U.S. DEPARTMENT OF ENERGY

United States Department of Energy

May, 2011

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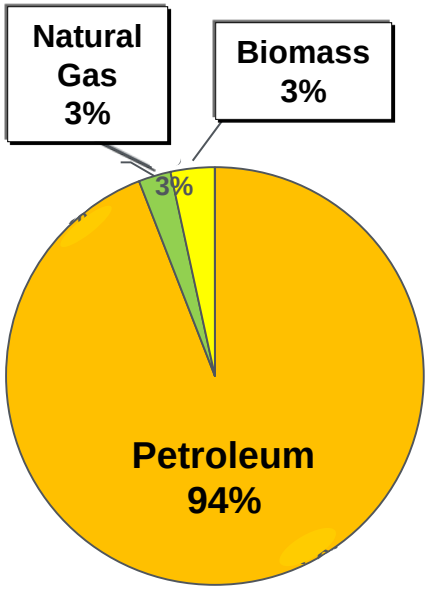
We are Highly Dependent on Oil



U.S. Transportation Fuel Share (2009)

- Transportation is responsible for 2/3 of our petroleum usage
- On-Road vehicles responsible for ~80% of transportation petroleum usage
- 240M vehicles on the road

New Oil Reserves are Harder to Find

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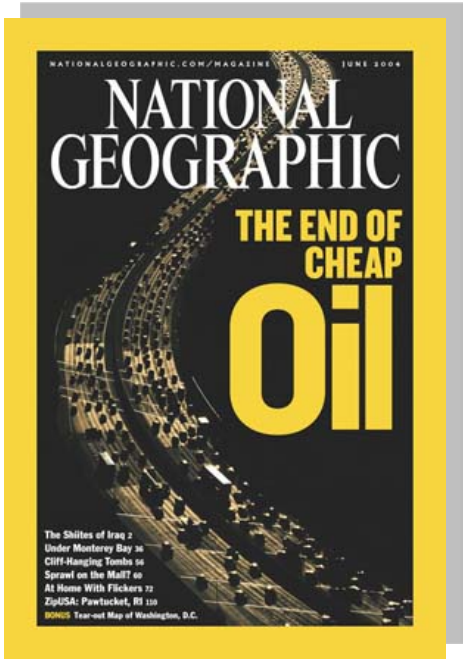
- Global discovery of new oil fields peaked in 1966.
- U.S. oil *production* peaked in 1971.
- World oil production has hardly grown at all since 2005.
- >$1B/day for imported petroleum.

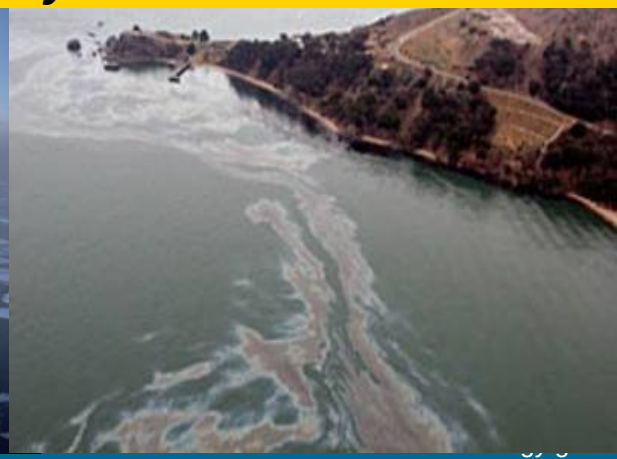
Source: Jeff Rubin, "Why the World is About to Get a Whole Lot Smaller"

World Oil Production

2005: 84.58 mbpd
2006: 84.54 mbpd
2007: 84.40 mbpd
2008: 85.37 mbpd
2009: 84.24 mbpd
2010: 87.3 mbpd



