Aggregated Storage Strategy of Electric Vehicles Combining Scheduled Charging and V2G

Y. Ota, H. Taniguchi, H. Suzuki, J. Baba, and A. Yokoyama

THE UNIVERSITY OF TOKYO
Motivation

Integration of Electric Vehicles into Power System

1. New electrical demand --> residential peak load
2. Demand response resource (Smart Charging)
3. Distributed energy storage (Vehicle-to-Grid)

Aggregated Storage Strategy

Satisfying the charging request for driving
Mitigating impact on the distribution grid
Bringing flexibility for the power system
**Aggregated Storage Strategy**

1. Scheduled charging (SC) on each EV
2. Vehicle-to-Vehicle (V2V) power offset against SC
3. Grid-to-Vehicle (G2V) of daily driving energy
4. Dispatch to EVs as State-of-Charge (SOC)
Driving Pattern

based on “Road Traffic Census, Vehicular Origin-Destination Survey”, Ministry of Transport, Japan

(a) Daily vehicle usage

(b) Daily driving distance

(based on "Road Traffic Census, Vehicular Origin-Destination Survey", Ministry of Transport, Japan)
Case 1: Immediate Charging

Battery capacity: 20[kWh]
Power consumption for driving: 0.1[kW/km]
Residential normal charger: 6[kW]

(a) Total charging power (3000 vehicles)

(b) State-of-Charge (three vehicles)
Case2 : Scheduled Charging

(a) Total charging power (3000 vehicles)

(b) State-of-Charge (three vehicles)
Case 3: Proposed Strategy

Scheduled charging is accommodated by the V2V. Daily driving energy is supplied from 9am to 3pm.

(a) Total power (3000 vehicles)

(b) State-of-Charge (three vehicles)
# Numerical Evaluation

<table>
<thead>
<tr>
<th></th>
<th>SOC (out) [%]</th>
<th>SOC (idle) [%]</th>
<th>Peak Power * [kW]</th>
<th>Averaged Power ** [kWh/h]</th>
<th>Averaged Loss *** [kWh/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Charging</td>
<td>&gt;95</td>
<td>94.84</td>
<td>0.943 (evening)</td>
<td>0.313</td>
<td>0.016</td>
</tr>
<tr>
<td>Scheduled Charging</td>
<td>&gt;95</td>
<td>87.58</td>
<td>1.357 (morning)</td>
<td>0.313</td>
<td>0.016</td>
</tr>
<tr>
<td>Proposed Strategy</td>
<td>&gt;95</td>
<td>85.16</td>
<td>1.309 (9am-3pm)</td>
<td>0.928</td>
<td>0.046</td>
</tr>
</tbody>
</table>

* With the ten minutes moving average filter
** In the proposed strategy, power values of scheduled charging and centralized dispatch (V2V&G2V) are taken into account.
*** 5% power conversion loss is assumed.
Conclusions

Aggregated Storage Strategy of Multiple EVs

Charging request is satisfied by the scheduled charging on each EV.
Flexible EV-DR is achieved by the centralized dispatch to the idling EVs.

--> Economic analysis between flexibility and energy losses
--> Benchmarking is being conducted on a standardized distributed grid model.
--> Decentralized approach is effective for implementation.

Thank you for your kind attention!
Yutaka Ota, yota@upn.t.u-tokyo.ac.jp