s when turbine heights were appreciably shorter, but wind farms correspondingly contained a greater number of turbines to acquire an adequate generation capacity (Thayer and Freeman, 1987; Carlman, 1988). Visual aesthetics may indirectly have an economic impact on local residents via perceived decrease in property value (Hoen, 2009).

From an overall assessment of the wind power planning and siting literature, we realize an appreciable lack of studies that compare the social, economic, and environmental impacts of the different sources of electricity generation. For instance, why is there extensive literature on the importance of local public participation, acceptance, control, and fairness for wind power development (Khan, 2003; Gross, 2007; Higgs et al, 2008; Nadaï and van der Horst, 2010), and not studies directly comparing the participatory process with natural gas extraction and coal mining?

The supply and use of electricity is accepted by society as a public good but there is an array of primary energy sources to generate power. Therefore, researchers should not focus exclusively on the social, economic and environmental impacts of wind power development in isolation. Rather, research should compare the impacts and benefits, adjusted with a functional unit of per MWh of end use electricity, of all forms of electricity generation, which is ultimately the public good/service being provided, for a given geographical area. This could be performed for the primary energy sources that supply a city, state, or a regional ISO's, electricity portfolio. Energy and land use planning scholars also need to compare the siting challenges and existing policy and planning frameworks across different primary sources of electricity generation.

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CHAPTER III

Wind Energy Development Outcomes in New England: Inter-governmental, Site-Specific, and Social Factors

Introduction

While energy and climate policy may remain temporarily stalled at the federal level, state and regional initiatives continue to press for a transformation to cleaner, renewable sources of electricity. The New England region leads in innovative policy drivers. The New England states with the largest consumer markets adopted ambitious renewable portfolio standards. Massachusetts mandates 15% of total net electricity generation from *new* renewable sources, while Connecticut mandates 23% and Rhode Island 15% from cumulative renewable sources by 2020 (EERE, 2010). They also collaborated with New York state and other Northeast states to form the nation's only mandatory carbon cap and trade program, the Regional Greenhouse Gas Initiative, which began auctioning carbon emission permits in the summer of 2009.

The region is compelled to maintain these assertive renewable energy policies because of a confluence of high energy import dependency, electricity prices, aging coal and nuclear power plants, and an informed public that remains concerned about climate change. The three southern New England states import significantly more energy than they generate, with their percentage of consumption from out-of-state production exceeding 85% (EIA, 2010). The region also experiences the highest retail electricity prices in the Continental U.S., matched only by the grid-isolated islands of Hawaii. As of November 2010 New England's residential retail electricity prices were more than 40% higher than the national average (EIA, 2011). The confluence of these factors compels the region to rapidly develop new energy facilities fueled by renewable sources.

Wind power is one the most environmentally benign of these sources, with considerably low life-cycle carbon emissions (Ardente, Beccali et al. 2008; Jacobsen, 2009; Wüstenhagen, Wolsink et al. 2007). However, while wind farm development accelerates in other areas of the United States, particularly within the Great Plains, construction remains considerably stalled within New England. The wind power planning and siting research that arose first in Europe, and is now emerging in the U.S., stresses three types of factors that influence development outcomes: inter-governmental policies, site-specific, and social factors (Breukers and Wolsink, 2007; Jobert et al, 2007; Khan, 2003; Nadaï and van der Horst, 2010) . Therefore, the intent of this paper is to determine how these three categories of factors lead to the success, prolonged delay, or failure of inland wind power projects in central New England. The siting difficulties of wind power are placed within the greater context of contemporary energy facility siting conflicts.

The three case studies examined include the 48 megawatt Glebe Mountain Wind Farm proposal in southern Vermont, which was halted by the developer in 2006; the 30 megawatt Hoosac Wind Farm in western Massachusetts, which remains in litigation; and the 24 megawatt Lempster Wind Farm in New Hampshire, which began producing electricity in 2009. These are the largest, grid-connected wind project proposals in the region to date. To ascertain why the project outcomes varied, semi-structured interviews were conducted with a range of stakeholders, including wind development firms, utility companies, state regulatory agencies, regional planning commissions, town officials, land conservation organizations, and opposition groups.

The paper finds that even if a majority of favorable factors exist within one or even two of the three siting categories, a project is not likely to succeed. Policies, site conditions, and public acceptance must all opportunistically align to ensure approval for a wind power project. A consensus exists from all three case studies, and across opposing stakeholders, for a need to move beyond reactionary conflict through a comprehensive, participatory land use energy planning process that identifies the most suitable areas for wind power.

Wind Power within the Context of Energy Facility Siting Conflicts

The placement of wind turbines has become the latest iteration of a long continuum of energy facility siting conflicts. While wind power possesses a unique set of market drivers, environmental and health impacts, and public benefits distinct from conventional fossil fuels and nuclear power, it continues to experience similar siting constraints.

Resistance to new energy facilities arose during the second half of the 20th century. As urban and suburban populations expanded, an increase in energy consumption, coupled with limited incentives for efficiency measures, led to demand for new facilities and requisite utility infrastructure (Vajjhala and Fischbeck, 2007; Aldrich, 2008). Yet the very force that creates demand for new facilities, suburban sprawl, increases the difficulty for developers and utilities to find economically viable locations for power plants, pipelines, transmission lines, and repositories for spent fuel waste such as coal ash and low-level radioactive nuclear fuel rods. This leads to a feedback loop, since the closer people reside to a proposed energy facility, the more likely they are to resist its construction (Thayer and Freeman, 1987; Dear, 1992). O'Hare and colleagues (1983, p. 6) found that "Public conflict seems to have become the rule rather than the exception. No matter what a developer proposes to build...someone will oppose it. No matter how safe the proposed facility looks to its developer and government officials, someone will oppose it. No matter how badly society's general well being depends on a new development, someone will oppose it."

The main periods of permitting approvals for new coal-fired plants (1860-1980) and nuclear reactors (1960-1990) appear to have passed in the United States. The permitting of new energy facilities in the 21st century relies on natural gas (1960 – onward), wind power (2000 – onward), and other emerging renewable technologies. The current policy and market drivers for fossil fuel and nuclear energy facilities are projections of increased energy consumption, maintaining reliable baseload electricity service, and creating local jobs. While wind power facilities are motivated by these factors, their development is additionally driven by state renewable portfolio standard mandates, carbon cap and trade systems, and state greenhouse gas emission reduction goals.

Developers once relied on a “decide-announce-defend” model for facility siting, yet an increase in public opposition forces a more inclusive, participatory process- which often ensures that following the older model will lead to “decide-announce-defend-abandon” (Beierle and Cayford, 2002; Vajjhala and Fischbeck, 2007). While multi-national firms have managed the development process for conventional energy projects, many smaller, regional-based firms have initiated the process for wind power. These smaller wind power projects are often acquired later in the review process by multi-national energy firms. On the permitting side, the authorization for conventional energy facilities typically resides with a state siting commission whereas for wind power this varies by state to whether the local planning board or state siting commission holds approval authority.

The public perception of new energy facilities has evolved during the past thirty years. Studies of nuclear power and natural gas plant proposals found the facilities to be locally undesirable, yet still considered beneficial by the general public (O’Hare et al., 1983). There is an acknowledgement of the need to mitigate local risk in order to receive the dispersed social benefits (Wolsink, 2000). Others observed that new facilities became absolutely unwelcome by the public, regardless of greater societal benefits (Dear, 1992). A recent comparison of nuclear power plant siting perceives the facilities as an outright public bad (Aldrich, 2008). Currently, wind power facilities are received favorably as a public good, with pockets of assertive opposition.

In the literature there is a far-ranging characterization of those who traditionally oppose new energy facilities (Schively, 2007). Public opposition is seen as reflective of civil society, those willing to engage and take a stand against a perceived public bad (Aldrich, 2008). Studies have characterized the opposition as highly rational and efficient in ensuring their own self-interest (O’Hare et al, 1983; Walker, 1991). Others have observed the opposition as an assertive, vocal minority that in essence contorts both municipal and state policymakers’ notion of local acceptance (Hunter and Leyden, 1995). On the other end of the spectrum, there are instances of citizen participation being seen as the nuisance itself, rather than the facility, by policymakers (McAvoy, 1999). Many interest groups contract their own professional consultants to testify on behalf of their position, to counter the findings of consultants contracted by state agencies or the

developer. This phenomenon is known as an “adversarial analysis” strategy (Busenburg, 1999). Finally, planners must recognize the importance of the opposition having the financial resources to engage in extensive legal appeal campaigns. Gathering or hiring expert consultants to present scientific information is a costly endeavor (O’Hare et al 1983). Therefore, resource mobilization remains a significant factor in the ability for an opposition group to remain involved, where wealthy residents may effectively outlast wealthy companies (Walker, 1991; Boudet and Ortolano, 2010).

A suite of conflict resolution strategies emerged to respond to facility siting opposition. Mitigation packages to both the host municipality and adjacent residents provide financial compensation for potential or verifiable adverse impacts (O’Hare et al, 1983). Other strategies observed to be effective over the past thirty years include informal consensus building between the stakeholders (versus a formalized set of hearings) and human services planning (Kasperson, 1992; Dear, 1992; Schively, 2007). However, these strategies have limited success in resolving the latest incidences of siting conflicts, especially for electricity infrastructure. Many energy analysts and consultants argue that state and regional policy reforms are required to overcome local opposition and meet the demand for new energy facilities and their requisite infrastructure (Vajjhala and Fischbeck, 2007). A regional authority for wind power development in New England holds promise since the electric grid is managed across several small states that possess high wind resources. An inter-state, regional renewable energy siting authority could mirror the Regional Greenhouse Gas Initiative (RGGI) and other Northeast environmental compacts (Rabe, 2010). As elaborated later in this article comprehensive, region-wide, land use plans are essential- enabling all stakeholders to participate in identifying the most suitable sites for wind power.

Wind Power Planning and Siting

There is no overarching framework for wind power siting in the United States but rather an array of guidelines targeted for specialized audiences. The American Wind Energy Association (AWEA), the trade group representing the U.S. based wind power industry, has modified its website pages and literature on siting several times. This illustrates how the industry has not formed a uniform position to siting issues. National

non-profit organizations such as the American Wind and Wildlife Institute (AWWI) and the National Wind Coordinating Collaborative (NWCC), along with the U.S. Department of Energy Wind Powering America and the U.S. Fish and Wildlife Service wind turbine siting task force also continually attempt to address siting conflicts in order to inform national and state policy (Figure 3.1).

AUTHOR	SITING GUIDELINE	AUDIENCE
U.S. Fish & Wildlife Service (2010)	Wind turbine guidelines advisory committee	U.S. Dept. of the Interior; wildlife biology
EERE Wind Powering America (2010)	New England Wind Forum Siting Considerations	general
National Wind Coordinating Collaborative (2010)	State of the Art in Wind Siting	federal regulators; civil engineering
EERE (2008)	20% Wind Power by 2030	general
BLM (2007)	Bureau of Land Management Wind Development Policy	projects on federal BLM land
EERE (2006)	Wind Energy Guide for County Commissioners	local government officials
National Wind Coordinating Collaborative (2005)	Technical Considerations in Siting Wind Developments	federal regulators; civil engineering
STATE WIND ENERGY SITING MODEL ORDINANCES		
Maine (2009); Oteri (2008); Massachusetts (2007); Pennsylvania (2006); New York (2005)		

Figure 3.1. List of Wind Power Siting Guidelines and Model Ordinances

The following figure represents a generic wind power siting process based on recommendations from the EERE’s Wind Energy Guide for County Commissioners, the 20% Wind Power by 2030 Plan, Wind Powering America’s New England Wind Forum, and interviews with wind power stakeholders (figure 3.2).

THE WIND POWER SITING PROCESS

- Wind power development firm analyzes wind resource maps and proximity to existing transmission lines
 - Once sites are chosen, review of local, state, and/or federal zoning ordinances (dependent on landowner and jurisdiction)
 - Conduct GIS land use siting assessment to determine buffers from houses, environmentally sensitive resources, recreational areas, and other land uses
 - Gauge local community support for wind farm while seeking project financing
 - Approval sought for 12 month placement of 80 meter anemometer towers
 - If 12 month wind resource data are favorable, proceed with negotiating long-term land lease with landowner
 - Submit permit application to municipal zoning and/or planning board; or to state or federal energy siting commission (authority depends on landownership, also varies by state)
 - Submit stream and wetland crossing permit application to state department of environmental protection (if applicable)
 - Negotiation of tax payments, capital improvements, and mitigation package with the host municipality(s) and any affected adjacent landowners
 - Secure long-term (10-15 year) purchasing contract with a large end-use customer or public utility
 - Submit transmission interconnection request to state energy siting commission and/or the regional ISO operator (varies by state)
 - Apply to be listed as eligible participant in state renewable portfolio standards in order to receive renewable energy credit revenue
-

compiled from EERE (2006); EERE (2008); EERE Wind Powering America (2010); and interview responses (2009-2010)

Figure 3.2. A Generic Wind Power Siting Process

U.S. Wind Power Planning and Siting Process Studies

The aforementioned wind power siting groups and task forces (EERE Wind Powering America, NWCC, AWWI, U.S. FWS) attempt to proactively mediate the siting conflicts that have arisen during the past thirty years of wind power development in the United States. Specific conflicts began to appear with the first modern wind farms built in California in the 1980s (Gipe, 1990; Thayer & Freeman, 1987). Early survey responses showed negative public perceptions towards early wind power technology, with strong reaction to the use of public funds for unreliable and intermittent electricity generation. Other key findings include a correlation between respondents' proximity to the wind farm and their increased opposition to it, and a visual preference for larger, but less turbines versus more, smaller turbines (Thayer & Freeman, 1987).

A considerable lapse occurs before wind energy development and corresponding siting studies emerge again in the U.S. In the early 2000s an Arizona study surveyed tribal attitudes toward wind energy facilities and found support when sacred sites and local economic benefits were considered (Acker, et al., 2003). A comparative policy analysis compared the European community-owned wind power model with innovative initiatives occurring in four U.S. states. Minnesota and Iowa, which mirrored the combination of strong policy mandates and community-investment incentives established in Northern Europe, experienced an exponential growth in wind power generation (Bolinger, 2005).

In 2008, the U.S. Department of Energy released the “20% Wind by 2030” plan, which announced that the federal goal of supplying 20% of the nation’s electricity from wind energy generation could feasibly occur by 2030 (EERE, 2008). The report provides a thorough assessment of the potential for, and the barriers to, wind energy development throughout the U.S. It suggests state agencies expedite the approval process by providing model wind ordinances to guide municipalities, and ensuring adequate mitigation for visual, wildlife, lighting, and noise impacts (EERE, 2008). In the same year, a contingent valuation survey conducted in North Carolina found strong local public opposition to wind development, with local officials catering to the opposition (Groothuis et al., 2008). The public’s primary concern in this case was perceived visual, noise, and shadow flicker impacts, as well as property devaluation.

Notably, those residents who expressed a willingness to voluntarily pay a premium for renewable electricity were more accepting of wind power, as were ancestral residents as compared to transplant residents (Groothuis, et al., 2008). Lastly, research on the social impact of and public attitudes towards the nation’s largest concentration of wind farms in northern Texas reveals general public support and upholds the prevailing wind energy siting theory that a not- in-my-backyard-reaction (NIMBYism) is not the sole predictor for opposition (Swofford & Slattery, 2010; van der Horst, 2007; Wolsink, 2000, 2007).

This review of the U.S.-based wind energy planning and siting literature reveals a patchwork of studies, with many regions remaining unexamined. Since market drivers and state policies for renewable energy continue to expand in the U.S., we can expect

other occurrences of wind power siting difficulties to arise in the near future. From comparing the wind power siting literature within an overall energy siting context, it appears that the not-in-my-backyard form of opposition is not as prevalent for wind power as it is for other energy sources (Aldrich, 2008; Boudet and Ortolano, 2010; Swofford and Slattery, 2010). Yet assertive opposition groups, that do not necessarily represent local or general public opinion, have been successful in mobilizing resources and providing adversarial analysis tactics to delay or halt many wind power projects in many tourist and scenic regions (Groothuis et al., 2008).

Since there has been limited wind power planning research in the United States so far, scholars have drawn from the extensive range of European case studies. They have provided U.S. researchers with the original wind power planning research methodologies, introduce the three main categories of siting factors as inter-governmental, site-specific, and social/institutional, and offer key findings.

European Wind Power Planning and Siting Process Studies

The first study on wind power in Europe, through content analysis and interviews, compared how Denmark and Sweden promote the industry (Carlman, 1988). Interestingly, both countries established “residence free” zones within prime wind resource areas, the opposite of many municipal zoning laws in the U.S. that in essence establish wind turbine free areas. A study comparing three Swedish municipalities determined that visual aesthetics was the major factor in opposition (Khan, 2003). The municipalities administered the proposals quite differently and there was divergent public opinion from the three towns (Khan, 2003).

A set of Irish and Scottish public attitudinal case studies found local acceptance to increase upon the completion of wind farm construction. Visual aesthetics, whether viewed positively or negatively, had the strongest influence on attitudes towards wind farms. The study also found that greater public acceptance occurred at closer proximity, countering the NIMBY theory (Warren et al., 2005). A comparative analysis of German, Dutch, and British wind power development outcomes determined that the manufacturing of turbines and local financial ownership influenced successful outcomes (in Germany

and Netherlands), while the protection of nature and historic landscapes and resistance to change impeded development (in the United Kingdom) (Breukers and Wolsink, 2007).

A survey of Western European case studies examined how socio-political, community, and market factors influence acceptance of specific wind projects (Wüstenhagen et al., 2007). The study found the demand for a more thorough local process stifles ambitious national renewable energy targets. Local acceptance follows a U-curve pattern- higher at pre-announcement of a specific projects, lowest during construction, then higher again post-construction. The study found visual aesthetics to be the main factor for opposition, thus inferring that the NIMBY phenomenon does influence wind power siting (Wüstenhagen, et al., 2007).

A French study measuring the effectiveness of federal energy policy to boost wind power capacity determined that conflicts occurred more between national governmental agencies, rather than local concerns pitted against top-down mandates. National landscape protection mechanisms counter national wind policy objectives through limiting projects based on visual impact and sensitive ridgelines (Nadaï and Labussiere, 2009).

A case study of West Saxony, Germany examined whether regional wind power planning conforms to revised national energy policy standards (Ohl and Eichhorn, 2010). An increase from 15% to 30% of electricity from renewable sources and a higher feed-in tariff placed pressure to increase wind power development. Energy policies also placed stricter standards on suitable development areas while regional plans' height limitation of 100 meters reduced siting potential within priority areas by 50%. The study determined that the regional participatory planning process hampers the siting of the larger and more efficient turbines (Ohl and Eichhorn, 2010).

Lastly, a broad review of European Union case studies observed how efforts to achieve national renewable energy targets impact spatial planning and the physical landscape (Nadaï and van der Horst , 2010). The study determined that top-down decision-making is risking the alienation of the local public. The main tension is between arbitrating a globalised public good, reduction of greenhouse gas emissions, and a localized public bad in the form of landscape impact. A considerable gap exists between general and qualified public acceptance, and where conflicts exist, they are based not on

technical but rather contextual aspects, which are perceived differently by stakeholders (Nadaï and van der Horst, 2010).

Methods

In order to determine why some inland commercial wind power projects in central New England are successful while others are not, three projects with varying outcomes were studied. The 48 megawatt Glebe Mountain Wind Farm in southern Vermont, which began in 2002 and was halted by the development firm in 2006, represents a failed outcome. The 30 megawatt Hoosac Wind Farm in western Massachusetts, which began in 2002 and, as of this writing, remains in litigation, represents a delayed outcome. And the 24 megawatt Lempster Wind Farm in New Hampshire, which began operations in 2009 after a relatively expeditious two-year permitting process, represents a successful outcome (Table 3.1).

The selection criteria include an inland study area location contained within a single regional electricity transmission grid, within the same renewable energy credit and carbon trading market, and within the same mountainous terrain (figure 3.3). The case studies represent the only large commercial-scale wind project proposals, with at least 20 megawatts in generation capacity, within 100 miles of the Boston metropolitan statistical area (MSA), the major load center of New England. The 5.5 megawatt Searsburg wind farm in Southern Vermont was not included because of its smaller generation capacity and its status as a Department of Energy pilot program. The 15 megawatt Berkshire and 8 megawatt Minuteman wind farms in Western Massachusetts fall below the 20 megawatt threshold. The 132 megawatt Kibby Mountain, 57 megawatt Stetson Mountain, and 42 megawatt Mars Hill wind farms in Maine were excluded because they currently do not supply power to the New England ISO grid and are beyond 100 miles of the Boston MSA.

As mentioned in the introduction, the greater New England region was chosen because it possesses the highest rate of energy import dependency, the highest retail electricity prices in the continental U.S., and major energy and climate policy directives (EIA, 2010; EIA, 2011). In short, the New England states realize they have an energy supply problem and have taken considerable political action. Each of the case studies

represents a separate New England state, and as such are influenced by both common regional and unique state policy and permitting frameworks.

Table 3.1: Summary of Central New England Wind Farm Case Studies

WIND FARM	HOST TOWN (data from U.S. Census, 2009)	DEVELOPMENT FIRM	NAMEPLATE CAPACITY	ESTIM. ANNUAL ELEC. GEN.	OUTCOME
Glebe Mountain	Londonderry, VT pop: 1,721 avg. income/capita: \$27,200	Catamount Energy/ Duke Energy	48 MW	107-128 GWh	Project retracted by company June 2006
Hoosac Wind	Florida & Monroe, MA pop: 822 avg. income/capita: \$21,600	Iberdrola Renewables	30 MW	65-79 GWh	Ongoing permitting appeals process
Lempster Wind	Lempster, NH pop: 1,090 avg. income/capita: \$25,500	Iberdrola Renewables	24 MW	52-63 GWh	Began operating June 2009

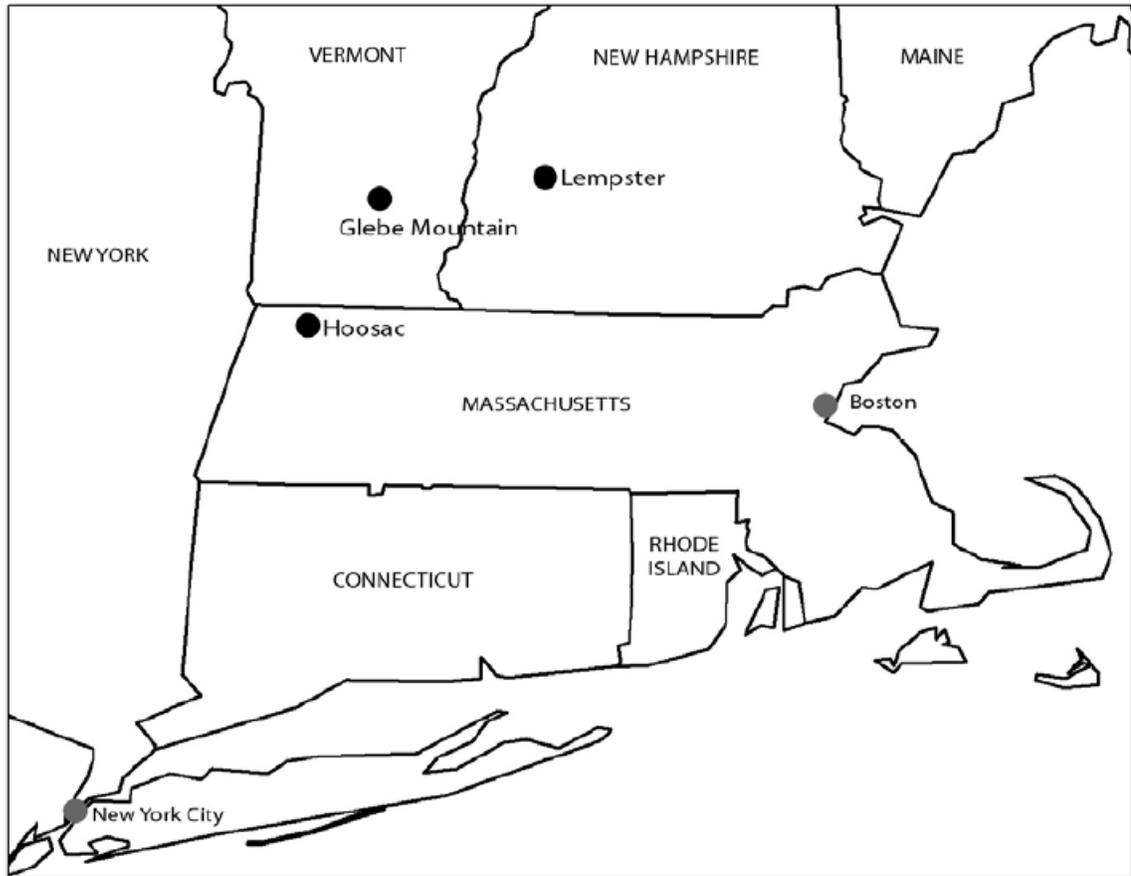


Figure 3.3: Location of case studies

From autumn 2009 through spring 2010 forty-five semi-structured interviews were conducted with a broad range of stakeholders. The individual stakeholders were chosen through a combination of their senior leadership roles and through snowball references by their peers. They include representatives from wind development firms, electric utilities, local business associations, state regulatory agencies, regional planning commissions, town governments, environmental non-profit organizations, and opposition groups (Table 3.2). These groups were chosen as interview subjects in order to acquire a comprehensive representation, across a spectrum of protagonists and antagonists, of how wind power development is perceived.

The response rate from the electronically mailed request letter and follow up phone call was surprisingly robust. Only one interview candidate directly declined in order to ensure confidentiality during an active lawsuit. Arranging interviews with the

stakeholders of the Hoosac Wind (delayed outcome) case study was more challenging than with the other two cases, perhaps because the project remains in the sensitive permitting and litigation phase.

Table 3.2: Interviews with Wind Power Development Stakeholders, 2009-2010

Stakeholder Interest Group	Glebe Mtn. So. VT	Hoosac Wind W. MA	Lempster So. NH	New England Region
Wind Power Developer	•		•	
State Energy Agency	•	•	•	
State Energy Regulator & Counsel	•	•	••	
Electricity Utility	•	•	•	•
Local Town Counsel		•	•	
Local Town Officials	••	•	•	
Regional Planning Commission	•	•	•	
Chamber of Commerce		•		
Anti-Wind Power Group	••	•	•	
Pro-Wind Power Group	•	n/a	n/a	
Sub-regional Level Conservation NGO	n/a	•	•	
State Level Conservation NGO	••	••	••	
New England Conservation NGO				•••••
National Wind Power NGO				••
Wind Power Consultant				••
N = 45	12	11	12	10

The interviews ranged in length from thirty minutes to two hours in length, depending upon the respondent’s availability and willingness to share their knowledge of the case study project. The same twenty-one questions—about policy, site-specific, and social factors—were asked in the same order to every participant, with the questions informed by the European wind power case study findings (Breukers & Wolsink, 2007; Jobert, et al., 2007; Nadaï & van der Horst, 2010). The semi-structured interview methodology allowed for the participants to freely elaborate and contribute additional influential factors that were unaddressed in the literature (Appendix A).

The following three case study descriptions provide a project profile, timeline, summary of the project's significance, and summary of the stakeholder interview findings. This is followed by separate sections that detail the inter-governmental policy, site-specific, and social factors for each case study.

