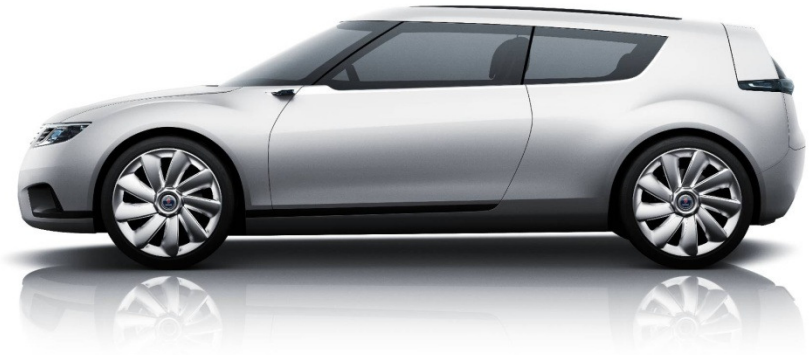


Opportunities with the use of Ethanol in Automotive



2nd BioEthanol Conference
Kjell ac Bergström



Milano March 4th 2009
GM Powertrain - Sweden



Alternative Fuels - Today and in the Future

TODAY

- Adaptations to existing Generation of Technology
- Restricted by Base Engine Specification
- Only allowed through Waiver of Legal Requirements

IN THE FUTURE

- Possible to optimize the Powertrain to the Fuel
- Higher Efficiency
- Lower Exhaust and CO₂-Emissions



Future Fuels – The Challenges

ENERGY SUPPLY & SECURITY

- Future Global Energy Demands exceeds our Prospective Supply
- Several Risks could disrupt Existing Supply
- Controlling Energy is Political Power

ENVIRONMENTAL CHALLENGES

- Stringent Regional "Zero Emission" Requirements
- Growing Concern over Green House Effects / CO₂-emissions
- Potential for Regulations that exceed Technical Capability and Business Feasibility



Renewable Fuels – A real Alternative ?

ENERGY SUPPLY & SECURITY

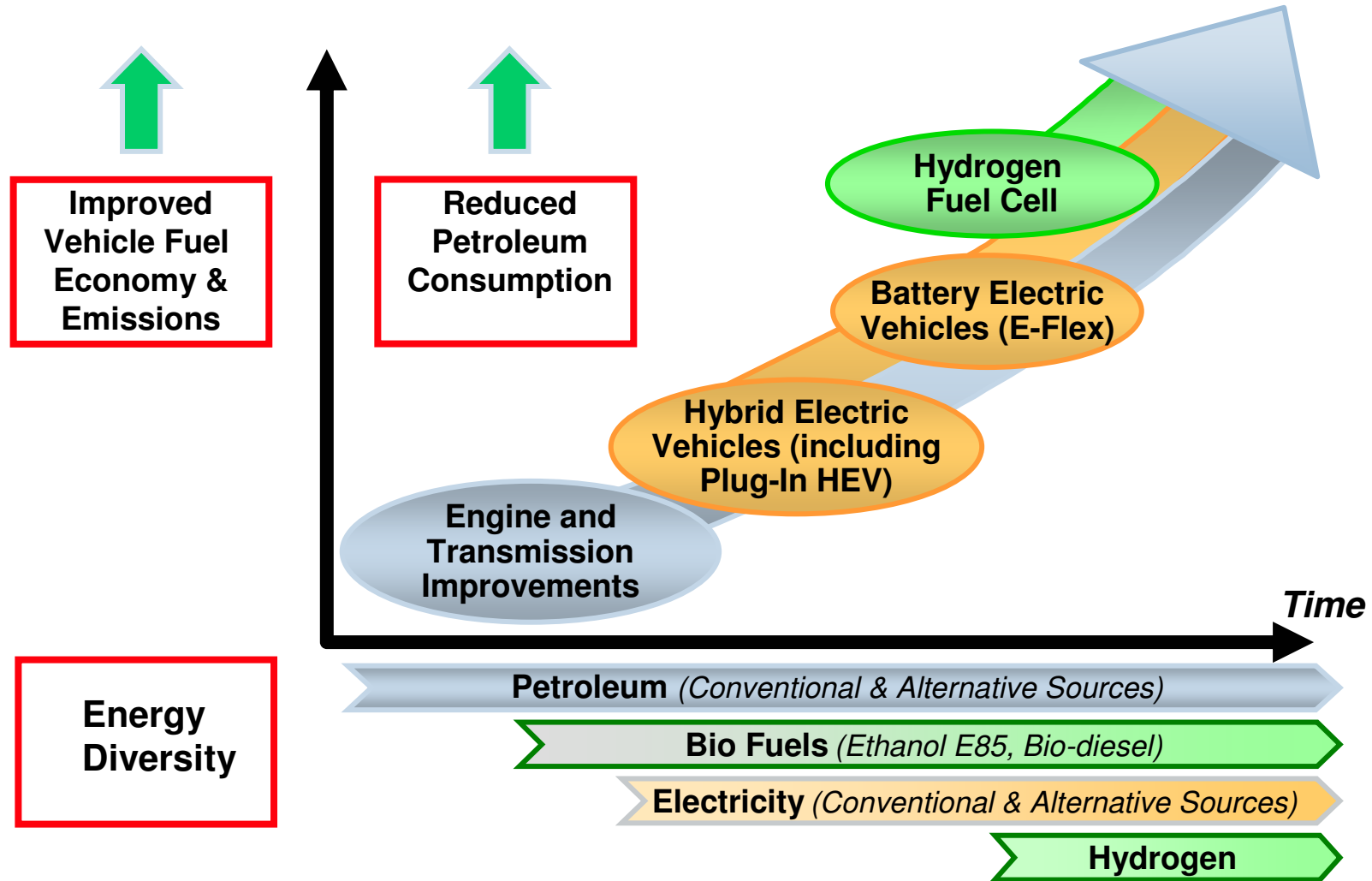
- Could be a part in Securing Future Energy Supply
- Dependent on Local and Regional Conditions
- Growth Possibilities for Local Industries

