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SUSTAINABLE CLIMATE SOLUTIONS

Feasibility of providing a fully inhabited planet earth with energy, based on photovoltaics

The goal of this work is to calculate a theoretical global energy requirement based on a future population at a level of energy consumption similar to that of current day Germany. Based on this knowledge the required area to satisfy this demand will be calculated for an exemplary solar panel. The transformation to and from hydrogen for transport will be taken into consideration.

Scenario: Germany as one of the world's strongest economies and being one of the world's largest export nations represents a best-case scenario for a future world with high resource demands for its entire population with a high living standard. The amount of energy to be provided must be equal to the energy necessary to enable all public processes. Thus, using the gross energy consumption, which includes heat, electricity as well as energy used for transportation in the form of fuel best represents a complete change to renewable sources.

In order to determine the energy consumption of Germany per capita, the gross energy consumption is necessary. Based on the Umweltbundesamt (UBA)[1] the gross energy consumption of Germany in the year 2018 amounted to **2499000000000 kWh** or **2499 TWh**.

By the end of the same year the population of Germany as given by the Statistisches Bundesamt (DESTATIS)[2] was around 83 million people. This results in:

$$\frac{2499TWh}{83019000capita} \approx 30101\frac{kWh}{capita}$$

As calculated the gross energy consumption of a German citizen can be assumed to be around 30 101 kWh/capita regarding total energy consumption.

Assumption: Based on the current fertility rate estimated by The World Bank[3], which is lower than that of the United Nations[4], we must assume a global population that peaks within the next 80 years. This leads to the conclusion that a pessimistic prognosis is more accurate. Thus, we assume the global population to be around 8.9 billion by the year 2050 as per the UN low population growth scenario.

This allows an estimate of the global gross energy consumption in the year 2050 based on Germany in 2018:

$$30101\frac{kWh}{capita} \times 8900000000capita \approx 267903TWh$$

With an estimated global energy consumption of **267903 TWh** we can further calculate the area needed to provide this amount of energy using photovoltaic panels.

To calculate the area needed to fulfil the amount mentioned above the following formula[5] is used:

$$E = A \times r \times H \times PR \Leftrightarrow A \times \frac{E}{r \times H \times PR}$$

With:
E = Energy (kWh)
A = Total solar panel Area (m^2)
r = solar panel yield or efficiency (%)
H = Annual average solar radiation on tilted panels (shadings not included)
PR= Performance ratio, coefficient for losses

For the respective values of panel efficiency and solar radiation an exemplary power plant was used. The performance ratio, which includes losses due to various factors like cables and inverters, will be set to **0.75**. The Kamuthi Solar Power Project[6] in the south of India will be used to calculate the solar panel yield, since a type of panel being used is known to be similar to the Canadian Solar CS6X-310P Solar Panel - 310 Watt Max Power[7]. The annual average can be calculated using the Global Solar Atlas for the approximate location of the project. With the panel efficiency of **16.16%** and an on-site annual radiation value of **1980 kWh/m²** the equation delivers a required area of:

$$A = \frac{267903TWh}{0.1616 \times 1980\frac{kWh}{m^2} \times 0.75} \approx 1116000km^2$$

This is roughly equal to the land area of South Africa[9]. Additionally, the round-trip efficiency of hydrogen as a means of storing the power for further distribution can be assumed to be around **30%**[10].

This results in triple the area necessary:

$$A = \frac{267903TWh}{0.1616 \times 1980\frac{kWh}{m^2} \times 0.75 \times 0.3} \approx 3721000km^2$$

Requiring an area roughly twice the size of Indonesia[11]. This however only equates to **0.73% of earths total surface area** of 510 072 000 km^2 [12].

