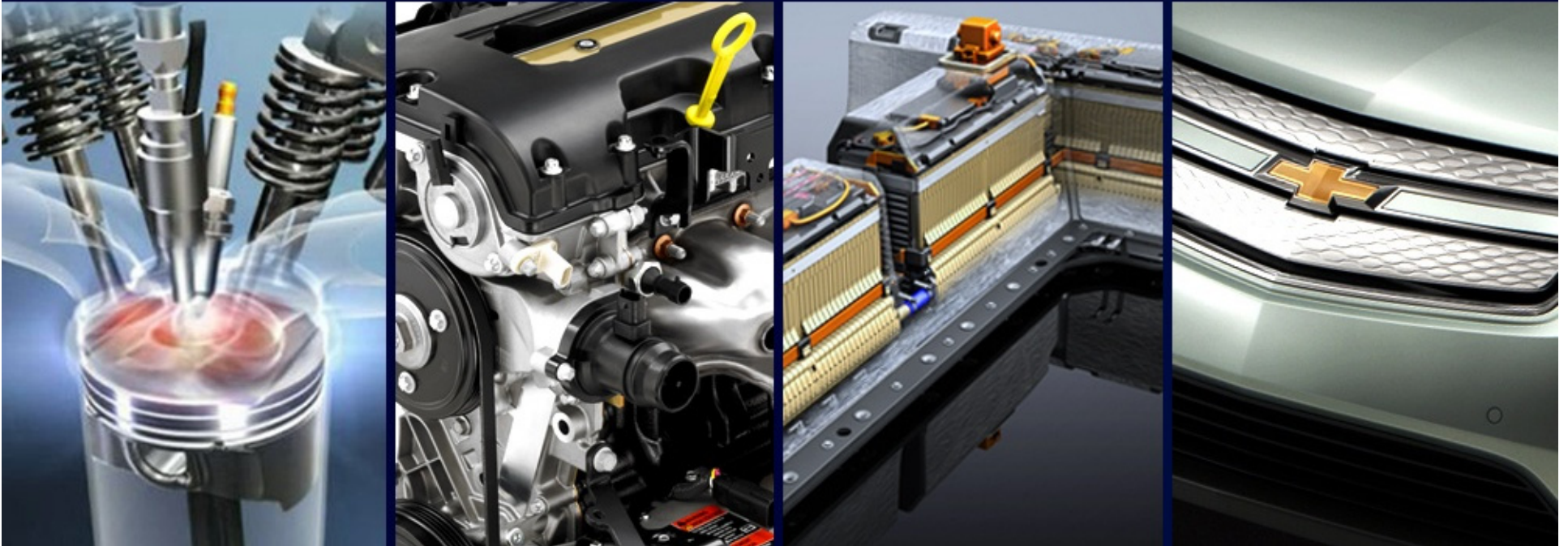


OEM Outlook: Batteries and Charging Infrastructure

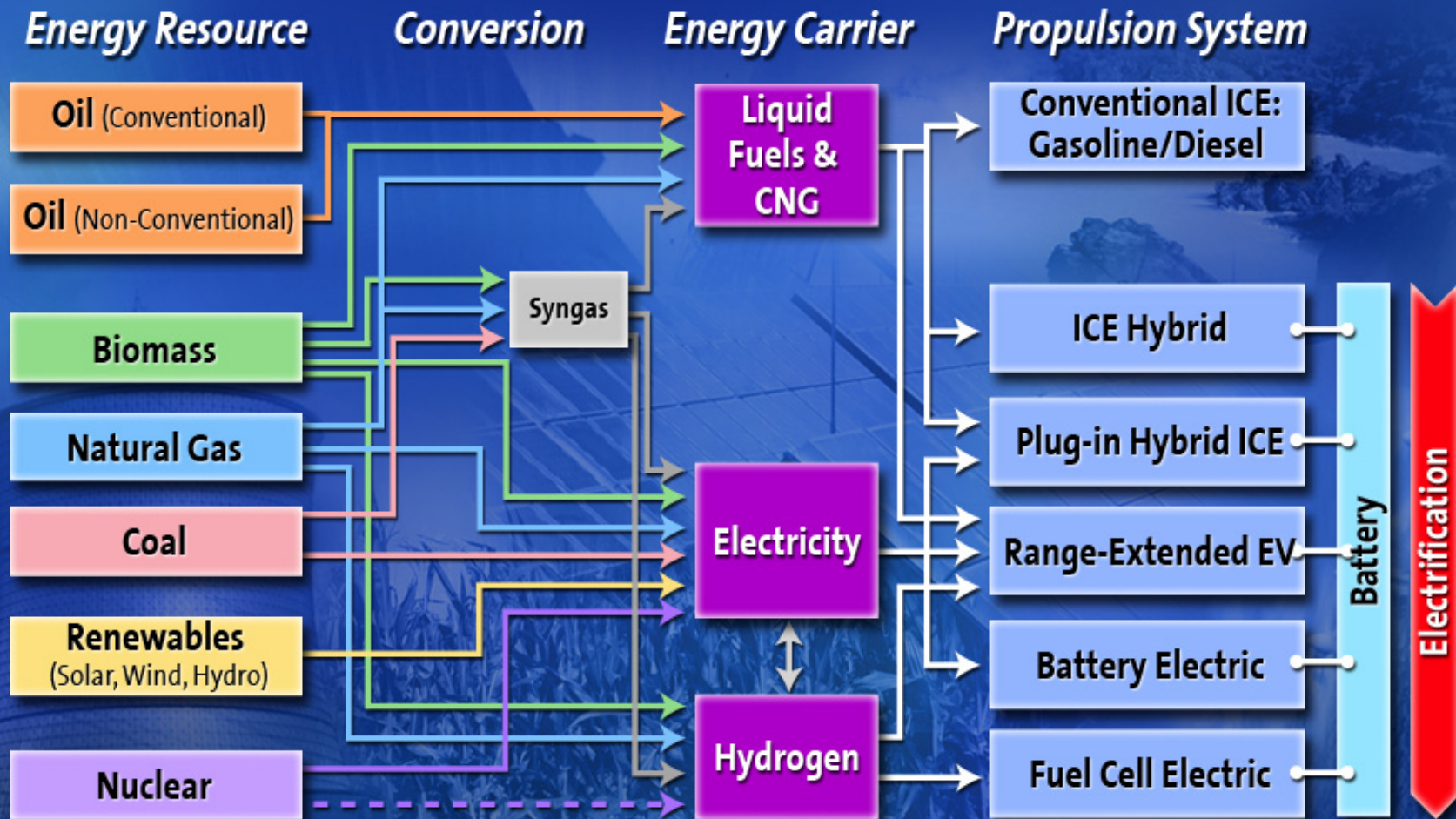
