Cigré Young Members Showcase, 20th February 2018

SC C1 – SYSTEM DEVELOPMENT AND ECONOMICS

PS3 / COORDINATED PLANNING BETWEEN GRID OPERATORS ACROSS ALL VOLTAGE LEVELS

University of Strathclyde Engineering

Characterisation of Electric Vehicle Rapid Charging Demand based on Smartphone Locational Data from Google Maps

James Dixon

Department of Electronic and Electrical Engineering

University of Strathclyde, Glasgow

james.dixon@strath.ac.uk

Context

1. Lack of off-street parking

2. Range anxiety

3. Changing Car Ownership

Human Behaviour

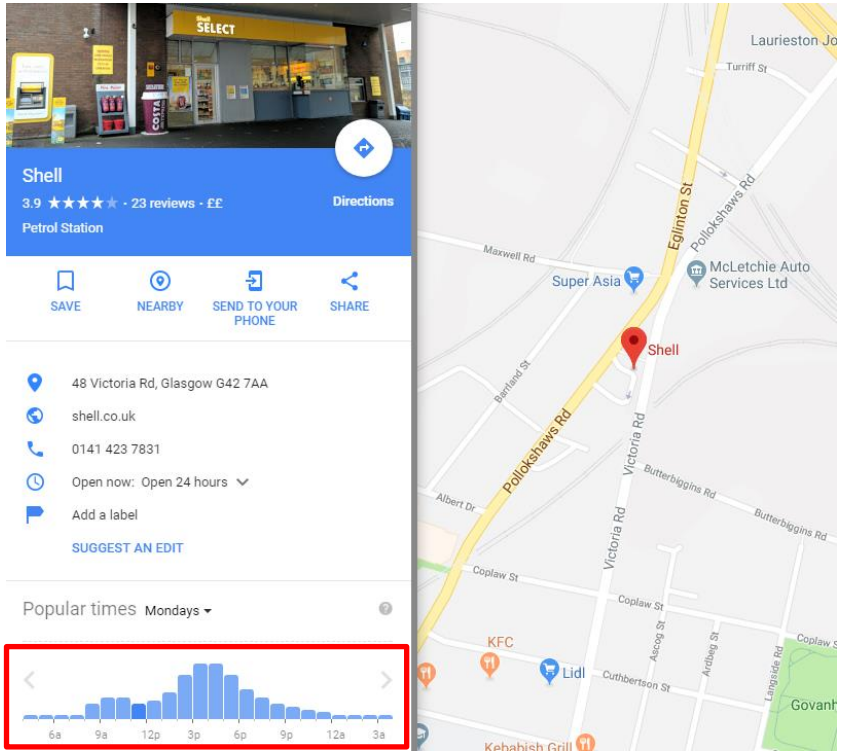
- Widespread EV uptake hasn't happened yet in the UK
- It's difficult to predict how people will behave
- Most of the work to date is based on surveys, which represents peoples' *perception* of their behaviour

Google Maps Popular Times

- Collected from Smartphone users with the Google Maps application (and location history enabled)
- Hourly popularity (%) data based on ‘peak popularity’ for a given day of the week

+

- Captures users’ actual movement patterns
- Constantly changing
- ‘Sample size’ is potentially very large

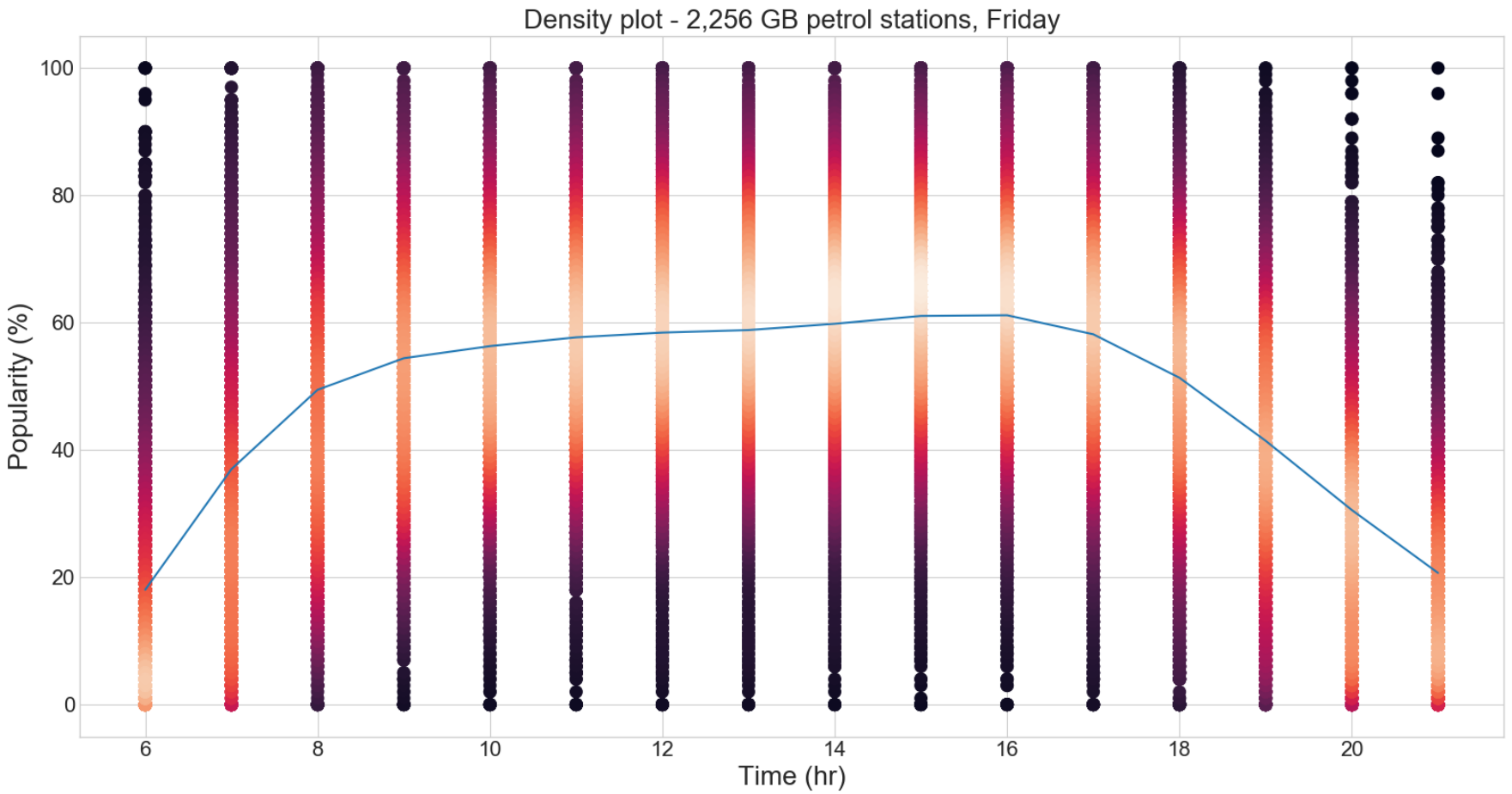


-

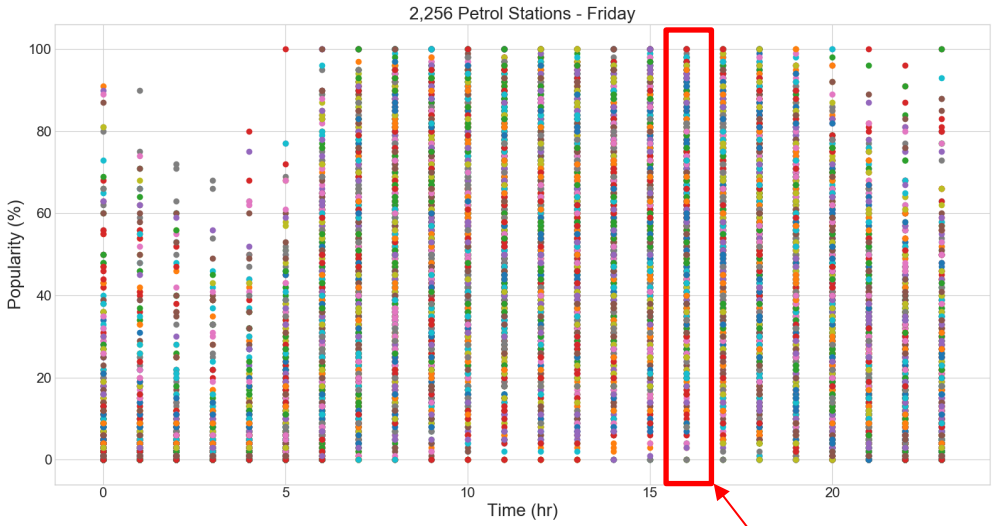
- No absolute numbers
- No seasonal variation
- Selection bias?

