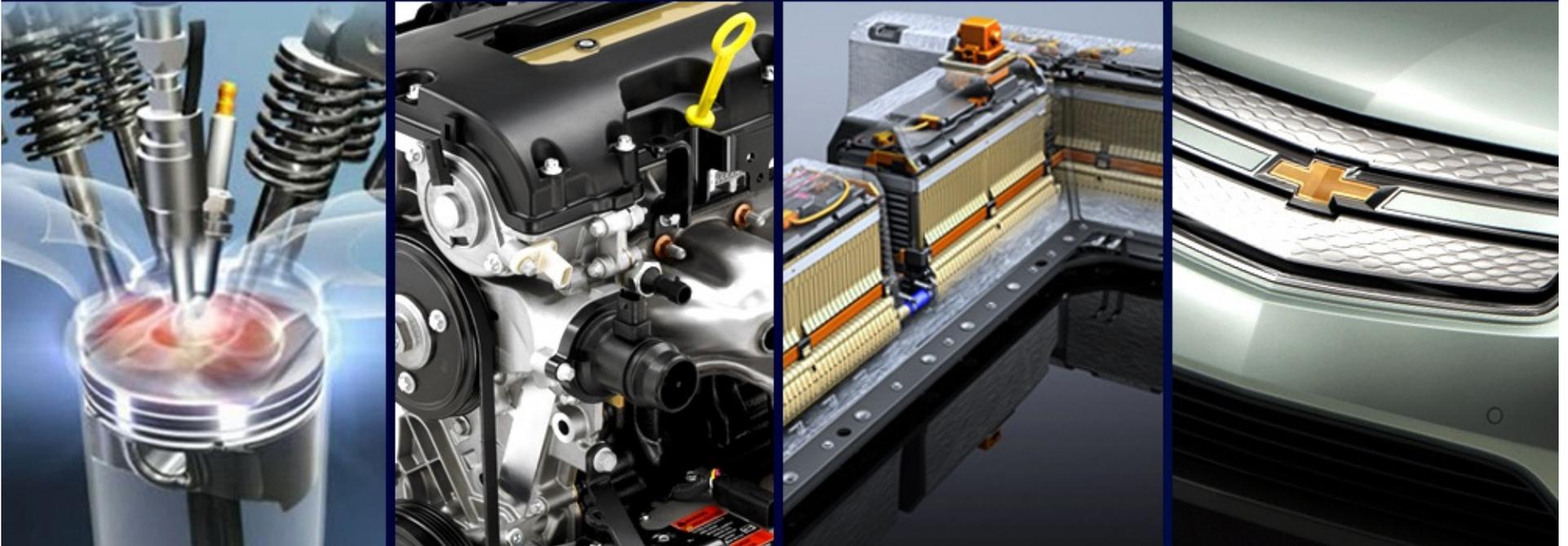


# OEM Outlook: Batteries and Charging Infrastructure

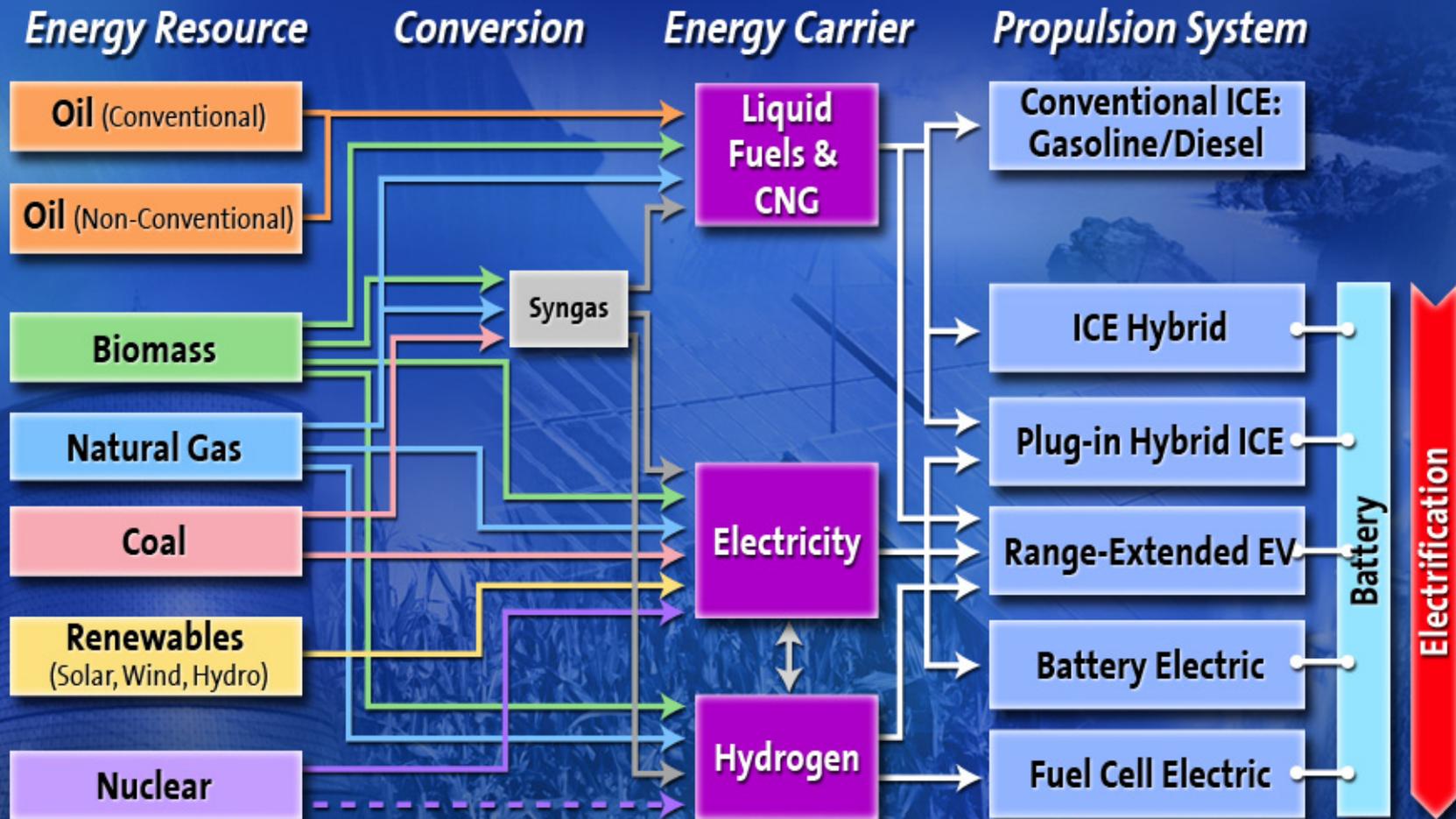
