



# TECHNOLOGY LEADERSHIP



**Larry Burns**

*Vice President, Research & Development and Strategic Planning*

# ***Forward Looking Statements***

In the following presentation and in related comments by General Motors management, we will use words like "expect," "anticipate," "estimate," "forecast," "goal," "project," "targets" and similar expressions to identify forward looking statements that represent our current judgments about possible future events. We believe these judgments are reasonable, but actual results may differ materially due to a variety of important factors.

Among other items, such factors might include: the pace of introductions and market acceptance of new products; relationships with our labor unions, changes in the competitive environment and the effect of competition on our markets, including on our pricing policies; price increases or shortages of fuel; and changes in laws, regulations or government policies affecting our vehicles.

GM's most recent annual report on Form 10-K and quarterly reports on Form 10-Q provide information about these factors, which may be revised or supplemented in future reports to the SEC on Form 10-Q or 8-K.

We caution investors not to place undue reliance on our forward-looking statements. Except where expressly required by law, we undertake no obligation to update publicly or otherwise revise any forward-looking statements, whether as a result of new information, future events or other factors.

## *Opportunity*

- Growth industry
  - 2007: 70M sales
  - 2016: 94 M sales

## *Challenge*

- Sustainability



**35%** of World's Energy  
comes from **PETROLEUM**



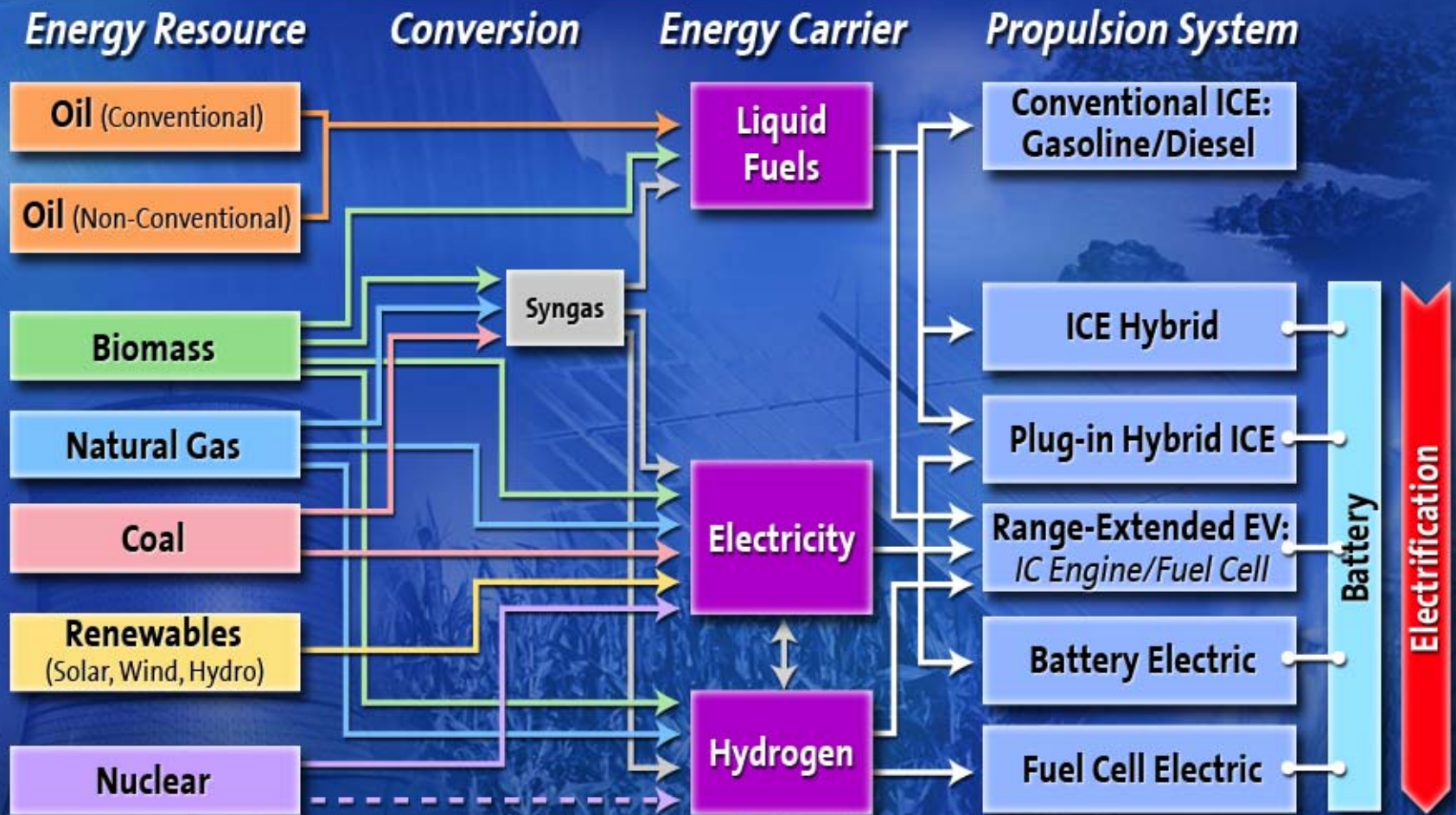
We'll Need  
**70% More Energy**  
in **2030** Than in **2004**



