Science AMA: I'm Alice Orrell, a researcher at Pacific Northwest National Laboratory (PNNL) where we are examining the future of clean, wind-generated energy at your home or business. AMA!

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Abstract

Hi Reddit! When most people think about producing electricity at a private business or residence, they think of solar panels on rooftops. This is one form of 'distributed energy' or distributed generation. Just like rooftop solar panel, distributed wind systems can also produce electricity that is consumed on site or locally. A growing number of business owners and homeowners are using distributed wind power, thanks to innovative business models and other trends – all documented in a report our team prepared for the Department of Energy. What is distributed wind power? It is wind power generated near where it will be used rather than being generated at large wind farms and then transmitted to the power grid. Distributed wind can range from a small, solitary turbine at a remote cabin to several large turbines powering a manufacturing facility. I like to call distributed wind "clean, homegrown energy." ** Thank you Reddit, I've enjoyed fielding your questions and will check back in later to follow up on these threads. Once again, the Department of Energy's Distributed Wind Market Report is at http://energy.gov/eere/wind/downloads/2016-distributed-wind-market-report. I also encourage you to follow PNNL on Facebook at www.facebook.com/PNNLgov and Twitter at @PNNLab and for more energy-focused topics on Twitter, @energyPNNL. You'll also find PNNL on Google+ and LinkedIn. Thanks!

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ALICEORRELL R/SCIENCE

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Hi and thanks for joining us today!

What are your thoughts on the use of phase-change materials for small-scale thermal energy storage vs lead-acid batteries?

PHealthy

Hi!

Battery technology isn't really my area of expertise! We do a lot of battery research here at PNNL, though. If you're interested in learning about that you can check out: http://energystorage.pnnl.gov/grid.asp. You won't find much on lead-acid batteries, though. Bit of an "old" technology.

I'm curious about economics. Is there a breakeven point at/near current commercial price levels? Any thoughts about equipment longevity, too?

ALR3000

Hello, thanks for the question!

The cost effectiveness of a distributed wind energy system depends on many factors - your site's wind resource, the amount of land space you have, turbine and tower equipment costs, annual maintenance costs, the availability of incentives, and your current electricity rate from the utility.

The energy from a behind-the-meter distributed wind project typically displaces a retail electricity rate, so a breakeven point can vary.

Levelized cost of energy (LCOE) is a function of a project's costs (installed and operation & maintenance) divided by its annual energy production. The energy from behind-the-meter distributed wind projects typically displaces retail electric rates, so it is fair to compare a project's LCOE to the retail rate it avoids.

In the Distributed Wind Market Report, we analyzed performance and cost for a wide range of projects. For our project dataset sample, the large turbine project average LCOE was 5¢/kWh. The midsize turbine project average LCOE was 8¢/kWh. The small wind average LCOE was 24¢/kWh, but we've also seen LCOEs in the 11-12¢/kWh range and lower. According to the U.S. EIA, average residential retail electric rates in the continental United States range from 9.3¢ to 20¢/kWh, which small wind turbines are most likely to displace, and average commercial rates range from 7.5¢ to 15¢/kWh, which mid-size and large turbines could displace. Hawaii, Alaska, Puerto Rico, the USVI, and Guam have higher rates, making distributed wind more cost competitive in those areas.

For example, we know of a 7.5 kW wind turbine that was installed at a remote telecommunications site. The electricity from the wind turbine would displace diesel generator power where the diesel had to be helicoptered in. So even though that project had fairly high installation costs, it was still cost effective because it was displacing very high energy costs.

Small wind turbines can operate for 20-30 years. Following the preventative maintenance schedule recommended in the manufacturer's owners' manual is recommended.

Thanks for coming to talk with us today! Can wind energy work anywhere, or is it only economically viable in windier areas? If the area matters, where is windier? How does it vary broadly by region and also on a smaller scale by exact location (like on a hill)?

asbruckman

The key factor for a wind project is the wind resource!

For small wind systems, you generally need at least an annual average wind speed of 4 m/s at a height of 30 m for a wind project to make sense.

To get a general idea if your region has good wind resources, look at the WINDExchange Wind Resources page, which has state wind maps (https://windexchange.energy.gov/maps-data), or the NREL WIND Toolkit Distributed Wind Resource layer (https://maps.nrel.gov/wind-prospector/?visible=wind_3tier_site_metadata#/?aL=0&bL=groad&cE=0&lR=0&mC=40.21244%2C-91.625976&zL=4).