GM

Britta Gross

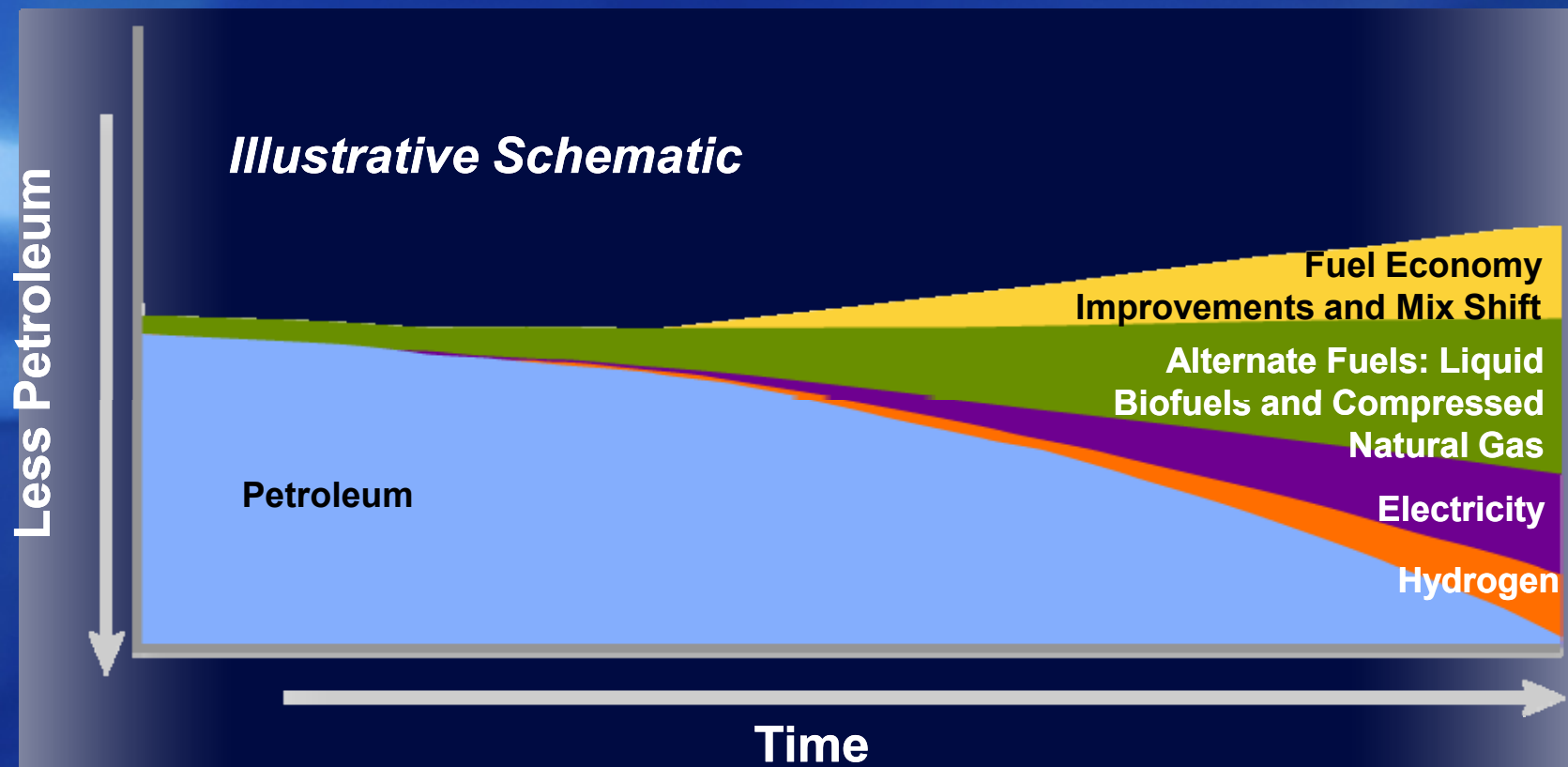
Director, GM R&D, Global Energy Systems and Infrastructure Commercialization