Case Study 1: Glebe Mountain Wind Farm, Londonderry and Windham, Vermont

Project Profile

The Glebe Mountain Wind Farm proposal began in 2002 and formally ended in June 2006. Straddling the towns of Londonderry and Windham in southern Vermont, the 48 megawatt capacity project proposed twenty-seven turbines with 1.8 megawatt nameplate capacities. A majority of the proposed tower sites were along the Glebe Mountain ridgeline. The Magic Mountain ski resort owns and manages the project site. The wind power development firm was originally the Vermont-based Catamount Energy Corporation, but Catamount and its 3,000-acre leasing arrangement for access, construction, and maintenance of the wind farm were acquired in the spring of 2004 by Marubeni Power International (Letovsky, 2005). In early 2006, Duke Energy Corporation acquired the Catamount Energy Corporation and the Glebe Mountain proposal from Marubeni.

Had it been constructed, the wind farm would have generated approximately 107-128 GWh of electricity, based on a capacity factor range of 25-30%, providing for the annual electricity consumption of up to 18,000 Vermont homes. In March 2006, a few months prior to the project's termination, Central Vermont Public Service (CVPS) entered into a 20-year purchasing agreement with Duke Energy. The contract arranged for CVPS to pay a below-market rate of 95%, with the intention of carrying a short-term surplus and lowering consumer electricity rates. The project ended before municipal tax revenues could be negotiated. The project timeline is represented in figure 3.4.

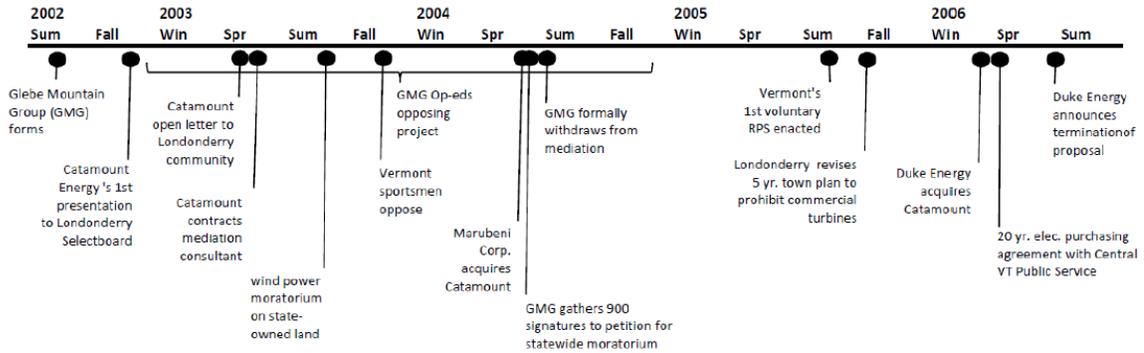


Figure 3.4. Glebe Mountain project timeline (Londonderry, VT)

Significance of Project

The Glebe Mountain Wind Farm is the first large-scale, grid-connected proposal in central New England to be terminated by a developer prior to initiating the formal siting review process. Several utility-scale wind farms in New England remain delayed in the approval process, yet few are ultimately denied by state or national authorities. The project is also significant in that it experienced such strong, persistent opposition within the two host towns. The opposition was led by the interest group the Glebe Mountain Group, formed in the summer of 2002. This case study conforms to a “decide-announce-defend-abandon” outcome of energy facility siting opposition (Beierle and Cayford, 2002). The Catamount Energy firm exhausted resources by defending a barrage of environmental concerns from the Glebe Mountain Group. By the time a public participatory mediation process began, it was too late- the acrimonious positions had already been entrenched. Below, the reasons behind such vociferous local opposition, as well as the responses of the local and state policymakers and regulators, are explored. The main factors that influenced Catamount Energy Corporation’s decision to terminate the project prior to initiating the formal permitting process are also delineated.

Stakeholder Interview Findings

Unlike the other two cases discussed below, federal policy had a limited influence on the Glebe Mountain project, whereas both site-specific and social factors contributed

to its failed outcome (Table 3.3). Aside from the former and existing land use of the site, which provided an opportunity for development, the remainder of site-specific factors contributed to the failure of the project. The most influential of these were the community’s concerns about surrounding land use and visual aesthetics, followed by their concerns about the impact on wildlife habitat and noise level. The social factor with the greatest influence was the perceived negative impact on surrounding property values, followed by a lack of local, in-town, public support, limited expectations for increased tax revenue, and the cultural composition of the two host towns. Below, the impact of policy, site-specific, and social factors are described in more detail.

Table 3.3: Factors Influencing the Failed Outcome of the Glebe Mountain Wind Farm Project

Policy Factors	Site-Specific Factors	Social Factors
OVERALL STATE POLICY <ul style="list-style-type: none"> • Governor & administration explicitly opposed wind farms; moratorium on state-owned lands 	VISUAL AESTHETIC CONCERNS <ul style="list-style-type: none"> • Visual aesthetics drives policy and is part of the state permitting process; Act 250 requires visual impact analysis for development above 2500’ 	EXISTING MUNICIPAL TAX BASE AND EXPECTED REVENUE <ul style="list-style-type: none"> • State Act 60 property tax redistribution requirement; developer’s PILOT offered too late
STATE REGULATORY PROCESS <ul style="list-style-type: none"> • Permitting by two authorities: Public Service Board and Act 250 land use standards when over 2500’ in elevation 	SURROUNDING LAND USE <ul style="list-style-type: none"> • 2nd homes on mountain base are adjacent to the site; recent property owners expect landscape would remain the same 	PERCEIVED IMPACT ON PROPERTY VALUES <ul style="list-style-type: none"> • Owners expect devaluation, but VT PSB will approve if project benefits the state overall; ski resort (site owner) supported project
RESPONSE OF STATE AGENCIES <ul style="list-style-type: none"> • VT agency of natural resources concerned with wind projects; public benefit clash between natural resource protection vs. renewable electricity 	SENSITIVE WILDLIFE HABITAT <ul style="list-style-type: none"> • Concerns of bat mortality and bear corridor fragmentation; Both developer and opposition contracted consultants who presented separate findings 	LOCAL, IN-TOWN SUPPORT <ul style="list-style-type: none"> • Planning commission changed town plan during process to prohibit large turbines; Mediation process lacked trust and intent to compromise, was emotional and divisive
	NOISE LEVEL <ul style="list-style-type: none"> • Town sought assurances that noise levels would be mitigated; currently no state regulation exists for turbine noise; difficult to test prior to operation 	CULTURAL COMPOSITION OF HOST TOWN <ul style="list-style-type: none"> • Long-term population not as opposed as the transplants. The town is split between upper and lower income residents. 2nd homeowners persuaded local working class to oppose project with threat of moving away, loss of jobs

Policy Factors

Three policy factors influenced the failed outcome of the Glebe Mountain project. First, Vermont's state policies were not conducive to wind power development. The Douglas administration explicitly opposed the construction of large, utility-scale wind farms. The administration passed a moratorium against development on state-owned lands in 2003, limiting the land area available for wind power while signaling the state's unwillingness to directly collaborate with wind development firms. Vermont is the only state in the Northeast that does not mandate a renewable portfolio standard (RPS). During the timeframe of the Glebe Mountain project (2002-2006), the state enacted a voluntary RPS for meeting only new electricity load demand.

The second influential policy factor was Vermont's inconsistent state regulatory permitting process. Vermont towns lack the authority to permit wind power projects; however, they can either promote or discourage projects through local zoning or the town master plan. When the proposed site's elevation exceeds 2,500 feet above sea level, wind farm projects must be submitted to both the Vermont Public Service Board (VT PSB) and the separate Act 250 land use review board (Foster, 2009). Several interview respondents criticized the VT PSB for employing ad-hoc, arbitrary standards for wind power siting issues such as noise, lighting, and shadow flicker. A state energy official responded that wind farm proposals are new, with every ridgeline site being sensitive, which requires each project to be reviewed on a case-by-case basis. As a wind developer noted, "It is more difficult to permit a wind farm than a natural gas facility."

The third significant policy factor was a lack of support from the Vermont Agency of Natural Resources. Stakeholders attribute this to the influence of the Governor's office, which appoints high-ranking agency administrators. Over the years, the agency requested that the VT PSB deny permits to several wind farm projects across the state based on a concern for preserving wildlife habitats, and when the VT PSB has approved permits for wind farms, the agency has been the primary champion for stringent environmental mitigation packages. The agency's lack of support was a factor in the Glebe Mountain proposal's failure, although the proposal was terminated by Catamount Energy Company prior to a submission to the VT PSB and the Agency of Natural Resources for review.

Site-Specific Factors

According to the interview respondents, the most influential factor in the failed outcome of the Glebe Mountain project was the tenacious resistance from the adjacent residents. Second homes line the mountain base directly below the proposed site and, according to respondents, these residents wanted the ridgeline to remain unchanged. A member of the opposition group expressed that “Glebe Mountain has already been destroyed by Magic Mountain [ski resort]- why ruin it more?” Another voiced that “landowners assume the features of the landscape will be protected when they move to a rural area.” A state official lamented the prominent role of visual aesthetics in the state permitting process and suggested that the state legislature explicitly define how visual aesthetic concerns could be mitigated to enable future wind farm proposals a greater likelihood of success.

A third site-specific factor was the perceived impact on ecologically sensitive plants, wildlife, and their habitats. Stakeholders remained divided over the actual extent of the impact the wind farm would have on the environment. Catamount Energy Corporation and the Glebe Mountain Group contracted separate environmental consultants, and the two consultants presented contradictory findings. This represents a case of the adversarial analysis strategy, where the opposition is able to impede progress based on raising doubts through conflicting scientific opinion (Busenburg, 1999). Both the Glebe Mountain Group and the town displayed disinterest in moving forward with the state mitigation process. Only one member of the Londonderry town selectboard entrusted the VT PSB to ensure a strong mitigation package and enforce the state’s requirement of 4:1 acre mitigation for impacted lands.

Residents living near the site also expressed concerns over the expected increase in ambient noise levels from the twenty-seven turbines. Town officials sought assurances that noise levels would be adequately mitigated, but this concern was difficult for the developer to assuage. Noise remains difficult to predict prior to a wind farm’s operation, and Vermont’s lack of regulation for wind turbine noise provides little incentive for developers to mitigate prior to a complaint.

Social Factors

Four social factors influenced the failure of the Glebe Mountain project: public opposition, property valuation, tax structure, and socio-economic composition of the towns. First and foremost, the project fomented considerable in-town local opposition. A wind developer lamented that this was “a classic case of NIMBY, the opposition will never agree on any project going forward.” The public meetings organized by Catamount Energy became increasingly rancorous. The company eventually agreed to a mediation process with the Glebe Mountain Group to be facilitated by a third party facilitator. Stakeholders involved in the mediation process reported that the consensus-building lacked authenticity. An “I do not trust you” attitude persisted on both sides, and the mediator departed halfway through the process. Participants described the process as very emotional and divisive, comparing it to national political debates on healthcare and immigration. This led the Londonderry Town Planning Commission to prohibit large wind turbines on ridgelines through a modification of the town’s five year master plan.

The second social factor was an apprehension among local residents that the wind farm would negatively impact surrounding property values. Many stakeholders referenced the enactment of Vermont’s land use protection act, Act 250, in the 1970s as a response to unchecked growth occurring in the state. One respondent equated the proposed wind farm to a landfill: “If you are next to it, it will affect your property value, but not if you are three miles away.” A Londonderry town official asserted that, although the opposition downplayed its relevance, property devaluation was the main, genuine concern of the Glebe Mountain Group.

A third social factor involves Vermont’s municipal tax structure. Vermont’s Act 60 requires the state to collect municipal property taxes and redistribute the revenue evenly to all towns; thus, a wind developer cannot promise direct tax benefits to a host town, especially one that already contributes more than it receives in Act 60 allocations. Being relatively wealthy compared to other parts of the state, the towns near Glebe Mountain did not expect a significant increase in tax revenue from the wind farm. Towards the end of the project, after receiving considerable local backlash, the developer offered an alternative form of local compensation, an annual payment in lieu of taxes (PILOT). Most local stakeholders considered this offer to be too little, too late.

The final social factor influencing this case's failed outcome was the mixed socioeconomic composition of the host towns. One stakeholder commented that "half the townspeople have money while half have nothing. The latter have lived in Londonderry most of their lives." Respondents complained that the second home-owners, the "transplants" were twisting the arms of the local working class. The opposition group ultimately persuaded the working class to oppose the project by threatening to relocate, and thus reduce the amount of available lawn care, house maintenance, and other service business.

Case Study 2: Hoosac Wind Farm Proposal, Florida and Monroe, Massachusetts

Project Profile

The Hoosac Wind Farm project began in 2002. Since the application for the first special permit in autumn 2003, the project has received three additional wetland permit approvals through local, state, and judicial authorities. Each approval, however, has been summarily appealed by the same abutting landowner's lawsuit (TRC, 2009). The 30 megawatt proposal consists of twenty turbines with 1.5 megawatt nameplate capacities. The site is split between two ridgelines in the towns of Florida and Monroe in Berkshire County, Massachusetts.

Three different wind development firms have managed the Hoosac Wind Farm project. KMS Mountain Energy initiated leasing negotiations with the landowners in 2001. EnXco took over the project in 2003 and then Oregon-based PPM Energy, a subsidiary of the Spanish-based Iberdrola Renewables, acquired the project in 2006 (TRC, 2009). PPM Energy maintains the leasing rights for the two ridgeline locations and access road easements.

If successful, the wind farm would provide approximately 65-79 GWh of electricity, based on a capacity factor range of 25-30%. This would provide for the annual electricity consumption of up to 10,700 Massachusetts homes. PPM Energy entered into a pilot agreement with the towns of Florida and Monroe to pay a preset amount for several years in lieu of tax assessments. The arrangement is valid for the ten turbines on publicly-

owned land, but not for the ten located on private land (TRC, 2009). The towns would receive annual tax revenues from the towers sited on private land. The project timeline is represented in figure 3.5.

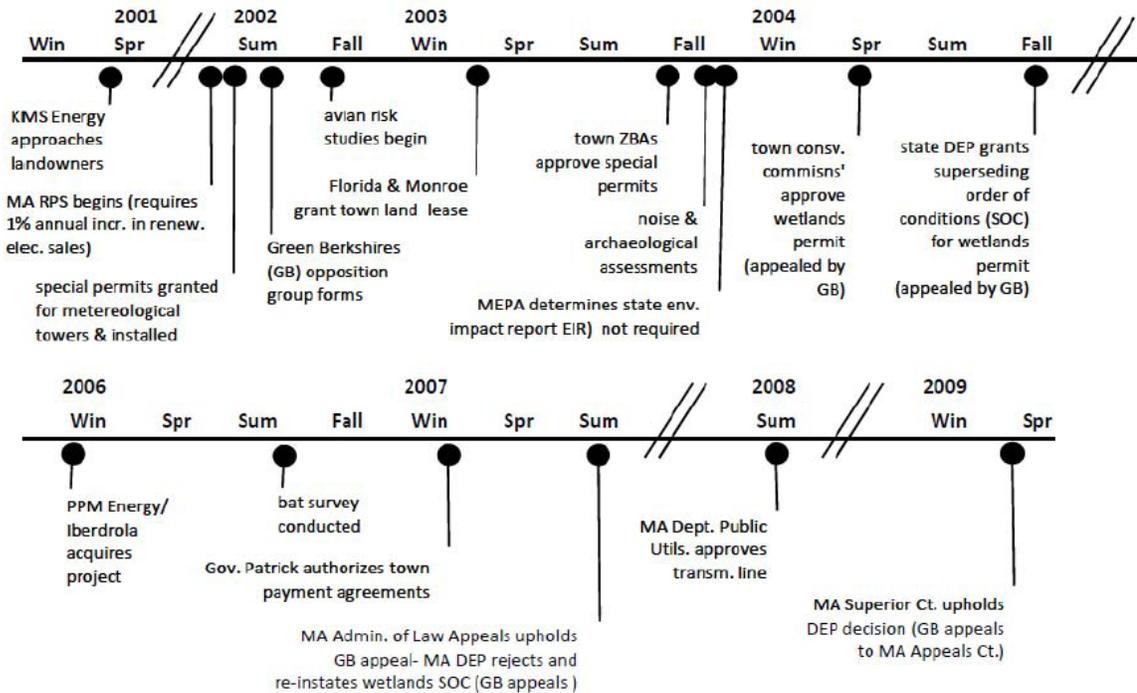


Figure 3.5. Hoosac Wind project timeline (Florida and Monroe, MA)

Significance of Project

The Hoosac Wind Farm received considerable local support in both the towns of Florida and Monroe, with 70% approval at town hall meeting votes (TRC, 2009). However a landowner abutting the access road, joined by nine other Florida residents and supported by the opposition group Green Berkshires, persistently appeals the project’s wetland approvals. The Hoosac Wind Farm is the largest of several Massachusetts inland, utility-scale projects that remain in the permitting stage after nine years of extensive site, meteorological, and environmental reviews. Below is a discussion of the reasons behind this project’s delay despite its having received local and state government approvals, as well as a favorable response from the majority of local residents.

Stakeholder Interview Findings

Based on the interview responses, the Hoosac Wind project's delayed outcome is mainly attributable to site-specific factors, in contrast to the other two cases. Half of the policy factors contribute to the delayed outcome, while the other half offers opportunities. Social factors also represent more opportunities than barriers, and will likely contribute to the project's eventual success (Table 3.4).

The policy factors influencing the delayed outcome include the state permitting process, the lack of a statewide wind energy plan, the lack of designated wind overlay districts, and the involvement of outside interveners. The policy factors that could lead to a successful outcome include state energy policies, the state renewable portfolio standard, and the federal production tax credit and recovery act loans. The site-specific factors that have led to delay include visual aesthetic concerns, perceived stream and wetland impacts, and the impact on sensitive wildlife habitats. The two most influential social factors that are expected to lead to project success are considerable in-town, public support and an expected increase in tax revenue, while the response of conservation organizations may have contributed to the delay. Below, these factors are discussed in greater detail.

Table 3.4: Factors Influencing the Delayed Outcome of the Hoosac Wind Farm Project

Policy Factors	Site-Specific Factors	Social & Institutional Factors
<p>STATE REGULATORY PROCESS</p> <ul style="list-style-type: none"> conservation groups and towns oppose energy siting reform act ; state seeks to streamline permitting; current permitting process lasts 6 years 	<p>VISUAL AESTHETIC CONCERNS</p> <ul style="list-style-type: none"> A major concern, yet highly subjective; a wedge issue between conservation groups concerned with climate change versus preserving scenic landscapes 	<p>RESPONSE OF CONSERVATION ORGANIZATIONS</p> <ul style="list-style-type: none"> State of MA frustrated the conservation community with aggressive positions on siting wind power on public lands; conservation groups remain concerned about preserving unfragmented areas, wide range of acceptance exists
<p>LACK OF STATEWIDE WIND ENERGY PLAN OR DISTRICTS</p> <ul style="list-style-type: none"> While MA recently adopted an ocean management plan that considers energy resources, the state lacks a comparable land management plan 	<p>SENSITIVE WILDLIFE HABITAT</p> <ul style="list-style-type: none"> Disturbance of rare goldenrod species mitigated through off site replanting; full MEPA review not required,; no state or federal bird or bat protection requirements 	
<p>STANDING CRITERIA FOR PROJECT INTERVENERS</p> <ul style="list-style-type: none"> Standards for establishing standing have been modified since Hoosac Wind, interveners now required to raise concerns at local review 	<p>MITIGATION OF STREAM AND WETLAND DISTURBANCE</p> <ul style="list-style-type: none"> Access road crosses 12 streams from town road to the site; current lawsuit involves how state DEP reviews riverbank alteration related to bridge construction 	
Factors that May Influence a Successful Outcome		
<p>OVERALL STATE POLICY</p> <ul style="list-style-type: none"> Green Communities Act encourages by-right zoning; also established the wind siting reform task force to streamline permitting; Long-term fixed contracts required 		<p>EXISTING MUNICIPAL TAX BASE AND EXPECTED REVENUE</p> <ul style="list-style-type: none"> A significant revenue source for two remote towns with minimal tax base; both towns concerned that developer will withdraw if lawsuits continue
<p>STATE RENEWABLE PORTFOLIO STANDARD (RPS)</p> <ul style="list-style-type: none"> RECs improved by 2008 Green Communities Act; RPS mandate increases annually from .05% to 1% 		<p>LOCAL, IN-TOWN SUPPORT</p> <ul style="list-style-type: none"> Both host towns approved project by majority votes. Locals angered by wealthy opposition based in south Berkshires
<p>FEDERAL PRODUCTION TAX CREDIT (PTC) & ARRA GRANTS</p> <ul style="list-style-type: none"> PTC influential since 1990s, subsidies have increased over time 		

Policy Factors

One policy factor that has contributed to the delay of the Hoosac Wind project is Massachusetts's cumbersome permitting process. In the state of Massachusetts, towns maintain considerable zoning and siting authority, even over energy facility proposals. Currently, only proposals for energy facilities with generation capacities larger than 100 megawatt are reviewed by the state Energy Facility Board review. This means that 352 municipalities dictate the siting of new, renewable energy projects through special permits, while only the siting of conventional power plants is authorized at the state level. One stakeholder lamented that coal-fired power plants receive a better, more streamlined permitting process than do renewable energy projects. Despite the state implementing two fast-track initiatives for wind power permitting, the Hoosac Wind permitting process has lasted at least seven years. Many respondents also reported that the lack of a statewide wind energy plan and state designation of wind power overlay districts as part of the problem.

On the town level, both Florida and Monroe expedited the approval process, but the state's minimal standing criteria for project interveners caused further delays. In Massachusetts, an interest group within fifty miles of the host town can delay the approval process by financing legal appeals. In this case, the towns' decisions were appealed by the opposition group Green Berkshires, based in Great Barrington, and the process had to be shifted from executive to judicial oversight. One town official expressed the frustration of the townspeople this way: "Why is everyone able to stop a project in our town? If we have control over our project, then why has it taken so long to build?"

The project's delay has led the state legislature to enact considerable energy policy reforms. Interveners must now first object at local hearings in order to establish standing for further appeal. In addition, the Green Communities Act of 2008 amplified the renewable portfolio standard from a 0.5% to a 1% annual increase, provided incentives for towns to enact by-right wind energy zoning, and established a wind energy siting reform task force. Federal programs, such as the federal production tax credit and the recovery act loans, have also kept the project alive, according to respondents.

Site-Specific Factors

One of the site-specific factors that led to the project's delay is the visual aesthetic concern of the local residents. Some residents attempted to voice their concerns using objective measures: "It is quite different to view a 340 foot tall turbine in the Berkshires than in the Great Plains. The visual impact is far different. The scale of the landscape is more intricate in the Berkshires." One conservationist expressed that the state should ascribe established scenic criteria to the placement of wind turbines. Most stakeholders, however, concurred that visual aesthetics are subjective. One conservationist identified aesthetics as the greatest influence on public perception, but as having the least environmental importance and the greatest subjectivity. An economic development director offered another aspect on the subjectivity of personal aesthetics: "The 1.5 megawatt wind turbine at the nearby Jiminy Peak ski resort now attracts more tourists to the area. There are those who think wind turbines look majestic while others come to the Berkshires for a pristine landscape." Ultimately though, the Hoosac Wind project does not remain in litigation because of this factor.

According to land use attorneys, the most significant barrier is the ongoing question of how the wind farm will affect local streams and wetlands. A lawsuit stemming from this project will determine how the Massachusetts Department of Environmental Protection reviews bridge construction applications for streams. The appeal now centers on riverbank alteration and bridge span, technicalities that many stakeholders argue unnecessarily delay this project as well as other wind power developments. Other stakeholders see the lawsuit as an important indicator for how the state will protect sensitive streams and unfragmented forests from all forms of development.

Delays have also been caused by state and locally-based conservation organizations' concern over the project's impact on ecologically sensitive plant and wildlife habitats. The site is located within a remote, unfragmented forest. The project came close to requiring a Massachusetts Environmental Protection Act (MEPA) environmental impact review (EIR), but maintained exemption status by retracting a state-issued grant and by developing on less than fifty acres. Conservationists sought the EIR since avian and bat protection standards are lacking at the town, state, and federal

levels. Many stakeholders were frustrated that the project did not have to undergo the EIR.

Social Factors

On the social level, there are factors contributing both to the project's delay and to its potential success. The response from conservation organizations may be contributing to the delay. There is a divide among these organizations over the issue of wind power. Wildlife preservation and recreational-focused environmental groups remain skeptical of wind power's benefits, while the climate change and pollution-focused environmental groups remain solidly in favor. In Massachusetts, the state's Executive Office of Energy and Environmental Affairs (EOEEA), which oversees the departments of energy resources, environmental protection, and conservation and recreation, assertively supports wind power development. Many conservationists have expressed consternation over how the EOEEA has not openly communicated state energy and environmental objectives with them. This divide has impeded conservationists from lending support to the Hoosac Wind project.

While the conservation community's opinion remains unsettled, public support in the host towns of Florida and Monroe has been quite unified in support of the Hoosac Wind Farm. Both town meeting votes revealed 70% in favor of the wind farm. A local official observed that the towns have been waiting for at least four years for construction to commence, since the town planning boards, zoning board of appeals, and conservation commissions all approved the special permit. The dissension is led by Green Berkshires, a citizens-group composed of twenty-four core members, four of which are affected landowners in the town of Florida, who has financed multiple lawsuits.

Another social factor that may contribute to the ultimate success of the project is the promise of a substantial increase in revenue for the rural, sparsely populated towns. This may explain in part the widespread local support. Hoosac Wind will provide the towns with a substantial fixed revenue source through payment in lieu of taxes (PILOT), while ensuring a predictable expense for twenty years for the development firm Iberdrola. Officials from both towns are concerned that Iberdrola will depart if the permitting

process continues to languish in the courts.

Case Study 3: Lempster Wind Farm, Lempster, New Hampshire

Project Profile

The Lempster Wind Farm project began in 2004, initially went online in November 2008, and completed site restoration work in June 2009. Located in the town of Lempster, Sullivan County, it is the first constructed and operational wind farm in the state of New Hampshire. The 24 megawatt capacity project consists of twelve turbines with 2 megawatt nameplate capacities. Most of the towers are setback from the Lempster Mountain ridgeline and are partially visible from Route 10, the sole major road to the site. Iberdrola Renewables developed the wind farm through its subsidiary company Community Energy. The firm possesses a long-term access and operations lease on the property of Kevin and Deborah Onnela (Murray, 2009).

The wind farm generates approximately 52-63 GWh of electricity, based on a capacity factor range of 25-30%, providing for the annual electrical consumption of up to 8,300 New Hampshire homes. The Public Service of New Hampshire is the sole purchaser, and it in turn sells 10% to the New Hampshire Electricity Cooperative. The town of Lempster receives no direct or discounted electricity from the facility. However, Lempster expects annual tax revenues of \$30-40 million from the wind farm, increasing the town's total tax revenues by 25-33% (Brooks, 2009). The project timeline is represented in figure 3.6.

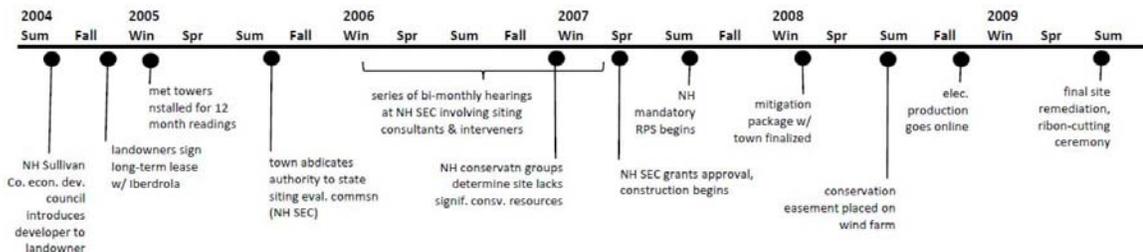


Figure 3.6. Lempster Wind project timeline (Lempster, NH)

Significance of Project

The Lempster Wind Farm is not only the first grid-connected project in New Hampshire, it is also the first successful large wind farm in New England outside of Maine. The wind farm is located within one-hundred miles of Boston and other areas of southern New England. It is within a scenic rural area that planners consider prime for retirement, second home development, and tourism. The project experienced limited local public opposition. This section explores the reasons why the Lempster Wind Farm was successful in securing final permitting approval, while the other wind farm projects discussed in this article were not.