The maps will show you if wind speeds in your area are strong enough to further investigate the wind resource. Of course, the maps are just a starting point—the actual wind resource on your site will vary depending on topography and structure interference. And a localized site with good winds, such as a ridge top, may not show up on the maps. If you suspect there is a viable wind resource on your site and you would like to proceed with evaluating the feasibility of installing a distributed wind system, we encourage you to contact a distributed wind installer in your area to conduct site and resource assessments.

You can have varied wind resources within the same property. If you live in complex terrain, an installer will assist you in selecting the most productive installation site. If you site your wind turbine on the top or on the windy side of a hill, for example, you will have more access to prevailing wind than in a gully or on the leeward (sheltered) side of a hill on the same property. Your installer will assist you in considering existing obstacles and planning for future obstructions, including trees and buildings, which could block the wind.

For more information, please consult WINDExchange's Small Wind Guidebook (https://windexchange.energy.gov/small-wind-guidebook)or contact the Distributed Wind Energy Association (http://distributedwind.org/home/) to find a small wind installer in your area.

What do you think is currently the best market for distributed wind?

Do you believe the distributed wind learning curve will mirror that of large wind? What do you believe the LCOE will be in 2030?

Do you see any future for small, often roof (or other structure) mounted vertical axis wind turbines? I'm thinking of the sort installed at this Whole Foods in Brooklyn or at Lincoln Financial Field.

boo_baup

Three key factors create a good distributed wind market: wind resource, policy, and cost of electricity. The best market for distributed wind is where the wind resource is strong, the cost of electricity your system would displace is high, and your jurisdiction has favorable wind energy policies (i.e., incentives, net metering, streamlined interconnection standards).

Many people want to put wind turbines, both vertical-axis and horizontal-axis, in urban, or built, environments, and on rooftops because of the visibility. Installing a wind turbine is synonymous with 'going green.'

But it is challenging to accurately estimate the wind resource in a built environment. Houses and trees can obstruct wind flow and cause turbulence. Now think about large buildings and urban infrastructure. You can try to model the wind flow around a building or on a rooftop, but it is expensive and still does not provide a dependable estimate. There are just too many variables. Then, because of the unknown resource and the turbulent environment, these turbine installations typically underperform. And they are more expensive to install.

It is generally not recommended to put turbines – horizontal axis or vertical axis - on rooftops or in built environments. You want tall towers in areas free of obstructions so you can generate cost-effective energy reliably.

For more information about wind turbines in the built environment, you can look at this report: https://www.nrel.gov/docs/fy16osti/65622.pdf.

How much do wind turbines affect air flow near them? And if it's a significant amount do wind farms run into issues where they interfere with themselves?

E-Dupes

Yes, the air flow around one wind turbine can affect the air flow at the next turbine downstream in a wind farm. This is called wake effect. During the wind farm design process, turbine spacing is optimized to minimize wake effect.

The U.S. Department of Energy DOE's Atmosphere to Electrons (A2e) project is looking at ways to

improve the whole wind plant performance, not just individual turbine performance. You can learn more here: https://a2e.energy.gov/.

I've read that the problem with household size wind generators is that they are noisy. Has the technology improved in recent years to make them quieter?

nebulou

Wind turbines can create two kinds of sound: a mechanical hum produced by the generator and a "whooshing" sound produced by the blades moving through the air. The vast majority of wind turbines are designed so that the turbine rotor is upwind of the tower, which mitigates low-frequency and impulsive sound. The presence of turbine sound depends on atmospheric conditions, and the ability for humans to perceive wind turbine sound varies based on the presence of other nearby sources of sound and site-specific topography. However, the sound pressure levels for modern wind turbines at distances greater than 400 meters are typically less than 40 decibels (dBA), which is comparable to the lowest limit of urban ambient sound.

