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Revealing the Dark Side of Wind Power

Surprising new research suggests harvesting cleaner energy may have serious consequences for the environment.

By
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It’s not always sunny. Photographer: Joel Saget/AFP/Getty Images

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Any solution to global warming will almost certainly rely on an expansion of renewable energy, reducing carbon dioxide emissions with clean solar or wind energy and related technologies. It’s still far from clear, however, which technologies might deliver copious amounts of energy when we need it while avoiding negative environmental consequences.

Research published today may help clarify the situation — and it’s not encouraging for wind-power enthusiasts. It suggests that the power available from wind is much more limited than many experts thought, and that deployment on a larger scale could significantly raise temperatures over the Earth's surface, as turbines alter atmospheric flows. The research highlights a painful but not altogether surprising reality: Even the cleanest renewable technologies come with environmental costs.

As human energy demand keeps rising, especially in India and China, carbon dioxide emissions will soar unless we shift to zero-carbon energy sources. Recent progress has been encouraging. Still, in 2017, wind and solar energy together accounted for less than 8 percent of the U.S.'s electricity. Questions remain about how much energy we might expect any one technology to supply and what the consequences of significantly scaled-up use might be.

For wind power, researchers have debated how much energy might ultimately be harvested, with estimates of the available energy density — how much we might gather per unit of surface area — ranging all the way from 0.5 to 200 watts per square meter. The higher figures tend to come from studies of single turbines in isolation, and lower numbers when considering how, in larger wind farms, one turbine can disrupt wind flows and reduce the energy-gathering efficiency of other turbines nearby. The lowest estimates come from theoretical studies of the physics of atmospheric flows. The new study comes down firmly on the lower end of the range.

Lee Miller and David Keith of Harvard University looked at historical data on U.S. wind farms. In 2016, they found that the mean power density for 411 onshore wind-power plants was 0.50 watts per square meter. Figures were similar in the 26 years prior. Moreover, they found that wind plants encompassing the largest areas had the lowest power densities, as expected. This figure implies that meeting current U.S. electricity needs alone would require wind farms to cover fully 12 percent of the U.S. land area. Wind power has physical limitations.

Miller and Keith found something even more surprising in another study that looked at a related question: What should we expect the climate impact of significant wind energy generation to be? Removing energy from atmospheric winds means those winds carry less energy afterward, moving more slowly, among other things. To explore the possible consequences, the researchers used an atmospheric model to simulate the effect of low-density wind turbines operating over the windiest one-third of the continental U.S. to generate enough power to meet current U.S. electricity demand — a plausible scenario for wind-power use in the late 21st century.

The simulations revealed that interactions of the turbines with the atmosphere would likely lead to a redistribution of heat in the lower atmosphere, resulting in a 0.54 degrees Celsius (0.97 degrees Fahrenheit) warming within the wind farms' region itself, and an increase of 0.24 degrees Celsius (0.43 degrees Fahrenheit) over the continental U.S. This result, they note, actually matches up pretty well with recent satellite observations of local warming around wind farms operating in California, Illinois, Iowa and Texas. They also found that an expansive wind farm would need to operate for more than a century or so before the reduction of global carbon dioxide emissions would offset the local warming effect.

These findings lend support to a significant body of research suggesting that wind energy's potential is much more limited than previously thought. Miller and Keith also looked at U.S. solar farms, finding an achieved energy density about 10 times higher than for wind farms. Solar arrays in their study also led to much less local warming.There may be a good reason to shift future investments toward solar energy, as some big investors are doing already.

This isn't to say, of course, that wind power has no future. It's already making a significant contribution to energy supplies in various nations around the world. Miller and Keith emphasize that using either wind or solar is far preferable to sticking with fossil fuels. But wind power has greater limits than solar power and will likely have bigger consequences for the environment. The atmosphere is far from being an inexhaustible resource of energy; our energy extraction will have important consequences, and quite quickly.