Data

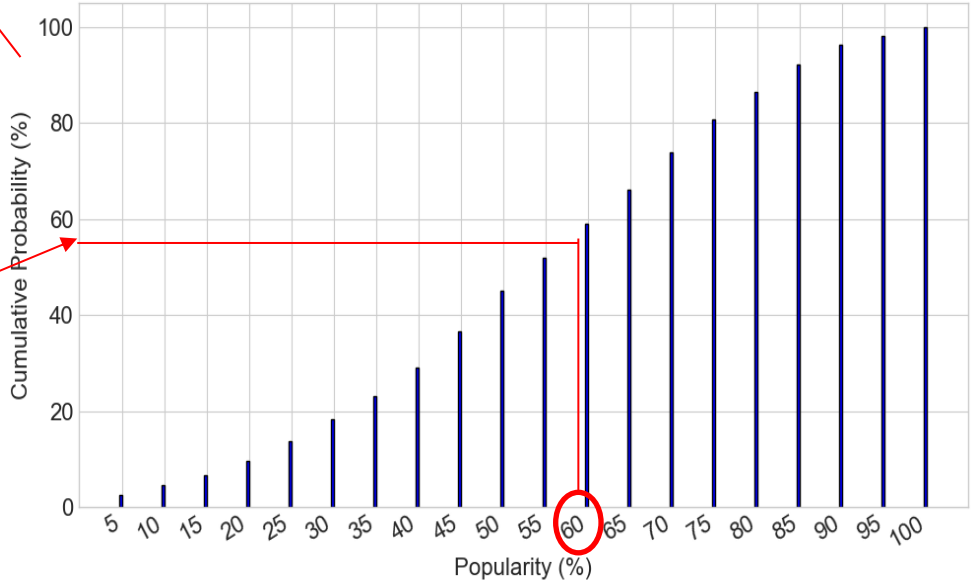
University of Strathclyde Engineering



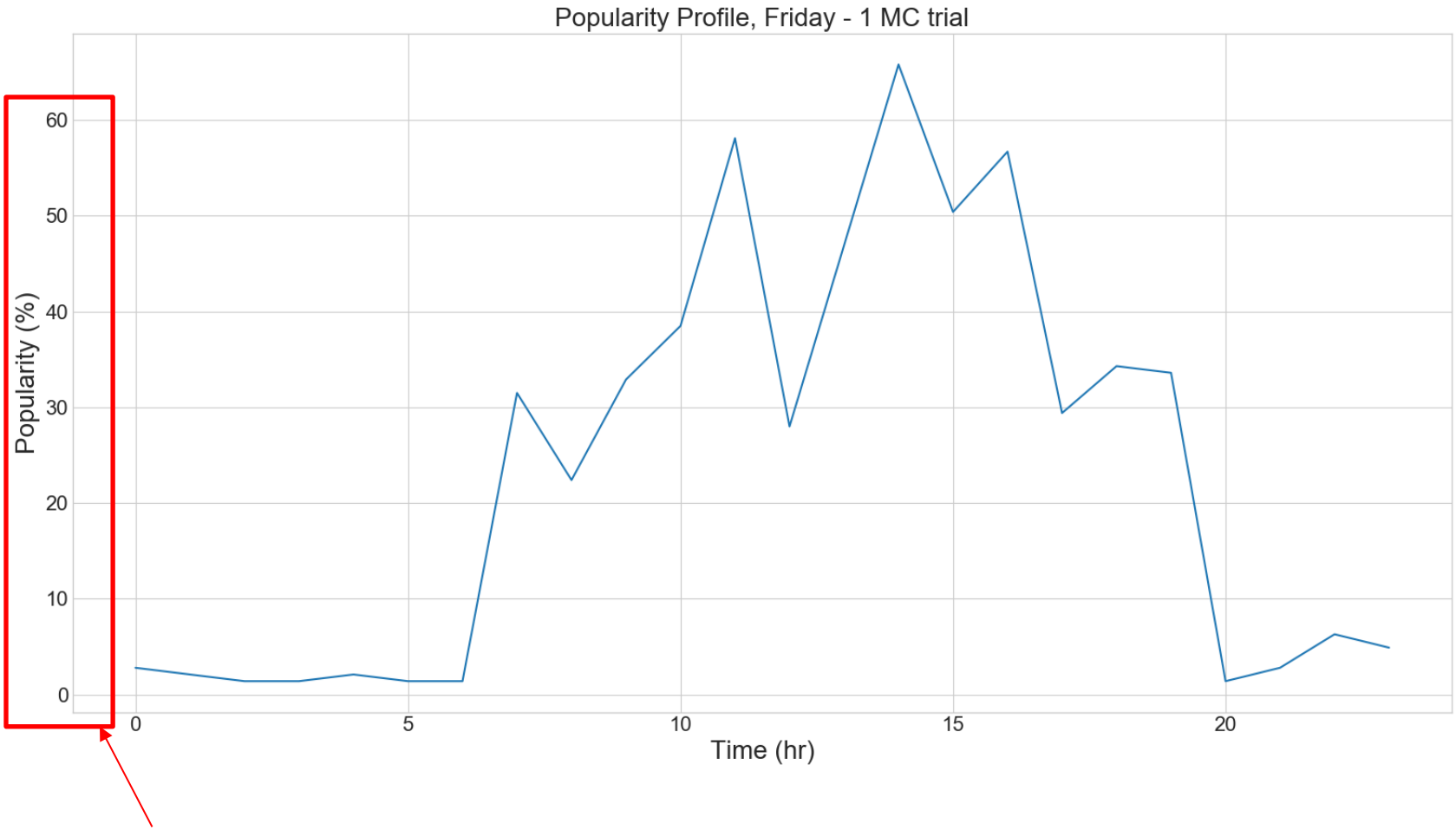
Monte Carlo



State Sampling Monte Carlo



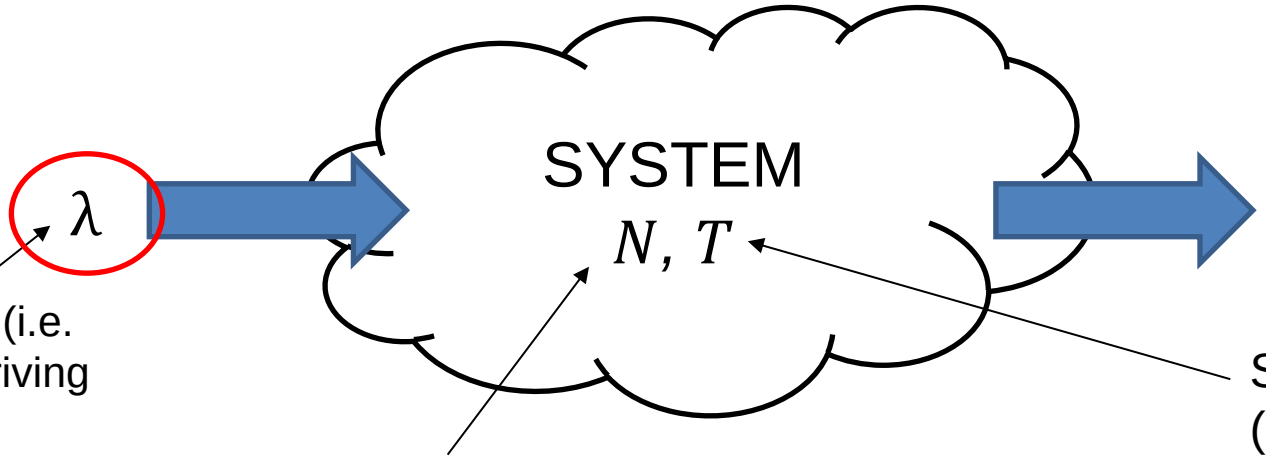
Monte Carlo



How does this translate to number of vehicles?