GM

Britta Gross

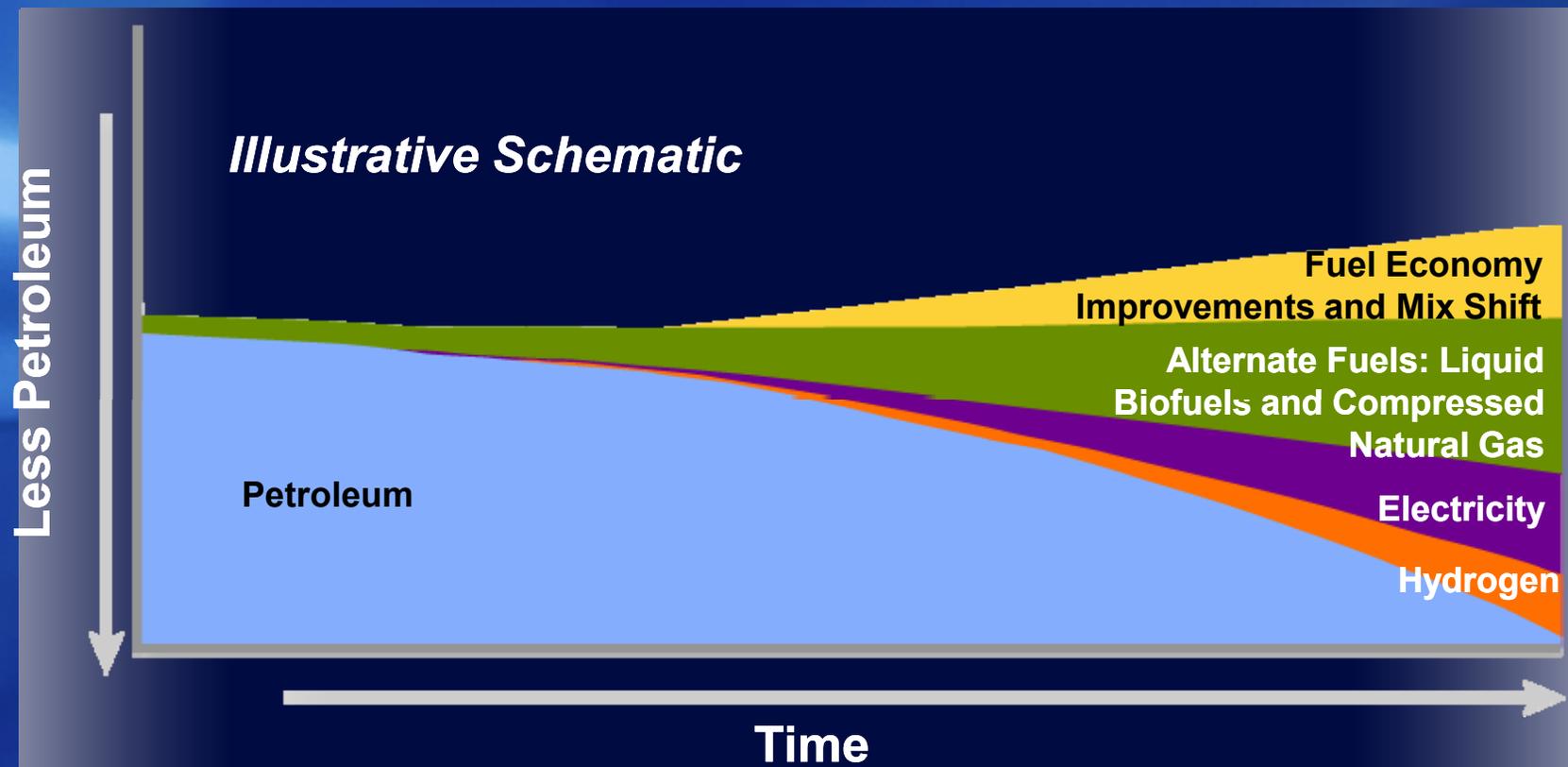
Director, GM R&D, Global Energy Systems and Infrastructure Commercialization