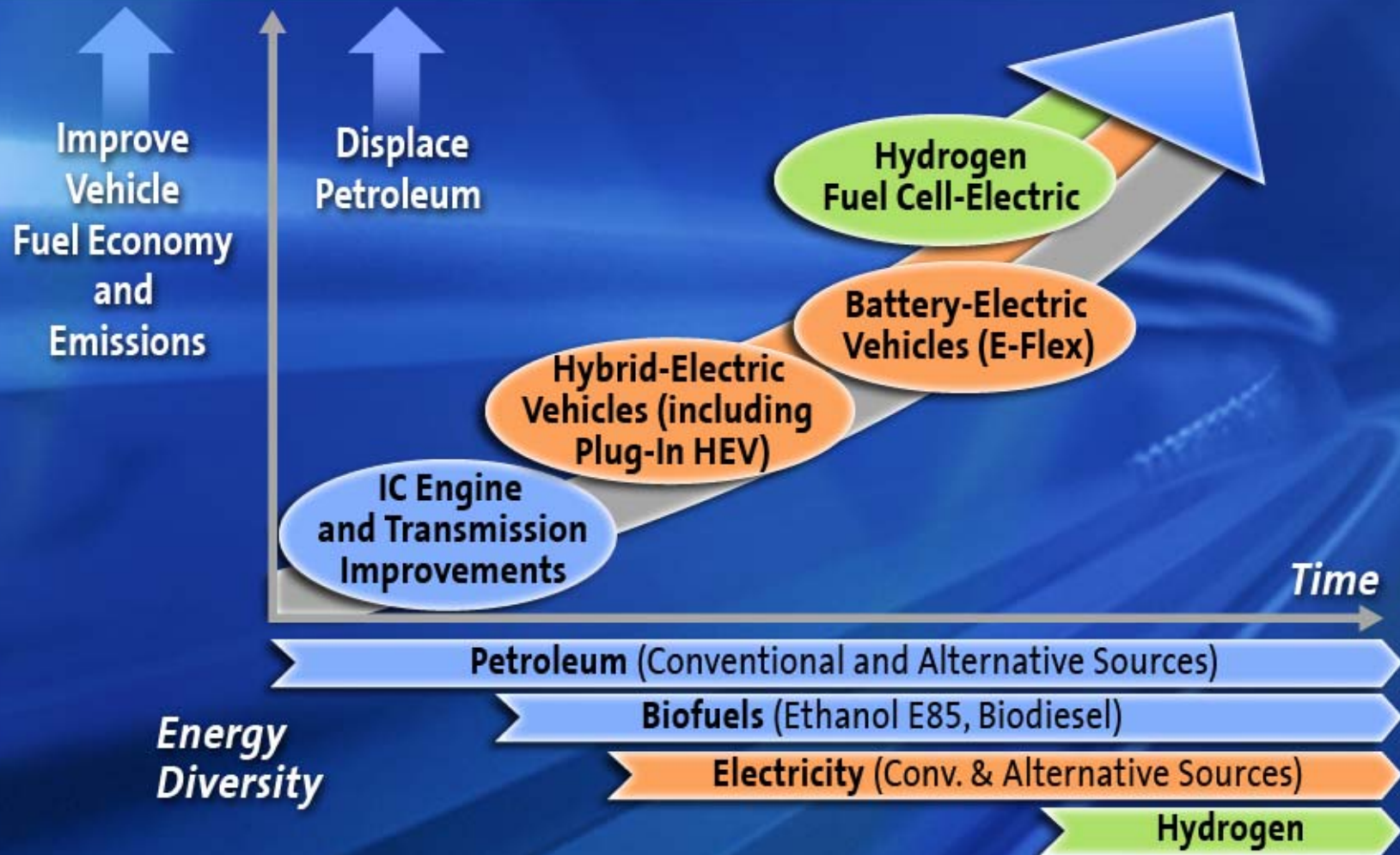
*GM Strategy:* Displace Petroleum  
Through Energy Diversity



