Comparing infrastructure costs for hydrogen and electricity

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National Renewable Energy Laboratory

2012 Department of Energy Fuel Cell Technologies Program Annual Merit Review

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# Overview

<table>
<thead>
<tr>
<th><strong>Timeline</strong></th>
<th><strong>Barriers</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start Date: October 2010</td>
<td>4.5 A. Future Market Behavior</td>
</tr>
<tr>
<td>Project End Date: September 2012</td>
<td>• Competition within advanced vehicle market</td>
</tr>
<tr>
<td>Percent Complete: 40%</td>
<td>4.5 E. Unplanned Studies and Analysis</td>
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<tr>
<td>Funding received in FY11: $25k</td>
<td>• Response to DOE request</td>
</tr>
<tr>
<td>Funding for FY12: $50k</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Budget</strong></th>
<th><strong>Partners</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project funding</td>
<td>Reviewers</td>
</tr>
<tr>
<td>• DOE share: $75,000</td>
<td>• TIAx, FPITT, DOE VTP</td>
</tr>
<tr>
<td>• Contractor share: none</td>
<td>• NREL Staff, Center for Transportation Technologies and Systems</td>
</tr>
<tr>
<td>Funding received in FY11: $25k</td>
<td>NREL Project Team</td>
</tr>
<tr>
<td>Funding for FY12: $50k</td>
<td>• M. Melaina, D. Steward, M. Penev</td>
</tr>
</tbody>
</table>
Comparing infrastructure costs for hydrogen and electricity

Analysis compares retail capital costs on a per mile basis between advanced vehicles

Analysis Framework
Data:
• Results from the Hydrogen Station Cost Calculator (HSCC)
• Summary review of multiple current and projected EVSE costs (PIA, etc.)

Models & Tools
• Simple cost comparison model (Excel)
• SERA model

Studies & Analysis
• Market Transformation Analysis
• Long-term Analysis
• Environmental Analysis
• Cross-cut Analysis

Outputs & Deliverables
• Final report
• Inputs to future work with SERA model

• NREL’s Center for Transportation Technologies and Systems (CTTS)
• Fuel Cell Technologies Program
• Vehicle Technologies Program
• UC Davis, TIAX and CEC

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Social benefits of advanced light-duty hydrogen and electric vehicles

Both hydrogen and electric vehicles have the potential to “remove the vehicle from the environmental equation”

• **Climate Change.** Hydrogen and electricity increase the diversity of low-carbon energy resources that can be relied upon to meet long-term greenhouse gas reduction goals.

• **Energy Security.** Hydrogen and electricity supply pathways require very low volumes of petroleum fuels.

• **Air Pollution.** Hydrogen and electric miles driven have zero tailpipe emissions, reducing criteria emissions in urban areas.

**Deployment Goals**

• 1 Million electric vehicles by 2015 \(^{(9)}\)

• California: ~50,000 FCEVs by 2015-2017 \(^{(1,2)}\)
EVSE and hydrogen retail stations are high-risk investments

Many insightful studies have compared vehicles & fuels, but few have focused on retail infrastructure costs.

- Both hydrogen stations and electric vehicle supply equipment (EVSE) systems have been deployed in increasing volumes
- Additional data is starting to become available for more reliable “current” cost estimates
- Future cost estimates are even more uncertain. We apply broad ranges for our cost estimates.
- We do not estimate upstream electricity system costs (transformers, etc.) and therefore underestimate full EVSE costs

Societal lifecycle costs of cars
(Ogden, Williams, Larson 2004)

McKinsey Report
Powertrains for Europe
(McKinsey 2010)

Total cost of ownership
Request for Information
(DOE 2012)
Objectives #1: Apples-to-Apples

Both FCEVs and PEVs have market adoption challenges, but how do retail fueling infrastructure costs compare?

OBJECTIVE #1: Compare retail infrastructure costs on a common transportation energy service basis: per vehicle mile traveled

- Hydrogen and electricity supply pathways have highly variable costs and social benefits, but retail infrastructure can be compared with a lower degree of variability.
- Retail infrastructure carries significant investment risk and will require subsidies as markets develop, justifying side-by-side cost comparisons.
- Early market ramp-up and investment dynamics will be distinct between the two fuel types, but these differences should lessen with mass deployment.
The comparison basis chosen is fueling service to 10% of all light-duty vehicles in a typical 1.5 million person city in 2025.

