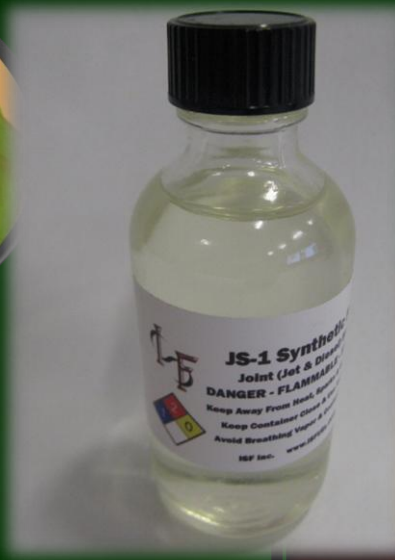


ExxonMobil Tech Symposium Synthetic Fuels and Lubricants From Fossils to the Future

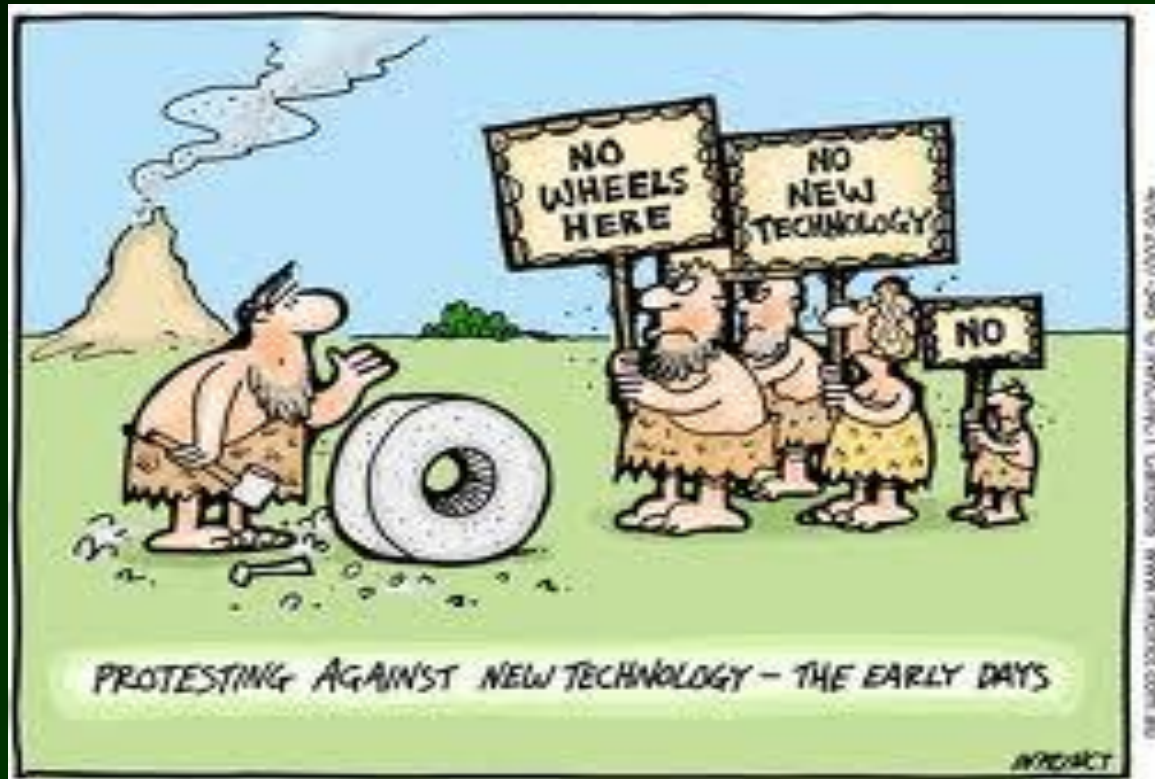


Joint Synthetic 1 (JS-1)



Rolf Onjukka
Integrated Synthetic Fuel Incorporated / Aerotech Engineering
www.isfuel.com Date: 09/16/2010

How do we react to new technology?



***“Those that fail to learn from history, are doomed to repeat it.”
-Winston Churchill***



The Technology is HERE!

- Why aren't we there yet?

- Historically speaking, most (like all) new technology that is introduced to society encounters great emotional barriers.



New Technology: Political Problems

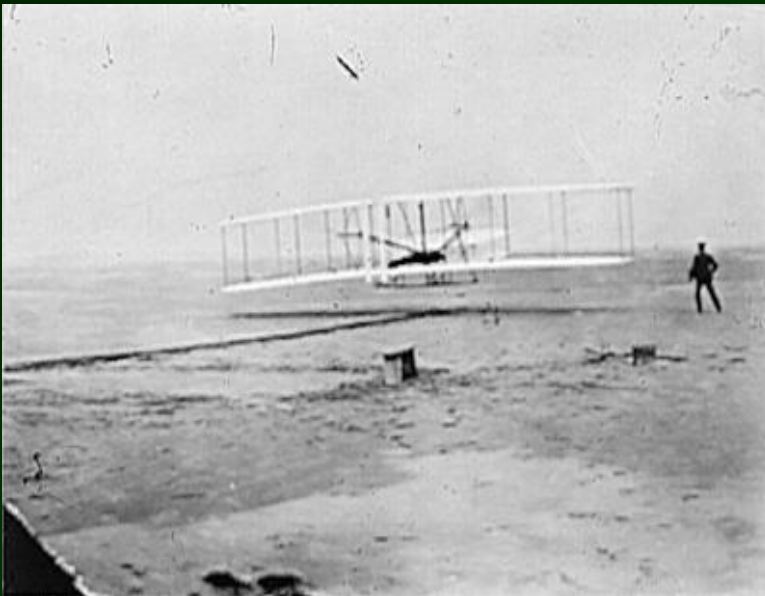
When everyone figures out that the new technology is good for society, the politics begin.



Finally,,,New technology solves the original problem

Man really wanted to fly...

So he did! And developed bigger, better, & faster aircraft



Synthetic Jet fuel. Technology in action.. Again.

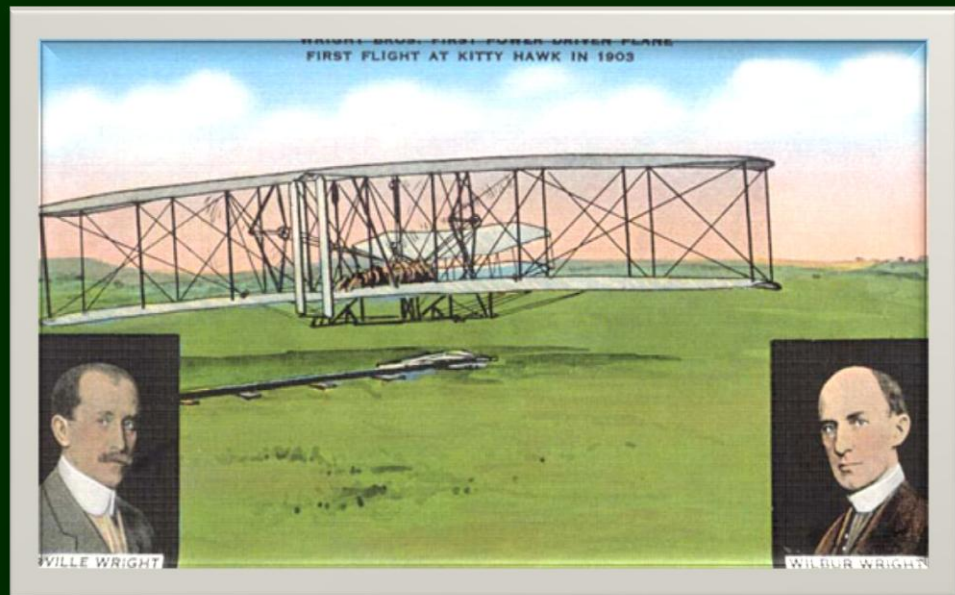


09/16/2010

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Chronology – The Good Old Days

- 1859 - First oil well in Titusville, PA (Col. Edwin Drake & Uncle Billy Smith)
Petroleum makes whale and coal oil obsolete.
- 1870 - Standard Oil (Exxon) & Vacuum Oil (Mobil) develop Gargoyle 600-W steam cylinder oil.
- 1903 - ExxonMobil predecessor companies supply the Wright brothers with fuel and oil for early flights in Kitty Hawk, NC.



The Age of Discovery

- 1911 – Gasoline (former waste by-product) sales for cars and trucks exceed kerosene (used for lamps and heating).
- 1915 – Indy winners use Mobil products.