Queue Theory

Single queue, multiple server
M/D/c queueing problem



Arrival rate (i.e. vehicles arriving per hour)

(Poisson)

Number of agents in the system (i.e. the forecourt occupancy)

Service time (i.e. the total time spent at a petrol station)

(Deterministic)

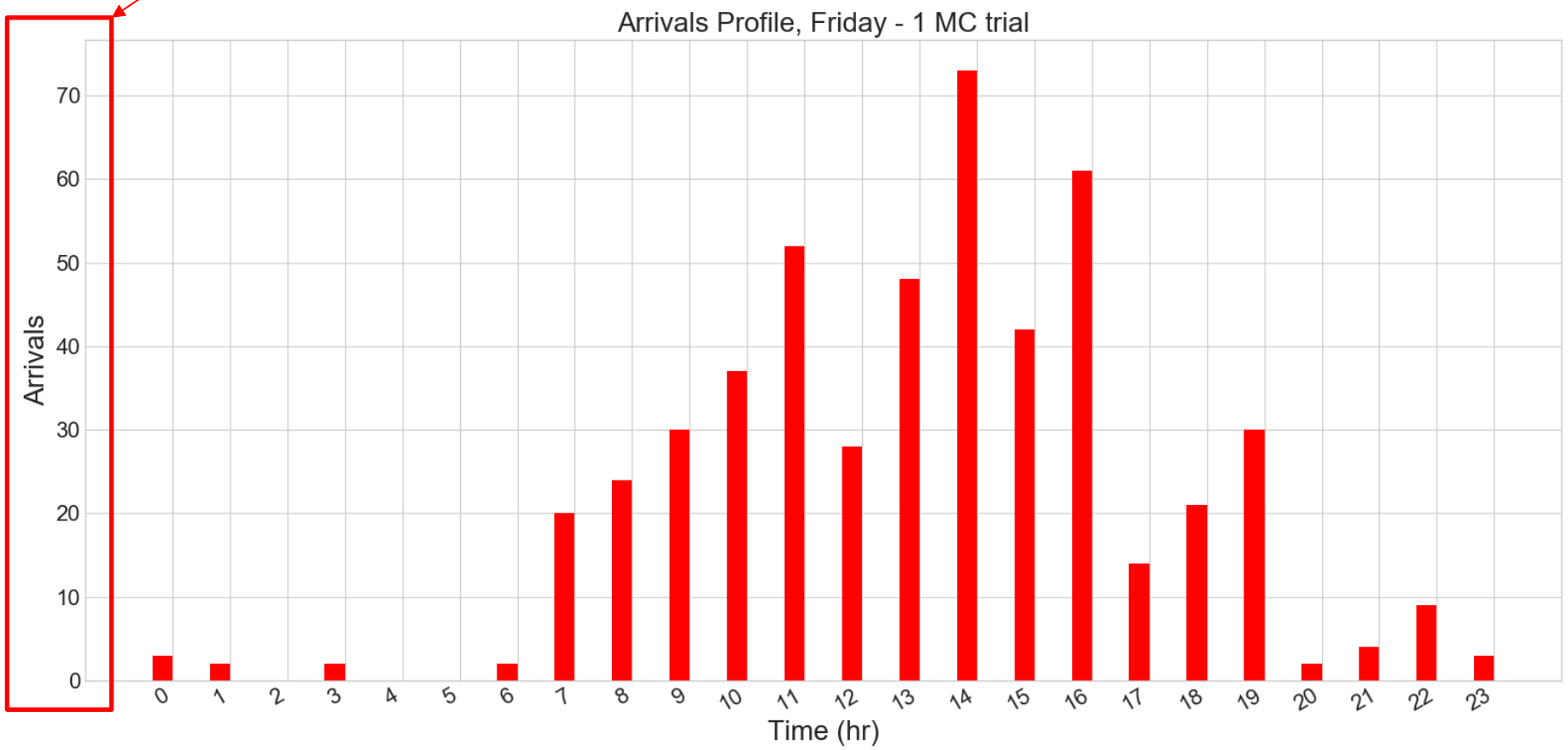
Little's Theorem

$$N = \bar{\lambda} T$$

Poisson distributed

Arrival Profile

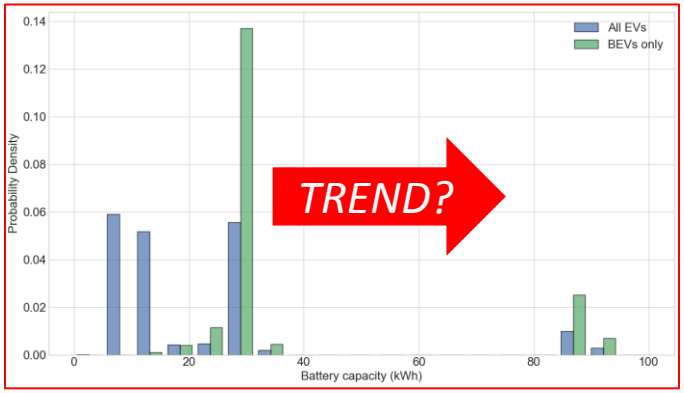
Number of vehicles arriving in a given hour

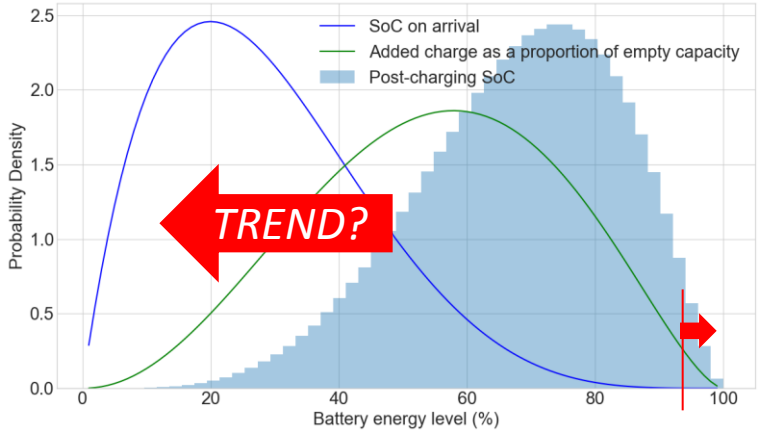


EV Charging Forecourt

University of Strathclyde Engineering

UK EV Sales, 2017[2]





Battery capacity (kWh)

Battery State of Charge on arrival (%)

Charge to add, as proportion of empty capacity (%)

