

Roundabouts and the Energy Consumption of Electrical Vehicles

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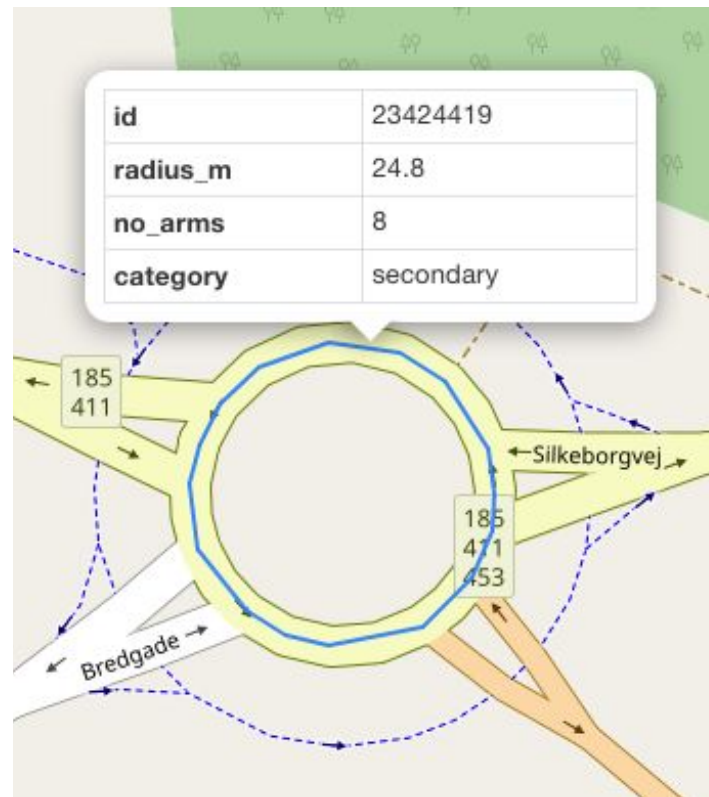


Introduction

- Transportation sector:
 - 23-36% of all GHG in developed countries.
 - Passenger vehicles account for almost half of it.
- Electrical vehicles do not emit GHG, but...
 - 306g of CO₂ per kWh of electricity produced in EU-28.
 - 393g in the US and 560g in China.
- Roundabouts:
 - Eco-friendly, cheaper, and safer.
 - Popularity growing worldwide, specially in Europe and the US.
 - Current literature focus on safety, performance, or ICEVs.

