
GM
ADVANCED PROPULSION TECHNOLOGY:
DRIVING TO A SUSTAINABLE FUTURE
YBRID
2 MODE
DAN HANCOCK
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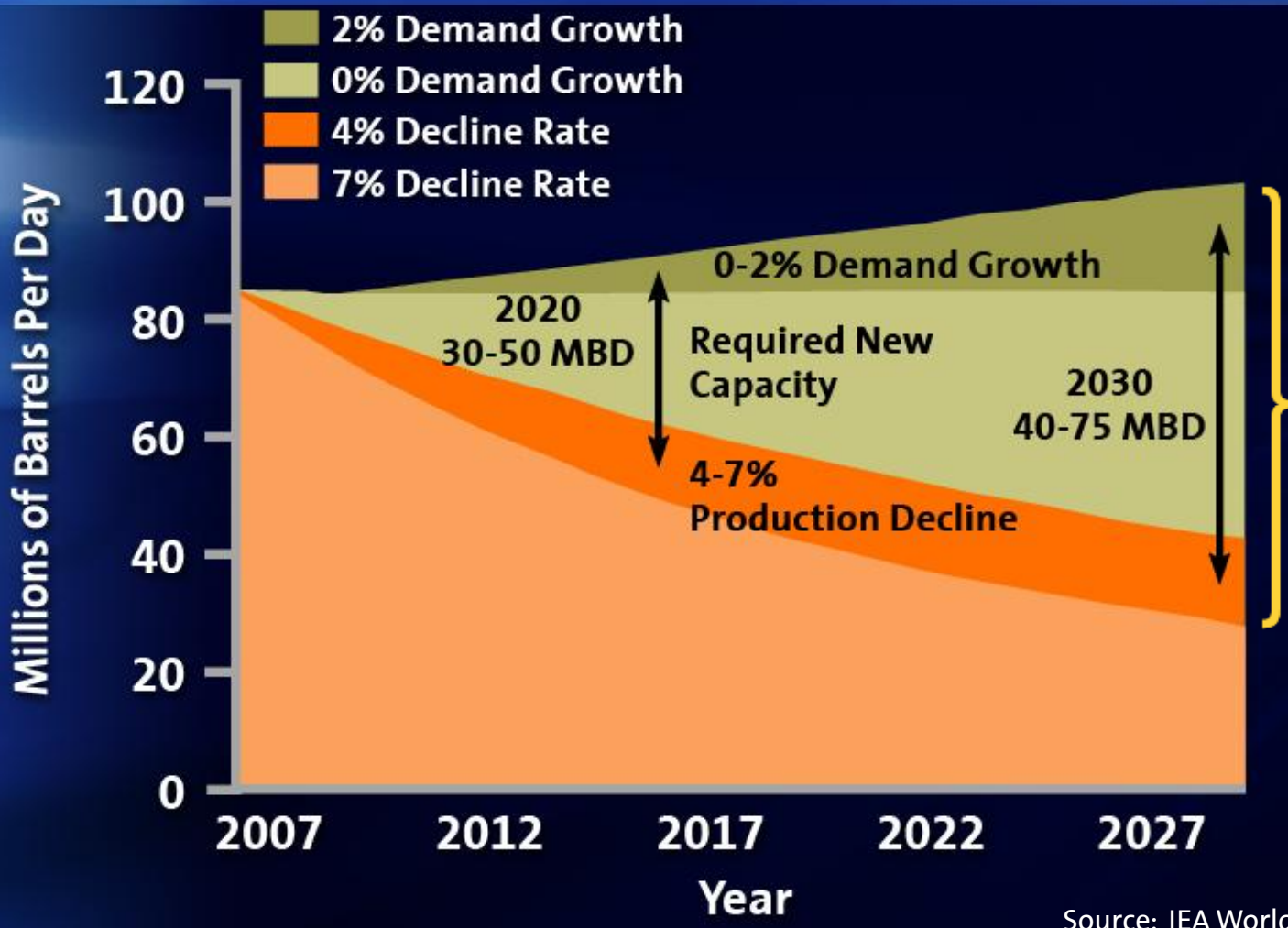
General Motors Company

