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P2 2 Taylor's Turnstile Turbines: The Swiftie Solution

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Abstract

We investigate the total of the CO₂ emission produced by private jets taken by Taylor Swift across her 2023 US Eras tour. This totalled 52,300 kg of CO₂ which is equivalent to 6.20 GW of power. Additionally, we explored the implementation of wind turbine-like turnstiles across this tour to see how much power could be generated back by her fans. We found that with 1.96 million people only 1.08 MW would be generated, equating to 0.0175% of the power used for private jet travel.

Introduction

A study conducted in 2022 by the sustainability marketing firm 'Yard' found that of the highest CO₂ emitting celebrities from private jet travel, American Singer-Songwriter Pop superstar Taylor Swift sits at the top [1]. This was done using online registered celebrity private jet flight records. As an extremely popular artist, Ms Swift is constantly traveling around the world on tours to perform for her millions of fans (Swifties). Across the course of a tour she takes numerous flights via private jets traveling varying distances and durations, leading to an accumulated production of CO₂. We investigate the CO₂ emissions that her 2023 US Eras tour would produce and explore the possibility of utilizing her enormous concert attendees as a form of renewable energy. We implement a model using Turnstile Turbines to see if this strategy will offset her Private Jet Proclivities.

Theory

In order to explore this approach to renewable energy (The Swiftie Solution), we must first calculate the amount of CO₂ that was produced on

this particular tour. This is achieved by totalling both the flight time and flight distances between each venue on her listed tour schedule from social media [2]. Assuming these private jets travelled the same path as commercial planes, we used an online flight calculator [3] to calculate both flight time and distance between each venue. The total flight distance across this tour is converted to kg of CO₂ using a rate of 4.9kg of CO₂ per mile for private jet travel [4]. This is then converted to kWh from the value of 0.233 kg CO₂ per kWh [5]. Along with flight duration and distance, we totalled the capacities of each venue she performed at on the assumption that she sells out at each concert. This equates to a total of 1.96 million people.

For the Turnstile Turbines, we modelled the turnstiles in each arena as a wind turbine. This is similar to the experiment conducted by IBERDROLA in 2023 where the turnstiles in the Miromesnil Metro station were converted into miniature wind turbine blades [6]. From this model, we calculate the amount of power generated from these turnstiles using the equation below for wind turbines [7]:

$$P = \frac{1}{2} C_p \rho \pi R^2 V^3 \quad (1)$$

where C_p is the efficiency coefficient, ρ is the density of air, R is the length of the blades and V is wind speed in ms^{-1} . As our turbines are powered by people, wind speed is changed to walk speed to simulate concert goers entering the stadium.

Results

Utilizing the online flight calculator, the measurements of Ms Swift's private jet journeys across this tour were calculated to be approximately 10,700 miles taking 28 hours to complete. Using the previously mentioned conversions, the total value of kg of CO_2 emitted across this tour is 52,300 kg. Converting this to kWh and multiplying by the flight time gives an equivalent amount of power used for travel during this tour to be approximately 6.20 GW.

The Turnstile Turbine power produced is calculated using Equation 1. We assume: a motor efficiency of $C_p = 1$ for a maximum value, the value of standard air density as 1.22 kgm^{-3} , a blade size of 0.5 m and an average walk speed of 0.833 ms^{-1} (3 kmh^{-1}). Inputting these into Equation 1, we calculate a value for the power generated per person in these turnstiles to be 0.277 W. In order to test the validity of this equation and parameters, we compared it to the figures cited in the IBERDROLA study which stated that with the movement of 1.5 billion people through turbine-like turnstiles, 136 MW would be generated. Dividing this value by the amount of people cited gives a result of 0.0907 W per person. This value is only a factor of 0.327 smaller than our calculated value so we believe our result to be valid.

With this value of W generated per person with our Turnstile Turbines, we multiplied this by the maximum number of attendees Ms Swift could have at all her venues during this tour (1.96 million people). This gives a value for the theoretical amount of watts generated using these turnstiles at this particular tour as 1.08 MW.

Conclusion

The amount of power generated by the Turnstile Turbines is dwarfed by the amount of power used for Ms Swift's travels with only 0.0175% of the power being generated back. At these rates Ms Swift would need around 11,400 times more than her current attendance to break even, equating to around 22.4 billion people. That's a lot of Swifties!

Overall, these values show that even with an attempt at reclaiming the power used for flight, the emissions from private jets are not a "Love Story".

References

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