Too much or not enough ? Planning electric vehicle charging infrastructure : modeling options and perspectives

Electric Mobility and Territories
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Plan

1. Background on EV and charging infrastructure
2. Charging infrastructure and linked issues
3. Location methods
4. Conclusion

Plan

1.1. Context

ICE Vehicle
~15% of global GHG emissions[1]
~40% of French GHG emissions
Acoustic pollution

→

Electric vehicle
No tailpipe emission
Reduced particulate emissions
Reduced noise

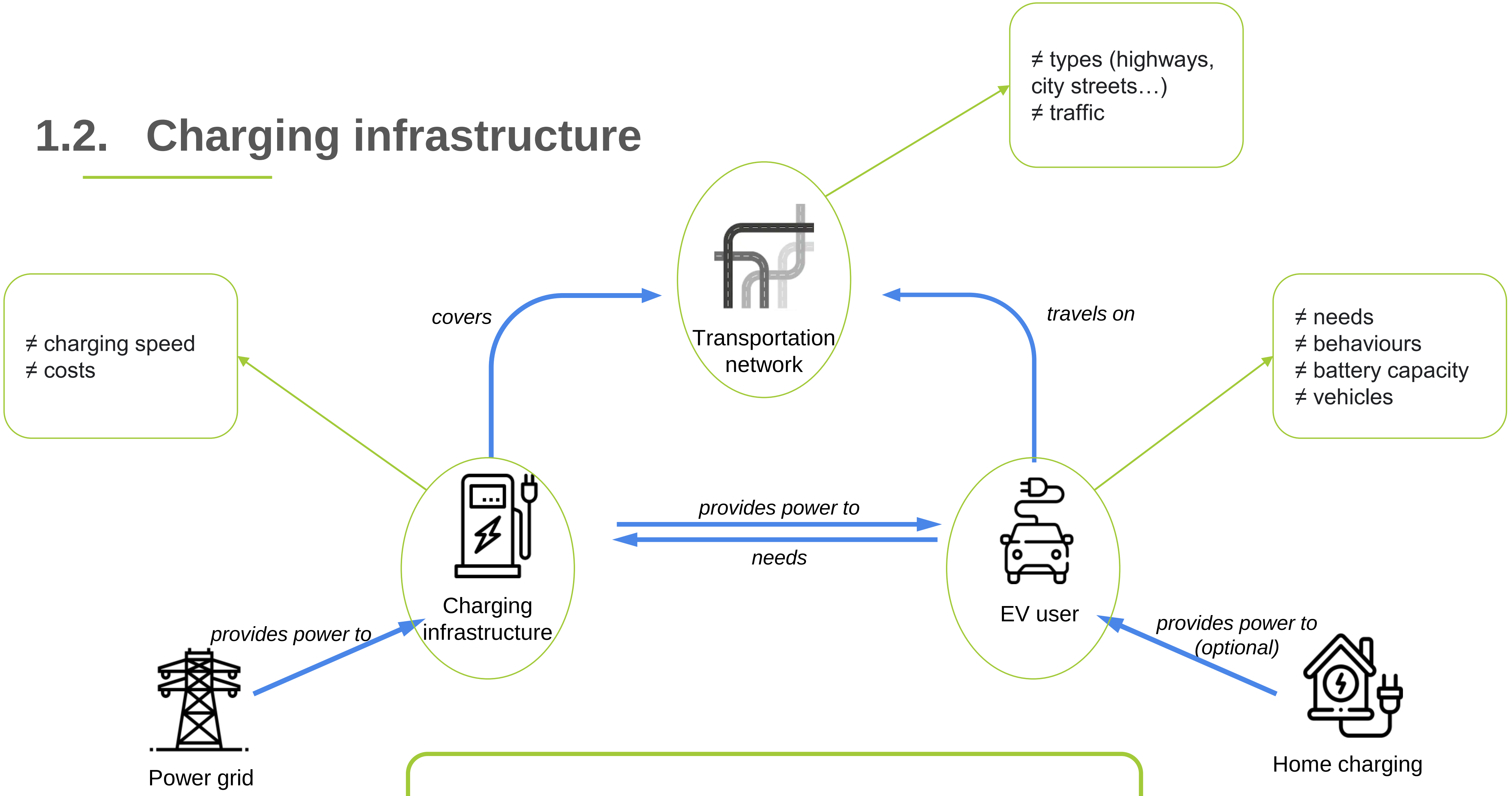
Two main barriers for EV adoption[2]