ENVIRONMENTAL CHALLENGES

- Could with right Process reduce the Net CO₂-emissions
- Limitations with First Generation Fuels
- Potentials with Second and Third Generation Fuels

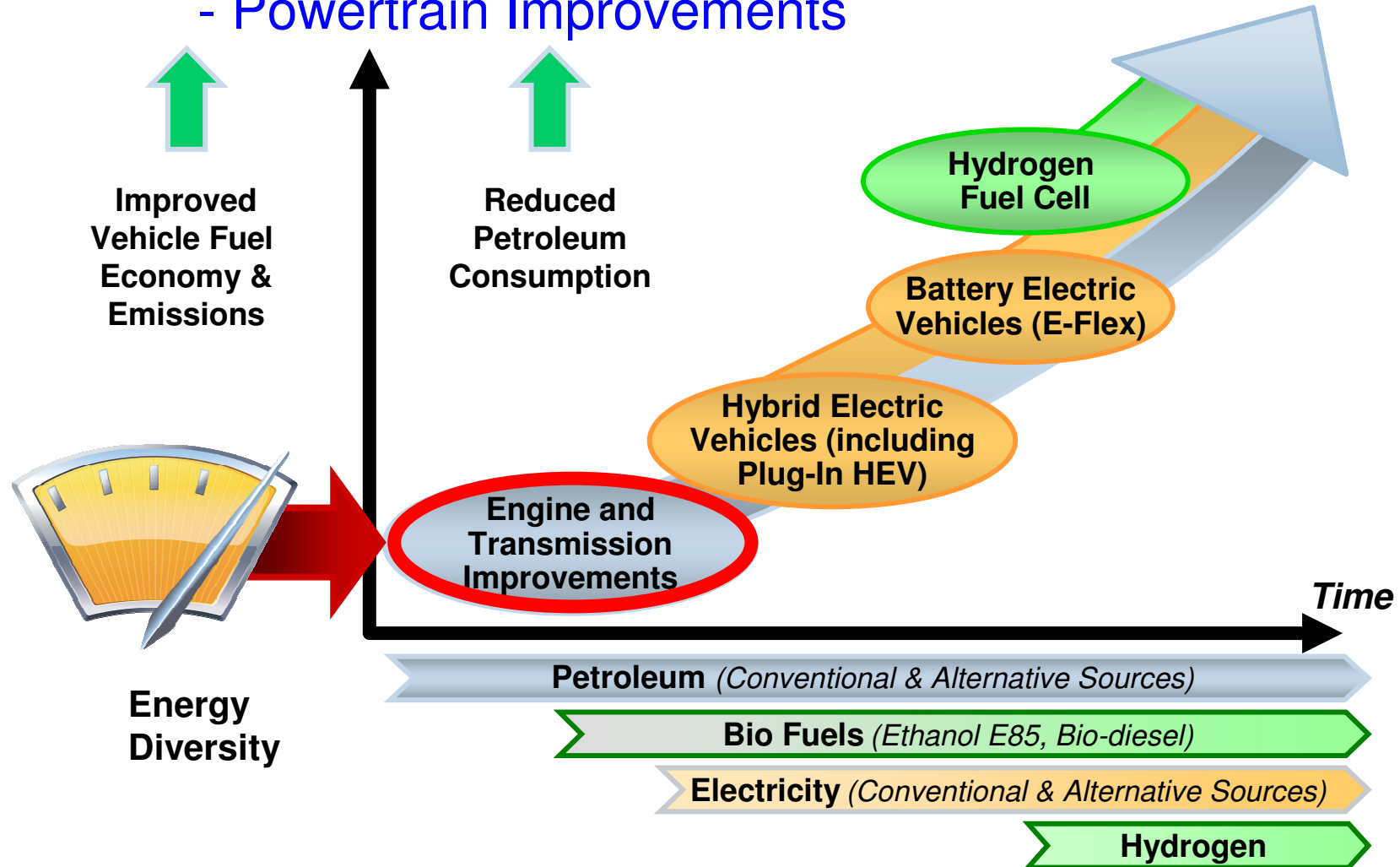


GM Alternative Propulsion Technology Strategy



