

Electric Drive Vehicles in the U.S.: Markets, Research, and Strategies

电动汽车在美国：市场，研发和策略

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Larry Johnson, Ph.D., Director
Transportation Technology R&D Center
Argonne National Laboratory

Outline

概述

- Rationale: **Why electric-drive vehicles?**
为什么电动汽车?
- Markets **Provide a perspective on the markets for:**
HEVs, PHEVs, EVs
and the need for R&D
为电动汽车研发提供市场视角
- Research: **Research Programs in the US:**
VTP Battery Research
CERC-CVC
Multi-lateral EVI
Bi-lateral EVI
在美国的研究项目
- Strategies **PHEV and EV Demonstrations plus Infrastructure**
National vehicle demonstration program
ARRA (American Recovery and Reinvestment Act of 2009)
EV Everywhere
California Initiative
电动汽车展示项目和设施

Why electric drive vehicles? 为什么电动汽车？

■ National Benefits 国家利益

- Reduced petroleum consumption – reduced reliance on foreign oil
- Reduced (or eliminated) tailpipe emission
- Reduced greenhouse gas emission

■ Consumer Benefits 消费者利益

- Lower operating costs
- Increased reliability
- Quieter

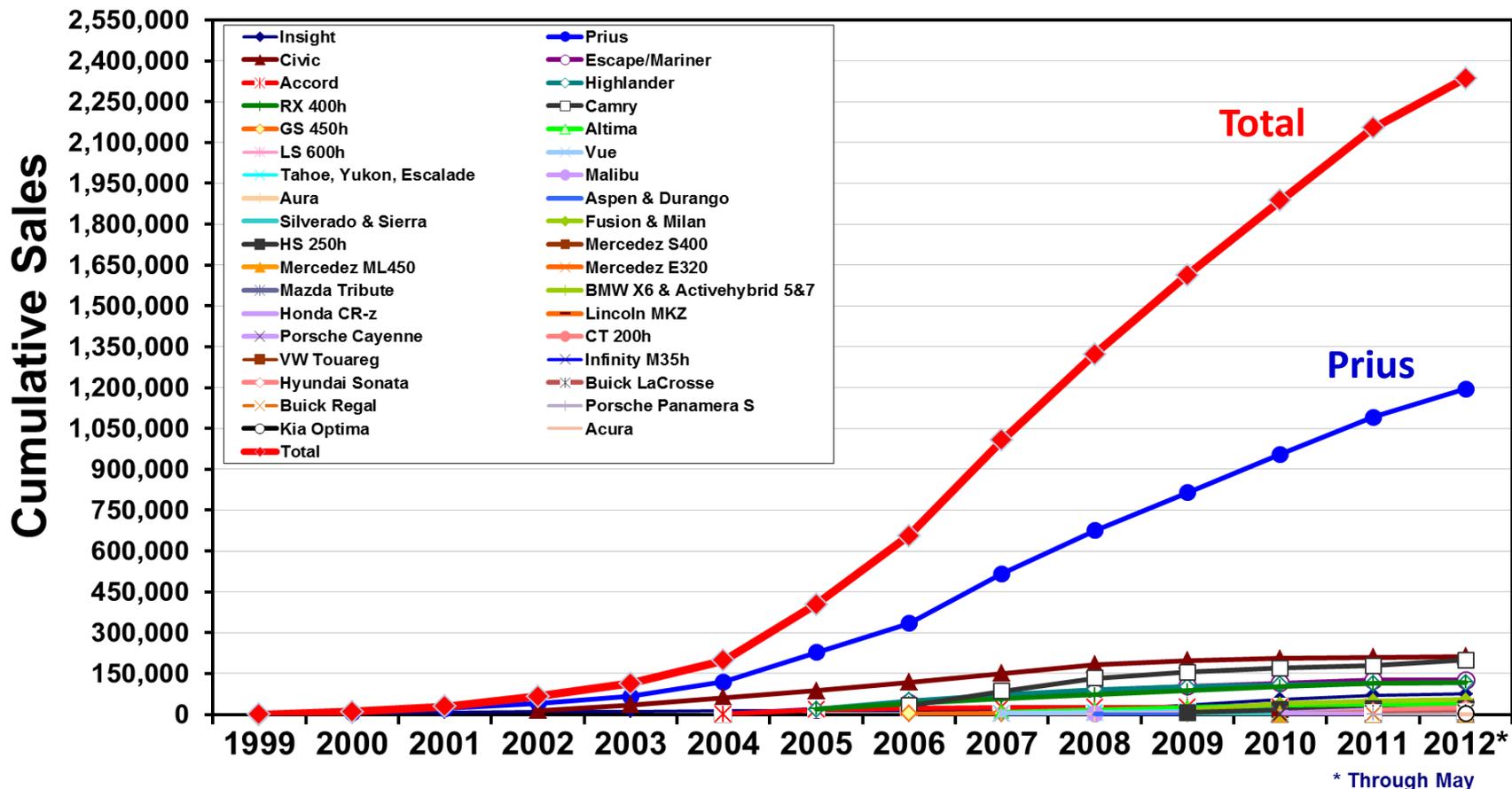
■ Utility Benefits 电力利益

- Overnight charging – use existing electricity generating capacity



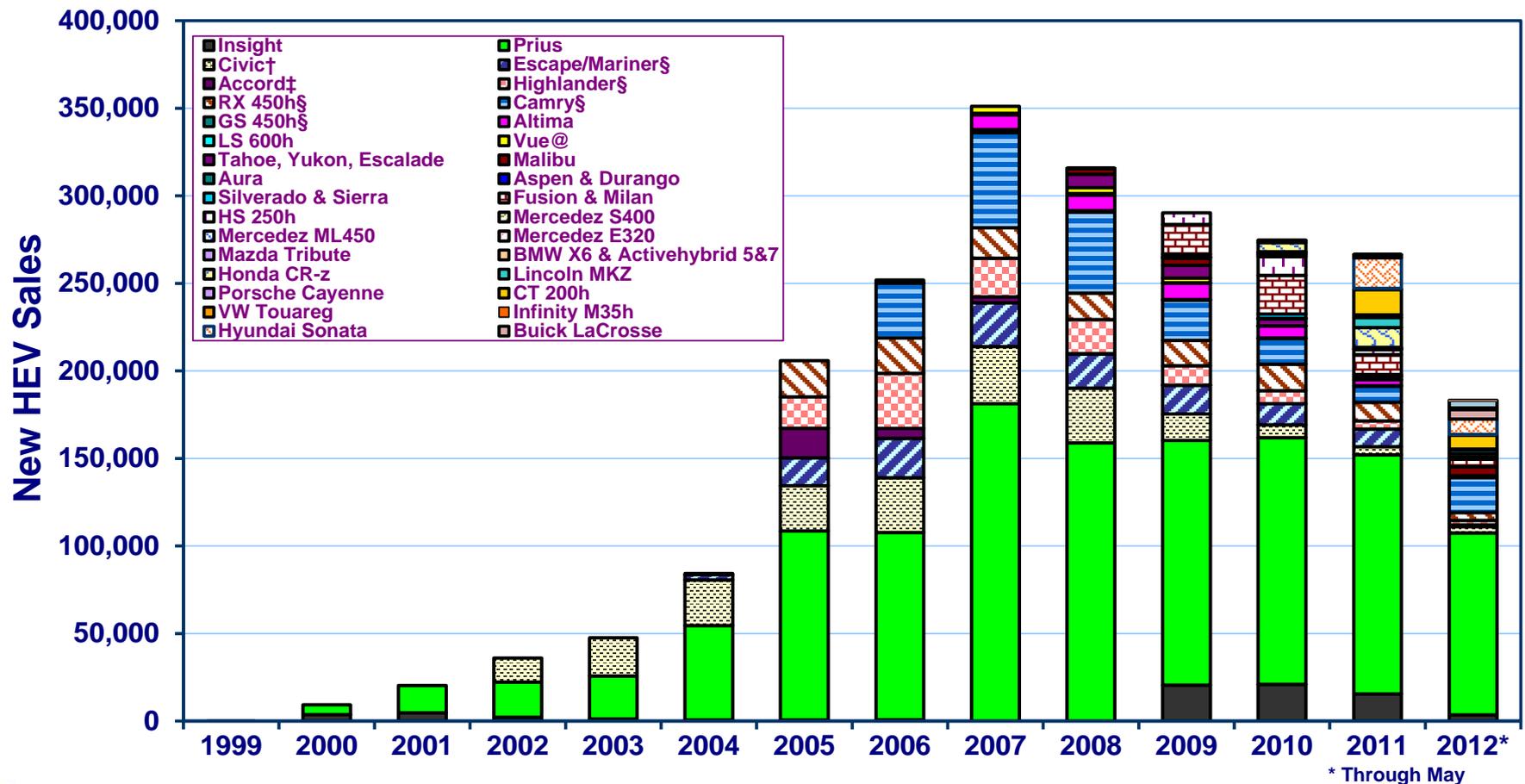
The Good News 喜人的销售情况

- There are over 2.3 million HEVs on the road in the US; Prius share is half
- Including plug-in vehicles account for 3.3% of light-duty vehicle sales
- There are nearly 40 models of HEVs and plug-in vehicles
- Sales of HEVs in Jan - May 2012 are up 55% over the same period last year



