Cloud-Based Services for Electric Vehicles

April 11, 2012

UC-Santa Cruz
ISM 270
Prof. Kevin Ross

Geoff Ryder, Ph.D.
Sustainability Management & Strategy Team
SAP Labs, Palo Alto
geoff.ryder@sap.com,
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Agenda for April 11, 2012

-1. Introducing SAP

-2. Introducing Electric Vehicles

-3. SAP Innovation: the EV Cloud

-4. ISM 270 Web Programming Homework: Mapping Applications
Introducing SAP

- Households now served by utilities using SAP smart grid / AMI solutions
- Vehicle engines produced per day under mfg processes managed by SAP software
- DJSI has ranked SAP as the #1 sustainable IT company every year since 2007
The Economic Impact of SAP Solutions

- Processing 2.5 billion utility bills per year
- Production of 32,000 car engines per day
- Production of 4 million tons of chemicals per day
- 50 million bank accounts
- 75% of worldwide annual beer production (1.5 billion hectoliter)
- $330 million retail outlet transactions per day
- 54 million annual healthcare patient visits (USA only)
- Production of 40 million barrels of oil per day
- 65% of worldwide chocolate annual production of 2.2 million tons
Introducing Electric Vehicles
How Many EVs are there?

Current US Vehicle Fleet: ~ 246M

US EV Sales, 2015: ~ 1M?

Source: Electrification Coalition
PEVs – Where are the costs?

<table>
<thead>
<tr>
<th>Component System</th>
<th>Conventional Vehicle*</th>
<th>PHEV</th>
<th>BEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Series</td>
<td>Parallel</td>
</tr>
<tr>
<td>Body</td>
<td>26.46</td>
<td>14.7</td>
<td>16.8</td>
</tr>
<tr>
<td>Engine</td>
<td>21.53</td>
<td>11.9</td>
<td>13.7</td>
</tr>
<tr>
<td>Transmission</td>
<td>5.03</td>
<td>2.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Chassis</td>
<td>25.94</td>
<td>14.4</td>
<td>16.5</td>
</tr>
<tr>
<td>Vehicle Assembly</td>
<td>21.04</td>
<td>11.7</td>
<td>13.4</td>
</tr>
<tr>
<td>Motors/Gens/high voltage</td>
<td></td>
<td>13.9</td>
<td>7.8</td>
</tr>
<tr>
<td>High power electronics</td>
<td></td>
<td>5.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Batteries (16P/24B)</td>
<td></td>
<td>24.8</td>
<td>25.1</td>
</tr>
<tr>
<td>Total for electrification</td>
<td>44.5</td>
<td>36.3</td>
<td>48.4</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost (mfg - approx)</td>
<td>$18,000</td>
<td>$32,300</td>
<td>$28,250</td>
</tr>
</tbody>
</table>

* SOURCE: Argonne National Laboratories

Significant cost reduction need/opportunity

- BEV range/performance not same as PHEV
Years of Global Experience with a Wide Range of Customers & Partners

SAP Research & Intel Research, Ireland
- High Performance Computing for EV Analytics
- Home Energy Mgmt. Sys. Integration

SAP Research, Germany
- EU-Wide EV Service Clearinghouse/Mkt
- Consolidated Billing for Roaming Scenarios
- EVs, Renewable Generation, & Smart Grid
- Ride Sharing
- Stromos Electric Vehicle Fleet

Smart Grid Lab
AMI Integration

SAP Labs, Palo Alto
Nissan Leaf Electric Vehicle Fleet

SAP Labs, India
Reva Electric Vehicle Fleet

SAP Singapore
Mobile Computing Initiatives for Urban Transportation

Years of Global Experience with a Wide Range of Customers & Partners
SAP Addresses Three Roadblocks to EV Adoption

1. Lack of Information
2. Lack of Infrastructure
3. Range Anxiety
EV Cloud Platform

Partnering Utility

EV Cloud
SAP & Partner Applications

EV Head Unit / Center Stack
EV Driver’s Mobile Device
EVSE, EV Service Provider
Retail Partner
Regulator, Public Authority
EV Data Sharing & Analytics, Europe: the Green eMotion Project

