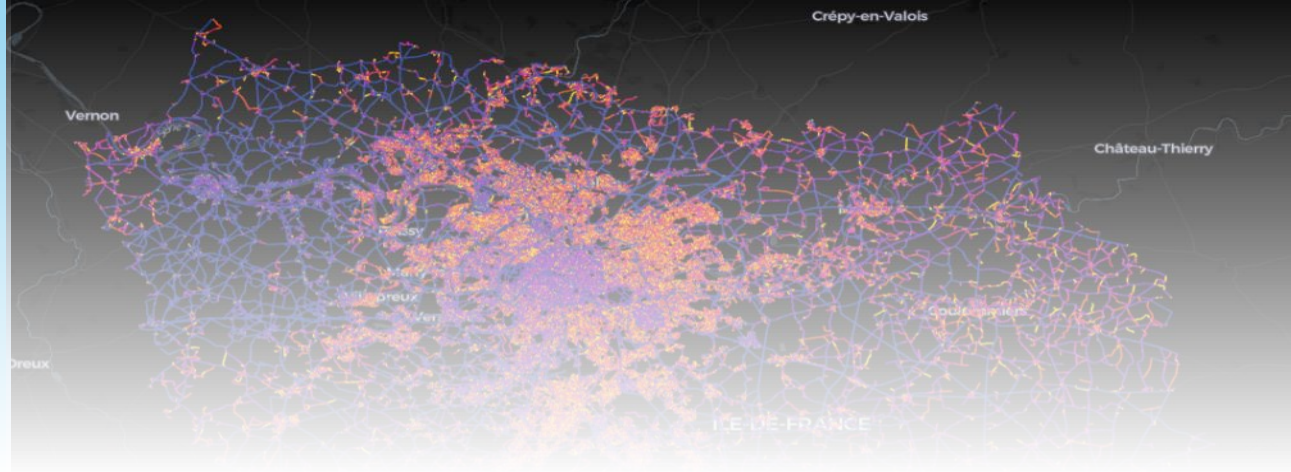

Agent-Based Assessment of the Paris LEZ Policy* Considering Individual Adaptations

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UPPER
Unleashing the Potential of Public Transport in Europe

IFP Energies nouvelles

MATSim user meeting 2025, June 12-13, Technical University of Munich

AGENDA

Mobilité durable

- Introduction
  - General context
  - Research questions
- Methodology and assumptions
- Results
  - Behavioral changes
  - Emissions
- Conclusion and perspectives

GENERAL CONTEXT

Mobilité durable

- **Transportation and air pollution**
  - **Responsible** for **310 000 premature deaths** in Europe each year (EEA, 2020)
  - In France (2019), **51.8% of NO_2 , 16% of PM2,5 , 11% of CO** , emissions[1].
- **Policy measures to reduce private car use[2]**
  - EU-27 aimed through **zero pollution** action plan to reduce the number of premature deaths due to exposure to fine particulate matter **by 55% by 2030, compared to 2005** (EEA, 2022)**.**
  - **Encourage** the use of **public transport** (UPPER project)
  - **Low emission zones** (Gonzalez, J. N., Gomez, J., & Vassallo, J. M. (2022))**:** Stockholm (Sweden), Berlin (Germany), **Paris (France) -**
    - **2019 : Crit'Air 4 et 5**
    - **2025 : Crit'Air 3 /!**
  - **Limit speed reduction:** Amsterdam (Netherlands), **Paris (France)**
    - **2024/10/01: 70 km/h to 50 km/h incoming presentation soon**

