FABRIC'S APPROACH TOWARDS THE ESTIMATION OF ENERGY STORAGE SYSTEM REQUIREMENTS FOR GRID IMPACT REDUCTION

A simulation based study.

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FABRIC INTRODUCTION

Large-scale adoption of pure **Electric Vehicles (EVs)** in future transportation systems through **Advanced on-road charging solutions** to improve:

- driving range and battery lifetime; energy efficiency and price of the Full Electric Vehicles (FEV), given the need for a smaller battery.

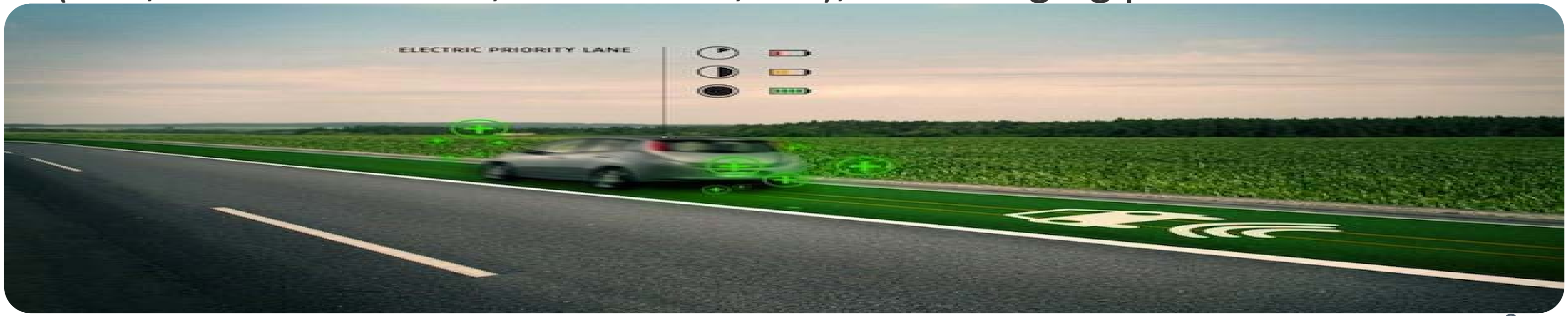
THE FUTURE OF EV CHARGING: WIRELESS

- Allows EV charging while travelling (dynamic) or during short stops ideal for urban environment (stationary)

Increased range | Smaller batteries | Increased mobility | No visual pollution

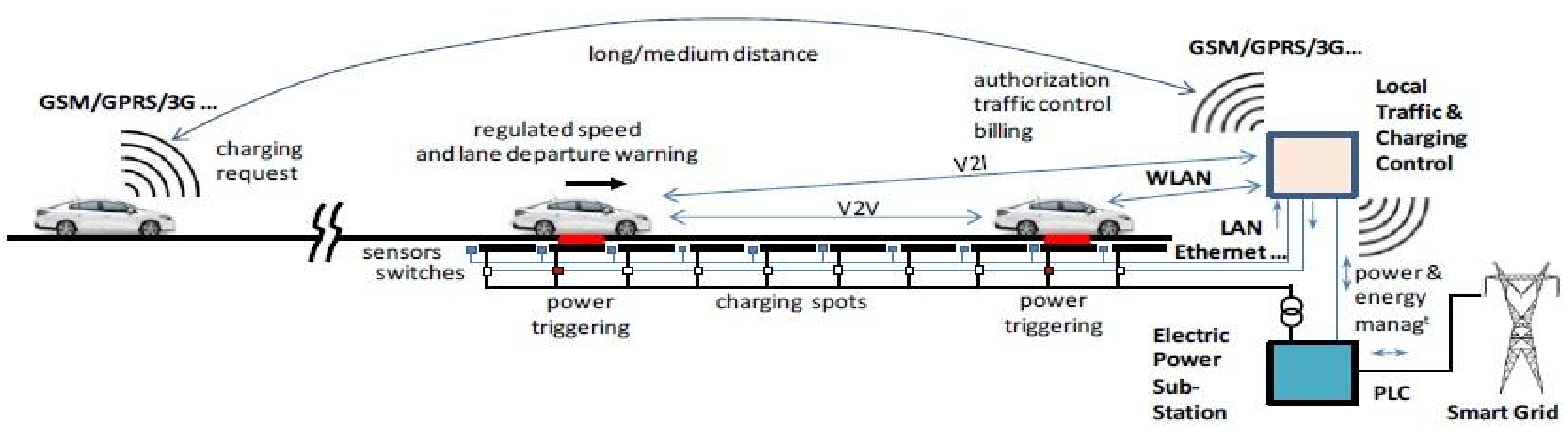
Driver benefits: Reduced range anxiety | Cheaper EVs | More comfort | Safer