- **Industries:**
  - ABB, Better Place, Bosch, IBM, SAP, Siemens

- **Utilities:**
  - Danish Energy Association, EDF, Endesa, Enel, ESB, Eurelectric, Iberdrola, RWE, PPC

- **Electric vehicle manufacturers:**
  - BMW, Daimler, Micro-Vett, Nissan, Renault

- **Municipalities:**
  - Barcelona, Berlin, Bornholm, Copenhagen, Cork, Dublin, Malaga, Malmö, Rome

- **Research institutions and universities:**
  - Cartif, Cidaut, CTL, DTU, ECN, Imperial, IREC, RSE, TCD, Tecnalia

- **EV technology institutions:**
  - DTI, FKA, TÜV Nord

+ External stakeholders to facilitate the access to information not held by the consortium, to disseminate Green eMotion knowledge and encourage its application outside the consortium.
Top 5

Five reasons for utilities to join the EV Cloud to help transform their electric vehicle programs
EV Cloud Platform

1. Pre-Purchase & Program Enrollment
2. Data Sharing & Analytics
3. Grid-Aware Charging
4. Unified Statement
5. Green Energy
**Top 5**

1. **Enrollment**
2. Analytics
3. Grid-Aware
4. Statement
5. Green Energy

- **Pre purchase education and financial planning**
  - Prospect EV drivers - education and pre-purchase financial planning
  - Sign EV drivers up for loyalty plans, reward programs
  - Easy to make changes and updates

- **Enroll new EV drivers in energy plans @ Dealership**
  - Information on energy plans, policies
  - New customer enrollment notifications
  - Participating Dealership

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Example of a SAP CRM loyalty program: Centrica
Advanced technology powering the SAP EV Cloud Platform

- Predict EV charging clusters, hot spots, & transformer upgrades
- Data-driven evaluation of new rate structures and business models
Advanced technology from SAP

HANA: High Performance Analytic Appliance

Source: Farber et al. 2011
Top 5

1. Enrollment
2. Analytics
3. Grid-Aware
4. Statement
5. Green Energy

Source: Farber et al. 2011
SAP EV Cloud enables grid-aware charging

- Help drivers understand & take advantage of **TOU pricing**;
- Help enable **automated demand response** to public charge spots and home chargers;
- “Macro DR” for grid support, “Micro DR” to manage hot spots
- Enable demand response **directly to the car**: **proactive response**, **vs. reactive**

…DR not limited by the number of charge spots
The Impact of Electric Vehicle Charging on the Grid

**Problem:** can older poletop transformers in our service territory handle the new load?

- **Orange:** typical peak residential electricity use, kW
- **Blue:** peak EV charging rate, kW

<table>
<thead>
<tr>
<th>Location</th>
<th>kW</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Springdale, AR</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>South Bend, IN</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Dulles, VA</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>Hartford, CT</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tesla, 240V at 80 A</td>
<td></td>
<td>19.2</td>
</tr>
<tr>
<td>PEV, 240V at 32 A</td>
<td></td>
<td>7.7</td>
</tr>
<tr>
<td>PEV, 240V at 15 A</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>PEV, 120 V at 12 A</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

(Research by Arindam Maitra, EPRI, 2010)
Asset Capacity versus EV Penetration Level
(Research by Arindam Maitra, EPRI, 2010)
Scenario: encourage more charging station deployments by managing demand charges

Utility demand charge tariff structure: the electricity bill for a business is based on its peak load during the month.

Allowed rate of charge for retail customers at this address, **controlled / uncontrolled**
Unified statement of charging activity through the SAP EV Cloud

Pull together records of charging activity across SAP partners, and combine into a unified statement inserted into the driver’s residential electric bill or provided via Portal & Mobile Device. Compute metrics of interest to the driver, such as emissions and fuel use avoided.