PETROLEUM SUPPLIES …

35%
OF WORLD'S ENERGY

96%
OF TRANSPORTATION ENERGY

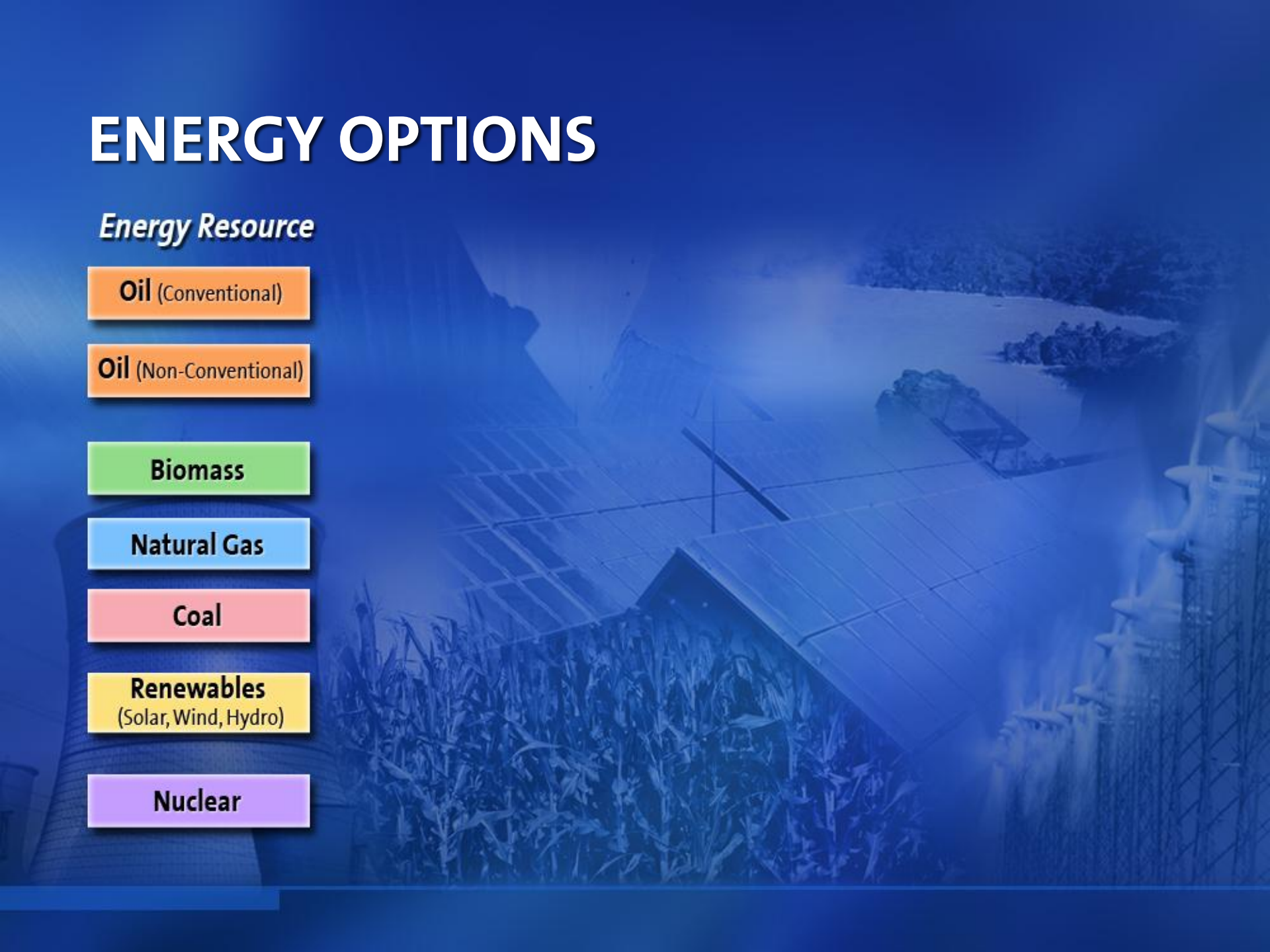
FUTURE PETROLEUM DEMAND



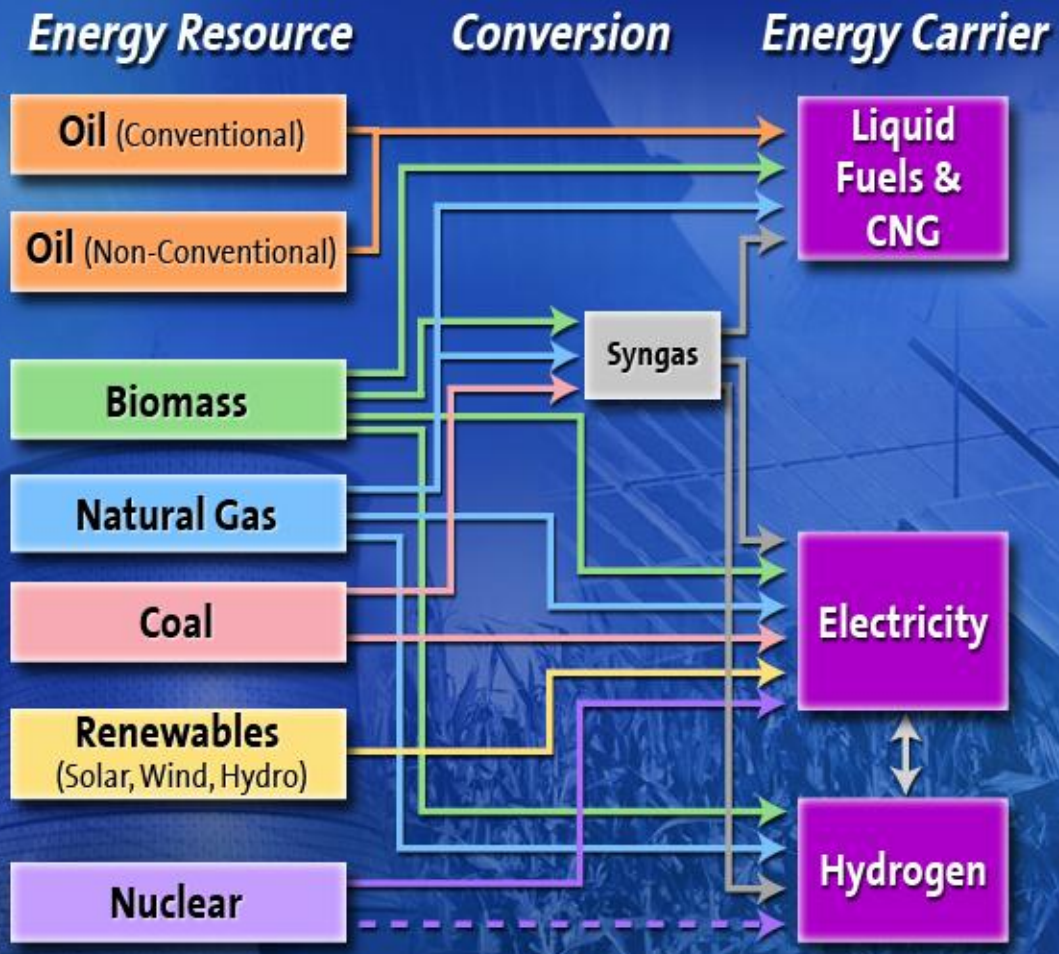
Need 6 New Saudi Arabias by 2030!

