ADDRESSING ELECTRIC-VEHICLE RANGE ANXIETY IN URBAN AND RURAL AREAS

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SUMMARY

STELLANTIS

Stellantis is created in January 2021

Stellantis is the 4th world biggest automotive manufacturer

Stellantis is 14 brands

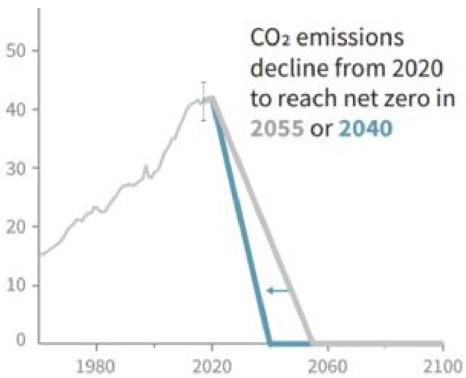
Stellantis is 400000 employees in 50 countries

- **Introduction**
- Literature review
- Methodology
- Results
- Robustness checks
- Conclusion

STELLANTIS

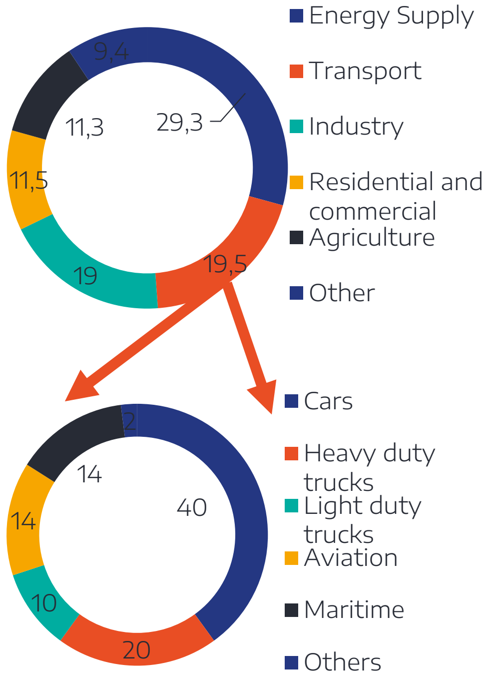
Climate change

Carbon neutrality needed by **2050** to limit global warming by 1,5°C.



(IPCC, 2018)

GHG emissions



Europe (EEA, 2019)

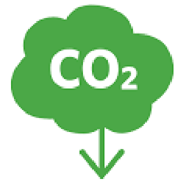
Public interventions

- Low emission zones in cities.
- Ban combustion vehicle sale.

- Penalty on automakers.

