Electric Vehicle Charging Pricing Framework for Multi Agent Transportation Simulation (MATSim)

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Outline

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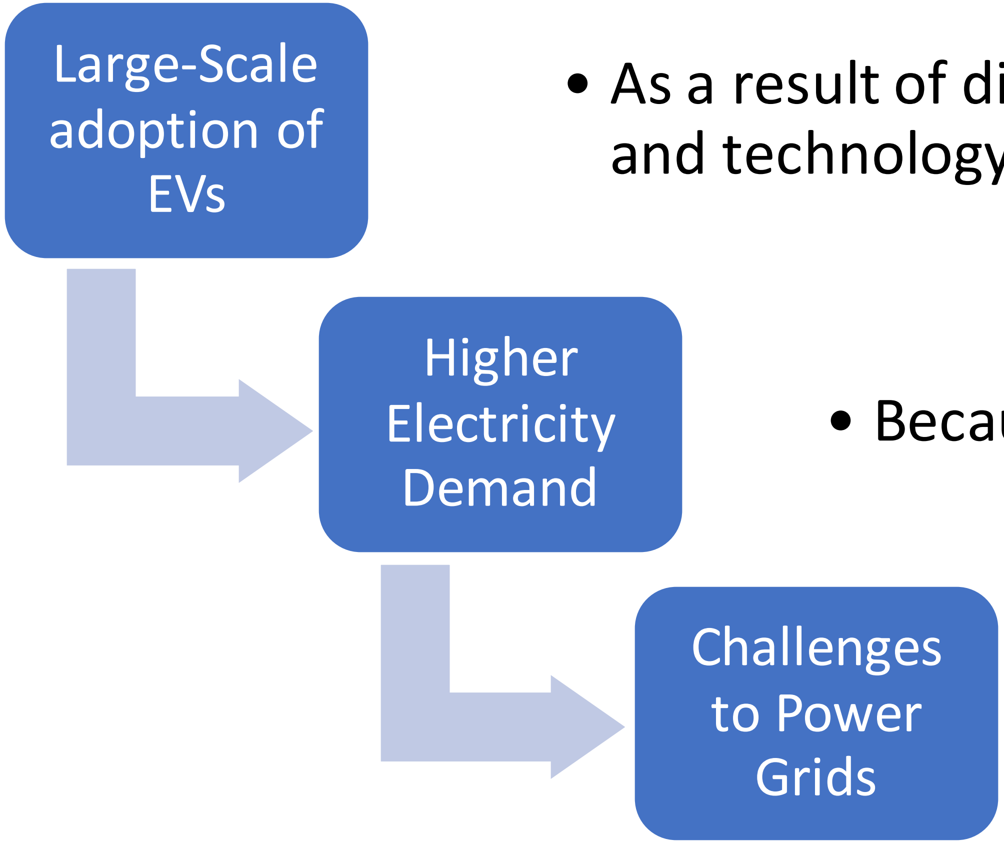
Challenges



- As a result of different incentives and technology improvement
- Because of more charging need
- Energy loss, damages, etc.

Motivations

Charger pricing in an urban setting creates a control tools for

- Managing temporal and zonal electricity supply constraint from the power grid.
- Modify activity location and duration choice behavior for EV users and thus improve system performance for the traffic network.
- And finally managing the queue in chargers and thus improving user satisfaction.

