VRIJE UNIVERSITEIT BRUSSEL

MOBILITY, LOGISTICS & AUTOMOTIVE TECHNOLOGY RESEARCH CENTRE

EVERGi RESEARCH GROUP

EVERGI

INNOVATING THE ENERGY TRANSITION

Electric vehicle charging sessions generator based on clustered driver behaviors

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EVS35

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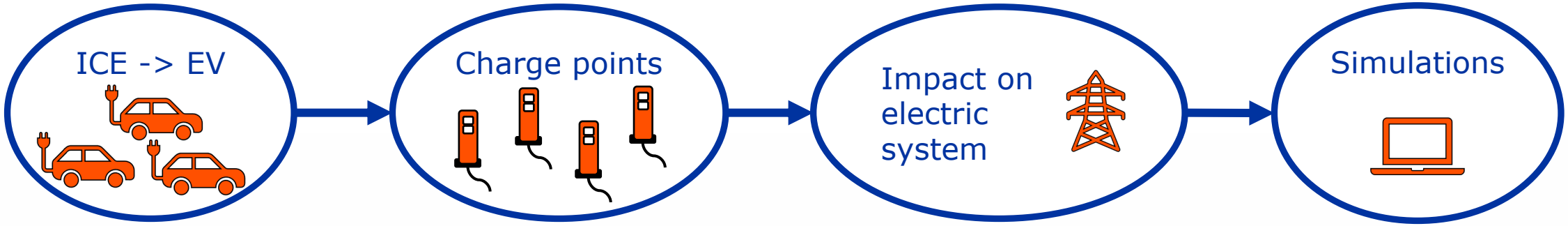
1) CONTEXT

PROBLEM AND OBJECTIVE



Problem to tackle:

- Simulations require data -> In particular for **drivers' behavior (= charging events)**

Goal of this research:

- Generate **electric vehicle charging sessions** for **particular charging sites** with particular **driver profiles** as input data for simulations

2) METHODOLOGY

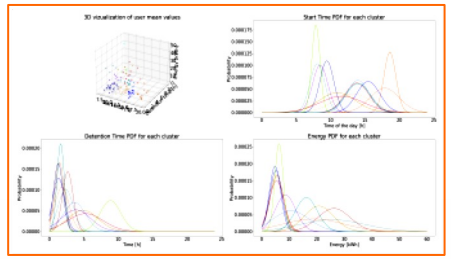
IN TWO STEPS

STEP 1 : Analysis

Historical data

- From existing chargers
- From employee's check-in, check-out system
- From other charging sites

Clustering



Clusters

Group 1: Employee behavior
- Group 1a: Employee type 1
- Group 1b: Employee type 2

Group 2: …

2) METHODOLOGY

IN TWO STEPS

STEP 1 : Analysis

Historical data
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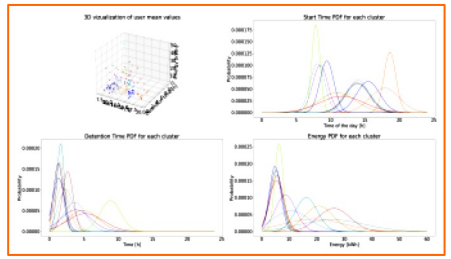


Clusters

Group 1: Employee behavior
- Group 1a: Employee type 1
- Group 1b: Employee type 2

Group 2: …

STEP 2: Generator

Generator parameters
1. Set period to simulate
2. Optional:
   - Modify some parameters of a cluster
   - Add or remove clusters

Generator

Generates per cluster, per day and per session, new data points:
Plug-in, plug-out, energy and power

2) METHODOLOGY

A) ANALYSIS - CLUSTERING

Goal of the analysis:

- Identify types of drivers (=groups of drivers) with similar charging behavior

How:

- Using k-means clustering algorithm

Two levels clustering:

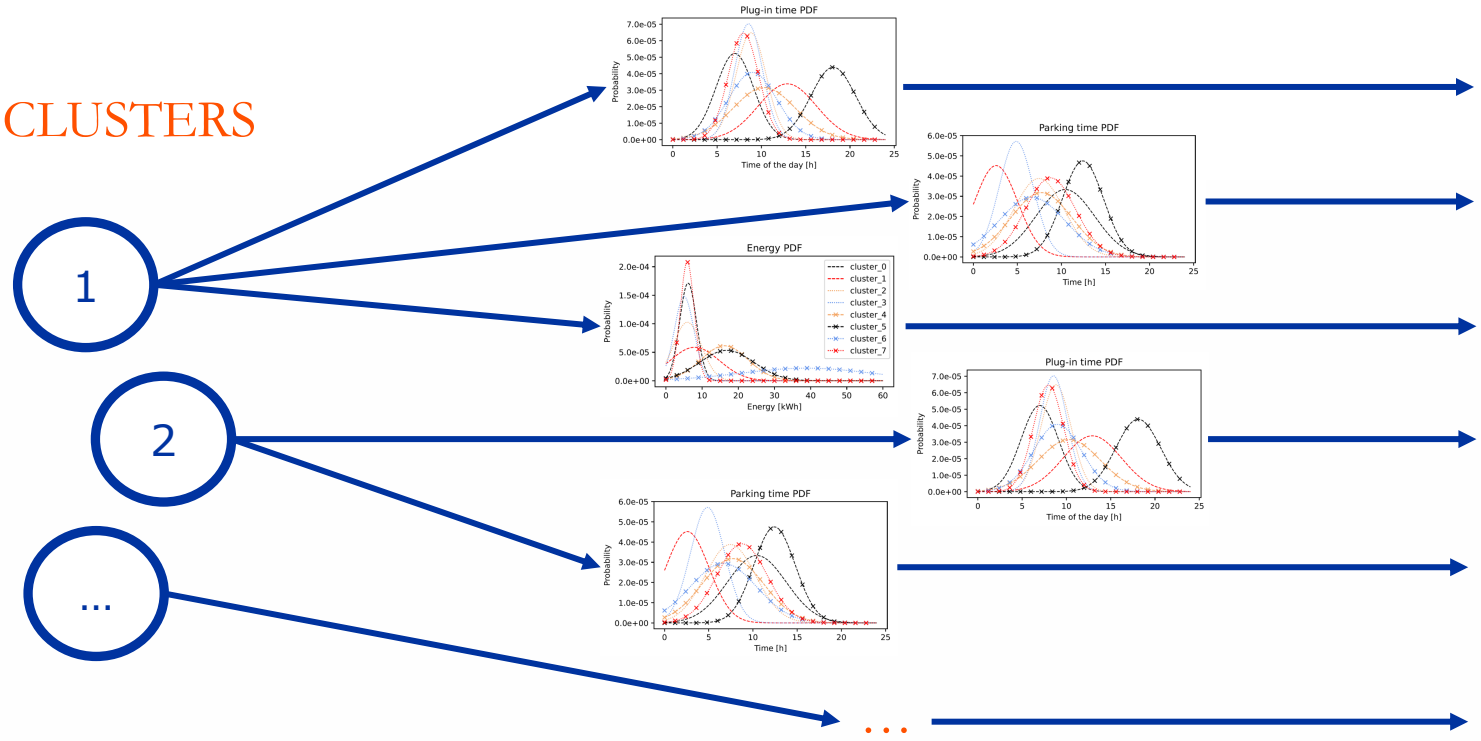
- Level 1) Cluster plug-in time, parking time and energy consumed
  - These three parameters are usually available in OCPP protocol
- Level 2) Cluster the frequency of charging
  - To differentiate drivers with different frequency of charging

2) METHODOLOGY

B) GENERATOR

EXTRACT CHARACTERISTICS

CLUSTERS



Generates charging sessions:

1) Per day
2) Per cluster
3) With associated plug-in time, parking time and energy needs

3) RESULTS

A) USE CASE OF A HOSPITAL PARKING

Use case:

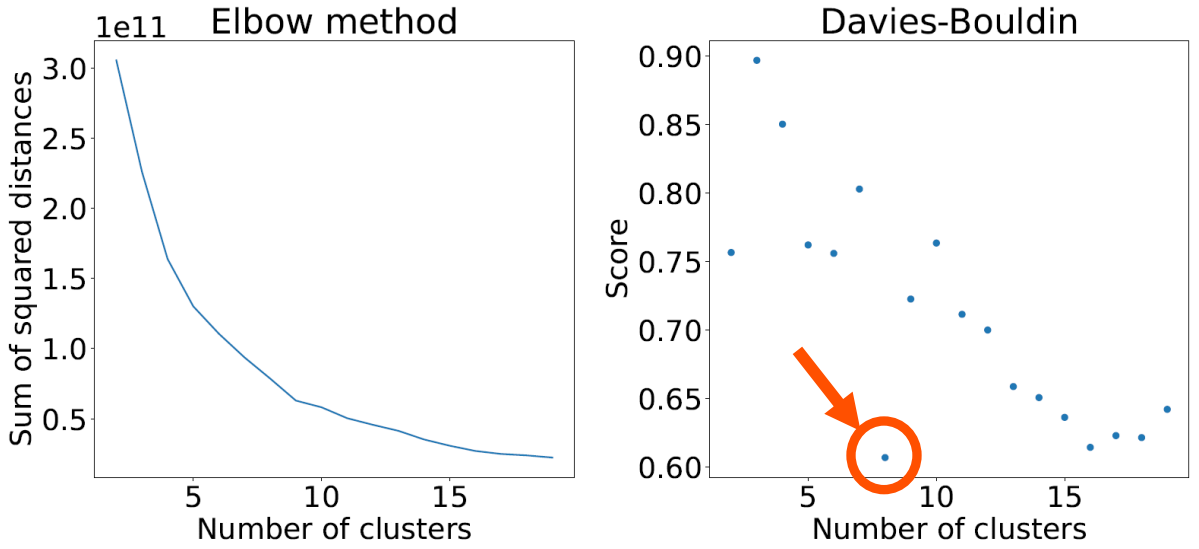
- Hospital parking
  - 6 chargers of 2 times 22 kW maximum charging power (Type 2)
  - Existing historical data between mid 2018 and beginning 2020
- Objective:
  - Assess impact of adding new electric vehicle drivers to the hospital parking lot

3) RESULTS

B) CLUSTERING OF DRIVERS

Find number of clusters using specific scores

- Elbow method = not straightforward
- Davies-Boudin score = lowest score is 8 clusters