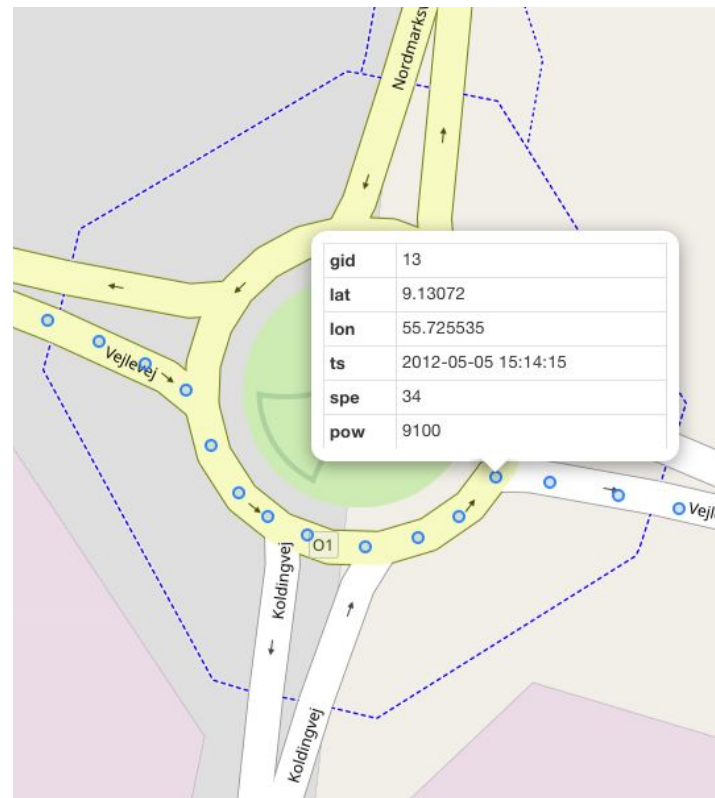
Roundabouts

- Type of circular intersection.
- Designed to allow traffic to flow without idling.
- Modern roundabouts:
 - Safer.
 - More environmentally friendly.
 - Cheaper to build and maintain.
- Parameters:
 - Radius.
 - Number of arms.
 - Category (from OSM).

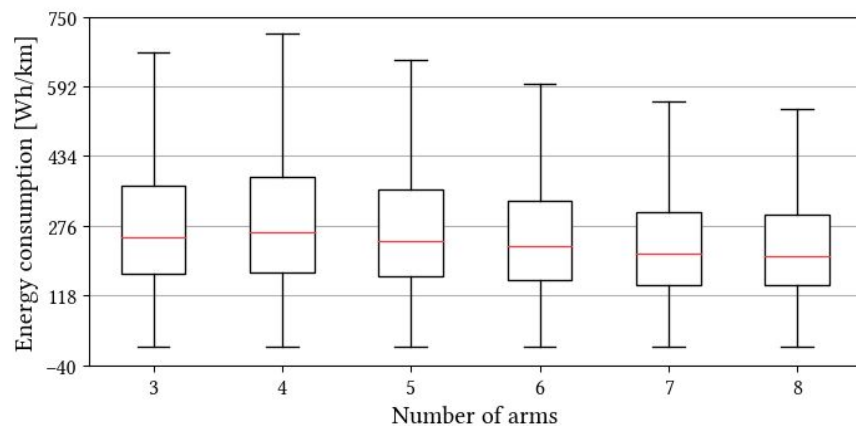
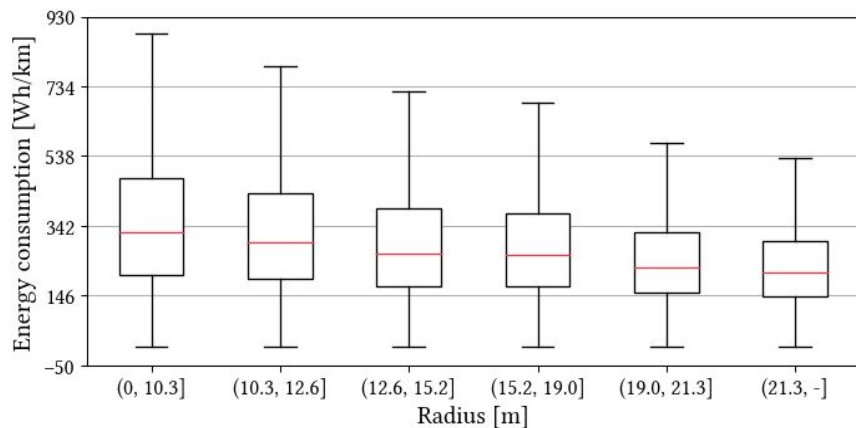


Data Statistics

- 1-Hz data quality:
 - 1.6% didn't register GPS points.
 - 97% have 2+ points, 51% have 6+ points.
- Cleansing:
 - GPS and OBD anomalies.
 - Map-matching anomalies.
 - Number of arms and categories.
- Dataset:
 - 98,228 trajectories.
 - 1,186 roundabouts.
 - 188,897 passes.