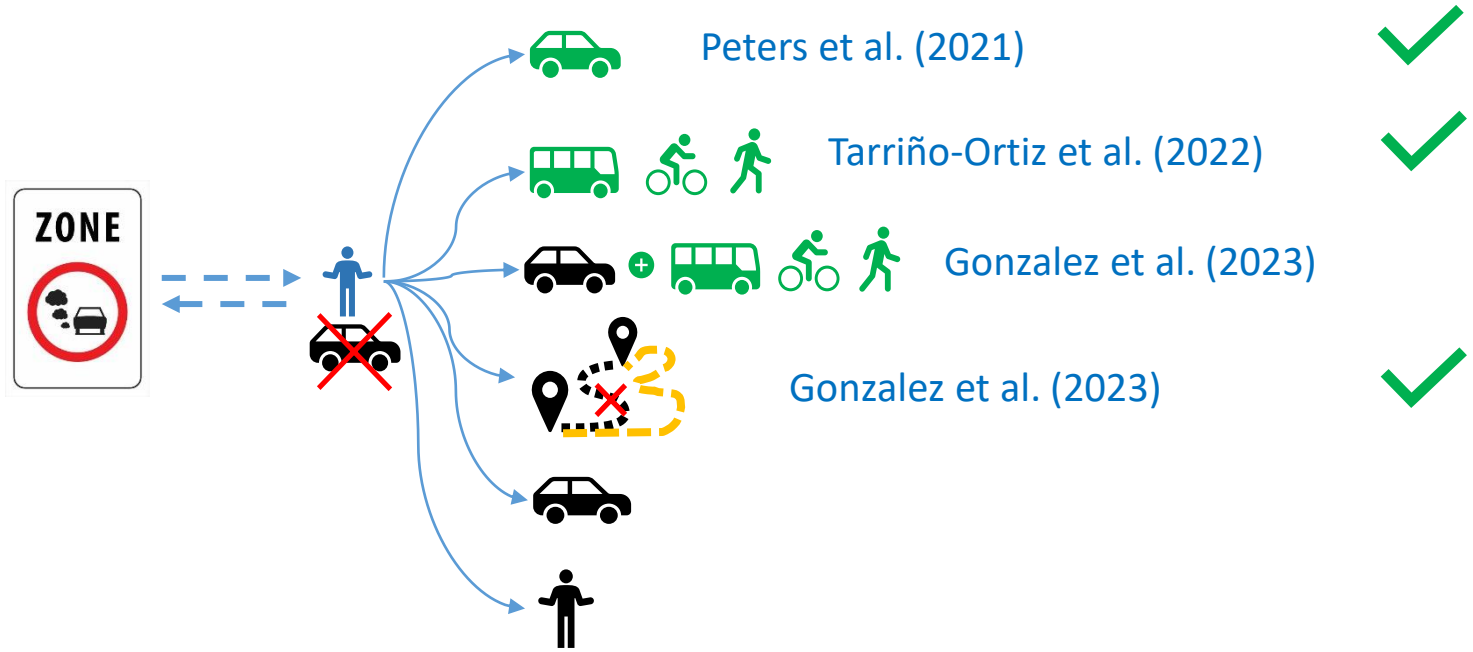
UPPER
Unleashing the Potential of Public Transport in Europe

1. ***Source:*** *Citepa, rapport Secten, mai 2020*
2. **https://urbanaccessregulations.eu/**

https://urbanaccessregulations.eu/countries-mainmenu-147/france/paris

RESEARCH OBJECTIVE

Mobilité durable



- Consider **key behavioral changes** to ensure the **acceptability** of the LEZ policy
- **Address a gap** in simulations studies that often **overlooking multiple mobility adaptations** (e.g., Yin et al., 2024; Ferreira et al., 2015)
- Use **agent-based simulation (*MATSim*)** to evaluate the Paris LEZ incorporating three behavioral adaptations: vehicle replacement, modal shift, and destination change
  - Simulate agents' adaptations under defined assumptions
  - Provide a **multi-scale environmental impact assessment** (Paris, VGP, Île-de-France)
  - Conduct a **socio-economic analysis** of LEZ impact

WORKFLOW

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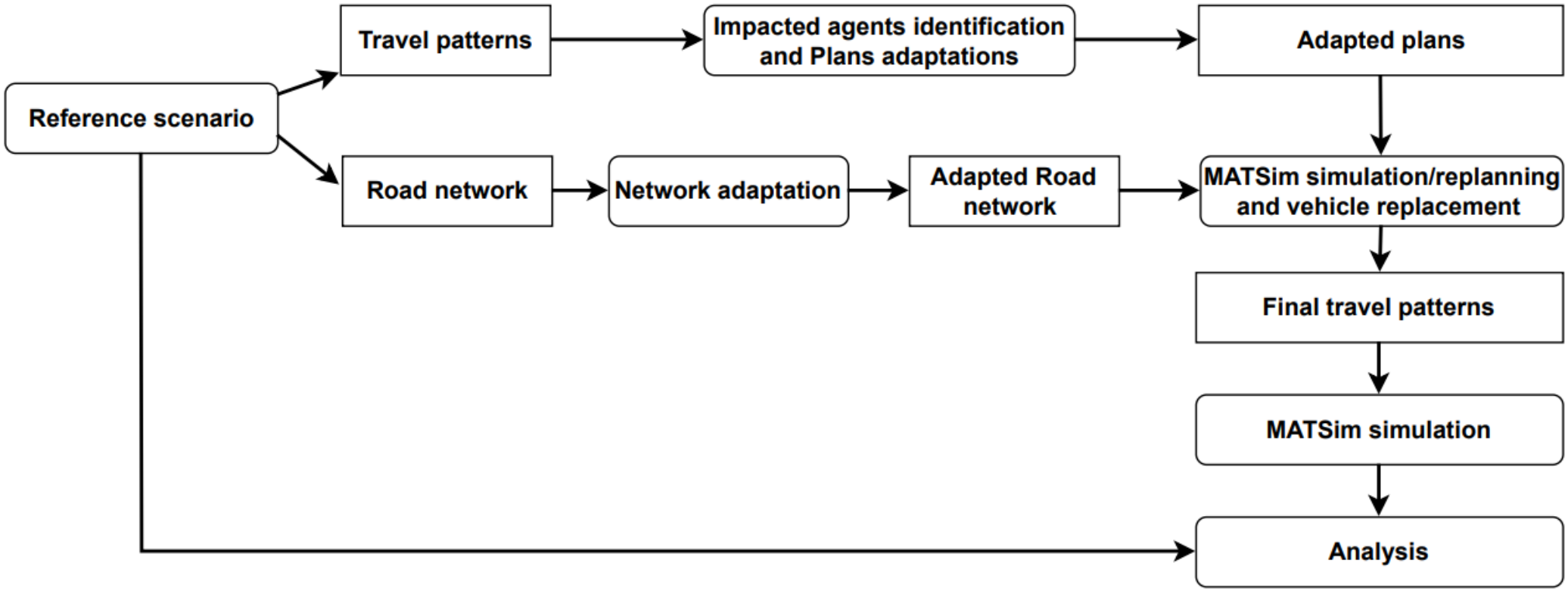
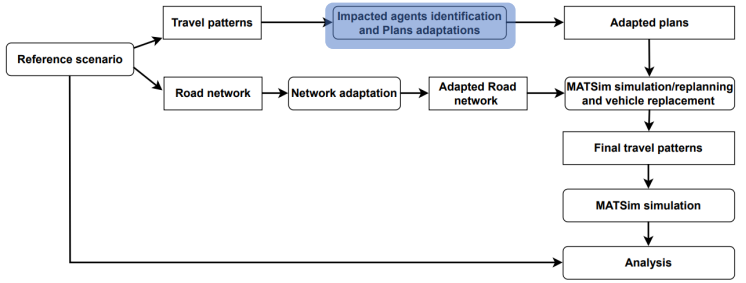


