100% renewables doesn't equal zero-carbon energy, and the difference is growing

23 May 2019

Credit: CC0 Public Domain

While 160 companies around the world have committed to use "100 percent renewable energy," that does not mean "100 percent carbon-free energy." The difference will grow as power grids become less reliant on fossil power, according to a new Stanford study published today in *Joule*. Entities committed to fighting climate change can and should measure the environmental benefits of their renewable strategies accurately, the authors write.

Current methods of estimating greenhouse gas emissions use yearly averages, even though the carbon content of electricity on the grid can vary a lot over the course of a day in some locations. By 2025, the use of yearly averages in California could overstate the carbon reductions associated with solar power by more than 50 percent when compared to hourly averages, the paper shows. One finding of this analysis is that wind power—not solar—needs to be the next wave of investments for California. Similar analyses could suggest different options like nuclear power, geothermal energy, and long-range transmission in other locations.

"To guarantee 100 percent emissions reductions from renewable energy, power consumption needs to be matched with renewable generation on an hourly basis," said Sally Benson, co-author of the paper and co-director of the Precourt Institute for Energy.

"Just purchasing more solar energy in a grid that already has lots of solar generation will not result in zero emissions," Benson, professor in the Energy Resources Engineering Department in the School of Earth, Energy & Environmental Sciences, also said.

Annual vs. hourly accounting

Corporations that claim to be 100 percent renewable do not actually cover all their power use with renewables, as some acknowledge. Instead, they purchase or generate enough renewable energy to match 100 percent or more of their electricity use over the course of the year. For energy purchases dominated by solar power, an entity generates far more electricity than it uses during the afternoon and sells the excess. Then at nighttime it purchases power from the grid, which is much more carbon-intensive if generated by burning of fossil fuels.

The use of annual averages of the carbon content of grid power is valid only when fluctuations in renewable generation are small, or when all excess renewables can be stored. Places like California, Hawaii and some European countries experience large fluctuations in carbon content due to existing renewables, and do not yet have enough storage capacity to capture all excess electricity. In

California, intentional reductions in solar and wind production, or "curtailments," reached 3 percent of total generated energy in two months last year, the paper cites.

The difference in environmental benefit between wind and solar in today's accounting methods therefore doesn't account for the time of day when power is delivered. Instead, the difference between emissions reductions from wind and solar generation is only related to the difference in carbon footprint between the two technologies.

"Both the carbon footprint of a large consumer and the environmental value of renewable energy assets depend on the grid they interact with," said energy resources engineering Ph.D. student Jacques de Chalendar, lead author of the study. "Using hourly data is the best way to measure the environmental benefit of renewables, and this will become increasingly true wherever renewable generation is growing."

Investing in non-solar renewables

The problem with investing in more solar panels in California is that the output often will not cause fossil fuel based generators to turn off, because they are already idle at the time of day the solar panels will produce power. In the paper's case study, which approximated a hypothetical 1 megawatt constant load in California, short-term annual and hourly carbon estimates did not show significant differences in 2018. But by 2025, the two methods of estimation varied widely.

Using annual accounting, a 100 percent solar strategy in 2025 would reduce carbon emissions by 119 percent of the hypothetical company's carbon footprint. Using hourly emissions, though, the number shrinks to 66 percent, according to the study. For a 100 percent wind power strategy, annual averages indicate 131 percent carbon reductions, which actually jumps to 135 percent using hourly data.

"In California, gas is often the marginal generation source and has a higher emissions rate than average grid power, which is why purchasing renewables can result in a net negative carbon footprint," said de Chalendar. "A consumer with a 100 percent renewable energy supply can actually reduce the carbon footprint of the grid in addition to their own carbon footprint."

Energy storage

Hourly carbon accounting methods could help large consumers increase their use of low-carbon power from the grid. With more accurate information, consumers can move flexible consumption to times of the day when grid power is cleanest. The data could also help consumers decide whether they should invest in large-scale energy storage projects as the most economical way to meet their carbon targets. This is because energy storage allows consumers to draw electricity from the grid during low-carbon periods and store it for later use.

Stanford University, for example, recently electrified its heating and cooling system and added thermal storage to cut emissions to a third of their 2014 peak levels. By using its energy storage to maximize purchases of electricity in the afternoon when solar power dominates the California grid, Stanford could reduce emissions from heating and cooling by an additional 40 percent, according to a study published earlier this month by the authors of this paper.

Location-specific analyses might suggest different types of low-carbon investments and strategies for other regions, the paper notes. In Great Britain, for example, grid carbon intensity is currently lower at night, meaning different types of renewable investments or consumption behaviors might be better. Alternatively, long-range transmission of electricity could also allow entities to transport low-carbon electricity elsewhere when there is an oversupply and receive low-carbon electricity when there is a minimal amount of renewable electricity generation.

"Transparent, precise and meaningful carbon accounting is necessary," Benson said. "And if it's done properly, we can make the right investments in renewable power and create a more sustainable grid."

More information: *Joule* (2019). DOI:

10.1016/j.joule.2019.05.002 ,
www.cell.com/joule/fulltext/S2542-4351(19)30214-4

All data and supplemental code used in their commentary are publicly available here.

Provided by Stanford University

APA citation: 100% renewables doesn't equal zero-carbon energy, and the difference is growing (2019, May 23) retrieved 28 September 2020 from https://techxplore.com/news/2019-05-renewables-doesnt-equal-zero-carbon-energy.html