Water footprint could tip scale for sustainable, emission-reducing energy options

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Few comparisons of carbon-curbing technology also analyze the impact on water resources. A new INL study assessed the water footprint of numerous near-term energy generation options, and is one of the first to paint such a complete picture.

Green energy won't be sustainable if it uses too much blue. Low-carbon energy options that increase water consumption could be swapping one problem for another.

That's the premise of a new analysis reported by Idaho National

Laboratory researchers. They assessed the water footprint of numerous near-term energy generation options and found some surprising results.

For example, replacing gasoline with ethanol made from energy crops would greatly increase the water required to make vehicle fuel. Yet significant water savings could be realized by replacing coal-fired power plants with plants fueled by natural gas. Increasing efficiency and reducing demand also are win-win-win in terms of cost, carbon emissions and water impacts.

Energy discussions often touch on water consumption, but few carbon-curbing technology comparisons also analyze the impact on water resources. The new study is one of the first to paint such a complete picture. It exemplifies how INL, as one of the U.S. Department of Energy's national laboratories, uses research innovation, testing and evaluation to help industry apply new energy solutions that safely, securely and sustainably expand energy supply and improve efficiency.

The study has attracted international interest because its findings could help inform far-reaching decisions about sustainable energy generation options.

"In discussions about climate change, various solutions are often presented as equal, but they all have a very different type of impact," said INL research scientist Craig Cooper, co-author of the study, which was published in the March 20 issue of *Environmental Science & Technology*. "We've got to consider not just the cost or the climate, but think about it all in the context of being better stewards."

The ripple effect

Water is an essential component of many types of energy production. Creating and extracting resources such as biomass or fossil fuels requires

water, as does converting these resources into energy.

Nuclear energy facilities use water for cooling and to generate steam. So do coal plants. Even wind and solar energy have water footprints because they typically require coal, nuclear or natural gas backup to ensure electricity is available when sun or wind is not.

Yet water use tends to take a back seat in greenhouse gas (GHG) emission discussions. Emission-reducing options available today include increasing efficiency, reducing demand, and switching from coal to gas. Energy technology options for reducing emissions include wind and solar power, carbon capture, nuclear energy and biofuels. Numerous analyses have compared their relative costs, emissions and energy capacity.

Replacing coal-fired plants with natural gas plants, increasing efficiency and reducing demand are all win-win-win in terms of cost, carbon emissions and water impacts.

Water usage could be the factor that tips support in favor of one approach or against another.

"We need a better understanding of what energy transitions we're going

to have to go through to address climate change and resource security, and how sustainable those changes are," Cooper said. "All around the world, including the Western U.S., water resources are really strained, and these energy changes are going to impact how we go about using our water."

A stepping stone

To help clarify these issues, Cooper and INL co-author Gerald Sehlke used published data to compare the amount of water consumed by several carbon-curbing approaches. Their analysis revealed that some options are thirstier than others.

One of the biggest opportunities for water savings is replacing coal-fired power with plants that run on natural gas. "Gas turbines just tend to be more efficient relative to the amount of fuel burnt," said Sehlke. "You get more heat for less water."

Other big water savers included replacing coal plants with wind and solar power (with batteries or natural gas as a backup), reducing demand and increasing both generating and usage efficiency. In fact, increasing the generating efficiency at coal plants could potentially save more water than reducing vehicle use.

Most carbon capture/sequestration approaches would increase water demand, largely because the process requires additional energy, and thus additional water. Replacing coal plants with traditional nuclear energy technology would also boost water use. However, the effect would be reduced by the next generation of more efficient reactors being researched and developed at INL and other DOE national labs. The biggest water impact stems from an option many consider the greenest: bioenergy crops.

"What really surprised me was the huge added water cost for biocrops grown specifically to make biofuels—that blew my mind," Cooper said.

However, biofuels made from existing agricultural leftovers such as wood chips, corn cobs or wheat straw would have a much smaller impact on water resources. That's why DOE and INL are researching and demonstrating ways to improve utilization of existing agricultural resources for energy.

Lead a horse to water

The paper notes an additional confounding factor: impacts of energy choices are distributed. For example, water users who may benefit from reduced electricity or vehicle use are not necessarily the same people bearing the cost of that solution.

"The ones who feel the impacts of resource extraction are often in the West," said Cooper. "But the ones whose behavior would have to change don't live in those places."

That's where policymakers come in. The authors hope analyses like theirs will help inform decisions that weigh impacts to water, energy costs and GHG emissions. The issue certainly has the attention of the international community.

Soon after the paper was published, Cooper was invited to discuss it at the Islamabad Energy Conference, a scientific meeting about Pakistan's energy future. The broader energy-water nexus issue is a topic of growing international interest, said Sehlke. At the last World Water Forum conference three years ago, the only published research presented on the topic was related to a U.S. report for Congress that INL helped produce, he said. At this year's meeting, "there were 10 or 11 sessions on the energy-water nexus."

"The U.S. overwhelms other nations in terms of the amount of energy-water research conducted and reports published," Sehlke said. "But from a policy perspective, I think most of the world is more sensitive to it than we are."

Things are starting to change, however. Cooper and Sehlke are working with the Mountain West Water Institute (MWWI) and other researchers and agencies to help develop ways to make more sustainable use of water resources. The institute—a regional science and technology research partnership coordinated by INL—brings together different disciplines to help solve energy-water challenges.

"We have a lot of tools in our 'water toolbox,' but one of our biggest challenges is learning how to use those tools more effectively," Cooper said. "This task is well suited to the MWWI."

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