Electrification

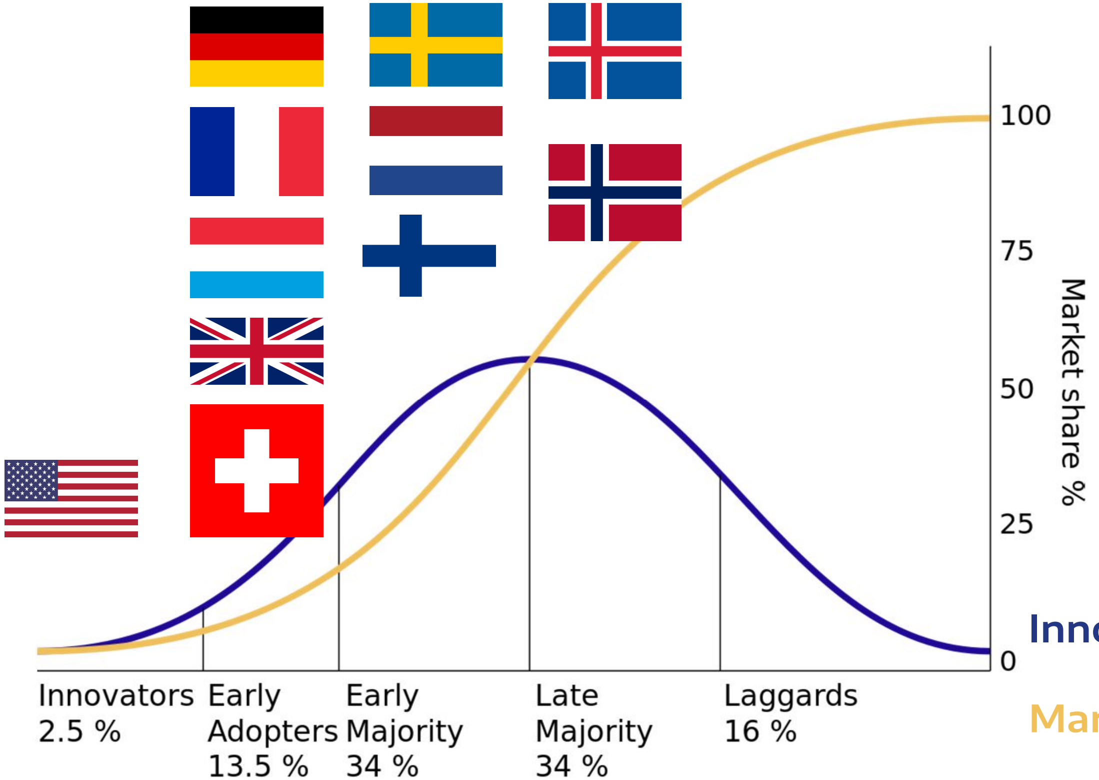
Automakers are committed in electric models.



ELECTRIFICATION IS A KEY ELEMENT TO MEETING CLIMATE CHANGE NEEDS

ACTUAL SITUATION OF THE ELECTRIC VEHICLE TRANSITION

Countries with the highest share of EV in new passenger car sales in 2020 (ACEA, CAAM, EV-Volumes (2020)).



Innovation Adoption Curve

Market Share Evolution

LARGE HETEROGEINITY BETWEEN COUNTRIES

DIFFERENCE BETWEEN ICEV AND EV ECOSYSTEMS

The ICEV Case

The EV Case

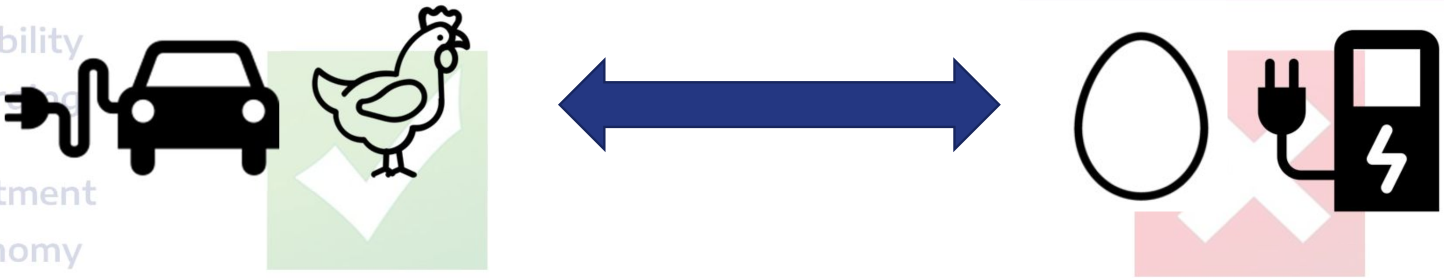
CHICKEN AND EGG ELECTRIC-MOBILITY DILEMMA