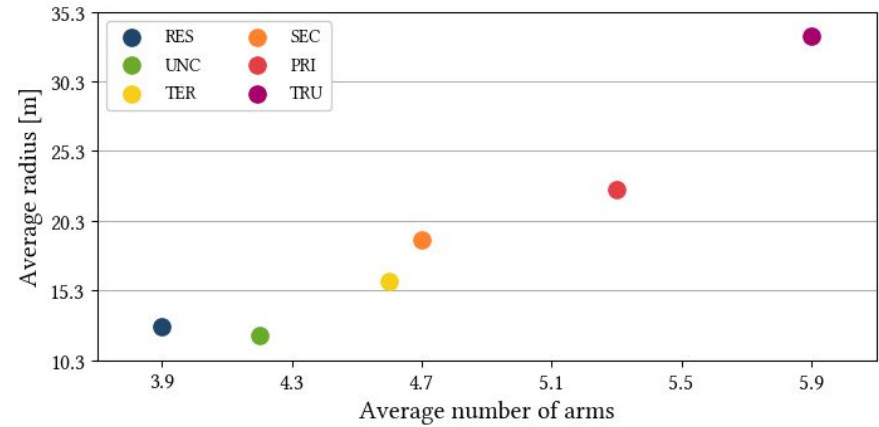
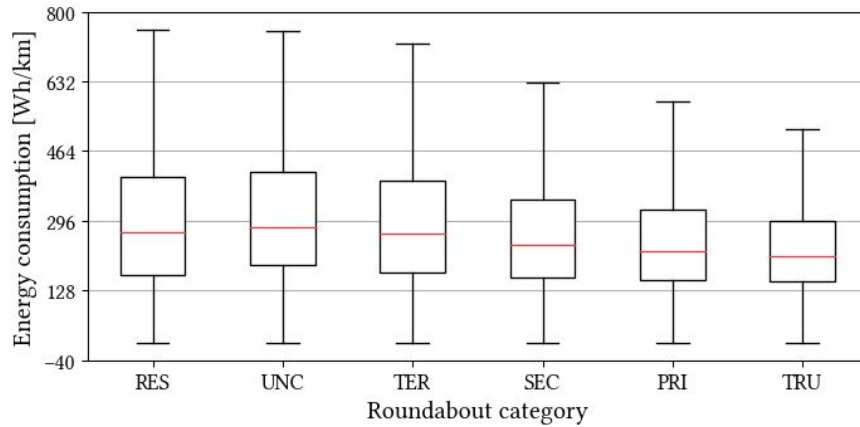


Radius, Number of Arms, and Category



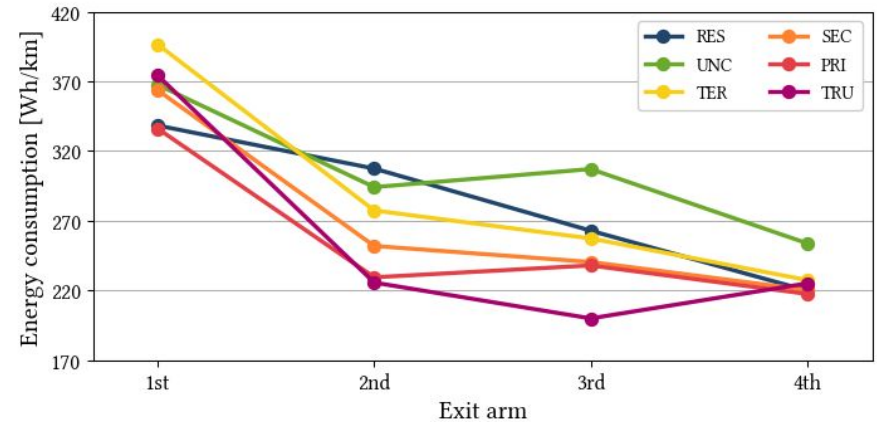
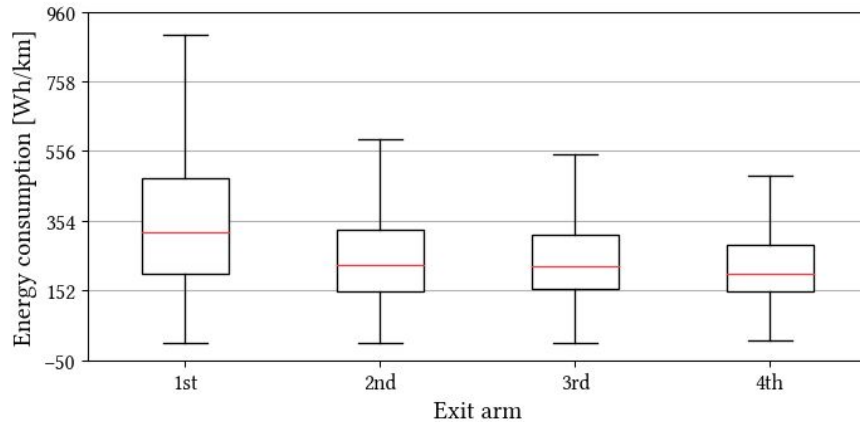
- For the radius, the average starts at 323 Wh/km and it ends at 210 Wh/km (35% less).
- For the number of arms, the average starts at 251 Wh/km and it ends at 208 Wh/km (21% less).
- Similar values and similar trend across the board.

