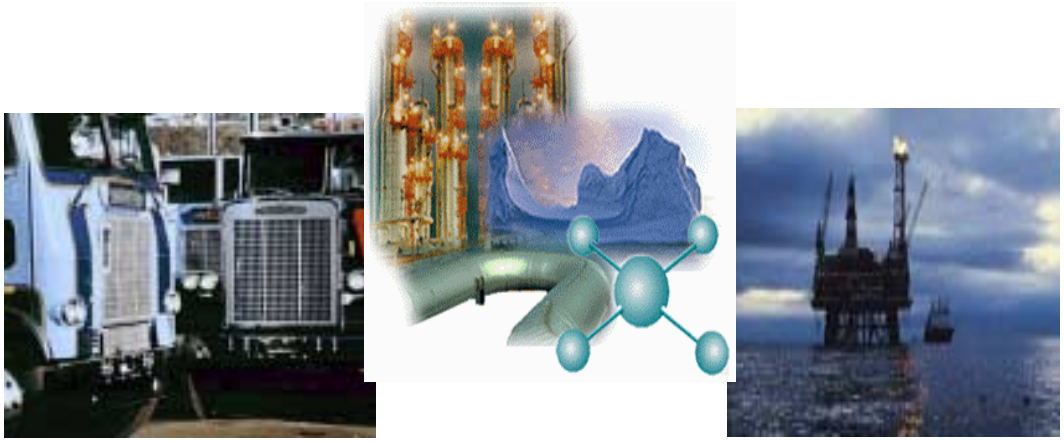

Overview of Gas-to-Liquids Program: Its Role in Ultra-Clean Transportation Fuels Initiative and Commercialization Strategy

by
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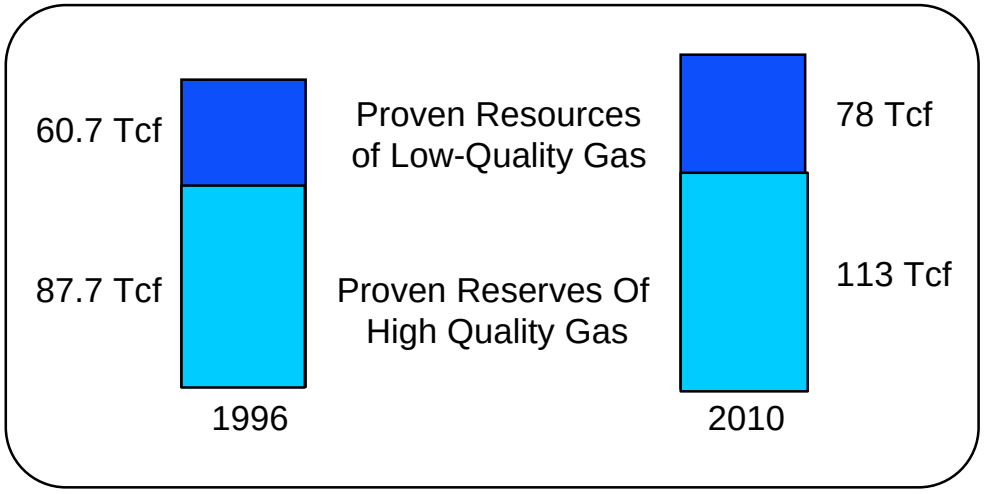
Natural Gas Processing
Program Drivers

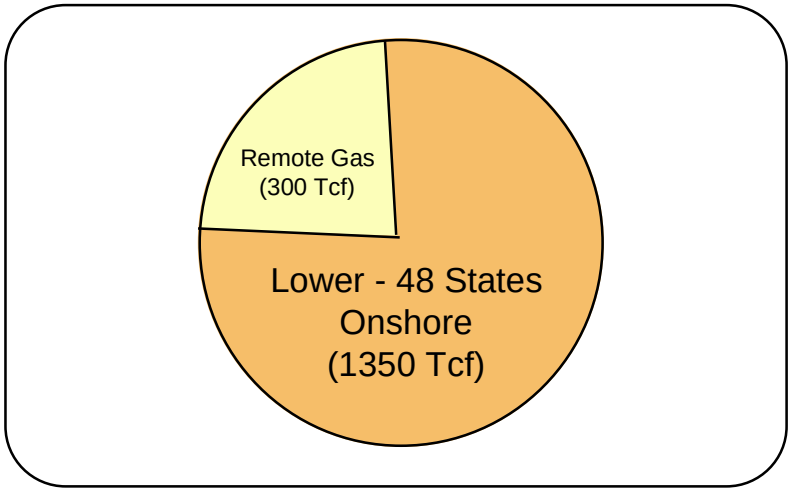
Federal Government Role:

- Ensure reliable supply of pipeline quality natural gas
- Provide science and technology leadership

  Develop advanced technology for economic conversion of remote gas to easily transportable and clean liquids - liquified natural gas, petrochemicals, fuels
- Demonstrate advanced utilization technologies for methane being vented from coal mines to address environmental concerns

Challenge: Convert unmarketable low-quality and remote gas resources into value-added products





41% of Lower - 48 gas reserves do not meet pipeline specifications

Remote locations refer to Alaska and Deep Offshore Gulf of Mexico

Why Gas-to Liquids?

- GTL option allows use, and extends life, of existing Trans-Alaska oil pipeline -- leading to additional North Slope oil production
- Advanced GTL technologies will allow remote and deep gas to be converted to transportable liquid fuels and petrochemicals
- Diesel fuels made with gas-to-liquids technology have environmental and efficiency benefits over petroleum-derived diesel

Gas to Liquids
Impact of Technology

Advanced gas-to-liquids (GTL) technologies will allow conversion of remote gas to transportable fuels and petrochemicals

- Advances in separation technologies promise 25+% cost reduction breakthroughs for GTL conversion (from current technology $26-28/bbl to $18 - 22/bbl)
- Small-scale technologies of both LNG manufacture and GTL conversion can meet space and size limitations of remote offshore platforms and isolated, small gas deposits

Program Strategy

- **Establish U.S. lead in Gas-to-Liquids Conversion Technologies for fuels and chemicals**

- **Develop government/industry partnerships to stimulate deployment of technical commercial plants for mitigation of technology and market risks**

- **Partner with other NETL Product lines (Coal Transportation Fuels, Advanced Fuels) and other DOE offices (Energy Efficiency, Office of Transportation Technology) in an effort to leverage program funding**