Stations Availability

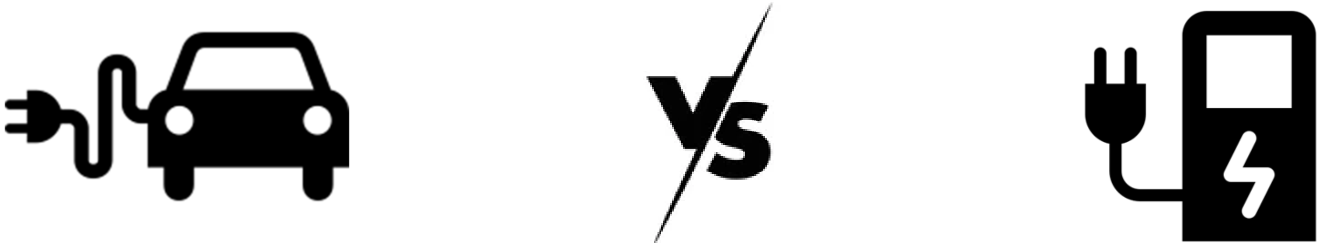
Refuelling/Char
Duration

Vehicle's Investment

Vehicle's Autonomy



ELIMINATING THE CHICKEN AND EGG ELECTRIC-MOBILITY DILEMMA



1. Should we invest in charging infrastructure deployment and/or charger instalment subsidies?

   If so, which charging power?

2. Should we have higher subsidies for EV purchasing?

   If so, which EV size?

3. Should we have bigger batteries or more charging stations?

INNOVATIVE BUSINESS MODEL FOR THE CHARGING POINT OPERATOR IS NEEDED

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LITERATURE REVIEW

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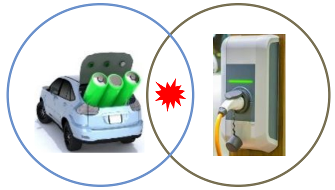
The question "Which combination of battery capacity and charging power" is rarely studied the literature



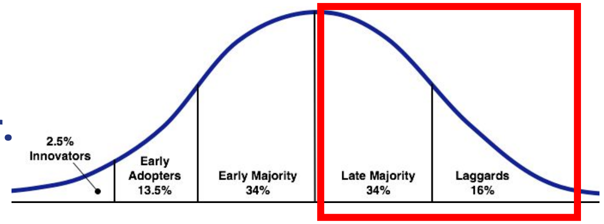
Paper	Country	Stream	Used data / Methodology	Daily/long trips	Conclusions
Jabbari and Mackenzie (2017)	-	3	A simulation of cost comparison to deploy more fast charging points	-	High reliability of access and high utilization rate of charging stations could be achieved by installing a large number of chargers
Wood et al. (2015)		3	A simulation of the driving behavior after increasing the battery capacity and installing fast charging points	-	It is more costly to add 100-km to the BEV autonomy than to increase the charging network
Funke et al. (2019)		3	400 real-world driver data from German commercial vehicles/ Cost model	Long trips	Cost comparison of the investments in bigger battery and in more charging stations: 50 kWh battery is the optimal solution Invest in fast charging infrastructure rather than batteries

Conclusion: Invest in fast chargers than in bigger batteries for long trips needs (in the case of the USA and Germany)

1. What about daily trips needs (home-work)?
2. What about 7, 22, 50 kW chargers?
3. Which trade-off between battery capacity and types of chargers when no at-home sockets?

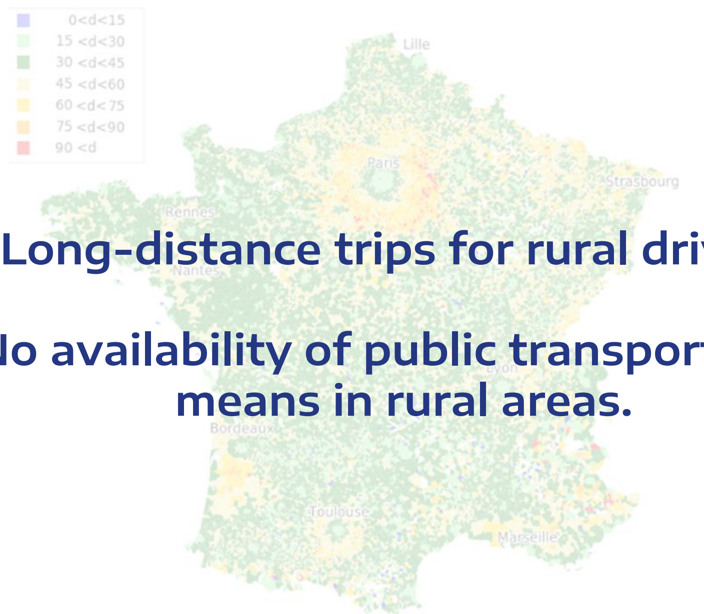
Research Question: For people who **cannot install a charger** at home: where should we invest? In **bigger batteries** or in more **available charging points**? And which **power** of charging?