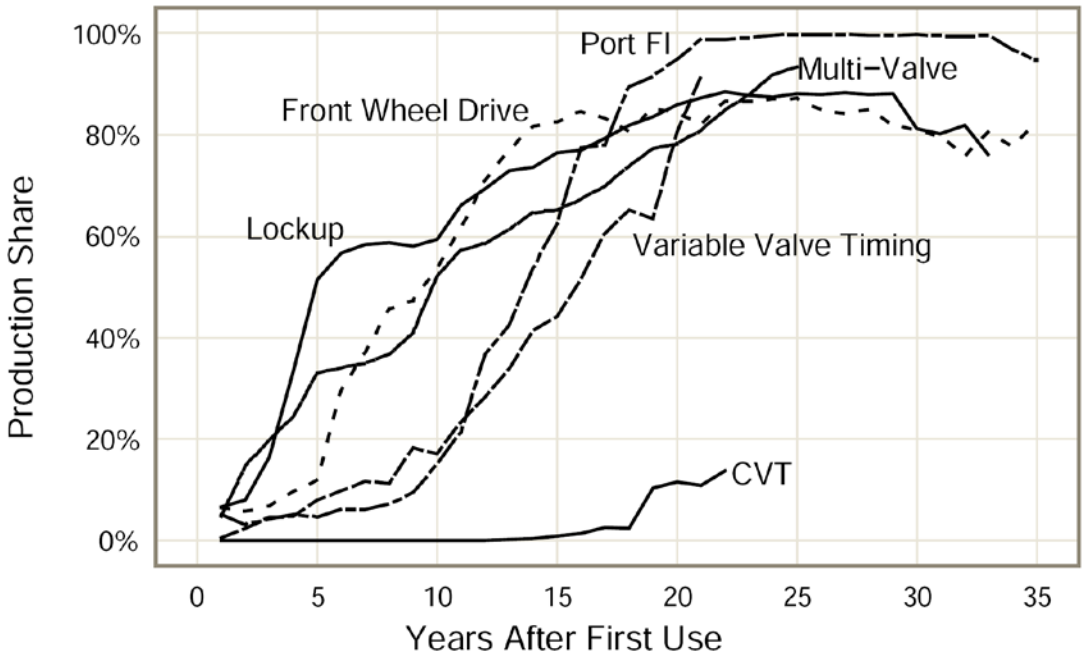
The Cost of Oil is More than Monetary



Realizing Benefits of Vehicle Technology Takes Time

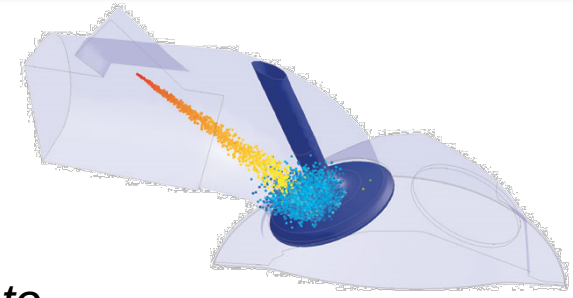
Vehicle Technology Penetration

Years After Initial Significant Use



U.S. Vehicle Market

- About 240 million light-duty vehicles on the road
- Approximately 11.5M new cars & light trucks sold in 2010; the average was 15.7 M/yr from 2002-2007
- Hybrid vehicles at about 3% of sales



It has taken about 15 – 20 years for a technology to reach maximum market penetration.

Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2010, EPA420-R-10-023, November 2010, p. 69