Power rating

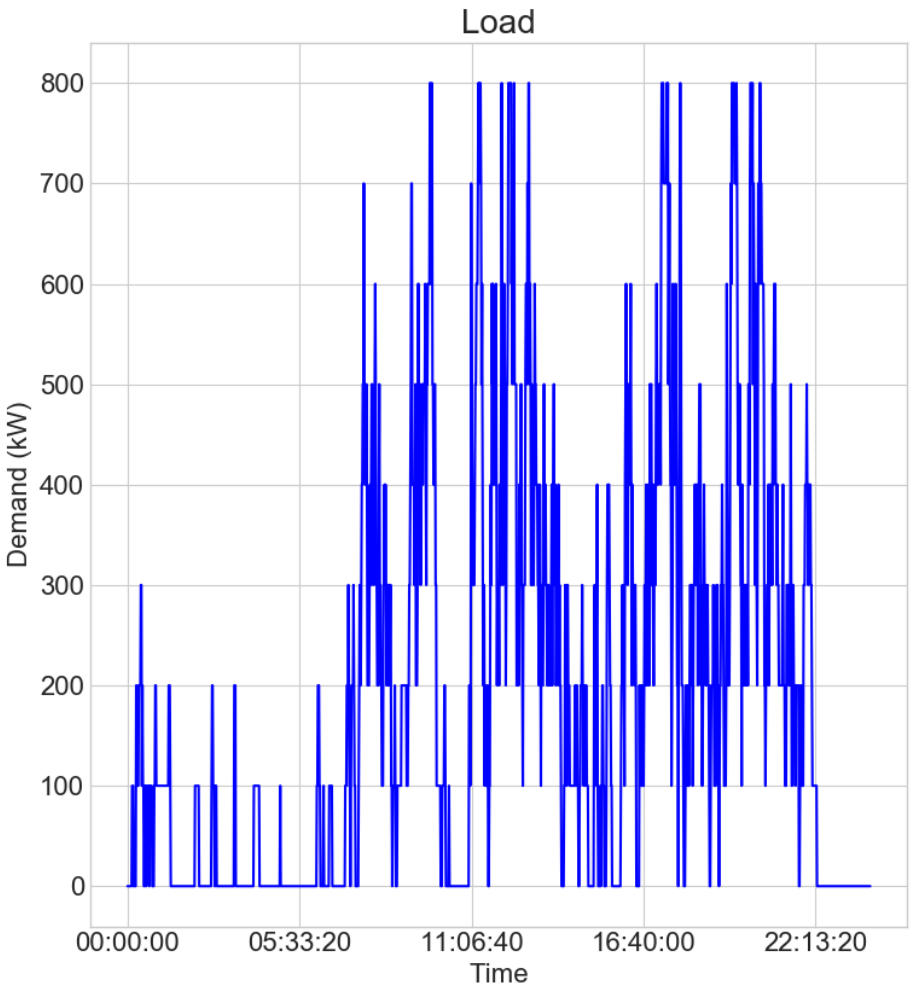
Number of chargers

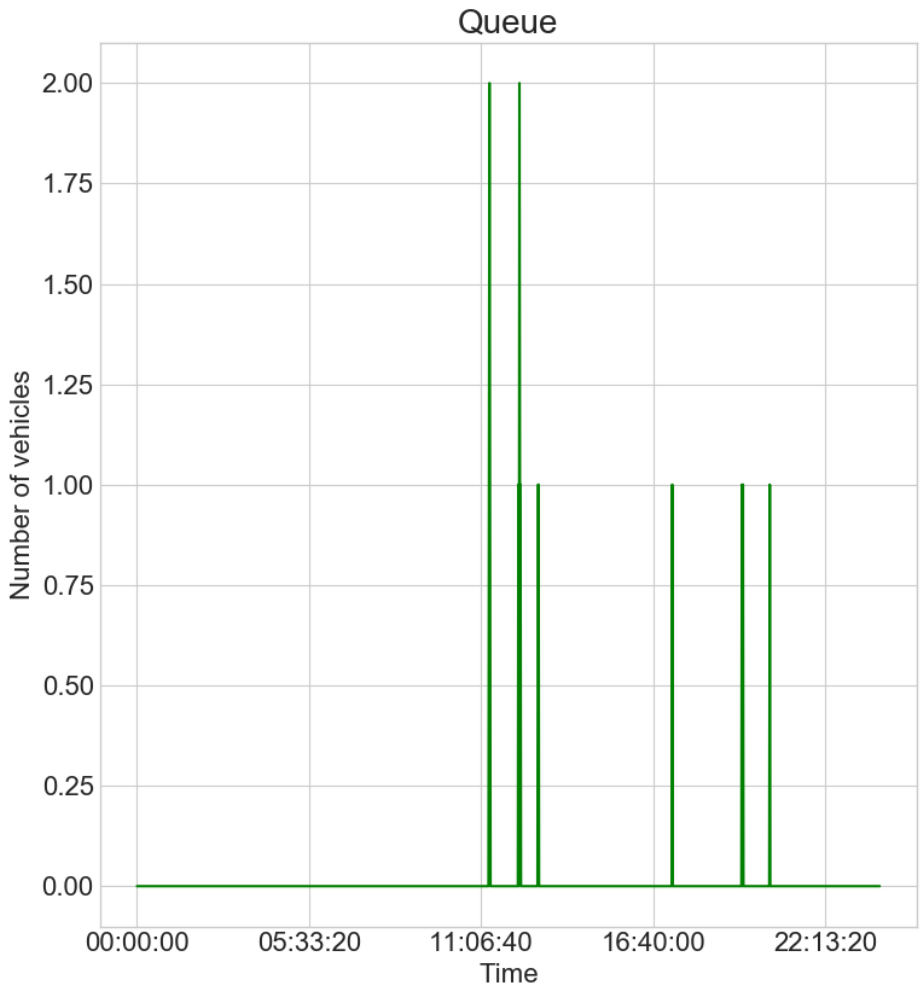
Choice variables

[2] RAC Foundation, "Plug-in grant eligible vehicles licensed," 2017. [Online]. Available: https://goo.gl/ZnR1fZ.

Results (one MC trial)