~~Price~~

Range anxiety

[1] European Environment Agency. Greenhouse gas emissions from transport in Europe, 2019.
[2] Nigel Berkeley, David Jarvis, and Andrew Jones. Analysing the take up of battery electric vehicles: An investigation of barriers amongst drivers in the UK

1.2. Charging infrastructure



How to deploy a charging infrastructure?

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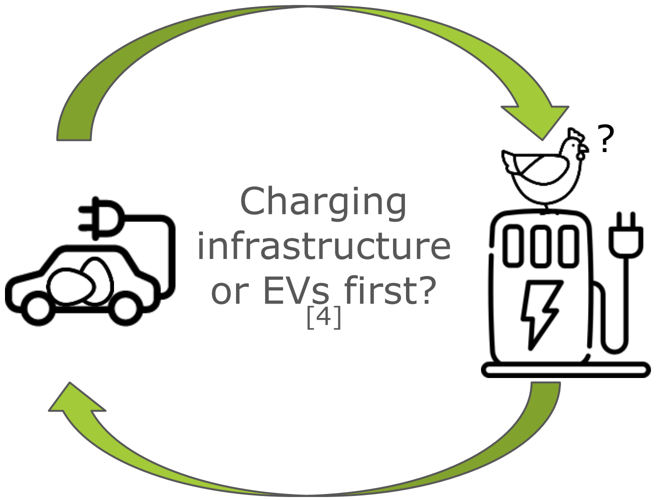
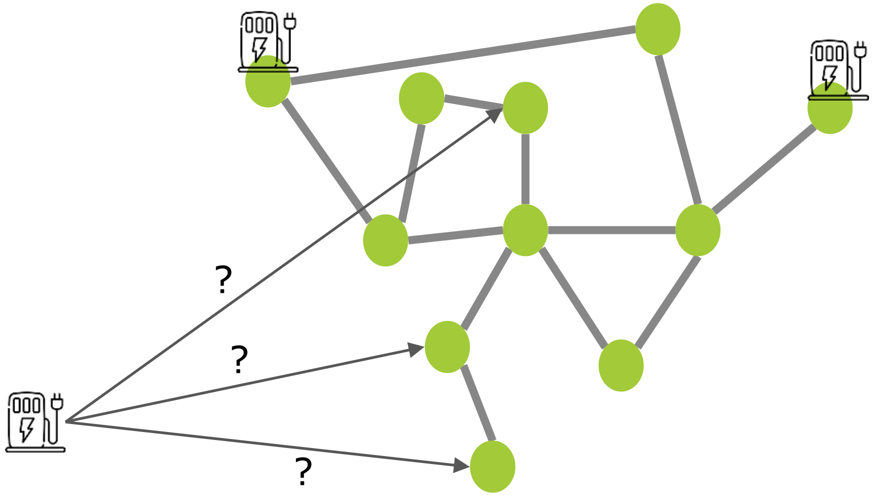
2.1. Charging infrastructure and EV acceptance

Vehicle range	Refueling time	Refueling availability
~1000km for ICEVs	~10mn for ICEVs	~60 000 gas pump (France)
~300km for EVs	~30mn-20h for EVs	~30 000 charging points (France)

