FORECASTING RESIDENTIAL CHARGING DEMAND FOR PUBLIC CHARGING STATIONS IN URBAN AREAS

A SPATIAL-TEMPORAL APPROACH

35th International Electric Vehicle Symposium and Exhibition (EVS35)

Oslo, Norway
11th – 15th June 2022

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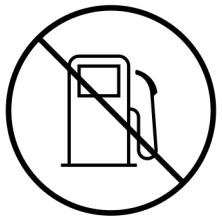
FORECASTING CHARGING DEMAND



Local governments increasingly **restrict combustion engine** cars (ICCT, 2021)

- **Public EVCI** is essential to support EV adoption
- This is **challenging**, especially in **urban areas**
- Urban planners should decide **where** and **when** to place new charging stations
- Charging **demand forecasts** support this

CHALLENGE VS. SOLUTION

Challenge:

Make predictions on:
- Detailed spatial level
- Longer time horizon

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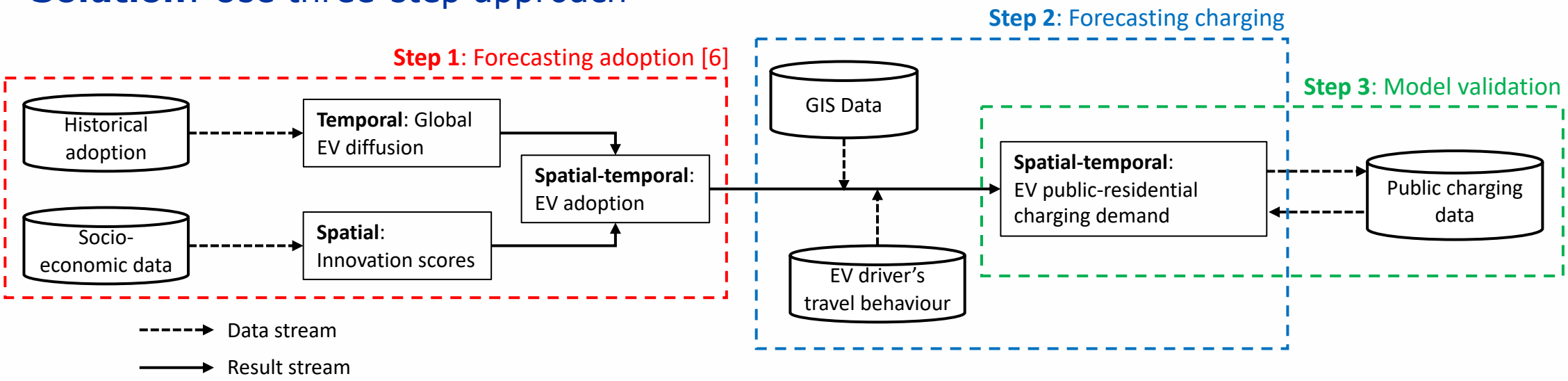
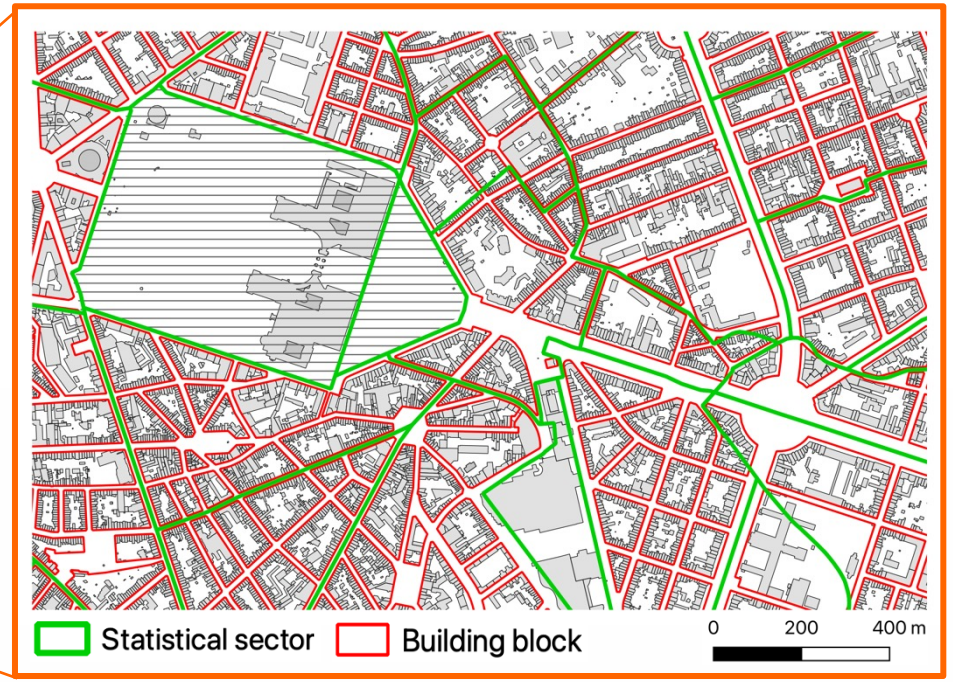
Having limited data
- Few EV adopters
- Limited existing EVCI

