Presentation to the

Aviation Fuel Working Group/17 Meeting

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International Air Transport Association

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OSD Clean Fuel Initiative

Vision:

DOD intends to catalyze the commercial industry to produce clean fuels for the military from secure domestic resources using environmentally sensitive processes that create jobs and wealth in the United States.

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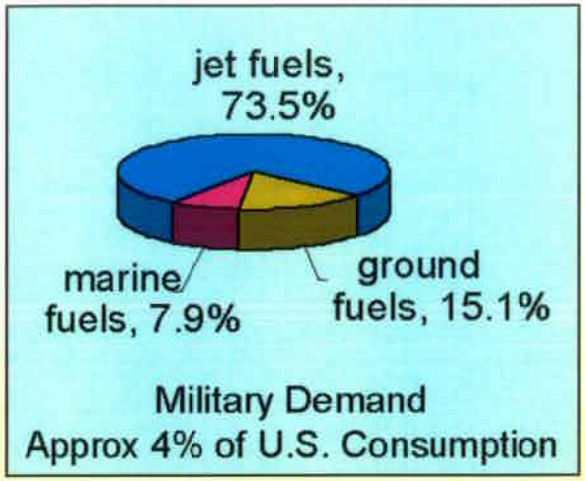
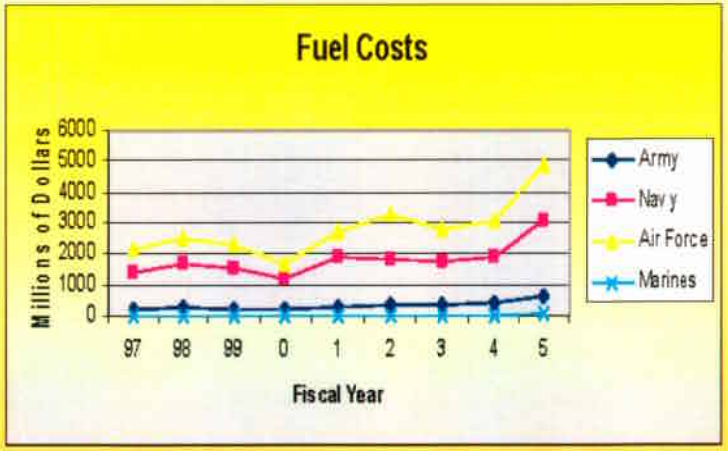
DoD Concerns

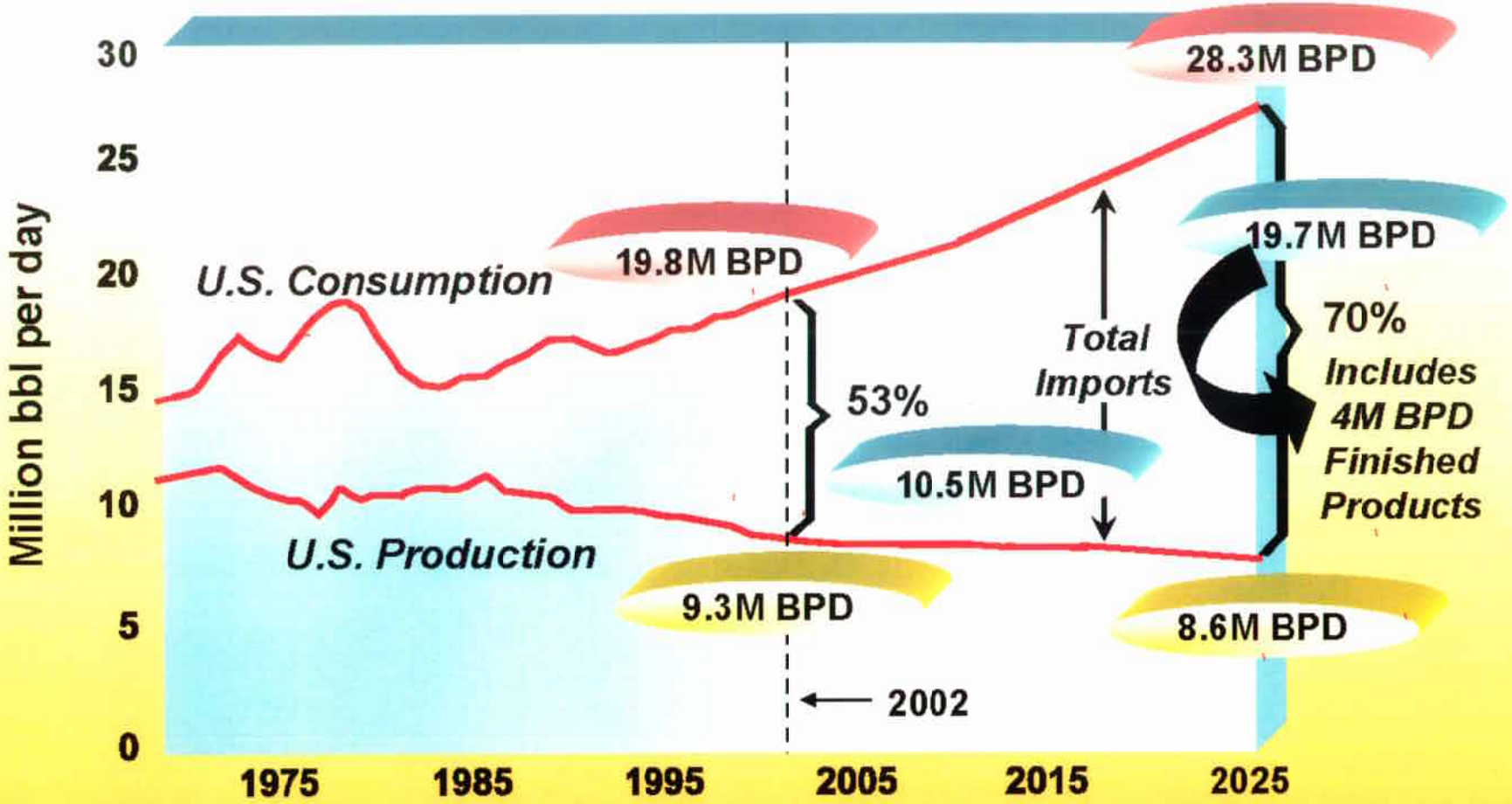
- Secure and reliable sources of energy
  - Dependent on foreign oil
  - Becoming dependent on foreign refined fuels
- Supply chain vulnerability
  - Dependent on mega refineries
  - Terrorist threats or natural disasters
- Need for cleaner fuels
  - DoD exempt from some EPA regulations
- Potential limits on deployments
  - Possible conflict with EU rules



