

Areas of industrial wind facilities*

<u>facility</u>	<u>capacity/area</u> †	<u>acres/MW</u>
Mojave Co., Ariz.	425 MW/24,527 acres	58
Snowflake, Ariz.	99 MW/7,000 acres	71
Altamont Wind Resource Area, Calif.	580 MW/50,000 acres	86
Fountain Wind, Shasta Co., Calif.	347 MW/37,436 acres	108
Montezuma Hills, Calif.	180 MW/6,800 acres	38
Pine Tree Wind Farm, Tehachapi Hills, Calif.	135 MW/8,000 acres	59
Tule Wind Project, East County, Calif.	131.5 MW/12,000 acres	91
Cheyenne Ridge Wind Project, Colo.	500 MW/100,000 acres	200
Colorado Green, Lamar	162 MW/11,840 acres	73
Prairie Wind, Colo.	69 MW/7,000 acres	101
Twin Buttes, Colo.	75 MW/9,000 acres	120
Winergy offshore, Del.	1,101 MW/67 mi ²	40
Cassia County, Idaho	200 MW/4,500 acres	23
Boone County, Ill.	27 MW/800 acres	30
Baileyville Wind Farm, Ogle County, Ill.	80 MW/5,000 acres	62
Big Sky, Ill.	75 MW/10,000 acres	133
Bishop Hill, Ill.	400 MW/25-30,000 acres	62-75
Crescent Ridge, Ill.	54.5 MW/2,200 acres	40
LaSalle Country, Ill.	384.5 MW/25,000 acres	65
Mendota Hills, Ill.	50.4 MW/3,500 acres	69
Rail Splitter, Ill.	100.5 MW/11,000 acres	109
Twin Groves Wind Farm, McLean County, Ill.	396 MW/21,000 acres	53

Walnut Ridge, Bureau County, Ill.	225 MW/14,000 acres	62
Jordan Creek Wind Farm, Warren County, Ind.	300 MW/27,000 acres	90
Cerro Gordo, Iowa	42 MW/2,110 acres	50
Franklin County, Iowa	200-300 MW/40,000 acres	133-200
Pomeroy Wind Farm, Pocahontas County, Iowa	198 MW/8,200 acres	41
Elk River, Kan.	150 MW/8,000 acres	53
Ford County, Kan.	100.5 MW/5,000 acres	50
Smoky Hills, Kan.	100.8 MW/20,000 acres	198
Spearsville, Kan.	100 MW/10 mi ²	64
Cape Wind (off shore), Mass.	420 MW/24 mi ²	37
Harvest Wind Farm, Mich.	53 MW/3,200 acres	60
Huron County, Mich.	48 MW/4,700 acres	98
Muskegon, Mich.	31.5 MW/8,000 acres	254
Goodhue Wind Project, Minn.	78 MW/32,700 acres	419
Grand Meadow Wind Farm, Dexter, Minn.	100.5 MW/10,000 acres	100
Palmer's Creek Wind Farm, Minn.	44.6 MW/6,150 acres	138
Pleasant Valley Wind Farm, Minn.	300 MW/80 mi ²	171
Trimont Area Wind Farm, Minn.	100.5 MW/8,900 acres	89
Bluegrass Ridge, Mo.	56.7 MW/7,000 acres	123
Judith Gap, Mont.	135 MW/8,300 acres	61
Pierce County, Mont.	150 MW/72 mi ²	307
Ainsworth, Nev.	59 MW/11,000 acres	185
Colfax County, N.M.	20 MW/800-1,200 acres	20
Grant County, N.M.	2150 MW/25 mi ²	64
Cherry Valley, N.Y.	60 MW/1,200 acres	40-60
Fenner, N.Y.	30 MW/1,500 acres	50

Gore Mountain, N.Y.	27.5 MW/1,700 acres	62
High Sheldon, N.Y.	112.5 MW/10,000 acres	89
Long Island Sound, N.Y.	140 MW/8 mi ²	37
Pasquotank and Perquimans Counties, N.Car.	208 MW/34 mi ²	105
Pierce County, N.Dak.	150 MW/72 mi ²	307
Velva, N.Dak.	12 MW/3 mi ²	160
Wilton Wind Energy Center, N.Dak.	49.5 MW/8,000+ acres	162
Black Fork Wind Farm, Ohio	201.6 MW/46,000 acres	228
Blue Canyon V, Okla.	99 MW/12 mi ²	78
Arlington, Ore.	104 MW/14,000 acres	135
Biglow Canyon, Ore.	350-450 MW/25,000 acres	56-71
Elkhorn Valley, Ore.	101 MW/10,000 acres	99
Shepherds Flat, Ore.	750 MW/32,000 acres	43
Forkston Twp., Pa.	75-125 MW/7,400 acres	59-99
Block Island, R.I.	>1,000 MW/>260 mi ²	166
Titan I, Hand County, S. Dak.	25 MW/7,500 acres	300
Galveston Offshore, Texas	150 MW/11,355 acres	76
Desert Sky, Texas	160.5 MW/15 mi ²	60
Horse Hollow, Texas	735 MW/47,000 acres	64
Pampa Wind Project, Texas	4,000 MW/400,000 acres	100
Stanton, Texas	100 MW/12,000 acres	120
Wildorado Wind Ranch, Texas	161 MW/16,000 acres	75
Milford Wind Corridor, Utah	300 MW/40 mi ²	85
Sheffield, Vt.	52 MW/3,000 acres	58
Big Horn, Wash.	200 MW/15,000 acres	75