Stakeholder Interview Findings

According to stakeholder responses, all three factor categories—policy, site-specific, and social—contributed to the success of the Lempster Wind project (Table 3.5). As with Hoosac Wind, policy factors such as state energy policies, the state renewable portfolio standard, and the federal production tax credit and recovery act loans contributed to a successful outcome. The minimal standing criterion for interveners was also identified as an influential policy factor, although it appears not to have delayed the outcome in this case. Distinct from the other cases, stakeholders spoke of how the New Hampshire permitting process favored wind power development. In terms of site-specific factors, the former and existing use of the site, the ownership structure, and the local economic base contributed to the project's success. In terms of social factors, Lempster Wind received substantial in-town, public support and benefited from the expectation of increased tax revenues for the town. The cultural composition of the town was also influential, yet it led to a successful outcome, in contrast to the Glebe Mountain project. These factors are discussed in greater depth below.

Table 3.5: Factors Influencing the Successful Outcome of the Lempster Wind Farm Project

Policy Factors	Site-Specific Factors	Social & Institutional Factors
<p>OVERALL STATE POLICY</p> <ul style="list-style-type: none"> Climate Change Task Force; new PILOT law requires long-term fixed contracts 	<p>FORMER/EXISTING USE OF PROJECT SITE</p> <ul style="list-style-type: none"> Site is a formerly logged forest; conservation NGOs determined the site lacked high conservation values 	<p>EXISTING MUNICIPAL TAX BASE AND EXPECTED REVENUE</p> <ul style="list-style-type: none"> Very low tax base, receiving significant revenue increase; unable to reach agreement on payment in lieu of taxes (PILOT)
<p>STATE RENEWABLE PORTFOLIO STANDARD (RPS)</p> <ul style="list-style-type: none"> REC market is essential in New England since development costs twice the U.S. average; MA's RPS drove development in NH prior to its own RPS 	<p>OWNERSHIP OF PROJECT SITE</p> <ul style="list-style-type: none"> Single landowner for project site made negotiations easier; the landowner was an influential figure in a town of 800 people 	<p>LOCAL, IN-TOWN SUPPORT</p> <ul style="list-style-type: none"> Overwhelming public support at town meetings; town leaders support; 2-3 adjoining property owners openly expressed opposition
<p>STATE REGULATORY PROCESS</p> <ul style="list-style-type: none"> Site Eval. Committee created in 1970s to streamline 30MW+ energy projects, but not equipped for wind; town successfully petitioned SEC to handle project 	<p>MAKEUP OF LOCAL ECONOMY</p> <ul style="list-style-type: none"> Remote, rural town with no zoning and no large tourist attraction 	<p>CULTURAL COMPOSITION OF HOST TOWN</p> <ul style="list-style-type: none"> mostly working class, year-round residents who welcome all forms of development, including gravel pit and motor-cross parkway
<p>FEDERAL PRODUCTION TAX CREDIT (PTC) & ARRA GRANTS</p> <ul style="list-style-type: none"> Annual renewal of PTC created uncertainty, but still drives wind power projects as well as new, direct loans from ARRA 		
<p>Factors that Would Influence a Failed Outcome</p>		
<p>STANDING CRITERIA FOR PROJECT INTERVENERS</p> <ul style="list-style-type: none"> Most vocal interveners were not local, lived over 100 miles away; NH-SEC reviewed every study 	<p>VISUAL AESTHETIC CONCERNS</p> <ul style="list-style-type: none"> A major concern of opposition; less criticism of visual impact now than prior to construction; positive remarks heard from those viewing wind farm in the distance <p>NOISE LEVEL</p> <ul style="list-style-type: none"> Noise was main concern of opponents; the NH-SEC required developer to mitigate noise levels by providing AC and central unit fans for impacted residents 	<p>INVOLVEMENT OF ADJACENT TOWN(S)</p> <ul style="list-style-type: none"> Lempster one of few towns to lack zoning; adjacent town of Goshen intervened in NH-SEC application, frustrated with requirement to upgrade transmission through town center

Policy Factors

As with the Hoosac Wind case, Lempster Wind benefited from assertive state energy policies. Prior to the Lempster Wind project's inception, New Hampshire had already established a climate change task force, a new payment in lieu of taxes (PILOT) law requiring long-term fixed contracts, and a renewable portfolio standard (RPS) mandate. Prior to the creation of the New Hampshire RPS, the Massachusetts RPS drove wind power development proposals in the state, since the renewable energy credits (RECs) are tradable between the New England states. Renewable energy credits are essential since wind energy development costs in the region are twice the national average.

Distinct from the other two cases, the state permitting process in New Hampshire was actually identified by stakeholders as a factor contributing to the success, rather than failure or delay, of the project; this may be because the permitting process is more streamlined in New Hampshire than in Massachusetts or Vermont. The state site evaluation committee (NH SEC) was created in the early 1970s to streamline energy projects greater than 30 megawatt. Although Iberdrola's 24 megawatt capacity did not meet this minimum threshold, the town of Lempster successfully petitioned the NH SEC to oversee permitting because the town lacked zoning and therefore a zoning review process.

The only policy factor that potentially could have delayed the outcome was the limited standing required for interveners. Several stakeholders questioned why the NH SEC was compelled to "sit through and review every questionable study." They commented that the most vocal intervener, director of the Industrial Wind Action Watch, did not reside in the host town, lived over 100 miles away, and would not be directly impacted. Ultimately, however, the limited standing did to appear to delay the outcome in this case.

Site-Specific Factors

The ownership structure of the site contributed to the project's success. The wind farm was built predominately on one large property owned and managed by a single

owner, who had lived in the town his whole life. The landowner was an influential figure in a town with less than five hundred people. The property remains in logging, and the conservation organizations in New Hampshire concurred that good forestry practices could co-exist on the same site as the wind farm, thus achieving a balance between sustainable forestry and sustainable energy production.

Stakeholders also identified the composition of the local economy as a significant factor contributing to the success of the project. Few jobs exist in the town—a gravel pit is one of the major employers—and the wind farm provided several appealing, albeit temporary, construction jobs. Lempster also lacks zoning and its main recreational venue is a motor-cross speedway; the town is an isolated pocket within central New England, and it is not reliant on tourism.

Visual aesthetic concerns arose but were not as prominent as in the other two cases. Less criticism occurs now than prior to construction, and several stakeholders mentioned hearing favorable remarks from those residents of the region who can see the wind farm in the distance. Many of the stakeholders view the string of turbines as a welcome addition to the central New Hampshire landscape.

Social Factors

One of the social factors contributing to the success of the Lempster Wind project was the overwhelming local, in-town support expressed at public meetings. While three adjoining property owners expressed their opposition to the wind farm, no lawsuit was brought against the state site evaluation committee. The adjacent town of Goshen did oppose the project; Goshen town officials intervened at the state hearings with concerns about regional transmission infrastructure improvements. Despite receiving compensation from Iberdrola, Goshen officials remained frustrated that large utility poles were placed in the historic town center. Yet this opposition from a neighboring town was not enough to significantly counteract the host town's overwhelming support for the project.

The socio-economic composition of Lempster was another social factor that contributed to the project's success. The composition of Lempster resembles that of Florida and Monroe, Massachusetts (of the Hoosac Wind project) more than it does Londonderry, Vermont (of the Glebe Mountain wind farm). Lempster is comprised of

mostly working class, year-round residents who, according to one stakeholder, “welcome any and all forms of development.” With a very low tax base, townspeople recognized the benefits the wind farm would bring in the form of significantly increased revenue for the town. Although a PILOT arrangement was discussed, the town and Iberdrola were unable to reach an agreement on it. Instead, the town will annually assess the taxable value of the wind farm as a commercial property.

Summary of Case Study Findings

Three main findings are observed when comparing between the inter-governmental policy, site-specific, and social factors of the three wind farm case studies: states must reform energy *siting* policy to support their established energy supply policy (renewable portfolio standard); visual aesthetics remain the most significant site-specific concern; and the host municipalities experienced unique public responses- there were no social factors that uniformly influenced all three projects.

Glebe Mountain—the only project with a failed outcome—is also the only project lacking a positive policy factor. This indicates that state energy *siting* policy reform is necessary for wind power expansion to occur in Vermont. As a wind developer in Vermont stated, “People assume that wind power should be a given in New England, but it’s actually more difficult to permit a wind farm than a combined natural gas power plant.” New Hampshire and Massachusetts provide stronger state incentives and requirements, such as renewable portfolio standard mandates. However, Massachusetts continues to struggle in enacting a more streamlined permitting process. The states need to review and reconsider the lack of standing criteria for interveners, as stakeholders from both the Lempster Wind (NH) and Hoosac Wind (MA) projects identified this as a factor that delays approval. This factor was not relevant in the Glebe Mountain project, because the case did not reach the formal permitting review stage.

Regarding site-specific factors, stakeholder groups in each case study identified visual aesthetic concerns as significantly influencing project delay or failure. The surrounding land use composition- of second homes- was the primary factor for project failure for Glebe Mountain, while not a factor for the other two cases. The Lempster

Wind project did not experience the same degree of concern over sensitive wildlife habitat, stream, and wetland disturbance, while the ownership of the project site and the makeup of the local economy contributed to its successful outcome.

The case study findings diverged the most in terms of the influence of social factors on project outcomes. Local in-town , public support, the existing tax base, and an expected increase in tax revenue led to project success for Lempster Wind, and these factors hold promise for Hoosac Wind, while they led to project failure for Glebe Mountain. The origin and type of wind developer as well as the perceived impact on surrounding property values also led to a failed outcome for Glebe Mountain, while not being significant factors for the other two cases. The attitude of the adjacent town delayed the Lempster Wind project, whereas the response from conservation organizations may have contributed to the delay of the Hoosac Wind project.

Implications for Planning and Policy

An implication from the case study outcomes is that New England may not actually represent what many assume to be an ideal framework for wind power development. The convergence of expensive electricity, limited in-state conventional energy resources, and advanced sustainable energy and climate policy at the state level all allude to a renewable energy renaissance. However, more expedient development occurs in locations such as Texas and Iowa, with cheaper electricity rates, other primary sources of energy (natural gas and biofuels), and relatively minimal energy or climate policy. This stresses the importance for both planners and developers to recognize not only the policy drivers, but also any counter-acting policies, site-specific factors, and social responses. The Massachusetts case mirrors the experiences in the United Kingdom and France, where federal cultural and historical protection objectives conflict with assertive energy policies and impede wind farm siting (Breukers and Wolsink, 2007; Nadaï and Labussiere, 2009; Nadaï and van der Horst, 2010).

This study's results also illustrate the importance of not only local public support, but also state-level leadership for the success of wind power development. Each of the three New England states studied here approaches wind power development siting quite

differently, despite being located within the same regional electricity, renewable energy credit, and carbon trading markets. Vermont and Massachusetts legislators and energy officials should acknowledge the New Hampshire Site Evaluation Committee as a model for streamlining large, utility-scale wind projects. Among the interview respondents, there was a unanimous interest in statewide and regional wind power plans that take into consideration a comprehensive set of land use and environmental variables in order to determine the most suitable zones for wind farms. This would follow the Swedish and German approaches, where a minimum percentage of the areas with high wind resources must be identified by the localities as residence-free and wind power development zones (Khan, 2003; Jobert et al, 2007; Ohl and Eichhorn, 2010). This is similar to the requirements in Connecticut and Massachusetts that municipalities must provide a minimum percentage of affordable housing (M.G.L., 1969; Connecticut Statute, 1991).

Public response in central New England to wind power siting proposals does not readily conform to the NIMBY or LULU standard associated with other energy facilities. A majority of local townspeople consent to the construction of wind farms. As noted with the Hoosac Wind Farm case, the townspeople remain frustrated that outside interests are attempting to halt a development with overwhelming local support. The opposition arises from *pre-emptive reactionism*, where financially resourceful special interest groups mount grassroots campaigns several towns removed from the site. This complicates the common New England thread of self-determination, where towns vociferously oppose outside forces dictating their future (Foster, 2009). This response from parties not immediately adjacent to the site, but within the same region, also differs from the grassroots populism identified in earlier studies of hazardous waste facilities (Heiman, 1990; Portney, 1991).

Wind power must rapidly develop as an essential new addition to a region's energy portfolio in order for any substantial decline in energy import dependence, air and water pollution, and greenhouse gas emissions. Wind power remains a necessary element to realize state energy policies and for states to attain their 2020 renewable portfolio standards mandates. In order for this to occur more comprehensive, landscape-scale planning is required for the siting of clustered and individual wind turbines. According to a New England energy attorney, "scientific, statewide wind energy plans are needed to

establish better siting criteria. This is useful not necessarily for expediting wind power beyond what the public may tolerate, but to simply do it right.” This remains a challenge in New England where conservationists have criticized the failure of land use planning and the inability for the states to provide a collective regional land use vision. Conservationists have begun to realize the danger of relying on fee-simple and conservation easement purchases to satisfy long-term conservation objectives (Foster, 2009).

This regional-scale process needs the participation of the major land owners and land managers, such as municipalities, land trusts, state and federal agencies (Wiseman, 2011). Wind power land use siting assessments are a beneficial tool and can assist this process in identifying the most suitable and least impactful locations for wind turbines (Weimar, Publicover, and Allison, 2010). A comprehensive regional, landscape-scale participatory process informed by geographic information science-based land use assessments would diminish pre-emptive reactionism through pro-active planning (Higgs et al., 2008). A senior New Hampshire conservationist and Massachusetts regional planner both stress that the siting process remains problematically reactionary since there is no call for planning for wind power, “the states need to develop a comprehensive land use framework that includes siting for wind power.”

Energy facility siting remains one the greatest challenges to planners and policymakers. The findings from thirty years past remain instructive today within a twenty-first century context. They speak of the primary challenge municipal and state governments face in achieving the ambitious 20% by 2020, 80% by 2050 fossil energy and greenhouse gas reductions: “The problem of locally undesirable, though generally beneficial, facilities has become more than a nuisance or a paradox of planning theory. Some facilities threaten to be impossible to provide at all if the means cannot be found for reducing or overcoming local opposition. Furthermore, the situation seems to be getting worse.” (O’Hare et al, 1983).

The New England wind power case studies illustrate the limits to an expeditious transition to renewable energy sources, despite wind power’s promised respite from the considerable environmental pollution associated with nuclear and coal waste. No energy facility is constructed without corollary impacts to adjacent landowners and the

environment, but planners should recognize the advantages of wind power as a viable, cleaner, safer source of electricity (EERE, 2008; Jefferson, 2008; Jacobsen, 2009). As the awareness of both the broad public health dangers of fossil and nuclear fuels and of climate change spreads in our society, the more likely wind power will gain approval in currently contested locations.

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CHAPTER IV

A Wind Power Siting Assessment for Western Massachusetts: Quantifying Physical, Environmental, Land Use, and Conservation Exclusions

Introduction

For many U.S. states, the combination of high energy import dependency, high electricity prices, aging nuclear and coal-fired power plants, and heightened concern for climate change creates an atmosphere conducive to advancing renewable energy production (American Lung Association, 2011; EIA, 2010b; EIA, 2011; Jacobsen, 2009; Krosnick and Villar, 2010; Sawin, 2010). Massachusetts is one of these pioneering states, despite the fact that it has limited land area relative to most other states for renewable resources. The state currently relies on fossil fuels for a majority (80%) of its electricity supply, followed by nuclear power (14%) (EIA, 2010b). To increase the percentage of its electricity portfolio that comes from renewable sources, Massachusetts reauthorized a more assertive renewable portfolio standard (RPS) in 2009. In addition, the 2008 Green Communities Act requires utilities to solicit long-term purchasing agreements with renewable power producers, net metering for wind turbines up to 2 MW in nameplate capacity, and enables municipally-owned power companies to own and manage renewable energy facilities, including wind turbines (M.G.L., 2008).

Although there is a concerted legislative effort, a public receptive to climate change response and clean energy development, and the highest electricity prices in the continental United States, wind power development continues to languish in Massachusetts (EIA, 2010a; Krosnick and Villar, 2010; Leiserowitz et al., 2010). The state has commissioned wind power land use assessments in the past, with a particular emphasis on the mountainous western region (Publicover, 2004; Navigant, 2009). Each of these reports represents a specific interest, and therefore focus on a narrow range of

factors such as conservation and recreation values, or the siting potential only within state-held lands.

This wind power siting assessment employs a comprehensive set of thirty-seven exclusionary variables to determine the amount of suitable land area and the corresponding electricity generation potential for Western Massachusetts. The variables are incorporated into three raster-based GIS models. The first scenario model represents the position that wind power and land conservation cannot coexist and assumes that enough privately-held, non-scenic, unprotected lands exist for wind power development. The second scenario model represents the position that wind power development is vital to meeting the state's renewable portfolio standard, mitigating climate change, and improving regional air quality, and therefore is suitable within all high wind resource areas within both public and unprotected private lands. The third scenario model represents a balance between the two divergent positions.

The intent of this study is to improve the wind power siting and planning process by contributing a GIS suitability modeling method that incorporates a more complete set of physical, environmental, land use, and conservation variables. Newly incorporated variables include municipal preserves, parks, forests, and water supply districts, rare species habitat areas, state areas of critical environmental concern, telecommunication and emergency towers, designated scenic landscapes, conservation restrictions, and agricultural restrictions.

The first section of this paper provides a brief overview of wind power land use assessments, as well as those specifically conducted for the Western Massachusetts study area. It explains the social and political forces involved in wind power facility siting within such a contested landscape. The methodology section introduces the study area, the origins of the GIS datasets, and the five selection categories comprised of thirty-seven exclusionary criteria for wind power siting suitability. It then describes the development of the three, separate suitability models, the scenarios they represent, and lists the specific exclusion and distance buffering criteria for each explanatory variable. The methodology section concludes with a description of the three spatial analysis modeling steps needed to determine the suitable land area and the associated electricity generation potential for each of the three models, when the thirty-seven exclusionary variables are taken into

account. The third section describes the findings from the three raster GIS land suitability models, noting which category of variables had the greatest impact in limiting suitable land areas for wind power generation. The fourth, concluding section compares the results of the three models and analyzes how key individual variables influenced the range of land area suitable for wind turbines. The paper provides recommendations for improving wind power siting research and implementation within high wind resource landscapes overlapped with a mosaic of land uses, development rights, and long-term management objectives.

Background

Wind power land use assessments

Many geographic information system-based (GIS) wind power land use assessments exist for high wind resource areas throughout the United States and the world. The National Renewable Energy Laboratory (NREL) began using land siting criteria in 1991 with a series of land exclusion models in order to refine the estimates of wind resources for each U.S. state (Elliott, Wendell, and Gower, 1991). Because of limited GIS data and computer modeling capability at the time, these initial assessments were at low raster resolutions and were unable to represent physical variables such as slope gradient, proximity to existing paved roads, and existing transmission lines. Other data layers that were spatially unavailable at the time include those representing environmental resources such as wetlands, sensitive habitat, and wildlife refuges, as well as infrastructure such as telecommunication towers and airports, and distance buffers for residential, institutional, and recreational land.

As GIS land use data and mapping resolution improved, subsequent studies began to incorporate these missing variables (Short, 1999; Heimiller, 2001). Baban and Parry assessed the suitability of locating wind farms within a rural region of the United Kingdom through two GIS models: a criteria-based boolean model and a weighted model based on public survey responses (Baban, 2001). This assessment was the first to include proximity to transmission lines and to major roads and established buffer distances to

environmental resources. The Michigan Renewable Energy Program (MREP) utilized the National Renewable Energy Laboratory's (NREL) land use criteria to establish a 2006-2020 assessment of wind power capacity potential for the state of Michigan (Schwartz, 2003; MREP, 2005). The MREP assessment introduced substantial buffer distances for airports, wildlife refuges, wetlands, ecologically sensitive areas, federal parks, and land trust property while excluding 50% of state and federal forest land. Rodman and Meentmeyer assessed land areas for wind turbine placement within the nine-county central California region by employing a rule-based, weighted GIS suitability model (Rodman and Meentmeyer, 2006). Their model introduces endangered plant species sites as a new variable and explicitly prioritizes farmland and ridgeline areas. Acker and colleagues (2007) also incorporated the NREL land use criteria to assess the wind power capacity potential within the state of Arizona, using a boolean GIS model. Finally, Bravo and colleagues (2007) assessed the generation capacity potential in Spain for six renewable energy technologies, including wind power, within mountainous terrain. This assessment introduced a more restrictive variable for steep slopes and excludes all forest cover.

These previous wind power land use assessments inform energy analysts, geographers, and planners of the main siting variables to incorporate in future assessments. However, a comparative review, which is included within chapter two, the Literature Review, found a lack of uniform exclusionary standards. A conspicuous gap exists between how energy and land use researchers determine which exclusionary variables to include and the specific metrics used for each variable, and the criteria is often informed by different sources. In terms of an appropriate geographic scale, multi-county-level wind power land use assessments provide greater resolution, more accurate calculations, and may assist in establishing wind overlay districts within the most suitable areas within a state. A multi-county focus enables the incorporation of higher resolution raster data and often illustrates flaws in variable criteria selection.

Wind power land use assessments for Western Massachusetts

Several non-peer reviewed GIS wind siting assessments have been conducted for Western Massachusetts as well, producing divergent results (Potts et al., 2001;

Publicover, 2004; Navigant, 2009). The first measured surface and atmospheric conditions to predict wind speeds at 50 meters and determined that the northwestern corner of Massachusetts has the greatest wind resources in the region. The study determined many of the western ridgelines had wind speeds less than the original NREL projections (Potts, et al., 2001). However, a majority of the anemometers used to collect wind speed data were 40 meters or less in height, while 80-meter tall anemometers are necessary to accurately predict the wind resource of today's turbines, which are typically 70-80 meters in hub height.

A second study, commissioned by the state of Massachusetts and performed by the Appalachian Mountain Club, employed a weighted suitability GIS model to assess potential conflicts between wind power development and four land use categories: (1.) existing conservation status, (2.) ecological factors, (3.) recreational factors, and (4.) scenic factors (Publicover, 2004). This conservation and recreation-oriented study found that 53% of the developable ridgelines fall within public lands which have a primary purpose of conservation. The study determined that the higher the wind power class, the greater the land use conflict, and that a significant conflict occurs between conservation and recreation values and wind power development throughout Western Massachusetts (Publicover, 2004).

Another state-commissioned study, by Navigant Consultants, assessed the renewable energy potential of state-owned lands and determined the potential generation capacity for wind power within the state lands of Western Massachusetts to be 946.5 megawatts (Navigant, 2009). The figure derives from an unpublished University of Massachusetts Wind Energy Center GIS land use assessment which limited suitable land areas to those that could accommodate at least five, 1.5 megawatt-rated turbines (Navigant, 2009). This limitation means that all suitable areas large enough for between one and four 1.5 MW turbines were removed from the model. Although the clustering of several turbines into a wind farm can be considered economical, the only turbines currently operating in Massachusetts are single placement (Jiminy Peak, Otis Stone Quarry, and Municipality of Hull), which illustrates that single placement turbines should not be excluded from consideration, especially since they have been sited more quickly than wind farms.

These assessments occurred in the context of a state that has done numerous wind power studies, despite the fact that Massachusetts has a limited land area relative to most states. The combination of high energy import dependency, high electricity prices, aging nuclear and coal-fired power plants, and heightened concern for climate change creates a legislative atmosphere conducive to advancing renewable energy production (EIA, 2010b; EIA 2011; Jacobsen, 2009; Krosnick and Villar, 2010). Yet Massachusetts currently relies on fossil fuels for 80% of its primary energy source for electricity (Figure 4.1). Half of the state’s electricity supply is generated from natural gas, the most expensive energy source, while 20% is generated from coal, and 14% from nuclear power. Wind power currently provides .01% of the state’s electricity supply (EIA, 2010a).

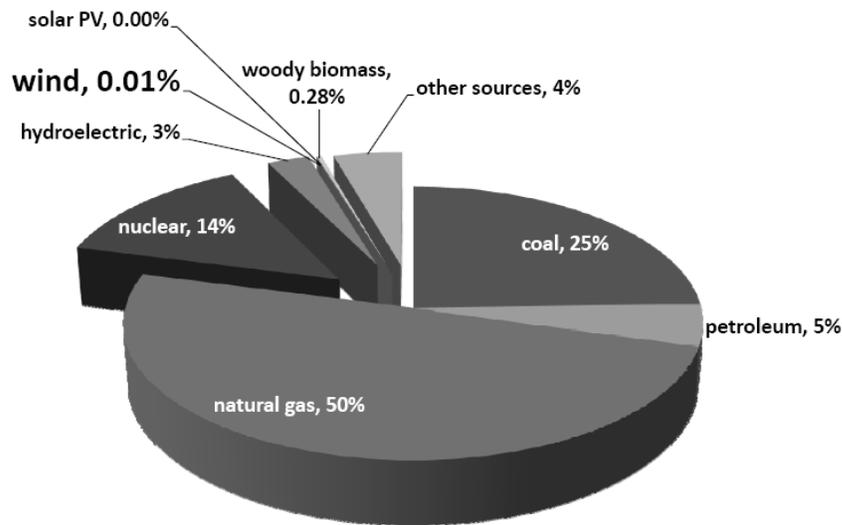


Figure 4.1. Massachusetts electricity generation by primary energy source, 2010.

In an effort to increase the percentage of its electricity portfolio that comes from renewable sources, the state of Massachusetts reauthorized a more assertive renewable portfolio standard (RPS) in 2009. The Massachusetts RPS requires 5% of electricity sales to be generated from renewable sources by the end of 2010, with an annual 1% increase thereafter, with no date of expiration. Therefore, the Massachusetts RPS mandates 15% of electricity sales from renewable sources by 2020. In addition, the 2008 Green Communities Act requires utilities to solicit long-term purchasing contracts of 10 years or

greater with renewable power producers, net metering for wind turbines up to 2 MW in nameplate capacity, and enables municipally-owned power companies to own and manage new renewable energy facilities, including wind turbines (M.G.L., 2008). The Green Communities Act also provides energy and environmental technical and financial assistance to qualifying municipalities. Two of the five qualifications are that a town must adopt as-of-right renewable energy siting in designated districts and expedite the permitting process for new renewable generation facilities.

Yet, despite these concerted legislative and administrative efforts, a public receptive to climate change action and clean energy development, and the highest electricity prices in the continental United States, wind power development continues to languish in Massachusetts (EIA, 2010a; Krosnick and Villar, 2010; Leiserowitz et al., 2010). The State is cognizant of the difficulties in siting and permitting wind power. To address this, in 2009 the legislature began deliberating the Wind Energy Siting Reform Act. Two aspects of the act generated unfavorable responses from several rural towns, regional planning agencies, and conservation organizations located within the high wind resource areas of Western Massachusetts. The first aspect involves the desire to streamline and expedite the wind power permitting process. Currently, the host municipality retains permitting authority for any electricity generation facility below 100 megawatts in nameplate capacity, and fragmented land ownership and management make it difficult for a wind farm to reach this regulatory threshold. The act proposes that commercial wind farm projects, regardless of their size, receive the same permitting process as all other power plants. However, since Massachusetts is a home rule state, the potential forfeiture of local autonomy unsettles many towns and regional planning councils.

