Solar futures: a systematic review of long-term global solar photovoltaic adoption scenarios

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Solar photovoltaic (PV) technology has been the fastest-growing renewable energy technology in recent years. Since 2009, it has in fact experienced the largest capacity growth of any power generation technology, with benchmark levelized costs falling by four-fifths [1]. In addition, the global technical potential of PV largely exceeds global primary energy demand [2]. Nonetheless, PV typically only appears as a relatively marginal option in long-term energy modelling studies and scenarios. These include the mitigation pathways evaluated in the context of the work of the Intergovernmental Panel on Climate Change (IPCC), which rely on integrated assessment models (IAMs) of climate change and have in the past underestimated PV growth as compared to observed rates of adoption [2]. Similarly, global energy projections, such as the International Energy Agency's World Energy Outlook, have been relatively conservative regarding the role of solar PV in long-term energy transitions.

In order to better understand the long-term global role of solar PV as perceived by various modeling communities, this work synthesizes a broad ensemble of scenarios for global PV adoption at the 2050 horizon. This ensemble includes 784 IAM-based scenarios from the IPCC SR15 and AR5 databases, and 82 other systematically selected scenarios published over the 2010-2019 period in the academic and gray literature, such as PV-focused techno-economic analyses and global energy outlooks. The scenarios are analyzed using a descriptive framework which combines scenario indicators (e.g. mitigation policies depicted in a scenario), model indicators (e.g. the representation of technological change in the underlying model), and meta-indicators (e.g. the type of institution which authored a scenario). We extend this scenario framework to include a text-mining approach, using Latent Dirichlet Allocation (LDA) to associate scenarios with different textual perspectives identified in the ensemble, such as energy access or renewable energy transitions. We then use a scenario discovery approach to identify the combinations of indicators which are most strongly associated with different regions of the scenario space.

Preliminary results indicate that the date of publication of a scenario has a predominant influence on projected PV adoption values: scenarios published in the first half of the 2010s thus tend to represent considerably lower PV adoption levels. In parallel, higher projected values are more strongly associated with renewable-focused institutions. Increasing the institutional diversity of
scenario ensembles may thus lead to a broader range of considered futures [3].

References