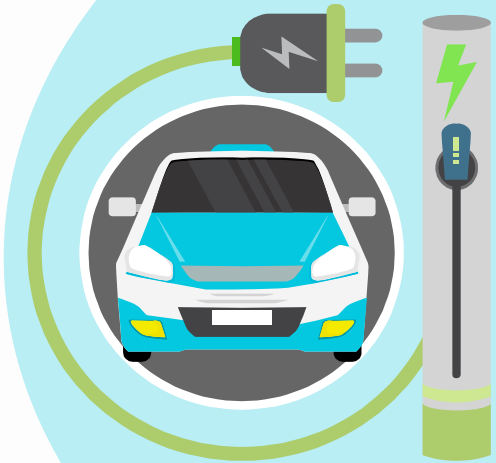
U.PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

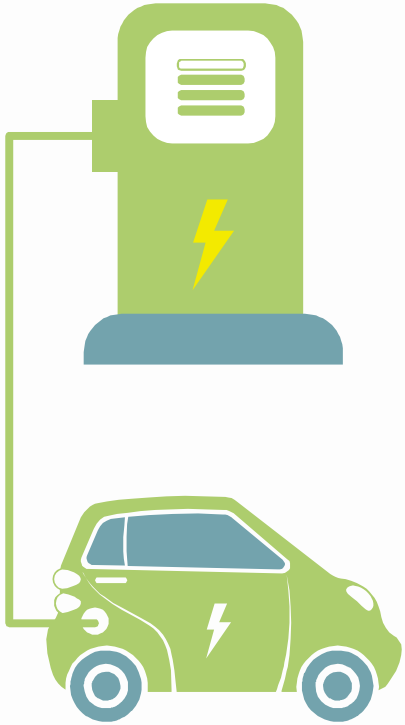
RECHARGING STATIONS DISTRIBUTION FOR *E-MOBILITY*

MEIC | Systems Modelling and Simulation
2023/2024



Group 08
Francisco Cerqueira - 201905337
Luís Matos - 201905962
Pedro Machado - 201906712

Table of Contents



1. Problem Formalisation

- The problem centers on conducting a detailed analysis of how variables and the **distribution of charging stations impact** the **integration and usability of electric vehicles** within the **urban landscape of Porto**.

- This includes **understanding the effects** of factors like **charging station locations**, **market demand fluctuations**, **travel habits**, and infrastructure on the **adoption and functionality of electric vehicles.**

2. Motivation

- Integration of electric vehicles heavily relies on strategically positioned and well-managed charging stations;
- EVs take considerably longer to charge compared to the rapid refueling of traditional vehicles;
- Uncertainties in market demand make the installation of charging stations a risk;
- Success depends on strategically placing stations based on demand to match user expectations.

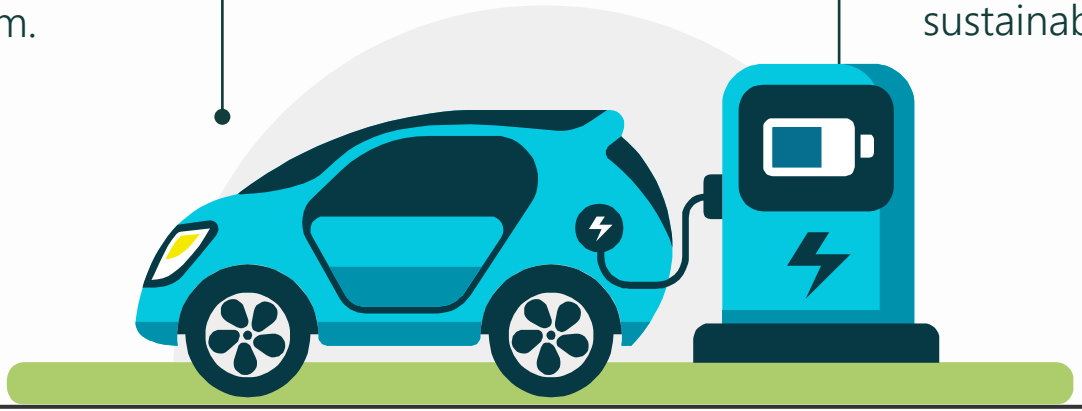
3. Goals

2. Analyse what variables influence the system.

3. Simulate different scenarios.

1. Check how the stations distribution affects the system.

4. Make well-informed decisions to support sustainable urban mobility.



4.1 **Methods and Materials**: Model

- Agent Based Simulation

Descriptive and speculative

Electric Vechiles

Attributes: centroid, battery level, batery capacity, target battery level, alert battery level and desirable travel distance.