The second aspect involves the intended use of state-held public lands. The Wind Siting Reform Act would enable wind turbines to be placed within state forests, which comprise 28%—27,155 hectares—of the region's wind resource land areas, and which are managed by the Department of Conservation and Recreation, under the jurisdiction of the state's Executive Office of Energy and Environmental Affairs (EOEEA). The debate continues on whether state-owned lands should accommodate renewable energy

production, or whether they should be maintained exclusively for conservation and recreational use.

Methodology

Research Study Area

The research study area encompasses the 51 towns within the four westernmost counties of Massachusetts—Berkshire, Franklin, Hamden, and Hampshire—that possess a minimum of Class 4 wind resources at 70 meters above the ground surface (Figure 4.2). The National Renewable Energy Laboratory defines class 4 wind resources and above as economically viable for electricity generation. Class 4 wind resources have average wind speeds exceeding 6.3 meters per second (15.7 miles per hour). 25% of the region possesses class 4 or greater wind resources (95,310 out of 388,740 hectares) (Figure 4.3). As described earlier in the chapter, Western Massachusetts has been periodically studied for its wind resource potential and in order to identify potential conflicts between wind power, conservation, recreation, and other land uses (Potts et al., 2001; Publicover, 2004; Navigant, 2009). Two commercial-scale turbines are currently operating in this region, a 1.5 MW turbine at the Jiminy Peak ski resort in Hancock and a 900kW turbine on the former Williams Stone quarry in Otis. Three additional commercial wind farm projects are in various stages of the permitting process: the 30 MW Hoosac Wind Farm in Florida and Monroe, the 15 MW Berkshire Wind Farm in Hancock, and the 8 MW Minuteman Wind Farm in Savoy.

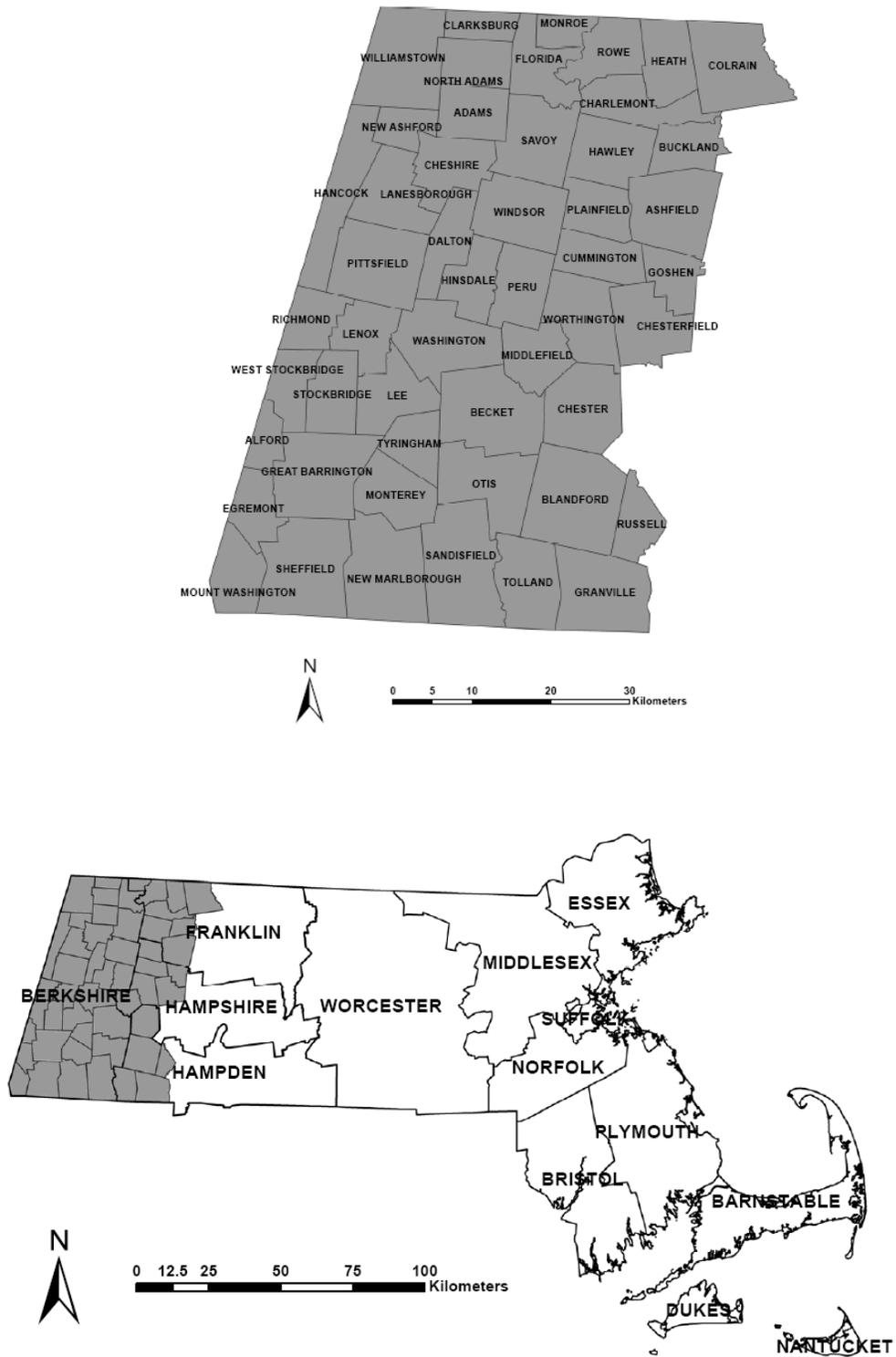


Figure 4.2. The geographic study area of 51 towns in Western Massachusetts

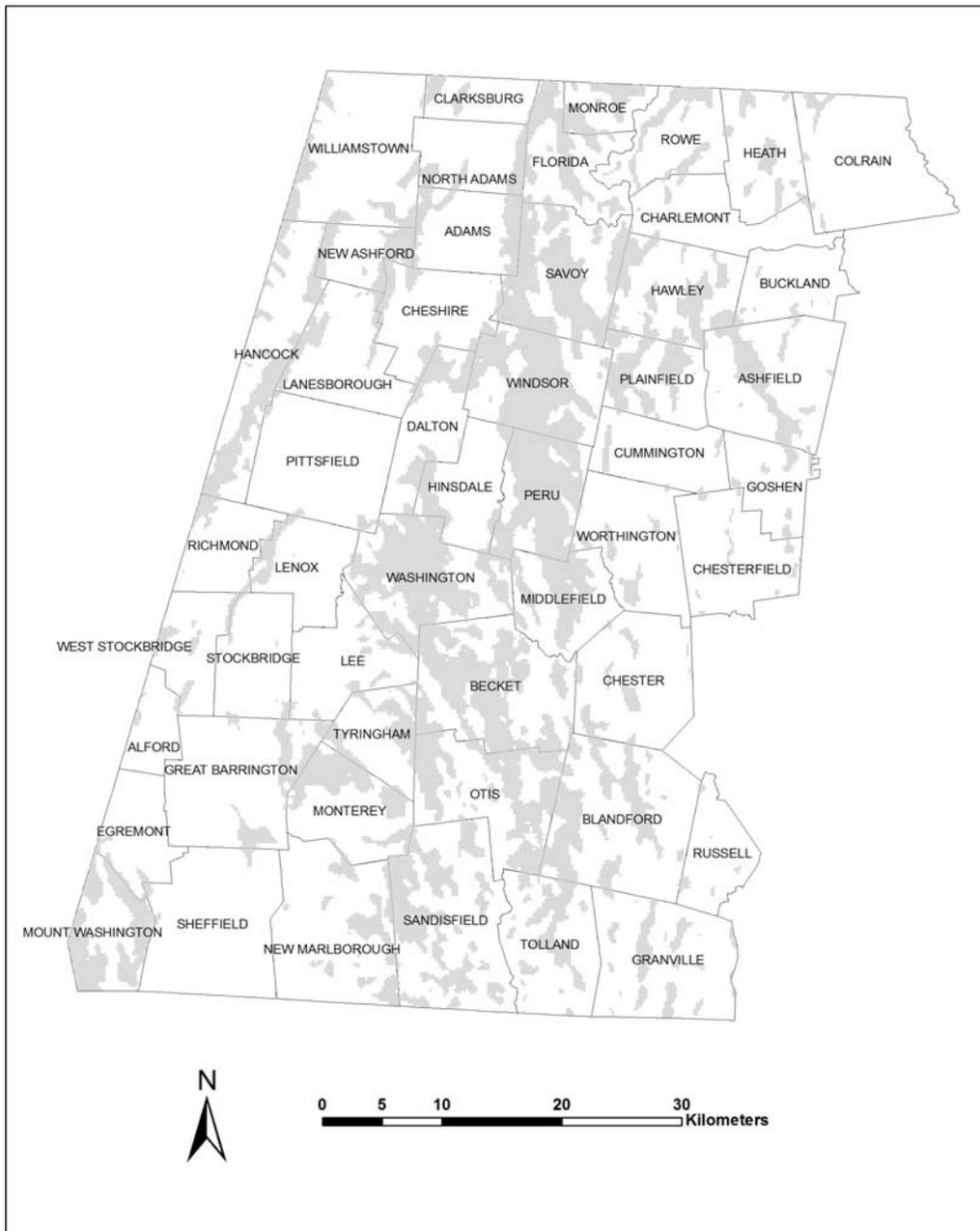


Figure 4.3. Western Massachusetts Class 4 wind resources at 70 meters elevation above ground level (95,310 hectares, 25% of study area)

GIS Database Sources

GIS vector datasets were acquired by the author from October 2009 through February 2010. The majority originate from the state of Massachusetts's Office of Geographic and Environmental Information's online service, also known as MassGIS (MassGIS, 2010). The 2005 Land Use dataset, released June 2009, and the Protected and Recreational Open Space dataset, updated July 2009, provided the majority of relevant siting variables. A MassGIS representative distributed the 2007 Utility Transmission Lines dataset by email upon the author's request. The 70 meter height wind resources raster dataset, at 30 meter resolution, originates from the 2003 AWS/Truewind map series commissioned by the Massachusetts Technology Collaborative (Figure 4.3). The telecommunication tower and antenna datasets were acquired from the Federal Communications Commission Geographic Information Systems homepage (FCC, 2010). The scenic landscapes dataset, digitized in 1999, originates from the Trustees of Reservations, a well-established statewide land conservation organization. Through GIS queries and the conversion of the original vector shapefiles into 10 meter resolution raster datasets, the author established thirty-seven siting explanatory variables.

Categories of Siting Variables

The wind power siting explanatory variables are organized into five categories—physical and technical, environmental resources, visual and communication, land use, and land protection—with wind resources as the dependent variable for each category (Table 4.1). The physical and technical, environmental resource, and land use variables are derived from the methodology of previous siting assessments (Acker et al., 2007; Baban, 2000; Publicover, 2004; Rodman and Meentmeyer, 2006). The visual/communication and land protection categories, and the variables within them, are unique to this study.

The physical and technical variables include slope gradient, proximity to major roads and town roads, and proximity to existing transmission lines. Environmental resource variables include wildlife preserves held by municipal, state, and federal agencies, state designated rare species habitats, areas of critical environmental concern, water supply districts, wetlands, and waterways. Land use variables include airports,

municipal, state, and federal parkland, long-distance recreation trails, active recreational areas, and institutional and residential land. Visual and communication variables include radio, television, emergency and cellular communication towers, and a designation of scenic landscapes by the Trustees of Reservations. Lastly, the land protection variables account for conservation and agricultural restriction easements held on private, municipal, land trust, and non-profit property, as well as municipal and state forests without conservation restrictions (Table 4.1).

Table 4.1. The five categories of wind power siting variables

PHYSICAL & TECHNICAL	ENVIRONMENTAL RESOURCES	LAND USE	VISUAL & COMMUNICATION	LAND PROTECTION & CONSERVATION RIGHTS
Slope Gradient	Municipal Wildlife Sanctuaries	Airports	Radio & Television Towers	Private w- Conservation Restriction
Proximity to Major Roads & Town Roads	State Dept. Fish & Game Preserves	State Parks and Reserves (MA DCR)	Emergency Radio Towers	Private w- Agricultural Preservation Restriction
Proximity to Transmission Lines	Federal Wildlife Refuge & Wilderness Areas	Federal Park or Recr. Area (NPS)	Cellular & Commun. Towers	State Forest (MA DCR)
	State NHESP Rare Species Habitat	Designated Long-Distance Recr. Trails	TTOR Scenic Landscape Designation	Municipal Forests w- Conservation Restriction
	State Areas of Critical Env Concern (ACEC)	Municipal Park		Municipal Forests w-out Developmt. Restriction
	Water Supply District Land	Active Recreation Land		Land Trust Property w- Conservation Restriction
	Forested Wetlands	Institutional Land		Land Trust Property w- Agric. Presv. Restriction
	Non-Forested Wetlands	Higher-Density < 1/2ac Residential		Land Trust Property w-out Devel. Restrict
	Lakes, Reservoirs, Rivers	Lower-Density > 1/2ac Residential		Non-Profit Property w- Conservation Restriction
	Streams			Non-Profit Property w- Agric. Presv. Restriction
				Non-Profit Property w-out Devel. Restrict

Although this assessment incorporates an extensive collection of siting explanatory variables, relevant GIS data limitations persist. For example, the availability of electricity transmission voltage capacity within a GIS dataset will be useful for future energy siting assessments. This would show where significant infrastructure improvements would need to occur before or during the installation of wind turbines. Military installations and aerial exercises may also be relevant variables for assessments, although this data may be difficult to acquire. It is important to note that this assessment marks a snapshot in time. The frequent updating of source GIS datasets may necessitate new assessments to be performed every five to ten years. States may want to contract an assessment during the renewable portfolio standard reauthorization process in order to inform policymakers of any changes in land use patterns that would affect both current and future renewable energy potential.

The Development of the Wind Power Siting Suitability Models

This study provides three distinct wind power siting suitability models for Western Massachusetts. Each suitability model was created from the aforementioned set of thirty-seven land use variables. The first model represents the scenario that wind power and land conservation cannot coexist, and that wind turbines should not intrude upon any designated open spaces or scenic landscapes, public or private, legally protected or not (Berkshire Natural Resources Council, 2005;). Any environmental, economic, or public health benefits are not worth the impacts to sensitive forest ecosystems and wildlife caused by the construction and operation of wind farms.

The proponents of this position declare that enough privately-held, non-scenic, unprotected lands exist for wind power development (Dodson, 2009; Tillinghast, 2009; Trustees of Reservations, 2009). To represent this scenario, the study's first, most exclusionary model allocates the maximum buffer distances found within previous wind power land use assessments and within the stricter New York and Pennsylvania state model wind ordinances (Table 4.2; New York, 2005; Pennsylvania, 2006). The intent of model 1 is to determine how much suitable land area exists on private, unprotected property that is substantially distanced from all the land use exclusionary variables. The

model represents the preferences of those interest groups who oppose wind power development, including many, but not all, statewide and local conservation organizations.

The second scenario proposes that, since wind power development is vital to meeting the state's renewable portfolio standard, mitigating climate change, reducing electricity prices, and improving regional air quality, development should occur on all technically suitable areas within both public and private land that is beyond adequate buffer distances. Wind turbines should be constructed and operated employing best management practices while mitigating site-specific impacts whenever suitable sites overlap within unprotected, but state-designated, environmentally sensitive areas. This position is represented by model 2, the least exclusionary model, which incorporates the buffer guidelines of the Maine and Massachusetts model wind ordinances, with the majority of distance buffers established at 160 meters (Table 4.2; Maine, 2009; Massachusetts, 2007). It most closely reflects the state of Massachusetts's assertive policies for expediting wind power development within suitable land areas, including on public lands. Model 2 includes as suitable state forest lands, open space lands with agricultural preservation restrictions, or municipal, non-profit, and land trust property without development restrictions (Table 4.2).

The third and final scenario proposes that a balance can be reached between wind power development and the long-term protection of conservation and recreation values. This scenario asserts that wind power should be generated not only on private but also on physically and environmentally suitable public lands. To represent this position, model 3, the balanced exclusions model, employs buffer distances that exceed many of the guidelines of the Maine and Massachusetts model wind ordinances, increasing the required distance from many adjacent land uses from 160 meters to 300 meters (Table 4.2; Maine, 2009; Massachusetts, 2007). This model does not exclude unrestricted public lands, such as municipal and state forests, from suitable areas for wind power development (Table 4.2). The intent of the third model is to determine how much suitable land area exists on private and public unprotected property that is adequately distanced from the other land use exclusions.

Table 4.2. The five categories of wind power siting explanatory variables and the criteria for each of the three models

Physical & Technical Variables	1st Model- Most Exclusions	2nd Model- Least Exclusions	3rd Model- Balanced Exclusions
Y1 wind resource at 70m in height	> 6.3 m/s	> 6.3 m/s	> 6.3 m/s
X1 slope gradient	< 10%	< 20%	< 20%
X2 major & town roads	w/in 160 - 1,600m	w/in 160 - 3,000m	w/in 160 - 1,600m
X3 transmission lines	w/in 160 - 3,000m	w/in 160 - 10,000m	w/in 160 - 10,000m
Environmental Resources Variables	1st Model- Most Exclusions	2nd Model- Least Exclusions	3rd Model- Balanced Exclusions
Y1 wind resource at 70m in height	> 6.3 m/s	> 6.3 m/s	> 6.3 m/s
X1 municipal wildlife sanctuaries	500m buffer	160m buffer	300m buffer
X2 state dept. fish & game preserves	500m buffer	160m buffer	300m buffer
X3 federal wildlife refuge & wilderness	500m buffer	160m buffer	300m buffer
X4 state NHESP rare species habitat	500m buffer	NOT EXCLUDED	160m buffer
X5 state areas of critical env. Concern	500m buffer	NOT EXCLUDED	160m buffer
X6 water supply district land	160m buffer	NOT EXCLUDED	30m buffer
X7 forested wetlands	160m buffer	30m buffer	30m buffer
X8 non-forested wetlands	160m buffer	30m buffer	30m buffer
X9 lakes, reservoirs, rivers	160m buffer	30m buffer	30m buffer
X10 streams	160m buffer	30m buffer	30m buffer
Land Use Variables	1st Model- Most Exclusions	2nd Model- Least Exclusions	3rd Model- Balanced Exclusions
Y1 wind resource at 70m in height	> 6.3 m/s	> 6.3 m/s	> 6.3 m/s
X1 airports	3000m buffer	3000m buffer	3000m buffer
X2 state parkland (MA DCR)	500m buffer	160m buffer	300m buffer
X3 federal parkland (NPS)	500m buffer	160m buffer	300m buffer
X4 long-distance recreational trails	800m buffer	160m buffer	300m buffer
X5 municipal parkland	500m buffer	160m buffer	300m buffer
X6 recreational	500m buffer	160m buffer	300m buffer
X7 institutional	500m buffer	160m buffer	300m buffer
X8 lower-density residential (> 1/2ac)	500m buffer	160m buffer	300m buffer
X9 higher-density residential (<1/2ac)	800m buffer	160m buffer	500m buffer
Visual and Communication Variables	1st Model- Most Exclusions	2nd Model- Least Exclusions	3rd Model- Balanced Exclusions
Y1 wind resource at 70m in height	> 6.3 m/s	> 6.3 m/s	> 6.3 m/s
X1 radio & television broadcast towers	500m buffer	500m buffer	500m buffer
X2 emergency radio towers	800m buffer	500m buffer	500m buffer
X3 cellular and communications towers	500m buffer	500m buffer	500m buffer
X4 scenic landscapes (design. by TTOR)	excluded	NOT EXCLUDED	NOT EXCLUDED

Conservation Rights Variables	1st Model- Most Exclusions	2nd Model- Least Exclusions	3rd Model- Balanced Exclusions
Y1 wind resource at 70m in height	> 6.3 m/s	> 6.3 m/s	> 6.3 m/s
X1 private land w- conservation restrictn	500m buffer	160m buffer	300m buffer
X2 private land w- agric. presvtn. restrictn	300m buffer	NOT EXCLUDED	160m buffer
X3 state forests (MA DCR)	160m buffer	NOT EXCLUDED	NOT EXCLUDED
X4 municipal forests w- consv. restrictn	500m buffer	160m buffer	300m buffer
X5 municipal forests w/out consv. restrictn	160m buffer	NOT EXCLUDED	NOT EXCLUDED
X6 land trust property w- conservtn. restrn	500m buffer	160m buffer	300m buffer
X7 land trust property w- agric presv. restrn	300m buffer	NOT EXCLUDED	160m buffer
X8 land trust property w/out dev. restrn	300m buffer	NOT EXCLUDED	160m buffer
X9 non-profit property w- conservtn. restrn	500m buffer	160m buffer	300m buffer
X10 non-profit property w- agric presv. restrn	300m buffer	NOT EXCLUDED	160m buffer
X11 non-profit property w/out dev. restrn	300m buffer	NOT EXCLUDED	160m buffer

Three steps were required to determine how the thirty-seven siting variables impact the potential for wind power generation in Western Massachusetts. The first step was to establish sub-models for each of the five categories, in order to determine the influence of each category on how much suitable area remained available for each of the three models (Table 4.2). For example, to determine how many suitable hectares remained within the wind resource land area once the physical and technical variables were excluded. This involved running raster-based Boolean AND operations, where the dependent variable Y1, Wind Resource at 70 meters in height > 6.3meters/sec. and X1 slope gradient < 10% and X2 major and town roads is within 160-1,600 meters and X3 transmission lines is within 160-3,000 meters. This operation provided a resulting suitability area of 12,179 hectares for Model 1 (Table 4.2).

The second step involved combining the resulting suitable land areas from all five of the categories to determine how many hectares within the wind resource land area are suitable (Tables 4.3-4.5). This involved a second round of Boolean AND operations, where for each of the three models the suitable areas for 1. physical resources and 2. environmental resources and 3. land use and 4. visual and communication resources and 5. conservation rights all overlap. Again for Model 1, this resulted in a total suitability land area of 364 hectares.

The third and final step involved running a GIS neighborhood statistics analysis to further define the suitable land area for tower sites in order to establish an equivalent

generation capacity for each of the three models (Table 4.6). This step removes the suitable land areas that are less than 6,400 contiguous circular meters, the area necessary for operating an 80-meter hub height, 2 megawatt turbine with a rotor blade diameter of 80 meters (Danish Wind Industry Association, 2010). For model 1 the resulting suitable land area for tower sites is 92 hectares (Table 4.3).

Findings

The Most Exclusionary Model

For model 1, the most exclusionary model, physical resources had the greatest impact, with only 12.8% of the wind resource land area—12,179 hectares—suitable for wind power development. Environmental resources and land use variables also significantly diminished suitable areas, with 32% (29,991 hectares) and 34% (32,280 hectares) of the wind resource land area suitable, respectively. The conservation rights variables left 51% of the wind resource land area as suitable, while visual and communication resources left 90% of the area suitable (Table 4.3).

Table 4.3. Suitable land area for wind power development accounting for the most exclusionary criteria

1. MOST EXCLUSIONARY SUITABILITY MODEL	PHYSICAL RESOURCES	ENVIRONMENTAL RESOURCES	LAND USE	VISUAL & COMMUN. RESOURCES	CONSERVATION RIGHTS	TOTAL SUITABLE LAND AREA
SUITABLE AREA IN HECTARES	12,179	29,991	32,280	85,416	48,620	364
% AREA Within WIND RESOURCE LAND AREA	12.8%	31.5%	33.9%	89.6%	51.0%	0.4%
% OF WESTERN MASS LAND AREA	3.1%	7.7%	8.3%	22.0%	12.5%	0.1%

When all five variable categories are combined to form model 1, only 364 hectares are found to be suitable for wind power development, equaling 0.4% of the wind resource land area and 0.1% of the total Western Massachusetts study area (Table 4.3). This is attributable to a weak overlap between each of the categories. If all five

categories' suitable areas overlapped 100%, then the total suitable area for model 1 would be 12.8%, the percentage of the category with the least suitable area (physical resources). Instead, most of the land areas found suitable in one category are deemed unsuitable in another category, and therefore negligible overlap exists.

After removing those land areas of less than 6,400 contiguous, circular meters, the land area suitable for tower placement is further limited. The resultant suitable area for towers for model 1 is 92 hectares, equivalent to 23 two-megawatt tower sites and an annual output of 74 – 112 GWh (Table 4.6). This represents 0.13% – 0.2% of Massachusetts's current end-use electricity consumption and 0.9 % - 1.3% of the state's 2020 RPS mandate, if consumption remains at the 2008 level. Model 1 shows the greatest potential for wind power placement in the southern towns of Otis, Blandford, and Tolland, which calls into question the site selections for the Hoosac Wind (towns of Florida and Monroe), Berkshire Wind (Hancock), and Minuteman Wind (Savoy) proposals, all of which are located in the northern part of the study area. These wind farms are identified on the following map with red outlines (Figure 4.4).

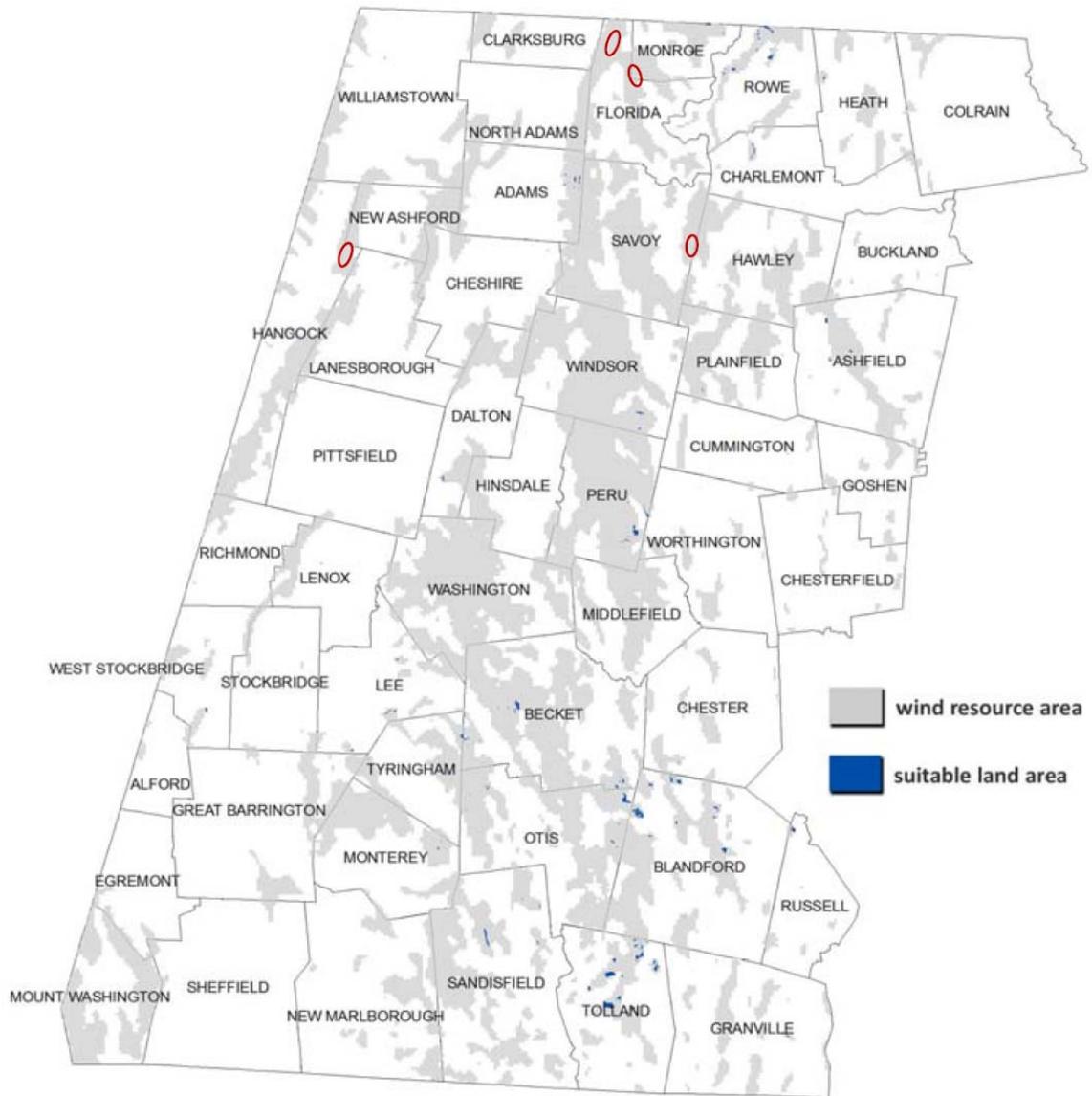


Fig 4.4. Map of Model 1: the Most Exclusionary Model for siting wind power turbines in Western Massachusetts (wind farm proposal locations are circled in red)

The Least Exclusionary Model

For the second model, the least exclusionary model, the physical resource category remains the most limiting, with 51% (48,580 hectares) of the wind resource land area suitable for wind power development. The environmental resources and land use categories limit the suitable land area to 79.6% and 71.1%, respectively, while both the visual and communication and the conservation rights categories have negligible impacts, with suitable areas of 97% and 94%, respectively (Table 4.4).