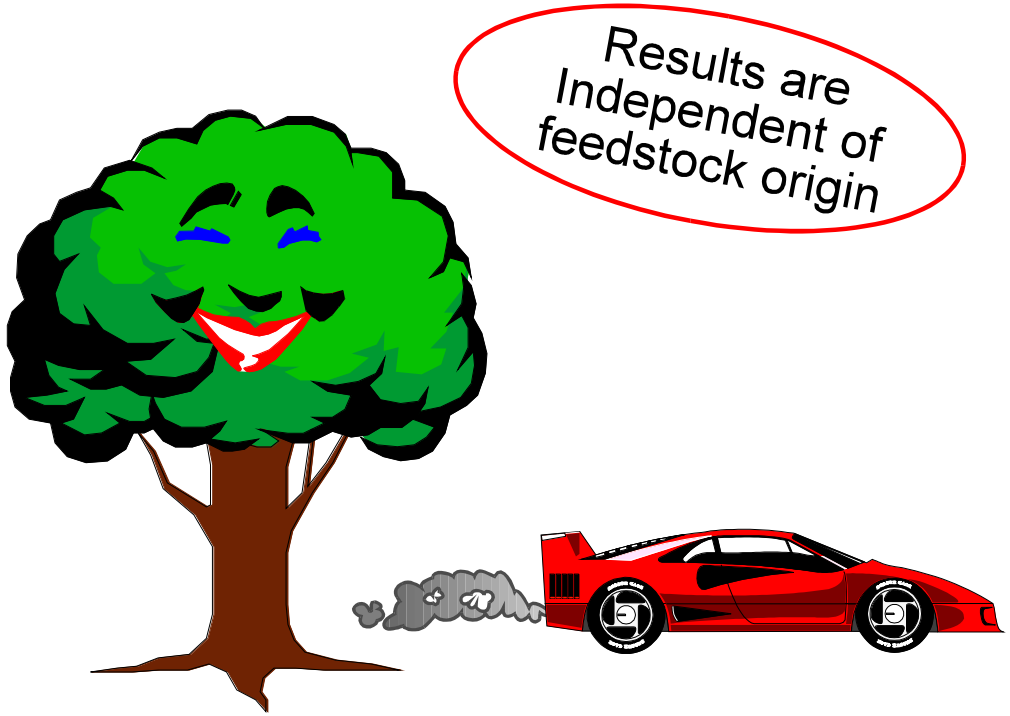
Program Benefits

- Enhanced utilization of on/offshore natural gas resources (1200 Tcf)
- Monetization of 100 Tcf of stranded gas resources in Alaska
- Continued operation of TAP transporting both petroleum and gas-derived fuels for at least 25 years
- Continued operation will result in recovery of an additional 1 billion barrels of petroleum
- Increase of domestic natural gas production by 1 Tcf per year for each 172 million barrels of fuel produced (Btu exchange basis)

Emissions Performance of Fischer-Tropsch (F-T) Diesel Fuels Is Superior to Petroleum Diesel Fuels

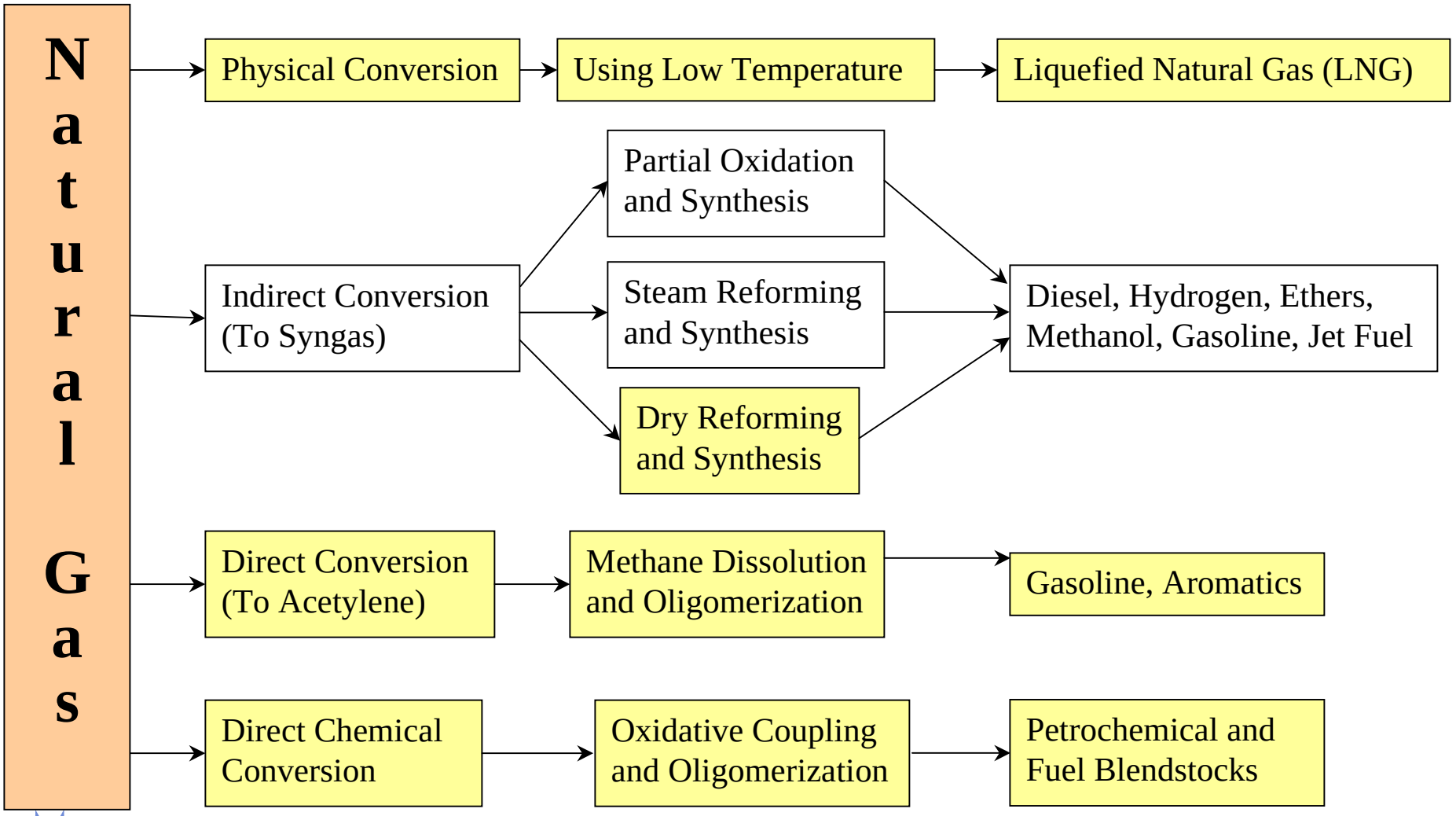
Emissions Reduction Relative to Low Sulfur Petroleum Diesel	
Hydrocarbons	41-46%
CO	45-47%
NOx	9%
Particulates	27-32%

