EV WIRELESS CHARGING DEMAND ANALYSIS FOR VARIOUS TRAFFIC PATTERNS AND ENVIRONMENTS

A simulation based study.

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WHAT IS ELECTROMOBILITY

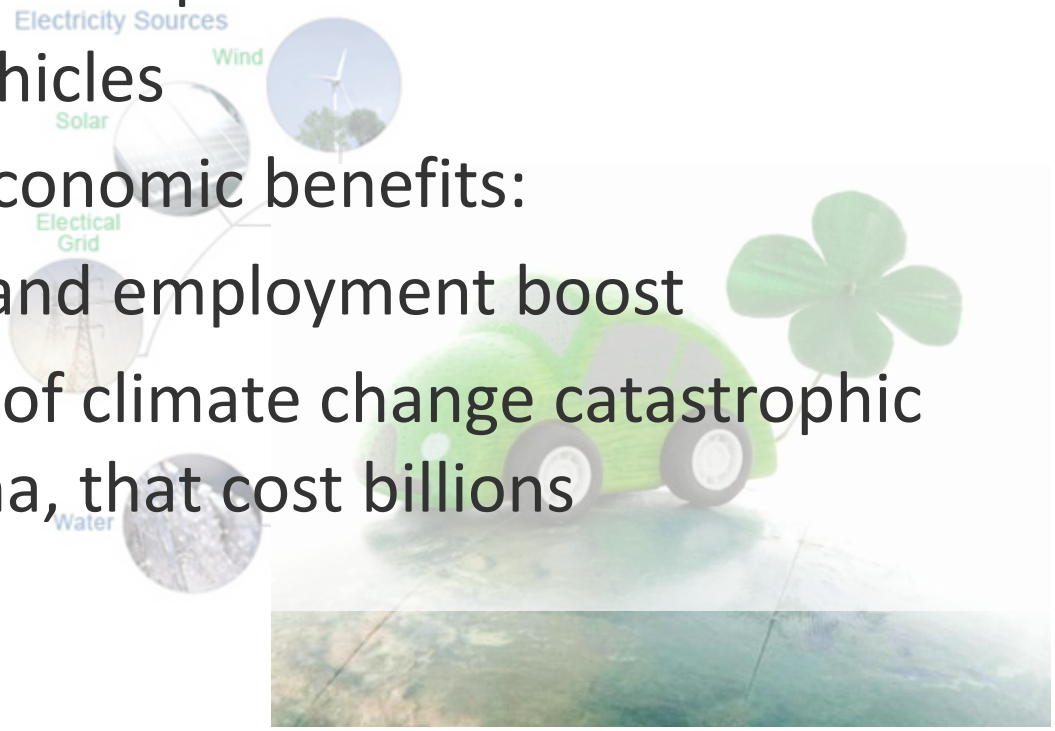
- Electromobility or electric mobility or e-mobility is the propulsion of vehicles using electricity instead of conventional fuel.