# Energy Diversity



# Advanced Propulsion Technology Strategy



## *Example Improvements*

- Active Fuel Management
- Energy-efficient six-speed transmissions





# ETHANOL



VHC  
FLEXPOWER

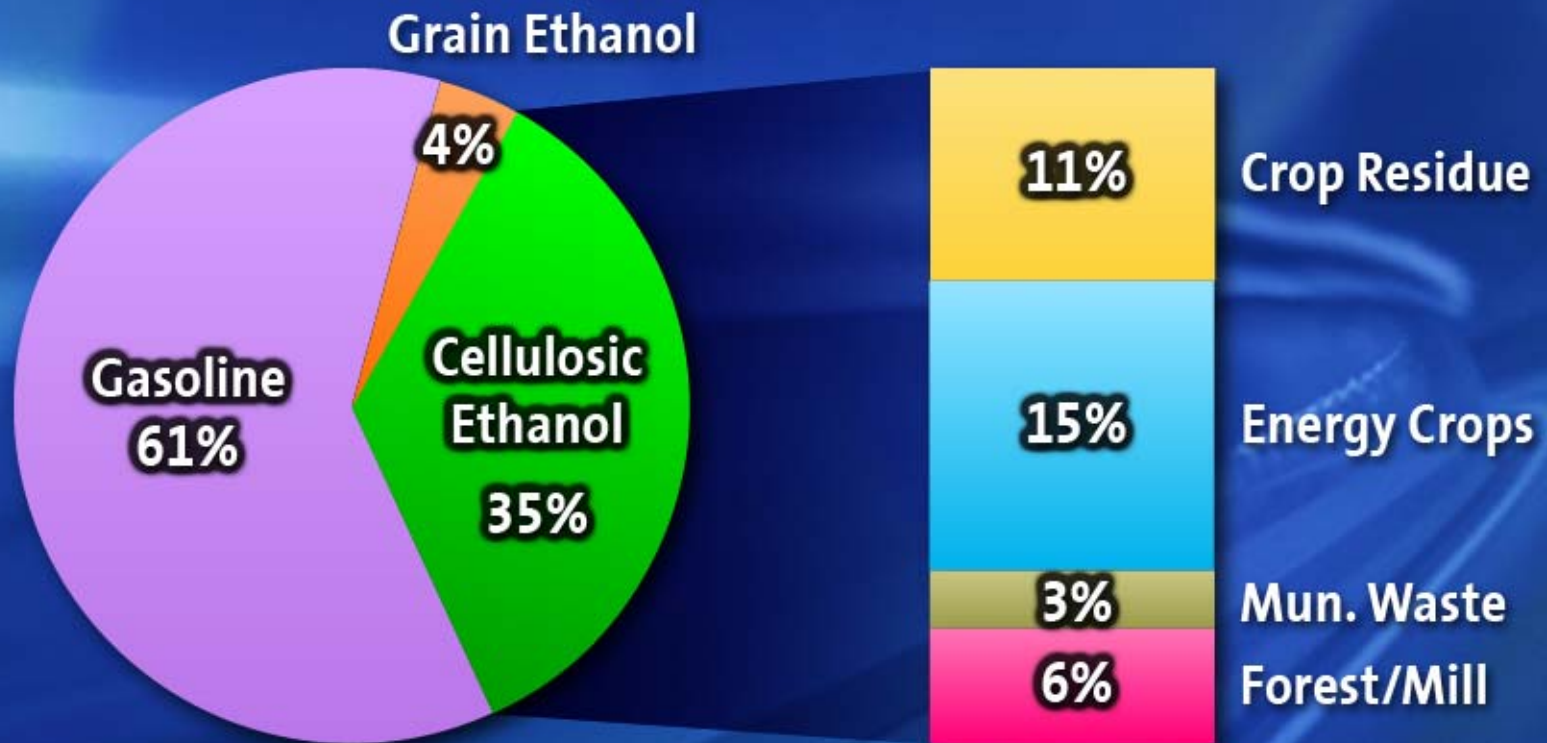
LEXFUEL  
E85 ETHANOL



# ***Ethanol Basics***

- Alcohol derived from biomass – corn, sugar, plant fiber (cellulose)
- 1.5 gallons ethanol = 1.0 gallon gasoline
- Can be produced in volume around the world
- Affordable alternative to gasoline
  - Potential cost of \$1.35-2.25 per gallon gasoline equivalent
- Reduces CO<sub>2</sub> emissions
- Minimal cost to modify the vehicle

# *Ethanol Potential by 2020*



All percentages are on an energy equivalent basis. Based on University of Toronto data.