Radius, Number of Arms, and Category



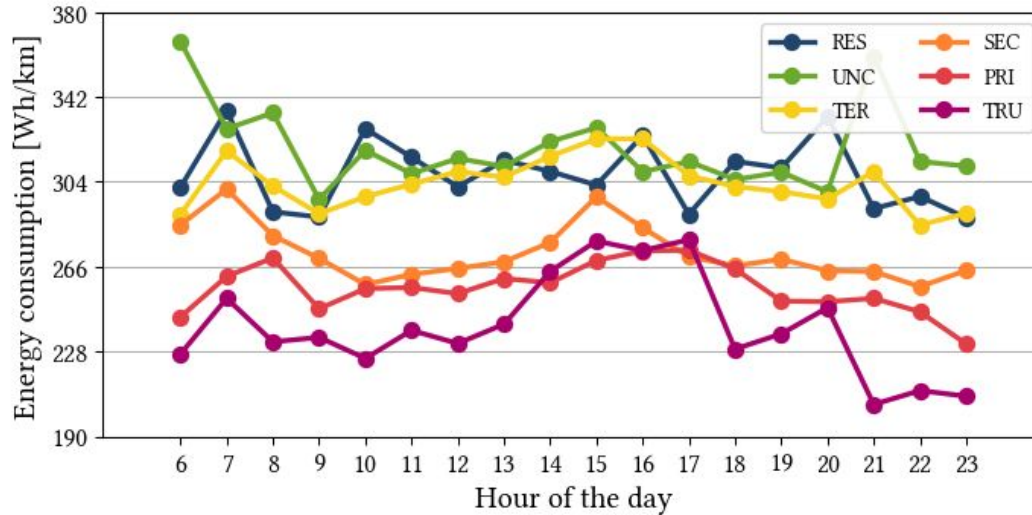
- For the category, the average starts at 268 Wh/km and it ends at 211 Wh/km (21% less).
- As we move from residential to trunk roundabouts, we increase the radius and number of arms.
- The category encompasses both the radius and the number of arms.