Source: IEA World Energy Outlook, 2008

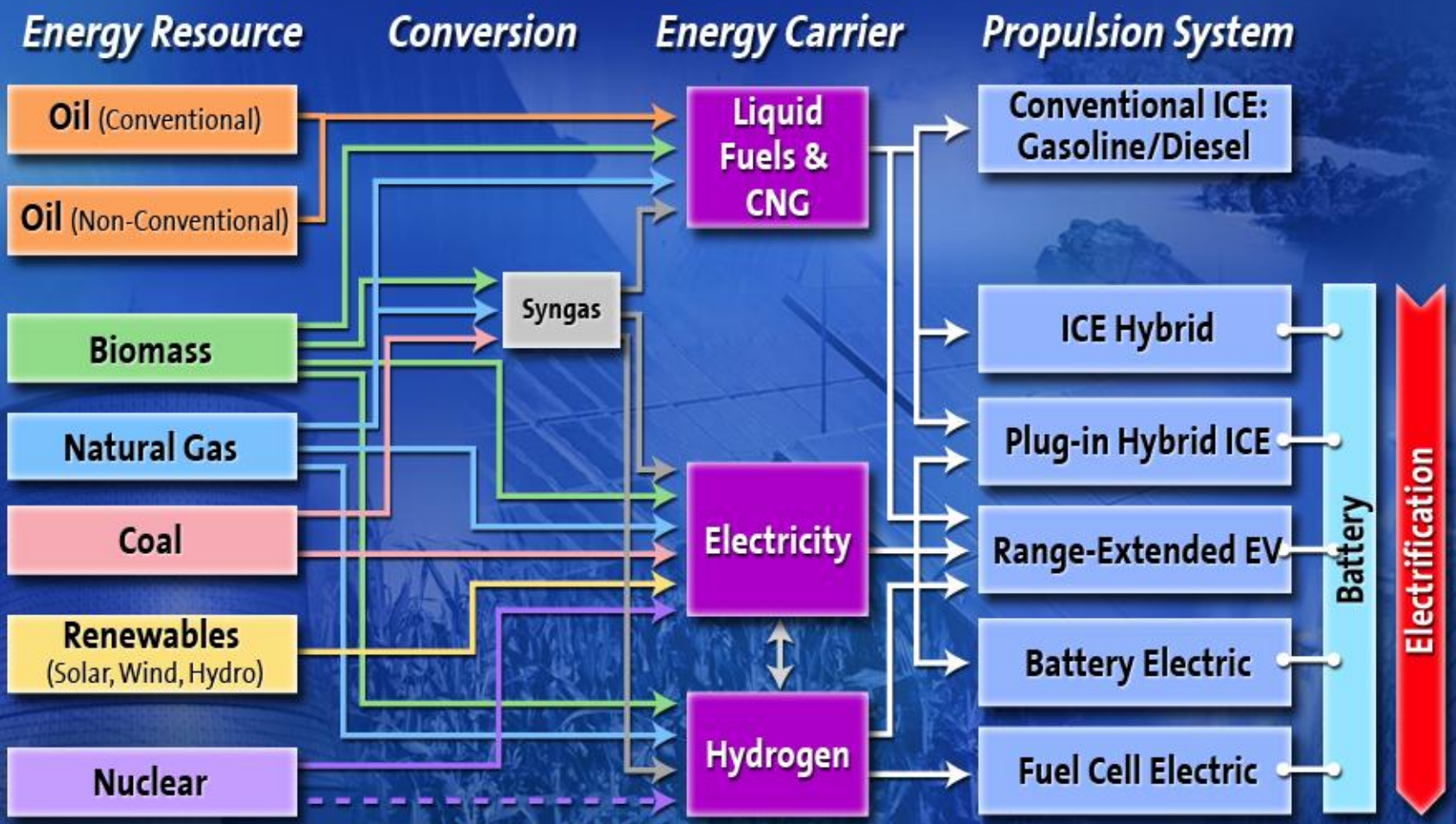
ENERGY OPTIONS



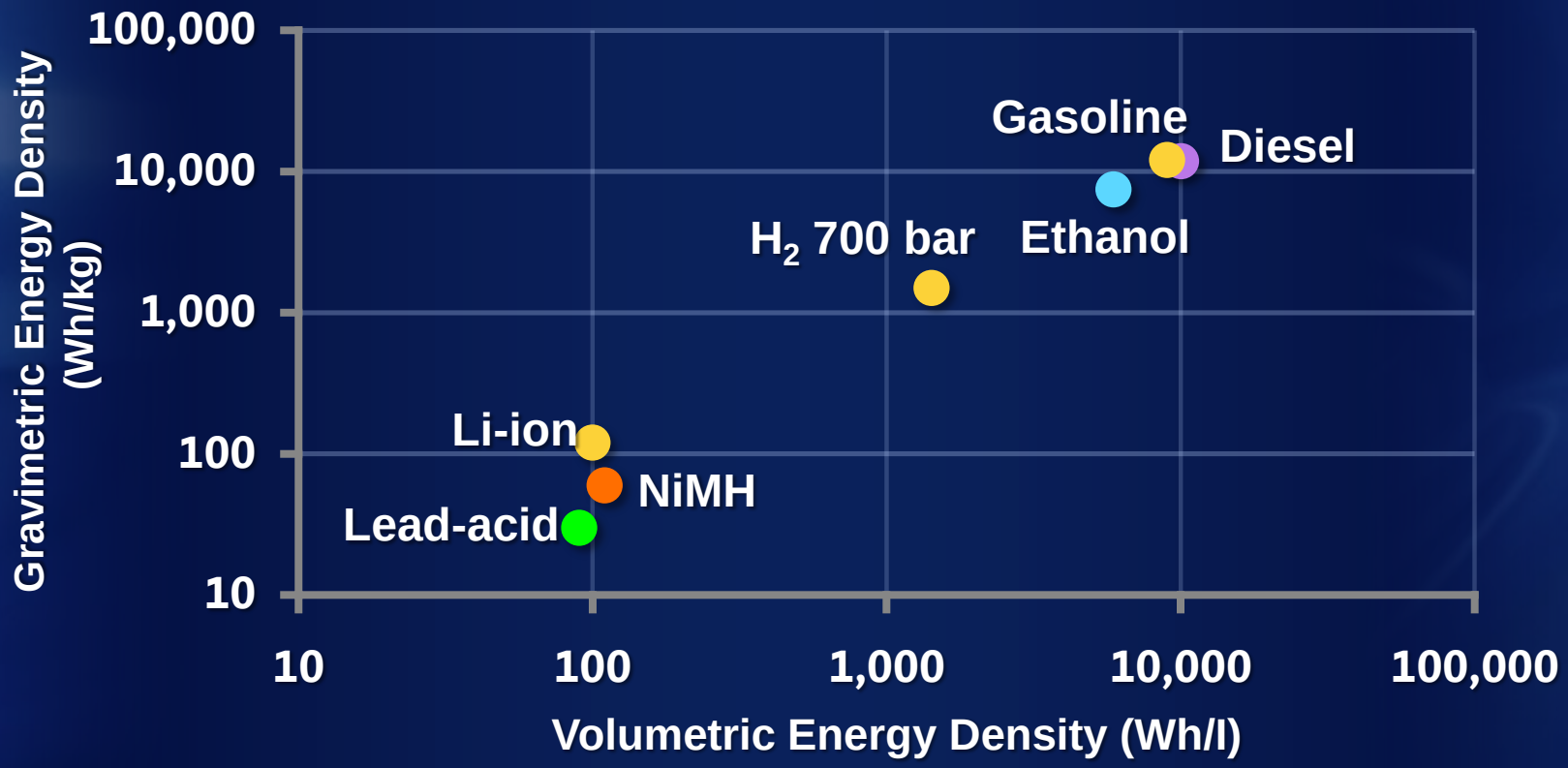
ENERGY OPTIONS



ENERGY OPTIONS



ENERGY STORAGE DENSITY
(Including Fuel Tank/Battery)



- Battery improvement expected, but still 100x lower density than liquid fuels
