A SPATIO-TEMPORAL APPROACH FOR EV CHARGING INFRASTRUCTURE DEPLOYMENT

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Overview

The current climate issue requires a drastic reduction in anthropogenic greenhouse gas emissions. Among the highest emitting sectors, road transport accounts for between 20 and 25% of these emissions in Europe and the US [1]. A transition in this sector toward greener mobility is therefore an important lever in reducing global greenhouse gas emissions.

The solution currently at work is to transform the fleet of internal combustion vehicles into a fleet of electric vehicles, with much lower emissions [2]. But such a transformation cannot take place without the acceptance of electric vehicles by users. This acceptance among the whole population is slowed down by a number of barriers, the two main ones being the price of vehicles, which is expected to disappear in quite a short term, and the range anxiety, which can be defined by the fear for an electric vehicle user that the car's battery will run out of power before they can be able to reach their destination or a suitable charging point. The best way to tackle this range anxiety issue is, rather than increasing vehicle's range, to deploy a charging infrastructure adapted to EV user's needs [3].

But due to the high cost of deploying a full charging infrastructure, it cannot be a prerequisite for the pre-eminence of electric vehicles in the fleet on the road : the infrastructure cannot precede the democratization of electric vehicles, but must accompany it, as the lack of certainty of a return on investment and the high costs involved in achieving a final charging infrastructure prevent it to be deployed all at once [4].

So the deployment of the infrastructure must be done according to a coherent planning to be as useful as possible to the users, and this as soon as the first charging stations are installed, in order to ensure the growth of the fleet of EVs necessary for the growth of the infrastructure [5].

Methods

We first identified five criteria to consider when determining the utility of placing a charging station at a location. These five criteria are :

- the number of vehicles that park at a location,
- their state of charge when they park,
- the parking time at the location
- the infrastructure coverage of the area under consideration.

We quantify each criterion with a score ranging from 0 to 1 for each location, which then allows us to play with the importance of each criterion in the final score of each location.

We then take an iterative approach. A budget for the infrastructure is determined for each time step. For each step, an optimization is done to determine how to best use this budget. The new stations are then placed according to the results of the optimization, which will have an effect on the user behavior. The new data relative to the above criteria are then collected for the next step, the scores are recalculated, the new stations are placed, and so on until the last step.

Results

In order to acquire the data and study the user response to the new stations, we simulated electric vehicles in the Berlin area with MATSim. The goal is to have an infrastructure that adapts to user behavior, so users do not change their plans: they charge during their activities if they have the possibility, but do not make specific detours or stops for charging. We then observe whether drivers fall below their range anxiety threshold, or run out of battery before they can recharge.

A first result that seems quite logical but that is always good to observe is that as we increase the number of charging stations, less and less users fall below their range anxiety threshold, and even less run out of battery.

We also observe that compared to a maximum coverage method, our model also allows fewer vehicles to run out of battery. On the other hand, it is less effective than a model that specifically minimizes the number of cars that run out of battery, which is expected since these models do not care about the extra time it takes the user, while our model does not add any time or detour to charge in order to keep an EV utilisation comfort comparable to a conventional one.

More analysis with differrent budgets, range anxiety thresholds, parking search radius or share of the population with access to a charger at home are in progress.

Conclusions

We developed a model for the placement of charging stations for electric vehicles that focuses on user behavior, so that the charging of their vehicle is integrated into their daily life. This model allows us to make a spatio-temporal planning of the deployment of a recharging infrastructure, in order to accompany the democratization of electric vehicles. The first results indicate that our method helps reducing range anxiety without adding constraints due to the use of electric vehicles rather than conventional vehicles.

References

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