Emissions Reduction Relative to Low Sulfur/Low Aromatics Petroleum Diesel	
Hydrocarbons	25-31%
CO	34-38%
NOx	5%
Particulates	23-29%

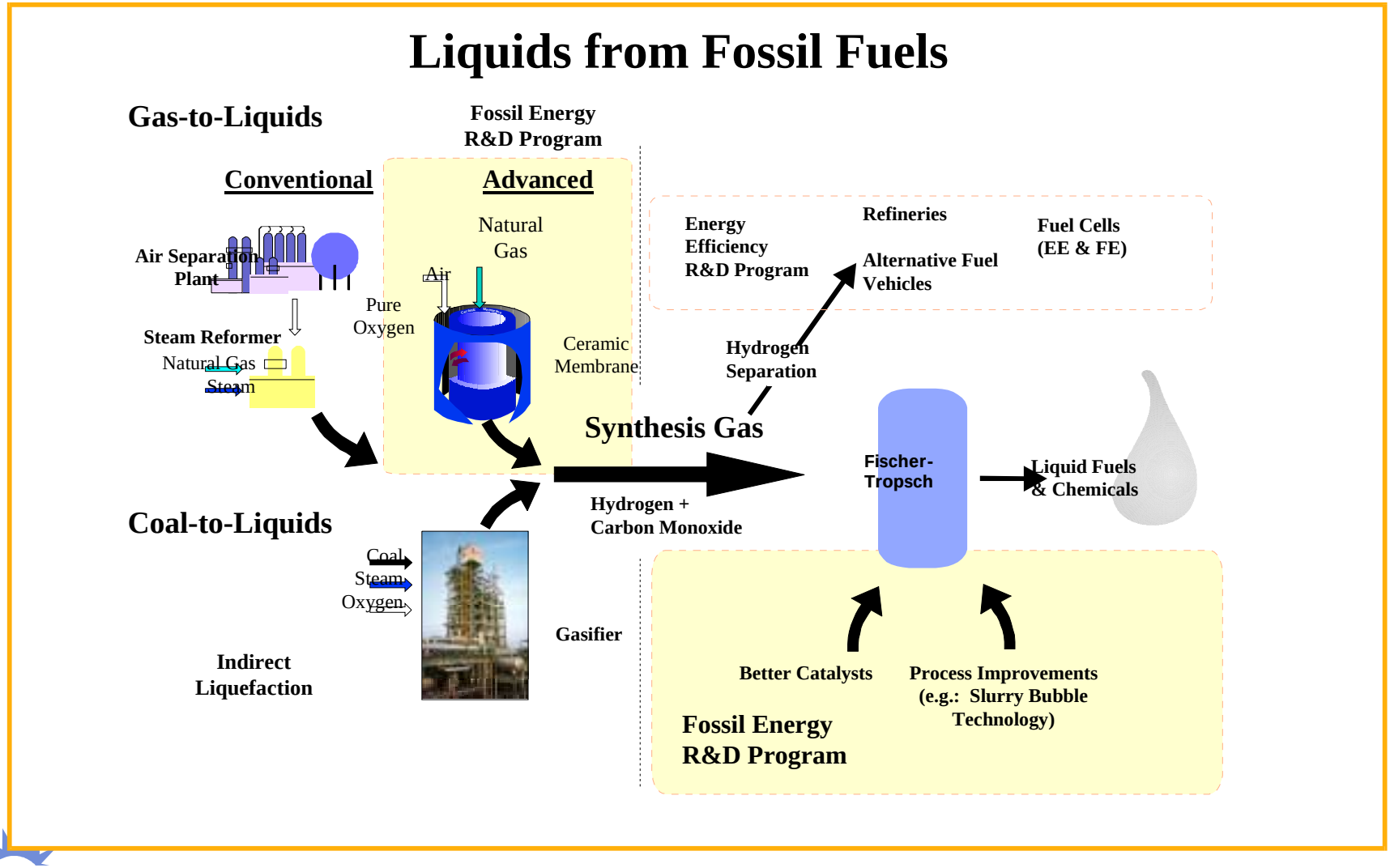


*Ranges based on three fuels, i.e., summer, winter, and California formulations, produced from natural gas and coal feedstocks.