ENERGY OPTIONS



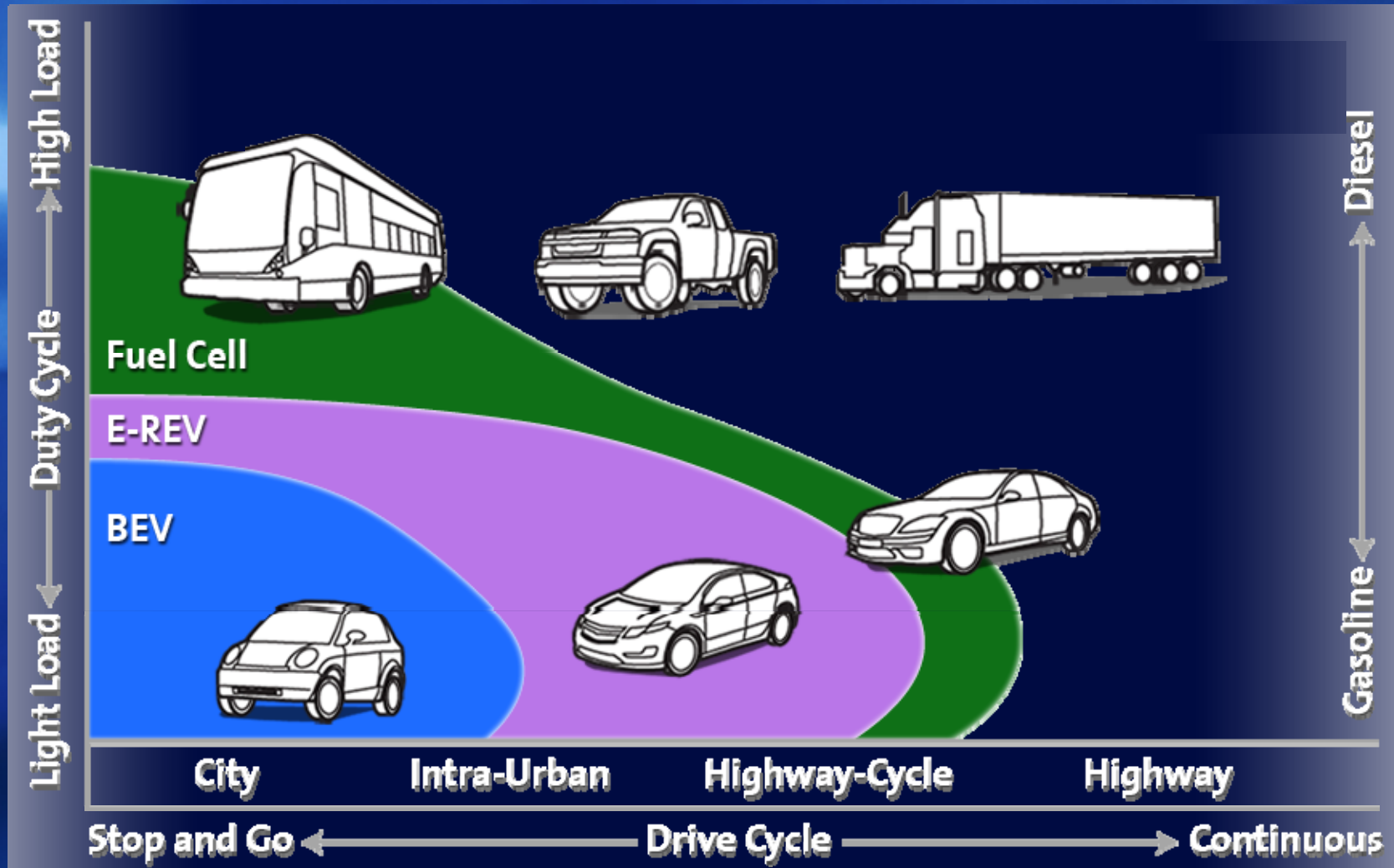
PETROLEUM DISPLACEMENT “AND” SCENARIO



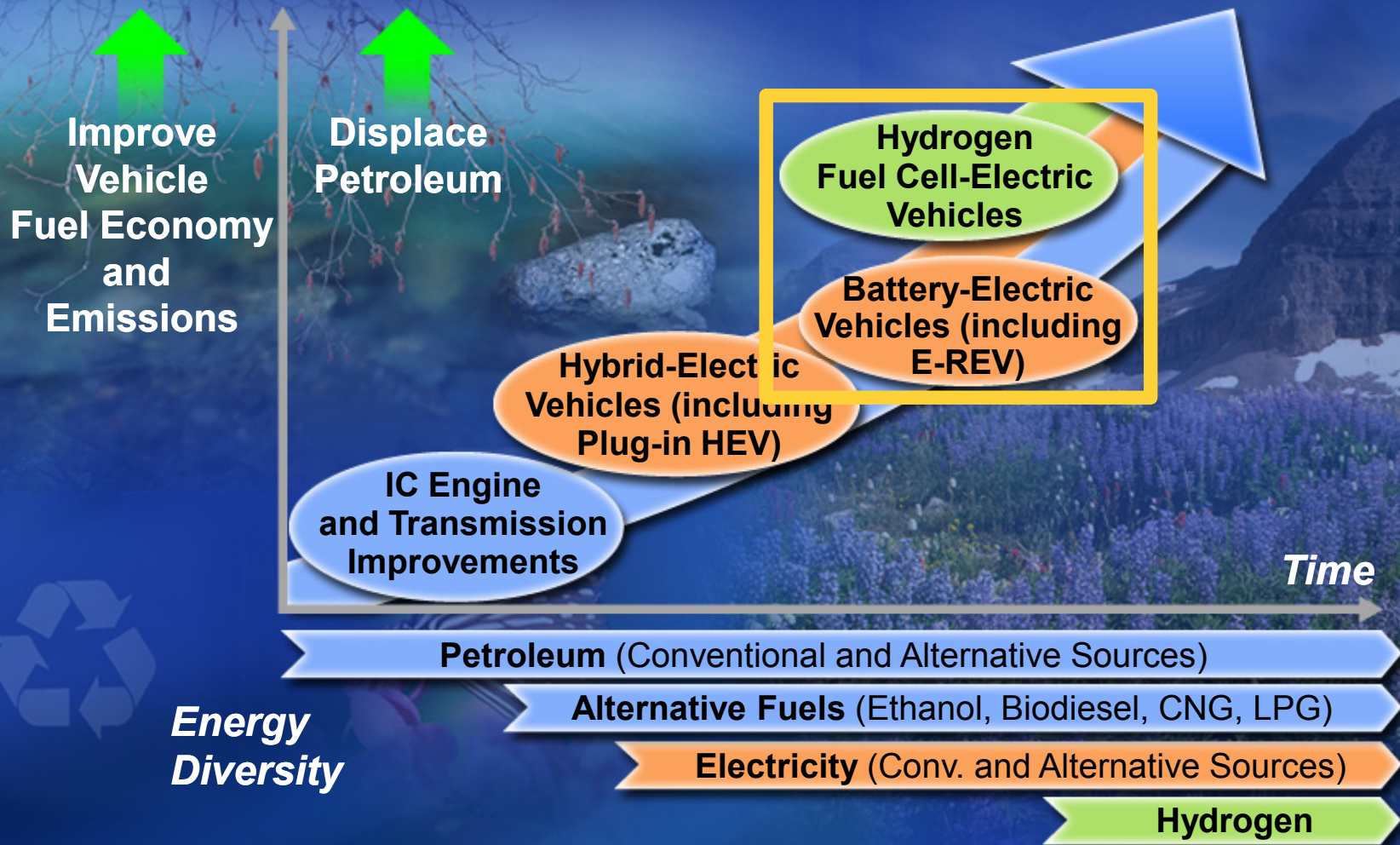
Start soon with early options; finish with strongest long-term portfolio