3) RESULTS

B) CLUSTERING OF DRIVERS

Find number of clusters using specific scores

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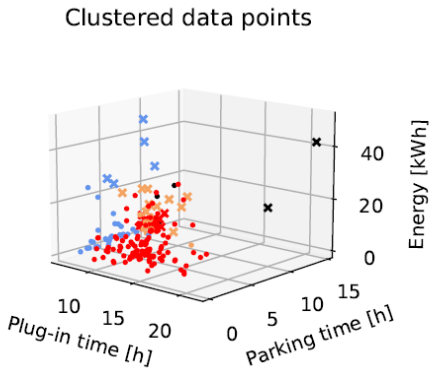
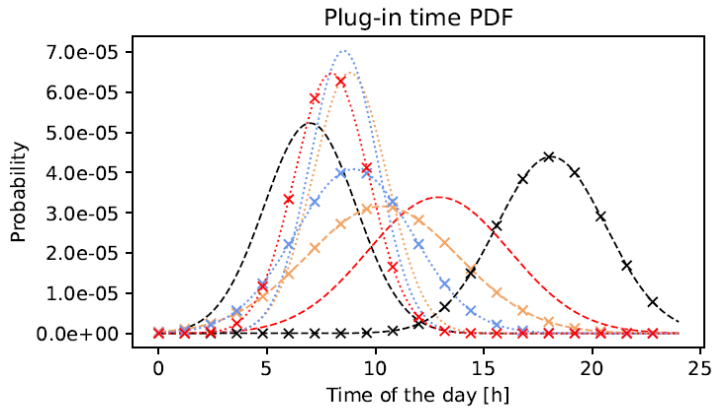
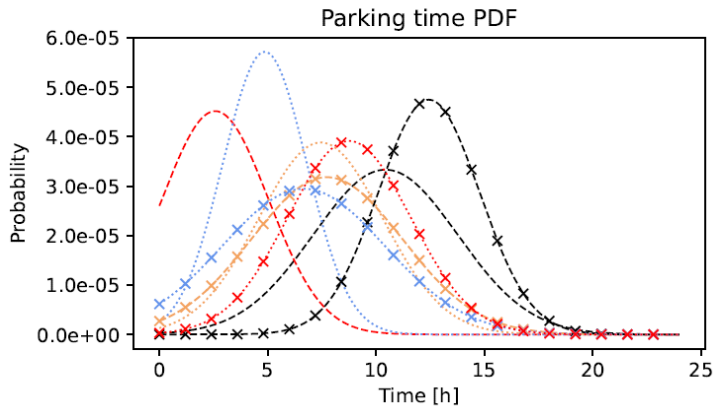
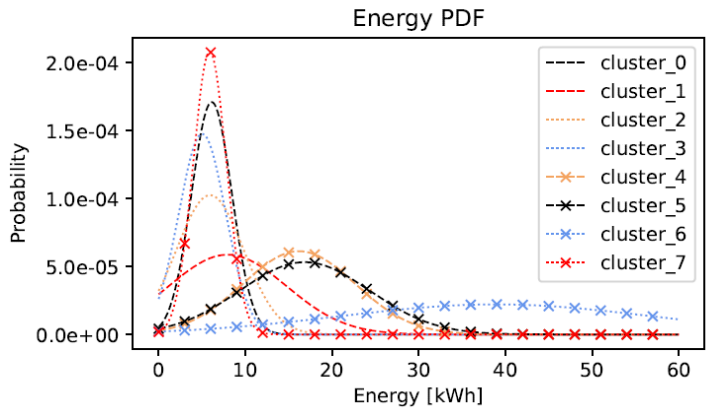
Check and analyze the clusters