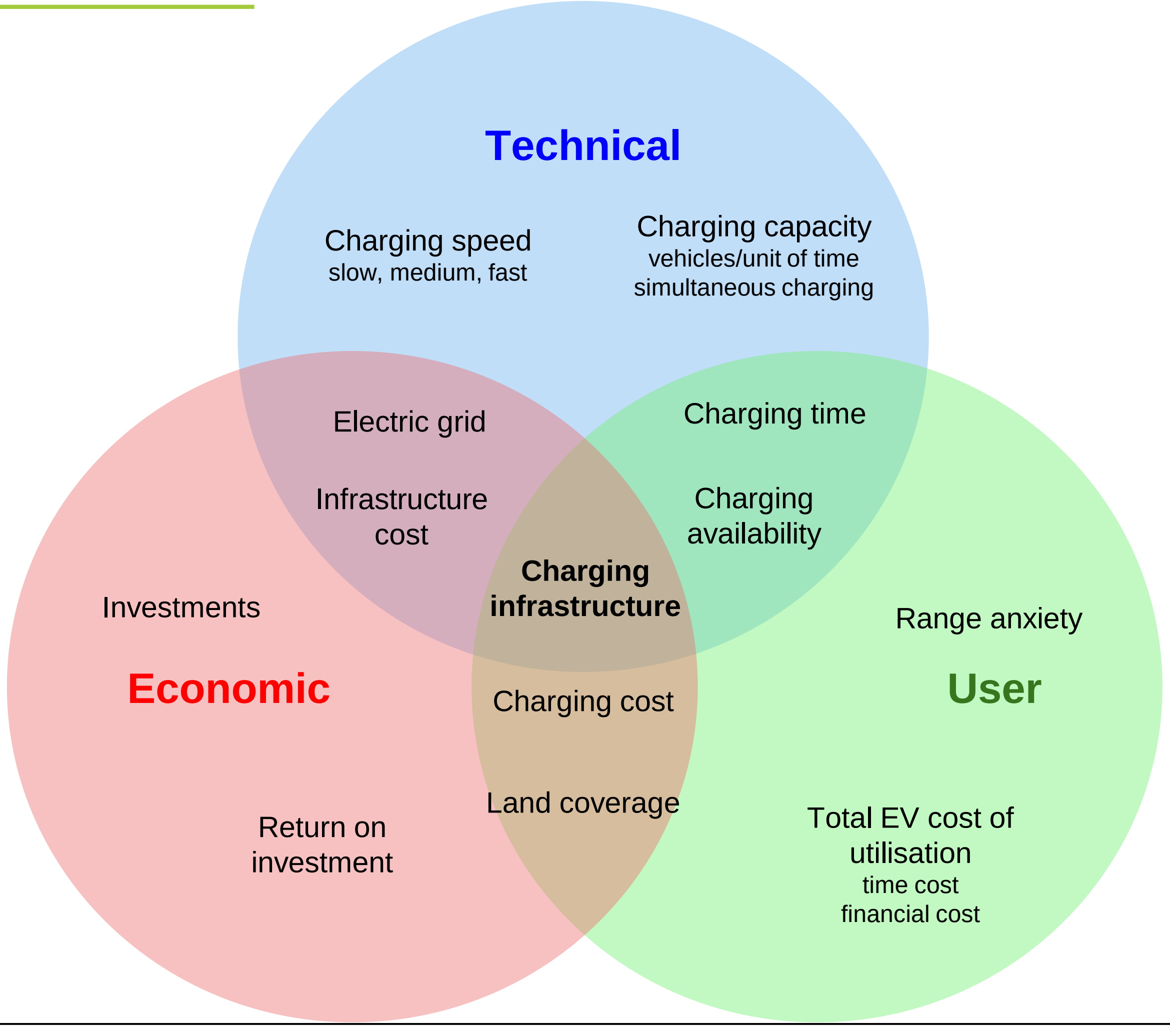
Need for a suitable infrastructure in order to enable the democratisation of electric vehicles[3]





[3] France Stratégie. Panorama des politiques publiques en faveur des véhicules à très faibles émissions - Note de synthèse. page 140, 2018.
[4] Delacrétaz, Lanz, and Van Dijk. The chicken or the egg: Technology adoption and network infrastructure in the market for electric vehicles.

