2011 DOE Vehicle Technologies Program Review Presentation

Smith Electric Vehicles:
Advanced Vehicle Electrification + Transportation Sector Electrification
Robin Mackie-Presenter & Principal Investigator
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

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

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.
- Smith US- acquired Smith UK at January 1, 2011, thus securing all Intellectual Property internationally to the product.
- 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

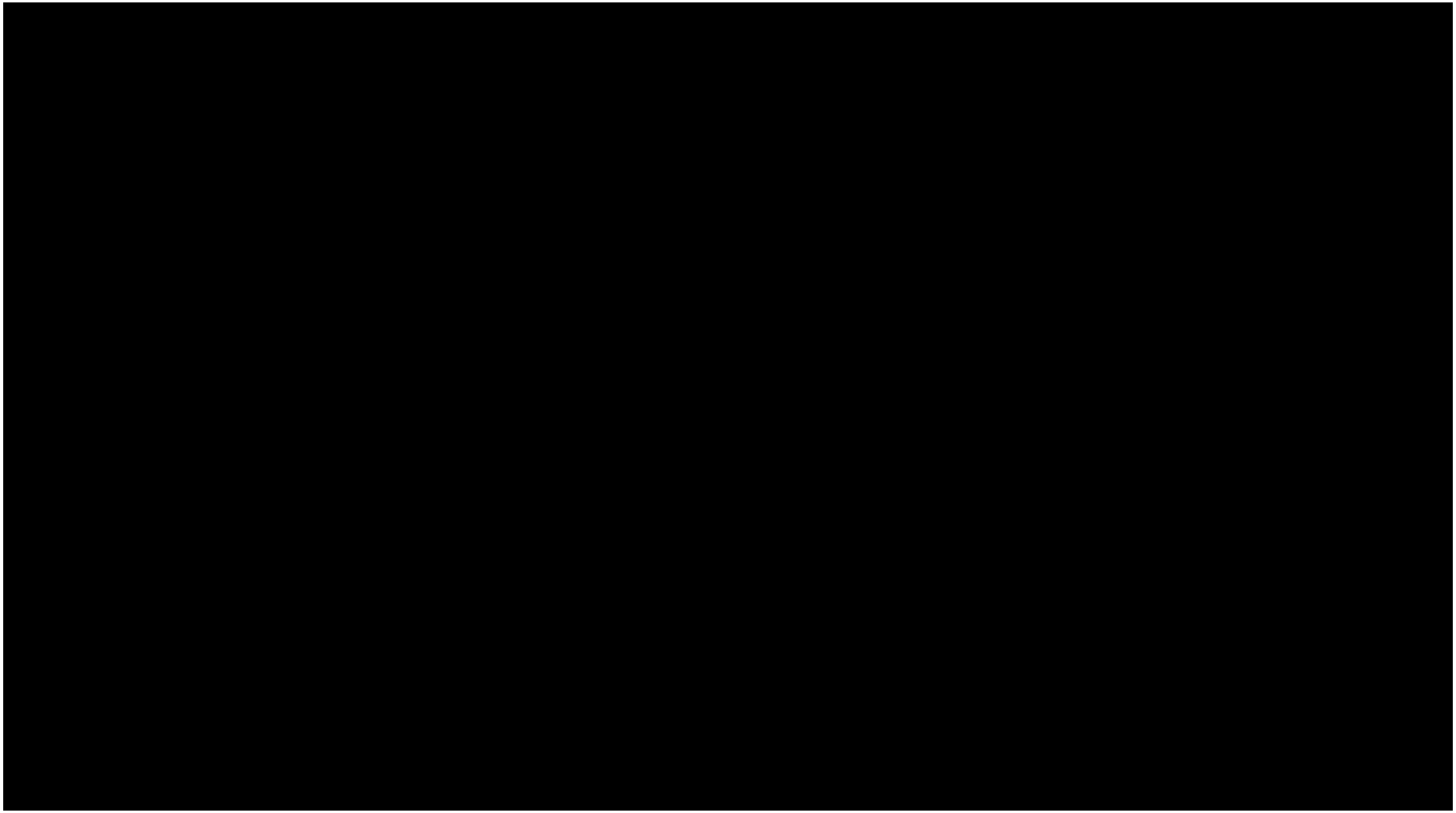
Future Work

- 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

SMITH ELECTRIC VEHICLES

Select Vehicle and Area		
Smith Vehicle kWh	Comparable Vehicle Class	State
80	Class 6	US