The Bad News 低迷的市场占有率和高成本的电池

- There are over 235 million cars and light trucks on the road in the US
Electric-drive vehicles comprise only 1% of the light-duty vehicle stock
- Sales of HEVs peaked in 2007, although this year's sales look promising
- High cost of batteries limits sales of HEVs - hence the need for R&D



Battery R&D in the Department of Energy's Vehicle Technologies Program

美国能源部车辆项目组的
电池研发

Objective: Develop batteries for a large EV market

目标：开发能使电动汽车广泛市场化的电池

Vehicle Types and Benefits

HEV



Toyota Prius

→ ~50 MPG

- 1 kWh battery
- Battery Power Rating: 25kW
- Battery Cost: about \$1,200

PHEV



Chevy Volt

→ ~100 MPGe

- 16 kWh battery
- Battery Power Rating: 120kW
- Battery Cost: about \$10,000

EV



Nissan Leaf

→ All Electric

- ≥ 24 kWh battery
- Battery Power Rating: ≥ 110kW
- Battery Cost: about \$15,000

- ❑ **Battery affordability and performance are the keys. Program targets include:**

- Increase performance (power, energy, durability)
- Reduce weight & volume
- Increase abuse tolerance
- LOWER COST!

- ❑ **2015 GOAL: Reduce the production cost of a PHEV battery to \$300/kWh (70% below 2008 value)**

- ❑ **EV Everywhere: Reduce the production cost of an EV battery to \$125/kWh by 2022**

The DOE Vehicle Technologies Battery R&D Program

美国能源部电池研发项目

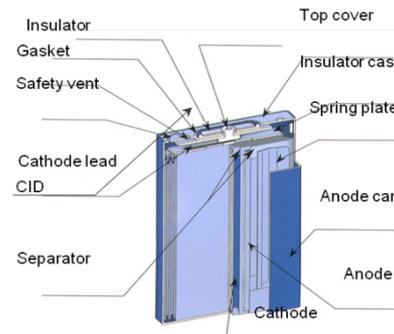
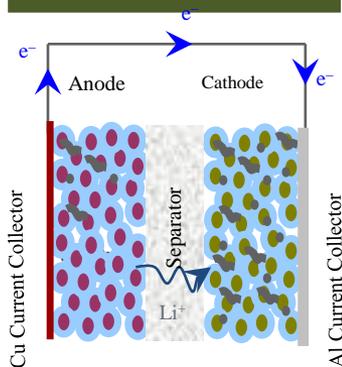
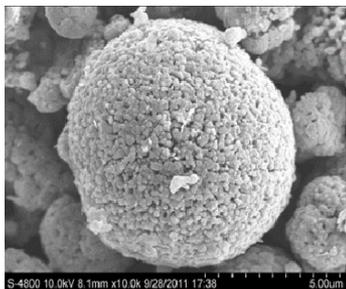
Energy Storage R&D
\$93M

**Exploratory
Materials
Research**
\$26M

**Applied Battery
Research**
\$16M

**Battery
Development**
\$39M

**Testing, Analysis
& Design**
\$12M



New Materials Research
Diagnostics & Modeling

**Electrochemistry
Optimization**
Power & Capacity
Life, Improvement

**Next Generation Cell
Development**
**Performance & Cost
Reduction**

Standardized Testing
Life/Cost Projections
Design Tools

Battery Technical Targets and Status for PHEVs

插电式混合动力电动汽车电池技术目标和现状

DOE Energy Storage Targets	PHEV (10 mile AER)		PHEV(40 mile AER)	
	Target	Status (2011)	Target	Status (2011)
Discharge Pulse Power: 10 sec (kW)	45	~70	38	~95
Regen Pulse Power: 10 sec (kW)	30	~40	25	~70
Available Energy (kWh)	3.4	3.4	11.6	11.6
Calendar Life (year)	15	8-10	10+	8-10
Cycle Life (deep cycles)	5,000	3,000-5,000	5,000	3,000-5,000
Maximum System Weight (kg)	60	~57	120	~175
Maximum System Volume (l)	40	~45	80	~100
System Production Price (@100k units/year)	\$1,700	~2,600	\$3,400	~6,850