WHY ELECTROMOBILITY?
SOCIAL BENEFITS

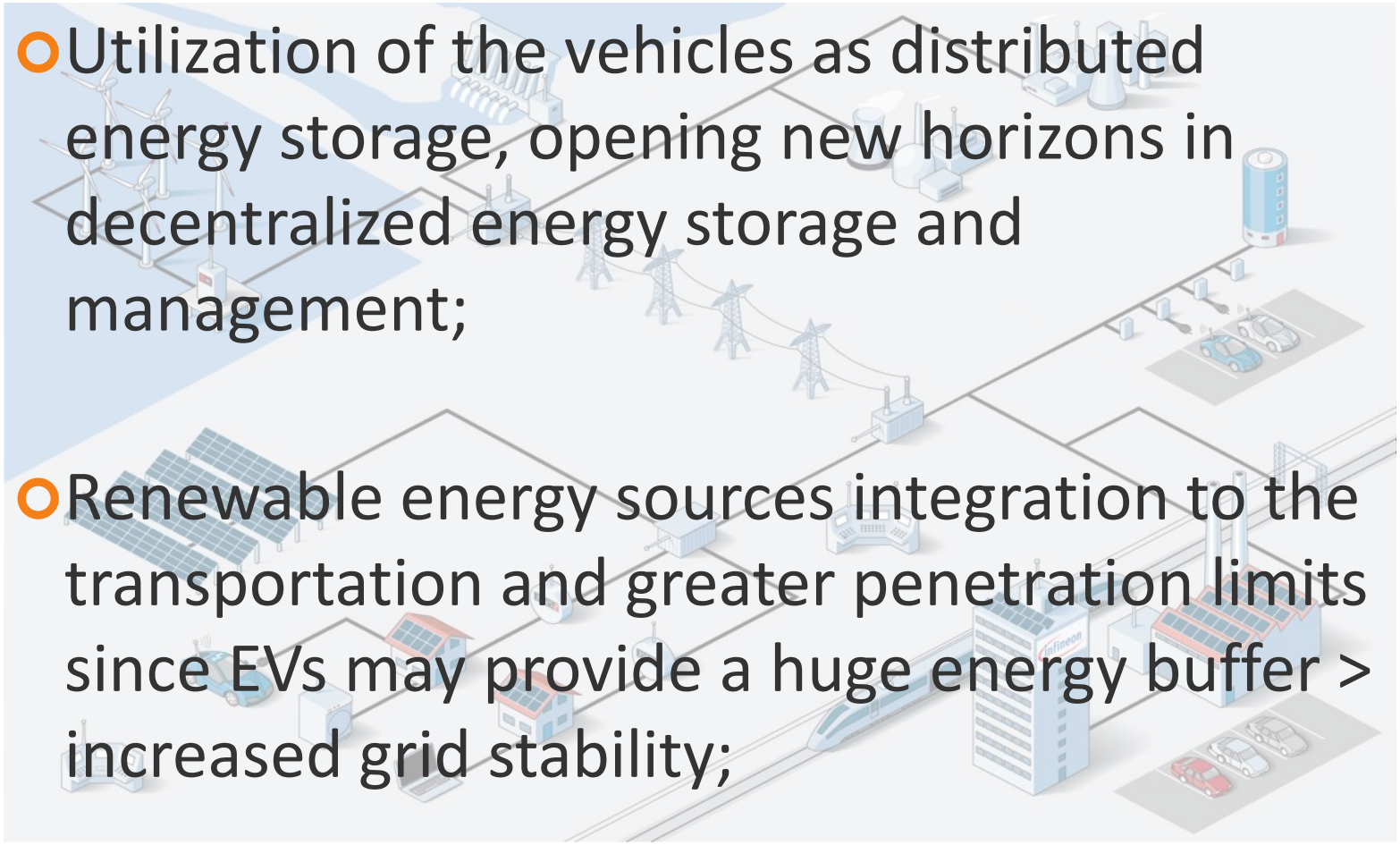
- Environmental benefits:
  - Minimization of vehicle produced air pollutants
  - RES-produced energy, consumed by EVs maximizes benefits

WHY ELECTROMOBILITY?
SOCIAL BENEFITS

- Societal benefits:
  - Cleaner city air > better quality of life, reduction of hospitalizations
  - Quieter vehicles
- Large-scale economic benefits:
  - Industrial and employment boost
  - Reduction of climate change catastrophic phenomena, that cost billions