- Hydrogen has significantly higher energy density than current batteries

Global Fuel Economy/CAFE/ CO_2 Challenges

Canada
- Green Levy
- 6.6L/100km (35.5 mpg) in2016
- Quebec; 34.7 mpg in 2016

US-Federal
- 35.5 mpg by 2016
- Gasoline $3/gallon

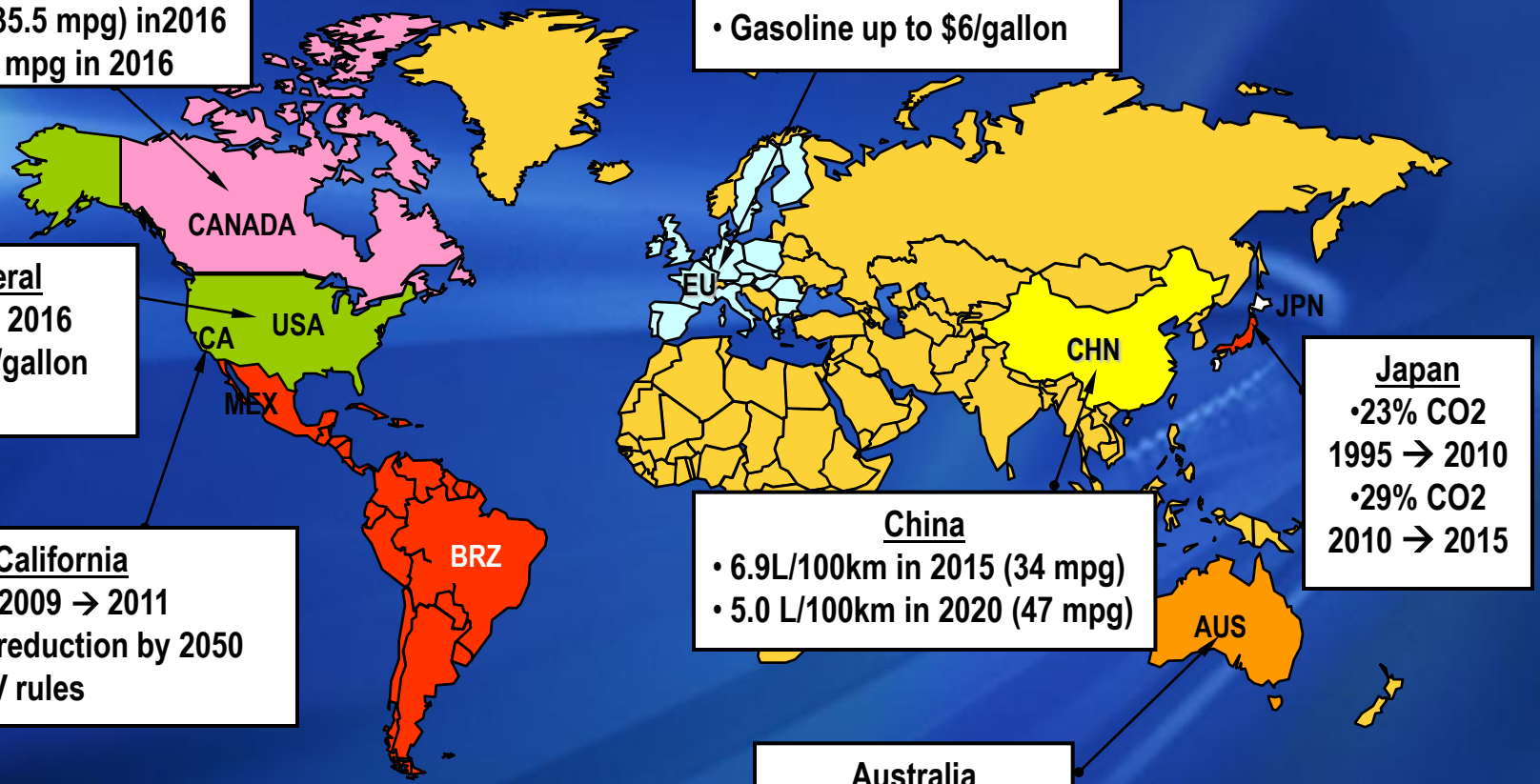
California
- 40% mpg 2009 → 2011
- 80% CO2 reduction by 2050
- ZEV, PZEV rules