Electric Vehicle GHG emissions are:	
9.10	% of Gasoline Vehicles
11.36	% of Diesel Vehicles
16.98	% of CNG Vehicles
17.80	% of Propane Vehicles
14.77	% of Diesel Hybrid Vehicles

Electric Vehicle GHG emissions are:	
90.90	% cleaner than Gasoline Vehicles
88.64	% cleaner than Diesel Vehicles
83.02	% cleaner than CNG Vehicles
82.20	% cleaner than Propane Vehicles
85.23	% cleaner than Diesel Hybrid Vehicles

Vehicle Footprints by Fuel and Daily Range

Smith Electric Vehicle Carbon Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
30.33965614	0.015169828

CNG Vehicle Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
178.7197609	0.08935988

Gasoline Vehicle Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
333.4049409	0.16670247

Propane Vehicle Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
170.4611415	0.085230571

Diesel Vehicle Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
267.0676692	0.133533835

Diesel Hybrid Footprint	
Total *pounds* GHGs emitted per daily range	Total short *tons* GHGs emitted per daily range
205.4366686	0.102718334

Glossary:

SEV - Smith Electric Vehicles
GHG - Greenhouse Gas
CNG - Compressed Natural Gas
CO_2 - Carbon Dioxide, a greenhouse gas.
CH_4 - Methane, a greenhouse gas.
NO_2 - Nitrogen Dioxides, a greenhouse gas.

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).

Formulas:

SEV	GHGs = (KWH*Emissions Factor Coal*Percentage Coal) + (KWH*Emissions Factor Oil*Percentage Oil) + (KWH*Emissions Factor Gases*Percentage Gases) + (KWH*Emissions Factor Nuclear*Percentage Nuclear) + (KWH*Emissions Factor Renewables*Percent Renewable) + (KWH*Emissions Factor Biomass*Percent Biomass)
Gas and Diesel	GHGs = (Miles Driven/ Miles per Gallon) * CO2 Emissions Factor * CH4 & NO2 Emissions Factor
CNG	GHGs = ((Miles Driven / Fuel Economy) * Pounds CO2) + (Pounds CH4/Mile * Miles) + (Pounds N20/Mile *Miles)
Propane	GHGs = (Miles Driven / Effective Fuel Economy) * (Pounds CO2) + (Pounds CH4/Mile * Miles) + (Pounds N20/Mile * Miles)
Diesel Hybrid	CO2 Equivalent = (Miles Driven/Net Fuel Economy)*(CO2 Emissions Factor)*(CH4 & NO2 Emissions Factor)

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

Electricity

Fuel	CO2AWh*	CH4AWh*	NO2WWh
Coal	0.789986496	0.0000118	0.0000206
Oil	0.614296047		
Gases	0.445245584		
Nuclear	0		
Renewable	0		
Biomass	0.812978637		

*All in pounds

Sources:
Formula & Emissions Factors: IPCC Guidelines for National Greenhouse Gas Inventories; http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
Energy Mix: Argonne National Lab GREET 1.8c.0; http://greet.es.anl.gov/
State Energy Mix: U.S. Energy Information Administration; http://www.eia.doe.gov/cneaf/electricity/epm/table1_6_a.html

Gas and Diesel

CO_2 Content of Diesel
Grams CO_2 Per Gallon - 2778
Oxidation Factor - 0.99
Molecular Weight of CO_2 - 44
Molecular Weight of Carbon - 12
Total Grams CO_2 in Gallon Diesel - 10,084
Total Pounds CO_2 in Gallon Diesel - 22.2

CO_2 Content of Gasoline
Grams CO_2 Per Gallon - 2421
Oxidation Factor - 0.99
Molecular Weight of CO_2 - 44
Molecular Weight of Carbon - 12
Total Grams CO_2 in Gallon Gas - 8,788
Total Pounds CO_2 in Gallon Gas - 19.4

Gasoline Fuel Efficiency Penalty:
Gasoline vehicles are assumed to have a 30% fuel economy penalty. This figure is widely used, and studies such as Baker et al (2004) suggest this figure may be higher (although that study looked at lighter-duty vehicles).
http://pubs.acs.org/doi/full/10.1021/es034925d

CH_4 & NO_2 Emissions (Gas and Diesel)
CO2 estimate multiplied by 100/95.