Analysis Informs Strategy

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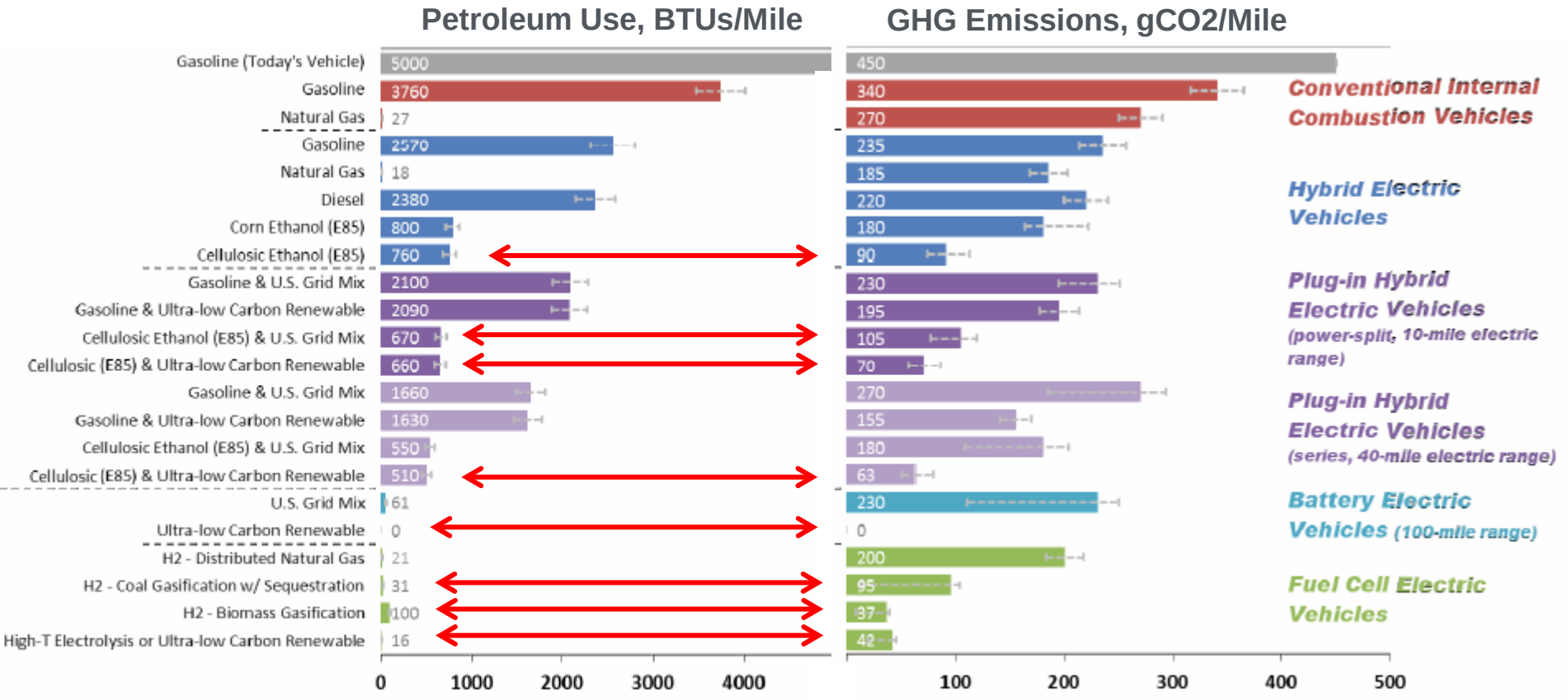
The Only Options That Achieve Very High Petroleum Reductions and Very Low Carbon Emissions Combine Electric Drive With Low Carbon Fuels



"To make sure we stay on this goal we're going to need to do more" President Obama remarks at Georgetown University, March 30, 2011

President calls out goal of 1 million PHEVs on the road by 2015 in State of the Union address