Solution: Use three-step approach



BRUSSELS CAPITAL REGION



Spatial level:

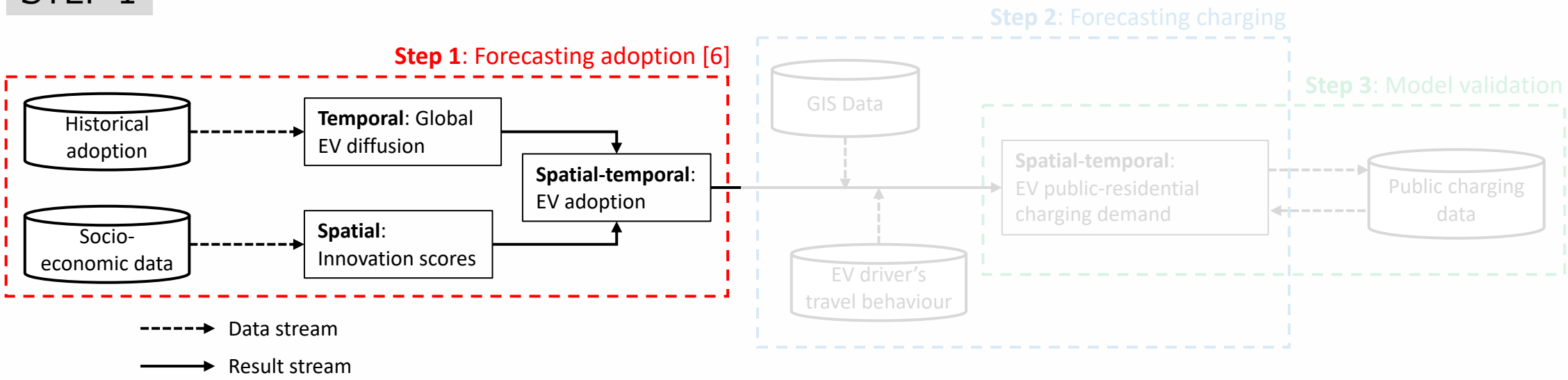
- 4,992 building blocks

Temporal level:

- 10 year forecast

1. FORECASTING ADOPTION

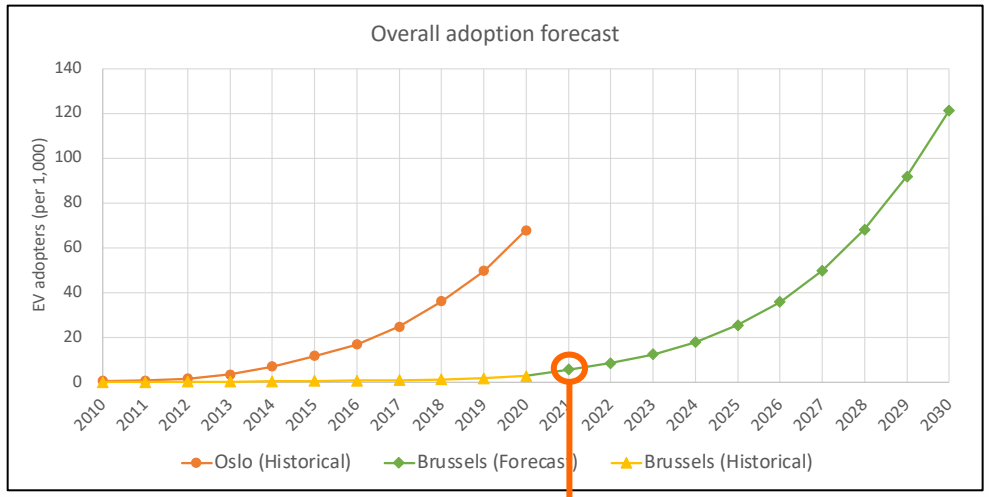
STEP 1



COMBINING TEMPORAL AND SPATIAL

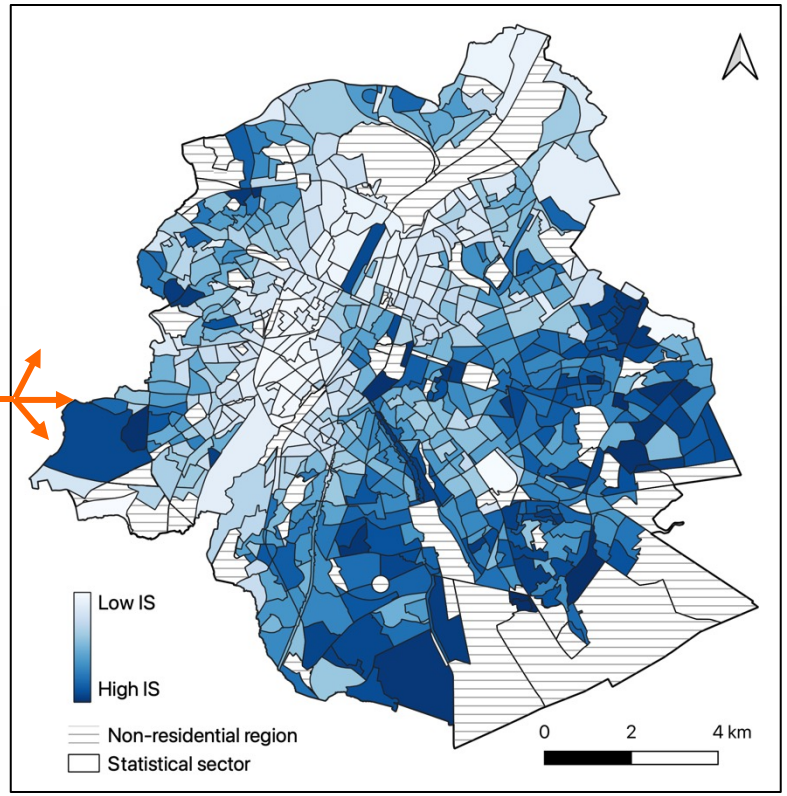
STEP 1

Temporal



5640 EVs

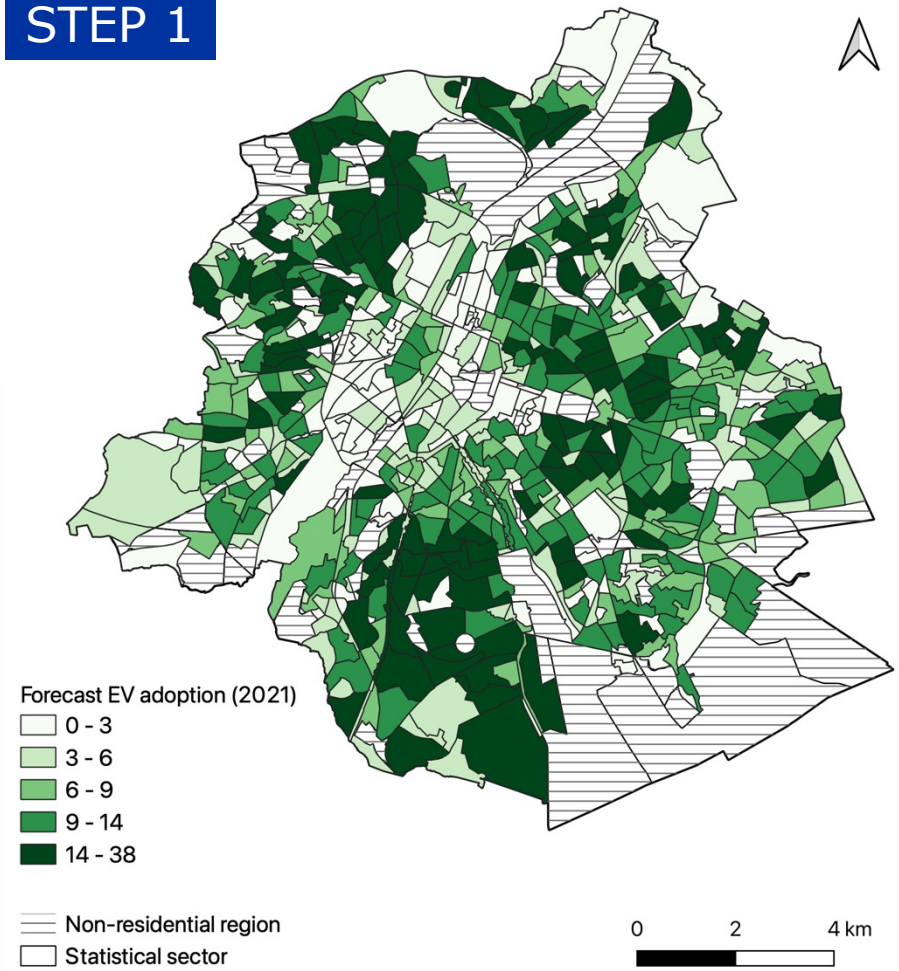
Spatial

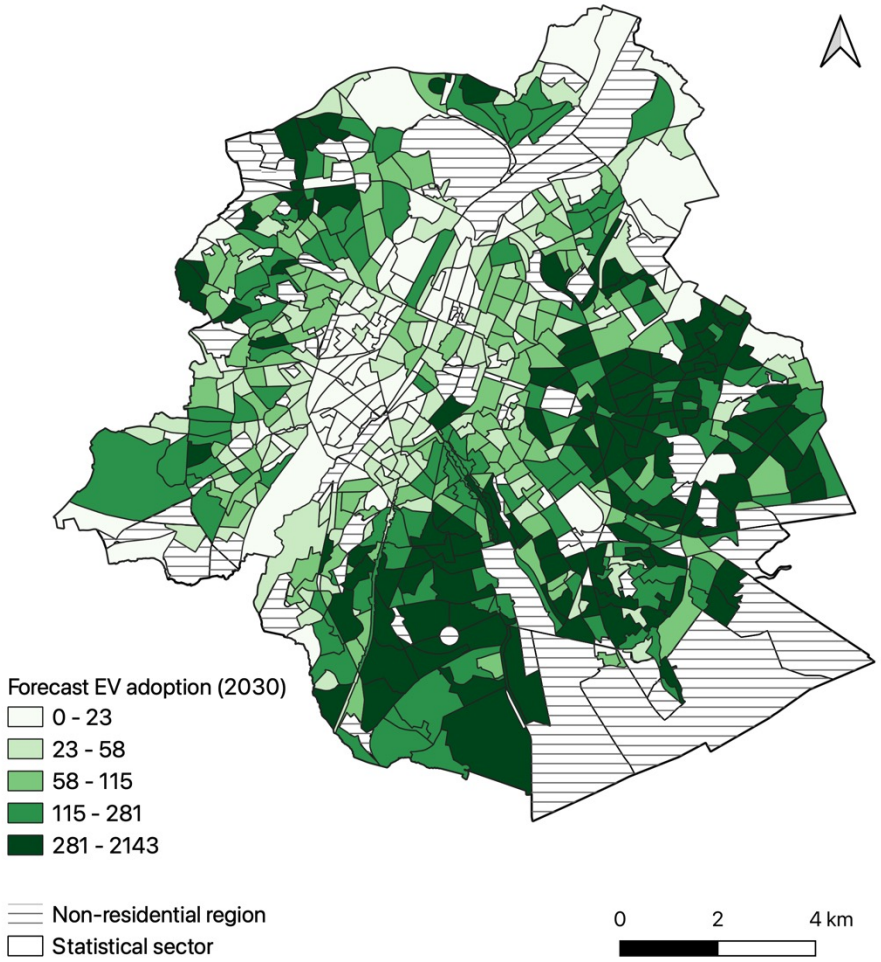


F. Heymann, F. v. Scheidt, F. J. Soares, P. Duenas, and V. Miranda, "Forecasting Energy Technology Diffusion