Electrification of the Automobile

March 31, 2010

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Director, Electrification Programs and Engineering
Ford Motor Company
Electrification of vehicles: An 100-year-old vision...

- In the early 1900's more than 27 companies were building electric cars, ~1/3 of the cars on the road were electric.

- In 1912, an electric roadster sold for $1,750, while a gasoline car sold for $650.

- In 1914, Henry Ford and Thomas Edison experimented with an electric car using Edison Batteries.

- In 1915 the Ward Motor Vehicle Company offered an electric wagon for $875 on an one-year installment plan for the vehicle and a $10.50 month rental fee for the Edison Storage battery.
### Near Term
- Significant number of vehicles with EcoBoost engines
- Electric power steering – begin global migration
- Dual clutch and 6 speed transmissions replace 4 & 5 speeds
- Flex Fuel Vehicles
- Add Hybrid applications
  - Increased unibody applications
  - Introduction of additional small vehicles
  - Battery management systems – begin global migration
  - Aero improvements
  - Stop/Start systems (micro hybrids) introduced
  - CNG/LPG Prep Engines available where select markets demand

### Mid Term
- EcoBoost engines available in nearly all vehicles
- Electric power steering - High volume
- Six speed transmissions - High volume
- Weight reduction of 250 – 750 lbs
- Engine displacement reduction aligned with weight save
- Additional Aero improvements
- Increased use of Hybrid Technologies
- Introduction of PHEV and BEV
- Vehicle capability to fully leverage available renewable fuels*
- Diesel use as market demands
- Increased application of Stop/Start

### Long Term
- Percentage of Internal combustion engines dependent on renewable fuels
  - Volume expansion of Hybrid technologies
  - Continued leverage of PHEV, BEV
  - Introduction of fuel cell vehicles
  - Clean electric / hydrogen fuels
  - Continued weight reduction actions via advanced materials
Drive green.
<table>
<thead>
<tr>
<th>Year</th>
<th>BEV (Battery Electric Vehicles)</th>
<th>PHEV (Plug-in Hybrid Electric Vehicles)</th>
<th>HEV (Hybrid Electric Vehicles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Transit Connect (Global C-Platform)</td>
<td>Global C-Platform</td>
<td>Escape</td>
</tr>
<tr>
<td>2010</td>
<td>Focus (N.A.) (Global C-Platform)</td>
<td>Next Generation HEV</td>
<td>Fusion/Milan</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2018+</td>
<td></td>
<td></td>
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</tbody>
</table>

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Drive green.
<table>
<thead>
<tr>
<th></th>
<th>2010 CY</th>
<th>2011 CY</th>
<th>2012 CY</th>
<th>2013+ CY</th>
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</thead>
<tbody>
<tr>
<td><strong>BEV</strong></td>
<td></td>
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<tr>
<td>Battery Electric</td>
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<td></td>
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</tr>
<tr>
<td>Vehicles</td>
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<tr>
<td><strong>PHEV</strong></td>
<td></td>
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<tr>
<td>Plug-in Hybrid</td>
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<td></td>
<td></td>
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<tr>
<td>Electric Vehicles</td>
<td></td>
<td></td>
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<tr>
<td><strong>HEV</strong></td>
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</tr>
<tr>
<td>Hybrid Electric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ford of Europe – Drive green.**
Ford Global Electrified Volume

- Balanced Portfolio
- Global Flexibility
- Volume will be predominantly HEV
- Plug-ins gaining acceptance

Balanced growth also provides flexibility to react to volatile external factors
Note: Data is aggregated from consultancy papers as follows:
Roland Berger, Powertrain 2020 – “China’s ambition to become market leader in E-Vehicles,” April 2009
Note:
- All data is from CSM Worldwide global comprehensive vehicle production and sales forecasts, 3/05/10.
- Major manufacturers are those with >50,000 electrified vehicle sales projected in 2015.
- Customer-Focused
  - Great Features
  - Functional Technology
  - Meets Transportation Needs
  - Affordable