European Union
- 130g/km in 2015 (43 mpg)
- 95g/km in 2020 (58 mpg)
- Local CO2 taxation
- Gasoline up to $6/gallon

China
- 6.9L/100km in 2015 (34 mpg)
- 5.0 L/100km in 2020 (47 mpg)

Japan
- 23% CO2 1995 → 2010
- 29% CO2 2010 → 2015

Australia
- 17% 2003 → 2010



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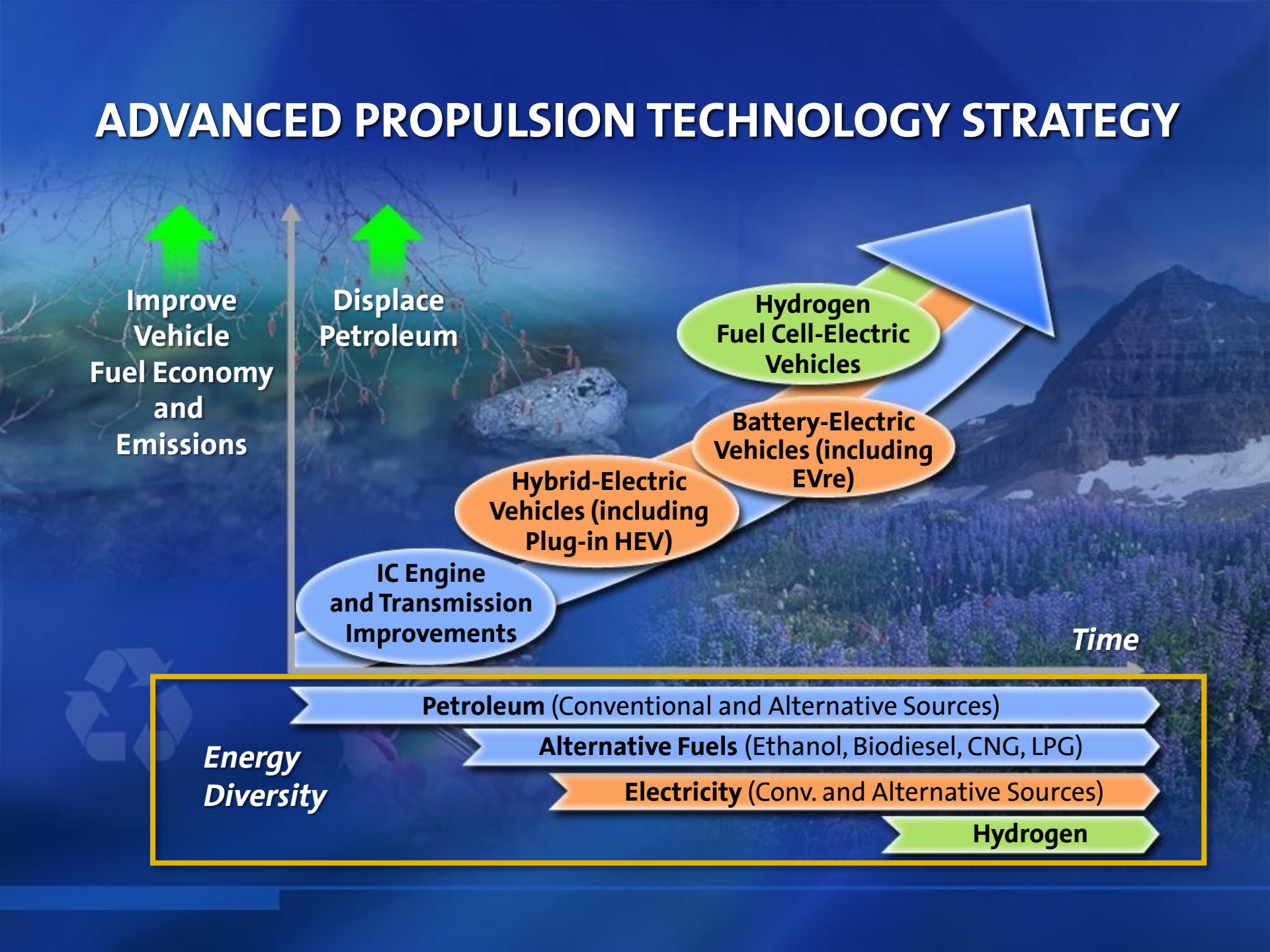
ADVANCED PROPULSION TECHNOLOGY STRATEGY