2.2. Research areas and linked issues



3 issues :

- Location issues
- Sizing issues
- Using issues

2.3. Infrastructure goals

Two main categories

Minimize installation costs for a given demand[5]

- Installation cost
- Operation cost
- Electric power cost
- Maximize charger utilisation

Maximize the service for a given budget[6]

- Minimize the waiting time
- Minimize the deviation needed
- Maximize the number of EVs
- Maximize the amount of energy provided
- Maximize the distance that can be travelled
- Maximize feasible trips

[5] Xiaohong Dong, Yunfei Mu, Hongjie Jia, Jianzhong Wu, and Xiaodan Yu. Planning of Fast EV Charging Stations on a Round Freeway
[6] Csiszár et al. Urban public charging station locating method for electric vehicles based on land use approach

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1. Background on EV and charging infrastructure

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3. Location methods

3.1. Node based approach
3.2. Path based approach
3.3. Tour based approach
3.4. Main points of comparison

4. Conclusion

3.1. Node-based approach

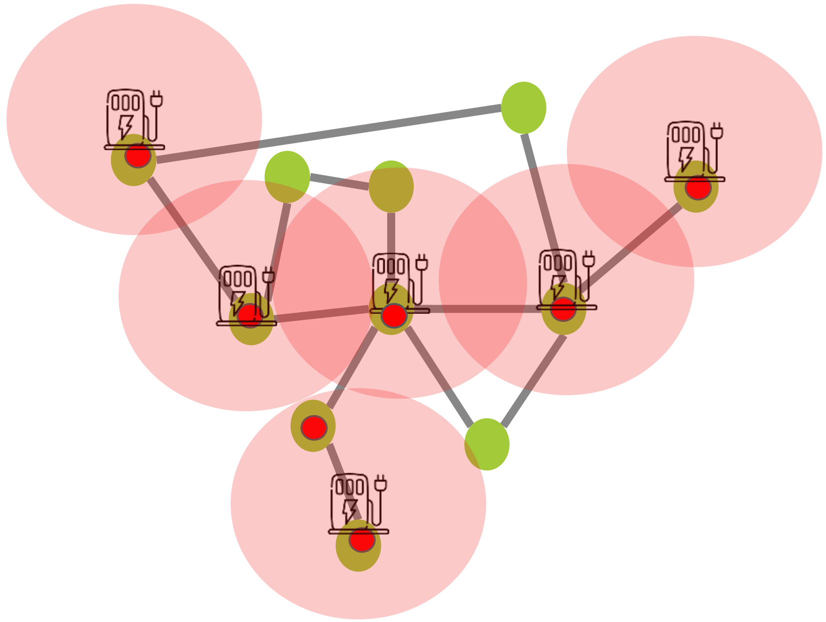
Covering model

- A set of potential locations
- A set of demand points to satisfy
- **Goal: minimise installation costs and distances to load points**

SCLM[7]
Minimize the number of facilities while covering all the demand

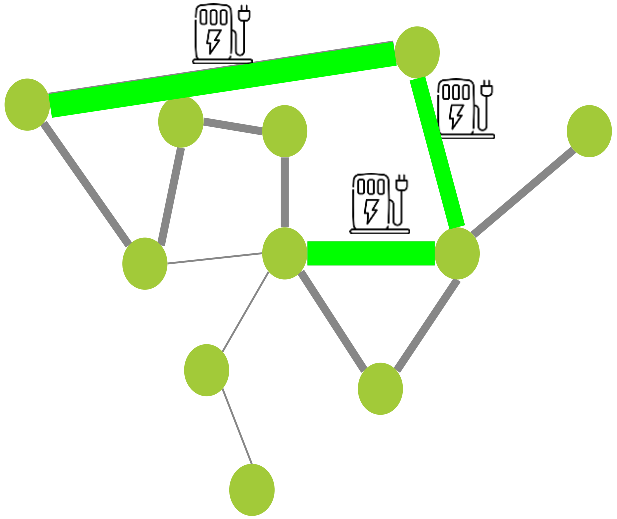
MCLM[8]
Maximize the number of location covered for a given number of stations

***p*-median[9]**
Minimize the distance between demand and stations for a given number of stations



[7] Ying Wei Wang and Chuan Ren Wang. Locating passenger vehicle refueling stations.
[8] Frade, Ribeiro, Gonçalves, and António Antunes. Optimal location of charging stations for electric vehicles in a neighborhood in Lisbon, Portugal.
[9] Jia et al. A novel approach for urban electric vehicle charging facility planning considering combination of slow and fast charging.

