Recharging stations distribution and use schemes for e-mobility

City-wide distribution schemes

Grupo 6:

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1. **Project introduction**

Context of the application domain

In the current days, Electric vehicles (EVs) are becoming increasingly popular on a worldwide scale, as a sustainable approach to internal-combustion-engine vehicles (ICEVs) by reducing CO2 emissions, increasing energy efficiency, decreasing oil reliance, and improving passenger trip comfort. For this to be achieved, EV adoption is heavily reliant on the continuing growth of charging stations, as well as proper access to charging facilities. As this industry grows, the creation of a public charging network is necessary, particularly in urban areas where many drivers don't have access to private charging.

Problem Statement

With the increase in the demand for electric vehicles, the need for infrastructures to support them has also risen. Amongst them are recharging stations and the good planning on their placement is vital to satisfy this demand while reducing operating costs and achieving high fluidity of private vehicles.

Simulation questions & hypotheses

What would be the best places for the recharging stations to be in?

Should we consider geographic distribution or adapt to population density and demographic variables?

Can the increase of charging cost according to how busy a station is at a certain point decrease saturation?

Is it beneficial to introduce fast-charging stations? Where?s

Can the efficient placement of the statements further increase interest in electric vehicles? If so, it can help achieve ecological goals.

Aim and goals of the project

The goal is to find the balance between benefits and cost in the distribution of recharging stations in order to satisfy the increasing demand. It is also important to achieve maximum utilization without flooding any of the stations.

2. **Problem Formulation**

Model Classification

In the context of our problem, we had to think in terms of a distributed system of recharging stations for EV and how its variables behave between them.

We start by classifying our simulation model as:

- Normative – we will be trying to optimize the distribution of charging station and their amount
- Speculative – we will be building our simulation model based on some assumptions around the vehicles behavior, their numbers and routes

System Variables

Regarding the variables that describe our model, we will have input variables that will eventually influence the outputs that are used to validate our different system approaches. For the exogenous variables, we separate them in two main groups: the controllable and uncontrollable:

- Controllable:
  - City map representation and the respective chosen size
  - Charging type available at the stations (fast-charging or not)
  - Number of charging stations and their distribution
  - Number of vehicles, their starting and ending points and their routes
- Uncontrollable:
  - Percentage of the population that uses EV
  - Traffic at different parts of the day
  - Waiting time between each charging, which will depend on the type of charging a person uses, the percentage of battery left and how much he wants to reach

For the endogenous/output variables we listed the following ones:

- The traffic generated in the proximity of each recharging station
- Average station utilization time percentage
- The total wait time at each station

System Performance

As mentioned before, our simulation problem has the goal of optimizing station distribution to meet the increasing demand of EV's. In order to observe the performance of the simulation, we will take into account the following measures:

- The number of vehicles for each station
- The average waiting time to charge
- Average station busy time

As performance indicators we will guide our simulation system through the following objective functions:

- Minimize number of vehicles on the station and wait time to charge
- Maximize station utilization rate

Operational Policies

As some operational policies to help reaching our goals we thought of:

- Introducing a fee based on how many vehicles are at the station when the vehicles arrive at said station
- Introduce a penalty if a user takes too long to leave the station after the vehicle has been fully charged
- Reduce the price of charging at barely contested stations

Data Collection

- OSM
- Netlogo existing models
- Loggibud project on github

Simulation of Different Scenarios

For the simulation of the model, several scenarios will be tested, among which they will share a set of restrictions regarding the environment in which the simulations will take place, namely the following:

- Number of EV chargers at each station
- Charging price
- Charging type available at the station

Regarding the simulation scenarios, different ones could arise to validate if they could be a positive introduction to the model.

For an introductory model we would have only one type of station. But at later stages we can introduce more variables and make different conjunctions, such as the number of charging stations and their number of chargers, the type of charging stations and the price variation between each charging station, comparing the results of each scenario.

Operational Decisions Supported by the Model

One could make operational decisions based on the results of each simulation scenario and their different variables. The variables to make decisions upon would be station placement, station type and operational policies.