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Study finds unprecedented production of metals needed to meet some solar energy goals

6 November 2014, by Francesca Mccaffrey

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Several government agencies, academic researchers, and firms have proposed scenarios for the future in which photovoltaic (PV) technologies grow rapidly. To support such growth, PV technologies would need to be developed with resource constraints in mind. For some PV technologies, the production of the required input materials would need to grow at a rate never before seen in the metals industry, according to a new analysis by MIT researchers.

The future availability of critical materials is a widely acknowledged concern within the energy community. Other studies have examined whether projected production growth rates are realistic, but they have approached the question through the lens of constraints such as annual metal production levels and reserves.

MIT graduate student Goksin Kavlak, postdoctoral associate James McNerney, Professor Robert Jaffe of physics, and Professor Jessika Trancik of engineering systems develop a novel method in a paper recently published in *Proceedings of the 40th IEEE Photovoltaic Specialists Conference.*

"We provide a new perspective by putting the projected PV metal requirements into an historical context," says Trancik, who is the Atlantic Richfield Career Development Assistant Professor in Energy Studies at MIT and the team lead. "We focus on the changes in metals production over time rather than the absolute amounts."

This approach allows for an assessment of how quickly metals production would need to be scaled up to meet the rapidly increasing PV deployment levels required by aggressive low-carbon energy scenarios.

To calculate the metals production growth rates required under those scenarios, as lead author Kavlak explained in a recent interview, the researchers first estimated the required production in 2030 for each metal of interest, and then calculated the annual growth rate needed to reach that level. They took into account the projected demand for each metal by both the PV sector and other industrial sectors. In addition, they looked at the effect of potential improvements in PV technology that would reduce the amount of each metal required in production.

The researchers then compared these projected growth rates to historical metals production growth rates in order to "understand the extent of production growth that happened in the past and whether the projected growth rates have historical precedent," says Trancik.

The results of this analysis differed from one kind of PV technology to another. For silicon-based PVs, which include first-generation panels using crystalline silicon solar cells, the results presented an optimistic view of the future.

"Silicon-based PVs look promising from a material point of view: The growth-rate of silicon production required to meet high deployment goals does not exceed historical norms," says Jaffe, the Morningstar Professor of Physics and MacVicar Faculty Fellow at MIT.

The outlook is more complex for newer photovoltaic technologies, especially increasingly attractive thin-film PV technologies. While a handful of thin-film solar panels use silicon in their absorption layers, many make use of other metals, such as cadmium telluride and copper indium gallium diselinide, commonly referred to as CIGS.

Trancik summarized the paper's findings concerning CIGS and cadmium telluride production: "To meet even relatively small percentages of electricity demand by the year 2030, these technologies would require historically unprecedented [metals production] growth rates."

The reasoning? In mining, CIGS and cadmium telluride are considered byproduct metals, not mined for their own sake, but only accessible as byproducts of the mining processes for other metals, such as copper. Upping their production, therefore, is a cost-intensive process.

"It is quite possible that the cost and availability of these critical elements will constrain deployment of otherwise game-changing technologies," said Jaffe.

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Provided by Massachusetts Institute of Technology