# Challenges

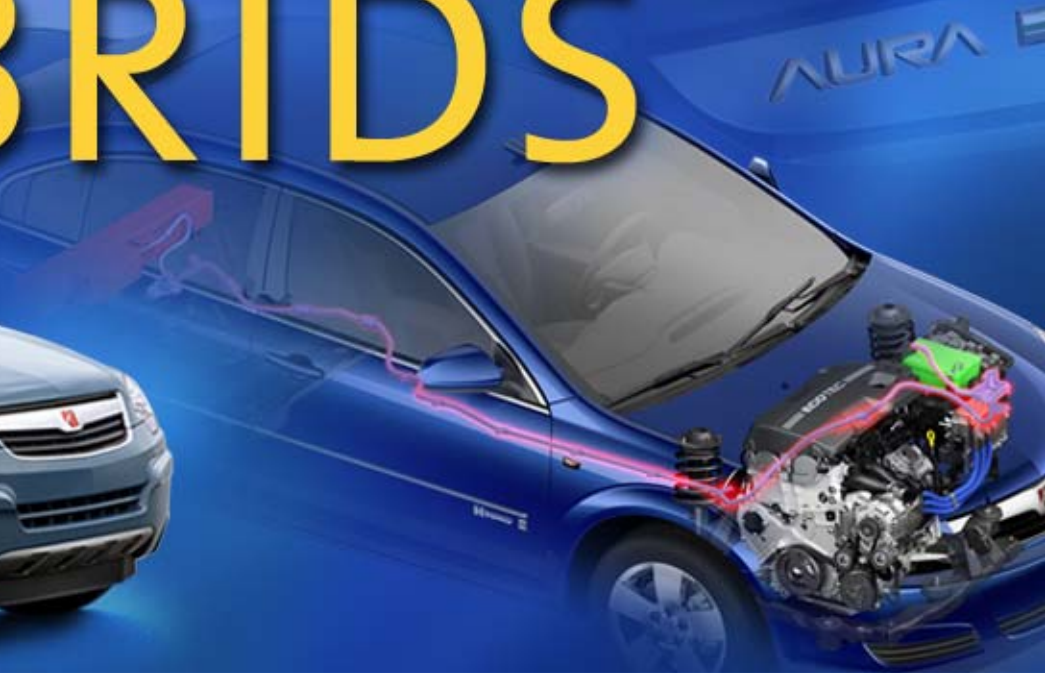
- Food crops currently used to produce ethanol
- Vehicle range
- Ramp-up of required ethanol production and distribution channels



HYBRID  
2 MODE



# HYBRIDS



## ***GM Hybrids***

- Hybrid System – 10- 25% fuel economy gain
- 2-Mode Hybrid System – 25-40% fuel economy gain
- **Beginning this summer, 16 programs over next four years – 1 every 3 months!**