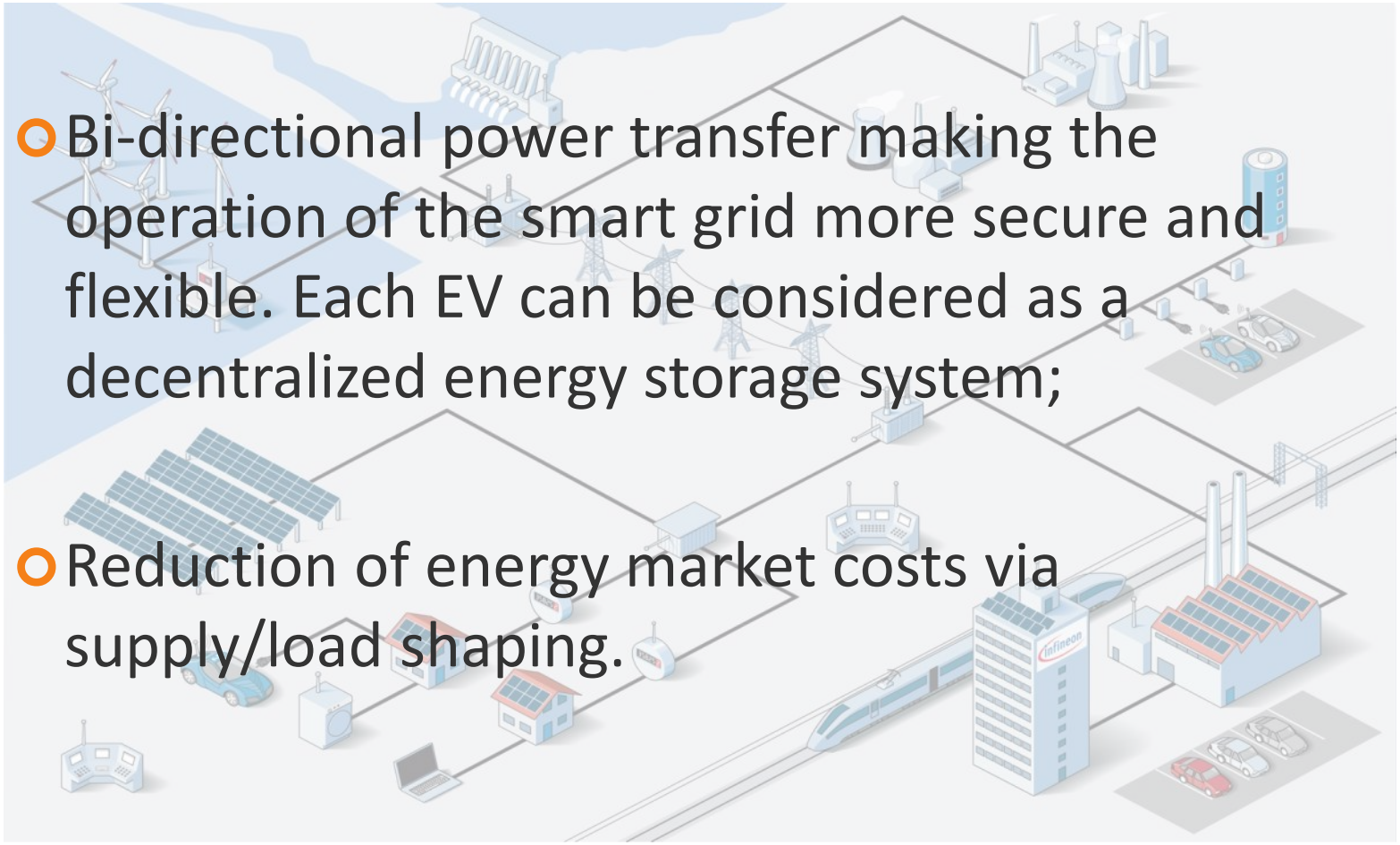


WHY ELECTROMOBILITY?
GRID BENEFITS



- Utilization of the vehicles as distributed energy storage, opening new horizons in decentralized energy storage and management;
- Renewable energy sources integration to the transportation and greater penetration limits since EVs may provide a huge energy buffer > increased grid stability;