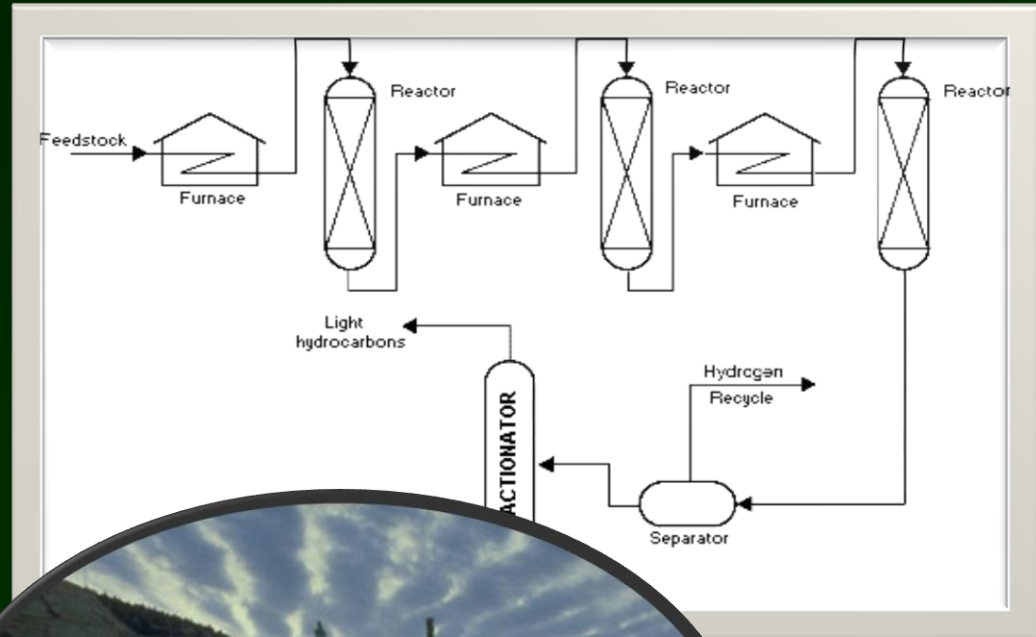


Discovery Continues

❖ 1913 – Bergius (Germany) develops hydrogenation process for production of synthetic oil from coal to yield complex cycloalkane ring compounds.

❖ 1921 – Standard Oil produces one barrel of synthetic oil from one ton of shale rock.

❖ 1925 – Fischer & Tropsch (Germany) develop synthetic oil using indirect gasification and catalytic synthesis to yield long chain paraffin – later called FT.



The Age of Progress - Synthetics

- 1930 – (thru 1940) Zorn (I.G. Farben Ind. – Germany) and Zisman (U.S. Navel Research Lab) synthesize esters, diesters, and polyesters that have properties of natural oil without the tendency to gel or gum when exposed to high temperature, low pour point, and high Viscosity Index (VI) to lube delicate instruments at low temperature and jet engines at high temperature.
- 1931 - Bergius & Bosch (Germany) receive Nobel Prize for Chemistry for synthetic oil production from coal.
- 1936 – Hitler launches Coal to Liquid (CTL) program for fuel and lubricants.



The Age of Progress - Petroleum

- 1942 - First big fluid cat cracker goes on stream in Baton Rouge, LA dubbed the “four horseman”
- 1950 - Petroleum oil spec MIL-O-6081 introduced for GE J47 (used on Convair B-36 and Boeing B-47)



- 1952 - Exxon introduces “Uniflow” multigrade motor oil.



The Beginning of the Jet Age

- 1947 -The first military spec (AN-0-9) covering petroleum oils in turbine engines is followed by Air Force spec 3519 and MIL-L-7808
- 1951- ESSO develops diester based synthetic oils (e.g. EEL-3, EATO 15, & 35 to meet specs)
- 1958 - Pan Am flies B707 on first transatlantic jet from NY to London with Mobil aviation fuel and syn oil.



Synthetic Technology Matures



- 1963 – DoD issues aircraft instrument, gear, and actuator screw diester based synthetic spec (MIL-PRF-23827). Is a good lubricant, but does react with water to change properties and make acid.
- 1965 – Mobil develops Mobilgrease 28 – a Polyalphaolifin (PAO) synthetic general purpose Wide Temperature Range (WTR 165 to +350F) to meet MIL-G-81322. WTR grease makes polyester and mineral oil grease obsolete.
- 1974 – Mobil 1 synthetic motor oil introduced using PAO synthetic.



The Industry Gets Tougher



- 1970 – Arab oil embargo raises oil prices and stimulates development of alternative energy concepts and synthetic fuel, oil, and lube.

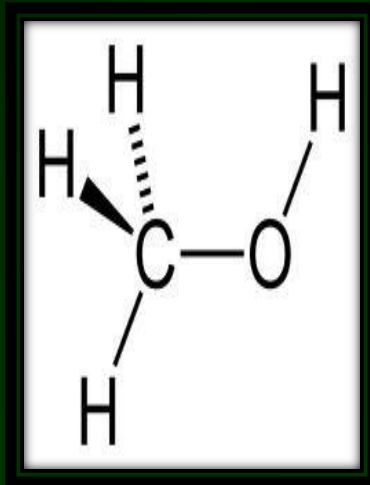
- 1972 – Jersey Standard (ESSO) becomes Exxon.



1984 – Oil glut drops oil price and halts alternative energy projects.



1972 – Mobil develops Methanol conversion to high octane Gasoline (MTG) using Zeolite catalyst.



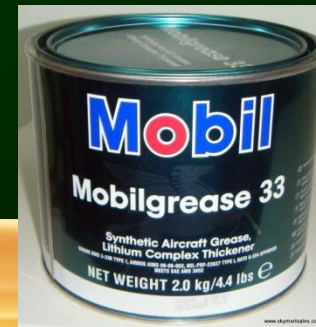
Synthetic Technology Evolves

- 1992 – First 0W60 PAO synthetic introduced in Germany.
- 1995 – Society of Automotive Engineers (SAE) and American Petroleum Institute (API) remove the word “synthetic” from specs, books, and guides following extensive debate, complaints (Mobil vs. Castol), rulings and confusion regarding cracked and hydrotreated petroleum that is called synthetic.”



A New Century of Synthetic Technology Begins

- 2001 – ExxonMobil Research and Engineering Co. (EMRE) develop Scanfining process to remove 95% of sulfur from gasoline.
- 2001 – Boeing introduces lithium complex thickened synthetic aircraft grease (BMS 3-33) to meet operating temperature of aviation (-100 to +250F).
- 2003 – Ultra Low Sulfur (ULS) diesel fuel becomes law. Jet fuel does not.
- 2006 – Mobilgrease 33 is qualified to BMS 3-33 using polyalphaolifin (PAO) as base oil. PAO makes pure diester based greases obsolete. Can be used in 90% of aviation lube requirements.
- 2005 – Gas to Liquid (GTL) diester base stocks encroach on PAO synthetic motor oil (in U.S. only)



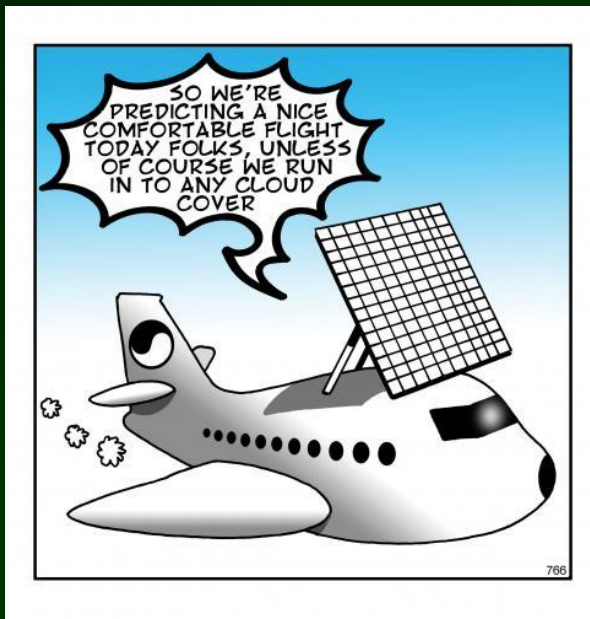
Recent Synthetic Fuel Initiatives and Discovery

- 2006 – Testing of GTL jet fuel begins by USAF.
- 2006 – Civil Aviation Alternative Fuel Initiative (CAAIFI) is launched.
- 2008 – Jet fuel specs are revised to allow up to 50% Synthetic Paraffinic Kerosene (SPK) or Hydrotreated Renewable Jet (HRJ).
- 2009 – FAA, CAA, Boeing, and Airbus warn of Fatty Acid Methyl Ester (FAME) contamination from biodiesel. Only is in 5 ppm is allowed. Testing to show 100 ppm is OK in progress.
- 2010 – Integrated Synthetic Fuel (ISF) with collaboration with Rentech, AFRL, and SWRI test fully synthetic joint jet and diesel fuel (JS-1). This fuel made from ring and chain compounds shows compliance with all commercial and military jet and diesel specifications with minimal standard additives.
(lubricity test for diesel is underway)



