The state of the EV market and smart charging

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II. Nearly 100 EVs announced by 2023

III. Investment in public charging infrastructure

IV. Rise of higher power DC fast charging

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I. Countries and cities proposing banning gas and diesel cars

<table>
<thead>
<tr>
<th>Country</th>
<th>Proposed Ban</th>
<th>City</th>
<th>Proposed Ban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>2025</td>
<td>Madrid</td>
<td>2020</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2030</td>
<td>Copenhagen</td>
<td>2019</td>
</tr>
<tr>
<td>Germany</td>
<td>2030</td>
<td>Munich</td>
<td>TBD</td>
</tr>
<tr>
<td>India</td>
<td>2030</td>
<td>Stuttgart</td>
<td>TBD</td>
</tr>
<tr>
<td>Scotland</td>
<td>2032</td>
<td>Oslo</td>
<td>2019</td>
</tr>
<tr>
<td>UK</td>
<td>2040</td>
<td>Bogota</td>
<td>TBD</td>
</tr>
<tr>
<td>France</td>
<td>2040</td>
<td>London</td>
<td>2025</td>
</tr>
</tbody>
</table>

- Big announcements
- Details are important
- Many announcement doesn’t contain details
II. US EV sales exceed 856k through May 2018
II. Customer choice increasing with 98 99 EVs by 2023
II. More and more EVs will be SUVs, crossovers, and vans

Source: Dan Bowermaster, Los Angeles, December 2017; www.insideevs.com, accessed 3/28/2018
III. Utilities are proposing ~$2.8B in EV charging infrastructure

Key Challenges
- EV awareness
- Customer education
- Easy and reliable public charging infrastructure (to find, access, use, and pay)
How will charging EVs impact the grid? Two looks

**EPRI Grid Impact Phase 1 Study, 2012**

<table>
<thead>
<tr>
<th>AC Charge Rate of EV</th>
<th>Circuit 1 Needed Upgrades (of 286 Transformers)</th>
<th>Circuit 2 Needed Upgrades (of 292 transformers)</th>
<th>Circuit 3 Needed Upgrades (of 161 transformers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 kW</td>
<td>5 (2%)</td>
<td>7 (2%)</td>
<td>37 (23%)</td>
</tr>
<tr>
<td>6.6 kW</td>
<td>62 (22%)</td>
<td>88 (30%)</td>
<td>103 (64%)</td>
</tr>
<tr>
<td>9.6 kW</td>
<td>192 (67%)</td>
<td>132 (45%)</td>
<td>136 (84%)</td>
</tr>
<tr>
<td>19.2 kW</td>
<td>285 (100%)</td>
<td>229 (78%)</td>
<td>155 (96%)</td>
</tr>
</tbody>
</table>

**California Investor-Owned Utility, EV Upgrade Real World Results, Oct 2017**

<table>
<thead>
<tr>
<th></th>
<th>PG&amp;E</th>
<th>SCE</th>
<th>SDG&amp;E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVs</td>
<td>142,732</td>
<td>108,135</td>
<td>26,498</td>
<td>277,365</td>
</tr>
<tr>
<td>Service Upgrades</td>
<td>228</td>
<td>197</td>
<td>35</td>
<td>460 (0.16%)</td>
</tr>
</tbody>
</table>

Trend 1: Range (in miles) of battery electric vehicles (BEVs) is increasing
Trend 2: here come the big EVs

Sources: CleanTechnica.com, GreenCarReports.com, SchoolBusFleet.com; electrive.com, LG&E and KU, Dan Bowermaster
IV. Both trends are leading to higher power DC fast charging
DC Fast Charger Load Profiles

- “Needle” Peaks
- Load factors under 10%
- Typical C&I customer rate class average of 40 - 50%
Electric Heavy Duty Trucks – Tesla Semi example

- Tesla Semi Class 8 Tractor (preliminary)
  - Range of 300 – 500 miles (2 kWh/mile)
  - Estimate - required usable battery pack 600 – 1000 kWh
  - For recharge - add 400 miles in 30 minutes
    - Average charge rate ~ 1.6 MW
    - Peak charge rate significantly higher
    - ‘Overnight’ recharge rate 100 – 200 kW

- Truck and cargo info (U.S.A.)
  - 50% of shipping ton-miles for trips of < 500 miles; 73% are < 1,000 miles
  - Analysis needed - cost effectiveness, driving patterns, and operational impacts

- Cummins and other truck companies also working on EV and other technologies
- Hydrogen fuel cells or battery exchange could also play a role in the future
DC-as-a-Service Public Working Group
What if utilities provide DC voltage to customers?

Today

UTILITY
MEDIUM VOLTAGE
AC
SERVICE TRANSFORMER

CUSTOMER
AC
User Transformer
DC Bus (~800Vdc)

DC

Future?

UTILITY
MEDIUM VOLTAGE
AC

CUSTOMER
DC

AC

Photos: Dan Bowermaster/EPRI, insideevs.com (2)
V. Reality is crowded and tough: integrated EV charging management has technical, commercial, and regulatory challenges and opportunities.
EPRI, automotive and utility industries jointly developing comprehensive Open Vehicle-Grid Integration Platform (OVGIP)

- Unified, single, open interface to utility or 3rd party DRMS
- Engages all stakeholders in the ecosystem
- Customer-centric with commercialization intent

- V1G first, V2G next
- Platform / applications approach
- Scalable, secure, low-cost
- Phase 2 of development pilot commenced in 2017
Utility-OEM Open Vehicle-Grid Integration Platform has depth
Its use cases directly address VGI roadmap priorities

**VGI Use Case Priorities**

**OVGIP Use Cases**

1. Automated Utility Electricity Rate Tariff Processing
2. Locational Demand Response; Balancing Resource
3. Interface with Home Energy Management System / ESI
4. Interface with Building Energy Management System
5. Pricing Signal Events
6. Interface with EVSE Network Provider
7. Optimized Load Management (ISO/IEC 15118)
8. Vehicle Roaming
9. EVSE Networking Functionality
10. Metering and Data Exchange
11. Customer Enrollment and Administration
Open Vehicle-Grid Integration Platform has breadth
EPRI leading development of expanded platform to support Advanced Energy Communities
What about EVs and natural disasters?

Includes integration with
- Managed Charging
- Vehicle-to-Grid
- MaaS based EVs and DC fast charging
- Portable Storage

Courtesy: Maven GIG, FreeWire, OrbComm, Fiat Chrysler Automobiles, General Motors, Chanje, Inc
Summary: Customer-owned resources and EVs a huge opportunity – if customers accept and market exists

- **Key observations**
  - EVs can be a huge grid resource.
  - Need scalability and security at the lowest possible cost.
  - Successful and beneficial integration of EVs contingent upon reliable availability for them to provide grid services.

- **Key barriers**
  - Technology: How to make technology interoperate reliably and integrate with the grid?
  - Value: How to assess and realize value, including appropriate market mechanisms?
  - Customers: Is any of this non-intrusive, customer-centric and friendly?
Convergence of technical, program, and policy aspects of Electrification

Presentations, panels, and workshops:

- Transportation electrification
- Residential, commercial, and industrial electric technologies
- Emerging technologies – indoor agriculture, additive manufacturing, and others
- Environmental, policy, regulatory aspects of electrification

Large and diverse exhibit hall for all electric technologies

For more information and to join our mailing list, please go to [www.electrification2018.com](http://www.electrification2018.com)
V. Looking Ahead – Today and Tomorrow

- New transportation models
- 200+ mile mass-market battery EVs
- High power charging
- Smart charging programs
- Autonomous driving ($80B invested)
Together…Shaping the Future of Electricity