INRODUCTION
In recent years, due to the rapid development of electric vehicles (EVs), electric buses used in urban fleets have become a key topic of study. The opportunity to reduce particulates and greenhouse gases emissions in the heart of cities, where many people live, has been driving this research. However, for bus operators, the transition from fossil fuel buses to electrically driven ones is not an easy process, because of different operating constraints: the charging time is a few orders of magnitude longer and the range of the operation is limited. Additionally, the charging infrastructure has to be completely designed and complex electrical constraints must be taken into consideration. This Master Thesis aims at developing a methodology that can be applied to achieve a feasible and cost effective transition from diesel buses to battery electric ones.

Methodology

1) Bus number minimization
2) Profitability maximization
3) Load profiles computation
4) Electrical architecture design

Theory

A Vehicle Routing Problem was developed in order to minimize the number of buses required to cover a given set of rides. The VRP is formulated as a directed graph, and different constraints ensure that all the selected rides are covered, that buses drive to charging station before being out of energy, and that the minimum number of buses is chosen.

The more buses run, the better their profitability. Therefore this step of the methodology aimed at maximizing the usage of the buses under constraints of SoC and availability at the depot. Moreover computation were realized to give a relationship between number of electric buses, total distance covered, and total number of buses.

Given the maximized routing of the bus, this third step of the methodology developed the minimum connection power required to charge the bus so that they can operate under the given routing. The charges profiles were also computed. The algorithm allowed reductions between 50 and 92 % of the worst case power rating.

Given the load profiles and the connection power from the previous step, a recharging infrastructure based on a DC common bus was developed in this step. The conversion steps are the following: MV Grid, AC/DC rectification, DC Bus, DC/DC chargers, EVSE, bus battery.

Results

Coverage of electrical standard buses in different scenarios

Optimized power required at the depot for 10 Buses, 10 Gbuses, 1 Kbus and 9 Mbus in scenario 11

Conclusion/Perspectives

A methodology to ease the integration and the planning of battery electric buses was developed. This methodology was applied to the case study of Zurich, but it could be applied to any cities. This opens a much broader field of investigation, next steps being actual testing of electric buses and implementation of routing strategies.

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Relevant References