**Graph: System On-Cost vs. Cost per kWh**

- **BEV**
- **PHEV**
- **HEV**

- **2012CY**
- **2016CY**
- **2020CY**

- **$750**
- **$500**
- **$250**

- 100 mile range
- PHEV / BEV costs converge due to base P/T deletion
- High Vol – 250k+
### Electrification Technologies –

<table>
<thead>
<tr>
<th>Function System</th>
<th>Engine stop/start</th>
<th>Engine Assist (Downsize)</th>
<th>Regenerative Brake</th>
<th>Electric launch</th>
<th>All Electric Drive</th>
<th>Fuel Economy Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-hybrid (14V)</td>
<td>YES (&gt; 0.3 sec)</td>
<td>Minimal (&lt; 3 kW)</td>
<td>Minimal (&lt; 3 kW)</td>
<td>NO</td>
<td>NO</td>
<td>3-6%</td>
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<tr>
<td>Mild Hybrid (42V)</td>
<td>YES</td>
<td>Modest (&lt; 9 kW)</td>
<td>Modest (&lt; 9 kW)</td>
<td>NO</td>
<td>NO</td>
<td>8%/12%</td>
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<tr>
<td>Medium Hybrid (100+V)</td>
<td>YES</td>
<td>YES</td>
<td>YES (full benefit)</td>
<td>NO</td>
<td>NO</td>
<td>40%</td>
</tr>
<tr>
<td>Full Hybrid (300V)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>Yes</td>
<td>55%+</td>
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<tr>
<td>Plug In Hybrid (based on Blended Full)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>Yes</td>
<td>80%+</td>
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<tr>
<td>Battery Electric Vehicle</td>
<td>YES</td>
<td>No Engine</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>Infinite</td>
</tr>
<tr>
<td>Feature</td>
<td>HEV</td>
<td>PHEV</td>
<td>BEV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>Yes (Power)</td>
<td>Yes (Energy)</td>
<td>Yes (Energy)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric AC</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC/DC Converter</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regen Brakes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor(s)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter(s)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Transmission</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EV Gearbox</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Charger</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Drive green.
Ford’s “Power Split” Hybrid System

- I4 Gasoline Engine w/ Atkinson Cycle
- Battery
- Electric Transaxle
- Super Ultra Low Emissions (AT-PZEV)
- Motors
- Inverters
- Series Regenerative Braking

Over 200 Ford Patents
Over 100 new Patents on Fusion

Drive green.
Ford’s “Power Split” Hybrid System

- Lower Speeds (Electric Drive)
  - Up to 47 mph

Moderate Speeds and Loads

Drive green.
System Optimization – Core Competency

- **Traction HV Battery**
  - \( V_{BAT} \)
- **Variable Voltage Converter**
  - \( V_{INV} \)
- **Motor Inverter**
- **Generator Inverter**

**Diagram Notes**:
- Lower Inverter & Motor Losses from Higher Inverter Voltage & Minimum-Loss Control
- Up to 20% loss reduction

**Text**:
- Optimum Battery Voltage for Best Fuel Economy
- Optimum Boost for Best Fuel Economy

- **Traction Motor**
- **Traction Generator**

**Graph**:
- Torque vs. Speed
- Drive green.

- Lower Inverter & Motor Losses from Lower Battery Voltage
- Up to 20% loss reduction
A Ford Full Hybrid Power Split architecture can be scaled down (for cost), or up to provide PHEV functionality (blended operation).
A “Power Split” Blended PHEV System

**ELECTRIC DRIVE**
At urban speeds, the high-capacity plug-in hybrid battery allows for extended battery-only driving distance.

**BLENDED ELECTRIC/ENGINE DRIVE**
At higher power demands and vehicle speeds, the vehicle automatically switches to blended electric/engine mode, providing propulsion using both the engine and the high-capacity battery.