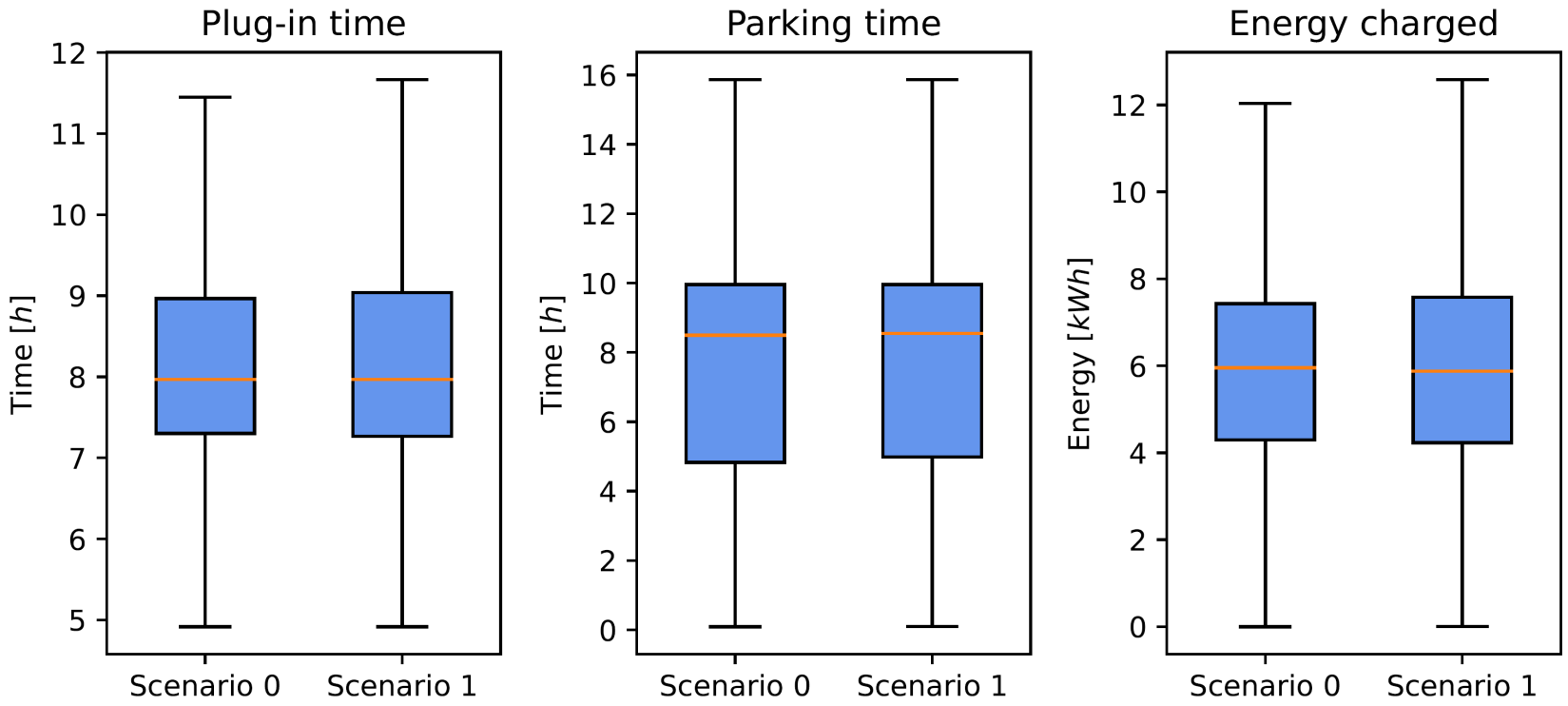
3) RESULTS

B) VALIDATION

Scenarios:

- Scenario 0: Real historical charging sessions data
- Scenario 1: Recreating scenario 0 with the generator