in Space and Time: Model Design, Parameter Choice and Calibration," IEEE Transactions on Sustainable Energy, vol. 12, no. 2, pp. 802-809, 2021.

FORECASTED ADOPTION

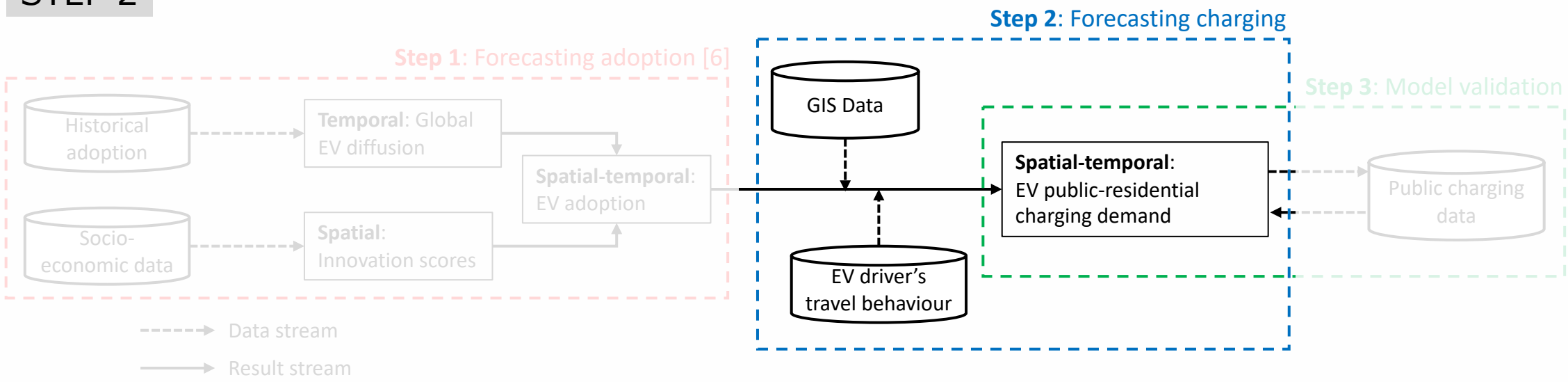
STEP 1





2. FORECASTING CHARGING

STEP 2



CALCULATE CHARGING DEMAND

STEP 2

$$1\ \text{EV} = (ADT \times EC \times RCR \times \lambda PCR_{bb} \times 365)\ \text{kWh per year}$$