Table 4.4 Suitable land area for wind power development when accounting for minimum exclusions

2. LEAST EXCLUSIONARY SUITABILITY MODEL	PHYSICAL RESOURCES	ENVIRONMENTAL RESOURCES	LAND USE	VISUAL & COMMUN. RESOURCES	CONSERVATION RIGHTS	TOTAL SUITABLE LAND AREA
SUITABLE AREA IN HECTARES	48,580	75,912	67,781	92,816	89,361	28,570
% AREA Within WIND RESOURCE LAND AREA	51.0%	79.6%	71.1%	97.4%	93.8%	30.0%
% OF WESTERN MASS LAND AREA	12.5%	19.5%	17.4%	23.9%	23.0%	7.3%

Combining the five variable categories to form model 2 results in 28,570 hectares suitable for wind power development, equaling 30% of the wind resource land area and 7.3% of the total Western Massachusetts study area (Table 4.4). Model 2 possesses the strongest overlap between the suitable areas for each of the categories, with the difference between the most restrictive category, physical resources (51% suitability), and the model’s total suitable land area (30%) at 1.7x, compared to 3x (from 50.2% to 16.6%) for model 3 and 32x (from 12.8% to 0.4%) for model 1.

The land area suitable for tower placement is further reduced—from 28,570 to 15,970 hectares—once those land areas of less than 6,400 contiguous, circular meters are removed. This equates to a maximum of 3,993 two megawatt turbine sites with an annual output of 13,034 – 19,551 GWh (Table 4.6). This would supply 23% - 35% of Massachusetts’s current end-use electricity consumption and would meet the state’s incrementally increasing RPS mandate up until 2028, if consumption stabilized at the 2008 level.

Geo-spatially, model 2 shows the greatest potential for wind power placement within an east to west corridor stretching from the town of Ashfield to the town of Adams, and in a large cluster in the southern section of the study area comprised of twelve towns (Figure 4.5). This model represents all three proposed commercial-scale wind farms (Hoosac Wind, in Florida and Monroe; Berkshire Wind, in Hancock; and Minuteman Wind, in Savoy- identified on the map with red outlines) as suitable sites, based on minimal exclusionary criteria.

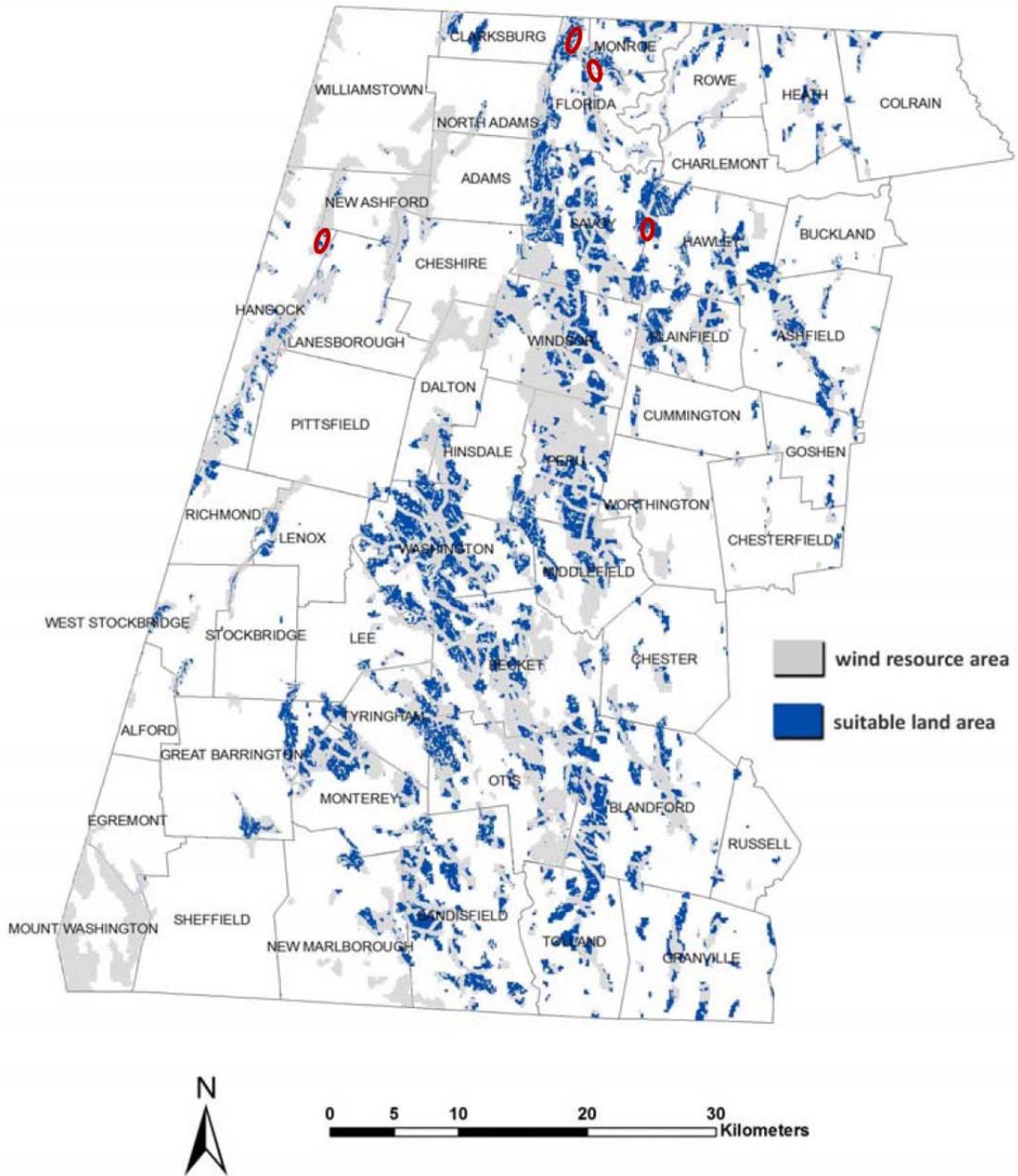


Fig 4.5. Map of Model 2: the Least Exclusionary Model for siting wind power turbines in Western Massachusetts (wind farm proposal locations are circled in red)

The Balanced Exclusionary Model

For the third and final model, the balanced exclusionary model, the physical resource and land use categories had the greatest impact, with 50% (47,824 hectares) and 54% (51,362 hectares) of the wind resource land area suitable for wind power development, respectively. Buffers for environmental resources limited suitable areas to 61% (58,158 hectares), while conservation rights variables limited suitable areas to 84.5% (80,533 hectares). Visual and communication resources had a negligible impact for this model, with 97.4% of the wind resource area remaining suitable (Table 4.5).

Table 4.5. Suitable land area for wind power development when accounting for a balanced set of exclusions

3. BALANCED EXCLUSIONS SUITABILITY MODEL	PHYSICAL RESOURCES	ENVIRONMENTAL RESOURCES	LAND USE	VISUAL & COMMUN. RESOURCES	CONSERVATION RIGHTS	TOTAL SUITABLE LAND AREA
SUITABLE AREA IN HECTARES	47,824	58,158	51,362	92,816	80,533	15,863
% AREA Within WIND RESOURCE LAND AREA	50.2%	61.0%	53.9%	97.4%	84.5%	16.6%
% OF WESTERN MASS LAND AREA	12.3%	15.0%	13.2%	23.9%	20.7%	4.1%

Combining all five variable categories to form model 3 results in 15,863 hectares suitable for wind power development, equaling 16.6% of the wind resource land area and 4.1% of the total Western Massachusetts study area (Table 4.5). More overlap exists between the suitable areas for each of the categories in Model 3 than in Model 1; however, the difference between the most restrictive category, physical resources (50.2%), and the model’s total suitable land area (16.6%) remains significant.

Once those land areas of less than 6,400 contiguous, circular meters are removed, the land area suitable for tower placement is further limited—although not as extensively as in the most exclusionary model. The resultant suitable area for towers for model 3 is 8,579 hectares, equivalent to 2,145 two-megawatt tower sites and an annual output of 6,994 – 10,490 GWh (Table 4.6). This is a substantial increase over the projected electricity generation from model 1, and equals 12% – 19% of Massachusetts’s current

end-use electricity consumption and 83% - 125% of the state's 2020 RPS mandate, if consumption remains at the 2008 level.

Geo-spatially, model 3 shows the greatest potential for wind power placement within an east to west corridor stretching from the town of Ashfield to the town of Adams, and in a large cluster in the southern section of the study area comprised of twelve towns. This model shows the proposed Minuteman Wind Farm within the area of suitability, but does not represent the Hoosac Wind or Berkshire Wind farm sites as suitable based on the balanced exclusionary criteria (Figure 4.6).

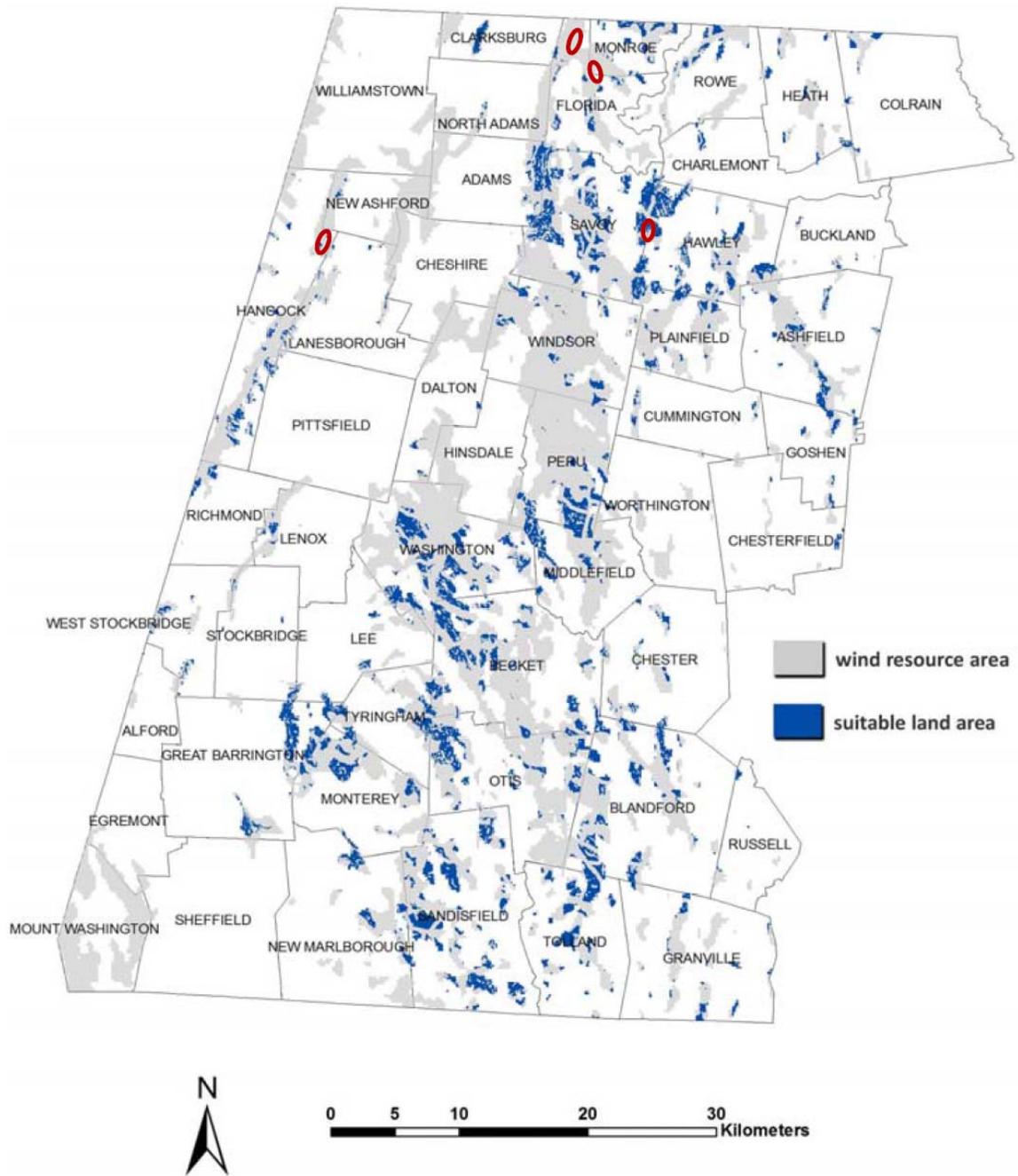


Fig 4.6. Map of Model 3: A balanced exclusionary model for siting wind power turbines in Western Massachusetts (wind farm proposal locations are circled in red)

Comparison of Suitable Land Area for Tower Sites and Electricity Generation

The gap between the resulting suitable land areas of 364 hectares (0.4% of wind resource area) from model 1, and 28,570 hectares (30% of wind resource area) from model 2 is quite substantial (Figure 4.7). The results of model 1 conspicuously illustrate that wind power development cannot occur in Western Massachusetts if the most exclusionary criteria are employed. At the same time, it is unrealistic to expect that the maximum number of towers feasible in model 2—nearly 4,000—will ever be constructed within a four-county region of only 3,887 square kilometers. Model 3, the balanced exclusionary model, moderates between these two extremes with a maximum of 2,145 sites for 2-megawatt turbines, equivalent to an electricity generation range of 7,500 – 11,300 GWh/year, which would meet 12% to 19% of the state’s electricity consumption (Table 4.6).

Table 4.6. Comparison of suitable land area for tower sites and electricity generation

EXCLUSION MODELS	TOTAL SUITABLE LAND AREA (HA)	SUITABLE LAND AREA FOR TOWERS (HA)	MAX. TOWER SITES (1 per 4 HA)	GENERATION CAPACITY (2MW/turbine)	ELEC GEN. (w/ 20-30% CAPACITY FACTOR & 7% TRANSM & DISTR. LOSS)	% OF MA ELEC. CONSUMPTN (55.9 TWh, 2008)
Model 1 Most	364	92	23	46 MW	74 - 112 GWh/yr	0.13% - 0.20%
Model 2 Least	28,570	15,970	3,993	7,985 MW	13,034 - 19,551 GWh/yr	23% - 35%
Model 3 Balanced	15,863	8,579	2,145	4,290 MW	6,994 -10,490 GWh/yr	12% - 19%

Limitations

The question remains: How many towers can pragmatically be constructed within the study area by 2020 or even by 2030? A comprehensive set of quantifiable siting variables is useful, but other contentious, currently non-quantified variables remain. These include, but are not limited to, the shadow flicker phenomena of sunlight reflection off wind turbine rotor blade, increases in ambient noise level, and the valuation of adjacent properties. Because large-scale wind turbines are a relatively new technology, and most wind farms are located within sparse rural populations, there remains a lack of

scientific, peer-reviewed findings of any human health impacts associated with wind turbines. Future public health findings should be noted to improve buffer distance standards for wind power land use assessments and ordinances. It is also important to recognize how non-empirical political and social factors also influence the siting of wind turbines, as witnessed by the protracted permitting processes for the Hoosac Wind and Berkshire Wind projects and the persistent opposition to state wind energy siting reform legislation that is described in chapter three.

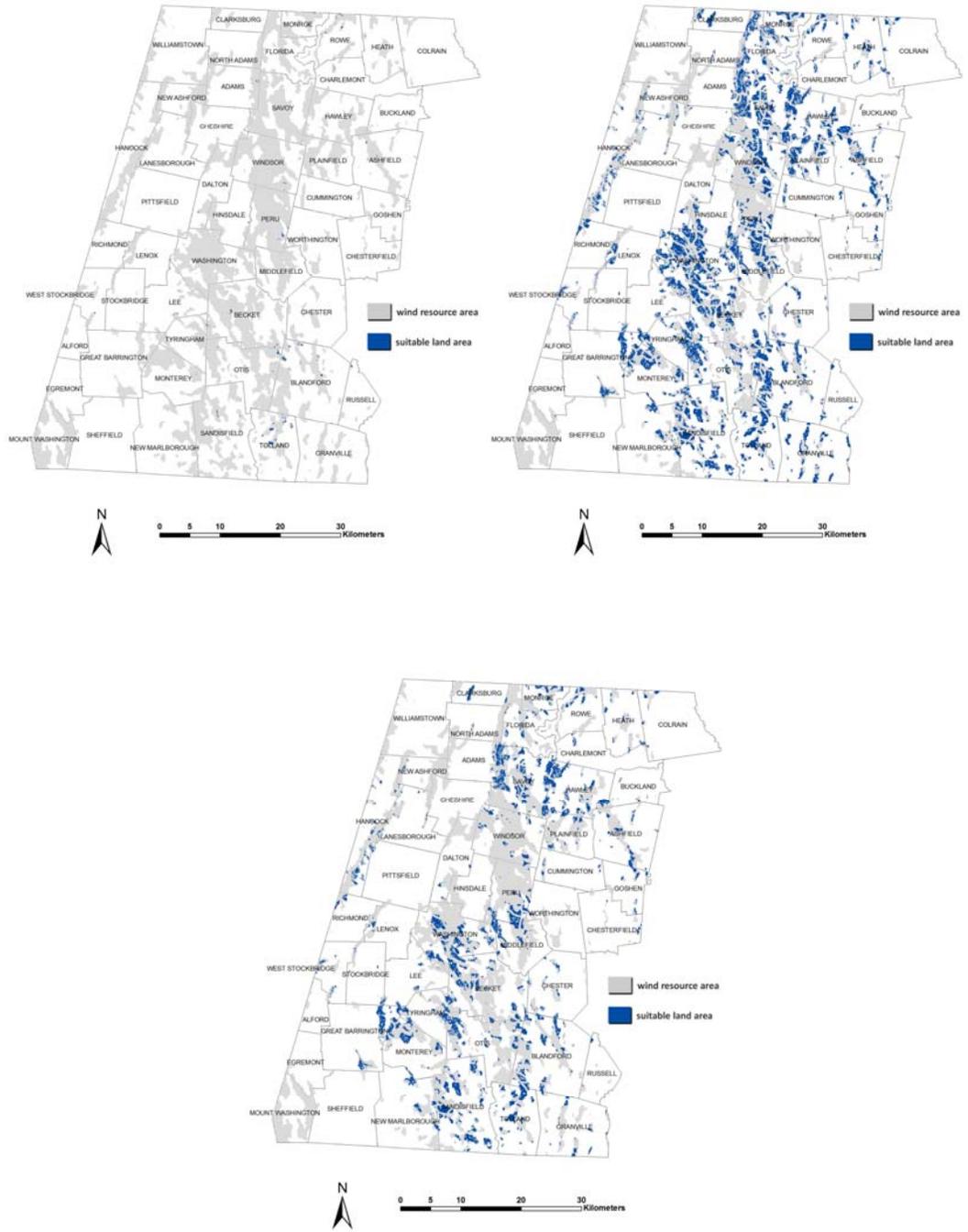


Fig 4.7. The three land use exclusionary models assessing wind power siting suitability in western Massachusetts: 1. Most Exclusionary, 2. Least Exclusionary, 3. Balanced Exclusions

Conclusion

This study contributes a GIS suitability modeling method that incorporates a comprehensive set of wind power land siting variables. Two new siting variable categories of telecommunications and land conservation are introduced and combined with the physical, environmental, and land use variables established by previous GIS assessments. While the bulk of the chapter focuses on how each of these five siting categories influenced the model outcomes, this concluding section describes the most influential *individual* variables.

Within all three models, physical resources are the most limiting of all the categories, which limit the suitable siting land area to 13%, 51%, and 50% respectively. Assigning a slope gradient of less than 10% versus 20%, combined with limiting proximity to within 3,000 meters, rather than 10,000 meters of existing transmission lines significantly influences the siting suitability outcome. Yet proximity to major roads or town roads is not a limiting factor. Few wind resource areas are within 3,000 meters of existing transmission lines, but most are within 1,600 meters of graded roads. This is a major constraining variable, since developing wind turbines beyond 3,000 meters from existing transmission lines requires an expensive and uncertain expansion of new transmission lines through utility easement acquisition (Vajjhala and Fischbeck, 2007). Environmental resources are the second most limiting set of variables for model 1 (31.5% lands remain suitable), while land use is the second most limiting for both models 2 and 3 (71.1%, and 53.9% respectively). The two most influential environmental variables are the state rare species habitat area and the state areas of critical environmental concern (where model 1 assigns a 500 meter buffer, model 2 includes these areas, and model 3 assigns a 160 meter buffer). These variables have no legal protection or designation, but rather guide municipal, land trust, and state conservation planning for future acquisition of conservation easements and land holdings.

In terms of the visual and communications category, the results show that designated scenic areas do not significantly exclude wind resource land areas from wind power siting suitability. The Trustees of Reservations' scenic viewshed variable, when combined with the communications variables, only excluded 10.4% of the wind resource areas in model 1, the most exclusionary model.

The extent of distance buffers between wind turbines and several land use variables, including state campgrounds and reserves, long-distance recreational trails, low-density residential areas, and high-density residential areas, considerably impacts the suitable areas for wind power. A shorter buffer distance from state campgrounds and reserves, long-distance recreational trails, low-density residential, and high-density residential, resulted in increased land area suitability, with model 1 = 34%, model 2 = 71%, and model 3 = 54%. An increased buffer distance for high-density residential areas (from 800 meters down to 160 meters) and low-density residential areas (from 500 meters down to 160 meters) also significantly reduced the suitable land area within the land use category.

The state forests variable is the most influential variable within the conservation rights category. State forests are lands outside of state campgrounds and designated state reserves. The intended use of state forest lands, according to the Massachusetts Department of Conservation and Recreation, is either conservation, recreation, or a combination thereof. However, commercial logging has been authorized in many state forests and the state has commissioned studies to determine the forests' biomass feedstock potential (Timmons et al., 2008). The management of state forest lands is a contentious issue with land conservation groups, many of whom hold adjacent property or conservation restrictions and seek comparable protection for state forests in order to ensure unfragmented wildlife habitat corridors, recreational access, and scenic qualities. Increased exclusion and buffer distance for lands with existing agricultural and conservation restrictions also diminishes the suitable area for wind power siting. Although many conservationists have declared wind turbines off limits within conservation-restricted areas, the state recently modified standards to enable wind turbines within lands held in an agriculture preservation restriction.

In summary, the most influential individual siting variables are steep slopes, proximity to transmission lines, state designated habitat areas, proximity to low-density residential properties, and state forest land. The inclusion/exclusion and the subsequent extent of buffer distances for these variables are informed by two divergent scenarios. The first scenario established a more exclusionary model, whose results provide virtually no opportunity for wind power siting in Western Massachusetts (0.4% of wind resource

area, 46 MW of generation capacity, meeting just 0.2% of the state's electricity consumption). Whereas the second scenario established a model with the minimum standards of exclusions, resulting in a significant amount of suitable sites (30% of wind resource area, 8,000 MW of generation capacity, meeting upwards of 35% of the state's electricity consumption). A balanced model moderates between these two extreme scenarios, resulting in an amount of suitable sites to provide 4,300 MW of generation capacity, and meet up to 19% of the state's electricity consumption. This model illustrates that an adequate amount of physically and technically viable sites currently exist- even when assigning distance buffers longer than those in state siting guidelines- in areas that do not impede upon legally defined and protected environmental resources, residential areas, or telecommunications infrastructure. It remains possible that the Western Massachusetts region can considerably contribute to satisfying the state's (and adjacent states') renewable portfolio standard mandate for the near future.

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CHAPTER V

Private and Public Ownership Composition and the Suitability of Wind Power Placement in Western Massachusetts

The land use criteria for wind power siting, established by the U.S. Department of Energy, provides preliminary guidance for individual states to assess their wind power siting potential (Elliott et al., 1991). It removes residential areas from consideration while considering all non-residential private land and half of public lands as suitable (Figure 5.1). However states such as Massachusetts, with substantial land trust holdings and conservation easement programs, require a more comprehensive breakdown of public and private land ownership and management.

RESIDENTIAL	18,535	19%	OFF-LIMITS
NON-RESIDENTIAL PRIVATE LAND	26,170	27%	SUITABLE
PUBLIC LAND	50,749	54%	50 / 50
TOTAL	95,310	100%	

Figure 5.1: Calculation of private (black) and public (grey) land within the prime wind resource area of Western Massachusetts based on the U.S. Dept. of Energy's wind power siting assessment guidelines. (Elliott, et al., 1991).

Private – Residential (19%)

For Western Massachusetts, high density residential (parcels less than 0.2 ha) with a 500 meter buffer currently overlap with 3% of the prime wind resource area (PWRA), while low density residential (parcels greater than 0.2 ha) with a 300 meter buffer occupy 16%. The 19% of residential areas can firmly be determined to be off-limits to wind power development (Figure 5.2).

Private – Non-Residential – Non-Restricted (14%)

Only 14% (13,343 ha) of the class 4+ wind resources area is within a private non-residential, non-restricted land category. This is the only land category that can definitively be considered suitable for wind power development (Figure 5.2). Not surprisingly, all three of the current commercial wind farm projects proposed within Western Massachusetts are located within this category (Figure 5.3). The remaining 67% of quasi-private and public lands underneath class 4+ wind resources possess questionable suitability status.