Vice President Biden announces community infrastructure project

Reaching 1 Million EVs by 2015

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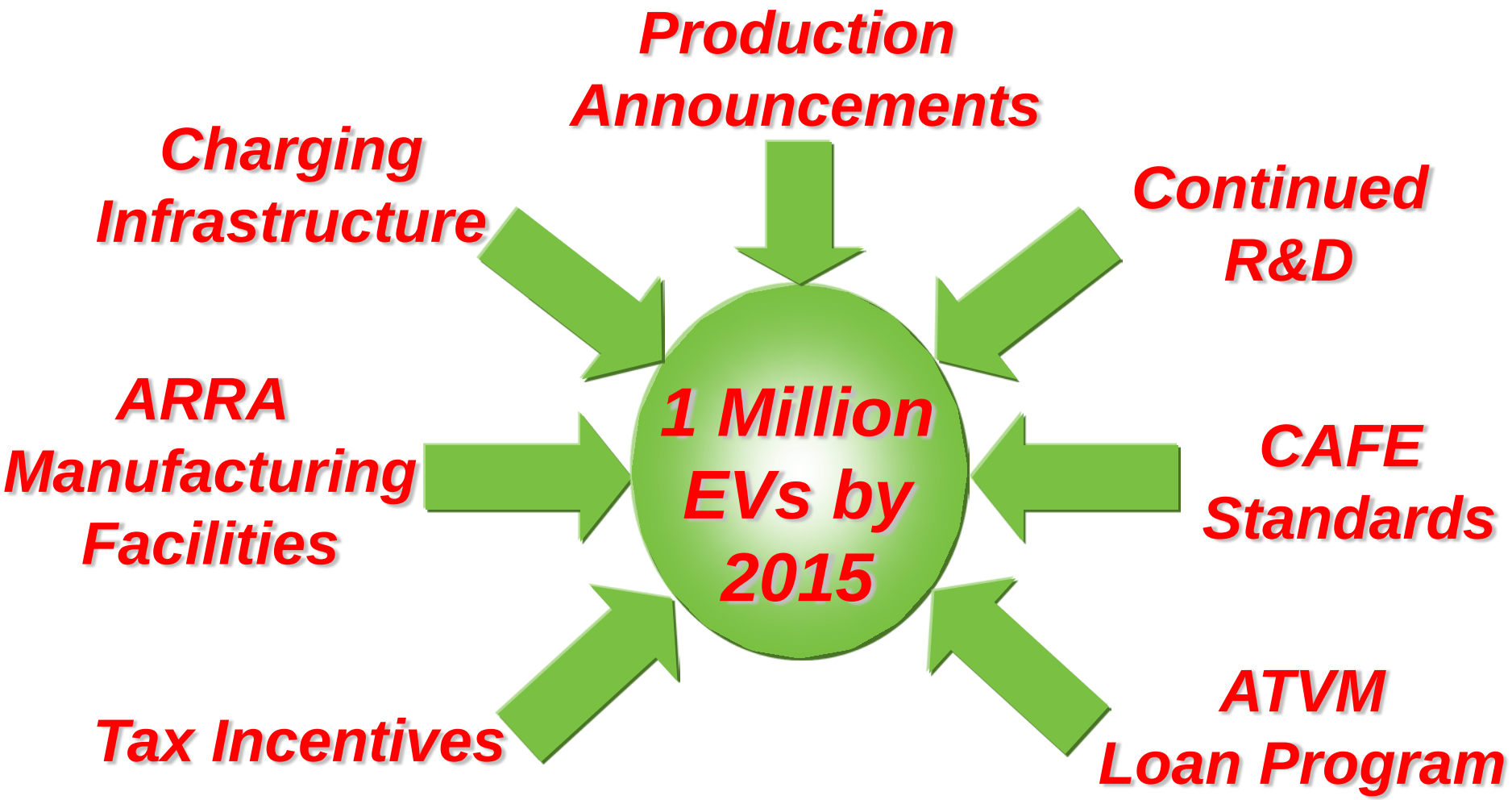


1 Million EV Goal is a Milestone, not a Finish Line

Open Questions About Electric Drive

What's Different this Time?

Grid Capacity

Charging Infrastructure

Battery Cost

What's Different This Time?

