# *Future Fuels: Developing Tomorrow's Energy*

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# INTRODUCTION

- ENERGY IS KEY FOR FUTURE  DEVELOPMENT ON EARTH
- CURENT CARBON BASED  ENERGY SYSTEM – UNSUSTAINABLE
- FUTURE ENERGY SYSTEM – NEED ALTERNATIVE FUELS  TO SUPPLEMENT INCREASING DEMAND
- FUTURE ENERGY AND FUELS- GLOBAL ISSUES

# WORLD-WIDE FUEL CHARTER (WWFC)

- **WWFC is a global document that promotes greater understanding of fuel quality needs of motor vehicle technologies and harmonizes fuel quality world-wide in accordance with vehicle needs and environmental concerns**
- **Charter backed by four global automobile associations:**
  - **ACEA (European Automobile Manufacturers Association)**
  - **Alliance of Automobile Manufacturers**
  - **Truck and Engine Manufacturers Association (EMA)**
  - **Japan Automobile Manufacturers Association (JAMA)**

  **plus 15 national associations from countries of the world**

# World-Wide Fuels Charter History

- First version released in 1998: subsequent versions added periodically
- Charter included four categories of gasoline and diesel fuels, each recommended for a given level of technological development of engines - from Category 1 (markets with no/minimal requirements for emission control) to Category 4 (markets with advanced requirements for emission control, including after-treatment technologies: US CA LEV 2, US EPA Tier 2, Euro 4.
- The 5th edition of the Charter released in September 2013
  - Introduced Category 5 for markets with highly advanced requirements for emission control and fuel efficiency (US 2017 LD fuel economy; CA LEV III or equivalent)
    - For gasoline, minimum octane (RON) raised to 95
    - For diesel fuel, hydrotreated vegetable oil (HVO) and Biomass-to-Liquid (BTL) accepted under certain requirements
    - Biodiesel up to 5% by vol. accepted in Category 4 diesel fuel; oxidation stability limits included and test method established
    - E100 and B100 Guidelines referenced

# WWFC 5th Edition Changes from 4th Edition

- Major change is addition of ‘Category 5’ fuel quality level above existing Category 4:
  - Provides for introduction of future advanced emissions control systems and improved fuel efficiency.
- Category 1 – 4 definitions have not changed substantially.
- Table shows WWFC Categories against target emissions levels.

| WWFC Category | US Emissions Level | EURO Emissions Level |
|---|---|---|
| 1 | Tier 0 | EURO I |
| 2 | Tier 1 | EURO 3/III |
| 3 | LEV / ULEV | EURO 4/IV |
| 4 | Tier 3, LEV II, HDD 2010 | EURO 6/VI |
| 5 | US 2017 LD FE, LEV III | |

# Requirements for All Markets

**Introductory section defines needs for all categories regardless of fuel quality level:**

- **Additives to be compatible with engine oils.**
- **No ash forming components.**
- **Good housekeeping to minimize contamination.**
- **Pipeline corrosion inhibitors must not interfere with fuel quality.**
  - **Reference to IDID issues caused by specific corrosion inhibitor.**
- **Adequate labelling of dispenser pumps.**
- **Ethanol and FAME components should comply with WWFC committee guidelines.**

# WWFC and Fuel Additives: Gasoline

- Intentional addition of metal containing additive prohibited.
- Deposit control additives (DCAs) are recommended to prevent build up of deposits in:
  - PFI, Direct Injection (DI) injectors and Intake Valve Deposits (IVD).
    - US and European industry standard tests recommended.
- DCA formulations should be based on synthetic carrier fluids to prevent:
  - Inlet valve sticking and
  - Excessive  Combustion Chamber Deposits (CCD) build up.
    - Several CCD tests are set out in the Categories with limits set

