EV WIRELESS CHARGING DEMAND ANALYSIS FOR VARIOUS TRAFFIC PATTERNS AND ENVIRONMENTS

A simulation based study.

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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

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

- Reduced range anxiety
- Cheaper EVs
- More comfort
- Safer

Driver benefits

ITS and Smart Cities 2014
THE FABRIC project: FACTS

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DYNAMIC WIRELESS CHARGING

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

Power (MW)

Time

Source: SAET

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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.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>VALUE</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>Total length of the road</td>
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<td>km</td>
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<tr>
<td>Average slope</td>
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<tr>
<td>Length of charging zones</td>
<td>30</td>
<td>m</td>
</tr>
<tr>
<td>Distance between charging zones</td>
<td>0</td>
<td>m</td>
</tr>
<tr>
<td>Power per unit of length</td>
<td>50</td>
<td>kW/m</td>
</tr>
<tr>
<td>Minimal technical headway in CWD lane</td>
<td>3</td>
<td>s</td>
</tr>
<tr>
<td>Vehicle speed</td>
<td>36</td>
<td>Km/h</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>
 Outcome:

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

36km/h

5 meters min

Source: SAET
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.
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

108km/h

10 meters min
Outcome

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

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