FOOD SECURITY:

Expert says algae cultivation will be needed as rising heat shrinks farmland

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ClimateWire: Thursday, October 8, 2015

Algae may be tiny, but new research suggests the single-celled organisms could play an outsized role in slowing the rate of global warming over the rest of the 21st century.

In fact, it is their small size, or rather their small land requirement, that could make them an important tool to help mitigate climate change, according to Brian Walsh, a research scholar at the International Institute for Applied Systems Analysis (IIASA).

Unlike most crops that have very specific growing conditions, algae cultivation works on degraded and unproductive lands, and the organisms can grow in brackish or salty water, reducing demands on a limited global freshwater supply. Autotrophic algae can also use carbon from the atmosphere directly for energy, helping to further reduce the amount of carbon in the atmosphere. While these benefits have been recognized by other researchers, Walsh's research focused on what would happen if algae production exploded around the world.

Walsh conducted his analysis using a new system dynamics model, called Felix (Functional Enviro-economic Linkages Integrated neXus), that he helped to develop with his colleagues at IIASA. The complex model integrates data from eight sectors, from energy and population to climate and land use, and its projections provide a broad look at how different types of energy use and policy will impact global temperatures over the remainder of the 21st century.

Last week, Walsh presented his findings at the Woodrow Wilson International Center for Scholars, outlining why algae use could become more significant, even if other tools like renewable energy and carbon capture technology became more widespread.

He pointed to a number on the screen behind him, 1,000 PgC.

"This number doesn't necessarily need to mean a lot to you. But it should mean something when I tell you that you are here at 500 petagrams of cumulative emissions from civilization. So in the last 150, 200 years of industrialization, we've blown through half our budget," he said. "And alarmingly, we're on track to run through the rest of our budget, the remaining 500 petagrams, by 2060. In just 45 years or so, we will have committed ourselves to at least 2 degrees warming, if not more."

The projection assumes a business-as-usual scenario. By 2100, emissions would increase 25 percent above 2010 levels, even with a projected energy mix of 60 percent fossil fuels and 40 percent from renewable sources like wind, solar and biomass. In order to reach that 40 percent, the model assumes that the use of wind power will have to increase by 215 times, solar power will be 38 times greater and biomass use will be 11 times greater.

A 'Hail Mary' solution needed

The situation could be much worse if the Intergovernmental Panel on Climate Change's most extreme projection becomes reality, in which case emissions could end up two times that amount and would result in an unmanageable temperature increase of around 5 degrees Celsius, Walsh said.

In order to prevent such an outcome and keep global warming below 2 C, the IPCC has recommended achieving net-zero or even negative emissions by around 2075.

"That's really an enormous task, but this is the only acceptable pathway if we define success as under 2 degrees of global warming," Walsh said. "Two degrees appears to be the point where we could live with climate change, and at 4 or 5, it's sort of all bets are off."

However, the researchers found that simply increasing renewable energy use further wouldn't be enough to significantly slow global warming. Even if the rate of renewable energy use climbed to 60 percent worldwide, the change reduced emissions by 20 percent from the business-as-usual scenario, according to the Felix model.

"Obviously, this is far short of our goal," Walsh said. "And when we look at our carbon budget under this scenario, we have

pushed our deadline from 2058 to 2061. It's simply insufficient."

At the same time, the very modest gains would come with a large environmental costs from deforestation and habitat disruption, particularly in the Southern Hemisphere, he added.

To make up the difference would require the use of carbon capture and sequestration (CCS) technology, which works by liquefying carbon emissions and then pumping them deep underground.

For CCS to capture the remaining 75 percent of emissions, every single coal, natural gas and biofuel plant worldwide would have to use the technology, conventional fuels could no longer be used in cars, and the entire energy sector would have to be electrified.

"This would be a real Hail Mary if it came to that point," Walsh said.

The problem with these two approaches is that they do not address the fundamental problem of land scarcity that links food prices, energy, water and the carbon system, he said.

"Algae may be that missing link," Walsh added.

Food demands could double

Even with intensified and more efficient land use, the increased use of renewables would likely lead to extensive deforestation and biodiversity loss, according to Walsh's model. At the same time, as the global population reaches 11 billion by the end of the century, the demand for food production is expected to double, requiring production of animal-based foods to increase by 117 percent and plant-based foods by 82 percent. This would also require an enormous amount of arable land, a commodity that is already in short supply.

Algae could help address this problem if it was used as a source of animal feed. Already, algae meal is used to feed animals, and research has shown that they can safely eat it as 10 to 42 percent of their diet without any ill effects.

Walsh and his colleagues modeled what algae production would look like if enough was grown to meet 35 percent of the animal feed demand, about 1 gigaton of biomass in 2100.

The researchers calculated that that amount of biomass could be grown on just 10 to 25 million hectares, the equivalent of 10 percent of the pasture area in the United States. That would free up 1.7 billion hectares of agricultural land that could be used either for growing more food for people or to grow biofuels without resorting to habitat destruction.

Still, achieving that level of algae growth would be no small task, because that much algae would represent an increase of four to five orders of magnitude over the current production capacity, Walsh said.

Panelists attending Walsh's presentation at the Wilson Center agreed that more research was needed to apply the findings to the real world.

"It definitely can scale, it's a very known process," said Jill Kauffman Johnson, the global sustainability director at the biotechnology company Solazyme, which uses some of its heterotrophic algae for animal feed. "The question is what are the impacts of scaling."

David Babson, a senior engineer at the Clean Vehicles Program at the Union of Concerned Scientists, said the research highlighted the need to view algae more as feed matter than as a source of biofuel, which has been the focus of much of the research on the organism.

"What this really shows is there needs to a better discussion about how we incentivize the use of biomass and the production of it," he said.

Babson suggested creating a carbon pricing system that would offer a higher price for algae that displaced animal feed rather than petroleum as one possible example.

"Going forward, more analysis needs to be done, and perhaps more analysis needs to be done around the carbon reduction and economic incentives that would be necessary to actually achieve the outcomes from this type of technology, so you could begin to develop public policies and planning for actually establishing the infrastructure and the pathway forward to do this," he said.

Walsh's paper based on the model, "New Feed Sources Key to Ambitious Climate Targets," is not yet published.

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