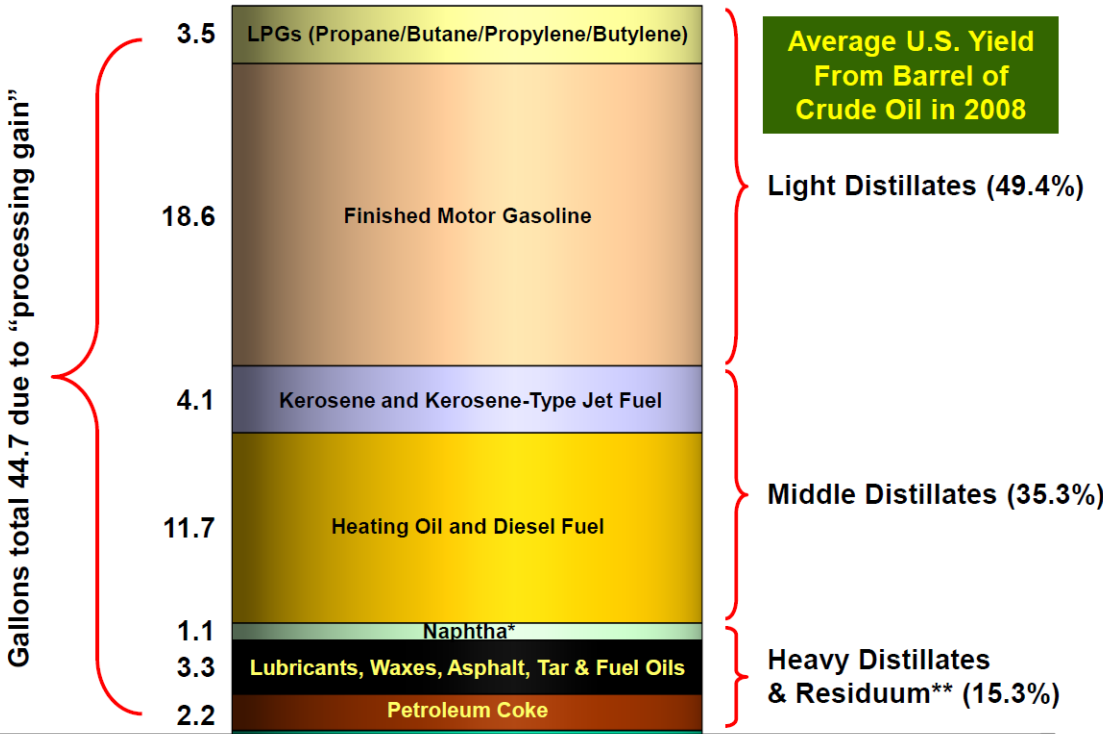
No Alternative to Diesel & Jet Fuel

- Diesel Powers Large Trucks, Trains & Ships
- No Alternative for Aircraft Propulsion
- Alternative Feedstock & Production – Only Viable Alternatives



Fuel Supply – Industry Risk

Jet Fuel Is a Drop in the Bucket, Subject to the Refinery Economics for All Petroleum Segments (incl. Gasoline)



* Feedstock for high-octane gasoline, petrochemicals and solvents

Sources: [Energy Information Administration](#) and [American Petroleum Institute](#)

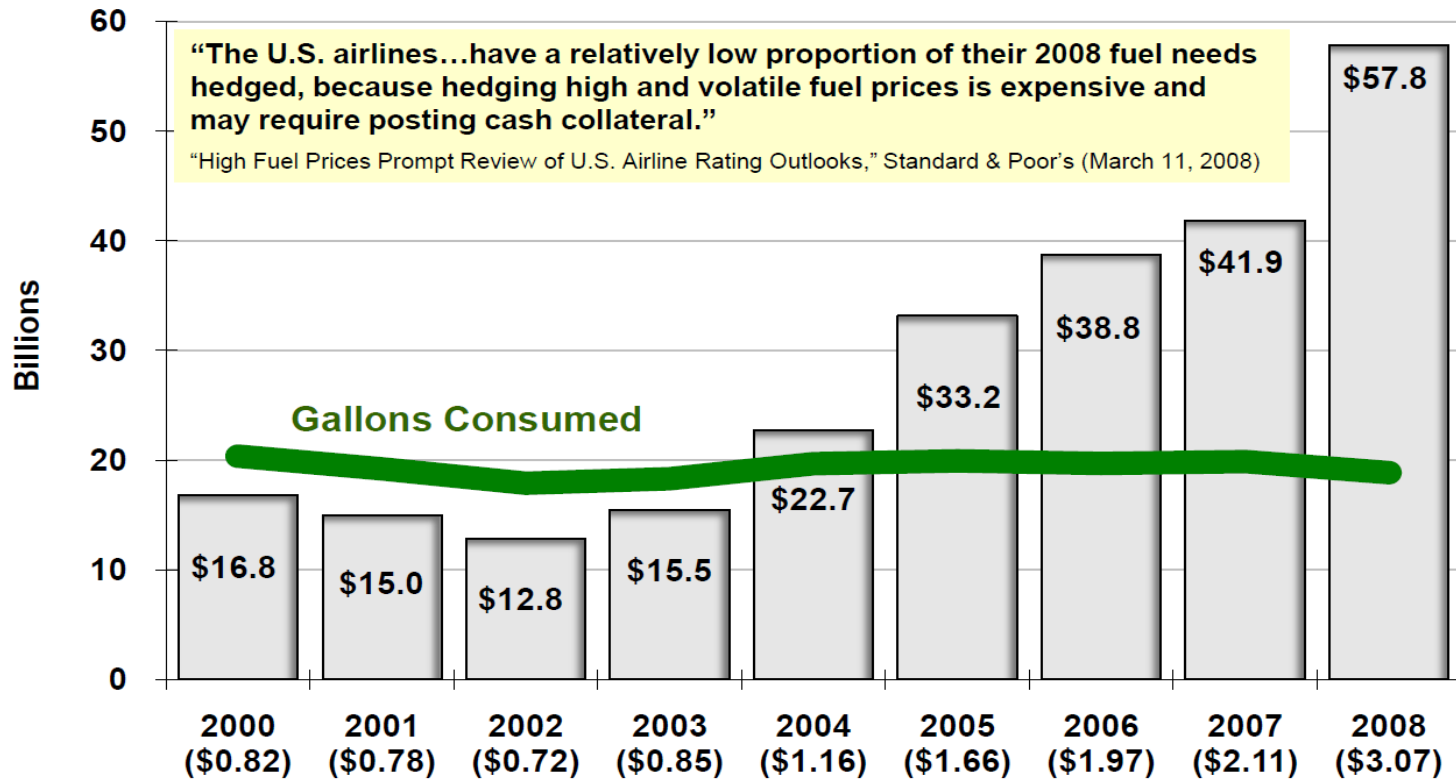
** Includes heavy oils used in industry, marine transportation and electric-power generation

www.airlines.org



Fuel Supply – Industry Risk

**In 2008, U.S. Airlines Spent \$16B More on Fuel
Despite Consuming > 5% Fewer Gallons**



Note: Value in parentheses below year is average price paid per gallon excluding taxes, into-plane fees, pipeline tariffs and hedging costs
 Sources: ATA, Energy Information Administration, Department of Transportation

www.airlines.org



Domestic Synthetic Fuel Production

- Utilizes Domestic Feedstocks – Coal, Biomass & Municipal Waste
- Creates Domestic Supply – Mitigates Supply Risks & Supports Domestic Economy
- New Facilities Focused on Diesel & Jet Fuels – Supply Security