- A typical 1.5M population city has a population density of 2900 persons/sq mi.
- With 0.8 LDVs per person, the city has 1.2M LDVs; 10% = 120,000 PEVs or FCEVs
- Assume miles driven on electricity or hydrogen per vehicle; estimate cost of required infrastructure per mile driven.

- Generalize costs and fueling patterns to all major U.S. cities
- Incorporate estimates for regional electricity and hydrogen costs
- Compare GHG emissions based upon regional fuel supply pathways
- Include dynamic rollout of vehicles and stations rather than “snapshot”

There is not necessarily one single or best way to establish an apples-to-apples comparison. This approach establishes geographic metrics for future work.
Simple approach; assume quasi-steady state; equivalent market share basis

Our approach focuses on long-term retail costs and attempts to normalize on a “cost per mile” and “city service” basis.

Capital and operating costs are levelized on a gasoline gallon equivalent (gge) basis

\[
\frac{\text{Station & Fuel Cost} ($/\text{gge})}{\text{Fuel Economy} (\text{miles}/\text{gge})} = \text{Cost per mile} ($/\text{mile})
\]

- Capital costs are levelized assuming 10% interest rate and 12-year life
- Fuel costs are estimated as national averages for 2025

City service is base on % share of light-duty vehicles (LDVs) and miles per LDV

\[
\frac{\text{Vehicles}}{\text{City}} \cdot (\% \text{Share}) \cdot \frac{\text{Miles}}{\text{Vehicle-Year}} \cdot ($/\text{mile}) = \frac{\$}{\text{City}}
\]

- Assumes 10% of all LDVs in city are either: fuel cell electric vehicles (FCEV) or plug-in vehicles (PEV) (PEV = BEV & PHEV)
- PEV mix is 20-30% battery electric (BEV) and 70-80% plug-in hybrids (PHEV). PEVs are in ideal households (see next slide).
Initial input assumptions: Vehicle efficiency and miles traveled

**An increase in average electric miles traveled by Plug-in Vehicles (PEVs) is induced in the Robust EVSE scenario**

**Fuel economy** \(^{(4)}\)
- FCEV = 59 mpgge
- PHEV = 45/141 mpgge (g/e)
- BEV = 113 mpgge (321 Wh/mi)
- 85% charging/batt. efficiency

**Battery size (CD range)**
- PHEV = 25 mi; BEV = 100 mi

**Typical daily VMT**
- 33 miles/day on average
- We assume hydrogen refueling is available outside the city to allow for long-distance trips
- PHEVs and BEVs are placed in ideal households (not average) that are able to achieve high annual electric miles despite limited battery size or range \(^{[A]}\)
- Induced miles, see note \(^{[A]}\)

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Next round of input assumptions: Vehciles per station and total capacity

More accurate estimates of station/vehicle ratios would require more robust station business case and consumer utility models.

### Large and Small Hydrogen Stations

<table>
<thead>
<tr>
<th>Station Size</th>
<th>Daily Capacity</th>
<th>Utilization</th>
<th>Number of FCEVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>1500 kg/day</td>
<td>75%</td>
<td>2010 FCEVs</td>
</tr>
<tr>
<td>Medium</td>
<td>500 kg/day</td>
<td>75%</td>
<td>670 FCEVs</td>
</tr>
<tr>
<td>Small</td>
<td>250 kg/day</td>
<td>75%</td>
<td>335 FCEVs</td>
</tr>
</tbody>
</table>

- 75% utilization for dynamic growth (almost steady state)

### Four distinct types of EVSE and two distinct EVSE Scenarios

<table>
<thead>
<tr>
<th>EVSE Type</th>
<th>Home Dominant</th>
<th>Robust Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 – Home</td>
<td>50% PHEVs/0% BEVs</td>
<td>60% PHEVs/20% BEVs</td>
</tr>
<tr>
<td>Level 2 – Home</td>
<td>50% PHEVs/100% BEVs</td>
<td>40% PHEVs/80% BEVs</td>
</tr>
<tr>
<td>Level 2 – Work</td>
<td>43.5 PHEVs or BEVs/L2-W</td>
<td>25 PHEVs or BEVs/L2-W</td>
</tr>
<tr>
<td>Fast Charge</td>
<td>none</td>
<td>84 PHEVs or BEVs/DCFC</td>
</tr>
</tbody>
</table>

#### All PEVs have home EVSE
- Units/City (1000s)
- Large: 48 : 72 : 2.7
- Medium: 58 : 62 : 4.8 : 1.0

More accurate estimates of station/vehicle ratios would require more robust station business case and consumer utility models.
EVSE capacity satisfies daily fluctuations in two distinct PEV charging scenarios

Vehicle-to-EVSE ratios for L2 Work and DCFC are based upon peak hourly demand constraints from simulated charging profiles. The balance of kWh supply is provided by home chargers (1 per PEV).