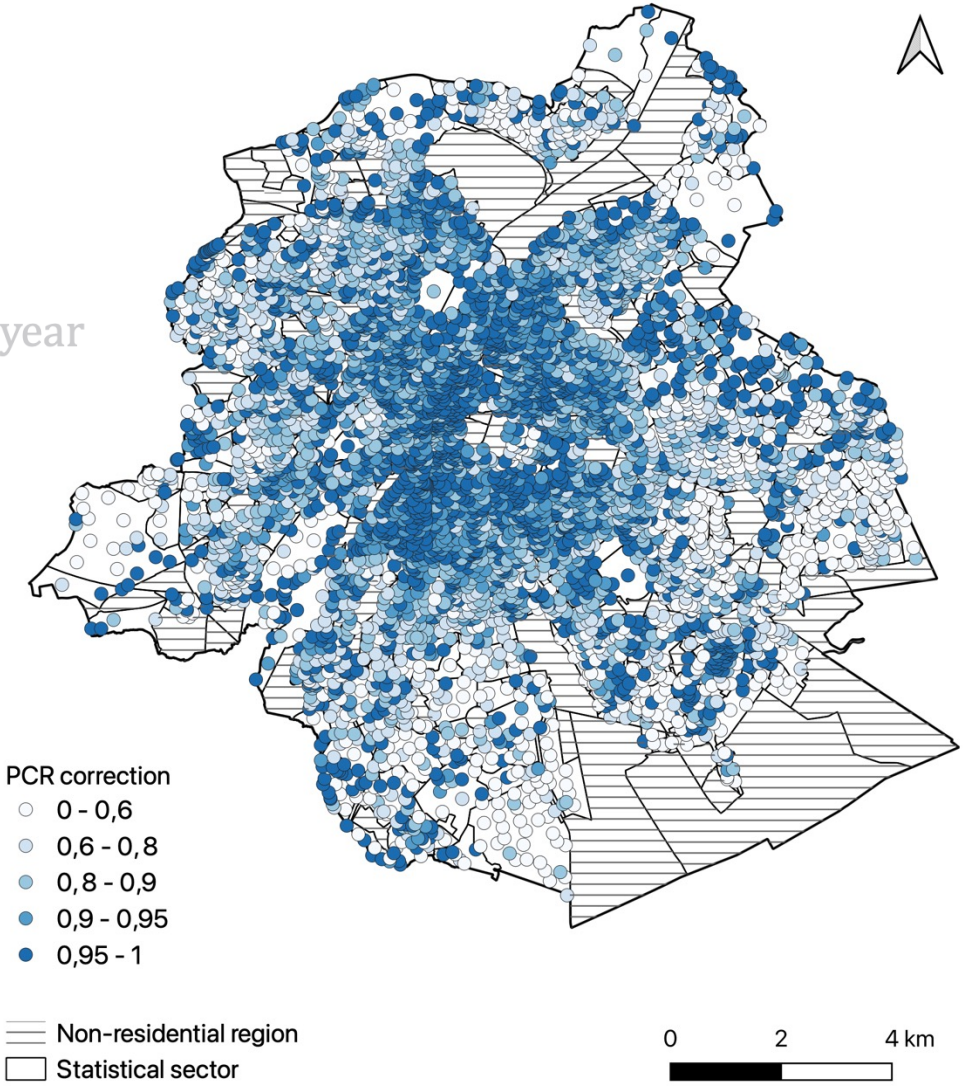
Average **D**istance **T**ravelled	**E**nergy **C**onsumed	**R**esidential **C**harging **R**atio	**P**ublic **C**harging **R**atio
25 km/day	0.2 kWh/km	20%	varies per building block

PCR CORRECTION

STEP 2

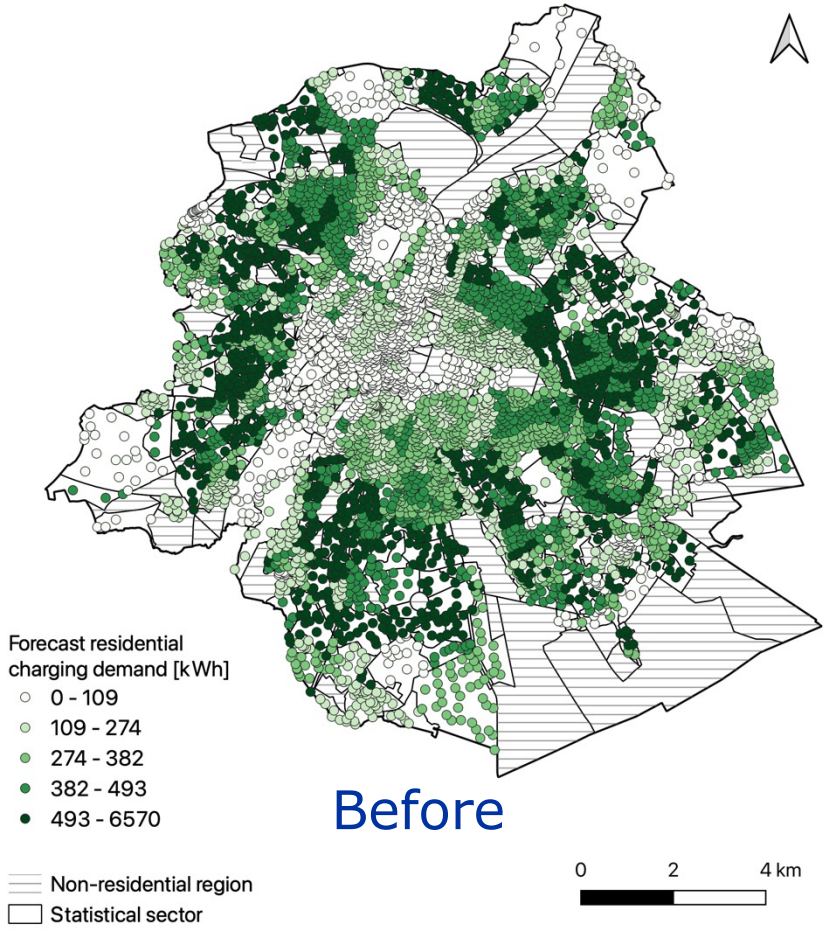
$$1\ \text{EV} = (ADT \times EC \times RCR \times \lambda \underbrace{PCR_{bb}}_{} \times 365)\ \text{kWh per year}$$

