Expert: The current pace of decarbonization in Massachusetts is too low to meet climate goals

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Having worked with renewables for the last 15 years, and listening to the lofty goals political leaders make to achieve net-zero carbon emissions,

UMass Lowell mechanical engineering Professor Christopher Niezrecki can tell you that as a state and a nation, we're not on track. It's not easy to wrap one's head around the scale of the problem and even harder to come up with viable solutions. There is global scientific consensus that in order to mitigate the primary effects of climate change, our society needs to decarbonize—cut our reliance on burning fossil fuels and aggressively pivot to renewable energy.

Similar to many other states, Massachusetts has committed to achieving net-zero carbon emissions by 2050, and to do so, the Commonwealth cannot rely on natural gas, gasoline and other fossil fuels. For many states and countries, a large part of that plan includes relying on wind, solar, or hydro resources as primary energy sources. Every state or country has different resources, constraints and requirements, and for Massachusetts, much of the decarbonization plan includes relying heavily on offshore wind energy.

Niezrecki and his colleagues recently conducted a study on the amount of wind energy necessary to decarbonize some of the primary energy-consuming sectors in Massachusetts, including replacement of natural gas and gasoline. Their analysis revealed that a daunting amount of wind energy is needed to replace fossil fuel reliance, and it is highly unlikely that the current trajectory will enable Massachusetts to meet the state's climate goals in the intended time frame. Their research is published in the journal *Wind Engineering*.

"The scary thing is, most states are worse off than Massachusetts," Niezrecki said.

Let's take a look at the replacement of natural gas, or methane, used for several different sectors (residential, commercial, industrial, vehicle fuel , electric power, and distribution). One proposal to eliminate CO_2 emissions is to replace natural gas with green hydrogen because, when

burned, hydrogen has no carbon emissions. The UMass Lowell study recent study found, conservatively, that complete replacement of natural gas used in Massachusetts with green hydrogen would require the annual energy output of 2,545 offshore wind turbines (12 MW/turbine)—an addition of 94 turbines per year through 2050.

Additionally, the approved wind procurements cover just over 10% of the energy required to generate the equivalent amount of hydrogen needed to replace natural gas. The procurements would need to be approximately 10 times larger to meet these demands.

Although replacement of methane with hydrogen provides a viable solution in terms of carbon reduction, it is not an efficient solution given existing constraints, according to Niezrecki.

"Green hydrogen production competes for limited renewable electricity that is not yet available. Direct use of renewable electricity for heat and power should be a first consideration, when possible and economical, rather than using renewable energy to generate green hydrogen fuel because of round trip efficiency losses. Without significant improvements in production methods, green hydrogen does not make sense for sectors that can be electrified by using renewable energy directly," he said.

Most people are familiar with the residential heating sector that primarily includes burning natural gas in furnaces and boilers. The use of electric heat pumps to replace furnaces is beginning to gain traction within Massachusetts and other cold-region states. If homes in Massachusetts were heated with green hydrogen produced from wind farms, approximately 3.5 times more electricity (or number of wind turbines) would be needed compared to heating homes using heat pumps.

In 2020, there were more than 2 million passenger vehicles in

Massachusetts, and consumption of gasoline is a significant source of CO_2 emissions. Today, most passenger vehicles rely on gasoline. In order to shift to electric vehicles, there would need to be approximately 292 offshore wind turbines dedicated solely to powering those vehicles. The approved offshore wind procurements represent only 92.5% of the need for passenger vehicle electrification, Niezrecki said.

If we focus just on electrification of EVs and replacing only natural gas in the residential sector using heat pumps, the approved offshore wind procurements fall short by a factor of approximately two times.

"It's important to note that this estimate does not consider the replacement of other carbon intensive fuels for heating (e.g., oil, propane, and wood), trucking, aviation, shipping, or the other natural gas industry sectors previously mentioned that would all require additional wind energy beyond these estimates. Massachusetts' current rate of transition to renewable energy is likely far too low to meet the state's 2050 net-zero carbon emission goal," Niezrecki said.

Recent studies from the National Renewable Energy Laboratory have investigated multiple pathways to achieve a net-zero U.S. power grid. The analysis estimates that the U.S. will need between 779 GW and 1342 GW of installed wind energy, while the current U.S. installed wind energy capacity is approximately 145 GW. This implies that the nation will need to increase existing installments by a factor of eight to nine times compared to what has been built out over the last quarter century. Similarly, the electrical transmission infrastructure must approximately triple compared to what currently exists and was built over the last 100 years, according to the professor.

Niezrecki believes it is very likely Massachusetts will need to rely on and import renewable energy—be it wind, solar, or hydro power—from other states and Canada to achieve net-zero carbon emission goals by

2050. Achieving net-zero emissions will require a multifaceted energy approach beyond just offshore wind energy. If all gasoline-powered vehicles were electrified and natural gas consumption replaced, the number of renewable power sources (e.g., wind turbines) and the amount of electricity would have to be significantly increased well beyond the existing procurements and the electrical grid would need to be greatly bolstered.

To achieve the state's climate emission goals, Niezrecki said we need to consume energy more efficiently and additional wind and other renewable energy procurements must be made in larger-scale and at a faster pace than what is currently happening.

More information: Jack Cimorelli et al, Estimate of the wind energy needed to replace natural gas with hydrogen, and electrify heat pumps and automobiles in Massachusetts, *Wind Engineering* (2023). DOI: 10.1177/0309524X231185322

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