Behaviour: charge battery, move arround (wander) and travel to charging stations.

States: wander, traveling (to station or home) and charging.

Charging Station

Attributes: coordinates, centroid, charging ports and (charging cars, waiting cars).

Behaviour: process incoming cars, charge cars and free finished cars.

Centroid

Attributes: coordinates and charging stations.

4.1 **Methods and Materials**: Model

VARIABLES

- Input

Note: all distributions are uniform

Controllable:

- Initial battery level distribution (%);
- Battery capacity distribution (km);
- Target battery level (%);
- Alert battery level (%);
- Station charging power (km/h);
- Car wander probability (%);
- Car moving speed distribution (km/h);
- Desirable travel distance distribution (km).

Uncontrollable:

- Centroids of Porto;
- Charging stations of Porto;
- SQM price for "freguesias" of Porto;

- Output

- Number of dead cars;
- Time spent waiting for charger;
- Time spent charging;
- Charging station usage;
- Traveled distance to reach station;
- Number of cars in charging station waiting line.

4.1 **Methods and Materials**: Model

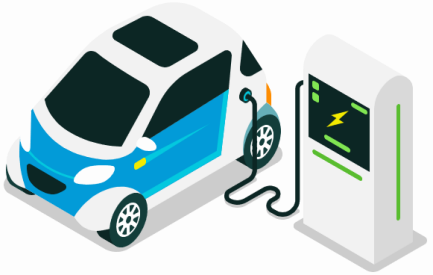
Find Stations Algorithm

1. Filter stations that the vehicle can reach with the current energy level;

2. If there are no stations, return;

3. Get the nearest free station that is at a distance smaller than the vehicle's desirable travel distance;

4. If did not find any, get the nearest station.



4.2 **Methods and Materials**: Data

Charging Stations

- Extracted from electromaps plataform.

Statistical Sections

- Extracted from INE plataform;
- Divided the city into statistical sections;
- Calculated the centroid of each one.

Electric Vehicles

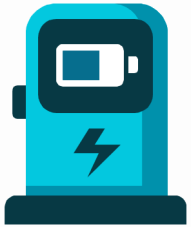
- **Estimation** to get the number of Evs in Porto;
- Combination of **housing square meter price** (*Idealista*), **number of electric vehicles in Portugal** (*INE*) and **total population in Porto** (*Pordata).*

4.3 **Methods and Materials**: Scenarios

A. Baseline Scenario

This scenario mirrors the **current real-world conditions**, using parameters aligned with well-established, **factual data**.

106 Charging Stations



1659 Statistical Sections

1526 Electric Vehicles

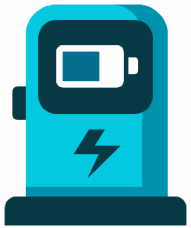
- Autonomy between [250, 500] km

4.3 **Methods and Materials**: Scenarios

B. Government Incentive for Buying Electric Vehicles

In this scenario, the **government introduces an incentive program**, financing a campaign that offers **tax benefits to individuals purchasing electric vehicles.**

106 Charging Stations =



1659 Statistical Sections =

~~1526~~ 1787 Electric Vehicles =

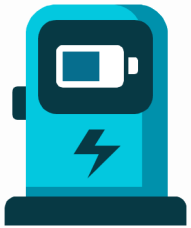
- Autonomy between [250, 500] km

4.3 **Methods and Materials**: Scenarios

C. Decrease in vehicles autonomy

In this scenario, electric vehicles experience a **decrease in their energy capacity**. This unexpected change could be attributed to a new technological glitch arising from a **software update meant to optimize performance but inadvertently affecting battery efficiency**.