# ENERGY OPTIONS



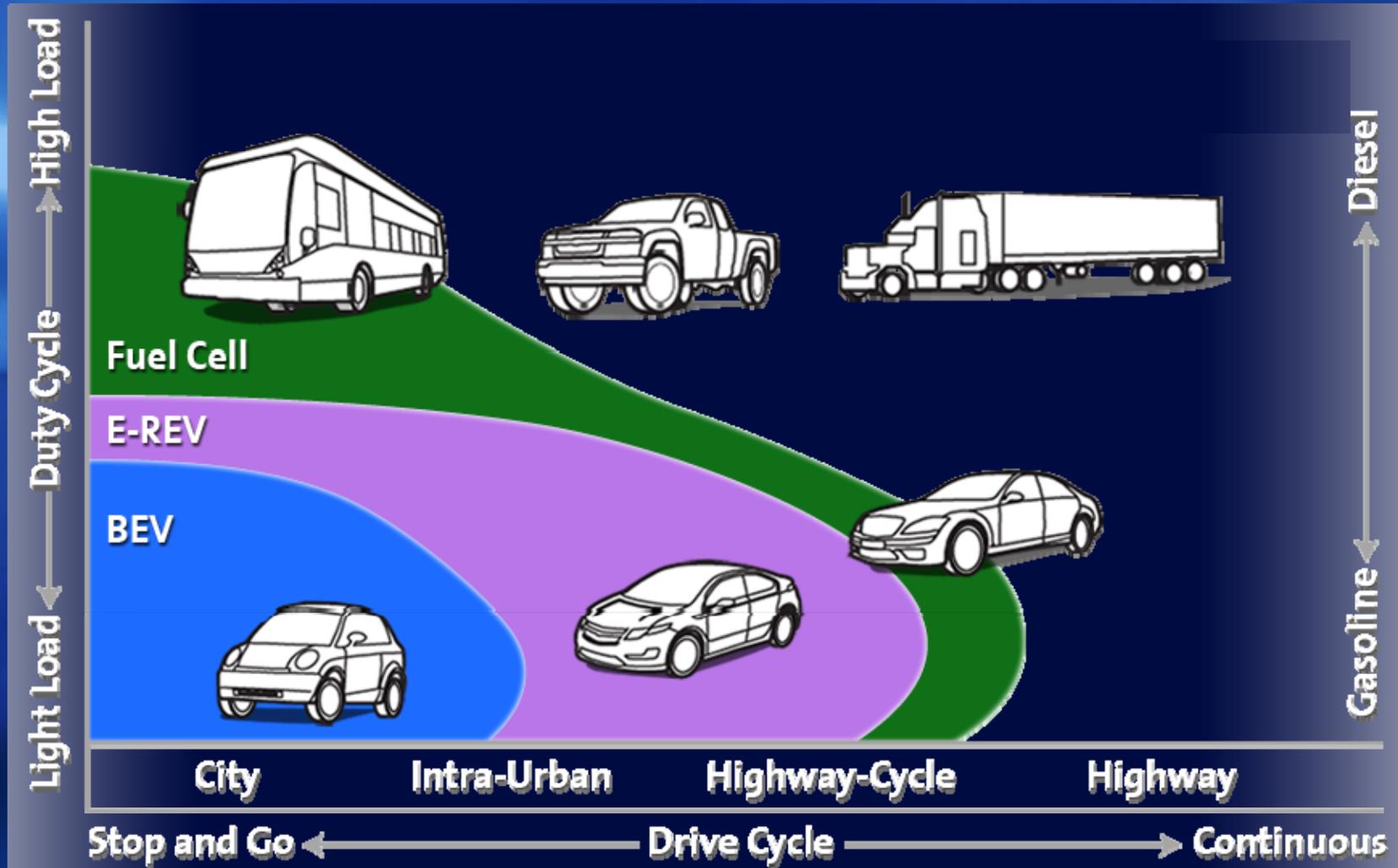
# PETROLEUM DISPLACEMENT “AND” SCENARIO



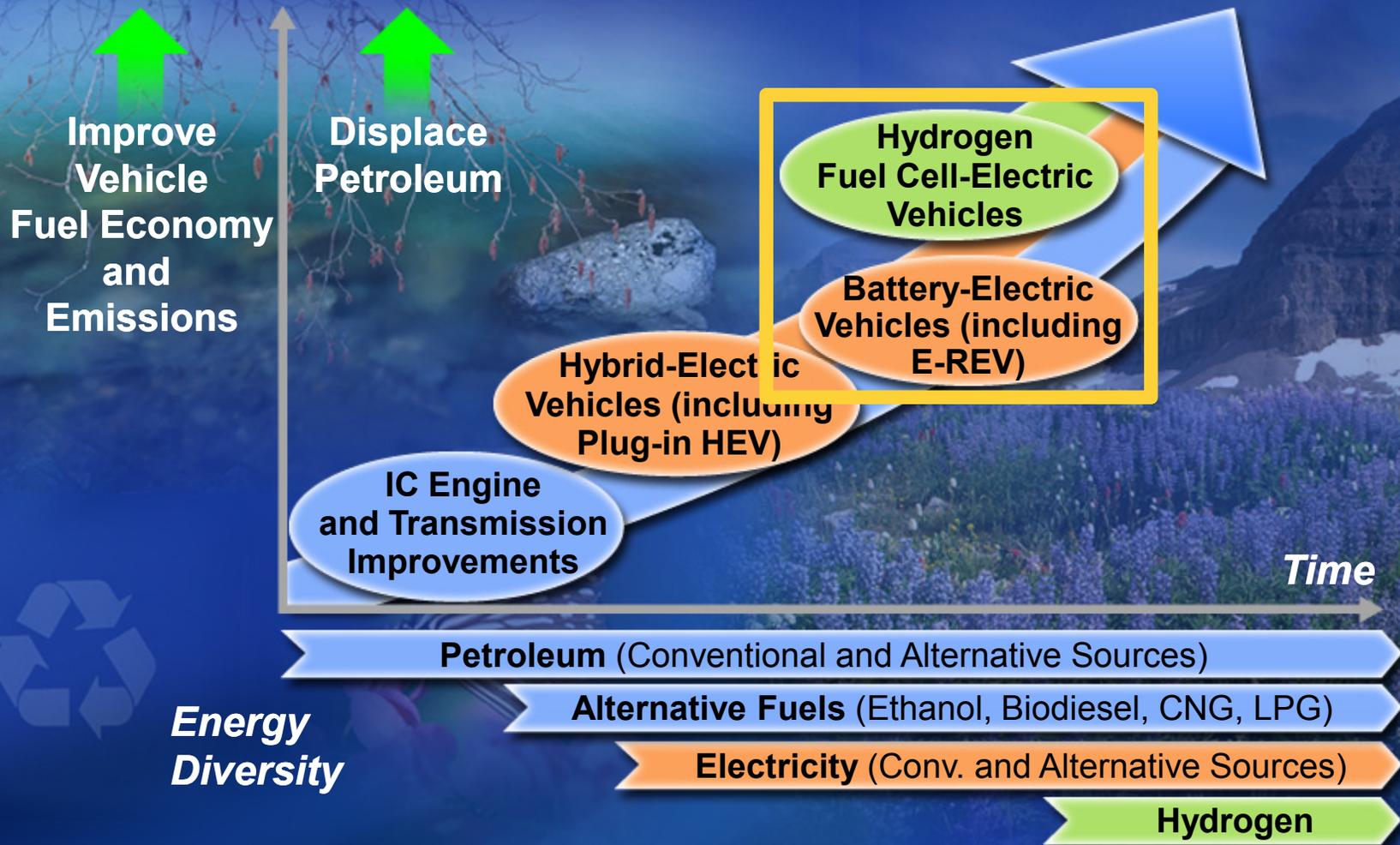
Start soon with early options; finish with strongest long-term portfolio

