Planning for electric vehicle needs by coupling charging profiles with urban mobility

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Supplementary Figure 1: Validation of mobility simulation with raw mobile phone data and the travel survey data. **a**, Distributions of stay duration in the simulation and two survey datasets, the 2010 CHTS, and the 2009 NHTS. The peak around 8 hours indicates the working hours of commuters. **b**, Comparison of trip distances among the simulation, the 2010 CHTS, and the 2009 NHTS. **c**, Motif distributions for commuters and non-commuters in the CDRs data and simulation (inset figure is in log scale).
Supplementary Figure 2: Comparisons of fractions of trip departures with surveys by time of the day and trip purpose. The simulated trips with three purposes, home-based-work (HBW), home-based-other (HBO), and non-home-based (NHB), are compared with the 2010 CHTS, and 2009 NHTS, respectively. The lower-right panel shows the fraction of all trips.
Supplementary Figure 3: Distribution of parameters of the TimeGeo model. a, $P(t)$, the global travel circadian rhythm of the population in an average week, for commuters and non-commuters. b, Marginal distribution of the three parameters, $n_w$, $n_w \beta_1$, and $n_w \beta_2$. The distribution of $n_w$ and $n_w \beta_1$ are approximated by log-normal distributions while the distribution of $n_w \beta_2$ is approximated by Weibull distribution. The left column shows the parameters of commuters, and the right column shows those of non-commuters.
Supplementary Figure 4: The fractions of PEV makers and types before Dec. 31, 2013 from CVRP Rebate Statistics datasets. The Clean Vehicle Rebate Project (CVRP) collects the up-to-date data characterizing new-vehicle rebates issued by the Center for Sustainable Energy. For each record, the dataset provides the vehicle ID, application date, vehicle category, vehicle make, and zipcode. Among the records, Nissan Leaf is the most adopted PEV in the research area. The second one is Chevrolet Volt, a plug-in hybrid EV with a smaller battery capacity than Nissan Leaf. Inset: The fractions of three types of PEVs: Barry Electric Vehicle (BEV), Plug-in Hybrid Electric Vehicle (PHEV), and others. The BEV is the major PEV adopted in Bay Area.
Supplementary Figure 5: The estimated PEVs incoming to each zipcode and the number of PEVs from charging sessions data in each zipcode in the Bay Area. It is noteworthy that the charging sessions are provided by a private company with a partial coverage of the market. Even so, we observe reasonable agreement of the most popular destinations for charging.
Supplementary Figure 6: Calibration of charging behavior with the charging station data. 

**a,** Distribution of work hours. The blue curve reflects the distribution of departure time from home of simulated commuters in the Bay Area; The red curve reflects the distribution of departure time from work; the green curve reflects the distribution of start time of the sessions from the charging datasets. The lag between blue and green curves represents the driving time of commuters from home to work in the Bay Area, which is around 30 mins on average.  

**b,** The drivetrain model of Nissan Leaf. The EV energy intensity implies the consumed energy per mile (kWh/mi) when the PEV is traveling at speed $V_{trip}$ (mi/hr).  

**c,** The charging behavior calibration of simulated PEVs. The light red curves reflect the distributions of charged energy of all PEVs in a target zipcode on weekdays in 2013 from charging station data. The dark red curve is the average. The light blue curves reflect the distributions of calibrated energy demand of simulated PEVs, with sessions 200 respectively randomly assigning a charging behavior to each simulated PEV. In our calibration model, the fraction of morning charge, daily charge, and two-days charge are 0.1, 0.35, and 0.55, respectively. The dark blue is the average.  

**d,** The calibration of charging speed. The purple curve reflects the distribution of actual charging speed (charging power per timeslot) from charging station datasets. The charging speeds of simulated PEVs are randomly drawn from the distribution of actual speeds. The dark blue curve reflects the final distribution of charging speeds of simulated PEVs. The two peaks are at $3.3kW$ and $6.6kW$, which are corresponding to the two levels of delivery $120V$ and $240V$. 
Supplementary Figure 7: The decrease in peak power measurements of end bound strategy under varying optimization schemes and $d$. a. The aggregate power curves of the three schemes, Optimal, Motif blind, and Motif aware with end bound strategy. Inset: the percentage peak load of the three schemes. b,c,d, represent the three schemes with different $d$. 
Supplementary Figure 8: The decrease in peak power measurements of flexible strategy under varying optimization schemes and $d$. a, The aggregate power curves of the three schemes with flexible strategy. Inset: the percentage peak load of the three schemes. b,c,d, represent the three schemes with different $d$. 
### Supplementary Table 1: Electric Vehicle Efficiency Ratings in 2014\(^{[2,3]}\)

<table>
<thead>
<tr>
<th>2014 PEV Models</th>
<th>EV Type</th>
<th>Electric Efficiency (kWh/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesla Model S (265-mile range)</td>
<td>BEV</td>
<td>0.38</td>
</tr>
<tr>
<td>Tesla Model S (208-mile range)</td>
<td>BEv</td>
<td>0.35</td>
</tr>
<tr>
<td>Chevrolet Volt</td>
<td>PHEV</td>
<td>0.35</td>
</tr>
<tr>
<td>Nissan Leaf (84-mile range)</td>
<td>BEV</td>
<td>0.30</td>
</tr>
<tr>
<td>Toyota Prius</td>
<td>PHEV</td>
<td>0.29</td>
</tr>
<tr>
<td>2014 Sales-Weighted Average of All EVs</td>
<td>BEVs and PHEVs</td>
<td>0.33</td>
</tr>
</tbody>
</table>

### Supplementary References:

