Optimisation of Electric Vehicles Charging Station

INTRODUCTION

As the number of electric vehicles grows, the need for charging stations and the relevance of limited resources problem increases. Many charging stations are powered only by a limited amount of electricity, therefore not all arriving cars can charge to their maximum potential. The distribution of electricity power to users must therefore be optimized. To ensure a positive charging experience for the customer, it is important to consider their needs when designing the charging station: while some prioritize fast charging, others aim for the lowest cost possible. The aim of our project is to develop a methodology for optimizing electric vehicle charging station work.

METHODOLOGY

The developed methodology allows the user to choose one of three categories based on their priorities (time and money costs).

1. Flash pass

This category is chosen by users whose priority is to charge the car as quickly as possible, and can pay a higher price for it.

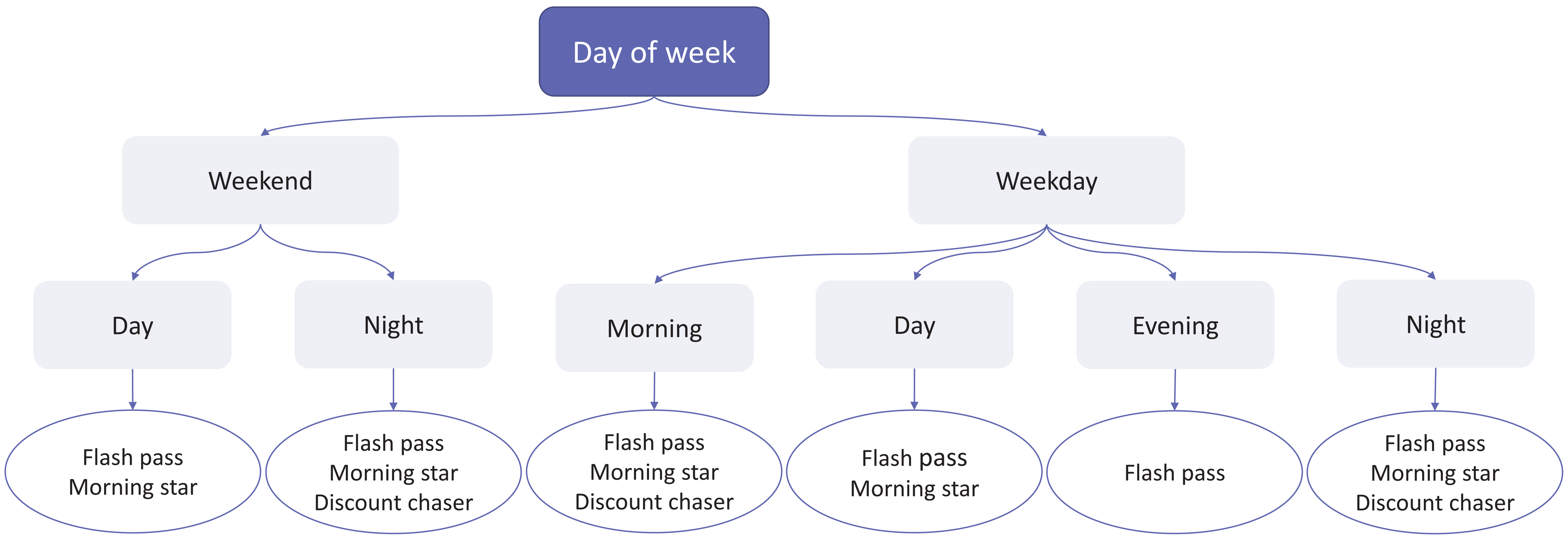
2. Morning star

Users who choose this category want to pay the standard price. Fast charging is not their priority.

3. Discount chaser

Users in this category want to charge an electric car only if the electricity price is lower than usual (during the night rate).

Taking into account the electricity price rates, the diagram shows at what time of day which category can be charged.



If there is not enough electricity to fully charge everyone in the station, then several possible scenarios are distinguished:

1. When there is not enough electricity for users of **different categories** - cars of a higher category are charged first.

2. When the electric power is not enough for cars of the **same category**, the available electric power is shared among all vehicles (linear programming model is applied).