Task

Output

IDENTIFICATION OF IMPACTED AGENT



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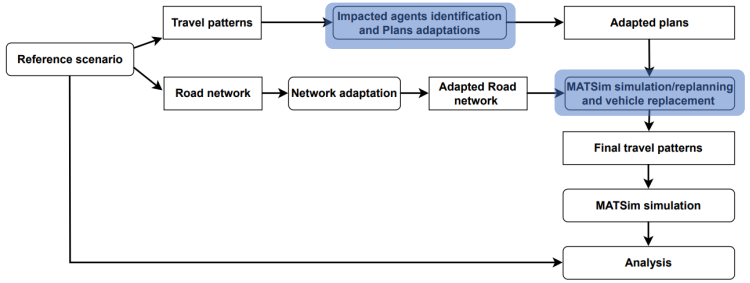
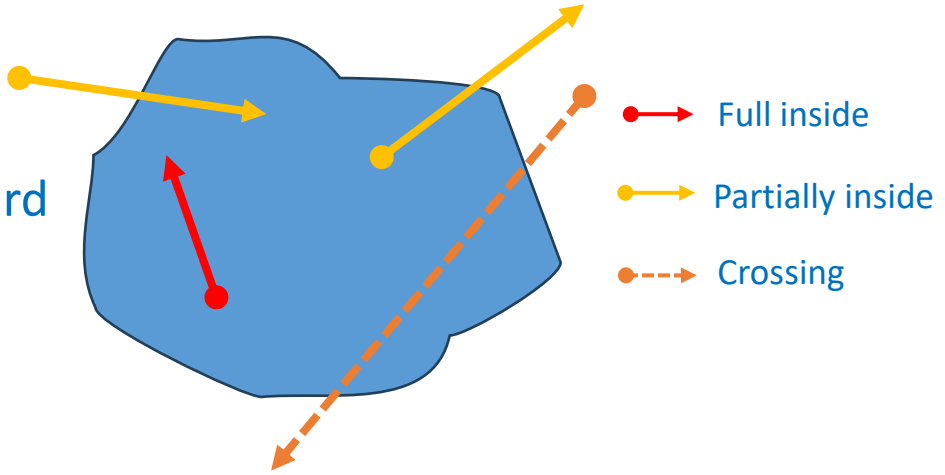
- **Based-on the reference scenario (without LEZ):**
  - Simulation output event (agent_id, link_id, time_step) → routes
  - Transport network (link_id, geometry)
  - Agents' vehicles fleet (agent_id, type, energy, Euro norm)
  - LEZ area (geometry)
- **Spatial SQL requests** to identified agents traveled in the LEZ area with no appropriate vehicle