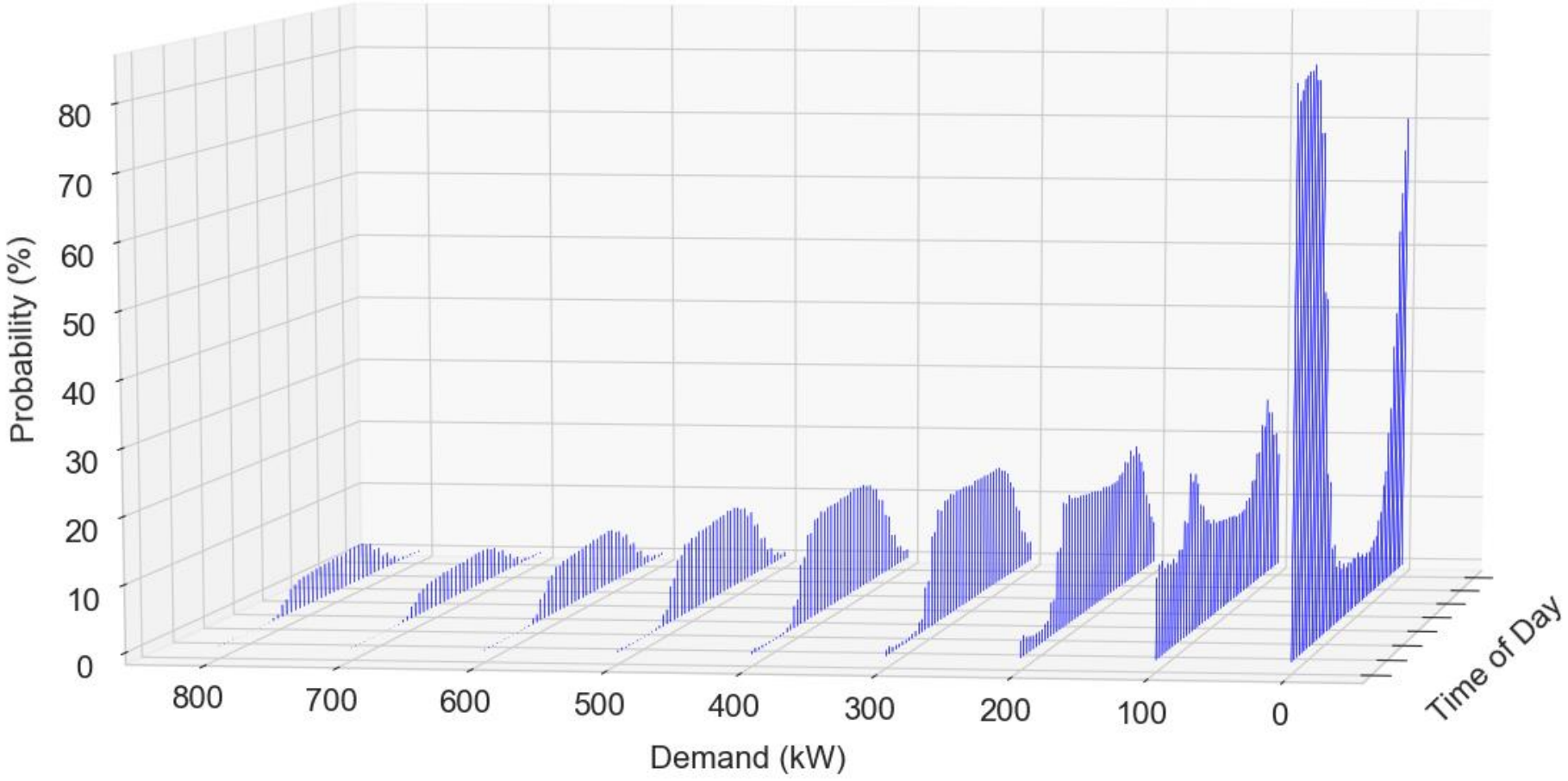
Friday, 8 x 100 kW chargers



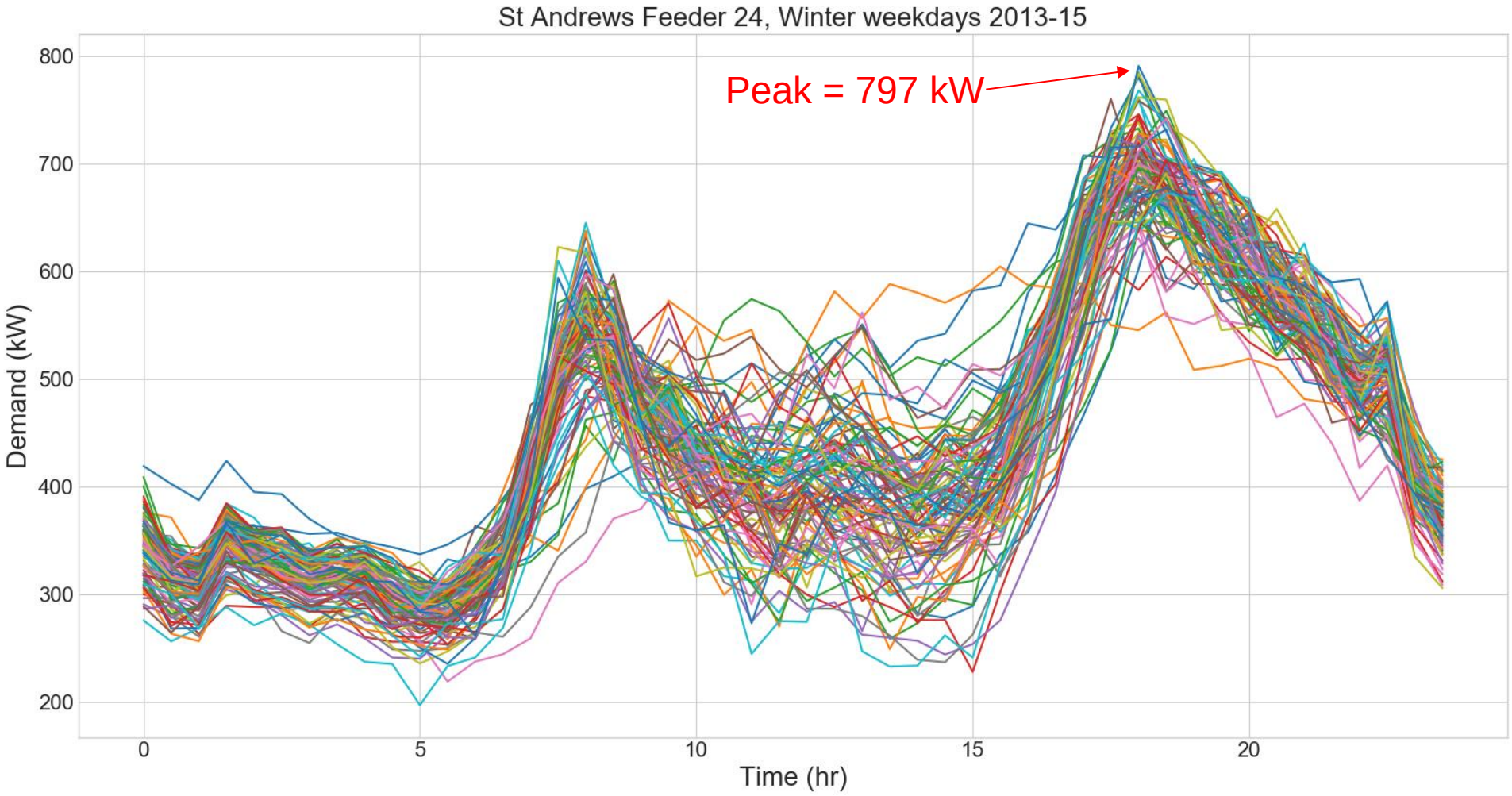


Histogram (10,000 MC trials)

