Wind Farms and Municipal Protection of Military Facilities from Encroachment

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Land Use Panel

by

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Curriculum Vitae of Miles Risley

Miles Risley is the City Attorney of Corpus Christi, a city of approximately 320,000 people on the coast of South Texas. He received his law degree from the University of Texas in 1992. He graduated summa cum laude from West Texas State University in 1989.

Mr. Risley has practiced municipal law since 1994. Prior to his appointment in Corpus Christi, he was the City Attorney of Wichita Falls and of Victoria, Texas. Prior to joining the City of Victoria Legal Department, he practiced with the law firm of Byington, Easton, and Risley, PC in Austin, Texas. He has also been an adjunct instructor at Victoria College and has served as a U.S. Army Military Intelligence Officer.

Mr. Risley has been a member of the International Municipal Lawyers Association (IMLA) for approximately 20 years, and has been an IMLA Local Government Fellow for more than 10 years. Mr. Risley also has received a Merit Certification in Municipal Law from the Texas City Attorneys Association (TCAA). He is a Fellow of the Texas State Bar College and has made presentations to IMLA, the TCAA, and the National Contract Management Association. In addition, he is currently on the Board of Directors of the Texas Coalition for Affordable Power, an aggregation group that purchases electricity for approximately 160 Texas cities and other political subdivisions and advocates for consumers of electrical power.

Mr. Risley has spoken on the following topics:

- "Smart Growth-A Global Perspective" presented to the International Municipal Lawyers Association 67th Annual Conference - October 2002
- "Municipal Court – The Basics" presented to the Texas City Attorneys Association - 2010 Summer Conference
- "Zoning & Platting Basics" presented to the Wichita Falls Planning & Zoning Commission - October 2010
- "Basic Contract Clauses" presented to Wichita Falls chapter of the National Contract Managers Association - July 2011
- "Municipal Regulation and Contracting with Tow Trucking Companies" presented to the International Municipal Lawyers Association 2012 Mid Year Seminar
- "Municipal Regulation and Contracting with Tow Trucking Companies in Texas" presented to the Texas City Attorney's Association – June 2013
- "The Most Dangerous Thing we do every Day is hitting "Send": Criminalized Information Transfer" – presented to the Texas City Attorney's Association – June 2015

In Wichita Falls, Mr. Risley assisted in the preparation of the Joint Land Use Study for the Sheppard Air Force Base, which is the U.S. Air Force's primary training base for pilot and which extensively addressed wind farms. In Corpus Christi, he dealt with the annexation of a large area next to the City that contained one of the country's largest planned wind farms. Corpus Christi Naval Air Station is a primary training base for the development of Navy pilots.

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Wind Farms and Municipal Protection of Military Facilities from Encroachment

Introduction

The need to develop sustainable energy resources is causing the world to face a new choice of costs and benefits. However, all sources of energy have some undesirable consequences. Fossil fuels pollute the air. Nuclear is expensive and adds to weapons proliferation. Hydroelectricity impairs salmon migrations and has mostly been fully developed. In contrast, wind energy is plentiful in many areas, especially many flat areas that lack sufficient hydro resources. In the past three decades, technological advancements and production scale have made wind a viable method of producing electricity. Unfortunately, it is afflicted with several side effects. One side effect is interference with radar. This is an especially important concern in communities with military bases.

Until recently, leaders of the American military relentlessly opposed wind energy wherever it threatened radar coverage nationwide. They have been forced to temper their opposition in response to a national policy that favors the rapid spread of renewable energy. Further, the spread of wind energy is accelerated by the federal wind energy production tax credit, which has been repeatedly extended for wind farms that have reached the construction phase. Nonetheless, when judging the viability of existing military installations, the impact of nearby wind turbines on their viability is a repeated matter for base closing commissions.

Federal policy can appear schizophrenic on the issue of wind power. The U.S. military has largely withdrawn its opposition at the national level. Instead, it takes wind turbines into account when judging the continued viability of local missions. This leaves the regulatory burden entirely on the back of states and their political subdivisions. For states like Texas, who largely limit regulatory intervention rights to cities, municipalities are left to their own creativity when limiting the growth of wind farms as a method of regulating wind farms in a way that allow them to maintain nearby military bases.

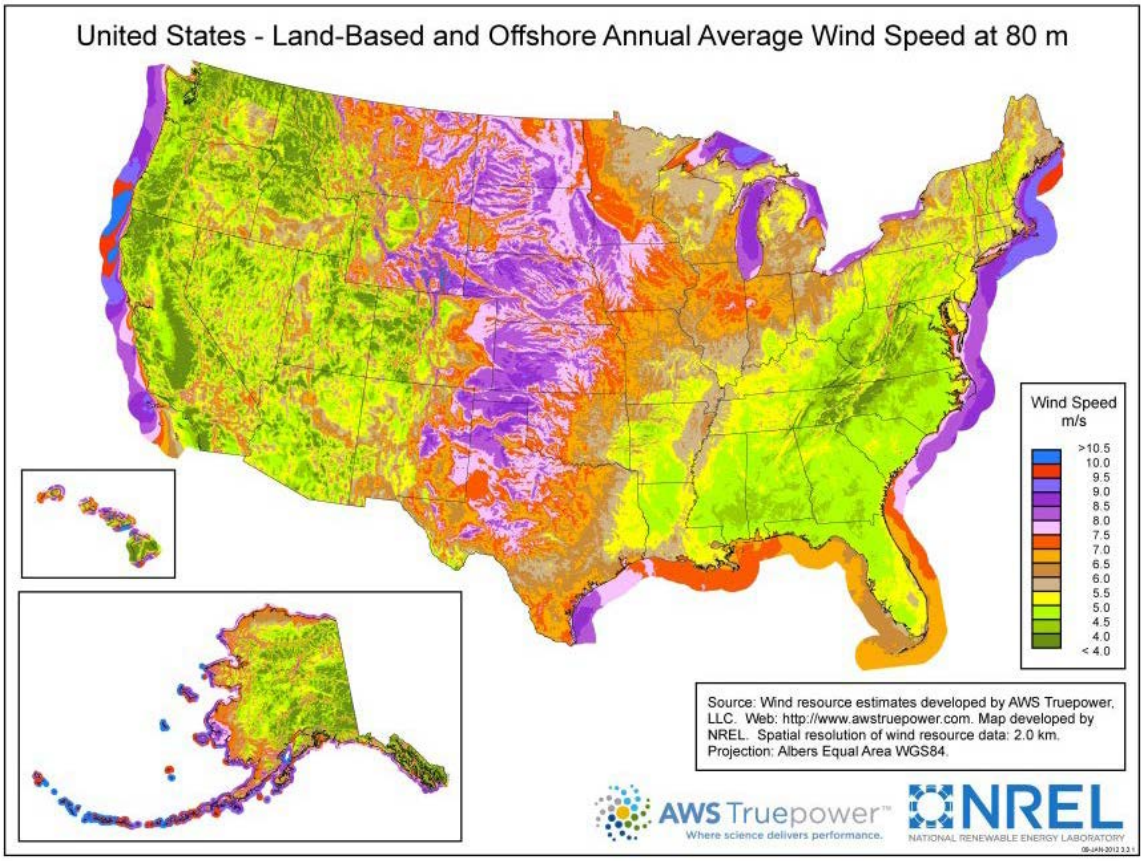
The federal government lacks jurisdiction to directly prohibit wind farms near military bases. However, the Joint Land Use Study (JLUS) process is a collaboration between local governments and military representatives from a local base that identifies conflicts with the military missions. Through the JLUS process, local governments can coordinate their regulatory authority with federal concerns to limit these nearby conflicts. One of the most recent common conflicts to air-related missions is wind farms.

1. Proliferation of Wind Farms in the United States

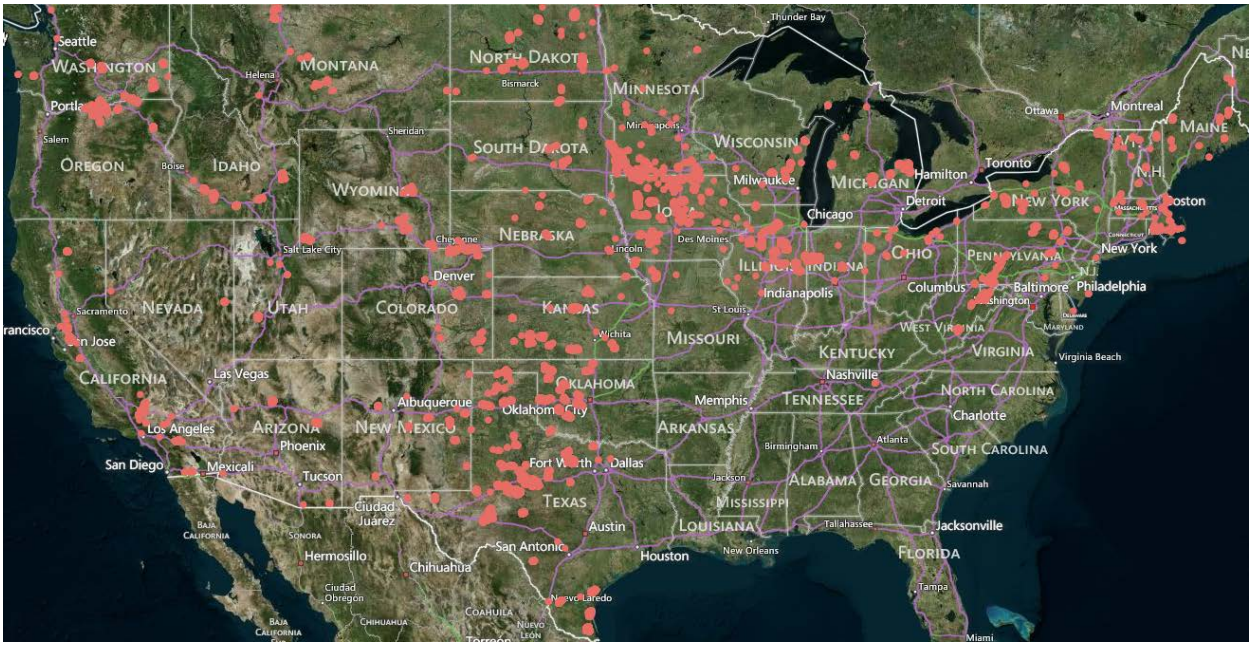
Since 1980, wind energy costs have fallen by more than a factor of 20 in some regions of the country — going from more than 55 cents per kilowatt-hour to less than 2.5 cents/kWh. http://thinkprogress.org/climate/2015/05/20/3660677/bigger-taller-wind-turbines-will-unlock-wind-power-across-united-states/

a. Current Locations of Wind Farms

Wind farms have initially been built in the highest wind areas that are adjacent to population centers; thereby minimizing both the cost of transporting wind energy to areas of demand and allowing higher winds to be accessed with current wind turbine technology. To date, wind farms have been built in areas experiencing average wind speeds higher than 7 meters per second.