Ref: DESC Fact Book

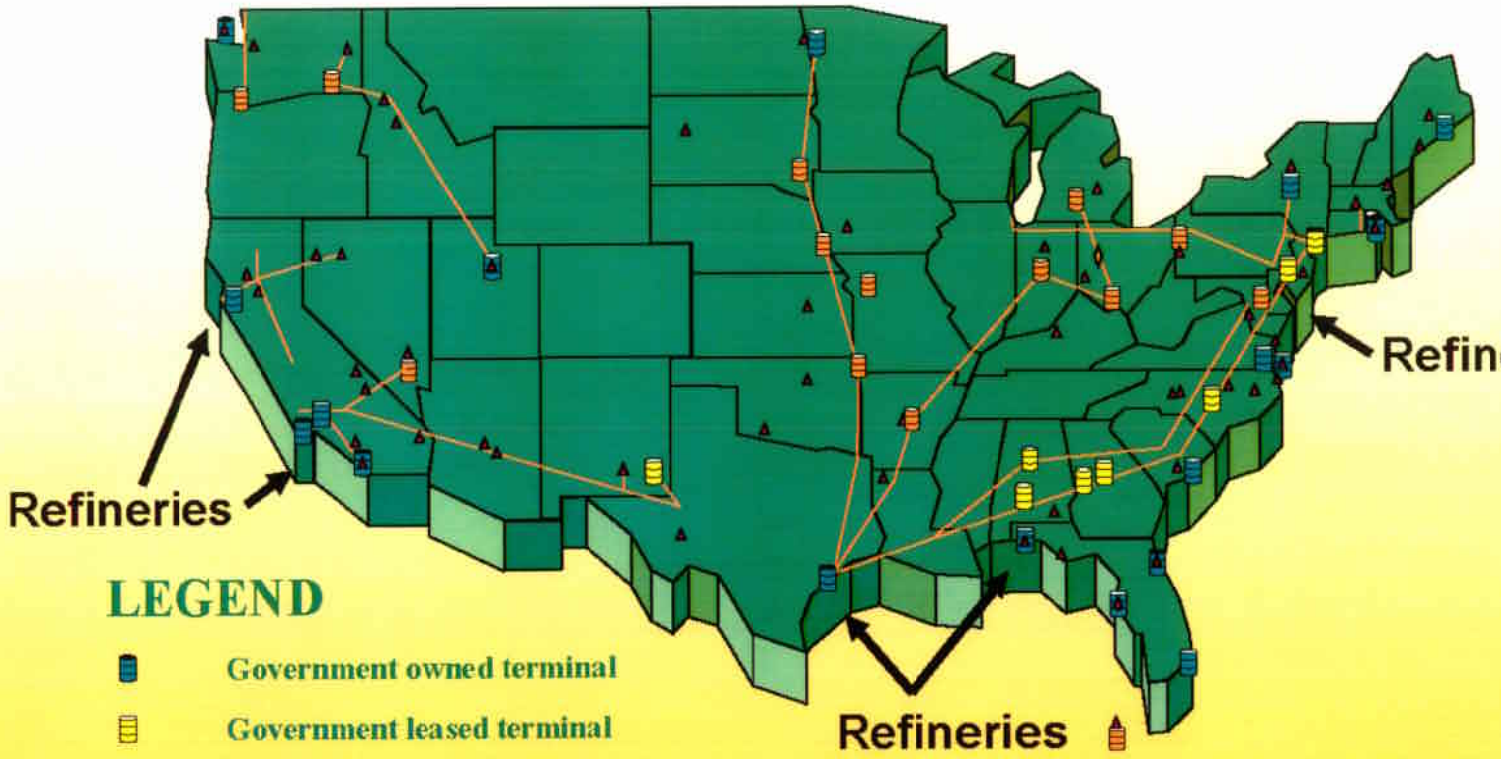


Increasing Reliance on Petroleum Imports



Source: EIA (AEO 2004); Reference Case Scenario
[Courtesy John Winslow-DoE]

MILITARY FUEL DISTRIBUTION IN THE UNITED STATES



LEGEND

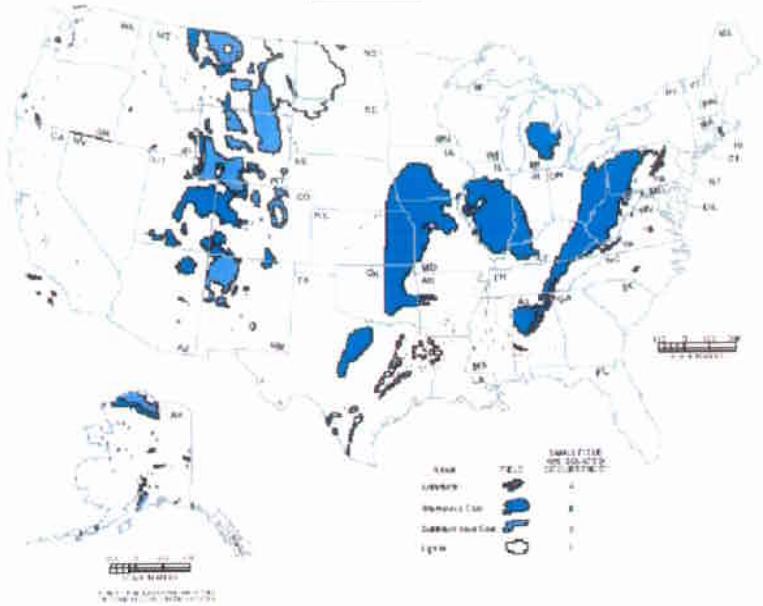
- Government owned terminal
- Government leased terminal
- Tender based terminalling
- Major fuel customer
- Common carrier pipeline used by DFSC

For Over 50 Years

Defense Energy Support Center

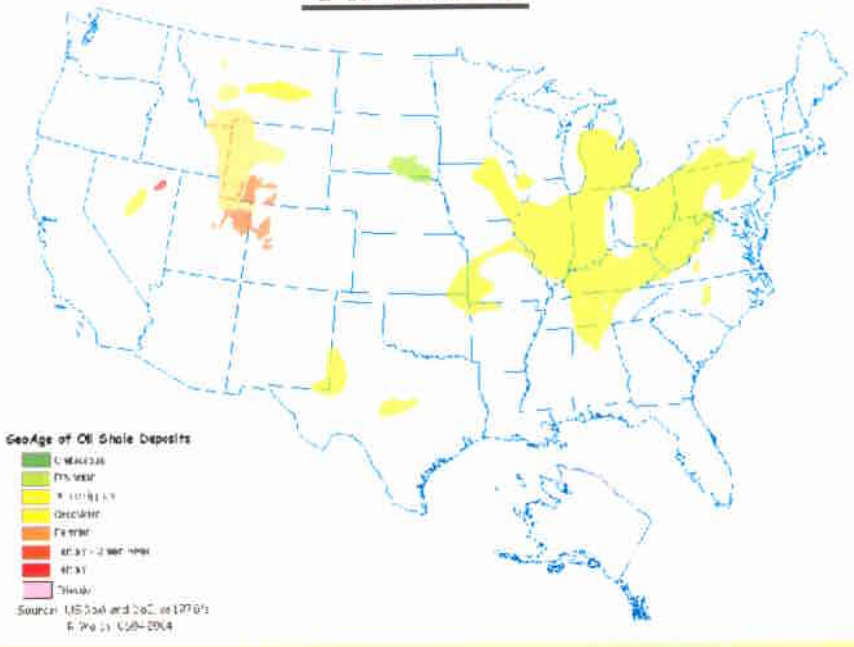
U.S. Energy Resources

Coal



Sources: United States Geological Survey, Coalfields of the United States, 1960-1961; Texas Bureau of Economic Geology, Lignite Resources in Texas, 1982; Louisiana Geological Survey, Near Surface Lignite in Louisiana, 1981; Colorado Geological Survey, Coal Resources and Development Map, 1981; and Mississippi Bureau of Geology, 1983

Oil Shale

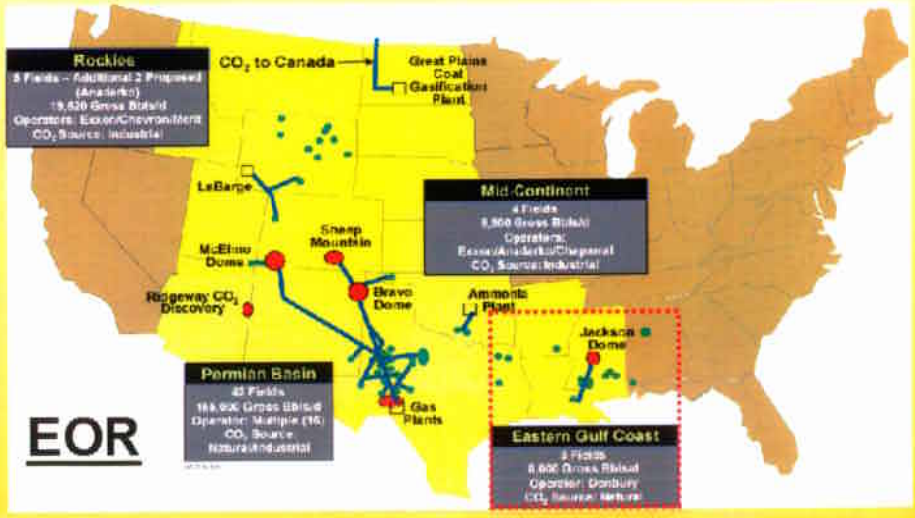


Domestic Resources

- 1 trillion barrels (shale)
- 800 billion barrels of FT (coal)
- 0.15 billion barrels (pet coke)
- 22.7 billion barrels oil reserves
- 32 billion barrels of oil (EOR)