Exit Arm



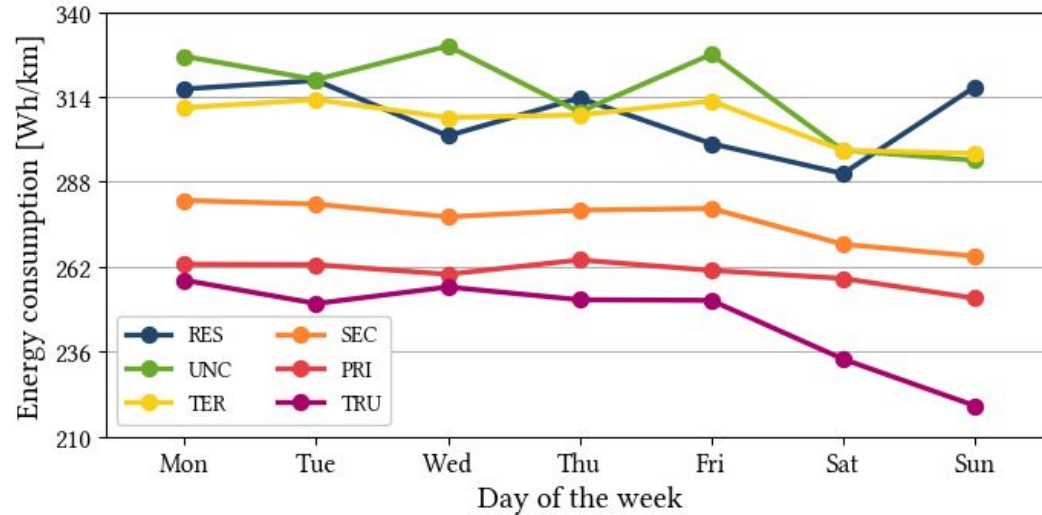
- The 1st exit has an average of 329 Wh/km, the others have 207-233 Wh/km (29-37% less).
- By categories, the 1st exit has an average of 362 Wh/km, the others, 227-263 Wh/km (27-37% less).
- Supports the study and evaluation of building shortcuts to avoid the roundabouts.

Seasonality



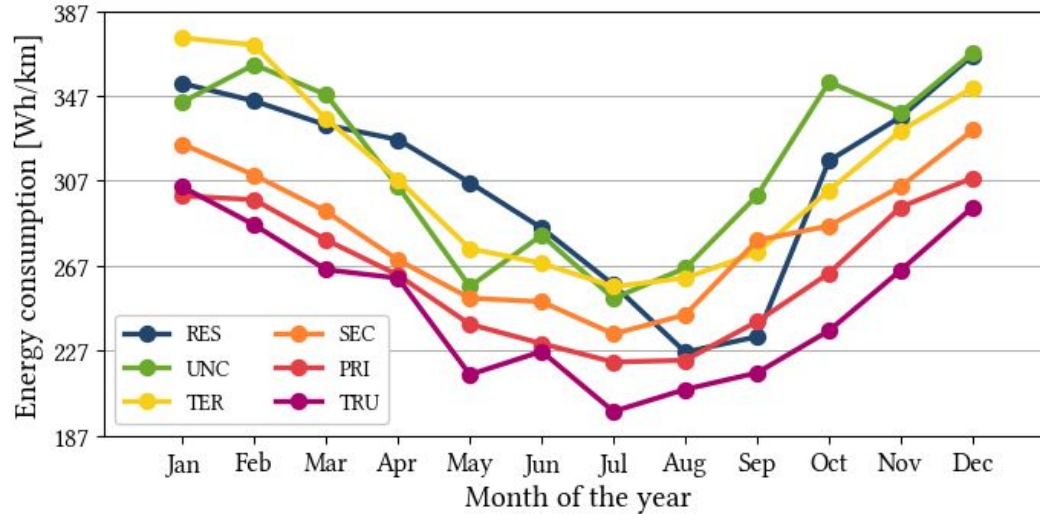
- Increased consumption between 6:00-8:00 (5-12%) and 15:00-17:00 (4-10%) for all categories.
- Trunk roundabouts showed increase of 24% between 6:00-8:00 and 25% between 15:00-17:00.
- Trunk roundabouts have a higher sensibility to congestion.