***GM Hybrid System***



***GM 2-Mode Hybrid System***



Engine Control Module

12 Volt Battery and Accessories

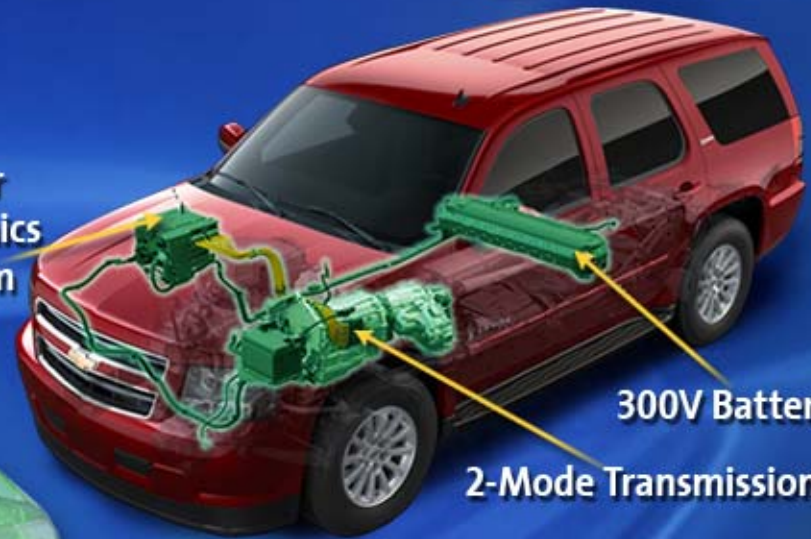
Power Electronics

Advanced Nickel Metal Hydride Battery Pack

**AURA** 

**HYBRID**  
2 MODE

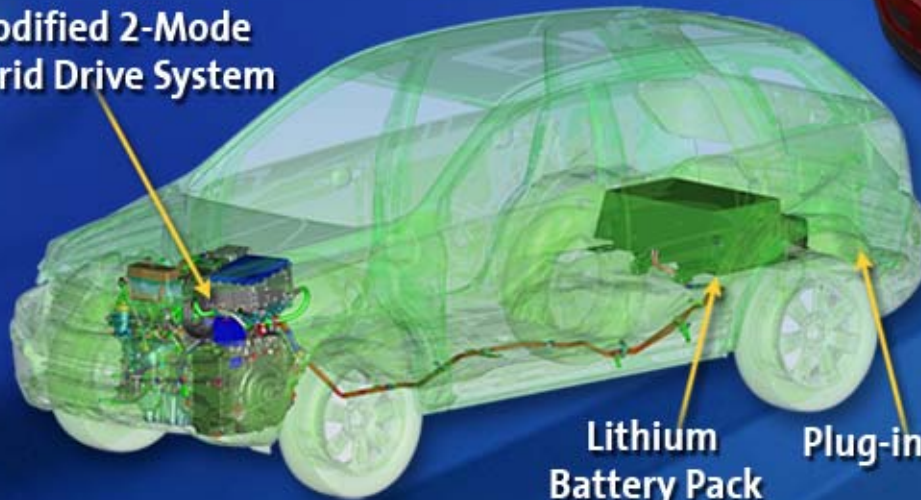
Power Electronics System



300V Battery

2-Mode Transmission

Modified 2-Mode Hybrid Drive System



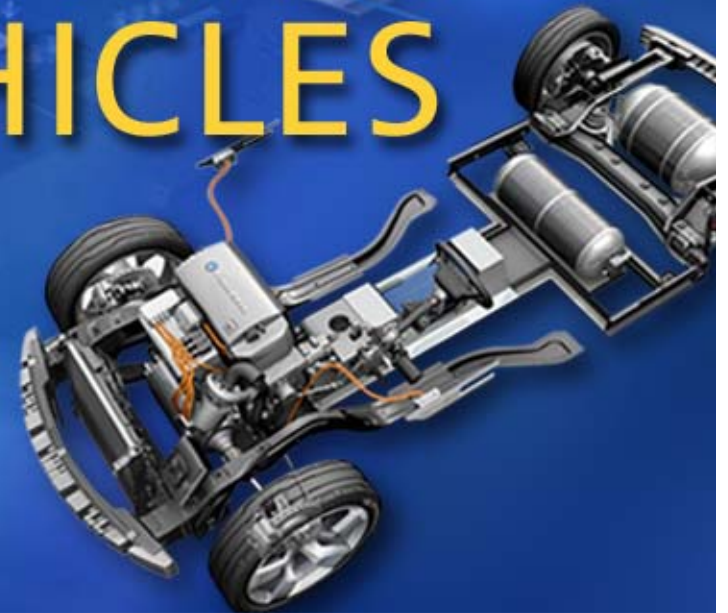
Lithium Battery Pack

Plug-in Charger

**Saturn VUE**  
**Plug-in Hybrid**



# ELECTRICALLY DRIVEN VEHICLES



# *Electricity Basics*

- Produced from many sources
- Relatively inexpensive
- Cyclical demand
- Hard to store
- Electricity and hydrogen are interchangeable