**HYBRID DRIVE**
In hybrid drive mode, the vehicle continues to operate as a standard hybrid electric vehicle.
<table>
<thead>
<tr>
<th>Component</th>
<th>HEV</th>
<th>PHEV</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>High Voltage Battery</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Traction Motor</td>
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<td></td>
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<tr>
<td>Generator</td>
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<tr>
<td>Inverter(s)</td>
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<tr>
<td>Electric AC</td>
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<td></td>
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<td>DC/DC Converter</td>
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<tr>
<td>Regen Brakes Hardware</td>
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</tr>
<tr>
<td>Transmission</td>
<td>Same</td>
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<td></td>
</tr>
<tr>
<td>Engine</td>
<td>Same</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charger &amp; Wiring</td>
<td>New</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Pumps/Cooling Circuits</td>
<td></td>
<td></td>
<td>Modified transaxle oil lubrication/cooling circuit</td>
</tr>
</tbody>
</table>

**Significant Re-use of HEV hardware to leverage scale**
Parallel Hybrid:
- Engine power = mechanical path
- Motor provides assistance

Series Hybrid:
- EV Operation w/Stop-Start
- High efficiency Regen Braking
- Engine downsizing
- Full-size drive needed

PowerSplit Hybrid:
- w/ benefits of both
- Simple transmission

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Multiple architectures to choose from…
Hybrid Battery Technology Comparison

Different Cells required for different applications...

NiMH HEV

Li-Ion HEV

Li-Ion PHEV

Li-Ion BEV

Specific Power (W/kg)

Specific Energy (Wh/kg)
For weight, size, performance and affordability evolution is required…

- **1st Gen**
  - EV Battery: 23kWh, 500lbs, 125 liters

- **2nd Gen**
  - EV Battery: 23kWh, 400lbs, 100 liters

- **Future**
  - EV Battery: 23kWh, 250lbs, 75 liters

- **Goal**
  - Fuel Tank: 23kWh, 125lbs, 60 liters
Specific Energy (Wh/kg) vs Specific Power (W/kg) diagram showing:

- Present Technology Options
- Technology Need

Examples:
- USABC PHEV-10
- USABC PHEV-40
Application/Usage (Drive Cycles)
- Peak to Average Power Ratio
- Thermal Cycling
- Power Cycling
- Desired Range

Technology
- Silicon Technology (IGBT, Diodes) – Industry Standards vs. Custom?
- Power Module Packaging and Cooling Technology
- Capacitor Technology
- Sensing Technology
- Battery Cell Technology

Commonality and Reuse
- Power Density – Package Size
- Fixed vs. Tunable
- Connection Systems

Total cost is very high…
Fuel economy / Energy economy vary significantly based on driving conditions.

- Low speed, stop and go city driving
- High speed highway driving
- Hilly terrain driving
- Driving with towing
- Off road driving
- Very high speed driving

Many factors to consider…with regional differences
**Inverter duty cycles simulated in Matlab/Simulink**

**Generated 90\(^{th}\) Percentile Drive Profile Equivalent to 10 Years/150k Miles**

Based on analyses of RWUPs, Estimate Inverter Usage

**System Design Optimization Needed for Low Cost, Robust Design**

Based on duty cycle and component degradation with cycling and time. Used to reconcile life vs. Fuel Economy & Performance

**Inverter Key Life Tests**

Accelerated tests to Validate inverter cycle life

**RWUPs based on PRVD**

90% Customer (Driving Style, Location)
90% Environment (Temperature, Terrain)
- Current Density (Silicon Area)
- Better Switching vs. Conduction loss trade-off
- Operating Junction Temperature (150 to 175°C)
- Lower Cost Starting Wafer Material
- Wafer Size (6 inch to 8 inch)
- Wafer Yield Improvements

Cost Drivers:
- Chip Shrink
- Higher Yields
- Larger Wafers

Multiple Technology Iterations Needed for Affordability
... competes with commonality and reuse or scale
SMARTGAUGE™ WITH ECOGUIDE

New Knowledge and Skills Needed: Customer and Engineer

New concepts required for Plug-In vehicles

GRAPHICALLY TRACKS DRIVER’S EFFICIENCY

Drive green.
Two Industries connected through a common Customer and “Fuel”
Appliances
Tools
Windmills
Home Generators
Solar Panels
Exploring Customer Value From “Plugging In”

- All New System View:
  - What components are in the new system?
  - How will the grid and energy flow be controlled in the future?
  - Who are the parties involved?
  - What new integration is needed?
  - What are the key technologies and standards needed?

