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P5_5 Electric Vehicle vs Solar Panels

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Abstract

This paper investigates whether it is possible to recoup an electric vehicle's charging costs by exporting solar energy over the same time-frame. It is found that it would take 13.11 days to export enough solar energy to break even against the costs of charging the EV.

Introduction

Traditionally known as a route to travel the whole of the UK, Land's End in southwestern Cornwall to John o'Groats in northeastern Caithness is famous around the world.

This paper evaluates whether it is possible to complete a cost-free drive of the route in a single day by weighing the costs of charging an electric vehicle using the UK's public charging network against energy generated by solar panels exported back to the grid.

If the costs cannot be recouped within the same time-frame, this paper discusses how long it would therefore take for solar panels to earn back the money spent to charge the EV.

Assumptions

There are several key assumptions that must be made to ensure this experiment is kept fair and consistent. The car used in the model is a brand new base model Volkswagen ID.3 electric vehicle.

The car begins the experiment from Land's End with 100% charged battery, however the range of the car will be taken to be 90% of the quoted range to account for inefficiencies in reporting and real world testing. The type of charging points used are taken to be rapid, which are slightly quicker than fast but slower than ultra-fast.

The solar panel system is assumed to contain 16 panels of size 1.6m^2 each, the efficiency of each panel is taken to be 20% [1], and 14 hours 40 minutes of sunlight is taken, the same time-frame as the trip. There are no losses of power in the system aside from cable losses equating to a 75% performance ratio [1].

Theory

The quickest route from Land's End to John o'Groats is calculated to be 837 miles and a driving time of 14 hours 40 minutes, traversing the A30, M5, M6, A74(M), M74, M73, M80, M9, A9, and the A99 roads [2].

The Volkswagen ID.3 is an electric vehicle which is likely to be a popular choice in future years. The base model, the ID.3 Life, is quoted to have a 213 mile range with the 'Pure' 148PS 52kWh (Net) battery package [3].

In order to calculate the cost of the trip, we use the equation:

$$c = f_c(k * u_r) + 1.5f_c \qquad (1)$$

Where c is the cost in £, f_c is the number of full charges required, k is the size of the battery in kWh, u_r is the average unit rate cost per kWh at a public charging point in £/kWh, and the $1.5f_c$ represents the minimum transaction charge per charge in £.

Solar panels are a common yet effective way to generate renewable electricity, resulting in a carbon footprint reduction as well as a cut on electricity costs. Each solar panel itself consists of silicon cells which allows the flow of electricity when light is captured.

The equation to determine the power generation from the solar panels is [1]:

$$E = A * r * t * PR \tag{2}$$

Where E is the energy generated in kWh, A is the total solar panel area in m^2, r is the solar panel efficiency, t is the hours of sunlight available, and PR is the performance ratio [1].

Octopus Energy's Fixed Outgoing tariff is their successor to the Feed-in-Tariff, and allows customers to sell electricity back to the grid [4].

The earnings from the Fixed Outgoing tariff is calculated to be:

$$e_e = E * 0.055 \tag{3}$$

Where e_e is the export earnings in £, E is the energy generated by the solar panels from equation (2) in kWh, and £0.055 represents the fixed unit rate per kWh of the Outgoing tariff [4].

Results

The ID.3 Life model is evaluated to do roughly 192 miles on a full charge. For the designated 837 mile trip, the ID.3 will therefore take 4.37 full charges in order to complete the journey. By using equation (1) and an average unit price per kWh of £0.15 [5], the cost is determined to be £40.64 for the ID.3 to complete the journey.

Upon taking values of $25.6m^2$ for the total area ($1.6m^2$ for 16 panels), 20% efficiency, 14hrs 40mins of sunlight available, and 75% performance ratio [1], the energy generated by the solar panels is computed to be 56.32 kWh. Taking advantage of the Outgoing tariff, the earnings from exporting the solar energy is calculated to be £3.10 while making the 14hrs 40mins car trip.

Discussion

In order to justify the trip from Land's End to John o'Groats, it is deduced that it would take 13.11 days of exporting 14hrs 40mins worth of solar energy back to the grid per day to break even and recoup the costs of charging the EV.

It is clear to see that the cost of charging the EV vastly outweighs the earnings from exporting the solar energy generated. Despite the experiment being for a disproportionate length of trip, it could be ascertained that electric vehicle charging needs to be become cheaper for there to be wider adoption. Further work could be done to determine potential enhancements that could be made to public charging points to increase charging speeds or reduce transaction and charging costs.

Conclusion

From the results, it is established that the cost of public charging a Volkswagen ID.3 from Land's End to John o'Groats is found to be £40.64, and £3.10 of solar energy was generated and exported to the grid over the same timeframe. It was also calculated that it would take 13.11 days of exporting solar energy in order to break even with the charging costs from the trip.

References

[1] `https://photovoltaic-software.com/principle-ressources/how-calculate-solar-energy-power-pv-systems` [Accessed November 2021]

[2] `https://www.rac.co.uk/drive/travel/uk-road-trips/lands-end-to-john-o-groats/` [Accessed November 2021]

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[4] `https://octopus.energy/outgoing/` [Accessed November 2021]

[5] `https://www.rac.co.uk/drive/electric-cars/charging/how-much-does-it-cost-to-charge-an-electric-car/` [Accessed November 2021]