THE FRENCH URBAN AND RURAL LAGGARDS



- **Laggards: drivers willing to buy a BEV and do not have an at-home charger.**
- **Identifying a solution for laggards could accelerate energy transition.**

Large heterogeneity among French driving behaviors.



- **Long-distance trips for rural drivers.**
- **No availability of public transportation means in rural areas.**

Daily Trips Needs (km).
F. Gonzalez (2020) representation based on ENTD 2018 database.

Large heterogeneity among French at-home charging availability.

50% of French households are not equipped with a private parking

Percentage of households equipped with a private parking (%)
Our representation based on INSEE 2016 database.

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METHODOLOGY: ADAPTED FROM (FUNKE ET AL., 2019)

- Daily travelled kilometres for French urban and rural needs
- BEV energy consumption

BEV needs

Simulating 5000 individual BEV profiles over a year **for urban and rural laggards**

- Charging power
- M/M/2 queue characteristics

Charging Infrastructure

Determining the number of 2-charger stations for **15-min waiting time** using M/M/2 queue model

- Vehicle investments
- Battery packs price
- Purchasing subsidies
- Charging instalment subsidies
- O&M costs (for CPs and BEVs)
- Electricity and fuel prices
- Charging tariffs

Cost model determination

- BEV customer cost model
- Charging Point Operator cost model

Cost comparison

Determining win-win situation(s) based on **Pareto fronts**

COST MODEL IDENTIFICATION

Equivalent Annual Cost (EAC) is the annual cost of owning, operating, and maintaining an asset over its entire life.

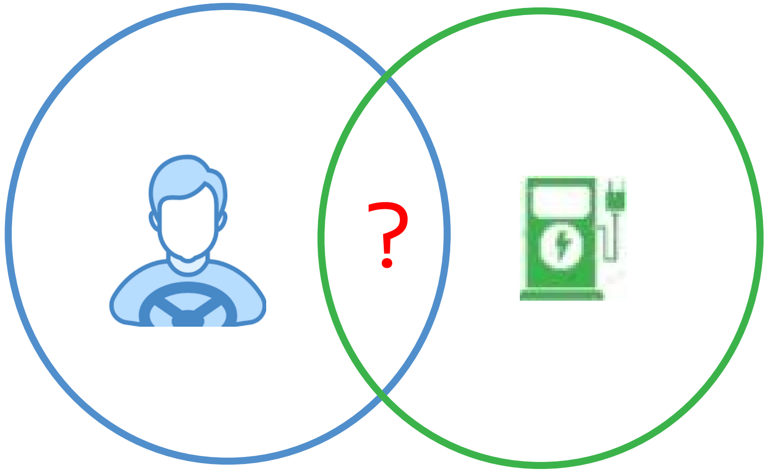
$$EAC = Amortized\ Investment + OPEX\ - Revenues$$

BEV driver

Minimizing the investments and the costs

$$\boldsymbol{min(\Delta EAC_i) = min(EAC_{BEV,i} - EAC_{ICEV,i})}$$

The difference in annual costs between purchasing a BEV and an ICEV



Charging Point Operator (CPO)

