Vehicle Electrification

Mike Degner & Sanjeev Naik
Ford Motor Company
General Motors Corporation
What is Vehicle Electrification?

**Conventional Powertrain**
- AFM/VVT
- SIDI
- 2-Step Lift
- D/S Turbo
- 6/8 speed AT
- dDCT
- HCCI
- Stop/Start

**Mild Hybrid**
- Engine off during deceleration and at idle
- Limited regen braking
- Electric power assist

**Full Hybrid**
- Full regen braking
- Engine cycle optimization
- Electric launch
- Limited pure electric drive
- Engine downsize

**Plug-In Hybrid Electric Vehicle**
- Plug-in rechargeable
- More electric drive during charge-depletion
- Reduced refueling

**Extended Range Electric Vehicle**
- Full-function electric drive
- Initial pure electric range
- Significantly reduced refueling

**Battery Electric Vehicle**
- 100% pure electric range
- Energy storage in a battery
- No exhaust emissions

**Total Battery Energy**
- % Vehicle Power Available from Battery
- % Vehicle Power Available from ICE

- Conventional Powertrain: ~100% 0.6 kWh
- Mild Hybrid: ~90% 16 kWh
- Full Hybrid: ~75% ~5 kWh
- Plug-In Hybrid Electric Vehicle: ~60% ~60 kWh
- Extended Range Electric Vehicle: ~40% 16 kWh
- Battery Electric Vehicle: > 100% > 21 kWh

**Functionality**
- Mechanical
- Engine Dominant
- Blended
- Electric with Engine Assist
- All Electric
History of Vehicle Electrification

- **Ayrton & Perry’s Electric Tricycle of 1882**: Believed to be the first road-going electric vehicle.

- **1902 Waverley Electric Automobile**: Indianapolis, Indiana.

- **1902 Columbia Electric**

- **Fred Allison on Ford Experimental EV (1913)**

- **1910 Baker Electric**

- **1908 Victoria Phaeton**

The images depict various historical electric vehicles, highlighting the evolution of electrified transportation.
Why Is Vehicle Electrification Happening Now?

**Price Stability**
- Electricity offers stable energy costs compared to oil

**Energy Security**
- Electricity utilizes local energy sources
- Diversify transportation energy needs

**Government Regulations**
- CAFÉ, CO2

**Sustainability**
- Global warming

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**Average Annual Retail Price**

<table>
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<th>Year</th>
<th>Gasoline</th>
<th>Electricity</th>
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<td>2010</td>
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**US Consumption, Production, and Import Trends (1949-2009)**

**Net Imports and Domestic Petroleum as Shares of U.S. Demand, 2009**

- U.S. Petroleum 49%
- Net Imports 51%

Challenges Facing Widespread Vehicle Electrification
Cost, Reliability, Infrastructure, Customer Acceptance

- Energy Storage Systems
  - Jeff Sakamoto
  - “Keeping up with the increasing demands for electrochemical energy storage”

- Electric Drives & Power Electronics
  - Matt Willard

- Electric Grid Infrastructure
  - Arindam Maitra
  - “Preparing the Distribution Grid to Embrace PEVs”

- Customer Acceptance
  - Rahul Mangharam
  - “The Car and the Cloud: Remote Automotive Controller Unit Diagnostics Testing and Reprogramming”