Desert Claim, Wash.	180 MW/5,237 acres	29
Hopkins Ridge, Wash.	150 MW/11,000 acres	73
Kittitas Valley, Wash.	181.5 MW/6,000 acres	34
Klondike II, Sherman County, Wash.	75 MW/6,400 acres	98
Linden Wind Farm, Wash.	50 MW/1,800 acres	36
Lower Snake River, Wash.	1,250 MW/94,900 acres	76
Nine Canyon, Kennewick, Wash.	63.7 MW/5,120 acres	80
Wild Horse, Wash.	64 MW/7,500 acres	118
Mountaineer, W.V.	66 MW/4,400 acres	67
Bent Tree, Freeborn County, Wis.	200 MW/32,000 acres	160
Forward Wind Energy Center, Wis.	200 MW/32,400 acres	162
Kewaunee County, Wis.	11 MW/603 acres	54
Monroe County, Wis.	80 MW/10,000 acres	125
Evanston, Wyo.	144 MW/7,800 acres	54
Campbell County, Wyo.	199.5 MW/14,000 acres	70
Converse County, Wyo.	200 MW/17,000 acres	85
Naikun Offshore, Hecate Strait, Br. Col.	396 MW/100 km ²	62
Blue Highlands, Ont.	49.5 MW/4,500 acres	91
Sederglan Wind Farm, Alb.	70.5 MW/3,900 acres	131
St. Joseph Wind Farm, Man.	138 MW/125 km ²	224
Prince I & II Wind Energy Project, Ont.	189 MW/10,000 hectares	55
Thunder Bay, Ont.	100 MW/8,000 acres	80
Anse-a-Valleau, Que.	100.5 MW/4,800 hectares	118
Stanstead Station, Que.	62 MW/920 hectares	37
Eurus wind park, Juchitán, Oaxaca	250.5 MW/6,178 acres	25
Codrington, Australia	18.2 MW/240 hectares	33

Dollar Wind Farm, Australia	79.2 MW/2,000 hectares	62
East Otago, Australia	650 MW/300 mi ²	295
Macarthur, Australia	334 MW/5,500 hectares	47
Ruševo-Krmpotsko, Croatia	90 MW/27 km ²	74
Horns Rev (off shore), Denmark	160 MW/24 mi ²	96
Horns Rev II (off shore), Denmark	209 MW/35 mi ²	107
Butendiek (off shore), Germany	240 MW/35 km ²	36
Duddon Sands (off shore), U.K.	500 MW/66 km ²	33
London Array, Thames Estuary (off shore)	1,000 MW/245 km ²	61
Walney (off shore), U.K.	450 MW/74.5 km ²	41
Walney Extension (off shore), U.K.	659 MW/145 km ²	54
E. Ayrshire, Dumfries, Galloway, Scotland	300 MW/8,000 hectares	67
Beinn Ghlas, Scotland	8.4 MW/300 hectares	88
Braes of Doune, Scotland	72 MW/1,000 acres	14
Lewis, Scotland	600 MW/45 mi ²	50
Novar, Scotland	17 MW/300 hectares	44
Sutherland, Scotland	50 MW/2,731 hectares	135
Windy Standard, Scotland	21.6 MW/350 hectares	40
Carno, Wales	33.6 MW/600 hectares	44
Makara Hills, New Zealand	210 MW/55 km ²	65
Quartz Hill, New Zealand	210 MW/3,000 hectares	35
Egypt (off shore)	2200 MW/1,600 km ²	180

*** The data are gathered mostly from news articles, some from government and company documentation. The list includes proposed (and possibly rejected) as well as operating facilities. Ridgeline facilities described only by length instead of the whole area taken are not included. An August 2009 study for the National Renewable Energy Laboratory**

examined land-use data for 172 projects, representing about 80% of the installed and targeted wind capacity in the U.S., and found an average area of 85 acres/MW.

According to "Permitting setbacks for wind turbines and the blade throw hazard," by Scott Larwood, presented at the 2004 California Wind Energy Collaborative Forum, University of California, Davis, the distance that turbines should be from each other for minimal wind interference is 3 rotor diameters when aligned perpendicular to the wind and 10 rotor diameters when parallel to the wind. This is also the spacing described by the New York State Energy Research and Development Authority and others. The minimum area required (where d is the rotor diameter) around each turbine in a single line where the wind is generally from one direction would therefore be $13d$ ($10d$ fore and $3d$ aft) \times $3d$, with an extra $1.5d$ at each end. The minimum area in an array would be $10d \times 10d$, with an extra $5d$ border.

For a stand-alone turbine, the area required would be a $13d \times 6d$ oval at a site where the wind is generally from one direction and up to a $20d$ -wide circle to use the wind from any direction. Depending on surrounding features, very tall towers allow reducing the area for a stand-alone turbine or a single line to some extent.

The GE 1.5-MW turbine, with a 70.5-m rotor span, therefore requires at least 38 acres per tower in a single line perpendicular to the wind (25 acres/MW) or 96 acres per tower in an array (64 acres/MW). Each Vestas V90 1.8-MW turbine, with a 90-m rotor diameter, requires 61-157 acres (34-87 acres/MW). Tom Gray of the American Wind Energy Association has written, "My rule of thumb is 60 acres per megawatt for wind farms on land."

That may still not be enough for maximum efficiency. More recent research at Johns Hopkins University by Charles Meneveau suggests that large turbines in an array need to be spaced 15 rotor diameters apart, increasing the above examples to 145-197 acres required per installed megawatt in an array.

Note that larger turbines are not substantially more efficient than small ones, because they require proportionally more space.

† ***Remember that capacity is different from actual output.*** Typical average output is only 25% of capacity, so the area required for a megawatt of actual output is four times the area listed here for a megawatt of capacity. And because three-fifths of the time wind turbines produce power at a rate far below average, even more ($2.5\times$, perhaps, for a total of $10\times$) -- dispersed across a wide geographic area -- would be needed for any hope of a steady supply.

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