Minimizing the costs

$$\boldsymbol{min(EAC_{CPO})}$$

$$\boldsymbol{min(Costs - Revenues)}$$

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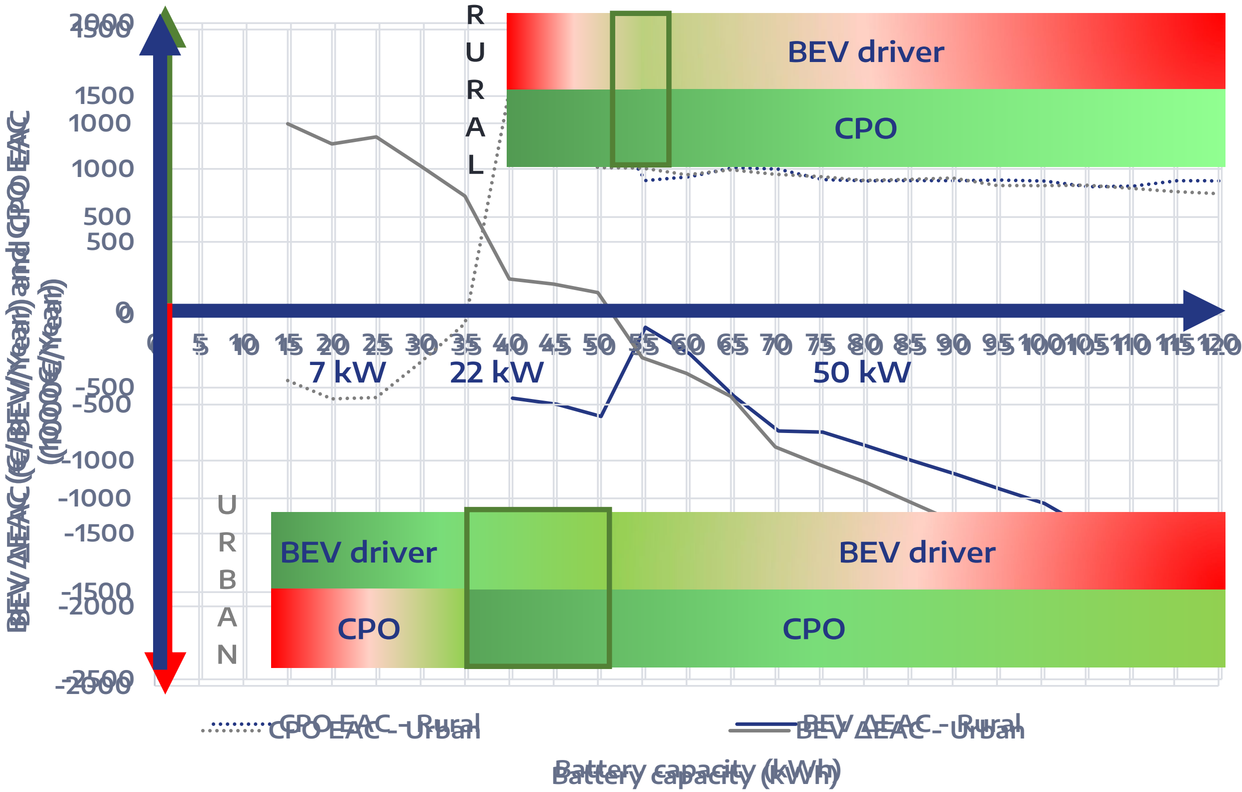
RESULTS – WIN-WIN SITUATIONS IDENTIFICATION FOR URBAN AND RURAL NEEDS

- Win-win situations are defined based on **Pareto fronts**.
- **Pareto front** is a situation where no individual can be better off without making at least one individual worse off or without any loss thereof:
  - The driver if **ΔEAC > 0**.
  - The CPO if **EAC > 0**.
- <u>For Urban needs:</u>
  - **Solution 1**: 35 kWh BEV and 22 kW chargers.
  - **Solution 2**: 40-50 kWh BEV and 50 kW chargers.
- <u>For Rural needs:</u>
  - **Solution**: 55 kWh BEV and 50 kW chargers.