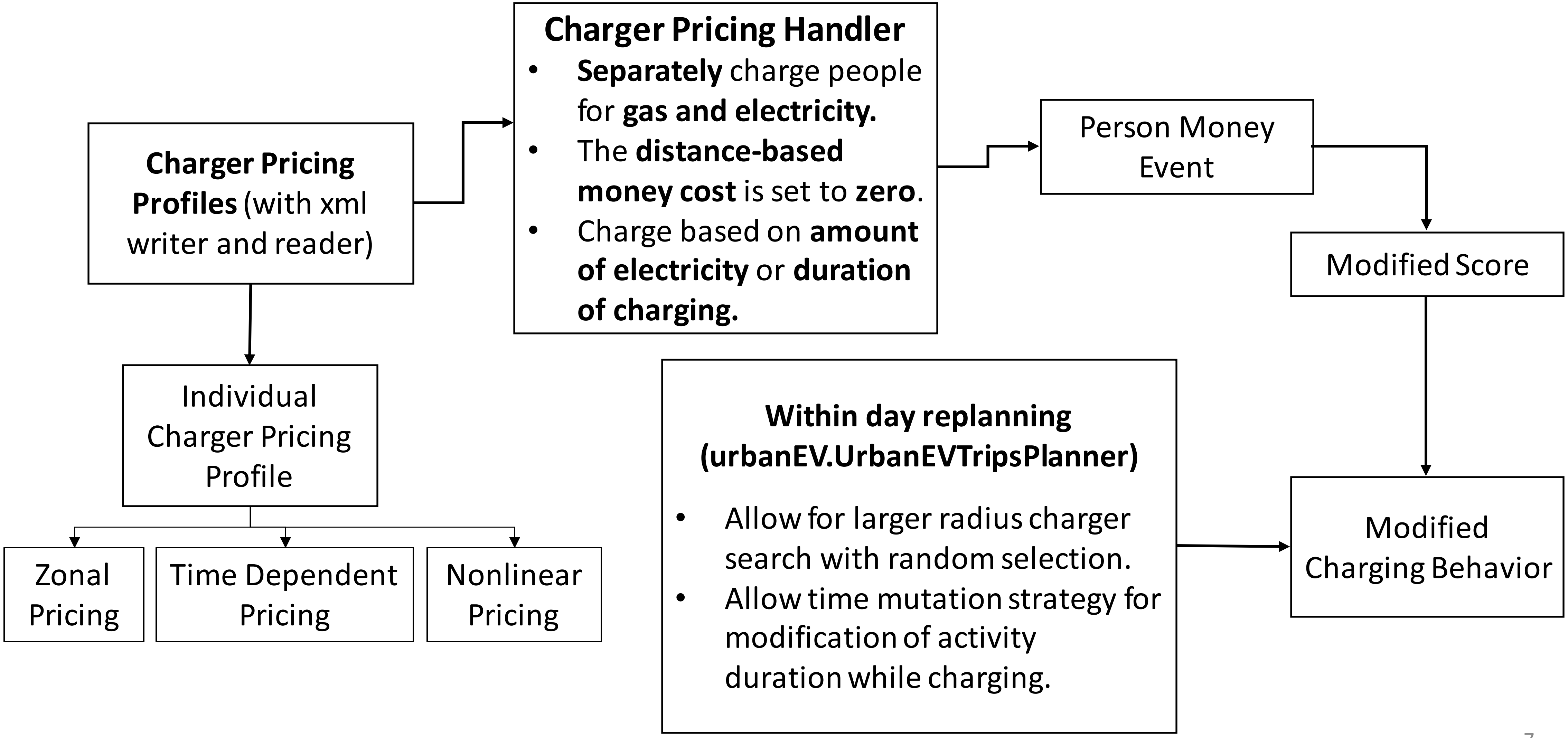
Research Background

- Waraich et al in 2013 considered different pricing schemes such as dump charging and time dependent (TD) charging in MATSim, and implemented it for the city of Zurich as a case study. Results show that changes in electricity price result in modified charging patterns.
- Ghavami et al. in 2014 considered non-linear pricing functions instead of linear flat pricing function using a Bayesian extension of the widely studied Walrasian pricing for PEV charging model.

Research Gap

- There is little literature on a framework that can apply TD pricing of UrbanEVs to a large-scale scenario and verify it using a transportation simulation.
- Although non-linear and TD pricing can reduce pressure on power grids, they cannot have any effects of traffic congestion, especially in the core areas of the cities (transportation point of view). Therefore, we consider the zonal pricing scheme as well.
- Very few studies have considered the EV charging pricing in MATSim.

EV Pricing Framework



Charging Pricing Schemes

- **Zonal:** Spatially group charger pricing. Allow electricity operator to manage spatial electricity supply constraint.

- **Time Dependent :** Peak and off-peak pricing. Allow electricity operator to manage peak hour electricity supply constraint

- **Nonlinear:** Different pricing scheme based on time of usage. Allow electricity operator to manage queue in the charging stations. (This scheme did not end with desirable results, and we are keeping it for the future work).

Test Cases

- **Four different pricing scenarios** have been applied to the **MATSim Montreal** scenario.

  - **Base case:** No pricing is applied
  - **Time dependent (TD)** : The electricity price is 50% higher during peak hours : charging usage will be compared with the base scenario
  - **Zonal:** The electricity price is higher in central business and industrial areas of the city and cheaper in outer areas : charging location will be compared with the base scenario

Assumptions

- The minimum level of state of charge (SOC) is considered as 20kWh.
- EV initial soc are randomly chosen between 30 and 50 kWh.
- The maximum battery capacities are 70kWh.
- Temperature condition is set to 15 degree Celsius.
- There different charger type including home, level 1, level 2, and fast chargers are considered with their real price in Montreal.
- The simulation has been run with 1% population of the Montreal scenario, with only 200 iterations.