# VEHICLE APPLICATION MAP

Will require both batteries and fuel cells to cover

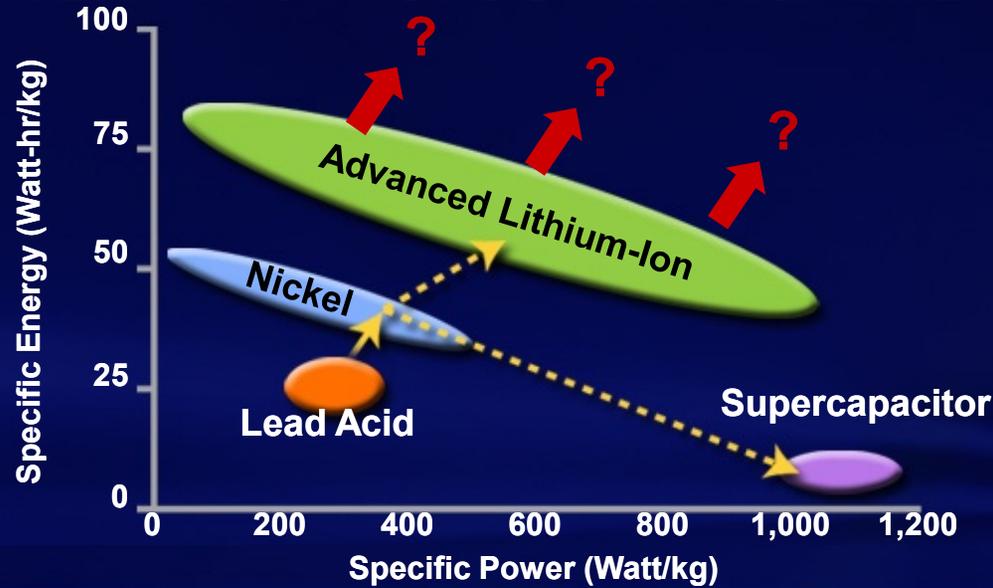


# ADVANCED PROPULSION TECHNOLOGY STRATEGY

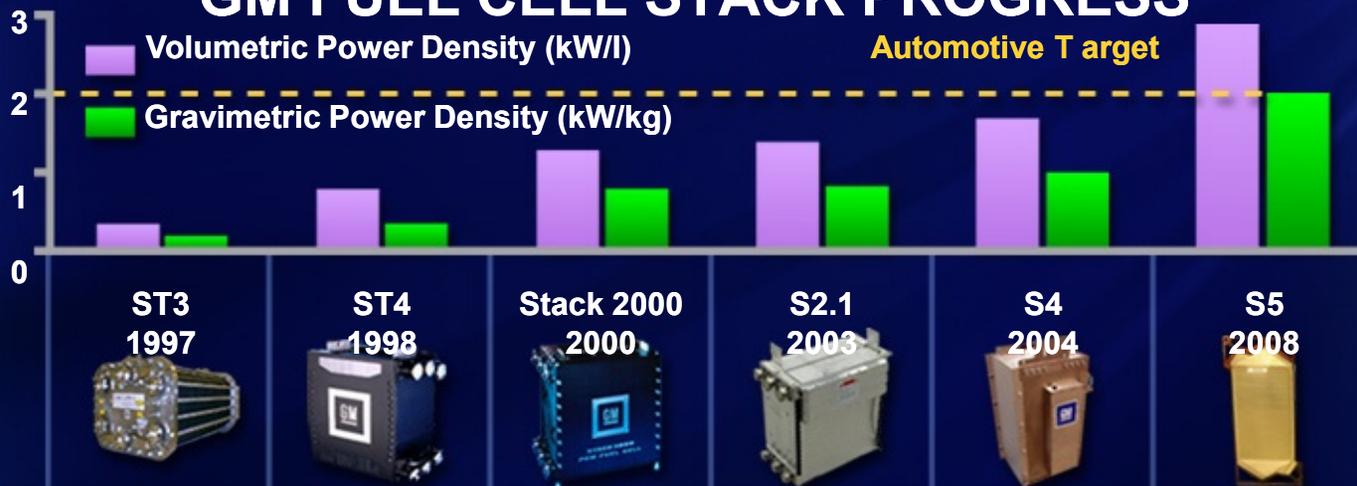




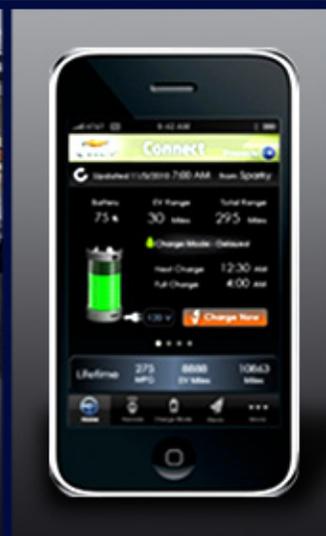
# BATTERY TECHNOLOGY IMPROVEMENTS



# GM FUEL CELL STACK PROGRESS

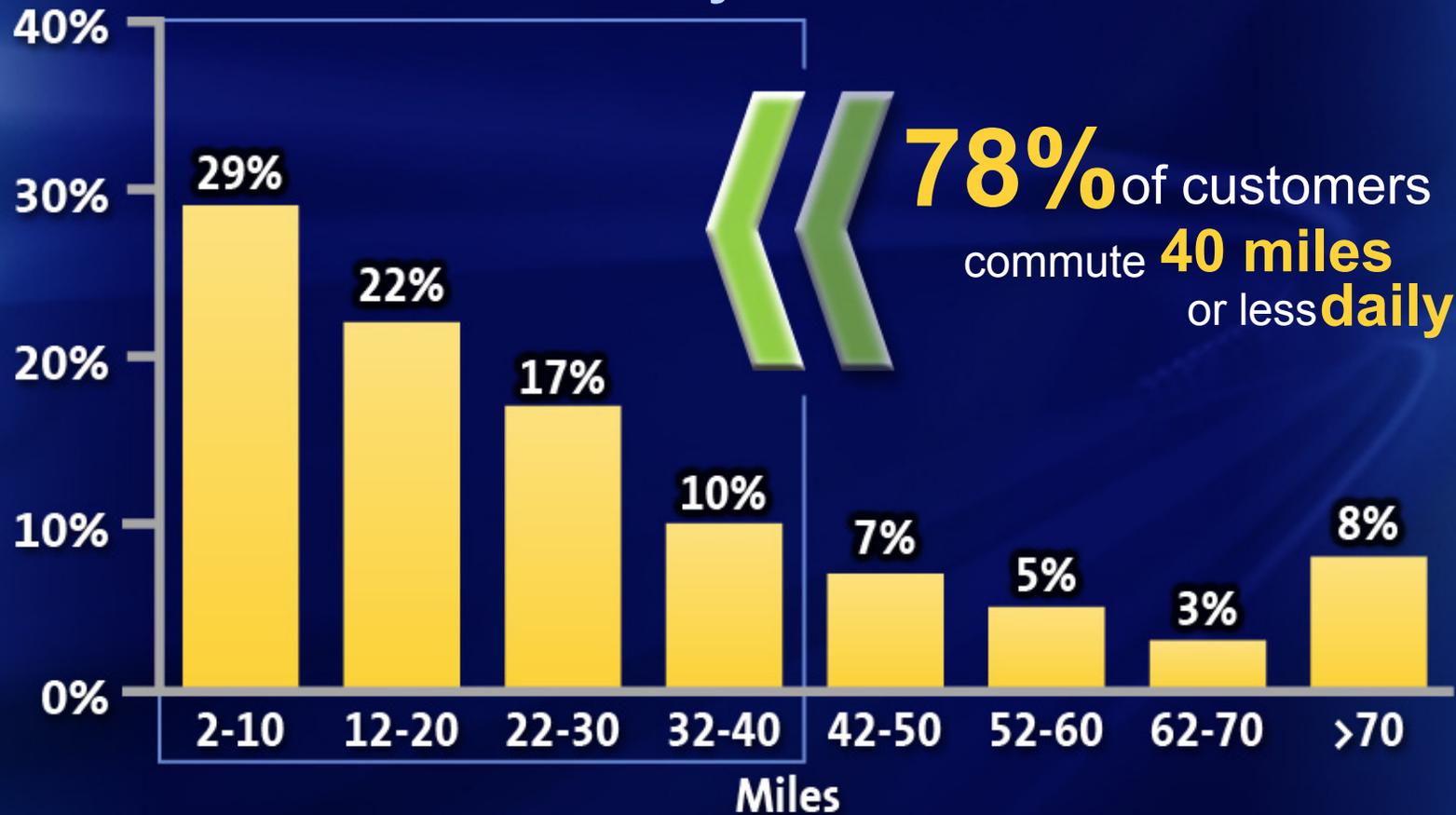


# CHEVROLET VOLT



# TYPICAL DAILY COMMUTE – U.S.

40 Miles Is the Key



Based on OmniStats Data posted by the U.S. Bureau of Transportation

# Chevrolet Volt

*Electric Vehicle (with a Range-Extender)*



Designed for **40** miles  
**BATTERY**  
Electric Drive  
*(typically 25-50 mile EV range)*

