Global renewable LCOE – including socio-economic factors in assessments of resource potential

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1. Overview

As the decarbonization of the energy system becomes a global issue, solar PV and wind power are the carbon free technologies that have recently seen the fastest diffusion and cost reductions. However, solar and wind resources are not evenly distributed and thus, as with other natural resources, some countries have greater potential than others to supply their electricity demand using domestic resources. In this study, we aim to understand not only which regions have the potential for self-sufficiency of renewable energy, but also which regions are most likely to become major exporters or importers of renewable energy.

To analyze the potential for self-sufficiency and export, we expand the conventional techno-economic analysis to further include socio-economic aspects associated with the investment in renewable energy technologies. Specifically, we take into account the heterogeneity of discount rate between countries, as argued by ref. [1]. Apart from the impact of country-dependent discount rate, we also evaluate the potential for self-sufficiency and export of renewable energy with regard to the future electricity demand. This paper aims to answer two main questions:

1) How can socio-economic factors affect the cost and potential for developing renewable energy?
2) Which are the countries with greatest potential for exporting renewable fuels/electricity?

2. Methods

To answer these questions, it is not enough to only assess the wind and solar resource potential. Economic factors (investment costs and discount rates), as well as demographic factors (electricity demand intensity and available land for wind and solar) also need to be considered. Therefore, we introduce three renewables levelized cost metrics, which we illustrate globally: **Renewable LCOE** ($RLCOE_0$), **Renewable LCOE with country-dependent discount rates** ($RLCOE_r$) [2], **Renewable LCOE available for export** ($RLCOE_{Ex}$). $RLCOE_{Ex}$ represents the marginal levelized cost for a country to supply its entire electricity demand using only domestic renewable resources.

3. Results

Figure 1a) shows the solar LCOE for the whole world at a resolution of 1 km given a discount rate of 5%. The cheapest solar PV resources can be found around the tropic of Cancer, and in most parts of Africa. Some parts close to the equator have mediocre resources, due to cloudiness, for instance East Indonesia and Central South America. Adding the country-specific discount rate changes the LCOE for solar quite significantly, see Figure 1b). The lowest costs are now found in the US, West China, and Saudi Arabia. The cost for solar PV in Africa and Latin America turns out to be rather high when the financial risk is taken into account, comparable to Central or even North Europe which have much poorer solar conditions.

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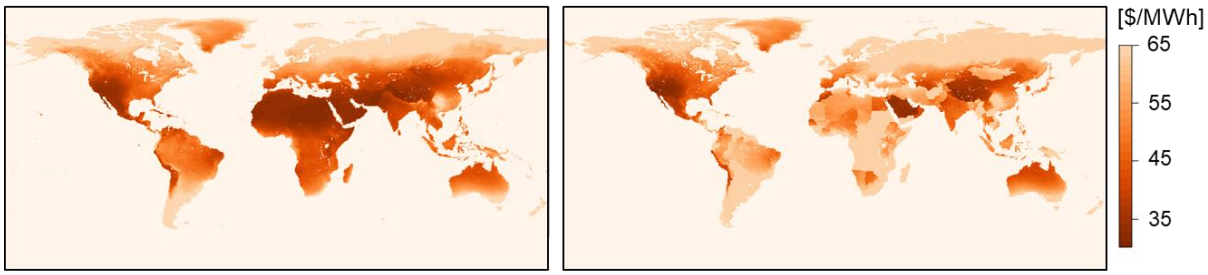

Figure 1 The *RLCOE* for solar in 2020 under uniform and heterogenous discount rates. The $RLCOE_0$ is calculated for each $1\ km\ \times 1\ km$ grid cell using a uniform discount rate of 5% while the $RLCOE_r$ is calculated using country-specific discount rates.

In Figure 2 we show the $RLCOE_{Ex}$ for all countries in the world. $RLCOE_{Ex}$ indicates the marginal cost for each country to cover its entire electricity demand using domestic renewable resources. Both the US and China show relatively low $RLCOE_{Ex}$ values, and thereby become potential exporters of renewable energy. The export possibilities are especially favorable for China, where neighboring countries display high $RLCOE_{Ex}$. A future where China and the US would no longer be dependent on energy imports has clear and important geopolitical consequences.

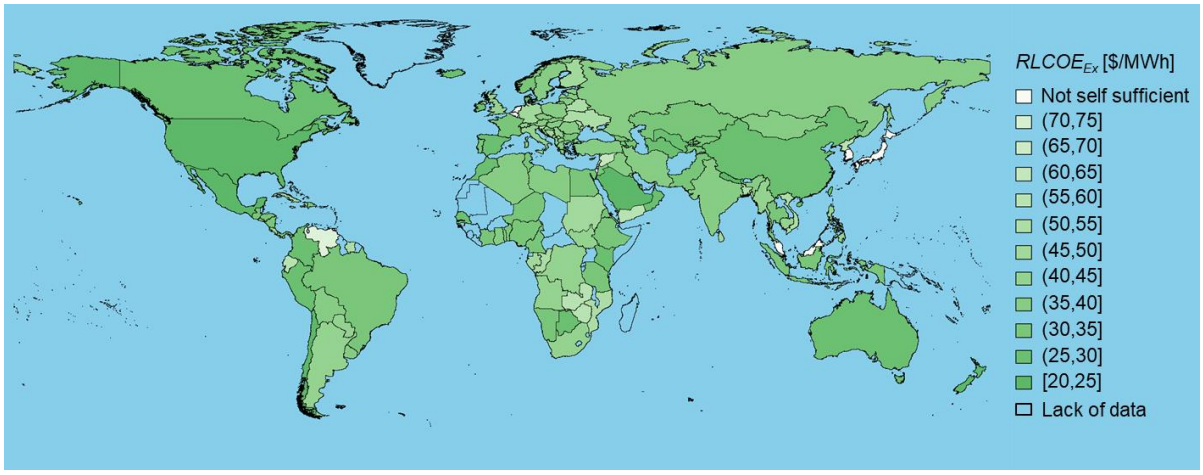

Figure 2 $RLCOE_{Ex}$ for 2050. $RLCOE_{Ex}$ is estimated for each country in the world, given projected demand in 2050 and with country-specific discount rates.

4. Conclusions

We find that globally heterogeneous socio-economic factors highly influence the cost of providing renewable electricity (and electricity-derived fuels such as hydrogen) in a future renewables-based energy system. We introduce a metric, the Renewable LCOE available for export ($RLCOE_{Ex}$), that may be used as a measure of a country's ability for self-sufficiency and export potential of renewable energy.

Reference

1. Egli, F., B. Steffen, and T.S. Schmidt, *Bias in energy system models with uniform cost of capital assumption.* Nature communications, 2019. **10**(1): p. 1-3.
2. Damodaran, A., *Country risk: Determinants, measures and implications-The 2021 Edition.* Measures and Implications-The, 2021.