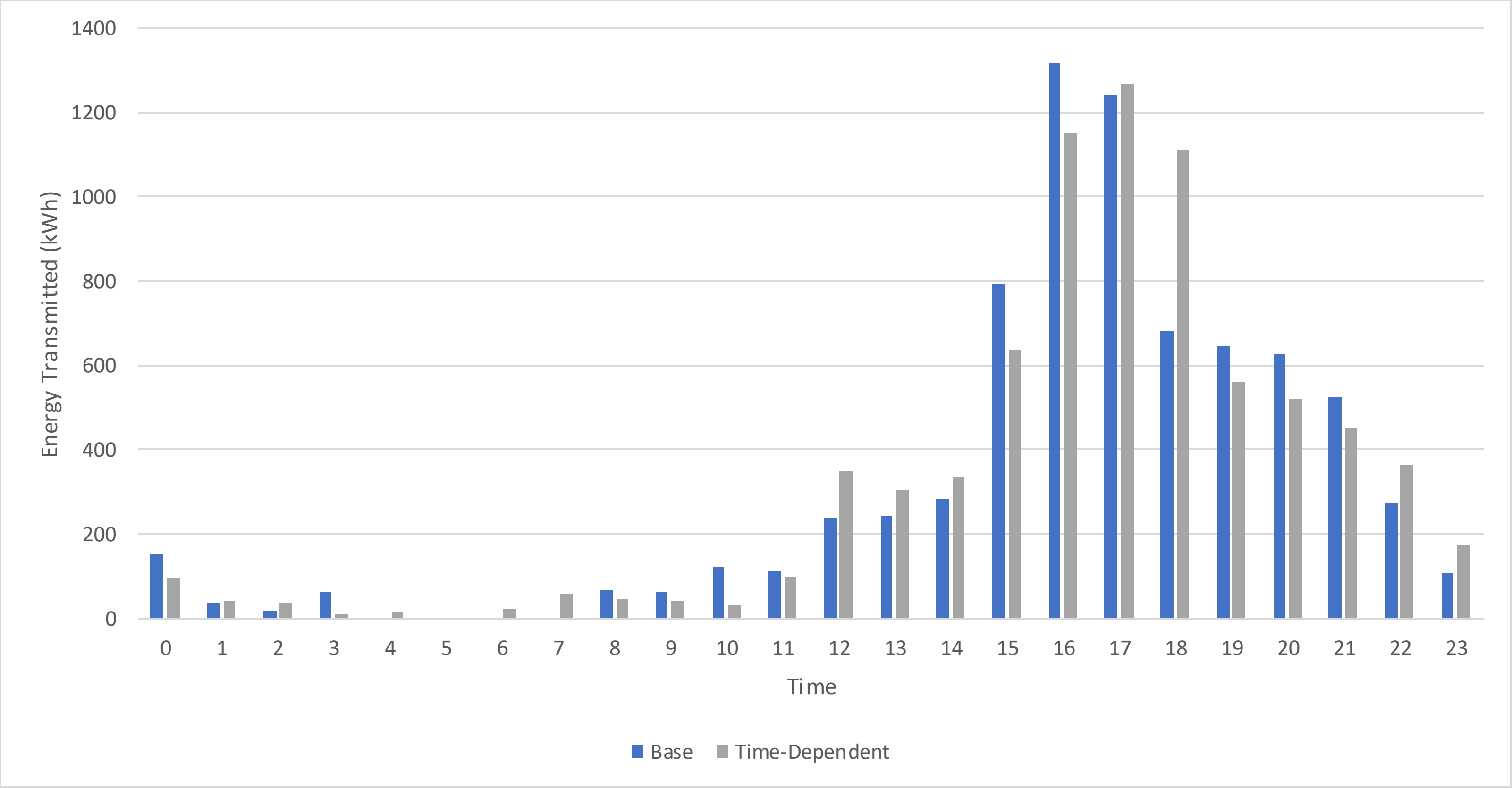
Scenarios

- TD
  - The electricity price is 1.5 times higher during peak hours
  - Peak hours : 8-10 am and 3-7 pm.

- Zonal
  - 6 arbitrary zones have been defined with different electricity price.