# WORLD-WIDE FUEL CHARTER (WWFC)

- WWFC is not a standard, rather a high level recommended guidance for fuel development and evolution world-wide. It is based on scientific evaluation and technical needs assessment for optimum vehicle performance
- WWFC is a global living document
  - As countries develop and apply new vehicle technology, they enter in a higher fuel category
  - The Charter continues to guide the development of new fuels, to match vehicle technology, maximize performance and satisfy emission requirements

# FUTURE ALTERNATIVE FUELS

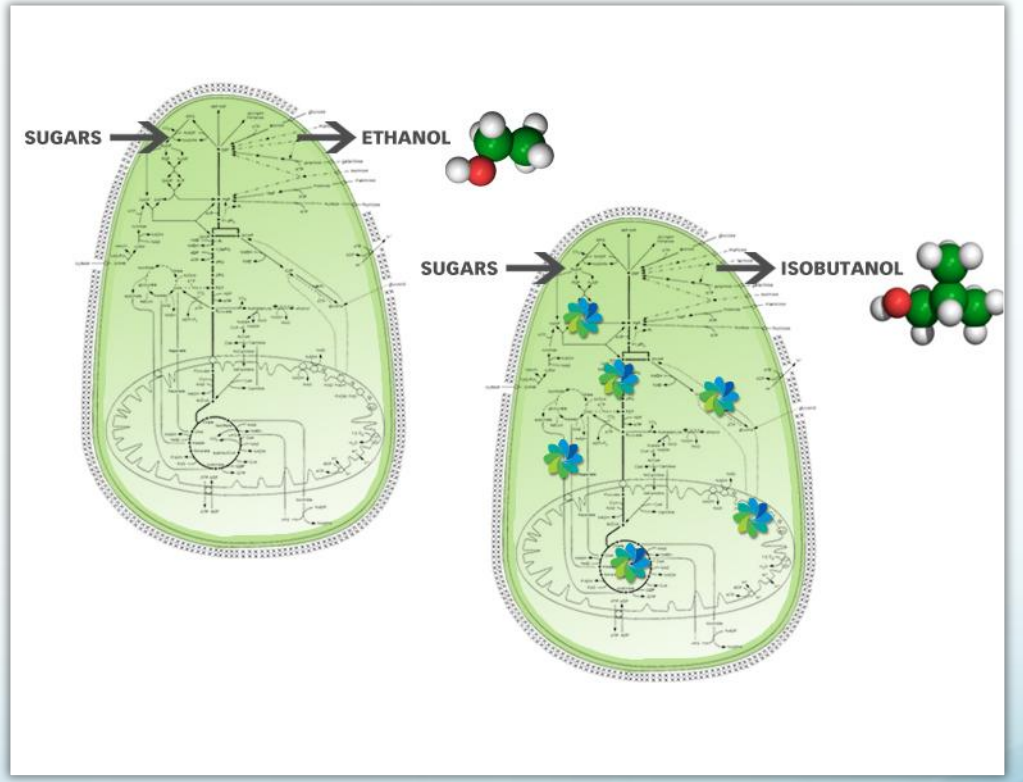
- SHOULD SUPPLEMENT PETROLEUM BASED FUELS
- PREFERABLE LIQUID FUELS, BUT ALSO GASEOUS FUELS
- NEED SUSTAINABLE FEEDSTOCK FOR ALTERNATIVES
- BTL, CTL, GTL, XTL

# BTL; BIOMASS - TO - LIQUIDS

- FIRST GENERATION BIOFUELS : ETHANOL AND BIODIESEL
  - DERIVED FROM EDIBLE/CULTIVATED FEEDSTOCK
  - CHEMICALLY DIFFERENT FROM CONVENTIONAL FUELS
  - LONG EVOLUTION (25 YEARS), SUPPORTED BY INCENTIVES
  - AT PRESENT INDUSTRY EXISTS, BUT PENETRATION IS INSUFFICIENT
- SECOND GENERATION BIOFUELS
  - NON EDIBLE FEEDSTOCK
  - SUPERIOR PROPERTIES
  - PROCESSED TO BE DROP-IN FUELS/OR HAVE BETTER BLENDABILITY WITH BASE FUELS