Small wind turbines certified to the American Wind Energy Association 9.1-2009 standard are tested for their rated sound level. The rated sound level is the sound pressure level (dBA) not exceeded by the wind turbine 95% of the time at a distance of 60 meters from the rotor with an average wind speed of 5 m/s (11.2 mph). You can see a list of certified small wind turbines and their rated sound levels here: http://www.irecusa.org/credentialing/certified-small-wind-turbines/

Depending on the site, proximity to nearby residences, and the permitting regulations, wind farm developers are typically required to address potential sound issues in the permitting process through setback requirements and must demonstrate that the project will comply with the applicable sound level regulations. Setbacks are standards defined to create space between areas of concern and the wind project. Common areas of concern include property lines, inhabited structures, and public roads, as well as communication and electrical lines. Sound requirements create a standard maximum level of allowed sound due to the operation of wind systems. These standards often include a defined method of measuring sound level. There are no national or international defined standards for wind turbine setbacks, with many organizations or local governments defining their own standards, typically incorporated into town or county ordinances.

For more information, see the (https://windexchange.energy.gov/projects/sound) on wind turbine sound and the list of other resources on OpenEI: Sound (https://openei.org/wiki/Sound).

Hi there!

I must say that I'm completely ignorant about this topic but I'm extremely curious.

So, solar panels look like a very simple thing to install at an apartment complex, without any significant loss of efficiency compared to a dedicated installation.

Are there mini-wind turbines (what do you need for one household? 1 kW? 3 kW?) that you can just put on your roof? I've scrolled quickly around your report and I've seen like a farm with 3 100 kW turbines over some very high poles. It doesn't seem like something that one could install at home!

lucaxx85

Glad you are interested in learning more!

A lot of factors play in role in deciding how big your distributed generation system should be. For rooftop solar, you may simply be limited by your roof size. For a small wind turbine, you generally need

about 1 acre of land so your turbine can have space away from ground obstructions, trees, property lines, and buildings. An experienced installer can help you properly site a small wind turbine.

A general piece of advice is to think about how you can reduce your household electricity demand first before installing distributed generation. What energy efficiency measures can you pursue (e.g., insulation, energy efficient appliances) to lower your electricity demand before sizing your system.

1 kW to 10 kW turbines are generally the size for households and small farms.

You do want a tall tower – wind speeds are higher at higher elevations – and taller towers get the turbine farther away from ground obstructions.

There are mini-wind turbines in the market. You'll see 400 W and 160 W turbines on sailboats and paired with solar PV panels to be power sources for remote locations.

We do NOT recommend installing wind turbines on rooftops!

Many people are interested in putting wind turbines in urban, or built, environments and on rooftops. It is challenging to accurately estimate the wind resource in a built environment. Houses and trees can obstruct wind flow and cause turbulence. Now think about large buildings and urban infrastructure. You can try to model the wind flow around a building or on a rooftop, but it is expensive and still does not provide a dependable estimate. There are just too many variables. Then, because of the unknown resource and the turbulent environment, these turbine installations typically underperform. And they are more expensive to install.

It is generally not recommended to put turbines on rooftops or in built environments. You want tall towers in areas free of obstructions so you can generate cost-effective energy reliably!

1-Hey, is it possible to produce electricity (directly) by hest energy? 2-What is the future of green energy(for the next 30 years)?

poyrazogluyigit

1) Hey, thank you for your questions! Could you clarify what "hest energy" is?

2) We expect that green energy sources will continue to be a growth industry. Wind, solar, geothermal, hydro, and other green sources will likely play a greater role in the energy mix of 2050, but it does depend on market conditions, equipment costs, and policy matters.

For wind power specifically, the U.S. Department of Energy (DOE) published a vision for wind energy in the United States that looks at potential scenarios over the next 30 years. Right now, we have about 82 gigawatts (GW) of cumulative wind power capacity installed in the United States, of which just under 1 GW is considered distributed. The DOE Wind Vision Study Scenario estimates that a total of 404 GW of cumulative wind power capacity could be installed by 2050. That would represent about 35% of electricity demand covered by wind power by 2050. Offshore wind, which saw the first project coming online in 2016, is also expected to grow significantly.

You can find more information about the U.S. Department of Energy's Wind Vision at https://www.energy.gov/sites/prod/files/wind_vision_highlights.pdf.

Where would the energy be stored? Or, would it only generate the amount of energy necessary to run things and the rest get lost? If you propose a sort of "battery," how would that be accessible to the standard consumer or would we be better off going with a solar roof and power wall from Tesla?

With the cost of energy and the differing amounts of energy used on a daily basis, how would a turbine be used in the city to power an apartment complex or a small mechanics shop that barely has enough room already due to skyscrapers that are affecting the air flow?