U.S. Total: 1.9 Trillion Barrels

EOR

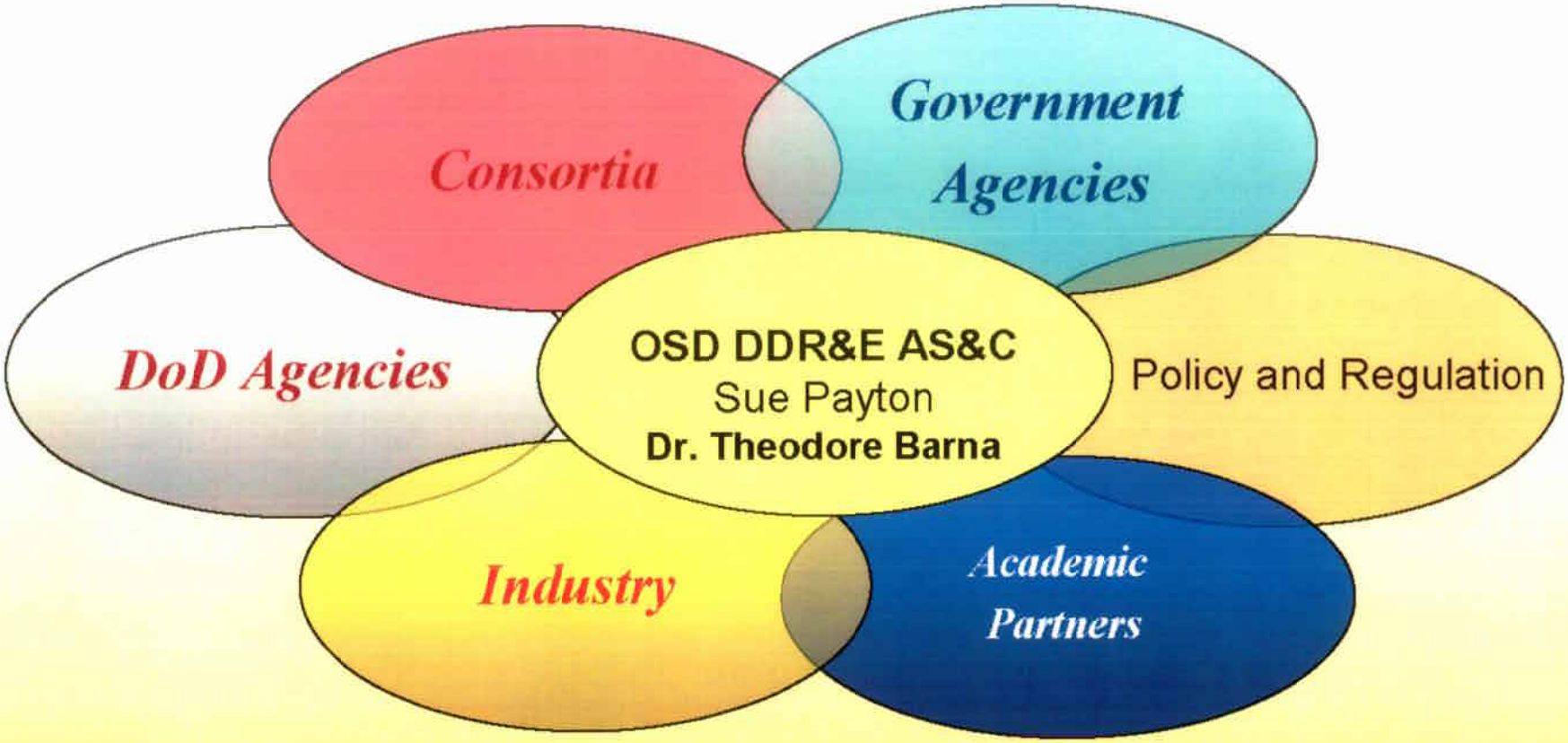


U.S. Total: 1.9 Trillion Barrels

As compared to the Middle East

Saudi Arabia:	261.8 Billion Barrels
Iraq:	112.5 Billion Barrels
UAE:	97.8 Billion Barrels
Kuwait:	96.5 Billion Barrels
Iran:	89.7 Billion Barrels
Qatar:	15.2 Billion Barrels
Oman:	5.5 Billion Barrels
Yemen:	4.0 Billion Barrels
Syria:	2.5 Billion Barrels

TOTAL: 685.5 Billion Barrels



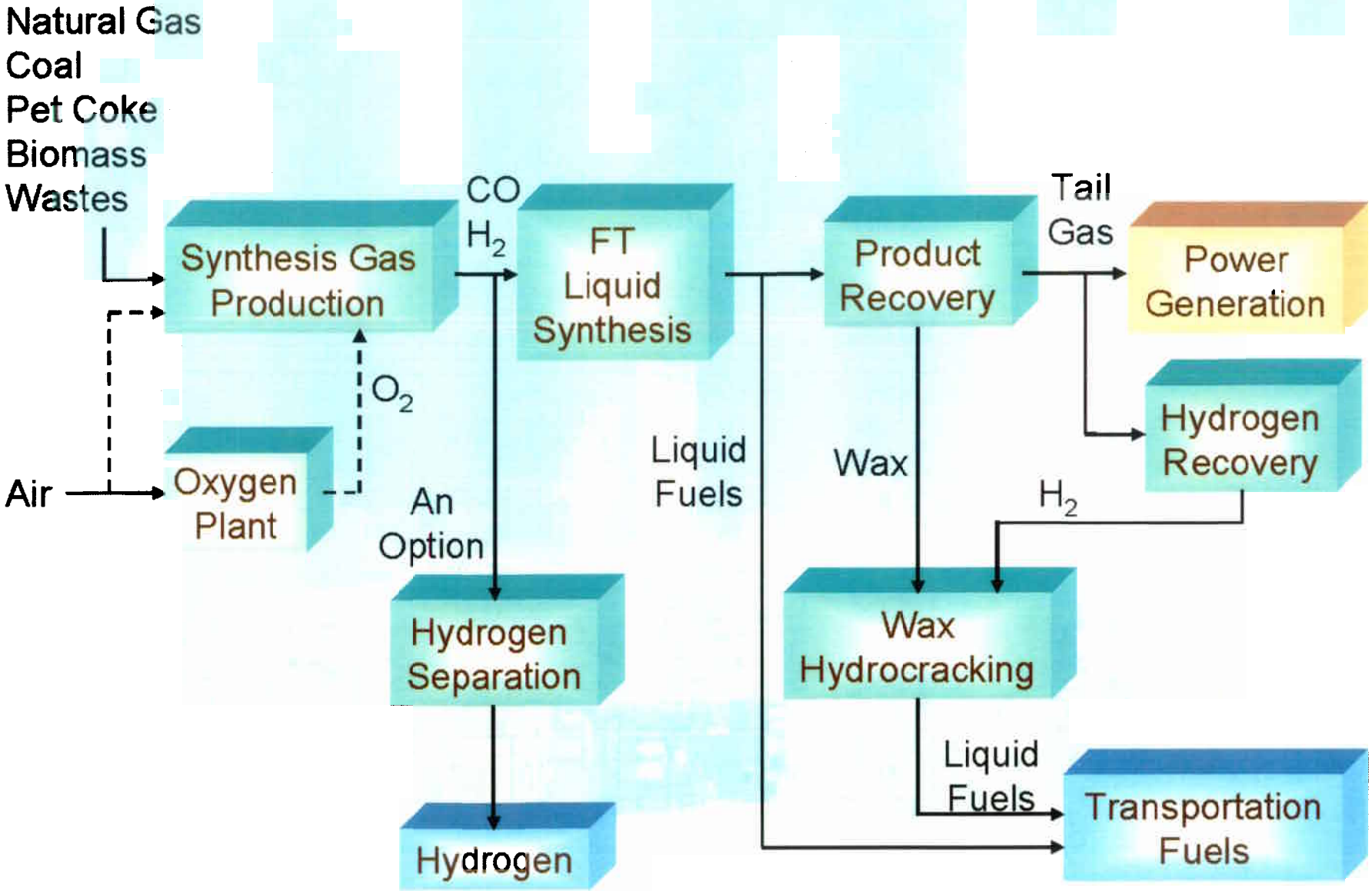
Office of the Secretary Of Defense Initiative