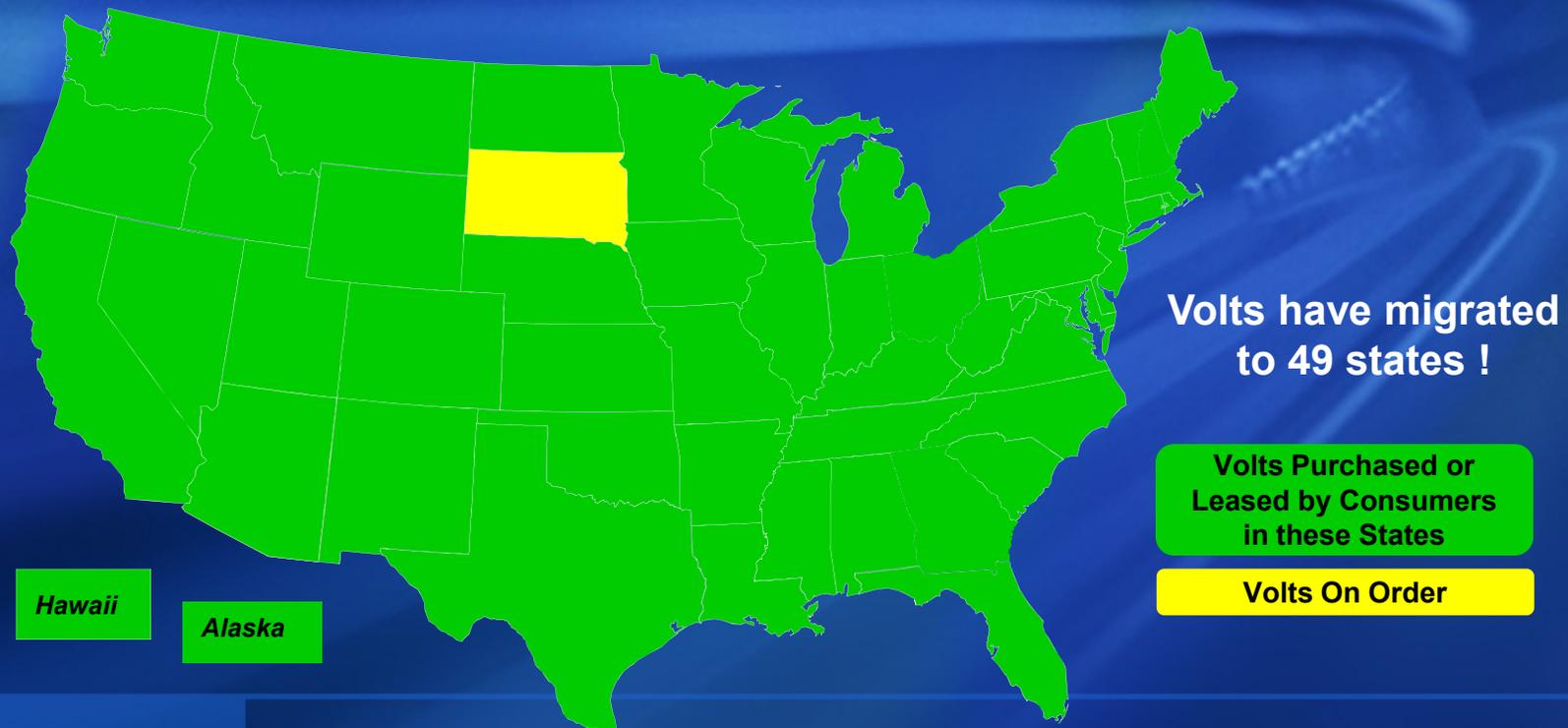


Designed for over **300** miles  
**EXTENDED RANGE**  
Driving on Gasoline

New EPA label: EV @ 93mpg (35 miles) + Gas @ 37mpg comb (344 miles) = Overall 60mpg (379 miles)

# Volt Rollout Status

- December 2010 - Ship to Commerce began with 7-state rollout
- Summer 2011 - Michigan assembly plant retooled to increase production
- September 2011 – Best month ever for Volt retail sales!
- October 2011 - Volt retail sales now in 27 states – national by year’s end
  - 2,200 Volts now at dealers or in transit for dealer demo’s
  - 4,000 Volts delivered to customers
- Supply driven - focus on Quality launch and progressive build-up of volume
- Greater fleet availability for MY2012