PLANS ADAPTATIONS AND REPLANNING STRATEGIES

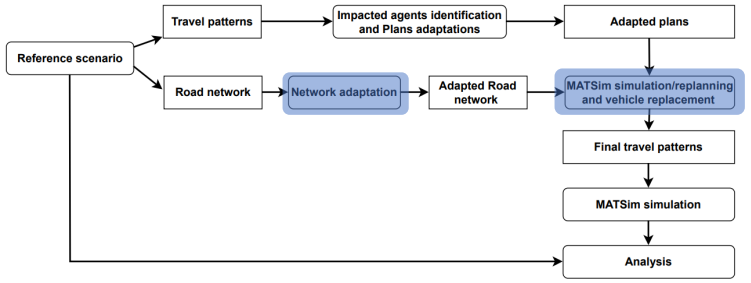


Mobilité durable

- **Three subpopulations with different strategies**:
  - ***lezConformAgent***
    - No impacted agents or whose replaced their forbidden car
    - Can use their conform vehicle anywhere
  - ***noConformInsideAgent***
    - *Impacted agents who perform modal shift from car* toward PT, bike, or walk
    - Cannot use car mode anymore (no car+other)
  - ***noLezConformFullCrossingAgent***
    - Impacted agents who perform route change
    - Use only car
- Delete all initial links and routes and replace the car by PT within the initial plans



NETWORK ADAPTATION AND SIMULATION



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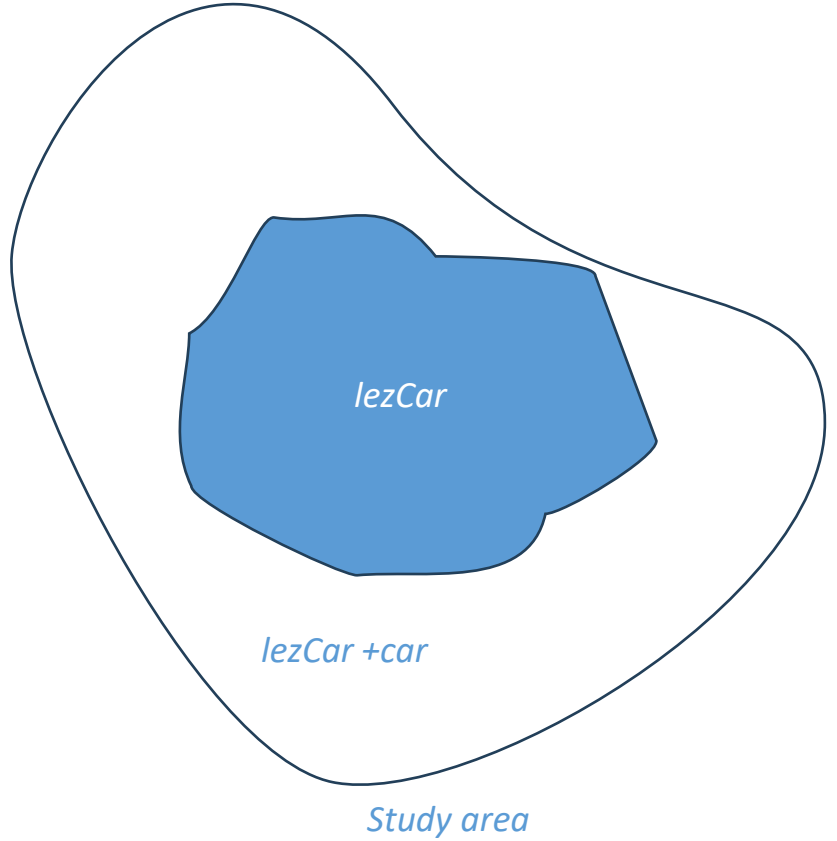
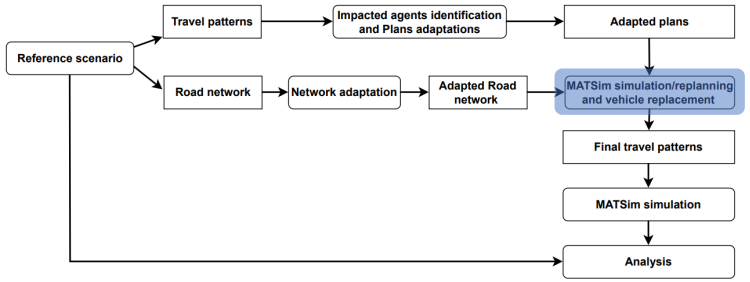
- **New car mode**
  - ***lezCar*** *allowed* into the whole network
  - ***car*** *allowed only outside the LEZ area*
- **Network modification**
  - Delete ***car*** mode within all links inside the LEZ area
  - Add ***lezCar*** mode into the whole network links
- Simulation
  - Adapting the config file to consider the new replanning strategies