- Form partnerships with other government agencies (DoE, DoT, EPA, Interior, Commerce etc.), industry and academia
- Catalyze industry development and investment in energy resources: Total Energy Development Program (TED)
- Evaluate, demonstrate, certify and implement turbine fuels produced from diverse energy resources: Battlefield Use Fuel of the Future (BUFF)

Total Energy Development (TED)

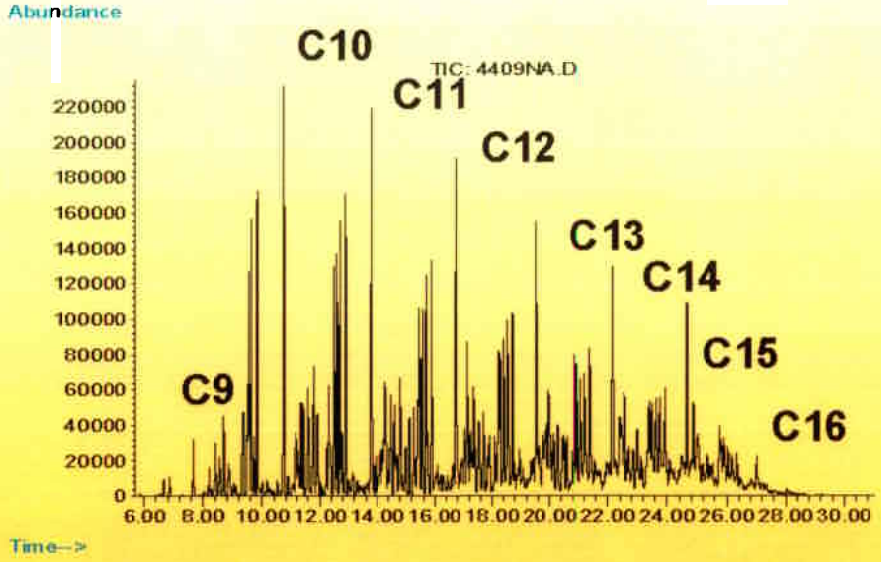
- Use all secure indigenous sources of energy
  - Coal, shale oil, petroleum coke, renewables
  - Dispersed production facilities
- Minimize government funding—focus on qualification and certification
- Meet existing government mandates and executive orders to ensure environmental compliance
- Couple program with advanced technologies to reduce the consumption of fuel
  - For example: Future Tactical Truck System, Fuel Cells, Advanced Turbine Engine Technologies (IHPTET/VAATE)
- Make a better fuel from coal and petroleum coke (Fischer-Tropsch fuels) and oil shale
  - Low (or no) Sulfur, cleaner burning, bio-degradable, low (or no) aromatics, reduced particulate emissions
  - Blends near term, neat fuel future goal

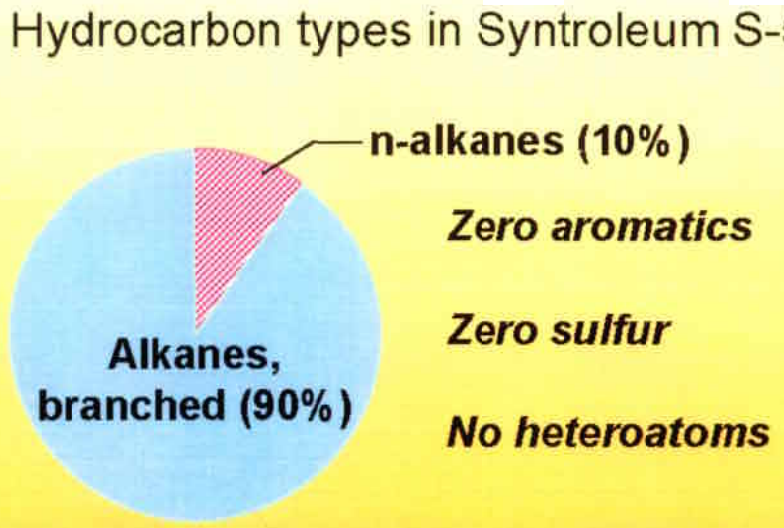
Fischer-Tropsch Technology



FT Fuels Reduce Emissions

- Less Pollutant Emissions
  - 2.4% less CO_2
  - 50% to 90% less particulate matter (PM)
  - 100% reduction in SOx
  - ~1% less fuel burn (increased gravimetric energy density)

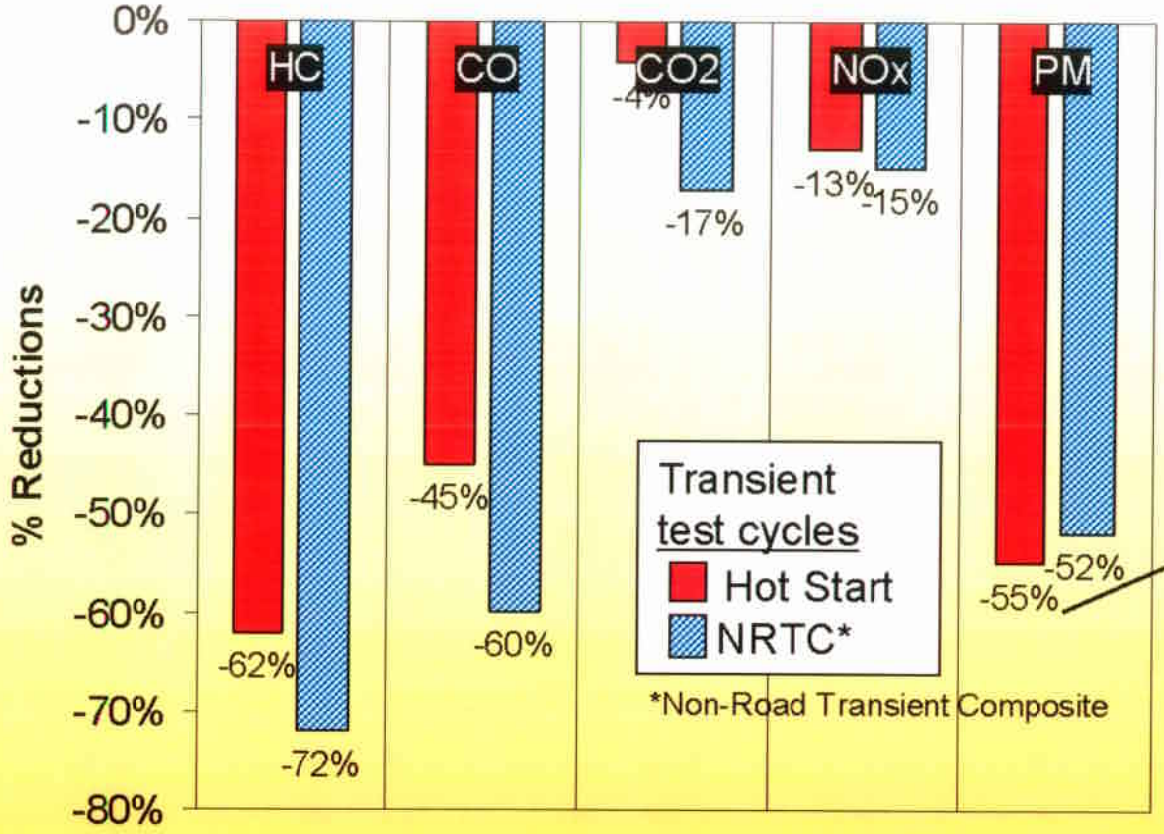




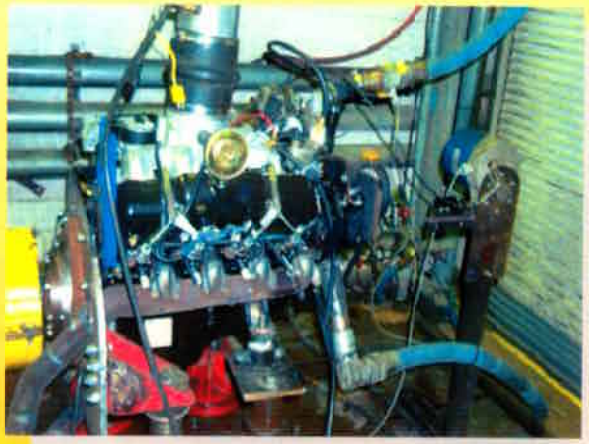
Highly Paraffinic Fuel – normal and isoparaffins

Petroleum derived fuels are rich in aromatics, cycloparaffins, and heteroatoms

Reduced Exhaust Emissions with FT Fuel Relative to Low-Sulfur Diesel Fuel



Over 50% reduction in particulate emissions in transient mode.