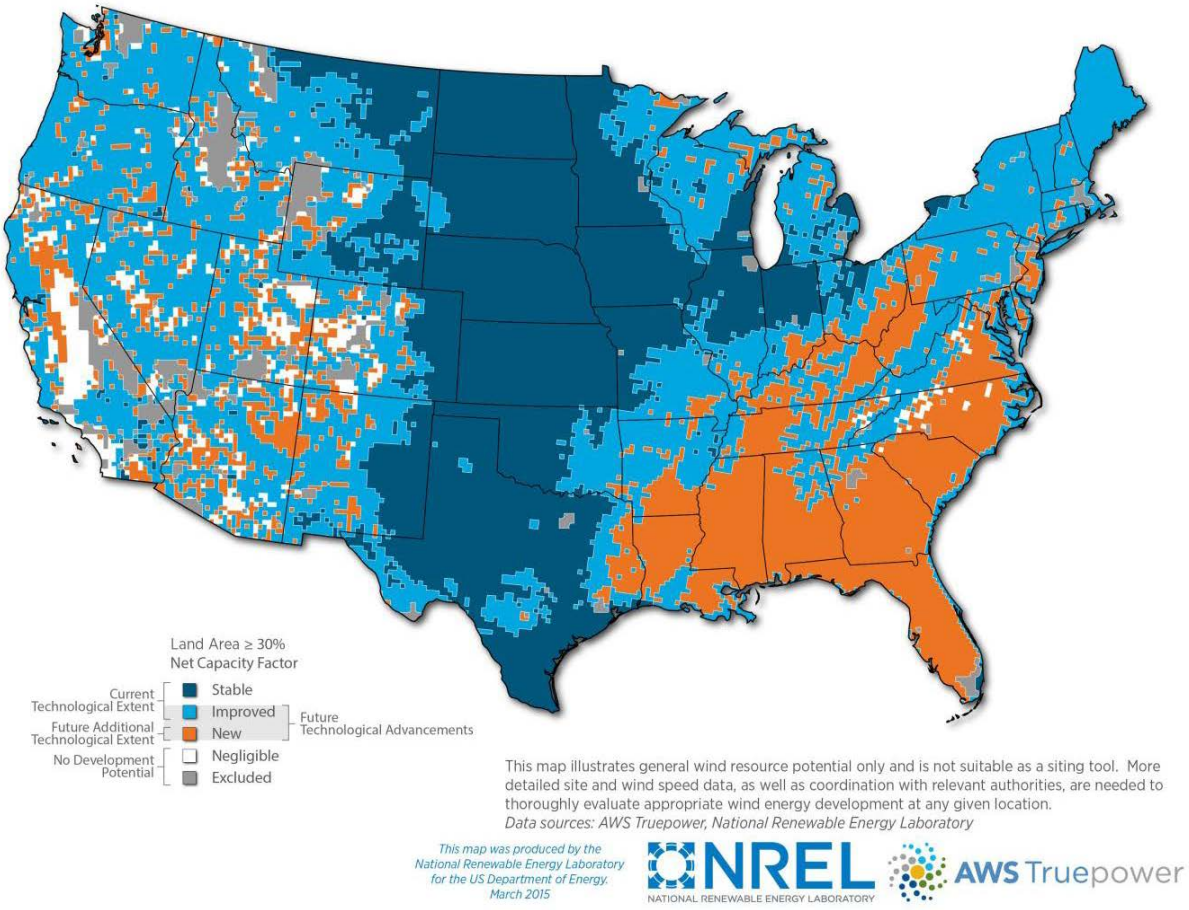
U.S. wind farms are shown in the following map. As you can see, most of the states have some wind farms. Only the southeastern states are largely bereft of wind farms. This map may be viewed as an interactive map at: http://eerscmap.usgs.gov/windfarm/



b. Future Areas of Wind Farm Development – Coming to an area near you.

A new report from the U.S. Department of Energy shows how advances in wind power technology and deployment will continue to make wind power cheaper and more accessible — and will make it possible to achieve at utility-scale levels in all 50 states by 2030. The report, "Enabling Wind Power Nationwide," shows how taller turbines that reach stronger winds high above the ground will be able to unlock previously untapped resources, primarily in the Southeastern U.S., where wind speeds tend to be lower. The deployment of taller wind turbines (already prevalent in Germany with average hub heights at 116 m) will expand U.S. land area available for wind deployment by 54%. See Enabling Wind Power Nationwide, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

Area opened up to wind turbine development by taller turbines is shown in light blue and orange below.



Between 2008 and 2013, wind energy developers began adopting taller turbines; thereby adding the area shown in blue in the map shown in Figure 4-2 below:

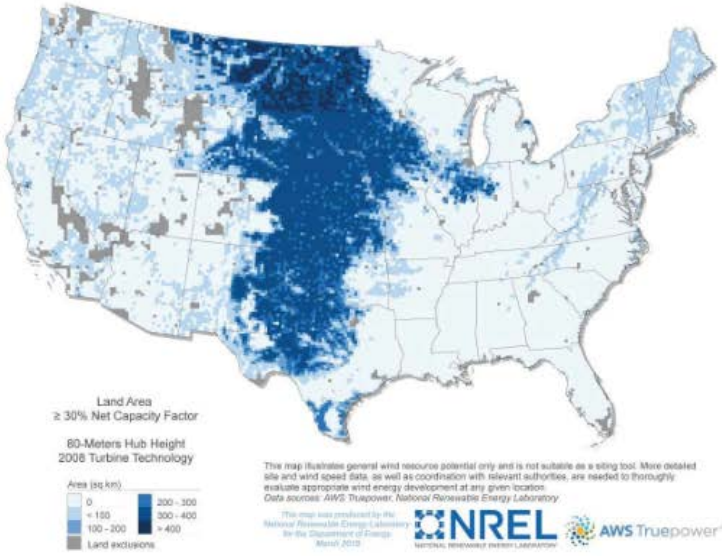


Figure 4-1. Land area achieving a minimum 30% net capacity factor by grid cell, based on 2008 technology
Source: DOE 2015

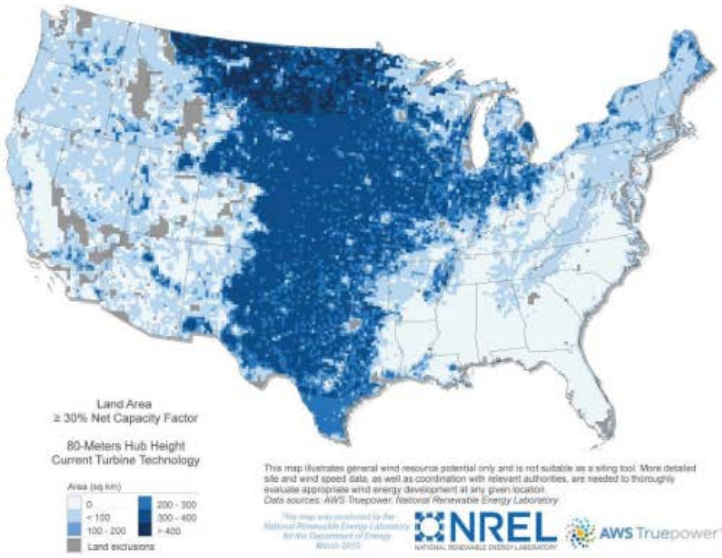


Figure 4-2. Land area achieving a minimum 30% net capacity factor by grid cell, based on 2013 technology
Source: DOE 2015

Source: Enabling Wind Power Nationwide, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

Even larger windmills are being planned that would extend cost-effective wind energy to much of the southeast. A conceptual wind turbine with a rotor diameter of 124 meters (relative to a 2013 U.S. average of 97 m) would provide a turbine rotor swept area approximately 2.4 times

greater than 2008 turbines with an average rotor diameter of 80 meters, and more than 60% more than the average turbine installed in 2013.

Relative to 2013, placing the conceptual turbine on a 110-meter hub would result in an increase in technical potential of about 54%; placing this turbine on a 140-meter hub would result in an increase of approximately 67%. Regions primarily affected by this increased technical potential include the Southeast, states bordering the Ohio River Valley, the Great Lakes Region, the Northeast, and portions of the Interior West and Pacific Northwest, as shown in Figure 4-4 below:

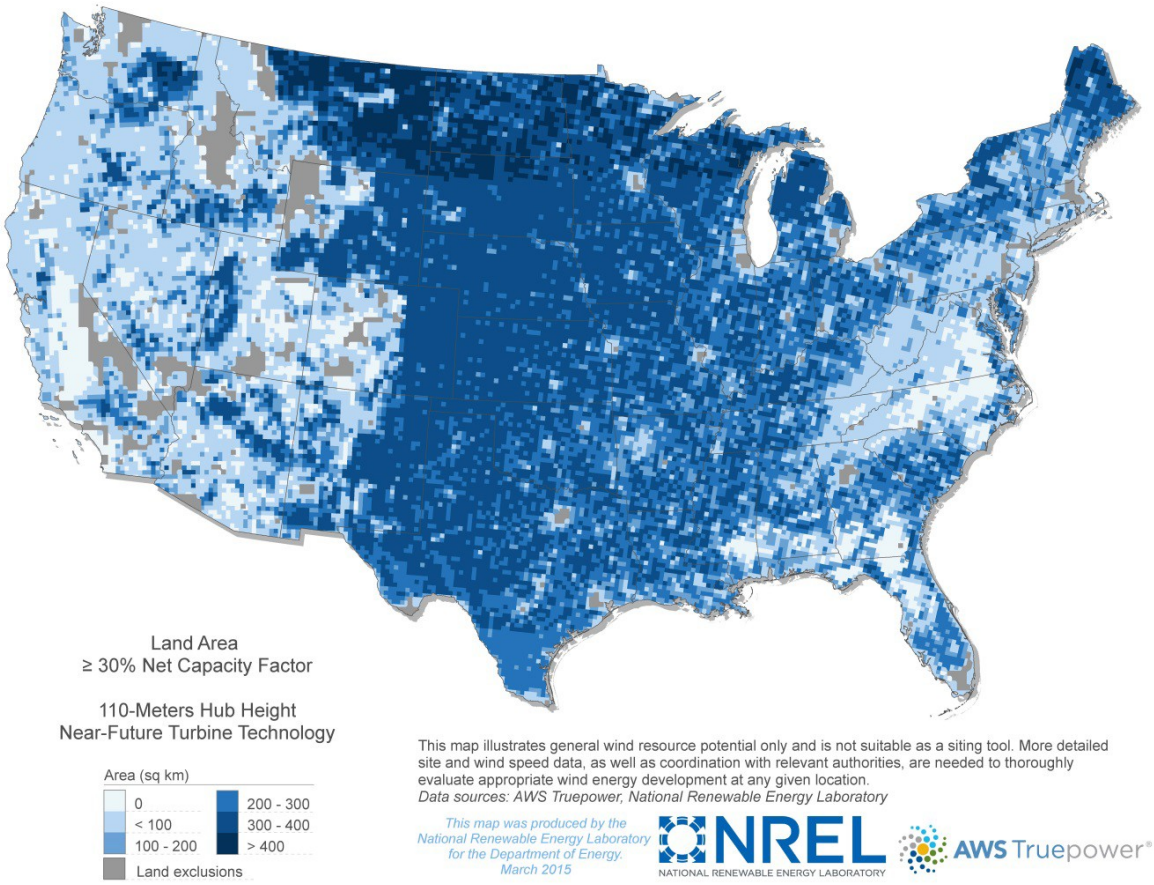


Figure 4-4. Land area achieving a minimum 30% net capacity factor by grid cell, based on lower specific power (150 W/m^2) and a 110-m hub height.

Source: Enabling Wind Power Nationwide, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

Future hub heights could go to 140 meters. At hub heights of 140 meters, the following map shows that the majority of the country would have net capacity factor greater than 30%:

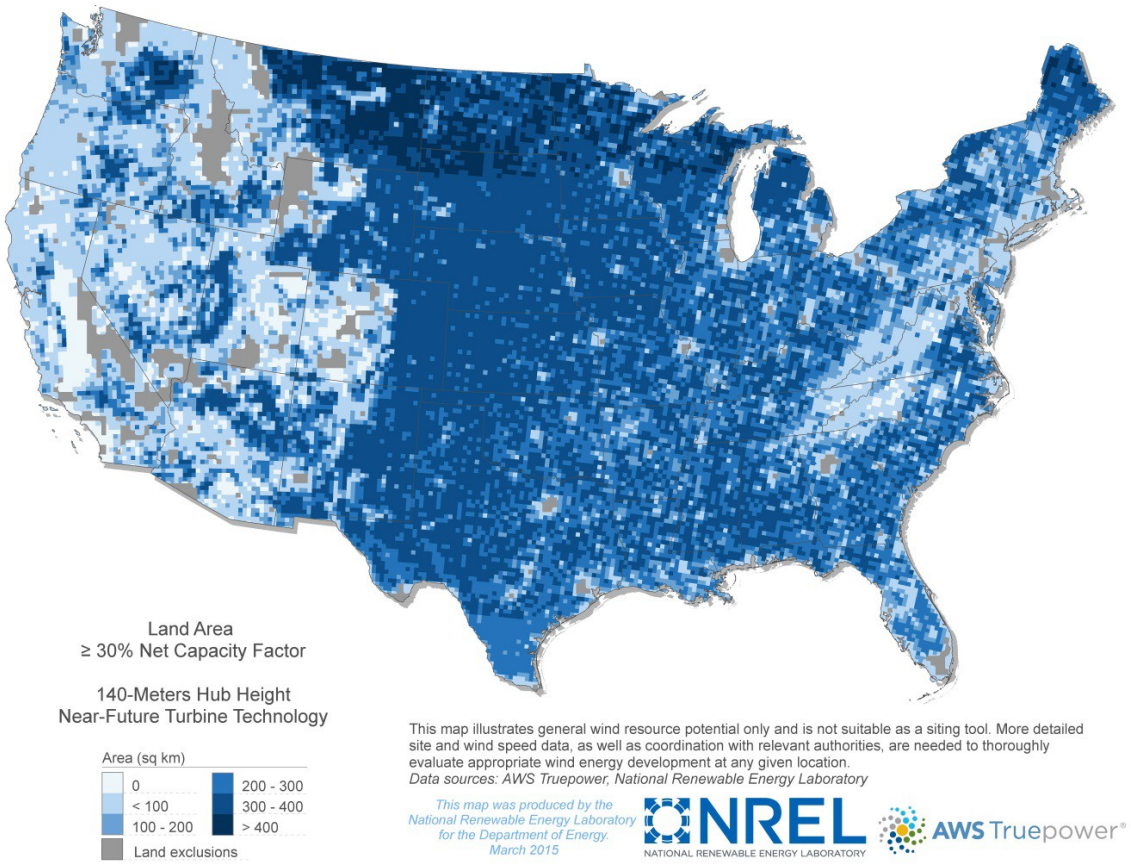


Figure 4-5. Land area achieving a minimum 30% net capacity factor by grid cell, based on lower specific power (150 W/m^2) and a 140-m hub height

Source: DOE 2015

Source: Enabling Wind Power Nationwide, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

c. Increasing Size of Modern Windmills

The current standard height for most wind turbines is 80 meters, or 262 feet, however turbine heights of up to 120 meters, or 393 feet, are already common in parts of Europe. The Energy Department is working with wind turbine manufacturers to develop new turbines that stand 360 to 459 feet tall — as calculated from the center of the rotor — and have blades more than 196 feet long. Taller than the Statue of Liberty, the DOE estimates than even at the 110-meter height the potential for wind deployment in the U.S. increases by 54 percent, with it rising another 13 percent to 67 percent at the 140-meter height. This would open up an additional one-fifth of the land area in the U.S. for wind turbines, especially in the Southeast. http://thinkprogress.org/climate/2015/05/20/3660677/bigger-taller-wind-turbines-will-unlock-wind-power-across-united-states/

Due to friction, the terrain causes the wind layers closest to the ground to move more slowly than the wind layers above it, thereby resulting in the typical mean wind velocity profile as shown by Figure 3-4. This variation of speed as a function of height is called the wind shear. Because of wind shear effects, the bottommost portion of the rotor will extract less energy from the wind, as compared to the topmost section. This has two implications: First, at a given hub height, the energy extraction by the rotor decreases in proportion to increases in wind shear, compared to a rotor operating at constant wind speed across its entire swept area. Second, increasing the hub height will allow the rotor to capture more energy for the same rated power and swept area. Gains of 20-45% are possible by increasing the height of the towers from 80 meters to 140 meters in moderate-to-high shear sites. This is because the power varies as the cube of the wind speed, and even modest increases in wind speed (as a function of height) contribute to the power captured. See *Enabling Wind Power Nationwide*, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

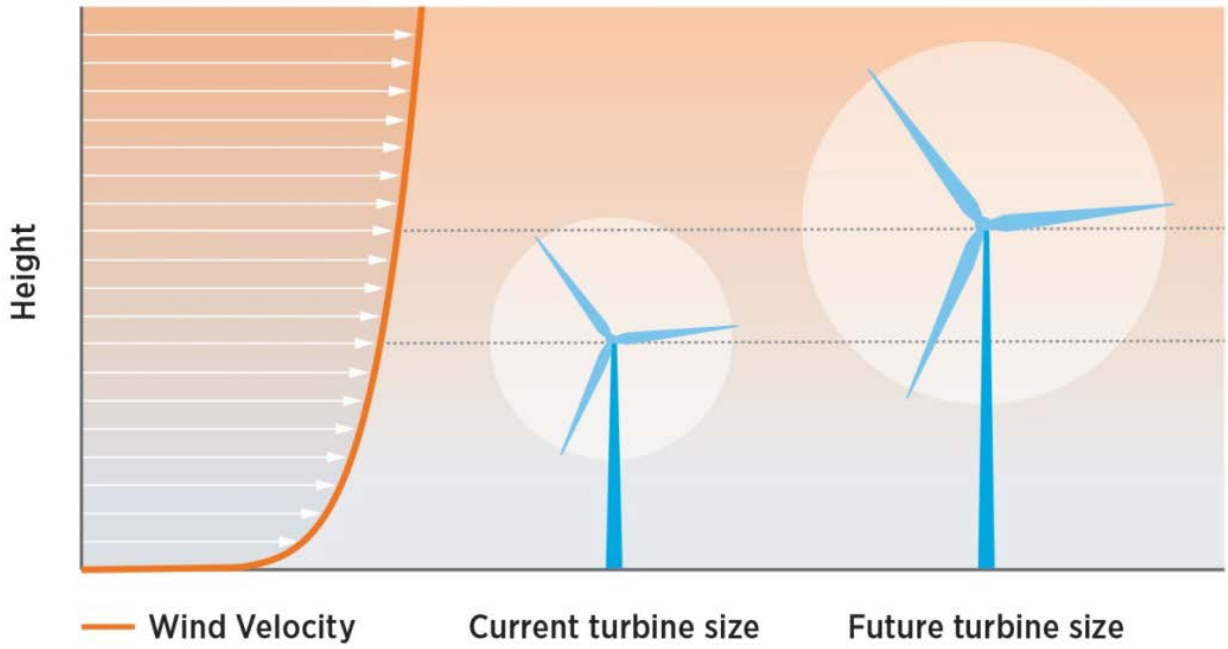
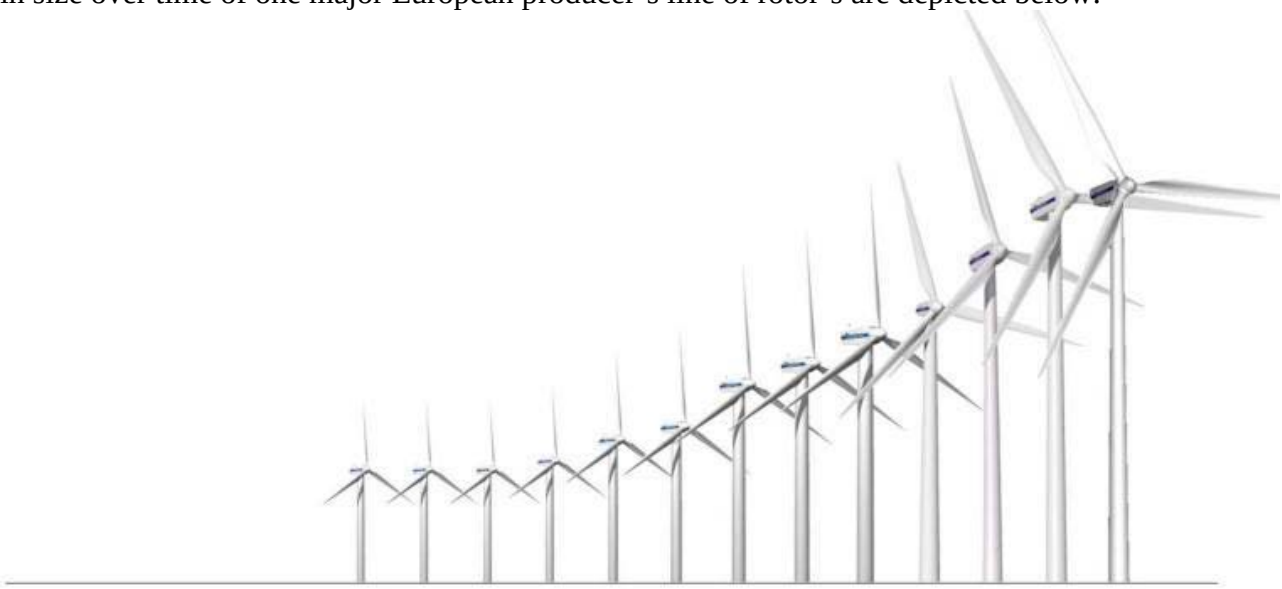