VEHICLE APPLICATION MAP

Will require both batteries and fuel cells to cover



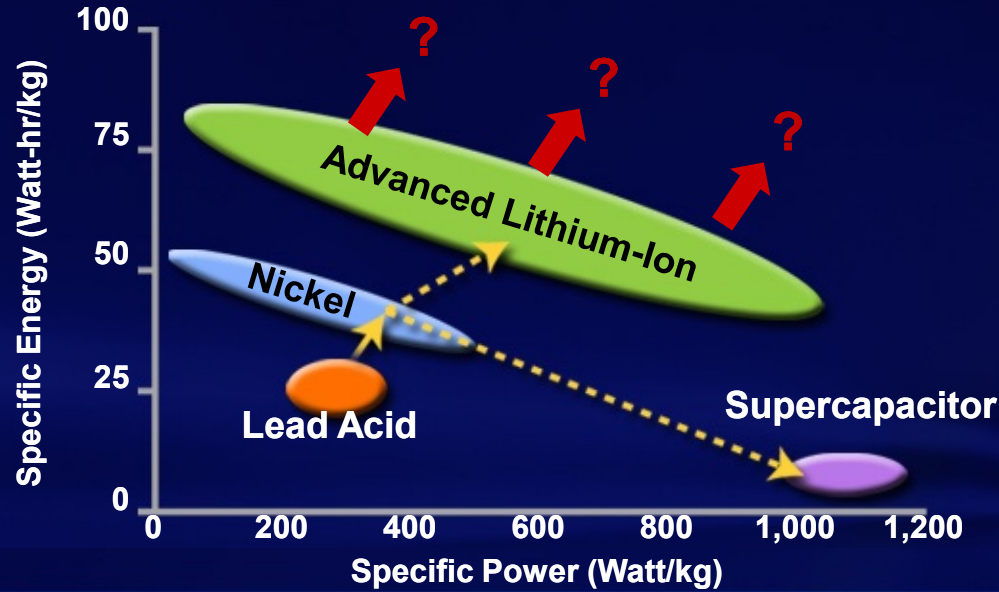
ADVANCED PROPULSION TECHNOLOGY STRATEGY



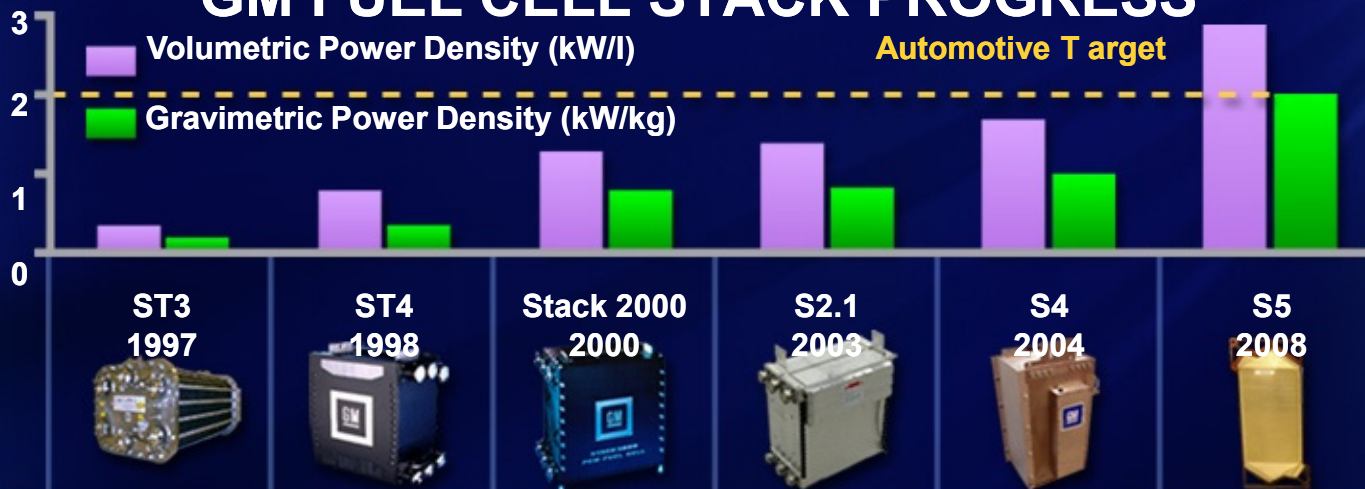
NiMH VS. LI-ION BATTERY PACKS



