THE IMPACT OF THE WEATHER ON ELECTRIC VEHICLE FLEET DEMAND

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Overview

Many countries around the world are undergoing a rapid transition to electric vehicles (EVs), and must prepare their electricity systems to accommodate this new source of demand. To integrate EV charging into power system operations and planning requires understanding and predicting the demand from this new electric fleet. On an individual vehicle level, it is clear that the prevailing weather has a significant impact on EV range and electricity consumption per kilometre. However, the aggregated effect of this relationship between the weather and electricity demand across a fleet of EVs has seen only limited research. This research derives an empirical relationship between ambient temperature and electricity consumption to estimate how future electric fleets will be impacted by the weather, using Germany as a case study.

Methods

Empirical relationships between temperature and electricity consumption per kilometre driven for battery electric EVs (BEVs) were taken from eight sources in the literature. These relationships were standardised through the use of change point regression to identify threshold temperatures below/above which vehicle energy consumption increased, and the increase in consumption per km for each °C that daily-average air temperature moved beyond these ranges (primarily due to the use of heating and air conditioning).

The resulting relationship between temperature and vehicle electricity consumption was then applied to historical location-specific temperature data across Germany between 2015 and 2020 (taken from www.renewables.ninja). This gave an estimate of the time-varying national electricity demand to recharge the electric vehicle fleet, given the prevailing weather. The seasonal and day-to-day variation in this demand profile was contextualised against historical electricity demand for Germany (taken from www.entsoe.eu).

Results

As EV consumption is highest during periods of cold weather, we find that demand from an electric fleet would be 22% higher during the ten coldest days of the historical data, compared to demand during the ideal conditions for EV efficiency (between 12°C and 17°C). This result is almost double the 12% increase in existing national demand for the same 10 days. Isolating the coldest day during the historical data, where mean national temperature fell to -9.5°C on the 28th of February 2018, demand from an EV fleet would have been 25% higher than during ideal conditions. Over winter (Dec-Feb) demand from an electric fleet is 12% higher than the annual average, whereas in summer months (Jun-Aug) it is 6% lower.

The highest ten days of national demand during the historical data was 22% above mean demand, where average temperature was on average -0.7°C. During these ten days, demand from an electric fleet would have also increased by 16%, suggesting a coincidence between system peak demand and electric fleet loads during cold weather periods.

Conclusions

This works provides a national scale assessment of how electricity demand from future electric fleets may change depending on the weather. For acute changes in temperature, electricity demand from an EV fleet will significantly increase and may further exacerbate the existing peak demand within electricity systems (which is also weather dependent). The observed changes in fleet electricity demand due to the weather will also have seasonal implications, where countries with colder climates will experience greater demand during the winter months. On the other hand, countries with warmer climate will observe the opposite effect.

This work has shown that integrating a fleet of EVs into future electricity system may be more challenging than would be anticipated from existing models which focus on the short-term profile of charging demand (i.e. diurnal shifting) and neglect the seasonal variation in fleet-wide loads demonstrated here. This work illustrates the need for further research on the influence of the weather on electricity demand, particularly for the transportation sector, where possible smart charging strategies may need to be integrated with weather patterns.