FT fuel burns more completely and emissions are significantly cleaner than EPA certified low-sulfur diesel fuel tested in 6.5L diesel engine.

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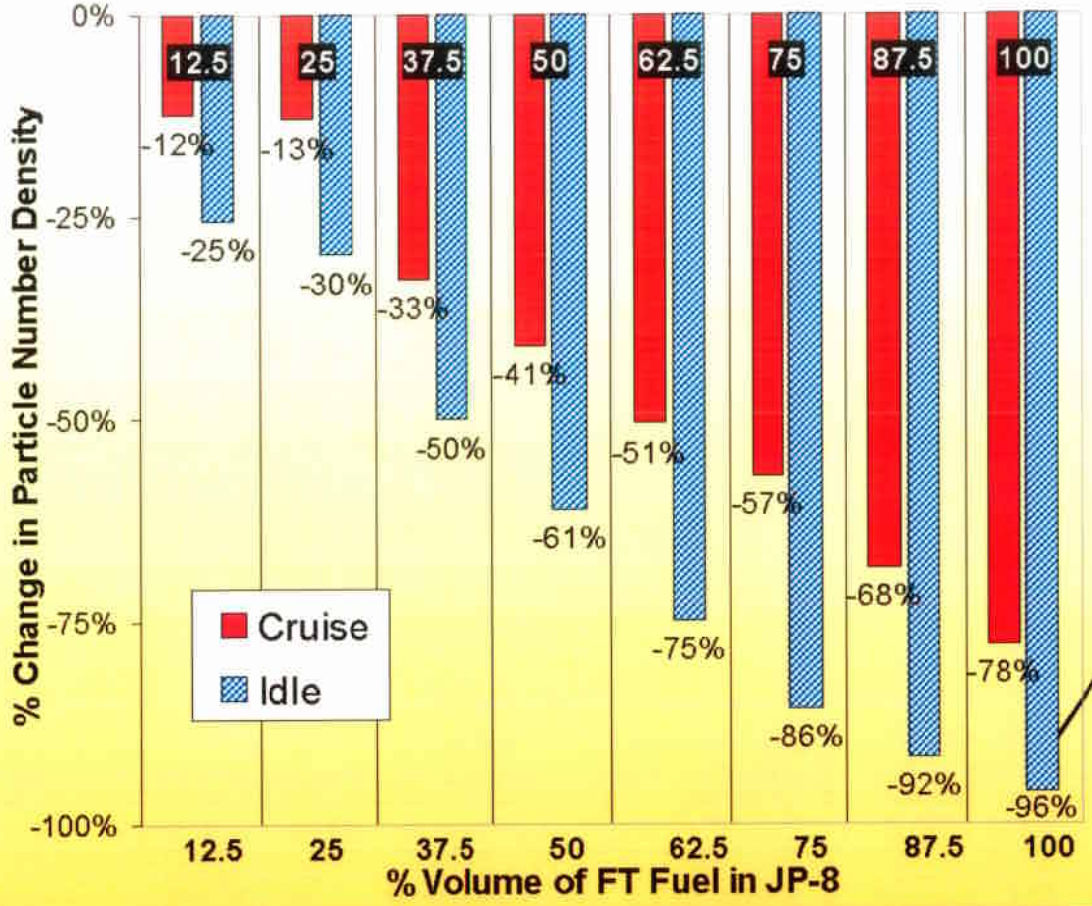
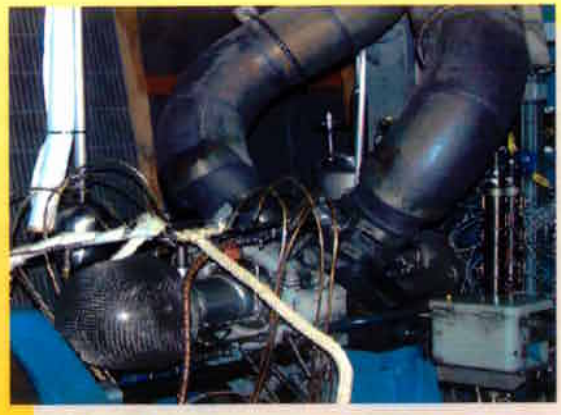
  - Blends near term, neat fuel future goal

Reduced Particulate Emissions with FT Fuel Relative to JP-8



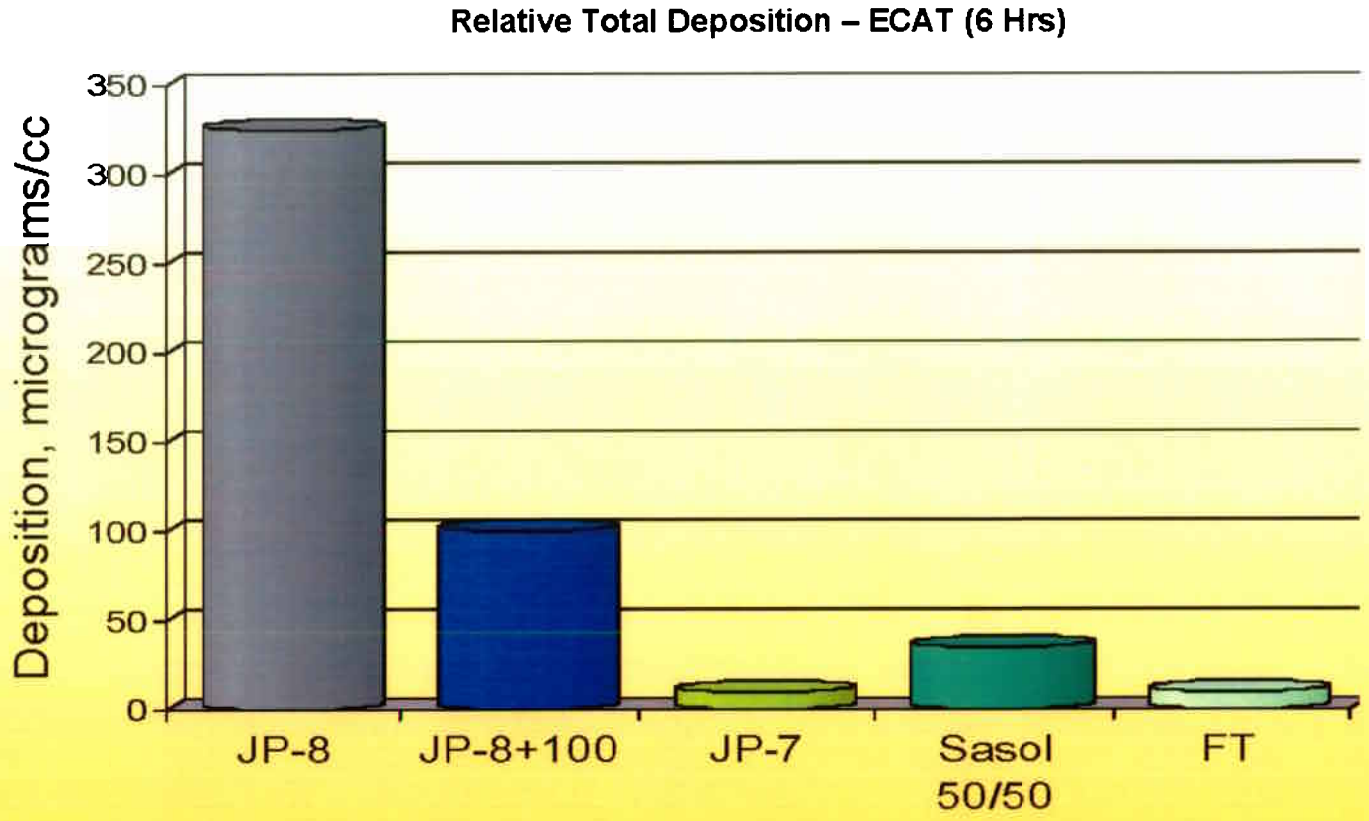
96% reduction* in particulate emissions at idle conditions.