Quasi-Private – Non-Residential – with Agricultural Easement (2%)

Private lands with state-held agricultural preservation restrictions were recently permitted to develop wind power, based on a December 2009 determination of approval by the Massachusetts Executive Office of Energy and Environmental Affairs. This office oversees the state departments of Energy Resources (MA DOER), environmental protection (MA DEP), and agricultural resources (MDAR). Private land with agricultural restrictions, including a 160 meter buffer, fall within 2% (1,459 ha) of the PWRA (Figure 5.2). Since the state maintains a secondary ownership right on these lands, the suitability for wind power placement is subject to administrative and legislative review.

	hectares (2009)	% of Wind Resource Area (2009)		Ownership / Management	Suitability
 HIGH DENSITY (< 1/5 ha)	2,863	3%	19%	PRIVATE	OFF-LIMITS
 LOW DENSITY (> 1/5 ha)	15,672	16%			
 NON-RESIDENTIAL, NON-RESTRICTED LAND	13,343	14%	14%		SUITABLE
 PRIVATE LAND w- AGRIC. RESTRICTION	1,459	2%	6%	QUASI- PRIVATE	SUITABLE ('09)
 PRIVATE LAND w- CONSERVATN RESTRICTN	4,538	5%			?
 LAND TRUST & NON-PROFIT w- AGRIC RESTRICTION	-	0%	7%	QUASI- PUBLIC	?
 LAND TRUST & NON-PROFIT w- CONSERVATN RESTRICTN	848	1%			
 LAND TRUST & NON-PROFIT w- NO RESTRICTION	5,982	6%			
 FEDERAL PARK & PRESERVE	1,515	2%	17%		OFF-LIMITS
 STATE PARK & PRESERVE	13,911	15%			
 MUNICIPAL PARK & PRESERVE	444	0.47%			
 FEDERAL FOREST (USFS / BLM)	-	0%	37%	PUBLIC	?
 STATE FOREST	28,427	30%			
 MUNICIPAL FOREST & WATER DISTRICTS	6,452	7%			
	95,310	100%	TOTAL WIND RESOURCE LAND AREA		

*Layers include 160m buffer (except high density residential w- 500m and water districts w- 30m)

Figure 5.2. Current Land Use and Ownership Composition Within the Prime Wind Resource Area

Quasi-Private – Non-Residential – with Conservation Easement (5%)

Private lands with conservation easement holdings fall within a category of quasi-private land ownership and management. Private lands with state and non-profit held conservation restrictions cannot install wind turbines unless the restriction expressly grants this use, or the restriction is amended to enable this use. An amendment would require the title holder to re-compensate the restriction holder for the difference in property value as well as any difference in prior tax deductions associated with donation proceeds. Several land trust directors in New England are skeptical regarding the feasibility of amending existing conservation restrictions. Therefore, the 5% (4,538 ha) of lands with conservation restrictions within the prime wind resource area are unavailable (Figure 5.2).

Quasi-Public – Non-Residential - Land Trust and Institutional Holdings (7%)

Land trust and non-profit institution holdings fall within a category of quasi-public land ownership and management. 1% of PWRAs consist on land trust property where the state holds the conservation restriction. 6% of lands within PWRAs are owned by land trusts and non-profit institutions with no secondary restrictions. This 7% (6,830 ha) of the PWRA has an unknown suitability status, since the ability to develop wind power remains the discretion of each individual land trust title holder (Figure 5.2). For the 1% of land trust property with state-owned conservation restrictions, it is assumed the state will maintain a favorable position in allowing wind development- as long as the conservation values protected by the restriction are not adversely impacted.

Public Land

Public land represents the largest category of land ownership and management within Western Massachusetts. Federal, state, and municipal land contain various uses, activities, and ranges of conservation values, and therefore maintain separate management decision making structures. For example in this study, public parks and preserves are separated from public forest land and water districts.

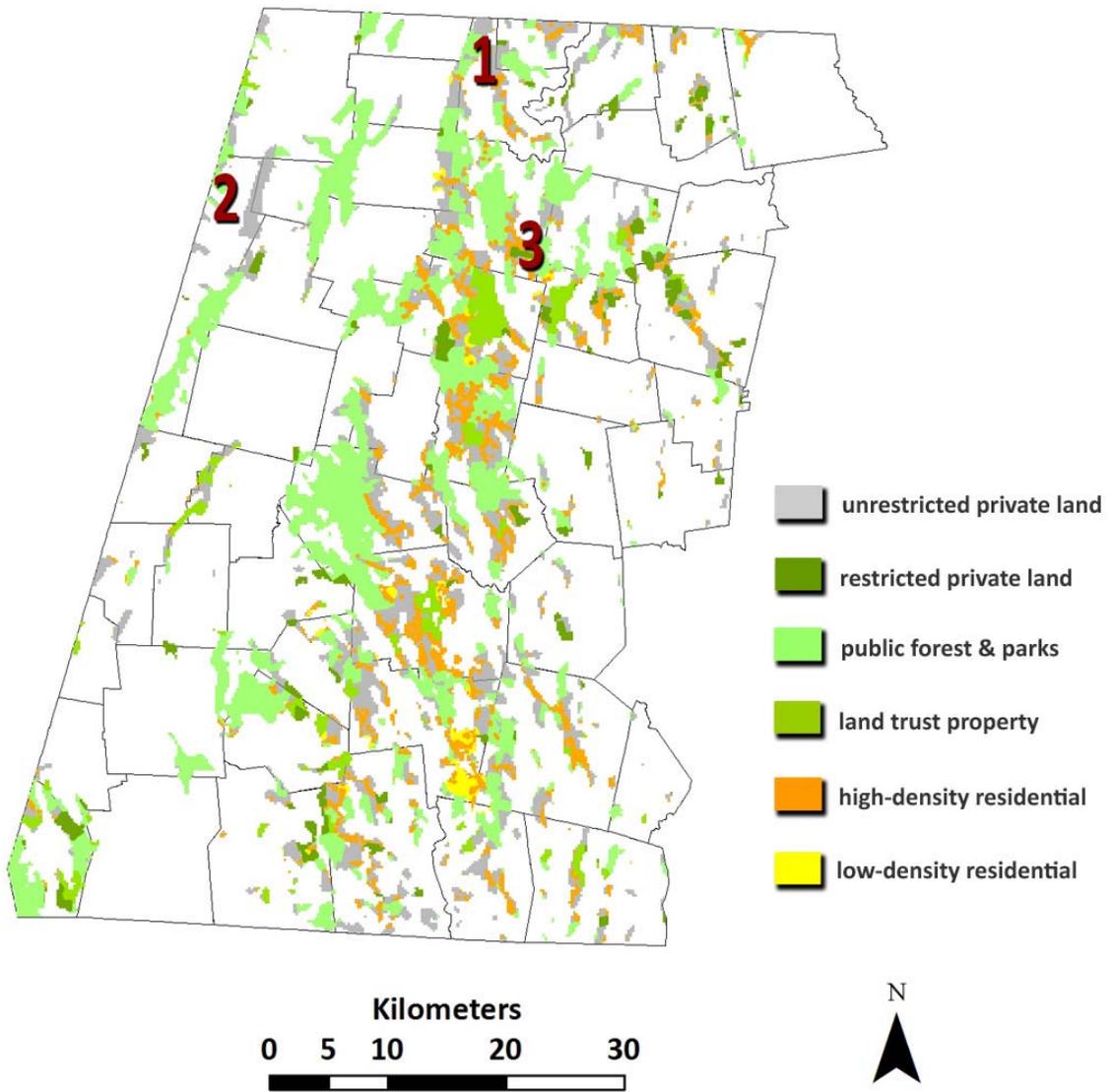
Public - Parks and Preserves (17%)

There is a minimal federal management presence in Western Massachusetts, with national wildlife refuges and national park service Appalachian Trail buffers overlapping with 2% (1,515 ha) of the PWRA. National forests and Bureau of Land Management lands are absent within the study area. The State of Massachusetts is the major land owner and manager. State parks and preserves overlap with 15% (13,911 ha) of the prime wind resources area, and there is a limited amount of municipal parks and preserves, 0.47% (444 ha) within prime resources areas. Combined, the 17% of federal, state, and municipal parks and preserves should be determined unavailable (Figure 5.2).

Public – Forests and Water Districts (37%)

The final land use and management category of public forest land remains the most contentious. Several land trusts, local conservation groups, and citizen activists

oppose the State of Massachusetts plans to allow renewable energy development, including wind power, on public forests (Navigant, 2009). This is a significant impediment to wind power development since state forests comprise 30% (28,427 ha) of the PWRA, and municipal forests and water districts comprise 7% (6,452 ha). Because of political backlash the wind power development suitability for this sizeable area of public land, representing 37% of the PWRA, remains uncertain (Figure 5.2).



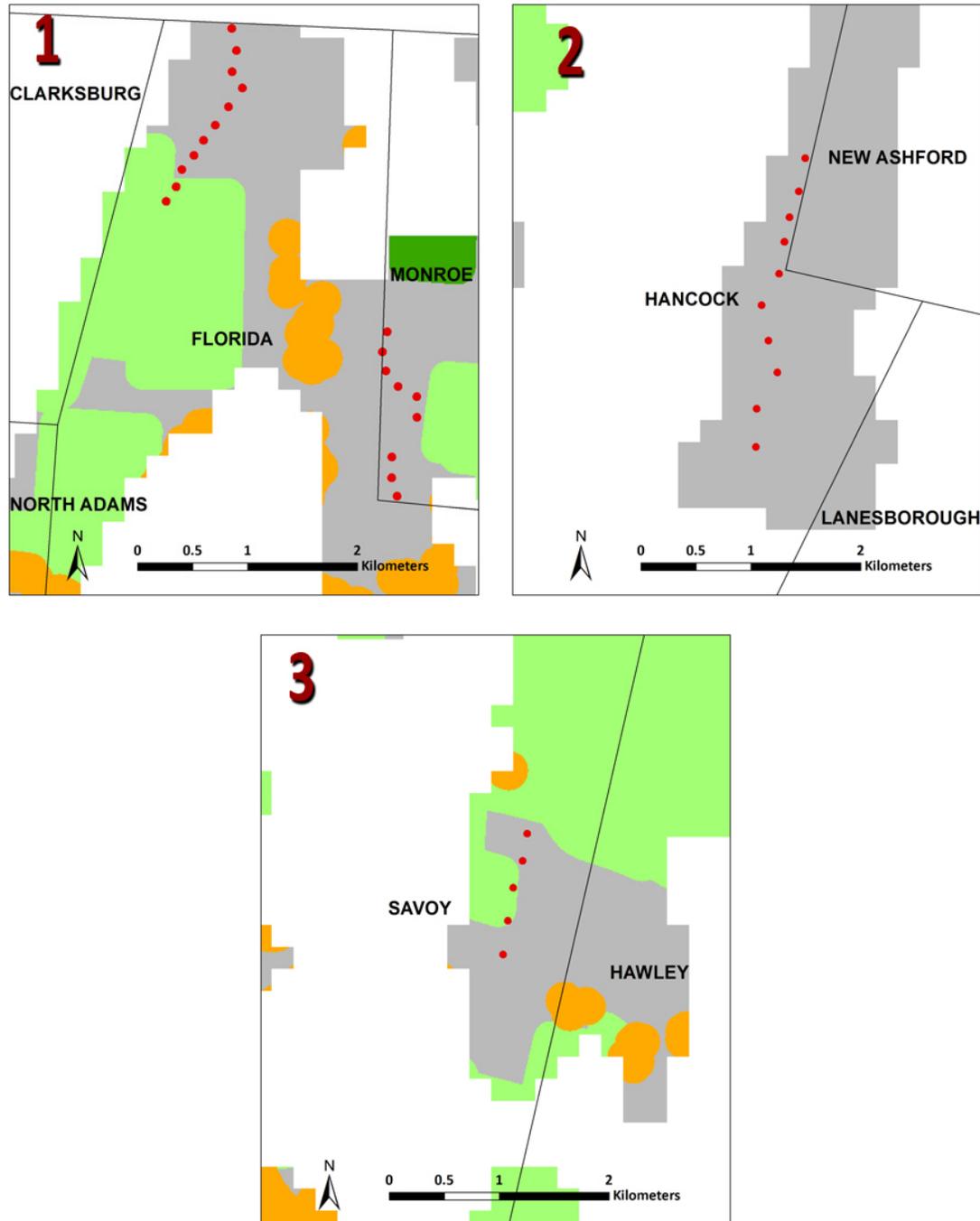


Figure 5.3: Location of Hoosac (30MW), Berkshire (15MW), and Minuteman (8MW) Wind Farm Projects

Determining the current composition of land use and ownership within prime wind resource areas is instructive for recognizing where conflicting or complimenting interests may lie (Weimar et al, 2010). The three site maps for the Hoosac, Berkshire, and Minuteman wind farm proposals illustrate how wind power development is currently constrained within the marginal 14% of prime wind resources area categorized as non-restricted/non-residential private land (Figure 5.3). However the use and ownership of even this land category may shift over time. Therefore, it is essential to analyze historic trends to determine the actual extent of land use and land ownership change over time. To what degree has land use and ownership been converted during the last twenty-five years, and how might this effect both the current and future potential for wind power development?

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CHAPTER VI

The Impact of Land Use Conversion and Land Conservation on Wind Power Development in Western Massachusetts (1985-2009)

Introduction

Land use planners recognize and spatially analyze how incremental land use conversion has impacted rural areas. Low-density rural residential development, known as exurban sprawl and the wildland-urban interface, continues to reduce the natural resource base and rural economies within the United States (Brown, Johnson, et al., 2005; Daniels, 1998; Davis, Nelson, et al., 1994; Nelson, 1990; White et al., 2009). By the turn of the 21st century, the area of exurban development consumed almost 15 times the land of higher density urbanized areas, with implications for future farmland, forest cover, and wildlife habitat (Brown et al, 2005). A significant, but currently under-studied, aspect of wind power development is how this conversion of rural property from working lands to exurban development will diminish the amount of prime wind resource areas available for renewable electricity generation.

In response to exurban sprawl, a subtle and seemingly uncontroversial shift occurred in rural land use and ownership during the past quarter century. States, municipalities, and land trusts began a widespread reliance on conservation easements to protect, in perpetuity, one or more *conservation purposes* for the long-term benefit of the general public. These legally designated conservation purposes include scenic open space, wildlife habitat, outdoor recreation, and/or historical sites (McLaughlin, 2010). An example of this shift can be seen in western Massachusetts, where only 435 acres (176 hectares) were held in conservation easements in 1985, but by 2009 over 13,881 acres (5,620 hectares) were permanently protected. The proliferation of land conservation activity countered the spread of exurban residential development occurring during this

period (Daniels, 1998; Daniels and Lapping, 2005; White et al., 2009). Land use scholars have observed a major, unintended consequence of this now ubiquitous method of permanent land conservation (Aaronsen and Manual, 2008; Davies, 2010; Korngold, 2007; McLaughlin, 2005; Thompson, 2004). Conservation easements also have the potential to substantially limit now, and in the future, the ability of rural lands to provide other, equally significant public benefits and conservation purposes, such as accessing wind power resources for low carbon, renewable energy generation.

This chapter addresses this major environmental dilemma by determining the degree to which land conservation and land use conversion have, in combination, reduced access to prime wind power resources. The following section first describes the importance of recognizing how rural exurban sprawl and the wildland-urban interface may limit wind resource access. Secondly, the conservation versus preservation approaches to public land management is provided within the context of wind power development, followed by a focus on private land management and the use of conservation easements. The next section describes the comparison of land use and land ownership change from 1985 and 2009 of a four-county area of Western Massachusetts, which illustrates that exurban residential development is not the only land use factor impeding wind power development. Lastly, the study's findings demonstrate how a continual increase in both exurban residential development *and* conserved private land has significant implications for future wind power development and for meeting the state's annual renewable portfolio standard mandates.

Rural Land Development, Land Conservation, and Access to Wind Resources

Land Use Provides Significant Variables for Wind Power Siting

Land use scholars recognize the potency of incremental land use conversion in diminishing rural economies and rural character. Studies have emphasized how low-density, exurban residential growth reduces the natural resource base, such as agriculture and forestry production (Brown, Johnson, et al., 2005; Daniels, 1998; Davis, Nelson, et al., 1994; Nelson, 1990; White et al., 2009). From 1982 to 2003 over 14 million hectares

(34.6 million acres) of countryside was converted into developed land in the U.S. from 1982 to 2003 and 22 million more hectares (54.4 acres) are projected to be developed into residential and commercial use by 2030 (White et al., 2009). By the turn of the 21st century, the area of exurban development consumed almost 15 times the land of higher density urbanized areas, with implications for future farmland availability (Brown et al, 2005). Exurban sprawl has also been shown to limit access to prime mining and quarry resources for basic construction and building materials (Kendall et al, 2008). Ironically by paving over vast stretches of land, almost 50 percent of limestone, the main ingredient for concrete, is now inaccessible in many U.S. regions.

The effects of rural land development also extend beyond quantifiable physical or legal manifestations. Sociologists recognize how the transformation from farmland and forestry into large-lot residencies and vacation home subdivisions, and the resulting demographic shift, leads to ever more isolated and smaller agrarian communities (Miller and Luloff, 1981; Salamon, 2003; Smith and Krannich, 2000). Regional planners have analyzed public acceptance and perception of various forms of rural land development to determine whether these forms diminish rural character, with an implicit assumption that a traditional agrarian economy exemplifies rural livelihood (Harrill, 2004; Ryan, 2002; Ryan, 2006).

A more recent rural phenomenon is the relationship between land use and energy production. A surging demand for renewable energy feedstock now places greater stress on rural landscapes, as ethanol from corn, biodiesel from soybeans, and electricity from woody biomass and wind currents bolster the treatment of land as commodity. The Nature Conservancy estimates a minimum of 27 million hectares will be needed to satisfy increasing energy supply demands from renewable sources during the next 20 years (McDonald, 2009). Energy now joins forestry, farming, recreation, and conservation as another competing, or potentially complimentary, rural land use (Outka, 2011). While many environmental scholars are concerned with energy sprawl or a renewable energy footprint, this paper is concerned with the converse trend (McDonald, 2009; Outka, 2011; Searchinger et al., 2008). This paper argues that a continual increase in legally conserved private lands, in addition to exurban residential sprawl, will limit the ability to realize

renewable energy development in the very areas that possess prime resources.

The Encroaching Wildland-Urban Interface

Several foresters warn of the impact of the rapidly increasing wildland-urban interface occurring throughout the United States (Foster et al., 2005; Radeloff et al., 2005; Smail and Lewis, 2009; Stein et al., 2009). The wildland-urban interface (WUI) is another specific form of exurbanization, defined as the land area where residential property adjoins undeveloped vegetated land (Radeloff et al., 2005). The WUI currently covers 9% (720,000 square kilometers) of the total land area in the United States and more than 23 million additional hectares of rural forests are forecasted to be converted into exurban housing from 2000 to 2030 (Radeloff et al., 2005; Stein et al., 2009). The wildland-urban interface is particularly pronounced along the East Coast, covering over 60% of the total land area in Connecticut, Rhode Island, and Massachusetts. Planners and emergency response managers are also increasingly concerned with the spread of the WUI since this interface is where human-ecological conflicts occur, including wildfire destruction of houses, fragmentation of wildlife habitat, accelerated introduction of invasive species, and overall biodiversity decline (Baldwin et al., 2009; Daniels and Lapping, 2005; Foster et al., 2005; Radeloff et al., 2005; Smail and Lewis, 2009).

The wildland-urban interface also impacts traditional rural economic activity such as farming, logging, materials extraction, as well as the relatively recent federal and state-level directives for harnessing renewable resources. In the case of wind power, an adequate buffer distance is required between an operating turbine and occupied buildings, a conservation resource (i.e. wetlands, wildlife refuge), or other adjoining land uses. These buffers often extend across property boundaries. As land conversion continues within prime wind resource areas, there will be pressure to increase the buffer distance from turbines, which will further limit the suitable land area for sites.

The Conservation Versus Preservation Debate of Public Lands

There is no consensus from the Northeast land trusts and conservation organizations regarding the development of, let alone the planning for, wind power

(Allison et al, 2006; BNRC, 2005; Foster 2009; TTOR, 2009). This is despite an awareness that energy extraction and transmission is rapidly becoming a paramount issue for land use planning and management (Foster, 2009; McDonald, 2009; Outka, 2011). In order to provide a context for how the current state of land conservation is impacting wind power, the following section will briefly describe the land preservation versus conservation debate.

The presumption of many environmentalists is that the restriction of development through the preservation of rural landscapes inherently benefits society (Binkley, 1998). Reflecting many citizen environmental advocates' increasing disconnection with rural economies and ecological systems, public lands management has become more of an idealized, social construction rather than valid science (Binkley, 1998). Hays's (2007) citizen-based forest reformers passionately protect their familiar remaining local forests, but do not focus beyond the next mountain range when advocating for what they perceive to be the proper use of public lands, which is to leave them alone. This localized preservationist ethic is responding to an unfortunate track record of natural resource mismanagement at the state and federal levels (Bosselman, 1994; Huffman, 2000). This in turn, may explain why many self-proclaimed environmentalists react negatively to wind power development on state and federal lands.

George Perkins Marsh and John Muir's influential transcendentalist preservation ethic prioritized a non-anthropocentric aesthetic and spiritual view, versus a consumptive and extractive material use of rural land (Callicott, 1990; Hays, 1959; Karp, 1989). In contrast, Gifford Pinchot advocated for an egalitarian conservation ethic, a wise use of forests (Binkley, 1998; Callicott, 1990; Karp, 1989). Pinchot's creed of natural resource use "the greatest good to the greatest number for the longest time," readily identifies with today's call for a sustainable extraction of resources (Pinchot, 1910). He framed his management approach as economically efficient, democratic, and receptive to technological advances. Despite considerable opposition in the Western states to many of his management proposals, Pinchot remained sanguine that public opposition can be overcome, that public conflicts over resource extraction are surmountable (Meyer, 1997).

The disagreement between Muir and Pinchot over the Hetch Hetchy Reservoir Dam is widely used to illustrate the preservation versus conservation debate to the use of

public lands (Binkley, 1998; Hays, 1959). However, environmental historians observe that Muir's attitude toward the natural world does not readily contradict Pinchot's utilitarian mindset (Binkley, 1998; Meyer, 1997). Muir states "timber is as necessary as bread, and no scheme of management failing to recognize and properly provide for this want can possibly be maintained" (Meyer, 1997). Would Muir then also concede that, in this era, electricity is just as necessary to society?

Aldo Leopold also emphasized a non-anthropocentric ecological land ethic similar to Muir, but he also recognized, along with Pinchot, the need for active resource management (Callicott, 1990). Deep ecologists challenge Leopold's notion that a land ethic must follow an incremental, evolutionary process- since pressing global ecological crises disallow a slow debate on our relationship to the land (Karp, 1989, Mahoney, 2002).

Many environmental historians claim that the traditionally-cited preservationists (Thoreau, Emerson, Muir, and Leopold) consented to natural resource extraction, as long as resources were being extracted *pragmatically, wisely*, or in the modern vernacular, *sustainably* (Foster, 2009; Hays, 2007; Meyer, 1997). The question is to what degree is natural resource extraction socially and environmentally harmful? We have come to recognize that patch-cut forestry and organic farming is more sustainable versus clear-cutting and chemically-reliant monoculture farming methods. We should also now recognize an inconsistency with primary energy extraction. Harnessing wind power is a more sustainable source of electricity versus mountain top mining removal and hydraulic fracturing. Through the aggregate development of wind farms society preserves larger-scale ecosystems through abating climate change by providing electricity free from greenhouse gas emissions.

Private Land Conservation and Wind Power Siting

The contentious debate over the management of public lands will continue, especially over how to balance renewable energy resource extraction with other conservation values. A considerable portion of wind resources, however, flow over private lands as well. During the past twenty-five years the main land conservation strategy shifted from public land acquisition to quasi-private land trusts acquiring and

managing conservation easements, and to a lesser degree, the outright, fee-simple ownership of property. Several land use scholars are noticing and critiquing this shifting strategy, as the amount of private rural land under conservation easements continues to increase (Aaronson and Manuel, 2008; Cheever, 1995; Hays, 2007; McLaughlin, 2005; Thompson, 2004).

A conservation easement is a deed restriction that follows the title of the property, and all residential, commercial, industrial, or other uses are prohibited unless expressly stated within the deed (Daniels and Lapping, 2005; Schmidt, 2008). The federal tax code, under section 170(h), currently recognizes four conservation purposes for establishing a conservation easement and for the current landowner to receive federal funding and/or a charitable tax deduction. The land must be preserved for recreation, significant wildlife habitat, scenic open space, or areas and structures of historic importance (Aaronson and Manuel, 2008; McLaughlin, 2010).

Conservation easements are typically held by either state governments, or more typically, by private, non-profit land trusts. Land trusts, also known alternatively as conservation organizations, grew exponentially in the 1980s and 1990s as a response to the limited federal funding and management of natural and ecological areas (Brewer, 2003; Cheever, 1995; Myers, 1993). They were successful in navigating what was at the time a politically unbiased, non-controversial, free-market approach to land conservation—the voluntary placement of limited restrictions on private property in return for financial compensation (Cheever, 1995; Mahoney, 2002). The land in the U.S. protected by conservation easements held by land trusts increased from 182,200 hectares (450,000 acres) in 1990 to over a million hectares (2.6 million acres) in 2000 (Mahoney, 2002). The overarching concept is that the private landowner benefits through a one-time compensation while the general public benefits presently and in the future with more scenic open space, recreational opportunities, wildlife habitat, and historically preserved landmarks.

Land trusts are considered by many scholars as invaluable for achieving smart growth objectives that the land use and regional planning process are unable to because of the more contentious nature of down zoning, and aversion to local regulation as well as regional governance (Daniels and Lapping, 2005; Hamill and Sturm, 2003; Korngold,

2007; Schmidt and Paulsen, 2009). In many communities land trusts are often the only institutions capable of protecting threatened landscapes and natural resources considered vitally important by the public.

A main criticism, however, has been the inability of conservation organizations to quantify how specific protected parcels hold significant conservation values for the greater benefit of the public (Aaronson and Manuel, 2008; McLaughlin, 2005; Steward and Duane, 2009; Thompson, 2004). According to many land use scholars, the genuine intent of a conservation easement remains questionable for hundreds of properties (Aaronson and Manuel, 2008; Cheever, 1995; Korngold, 2007; McLaughlin, 2010). One of the most frequently used conservation purposes, the scenic open space provision, remains ambiguous and difficult to measure (Aaronson and Manuel, 2008). Most of a land trust's financial resources are applied towards easement acquisition while the requisite stewardship of existing held properties and easements is often short-changed. Another criticism is that conservation easements are not able to accommodate emerging and unforeseen social needs and technologies. The restrictions remain static while society, and the land itself, dynamically changes over time (Korngold, 2007; Mahoney, 2002; McLaughlin, 2005; Thompson, 2004). Mahoney (2002, p. 786) stresses that "unless the original parties to the easement are able to predict with astonishing accuracy the needs and preferences of the next and subsequent generations, substantial amendments and extinguishment of conservation easements will be necessary... The extensive use of conservation easements as an anti-development tactic may create ecological, legal, and institutional problems for later generations."

Land use planners are equally concerned that land conservation could remain an ad hoc movement that does not integrate with the comprehensive planning process (Daniels and Lapping, 2005; Schmidt 2008; Schmidt and Paulsen, 2009). According to Korngold (2007), "there is a risk to effective policy making and democratic principles when local public land use decisions are delegated to non-representative, non-accountable private organizations." Therefore, an ongoing reliance on conservation easements may undermine the viability of the regulatory and zoning approach, making environmental protection increasingly, and unnecessarily, too expensive to maintain (Echeverria, 2005).

At the same time, municipal planners and attorneys have not strongly collaborated with conservation organizations in using conservation easements as an effective planning tool (Brewer, 2003; Daniels and Lapping, 2005; Echeverria, 2005; Schmidt, 2008). This could arise from the differences in land trust and land use planning frameworks. Land trust projects tend to react narrowly to immediate threats of locally undesirable development, whereas planning is more proactive as it incrementally guides real estate development in long-term phases over a more expansive geographical area. Despite the shortcomings of conservation easements, their use has protected an impressive amount of threatened farmland, forests, and historical sites during the past forty years. The overall consensus is not to refrain from employing easements, which effectively reduce long-term transaction costs and halt many “tragedy of the commons,” but to make them more flexible to adapt to future public needs (Korngold, 2007; Thompson, 2004).