MAXIMIZING FUEL EFFICIENCY

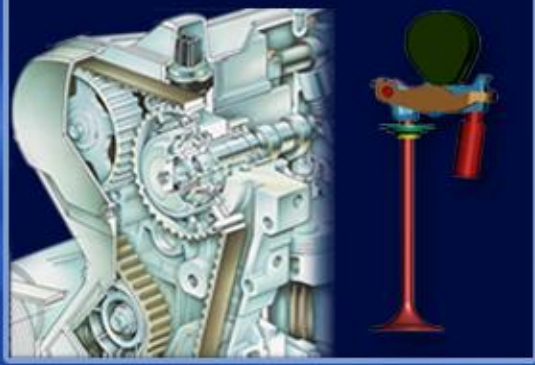
130%
FOR CARS

80%
FOR TRUCKS

IMPROVING GASOLINE ENGINES

- Modular and Flexible Architectures
- Reduced Mass
- Improved Combustion Technology
- Integration of Leading Edge Technologies

Cam Phasing, Variable Valve Lift, Active Fuel Management



Port Deactivation with EGR

Spark Ignition Direct Injection

Downsized SIDI Turbo Boosting

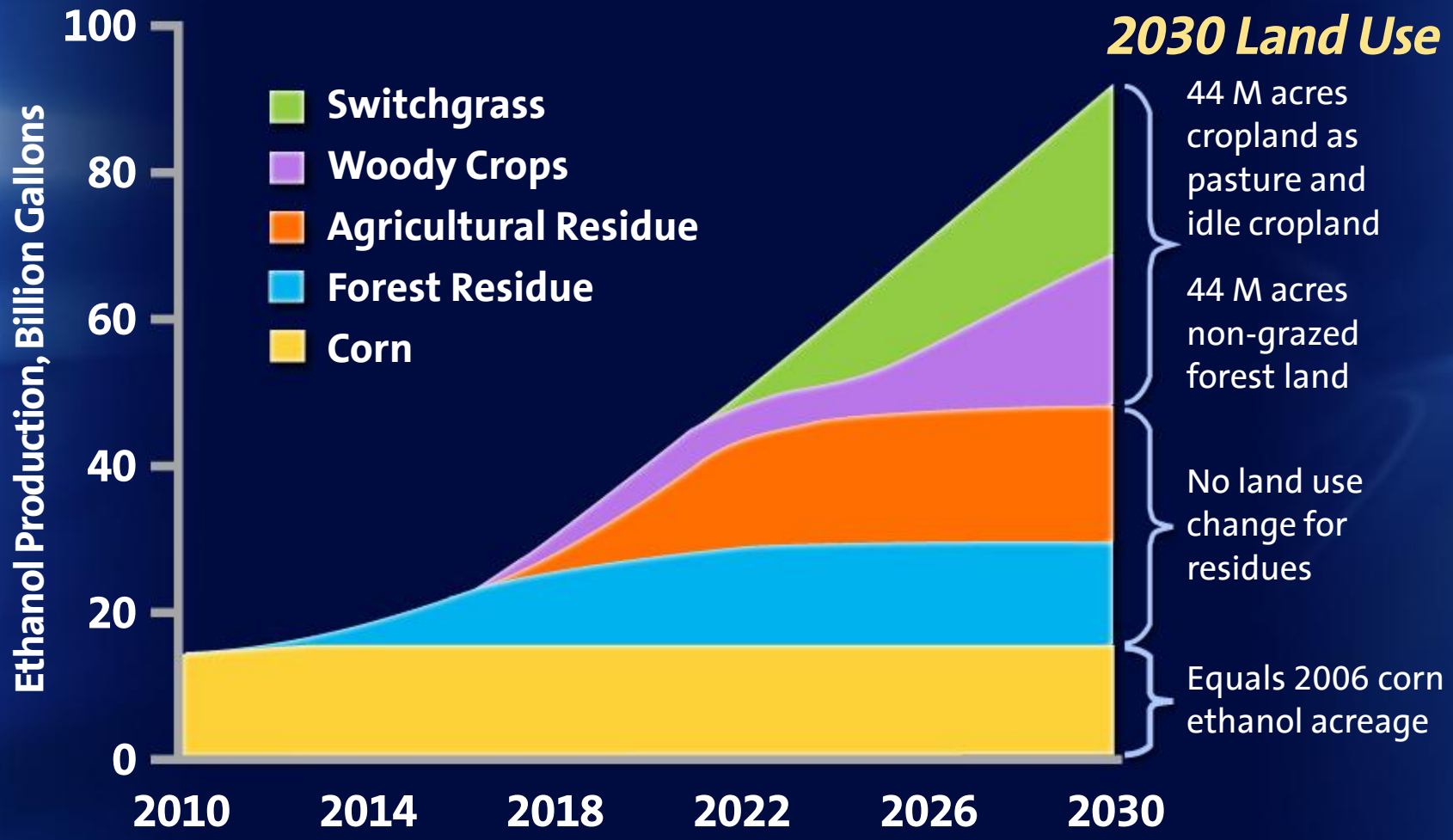
HCCI – Homogeneous Charge Compression Ignition

