2011 DOE Vehicle Technologies Program Review Presentation

Smith Electric Vehicles:
Advanced Vehicle Electrification + Transportation Sector Electrification
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Smith Electric Vehicles- US Corp
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Overview

Timeline
>Start- April 2010
>Finish- October 2013
>27% Complete to date

Barriers & Risks
>Immature supply chain
>Component cost vs diesel
>Development of data transfer system

Budget
Total Project Funding-
>DOE $32M
>Smith US $36M
>DOE funding received to date $8.7M

Partners/Collaborators
>Smith UK
>Initial customers
>Suppliers
>Institutions
Objectives/Relevance

Relevance to American Recovery and Reinvestment Act-

• Accelerate the development, production and acceptance of AEV’s in the US commercial market to substantially reduce petroleum consumption, reduce vehicular emissions of greenhouse gases, increase energy security, and create US jobs.

Project Objectives-

• Manufacture and sell to customers 510 medium duty commercial All Electric Vehicles (AEVs) operating under various conditions in several geographical regions of the US;
• Collect and submit to the National Renewable Energy Laboratory (NREL) 2 to 3 years of performance data from the Smith-developed telemetry system;
• Develop Second Generation powertrain, battery and charging systems to enhance performance and reduce overall vehicle cost.
• Create 225 new jobs at Smith US.
## Project Milestones

<table>
<thead>
<tr>
<th>Milestone Title</th>
<th>Milestone Description</th>
<th>Planned Start Date</th>
<th>Planned End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Customer Program Vehicle Build Complete for Project</td>
<td>Initial vehicle deliveries as part of the project</td>
<td>4/1/2010</td>
<td>4/30/2010</td>
</tr>
<tr>
<td>Installation of telemetry system on initial customer program vehicle</td>
<td>Vehicle data received on Smith Servers</td>
<td>9/1/2010</td>
<td>10/31/2011</td>
</tr>
<tr>
<td>Initial customer vehicle initial data capture and reporting to DOE</td>
<td>Send complete data set to DOE for initial vehicles</td>
<td>11/1/2010</td>
<td>6/30/2013</td>
</tr>
<tr>
<td>Customer vehicle final data capture and reporting to DOE</td>
<td>Final data receipt from vehicles and final report submission to the DOE</td>
<td>10/31/2010</td>
<td>10/4/2013</td>
</tr>
<tr>
<td>255 Vehicles Deployed under program</td>
<td>Halfway point of vehicle deployment</td>
<td>4/1/2010</td>
<td>3/31/2011</td>
</tr>
<tr>
<td>Vehicle Deployment Complete</td>
<td>Final Vehicle deployed under program</td>
<td>4/1/2010</td>
<td>10/31/2011</td>
</tr>
</tbody>
</table>
Approach

- Transfer the technology and expertise of Smith UK to the Smith US through deployment of proven processes and training of US employees.
- Obtain purchase orders from key major US customers from various industries to purchase the vehicles and participate in the demonstration project.
- Complete the homologation of the current Newton platform to Department of Transportation (DOT) requirements.
- Establish technical teams focused on development of second generation vehicle systems using a “stage and gate” project management approach.
- Establish an ISO 9001 Quality Assurance plan.
- Environmental (NEPA status) and Safety—build vehicles that meet California Air Resources Board Zero Emissions Standards and NHSTA safety requirements. NEPA approval was obtained February 2010 (Categorical Exclusion CX-B).
Approach (continued)

- 88% of the $32M DOE/ARRA Grant will be paid to commercial AEV buyers participating in the DOE Electric Fleet Data Collection Program.
  - Upon signing an agreement at the time of purchase order, the customer agrees to participate in either a two or three year data collection program.
  - The amount paid to each participation client is based upon the duration of participation and the value of the vehicle.
  - Data is transmitted wirelessly real-time via the Smith telemetry system to secure servers located at the Smith US Missouri facility.
- The remaining 12% of the Grant is a 32.3% reimbursement of Project Development costs.
Technical Accomplishments and Progress

- Homologation of the Smith UK Newton platform to DOT requirements.
- Successfully transferred to Smith US the Smith UK proven technology to design and build AEVs on the existing Newton platform.
- Successful localization of the supply base where applicable.
- Initiated second generation development programs for battery, drivetrain and charger systems.
- Established a manufacturing facility.
- Obtained confirmed program related orders from qualifying customers for 235 vehicles, of which 147 have been delivered.
- Successfully developed, implemented and gained NREL approval of the Smith Data Acquisition and Reporting System. Data transfer to the NREL commenced November 2010.
- Established ongoing cost down and quality improvement initiatives.
Technical Accomplishments and Progress - Products

Smith US Boom Truck for P,G&E

Smith US stake-bed, flat bed for KCP&L

Smith US refrigerated box for Down East

Smith US box vans for AT&T, Coca Cola, Staples
Collaborations/Partnerships

Collaborations:
– Smith UK - Smith US initially obtained a license in perpetuity for Smith technology within North America.
– Institutions - colleges and universities assistance on technological research & development, education and training.