GM Alternative Propulsion Technology Strategy

- Powertrain Improvements



Powertrain Improvements

ENERGY EFFICIENCY

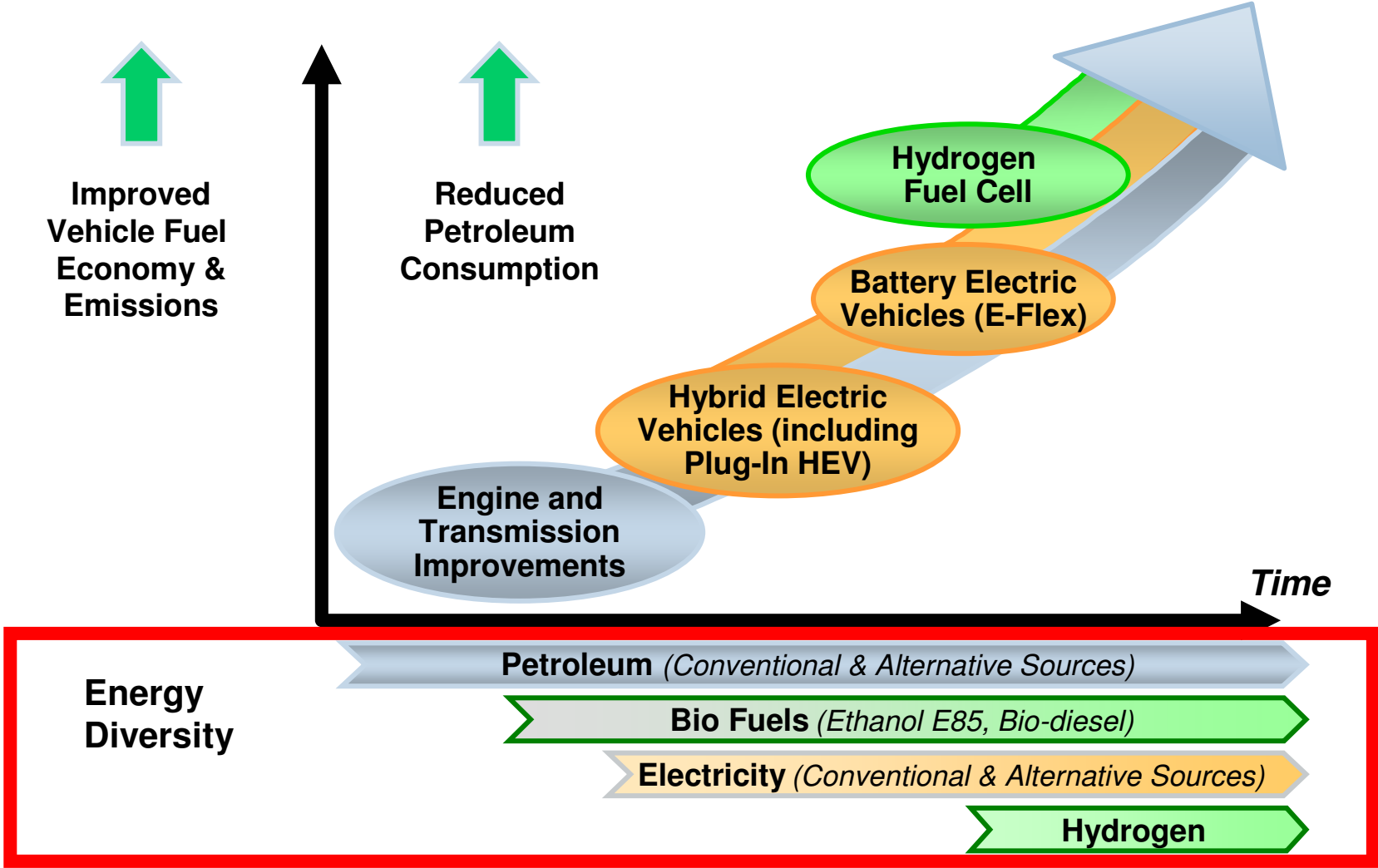
- Improve Fuel Efficiency of Conventional Propulsion Vehicles
- Make Big Engines act like "Small" Engines
- Make Small Engines act like "Big" Engines