GM E85 FLEX-FUEL VEHICLES

OVER 5.5M VEHICLES WORLDWIDE AND 17 MODELS IN NORTH AMERICA

GM

SANDIA/GM STUDY:
BIOMASS FOR 90B GALLONS OF ETHANOL



FUTURE FLEX-FUEL VEHICLES …
DIRECT-INJECTED AND TURBO ENGINES

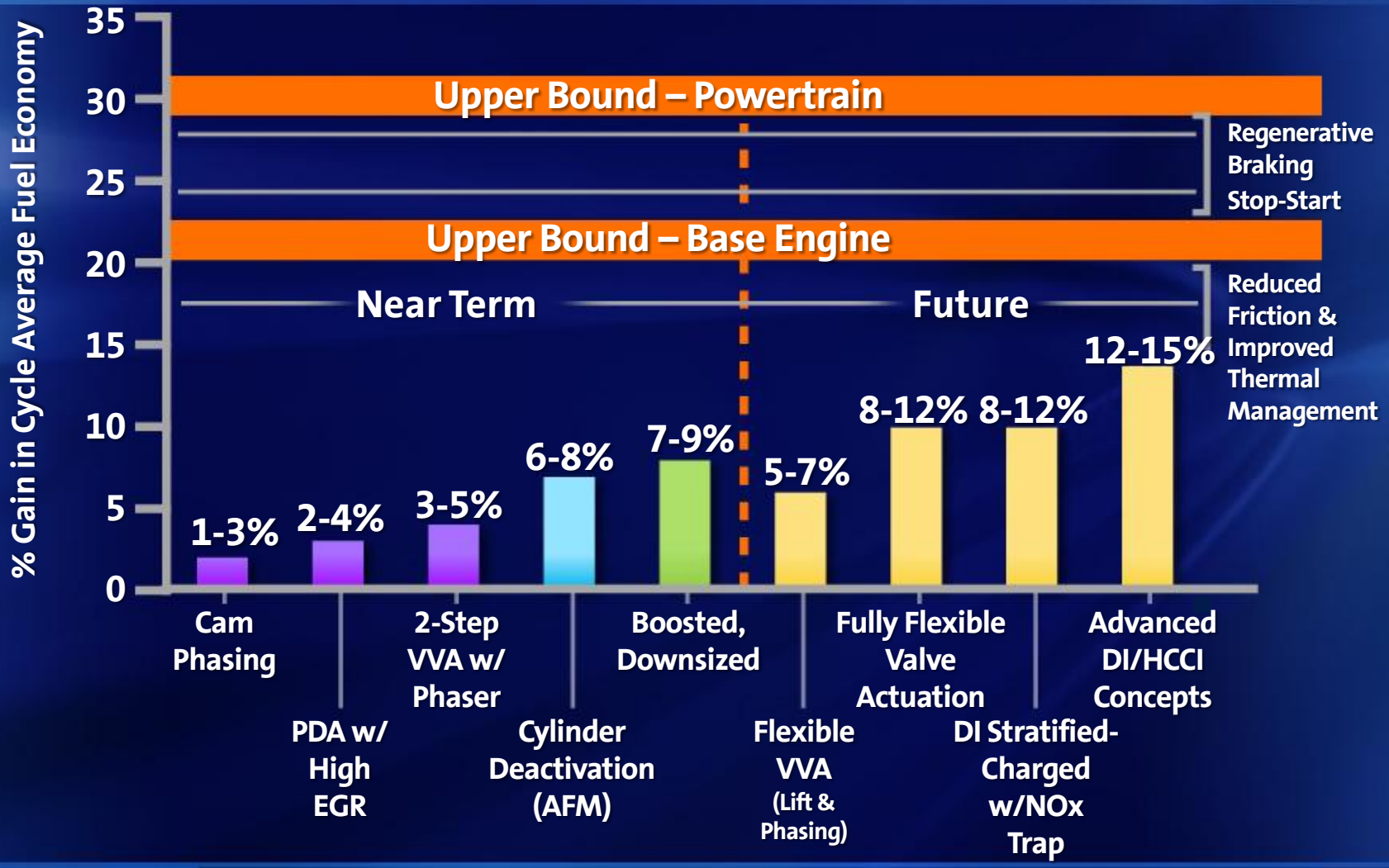
FLEXFUEL
E85 ETHANOL

coskata

MASCOMA

GM

FUEL ECONOMY POTENTIAL



GM VEHICLE ELECTRIFICATION STRATEGY

PORTFOLIO OF SOLUTIONS FOR FULL RANGE OF VEHICLES THAT PROVIDE CUSTOMER CHOICE

Petroleum and Biofuels (Conventional and Alternative Sources)

Electricity – ZEV Fuel

GM Hybrid | 2-Mode | 2-Mode PHEV | Extended-Range EV | Battery Electric | Fuel Cell