106 Charging Stations =



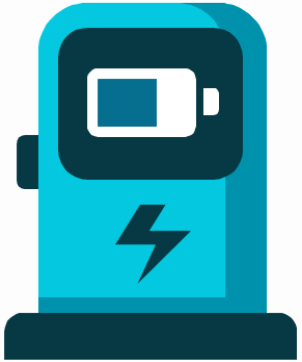
1659 Statistical Sections =

1526 Electric Vehicles =

- Autonomy between [250, 500] km
  [150, 300]

4.4 Methods and Materials: KPI's

Charging Stations



#1 Average station workload
(percentage of the time they are used)
Expected Value: 75%

#2 Number of charging stations
(/100K population)
Expected Value: 60

4.4 Methods and Materials: KPI's

Electric Vehicles

#3 Average travel distance
(when travelling to charging station)

Expected Value: 5 km

#4 Average time waiting for charger

Expected Value: 20 min

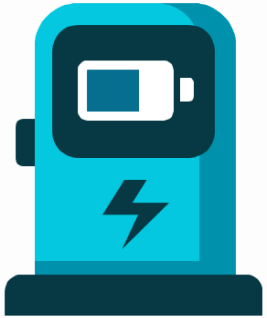
4.5 **Methods and Materials**: Decision criteria