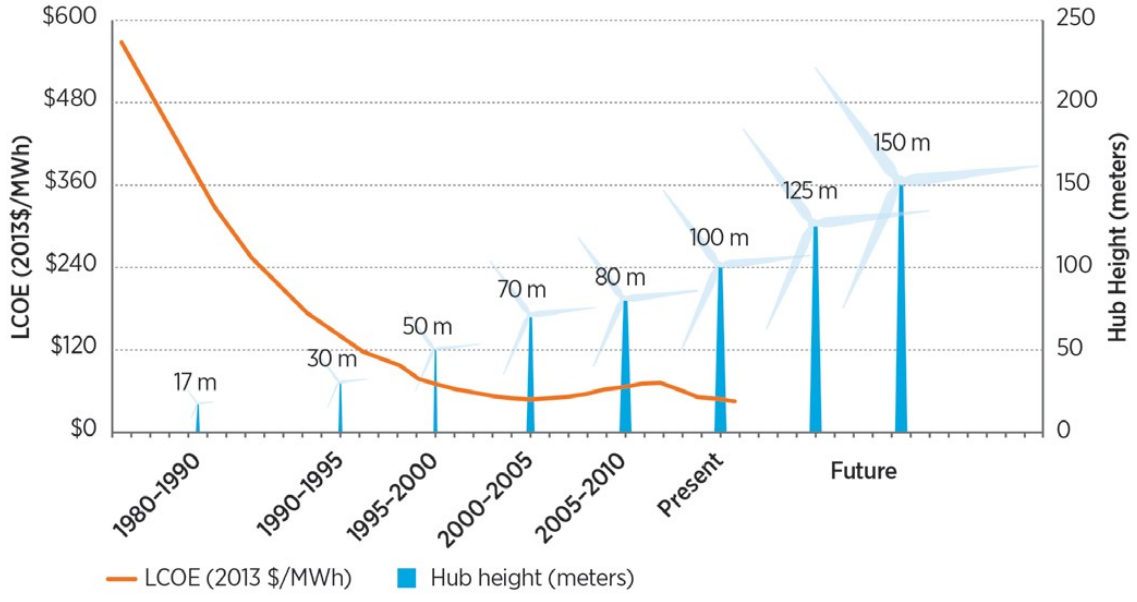
Figure 3-4. Representative wind atmospheric boundary layer velocity profile with two turbines of different heights

Rotor size increases have already occurred in Europe and are spreading to the U.S. The increase in size over time of one major European producer's line of rotor's are depicted below:



Product/Rotor diameter (m)	V15	V17	V19	V20	V25	V27	V39	V44	V47	V52	V66	V80	V90
Year of installation	1981	1984	1986	1987	1988	1989	1991	1995	1997	2000	1999	2000	2002
Capacity (kW)	55	75	90	100	200	225	500	600	660	850	1750	2000	3000
MWh/year	217	265	301	346	481	647	1304	1581	1947	2530	4705	6768	9152

Hub heights up to 70 meters caused dramatically decreasing costs of energy. Figure 5.1 shows that increasing hub height will no longer significantly reduce the cost of energy produced by a wind turbine. However, hub heights will continue to increase in areas that need these higher hub heights to make wind energy viable in lower wind regions. In the U.S., these lower wind regions will be in the southeast and Atlantic states.



Note: LCOE is estimated in good to excellent wind resource sites (typically those with average wind speeds of 7.5 m/s or higher), excluding the federal PTC. Hub heights reflect typical turbine model size for the time period.

Source: Wiser and Bolinger

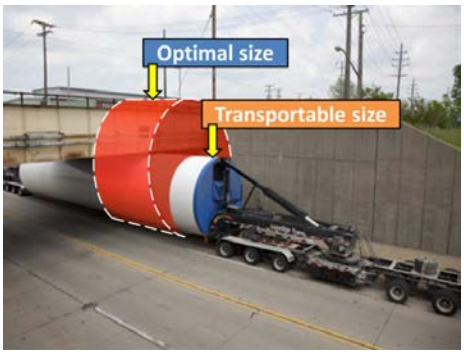
Figure 5-1. Wind technology scale up trends and Levelized Cost of Electricity (LCOE) Source: Wiser and Bolinger 2014

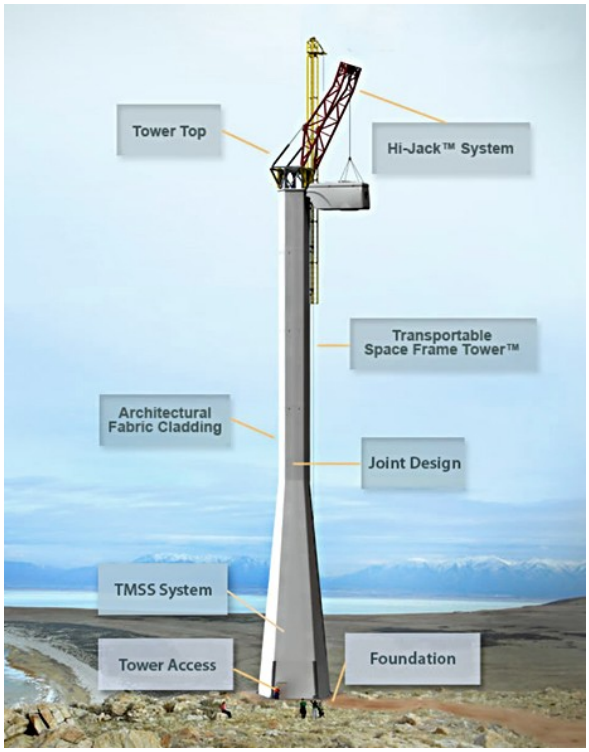
To make wind power viable in the south and Atlantic states as envisioned by U.S. Department of Energy, further height increases will be necessary. These heights will mirror earlier expansions in Europe. The largest European onshore turbines have hub heights of 135 meters. Power Technology.com, January 2, 2014. http://www.power-technology.com/features/featurethe-worlds-biggest-wind-turbines-4154395/



https://en.wikipedia.org/wiki/Enercon_E-126

The primary limiting factor of increasing hub heights is the transportation costs of components. New technologies are providing for on-site assembly, which should allow height and size increases to continue into the future. The figures below show how a space frame system could be used to enable a continued increase in turbine heights thereby allowing the Optimal Size diameter base to be transported.





Source: Enabling Wind Power Nationwide, U.S. Department of Energy Report – May 2015. http://energy.gov/eere/wind/downloads/enabling-wind-power-nationwide

2. Military Bases

a. Locations of Military Bases in U.S.

Military bases are located in many areas that are near wind farms. However, not all military bases are affected equally by nearby wind farms. The military bases most susceptible to wind farm interference are air force bases and naval air stations. Naval air stations in particular are clustered along the Gulf and Atlantic seaboard, which will coincide with the areas that will receive the tallest turbines under the plans envisioned by the U.S. Department of Energy.





b. Joint Land Use Study process

The official process by which the military interfaces with local officials is the Joint Land Use Study (JLUS) process. When a Military Service believes an installation may be experiencing incompatible development problems or that there is the likelihood for incompatible development that could adversely affect the military mission, the Service may nominate the installations for a JLUS to the U.S. Department of Defense Office of Economic Assistance (OEA). OEA staff visits the installation, meets with the local base command and local government officials. OEA will evaluate existing or potential encroachment problems, the availability of incompatible land use information, and local development controls to determine if a JLUS is justified. A JLUS will proceed if there is both base command and local jurisdiction interest. See *Office of Economic Adjustment—Joint Land Use Study Program - January 2007, http://webcache.googleusercontent.com/search?q=cache:YT56IZLtlEIJ:www.oea.gov/library/directory/assistance/jlus/joint-land-use-study-program-description/view+&cd=3&hl=en&ct=clnk&gl=us*

JLUS reports identify conflicts with military missions. The mitigation of these conflicts enables communities to defend the missions that are assigned to each base. Maintaining the presence of these missions enables local communities to maintain the personnel that are assigned to these missions. The JLUS process generally creates a summary report of recommendations, a general JLUS final report, and a background report. Examples of these documents can be found at the found at the following links:

- http://www.wichitafallstx.gov/DocumentCenter/View/22177
- http://www.wichitafallstx.gov/DocumentCenter/View/22178
- http://www.wichitafallstx.gov/DocumentCenter/View/22179
- http://joom.ag/ZlKX
- http://www.ccjlus.com/images/documents/NASCC%20JLUS%20Background%20Report%20FINAL_sm.pdf
- http://www.nafelcentrojlus.com/images/Documents/naf_el_centro_jlus_document_report_final_june_2014.pdf
- http://www.nafelcentrojlus.com/images/Documents/naf_el_centro_jlus_background_report_final_june_2014sm.pdf
- http://www.okc.gov/planning/documents/jlus%20final%20report.pdf
- https://www.sanantonio.gov/Portals/0/Files/OMA/Lackland.JLUS.pdf
- http://www.currycounty.org/wp-content/uploads/0311_JLUSStudy.pdf
- http://paxjlus.com/images/documents/nas_pax_jlus_background_report_jan_2015.pdf

c. Wind Farms Identified as threats to Air and Radar Operations in JLUS Reports

The following statements have been made in JLUS reports:

> Wind turbines have two potential compatibility issues: frequency impedance and vertical obstruction. See http://www.ccjlus.com/downloads/documents-handouts/doc_download/10-nas-corpus-christi-jlus.html

The second potential impact of wind farms on military operations is that they can potentially interfere with radar systems. Sheppard AFB utilizes a digital ASR system to monitor and track its aircraft during training flights. The presence of large wind farms can have several effects on radar systems, depending on the size of the farm, number of towers, distance between towers, height of towers, and distance from the radar. The two main impacts that large wind farms can produce are screening, or blocking out portions of the "field of view", so that it cannot see aircraft that fly behind the "screen", or causing false readings on the radar that make it appear there are aircraft flying in the area that are not really there. See http://www.wichitafallstx.gov/DocumentCenter/View/22179

Studies have shown that wind turbines affect not only aircraft because of their height, but they also affect radar. Proven mitigation methods include spacing between turbines, terrain masking, and terrain relief. These methods keep wind turbines out of the line of sight of radars. Other methods are being analyzed but have not been proven to work as well as regulations. See http://www.currycounty.org/wp-content/uploads/0311_JLUSStudy.pdf

Future commercial wind energy exploration presents possible threats to NAS PAX despite its potential for private industry. The presence of wind farms present challenges to air and weapons testing such as:

- Obstruction
- Radio frequency (RF) clutter
- Screening.

Radio frequency (RF) clutter sources, such as wind turbines, have the potential to corrupt the accuracy of these measurements. This corruption is produced by the rotating wind turbine blades inducing undesired Doppler shift on the radar signal. Wind farms heighten this effect due to the increase in density of wind turbines. See http://paxjlus.com/

Heights of structures such as cell towers and energy development facilities like wind energy conversion facilities exceeding heights of 200 feet can be incompatible with the NAFEC training mission. Towers exceeding 200 feet pose a threat to the safety of pilots who train at low-levels. The low-level flight training activities need unobstructed, navigable airspace to perform and complete flight operations. This is important for pilots required to complete a certain number of hours in training. See ftp://ftp.co.imperial.ca.us/icpds/jlus/nafec-jlus-background-report.pdf

Wind farms have been identified as threats to missions in many JLUS reports. In fact, JLUS reports are addressing wind farms in more and more detail. Indeed, the Cannon Air Force Base JLUS described above contains a 60-page study addressing the impact of wind farm development on radar systems. See Appendix H in the Report to the Congressional Defense Committees, The Effect of Windmill Farms on Military Readiness 2006. Cannon Air Force Base JLUS. See http://www.currycounty.org/wp-content/uploads/0311_JLUSStudy.pdf

3. Impact of Wind Farms on Military Missions

a. Military moderates its Opposition to Wind Farms.

The military has long recognized that wind farms affect aviation-related military missions. Until recently, the U.S. military leaders generally opposed any wind farm development that could impair any military mission, regardless of mitigation oppositions.

In 2006, a Defense Department study was put in the 2006 Defense Authorization Act -- inserted by Mark Warner and Massachusetts area senators who were attempting to block the Cape Wind offshore wind farm. This study led to more than a dozen large wind projects being halted in various areas throughout the country by "proposed hazard" letters from the Federal Aviation Administration saying the projects must be halted for the Defense department study. See “Wind Power Projects Halted” by By Kari Lydersen, Washington Post, June 10, 2006 http://www.washingtonpost.com/wp-dyn/content/article/2006/06/09/AR2006060901420.html

Also in 2006, the Sierra Club filed a lawsuit arguing that the holds on wind farms due to military radar concerns were in effect halting the entire industry and creating a de facto moratorium on wind farm development. “Fears of Radar Interference Threaten Oregon Wind Farm, but Solutions Exist Software and Hardware Upgrades Can Eliminate the Problems” By Dave Levitan, InsideClimate News, Apr 19, 2010. http://insideclimatenews.org/news/20100419/fears-radar-interference-threaten-oregon-wind-farm-solutions-exist

In 2010, Air Force officials testified before the Texas legislature, indicating that windmills 120 miles from Dyess Air Force Base were interfering with military missions:

> “windmills throughout West Texas could pose a potential hazard to B-1 bombers and C-130 transports that fly missions from the base. More than 2,000 turbines have been built within 100 miles of Dyess and others are farther west.
>
> Starr said base officials have persuaded wind turbine developers to redesign projects to avoid adversely affecting operations on or near the base. But he said wind turbines elsewhere in West Texas can interfere with low-level training missions that can sometimes extend up to 120 miles from the base.
>
> In the worst case, Starr said in a statement, they can form "an unknown and potentially catastrophic hazard to our aircrews."
>
> See Apr 30, 2010 - Dave Montgomery - Fort Worth Star - McClatchy-Tribune Regional News. http://www.geni.org/globalenergy/library/technical-articles/generation/wind/mcclatchy-tribune-regional-news/military-officials-say-wind-turbines-can-stir-up-problems-for-bases/index.shtml

The staunch opposition to any wind farm anywhere dissipated with defense department mandates to be friendlier to renewable energy. A provision was placed in the 2011 Defense Authorization Act that allows energy developers to more easily work with the Defense Department. This is matched by a presidential administration goal, issued in December 2013, to double renewable energy by 2020. See *O’Malley to decide whether all wind turbine projects should be delayed until 2015*, by Jenna Johnson, May 4, 2014 http://www.washingtonpost.com/local/md-

politics/omalley-to-decide-whether-all-wind-turbine-projects-should-be-delayed-until-2015/2014/05/04/059e0212-cc69-11e3-93eb-6c0037dde2ad_story.html.

In recent years, military officials have become circumspect when discussing wind energy issues. Further, the military has now issued official targets that encouraged alternative energy development on military bases. In addition, military officials began working with wind developers to execute letters of agreement that would allow the military to moderate its opposition to wind farms in exchange for mitigation steps for the harmful effects of wind farms on military radars. See *Agreement Between The Department Of Defense, And The Department Of The Navy, And E.On Climate, Renewables, North America, And Petronila Wind Farm, LLC.* http://www.cleanenergylawreport.com/files/2014/12/Petronila-MOA.pdf

In 2013, the military went further. In its 2013 assessment of the impact of climate change on military installations, the Department of Defense stated:

> Climate change will have serious implications for the ability of the Department of Defense to maintain its natural and built infrastructure and to ensure military readiness. The greater threat to our national security is not a wind farm but climate change.
>
> See *Eastern Shore Wind Farm Vs. Naval Air Station: Take 2*, August 14, 2014 By James McGarry, Chief Policy Analyst. http://chesapeakeclimate.org/blog/eastern-shore-wind-farm-vs-naval-air-station-take-2/

b. Reasons for Military concerns with Electromagnetic Interference with Radars

In May 2011, the White House Office of Science and Technology completed an internal decision-making study at the request of the National Security Staff entitled "Report of the Interagency Task Force on the Impacts of Wind Turbines on Electromagnetic Sensing and Communications Capabilities." The report found that wind turbines were interfering with government radars used for national defense, national security, aviation safety, and weather forecasting "by creating clutter, reducing detection sensitivity, obscuring potential targets, and scattering target returns. These effects on radar systems tend to inhibit target detection, generate false targets, interfere with target tracking, and impede critical weather forecasts." Page 8 of *IFT&E Industry Report Wind Turbine-Radar Interference Test Summary*, September 2014. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=http%3A%2F%2Fenergy.gov%2Fsites%2Fprod%2Ffiles%2F2014%2F10%2Ff18%2FIFTE%2520Industry%2520Report_FINAL.pdf&ei=HlaYVYT7DsjcsAXJrqyoBQ&usg=AFQjCNFnJwt5STYrSY007xlDVrbHOQhSlQ&bvm=bv.96952980,d.b2w

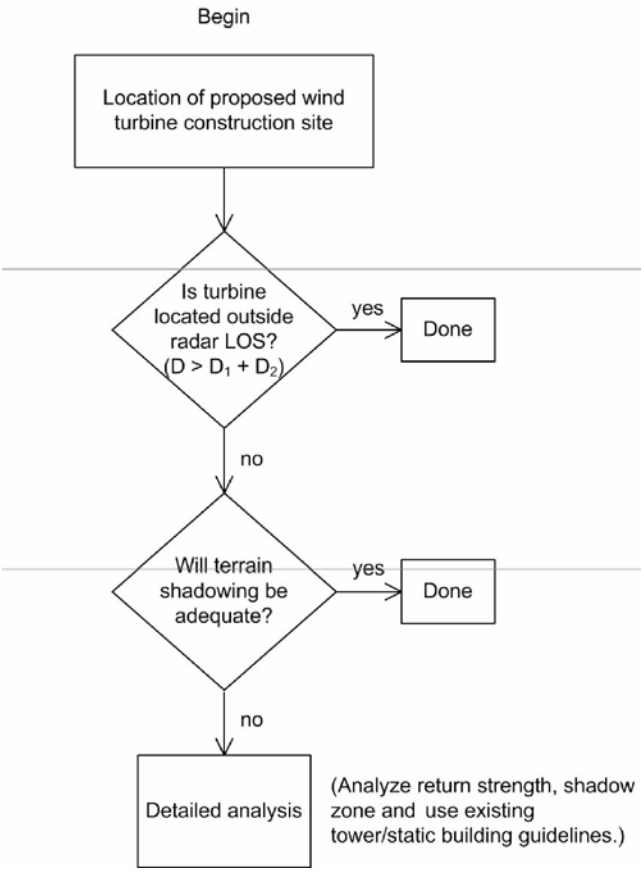
Some of the traditional military opposition to wind farms stems from limitations in the radars themselves. A 2008 Study noted:

> The United States' long range radar infrastructure is aging and inflexible. Perimeter radar systems are typically the ARSR-4, which was designed in the early 1990's. The radars in the interior of the United States are much older. Approximately 80% of the radars are a late 1950's design that was upgraded in the early 1980's; the rest were designed in the early 1970's. In contrast, computing speed has increased 600 fold since the early 1990s. We were told by an independent radar expert (M. Tuley, private communication) that

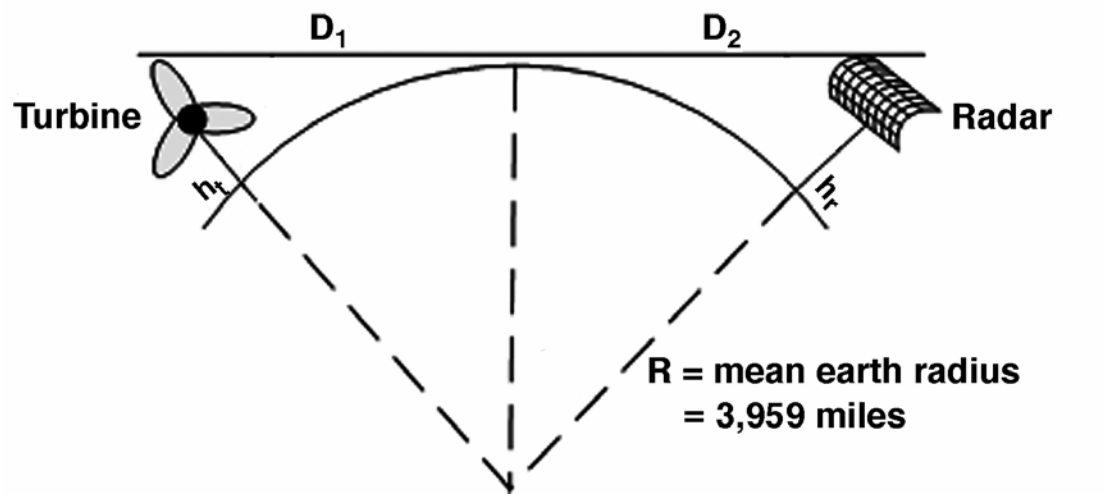
even if the radar beam were physically modified to prevent direct line of site with a wind farm, the processing is often hard wired, and unchangeable for older systems. Unfortunately, some air-security radars are stuck with outdated and inflexible processing capabilities, far less than those of a current laptop computer. Any radar update program should strive to enable the radar to connect to modern computing power, with processors that are easily replaced as computing power continues on its exponential growth curve. Such development will allow flexible evolution of backend signal processing and mitigation algorithms. The limited capability and lack of flexibility in long range primary radar is a national security issue.

See *Wind Farms and Radar*, January 2008 by the Mitre Corporation JSR-08-125 for the US Department of Homeland Security
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=http%3A%2F%2Ffas.org%2Firp%2Fagency%2Fdod%2Fjason%2Fwind.pdf&ei=0mOYVeiXI4axyQTk9YK4Dw&usg=AFQjCNGe3GkF4caOVbXhEEtcchZnETtolw

Some radar studies will focus on the ground based radars that track aircraft. These studies follow the following flowchart to analyze impact:



The Line of Site (LOS) analysis focuses on the whether the radar is within the line of site of the wind turbine.



The refractivity of the atmosphere causes bending of radio waves. This effect can be taken into account by replacing the true earth radius by an effective earth radius. Atmospheric refraction varies widely, depending on the local climate. However, an effective earth radius of 4/3 times the true earth radius is representative of the effect of atmospheric refraction under normal conditions.

For example, the height of the radar above mean sea level is 50 feet and the height of the wind turbine is 300 feet. Therefore, the total LOS distance between the two is (using equation (3)): $D = 1.41(\sqrt{50} + \sqrt{300}) = 34.4$ miles. In other words, if the proposed 300' tall wind turbine farm is greater than 34.4 miles from the radar, no adverse effects on the radar would be anticipated.

The terrain shadowing analysis looks at the effect of terrain on the radar's interaction with a wind turbine.

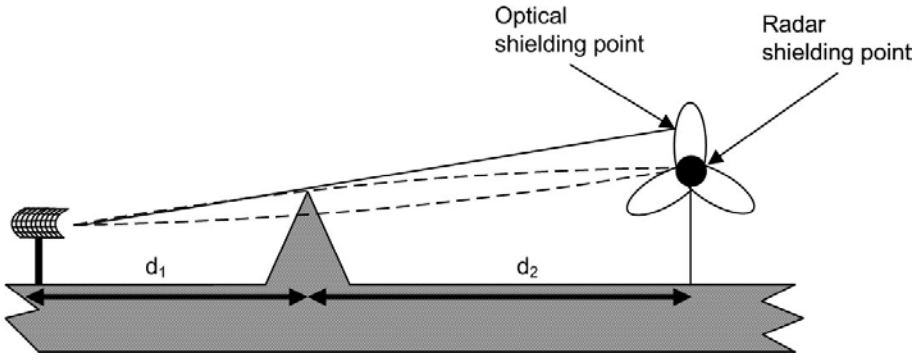


Figure 3. Illustration of first Fresnel zone blockage.

Consider the situation illustrated in Figure 3. The solid line shows the optical shielding point. This is the blocking of the turbine that would be apparent by eye (no significant diffraction). At radar frequencies, however, the dotted lines show the shielding point based on total obstruction of the first Fresnel zone. This radar shielding point can be calculated by subtracting the radius RF of the Fresnel zone from the height of the obscuring object, and then calculating the optical shielding point using this reduced height for the obscuring object. *Assessment of the Effects of Wind Turbines on Air Traffic Control Radars*, July 2008, NTIA Technical Report TR-08-454.

c. Methods of Mitigating Wind Farm / Military Radar conflicts

There are several techniques for mitigating wind farm/radar conflicts:

- **Reduced Radar Cross Section (RCS) Turbines**. There are proposed concepts to modify the size, shape, or materials of the wind turbines themselves, especially focusing on the blades. The objective is to reduce the radar reflectivity of the wind turbine so that it is no longer a meaningful source of clutter to the primary radar. Vestas made an announcement in 2011 about their work in this area, after completing a successful test of a new wind turbine with less radar reflectivity. Vestas is currently manufacturing stealth wind turbines for a 96 MW wind farm in France, which will be the largest in the country. Ferrite paints and crystalline graphite are two of the radar absorbing materials that were used to make a conventional wind turbine stealthy. Applying the reducing materials used on stealth airplanes to entire turbine blades did not work because it reduced wind turbine performance too much. Further, blades typically incorporate a mesh or rod for lightning protection. Adding stealth materials to the leading and trailing edges of the blades was more economical. Replacing glass composites with radar-absorbent materials also helped. However, covering the nacelle and tower with these same materials was a good idea because this approach did not reduce wind turbine performance. Stealth Wind Turbines For 96 MW French Wind Farm, September 17th, 2014 by Jake Richardson http://cleantechnica.com/2014/09/17/stealth-wind-turbines-96-mw-french-wind-farm/

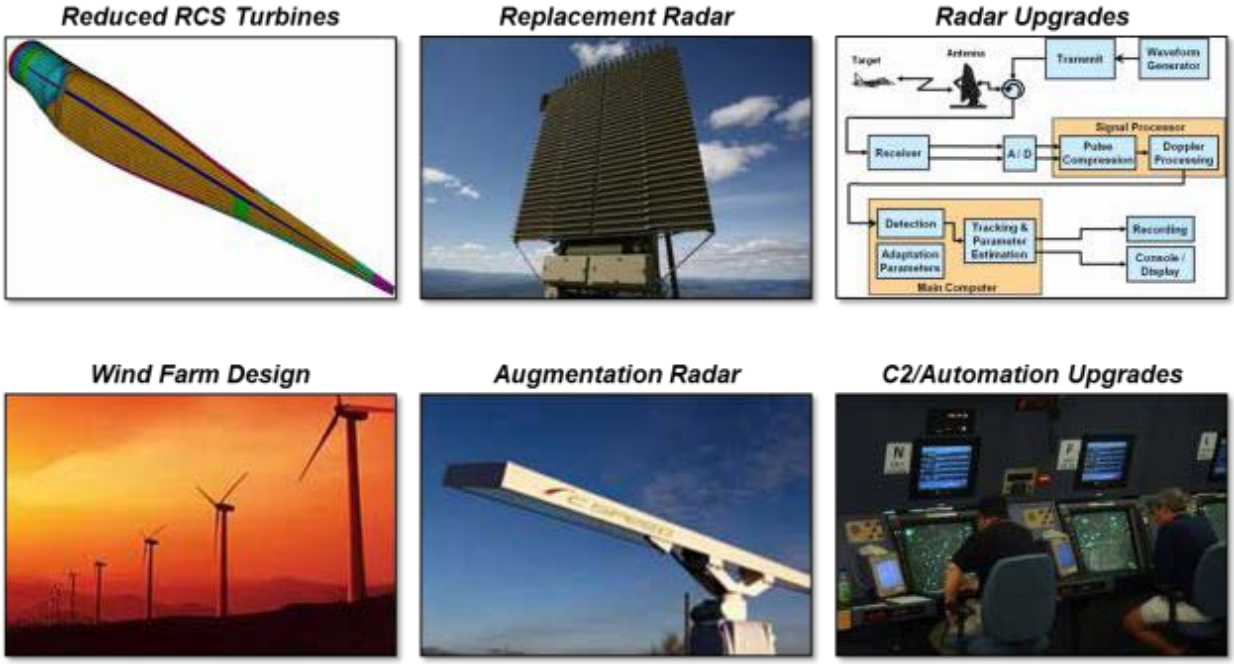
- **Wind Farm Design**. By changing the overall layout, number, or specific locations of turbines within a wind farm, the total impact on surveillance operations may be mitigated. One example of this approach is already frequently applied by placing wind farms out of the line-of-sight of radars. This approach can compromise wind developer priorities seeking the best wind resource.

- **Radar Replacement**. This approach replaces the existing radars with more advanced radars, typically phased array radars with narrow 3D beams and advanced clutter mitigation techniques. These could be placed at current radar sites, or in some cases at alternative, more desirable locations. This is generally the most expensive option for the military. However, it has shown some of the best results in testing.