Also, what is the maximum generation rate of said turbines? Would placing them on the roof of a 600ft skyscraper, where the wind is much "faster" and the constraint is much lower, affect the rate at which the turbine "spins" or is it set mechanically to have a maximum rotary speed, in turn throttling the power generation rate?

Quarentus

Energy could be stored in batteries or the Tesla power wall, or similar products.

A small wind turbine can provide electricity for an apartment building or small shop. That is very common, but we recommend ground-mounted systems in open areas. Certain sites, such as a downtown building, are not ideal sites.

Many people want to put wind turbines, in urban, or built, environments, and on rooftops because of the visibility. Installing a wind turbine is synonymous with 'going green.'

But it is challenging to accurately estimate the wind resource in a built environment. Houses and trees can obstruct wind flow and cause turbulence. Now think about large buildings and urban infrastructure. You can try to model the wind flow around a building or on a rooftop, but it is expensive and still does not provide a dependable estimate. There are just too many variables. Then, because of the unknown resource and the turbulent environment, these turbine installations typically underperform. And they are more expensive to install.

It is generally not recommended to put turbines – horizontal axis or vertical axis - on rooftops or in built environments. You want tall towers in areas free of obstructions so you can generate cost-effective energy reliably.

There is a limit on how much energy a wind turbine can extract from the wind! It is called the Betz limit: https://en.wikipedia.org/wiki/Betz%27s_law.

Hello! As I understand it one of the major attractions of distributed generation is that of avoiding the inefficiencies in transmission.

Do you know if there has been much research into at what point a wide network of low-efficiency generators with small transmission radii starts outperforming, say, a power station with a wide transmission network in terms of efficiency?

StonedPhysicist

Yes, distributed generation that is on-site, or interconnected at a key point on the distribution grid, or on a micro-grid, can provide resiliency and energy security benefits. Projects behind a distribution substation do not rely on the transmission system.

This is a good question about efficiency, but I don't know what research has been done in this area. I'm curious though, so I'll have to think about this later.

Hello Alice, glad to see another from the complex on Reddit. I was actually up at PNNL in July for the summer EFCOG Electrical Safety Task Team meeting.

We are starting to see more hazards associated in solar with larger/commercial applications, but I

believe most of that relates to large capacity farms. I've used small solar panels for remote applications where it's not feasible to run a new electrical feed out to a small piece of equipment. Could wind supplement/replace solar in these scenarios?

What kind of safety concerns are associated with wind energy? With solar you have hazards associated with storage (batteries) and then rectification. It's not until you get large solar farms where you start seeing highly hazardous scenarios (dc arc flash, difficulty controlling voltage output for maintenance activities, etc). Does wind have advantages here? I'm assuming you can have a mechanical brake for the turbine and you could lock out systems for maintenance?

MadMuirder

Some companies already sell solar/wind packages for remote applications because the technologies complement each other – sunny during the day and it can be windier at night. See these photos for examples:
http://epe.pnnl.gov/research_areas/distributed_wind/images/remote_monitoring_station.png,
http://epe.pnnl.gov/research_areas/distributed_wind/images/gorham_me7.png.

There are basic, mainly common sense, electrical safety issues to consider with small wind, but these do not necessarily differ from solar electrical safety considerations. During maintenance procedures or when grid problems occur and crews are working on power lines, wind technology (in general) has many different safety functions to protect people working on them. Safety measures include rotors being physically locked in place and inverters which sense abnormalities and do not allow power to flow from a turbine to the power grid (or end use). Inverters automatically sense utility power problems, stop the flow of power, and resume producing power when the power grid is up and running again. These inverters are subject to the same safety precautions as other inverters (keep moisture, flames, harsh chemicals, etc. away from the inverters).

What happens when there is no enough wind for a few days to run the turbine? (Is this possible?)

Considering the cost and energy production, which is more viable to home owners, solar panels or wind turbine(s)? (Considering almost same amount of solar and wind exposure)

Thanks for the AMA!

ArgumentativeBird

Wind is a variable resource, which means that it is not always available in the same amount all the time. So the site's wind resource will determine how much electricity the turbine will generate.

If you are connected to the grid (i.e., this turbine is at your home or farm), your local utility will supply the power you need when your turbine is not generating energy.

