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The future of logistics: How will electric trucks shape the future energy demand and distribution of Switzerland?

The here presented study addresses the technological feasibility of replacing current internal combustion engine trucks that were registered in Switzerland with battery electric trucks. Three types of BYD (a Chinese manufacturer) battery electric trucks with different loading and range capabilities were considered as potential replacements of registered internal combustion engine trucks.

Our method is based on truck journey data collected by the Swiss Federal Statistical Office. We find that already nowadays between 71% and 74.5% of trucks could be replaced by battery electric trucks, which would result in a net reduction of 0.67 Mt of CO_2 emissions. As many of the replaced trucks only cover small daily distances, we argue that larger battery packs than currently available in commercially offered trucks are a necessity.

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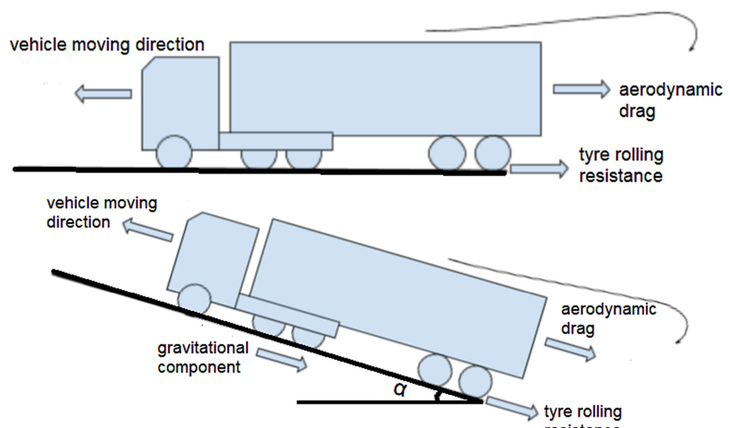
Introduction

Swiss-registered trucks (curb weight > 3.5 t), contributing more than 2.2 billion kilometers in 2017 road transportations [1], will be facing more regulations on emissions in the upcoming years [2]. A change of energy source for truck transportation is necessary.

Currently, BYD (a Chinese manufacturer that already sells battery electric trucks) has three offerings with different range capabilities and loading capacities. Three types of trucks will be assigned to replace current internal combustion engines based on surveyed drivers' maximum load weights [3].

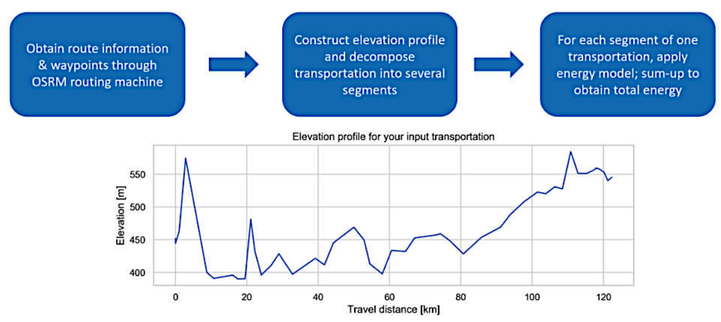
Energy demand model

This study constructed a battery electric truck energy model that can be applied on both flat surfaces and inclined surfaces, modified from [4]. The analytical energy functions' components on flat and inclined surfaces are shown in the figure below. Different efficiency and drainage rates are applied to the analytical energy model to obtain a realistic energy demand.



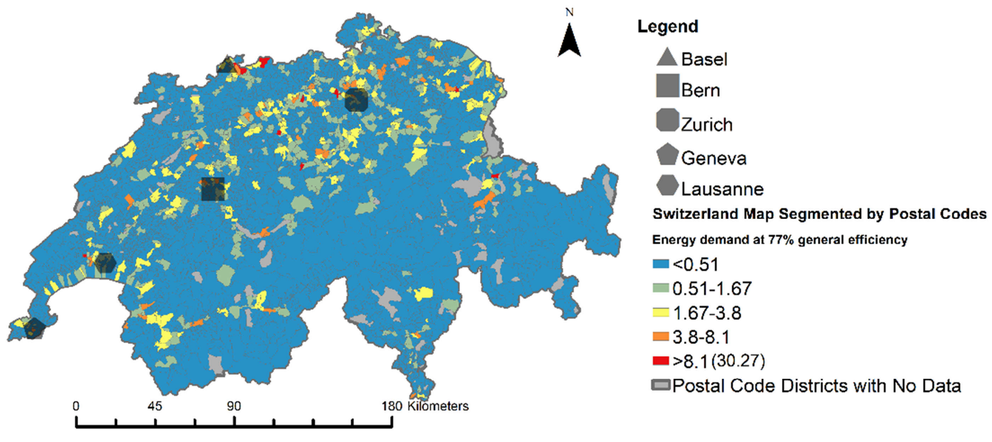
Route inclinations

The obtained data used postal codes as origin and destinations of each transportation; therefore, our routing used Swiss Post's postal codes with coordinates to obtain routing information along with elevation profile for a more accurate and precise energy demand calculation.
The data processing logic and the elevation profile result of one transportation from Zurich Seebach, 8052 to Bern, 3001 can be found in the figure below.



Effects on local energy demand

Electric trucks require 1.348 TWh annually, 2.4% of the total end-consumption of Switzerland [5], and they can avoid 0.67 Mt CO2 for Switzerland, 1.67% of the total Swiss CO_2 emissions [6]. In areas with low population, electric trucks can bring 2 times or higher electricity demand per capita compared to the national average (7520 kWh [6]), and grid reinforcement in these areas is recommended. The annual total energy demand for each postal code area under the assumption that all charging activities will happen during a nighttime break at the efficiency of 77% is presented in the figure below.



Future requirements for e-trucks

Areas where the electrification may have a large impact were identified between Bern and Zurich, Basel and its surroundings, areas surrounding Zurich, Chur and its surrounding areas, Lausanne and its surrounding areas, and areas around St. Gallen.
The current stage of BYD solutions can replace 71% to 74.5% of internal combustion engine trucks under an average drainage rate of 70% at 77% to 85% of the general efficiencies (middle figure). In order to reach 85% of electrification of trucks in the future, a minimal battery capacity of 285 kWh required (right figure).

Conclusions

This study concludes that the deployment of electric trucks will slightly increase the national energy demand by 2.4% at maximum, will reduce Switzerland's CO2 emissions by 0.67 Mt, and will stress grids on loosely-populated areas. Currently, at least 71% of internal combustion engine trucks can be replaced by electric trucks. Future industrial involvement and development of grid stabilization, charging coordination, fast charging technologies, and higher battery capacity may accelerate the deployment of electric trucks with favorable policies as catalysts.

References

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Partners

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DITET

[1]This poster is based on the semester thesis that Keyuan Yin wrote as part of his Masters in Energy Science and Technology at the Department of Information Technology and Electrical Engineering at ETH Zurich.