  Many Open Questions…
Today’s Unique partnership between automotive and utility sectors to accelerate the commercialization of PHEVs

Project goals:

- Development of open architectures, standards and specifications
- Create Customer Demand based on realistic expectations
- Creation of New Business Models
- Diversifies transportation energy supply

Future Vision: From Independent to Integrated

Two industries connected by a common fuel ... driving our transportation and energy future...
A 240V @ 30A circuit can provide ~ 6kW continuous charge

Existing battery: capable of charging at the vehicle worst case drive cycle discharge rate.

Existing wiring: capable of worst case drive cycle

When a Plug-in vehicle is Charging, it approximately doubles the household energy load...

Drive green.
Ford, Microsoft TEAM UP to help ELECTRIC VEHICLE OWNERS RECHARGE MOST EFFECTIVELY, AFFORDABLY

• Ford and Microsoft are teaming up to introduce Microsoft Hohm™, a free online application, to help future owners of Ford’s electric vehicles better manage their home’s energy use and vehicle recharging

• Ford and Microsoft also will work with utilities and municipalities to help develop an energy ecosystem that manages energy usage as consumer demand for electric vehicles grows

• Ford’s aggressive electrification plan includes five new vehicles in North America and Europe by 2013; in North America, they include the Transit Connect Electric later this year, Focus Electric in 2011, a plug-in hybrid and two next-generation hybrids in 2012 – joining four Ford and Mercury hybrids already on the road and a new Lincoln hybrid coming this fall

• Ford expects the Focus Electric to be the first Ford electric vehicle to use Hohm

Ford / Microsoft Joint Press Release 03/31/10
Microsoft and Ford: Shared Vision for the Future of Energy Efficiency

1. Save money by easily managing all home energy usage online using Microsoft Hohm™

2. Determine the best time to recharge Ford electric vehicles efficiently using Microsoft Hohm

3. Use smart recharging habits to help utility companies understand and better manage the demands placed upon the electrical grid – and prevent potential overloading
Demonstrated innovative wireless vehicle-to-meter communications and customer-directed control of charging

- Directed time-of-day charging
- Customer price-point charge acceptance
- Interruptible service acceptance
- Green charging options
- Capability provided to driver through touch screen/NAV
- Being rolled-out on all demonstration vehicles in fleet

More Ford Technology Options ... already under development!
Development of Open Architectures, Standards and Specifications
• Key to Mass Market PHEV Introduction

Automotive Vehicle Operation
• Feedback control
• Respond to customer action
• Provide consistent performance
• Customer expectation driven
• Transportation focused

Utility Grid Operation
• Feed forward control
• Provide low noise content power
• Optimize use of facilities
• Minimize Ancillary Service
• Maximize use of available power
• Stationary power driven

Vehicle-Grid Interaction Across Geographic Markets
MUST BE CONSISTENT

Near Term Solutions Needed:
• Energy measurement
• Mobile billing/roaming
• Infrastructure limitations
• Convenience charging
• Codes & standards
• Education

Drive green.
Charging Customer Segments

- **Charge at Home**
  - Main charge spot located in garage or driveway of residence.

- **Charge at Depot**
  - For fleets customers, main charge location is fleet depot where multiple chargers could be installed.

- **Charge at Work**
  - Main charge location is work — allowing urban commuters/street parkers to have reliable charge. Also allows extended range for home chargers.

- **Charge at Public Space**
  - For occasional trips, municipal charge locations could be viable option. If reservation system is implemented, could be used for main charge location.