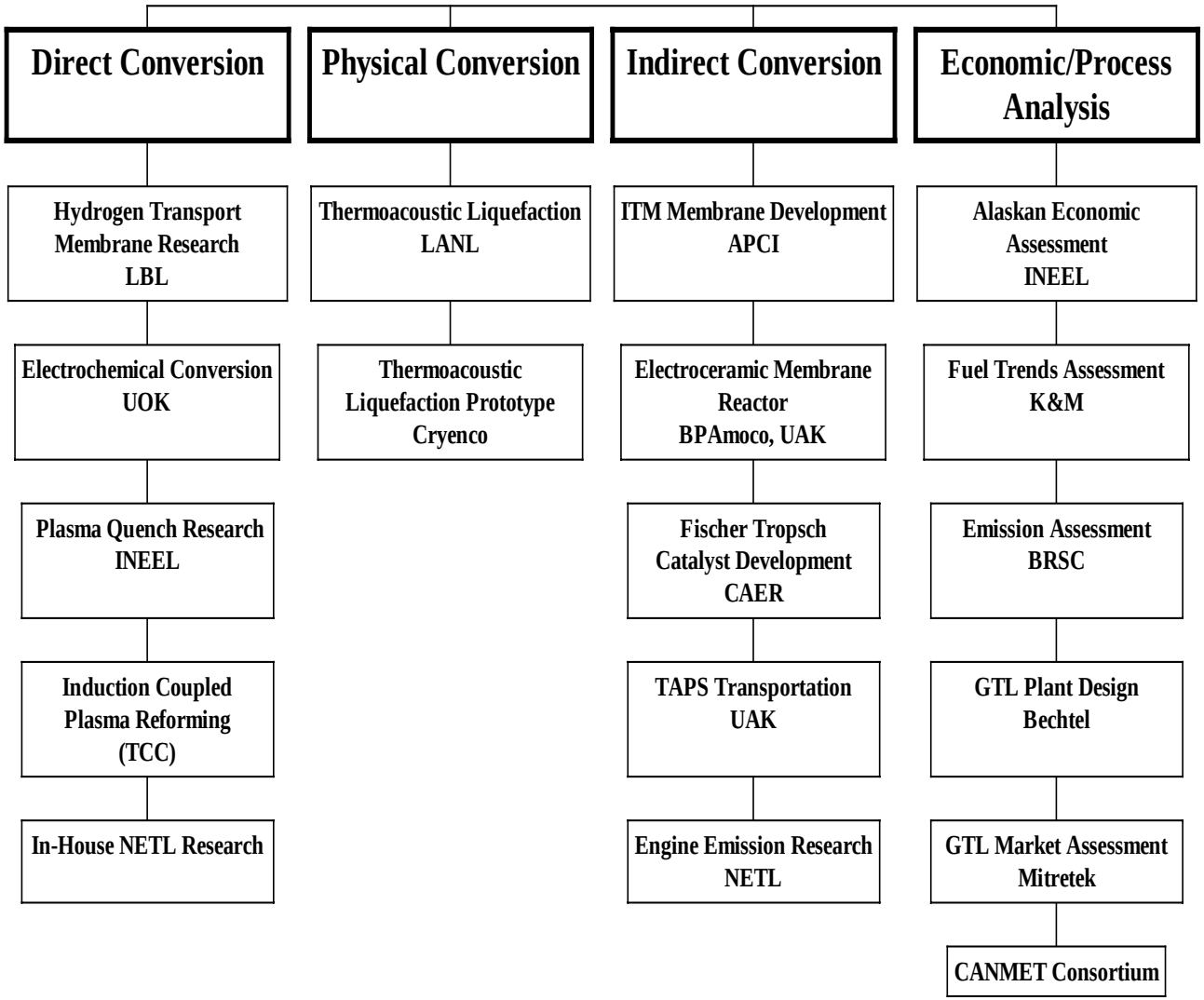
Natural Gas Conversion Processes



DOE Gas-to-Liquids Program



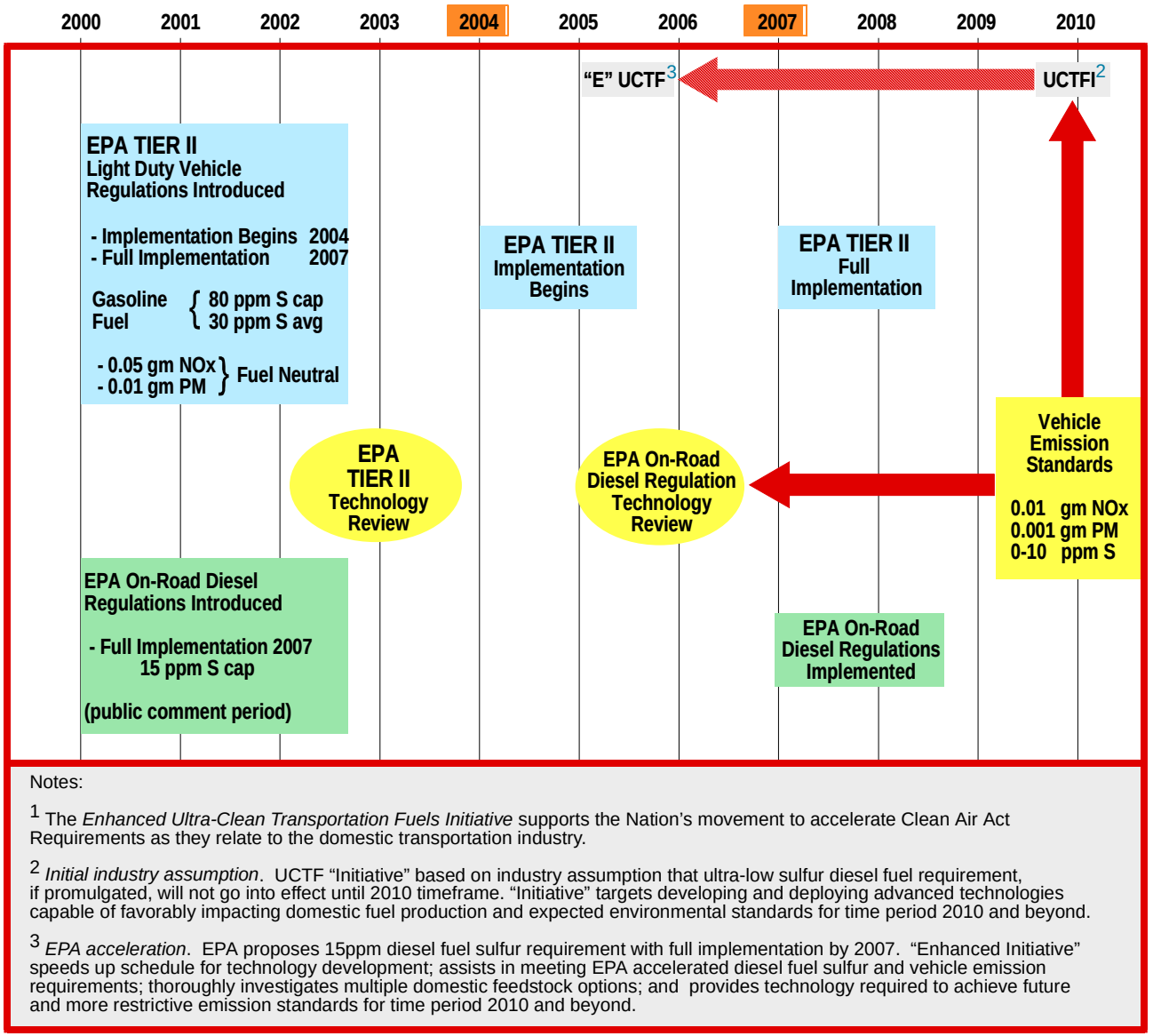
NETL Gas to Liquids Program



Natural Gas ...

- **Bridge fuel -- gas will play a significant role in the 21st century transition to a post-fossil economy**
- **Cleaner burning fossil fuel -- lower sulfur, particulates, NO_x; with lower capital investments required**
- **As an energy source, natural gas offers part of the solution to global efforts to reduce greenhouse gas emissions -- up to 50% less CO_2 than coal and 20-30% less than oil**
- **Domestic resource base needs to expand:**
  - Advanced exploration and recovery technology
  - New sources of gas (deep zones and methane hydrates)

Environmental Quality Drivers for Ultra-Clean Transportation Fuels[1]



Notes:

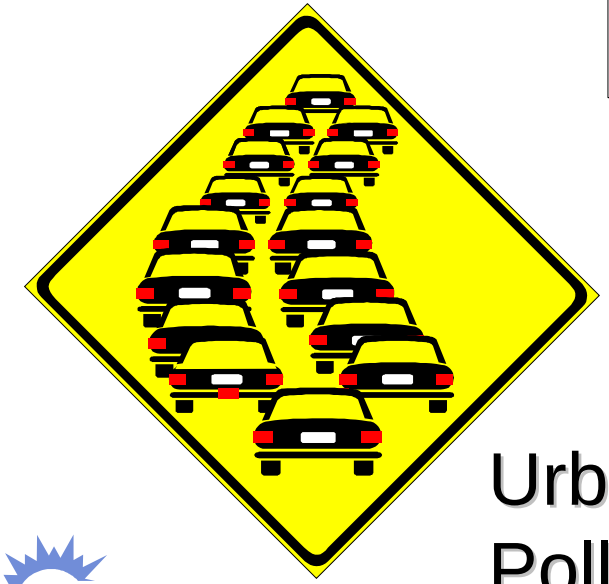
[1] The *Enhanced Ultra-Clean Transportation Fuels Initiative* supports the Nation's movement to accelerate Clean Air Act Requirements as they relate to the domestic transportation industry.