3.2. Path-based approach



Flow-capturing model

- A set of potential locations
- Measurement of vehicle flows at locations
- **Goal: minimise installation costs and capture the maximum amount of flow**

FCLM[10]
Maximize the amount of vehicles passing in front of stations

FRLM[11]
Takes into account the limited range of vehicles

[10] He et al. An optimal charging station location model with the consideration of electric vehicle's driving range.
[11] Michael Kuby and Seow Lim. The flow-refueling location problem for alternative-fuel vehicles.

3.3. Tour-based approach

Event capture problem

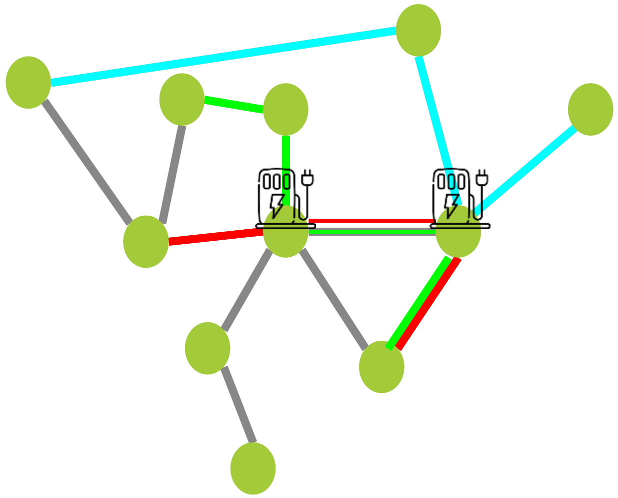
- A set of potential locations
- Vehicle activity data recovery
- **Goal: locating stations where the load opportunities are the greatest, without any additional constraints for users.**

Real-data based

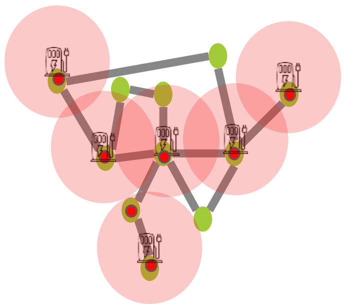
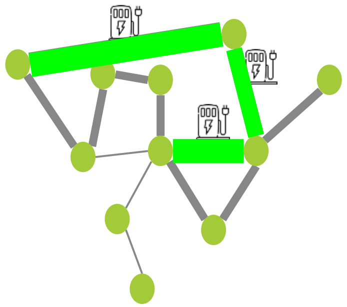
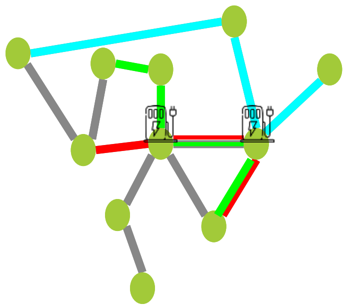
Hard to collect
More realistic

Multi-agent simulation based

Easier access to data and results



3.4. Main points of comparison

	Node-based	Path-based	Tour-based
Urban territory	+	- -	++
Highways	-	++	+
Charging need representation	- / +	+	++
User behaviour	-	- / +	++
Data requirement	Very low	Low	Very high

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EVs and charging infrastructure

- EVs and charging infrastructure form a two-sided market
- The first step toward a transition from ICE to EVs have to come from the public infrastructure side

Three main location methods in the literature

- Node-based
- Path-based
- Tour based

Charging infrastructure planning

- Must be over time
- Must take into account the previous infrastructure

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Thank you for your attention !