Early 1900s

1970s

1990s

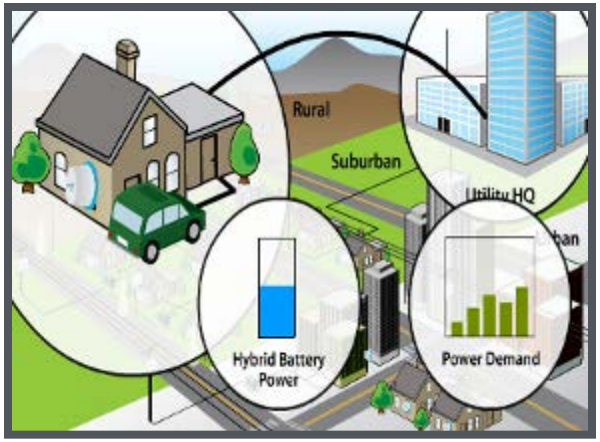
2010

Answer:

- Urgency of Energy and Environmental Challenges
- Battery Technology
- Cafe standards post 2016

Vehicle Electrification: Grid Impacts

- Current grid capacity could supply about 70% of our vehicles without adding capacity, but assumes:
  - vehicle would charge only during off-peak
  - “perfect” distribution of electricity
  - No localized affects such as overburdening neighborhood transformers
- EVs and PHEVs will not cause a grid “meltdown,” but we clearly need to work fast as vehicles are rolled out to reduce impacts
- Smart Charging will be key to lowering cost and minimizing impacts
- Time of day pricing also important



Build out of Charging Infrastructure

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Key Today: Home Charging

- Need to get the cost and installation process right. Currently a significant barrier

Public Charging

- Expensive if not well utilized
- Expansive to fully cover full driving patterns

Ideally need market pull to determine public infrastructure build out

- PHEV's are key to help initiate market pull for public infrastructure

DOE Battery Innovation, Market Acceptance and Cost Reduction

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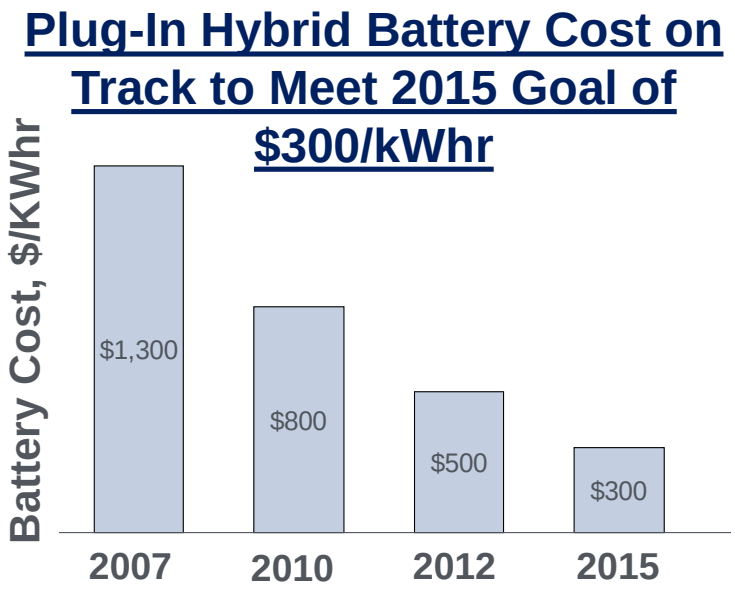
- 1990's → Nickel Metal Hydride (NiMH) batteries enable commercial introduction of HEVs
- 2000 – 2010's → Li-ion batteries enable next generation HEVs, PHEVs and EREVs
- Future → Next Generation Chemistry with 3x energy density: Li(metal) battery

DOE Energy Storage Goals	PHEV (2015)	
	PHEV-10	PHEV-40
Electric Range (miles)	10	40
Disch. Pulse Power: 10 sec (kW)	50	38
Regen Pulse Power: 10 sec (kW)	25	30
Recharge Rate (kW)	1.4	2.8
Cold Crank Power:-30 ºC/2sec (kW)	7	
Available Energy (kWh)	3.5	11.6
Calendar Life (year)	10+	
Cycle Life (cycles)	3,000-5,000 (deep)	
Maximum System Weight (kg)	60	120
Maximum System Volume (l)	40	80
Operating Temp. Range (ºC)	-30 to +52	