[2] *Initial industry assumption*. UCTF "Initiative" based on industry assumption that ultra-low sulfur diesel fuel requirement, if promulgated, will not go into effect until 2010 timeframe. "Initiative" targets developing and deploying advanced technologies capable of favorably impacting domestic fuel production and expected environmental standards for time period 2010 and beyond.

[3] *EPA acceleration*. EPA proposes 15ppm diesel fuel sulfur requirement with full implementation by 2007. "Enhanced Initiative" speeds up schedule for technology development; assists in meeting EPA accelerated diesel fuel sulfur and vehicle emission requirements; thoroughly investigates multiple domestic feedstock options; and provides technology required to achieve future and more restrictive emission standards for time period 2010 and beyond.

The Challenges Facing Us . . .
Globally

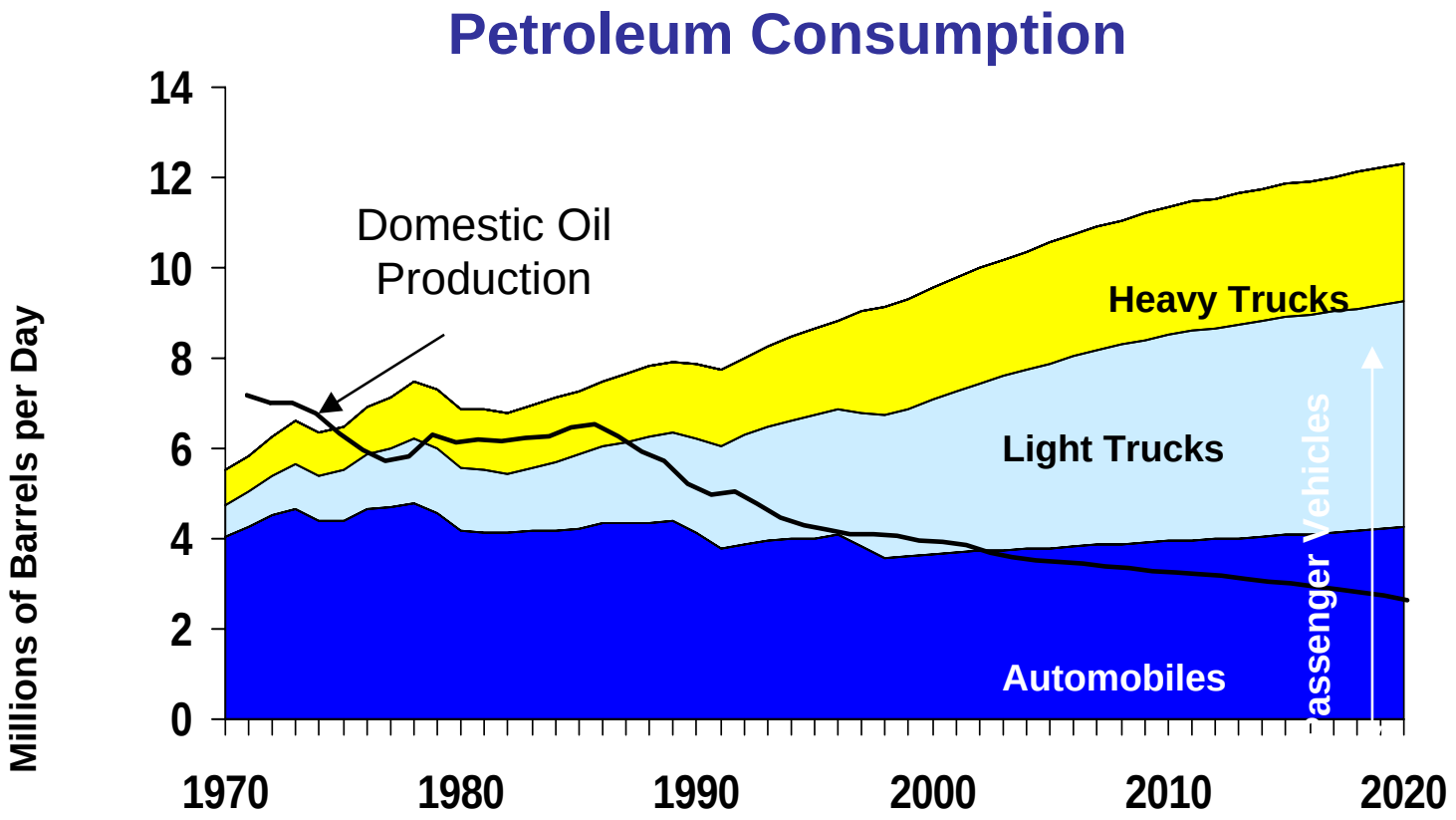
Growing
Petroleum
Consumption



Urban
Pollution

Global
Climate
Change

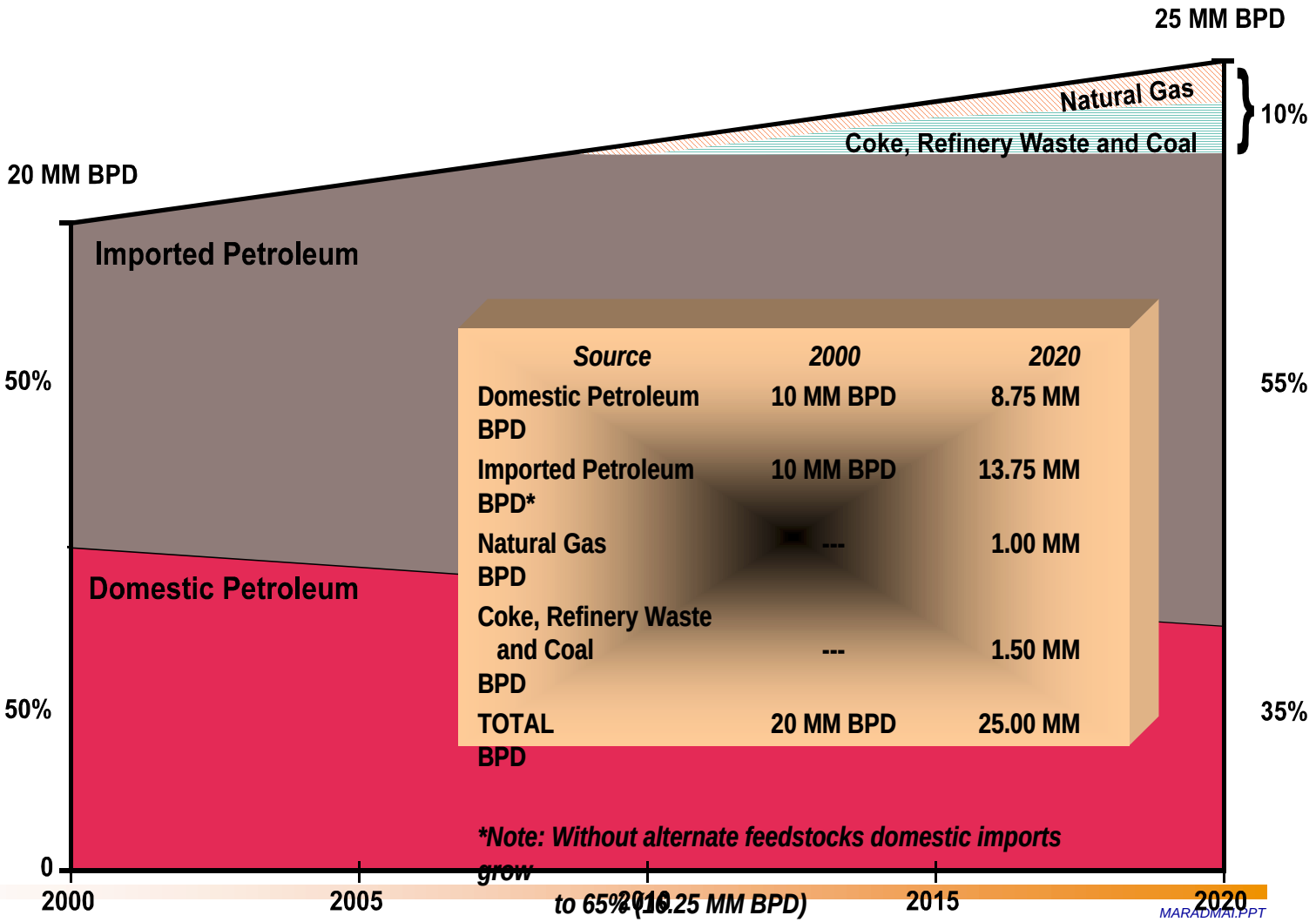
Transportation Now Uses More Oil Than Is Produced Domestically



Source: Transportation Energy Data Book: Edition 18, DOE/ORNL-6941, September 1998, and EIA Annual Energy Outlook 1999, DOE/EIA-0383(99), December 1998

Ultra-Clean Fuels for the 21st Century
The Domestic Supply Perspective

In 2020, clean, low-sulfur fuels from domestic petroleum play a significant role in U.S. transportation markets; alternative feedstocks produce 10% of our Nation's transportation fuels



Source	*2000*	*2020*
Domestic Petroleum BPD	10 MM BPD	8.75 MM
Imported Petroleum BPD*	10 MM BPD	13.75 MM
Natural Gas BPD	---	1.00 MM
Coke, Refinery Waste and Coal BPD	---	1.50 MM
TOTAL BPD	20 MM BPD	25.00 MM

**Note: Without alternate feedstocks domestic imports grow to 65% (16.25 MM BPD)*

Ultra-Clean Fuels for the 21st Century Goals

