First-ever global life cycle assessment of renewable energy future

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The Shepherds Flat Wind Farm is an 845 MW wind farm in the U.S. state of Oregon. Credit: Steve Wilson / Wikipedia.

A future where electricity comes mostly from low-carbon sources is not only feasible in terms of material demand, but will significantly reduce air pollution, a study published in the today's *Proceedings of the National Academy of Sciences* says.

An international team led by Edgar Hertwich and Thomas Gibon from the Norwegian University of Science and Technology conducted the first-ever global comprehensive life cycle assessment of the long-term, wide-scale implementation of electricity generation from renewable resources.

"This is the first study that has assembled and scaled up the assessment of individual technologies to the whole world and assessed technology implementation to 2050, taking the environmental impacts of production into account," Hertwich said.

The researchers did the study because so little is known about the environmental costs of a widespread global shift to renewable energy technologies such as wind and solar power, and what the effect of this shift might have on material requirements.

"Would the shift to low-carbon energy systems increase or decrease other types of pollution?" the researchers asked.

Previous efforts to answer this question have typically looked at single issues, such as selected pollutants, or the effects on land use or need for raw materials, such as metals. Previous studies have also neglected to look at the interactions between different technologies, the researchers said.

To address these shortfalls, Hertwich and his colleagues developed an integrated hybrid life cycle assessment model.

An important aspect of the model was that "it allowed the integration of electricity produced by these prospective technologies back into the economic model," Gibon said.

The researchers looked at concentrating solar power, photovoltaics, wind power, hydropower, and gas- and coal-fired power plants with carbon capture and storage (CCS). They also assumed that the efficiency of the production of important raw materials, such as aluminum, copper, nickel, iron and steel, for example, would improve over time.

The researchers used two different energy scenarios developed by the International Energy Agency to assess how renewable energy would perform.

The first of these was the Baseline scenario, in which global electricity production is assumed to increase by 134% between 2007 and 2050, and where fossil fuels maintain their high share in the

electricity generation mix, accounting for two-thirds of the total. Under this scenario, coal-based generation is 149% higher in 2050 than in 2007, accounting for 44% of all power generation.

The other was the BLUE map scenario, which assumes that electricity demand in 2050 is 13% lower than in the Baseline scenario because of increased energy efficiency, and that the power sector emits less pollutants from fossil fuels by reducing their use and adopting carbon capture and storage technologies, along with an increase in the use of renewable energies.

Low carbon technologies can demand much more use of raw materials per unit of power generation than conventional fossil fuel plants, the researchers noted. For example, photovoltaic systems need 11-40 times more copper than fossil fuel production, while wind power plants need 6-14 times more iron than fossil fuel production.

The researchers characterized these material demands from a broader perspective as "manageable but not negligible." For example, the amount of copper needed to build out photovoltaic systems by 2050 represents just 2 years of current copper production.

The demand for iron and steel would increase by a mere 10 percent, while the demand for aluminum will decrease. The change will also decrease air pollution and reduce fossil fuel extraction.

"Energy production-related climate change mitigation targets are achievable, given a slight increase in the demand for iron or cement, as two examples, and will reduce the current emission rates of air pollutants," Gibon said.

The human health benefits are clear, Hertwich said.

"Pursuing climate mitigation will limit the human health impacts from air pollution, while continuing with business as usual will increase it," he said.

More information: Integrated life cycle assessment of electricity supply scenarios confirms global environmental benefit of low-carbon technologies. Hertwich et al., *Proceedings of the National Academy of Sciences*, 2014. www.pnas.org/cgi/doi/10.1073/pnas.1312753111

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