Even moderate fractions of FT fuel blended in JP-8 significantly reduce exhaust emission particulates in T63 turbine engine testing.

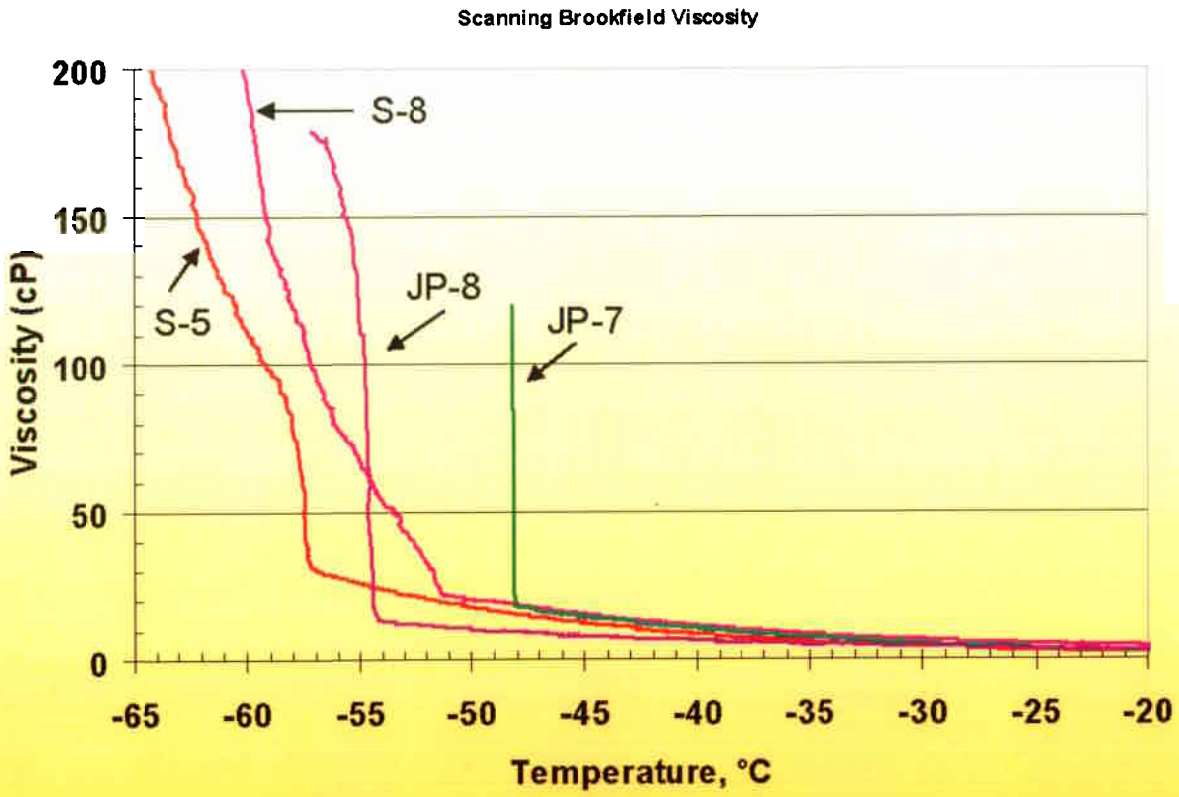
** Note: Results are highly dependent on engine model/year and composition of baseline fuel.*

FT Fuels Have Superior Thermal Stability



Increased fuel thermal stability enables development of very fuel efficient propulsion systems

FT Fuels Have Excellent Low Temperature Properties



Superior Low Temperature Properties Improve High Altitude Operations and Low Temperature Starting

FT Fuel Benefits for Navy Shipboard Use

Storage Stability Test Results
(Syntroleum S-5)

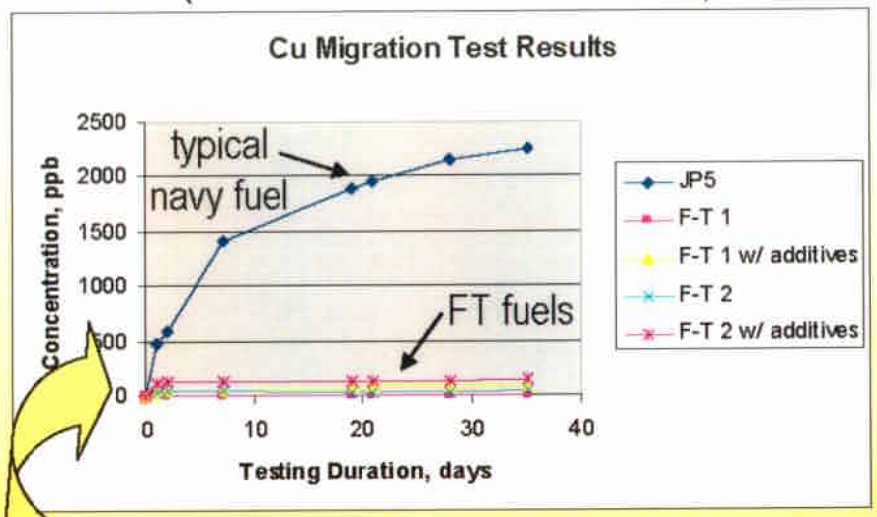
w/o AO	0 Hr	24Hrs	48Hrs	72Hrs	96Hrs
Saybolt Color	30	29	24	19	22
Peroxide, ppm	0	>240	>240	>240	>240
Gums, mg/100ml	0	0	0.1	1	7.9

20 ppm AO	0 Hr	24Hrs	48Hrs	72Hrs	96Hrs
Saybolt Color	30	30	30	30	30
Peroxide, ppm	0	0	0	0	0
Gums, mg/100ml	0.4	0.3	0.4	0.5	1.3
Antioxidant ppm	22.2	9.5	8.7	7.6	9.1

30 ppm AO	0 Hr	24Hrs	48Hrs	72Hrs	96Hrs
Saybolt Color	30	30	30	30	30
Peroxide, ppm	0	0	0	0	0
Gums, mg/100ml	0.1	0.3	0.3	0.3	0.4
Antioxidant ppm	33.3	33	33.7	33	33.3

FT fuel responds well to standard antioxidant (AO) used for petroleum fuel.

Compatibility Evaluation Test Results
(2 FT fuels: F-T 1 and F-T 2)



Low copper uptake of FT fuel = good long-term storage stability.

- ***Excellent long-term storage stability***
- ***Significant reduction in copper up-take***
- ***Increased thermal stability / Extended engine life***

FT Fuels Improve Aerospace Propulsion and Power Systems

FT iso-paraffinic kerosene (100%)

low emissions, high stability

2.2X – 9X increase in cooling

Current and advanced gas turbine aircraft
(Jet A/JP-8 replacement)

high stability, endotherm

1200 Btu/lb cooling

No sulfur, no aromatics

No poisoning, less coking of reformer catalyst

High thermal stability, high H/C

Hypersonic Vehicles
(JP-7 replacement)

ISP=362.5

Hydrocarbon Rockets
(RP-1 replacement)

Hydrocarbon reformers
(fuel cell power generation)

FT Fuels Benefit Air/Ground/Marine Propulsion and Power Systems

FT Fuels

clean alternative to petroleum fuel
(MADE IN USA)

E.O. 13149, EPAct

Alternative Fuel Vehicles (AFVs)
(non-tactical fleets; Post, Camp & Station)

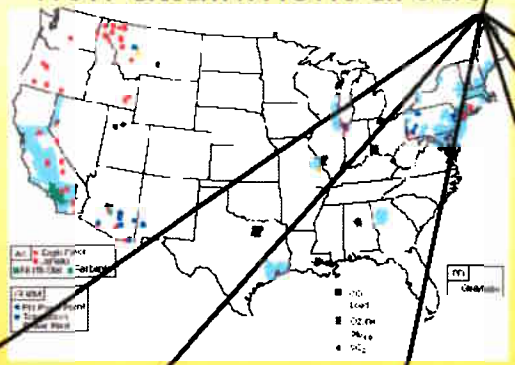
reduced exhaust pollutants
lower CO, PM, NOx

easier starts, all climates
high cetane, >74

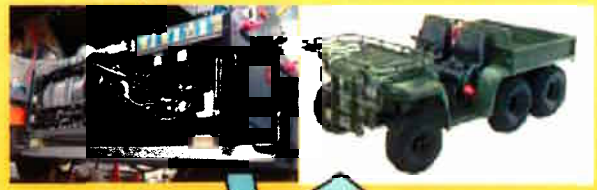
source of hydrogen
easily reformed

Diesel engine fleets

Fleets operating in
non-attainment areas



Fuel Cell Applications
(APUs in Vehicles)