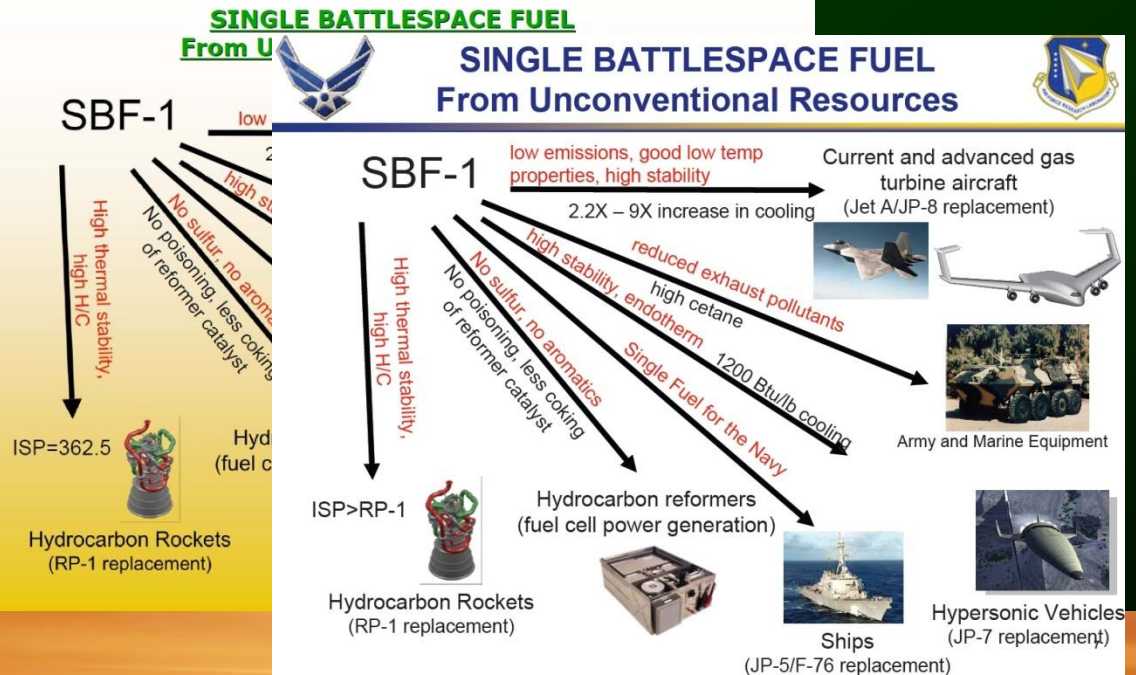


Joint Synthetic Fuel Developments

- JBUFF (Joint Battlespace Use Fuel of the Future)
- SBF (Single Battlespace Fuel)
- Military Interest – One Fuel for Trucking & Aviation

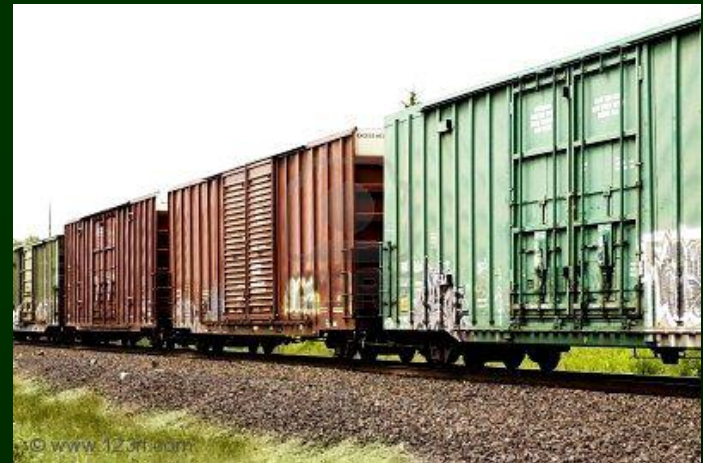
OSD Assured Fuels Initiative Goals

- **Total Energy Development (TED)**
 - Catalyze the industry to produce fuels for the military and domestic energy resources
 - Develop a roadmap to provide fuel for the Joint Battlespace Use Fuel of the Future program and implementation
- **Joint Battlespace Use Fuel of the Future (JBUFF)**
 - Develop fuel specifications that include non-petroleum components, for use in military equipment, aircraft ground vehicles
 - Validate use of the fuels in all tactical vehicles, aircraft
 - Provide a transition plan for DoD wide deployment



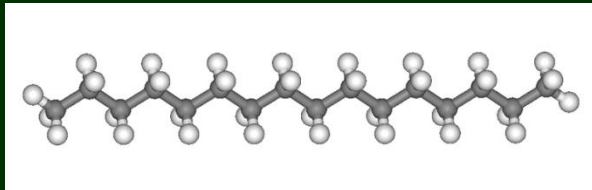
Joint Synthetic Fuel Benefits

- Wider Market (Diesel & Jet)
- Broad Industry Interest
 - Aviation, Trucking, Rail
 - Transportation Alliances
- Military Interest – Single Battlespace Fuel & Humanitarian Emergency Relief



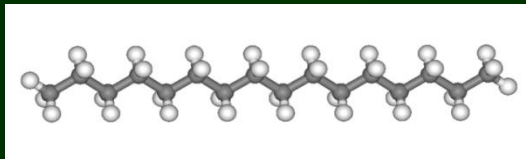
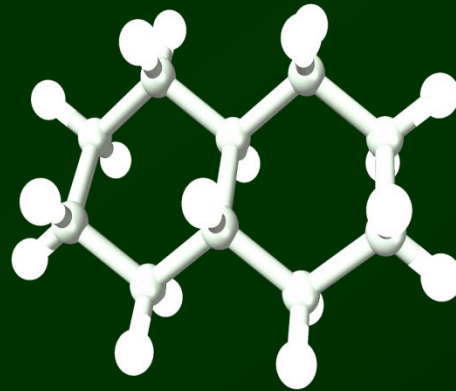
Candidates For Joint Synthetic Fuel

- FT Fuels (SPK)
 - Not Viable, Low Density & Fuel System Issues (O-ring Swell)
- Pyrolysis Derived Fuels
 - Not Viable, High Density & Cetane Issues
- Biodiesel & Ethanol
 - Biodiesel: Not Viable, Freeze Points
 - Ethanol: Not Viable, Low Energy Density & Safety Issues
 - Feedstock Issues: (Availability & Food)



Joint Synthetic One (JS-1)

- First Viable Joint Synthetic Jet and Diesel Fuel
 - Blend of High Density & Low Density Synthetic Fuels
 - Co-processing Increases Production & Efficiencies
- High Density Synthetic (HDS)
 - Pyrolysis Derived
 - High Density & Swells O-ring
- Low Density Synthetic (LDS)
 - Gasification (FT) Derived
 - Low Density & Good Cetane



JS-1 Joint Diesel and Jet Properties

TABLE 1: JBUF Synthetic Jet and Diesel Fuel JS-1 Test Status (1)

Spec	Test Property (Units)	JS-1	Range/Limit	ASTM Test Method
J	Appearance	Clear	Report	D 4176
J	Color (Saybolt)	30+	Report	D 156 or D 6045
J	Acidity, total (mg/KOH/g)	0.004	0.015 max	D 3242
J _m	Olefins (% vol)	0.8%	5 % max	D 1319
J	Sulfur (% mass)	0.022%	0.30% max	D 5453, D4294, or D2622
D	Sulfur (ppm)	12	15 max	D 5453
J	Aromatics, unsaturated (% vol)	1.9%	25% max	D 1319
J	*Aromatics, total (% vol) (w/o additives)	0.91%	25% max	D 5186, D6379, or D 6591
J	Distillation Temperature IBP (°C)	156.0	Report	D 86 (D 2887 for est. only)
J	10% recovered (°C)	175	205 max (186)	D 86
J	20% recovered (°C)	186	Report	D 86
J	50% recovered (°C)	210	Report	D 86
J	90% recovered (°C)	257	Report	D 86
J	FBP End Point (°C)	276	300 max (330)	D 86
J _m	T50 – T10	35	15 min	D 86
J _m	T90 – T10	82	40 min	D 86
J	Residue (% vol)	1.2%	1.5% max	D 86
J	Loss (% vol)	0.7%	1.5% max	D 86



JS-1 Joint Diesel and Jet Properties (cont.)

DJ	Flash point (°C)	52	52 min	D 93 or D 3828
J	Density, (kg/m ³ at 15°C)	810	775 - 840	D 4052
J	Density (lbs/gal at 15°C)	6.76	6.47 -7.01	D 4052
J	API gravity (at 60°F)	43.1	37-51	D 4052
J	Freezing point (°C)	-57	-47 max	D 2386, D 5972, or D 7153
J	Viscosity (at -20°C mm ² /s cSt)	5.9	8.0 max	D 445 or D 7042
J	Viscosity (at -40°C cSt)	10	12.0 max	D 445 or D 7042
D	Viscosity (at 40°C cSt)	1.5	2.4 max	D 445 or D 7042
J	Calculated Net Heat of combustion (MJ/kg)	43.4	42.8 min	D 3338
J	Actual Net Heat of combustion (MJ/kg)	43.6	42.8 min	D 4809
J _m	Hydrogen content (% mass)	14.2%	13.4% min	D 3701 or D 3343
D	Cetane Index	41	40 min	D 976 or D 4737 (Procedure A)
D	Cetane Number	53	40 min	D 613
J	Smoke point (mm)	27	19 min	D 1322
J	Naphthalenes (% vol)	0.6%	3.0% max	D 1840



JS-1 Joint Diesel and Jet Properties (cont.)