LINEAR PROGRAMMING MODEL

$$\sum_{i=1}^{n} (z_l l_i + z_t t_i) x_i \to \max ,$$

subject to

$$x_i \le a_i, \qquad i = 1,2,\dots,n,$$

$$\sum_{i=1}^{n} x_i \le b ,$$

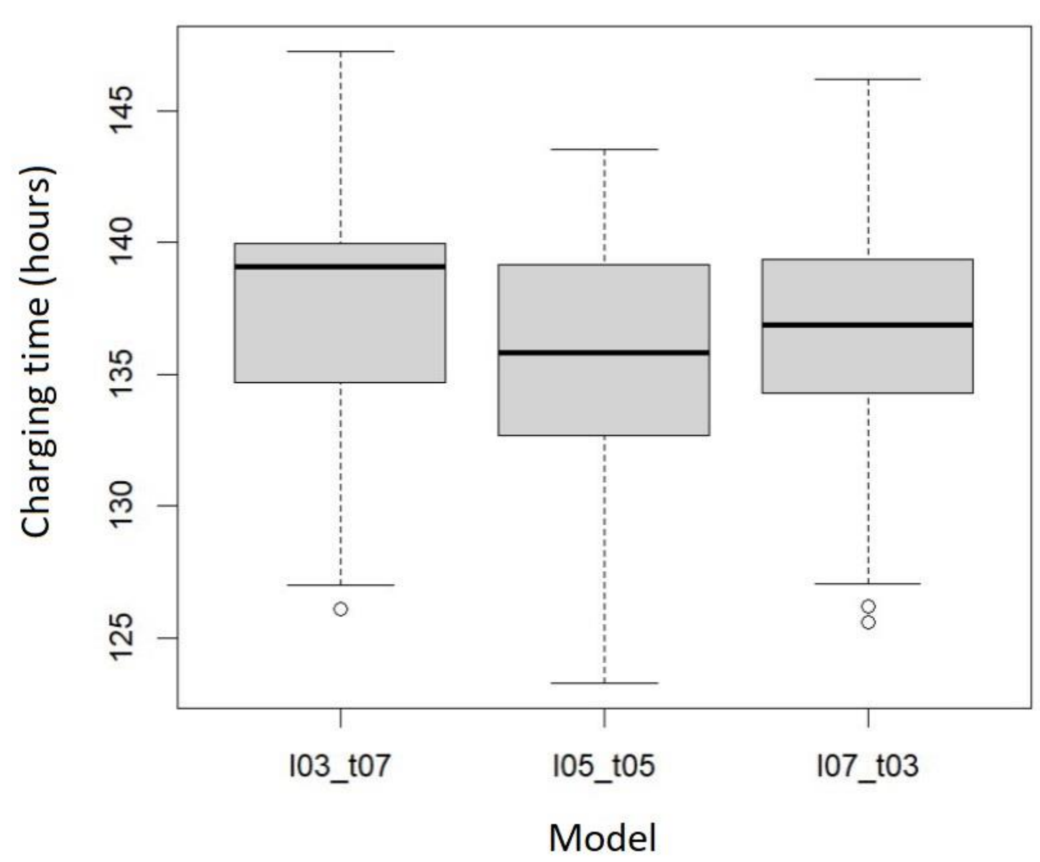
$$x_i \ge c_i, \qquad i = 1,2,\dots,n.$$

n – number of vehicles in the station,
x_i – charging power of the i-th car (kW),
l_i – variable indicating the priority of the car in the queue according to its arrival time,
t_i – variable indicating the priority of the car in the queue according to the battery capacity,
z_l, z_t – coefficients indicating the importance of arrival time and battery capacity (weights),
a_i – limitation of charging power of the i-th car (kW),
b – power limitation of charging stations (kW).

EXPERIMENTAL STUDY OF METHODOLOGY

- The main purpose of the experimental study is to find the most suitable linear programming model (to find suitable values of z_l and z_t). Three models were created.
- During testing, fifty realizations were performed for each model, simulating the arrival and charging of one hundred cars.
- The best model is chosen based on how quickly all vehicles in the queue will charge.

Model name	z_l value	z_t value
l03_t07	0.3	0.7
l05_t05	0.5	0.5
l07_t03	0.7	0.3



CONCLUSIONS

The performed statistical analysis, applying Dunn's statistical test and the Kruskal - Wallis test, showed that it is best to use the second model with coefficients z_l= 0.5, z_t = 0.5 for the charging model of electric cars.

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