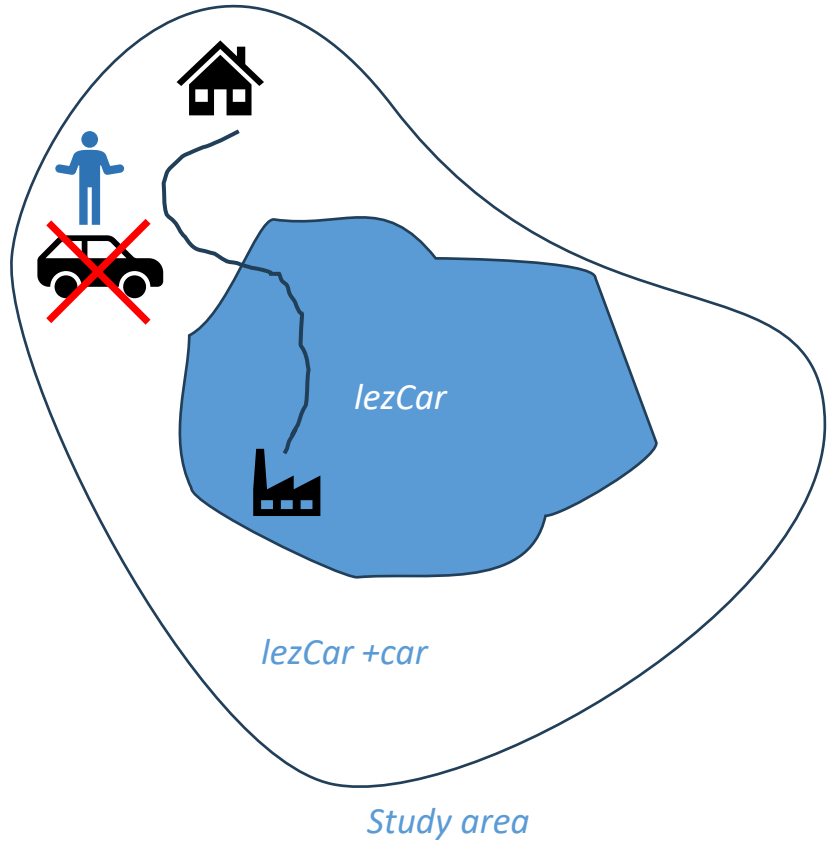
NON-COMPLIANT VEHICLE REPLACEMENT



Mobilité durable

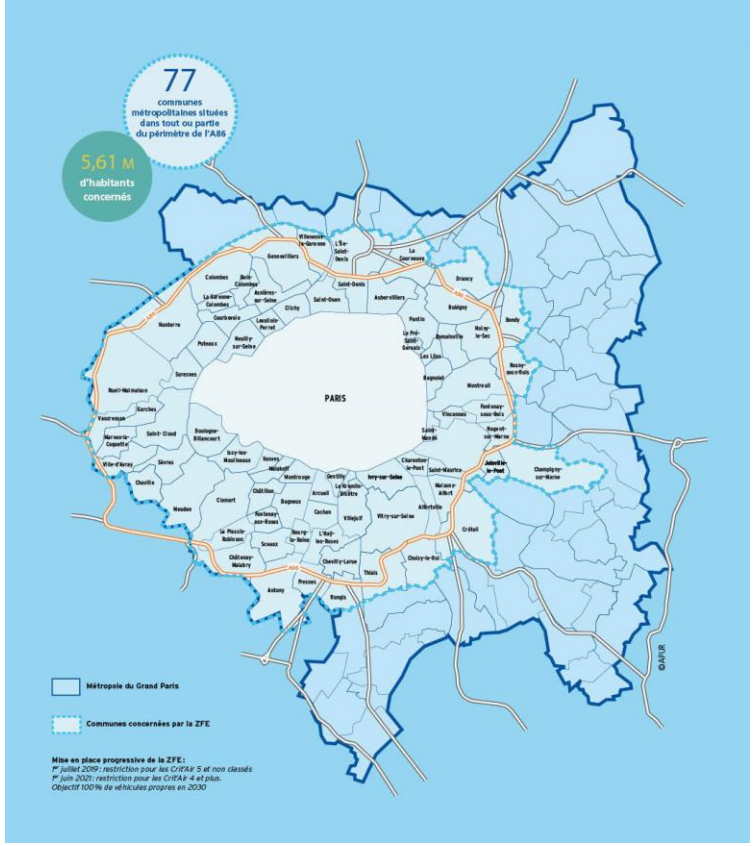
- **Based on**
  - **the replanning** simulation output as post-processing step
  - the **remaining compliant** car fleet
- **Conditioned** by the **inability** to **fully or partially** complete daily activities due to
  - Increased travel times from mode shift or rerouting