# CHARGING AND INFRASTRUCTURE



**120V Cordset**

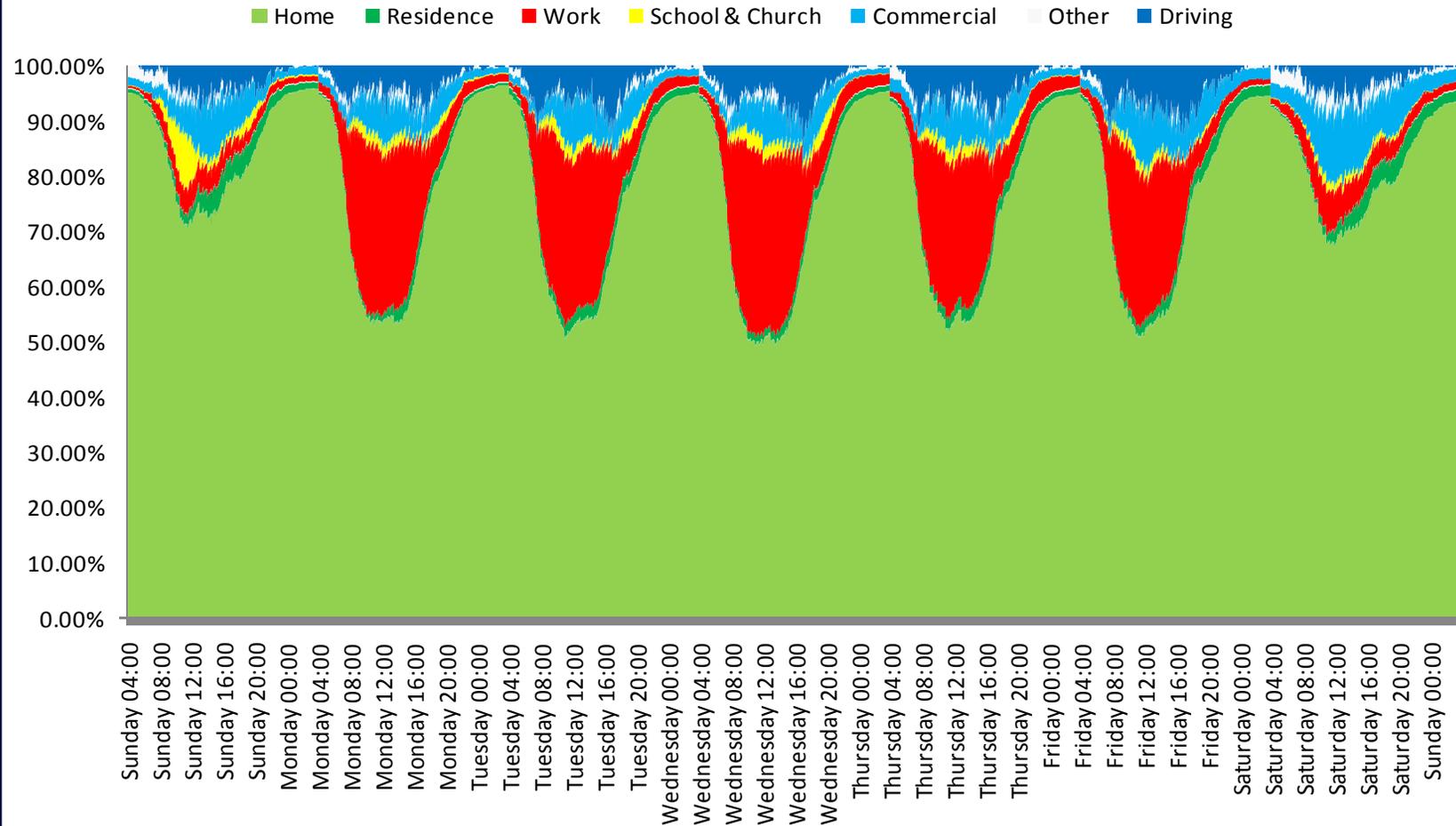


**240V Charge Station**

- 120V (1.2 kW) charging – household outlet
- 240V (3.3 kW) charging – one-time investment
- Charger and control logic on board the vehicle

# WHERE ARE THE CARS?

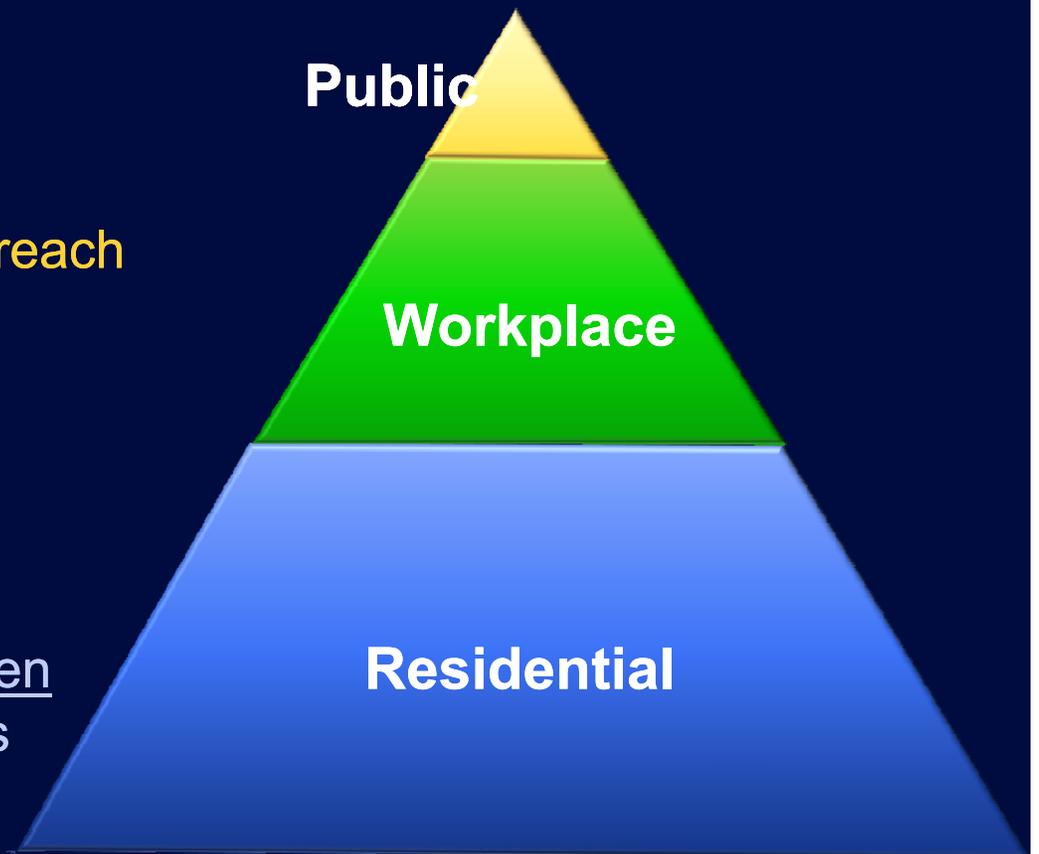
## Fleet Distribution during week



Source: 2001 National Household Travel Survey; GM Data Analysis (Tate/Savagian)– SAE paper 2009-01-1311

# CHARGING INFRASTRUCTURE

- **Public charging**
  - High visibility
  - Commercial/Retail
  - Public education and outreach
- **Workplace**
  - Corporate, municipal parking lots
- **Residential (majority)**
  - Satisfying consumer-driven home installation process
  - Permits, electricians, inspections, meters, rates

