LAB 3

Data analysis to estimate performance in migration from ICE to EV

Goal

- We will estimate the impact on the users of the transition from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs)
- We want to assess if EVs can meet user needs
- For this, we consider real trips of users done with ICE vehicles from UnipolTech data
- We will reproduce these trips simulating the energy consumption of EVs and their charge

Datasets

UnipolTech dataset

- Data collected by company
  - DO NOT share the data
- Trips of 1000 vehicles in 2 months
  - About 1.41 million records
  - **NOTICE: It does NOT mean 1.41 million trips**

Data sample

vehicle_id	trip_id	start_time	stop_time	road	total_distance
1	0	2023-09-29 13:55:35	2023-09-29 14:11:42	E	14.31
1	0	2023-09-29 13:55:35	2023-09-29 14:11:42	U	1.47
1	1	2023-09-29 14:32:24	2023-09-29 14:34:31	U	0.03
1	2	2023-09-29 15:12:03	2023-09-29 15:26:55	E	2.60
1	2	2023-09-29 15:12:03	2023-09-29 15:26:55	U	2.00
1	3	2023-09-29 15:37:38	2023-09-29 15:57:26	E	2.24
1	3	2023-09-29 15:37:38	2023-09-29 15:57:26	U	2.01
1	4	2023-09-29 16:13:55	2023-09-29 16:13:58	E	0.00
1	5	2023-09-29 16:16:28	2023-09-29 16:16:30	E	0.00
1	6	2023-09-30 05:05:39	2023-09-30 05:28:37	E	0.00
1	6	2023-09-30 05:05:39	2023-09-30 05:28:37	U	1.21
1	7	2023-09-30 05:35:17	2023-09-30 05:35:20	U	0.00
1	8	2023-09-30 06:07:07	2023-09-30 06:33:53	E	3.98
1	8	2023-09-30 06:07:07	2023-09-30 06:33:53	U	1.10
1	9	2023-09-30 06:44:43	2023-09-30 06:44:51	E	0.00

Vehicle ID:
from 1 to 1000

Data sample

vehicle_id	trip_id	start_time	stop_time	road	total_distance
1	0	2023-09-29 13:55:35	2023-09-29 14:11:42	E	14.31
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1	9	2023-09-30 06:44:43	2023-09-30 06:44:51	E	0.00

Trip ID **of the vehicle.**

FOR EACH VEHICLE:
start from 0

Data sample

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1	0	2023-09-29 13:55:35	2023-09-29 14:11:42	E	14.31
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Road	Type
U	Urban
E	Extra-Urban
A	Highway
-	Unknown

Data sample

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Traveled distance (km)

Possibly outliers

Data sample

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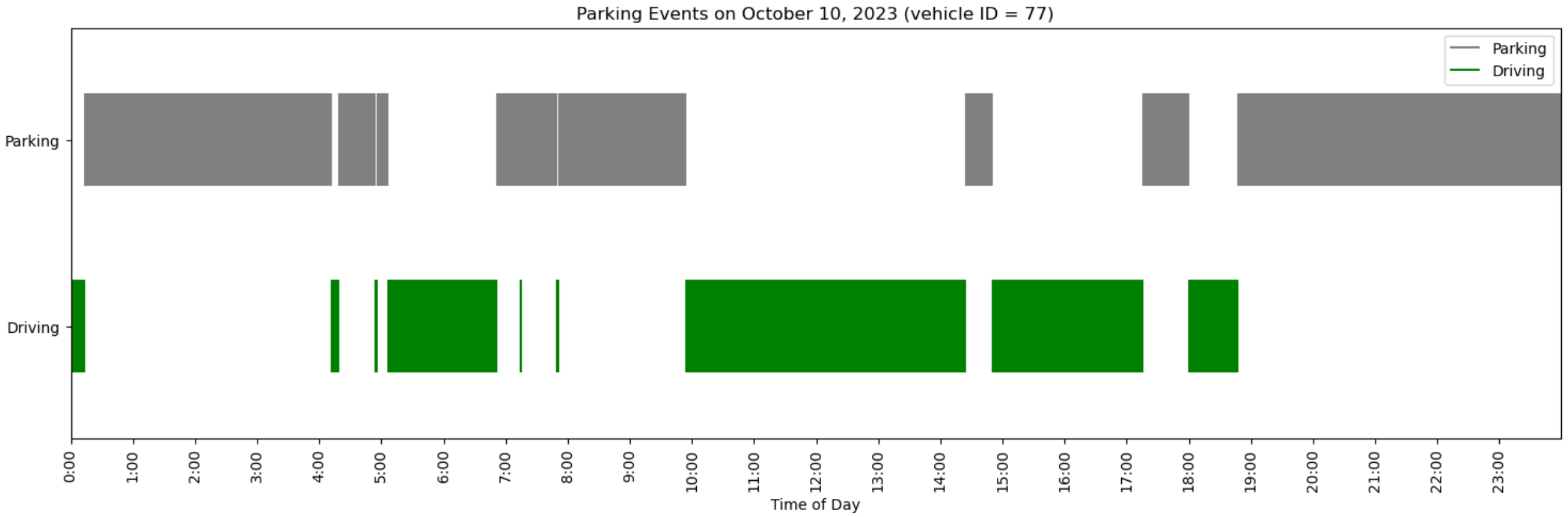
One single trip on different road types (14.31 km on extra-urban roads and 1.47 km on urban roads)