Data based on the results of the initial PHEV battery development contracts awarded by USABC to A123Systems, LGChem, and Johnson Controls

Battery Technical Targets and Status for EVs

纯电动汽车电池技术目标和现状

Energy Storage Goals	AEV (2020)	Current
Equivalent Electric Range, miles	200-300	✓
Discharge Pulse Power (10 sec), kW	80-120	✓
Regenerative Pulse Power (10 sec), kW	40	✓
Available Energy, kWh	40-60	✓
Recharge Rate, kW	120	50
Calendar Life, years	10+	TBD
Cycle Life, cycles	1,000 deep cycles	TBD
Operating Temperature Range, °C	-40 to 60	0 to 40
System Weight, kg	160-240	500-750
System Volume, liters	80-120	200-400
Production Cost (@100,000 units/year)	\$125/kWh	< \$600

- Initial EV battery development contracts started in FY2011
- Focus on high voltage/high capacity cathodes & EV cell design optimization
- Data based on initial work from USABC Envia Systems & Cobasys/SBLimotive contracts

Notable Commercialization Activities

著名的商业化应用案例

❑ Nickel Metal Hydride

- **Cobasys NiMH technology:** Every HEV sold uses intellectual property developed in the DOE battery program. The US Treasury received royalty fees.

❑ High Power Lithium-Ion (HEVs)

- **JCS nickelate technology:** BMW, Mercedes and Azure Dynamics /Ford Transit Connect

❑ High Energy Lithium-Ion (EVs)

- **A123Systems nano iron phosphate technology:** Fisker, BAE, and Hymotion's Prius, GM Spark
- **CPI/LG Chem manganese technology:** GM Volt extended range PHEV & Ford Focus EV