Seasonality



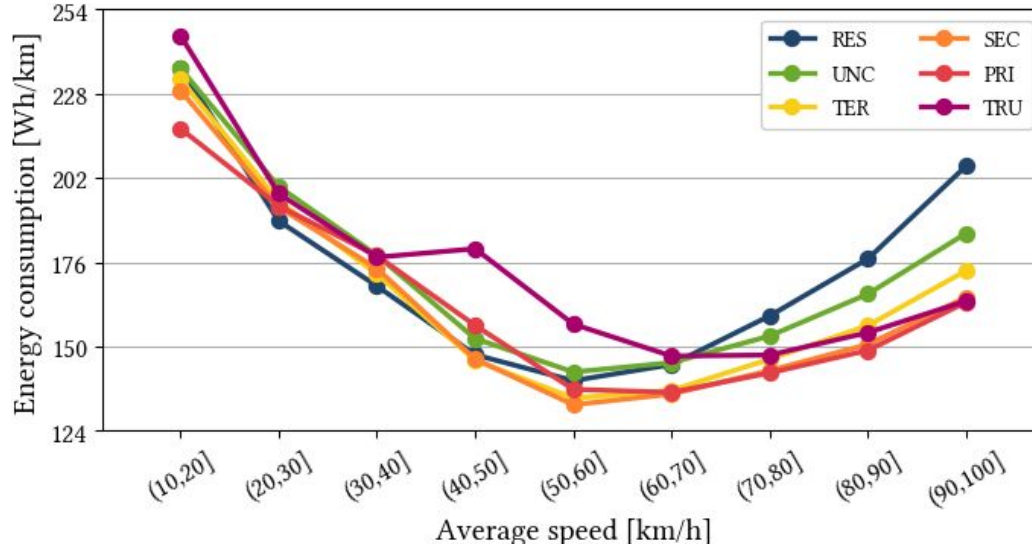
- Similar consumption from Monday to Friday, average decrease of 5-8% during the weekends.
- Residential roundabouts showed an increase of 3% on Sundays.
- Trunk roundabouts showed a decrease of 10% on Saturdays and 20% on Sundays.

Seasonality



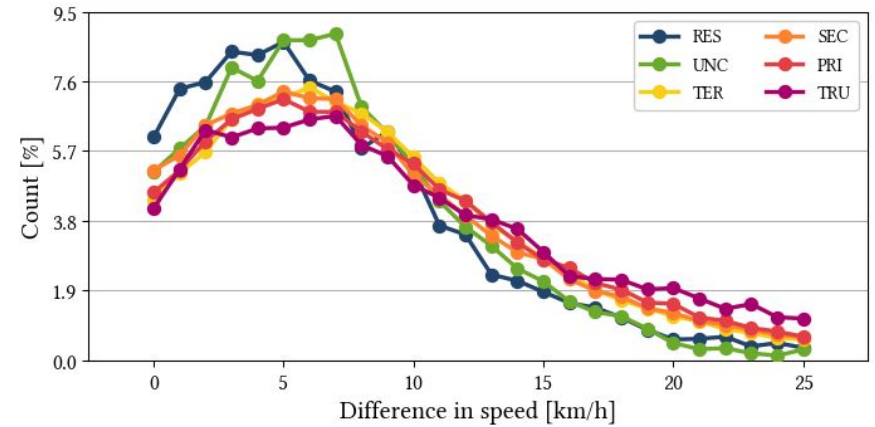
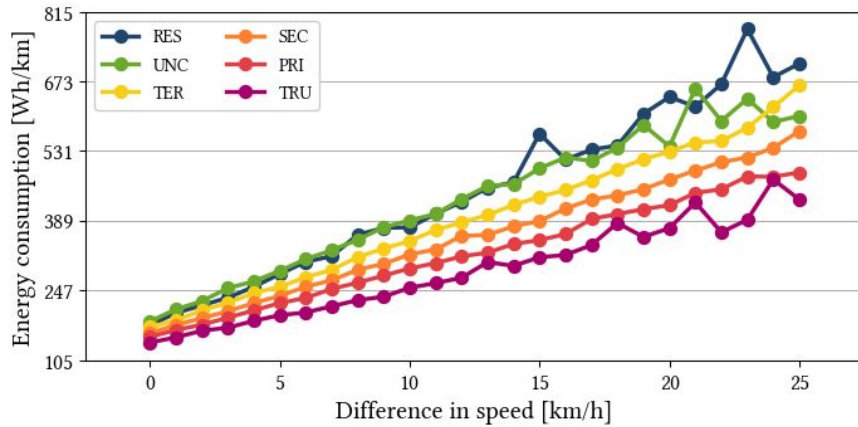
- Well-known pattern for EVs.
- Casually validates the operation of the OBD device and calculation of energy consumption.
- Two groups: residential, unclassified, and tertiary, and secondary, primary, and trunk (10-16%).