**Home Charging Scenario**
- Home charging is 86% of all kWh
- With 43 PEVs per Level 2 work EVSE, total capacity is 30% higher than daily peak shown below
- 20% of PEVs are BEVs

**Robust Charging Scenario**
- L2 Work and DCFC are 43% of all kWh
- 25 PEVs per L2 Work = 30% margin
- 84 PEVs per DCFC = 50% margin
- 30% of PEVs are BEVs

Charging profiles are derived from (12) [C]
EVSE station cost estimates

We assume a 15% reduction from today’s EVSE costs due to volume production, streamlined installation & learning.\[D\]

EVSE cost ranges are based on a variety of sources. No attempt was made to correct for specific EVSE attributes.

- Additional real-world data would improve cost estimates
- Installation costs vary greatly
- Ranges shown are not statistical or necessarily consistent between EVSE types
- We do not include upstream costs (transformers, etc.) and therefore underestimate full EVSE costs
- Multi-unit dwelling costs could be lower per cord

Hydrogen cost estimates are reviewed in a separate AMR presentation.
Retail capital costs: Total per city and levelized per mile traveled

City-wide capital costs per mile are within several % points between FCEVs, BEVs and PHEVs

Key Findings

- Capital costs per mile results are essentially indistinguishable given the uncertainty and variability around input assumptions
- Level 2 home chargers carry a relatively high capital costs, but provide high convenience
- Smaller connector and dispersed hydrogen stations limit economies of scale
- Change in capital costs per mile between Home and Robust scenarios is also small

Caveats and Limitations

- Results are sensitive to a number of input assumptions, some of which are highly speculative and simple “back-of-the-envelope” values. Additional empirical data will improve this analytic approach.
What is a realistic distribution of VMT by EVSE type? What will people pay?

To reduce overall costs, increased public EVSE infrastructure must be accompanied by a shift from Level 2 to Level 1 Home charging.

**HOME**
Electricity Use: 0.99M kWh/wk

**ROBUST**
Electricity Use: 1.13M kWh/wk

Consumer preferences, responsiveness to price signals, charging patterns and induced electric VMT will all play an important role in determining the future mix of EVSE types.
Sensitivity analysis of capital/mile

Key Assumptions

- Sensitivities reflect cost variations and uncertainties discussed above
- Cost sensitivities are large: from 2-3 cents per mile
- Hydrogen cost range is primarily due to assumptions about reductions achieved through experience and learning
- EVSE cost ranges are primarily due to uncertainty and variability in equipment and installation costs

Variability and uncertainty suggest more accurate or local/region-specific analyses could result in greater differentiation

Given our assumptions, a Robust EVSE infrastructure slightly reduces BEV costs per mile due to increased L1 Home charging, and slightly increases PHEV costs per mile due underutilized L2 Home EVSE
Total fuel costs per vehicle mile

Central values for total fuel costs suggest BEV and PHEV costs 19-16% lower than FCEV costs, but sensitivities are skewed high.

Key Assumptions for 2025
- Cost of hydrogen delivered to the retail station: $3.00/kg[^B]
- Cost of electricity:
  - $0.11/kWh Resid. (Home)
  - $0.095/kWh Comm. (Public)
  - AEO 2012 Early Release
- Cost gasoline: $4.02/gal (AEO)
- Fuel Economies
  - FCEV: 59 mpgge
  - BEV: 113 mpgge
  - PHEV: 141/45 mpgge (e/g)
  - HEV: 49 mpg
  - ICE: 33 mpg

PEV costs shown are for the Home scenario. Robust costs are 4-6% lower.
Including fuel economies and vehicle costs, FCEV and BEV costs per mile are comparable. PHEVs are ~10% less per mile.