#1 Average station workload

> 80%

Increase the number of chargers per station
OR
Create new stations

Charging Stations



#2 Number of charging stations

< 30

Increase the number of charging stations

#2 Number of charging stations

> 60

Decrease the number of charging stations

4.5 **Methods and Materials**: Decision criteria

#3 Average travel distance

> 7km

Redistribute the stations in a better way
OR
Create new stations

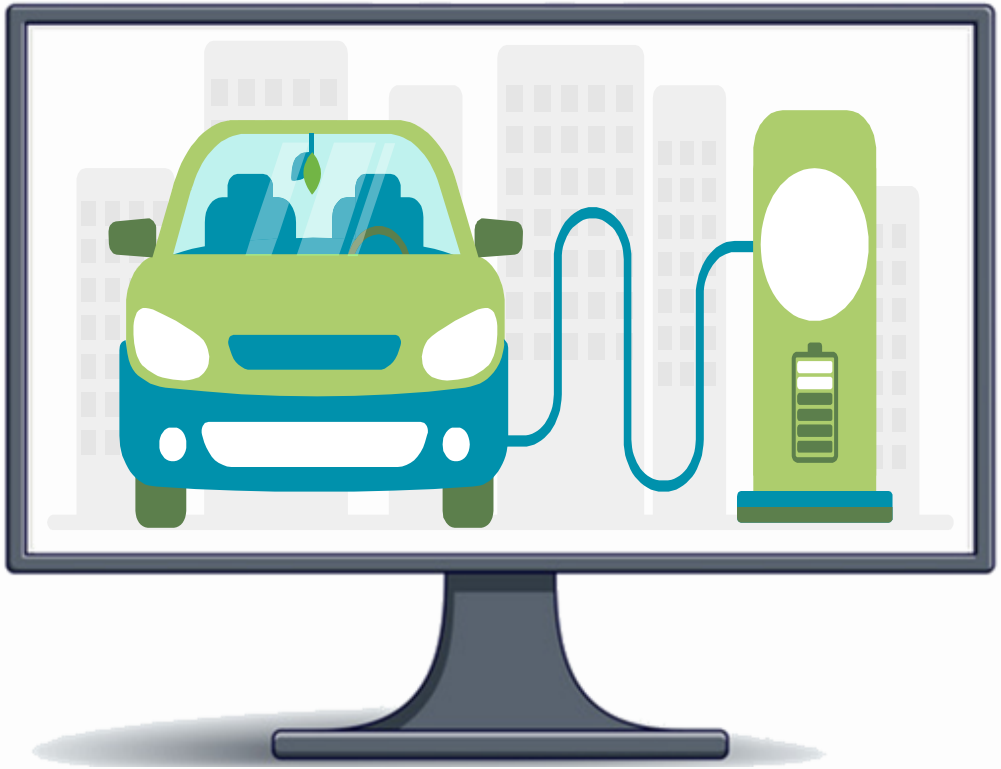
Electric Vehicles

#4 Average time waiting for charger

> 30min

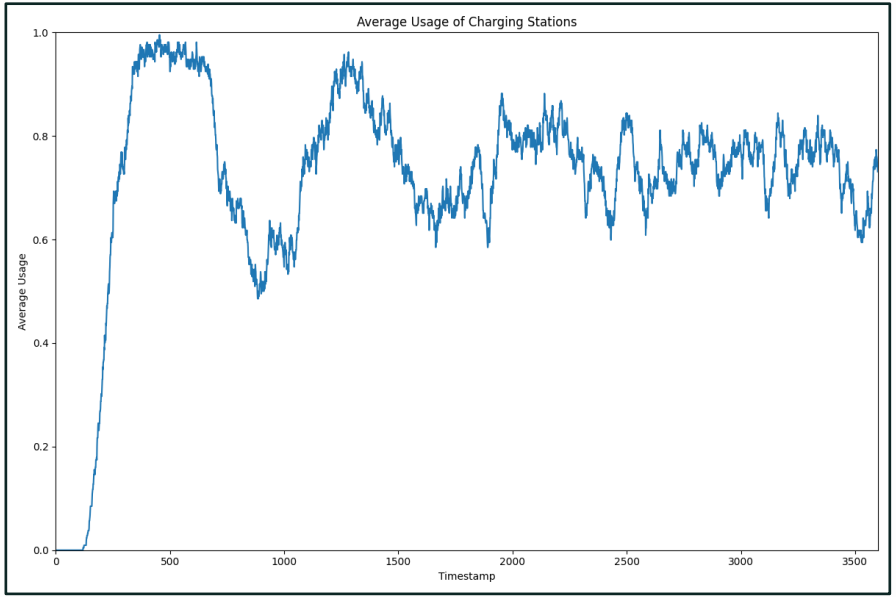
Increase charging power
OR
Increase number of chargers per station