Friday, 8 x 100 kW chargers

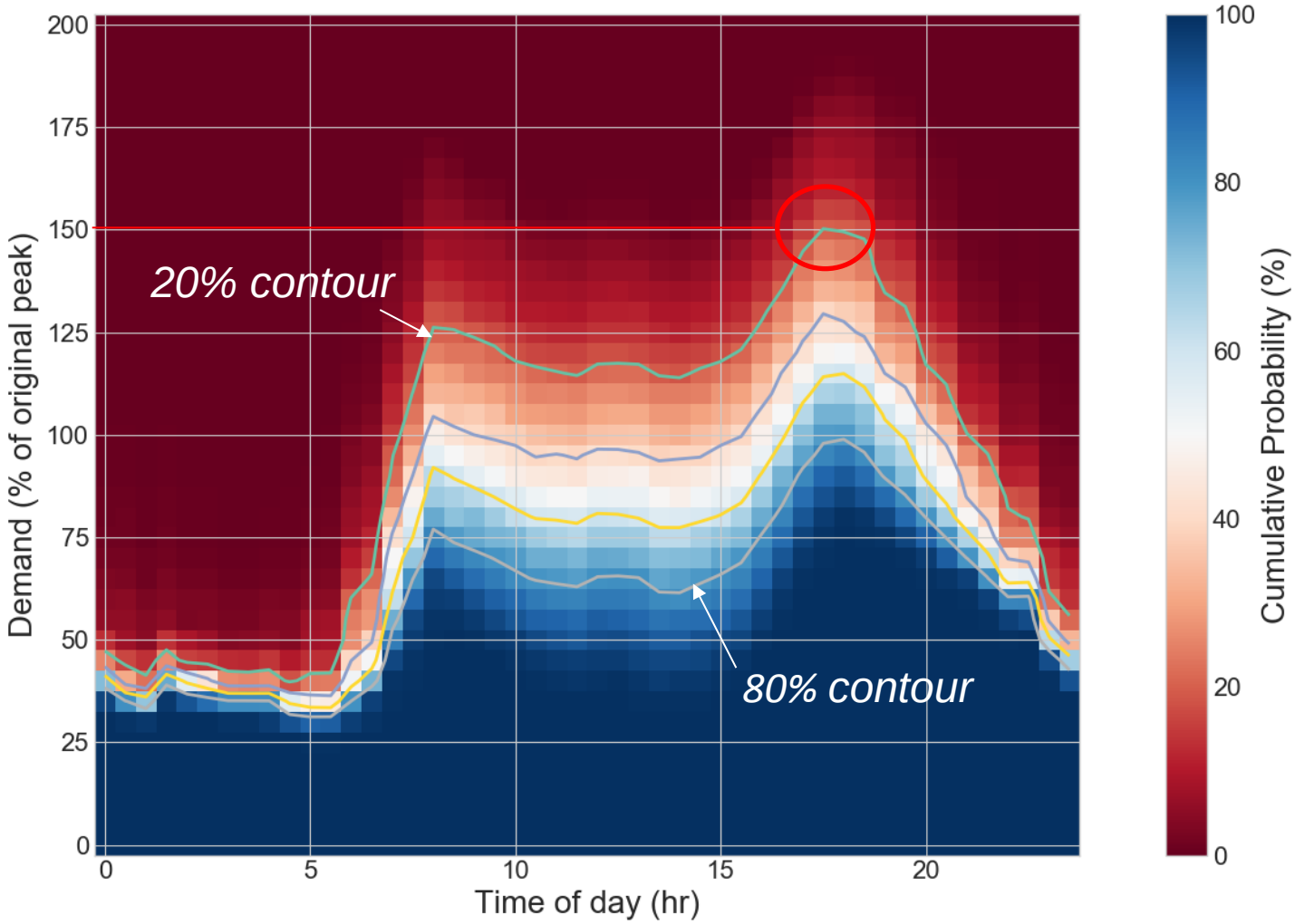


Comparison with Existing Load



Comparison with Existing Load

University of Strathclyde Engineering



Conclusion

University of Strathclyde Engineering

- There is an information gap in our knowledge of how people will charge their EVs – this method can help to bridge it
- It can also be applied to ‘destination charging’ (gyms, cinemas, supermarkets etc.) using a very similar method
- This method could be developed to evaluate the need for network reinforcement following integration of EV rapid charging infrastructure
- …and assess the feasibility of ‘smart’ alternatives