Commercial Applications

 COBASYS



Prius, Escape, Fusion



 Johnson Controls SAFT



Mercedes S400 HEV



 A123 SYSTEMS



Fisker PHEV



 **cpi** compact power, inc. / **LG Chem**



Chevy Volt PHEV



Collaborations with China

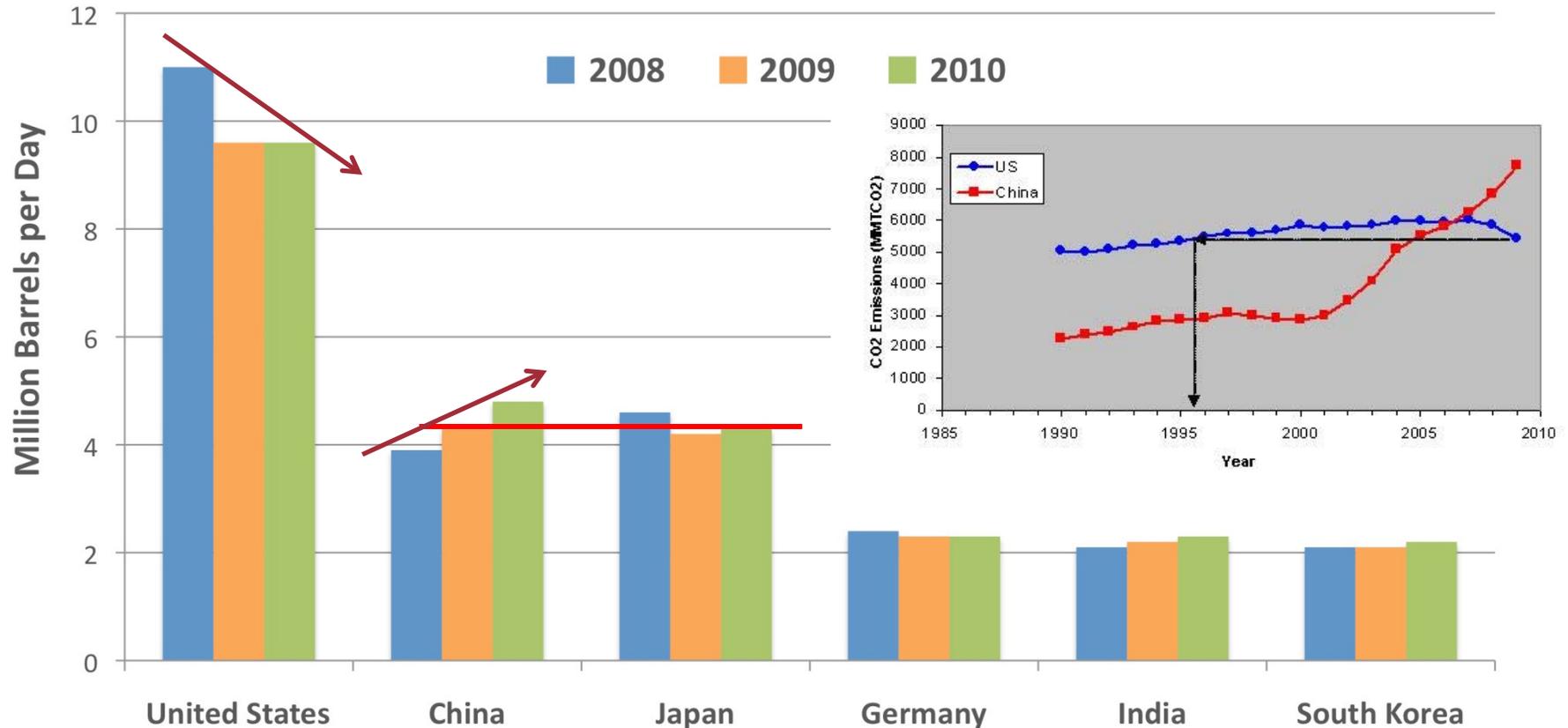
和中国的合作



Top World Oil Net Importers 2008-2010

2008-2010 年世界主要石油进口国日进口量

China became the world's second largest net oil importer in 2009



Source: U.S. Energy Information Administration (EIA), China Country Analysis Briefs, 2009-2011 (charts).
来源：美国能源信息管理局，中国国家分析简报，2009-2011

The Clean Energy Ministerial is a global energy policy forum

清洁能源部长会议是一个全球性的能源政策论坛

- The U.S. and China co-lead the EV initiative involving 13 countries and the IEA
- Provides a policy forum for global cooperation on EV deployment
- Goal: Put at least 20 million electric vehicles on the road worldwide by 2020 based on announced targets of EVI countries
- Members exchange data on...
 - National targets for EV deployment
 - Current national stock/sales of EVs
 - Relevant policies and incentives
 - Public investment in RD&D



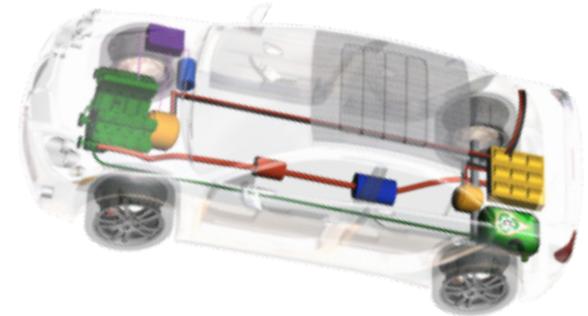
Clean Energy Research Center – Clean Vehicle Consortium

清洁能源研究中心-清洁汽车联合会

“The objective is to contribute to dramatic improvements in technologies with the potential to reduce the dependence of vehicles on oil and/or improve vehicle fuel efficiency”

Through the synergy of six Thrust Areas:

- Energy Systems Analysis, Technology Roadmaps and Policies
- Vehicle-Grid Interface
- Vehicle Electrification
- Lightweight Structures
- Batteries and Energy Conversion
- Advanced Biofuels and Clean Combustion



U.S.-China Electric Vehicles Initiative launched Nov 17, 2009

2009年11月17日，奥巴马总统和胡锦涛主席宣布了中美电动汽车合作草案

■ Shared interest in accelerating the deployment of electric vehicles

- To reduce oil dependence
- Cut greenhouse gas emissions
- Promote economic growth

■ Sponsored by:

- U.S. Department of Energy
- China's Ministry of Science and Technology

■ Three focus areas

- Battery Technology Roadmapping
- Battery Test Procedures
- Vehicle Demonstrations and Infrastructure

■ Alternate venues between US and China

- August 2010 at Argonne
- May 2011 in Beijing
- August 2011 at Argonne
- April 2012 in Hangzhou
- August 2012 in Boston