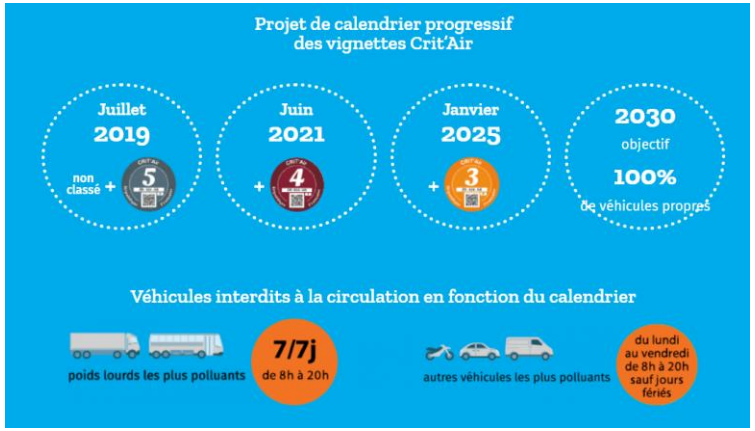
    →Those are agents likely to replace their banned vehicle and shift into *lezConformAgent* sub-population
- **Assumptions & Constraints**
  - **PT travel time ratio threshold** (PT time / car time) ≤ **2.7** (Leviaux & Péguy (2022))
  - Avoid exceed travel time (<=75th percentile) for PT (<60 min), bike (30 min) or walking (<15 min)



PARIS LOW EMISSION ZONE

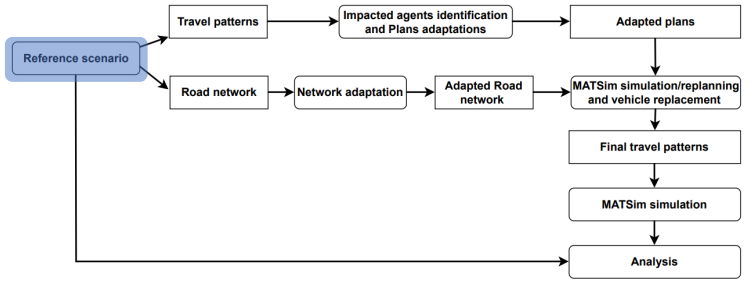
- In France, cities where pollutant emissions thresholds defined by WHO are exceeded must implement a ~~Low Emission Zone (LEZ)~~
- In Paris, the LEZ legislation* includes
  - a perimeter and times slots where vehicles circulation is restricted,
  - a schedule for future restrictions,
  - and exemptions.
- The classification of vehicles in LEZ is determined by the Crit'Air system, which itself is based on the vehicle's Euro emission standard
  - **Next vehicles restrictions is C3 (**Gasoline Euro 2 & 3 Diesel Euro 4) **in 2025 /!**





* https://metropolegrandparis.fr/fr/la-zone-faibles-emissions-metropolitaine

SIMULATION FRAMEWORK



Mobilité durable

- **eqasim** generates Ile-de-France* population, travel demand and light vehicle fleet
  - The approach allows to assign a vehicle to each agent while retaining an age and energy distribution
- **MATSim** simulates **behavioral adaptations** in response to the **LEZ**
- MATSim emissions module coupled with HBEFA computes pollutant (NO_X and particles) and GHG (CO_2) emissions

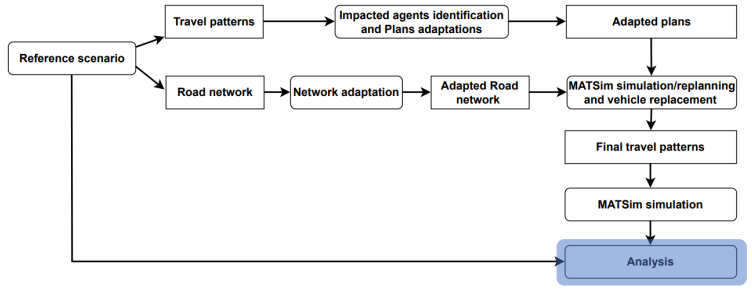
eqasim
- IdF population
- IdF trave demand
- Vehicle fleet
- Road network

MATSim
- Agent displacements
- Agent LEZ behavior

Emissions contribution
- NO_X and particles pollutant emissions
- GHG (CO_2e) emissions