This section outlined the conservation approaches on both public and private rural lands, and how these approaches may impact natural resource extraction- especially the harnessing of wind power for electricity. The next section describes a specific case study. The study examines the extent to which land use conversion and land conservation, in combination, have reduced the land availability within the prime wind resource areas of Western Massachusetts from 1985 to 2009.

Methodology

The Research Study Area

Western Massachusetts provides an ideal area to analyze exurban growth and conservation easement patterns within prime wind resource areas (PWRA), because of the combination of adequate class 4 wind resources, a strong conservation movement, and a wealth of accessible GIS data from state and non-profit organizations. The Commonwealth of Massachusetts has a long tradition of land conservation, with well-established statewide organizations such as the Trustees of Reservations, Mass Audubon, Berkshire Natural Resources Council, the Nature Conservancy, as well as environmental advocacy groups including the Conservation Law Foundation and Environment

Massachusetts. These organizations, along with several community-based land trusts, pioneered the expanded use of conservation easements in the mid-1980s. The Massachusetts Office of Geographic Information (MassGIS) also provides an extensive array of current and historical GIS data, which are essential to analyze temporal shifts in land use patterns. The office collaborates with multiple land trust organizations throughout the state in continually acquiring and updating property, conservation easement, and other land use and coverage data.

The research study area encompasses 51 towns within the four westernmost counties of Massachusetts—Berkshire, Franklin, Hamden, and Hampshire (Figure 6.1). This study determines that 25% of the area possesses a minimum of Class 4 wind resources (with average wind velocities exceeding 6.3 meters per second) according to the AWS Truewind GIS dataset for 70 meters above ground (Figure 2). Western Massachusetts has been studied previously for its wind resource potential and in order to identify potential conflicts between renewable energy generation, environmental conservation values, active recreation, and other land uses (Navigant, 2009; Publicover, 2004). Only two commercial-scale turbines currently operate in this region, a 1.5 MW turbine at the Jiminy Peak ski resort in the town of Hancock and a 900kW turbine on the former Williams Stone quarry in the town of Otis. Three additional commercial wind farm projects remain in various stages of the permitting process: the 30 MW Hoosac Wind Farm which straddles the towns of Florida and Monroe, the 15 MW Berkshire Wind Farm in the town of Hancock, and the 8 MW Minuteman Wind Farm in the town of Savoy.

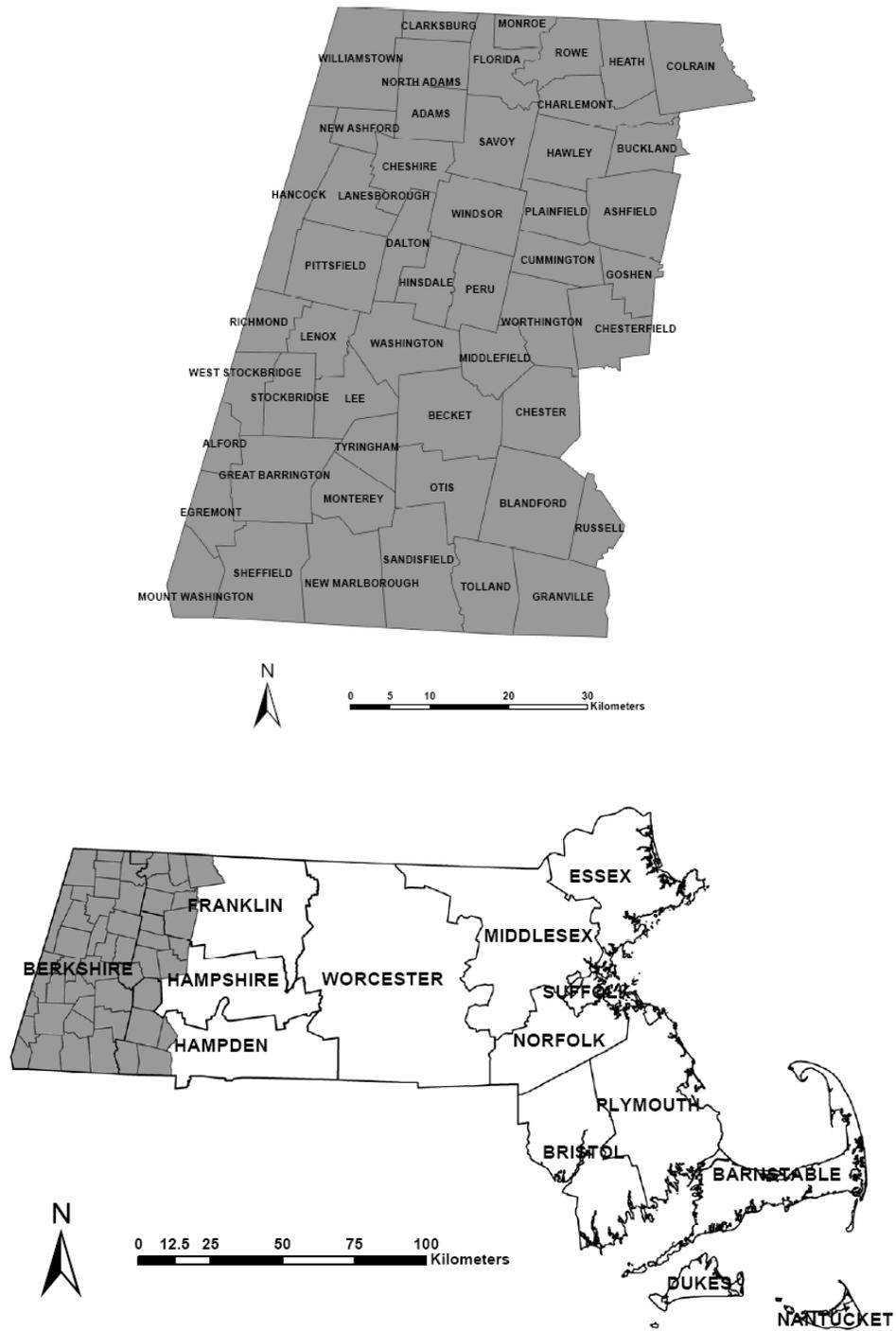


Figure 6.1. The four-county study area of Western Massachusetts

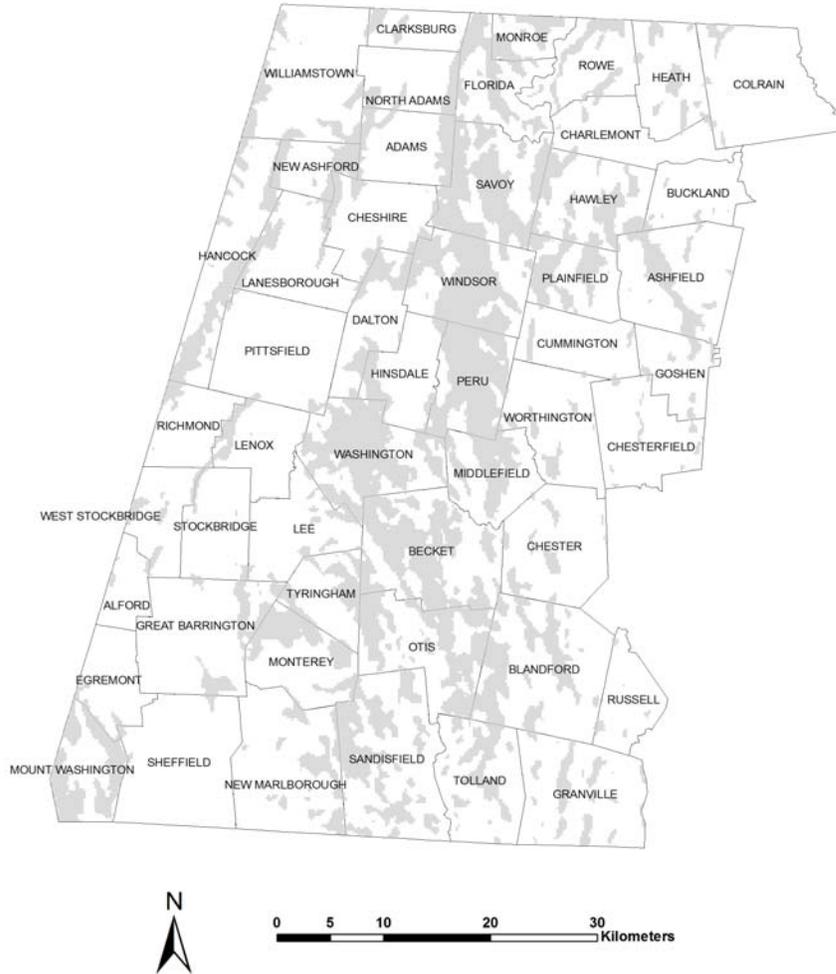


Figure 6.2. 25% of the study area possesses prime wind resources (95,310 hectares)

Establishing the GIS Datalayers

This study uses geographic information systems (GIS) data layers from the Massachusetts Office of Geographic and Environmental Information (Mass GIS) obtained from October 2009 through March 2010. Two new, distinct datasets were created through a series of queries and geoprocessing of GIS data from the 1985 and 2006 *Massachusetts Land Use* datasets, which were revised and released in June 2009, the 2010 *Massachusetts Protected and Recreational Open Space* dataset acquired in March 2010, and from the Berkshire Natural Resource Council's property holdings dataset acquired in March 2010. A description of the GIS processing and modeling steps

is described in Appendices B and C, and the original GIS database sources are listed in Appendix C.

The missing dates for data layer attributes possessing an empty data field for the sale of a conservation restriction deed were acquired through the State of Massachusetts online Land Records Database administered by the Office of the Secretary of State (accessed from March-May 2010), and from data records provided by the Berkshires Natural Resources Council. The 70 meter height wind resources dataset, used to determine the land areas of greatest wind power generation potential, originates from the 2003 AWS/Truewind map series commissioned by the Massachusetts Technology Collaborative.

Research Scope

To measure the reduction of availability to wind resources over time, this study calculates the land use and land ownership composition directly below the prime wind resource area (PWRA) at two distinct dates. Land use/land ownership GIS models were established for the year 1985, with a cut-off date of December 31, 1985, and for the year 2009 (with land use data through December 31, 2005 and land ownership data through December 1, 2009). This study analyzes how parcels change in land use designation (e.g. from agriculture or forestry into residential), as well as whether a conservation easement was granted at any time on or after January 1, 1986. The findings for the twenty-five year timeframe are derived from the total, aggregated difference in land hectares between the 1985 and the 2009 models.

Land areas with one or more significant environmental resources were excluded from the 1985 and 2009 models, to obtain a more accurate accounting of suitable turbine siting within the PWRA. The environmental resource exclusions include areas with slopes greater than 20%, and areas located within 30 meters of reservoirs, lakes, rivers, streams, forested wetlands, and non-forested wetlands. These exclusions further reduced the suitable siting areas within the prime wind resource area from 95,310 hectares to 64,023 hectares (Figure 6.3). The original GIS database sources for these variables are detailed in Appendix D.

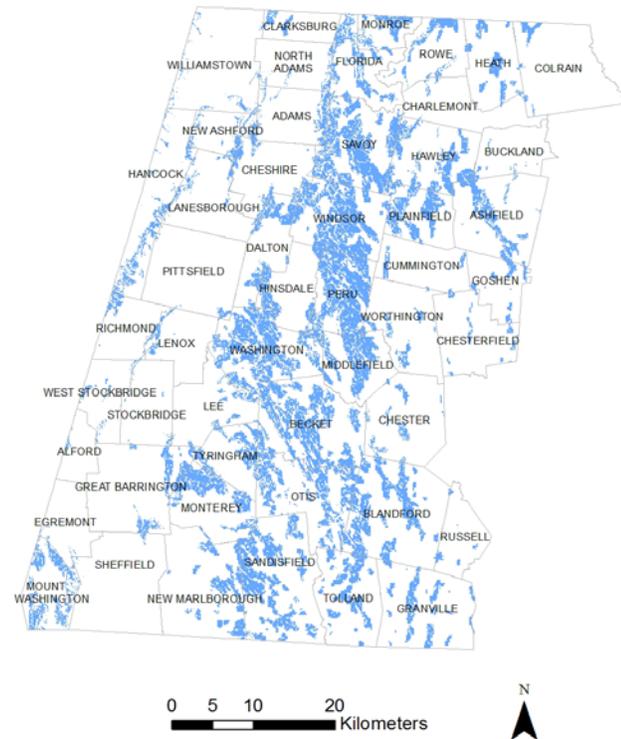
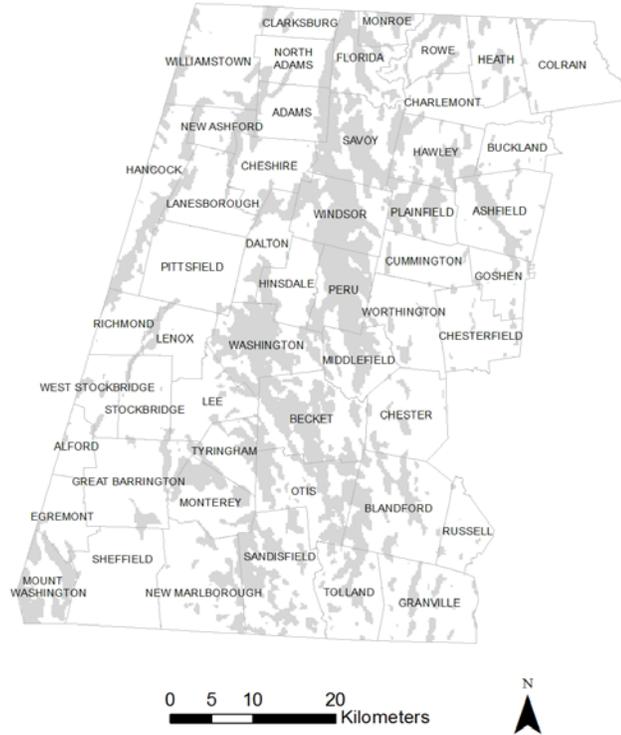


Figure 6.3: The Class 4+ Prime Wind Resource Areas (95,310ha, 25% of the study area) and Class 4+ Prime Wind Resource Areas when Accounting for Environmental Exclusions (64,023ha)

Findings

Reduction of Prime Wind Resource Areas from Residential Development

The reduction of PWRA is analyzed within two residential density categories, in order to distinguish whether lower-density has a greater impact than higher-density residential development. For this study, high density residential represents parcels less than 0.2 hectares (0.5 acres) in size and includes a 500 meter buffer. Low density development represents parcels greater than 0.2 hectares, or 0.5 acres in size, and includes a 300 meter buffer. From 1985 to 2006 the high-density residential area buffer within the four-county Western Massachusetts study area increased by 25%, a net increase of 10,419 hectares, and the low-density residential area buffer increased by 33%, a net increase of 28,662 hectares (Table 6.1).

Table 6.1. Reduction of Prime Wind Resource Areas from Residential Development, 1985-2006

1985 - 2006 RESIDENTIAL	HECTARES WITHIN TOTAL STUDY AREA			HECTARES WITHIN WIND RESOURCE AREA					
	1985	2006	% CHANGE	1985	2006	% CHANGE	% Wind Resource Area in residential buffers (1985)	% Wind Resource Area in residential buffers (2006)	% Wind Resource Area Lost (1985-2006)
HIGH DENSITY RESIDENTIAL < 1/2 acre; 1/5 hectare including 500m buffer	42,475	52,894	25%	1,313	1,626	24%	2.05%	2.54%	0.5%
LOW DENSITY RESIDENTIAL > 1/2 acre; 1/5 hectare including 300m buffer	151,184	190,988	26%	16,699	21,587	29%	26%	34%	7.6%
TOTAL RESIDENTIAL (removing buffer overlaps)				17,151	22,083	29%	27%	34%	7.7%

Within the class 4 or greater wind resource areas with environmental resources excluded (64,023 hectares), high density residential areas increased by 24%, removing 313 hectares from wind power development potential. Low density residential areas increased by 29%, removing an additional 4,888 hectares. After accounting for the buffer overlaps between the two variables, this equates to a 7.7% reduction in access to the PWRA occurring over 20 years, as the percentage of residential land use within the PWRA enlarged from 26.8% to 34.5% (Table 6.1). The land use change that resulted

from the growth in residential development (removal of 4,930 hectares) is, within itself, a significant phenomenon for land use planners, state energy officials, and wind power developers to consider. As mentioned earlier, however, there are also land ownership trends that correspondingly impact the availability of the region's prime wind resources.

*Reduction of Prime Wind Resource Access from
Land Conservation (Primary Ownership)*

Land conservation from primary ownership is measured through land trust and rural non-profit institutions' (YMCA, Boy Scout and Girl Scouts of America camps, etc.) fee-simple land acquisition from 1985 through 2009. This property is further sub-categorized into parcels with and without secondary conservation rights (table 6.2).

**Table 6.2. Reduction of Prime wind Resource Availability from Land Conservation
(Primary Ownership), 1985-2009**

1985 - 2009 LAND TRUST & NGOs	HECTARES WITHIN TOTAL STUDY AREA			HECTARES WITHIN WIND RESOURCE AREA					
	1985	2009	% CHANGE	1985	2009	% CHANGE	% Wind Resource Area in land trust buffers (1985)	% Wind Resource Area in land trust buffers (2009)	% Wind Resource Area Lost (1985-2009)
LAND TRUST Property w- no restrictions including 160m buffer	8,792	14,013	59%	2,430	2,872	18%	3.8%	4.5%	0.7%
LAND TRUST Property w- agriculture restriction including 160m buffer	-	283		-	-		0%	0%	0.0%
LAND TRUST Property w- conservation restriction including 300m buffer	144	4,285	2869%	0	711	710940%	0%	1.1%	1.1%
NON PROFIT Property w- no restrictions including 160m buffer	6,553	6,553	NO CHANGE	1,123	1,123	NO CHANGE	1.8%	1.8%	0.0%
NON PROFIT Property w- agricultural restriction including 160m buffer	-	182		-	-		0%	0%	0.0%
NON PROFIT Property w- conservation restriction including 300m buffer	350	755	116%	27	29	7%	0.04%	0.05%	0.0%
TOTAL LAND TRUST & NON-PROFIT (removing buffer overlaps)				3,580	4,573	28%	5.6%	7.1%	1.6%

While fee-simple land trust holdings increased by 8,220 hectares (by 92%, almost doubling in land area) from 1985 to 2009, fee-simple, rural-based non-profit institution holdings increased only by 587 hectares (9%) within the study area (Table 6.2). This 25 year timeframe was an era where the conservation restriction was employed as the major mechanism for protecting the landscape from development. While only 144 hectares of conservation restrictions existed on land trust property in 1985, the total expanded to 4,285 hectares by 2009.

Within the class four or greater wind resource areas with environmental resources excluded (64,023 hectares), fee-simple land trust acquisition increased by 18%, affecting

the wind power development potential of 442 hectares. Approximately one half of the land trust holdings acquired since 1985 also possess secondary conservation restrictions, which are held mainly by a state agency or another land conservation organization. In 1985 conservation restrictions did not exist on land trust held property located within the PWRA. By 2009 711 hectares of land trust property, 1.1% of the PWRA, possessed secondary protection. Within the PWRA non-profit institutional lands continue to represent 1.8%, since there was a negligible increase of 2 hectares occurring during the 25 year timeframe. The percentage of combined land trust and non-profit institutional land within the PWRA, upon removing buffer overlap, increased from 5.6% to 7.14%, equating to a 1.54% reduction in availability (table 6.2).

The combination of fee-simple residential and land trust acquisitions, accounting for buffer overlap, leads to a 6,606 hectare, 10.3% reduction in prime wind resource area availability (table 6.2). While land use projections often recognize changes in ownership, wind power land use assessments have not. However the combination of these two land variables alone does not provide a complete recognition of ownership barriers to wind power suitability within prime wind resources areas. Measuring the degree of conservation easement transfers is essential in order to determine the extent of reduced availability.

Reduction of Prime Wind Resource Access from Land Conservation

Land conservation from secondary ownership is measured through the sale of agricultural preservation restrictions, including a 160 meter buffer, and conservation restrictions on privately-held land, including a 300 meter buffer, in the study area from 1985 to 2009.

Table 6.3: Reduction of Prime wind Resource Availability from Land Conservation (Conservation Easements), 1985-2009

1985 - 2009 PRIVATE LAND with RESTRICTIONS	HECTARES WITHIN TOTAL STUDY AREA			HECTARES WITHIN WIND RESOURCE AREA					
	1985	2009	% CHANGE	1985	2009	% CHANGE	% Wind Resource Area	% Wind Resource Area	% Wind Resource
							in restriction buffers	in restriction buffers	
							(1985)	(2009)	(1985-2009)
PRIVATE LAND w- agric. restriction including 160m buffer	1,855	15,012	709%	19	1,209	6232%	0.03%	1.9%	1.9%
PRIVATE LAND w- conserv. restriction including 300m buffer	1,121	24,187	2057%	157	4,457	2748%	0.2%	7.0%	6.7%
TOTAL PRIVATE LAND w-restrictions (removing buffer overlaps)				176	5,628	3105%	0.3%	8.8%	8.5%

Both agricultural and conservation restrictions on private land substantially increased within the study area, from buffer areas of 1,855 to 15,012 hectares and 1,211 to 24,187 hectares, respectively (table 6.3). The increase was even more pronounced within the PWRA, with land within the agricultural restriction buffer expanding from only 19 to 1,459 hectares and land in the conservation restrictions buffer expanding from 125 to 4,538 hectares (Table 6.3). Agricultural restrictions on private land represent 1.9% of the PWRA in 2009 while having represented only 0.03% in 1985. The expansion is more pronounced for conservation restrictions on private land, from 0.2% to 7.0% in the 25 year timeframe.

*The Total Reduction of Prime Wind Resource Access
from Land Use Conversion and Land Conservation*

Land conservation restrictions on private land reduced the availability to wind power development (8.5%, 5,491 hectares) more than exurban residential development (7.7%, 4,930 hectares) (table 6.3). The total change within the prime wind resource area from the three categories of residential, primary conservation ownership, and conservation easements, when adjusting for buffer overlap, equals 11,601 hectares, 18% of lands that were suitable as of 1985 became unavailable by 2009 (Figure 6.4).

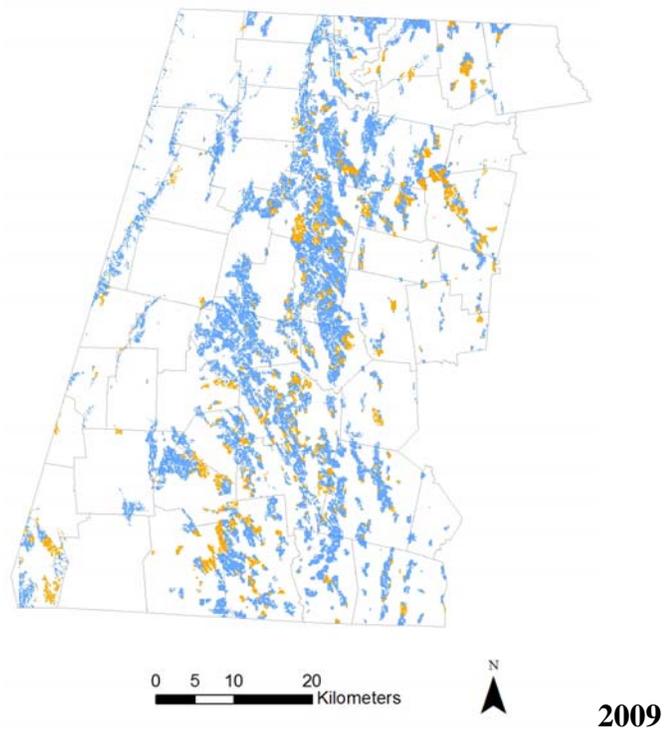
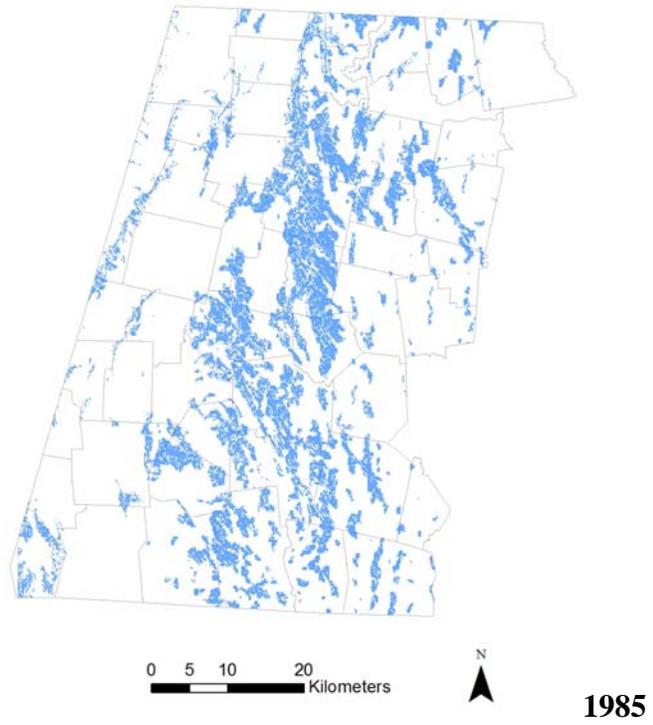


Figure 6.4. Extent of Land Use and Ownership Change within the Prime Wind Resource Areas of Western Massachusetts, 1985-2009

Implications for Regional and Landscape Planning and Policy

Again, the total change within the prime wind resource area from land use conversion and land conservation is 11,601 hectares, 18% of lands that were suitable as of 1985 became unavailable by 2009. This reduction of access to prime wind resource areas has led to a substantial loss of zero-carbon electricity generation potential. After accounting for the requisite minimum 6,400 square meters needed for a 2.0 MW turbine rotor blade area, the suitable siting area is 6,579 hectares (table 6.4). The placement of one turbine platform per four hectares, the standard spacing according to the University of Massachusetts Wind Energy Center (Navigant, 2009), would enable a maximum installation of 1,645 2.0 MW turbines, with a corresponding aggregate generation capacity of 3,290 MW. The average annual electricity generation with a 20% - 30% capacity factor equals 5,767 – 8,651 GWh. This means that the capability of supplying 10% - 15% of Massachusetts’ electricity consumption in 2008 (57,640 GWh, EIA, 2010) was lost from 1985-2009 (Table 6.4).

Table 6.4. The Equivalent Wind Power Siting Potential and Zero-Carbon Electricity Generation Loss Associated with Land Use and Ownership Change, 1985-2009

	95,310 ha	class 4+ (6.3m/s at 70m) wind resource area
	64,023 ha	wind resource area after environmental exclusions
	18%	11,601 ha land use & conservation conversion 1985-2009
<hr/>		
areas with min. 6,400m ² rotor blade area	6,579	ha
1 turbine platform per 4 ha avg.	1,645	2.0 MW turbines
max. generation capacity	3,290	MW
avg. annual elec. gen. at 20% - 30% capacity	5,767 - 8,651	GWh
as percentage of MA elec. consumption (2008)	10% - 15%	
<hr/>		

Although conservation easements currently prohibit access to and generation from wind power resources, they do not necessarily have to in the future (Korngold, 2007; Mahoney, 2002; McLaughlin, 2010). Policy changes will be required at the state and federal level to ensure that conservation easement owners are able to designate specific

envelopes within conservation properties for wind turbine platforms, access roads, and requisite electrical transmission lines.