Key Assumptions

- Vehicle fuel economy and cost ranges are from DOE RFI (2012)
- Future gasoline prices are more uncertain and variable than electricity or hydrogen prices
- Low-carbon fuels would tend to be more expensive

- Including a $150/tonne CO₂e carbon price signal tends to level out cost comparisons (assuming average grid in 2025 from AEO, hydrogen from central natural gas, and conventional gasoline)

Increasing BEV daily VMT to be comparable to FCEVs is key to comparable costs
Collaboration

Multiple types of reviews have been completed

- Hydrogen station costs based upon HSCC feedback from topic/industry experts
- Review with NREL Staff within the Center for Transportation Technologies and Systems
- Review with the USDRIVE Fuel Production and Integration Tech Team (ExxonMobil, Chevron, Shell Oil Products, ConocoPhillips and Air Products and Chemicals, Inc.)
- Review with DOE Staff in the Vehicle Technologies Program
- Review with analysts at the Institute of Transportation Studies at UC Davis
- Collaborative review with TIAX and California Energy Commission is in progress

Work contributes to ongoing scenario analysis activities

- Additional stakeholder input could be integrated as broader scenario assumptions are developed
Future work: geographic variability

Fuel costs vary by city and region
- Gasoline and electricity price baselines are important for determining competitive advantage and social benefits
- Consumer adoption patterns and preferences also vary locally/regionally

Low carbon energy resources vary regionally in cost and GHG intensity
- Biomass resources and low carbon electricity supply can be regional
- Hydrogen supply pathways also vary regionally in cost and GHGs
Role of consumers, infrastructure investors and incentives

Relative benefits/advantages of vehicle drivetrains depend upon consumer preferences

- Fueling behavior and preferences will determine the premium consumers offer for increased convenience
  - Future work is needed in this area
- Vehicle utility will vary across adopter types
- Vehicle and fuel subsidies will influence consumer behavior and investor behavior
- Investment business case analysis is needed to understand most effective policies

Population density needs to be taken into account

- Example: Consumers in New York vs. Atlanta
- EVSE and hydrogen stations should be utilized more efficiently in higher density cities
Project Summary

Relevance
• Electricity and hydrogen can provide sustainable fuel to vehicles
• Retail infrastructure costs are a significant market barrier for each

Approach
• Comparing EVSE and hydrogen station on an apples-to-apples basis. Examine a hypothetical city of 1.5M persons and 10% advanced LDVs
• Costs per mile and per city are compared
• Sensitivities are run on cost estimates and vehicle cost/performance

Technical Accomplishments and Progress
• Capital costs for retail equipment appear to be very similar between EVSE and hydrogen stations over the long term, with the VMT distribution and utilization of EVSE infrastructure by type being a key factor
• Consumer expectations and premiums on convenience are key to $/mile costs
• Long-term costs of low-carbon hydrogen and electricity may shift advantage

Collaboration
• Multiple reviews have been conducted

Proposed Future Research
• Geographic variability and consumer/investor behavior
Technical Backup Slides
Costs for Level 1 Residential EVSE

**Explanation of Level 1 Residential Costs**

- **CENTRAL** equipment costs are the median of all equipment types shown in figure above. CENTRAL Installation costs are average of MRW and SLZK-H.
- **HIGH/LOW** costs are equal to the CENTRAL value plus/minus 33% of the difference between the CENTRAL value and the highest and lowest values for equipment and installation.
- Note that Morrow installation cost assumes a new 20A circuit. May not need this in all residences.

### Table: Level 1 Residential Cost Breakdown

<table>
<thead>
<tr>
<th>Value Type</th>
<th>Equipment</th>
<th>Installation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>$475</td>
<td>$302</td>
<td>$777</td>
</tr>
<tr>
<td>Low</td>
<td>$318</td>
<td>$202</td>
<td>$520</td>
</tr>
<tr>
<td>High</td>
<td>$569</td>
<td>$352</td>
<td>$921</td>
</tr>
</tbody>
</table>

### Diagram

- **CENTRAL**
- **HIGH**
- **LOW**
- **MRW-1R**
- **PSNC**
- **VLT**
- **CC-15**
- **SLZK-L**
- **SLZK-H**
- **Legrand**
- **LvtnG120**

\[\begin{align*}
\text{Value Type} & \quad \text{Equipment} & \quad \text{Installation} & \quad \text{Total} \\
\text{CENTRAL} & \quad 475 & \quad 302 & \quad 777 \\
\text{Low} & \quad 318 & \quad 202 & \quad 520 \\
\text{High} & \quad 569 & \quad 352 & \quad 921 \\
\end{align*}\]