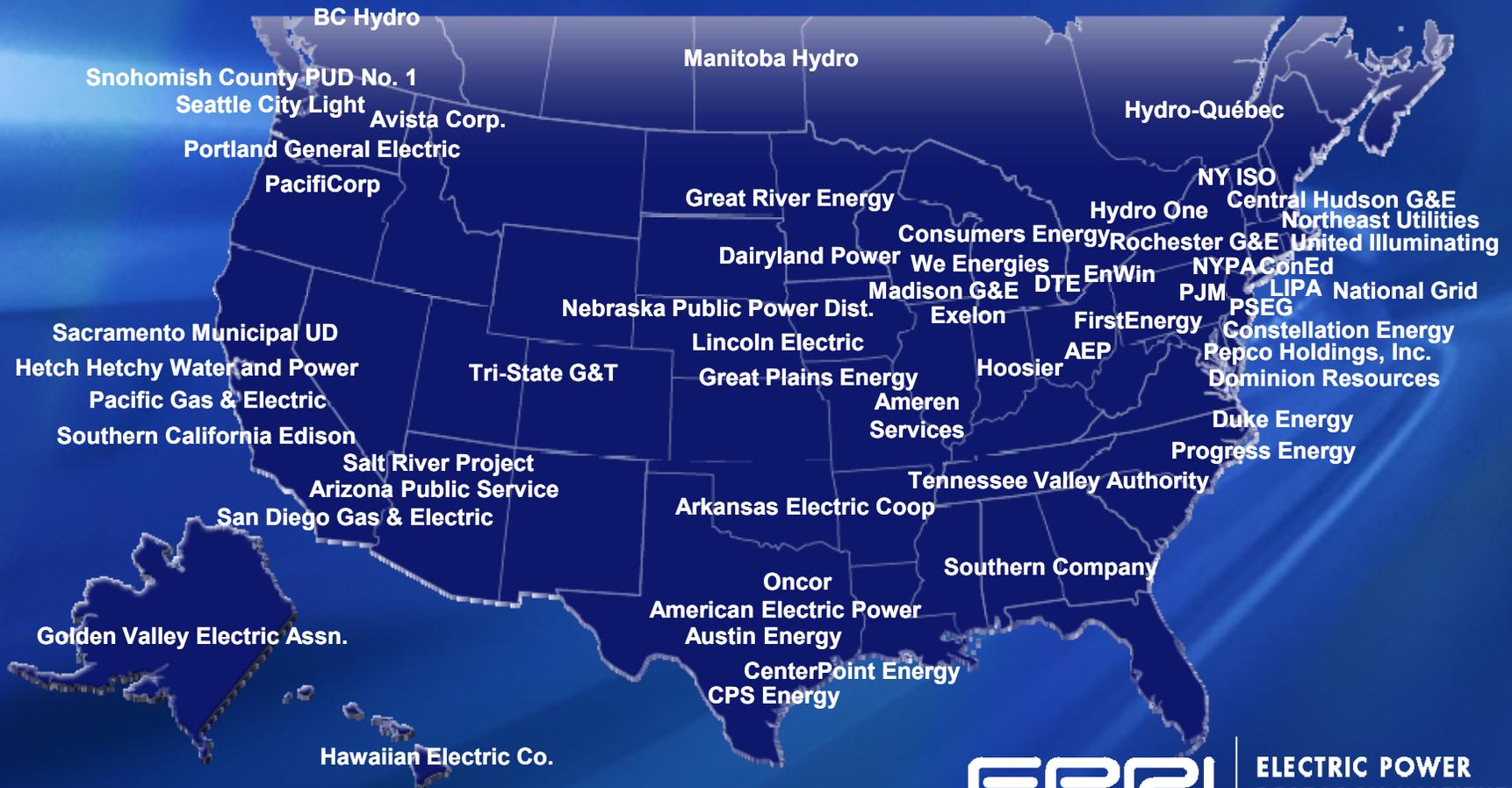


# HOME CHARGING INSTALLATION – EARLY LEARNINGS

## 240V Home Charging (120V cordset is standard with Volt)

- 58% of Volt customers choosing 240V charging
  - 35% hardware only and 23% hardware with home installation
- Home charging installation \$500-\$6,000 (~\$1,500 avg)
  - Permitting costs \$25-\$325
  - 2<sup>nd</sup> meter incremental costs ~\$1,000 (overhead) to ~\$3,000 (underground)
  - 240V hardware (EVSE) additional \$490-\$1,500
- Standard installations typically take 2-4 hours
  - Non-standard installations can require trenching, service upgrades, etc.
  - Utilities vary on time-of-use (TOU) options (2<sup>nd</sup> meter, sub-meter, whole house TOU)
  - Total time from registration to inspection can be 1-6 weeks
- Inspectors are learning about EV charging, charging equipment suppliers, meter options
  - Numerous requests for additional info, drawings, visits, code interpretations

# GM/UTILITY PARTNERS FOR VOLT RETAIL MARKET ROLLOUT

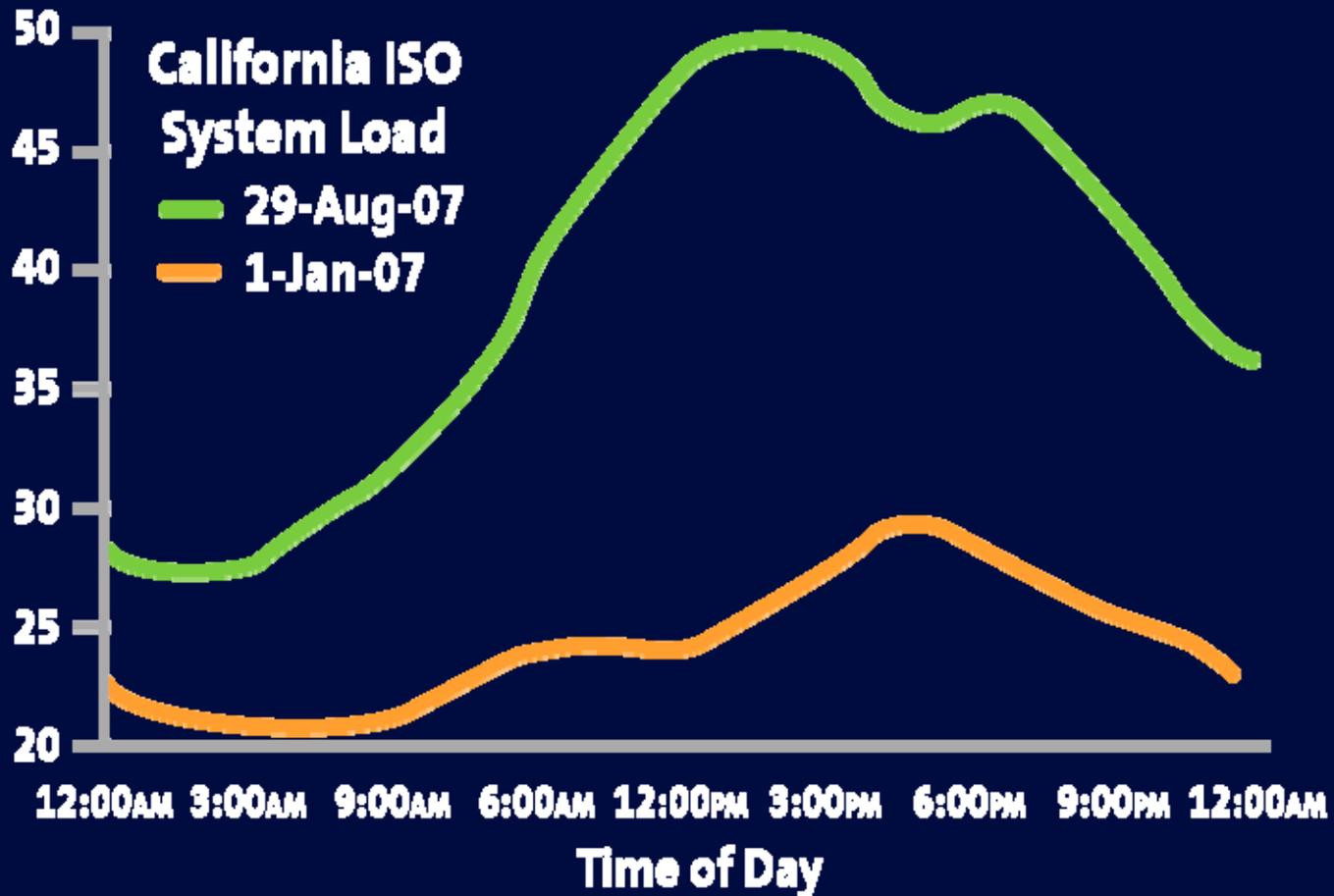


**EPR**I

**ELECTRIC POWER  
RESEARCH INSTITUTE**

# ELECTRIC GRID DESIGNED FOR PEAK DEMAND

## VOLT LEVERAGES OFF-PEAK FOR CHARGING



# PLUG-IN READY COMMUNITIES

## Required Stakeholders

- Dedicated project leader
- State, city, county
- Clean Cities Orgs/AQMD
- DOT
- Utilities (municipal and regional)
- Regulators/public utility commissions
- Permitting and code officials
- Local employers
- Local universities

