

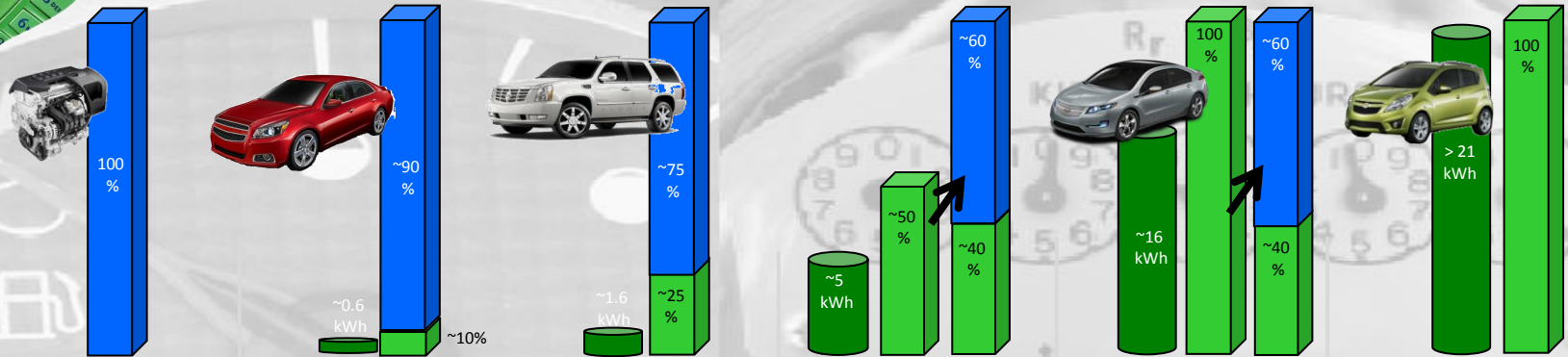
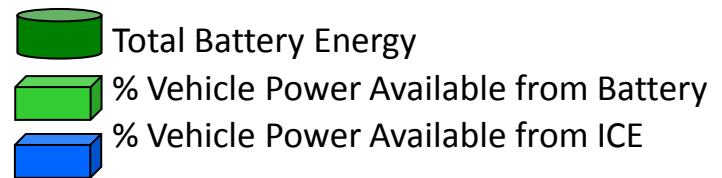
# Vehicle Electrification