SUMMARY

ROBUSTNESS CHECK 1

Mixing the usage between BEV sizes and charging powers: all BEVs could charge using all powers.

Fast charging services

ROBUSTNESS CHECK 2

Changing the charging tariffs of other operators.

Similar results to our baseline case study.

ROBUSTNESS CHECK 3

Increasing the charging tariffs by 50%

Recommendations for revising the charging tariffs

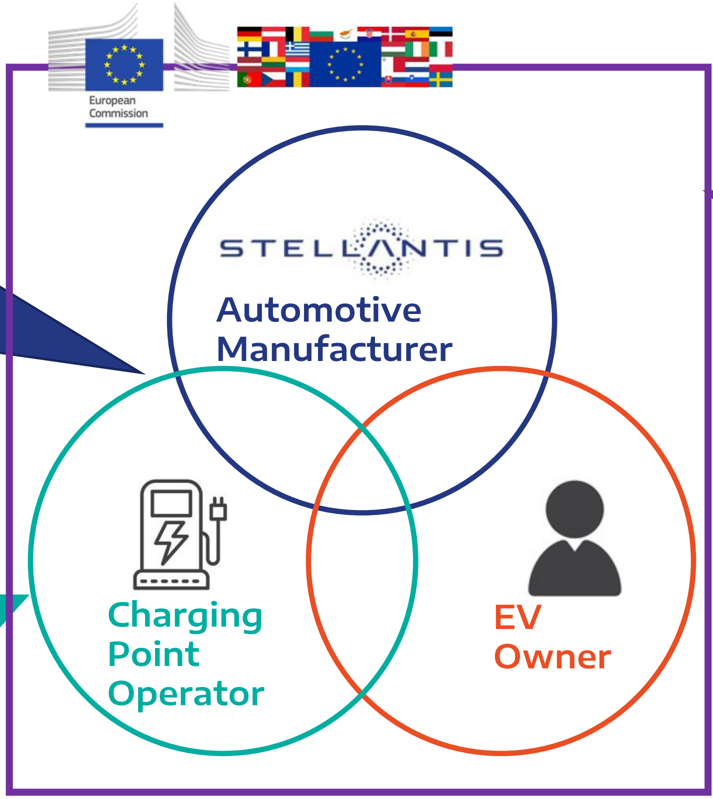
The results of the robustness checks are similar to our results

Policy recommendation: The **impact** of **increasing the charging tariffs** on the drivers' behaviours

VEHICLE MARKETING PER USAGE:

- Rural usage: 55 kWh BEV
- Urban usage: 35-50 kWh BEV

- **Deployment of 50 kW chargers.**
- **No tariffs increase for 50 kW charging services.**
- **Revising 7 and 22kW charging tariffs.**



- **More BEV subsidies → Larger Pareto fronts → More BEV choices for customers**
- **Charger installment subsidies:**
  - Rural usage: 50 kW chargers
  - Urban usage: 22-50 kW chargers

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CONCLUSION

- Analysis of the trade-offs between charging infrastructure and battery sizes.
- We used **the Equivalent Annual Cost**, by analyzing the business models of the charging point operator and the BEV customer.
- **For urban area:**
    - 35 kWh BEVs + 22 kW chargers
    - 40-50 kWh BEVs + 50 kW chargers
- **For rural area:**
    - 55 kWh BEVs + 50 kW chargers
- The results of the robustness checks are similar to our results:
    - **Future studies**: Investigate for a **win-win solution** for the **pricing** method variation for **rural** area
    - **Policy recommendation**: The **impact** of **increasing the charging tariffs** on the drivers' behaviours

THANK YOU FOR YOUR ATTENTION
QUESTIONS?

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