- Drivers do not have to deal with dirty and potentially dangerous cables (rain, cable vandalism, cable wear, etc); the charging process is easier



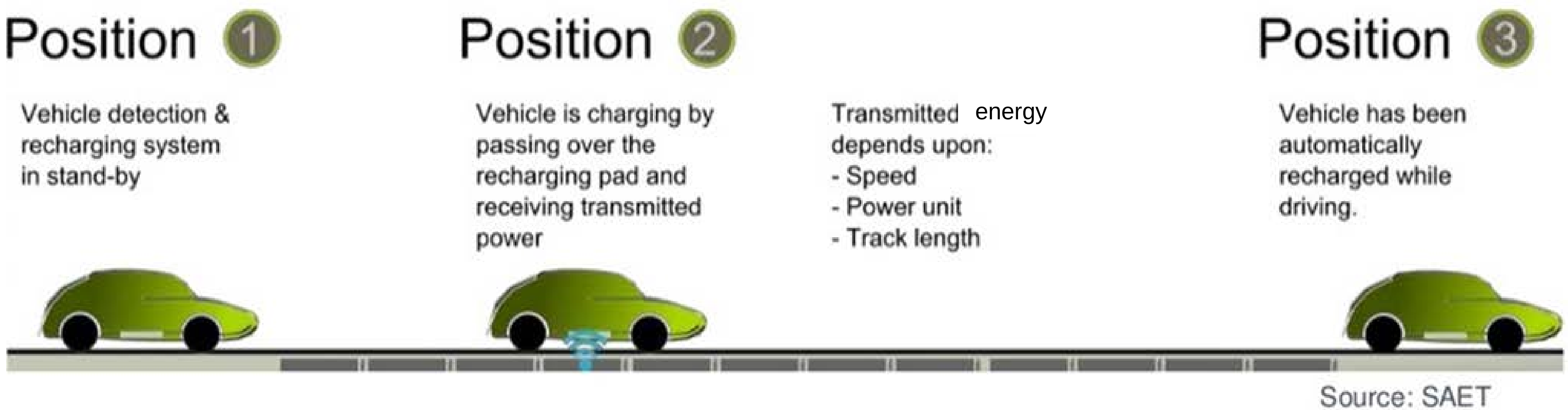
DYNAMIC WIRELESS CHARGING

- Charging process
  - Vehicle authorization
  - Charging profile negotiation
  - Power transfer while vehicle over the pads
  - Billing, payment, etc…



GRID IMPACT?

- How does this procedure affect the power grid? (What kind of power demand patterns are generated)
- Which parameters affect transmitted power in a macroscopic scale?



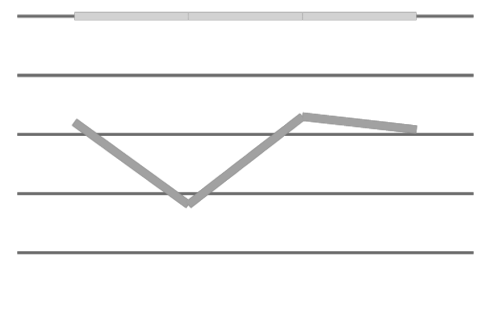
SIMULATION METHODOLOGY

Parameters:

1. Charging lane length. (8km)
2. Vehicle speed & length
3. Minimum headway
4. Traffic.
5. Maximum charging pad power level (50kW)

Scenario	P	V	h	l	d
Light traffic	0.15	36/108	5/10	5	570/1090
Medium traffic	0.50	36/108	5/10	5	1900/3500
Heavy traffic	0.75	36/108	5/10	5	2600/5000