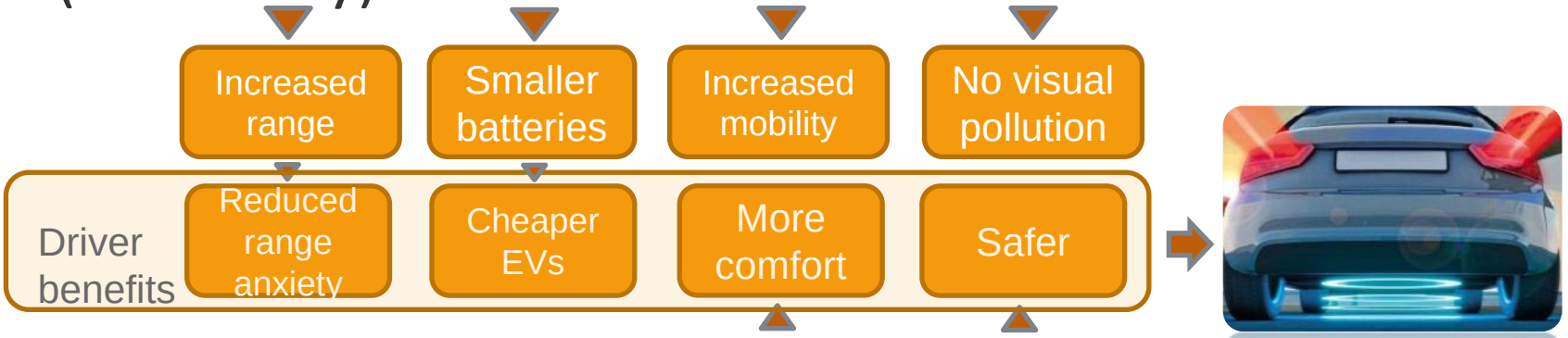
WHY ELECTROMOBILITY?
GRID BENEFITS



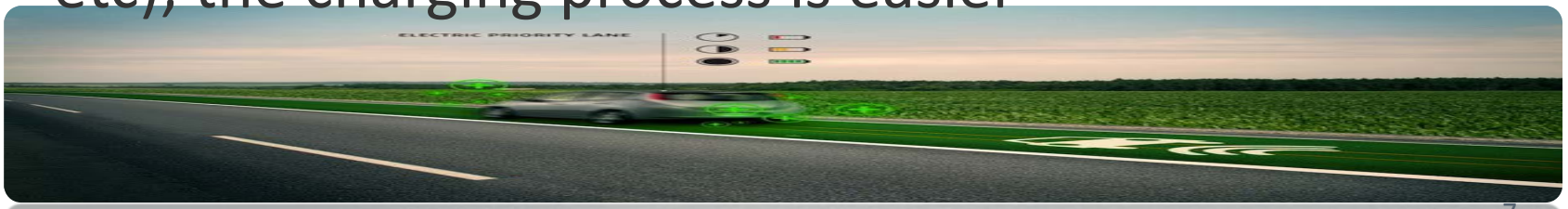
- Bi-directional power transfer making the operation of the smart grid more secure and flexible. Each EV can be considered as a decentralized energy storage system;
- Reduction of energy market costs via supply/load shaping.

THE FUTURE OF EV CHARGING: WIRELESS

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



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



THE FABRIC PROJECT: FACTS

Coordinator

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Consortium

Duration	48 Months
DG / Unit	Research and Innovation
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Funding	6.5 M€