$$PCR_{bb} = 1 - \frac{\#\ \text{Off-street parking}_{bb}}{\#\ \text{Households}_{bb}}$$

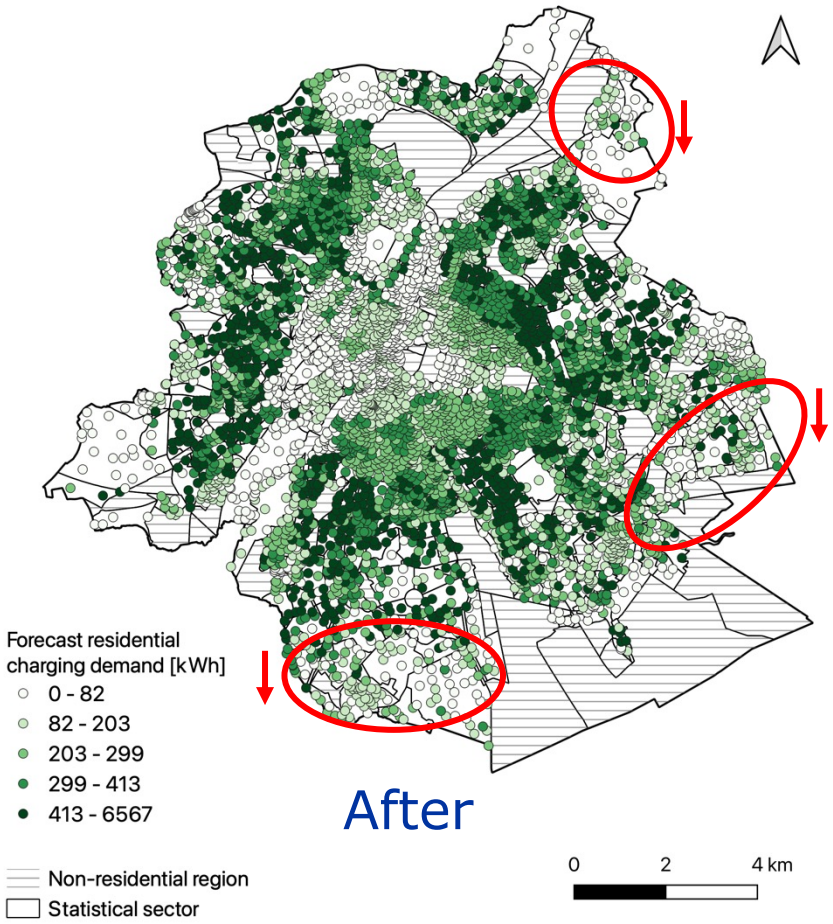


FORECASTED CHARGING DEMAND

STEP 2



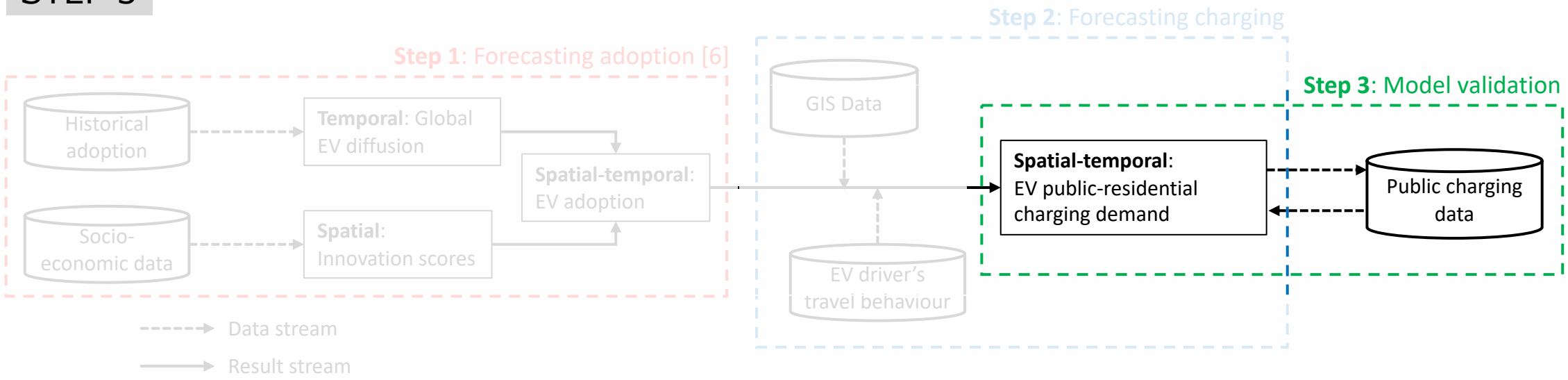
Before



After

3. VALIDATION

STEP 3