### Symbols and References

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Reference</th>
<th>Notes</th>
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<tbody>
<tr>
<td>SLZK</td>
<td>DOE 2011</td>
<td>L: Low; H: High.</td>
</tr>
<tr>
<td>MRW</td>
<td>Morrow 2008</td>
<td>1R: Level 1 Residential</td>
</tr>
<tr>
<td>PSNC</td>
<td>PIA 2012</td>
<td>Panasonic; Standard for Leaf</td>
</tr>
<tr>
<td>CC-15</td>
<td>PIA 2012</td>
<td>Clipper Creek; 15 A</td>
</tr>
<tr>
<td>VLT</td>
<td>PIA 2012</td>
<td>Standard with Volt</td>
</tr>
<tr>
<td>LvtnG120</td>
<td>PIA 2012</td>
<td>Comes with carrying case.</td>
</tr>
<tr>
<td>Legrand</td>
<td>PIA 2012</td>
<td>Legrand. Selects rate charge.</td>
</tr>
</tbody>
</table>

Includes mix of 10-15 Amp systems.
Costs for Level 2 Residential EVSE

Explanation of Level 2 Residential Costs

- CENTRAL equipment costs are median of all values shown. Installation CENTRAL costs are derived from estimates of median values from CFCI’s average East/West coast historical costs (in contrast to recent costs with increased labor), assuming median values are 13% less than average values.

- HIGH/LOW costs are equal to the CENTRAL value plus/minus 33% of the difference between the CENTRAL value and the highest and lowest values for equipment and installation.

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<table>
<thead>
<tr>
<th>Value Type</th>
<th>Equipment</th>
<th>Installation</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Central</td>
<td>$998</td>
<td>$1,320</td>
<td>$2,318</td>
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<tr>
<td>Low</td>
<td>$820</td>
<td>$1,011</td>
<td>$1,831</td>
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<tr>
<td>High</td>
<td>$1,583</td>
<td>$2,710</td>
<td>$4,293</td>
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Includes mix of 16-32 Amp systems.

Symbol Reference Notes

LEVEL 2 - Residential

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRW</td>
<td>Morrow 2008</td>
<td>2R: Level 2 Residential</td>
</tr>
<tr>
<td>CC</td>
<td>PIA 2012</td>
<td>Clipper Creek; LCS: model</td>
</tr>
<tr>
<td>ECO</td>
<td>PIA 2012</td>
<td>Ecotality Blink</td>
</tr>
<tr>
<td>GE</td>
<td>PIA 2012</td>
<td>General Electric</td>
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<tr>
<td>SCHDR</td>
<td>PIA 2012</td>
<td></td>
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<tr>
<td>SPX</td>
<td>PIA 2012</td>
<td></td>
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<tr>
<td>CFCI</td>
<td>Joffe 2010</td>
<td>Clean Fuels Connection; L: Low; H: High; Med: Median; EC: East Coast; WC: West Coast</td>
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<td>LvtnGrn</td>
<td>PIA 2012</td>
<td>Leviton Evr-Green 160</td>
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<tr>
<td>GM-Vltc</td>
<td>PIA 2012</td>
<td>SPX and GM, made for Volt.</td>
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<tr>
<td>Aero</td>
<td>PIA 2012</td>
<td>Estimated value (not official).</td>
</tr>
<tr>
<td>GE-Behar</td>
<td>PIA 2012</td>
<td>GE, designed by Yves Behar.</td>
</tr>
<tr>
<td>EV2100</td>
<td>PIA 2012</td>
<td>EV-Charge America, EV2100</td>
</tr>
<tr>
<td>SLZK</td>
<td>DOE 2011</td>
<td>L: Low; H: High.</td>
</tr>
</tbody>
</table>
Costs for Level 2 Commercial and DCFC

Morrow estimate is per 5 cords, based on a 10 cord system. Thus lower estimated installation costs.

Explanation of Level 2 Commercial costs

• CENTRAL equipment costs are median of all values shown. Installation CENTRAL costs are equal to CFCI-L2-Ave, which is the average for L2 public installations.