# Electricity Generation: Diversity Among U.S. States

U.S. Average



California



Rhode Island



Hawaii



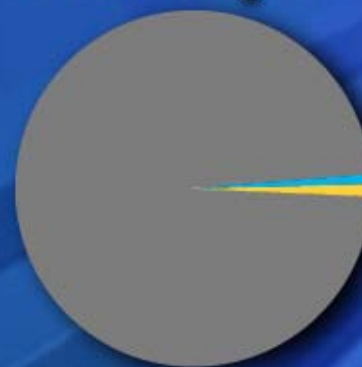
Vermont



Idaho



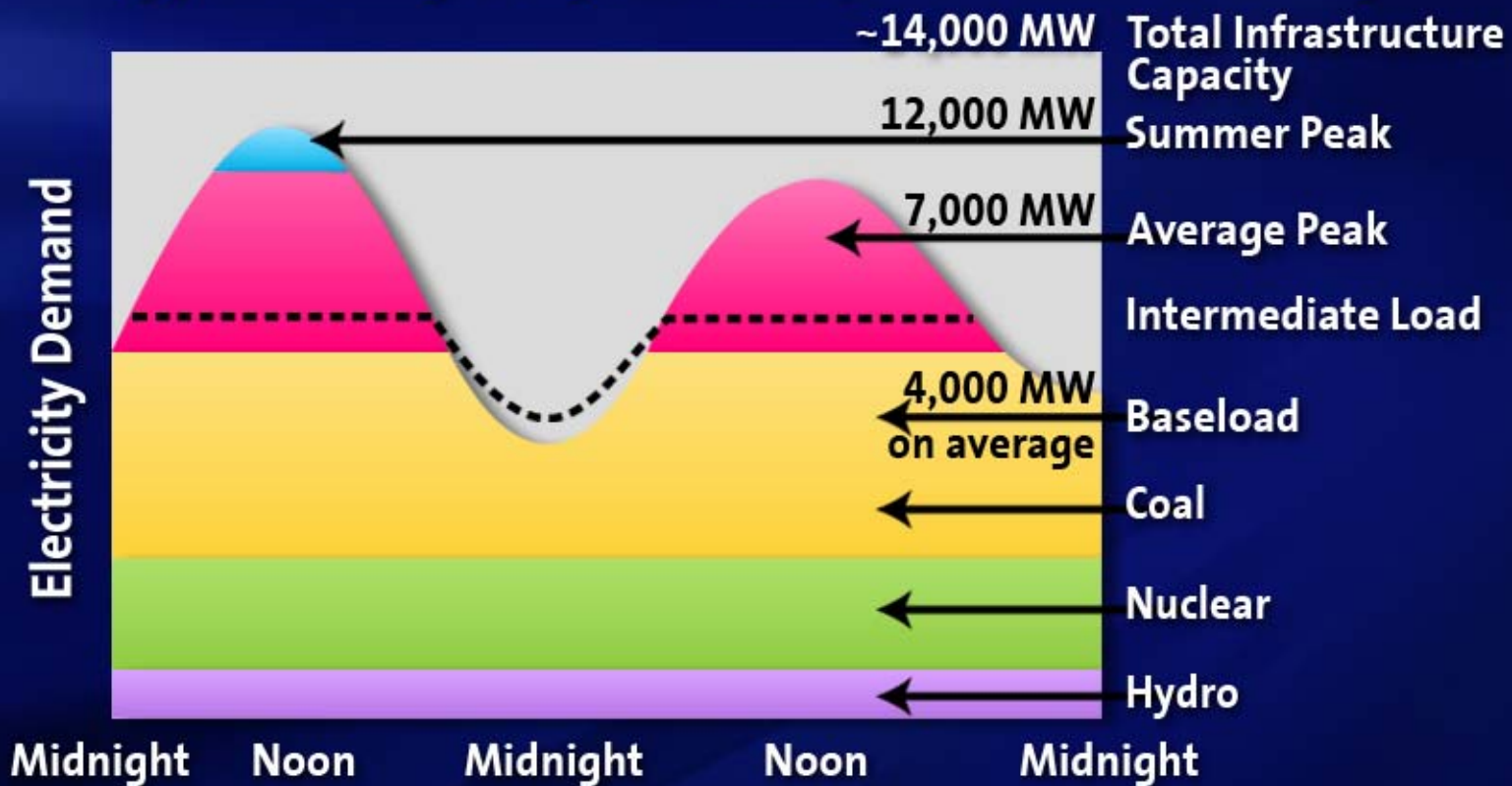
West Virginia



Source: EIA

# Why Is Electricity Important?

## Typical Utility Daily Load Shape for Midwest Utility

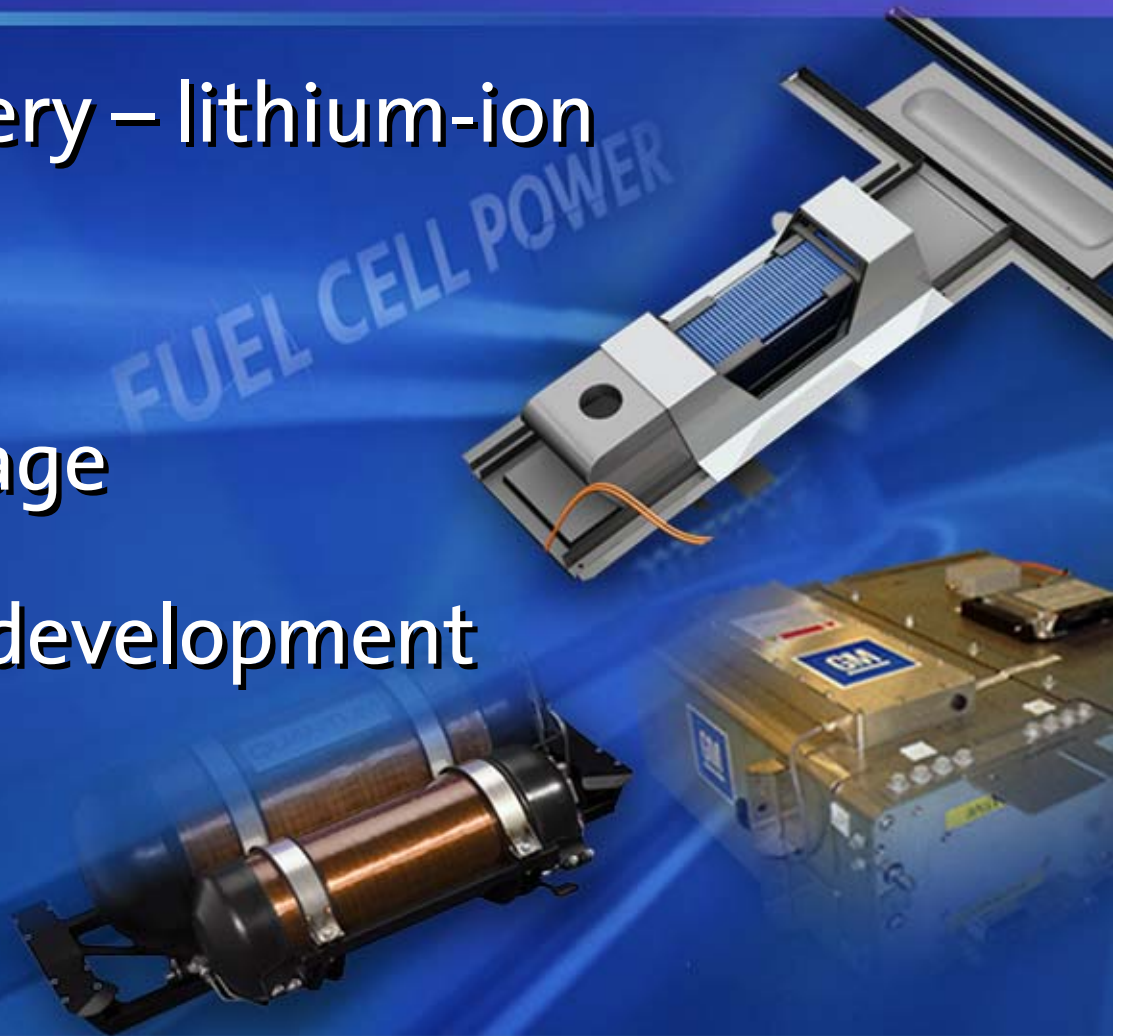


## ***GM E-Flex***

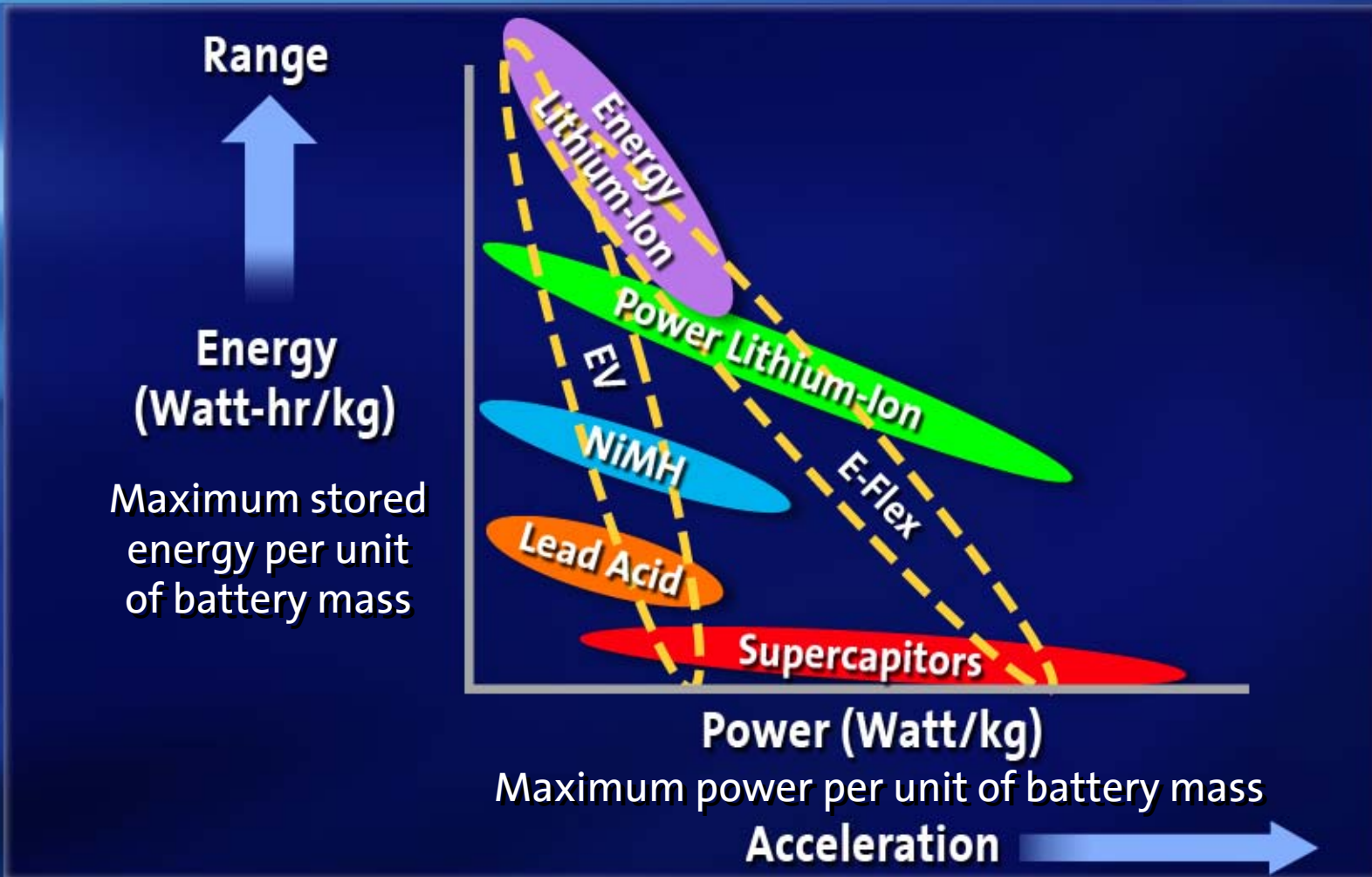
- Flexible electric drive system enabling variety of electrically driven vehicles
  - Common electrical drive components
  - Create and store electricity on board
    - Engine-generator
    - Hydrogen fuel cell
    - Advanced battery
    - Plug-in capable