Mr. Michael Smith
37 Main St.
Redwood City, CA 94062

Billing Period: 02-01-2014 – 02-28-2014

Electricity for Vehicle Use: 332.39 kWh
Cost of Electricity for Vehicle Use: $64.79

GHG Emissions Avoided, kg 293

Gallons of gasoline saved in February 32.5

Monthly Usage by Category

Public Charging 92 kWh
Home: Other Uses
Home: Electric Vehicle Charging 241 kWh

Electricity Used for Vehicles

Oct Nov Dec Jan 2014 Feb
330 kWh
Provisioning green energy offset plans through the SAP EV Cloud

- EV drivers buy **Renewable Energy Credits (RECs)** from SAP partners to offset non-renewable energy consumption.

- For normal vehicle use patterns, this will require **3-5 RECs per year**, where one REC corresponds to 1 MWh of energy.
Summary: EV Cloud Platform

1. Pre-Purchase & Program Enrollment
2. Data Sharing & Analytics
3. Grid-Aware Charging
4. Unified Statement
5. Green Energy
Simple ROI for one charging station, for a small business. One networked pedestal-mount EVSE costs $4K.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>5%, annual</td>
</tr>
<tr>
<td>EVSE Cost</td>
<td>$4,000 (EVSE) + $2,000 (install)</td>
</tr>
<tr>
<td>EVSE lifetime</td>
<td>7 years</td>
</tr>
</tbody>
</table>

With no public subsidy, the charging station must generate ~$1000 per year in revenue or more for the investment to have a positive net present value (NPV). With public subsidy for 50% of total cost → ~$500 per year

Options for revenue:

- (1) Reselling utility company electricity → revenue sharing agreement with EVSE network operator and utility
- (2) Charging more to park by the EVSE (priority classes, fleet discounts?)
- (3) Additional sales volume from higher customer traffic or longer customer stays
- (4) Providing other services for, e.g., municipal government
- (5) Claiming “low-carbon fuel credits” for electricity sold
- (6) Other types of revenue sharing with EVSE network operator
Mobile + Location = Value

Consumers are willing to share location in exchange for something of value...

84% Positive
“Made promotions more useful and valuable”
“Could use right away”

32%
35%
17%
n= 981
Source: ShopAlerts Brand Studies, 2010

...and retailers are paying more for location relevance

Advertiser $CPM Rates

$200 - $1,000

$1 - $12
$1 - $15

Web
Mobile Display
Location-Based

Source: Placecast analysis
Targeting Methods Used in Premium Campaigns

(% of campaigns using each method)

October 2011

Location: 61%
Device capability: 22%
Carrier: 8%
Handset: 5%
Age: 4%

Source: JumpTap
Pricing structures for electrical fuel, considering models from the utility, telecom, airline and oil & gas industries

<table>
<thead>
<tr>
<th>Billing</th>
<th>Fleet</th>
<th>Pre-Pay</th>
<th>Credit</th>
<th>Debit</th>
<th>Cash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiered Rate</td>
<td>Time-of-use</td>
<td>Flat</td>
<td>Service</td>
<td>Real-time</td>
<td></td>
</tr>
<tr>
<td>Price based on volume per period, e.g. 10c for the first 10 kWh, 15c for 10kWh - 20 kWh</td>
<td>Price based on time of use, e.g. 10c for off-peak/ nights &amp; weekends, 25c for peak / daytime</td>
<td>Unlimited use of service, e.g. unlimited text messages or nation-wide calls</td>
<td>Service level price based on service level agreement, e.g. $29.99 for 512kB upload / 6Mb</td>
<td>Real-time market-based prices, e.g. gasoline prices related to oil prices</td>
<td></td>
</tr>
</tbody>
</table>

- **Telecom**
- **Gas Stations**
- **Traditional Utilities**
- **Open for discussion**

**Airline Pricing**
Airlines are another industry with sophisticated pricing models and a service/product with similar characteristics to electricity.

**Overbooking flights** is an particular interesting strategy for maximizing utilization of capacity.
Thank You!

Geoff Ryder, EV Cloud Development Team, SAP Labs - Palo Alto
geoff.ryder@sap.com