Figure: Boxplot analysis for scenario 0 and scenario 1



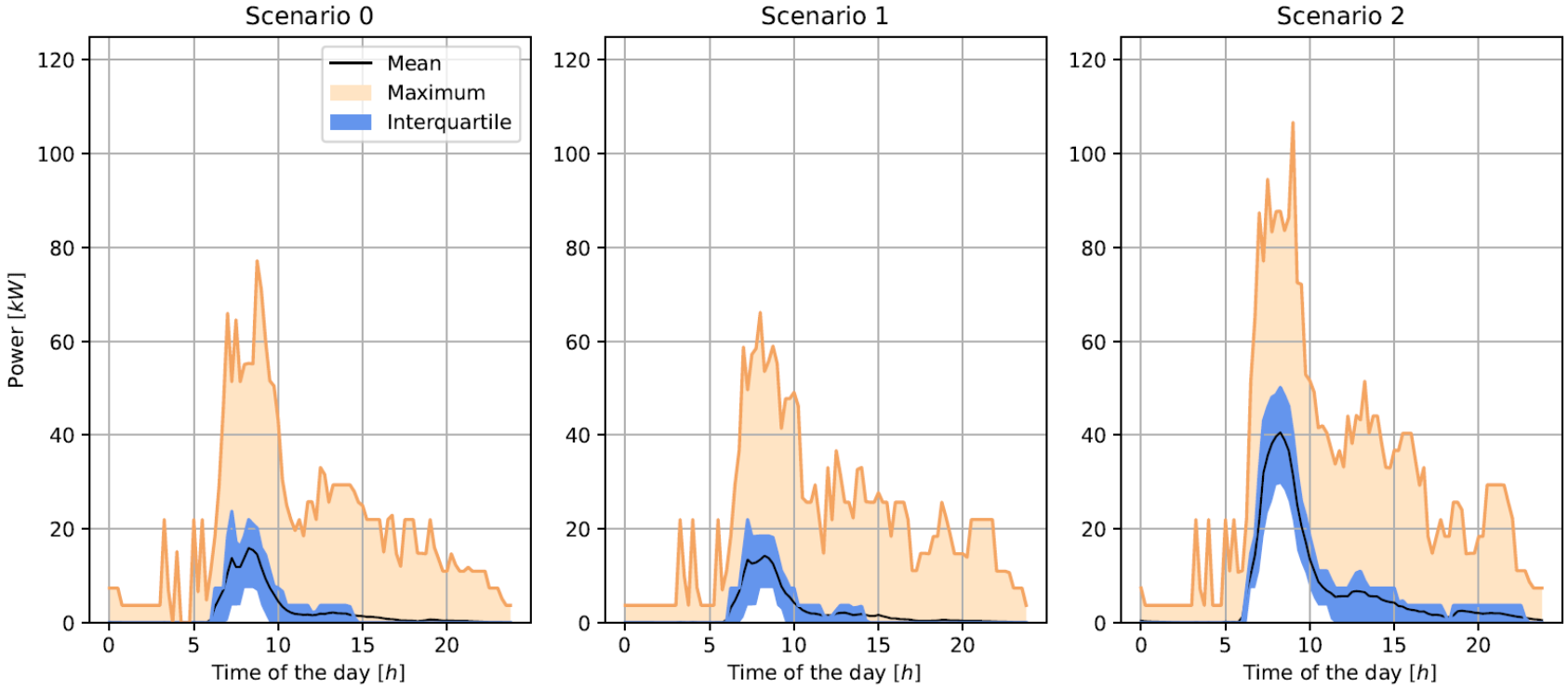
3) RESULTS

C) SIMULATION EXAMPLE

Scenarios:

- Scenario 0: Real historical charging sessions data
- Scenario 1: Recreating scenario 0 with the generator
- Scenario 2: Double the number of drivers of specific clusters

Figure: Yearly power demand, averaged over one day, using uncoordinated charging



CONCLUSION

- Methodology to generate electric vehicle charging sessions for particular charging sites
  - Using historical data
  - Differentiates between driver profiles
- Methodology is applied to a use case
- Results show:
  - Good fit between generated and historical data
  - Methodology is able to calculate future EV transition scenarios
  - Can be used as input for simulations

QUESTIONS ?

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3) RESULTS

B) CLUSTERING RESULTS

- Many morning arrivals but with different parking time and energy consumption
- The number of subclusters is shown in last column

Cluster ID	# of sessions	# of drivers	Plug-in time (mean value)	Parking time (mean value)	Energy (mean in [kWh])	Sub-Clusters
Cluster 0	350	4	Morning (06h59)	Very long (10h25)	Low (6.11)	2
Cluster 1	458	105	Afternoon (12h55)	Short (02h34)	Low (7.59)	3
Cluster 2	782	10	Morning (08h49)	Long (07h26)	Low (5.92)	3
Cluster 3	419	29	Morning (08h32)	Mid (04h52)	Low (5.02)	4
Cluster 4	170	10	Morning (10h19)	Long (07h43)	Mid (16.18)	2
Cluster 5	40	2	Afternoon (18h06)	Very long (12h26)	Mid (16.83)	2
Cluster 6	39	5	Morning (09h00)	Long (06h39)	High (38.88)	2
Cluster 7	1664	14	Morning (07h58)	Long (08h45)	Low (5.89)	4