Partnerships:
– Customers who have purchased vehicles and are working directly with Smith US in specifying product improvements and developing customer-centric options:
  – Geographically dispersed
  – Varying market sectors
– Suppliers
  – First Generation product suppliers working with Smith US on continuous improvement
  – Second Generation product suppliers
Future Work

• Meet the 510 vehicle deployment milestone of October 31, 2011;
• Transfer vehicle operating data monthly to the NREL-DOE to contract completion;
• Develop and validate the Generation 2 systems;
• Continue recruiting and training of key technical and operating staff;
• Continue to improve the production and assembly processes, and product quality;
• Continue to develop and improve the telemetry system;
• Develop regional service support;
• Strengthen the supply chain and reduce costs;
• Attend and demonstrate at local, regional and national exhibitions and conferences to advance interest in AEV technology.
Summary

- **Objectives/Relevance** - Manufacture and sell 510 commercial all electric vehicles in 18 months, and deliver to the NREL 2 to 3 years of operating data in order to accelerate the development and production of electric drive vehicle systems in the US to reduce petroleum consumption, reduce vehicular emissions of greenhouse gases, promote US energy security, and create 225 new US jobs.

- **Approach** - Utilize existing Smith UK technology and systems to develop a Smith US DOT-compliant all electric commercial vehicle for various industries in several geographical regions of the United States.

- **Technical Accomplishments** - Developed GPS-based operational monitoring system; made significant progress towards Generation 2 AEV drive, charging and battery systems; created 95 new US jobs; reduced supplier costs.

- **Collaborations/Partnerships** - Licensed with Smith UK for technology transfer and engineering/manufacturing training and assistance; worked with educational institutions on technology, education and training; made agreements with commercial industry leading companies to purchase Gen 1 vehicles; worked with vendors to improve supply chain.

- **Future Work** - Continuous improvements to existing manufacturing processes; hire and train new US workers; meet order/delivery milestones for the 510 vehicle demonstration; complete the Gen 2 projects and secure intellectual property; drive down purchase and manufacturing costs of primary and secondary components.
Summary (Continued)- Meet the Team
Technical Backup Slides
# Technical Backup

## Carbon Footprint Comparison

### Select Vehicle and Area

<table>
<thead>
<tr>
<th>Smith Vehicle kWh</th>
<th>Comparable Vehicle Class</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>Class 6</td>
<td>US</td>
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</tbody>
</table>

### Electric Vehicle GHG emissions are:

- 3.10% of Gasoline Vehicles
- 11.36% of Diesel Vehicles
- 16.38% of CNG Vehicles
- 17.60% of Propane Vehicles
- 14.77% of Diesel Hybrid Vehicles

### Electric Vehicle GHG emissions are:

- 50.30% cleaner than Gasoline Vehicles
- 88.64% cleaner than Diesel Vehicles
- 83.02% cleaner than CNG Vehicles
- 82.20% cleaner than Propane Vehicles
- 82.23% cleaner than Diesel Hybrid Vehicles

### Vehicle Footprints by Fuel and Daily Range

#### Smith Electric Vehicle Carbon Footprint

- Total pounds GHGs emitted per daily range: 30.33Kg
- Total short tons GHGs emitted per daily range: 0.01516T

#### CNG Vehicle Footprint

- Total pounds GHGs emitted per daily range: 178.7Kg
- Total short tons GHGs emitted per daily range: 0.0835T

#### Gasoline Vehicle Footprint

- Total pounds GHGs emitted per daily range: 335.4Kg
- Total short tons GHGs emitted per daily range: 0.1657T

#### Propane Vehicle Footprint

- Total pounds GHGs emitted per daily range: 179.4Kg
- Total short tons GHGs emitted per daily range: 0.0852T

#### Diesel Vehicle Footprint

- Total pounds GHGs emitted per daily range: 267.0Kg
- Total short tons GHGs emitted per daily range: 0.1353T

#### Diesel Hybrid Footprint

- Total pounds GHGs emitted per daily range: 295.4Kg
- Total short tons GHGs emitted per daily range: 0.1627T

### Formulas:

**SEV**

\[
\text{GHGs} = (\text{KWH} \times \text{Emissions Factor Coal/Percentage Coal}) + (\text{KWH} \times \text{Emissions Factor Oil/Percentage Oil}) + (\text{KWH} \times \text{Emissions Factor Gas/Percentage Gas}) + (\text{KWH} \times \text{Emissions Factor Nuclear/Percentage Nuclear}) + (\text{KWH} \times \text{Emissions Factor Renewables/Percent Renewable}) + (\text{KWH} \times \text{Emissions Factor Biomass/Percent Biomass})
\]

**Gas and Diesel**

\[
\text{GHGs} = (\text{Miles Driven} \times \text{Miles per Gallon}) \times \text{CO2 Emissions Factor} \times \text{CH4 & NO2 Emissions Factor}
\]

**CNG**

\[
\text{GHGs} = (\text{Miles Driven} / \text{Fuel Economy}) \times \text{Pounds CO2} + (\text{Pounds CH4/Mile} \times \text{Miles}) + (\text{Pounds N2O/Mile} \times \text{Miles})
\]

