Impact of Full Scale Vehicle Electrification on UK Energy Supply and Demand

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This is a business case evaluating the impact on the supply of energy of converting every car-type vehicle in the UK to an electric vehicle by 2020, and the changes required to make doing so sustainable.

1. Introduction

Electric vehicles (EVs) have been proposed as a promising solution to reducing the UKs carbon emissions and reliance on nonrenewable sources, with significant government subsidies currently offered to encourage their adoption [1].

Moving to EVs allows transportation to be run on a cleaner energy source due to it being produced either renewably, or conventionally with much greater efficiencies than possible in individual vehicles.

However, as traditionally the energy for consumer vehicles is transported off grid, in the form of petrol and diesel, electrifying this has a significant impact on future electrical energy demand, necessitating significant changes to current grid capacity, and distribution networks.

The Tesla Model S 90D will be used as the test vehicle, due to its high electrical efficiency, the amount of information available, and its proven time on the market.

A target year of 2020 has been chosen to allow available data values to be projected to a common year, EU ETS 2020 [2] European carbon targets to be considered, and UK 2020 national grid capacity and generation projections to be used.

2. Benefits

The primary benefit hailed is the reduction of emissions from individual vehicles. From a study by the US Environmental Protection Agency, it was shown that in 2015 the average CO_2 emissions per mile (CO_2/m) for an average vehicle is **411 grams** [3]**.**

An argument can be made that efficiencies would increase between 2015 and the target year, decreasing this value, but the assumption is made that it is unlikely that a significant enough proportion of old vehicles will be retired and replaced with new models to have significant impact.

It can be assumed that for an EV, the CO_2/m running emissions are **0 grams.** Therefore, it is proposed that converting to EVs will net a significant reduction in UK CO_2 emissions. Note, this does not account for CO_2 emissions during production, or transportation of components.

From a study by the Department of Transport, in 2016 car traffic grew by 2% to 252.6 billion vehicle miles/year (bvm). From this, that can be extrapolated to **262.81 bvm** in 2020. Therefore, the annual CO_2 emissions are taken to be 108015 billion grams**,** or **108 Mt (Metric megatons),** giving a net saving of that amount.

2015 UK CO_2 emissions are taken to be **404 Mt** [4], and it is known that the 2050 emissions target is **156 Mt** [5]

2.1. Conclusions

From a 2015 emissions value of 404 Mt, the 108 Mt carbon budget attained from converting every electric vehicle to an EV represents a saving of **28%**.

This is a significant saving, and a big step towards the target of 156 Mt by 2050. However, as will be shown, this is not accounting the resultant increases to future energy demand, with considerations for energy generation, and distribution.

3. Costs

The US Department of Energy states that the combined city/highway energy of a Tesla model S 90D to be **32kWh/100 miles.** [6]

Using the previous value of 262.81bvm, this results in 8.0832×10^{13} Wh/year, or **80.83T Wh.**

Last year (2017), the total electrical energy consumption by the UK was **27.1T Wh** [7]

3.1. Conclusions

Converting to EVs alone will raise the UK's electrical energy requirements to 107.93T Wh by 2020, requiring a 398% increase over current values, or an addition of **80.83T Wh**.

4. Analysis and Changes Required

The analysis has shown that going "all in" on consumer EVs has a significant benefit, reducing the UK carbon emissions by 28%, netting a significant step towards the UKs carbon targets for 2050.

However, the cost of doing so is almost a 400% increase in the UKs electrical energy demand, even before accounting for increases in any other areas.

This is problematic and requires changes in distribution, and generation.

4.1. Distribution

Electrical Energy is currently largely generated centrally and distributed to individual homes through a series of distribution networks.

At a base level, increasing the energy generation, requires an associated increase in the capacity of this network, requiring additional cables to be lain, pylons to be constructed, and distribution centers built. Due to the nature of an EV, this must additionally continue through to the residential networks, required to deliver the power to individual homes if at-home charging is desired. In addition to being costly, this is highly disruptive to the local area, if possible at all.

4.2. Generation

The values for generation in the UK from the national grid predictions for electrification of heat by 2020 (Figure 1) [8] are considered.

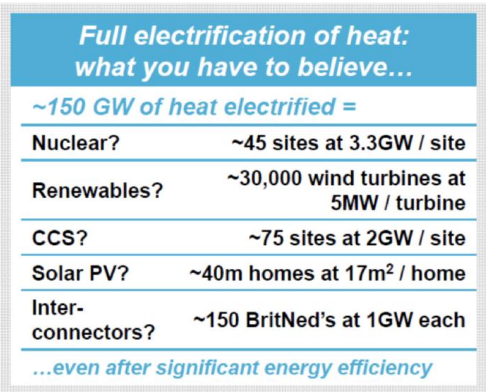

Figure 1 - UK 2020 Electricity Generation

From this, the following values can be determined.

Installation	Generation (Wh)	Generation (Wh/year)
Nuclear Site	3.3G	1.21T
Wind Turbine	5M	1.83G
Residential Solar PV (Thousand 17m^2 Installations)	3.75M	1.37G
Inter-Connector (BritNed Equivalent [9])	1G	0.37T

Three “all in” solutions could be considered to obtain the 80.83T Wh/year deficit from carbon neutral sources.

- 66.9 (67) new nuclear sites

- 44 thousand new wind turbines

- 59 million homes equipped with residential solar.

- 218 new BritNed equivalent interconnects.

While effective, all of the above minus solar PV would require significant changes to distribution network capacities, as outlined above.

4.3. Residential Solar PV

The residential solar option is an often-proposed solution, solving the generation aspect, and reducing the requirements for distribution.

However, as seen above, the number of homes required far outstrips the number of homes in the UK, at 59 million vs 27.2 million (2017) [10]

In addition to reduced power output during the winter, this means it is not a sustainable solution on its own. However, it could potentially be used to lessen the load on the central power distribution network.

5. Conclusion

The benefits of a nationwide deployment of EVs are clear, netting a 28% reduction in emissions, however, this has a significant impact on future energy demand.

The changes required to do so would require a large immediate investment in power generation, in the order of ~67 new nuclear sites, and a significant upgrade to distribution.

Both these problems could be reduced by residential solar PV, but not eliminated by this alone.

Therefore, without significant investment in these two areas, electrification of UK vehicles cannot be considered truly sustainable.

6. Bibliography

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