• HIGH/LOW costs are the CENTRAL value plus/minus 33% of the difference between the CENTRAL value and the highest and lowest values for equipment and installation.

<table>
<thead>
<tr>
<th>Value Type</th>
<th>Equipment</th>
<th>Installation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>$2,950</td>
<td>$4,135</td>
<td>$7,085</td>
</tr>
<tr>
<td>Low</td>
<td>$2,846</td>
<td>$3,123</td>
<td>$5,969</td>
</tr>
<tr>
<td>High</td>
<td>$3,462</td>
<td>$4,481</td>
<td>$7,943</td>
</tr>
</tbody>
</table>

DCFC equipment CENTRAL costs are median of values below ($27,500) plus $15,000 installation (= ave. SLZK $10-$20k).

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>SLZK</td>
<td>DOE 2011</td>
<td>L: Low; H: High.</td>
</tr>
<tr>
<td>Shrp ePump</td>
<td>PIA 2012</td>
<td>Shorepower, multi-head</td>
</tr>
<tr>
<td>MRW</td>
<td>Morrow 2008</td>
<td>2R: Level 2 Residential</td>
</tr>
<tr>
<td>CC</td>
<td>PIA 2012</td>
<td>Clipper Creek; LCS: model</td>
</tr>
<tr>
<td>ECO</td>
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<tr>
<td>Shrp ePump</td>
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<td>Shorepower, multi-head</td>
</tr>
</tbody>
</table>
**Additional Notes**

[A] PHEV miles: An equation based upon SAEJ1711 predicts 37% of VMT as electric for 25 mile battery PHEVs. Our estimate of 20 miles is therefore optimistic, and would not be representative across all households. BEV miles: Few longitudinal vehicle travel data sets exist to validate driving patterns for consumers who do not require long-range vehicles. The Puget Sound Regional Council’s 2007 Traffic Choices Study (5) dataset is one of few that contains the necessary daily driving pattern distributions from households in the Seattle urban area. NREL’s analysis of 398 vehicles from this study over a 3 month control period finds that 7.5% of vehicles did not drive over 100 miles in any given day within the 3 month period and also drove 30 or more miles per day on average. Seattle is a large urban area, but given that BEVs may also be shared among drivers within some households, our 31.1 mile daily average for 2% of vehicles in the nominal city is reasonable. Induced miles: the increase in electric VMT is a back-of-the-envelope estimate. While some data exist for driving patterns today with PEVs, a larger sample would be required to control for EVSE availability as a causal factor.

[B] Multiple production and delivery pathways would be involved. The nominal values of $3.00/kg is intended to be generic, but could be associated with (for example) $2.00/kg for production at a central natural gas SMR unit and $1.00/kg for multiple delivery modes.

[C] Parks, Denholm and Markel (2007) develop 4 hourly charging scenarios. Home L1 and L2 charging profiles are based upon the “Off-Peak Charging” scenario representing a utility-controlled schedule for off-peak charging. The L2 work and DCFC public profiles are based upon portions of the “Continuous Charging” scenario, with the work profile being the portion between 7 AM and 5 PM, and the DCFC public charging being the other hours of the day, with a peak from 5-7 PM. The “Uncontrolled” and “Delayed” scenarios were not used. Use of the Continuous Charging” or “Opportunity Charging” profile is most relevant, as it determines capacity margins for L2 Work and DCFC infrastructure.

[D] The 15% cost reduction is a back-of-the-envelope type estimate. Sufficient experience has not been accumulated with EVSE costs to develop an empirical experience curve (11). The 15% cost reduction for mass-market adoption could be referenced to an experience curve Progress Ratio of 98.5, assuming approximately 40 MW of installed capacity by 2013 (see http://www.theevproject.com), and a national cumulative of 53,000 MW (~25 times our generic city). This would be representative of a relatively mature technology with little cost reduction potential, a description that may apply to basic components of an EVSE system, but may not apply to new communications technology (which could reduce in cost) or cost components such as fees, permitting and labor (which may not go down significantly in cost). A more detailed breakdown of cost components by EVSE type and assessment of reduction potential would be needed to develop a more robust cost reduction estimate. Our estimate is relatively conservative, yet it is not an assumption that the technology will “stand still” from a cost perspective. In terms of uncertainty and lack of empirical data, this assumption is on par with our other estimates on absolute costs and EVSE distributions by type.
References


