Net energy analysis should become a standard policy tool, scientists say

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It takes energy to make energy technologies, like the lithium-ion battery that helps power this Chevrolet Volt. Net energy analysis calculates how much energy a technology produces and consumes over time to assess its long-term sustainability. Credit: Mark Shwartz/Stanford University

Policymakers should conduct "net energy analyses" when evaluating the long-term sustainability of energy technologies, according to new

Stanford University research.

Net energy analysis provides a quantitative way to compare the amount of energy a technology produces over its lifetime with the energy required to build and maintain it. The technique can complement conventional energy planning, which often focuses on minimizing the financial cost of energy production, say Stanford researchers.

"The clearest answer to 'why is net energy important?' is that net energy, not money, fuels society," wrote lead author Michael Carbajales-Dale, a research associate in Stanford's Department of Energy Resources Engineering, in the July 2014 issue of *Nature Climate Change*. "Net energy analysis can identify potential costs and barriers to technology development that a traditional financial analysis might not."

The report was co-authored by Adam Brandt, an assistant professor in energy resources engineering; Sally Benson a professor in the same department and director of Stanford's Global Climate and Energy Project (GCEP); and Charles Barnhart a postdoctoral scholar at GCEP.

"Put simply, we need to 'spend' energy to 'make' energy," Carbajales-Dale and his colleagues wrote. "The availability of energy fuels economic processes and economic growth. If the energy sector provided only enough energy to fuel its own processes, thereby providing no net energy, it would be of little use to society."

Sustainability studies

The authors cited a recent Stanford analysis, which found that the photovoltaic industry became a net energy provider about two years ago. Another 2013 Stanford study used net energy analysis to assess the long-term sustainability of wind and solar technologies. Calculations revealed that a typical wind turbine generates about 80 times more electricity over

its lifetime than it consumes during manufacture and installation, and that a solar photovoltaic system produces about 10 times more electricity than it consumes.

According to the authors, net energy analysis can also be used to assess the long-term land and ecosystem impacts of developing energy technologies and resources, such as the Canadian oil sands. A 2013 analysis found that the oil sands industry supplies about five times more energy to society than it consumes, compared to the conventional oil industry, which supplies 10 to 20 times more energy than it uses.

These results suggest that both industries are net energy producers. However, further analysis reveals that oil sands require more energy for their extraction and processing than conventional oil, the Stanford team noted. Over time, "this increased energy intensity results in larger climate impacts per unit of energy supplied from the oil sands," they said.

Financial impacts

Net energy analysis also allows investors to identify potential costs and barriers to the development of new technologies, the authors said. For example, a recent study analyzing the energy balance for large-scale hydrogen production showed that a solar photoelectrochemical cell with 5-percent conversion efficiency requires a lifetime of at least five years before the net energy returns are positive.

"Extending the lifetime up to 30 years can yield devices that deliver six times as much energy as was used in their manufacture," the authors wrote. "Similar work has shown that for grid-scale electricity storage, increasing the number of times that a battery can be charged and discharged is the single-most important improvement that can be made."

Energy analyses can even guide investments away from financially sound but environmentally imprudent technology choices, they said.

"When managing complex systems, it is vitally important to have the right set of indicators to guide our decisions," the authors concluded. "We would not drive a car without a speedometer, nor fly a plane without an altimeter. Net energy analysis can guide decision-makers at all levels, from households to governments. We believe it is time for policymakers to make greater use of this critical tool."

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