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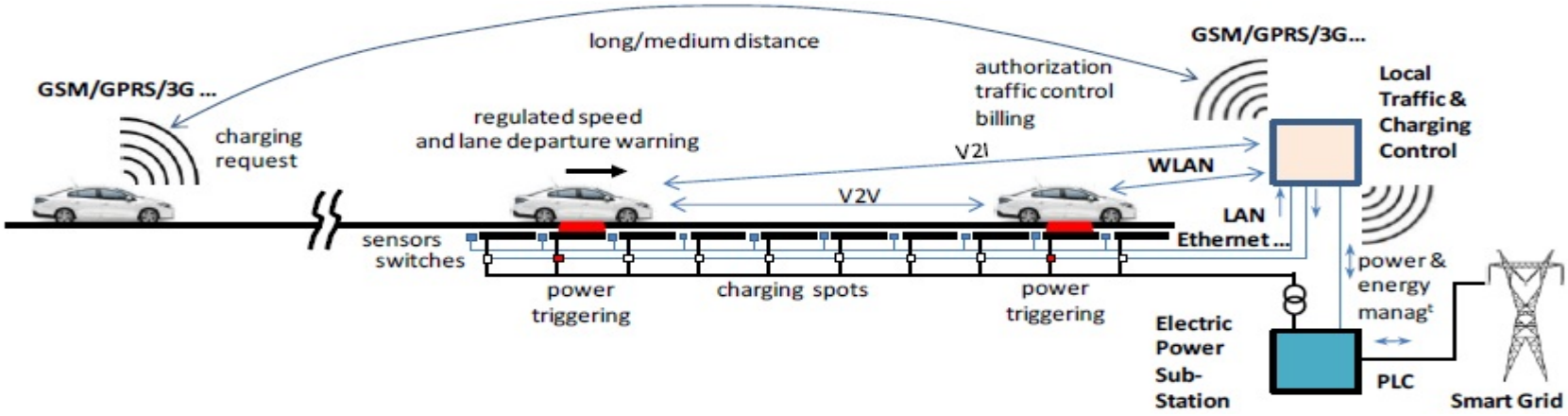
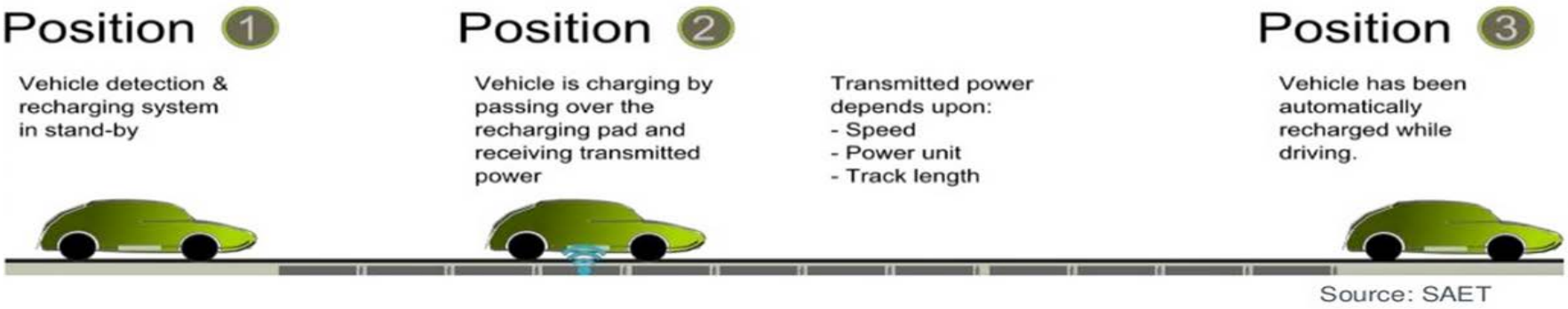
DYNAMIC WIRELESS CHARGING

- 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?



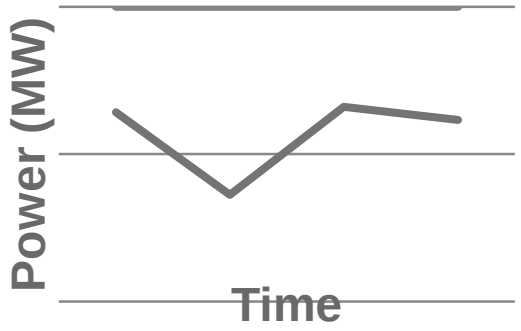
SIMULATION METHODOLOGY

Parameters:

1. Charging lane/pad length.
2. Vehicle speed
3. Traffic.
4. Maximum charging pad power level

Charging events are created according to traffic, pad/lane length

Charging events are translated to a power level according to the vehicle's speed and pad length



Source: SAET

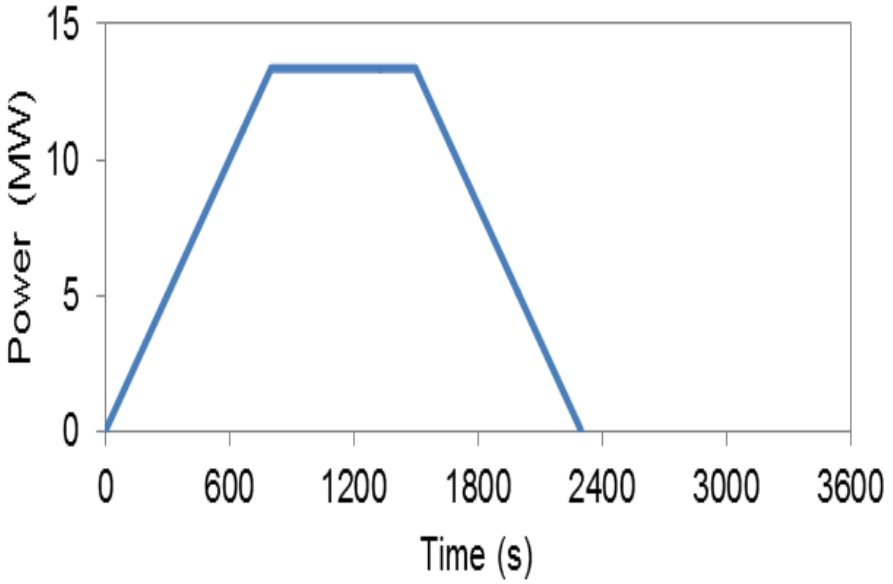
SCENARIOS AND OUTCOME (1/8)

- Coordinated charging scenario:
  - Vehicles gradually enter and exit the charging lane. (platoon)
  - Vehicles stay in the charging lane without overriding or skipping any charging pads.