Speed



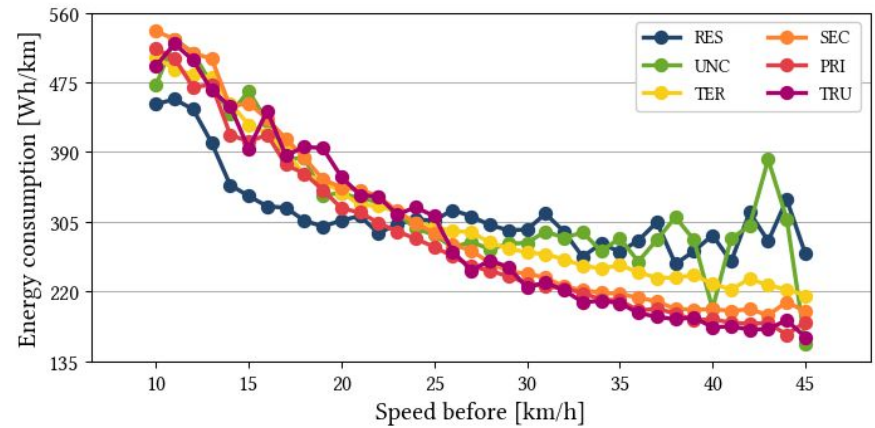
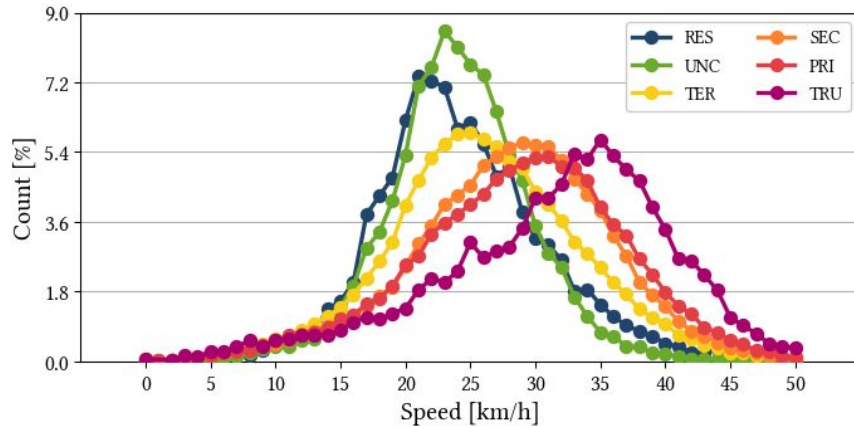
- Curve for the vehicles used in the study, but a well-known pattern for EVs.
- Lower consumption between 50 and 70 km/h.
- Road category plays little to no effect on it.

Speed



- Linear behaviour across all categories.
- 64-79% of the vehicles pass through the roundabouts with an increase of 0-10 km/h.
- Roundabouts prevent vehicles from accelerating too much inside them.

Speed



- Speed of 15-25 km/h for residential roundabouts, 30-40 km/h for trunk roundabouts.
- Polynomial fashion of order two (R^2 between 0.752-0.996).
- Performance inside the roundabouts highly correlated to the enter speed.

Summary

- Unprecedented numbers in the study of roundabouts.
- Showed that 1-Hz data can be used to study intersections.
- Novel and quantified information:
 - Radius, number of arms, and category.
 - Exit arm.
 - Seasonality.
 - Speed.
- The road category is a fair way to compare roundabouts.
- The speed right before correlates to the energy consumption inside the roundabouts.