On the flip side, if you generate excess energy (more than your house can use) and your utility offers net metering, you can send the excess generation to the grid. Net-metering is a billing arrangement by which customers receive credit on their utility bills for energy generated by their on-site renewable energy system.

Regarding your question on what is more viable to home owners, that really depends on site specific characteristics, such as the availability of wind and solar resources, as well as your needs, the cost of electricity, the cost of your land, and the policy environment. In some place wind will make a lot of sense financially, in others solar PV. Wind turbines typically have a smaller footprint than ground-mounted solar PV arrays. So in a windy place like Iowa, a 50-kW wind turbine could generate the equivalent of 120-kW of solar PV but use less ground space.

What is the near-term possibility of there being a combined Solar/Wind/Battery set-up that can be purchased and installed on homes roofs or yards in the near future? What sort of analysis of the effectiveness of combining wind/solar/battery into a single solution has been done or is being done? Is this a likely way forward?

gebkbk69

This is definitely a thing now. There are companies already selling solar/wind/battery packages. And I know distributed generation installers who have put these kind of systems together for customers from individual components.

Hi! I work in green(er) energy as well at a university. We are trying to develop electrolysis cells to work with green energy to produce energy dense fuels. I often talk about wind power, but not in the way you do. In my talks and papers wind power is often casually brushed aside as "It's only useful in certain places and at certain times, energy production needs to be stable and it's currently very difficult to use "intermittent" power sources.

From my research, the main opposition to wind power in residential areas are twofold. One: They're loud and two: they're ugly/often big. While the second point is debatable, the first is not. Are modern wind turbines still loud?

For my second question, it's simply the age old one... Wind doesn't blow all of the time. (In most places.) Have you partnered your turbines with other technologies such as fuel/electrolysis cells to enable completely grid-free operation at places such as a remote cabin?

Thanks for (hopefully) educating me on wind power a bit more.

corrado33

Hi! With respect to sound, nebulou had a similar question, so I've repeated some of that information here.

Wind turbines can create two kinds of sound: a mechanical hum produced by the generator and a "whooshing" sound produced by the blades moving through the air. The vast majority of wind turbines are designed so that the turbine rotor is upwind of the tower, which mitigates low-frequency and impulsive sound. The presence of turbine sound depends on atmospheric conditions, and the ability for humans to perceive wind turbine sound varies based on the presence of other nearby sources of sound and site-specific topography. However, the sound pressure levels for modern wind turbines at distances greater than 400 meters are typically less than 40 decibels (dBA), which is comparable to the lowest limit of urban ambient sound.

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These turbines have rated sound levels of round 37 to 50 dBA. Regular home noise, like the dishwasher in the next room can be between 50 to 60 dBA (http://www.dot.ca.gov/dist2/projects/sixer/loud.pdf).

If I was to install a wind turbine at my house, are there rules or regulations on how big it can be and say

I start to produce a substantial amount of energy combined with solar power, can I use that energy for anything that I want? Like, that's MY energy?

Mevil187

Yes, each jurisdiction (e.g., the town or county) typically has rules and regulations for siting wind and other distributed generation. These rules vary across the country and can even vary from town to town.

Your state will also have rules governing net metering. Net metering is a billing arrangement by which customers receive credit on their utility bills for energy generated by their on-site renewable energy system. With net metering, you are still connected to the local utility grid, but you use your energy generated on site, and when you are not generating enough, the utility is your back-up. Any excess generation that you don't use can be sent back to the grid, and still credited to your utility bill. The details depend on the utility and can vary widely, too.

A great source to learn more about what your state can offer is the Database of State Incentives for Renewables & Efficiency: http://www.dsireusa.org/.

what are you currently working on?

treemonkey404

Thanks for asking!

We just released another report that looks at the installed costs of small wind systems (up through 100 kW in size) in detail. You can read it here: http://wind.pnnl.gov/pdf/Benchmarking_US_Small_Wind_Costs_092817_PNNL.pdf.

On behalf of DOE, we will be conducting a workshop for other federal agencies in the spring to educate them about distributed wind. You can see last year's workshop presentation here: http://wind.pnnl.gov/pdf/DW_Workshop_Slides_final_PNNL.pdf.

And then next year, we will release the 2017 Distributed Wind Market Report.