One of the limitations of this study is the exclusion of the value of development rights purchased and/or received by charitable donation within the original GIS datasets. This data would allow the analysis of an additional explanatory variable- *public expenditure per conserved hectare*- to inform the debate on the financial and political implications of amending existing conservation easements in order to enable the siting of wind turbines on conserved properties. State, municipal, and land trust GIS personnel should consider incorporating the development right values in their databases.

Regional planning councils can play a considerable role in sharing data and leading landscape-scale energy planning processes (Wiseman, 2011). However these agencies are often caught between meeting ambitious state and federal energy goals while appeasing the concerns of their own municipal constituencies and local conservation organizations (Weiss, 2009; Weimar et al., 2010). Land trusts, as owners of a significant amount of conservation easements, must also become active stakeholders in comprehensive regional energy planning processes (Daniels and Lapping, 2005; Korngold, 2007; Schmidt, 2008; Schmidt and Paulsen, 2009; Weimar et al., 2010). State and county GIS departments should share GIS data layers with land trusts to establish accurate wind power land use assessments, aligning and identifying land areas of low conservation values with areas of prime wind power resources and siting potential (Publicover, 2004).

This study also introduces questions of whether and when the inherent value of renewable energy resources will be legally recognized by states and the federal government as publicly beneficial natural resources. Should land, and airspace, now be explicitly designated and conserved for the ongoing and future development of renewable energy (Alexander, 2011; Rule, 2011; Smith and Diffen, 2010)? Should future, as well as existing, conservation easements allow for renewable energy generation- such as wind turbines (Smith and Diffen, 2010)? The Internal Revenue Service currently does not consider either carbon sequestration or renewable energy generation as an eligible public benefit for the charitable tax deduction for a conservation easement, under Section 170(h) of the federal tax code (Aaronson and Manuel, 2008).

Lastly, the use of eminent domain should be recognized as another viable, third option beyond the use of conservation easements and zoning for securing access to renewable energy resources. Eminent domain remains widely used for transportation, water supply, and electrical utility projects and therefore will likely have the legal merit for wind power siting as well (Echeverria, 2005; McLaughlin, 2008). The use of eminent domain on properties with conservation easements will increasingly become a contentious land use issue, especially when condemning authorities preference undeveloped land while the landowner and the easement holder resist and hold fast to the perpetual validity of the deed restrictions (McLaughlin, 2008). Yet eminent domain may become necessary in rare cases where an essential, justified public need such as energy transmission infrastructure cannot be met because of an earlier private land transaction (Korngold, 2007; McLaughlin, 2005).

In order for the existing areas of prime wind resources to remain accessible in the future for electricity generation, the aforementioned issues must be addressed. If not, society will continue to lose the ability to harness one of the least impacting sources of energy, as witnessed in this Western Massachusetts case study, where during the past twenty-five years 18% of the prime wind resource areas were unintentionally restricted through incremental land use conversion.

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CHAPTER VII

Conclusion

This dissertation provides findings from three original research inquiries. The first study, informed by case studies in Europe and the U.S., examined the impact of inter-governmental policy, site-specific, and social factors on wind energy development outcomes within central New England. The second study introduces the two new siting variable categories of telecommunications and land conservation to GIS wind power land siting assessments. The study, with a more comprehensive set of siting variables, determined that a significant amount of suitable land area (at least 15,863 hectares) and corresponding electricity generation potential (7,000- 10,500 GWh/year) exists for Western Massachusetts. This is based on a suitability model that balances the opposing positions for wind power development. The third study determined that exurban residential development was not the only land use factor reducing the development potential (by 7.7%) within prime wind resource areas from 1985-2009. The onset of conservation easements on private lands has the largest impact within prime wind resource areas (8.5%). Combined, the land use and land conservation change from 1985 to 2009 has reduced the access to prime wind resource areas by 18% (11,601 hectares), an equivalent loss of 5,800-8,700 GWh/year of zero carbon electricity generation.

This concluding chapter describes the overarching observations, limitations, and recommendations from the three studies on wind power planning and development. The six main observations include:

- (1) Visual aesthetics remain the main rationale for opposing specific projects
- (2) The Not-in-my Backyard (NIMBY) debate for wind power remains unsettled
- (3) Widespread support for regional land use energy plans exists

(4) The wind resources of western Massachusetts can significantly contribute to the state's current renewable portfolio standard while balancing the concerns of conservation with renewable energy development

(5) Exurban residential development and conservation easements limit wind power development potential

(6) There is a need to legally define wind as a publicly beneficial resource

Visual Aesthetics Remain the Main Rationale for Opposing Specific Projects

The findings on visual aesthetics from chapter three, *Wind Energy Development Outcomes in New England*, correspond with case studies in several European countries as well as California and North Carolina (Groothuis et al, 2008; Nadaï and van der Horst, 2010; Thayer and Freeman, 1987). Interestingly visual aesthetics, and not environmental or public health impacts, remain the primary concern of those who oppose specific wind power projects (Rogers et al, 2008).

Planners recognized the public's concern over visual impact from the onset of modern wind power development. In the mid 1980's Carlman (1988) notes this as a moderate issue in Sweden and Denmark, while Thayer and Freeman (1987) observe this as a greater factor with the Altamont Pass Wind Farm in California. The Glebe Mountain (VT) and Hoosac Wind Farm (MA) interview responses concur with the earlier California findings that a lesser amount of taller turbines are preferred over a larger amount of smaller turbines. Groothuis and colleagues (2008) observed that residents in western North Carolina were willing to pay a premium for renewable electricity but opposed wind turbines being installed within their viewshed.

Recent British, German, and French studies now identify the threshold of public acceptance being reached- based primarily on the visual impact on the cultural and historical character of landscapes (Moller, 2010; Nadaï and van der Horst, 2010; Rogers et al., 2008). Top-down requirements for localities to plan and establish wind power zones increasingly confront backlash from conservationists and historic preservationists (Nadaï, 2007; Nadaï and Labussiere, 2009; Ohl and Eichhorn, 2010). The European

experiences readily compare to the struggle of individual states, such as Massachusetts, meeting their renewable portfolio standards through *domestic*, in-state primary energy sources versus a continued reliance on imports.

The opposition to Glebe Mountain felt there were too many (27) turbines towers being proposed on such an open, exposed ridgeline. Town and state officials stated that the project may have gained acceptance if it had been proposed in phases of 5-6 towers. Iberdrola Renovables, the developer of the Lempster Wind Farm (NH), was sensitive to the visibility of the project, and sacrificed generation efficiency by setting back two tower positions from the highway view. The Lempster Wind Farm's more remote, hidden site contrasts with the Glebe Mountain and Hoosac Wind Farms' more prominent ridgeline sites.

It is also important for planners and policymakers to recognize the strong opposition towards the construction of new access roads, transmission lines, and support towers, since wind turbines require them to connect with the existing infrastructure (Vajjhala and Fischbeck, 2007). The Hoosac Wind Farm's delay stems from multiple legal appeals of approved access road bridges over wetlands, not the placement of the turbine towers themselves. The need for transmission pole upgrades in the adjacent town of Goshen to serve the Lempster Wind Farm incited tensions between the two towns. Many Goshen residents resented the replacement of more historically-appropriate electrical poles with larger, "more unsightly" ones.

How should regulatory authorities weigh visual aesthetics among the other many siting criteria? Energy officials from Massachusetts, New Hampshire, and Vermont lament that visual aesthetics plays a prominent role in opposition, but is too subjective to consider during the siting review process. Opposition groups recognized this and downplayed the importance of visual aesthetics during the Lempster and Hoosac Wind Farm public hearings as well as in this study's interviews. Yet their websites and publications include cropped close-up imagery of towers dwarfing the landscape.

Finally, this study was limited to just one, combined electricity generation source and primary energy feedstock. Further studies are needed to compare the visual aesthetic impacts of a range of power plants and their associated feedstock extraction methods, such as through a visual preference survey. How does the visual impact of wind turbines

compare with electricity generated from coal, natural gas, nuclear, or wood-fired biomass?

The Not-in-my Backyard Debate for Wind Power Remains Unsettled

Visual aesthetics align closely with the Not-in-My-Backyard (NIMBY) response. The findings from this dissertation show that the debate on whether the NIMBY phenomena significantly influences public acceptance and the success in siting wind power projects remains unsettled. Warren and colleagues (2005) determined that greater public acceptance actually occurred at closer proximities in Scotland and Ireland. This mirrors the Hoosac and Lempster Wind case studies, where the opposition came from organizations based outside of the host towns, yet within the same state (Green Berkshires and the Industrial Wind Action Group, respectively). The Green Berkshires opposition group, although based fifty miles away from the site, played a prominent role in delaying the Hoosac Wind Farm, despite overwhelming public support from within the host communities and approval from the town and state permitting agencies. Town officials relayed how local community members were incredibly frustrated that an outside interest group was controlling the siting process, even though the majority of members in this group would not be directly affected by the outcome.

This introduces the dilemma of how to define which stakeholders are *local*. At what distance are individuals and groups not considered part of the *local/community* interest? I propose that this phenomenon is *pre-emptive reactionism*- where interest groups mobilize to defeat projects within their greater region so that developers will not consider siting facilities closer to them. Rather than Not-in-My-Backyard, the opposition arises from Not-in-My-Region. Other wind power siting studies provide different results. Khan observed that the proximity of wind farms to residential homes does influence public acceptance in Sweden (2003).

The Texas experience provides different results. Although Swofford and Slattery (2010) determined the NIMBY phenomenon not to adequately explain public opposition, there was an even split of acceptance towards an existing wind farm for residents within 5 kilometers, whereas 72% of residents within 10-20 kilometers expressed a positive attitude. The difference in the Scotland, Ireland, and New England versus Texas case

studies could be attributed to different landscape forms as well as the socio-economic status of the locality and its greater region (Warren et al., 2005; Swofford and Slattery, 2010). Bolinger found greater acceptance in the rural Minnesota and Iowa communities versus those in Wisconsin and Massachusetts (2005). Further research is needed to compare the local versus regional acceptance of wind farms using explanatory variables such as type of landscape (plains, flat agricultural, shoreline, mountains) and regional socio-economic status (through average property values and/or income levels).

The Glebe Mountain case study also illustrates the internal conflicts experienced by host towns with a mixed population of multi-generational working class and wealthy transplants. This is supported by the findings from the Groothuis et al. (2008) findings that recent transplants opposed wind projects more than the long-term residents in the rapidly exurbanizing area of western North Carolina. Further study is also needed to determine whether a correlation exists between the level of wealth and level of opposition towards wind power for landowners located adjacent to specific proposals and within the viewshed.

Finally, Wüstenhagen and colleagues (2007) question the usefulness of measuring Not-in-my-Backyard sentiments. Their review of Western European case studies identified a U-shape curve of public acceptance based on a wind power project's timeline. A local community tends to approve of wind power (generally) prior to announcement of a specific project. Acceptance drops substantially and remains low from the time a project is announced until it is constructed. Once construction is completed and the project goes online, public acceptance of wind power increases back to the pre-announcement level (Wüstenhagen et al., 2007). Therefore, a review of U.S. based case studies would be useful to compare with the European results to determine whether public acceptance follows this same temporal trend.

Regardless of whether they approved or disapproved of a specific project, the interview respondents from all three case studies agreed that regional land use plans were needed to make wind power development more inclusive, transparent, and to the greatest extent possible, predictable.

Widespread Support for Regional Land Use Energy Plans

The European wind policy framework supports the New England stakeholders' consensus for regional land use energy plans. Sweden, France, and Germany require municipalities with significant wind resources to initiate a wind power planning process. In Sweden, planners establish *residence free* zones in order to prohibit housing construction within parts of prime wind resources areas (Carlman, 1988). In Denmark, France, and Germany locally-created plans must identify a minimum percentage of land within prime wind resource areas where wind power projects will receive an expeditious permitting review (Jobert et al., 2007; Moller, 2010). Massachusetts has attempted to enact this very process with the Wind Power Siting Reform Act. Originally proposed in 2009, as of 2011 the act remains stalled in legislation. Land use legal scholars are beginning to argue for stronger inter-state regional authorities, below federal and above state levels. They would manage access to renewable energy resources- in order to either limit (Outka, 2011) or expand (Wiseman, 2011) their extraction and development. Calls for another form of U.S. regional energy governance misalign with the Massachusetts experience and findings from Europe which describe the friction between top-down energy mandates and fears of lost municipal control (Breukers and Wolsink, 2007; Nadaï and van der Horst, 2010).

Therefore, even with an inclusive public planning process and the subsequent identification of the most suitable sites for wind power, local acceptance of future projects will certainly not be guaranteed. Localities in Great Britain and Germany are beginning to push back against stronger national mandates for renewable energy, pitting biological, cultural, and historic conservation against wind power development (Breukers and Wolsink, 2007; Ohl and Eichhorn, 2010). In France, the objectives of the national energy agency conflict with the national cultural agencies in how and where to install wind turbines within the mountainous regions (Nadaï and Labussiere). Therefore, it is essential within the U.S., and especially within the New England context, to involve conservation groups, land trusts, and historical societies in the earliest stages of a land use energy planning process.

In response to the support of regional land use plans for wind power development, chapter four, *A Wind Power Siting Assessment for Western Massachusetts*, contributes

both a comprehensive set of variables and a GIS modeling method for an open regional planning process.

*The Wind Resources of Western Massachusetts can Significantly
Contribute to the State's Renewable Portfolio Standard*

The gap from the siting assessment's two comparative models is quite substantial—between the most exclusionary model's resulting suitable land area of 364 hectares (equaling 0.4% of wind resource area, 74-112 GWh/year, and 0.13% – 0.20% of state's electricity consumption) and the least exclusionary model's 28,500 hectares (30% of wind resource area, 13,000 – 19,500 GWh/year, and 23-35%). The results of model 1 conspicuously illustrate that wind power development cannot occur in Western Massachusetts if the most exclusionary criteria are employed. At the same time, it is unrealistic to expect that the maximum number of towers feasible in model 2—nearly 4,000—will ever be constructed within a four-county region of only 3,887 square kilometers.

The results from the third model, that balances wind power development with land conservation, demonstrate that enough suitable land currently exists within the prime wind resource areas of western Massachusetts to provide a significant amount of electricity. Interestingly, the designated scenic areas variable, created by The Trustees of Reservations, overlaps only with 10% of the prime wind resources area. This infers that the region's scenic areas, from a quantifiable standpoint, do not substantially reduce the suitable land within the prime wind resource areas. Of the 37 total explanatory variables, the following criteria/distance buffers (measured from the turbine tower platforms) were the most influential:

Not Excluded: State forests

Greater than 20%: Slope gradient

160 meters: State-identified rare species habitat
State-identified areas of critical environmental concern

300 meters: Long-distance recreational trails
Low-density residential (> 0.2 hectares)
State parkland, reserves, and campgrounds

500 meters: High-density residential (< 0.2 hectares)

Within 160 to 10,000 meters: Existing transmission lines

The model results in approximately 16,000 hectares of suitable land (16.6% of the wind resource area) that would enable up to 2,145 tower sites for a generation capacity of 4,300 megawatts. The corresponding electricity generation potential of 7,000- 10,500 GWh/year, based on a capacity factor range of 20-30%, equates to 12%-19% of the state's 2008 electricity consumption (55,900 GWh). This means that the western region of the state could, by itself, theoretically meet the 2020 renewable portfolio standard-15% of electricity supplied from renewable sources, if the 2008 electricity consumption level remained stable.

However, this scenario remains politically unlikely. The state possesses prime wind resources directly offshore and on its eastern shoreline and has also invested in other renewable technologies such as solar photovoltaics and woody biomass for a mix of renewable sources. It is also important for planners and policymakers to recognize how changing land use and ownership patterns slowly, but incrementally over time, reduce the current amount of suitable areas for wind power development.

*Exurban Residential Development and Conservation Easements
Limit Wind Power Development Potential*

Planners, energy analysts, and policymakers must reassess which land categories are considered suitable versus off-limits to wind power development. Wind power land siting assessments should be modified to recognize that not all non-residential private land is potentially suitable. As observed in chapter five, *Private and Public Ownership Composition*, only 14% of the land within the prime wind resource area of the study area

can be considered as potentially suitable (Figure 5.2). This is despite 27% of the prime wind resource area being within non-residential private land, since almost half of this land is either in a conservation easement or held fee-simple by a land trust.

The results from chapter six, *The Impact of Land Use Conversion and Land Conservation on Wind Power Development in Western Massachusetts*, offer a historical perspective. The study shows that from 1985-2009, access to 18% (11,601 hectares) of the prime wind resource areas were reduced due to a combination of exurban residential development and the accelerated use of conservation easements as the main legal mechanism for land conservation. This equates to a loss of over 1,600 turbine sites, the harnessing of 5,700-8,700 GWh/year of electricity, and meeting up to 15% of the state's 2008 electricity consumption.

A Need to Legally Define Wind as a Publicly Beneficial Resource

Lastly, the findings from this dissertation challenge the current differences in the legal designation of natural resources, which in turn directly affect renewable energy development. The federal tax code, in section 170(h), recognizes four eligible conservation purposes for establishing a conservation easement. The land must be preserved for recreation, significant wildlife habitat, scenic open space, or structures of historic importance (McLaughlin, 2010). A main criticism of the most frequently used conservation purpose- the scenic open space provision- is that it remains ambiguous and difficult to measure (Aaronson and Manuel, 2008; Mahoney, 2002). To balance this discrepancy, I argue that wind resources should be added as a conservation purpose. Class 4 or greater wind resources should be legally recognized by states and the federal government as a publicly beneficial natural resource (Alexander, 2011; Smith and Diffen, 2010).

Future Research

Additional research questions have emerged as a result of this work. First, how does the participatory process and public acceptance compare between U.S. and European-based wind power projects? Currently planning scholars are comparing results

across separate studies, but there is no comparative analysis that uses the same survey methodology during the same timeframe to directly compare wind power development outcomes occurring in U.S. states with those in Canadian provinces, European nations, and elsewhere in the world. An example would be a cross-Atlantic comparison between Texas, Iowa, Germany, and Denmark wind power policy, planning, and siting.

Second, what would be the result of a wind power land use assessment model that incorporates a stakeholder survey that collectively identifies exclusionary variables and establishes buffer distances? Would the average buffer distances for the land use variables from the responses be similar to those in previous wind power land use assessments and state model wind ordinances? Finally, how would the results from the western Massachusetts case study of historical land use change compare with other inland geographic regions that possess prime wind resources, experience exurban development, and rely on conservation easements to protect rural landscapes? Is the experience in western Massachusetts indicative of a broader land use trend occurring throughout the United States, or is it a unique outlier of land use change and land conservation?

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APPENDICES

Appendix A: Interview Questions and Resulting List of Influential Siting Factors

Initial Questions- Inter-governmental Policy

1. State energy policies/programs
2. Regional Greenhouse Gas Initiative (RGGI) auction proceeds
3. Federal energy policies/programs
4. Electricity transmission upgrades and planning
5. Other non-energy, environmental policies/programs
6. Other policy factors

Resulting List of Influential Siting Factors

1. State energy policies/programs
2. State renewable portfolio standard (RPS)
3. Response of state natural resource agency
4. Lack of statewide wind energy plan/districts
5. Standing criteria for interveners
6. Federal production tax credit (PTC) and ARRA grants
7. Federal agency attitudes/approach
8. Electricity transmission upgrades and planning

Initial Questions - Site-Specific Factors

1. Terrain and topographic features
2. Visual aesthetic concerns
3. Former/existing use of project site
4. Surrounding land uses
5. Ownership of the project site
6. Conservation and agricultural restrictions
7. Impact on ecologically sensitive plants and/or wildlife
8. The local economic base
9. Impact/mitigation of cultural, historical resources
10. Other site-specific factors

1. Terrain and topographic features
2. Proximity and access to existing transmission line
3. Visual aesthetic concerns
4. Former/existing use of project site
5. Surrounding land uses
6. Ownership of the project site
7. Conservation and agricultural restrictions
8. Impact on ecologically sensitive plants and/or wildlife
9. Impact/mitigation of stream and wetlands disturbance
10. The local economic base
11. Impact/mitigation of cultural, historical resources
12. Impact/mitigation of recreational resources
13. Impact/mitigation of road construction and closure
14. Noise levels on surrounding properties

Initial Questions- Social Responses

1. Origin and type of wind power developer
2. Ownership structure of wind turbines
3. Existing municipal tax base and expected tax revenue
4. Perceived impact on surrounding property values
5. Local, in-town, public support
6. Awareness of environmental impacts of existing electricity gen.
7. Other social responses

1. Origin and type of wind power developer
2. Ownership structure of wind turbines
3. Existing municipal tax base and expected tax revenue
4. Perceived impact on surrounding property values
5. Local, in-town, public support
6. Involvement/attitude of adjacent town(s)
7. Involvement/response from conservation organizations
8. Other alternative sources/means to meet state RPS
9. Cultural composition of the host town

Appendix B: Description of Geoprocessing Steps for Model that Determines Amount of Land Area Converted and Conserved within the Prime Wind Resource Areas of W. Massachusetts from 1985 – 2009.

- 1.) Create basemap of class 4+ prime wind resource areas within the study area
new datalayer: re_wind

- 2.) Establish the 7 land use and land conservation datalayers from the 1985 and 2009 datasets.
Convert all vector-based data into raster with 10 meter resolution
These layers include: (Y1) class 4+ prime wind resources areas; (X1) high-density residential w/ 500m buffer; (X2) low-density residential w/ 300m buffer; (X3) land trust land w/ no easement w/ 160m buffer; (X4) land trust land w/ consv. easement w/ 300m buffer; (X5) private conservation easements w/ 300m buffer; (X6) private agricultural easements w/ 160m buffer

- 3.) Exclude land areas with environmentally-sensitive resources from the prime wind resources area
new datalayer: wind_res_area_w-env_excls

- 4.) Clip the 7 land use and land conservation layers to the class 4+ prime wind resource areas
new datalayer set with suffix "_w-in"

- 5.) Through ArcGIS Map Algebra subtract the 1985 layers from the 2009 layers.
new datalayer set with suffix "_dif"

- 6.) Create map that represents the change in land use and ownership between the 1985 and 2009 datasets through a series of boolean operations

[privCR_dif] OR [privARDif] = [privdifBoolOR]
[lndtrNP_dif] OR [lndtrCR_dif] = [ldtrdifBoolOR]
[re_res_hi_dif] OR [re_res_lo_dif] = [resdifBoolOR]

then:

[privdifBoolOR] OR [ldtrdifBoolOR] = [protdifBoolOR]
[resdifBoolOR] OR [protdifBoolOR] = **[LUdif85-09]**

Appendix C: Datalayers Titles Throughout the Geoprocessing Steps for Models Determining Amount of Land Area Converted and Conserved within the Prime Wind Resource Areas of W. Massachusetts from 1985 – 2009.

*All feature classes were converted from vector to boolean raster format at a resolution of 10 meters.

Datalayer	Land Use 1985 w/in study area	Land Use 2009 w/in study area	Clipped to Wind Resource Area w/ Env. Exclusions	1985 Land Area subtracted from 2009 Land Area	Combination of layers to form final outcome map
Y1 prime wind resource area (Class 4+ at 70 meters above ground)	re_wind	re_wind	wind_res_area_w-env_excls		
<i>Original Source: AWS TrueWind- New England Wind Resource Maps, 2006 (at 50, 70, and 100 meters) Data released 2007.</i>					
X1 high density residential (w/ 500 meter buffer)	re_res_hi85	re_res_hi09	res_hi85_w-in res_hi09_w-in	re_res_hi_dif	
<i>Original Source: Commonwealth of Massachusetts Land Use - 1985 and 2005. Sorted by query of field LUCodes 10, 11, and 12. Data released June 2009.</i>					
X2 low density residential (w/ 300 meter buffer)	re_res_lo85	re_res_lo09	res_lo85_w-in res_lo09_w-in	re_res_lo_dif	
<i>Original Source: Commonwealth of Massachusetts Land Use - 1985 and 2005. Field LUCodes 13 and 38 Sorted by query of field LUCodes 13 and 38. Data released June 2009.</i>					
X3 land trust property w/ no easement (w/ 160 meter buffer)	re_lndtrNP85	re_lndtrNP09	lndtrNP85w-in lndtrNP09w-in	lndtrNP_dif	LUdif85-09
<i>Original Source: Commonwealth of Massachusetts Protected and Recreational Open Space - 2009. OpenSpace_Poly feature class. Date released July 2009. Sorted by Fields "Owner_Type," "Primary Purpose" and "Date of Recorded Deed"</i>					
X4 land trust property w/ easement (w/ 300 meter buffer)	re_lndtrCR85	re_lndtrCR09	lndtrCR85w-in lndtrCR09w-in	lndtrCR_dif	
<i>Original Source: Commonwealth of Massachusetts Protected and Recreational Open Space - 2009. OpenSpace_Poly feature class. Date released July 2009. Sorted by Fields "Owner_Type," "Interest Holder," "Primary Purpose," "Date Recorded Deed"</i>					
X5 conservation easement on private land (w/ 300 meter buffer)	re_privCR85	privCR09	privCR85_w-in privCR09_w-in	privCR_dif	
<i>Original Source: Commonwealth of Massachusetts Protected and Recreational Open Space - 2009. OpenSpace_Poly feature class. Date released July 2009. Sorted by Fields "Interest Holder," "Primary Purpose," "Date of Recorded Deed"</i>					
X6 agricultural easement on private land (w/ 160 meter buffer)	re_privAR85	privAR09	privAR85_w-in privAR09_w-in	privAR_dif	
<i>Original Source: Commonwealth of Massachusetts Protected and Recreational Open Space - 2009. OpenSpace_Poly feature class. Date released July 2009. Sorted by Fields "Interest Holder," "Primary Purpose," "Date of Recorded Deed"</i>					

**Appendix D: Wind Resource Area with Static Environmental Resource Exclusions
(wind_res_area_w-env-excls), 2009**

This GIS model excludes static environmental resources from the prime wind resource areas. Results in 64,023 ha of suitable siting area within the 95,310 ha of prime wind resource lands.

*All feature classes were converted from vector to boolean raster format at a resolution of 10 meters.

<u>Datalayer</u>	<u>Description</u>	<u>Original Source:</u>
re_wind	All land areas below class 4+ wind resources (6.3m/sec)	AWS TrueWind- New England Wind Resource Maps, 2006 (at 50, 70, and 100 meters). Data released 2007
re_towns	Town boundaries	Mass GIS: Berkshire_County_Poly 2009; Franklin_County_Poly 2009; Hamden_County_Poly 2009; and Hampshire_County_Poly 2009 databases
re_slope	All land areas with slopes > 20%	United States Geological Survey (USGS) DEM elevation database (accessed March 2010)
re_creek	Unnavigable waterbodies and a 30 meter buffer	Mass GIS: Berkshire_County_Poly 2009; Franklin_County_Poly 2009; Hamden_County_Poly 2009; and Hampshire_County_Poly 2009 databases
re_water	Rivers, lakes, and reservoirs and a 30 meter buffer	Mass GIS: Berkshire_County_Poly 2009; Franklin_County_Poly 2009; Hamden_County_Poly 2009; and Hampshire_County_Poly 2009 databases
wetlandsNF	Non-forested wetlands and a 30 meter buffer	Commonwealth of Massachusetts Land Use - 2005. Sorted by query of field LUCode 4, from MA Dept. of Env. Protection wetlands database
wetlandsF	Forested wetlands and a 30 meter buffer	Commonwealth of Massachusetts Land Use - 2005. Sorted by query of field LUCode 37, from MA Dept. of Env. Protection wetlands database