Strategies 策略

- **PHEV and EV Demonstrations**
插电式混合动力电动汽车和纯电动汽车展示
- **Recovery Act for Infrastructure**
基础设施恢复法
- **EV Everywhere**
电动汽车普及计划
- **California's ZEV Mandates**
加州零排放车辆政策

EV demos help guide technology and EVSE deployment

电动汽车展示有助于技术指导 and 电动汽车设备的发展

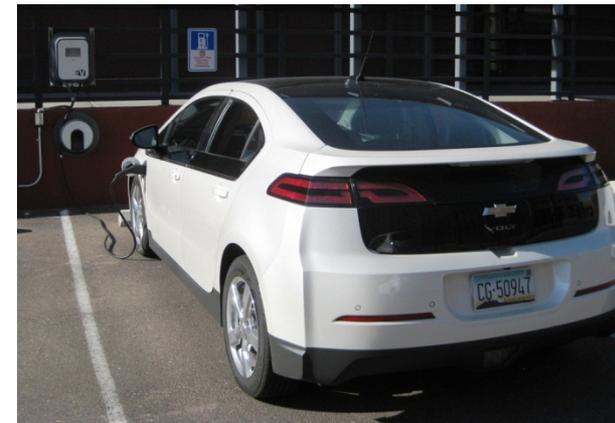
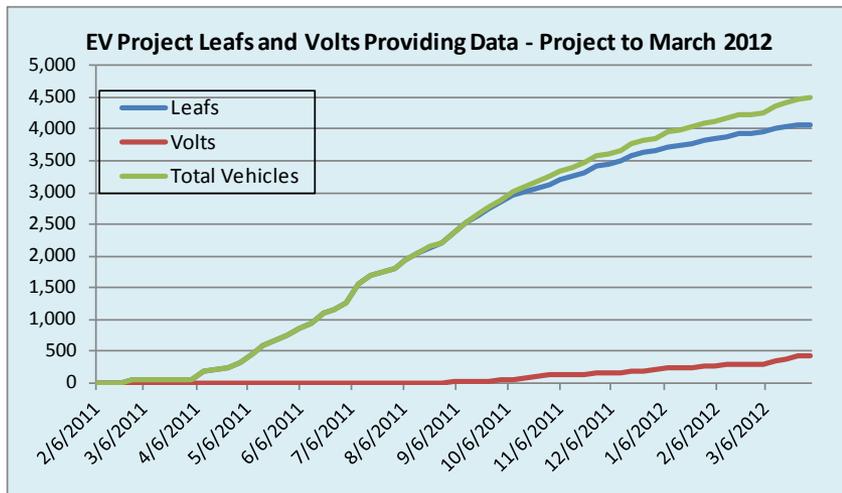
Total US Results* – as of March 2012

- 4,493 Leafs and Volts deployed and reporting data
- 5,432 EVSE installed and reporting data
- 22.6 million miles driven
- 665,968 charging events

LA Results* – as of March 2012

- 431 Leafs and Volts deployed and reporting data
- 433 EVSE installed and reporting data
- 2.1 million miles driven
- 51,000 charging events

* Data collected by the Idaho National Laboratory from ECOTality's EV Project



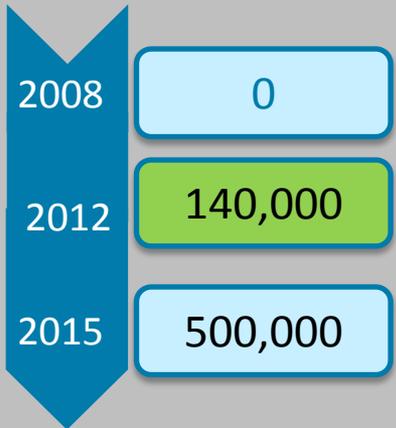
Chevy Volt Charging at a Level 2 EVSE

Recovery Act: Battery Manufacturing

恢复法案：电池制造业

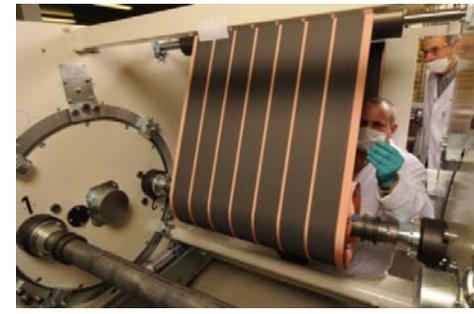
Establish U.S. EDV battery manufacturing capacity