Simulation

User/Vehicle travel pattern

- An example usage behavior of a vehicle
- We assume vehicle=user



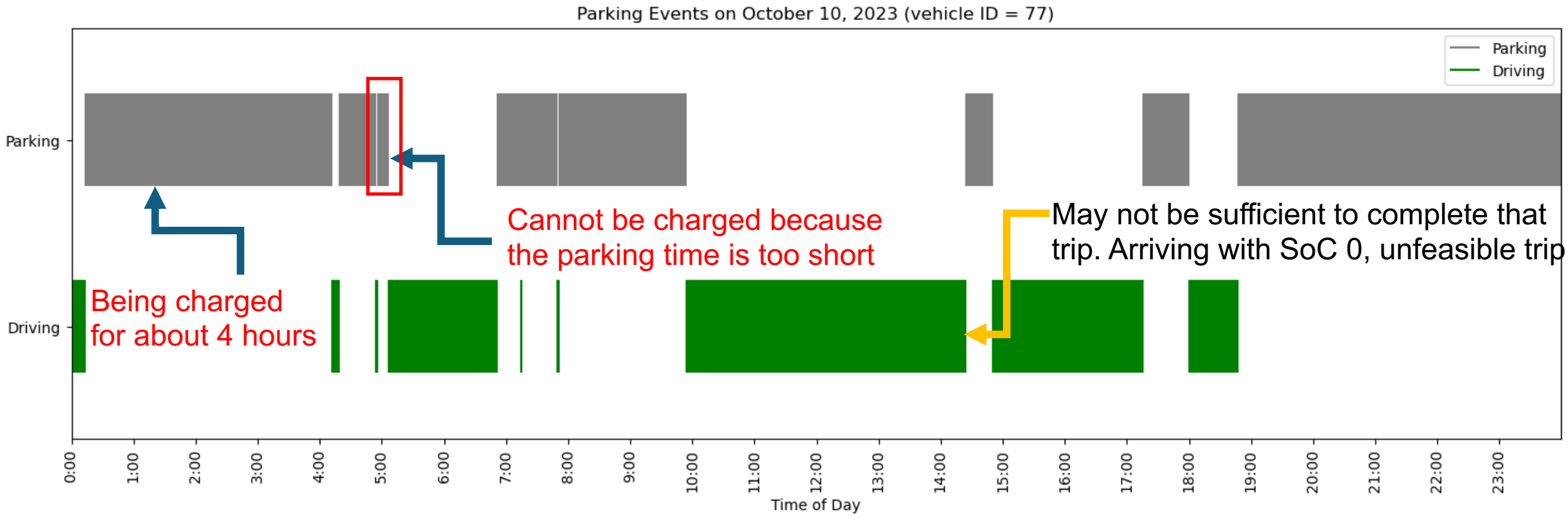
Simulate usage of EV vehicle

- State variable: State-of-Charge (SoC) of the battery
- Tracking possible charge events
- Parameters:
  - Battery capacity of vehicle (Wh)
  - Vehicle consumption (Wh/km)
  - Battery charging power upper bound (W)
  - When to charge vehicle (more on this later)

Simulate usage of EV vehicle

- Assume an **ideal scenario**
  - The vehicle will be always close to the charging station when parked
  - Every time the car is parked for at least k minutes, it will be charged at pre-defined charging power (constant over time/no losses)
  - The battery SoC is full before the first trip of our collection
  - When SoC not sufficient for a trip, we assume the vehicle still arrived at destination with **0 SoC** (left capacity) after trip – however the trip is marked as **unfeasible**
- This is an **optimistic case**, can be seen as an **upper bound for performance**

Simulate usage of EV vehicle



Simulation: transition to EV

- **Constraint**
  - The vehicle can be charged only if the parking duration not less than **20 minutes**
- **Parameters of EVs**
  - Vehicle consumption
  - Useable Battery capacity
  - Charging power
  - Fast charging power
  - Check https://ev-database.org/

Real Energy Consumption between 93 - 189 Wh/km

City - Cold Weather	149 Wh/km	City - Mild Weather	93 Wh/km
Highway - Cold Weather	189 Wh/km	Highway - Mild Weather	142 Wh/km
Combined - Cold Weather	167 Wh/km	Combined - Mild Weather	116 Wh/km

Indication of real-world energy use in several situations. Cold weather: 'worst-case' based on -10°C and use of heating. Mild weather: 'best-case' based on 23°C and no use of A/C. For 'Highway' figures a constant speed of 110 km/h is assumed. The energy use will depend on speed, style of driving, climate and route conditions.

Road	Type
U	Urban
E	Extra-Urban
A	Highway
-	Unknown

You can consider extra-urban and unknown as combined

Performance metrics to track

- Unfeasible trips (total and %)
- Battery average SoC (total and %)
- …
- …
- …

Try different vehicles and charging conditions

- At least three EV models
- Fast charge (DC) vs. slow charge (AC)
- Evaluate which are best for different clusters of users/vehicles
- Estimate charging costs

Thank you