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Electric trucks

Truck fleet electrification has minor grid implications

Electrification of truck fleets has been perceived as costly both in terms of vehicle and charging infrastructure investments. A new study shows that, with the right charging strategy, electrification of a short-haul delivery fleet does not require major investments in the electric grid substations.

Heavy-duty truck electrification is gaining momentum, with major European truck manufacturers signing a pledge to phase out sales of traditional combustion engine trucks by 2040 and focus on batteries, hydrogen and clean fuels[i]. Battery prices are expected to decrease significantly in the coming years, while charging infrastructure developments enable high-power charging of large batteries. As such, the life cycle costs of heavy-duty electric trucks are expected to become lower than those of heavy-duty diesel trucks, making electrification of heavy-duty trucks an interesting research area[ii,iii].

Electrification of truck fleets also requires recharging infrastructure, which may incur high investment costs and be a hindrance for deployment. In a new study in Nature Energy, Matteo Muratori and research team from National Renewable Energy Laboratory, with industry representatives from Oncor Electric Delivery Co. and Southern Company, use real-world operating data to explore the charging requirements and electricity distribution system implications of electrifying truck fleets[iv].

The researchers use vehicle drive cycle data from three truck fleets delivering food, beverages and warehouse goods with the heaviest truck classes. The fleets operate with moderate daily mileage: a maximum of less than 200 miles per day for fleets 1 and 2 and mostly less than 300 miles for fleet 3. All three fleets have ample depot charging opportunities of 14 hours per day on average. The long off-shift periods of the fleets enable various charging strategies, of which the researchers model three. The first strategy applies 100 kW charging power as soon as the shift ends until the battery is full. The second strategy also applies 100 kW power but delays the charging so that the battery is full on time for the next shift. The third strategy uses the entire off-shift period and applies the lowest possible charging power.

In the first charging strategy, for fleets 1 and 2, the peak load period of around three hours with 450-650 kW for 10 trucks coincides with the typical system-level evening summer peak (5-9 pm), while the second strategy's peak load coincides with the typical system-level morning winter peak (6-10 am). The third strategy cuts the peak load by more than 80% to levels of less than 23 kW per truck. These levels are widely available for electric cars. Fleet 3 had more varied off-shift periods for trucks, which resulted in a lower peak load of 320 kW for a fleet of 10 trucks in the first and second charging strategies, but higher charging power requirements with a maximum of 103 kW in the third charging strategy. The researchers assumed an average energy consumption of 1.8 kWh/mile, but included a sensitivity analysis with up to 2.8 kWh/mile consumption, which increased the charging power requirements by around 50%.

The researchers then looked at 36 real substations in Texas and considered how they would be able to manage a set of load profiles from two of the fleets. The analysis shows that the implications of battery electric trucks for the electric grid depend heavily on the charging strategy. Around 80% of substations are capable of charging 100 trucks with the 100 kW charging strategies, but around 90 % of substations can supply 100 trucks using the lowest possible charging power strategy, without requiring upgrades. This suggests that utilities and fleet operators should work together to use low charging power at depots and consider sharing the capital cost savings, which are available using solutions that do not require costly and time-consuming substation developments.

Muratori and the research team provide valuable insight into battery electric truck research on two aspects. First, the consideration of electrification of a fleet is a welcome addition to a research body that has mainly focused on the impacts of electrification on a vehicle level[v] or on the electrification potential on a national level[vi]. Second, the study examines the implications of electric trucks on the electric grid at a substation level, with cost analysis, while previous research has not considered the issue or touched upon it mainly on the national level[vii]. The fleet and substation level analysis is important because this is the level on which investment decisions are made. Fleet owners may invest in one or two electric trucks of different size to gain an understanding of new technology, but ultimately electrification is a strategic decision which is taken at fleet level; meanwhile the recharging implications of a fleet on the grid have to be considered at the substation level.

The researchers share a common view with previous research, that fleets focused on short-haul operations with long off-shift periods for low charging power requirements are the early candidates for electrification. This view has recently been challenged because the cost-competitiveness of electric trucks can improve with greater truck weights, which are not currently allowed in the United States but used in Australia, Sweden and Finland[iii]. However, heavy electric trucks, which are used in long-haul operations and do not have long off-shift periods for recharging at depot, require high-power fast charging in the 1 MW power range during driver's mandatory rest periods, likely to require substation upgrades near highway service stations.

Further research on the electrification of various types of road freight operations, combining the fleet approach and grid implications at substation level as Muratori and team have done, is needed to provide confidence to fleet owners and utilities to invest in electric trucks to decarbonize freight transport.

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Competing interests

The authors declare no competing interests.

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