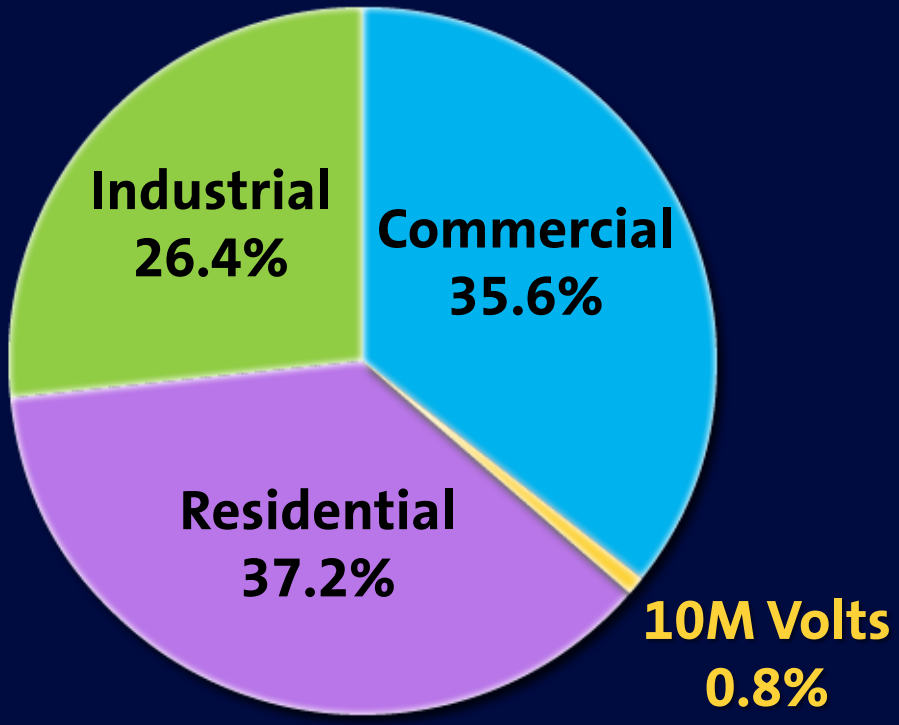
Electrification

EXTENDED-RANGE ELECTRIC VEHICLE WITH FLEX-FUEL CAPABILITY

40 MILES GAS-FREE

CHEVROLET VOLT

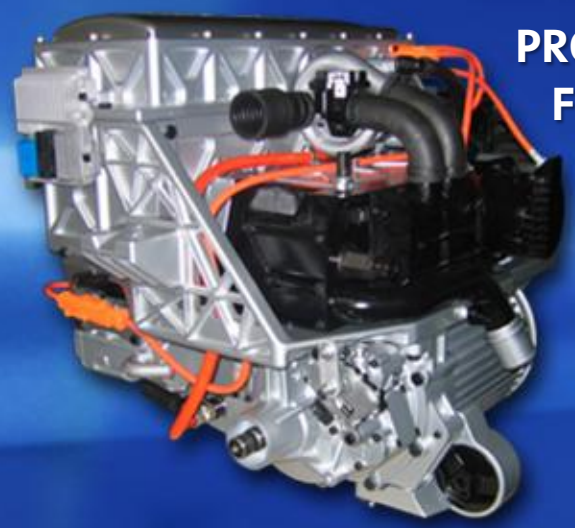
IMPACT ON THE GRID



Electricity: An important energy source with significant capacity to support transportation

10 million Volts would add a load that is less than 1% of the current total grid load

PROJECT DRIVEWAY



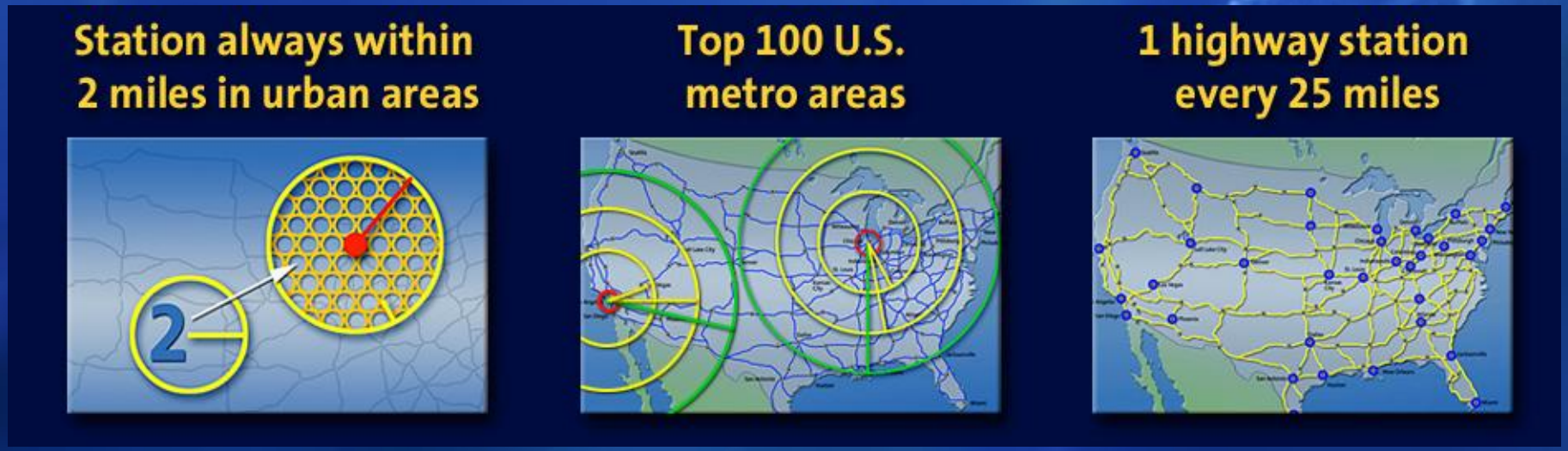
PRODUCTION-INTENT FUEL CELL SYSTEM

5,000
ORDINARY DRIVERS

1,400,000
MILES LOGGED

U.S. INFRASTRUCTURE DEVELOPMENT FOR FIRST MILLION FCEVs

- $10-15B investment would establish network of 11,700 stations
  - Top 100 urban areas
  - 130,000 miles of highway



SUMMARY

- Advanced propulsion technologies focused on both energy efficiency and energy diversity
- There is no single solution
- Our strategy is:
  - Continued improvement of conventional powertrains
  - More vehicles with biofuels capability
  - Increased electrification of the automobile