J	Cu Strip Corrosion (2 hr at 100°C)	1a	1 max	D 130
J	JFTOT Pressure Change (mm Hg)	0	12 max	D 3241
J	Thermal Stability Rating (at 325°C)	1	3 max	D 3241
J	Existent Gum (mg/100mL)	1.6	7 max	D 381
J	Particulate (mg/L)	0.08	1 max	D 2276 or D 5452
J _m	Filtration Time (minutes)	9	15	MIL-DTL-83133 Appendix B
J _m	Water Reaction Interface Rating	1	1 b	D 1094
J	Microseparometer (MSEP WISM w/o additives)	81	70 - 90 min	D 3948 or D 7224
J _m	Icing Inhibitor FSII (DiEGME % vol)	.1	0.10-0.15%	D 5006
DJ _m	Conductivity (pS/m at 85°C max)	455	150-600	D 2624
J _m	Lubricity (mm, BOCLE)	0.56	0.85 max	D 5001
D	Lubricity (micron, HFRR at 60°)	510	520 max	D 6079 (w/o CI/LI tested at 610)

(1) Ref. ARRL Sample No. 6412 dated 5/4/2010 with standard additives.

D: Controlling specification is D 975 for No. 1 & 2 Diesel; Cloud point is N/A due to low freeze point.

J: Controlling specification is D1655 & D 7566 for Jet A & A-1, Mercaptan Sulfur is N/A due to ultra low sulfur content.

J_m: Controlling specification is MIL-DTL-83133 for JP-8. AO, MDA, FSII & CI/LI additives are included except as noted.

* O-ring swell verified by separate test.



What led to the new fuel and processing method discovery?

- Concerns for domestic fuel supply & security
- Review of several military presentations for a Single Battlespace Fuel (SBF) or Joint Battlespace use Fuel of the Future (J-BUFF)
- A comprehensive study of the properties of various types of synthetic fuels (FT Fuels / PSU JP-900) and the various methods to produce them (e.g. Karrick / Gasification / Bergius)



How is this new fuel different & unique?

- JS-1 is a hybrid of multiple synthetic fuels to cover weaknesses of paraffin with strengths from cycloalkanes - by blending the properties off-set each other
- Current synthetic fuels have to be blended with petroleum jet fuel (limited to 50%) to meet jet fuel specification
- No known fully synthetic fuel to date has been able to pass both diesel & jet fuel specifications



What new processing methods were discovered?

- Each synthetic fuel used in the blend is made from traditional processing methods
- As the blend theory was realized the method to make each synthetic fuel was investigated
- Upon deep analysis it was realized that co-processing of both fuels would lead to synergistic relationships across the various methods - and lead to increased output with decreased operational expense



How does synfuel aid in domestic security?

- Synfuel can be made from coal, biomass & municipal solid waste (MSW) all available domestic supplies
- A domestic production grid guards against natural disasters & supply interruptions
- Domestic production hedges against geopolitical actions and market forces.



What is a fully synthetic joint fuel?

- Fully synthetic fuel requires no crude oil for production
- JS-1 is a first candidate joint fuel passes both diesel & jet fuel specifications that is fully synthetic.
- An interchangeable fuel is great for crisis situations
 - Emergency Relief
 - Humanitarian Efforts
 - Fuel Logistics for Jet or Diesel Shortages



How do you produce JS-1?

- Combined Low Temperature Carbonization (LTC), Fischer-Tropsch (FT) Processing & Hydrogenation
- Integration of CO₂ processing to produce gasoline & water
- Integration of waste biomass and municipal waste to lower taxable CO₂ output
- Cost savings & higher yield in co-processing
Up to 6 barrels per ton of feedstock



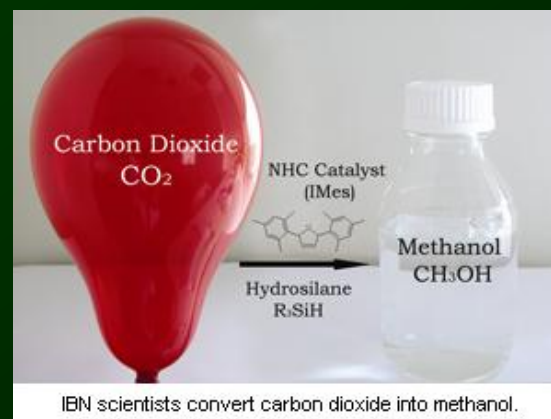
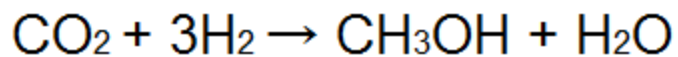
What benefits are in co-processing?

- Pyrolysis yields organic compounds and clean char / coke
- Char / coke for gasification (Low Density Synthetic - LDS)
- Organic compounds for (High Density Synthetic - HDS)
- Hydrogen production in one stream used in other
- Waste CO₂ used to produce gasoline and water
- Multiple uses of process heat and steam



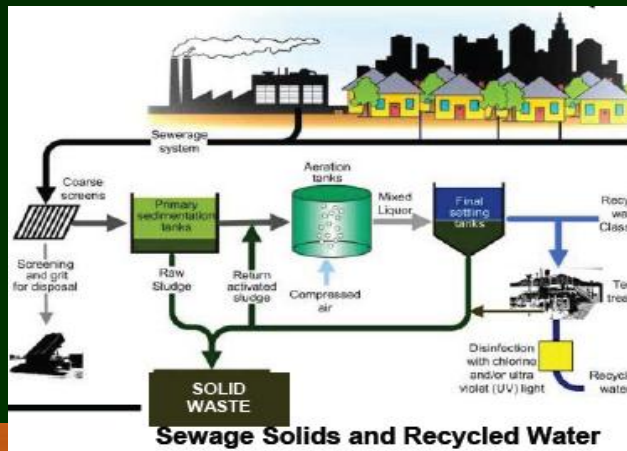
How is your process carbon negative?

- CO₂ waste converted to methanol and water, or further processed to gasoline and water (off set more oil products)
- Waste biomass used with feed stock blend (carbon neutral feedstock)
- Municipal solid waste may be used (carbon negative vs. methane from decomposition)
- Synthetic fuel burns cleaner (ultra low sulfur)

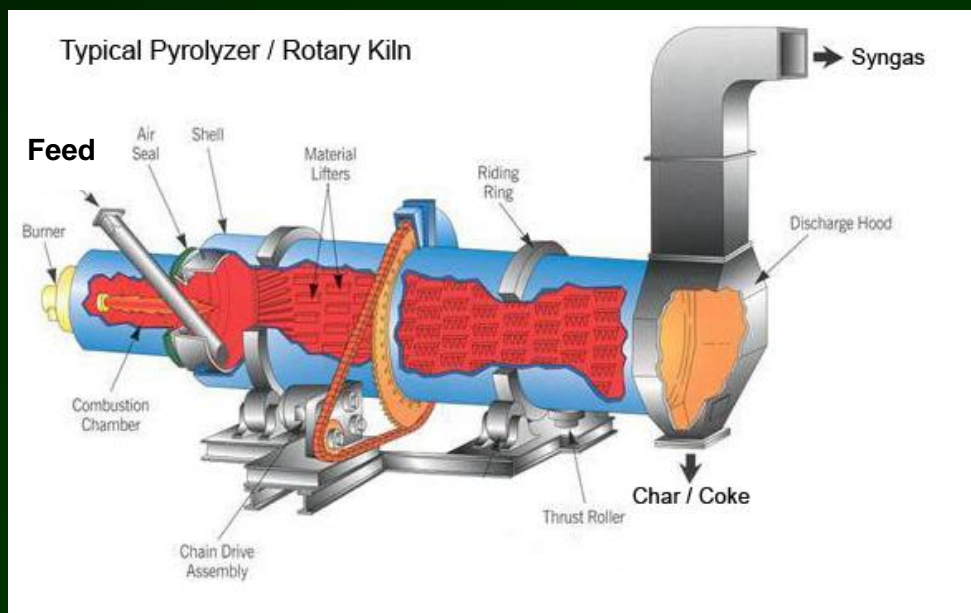
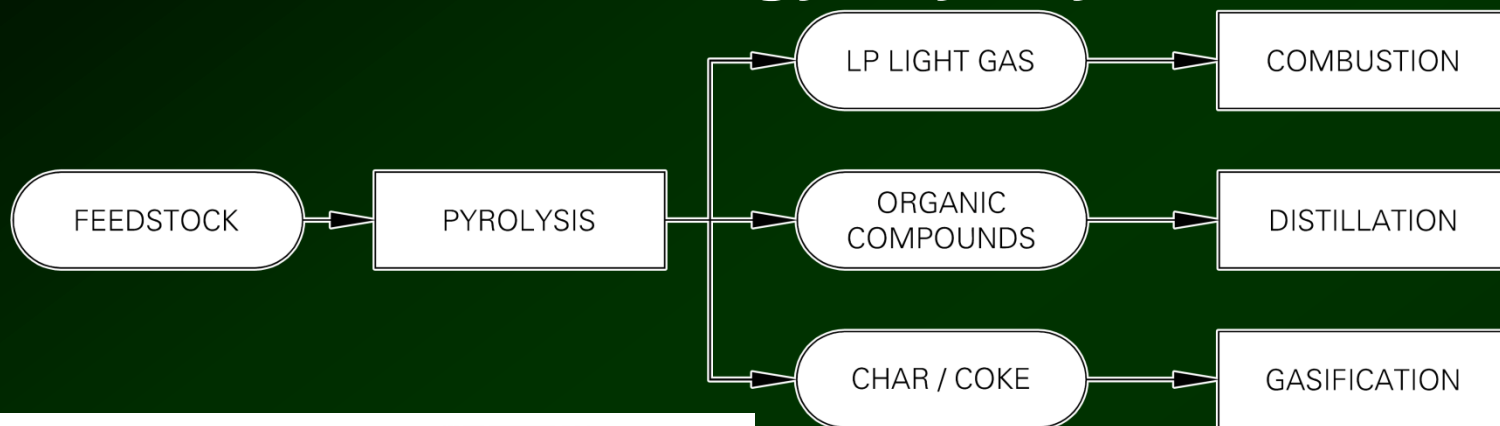