- Produce ultra-clean petroleum fuels from domestic and imported crude
- Produce ultra-clean fuels from alternative hydrocarbon feedstocks (natural gas, petroleum coke, refinery bottoms, coal, waste materials, biomass) that are equal to or better than current petroleum fuels
- Ensure fuel/engine/emission control combinations that meet future vehicle emission standards

Perspective is global, Nation's goal for cleaner environment as well as industry's desire for an expanded resource base are served

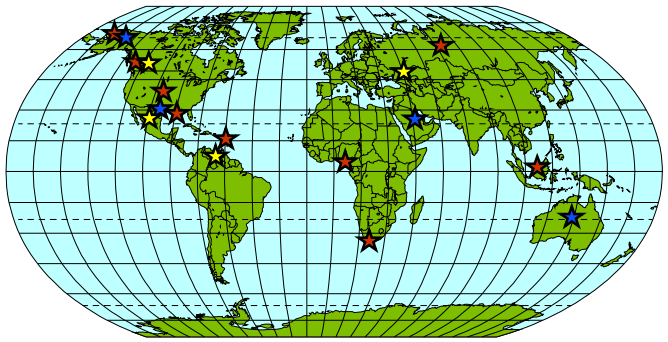
Create strategic partnerships targeted at the production of ultra-clean fuels that expand and diversify the fossil resource base

Proposed Ultra-Clean Transportation Fuel Products

- Ultra low sulfur, increased octane gasoline
- Ultra low sulfur, high cetane diesel
- On-board reformer fuel (hydrogen fuel cells)
- Fuel additives and blending components
- Ultra low sulfur lubricants
- Ultra clean jet fuel

Benefits

- More Jobs
- Cleaner Environment
- Lower Greenhouse Gas Emissions
- Expanded, More Diversified Fuel Resources
- Stronger, More Competitive U.S. Energy Industry



GTL Program Goal and Direction

- **Extend/expand/validate public database on GTL processes, products, and economics to aid in the inevitable private and public decision making necessary to best utilize our remote natural gas resources -- ANS, offshore**
- **Current Program Activity focus on process elements of established, but as yet non-commercial FT technology -- require incentives**
- **The program emphasis will continue, but may well be supplemented by fresh looks at how GTL technology can support attainment of new motor fuel performance demands that seem on the horizon**

U.S. Department of Energy
Ultra-Clean Transportation Fuels: Program Update

Office of Fossil Energy
National Energy Technology Laboratory
Major Fossil Energy Technology Areas