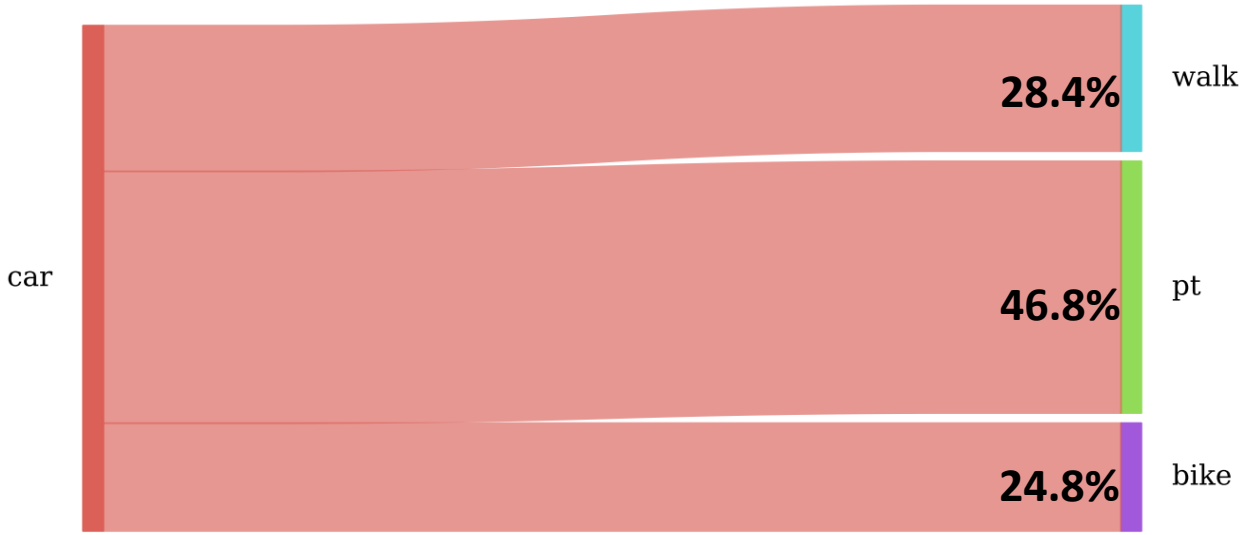
*Hörl, S. and M. Balac (2021) Synthetic population and travel demand for Paris and Île-de-France based on open and publicly available data, Transportation Research Part C, 130, 103291.

