Exploring the benefits of using locally generated solar energy, supported by a BESS, in reducing Well-to-Tank emissions associated with electric road freight fleets.

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The urgency to revert the negative prospects of climate change is motivating a global demand towards decarbonisation policies. The UK has pledged by law (Climate Change Act 2008) "to ensure the net UK carbon account for the year 2050 is at least 100% lower than the 1990 baseline"[1]. For that to happen, decarbonisation of the transport sector is required. Despite the estimated impact that the coronavirus (COVID-19) pandemic has had in reducing GHG emissions, the transport sector continues to be the highest GHG emitter in the United Kingdom [2]. According to the last available data, it emitted 109.5 MtCO2e in 2021, 91% of which came from road transportation [3]. Within this context, road freight transport plays an important role not only due to its GHG emissions but also because of its negative impact on air quality. Heavy goods vehicles (HGVs) and light goods vehicles (LGVs) are estimated to account for around 46% of total road transport NOx emissions [4], while making up just 6% and 18% of vehicle miles, respectively [5].

On the other hand, freight transportation is an important activity in our daily routine and a significant contributor to the UK economy. This might be the reason why future predictions point out a further increase in freight transport demand linked to an increase in population and GDP [6]. Precisely, freight transport demand is expected to increase by 7% and 28% in 2030 and 2050, respectively in relation to values from 2018 [6]. This will lead to an increase in GHG emissions if appropriate measures are not taken into consideration.

Road freight transport decarbonisation is a challenging path. However, one of the most promising solutions is the electrification of transport. Electrified powertrains, such as battery electric vehicles (BEVs), provide an interesting solution because they not only help to reduce air pollution but they also support noise abatement associated with transportation, which is particularly attractive in the context of city logistics [7]. However, BEVs can still emit significant quantities of GHG emissions if the energy used to charge them comes from fossil fuels such as coal, oil, or natural gas. In this regard, the use of renewable energies is crucial.

The present study is focused on identifying whether the barriers associated with the Well-to-Tank emissions (WTT) from the grid mix network on electric vehicle fleets could be addressed so that the benefits of road freight transport electrification could be further maximised. For that purpose, the adoption of on-site solar energy generation supported by a battery energy storage system (BESS) is explored for a waste management depot (WMD) with an electric refuse collection vehicle (eRCV) fleet. The system's energy flow is assessed by means of an energy management system based on an algorithm built on MATLAB/Simulink environment. The algorithm prioritises using Photovoltaic (PV) generated solar energy, with the support of a BESS, to cover as much of the energy demand as possible. The results are compared against a given base case scenario (BCS). The BCS refers to a hypothetical scenario in which the WMD does not have PV solar panels installed nor a BESS but wishes to switch its refuse collection vehicles to an electrically powered eRCV fleet. In this BCS, the grid mix will cover the eRCV fleet charging requirements and the depot's energy demand. The evaluation performed for both scenarios considers different charging patterns to provide a broader set of outcomes that could be applied. These consider different operational requirements, such as operating times, and contributes to the novelty of the work by including the fleet energy support. Additionally, the potential power constraint associated with fleet electrification when the power connection cannot be upgraded is explored for one of the determined charging patterns. Finally, the analysis considers the impact on grid dependency, GHG emissions and system lifetime costs.

Based on the results, it was found that introducing PV panels and a BESS reduces the grid dependency of the overall facility, the total cost over the system lifetime for certain BESS capacities, and the GHG emissions. Furthermore, depending on the charging pattern, the benefits of having PV panels and a BESS on site can be further maximised. However, at times, the upgrade of the power connection is not an option for different reasons outside the customer's control. Under these circumstances, the system incurs an extra cost due to the excess capacity charge if the grid connection power capacity is surpassed. The results demonstrate that under these circumstances, a BESS with a capacity of 10 MWh allows the system to meet the energy requirements without exceeding the contracted grid connection power capacity. However, when all amortised costs are included, the use of PV panels and a BESS must be implemented with other strategies, such as smart charging, to make it economically feasible.

The results from this study have the potential to align the objectives of transportation and logistics companies with the sustainability needs of the local government agenda around clean air zones and the decarbonisation of transport. Moreover, it will provide valuable insights for transport fleet operators regarding EV charging management for maximising potential solar energy generation and charging at a commercial depot.

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