What is your process utilization of water?

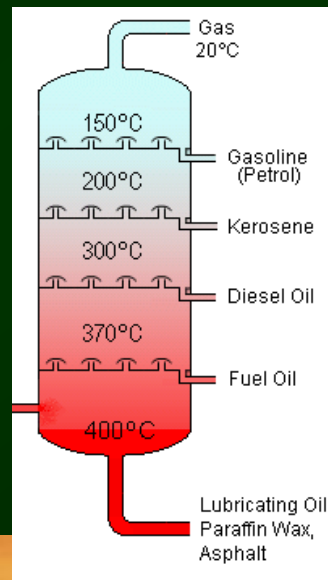
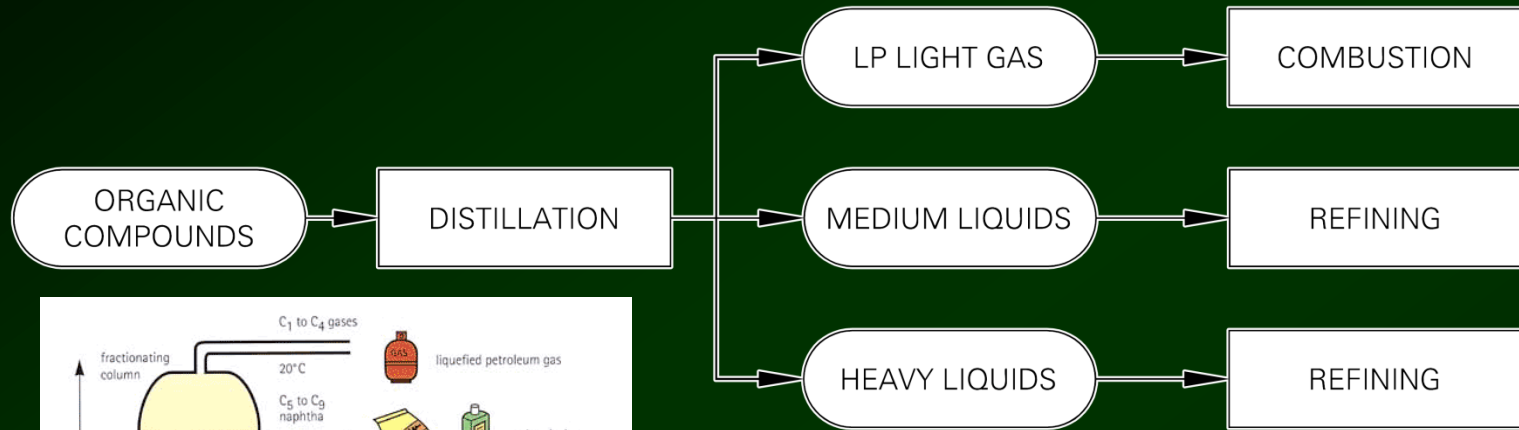
- Typical synthetic fuel processing plants are water intensive
- Municipal waste water highly useable
- Water treatment yields water for process and solid waste for pyrolysis
- Coal & Biomass water recovery
- CO₂/Methanol/Gasoline conversion Water Positive



Process Technology: Pyrolysis



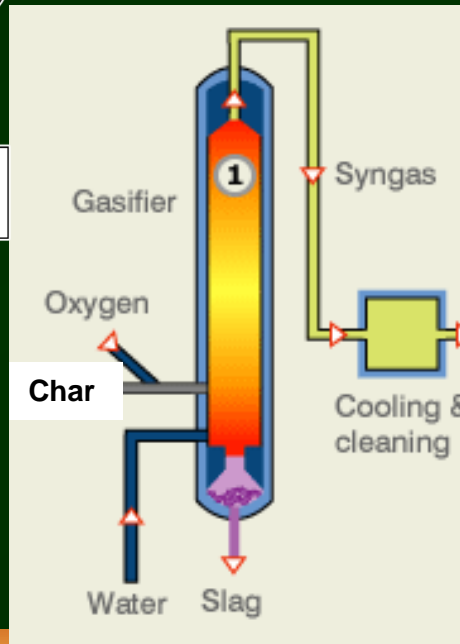
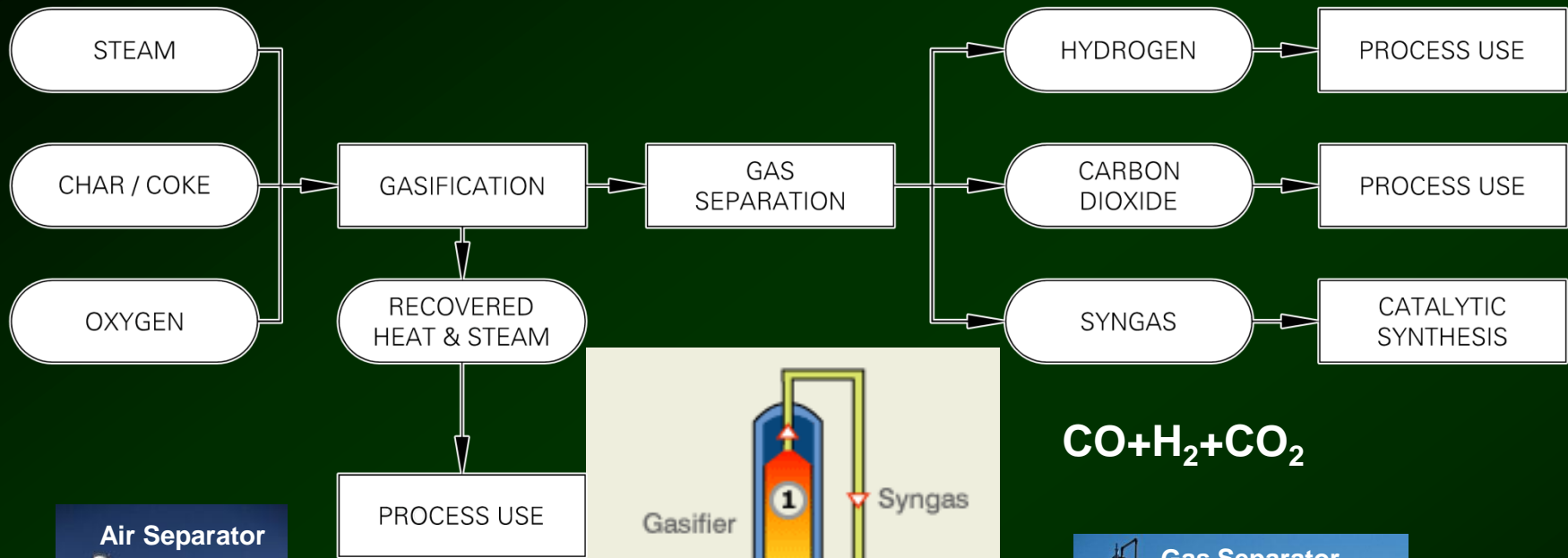
Process Technology: Distillation