DESCRIPTION	VALUE	UNITS
Total length of the road	8	km
Average slope	0	
Length of charging zones	30	m
Distance between charging zones	0	m
Power per unit of length	50	kW/m
Minimal technical headway in CWD lane	3	s
Vehicle speed	36	Km/h
Number of vehicles	500	

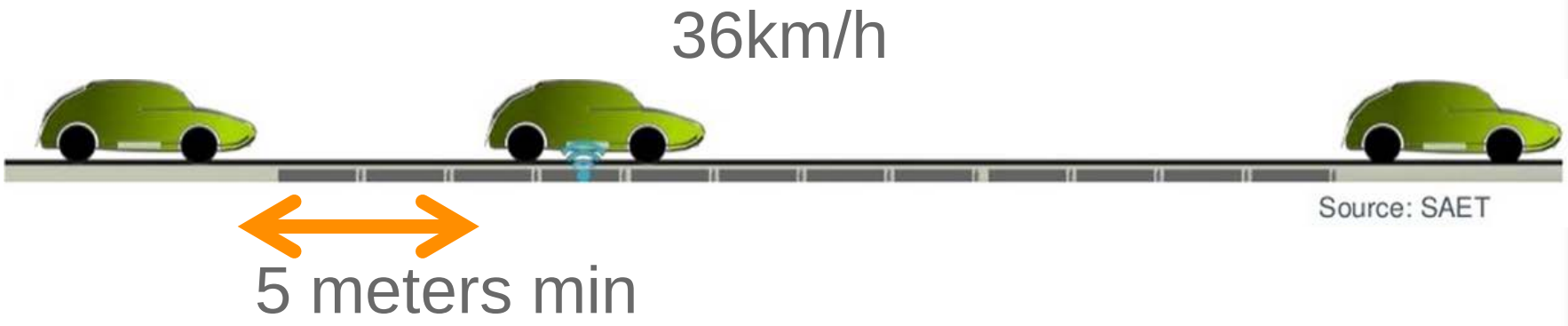
SCENARIOS AND OUTCOME (2/8)

- Outcome:
  - Demand pattern is grid friendly.
  - No variations or spikes imply fewer requirements on grid infrastructure! (Less smoothing, load balancing, etc…)



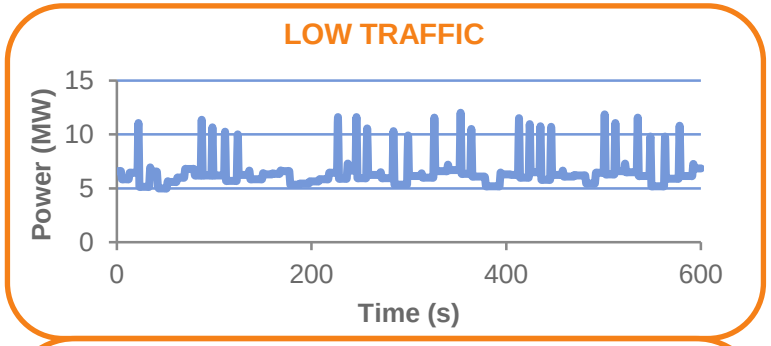
SCENARIOS AND OUTCOME (3/8)

