DATE: 03/07/2021
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SUBJECT: Fermi Problem Tech Note

1 PROBLEM 1

Assuming that all consumer vehicles and light trucks in the us were to migrate to BPEVs, how what would be the reduction in the yearly CO_2 emissions in the US?

We first need to know the number of consumer vehicles and light trucks in the US which account for 71.4% percent of all vehicles which is about 204.92 million vehicles [3]. In 2020 the US produced about 4,576 million metric tons of $\mathbf{CO_2}$ from all vehicles in the country. If we account for the 71.4% of those vehicles that we are replacing, we have 3,267 million metric tons of CO_2 produced by consumer vehicles and light trucks. Tesla manufactured and sold 500,000 vehicles in 2020 and helped reduce five million metric tons of CO_2 which means each vehicle saved 10 metric tons of CO_2 in a year compared to a gas fueled vehicle [5]. With this information we can calculate how much CO_2 will be reduced yearly.

$$4576\ \textit{million metric tons of}\ \mathrm{CO_2} \times\ 0.714 = 3{,}267\ \textit{million metric tons of}\ \mathrm{CO_2}$$

$$\frac{500{,}000\ \textit{Tesla vehicles}}{5{,}000{,}000\ \textit{million metric tons of}\ C0_2} = 10\ \textit{metric tons of}\ CO_2\ \textit{reduced per vehicle}$$

If each vehicle was replaced by a Tesla vehicle we would have:

$$\begin{aligned}&204{,}920{,}000\ \textit{vehicles}\ \times 10\ \textit{metric tons of}\ CO_2\ \textit{reduced}\\ &\qquad = 2{,}024{,}200{,}000\ \textit{metric tons of}\ CO_2\ \textit{reduced per year}\end{aligned}$$

$$\frac{2{,}024{,}200{,}000\ \textit{metric tons of}\ CO_2 \textit{reduced per year}}{4{,}576\ \text{million metric tons of}\ \mathrm{CO_2}\ \textit{from all vehicles}} = 44.78\%$$

2 PROBLEM 2

What would be the increase in required yearly generation of electricity in the US to charge those vehicles?

The US produced about 4,116 billion kilowatt-hours (kWh) in 2021 [1]. A Tesla vehicle requires about 4,000 kWh of electricity per year [5]. For 204.92 million vehicles that would lead to 819.68 billion kWh. That's about 19.91% increase in electricity production required to make this change.

$$4{,}000\ kWh\ per\ vehicle\ \times 204.92\ million\ vehicles = 819.68\ billion\ kWh$$

$$\frac{819.68\ billion\ kWh}{4{,}116\ billioin\ kWh} = 19.91\%\ increase$$

3 PROBLEM 3

Could that yearly increase in electricity demand be provided solely by local (i.e. generation near the demand, for example home rooftops) photovoltaic solar generation?

In 2021, photovoltaic solar generation accounted for 112 billion kWh of electricity out of 4,116 billion kWh, which is about 2.8% of all the electricity produced in the US [1]. That is only about an eighth or 13.66% of the electricity needed, thus unless we intensively increase photovoltaic solar generation around the country it will not be enough.

$$\frac{112\ billion\ kWh}{819.68\ billion\ kWh} = 13.66\%$$

4 PROBLEM 4

Could that yearly increase in electricity demand be provided by a rectangular grid of photovoltaic solar generation in the desert southwest (e.g. Arizona or Nevada). What area (square miles) of photovoltaic generation that region would be required, and what might be the environmental, economic, and cultural factors associated with such a solution?

In Arizona, a south facing 1kw panel with a 5.5 ft X 3.3 ft dimension can produce 1,752 kWh per year [2]. We already have 112 billion kWh from the current solar panels out there so we need to get the remaining out of 819.68 billion kWh which would be 707.68 billion kWh. If we were to use 1kw panels to produces the needed power, we would need roughly 403,926,941 panels. The total area to hold these panels would be 7,331,273,979 square feet which is roughly 263 square miles. The environmental aspect that would be very important to consider for this solution is the wildlife that might be impacted around where the solar panels would be put. This solution has great economical benefits as it would create lots of jobs. Cultural this solution would heavily increase the use of solar power around the country and push it to be the standard compared to using non-renewable sources of energy.

$$\frac{707.68\ billion\ kWh}{1{,}752\ kWh} = 403{,}926{,}941\ solar\ panels$$

$$5.5\ ft\ \times 3.3\ ft = 18.15\ ft^2\ area\ per\ solar\ panel$$

$$403{,}926{,}941\ solar\ panels\ \times 18.15\ ft^2 = 7{,}331{,}273{,}979\ ft^2\ total\ area$$

$$1\ mi^2 = 1\ mi\ \times 1mi = 5280\ ft \times 5280\ ft = 27{,}878{,}400\ ft^2$$

$$\frac{7{,}331{,}273{,}979\ ft^2}{27{,}878{,}400\ ft^2} = 262.97\ mi^2\ \approx 263\ mi^2$$

5 REFERENCES

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[4] S. Fields, S. Fields, About Spencer FieldsSpencer is the Manager of Market Strategy & Intelligence at EnergySage, View all posts by Spencer Fields →, P. D. H. N. 19, R. L. J. 31, B. artin J. 22, A. G. J. 21, D. J. O. 9, F. L. J. 20, S. F. P. authorF. 7, and S. W. N. 14, “How many solar panels do you need to charge an EV?: Energysage,” Solar News, 18-Oct-2019. [Online]. Available: https://news.energysage.com/how-many-panels-do-you-need-for-your-ev/. [Accessed: 05-Mar-2022].

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