**Propane**

\[
\text{GHGs} = (\text{Miles Driven} / \text{Effective Fuel Economy}) \times (\text{Pounds CO2} + (\text{Pounds CH4/Mile} \times \text{Miles}) + (\text{Pounds N2O/Mile} \times \text{Miles})
\]

**Diesel Hybrid**

\[
\text{CO2 Equivalent} = (\text{Miles Driven/Net Fuel Economy}) \times (\text{CO2 Emissions Factor} \times \text{CH4 & NO2 Emissions Factor})
\]

**Symbols:**

- SEV: Smith Electric Vehicles
- GHG: Greenhouse Gas
- CNG: Compressed Natural Gas
- CO2: Carbon Dioxide
- CH4: Methane
- NO2: Nitrogen Dioxide
- Pounds (lbs): Unit of mass, 16 ounces.
- Short Tons: A unit of weight equal to 2000 pounds, distinct from the measure of metric tons (1000 kilograms).
Technical Backup (Continued)

One 80 kWh Newton vehicle, operated for 1 year (260 days) on a normal daily range, will emit approximately 61,500* fewer pounds of greenhouse gases than a similar Class 6 diesel truck.

* This statistic is calculated from the data on the previous slide.
## Technical Backup (Continued) - Data Sources

### Fuel Sources and Assumptions

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Sources</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Energy Mix: Argonne National Lab; GREET 1.8 R.0; <a href="http://greet.ans.net/greet">http://greet.ans.net/greet</a></td>
</tr>
</tbody>
</table>

### Gas and Diesel

- **CO₂ Content of Diesel**: 44.4 lbs per gallon - 277 lbs
- **CO₂ Content of Gasoline**: 44 lbs per gallon - 242 lbs
- **Oxidation Factor**: 0.98
- **Molecular Weight of CO₂**: 44
- **Molecular Weight of Carbon**: 12
- **Total Grams CO₂ in Gasoline**: 10,084
- **Total Grams CO₂ in Gasoline - Fuel Economy**: 9,798
- **Total Pounds CO₂ in Gasoline - Fuel Economy**: 22.2
  - **Total Pounds CO₂ in Gasoline - Fuel Economy**: 18.4

### CO₂ & NOₓ Emissions (Gas and Diesel)

- **CO₂ Estimate Multiplied by**: 1.056

### Coal

- **CO₂ Content of Natural Gas**: 54.06 lbs per cubic foot
- **CO₂ Content of Natural Gas ( uncompressed)**: 128 lbs
- **CO₂ Content of Natural Gas (compressed)**: 36 lbs

### Other

- **Global Warming Potentials of Greenhouse Gases Relative to CO₂**
  - **Sources**: GREET 1, Version 1.0 R.0; http://greet.ans.net/greet
## Technical Backup (Continued)

### 80 kWh Newton Model: Technical Specifications

<table>
<thead>
<tr>
<th>Wheelbase WB (in)</th>
<th>GVW (lbs)</th>
<th>Chassis Curb Weight (lbs) *</th>
<th>Payload (lbs)</th>
<th>Overall Length OL (in)</th>
<th>Overall Height OH (in)</th>
<th>Overall Width OW (in)</th>
<th>Deck Length DL (in)</th>
<th>Cab to Axle CA (in)</th>
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</thead>
<tbody>
<tr>
<td>154</td>
<td>16,500</td>
<td>9,392</td>
<td>7,121</td>
<td>268</td>
<td>94-98</td>
<td>87</td>
<td>191</td>
<td>126</td>
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<td></td>
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<td>9,700</td>
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<td></td>
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<td>266</td>
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<tr>
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<td>10,121</td>
<td>16,312</td>
<td>344</td>
<td>94-99</td>
<td>87</td>
<td>268</td>
<td>173</td>
</tr>
</tbody>
</table>

* Values based on 80kwh model

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**Motor**: 120 kw induction

**Controller**: Vector control AC system with regenerative braking

**Batteries**: Lithium-Ion Iron Phosphate

**Charger**: Fully automatic - cable included

**Cab**: All steel two door with hydraulic lift, zinc coated panels with wax filled cavities and thermal insulation

**Interior**: Drivers seat, dual passenger seat, Sony stereo CD

**Steering**: Hydraulic PAS monoblock

**Suspension**: Front & rear, parabolic springs with transverse torsion bar stabilizer, hydraulic double acting shock absorbers

**Brakes**: Dual circuit, air brake system with WABCO ABS, air dryer parking brake, fail safe spring operated park brake to rear axle

**Chassis**: Ladder type, cold riveted and bolted with U-section side members and open profile cross members-steel

**Wheels**: 17.5 x 6.00 steel rims (16,500 lbs - 22,000 lbs), 245/70R17.5 tires on 17.5 x 6.75 steel rims, 8 stud fixing (26,400 lbs)

**Tires**: 215/75R 17.5

**Warranty**: 36 months bumper-to-bumper, 36 months drive train