METALS RESOURCE REQUIREMENTS FOR A RAPIDLY GROWING PHOTOVOLTAICS INDUSTRY

Goksin Kavlak, Massachusetts Institute of Technology, +1 203 500 6534, goksin@mit.edu
James McNerney, Massachusetts Institute of Technology, +1 401 243 3696, jmcn@mit.edu
Robert L. Jaffe, Massachusetts Institute of Technology, +1 617 253 4858, jaffe@mit.edu
Jessika E. Trancik, Massachusetts Institute of Technology and Santa Fe Institute, +1 617 715 4552, trancik@mit.edu

Overview

Photovoltaics (PV) is a low-carbon energy technology that can help mitigate climate change if deployed at significant scales. The future growth of PV has been estimated in various energy scenarios, based on projections of energy demand and the cost and performance of technologies in the future. Various international organizations [1, 2] environmental agencies and industry associations [3, 4], energy companies and other corporations [5, 6] and academic institutions and researchers [7, 8] have contributed to this literature. However, the input materials for some thin-film PV technologies are rare metals that are produced in small quantities today, as byproducts of other, more abundant metals. This raises questions as to possible metals production constraints on the scalability of some PV technologies.

This study [9, 10] evaluates the growth rates for metals production needed to match projected PV deployment levels outlined in various future energy scenarios. We evaluate projected production requirements against past observed growth in production across a wide set of metals in order to determine whether the required growth rates have historical precedent. We find that the required growth rates for several thin-film PV metals (tellurium and indium) would exceed the historical growth rates observed across the full set of metals sampled, if CdTe and CIGS thin-film PV technologies contribute even small percentages (5-10%) of global electricity by 2030. We also find that reducing the metal intensity to levels estimated in the literature would not be sufficient to keep the required growth rates for thin-film PV metals within the range observed in past data. In contrast, c-Si PV could be scaled up to meet a majority share of electricity without requiring growth in metals production to exceed historical rates.

Methods

We first analyze historical growth rates for the full set of metals for which yearly production data is available from the U.S. Geological Survey. We find, for example, that the median annual growth rate across all metals has been roughly 2% per year between 1972-2012. We then estimate the growth rates required for metals production to meet the metal demand associated with projected global PV deployment levels in 2030, based on a wide range of energy scenarios. We also study the effect of the changing metal intensity of PV technologies, based on a range of expectations published in the literature. Finally, we compare the required growth rates to the observed historical growth rates to assess whether the projected growth rates have historical precedent. An important contribution of this study is the approach developed: studying projected growth in a few metals against past trends in production observed across a large set of metals. The method developed captures the benefits of aggregating data in order to compare future projections to past observations of the metals production sector as a whole.

Results

The results highlight possible constraints to the scalability of several thin-film PV technologies at sustainable costs. The annual growth rates required for the byproduct metals (indium, gallium, tellurium, selenium) production to satisfy the energy scenario-projected PV demand levels in 2030 are either unprecedented or fall on the higher end of the historical growth rates distribution. Growth projections for CdTe {CIGS} technology to supply 3% {10%} or greater electricity demand by 2030 would require unprecedented metals production growth rates for tellurium {indium}. In constrast, c-Si technology can provide up to 100% of global electricity in 2030 without silicon production exceeding the historical growth rates observed across a large set of metals. As an example, Figure 1 shows the required growth rates for a thin-film PV metal, tellurium, to satisfy a range of annual CdTe installation levels in 2030.

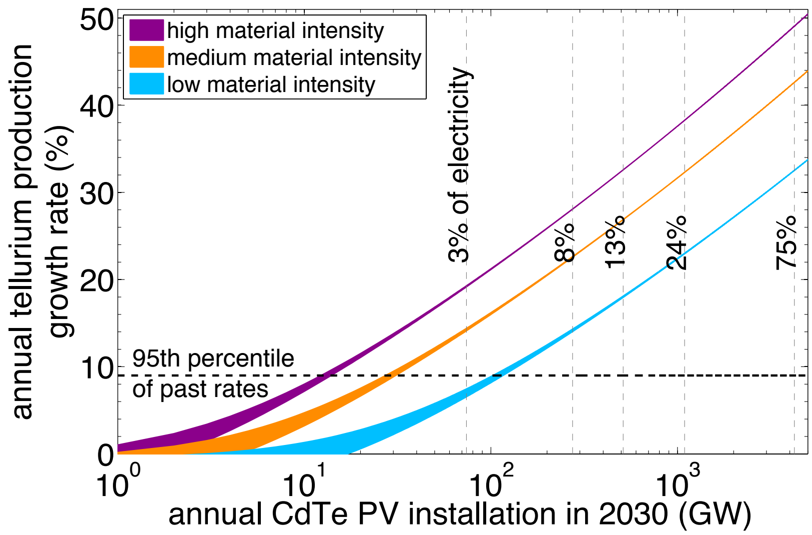

Figure 1: To supply even a small share of global electricity in 2030, several thin-film photovoltaics (PV) technologies, such as CdTe shown here, would require metals production growth rates that exceed those observed historically.

Conclusions

Continued rapid growth in PV deployment could require significant growth in the supply of some metals. In this paper, we estimate the growth rates needed in metals production to match PV deployment projections in 2030 for a range of future energy scenarios. We expect that the paper will contribute insight and methods that will be useful for evaluating the scalability of a range of PV and other technologies. Novel features of the paper include (1) the focus on possible constraints to the rate of scaling up metals production for PV, and (2) the use of an ensemble dataset of past growth rates in the production of a large set of metals to study this issue. More generally, the approach developed in this paper may be useful for assessing the scalability of a wide range of energy technologies to inform technology development in the laboratory and public and private research investment.

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