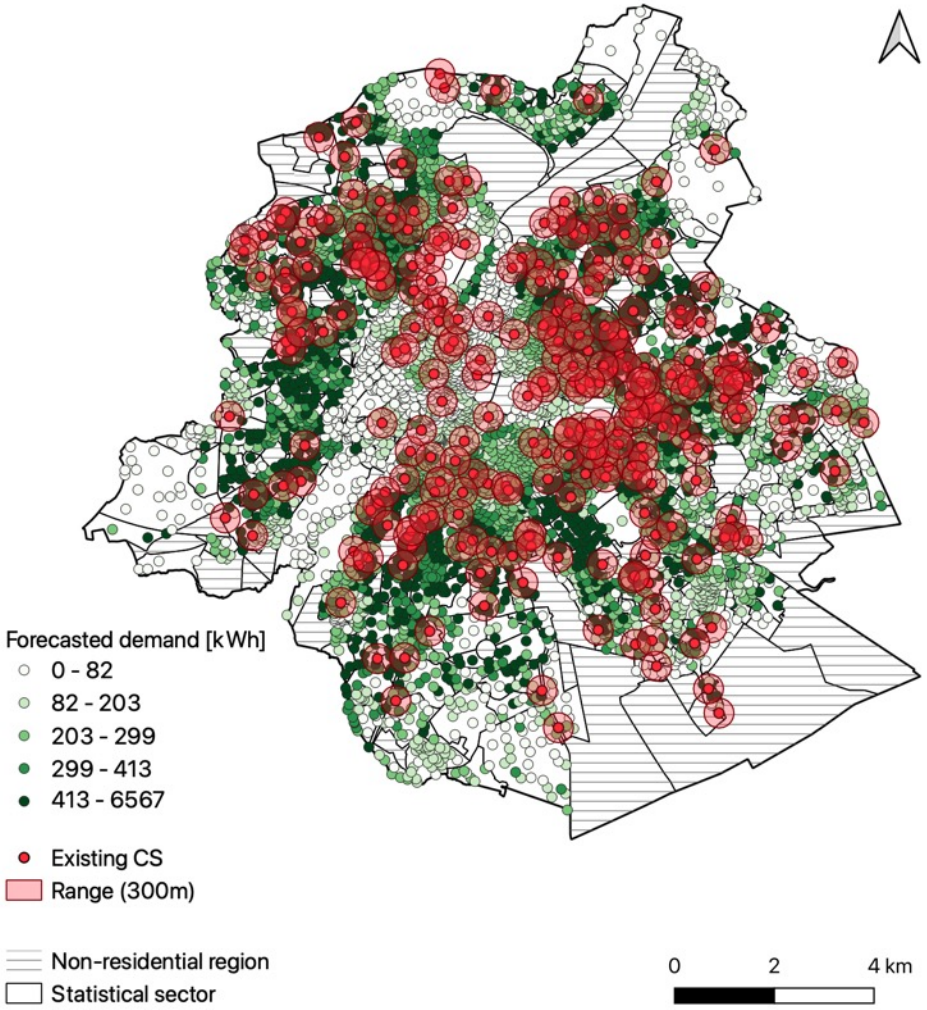
VALIDATION DATA

STEP 3

- Data on 253 public charging stations in 2021
- Residential charging defined as sessions that:
  - Start after 5pm
  - Last for at least 6 hours
- One-year-ahead forecasts for 2021 are validated