- **Augmentation Radar**. Also called infill radars. This approach would add radars in or around wind farms to augment the coverage of the existing radar. These radars tend to have a shorter range and higher resolution with the intention of tracking targets in areas that would be lost to the existing radar. In recent testing, infill radar systems tested generally performed better than the existing radars in detecting aircraft in the within/above wind turbine region. While most of these radars were still impacted by wind turbines, their improved resolution typically resulted in a smaller area affected. While questions still persist about infill radar integration and scalability, recently systems tested show promise.

- **Radar Upgrades**. This category includes concepts that would only make changes to the processing within the front or back end of existing radars, and focus on improving the detection process. These improvements may include modifying clutter maps, Constant False Alarm Rates (CFAR), or other filtering or preliminary tracking routines.

- **C2/Automation Upgrades**. This category includes concepts for improving the process at the automation system (e.g., STARS or AMOSS). Generally, this deals with improving tracking performance given the detections. Some examples include improving the tracking logic, or in the fusion process between different radars viewing the same aircraft or area.



See *Industry Report Wind Turbine-Radar Interference Test Summary*, September 2014. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAA&url=http%3A%2F%2Fenergy.gov%2Fsites%2Fprod%2Ffiles%2F2014%2F10%2Ff18%2FIFTE%2520Industry%2520Report_FINAL.pdf&ei=HlaYVYT7DsjcsAXJrqyoBQ&usg=AFQjCNFnJwt5STYrSY007xlDVrbHOQhSlQ&bvm=bv.96952980,d.b2w

For a more comprehensive database of mitigation issues, see http://energy.gov/sites/prod/files/2015/06/f23/Environmental-Projects-Report-6-22-15.pdf

d. Limited Federal Authority to directly require Mitigation of Hazards to Air Navigation

The FAA has the responsibility to evaluate structures and determine whether they present hazards to air navigation. To determine if a structure like a wind turbine will cause an impact on air travel, FAA regulations determine when an obstruction exists and how a study of that object should be conducted. If the FAA determines a potential obstruction is not a hazard to air travel, it issues a Determination of No Hazard. See 14 C.F.R. § 77.31. If the FAA determines a potential obstruction is a hazard to air travel, it issues a Determination of Hazard to Air Navigation. See 14 C.F.R. § 77.31.

> **14 C.F.R. § 77.31. Determinations.**
> (a) The FAA will issue a determination stating whether the proposed construction or alteration would be a hazard to air navigation, and will advise all known interested persons.
> (b) The FAA will make determinations based on the aeronautical study findings and will identify the following:
>
> > (1) The effects on VFR/IFR aeronautical departure/arrival operations, air traffic procedures, minimum flight altitudes, and existing, planned, or proposed airports listed in§ 77.15(e) of which the FAA has received actual notice prior to issuance of a final determination.
> > (2) The extent of the physical and/or electromagnetic effect on the operation of existing or proposed air navigation facilities, communication aids, or surveillance systems.
>
> (c) The FAA will issue a Determination of Hazard to Air Navigation when the aeronautical study concludes that the proposed construction or alteration will exceed an obstruction standard and would have a substantial aeronautical impact.
> (d) A Determination of No Hazard to Air Navigation will be issued when the aeronautical study concludes that the proposed construction or alteration will exceed an obstruction standard but would not have a substantial aeronautical impact to air navigation. A Determination of No Hazard to Air Navigation may include the following:
>
> > (1) Conditional provisions of a determination.
> > (2) Limitations necessary to minimize potential problems, such as the use of temporary construction equipment.
> > (3) Supplemental notice requirements, when required.
> > (4) Marking and lighting recommendations, as appropriate.
>
> (e) The FAA will issue a Determination of No Hazard to Air Navigation when a proposed structure does not exceed any of the obstruction standards and would not be a hazard to air navigation.

This FAA determination of no hazard is not strictly necessary for wind farm construction in most areas. The FAA lacks formal land use control authority over structures on private property. The FAA's only formal legal authority is the ability to require marking, lighting, and communicating the hazard to the flying community. The FAA does not have the authority to directly prohibit construction of a structure that presents a hazard. This authority is reserved for state and local governments.

Nonetheless, as a practical matter, wind farms may encounter difficulties obtaining insurance unless they obtain a Determination of No Hazard. Therefore, this determination is highly sought.

Also, wind farm developers who are building structures offshore or in areas subject to the jurisdiction of other federal agencies will face agency regulations that may require compliance with FAA determinations. See DeLoreto, Michael, "Judicial Review of the Aviation Hazard Determinations for Cape Wind: Why The FAA Got It Wrong" (2014). *Student Scholarship.* Paper 136. http://erepository.law.shu.edu/student_scholarship/136.

The initial step for a wind farm developer with respect to the FAA is notice. Title 14 of the Code of Federal Regulations CFR Part 77 states that any person/organization who intends to sponsor any of the following construction or alterations must notify the Administrator of the FAA. This notification is requested pursuant to 14 CFR § 77.9, which reads as follows:

14 CFR § 77.9 Construction or alteration requiring notice.

If requested by the FAA, or if you propose any of the following types of construction or alteration, you must file notice with the FAA of:

1. Any construction or alteration that is more than 200 ft. AGL at its site
2. Any construction or alteration that exceeds an imaginary surface extending outward and upward at any of the following slopes:
    a. 100 to 1 for a horizontal distance of 20,000 ft. from the nearest point of the nearest runway of each airport described in paragraph (d) of this section with its longest runway more than 3,200 ft. in actual length, excluding heliports
    b. 50 to 1 for a horizontal distance of 10,000 ft. from the nearest point of the nearest runway of each airport described in paragraph (d) of this section with its longest runway no more than 3,200 ft. in actual length, excluding heliports
    c. 25 to 1 for a horizontal distance of 5,000 ft. from the nearest point of the nearest landing and takeoff area of each heliport described in paragraph (d) of this section.
3. Any highway, railroad, or other traverse way for mobile objects, of a height which, if adjusted upward 17 feet for an Interstate Highway that is part of the National System of Military and Interstate Highways where overcrossings are designed for a minimum of 17 feet vertical distance, 15 feet for any other public roadway, 10 feet or the height of the highest mobile object that would normally traverse the road, whichever is greater, for a private road, 23 feet for a railroad, and for a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it, would exceed a standard of paragraph (a) or (b) of this section
4. Any construction or alteration on any of the following airports and heliports:
    a. A public use airport listed in the Airport/Facility Directory, Alaska Supplement, or Pacific Chart Supplement of the U.S. Government Flight Information Publications
    b. A military airport under construction, or an airport under construction that will be available for public use
    c. An airport operated by a Federal agency or the DoD
    d. An airport or heliport with at least one FAA approved instrument approach procedure
5. You do not need to file notice for construction or alteration of:

a. Any object that will be shielded by existing structures of a permanent and substantial nature or by natural terrain or topographic features of equal or greater height, and will be located in the congested area of a city, town, or settlement where the shielded structure will not adversely affect safety in air navigation

b. Any air navigation facility, airport visual approach or landing aid, aircraft arresting device, or meteorological device meeting FAA-approved siting criteria or an appropriate military service siting criteria on military airports, the location and height of which are fixed by its functional purpose

c. Any construction or alteration for which notice is required by any other FAA regulation

d. Any antenna structure of 20 feet or less in height, except one that would increase the height of another antenna structure.

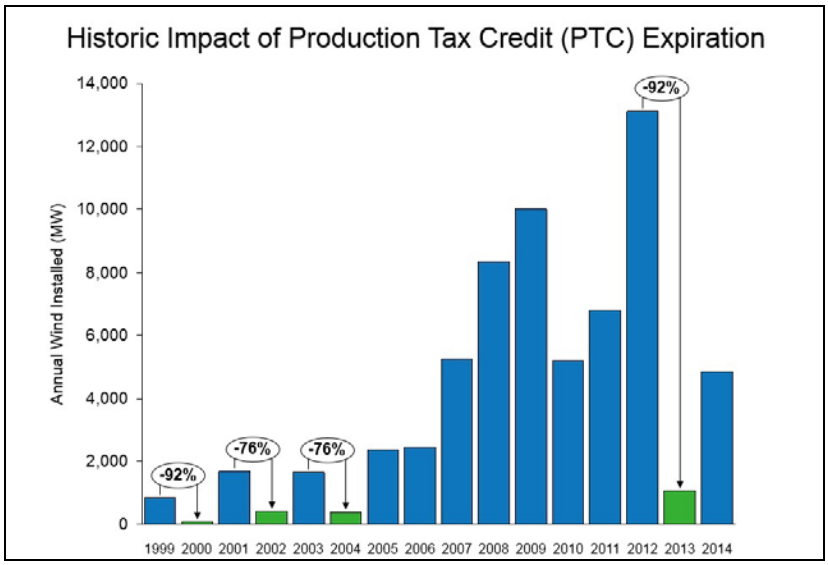
Persons failing to comply with the provisions of FAA Part 77 are subject to a civil penalty under Section 902 of the Federal Aviation Act of 1958, pursuant to 49 U.S.C. Section 46301(a).

Once a determination has been made, the FAA provides an internal appeals process called a Petition for Discretionary Review. Petitions for Discretionary Review, 14 C.F.R. §§ 77.37 through 77.41. The intent of this review is so individuals who were not given a prior opportunity can put forth substantive aeronautical comments related to the proposal, such as alleged impacts on air travel and radar systems. The Petition must include "new information or facts not previously considered or presented during the aeronautical study, including valid aeronautical reasons why the determination . . . made by the FAA should be reviewed." To provide further internal guidance, the FAA issued Order JO 7400.2G, which creates uniform procedures to be used in the administration of airspace management. FED. AVIATION ADMIN., PROCEDURES OF HANDLING AIRSPACE MATTERS, Order JO 7400.2G (April 10, 2008) *available at* http://www.faa.gov/documentLibrary/media/Order/7400.2G.pdf (hereafter cited as "Order JO 7400.2G"). For a complete list of further steps that can be taken in addressing wind turbine issues, see DeLoreto, Michael, "Judicial Review of the Aviation Hazard Determinations for Cape Wind: Why The FAA Got It Wrong" (2014). *Student Scholarship.* Paper 136. http://erepository.law.shu.edu/student_scholarship/136.]