# BIOBUTANOL

- BIOBUTANOL IS PROCESSED BY FERMENTATION ON NON EDIBLE BIOMASS
- USES:
  - DROP-IN GASOLINE BLENDSTOCK
  - 10% ETHANOL  CAN BE REPLACED BY 16% BUTANOL IN GASOLINE BLENDS
  - IMPROVED PROPERTIES: HIGHER  ENERGY CONTENT, HIGHER OCTANE NUMBER,
  - CAN GENERATE OTHER VALUABLE GASOLINE BLENDSTOCKS
  - CAN GENERATE DIESEL FUEL COMPONENTS
  - CAN GENERATE ISO-PARRAFINIC KEROSENE (IPK OR RENEWABLE JET FUEL)



# BIOBUTANOL – OPPORTUNITY FOR RENEWABLE JET FUEL

- ASTM TASK FORCE INVESTIGATED CONVERSION OF BIOBUTANOL TO PRODUCE RENEWABLE DROP-IN JET FUEL
- IN 2012 USAF FLEW A TEST FLIGHT USING A 50/50 BLEND OF ATJ (ALCOHOL –TO-JET) AND JP-8 FUEL
  - A-10 THUNDERBOLT JET
  - DIFFERENT THROTTLE BODIES
  - APU STARTS
  - ENGINE ASSISTED STARTS
- AFTER TEST STATEMENT:

  "ATJ FUEL IS A TECHNICALLY VIABLE ALTERNATIVE FOR MILITARY AND COMERCIAL APPLICATIONS"

# BIOBUTANOL – ADDITIONAL ADVANTAGES

- CAN BE SHIPPED IN PIPELINES BETWEEN REFINING AND BLENDING FACILITIES
- CAN GENERATE BLENDSTOCK FOR SEVERAL FUELS
- CAN GENERATE A NUMBER OF VALUABLE CHEMICALS, IMPROVING THE FLEXIBILITY OF THE DOWNSTREAM INDUSTRY

# CTL; COAL-TO-LIQUIDS

- CTL (Coal-to-Liquids) Technologies include:
  - Synthesis gas production and
  - Fischer-Tropsch (FT) conversion
- Largest production capability in South Africa
- Great potential and appeal in Asia Pacific Region (China, India Australia)
- Environmental benefits: no sulfur; low aromatics; higher cetane number; lower density
- CLT capacity planning and building
  - China; India and Australia
- Long way to go to become integral part in future energy scenario

# GTL; GAS-TO-LIQUIDS

- GTL (Gas-to-Liquids) traditional technologies include:
  - Synthesis gas production and
  - Fischer-Tropsch (FT) conversion
- Sasol corporation produces FT fuels from coal in South Africa and from natural gas in Qatar.
- Plans announced to build facility in Louisiana (from Gulf Coast region resource)
- Traditional FT process generates heavier components (for diesel and jet fuel); cracking is possible, but cost and complexity increases.
- Alternative approach by Mobil in the 70's: Syngas- methanol - gasoline
- New approach "STG plus": output can be gasoline, diesel, jet fuel, aromatics and other praised chemicals.
- Approach is simpler, lower cost, allows to scale down facilities

# Conclusions

- The future of global energy and fuels will likely be a combination of two categories of fuels:
  - Traditional fuels of today, evolving in tune with future requirements
  - A growing proportion of new alternatives, produced from low carbon feedstock (advanced biofuels), or from abundant fossil feedstock (superior liquid fuels)
- These categories will coexist in competition: technology development, performance, availability and economics may be crucial in deciding the winner. Favorable policies, incentives to support the early development, may also help.
- Liquid fuels will continue to exist in synergy with the internal combustion engines. These engines have served society and technology for over 150 years and will continue to do so, well into the 21st century.