MAPPING FORECASTS TO OBSERVATIONS

STEP 3



MODEL PERFORMANCE

STEP 3

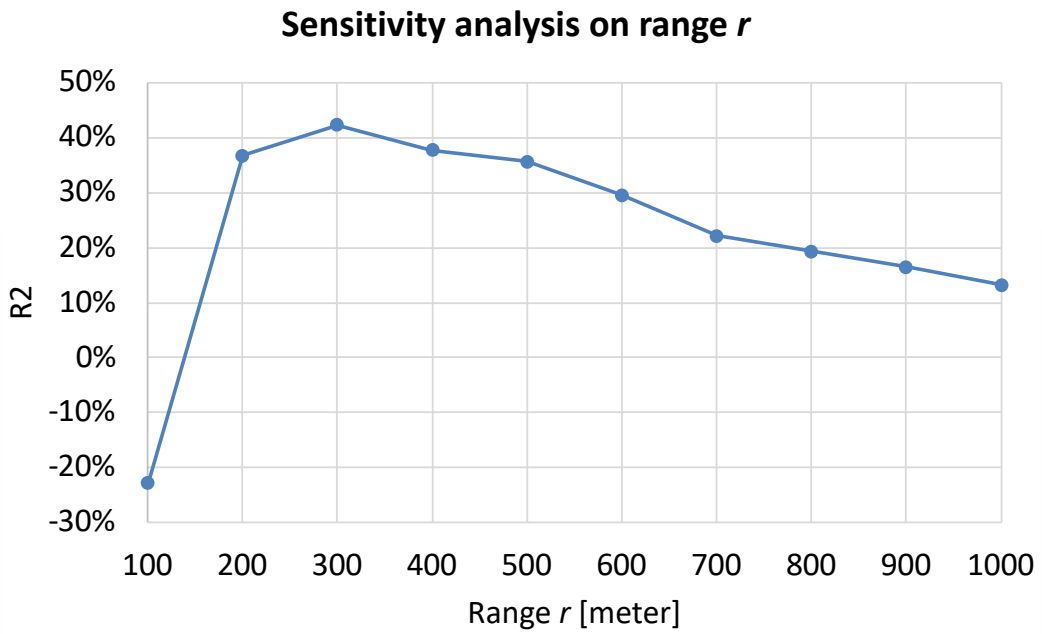
Charging station	Forecast	Observation
Station 1	…	…
Station 2	…	…
…	…	…
Station 253	…	…
Mean volume	**1,940 kWh**	

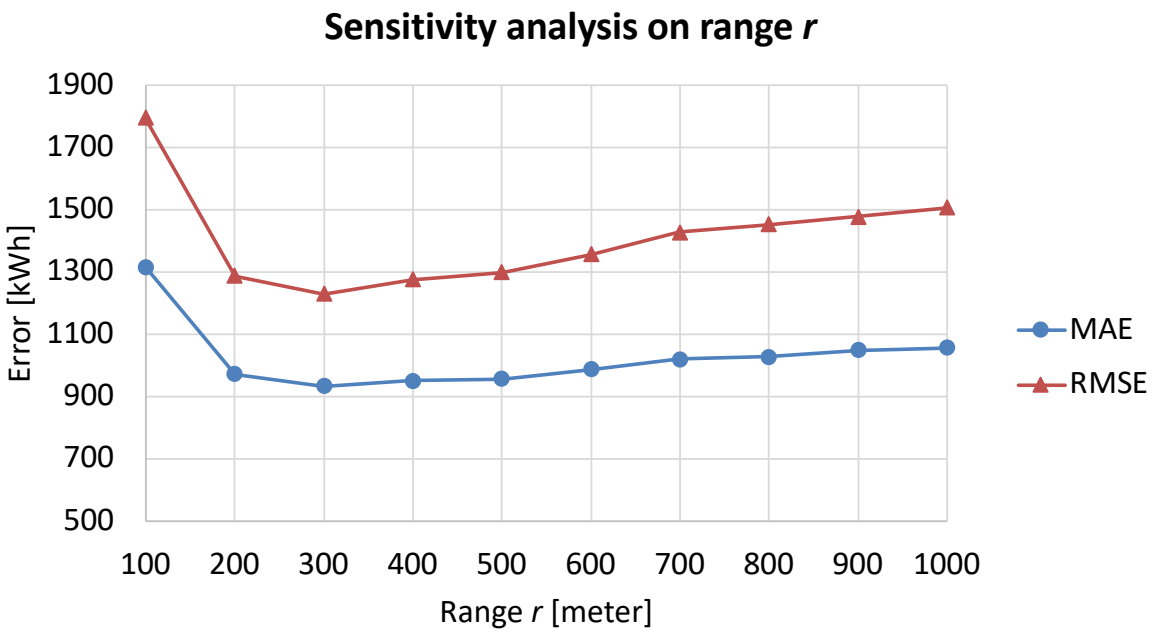
Criteria	Without PCR correction	With PCR correction
R^2	0.42	0.36
MAE (kWh)	935	979
$RMSE$ (kWh)	1,230	1,294

1. Model performance is **comparable** with existing research: $R^2 \in [0.32, 0.44]$
2. Model performance is **not improved** when **applying PCR** correction

SENSITIVTY ON RANGE

STEP 3





CONCLUSION

- We forecast demand over a **longer time horizon** at a **detailed spatial level**
- One-year-ahead predictions for 2021 are validated with **real-world charging data**
- Model **performance** is **comparable** with existing models (in terms of R^2)
- Correcting for **off-street parking availability** does not improve performance
- Spatial-temporal forecasts provide a **guideline** for EVCI roll-out strategies

THANK YOU

VRIJE UNIVERSITEIT BRUSSEL

Research Foundation Flanders
Opening new horizons

Grant No. 11I5122N

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