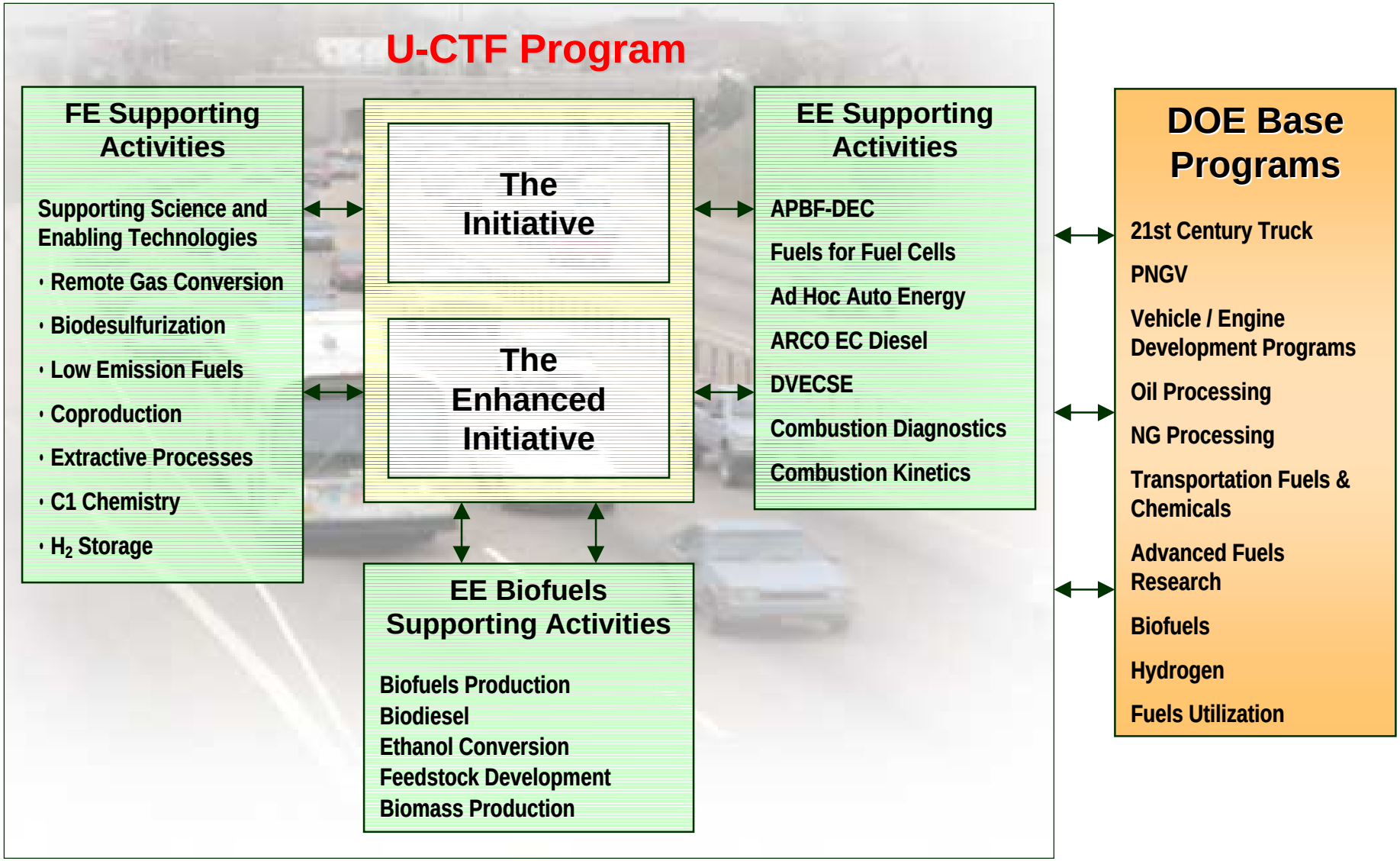
- Oil and Natural Gas Supply

- Central Power Generation (Vision 21)

- Distributed Power Generation

- Transportation Fuels

The U-CTF Program Plan



Our Perspective Through 2020

- Fossil fuels will continue to be the preferred option for transportation needs
- Urban and regional environmental pollution concerns will continue to intensify
- Demand for liquid transportation fuels will continue to grow, and because of environmental concerns, the demand for ultra-clean fuels will significantly increase
- Global climate change will continue to be an issue, requiring high end-use efficiencies in all applications including transportation (with possible sequestration)
- Thus, public investment in transportation fuels will focus on the use, with any needed modification, of existing infrastructure to accommodate environmental, efficiency, and economic goals

Transportation Fuels Program
Commercial and Military Applications

- *Supply and Delivery of Clean Transportation Fuels*
- *Land, Air, and Sea Applications*
- *Policy Support and R,D&D*

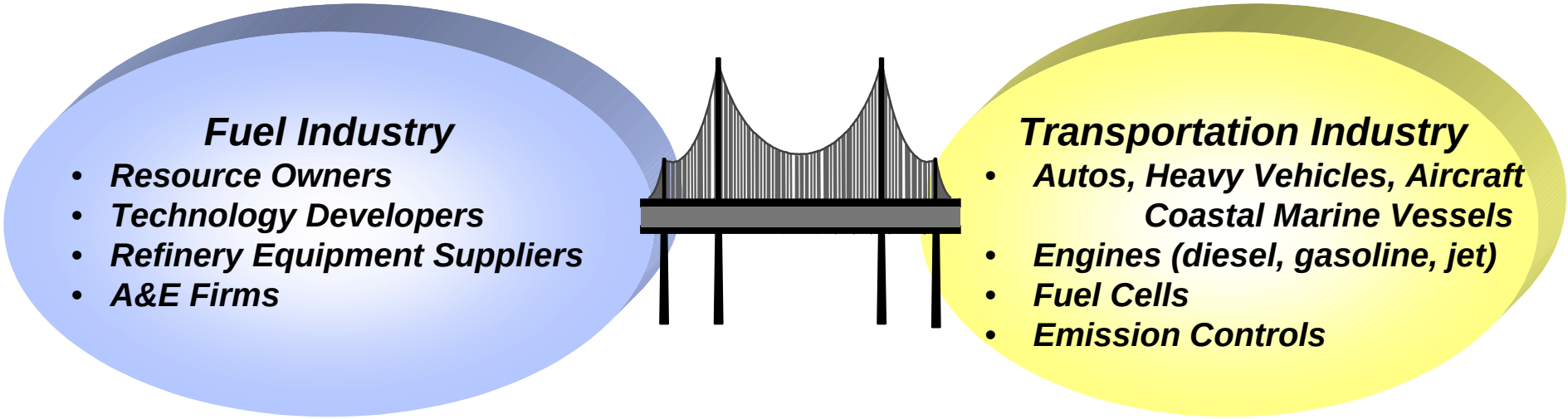
- **Fossil Energy Supply: Energy Security, Affordability, Acceptability**
  - Enhancing Domestic Resources
    - Petroleum
    - Natural Gas
    - Coal: mining (IOF) and processing
  - Environmental Issues