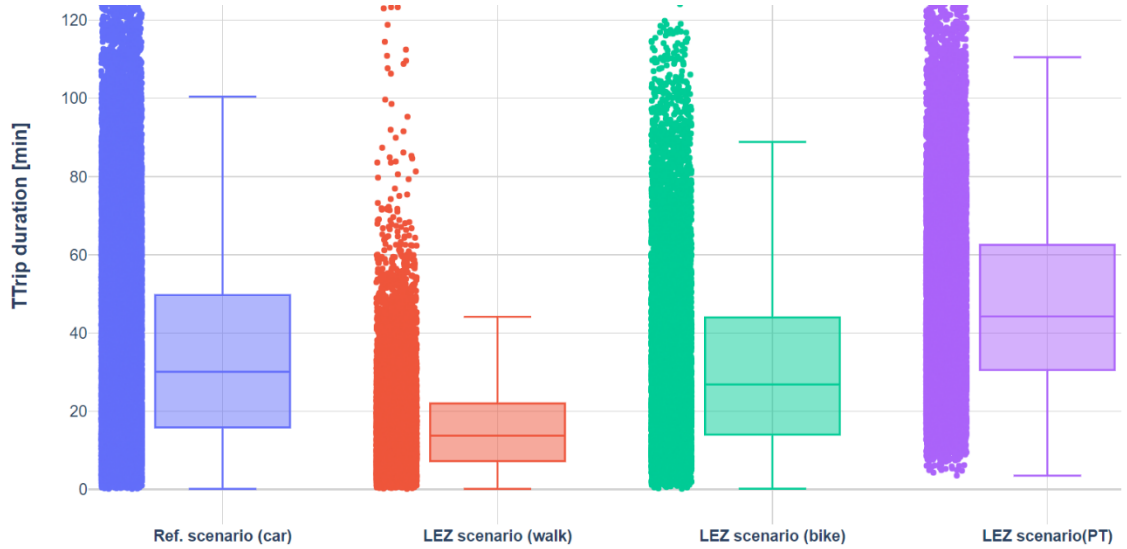
BEHAVIORAL CHANGES



Mobilité durable

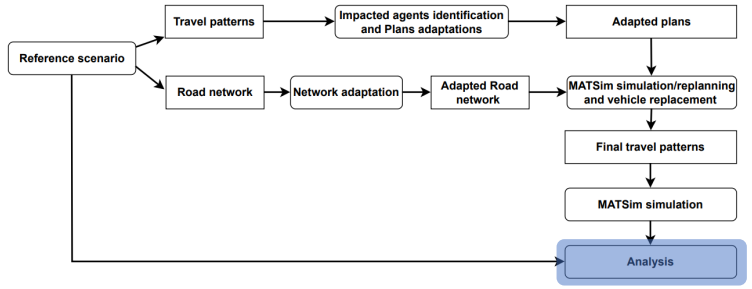
noConformInsideAgent sub-population





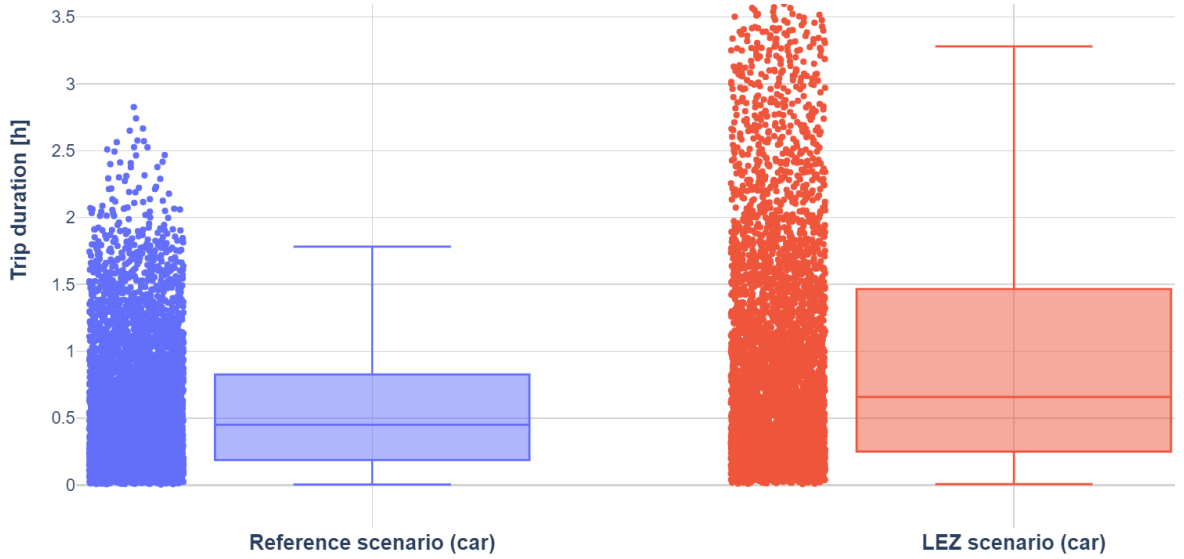
- *After applying **constraints*** complete daily activities
  - **3%, 9%, and 15%** shifted to w*to*alking, cycling, and public transport (PT), respectively
  - **73%** remaining replaced their non-compliant vehicle

BEHAVIORAL CHANGES

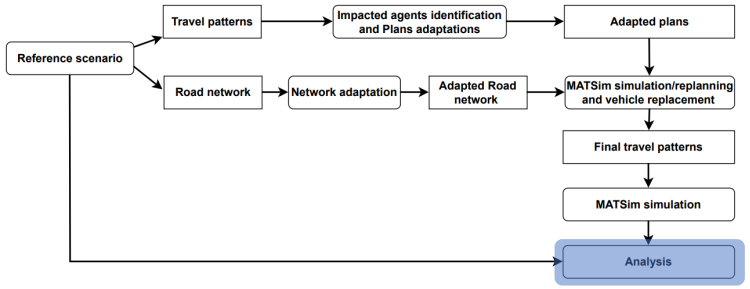


Mobilité durable

- ***noLezConformFullCrossingAgent* sub-population**
  - **94%** of agents who avoided the restricted zone kept their non-compliant vehicles
  - Only **6%** chose to replace



EMISSIONS



Mobilité durable

	LEZ area			MGP			IdF		
	NO_x	PM2.5	CO_2	NO_x	PM2.5	CO_2	NO_x	PM2.5	CO_2
Ref. scena.	12	0.3	6,274	13.8	0.3	7,108	32.2	0.8	15,644
LEZ scena.	9.9	0.07	5,954	11.5	0.13	6,901	30	0.5	15,420
Variation (%)	**-17.8**	**-74.2**	**-5.1**	**-15.2**	**-62.2**	**-3**	**-6.8**	**-41.3**	**-1.4**

- Larger LEZ areas lead to greater overall emission reductions
- **Particulate matter (PM)** emissions show the most significant decrease, compared to NOx and CO_2
- This is largely due to the **ban on Diesel Euro 4 vehicles**, which:
  - represent **10%** of the vehicle fleet
  - Contribute to **80%** of PM emissions

CONCLUSION

Mobilité durable

- Paris LEZ Policy (2025) Assessment via Agent-Based Simulation (MATSim)
  - Focusing on three key behavioral adaptations: Vehicle replacement, Modal shift (PT, bike, walking), Route change
  - Modeled through specific agent sub-populations
- Key Finding: **Banning Diesel Euro 4 vehicles** (10% of fleet) leads to a **major reduction in particle emissions** (80% of PM sources)
- **Limitations:**
  - Does not capture psychological/latent factors (opinions, perceptions, attitudes) → cf. Morton et al. (2021)
  - Assumes agents always adapt — no trip abandonment or fraud (e.g., non-compliant use)
- **Perspectives:**
  - Integrate population and car fleet evolution and new PT lines over time
  - Integrate intermodal alternatives (Yin et al. (2024)), trip abandonment, and fraud
  - Extend to geographic and temporal restrictions (Versailles Grand Parc)
  - Perform localized emissions analysis (e.g., LEZ periphery rebound effects)

THANK YOU FOR LISTENING!

https://www.brusselstimes.com/44817/belgium-s-slow-war-against-diesel-cars

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