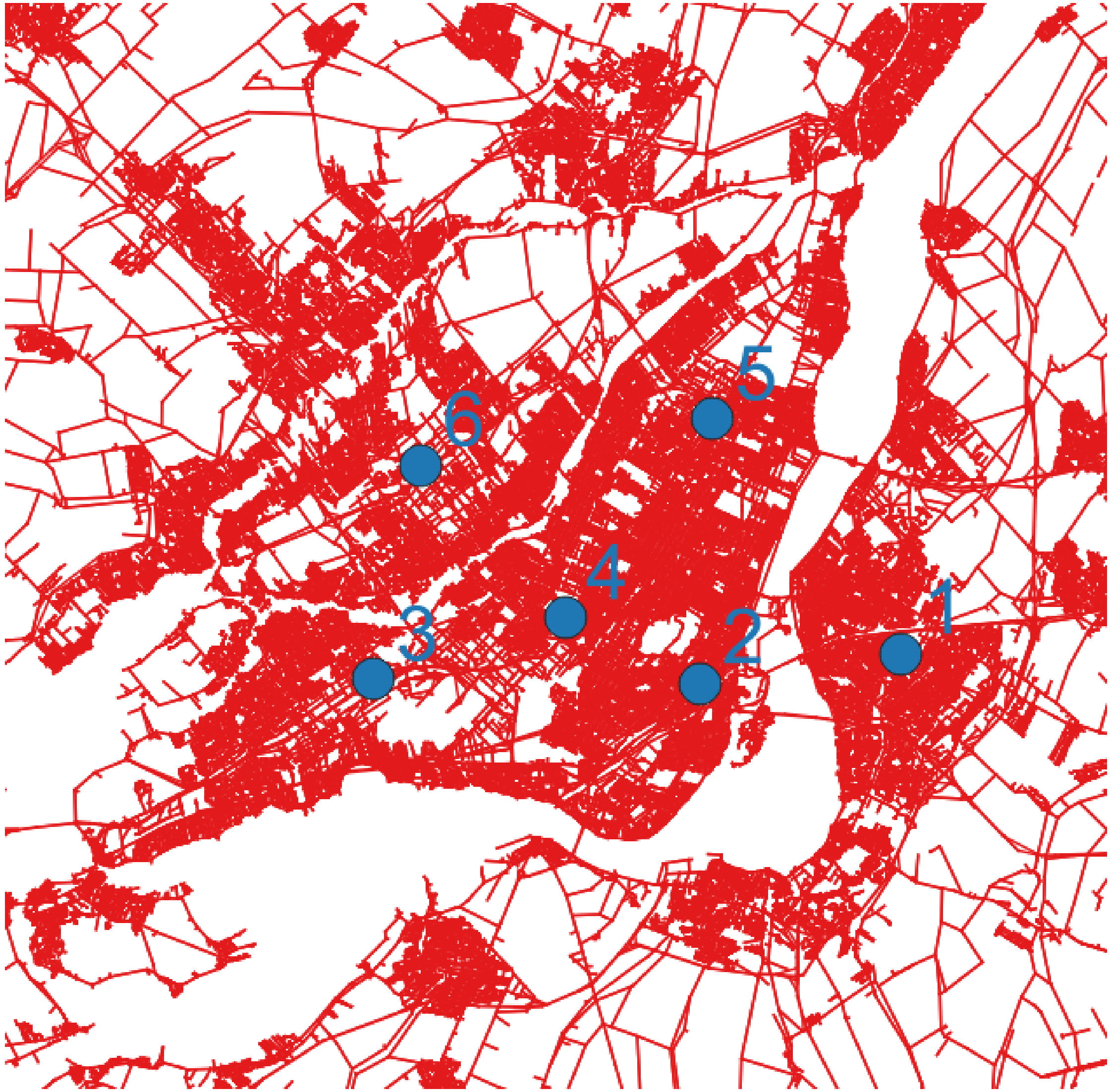
Total Energy Used (TD vs Base)

- The energy used has been shifted towards off-peak hours except for time 17 and 18.
- The time shift due to time mutation alone is not enough for shifting the charging event entirely from peak to off peak hours, We have to modify the charging replanning logic in the future work.



Selected Zones

- The whole Montreal are has been divided into 6 zones
- Dots are showing the center of each zone



The number of plugins (Zonal vs Base)

	Number of Plugs in each zone					
Zone	1	2	3	4	5	6
Base	92	58	67	43	104	107
	↓	↓	↑	↓	↓	↑
Zonal	85	52	77	31	98	114

	Pricing Multipliers in each Zone					
Zone	1	2	3	4	5	6
Multiplier	0.75	1.5	1	1.35	1	0.75
	Not OK	OK		OK		OK

Summary

- Results show that by applying the TD pricing, the peak usage hour is shifted towards off-peak hours.
- Results show that by applying the Zonal pricing, the number of plugins in zones with higher prices are reduced and the number of plugins in zones with less prices are increased.

References

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- Waraich, R. A. (2013). Agent-based simulation of electric vehicles: design and implementation of a framework (Doctoral dissertation, ETH Zurich).
- Ghavami, A., & Kar, K. (2014, March). Nonlinear pricing for social optimality of PEV charging under uncertain user preferences. In 2014 48th Annual Conference on Information Sciences and Systems (CISS) (pp. 1-6). IEEE