**Priority**

**Charging Infrastructure is a key enabler to Plug-In Vehicles**

*Drive green.*
1. Infrastructure Agreed to use SAE J1772 Standard
   - Three Charging Levels Defined
     • Level 1: 110V Standard household outlet (up to 2 kW)
     • Level 2: 220V (up to 19.2 kW) – Electric Vehicle Service Equipment (EVSE) Required
     • Level 3: 440V to DC Charging (up to 86 kW) - EVSE Required

2. National Electrician Code specifies installation requirements for EVSE

These two standards provide the framework that allow charge stations to be compatible with all plug-in vehicles in North America independent of manufacturer.
Target overnight charging (less than 8 hours) - base assumption that Level 2 installation will be required for BEV’s, and optional for PHEV
<table>
<thead>
<tr>
<th></th>
<th>Level 2 Home Charge Point</th>
<th>Level 2 Public Charge Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware (EVSE)</td>
<td>$700</td>
<td>$3,000</td>
</tr>
<tr>
<td>Quote/Permitting/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admin</td>
<td>$200</td>
<td>$500</td>
</tr>
<tr>
<td>Labor -Typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Range</td>
<td>$900</td>
<td>$3,500</td>
</tr>
<tr>
<td></td>
<td>$200 - $5,000</td>
<td>$1,000 - $10,000</td>
</tr>
<tr>
<td>Materials</td>
<td>$200</td>
<td>$500</td>
</tr>
<tr>
<td>Total Estimate (Typical)</td>
<td>$2,000</td>
<td>$7,500</td>
</tr>
</tbody>
</table>

Affordability will be Key
• Current plug-in owners on average charge at least two times per day\(^1\)
• Charge point availability is cited as the key adoption barrier to electric vehicles\(^2\)
• In an experiment, adding fast chargers at strategic city points increased electric fleet vehicle use – charge point usage did not increase but lessoned range anxiety\(^3\)
• Based on announcements, current public and private Level 2 infrastructure installation rates will not keep pace with plug-in sales.

1,500 public chargers currently tracked in U.S. on www.evchargermaps.com and www.mychargepoint.net

1 Reference UC-Davis Market Survey
2 Reference EPRI Focus Group Findings May 2009
3 Reference Tokyo Electric Power Company (TEPCO) experiment
Fuel prices impact sales – volatility is incredible in the US...

Peak of ~3.5% of Fleet

Today ~2.1% of a Smaller Fleet

Free Market Demand Not able to Deliver Accelerated Growth...
Policy, Volume and Volume Stability Needed

Drive green.
• **Aligned Goal**
  – Accelerate the production of HEV, PHEVs, BEVs, and V2H technologies that delight customers and provide a reasonable rate of return to all

• **New Business Approaches / Partnerships (OEM/Utility Collaboration)**
  – Today: World of independent solutions
  – Opportunity: Convergence of technologies and industries
  – Future: Transportation, Utilities and System Integrators become an interdependent system

• **Customer Affordability and Sustainable Business Proposition**
  – Customers desire price payment parity with Internal Combustion Engine
  – Cost of Ownership key to customers – Total Cost and Total Value
  – Near term jump-start the industry – combined incentives
  – Mid-term grow volume with customer focused profitable product
  – Long-term develop solutions to reduce cost and achieve profitability parity (sustainable business proposition for all)
The development of a sustainable electrified market will be dependent on close cooperation between

- Manufacturers
- Utilities
- System Integrators
- Battery suppliers
- Governments, and
- Consumers
Backup
Auto Brand Perceptions 2009: National Consumer Assessment

December 18, 2009
NRC #2009.102
Consumer Reports National Research Center
Electric Car: Purchase

- More than one-quarter (26%) of consumers said they are *likely* (top-two box of four boxes) to consider a plug-in electric car they next time they are in the market for a new vehicle, and 7% said *very likely* (top box). Likelihood to consider an electric car was flat across the core demographic segments of gender, age and household income.

- Nearly three-quarters (72%) said they are *unlikely* to contemplate buying an electric vehicle, including more than half of respondents (53%) who said they are *very unlikely*.