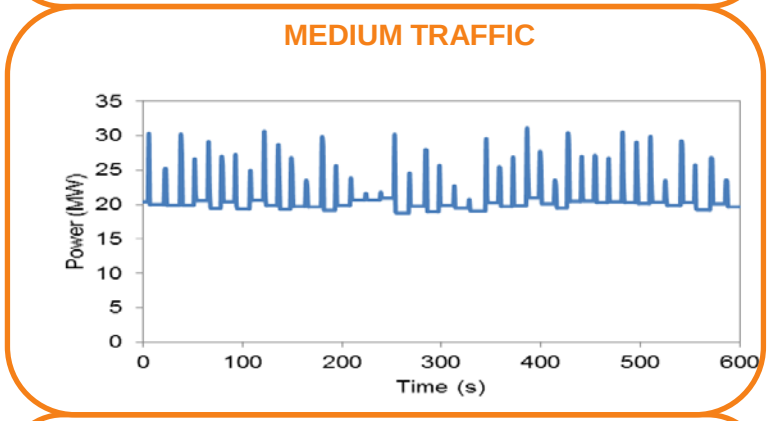
- Non-Coordinated charging scenario (36km/h-5m min headway):
  - Vehicles could enter the charging lane at any point of it!
  - Vehicles are free to override, stay on the lane as long as they desire!

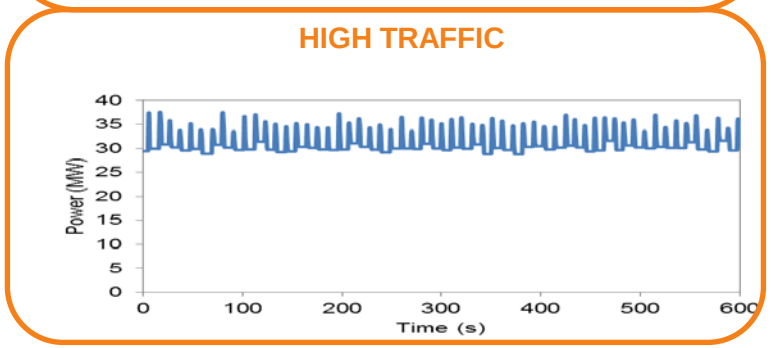


SCENARIOS AND OUTCOME (4/8)

- Outcome:
  - Non-coordinated charging causes demand fluctuation. Investment in energy systems is required in order to "smooth" out demand patterns.





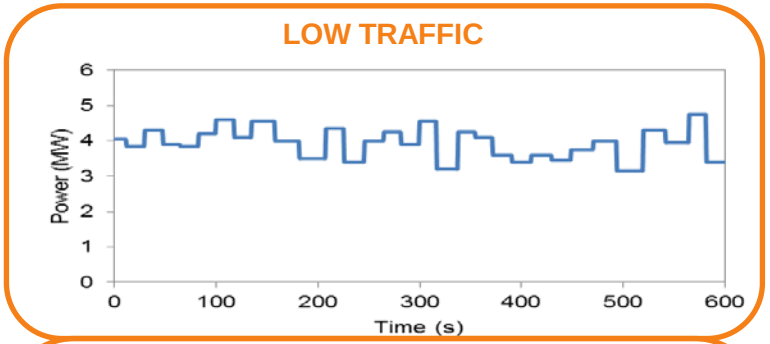


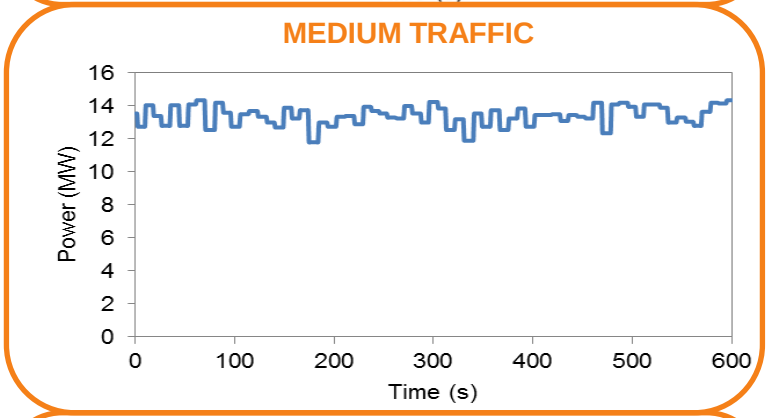
SCENARIOS AND OUTCOME (5/8)