4. Incentives for Wind Farm Development

a. Wind Energy Production Tax Credit

The primary federal incentive for wind farm development is the wind energy production tax credit. It has been enacted sporadically since 1992 and allowed to expire. Most recently, it was re-enacted in the last two weeks of 2014, but applied to all of the projects established in 2014. It is criticized as an inefficient means of promoting alternative energy. The Joint Committee on Taxation estimated the provision would cost $6.4 billion as the government provides a 10-year tax credit of 2.3 cents for every kilowatt-hour of electricity produced at projects that begin construction in 2014. http://breakingenergy.com/2014/12/17/wind-power-getting-the-ptc-extension-it-didnt-want/



https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0CAcQjRw&url=http%3A%2F%2Fwww.fierceenergy.com%2Fstory%2Fproduction-tax-credit-essential-wind-growth%2F2015-06-02&ei=65yZVfLBGsf9tQWcmaPgCw&psig=AFQjCNEdYfQBXl9tC_-gCxNW3CgVygJWUw&ust=1436216932813835

b. IRS Extension of Tax Credit

The PTC initially expired at the end of 2013 (but was extended in the last two weeks of 2014. The IRS issued guidance that has effectively extended the ability of projects in construction at the end of 2014 to qualify for the PTC as long as they are constructed by the end of 2016.

When Congress extended the wind energy production tax credit (PTC) at the beginning of 2013, it relaxed the terms upon which developers could qualify for the credit by requiring projects to "begin construction" by the end of 2013, the expiration date of the PTC. The IRS released guidance a few months later defining what it meant to begin construction. https://www.masterresource.org/production-tax-credit-ptc/irs-interpretation-rescuing-wind/

The IRS provided two methods for determining when construction began. Projects must start "physical work of a significant nature" by the deadline or, in the alternative, developers could meet the five-percent safe harbor rule. Since Congress did not mandate a project in-service date, the IRS introduced a rule requiring projects show "continuous construction" as a backstop to

ensure that projects could not be delayed for an indefinite period and still claim the PTC. Considerable debate followed regarding how the IRS would enforce "continuous construction." This ultimately led to the IRS releasing a second guidance wherein it offered developers the generous rule that if they were to get their projects in-service by Jan 1, 2016, the IRS would not closely scrutinize their development efforts. In effect, the IRS imposed a 2015 deadline for projects that wind developers took seriously and raced to meet. More than a year after the IRS released its first guidance, and six months after the PTC had expired, however, the wind industry was still complaining that the rules defining 'begin construction' were too vague. By August 2014, the IRS responded with new guidance that further relaxed the requirements by, in part, lowering the 5 percent safe harbor requirement to 3 percent.

On December 19, 2014, President Obama signed into law H.R. 5771, the Tax Increase Prevention Act (TIPA), which extended the PTC until December 31, 2014. The US Internal Revenue Service (the IRS) later released Notice 2015-25, which updated previously issued guidance to reflect the recent one-year extension of the renewable electricity production tax credit (the PTC) under Section 45 of the Internal Revenue Code of 1986 (the Code).

In accordance with TIPA, the Notice 2015-25 replaced all references to "January 1, 2014" in the Prior Guidance as they relate to the beginning of construction date with "January 1, 2015." Thus, the Prior Guidance was modified to take into account the one-year extension of the PTC, and a taxpayer was allowed to use the methods set forth in the Prior Guidance to establish that construction of a facility began in 2014. Furthermore, consistent with the one-year extension of the beginning of construction date, Notice 2015-25 extended the placed-in-service date for the deemed satisfaction of the continuous program of construction and continuous efforts requirements to January 1, 2017. https://www.mayerbrown.com/pt/IRS-Updates-Begun-Construction-Guidance-to-Reflect-One-Year-Extension-of-the-Production-Tax-Credit-03-12-2015/.

Under Notice 2015-25, if a developer began construction of a facility before January 1, 2015, and places the facility in service before January 1, 2017, the continuous program of construction and continuous efforts requirements are deemed satisfied, regardless of the amount of physical work performed or the amount of costs paid or incurred with respect to the facility before January 1, 2017.

c. State and Local Incentives for Wind Energy Development

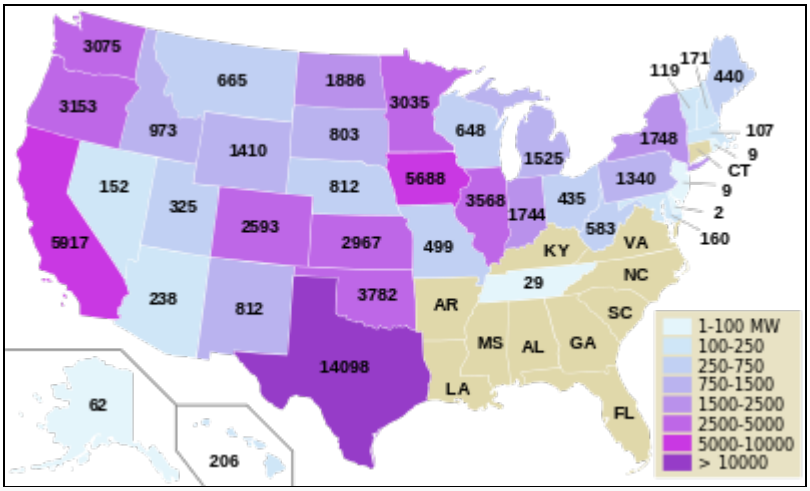
State and local incentives for wind energy development are extensive. Renewable power standards vary from 10% (Wisconsin) to 40% (Hawaii). Other states focus their incentives on tax exemptions, tax credits, and grants. For a comprehensive overview of these incentives, see Database of State Incentives for Renewables & Efficiency. http://www.dsireusa.org/ Less direct subsidies include the installation of subsidized transmission lines from wind-rich areas to population centers with energy demand.

5. Special Challenges in balancing Military Needs with Wind Farm Development in Texas

a. Lack of Local Regulatory Authority over Areas outside of Municipal Boundaries in Texas has led to massive expansion of wind power in Texas

Texas takes a hands-off approach to the regulation of land development outside of cities. In the past five years, Texas provided for the construction of a 3,600 mile network of transmission lines from high wind areas to high demand areas. This new transmission system, combined with Texas' light regulation in rural areas led to the most extensive expansion of wind energy of any state. Texas produced more than 10% of its electricity from wind in 2015. Due to the size of the Texas electricity market (equivalent to California, Arizona, and Nevada combined), combined with the presence of several high wind areas, Texas is installing wind capacity at a far greater rate than any other state. In 2014, Texas installed more than a third of the nation's new wind capacity. http://blogs.edf.org/texascleanairmatters/2015/07/02/texas-wind-energy-infrastructure-lives-on-for-now/

As the following map shows, the middle section of the country is the source of most of the wind energy in the U.S. This creates challenges for protecting the usefulness of military bases in Texas.



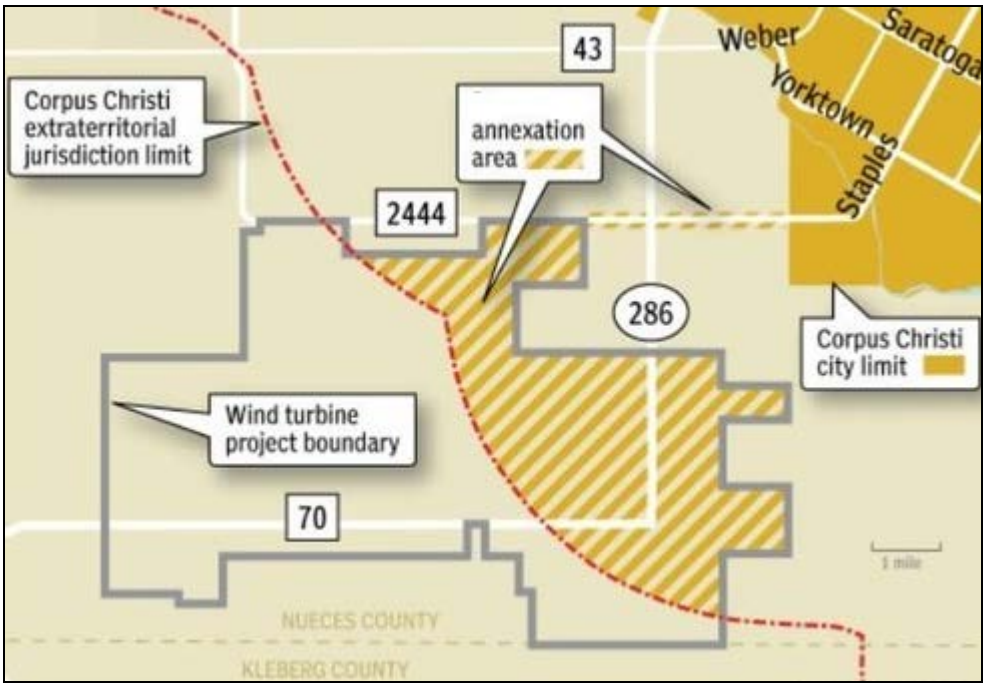
Map illustrating installed wind generating capacity for U.S. states at end of 2013
https://upload.wikimedia.org/wikipedia/commons/thumb/7/71/US_Installed_Wind_Power_Capacity.svg/400px-US_Installed_Wind_Power_Capacity.svg.png

b. Wichita Falls' approach – Limit county property tax abatement

Military cities have been faced with special challenges in dealing with the expansion of wind energy. In Wichita Falls, the Joint Land Use Study conducted for the Sheppard Air Force Base identified wind energy development as one of the main problems facing local missions. To address this development, the Sheppard JLUS focused on controlling County-issued tax abatements. As a practical matter, county taxes in Texas are relatively low; therefore, this will probably have limited effect.

c. Corpus Christi's Experience – Resultant Annexation

The Corpus Christi Naval Air Station Joint Land Use Study identified wind farm development as a major problem. Some of the areas near Corpus Christi are subject to U.S. Corps of Engineers jurisdiction, enabling the City to rely on Part 77 FAA approval. Unfortunately, the City is left with few options to protect the Naval Air Station from incompatible development outside its territory. Consequently, when a nearby wind developer pursued plans to develop a windfarm in in 2014, the City responded by annexing the portion of the wind development area that was in the City's extraterritorial jurisdiction.



d. Challenges to Annexation Approach to Regulation

Aggressive annexation approaches, such as the approach followed by Corpus Christi in 2014, led to political battles that were waged with newspaper advertisements and extensive lobbying. The wind developer offered to provide extensive but incomplete mitigation of the impacts of the proposed wind farm on the military base. The City now faces the task of providing state-required utility services to the annexed area. The lack of a wide seam of contiguity between the City and the annexed area enhanced the challenge of providing these services.