# *Key Enablers*

- Advanced battery – lithium-ion
- Fuel cells
- Hydrogen storage
  - Electricity
  - Hydrogen
- Infrastructure development



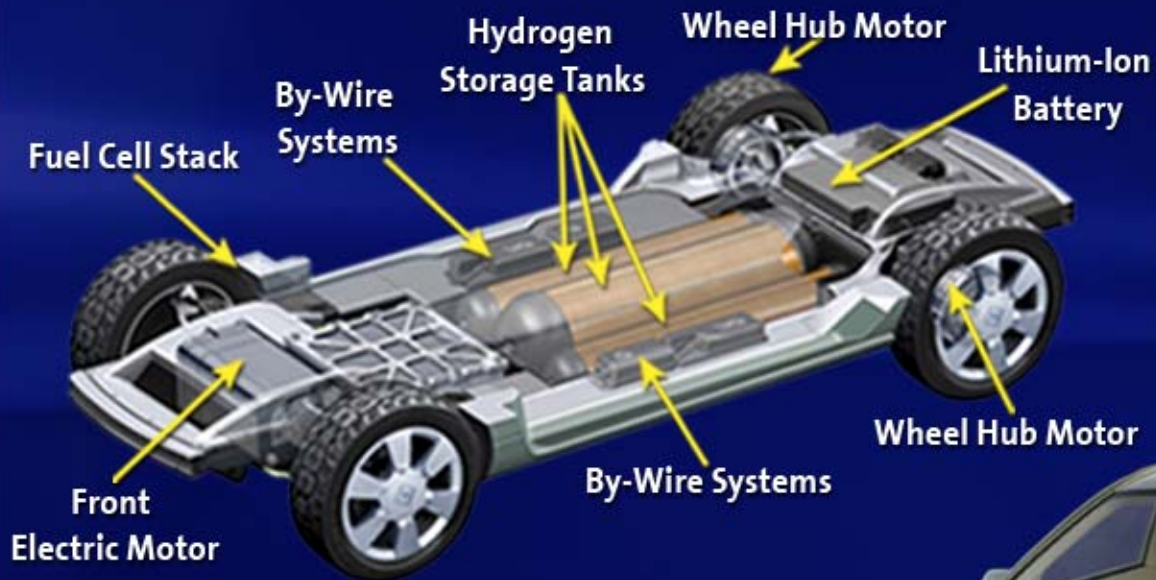
# Battery Technology Improvements



# *Hydrogen Basics*

- Hydrogen is an energy carrier
- Large global infrastructure already exists
- Can be competitive with gasoline on cost-per-mile basis
- Biggest challenge is managing the transition
- Since natural gas, electricity, and water are widely available, infrastructure could be sited anywhere
- \$10-15 billion investment would establish network of 12,000 stations (for 70% of U.S. population)
- 2% increase in U.S. natural gas supply could “kick-start” initial infrastructure for 10M vehicles

# SEQUEL



***World's most  
technologically  
advanced vehicle***



# EQUINOX FUEL CELL



## *Project Driveway*

- Largest fuel cell vehicle market test
- 100+ vehicles in the hands of customers



# Connecting the Dots

● Future

## Accelerated Industry Growth



## A Compelling Opportunity