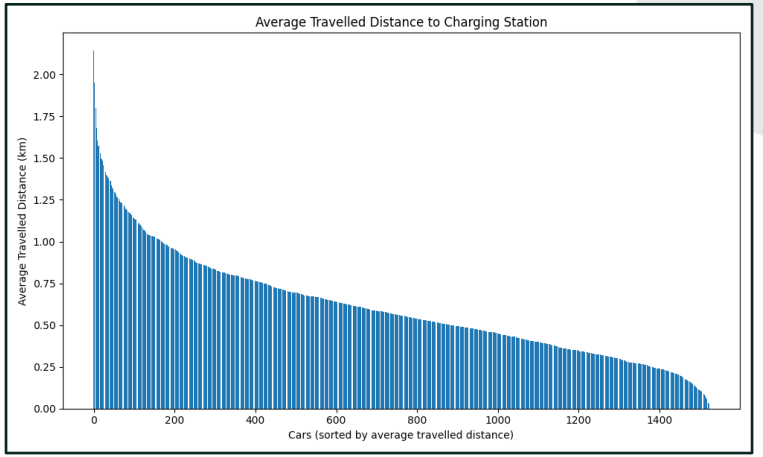
5. Demonstration

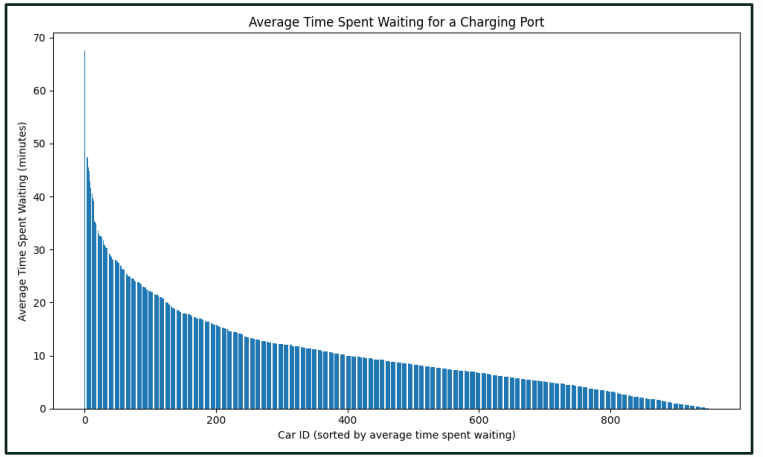


6. Results & Analysis

A. Baseline Scenario







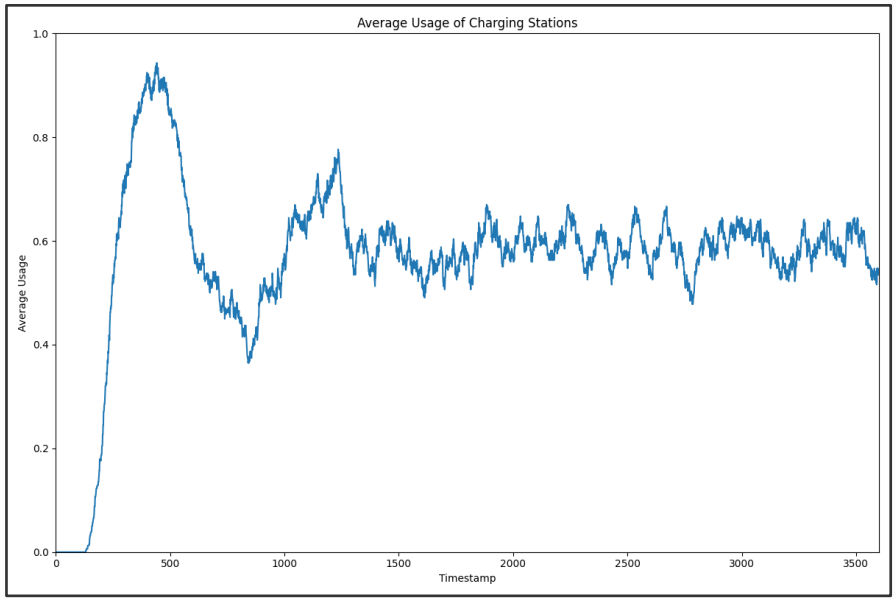
6. Results & Analysis

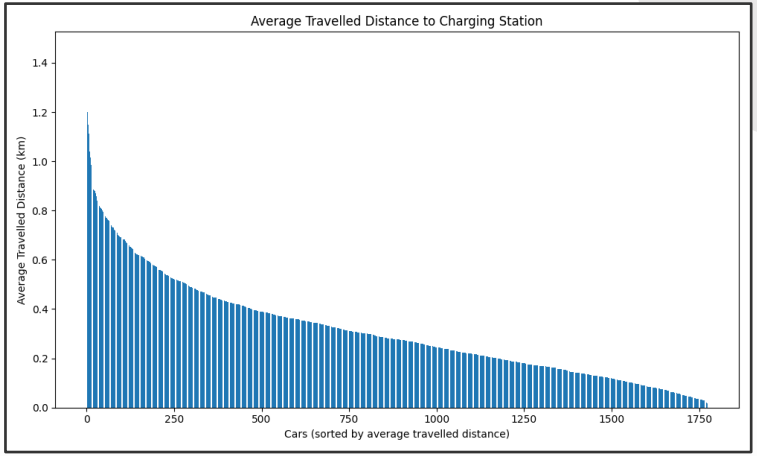
A. Baseline Scenario

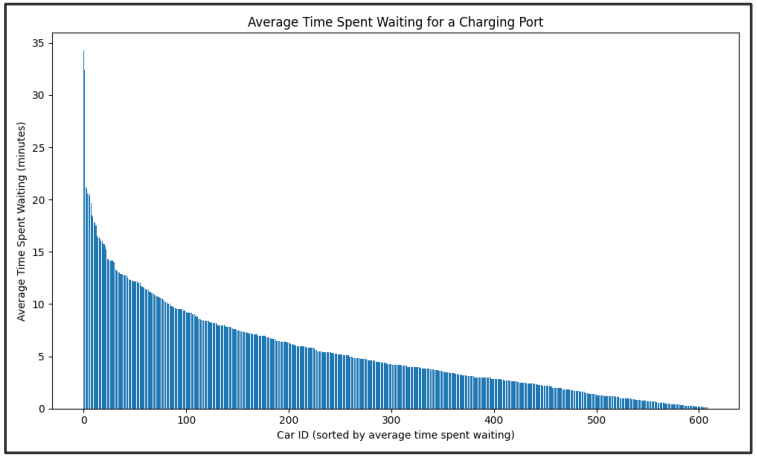
	VALUE
Average station workload	71.70%
Number of stations /100K population	45.21
Average travel distance	3.35 km
Average time waiting for charger	36.24 min

6. Results & Analysis

B. Government Incentive





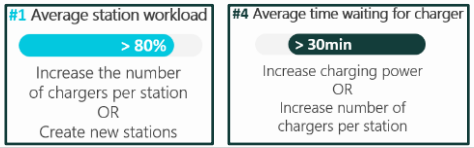


6. Results & Analysis

B. Government Incentive

	ORIGINAL VALUE	AFTER DECISION
Average station workload	83.20%	56.62%
Number of stations /100K population	45.21	45.21
Average travel distance	5.91 km	1.75 km
Average time waiting for charger	94.90 min	10.20 min