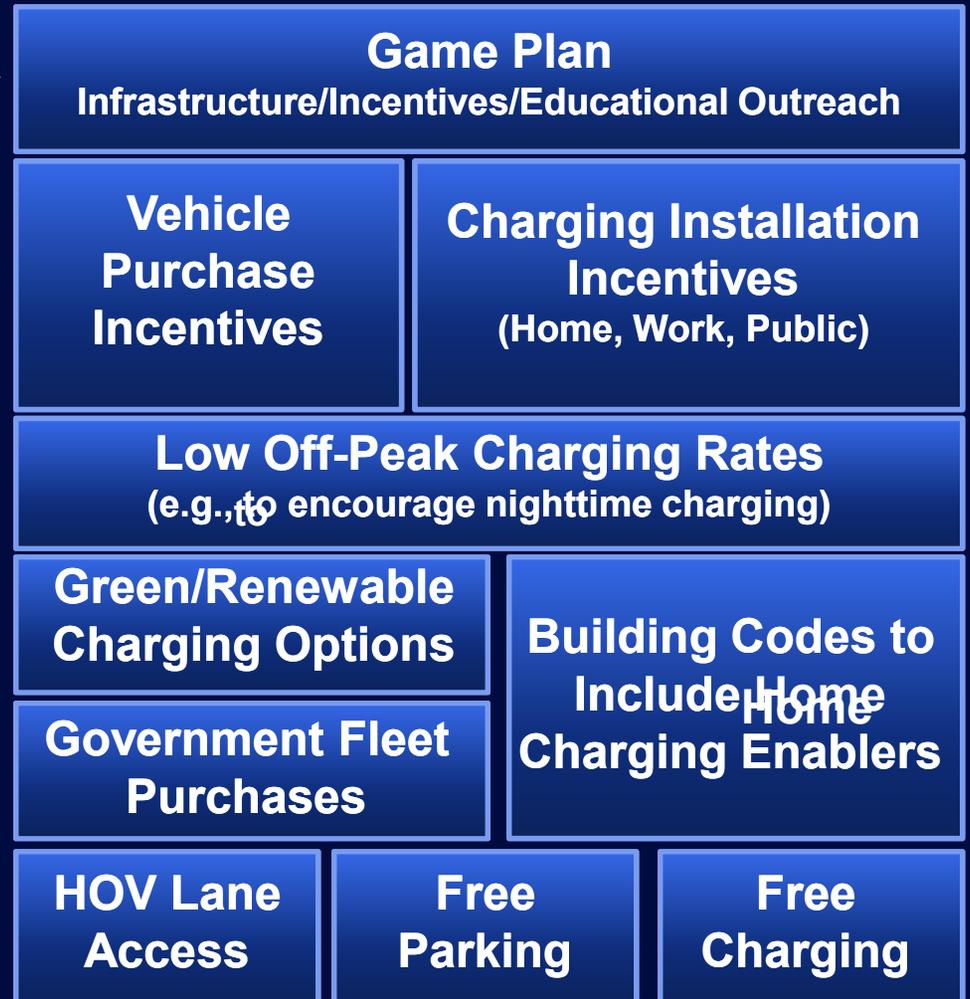


# PLUG-IN READY COMMUNITIES

## Required Stakeholders

## Desired Enablers

- Dedicated project leader →
- State, city, county
- Clean Cities Orgs/AQMD
- DOT
- Utilities (municipal and regional)
- Regulators/public utility commissions
- Permitting and code officials
- Local employers
- Local universities





# GM's Project Driveway

## Real World Experience with a Fuel Cell Vehicle

119 vehicles in 6 countries; Over 80,000 applicants  
80 Mainstream Drivers Using Fuel Cell as Personal Vehicle  
8,000 everyday drivers



2,000,000 miles logged



# GM Chevrolet Fuel Cell Equinox

## Real World Experience

**Successful operation through 4 full winters**

Photo from Winter Testing in Northern Ontario – 2008  
Field Operating Experience to  $-20^{\circ}\text{C}$





# GM Project Driveway

World's largest fuel cell vehicle demonstration

Over 1,980 hours on single vehicle systems  
Reduced CO<sub>2</sub> Emissions by 1.7 Million pounds (836 U.S. tons)





# Business to Business Partnerships

## Real World Experience

Fuel Cell Vehicle Rescuing Stranded  
Internal Combustion Engine Drivers





# Hydrogen Fueling Real World Experience



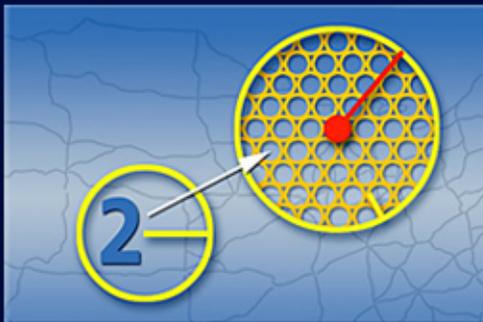
700 bar stations with 3 minute refueling – 300 miles  
Over 24,000 refueling events  
Over 53,000 kg of H<sub>2</sub> fueled



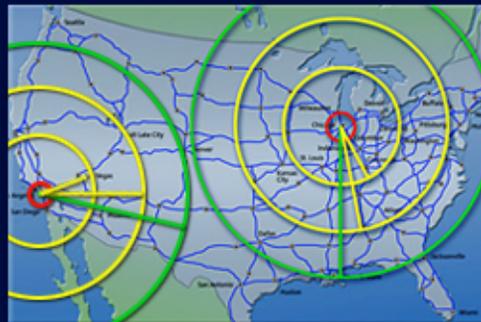
# U.S. INFRASTRUCTURE DEVELOPMENT FOR FIRST MILLION FCEVs

- \$10-25B investment would establish network of 11,700 stations
  - Top 100 urban areas
  - 130,000 miles of highway

**Station always within  
2 miles in urban areas**



**Top 100 U.S.  
metro areas**



**1 highway station  
every 25 miles**





# PROJECT DRIVEWAY



**25-50 MILES  
GAS-FREE**



**2,000,000  
MILES LOGGED**



# Compare and Contrast Infrastructure

- Hydrogen
  - Public infrastructure
  - Commercial installers, permitters, inspectors
  - Infrastructure installation has no impact on consumer
  - Upfront cost to install a station serving 1,000-1,500 customers/week
- Electrical
  - Home charging
    - 120V is viable (for an EREV or PHEV) and no-cost
    - 50-60% Volt customers opting for 240V home charging
      - Cost impact of 240V EVSE and home installation
      - Time and inconvenience for home installation
      - Patchwork of incentive programs help consumers, but add cost and complexity for OEM
    - Public charging is optional
      - Easier to rally local stakeholders to install a few public chargers
    - Distributed cost to establish home charging