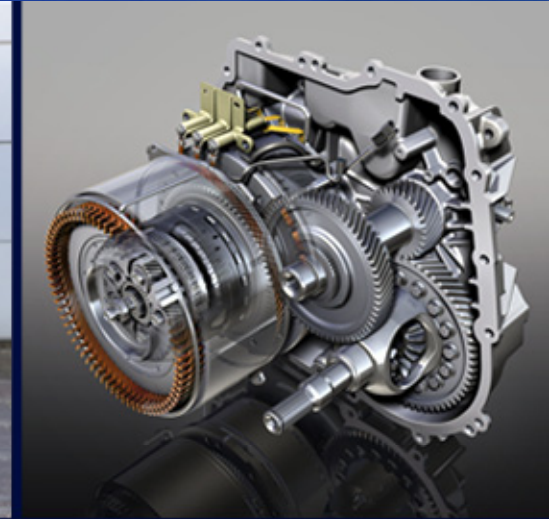
BATTERY TECHNOLOGY IMPROVEMENTS



GM FUEL CELL STACK PROGRESS

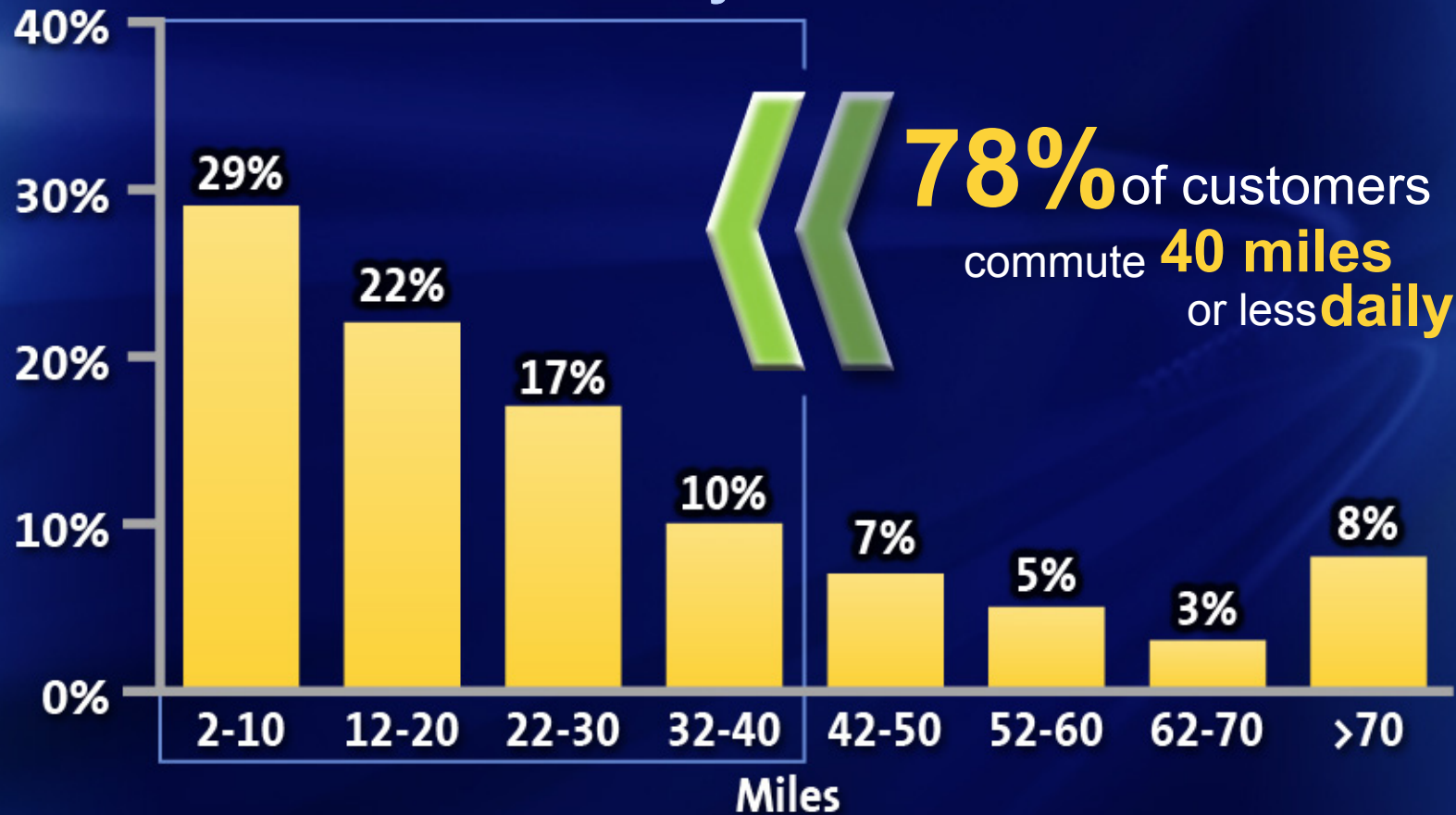


CHEVROLET VOLT



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)