*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

Functionality

Drive System

Mechanical

Engine Dominant

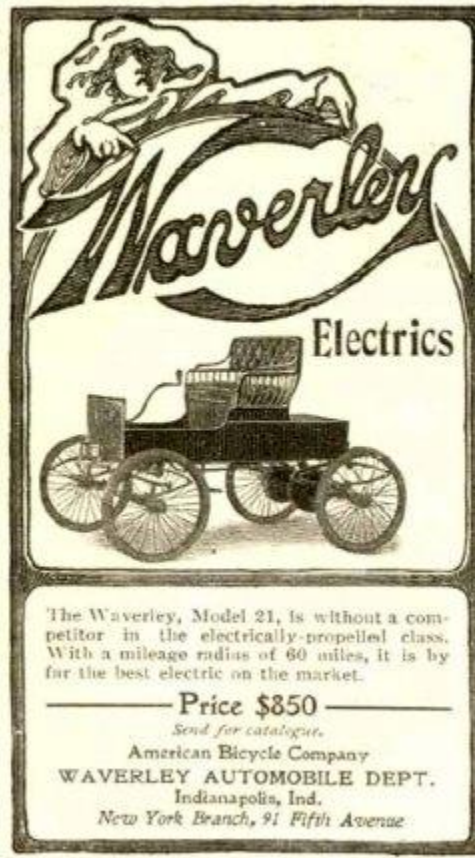
Blended

Electric with Engine Assist

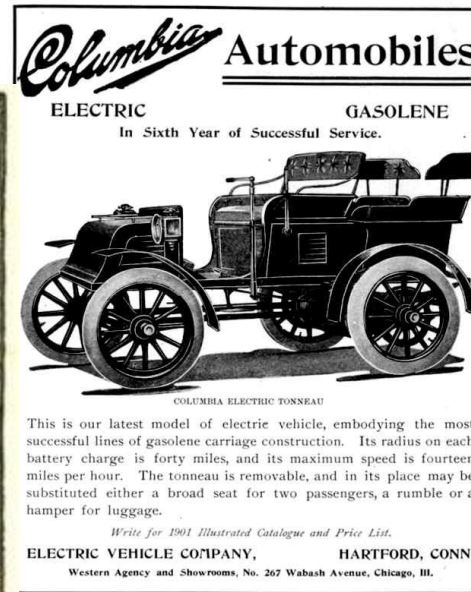
All Electric



# History of Vehicle Electrification



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



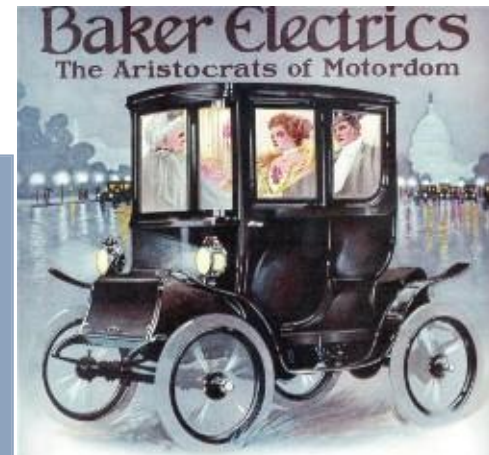
**1902 Columbia Electric**



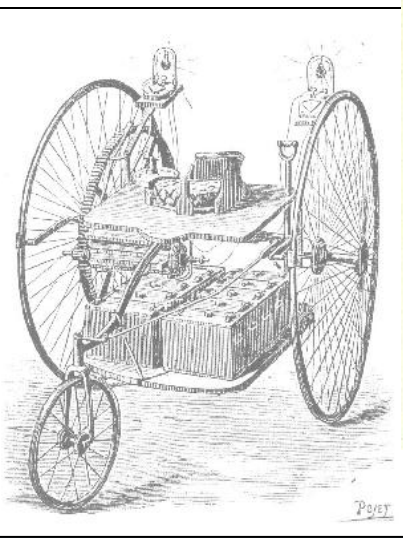
**1908 Victoria Phaeton**



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



**1910 Baker Electric**

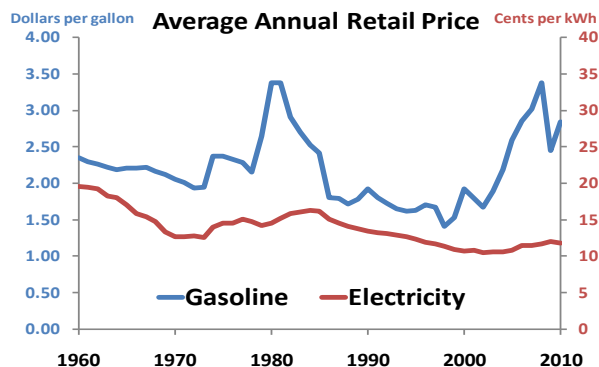


**Ayrton & Perry's Electric Tricycle of 1882**  
 Believed to be the first road going electric vehicle

# Why Is Vehicle Electrification Happening Now?

## Price Stability

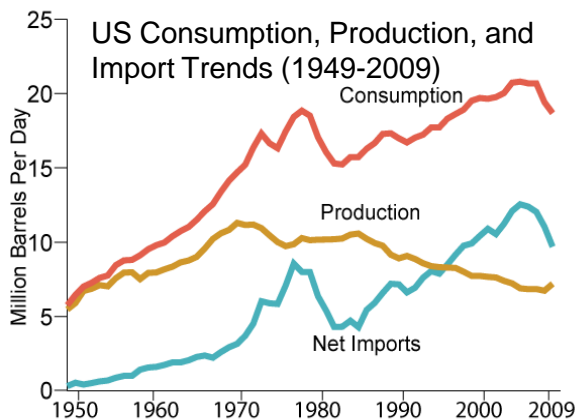
- Electricity offers stable energy costs compared to oil



Source: US Energy Information Administration, <http://tonto.eia.gov/emeu/steo/realprices/index.cfm>

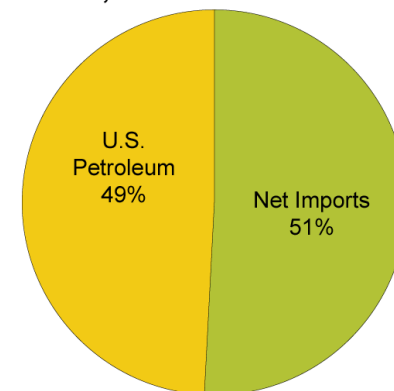
## Energy Security

- Electricity utilizes local energy sources
- Diversify transportation energy needs



Source: US Energy Information Administration, *Annual Energy Review 2009*, Table 5.1 (August 2010)

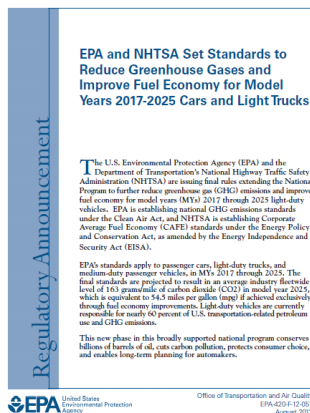
## Net Imports and Domestic Petroleum as Shares of U.S. Demand, 2009



Source: U.S. Energy Information Administration, *Petroleum Supply Annual 2009* (July 2010).

## Government Regulations

- CAFÉ, CO<sub>2</sub>



## Sustainability

- Global warming



# Challenges Facing Widespread Vehicle Electrification

Cost, Reliability, Infrastructure, Customer Acceptance

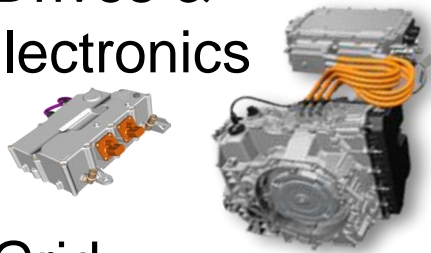
- Energy Storage Systems



Jeff Sakamoto

“Keeping up with the increasing demands for electrochemical energy storage”

- Electric Drives & Power Electronics



Matt Willard

“Stronger, Lighter, and More Energy Efficient: Challenges of Magnetic Material Development for Vehicle Electrification”

- 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”