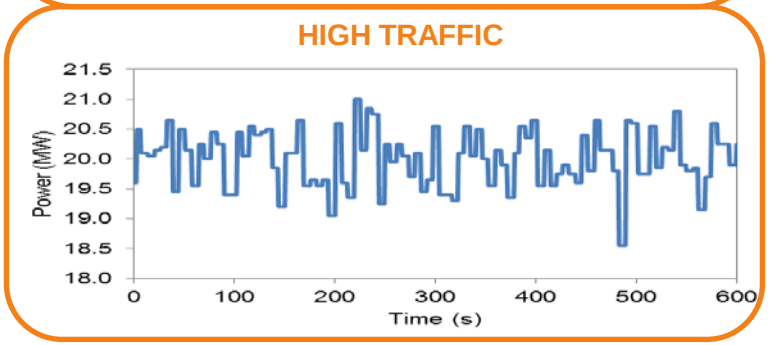
- Non-Coordinated charging scenario (108km/h-10m min headway)
  - Impact of higher speed on demand is assessed
  - Vehicles leave more space when they go faster, so headway has been adjusted accordingly

SCENARIOS AND OUTCOME (5/8)

- Outcome
  - Higher speed leads to less demand as vehicle density decreases (headway increases)
  - Less demand variation in comparison to the slow speed case.







SCENARIOS AND OUTCOME (6/8)

- 24h charging pattern
  - Traffic based on data provided by the NHTS. (2009 survey)
  - Scenario based on the hypothesis that there is an analogy between the overall traffic and the traffic that flows over a charging lane.

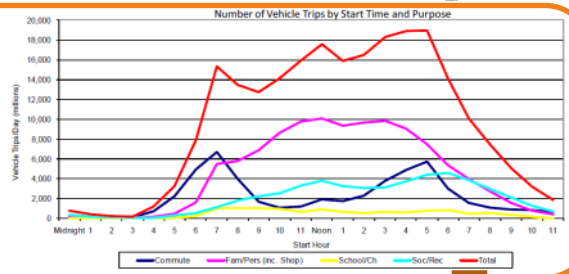
Source: SAET

24h simulation

SCENARIOS AND OUTCOME (6/8)

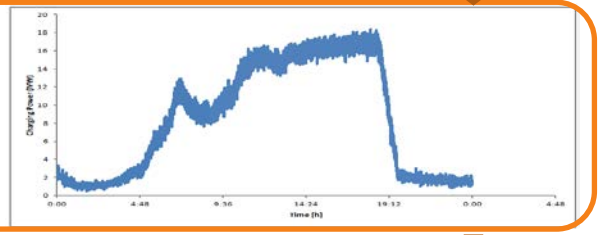
- Outcome
  - There is a natural co-ordination mechanism between the demand of a charging lane and solar irradiance
  - Attractive self consumption scenario!

DAILY TRAFFIC

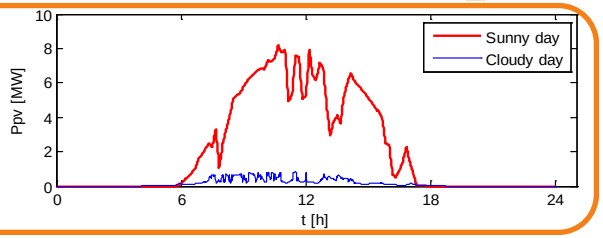


*Non-Coordinated charging scenario

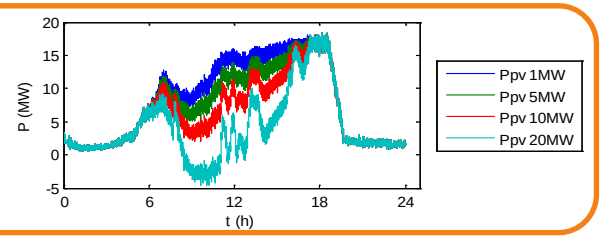
DAILY DEMAND



SOLAR SUPPLY



DECREASED DAILY DEMAND



SUMMARY (1/2)

- Coordinated charging schemes could lead to less infrastructure for demand smoothing. However the following are required:
  - Enforcement of policies
  - Infrastructure that enables platooning and vehicle co-ordination

SUMMARY (2/2)

- Speed and vehicle 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
- Use of solar energy for self consumption is an attractive solution in partially covering demand during day-light, especially in southern European countries.

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