CUSTOMER CHALLENGES

- Reduce Real Life Energy Consumption through Driver Behaviour
- Right Sizing of Vehicles
- Right Speeding of Vehicles



GM Alternative Propulsion Technology Strategy



Automotive Fuels – General Requirements

DESIGN ELEMENT FOR ENGINES

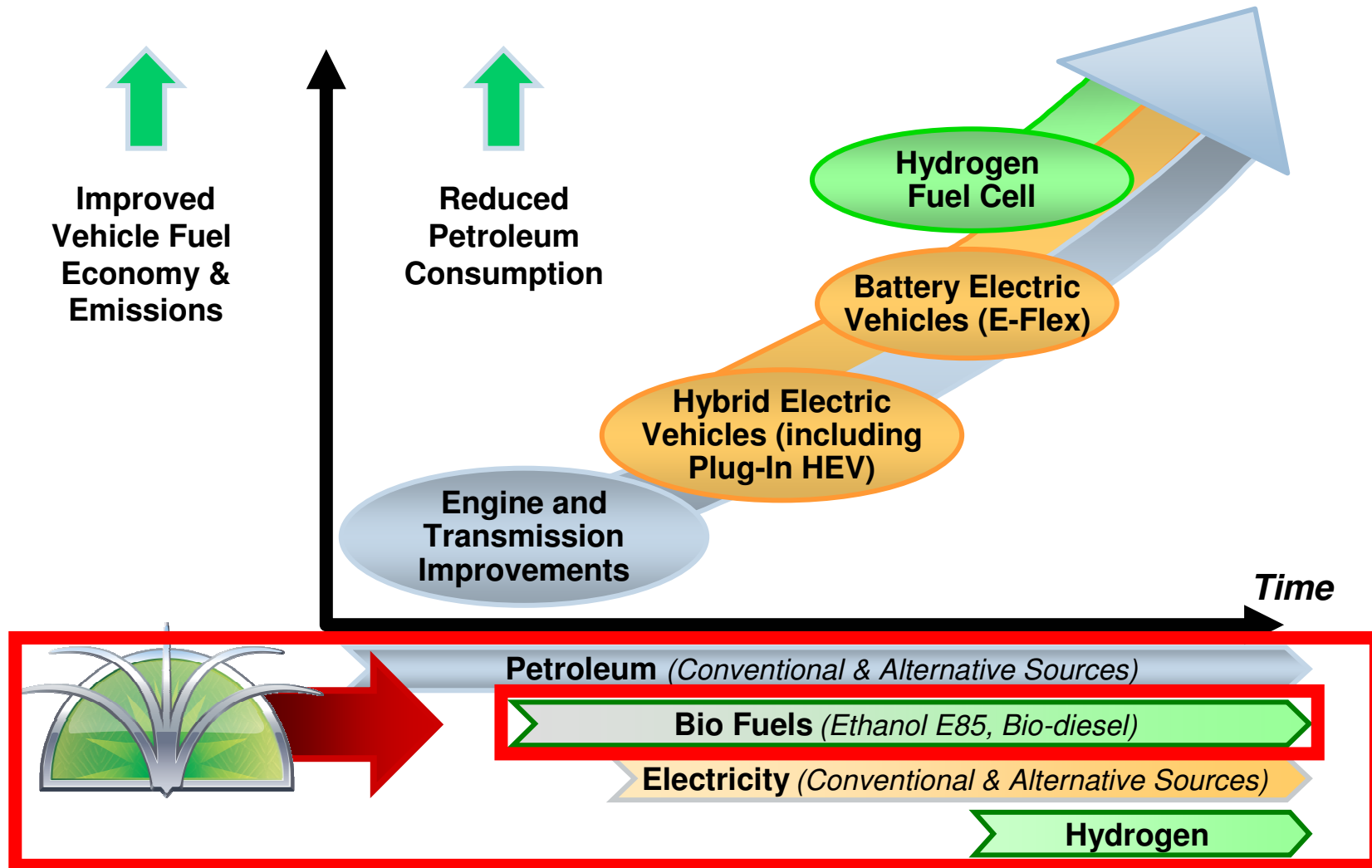
- Defines the Engine Combustion Process
- Defines the limitations and Boundries for Energy Conversion
- Defines the Packaging and Storage Constraints