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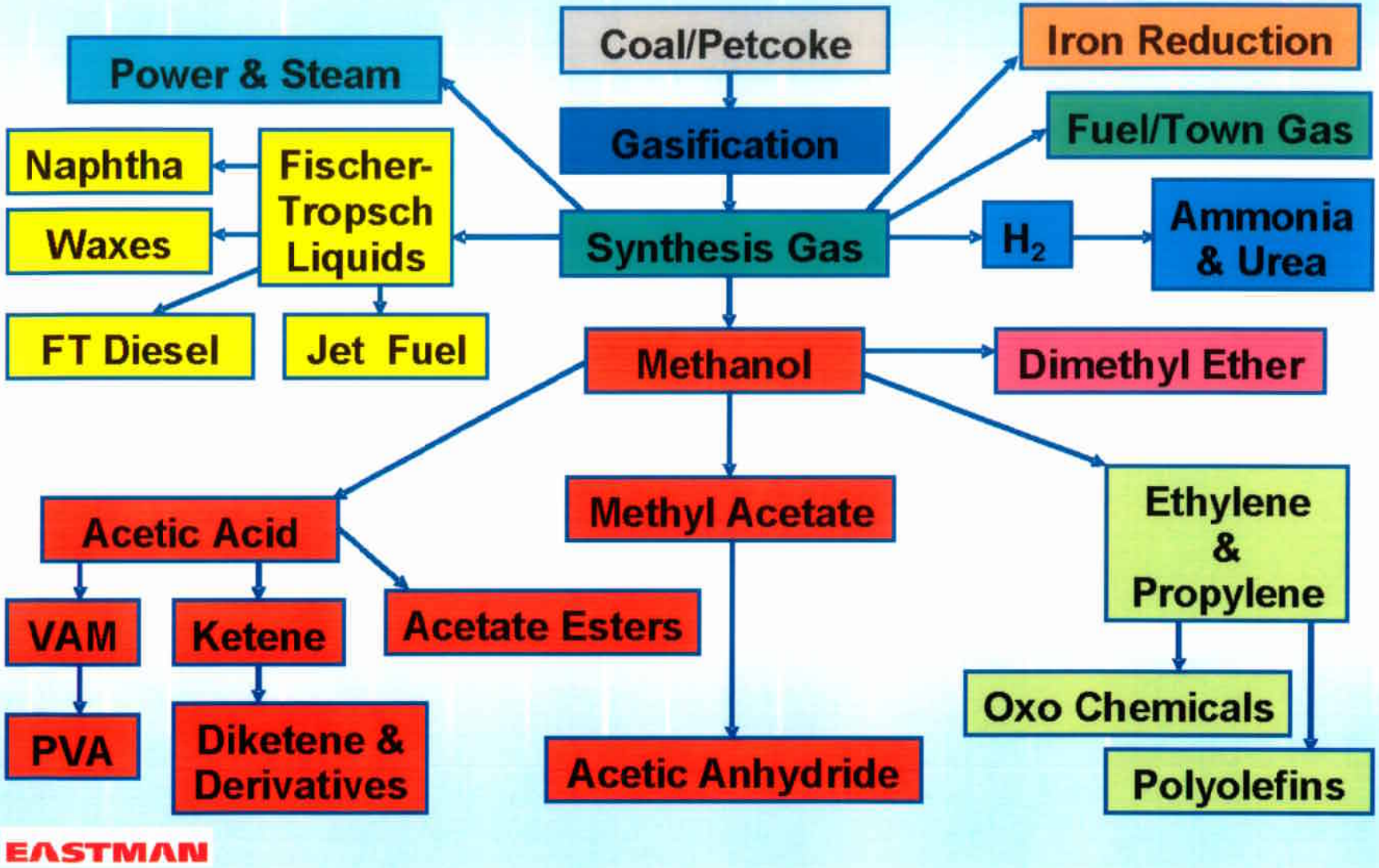
- Make a better fuel from coal and petroleum coke (Fischer-Tropsch fuels) and oil shale
  - Low (or no) Sulfur, cleaner burning, bio-degradable, low (or no) aromatics, reduced particulate emissions
  - Blends near term, neat fuel future goal
- Use Environmentally-Sensitive processes to produce fuel
  - Clean Coal Technologies such as the Fischer-Tropsch process, Mahogany Shale Research Project, Direct Coal Liquefaction
  - CO_2 sequestration for enhanced oil recovery (EOR)

Technologies to Produce Clean Fuels

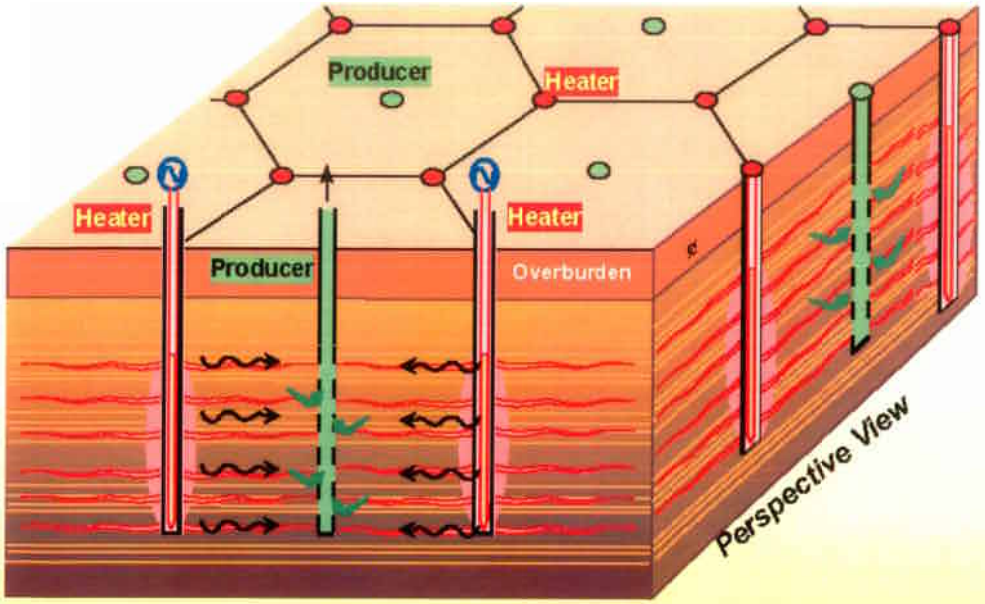
- Indirect Coal Liquefaction –
  Coal gasification followed by fuel production using the Fischer-Tropsch process
- Direct Coal Liquefaction –
  Coal liquefied using the HTI process followed by conventional hydrocarbon upgrading
- In-Situ Recovery of Shale Oil –
  Oil shale retorting underground (i.e. Shell Mahogany Research Project) followed by conventional hydrocarbon upgrading
- Above-Ground Retorting of Shale Oil –
  Oil shale retorting above ground followed by conventional hydrocarbon upgrading
- Enhanced Oil Recovery –
  Domestic U.S. oil recovered by using waste CO_2 followed by conventional hydrocarbon upgrading