- Likelihood to consider a plug-in electric car varied by metropolitan classification and geographical region. In urban areas, 29% of respondents reported being *likely* versus 22% of those in rural areas. In addition, more of those in the West (30%) or Northeast (29%) region said they were *likely* to consider an electric vehicle than consumers in the North Central (25%) or South (23%) region.
### A10 - How much EXTRA would you pay for an electric car than for a conventional, gasoline-fueled car? Would you say...

**Base: Very/Somewhat Likely to Buy Electric Car**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>HHId Income</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>Men</td>
<td>Women</td>
<td>18-44</td>
</tr>
<tr>
<td>452</td>
<td>229</td>
<td>223</td>
<td>234</td>
</tr>
<tr>
<td>Percent</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Nothing or $0 extra</td>
<td>20</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>$1-$1,999 Extra (Net)</td>
<td>36</td>
<td>36</td>
<td>37</td>
</tr>
<tr>
<td>$1-$249 extra</td>
<td>7</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>$250-$499</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>$500-$749</td>
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<td>7</td>
<td>5</td>
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<tr>
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<td>0</td>
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<td>$1,000-$1,499</td>
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<td>10</td>
</tr>
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<td>$1,500-$1,999</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>$2,000 Extra or More (Net)</td>
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<td>39</td>
<td>37</td>
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<tr>
<td>$2,000-$2,999</td>
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<td>15</td>
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<tr>
<td>$3,000-$3,999</td>
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<tr>
<td>$4,000-$4,999</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>$5,000 extra or more</td>
<td>20</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Don't know</td>
<td>6</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

**Median:** $2,068

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>HHId Income</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>Men</td>
<td>Women</td>
<td>18-44</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>$2,166</td>
<td>$2,008</td>
<td>$2,005</td>
</tr>
</tbody>
</table>

12/18/2009

Consumer Reports National Research Center

Drive green.
A7a - How likely are you to consider an electric car when you purchase your next new car? Electric cars are powered exclusively by electricity and are recharged by plugging them into an electrical outlet. Would you say you are...

**Base: Household Buys and Drives Cars**

<table>
<thead>
<tr>
<th>RESPONDENT BASE</th>
<th>Gender</th>
<th>Age</th>
<th>HH1d Income</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>TOTAL</td>
<td>Men</td>
<td>Women</td>
<td>18-44</td>
</tr>
<tr>
<td>1,726</td>
<td>841</td>
<td>885</td>
<td>840</td>
<td>856</td>
</tr>
<tr>
<td>RESPONDENT BASE</td>
<td>Very/Somewhat Likely (Net)</td>
<td>26</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Very likely</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Somewhat likely</td>
<td>19</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Somewhat unlikely</td>
<td>19</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Very unlikely</td>
<td>53</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>Somewhat/Very Unlikely (Net)</td>
<td>72</td>
<td>71</td>
<td>73</td>
<td>70</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

A7b - How likely are you to consider an electric car when you purchase your next new car? Electric cars are powered exclusively by electricity and are recharged by plugging them into an electrical outlet. Would you say you are...

**Base: Household Buys and Drives Cars**

<table>
<thead>
<tr>
<th>RESPONDENT BASE</th>
<th>Metro Class</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>TOTAL</td>
<td>Urban</td>
</tr>
<tr>
<td>1,726</td>
<td>851</td>
<td>429</td>
</tr>
<tr>
<td>RESPONDENT BASE</td>
<td>Very/Somewhat Likely (Net)</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Very likely</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Somewhat likely</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Somewhat unlikely</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Very unlikely</td>
<td>53</td>
</tr>
<tr>
<td>Somewhat/Very Unlikely (Net)</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Electric Car: Battery Charging

Base: Likely to Buy Electric Car

- Among those likely to consider buying a plug-in electric car, nearly two-thirds (63%) said they are more likely (top-two box of five boxes)—and one-third said much more likely (top box)—to purchase an electric if their place of employment had facilities for recharging the battery. Around 3 in 10 (29%) said this recharging convenience would not affect their likelihood to buy.

