AIMS Energy

AIMS Energy, 9 (6): 1170–1191.
DOI: 10.3934/energy.2021054
Received: 03 September 2021
Accepted: 10 November 2021
Published: 29 November 2021

http://www.aimspress.com/journal/energy

Research article

Can the 1.5 °C warming target be met in a global transition to 100% renewable energy?

Peter Schwartzman[1,*] and David Schwartzman[2]

[1] Department of Environmental Studies, Knox College, Galesburg, Illinois, USA
[2] Department of Biology, Howard University, Washington, DC, USA

* **Correspondence:** Email: pschwart@knox.edu; Tel: 3098771988.

Appendix

Are material resources adequate for creating 1.5 times present primary energy consumption level in 20 years?

In addition to what is provided in the discussion, we share the following to demonstrate that the material resources and land area needed for global solarization are already within reach: If 15% of present global rooftop area were to be used to site PV with an assumed conversion efficiency of 20%, the current global electricity power capacity would be created. (This calculation assumes a conservative solar radiation flux corresponding to the United Kingdom. An estimate of global rooftop area is 3.8×10^{11} m^2 from [1]). The photovoltaic industry is already taking seriously the challenge of creating terawatt scale infrastructure as previously mentioned.

Considering the constraints on extractable wind power on land as a result of decreasing kinetic energy as the number of wind turbines increase, most of this potential will be likely from wind turbines sited in the open ocean [2,3]. For example, the latter authors found in their modeling that a sufficiently large wind farm in the North Atlantic could supply comparable power to the present global consumption level, recognizing potential environmental impact of large arrays [4]. Consider the following example, suppose 10 MW capacity wind turbines supply all this energy, with a 35% capacity factor. Then producing 1.5 times the present global primary energy consumption level (19 TW) will require 8 million wind turbines in 20 years, assuming the lifespan of this technology exceeds this timespan. In comparison, 93 GW of wind turbine capacity was installed globally in 2020 [5], equivalent to 9,300 turbines with 10 MW capacities. Nevertheless, the production of 8 million wind turbines (10 MW each) is plausibly within the technical capacity of the global economy, noting that 92 million cars and commercial vehicles were globally produced in 2019 alone [6]. Resources needed for wind turbine production can be contributed from the conversion of the automobile-roadways complex to electrified rail and public transit powered by wind-solar energy sources as mentioned in the discussion. It should be noted that state-of–the-technology capacity factors now commonly reach 40 to 50%, requiring proportionately fewer turbines to supply the same energy [5]. Of course, a wind/solar transition using a mix of technologies would require significantly fewer turbines.

CSP in the Sahara could supply the current global electricity consumption on less than 6% of the Saharan land area as proposed in The Trans-Mediterranean Renewable Energy Cooperation (TREC) Project [7], not that CSP should be only sited in the Sahara of course.

References

1. Akbari H, Menon S, Rosenfeld A (2009) Global cooling: increasing world-wide urban albedos to offset CO_2. *Clim Change* 94: 275–286.
2. Possner A, Caldeira K (2017) Geophysical potential for wind energy over the open oceans. *Proc Natl Acad Sci USA* 14: 11338–11343.
3. Antonini EGA, Caldeira K (2021). Atmospheric pressure gradients and Coriolis forces provide geophysical limits to power density of large wind farms. *Appl Energy* 281: 116048.
4. Farr H, Ruttenberg B, Walter RK, et al. (2021) Potential environmental effects of deepwater floating offshore wind energy facilities. *Ocean Coastal Manag* 207: 105611.
5. GWEC (2021) Global wind energy report, Global Wind Energy Council, Brussels, Belgium.
6. IOMVM (2021) 2019 Production Statistics. International Organization of Motor Vehicle Manufacturers. Available from: https://www.oica.net/category/production-statistics/2019-statistics/.
7. EBCSE (2017) Trans-Mediterranean renewable energy cooperation (TREC). European business council for sustainable energy. Available from: http://www.e5.org/cooperations-spin offs/trec/.