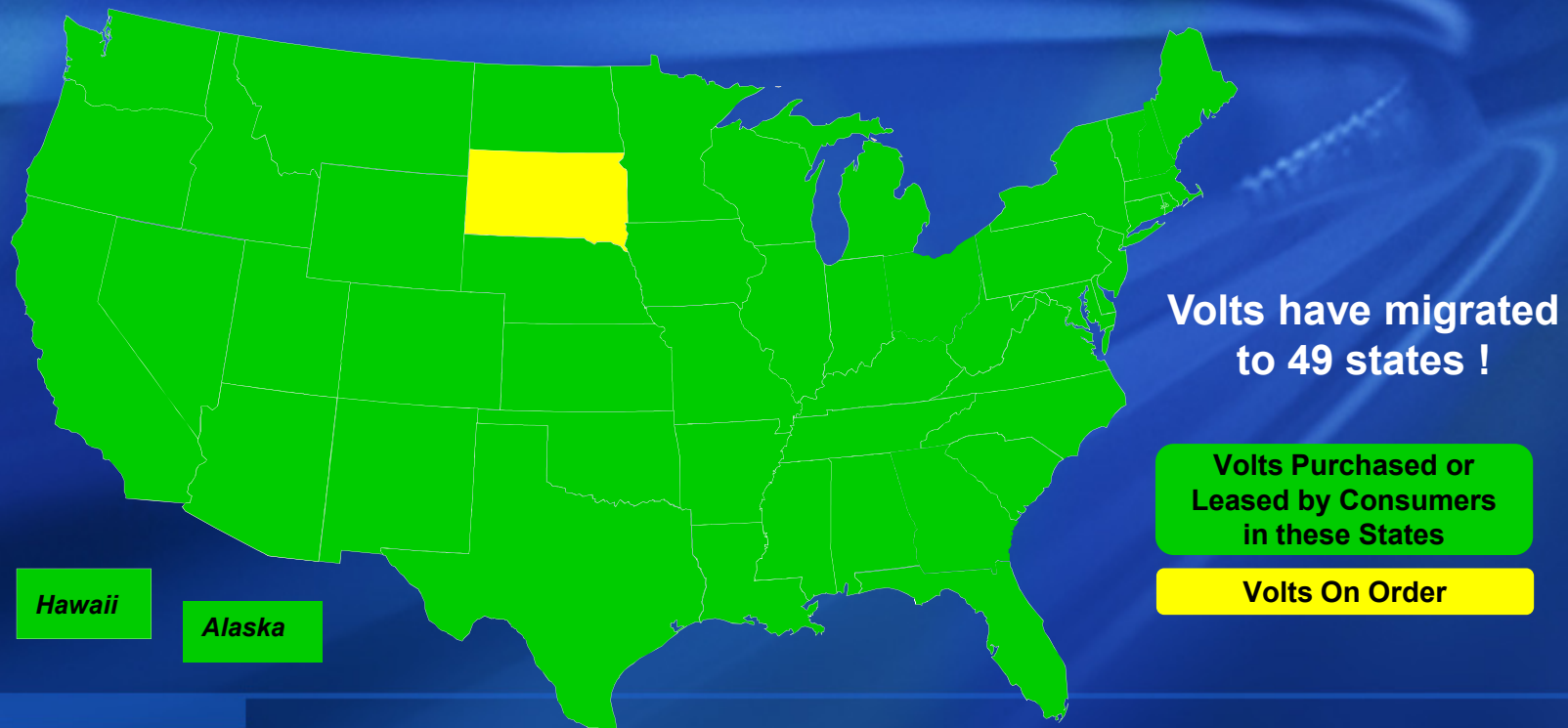


Designed for over **300** miles
EXTENDED RANGE
Driving on Gasoline

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

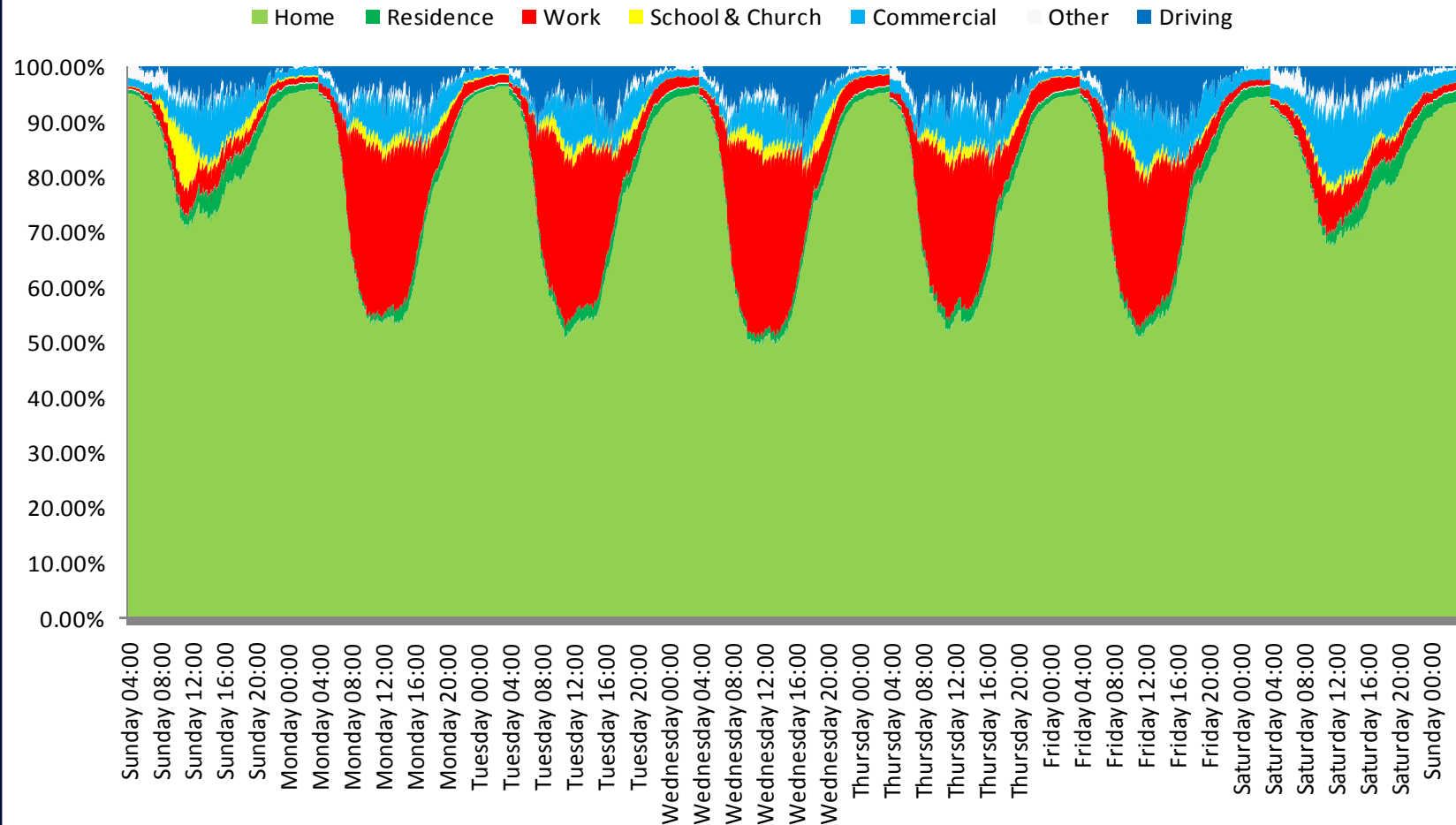


240V Charge Station

- 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?