Polygeneration Potential of Gasification

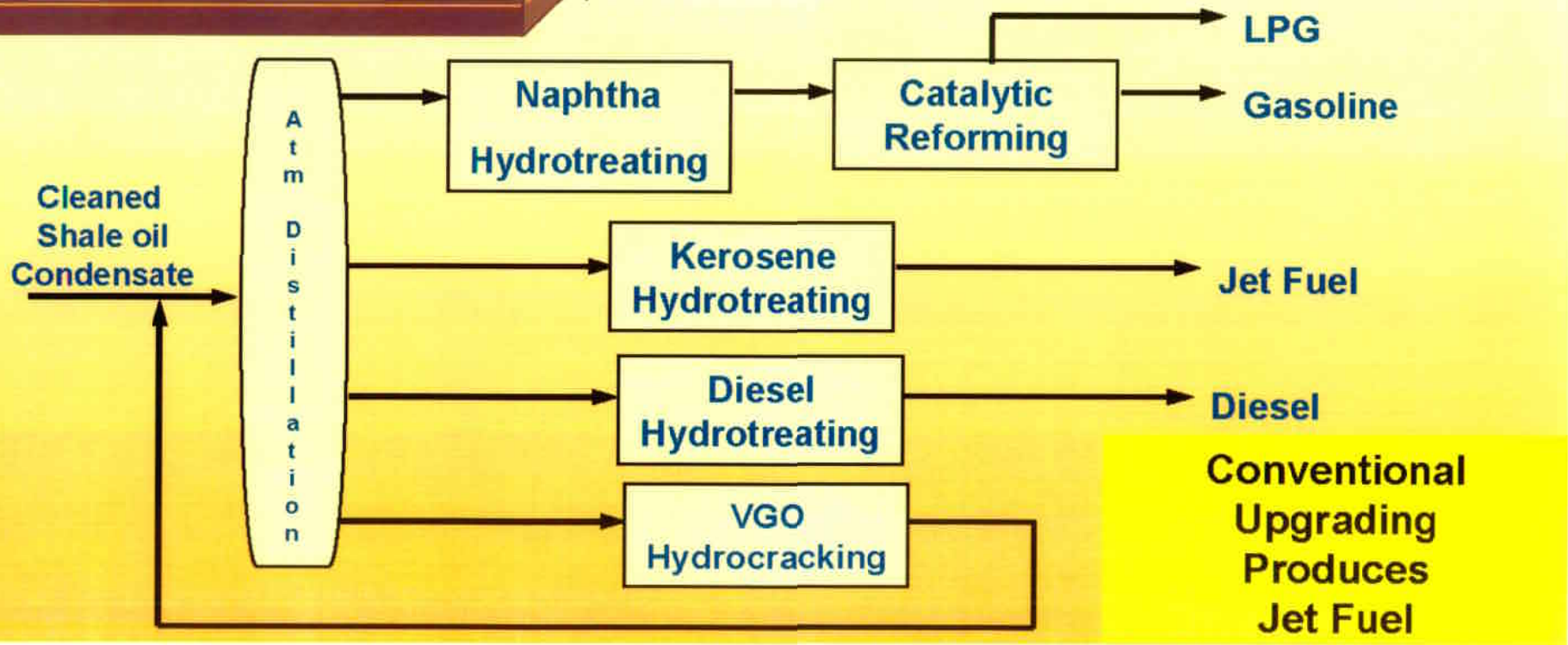


National Security, Power Security, Food Security

Shell's In-Situ Shale Oil Conversion Process



- Kerogen (shale oil) produced by *slow* heating with subsurface electric heaters
- Heat converts kerogen into oil (30+ API) and gas via a combination of thermal cracking an in-situ hydrogenation
- Products are brought to surface via traditional methods



Battlefield Use Fuel of the Future (BUFF)

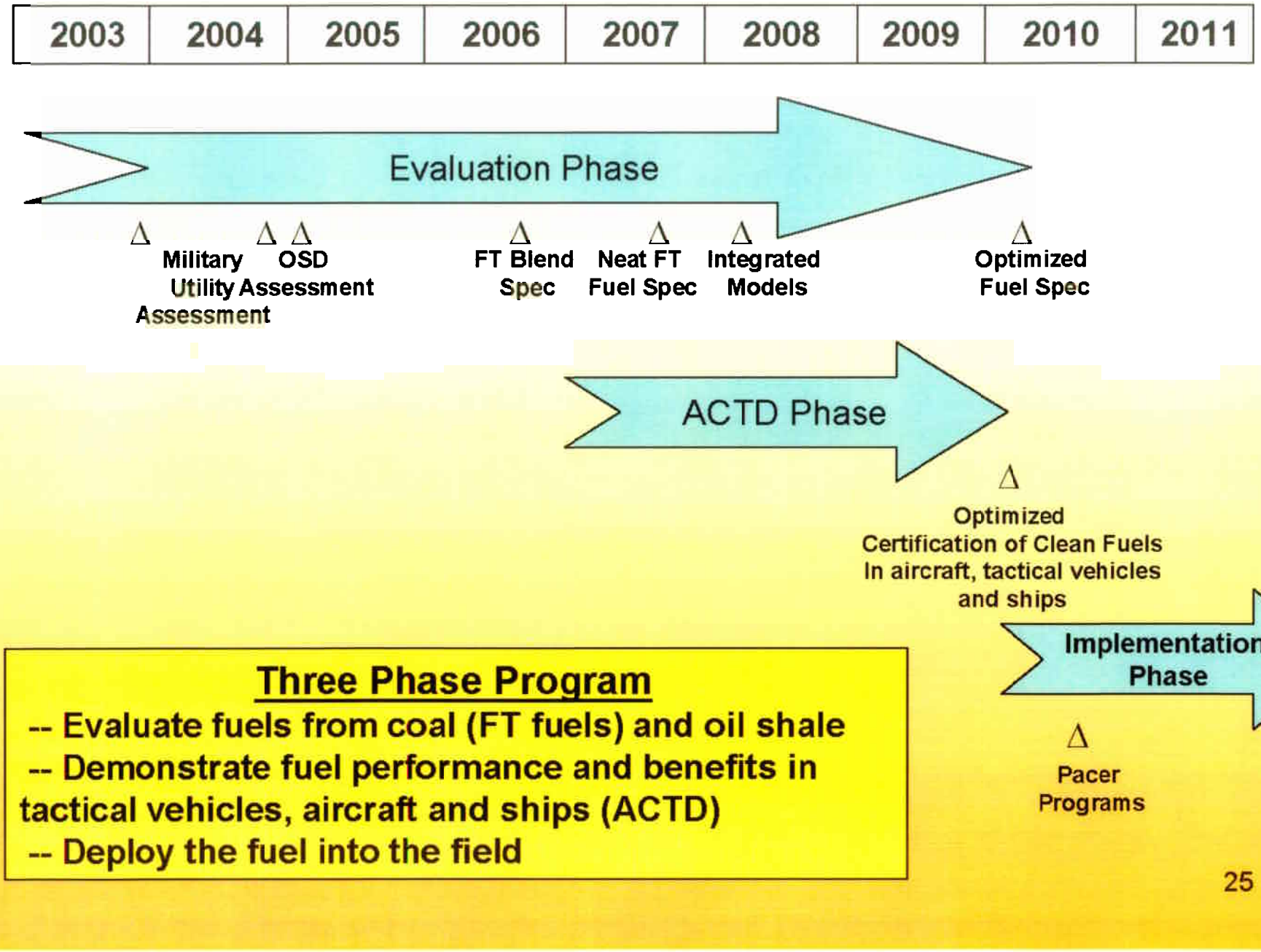
Three Phase Program

Phase I – Evaluate fuels from coal (FT fuels) and oil shale
Develop fuel specifications/ modeling tools
Complete component/subsystem evaluations

Phase II – Demonstrate fuel performance in non-tactical, tactical vehicles, aircraft, and ships
(Advanced Concept Technology Demonstration--ACTD)

Phase III – Deploy the fuel into the field
Establish lead-the-fleet pacer programs with full implementation by 2015

Battlefield Use Fuel of the Future (BUFF) Program



Three Phase Program

-- Evaluate fuels from coal (FT fuels) and oil shale

-- Demonstrate fuel performance and benefits in tactical vehicles, aircraft and ships (ACTD)

-- Deploy the fuel into the field

Time for Action is Now!

- U.S. need for secure clean energy is real and growing
- DoD has a vested interest in catalyzing the development of energy resources to reduce dependence on foreign oil
- DoD would like to see all energy resources developed in an integrated fashion
- State and Federal governments can be our bridge between the government R&D and private industry to develop the vast energy resources in the U.S.
- Coal, Oil Shale and Petroleum Coke are the near term source of Clean Fuels
- Joint participations by other government agencies (EPA, DOT, FAA, HSA, Commerce, Interior) strengthens the program
- Open invitation to all industrial, government (state and federal), and academic partners to participate in our Initiative