Sources :
CO_2 Content of Fuels: EPA Fact Sheet, Calculating GHG From Vehicles; http://www.epa.gov/oms/climate/420f05001.htm
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2001; http://epa.gov/climatechange/emissions/usinventoryreport.html

CNG

CO_2 Content of Natural Gas
Kilograms CO_2 per Metric Feet Cubed - 54.06
Pounds CO_2 per Cubic Foot - 0.11113
GGE Uncompressed in Cubic Feet- 126.6
GGE Compressed at 2400 PSI in Cubic Feet- 0.77

CH_4 Content of CNG
CH_4 Content of CNG in Grams per Mile - 1.966
CH_4 Content of CNG in Pounds per Mile - 0.0043428607

N_2O Content of CNG
N_2O Content of CNG in Grams per Mile - 0.175
N_2O Content of CNG in Pounds per Mile - 0.000385808959

Fuel Economy
Gallon Gas Equivalent is based on energy properties of fuel required to operate vehicles regardless of fuel source. For this reason the diesel fuel economy is multiplied by the emissions factor of CNG gallon gas equivalent.

Sources:
CO_2, CH_4, NO_2 Content: EIA Voluntary Reporting of Greenhouse Gases Program
http://www.eia.doe.gov/oiaf/1605/coefficients.html
Gallon Gas Equivalent: DOE Alternative Fuels and Advanced Vehicles Data Center

Propane

CO_2 Content of Propane
Kilograms CO_2 per Gallon - 5.75
Pounds CO_2 per Gallon - 12.6765801
Gallon of Gas Equivlant - 1.25

N_2O Content of Propane
N_2O Content of CNG in Grams per Mile - 0.175
N_2O Content of CNG in Pounds per Mile - 0.000385808959

CH_4 Content of Propane
CH_4 Content of CNG in Grams per Mile - 0.066
CH_4 Content of CNG in Pounds per Mile - 0.000145505093

Propane Fuel Efficiency Penalty
Propane vehicles are assumed to have a 10% fuel economy penalty, based upon manufacturer information shared at the Green Fleets conference (October 18-19, 2010).

Sources:
CO_2, CH_4, NO_2 Content: EIA Voluntary Reporting of Greenhouse Gases Program; http://www.eia.doe.gov/oiaf/1605/coefficients.html
Gallon Gas Equivalent: DOE Alternative Fuels and Advanced Vehicles Data Center

Diesel Hybrid

CO_2 Content of Diesel Hybrids
Kenworth T270 Class 6 Hybrid
Peterbilt Model 330 Class 6 Hybrid
Fuel economy claims - 30% improvement over diesel

CH_4 & NO_2 Emissions
CO_2 estimate multiplied by 100/95.

Sources:
Fuel Economy Improvement Claim: http://www.peterbilt.com/eco/ReadyTrucks-MediumDutyHybrids.htm
Fuel Economy Improvement Claim: http://www.kenworth.com/2300_med.asp
CH_4 & NO_2 Content of Fuels: EPA Fact Sheet, http://www.epa.gov/oms/climate/420f05001.htm

Other

Global Warming Potentials of Greenhouse Gases Relative to CO_2
CO_2 - 1
CH_4 - 25
N_2O - 298

Source:
GREET 1, Version 1.8c.0; http://greet.es.anl.gov/

Technical Backup (Continued)

80 kWh Newton Model: Technical Specifications

Wheelbase WB (in)	GVW (lbs)	Chassis Curb Weight (lbs) *	Payload (lbs)	Overall Length OL (in)	Overall Height OH (in)	Overall Width OW (in)	Deck Length DL (in)	Cab to Axle CA (in)
154	16,500	9,392	7,121	268	94-98	87	191	126
	22,000	9,700	12,324	268	94-99	87	191	126
	26,400	9,771	16,663	266	94-99	87	189	126
177	16,500	9,412	7,101	307	94-98	87	231	149
	22,000	9,678	12,346	307	94-99	87	231	149
	26,400	9,881	16,552	305	94-99	87	229	149
201	22,000	9,824	12,200	346	94-99	87	270	173
	26,400	10,121	16,312	344	94-99	87	268	173

* Values based on 80kwh model

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