STANDARDIZED & WELL-DEFINED PRODUCT

- Prerequisites for stable Emissions & low Fuel Consumption
- Fuel Blending Capability
- Integral part of the Quality Assurance
- Certified Fuel
 - Origin
 - Production Process
 - Environmental Impact

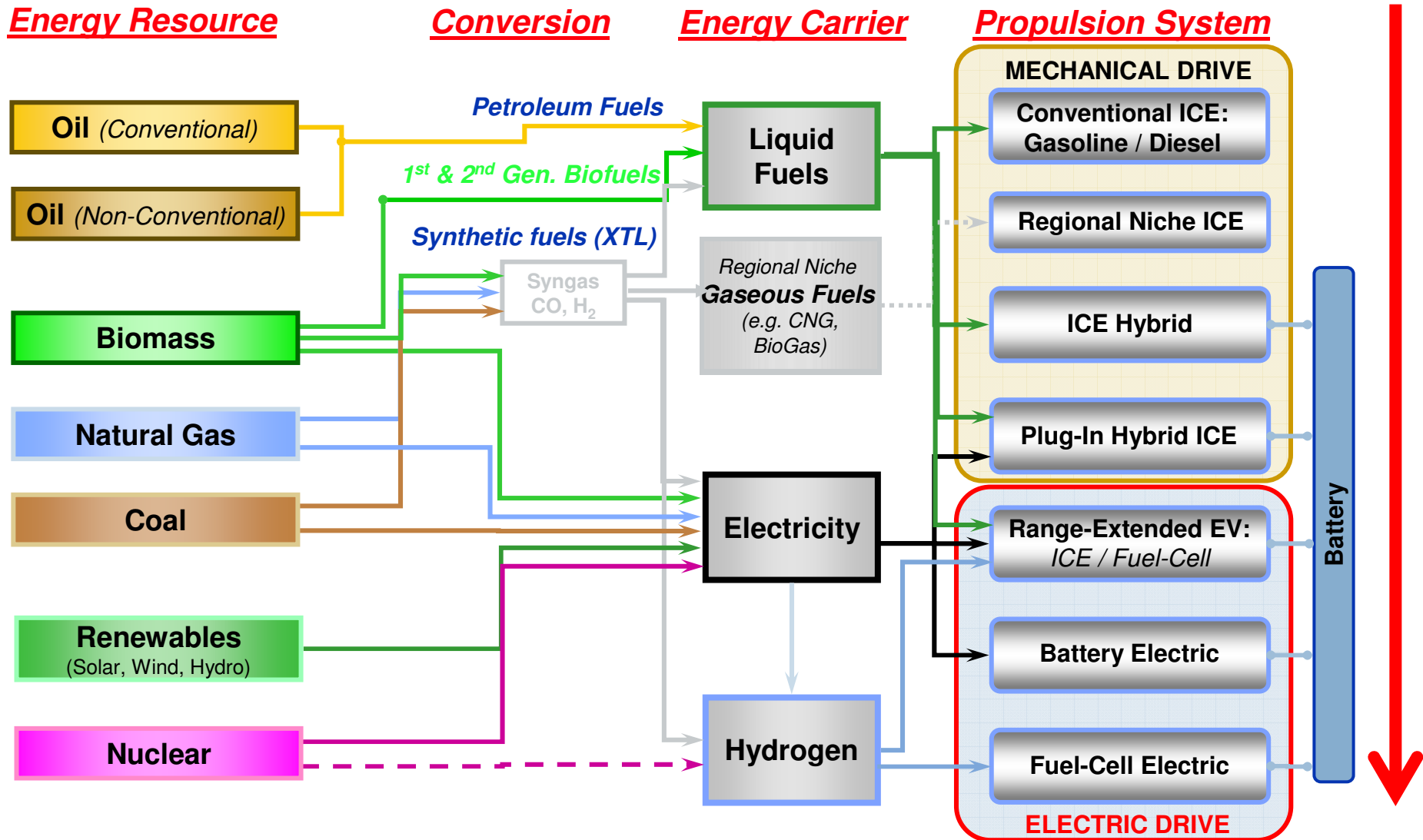


GM Alternative Propulsion Technology Strategy



Energy Diversity – Blending Strategy

Electrification



Energy Diversity – Potential Scenarios

SPARK IGNITED ENGINES

- Single hydrocarbon – ex. alcohols: M100, E100, Bu100

COMPRESSION IGNITED ENGINES

- DME (DiMethyl Ether)
- Synthetic – SynFuel Fischer Tropsch, BtL (Bio-to-Liquid)

HCCI-ENGINES – Dedicated Fuels

- Spark-Ignited Based – M100, E100, Bu100
- Compression-Ignited Based – SunFuel

OPTIMIZING THE ENGINES FOR THE FUEL

- Lower Emissions
- Higher Efficiency



Energy Diversity – Renewable Fuels



BIOFUELS

- Most significant Near-Term Solution to offset rising Vehicle Energy Demands and reduce Green House Gas Emissions
- Next-Generation BioFuels
 - Provide a clean, renewable Alternative to Petroleum
 - Not just Replacing, but better Engine Fuel than Petroleum

PRODUCTION CHALLENGES