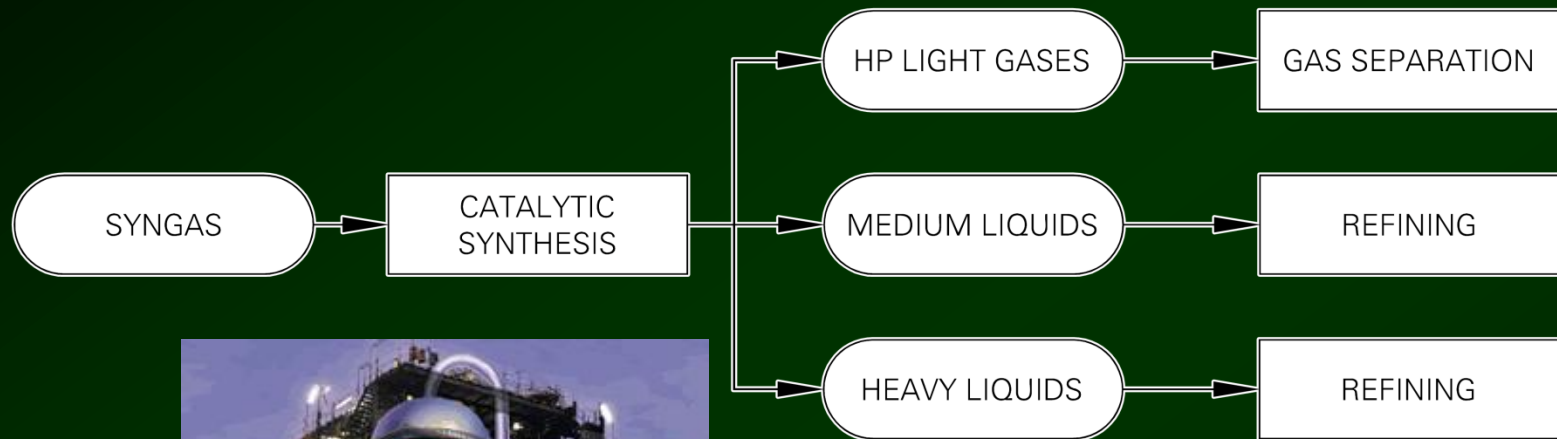
CO₂ to Air Separation
CH₄ to pyro burner



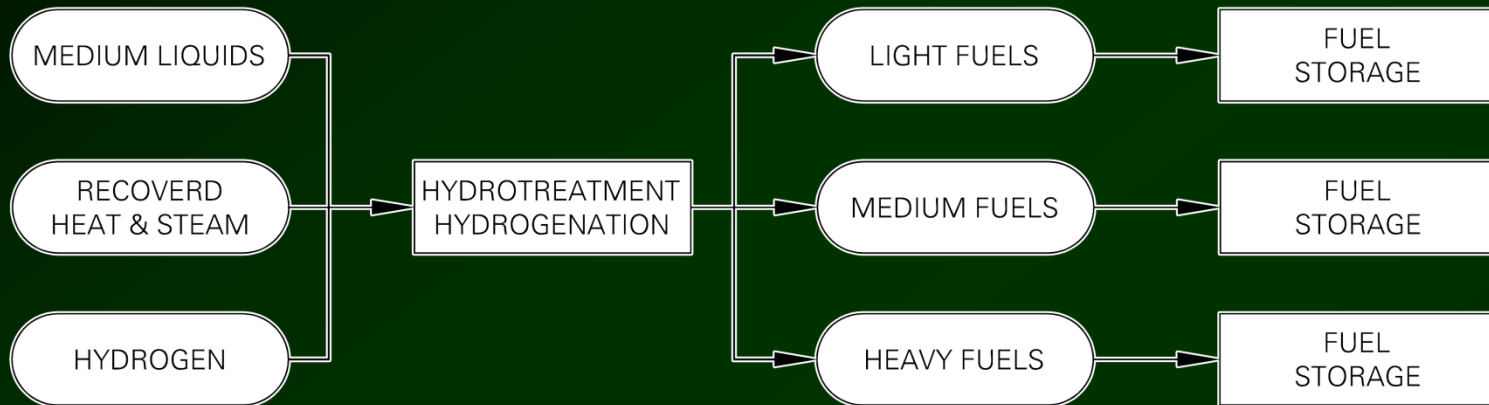
Process Technology: Gasification



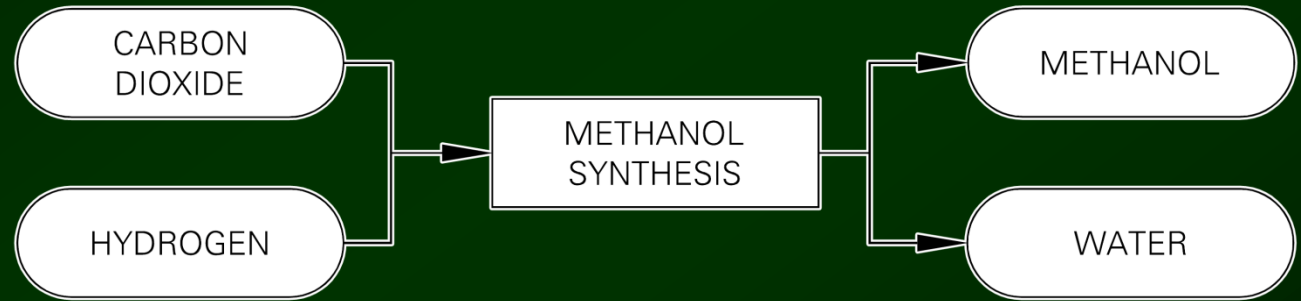
Process Technology: FT Synthesis



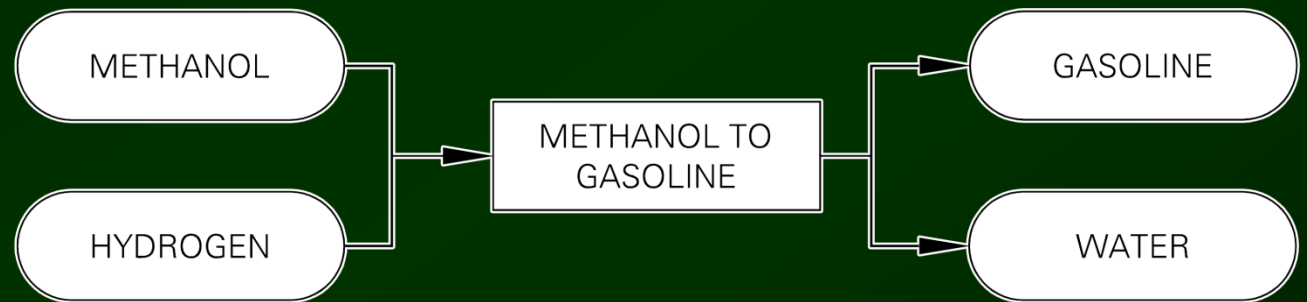
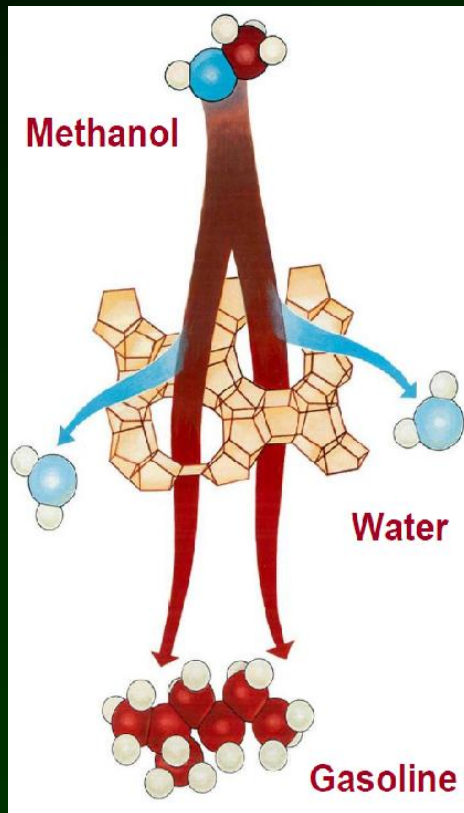
Process Technology: Hydrogenation / Hydrotreatment