...remember decision criteria



DECISION TAKEN: Increase the number of chargers per station from 2 to 3

ANALYSIS

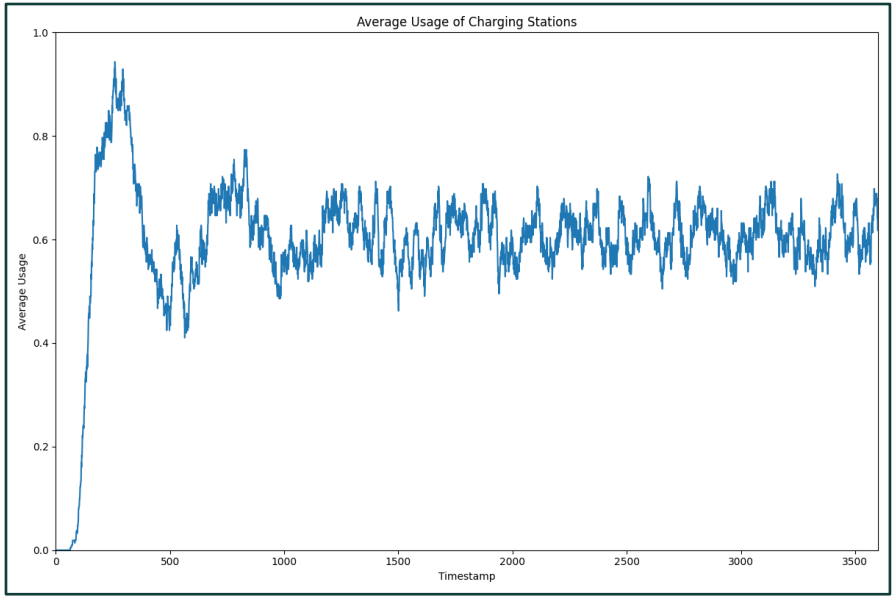
Decreasing the effective price of an EV by 5K€ resulted in an **increase of 17.1%**, or **261 EV's**.

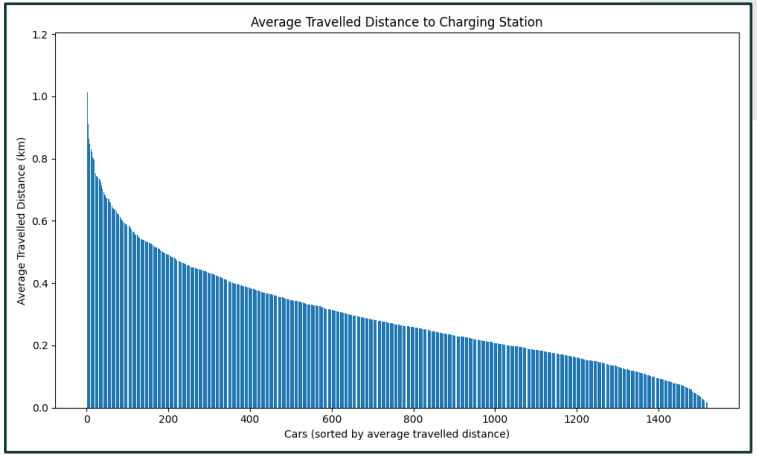
These expected growth led to an undesirable average charging station's **workload of 83%** (>80%), and, also a **261% increase of average waiting time**.

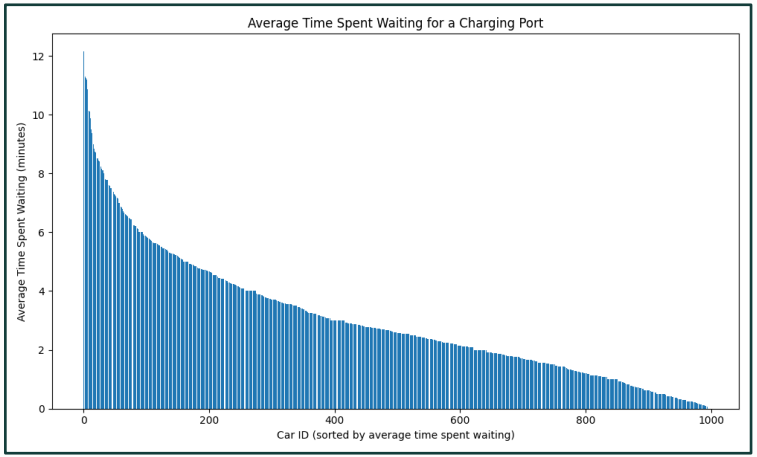
By **installing an extra charger** in each of the charging stations, **both of these problems are solved**, but it may be too well, might lead to an inefficient use of resources.