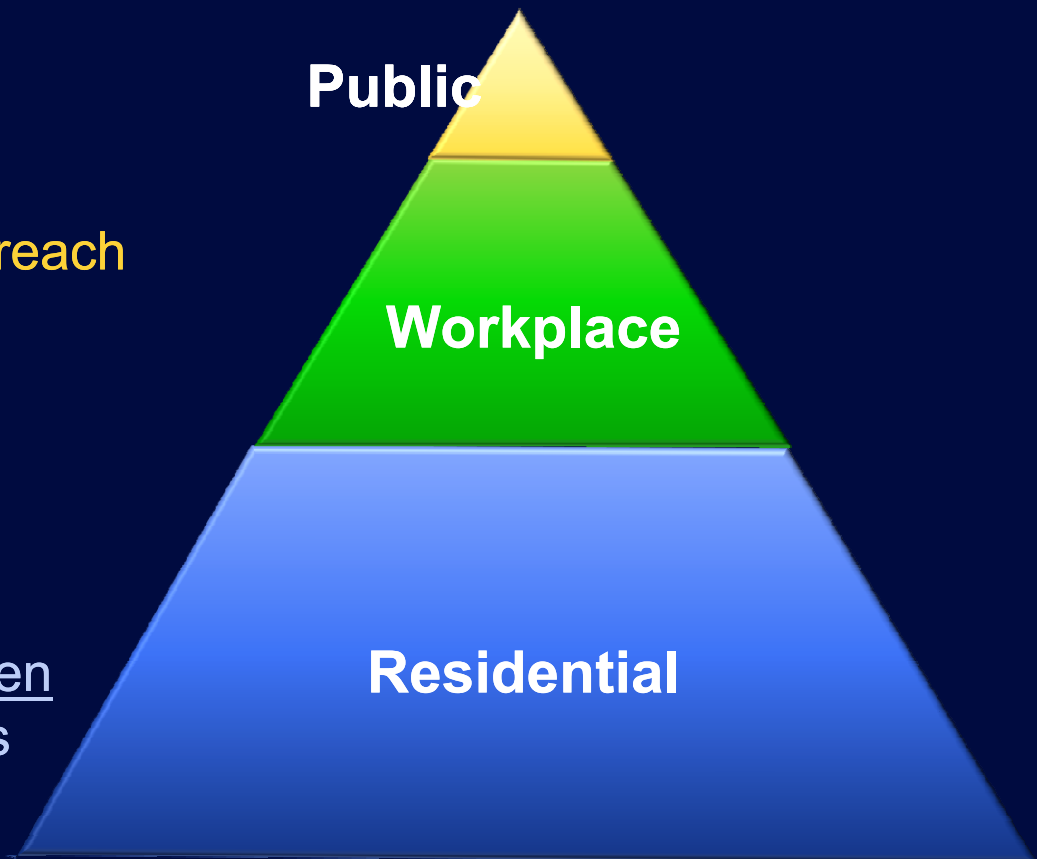
Fleet Distribution during week



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

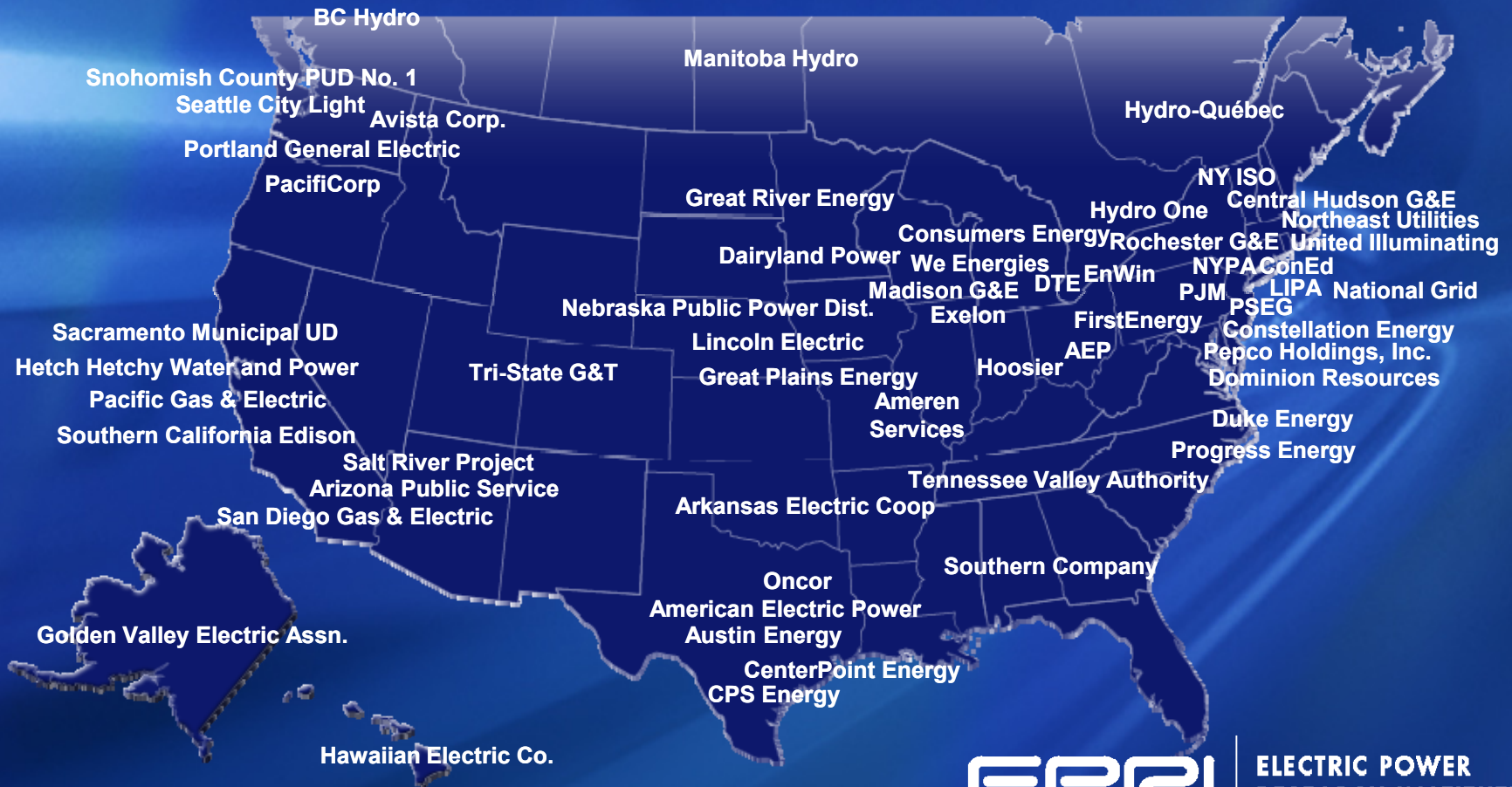


HOME CHARGING INSTALLATION – EARLY LEARNINGS

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

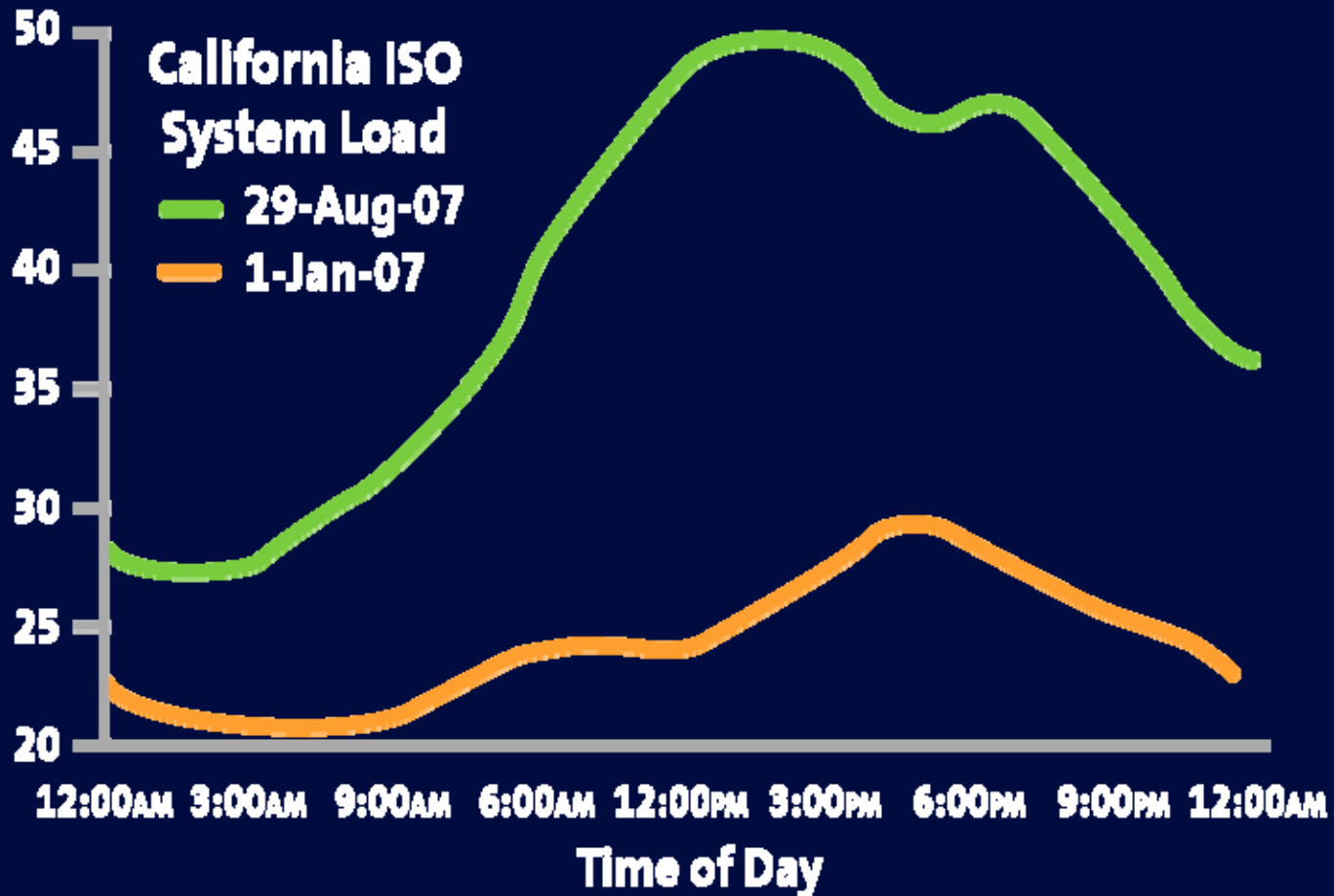
- 58% of Volt customers choosing 240V charging
 - 35% hardware only and 23% hardware with home installation
- Home charging installation \$500-\$6,000 (~\$1,500 avg)
 - Permitting costs \$25-\$325
 - 2nd meter incremental costs ~\$1,000 (overhead) to ~\$3,000 (underground)
 - 240V hardware (EVSE) additional \$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 (2nd 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



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°C





GM Project Driveway

World's largest fuel cell vehicle demonstration

Over 1,980 hours on single vehicle systems
Reduced CO₂ 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



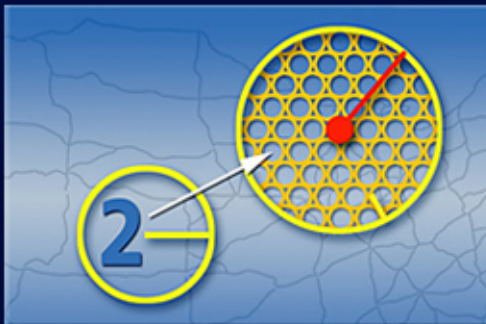
700 bar stations with 3 minute refueling – 300 miles
Over 24,000 refueling events
Over 53,000 kg of H₂ fueled



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