- Change in likelihood was higher for men (66%) than for women (59%), and to a lesser degree, it was higher for consumers aged 18-44 years and those earning under $50,000 per year.

A8 - Suppose that you could charge an electric car at work. How would that affect your likelihood to purchase an electric car? Would you be...

<table>
<thead>
<tr>
<th>Respondent Base</th>
<th>Gender</th>
<th>Age</th>
<th>HHIncome</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>452</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>Men</td>
<td>Women</td>
<td>18-44</td>
<td>45+</td>
</tr>
<tr>
<td>229</td>
<td>223</td>
<td></td>
<td>234</td>
<td>214</td>
</tr>
<tr>
<td>59%</td>
<td></td>
<td></td>
<td>64%</td>
<td>61%</td>
</tr>
<tr>
<td>Much/Somewhat More Likely (Net)</td>
<td>63%</td>
<td>66%</td>
<td>59%</td>
<td>64%</td>
</tr>
<tr>
<td>Much more likely</td>
<td>33%</td>
<td>37%</td>
<td>29%</td>
<td>34%</td>
</tr>
<tr>
<td>Somewhat more likely</td>
<td>30%</td>
<td>29%</td>
<td>30%</td>
<td>29%</td>
</tr>
<tr>
<td>Have no change in likelihood</td>
<td>29%</td>
<td>24%</td>
<td>34%</td>
<td>30%</td>
</tr>
<tr>
<td>Somewhat less likely</td>
<td>3%</td>
<td>4%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Much less likely</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Somewhat/Much Less Likely (Net)</td>
<td>6%</td>
<td>7%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Don’t know</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

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Consumer Reports National Research Center
Electric Car: Range

Base: Likely to Buy Electric Car

- Ideally, consumers would like a plug-in electric car to have a range of 89 miles (median) for daily driving. Men (106 miles) and respondents with household income under $50,000 (102 miles) reported the greatest range requirements.

- Although 45% of consumers said they would be satisfied with a range of under 75 miles, nearly 3 in 10 (29%) required a daily range of at least 200 miles.

A9 - Ideally, what range between charges would you want from an electric car for daily driving?

Base: Very/Somewhat Likely to Buy Electric Car

<table>
<thead>
<tr>
<th>RESPONDENT BASE</th>
<th>TOTAL</th>
<th>Gender</th>
<th>Age</th>
<th>HHId Income</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Men</td>
<td>Women</td>
<td>18-44</td>
<td>45+</td>
</tr>
<tr>
<td>Under 75 Miles (Net)</td>
<td>45</td>
<td>39</td>
<td>52</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td>Less than 10 miles</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10-19 miles</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>20-29 miles</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>30-39 miles</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>40-49 miles</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>50-74 miles</td>
<td>17</td>
<td>13</td>
<td>20</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>75-99 miles</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>100-149 miles</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>150-199 miles</td>
<td>7</td>
<td>10</td>
<td>3</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>200 miles or more</td>
<td>29</td>
<td>30</td>
<td>28</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>Don't know</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>MEDIAN (no. miles)</td>
<td>88.7</td>
<td>106.3</td>
<td>70.7</td>
<td>80.8</td>
<td>91.9</td>
</tr>
</tbody>
</table>

12/18/2009

Consumer Reports National Research Center
Electric Car: Price Premium

Base: Likely to Buy Electric Car

- Consumers who are considering the purchase of a plug-in electric car have widely differing opinions about what an acceptable price premium would be compared to a conventional vehicle.

- Overall, the median extra amount that they would pay was $2,068. But 20% would pay nothing additional, while an equal share would pay at least $5,000 extra.

- Slightly more than one-third (36%) would pay up to $2,000 extra, and roughly the same proportion would pay $2,000 extra or more (38%).

- Across major demographic segments, only one difference was statistically significant: 43% of consumers earning under $50,000 annually would pay up to $2,000 extra versus 31% of those earning more.