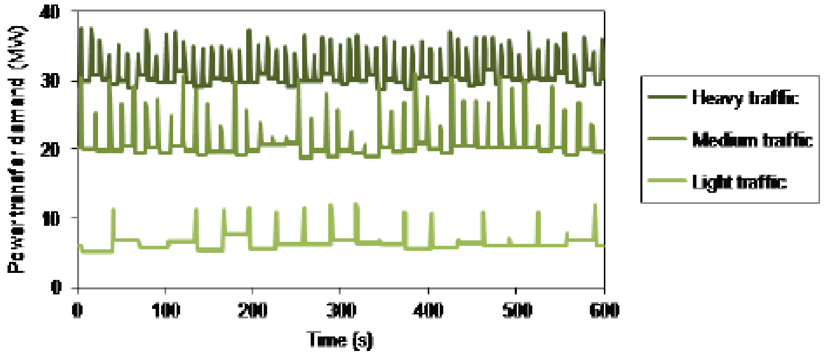
Charging events are created according to traffic, lane length ⇨ Charging events are translated to a power level according to the charging duration ⇨



Source: SAET

SCENARIO 1 (URBAN)

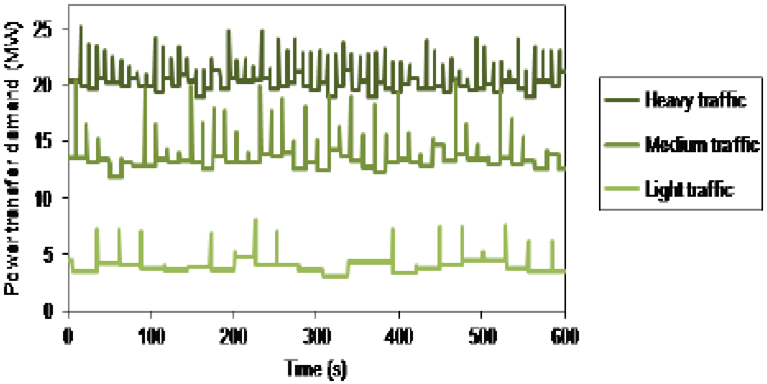
- Non-Coordinated charging scenario (36km/h-5m min headway):
  - Vehicles could enter the charging lane at any point of it!
  - Vehicles stay on the lane for at least 30m!
- Outcome:
  - Non-coordinated charging causes demand fluctuation. Investment in energy systems is required in order to "smooth" out demand patterns.



Scenario	Traffic	Avg	Stdev	Max
Urban	Light	6.33	1.07	12.05
	Medium	20.61	2.18	31.05
	Heavy	30.80	1.88	37.50

SCENARIO 2 (INTERURBAN)

- Non-Coordinated charging scenario (108km/h-10m min headway)
  - Impact of higher speed on demand is assessed
  - Vehicles leave more space when they go faster, so headway has been adjusted accordingly



- Outcome
  - Increase of minimum headway leads to less demand
  - Less demand variation in comparison to the slow speed case.

Interurban	Light Medium Heavy	3.95 13.29 20.15	0.52 0.89 0.82	8.20 20.30 25.15

ESS MOTIVATION

Ease demand-supply balancing by removing demand fluctuations

- Minimization of frequency variations due to demand supply mismatch (ensure grid stability)
- Minimization of losses due to load fluctuations
- Minimization of costs from over-dimensioning the grid
- …

ESS parameter calculation

- Storage system parameters
  - Nominal power rating Pss

Power time series (Aggregated)