Process Technology: Methanol Synthesis



Process Technology: Methanol To Gasoline



ExxonMobil



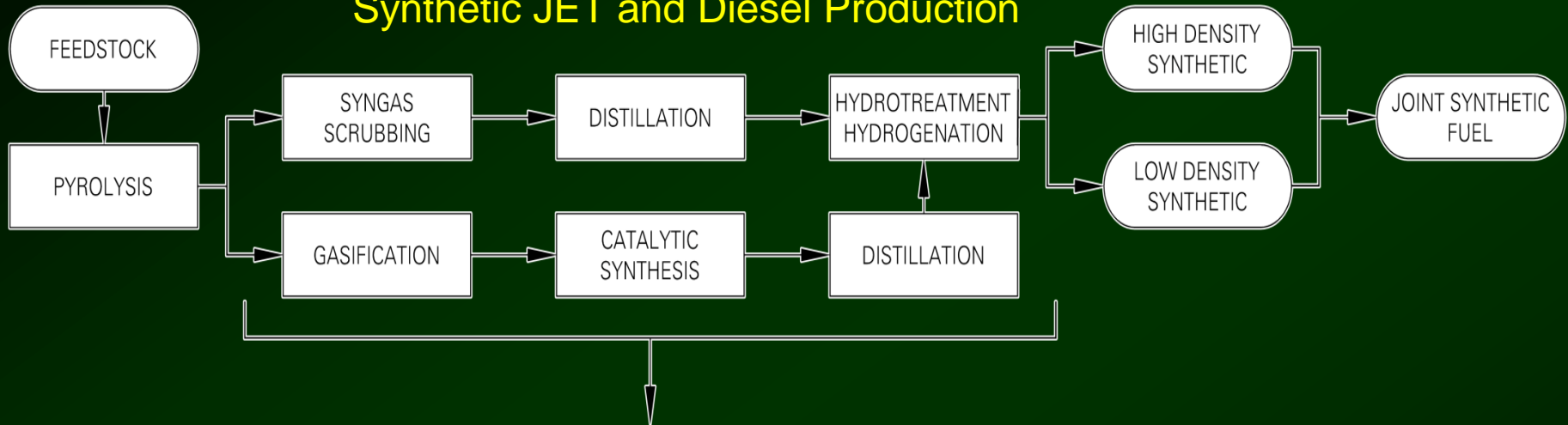
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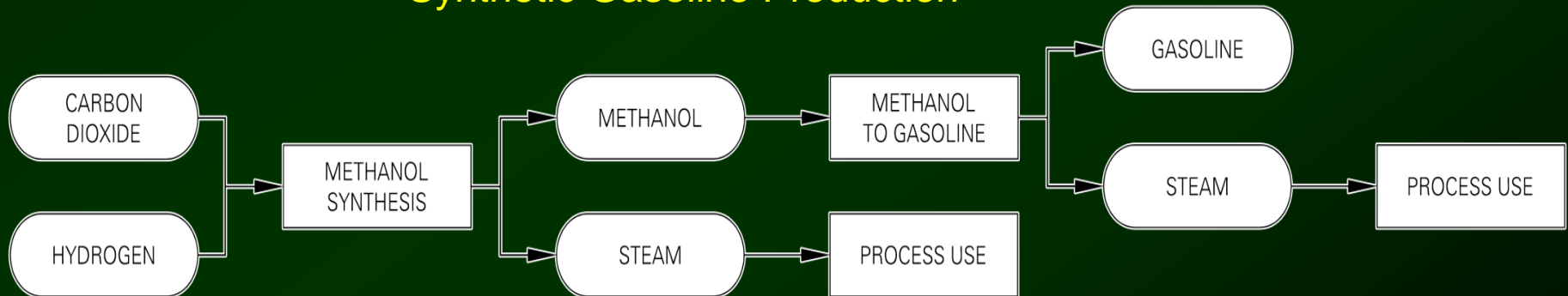
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Process Technology: JS-1 Process Summary

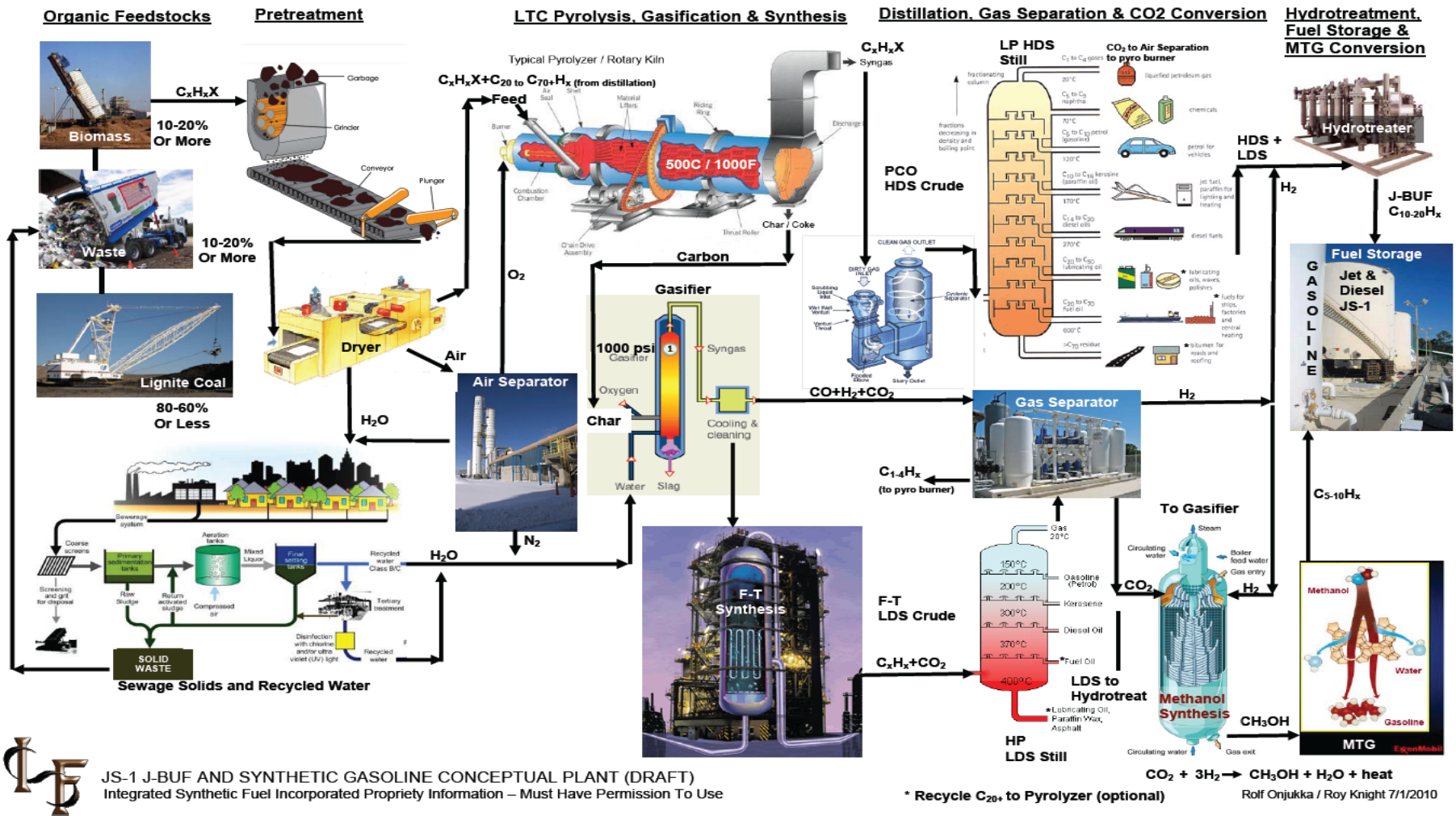
Synthetic JET and Diesel Production



Synthetic Gasoline Production



Process Technology: JS-1 Process Summary



JS-1 J-BUF AND SYNTHETIC GASOLINE CONCEPTUAL PLANT (DRAFT)
Integrated Synthetic Fuel Incorporated Proprietary Information – Must Have Permission To Use



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Domestic Production Grid

- Localized Production
 - Ensures production in non-threatened areas
 - Aids Supply Chain Logistics
- Supply Interruption Hedging
 - Interruption in one area does not lead to system failure
 - Example: Gulf Coast & Hurricanes
- Emergency Relief Logistics (e.g. Haiti earthquake)
 - Diverse production locations
 - Closer located back-up production facilities



Summary

- A Fully Synthetic Fuel Is Discovered called JS-1
- Process Utilizes Existing Technology In New Process Interaction That Leaves “No Molecule Left Behind”
- Processing Method Increases Fuel Yield and Decreases Operating Cost - and Utilizes CO₂ Emission For More Fuel & Water
- Fuel Is Made From Available Domestic Supplies (Waste, Biomass, and/or Coal) With a Domestic Grid That Will Ensure Fuel Supply, Fuel Security, and Aid In Economic Recovery
- Synthetic Fuel Is Following a Similar Pathway to Synthetic Lube



The way forward:

- File Patents and Market Technology Discovery
 - Joint ownership of fuel formula & process patents
 - Promote Economic & Security Benefits of Technology
- Feasibility Studies and Pilot Plant
 - Confirm Technology & Economics
 - Small Scale Confirmation / Test Fuel for Certification
 - Pilot Plant Provides Biomass & Waste Integration Test Platform
- Full Scale Plant Development
 - Find Finance & Producer For Full Scale Production



Questions & Comments?

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