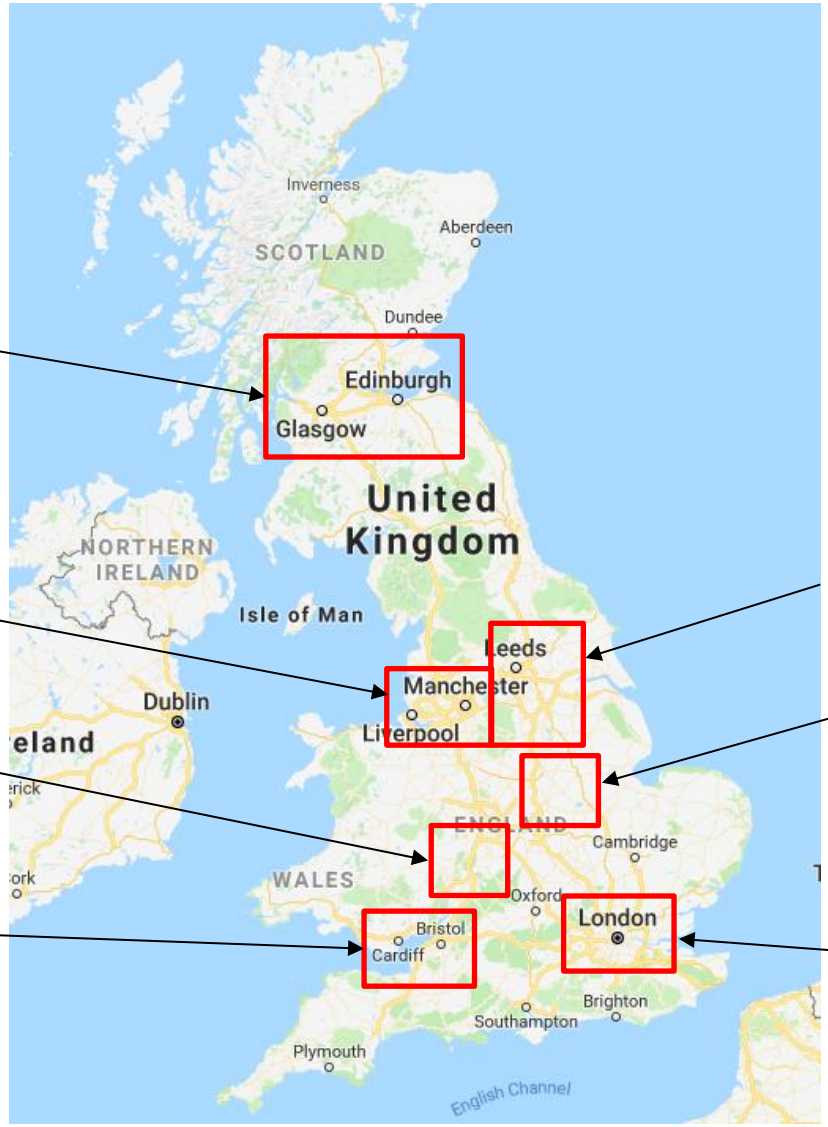
Q&A

University of Strathclyde Engineering

Appendix Slides

University of Strathclyde Engineering

GB Petrol Stations



Scottish Central Belt

Greater Manchester & Merseyside

West Midlands

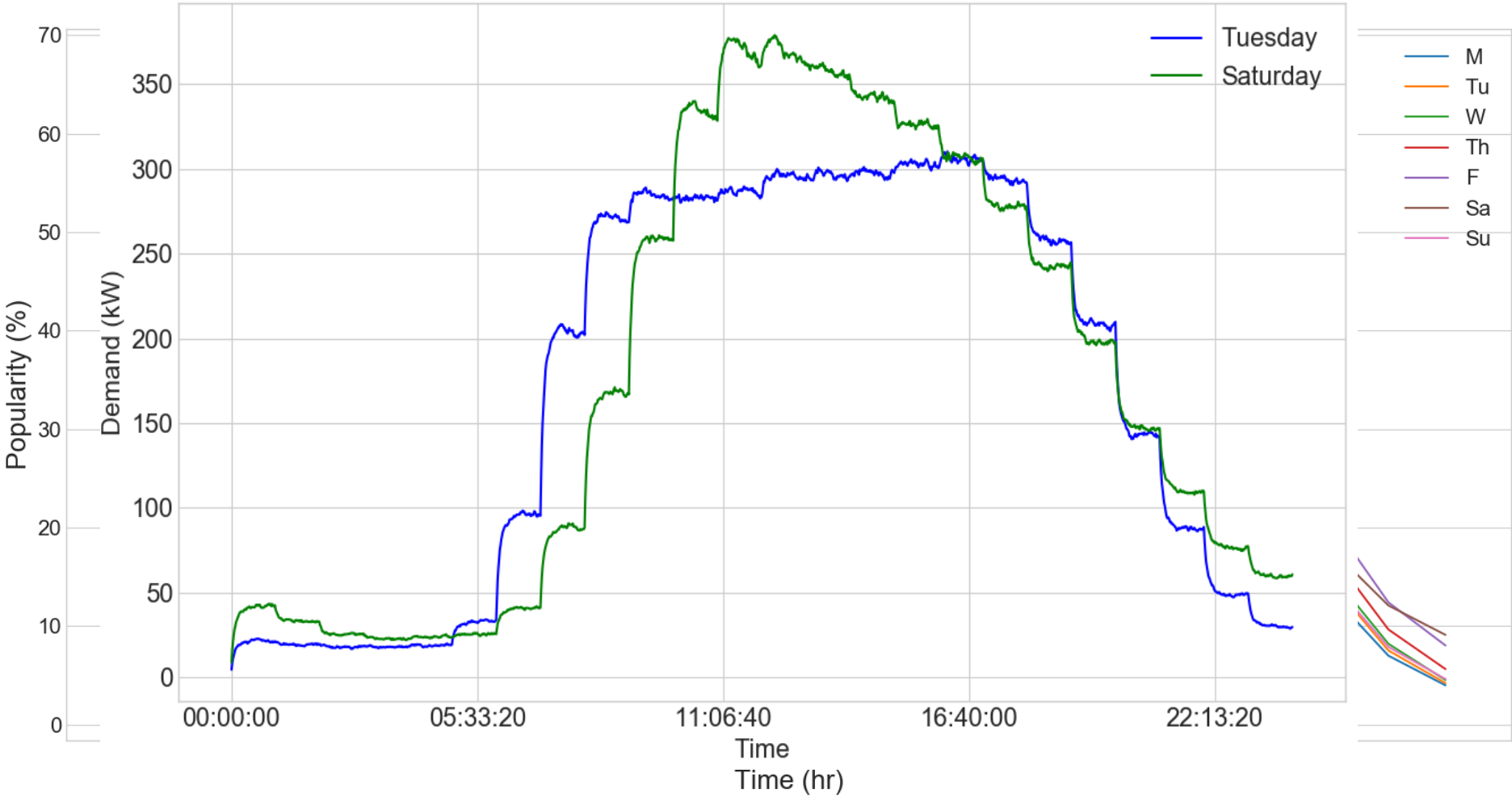
Avon & Glamorgan

Yorkshire

East Midlands

Greater London

Average Data



Queue Theory Service Time

Average throughput, GB petrol station = 6 million litres/year

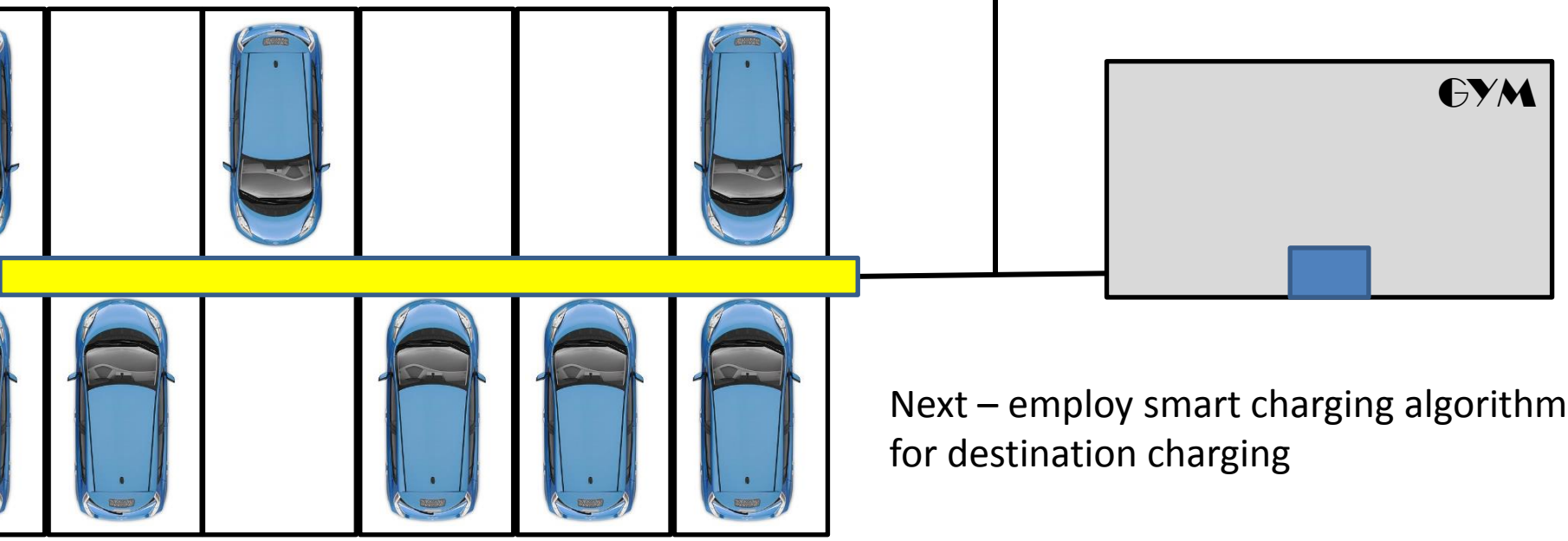
Average fuel delivery = 40 litres

Number of cars required to meet that throughput = 150,000/year

= *411 per day*

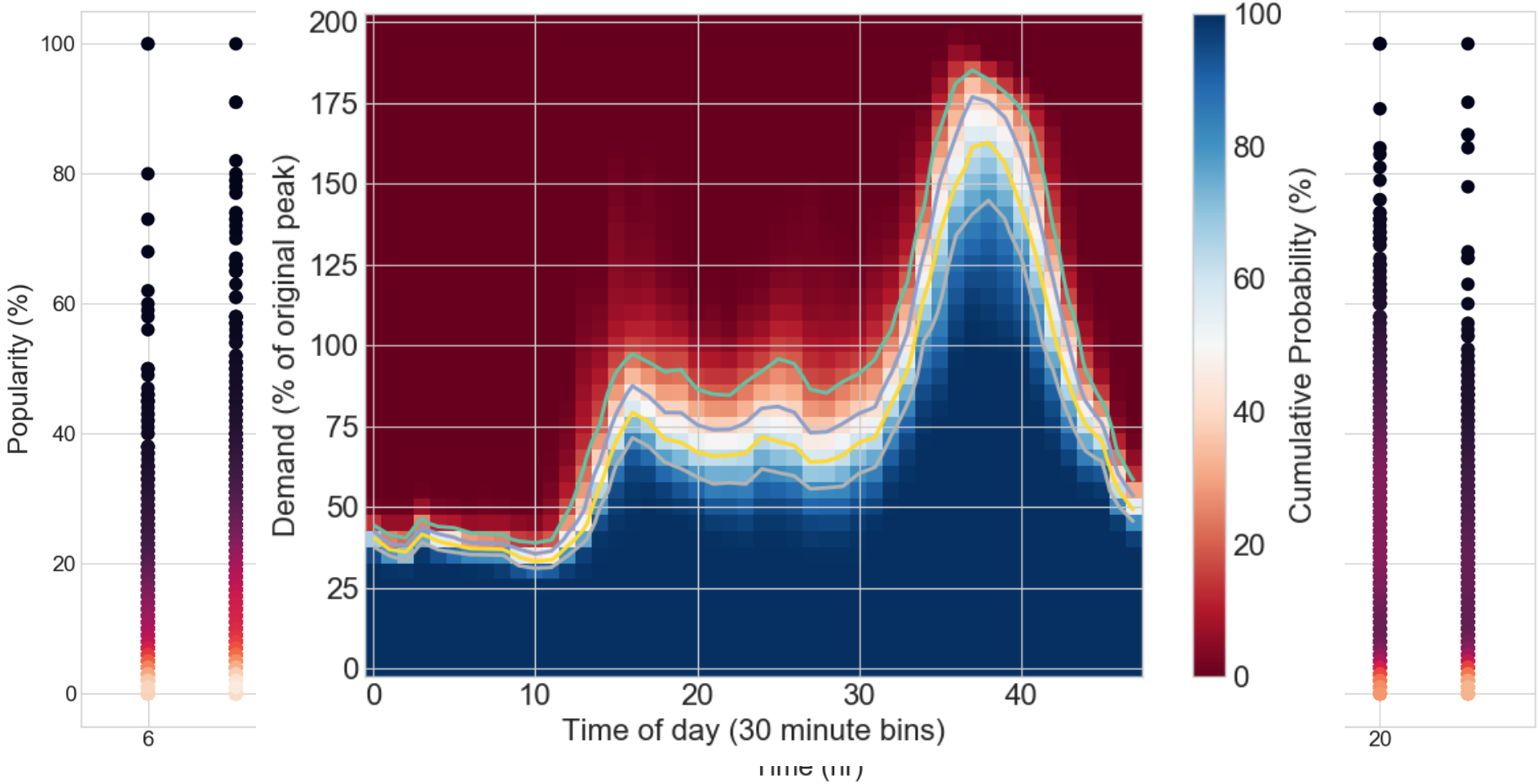
Destination Charging

Never queue for a connection
But maybe queue for *power*
Charger will charge @ rating when one of its 'units' becomes free