$$P_s(t) = P_{out}(t) - P_{ch}(t)$$

Desired (smoothed) output from the moving average

$$P_{out}(t) = \frac{1}{n}\sum_{1}^{n} P_{ch}(t-i)$$

Nominal power rating

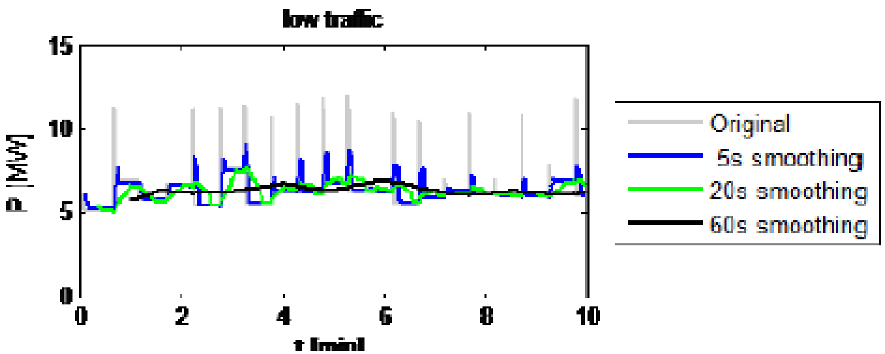
$$P_{ss} = max|P_s(t)|$$

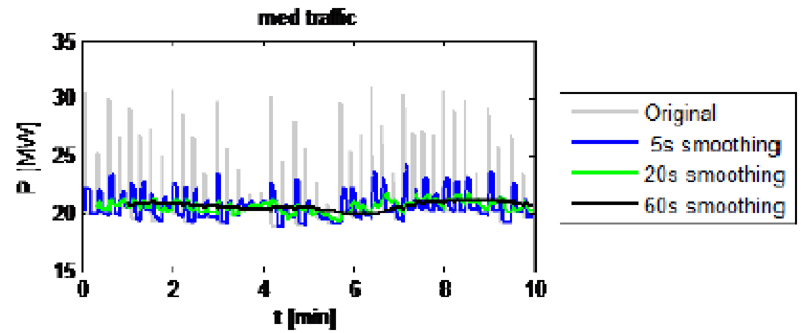
ESS parameter calculation

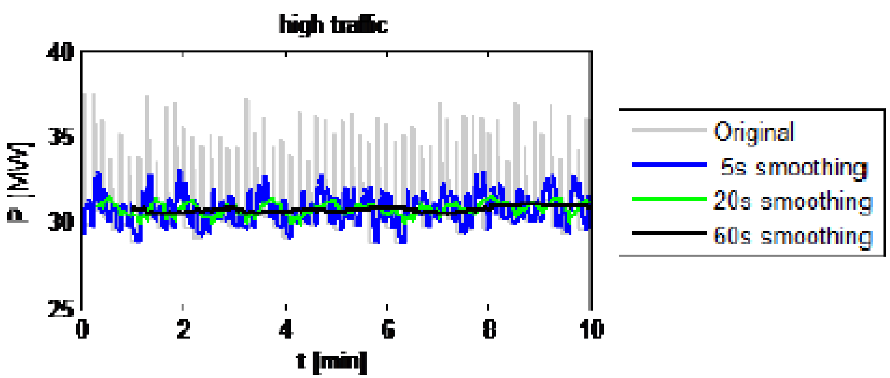
- Storage system parameters
  - Energy capacity Ess
    - By integrating Ps(t), Es(t) is obtained i.e the energy of the battery during the smoothing window. Then:

$$E_{ss}(t) = max(E_s(t)) - min(E_s(t))$$

Results







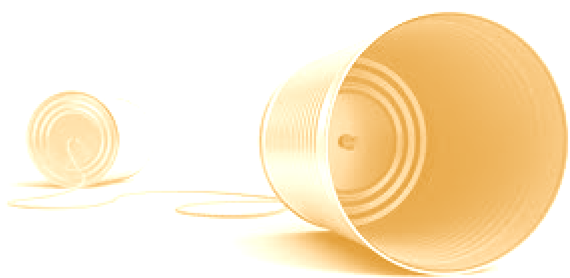
Similar results for the interurban case…

Results

- In the urban case most fluctuations have been removed with smoothing window of 5s i.e a storage system rated 11.4MW @ 8.2kWh
- In the interurban case smoothing requirements are lower. In order to smooth the demand a 60s window is required 2MW @ 8kWh
- Due to high charge and discharge power, systems must be placed near to the power transfer zones

Summary

- Vehicle speed, traffic density has a big impact on demand patterns and therefore the design of the energy system infrastructure
  - Detailed modeling required in order to enable a pro-active infrastructure design
- The combination of ICT solutions for demand side management with energy storage systems must be investigated in order to obtain an economically feasible solution.



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