- Ultra-Clean Fuels for the Existing Transportation Infrastructure
  - Advanced petroleum processing
  - Natural gas to liquids
  - Coal fuels and chemicals
  - Additives and lubricants

- Delivery System Reliability
  - Integrity of existing systems
  - Increasing complexity of products into distribution system
  - Hydrogen distribution/transportation system reliability

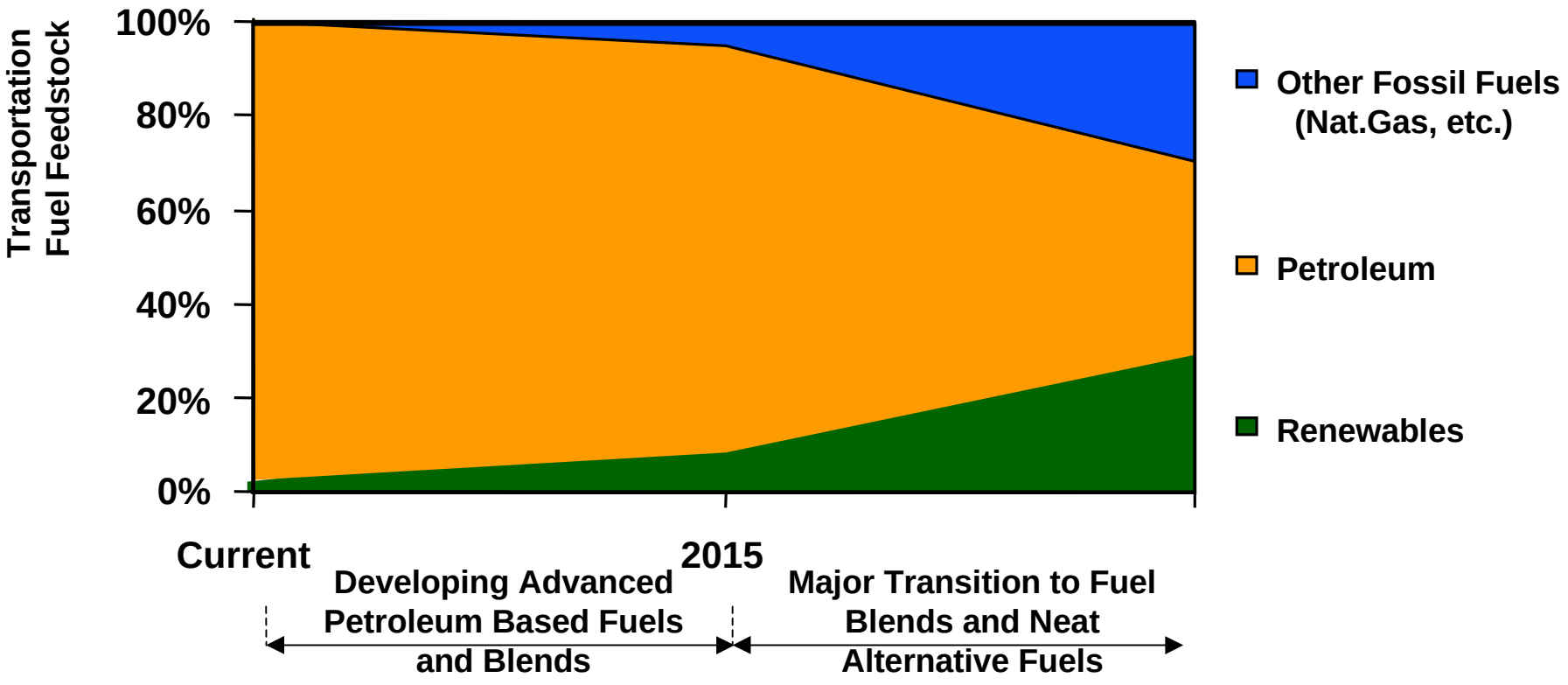
- Future Fuels: New Fuel/ Transportation System Infrastructure
  - Hydrogen
  - Biofuels
  - Novel fuels

Ultra-Clean Fuels…*a key piece of the complex and dynamic puzzle...*



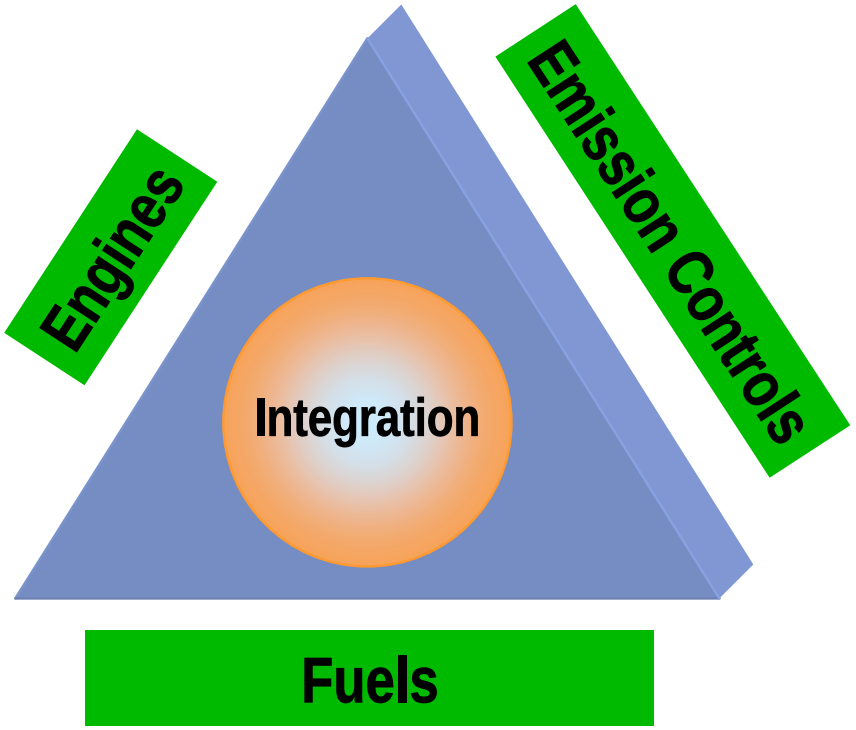
The U.S. Department of Energy's Ultra-Clean Fuels Program…partnering in the identification and development of advanced fuels for today's and tomorrow's transportation vehicles

Ultra-Clean Transportation Fuels
…diverse feedstocks -- common products….



Technology Integration

21st Century Ultra-Clean Transportation Systems



System Requirements

- *Ultra-low emissions*
- *High performance*
- *Long-term durability*
- *Low toxicity*
- *Affordability*

Strategic Partners