M2G EV Controlled Charging Overview

- Day-ahead forecasts of aggregated load are useful input to a Day-Ahead optimization to produce an initial optimal schedule
- Intra-day forecasts of individual charging stations are needed to determine optimal set-points for providing flexibility

Motivation

**What is the better Forecast?**

Forecasts $\hat{y}_1$ and $\hat{y}_2$ have identical Mean Absolute Error. $\hat{y}_3$ has arguably more value to optimization in energy management systems (EMS), depending on the specific use case (e.g. control of storage, load management, marketing energy, ….)

**What is the better Average?**

When averaging $x_1$ and $x_2$ using the traditional mean $\bar{x}$ the peak gets flattened out, while the adjusted average $x_{PM}$ keeps the peak at the same height. In specific use cases a peak-preserving average may be more useful in forecast models.

Adjustable Metric and Average

Extending the work of (Haben 2014) and (Charlton 2013), we propose to develop forecast models based on:

$$E_p^{\omega} = \min_{\text{conf}} \{ \| \hat{y} - y \|_p \} + \sum_{i=1}^{N} (E_p^{\mu}(x_i, \hat{y}))^\omega$$

We implemented the following forecast algorithms capable of minimizing the adjusted error and utilizing the adjusted average:

- Adjusted Average Forecaster (AAF) based on (Haben 2014)
- Permutation Merge Forecaster (PM) based on (Charlton 2013)
- Adjusted K-nearest Neighbors (AKNN)

Forecaster Evaluation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Ridge</th>
<th>Naive</th>
<th>AAF</th>
<th>PM</th>
<th>AKNN</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE</td>
<td>$E_{\mu=1}^{\omega}$</td>
<td>1.78</td>
<td>1.83</td>
<td>1.93</td>
<td>1.80</td>
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<tr>
<td>RMSE</td>
<td>$E_{\mu=2}^{\omega}$</td>
<td>2.42</td>
<td>3.18</td>
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<tr>
<td>$\omega=0$</td>
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<td>11.52</td>
<td>14.68</td>
<td>13.08</td>
<td>12.51</td>
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<tr>
<td>$\omega=1$</td>
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<td>11.48</td>
<td>14.73</td>
<td>13.14</td>
<td>12.47</td>
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<tr>
<td>$\omega=2$</td>
<td></td>
<td>7.11</td>
<td>9.58</td>
<td>8.55</td>
<td>7.98</td>
</tr>
</tbody>
</table>

- AKNN and Permutation Merge can most robustly minimize the adjustable error, while Ridge works best to minimize RMSE
- Future work will investigate the optimization of the forecast configuration based on a specific use case and implement more machine learning models capable of minimizing the adjusted error


(Charlton 2013) Nathaniel Charlton, Danica Vukadinovic Greetham, and Colin Singleton. On minimum cost local permutation problems and their application to smart meter data. University of Reading