- The Growing, Gathering and Processing of sustainable Feedstocks for these Future Fuels are critical
- Sustainable BioFuels made from Non-grain Sources could offset substantial part of Future Vehicle Energy Demand by 2030
- GM is supporting this development

Ethanol as an Engine FUEL – Pro's & Con's

PRO's :

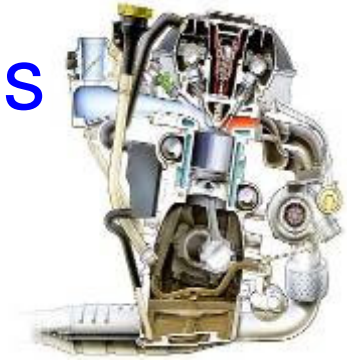
- High Concentration Blends like E85 or E100
 - Best use of the Fuels Advantageous Properties
- High E85 Octane Number - RON 105 => $(R + M)/2 = 96$
- High Heat of Vaporization Value - 2.8 times vs Gasoline
 - Gives Charge Cooling effect of 2.4 times vs Gasoline
 - Allows increased Compression Ratios and Spark Advance



CON's :

- Lower Calorific Value => Shorter Driving Range
- Low Vapor Pressure => Cold Start Ability
- Liquid Ethanol is chemically more aggressive

Adopt the Engines to Renewable Fuels



OPTIMIZE THE ENGINES

- Increasing Compressions Ratios
- Increasing Charging

UTILIZE THE ADVANTAGES

- Right-sizing / Down-sizing
- Pick the Right Size of Engine
- Even higher Compressions Ratios
- Even higher Charging Level
- Leads to higher Efficiency

GM Alternative Propulsion Technology Strategy