However, if we consider the amount of renewable energy already being produced in Germany, which is about 426 TWh for 2019 according to the Umweltbundesamt[13], we get a considerably smaller area. This number also roughly falls in line with a percentage of **18%** for renewables across the European union, given by Eurostat[14]. Since for locally generated energy no transportation is required, the hydrogen round-trip has no impact on that potion of energy produced. After subtraction of the above-mentioned value we end up with the following result:

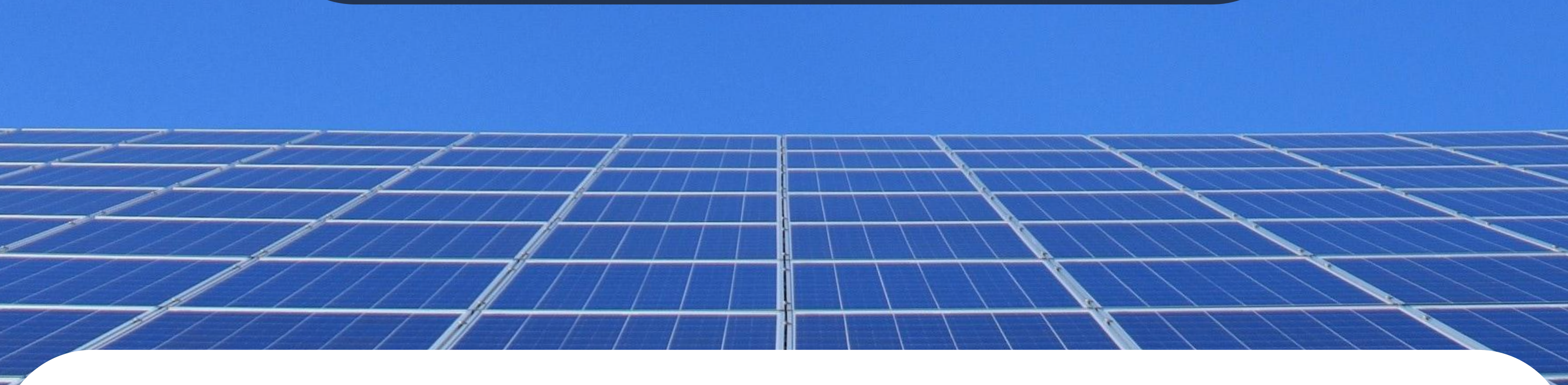
$$A = \frac{222234TWh}{0.1616 \times 1980\frac{kWh}{m^2} \times 0.75 \times 0.3} \approx 3087000km^2$$

This new result is roughly the area of India and only takes up around **0.6% of the earths surface**. At an area of around **1.92**$\mathbf{m^2}$ resulting from each panel with an installed capacity per panel of **310 Wp**[15] the total installed capacity results in:

$$\frac{3087000km^2}{1.92m^2} \times 310Wp \approx 500TWp$$

Based on the energy consumption of Germany, a projected world population in 2050 and an energy transportation system using hydrogen a photovoltaic project with an installed capacity of 500 TWp with a surface area of 3087000km^2 would be required to satisfy the global demand for energy.

This area is no bigger than the blue dot on the world map below.



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Sources

[1]https://www.umweltbundesamt.de/daten/energie/energieverbrauch-nach-energietraegern-sektoren
[2]https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/liste-zensus-geschlecht-staatsangehoerigkeit.html
[3]https://databank.worldbank.org/source/population-estimates-and-projections
[4]https://population.un.org/wpp/Download/Standard/Population/
[5]https://photovoltaic-software.com/principle-ressources/how-calculate-solar-energy-power-pv-systems
[6]https://www.adanigreenenergy.com/solar-power/Kamuthi
[7]https://www.solarelectricsupply.com/canadian-solar-cs6x-310p-solar- panel-max-power-wholesale
[8]https://globalsolaratlas.info/detail?c=9.351513,78.21373,11&s=9.388097,78.364792&m=site
[9]https://data.worldbank.org/indicator/AG.LND.TOTL.K2?locations=ZA&view=map
[10]https://pubs.rsc.org/en/content/articlehtml/2015/ee/c4ee04041d
[11]https://data.worldbank.org/indicator/AG.LND.TOTL.K2?locations=ID
[12]https://solarsystem.nasa.gov/planets/earth/by-the-numbers/
[13]https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen
[14]https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=sdg_07_40&plugin=1
[15]https://www.solarelectricsupply.com/canadian-solar-cs6x-310p-solar-panel-max-power-wholesale