Next Generation Lithium-Ion

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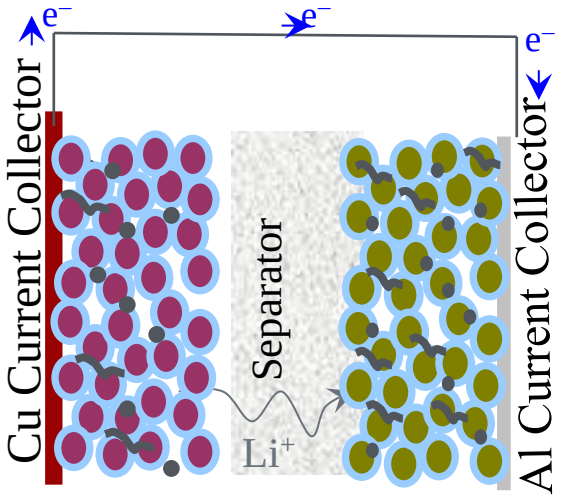
Next generation lithium-ion can increase the power and energy by 2X while decreasing cost by 70%

Anode

Today's Technology
(300 mAh/g)
-Graphite
-Hard carbon

Next Generation
(600 mAh/g)
-Intermetallics and new binders
-Nanophase metal oxides
-Conductive additives
-Tailored SEI



Electrolyte

Today's Tech (4 volt)
Liquid organic solvents & gels

Next Generation (5 volt)
-High voltage electrolytes
-Electrolytes for Li metal
-Non-flammable electrolytes

Cathode

Today's Technology
(120-160 mAh/g)
-Layered oxides
-Spinels
-Olivines

Next Generation
(300 mAh/g)
-Layered-layered oxides
-Metal phosphates
-Tailored Surfaces

Outlook for Battery Cost and EV Production Capacity

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On Track to Meet Administration's Goal of 1 Million EVs by 2015

	Battery Cost ($ per kWh)	Battery Production Capacity (10 kWh packs) ARRA	Battery Production Capacity (10 kWh packs) ATVM	Vehicle Production Capacity (announced,cumulative)
2008 2009	$1,000-$1,200	0	0	0
2010 2011	$700-$950	50,000		45,600
2012	Goal = $500	150,000	144,000	223,200
				486,200
2013 2014	Goal = $300			854,200
2015		500,000	488,000	1,222,200

9.88M kWh per year production capacity in 2015

>7.7M kWh per year capacity demand in 2015

Recovery Act : $2.0 Billion Manufacturing Supporting Electric Drive

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$1.5 Billion in funding to accelerate the manufacturing and deployment of the next generation of U.S. batteries

$500 Million in funding for electric-drive components manufacturing

Integrated Supply Chain

Material Suppliers

12 Awards

Cell Manufacturer

Battery Assembler

9 Awards

10 Awards

Electric Drive Component

End User

Recovery Act – Infrastructure Activities

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Transportation Electrification Demonstration Projects

Deployment of electric-drive vehicles and charging infrastructure

- Deployment of 13,000 electric-drive vehicles, light-duty through heavy-duty vehicles
- Installation of over 22,000 Level 2 charging sites and 350 (500VDC) Fast Chargers
- Collection of detailed operational data from vehicles and charging infrastructure
  - Driving and charge event data
  - Available via internet
  - Detailed data not available to DOE or through FOIA requests

10 Grants to establish comprehensive educational and outreach programs focused on electric-drive vehicles

- Funding of the first programs to educate first responders and emergency personnel in how to deal with accidents involving EVs and PHEVs

Working with Cities to Install Infrastructure

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- On January 26, 2011 Vice-President Biden announced a $200M program to help cities establish charging infrastructure:
  - Establish a comprehensive infrastructure plan
  - Encourage locally-based public and private sector collaboration
  - Leverage federal resources
  - Streamline building permit approval and installation procedures.
  - Initial build-out of the infrastructure.

Contact Information

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