6. Results & Analysis

C. Decrease in vehicles autonomy





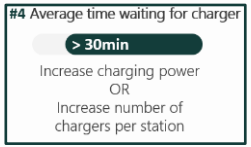


6. Results & Analysis

C. Decrease in vehicles autonomy

	ORIGINAL VALUE	AFTER DECISION
Average station workload	73.65%	59.45%
Number of stations /100K population	45.21	45.21
Average travel distance	4.70 km	2.92 km
Average time waiting for charger	44.02 min	19.48 min

...remember decision criteria



DECISION TAKEN: Increase the charging power from 250km/h to 320km/h

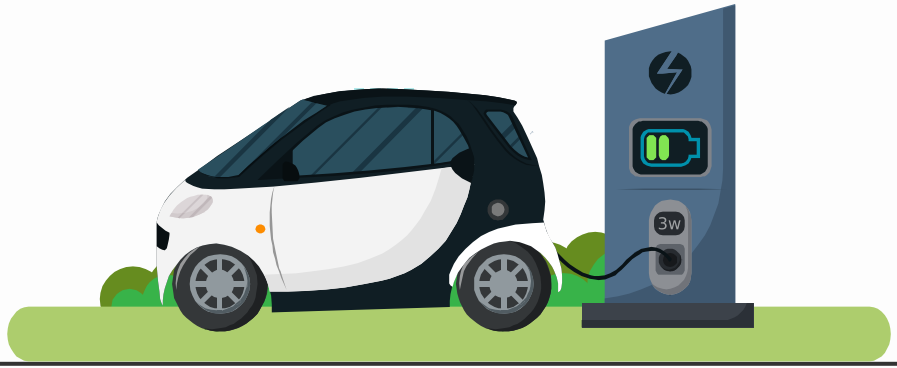
ANALYSIS

The **shrinkness of the EV's batteries by 40%** naturally resulted to a **surge of trips to charging stations**, but even though it may have **increased the waiting times by 25%** (8 min) it only led to a **small growth in average workload (2.7%)**.

One way to address these long waiting queues is to **increase the charging speed** of the chargers by **adding more 70Km** (28%) of autonomy for each hour.

7. Conclusions

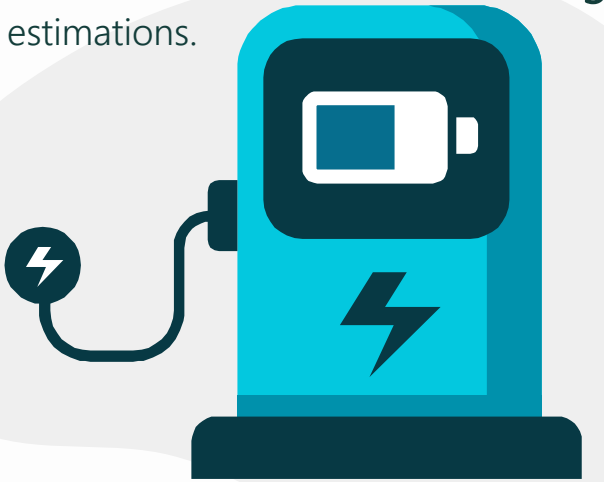
- Identified **challenges** in sourcing **data** for the **number of electric vehicles** (EVs);
- The **model** made was able to **effectively simulate various scenarios** using the developed model;
- The **decisions taken were successful** in improving the system to an **acceptable state**, by the key indicators;
- **Achieved all planned objectives** for the project.



8. Future Work

1. Gather data from more sources in order to avoid the need to do estimations.

2. Account for human routines.



3. Account for in-house charging.

4. Improve graphical representation of the simulation.