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

A simulation based study.

Authors: A. Amditis, T. Theodoropoulos and Y. Damousis (ICCS / I-SENSE)
J. Sallán, H. Bludszuweit (CIRCE)
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)

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

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

Increased range
Smaller batteries
Increased mobility
No visual pollution

ESARS 2015, Aachen Germany
Dynamic Wireless Charging

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

ESARS 2015, Aachen Germany
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?
Parameters:
1. Charging lane length. (8km)
2. Vehicle speed & length
3. Minimum headway
4. Traffic.
5. Maximum charging pad power level (50kW)

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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>P</th>
<th>V</th>
<th>h</th>
<th>l</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light traffic</td>
<td>0.15</td>
<td>36/108</td>
<td>5</td>
<td>10</td>
<td>570/1090</td>
</tr>
<tr>
<td>Medium traffic</td>
<td>0.50</td>
<td>36/108</td>
<td>5</td>
<td>10</td>
<td>1900/3500</td>
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<tr>
<td>Heavy traffic</td>
<td>0.75</td>
<td>36/108</td>
<td>5</td>
<td>10</td>
<td>2600/5000</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Traffic</th>
<th>Avg</th>
<th>Stdev</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Urban</td>
<td>Light</td>
<td>6.33</td>
<td>1.07</td>
<td>12.05</td>
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<tr>
<td></td>
<td>Medium</td>
<td>20.61</td>
<td>2.18</td>
<td>31.05</td>
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<tr>
<td></td>
<td>Heavy</td>
<td>30.80</td>
<td>1.88</td>
<td>37.50</td>
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</tbody>
</table>
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.

<table>
<thead>
<tr>
<th></th>
<th>Light</th>
<th>Medium</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interurban</td>
<td>3.95</td>
<td>13.29</td>
<td>20.15</td>
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<tr>
<td></td>
<td>0.52</td>
<td>0.89</td>
<td>0.82</td>
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<tr>
<td></td>
<td>8.20</td>
<td>20.30</td>
<td>25.15</td>
</tr>
</tbody>
</table>
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 $P_{ss}$

Power time series (Aggregated)

Desired (smoothed) output from the moving average

Nominal power rating

\[
P_s(t) = P_{out}(t) - P_{ch}(t)
\]

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

\[
P_{ss} = \max|P_s(t)|
\]
ESS parameter calculation

• Storage system parameters
  • Energy capacity $E_{ss}$
    • By integrating $P_s(t)$, $E_s(t)$ 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.
Theodoros Theodoropoulos,
ICCS Assistant Researcher
Developer @ I-SENSE
✉ t.theodoropoulos@iccs.gr
✉ +30 210 772 2466

9, Iroon Polytechneiou, 15773, Zografou - Athens, Greece

http://i-sense.iccs.gr/