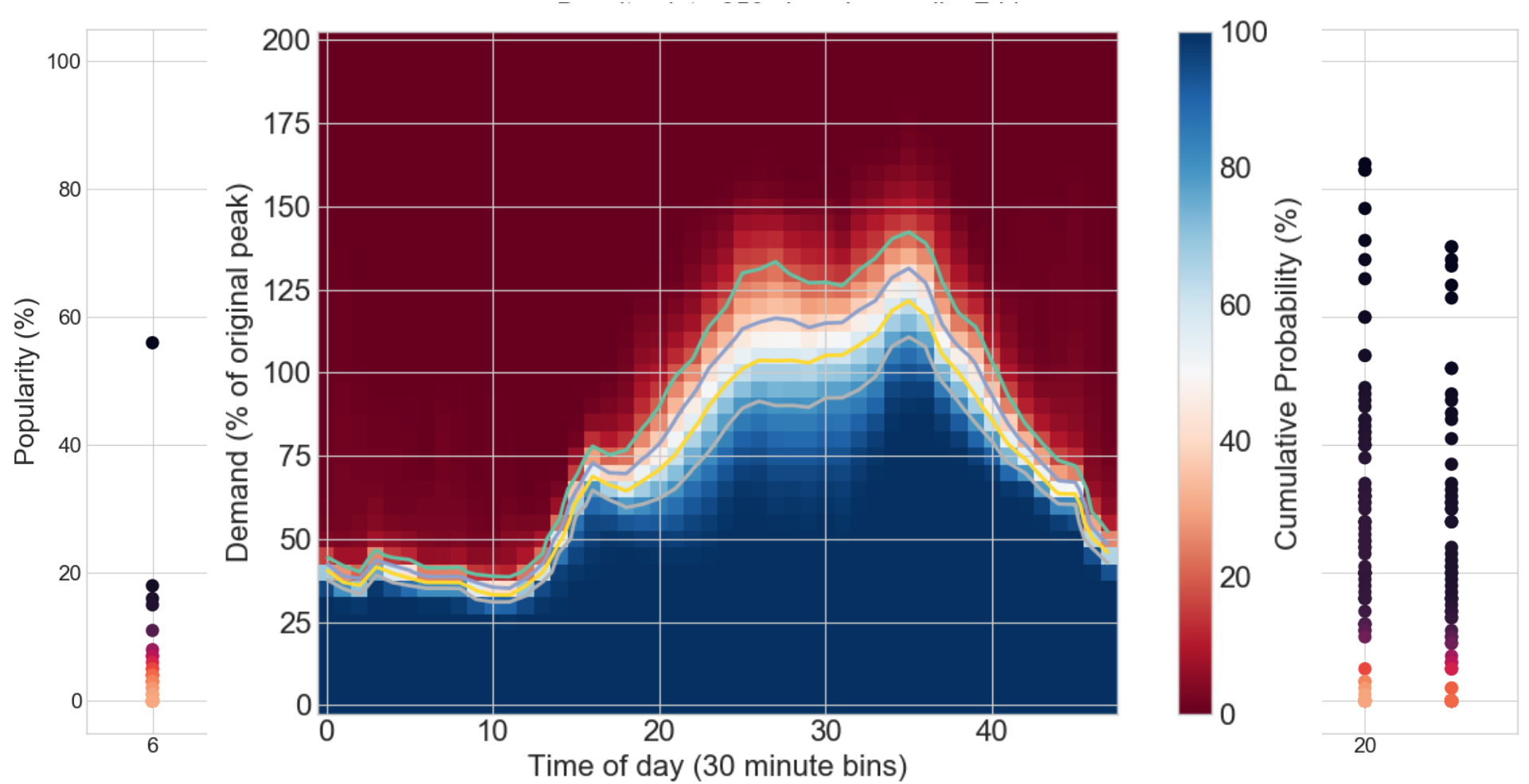


Next – employ smart charging algorithm for destination charging

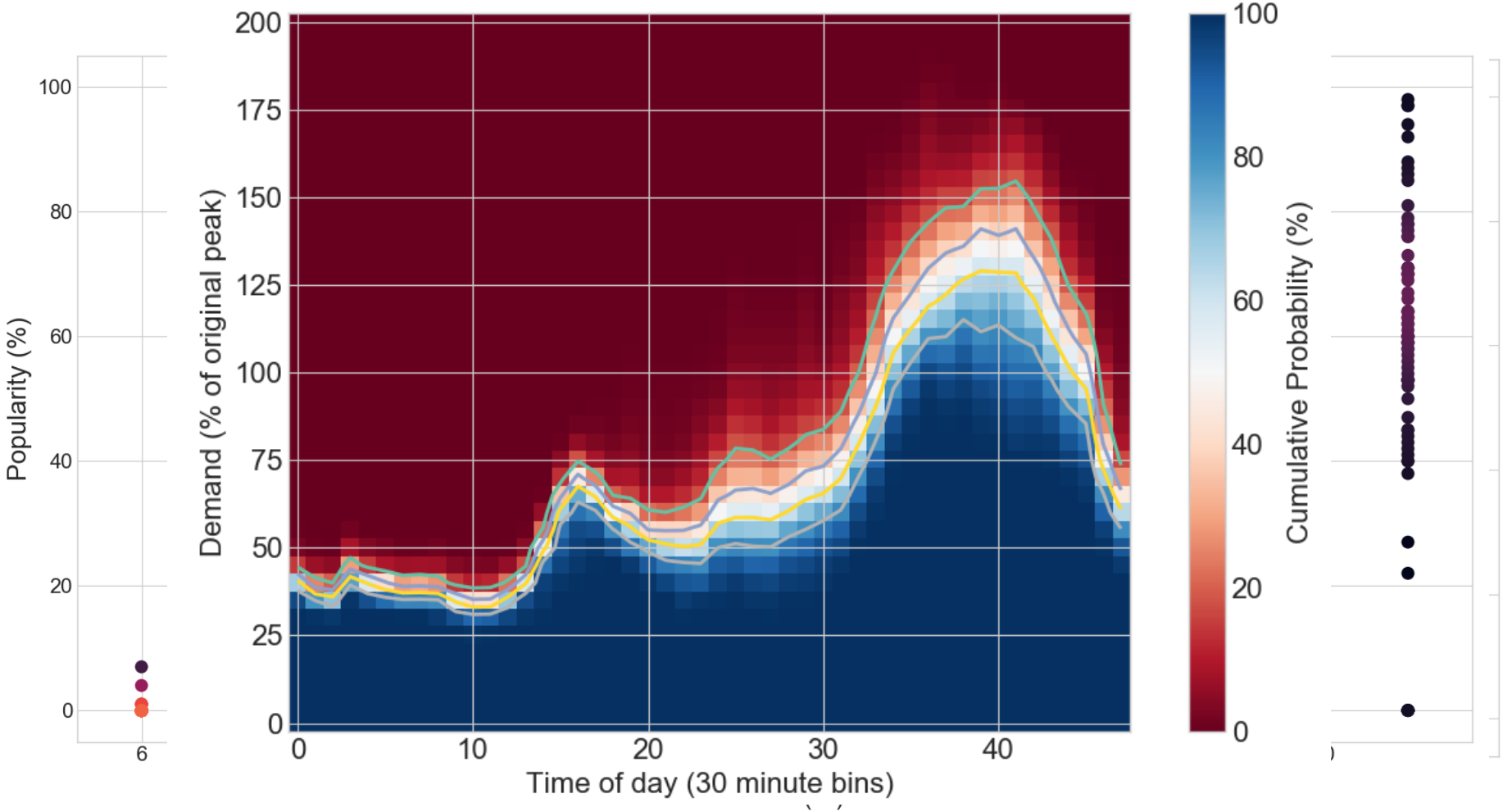
Gyms


Popularity (%)
100
80
60
40
20
0
6
Demand (% of original peak)
200
175
150
125
100
75
50
25
0
0
10
20
30
40
Time of day (30 minute bins)
100
80
60
40
20
0
Cumulative Probability (%)
20

Shopping Malls



Cinemas


Popularity (%)
100
80
60
40
20
0
6
Demand (% of original peak)
200
175
150
125
100
75
50
25
0
0
10
20
30
40
Time of day (30 minute bins)
100
80
60
40
20
0
Cumulative Probability (%)