ARRA: \$1.5B Cell & Pack Production Capacity (10 kWh packs)



~5M kWh / year

- ❑ **Johnson Controls:** cell production and pack assembly at in Holland, MI
- ❑ **A123Systems:** cathode, cell, & pack assembly in Livonia & Romulus, MI
- ❑ **EnerDel:** Cell production & pack assembly at Fishers & Mt Comfort, IN
- ❑ **General Motors:** battery pack assembly at Brownstown, MI
- ❑ **SAFT:** cell production at Jacksonville, FL
- ❑ **Exide:** advanced lead acid battery production established in Columbus, GA
- ❑ **East Penn:** Advanced Lead Acid battery production established in, PA
- ❑ **Dow Kokam:** cell & pack capability in Midland, MI in 2012
- ❑ **LG Chem:** cell & pack capability in Holland, MI in 2012



Toda America, Inc. Battle Creek



A123Systems, Livonia Facility



Recovery Act: Battery Manufacturing

恢复法案：电池制造业

Progress

Materials Production

Cathode

- TODA: production established
- BASF: *Target: Commission in 4Q*

Anode

- EnerG2: production established
- FutureFuel: production established
- Pyrotek: production established

Separator

- Celgard: production established
- Entek: *Engineering scoping completed*

Electrolyte

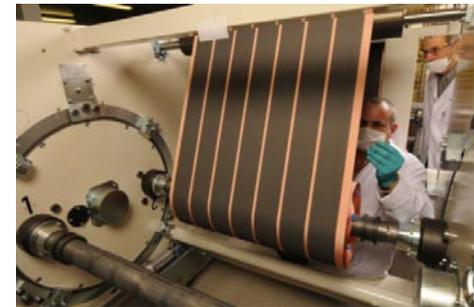
- Honeywell: Li-salt pilot plant operational
- Novolyte: *Equipment installation*

Lithium

- Chemetall Foote: lithium hydroxide

Cell Hardware

- H&T Waterbury: production established



Toda America, Inc. Battle Creek Facility



A123Systems, Livonia Facility



“EV Everywhere” Grand Challenge

“电动车随处可见”大挑战



A DOE Clean Energy Grand Challenge with the goal of *enabling U.S. companies to produce electric vehicles that are as affordable and convenient for the average American family as today’s gas-powered vehicles within the next 10 years (by 2022).*

President Obama announced the EV Everywhere Challenge on March 7, 2012

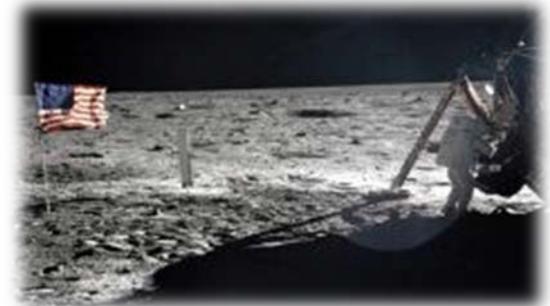
United States has a long history of successful technological challenges:



Cross-Atlantic flight

Moon landing

X-Prize



“EV Everywhere” Technical Focus Areas

“电动车随处可见”核心领域

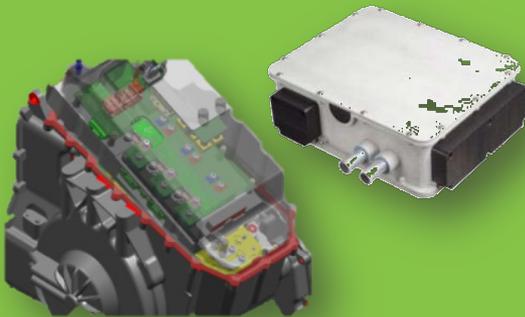
Advanced Batteries



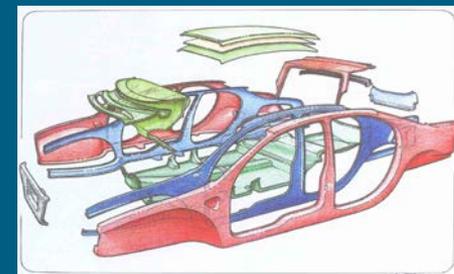
Vehicle Systems & Charging



Power Electronics & Electric Motors



Structural Materials Technology



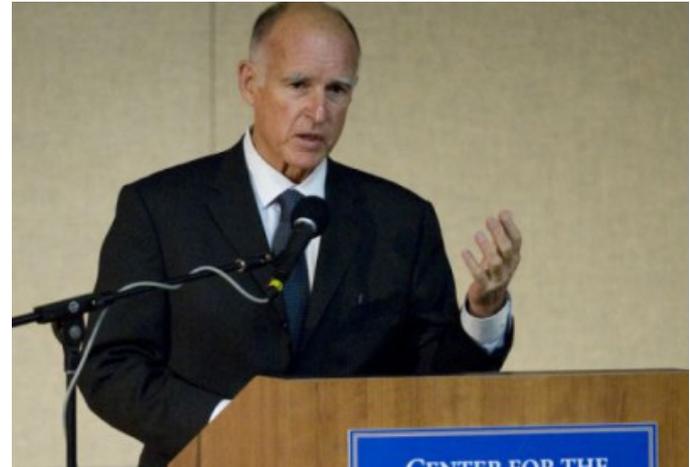
ZEV Mandates in California

加州零排放法案

- ***Greenhouse gas standard for cars and light trucks, model years 2017-2025***
 - Builds on California's first standard; later adopted by the federal government
 - Parallels federal program to create a single national program for manufacturers that addresses both greenhouse gas and fuel economy standards.
 - New standard reduces greenhouse gas emissions by 34% compared to 2016 levels.
- ***Reducing Smog-Forming Emissions***
 - Should reduce smog-forming pollution by an additional 75 percent from 2014 levels
- ***Zero Emissions Vehicle (ZEV) Regulation***
 - ZEV regulation results in 1.5 million ZEVs on the road by 2025 (15% of sales in 2025)
 - PHEVs will play a significant role over the next 20 years, but by mid-century, 87% of cars on the road will need to be full ZEVs to achieve climate goals.
- ***Clean Fuels Outlet***
 - Requires hydrogen fueling stations in support of ZEV H2 fuel cell vehicles

California's "Electric Highway" 加州“电力高速公路”

- **Executive Order by the Governor dispersing \$120M settlement with NRG Energy**
 - \$100M for:
 - 200 fast charging stations to be installed in:
 - the San Francisco Bay Area
 - the San Joaquin Valley
 - the Los Angeles Basin
 - San Diego County
 - 10,000 parking space charging stations at apartment complexes, large work sites, and universities and other civic sites
 - \$20M for taxpayer relief
- **Targets set by the Governor's Executive Order**
 - By 2015, all major cities in California will have adequate infrastructure and be “ZEV ready”
 - By 2020, the state will have established adequate infrastructure to support 1 million ZEVs
 - By 2025, there will be 1.5 million ZEVs in California; and
 - By 2050, virtually all personal transportation in the State will be based on ZEVs, and
 - GHG emissions from transportation will be reduced by 80 percent below 1990 levels.



California's GHG Policy Model is more than ZEVs

零排放汽车是加州温室气体法案模型的一部分

- Target specific GHG and oil reductions with broad array of rules and incentives
- Carbon cap-and-trade program to create price signal for carbon
 - To take effect in 2015
 - Imposed on refineries and fuels
 - Expected to moderately raise gasoline prices

VEHICLES

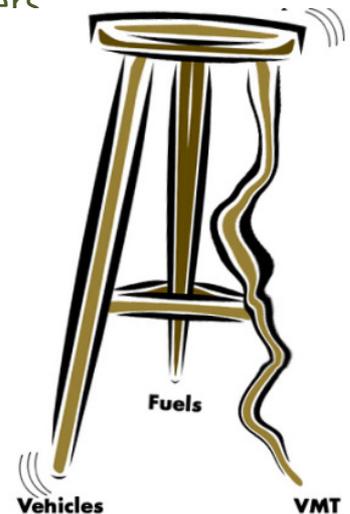
- GHG vehicle standards (cars)
- Zero Emission Vehicle (ZEV) requirements to overcome start-up barriers
- Financial incentives for advanced vehicles (EVs, PHEVs, FCVs)

FUELS

- Low carbon fuel standard required for oil companies (10% reduction in carbon intensity by 2020, requiring roughly 1/3 alternative fuels)
- Hydrogen fuel station requirements adopted
- 33% renewable electricity standards for electricity suppliers

VMT and Infrastructure

- Targets for reduced VKT and sprawl (7-8% reduction in VKT/capita by 2020 and 15% by 2035)



Thank you for your attention

谢谢！

