

ZERO S



Zero-emission Energy Recycling Oxidation System

June 2017



Leading the Way to American Energy Security

- **Patented Gasification / Oxidation Method & System**
- **A brilliant integration of established technologies:**
 - Rotary Kiln Technology
 - Gasification – Oxy-Fuel Technology
 - Rankine Cycle Technology
 - Fischer-Tropsch Fuels Technology
 - Gas Capture Technology
- **Constructed with off-the-shelf equipment & controls**
- **Zero emissions**
- **Zero waste streams**
- **Zero water demand**



Integrated Technologies

- **Rotary Kiln Technology**
 - In operation since early in the 1900's.
 - Today there are hundreds operating in the cement manufacturing industry and as incinerators in Europe, the U.S. and many other countries.
- **Gasification Technology**
 - Originally developed in the 1800s to produce town gas for lighting and cooking.
 - Utilized for the production of synthetic chemicals and fuels since the 1920s.
 - Rotary Kiln Gasifiers – operating in Japan & Europe



Integrated Technologies

- **Oxidation Technology**
 - Oxy-Fuel System - oxygen replaces air in gasifier (Air Separation Unit) zero Nox.
 - Endorsed by United Nations Intergovernmental Panel on Climate Change.
- **Rankine Cycle Technology**
 - Invented by William Rankine, a founding contributor to the science of thermodynamics.
 - 19th Century Technology.
 - Heat is supplied externally to a closed loop.
 - Heat Recovery Steam Generated Electricity.



Integrated Technologies

- **Fischer-Tropsch Technology**
 - Invented in 1923
 - Process is a catalyzed chemical reaction in which carbon monoxide and hydrogen (syngas) are converted into liquid hydrocarbons of various forms - diesel, gasoline, jet fuel
- **Gas Capture Technology**
 - CO₂ capture and sale for Enhanced Oil Recovery
 - Air Separation Unit that provides Oxygen also isolates Nitrogen and Argon for sale.
- **Clean Water Production**



The Most Flexible and Efficient System

- **Fuel Flexibility**

- Hydrocarbons – including Coal, Oil Shale & Tar Sands
- Municipal Solid Waste
- Car Tires
- Biomass – including forestry and agricultural waste
- Construction Waste
- Animal Waste – poultry & hog farms; feed lots

- **Output Flexibility**

- Synthetic Fuels – diesel, gasoline and jet fuel
- Electricity
- Process Steam
- Distilled Water
- Nitrogen, Oxygen and Argon
- Liquid CO₂
- Volcanic Glass and No-Carbon Flyash

The American Energy Security Study



Building a Bridge to Energy Independence and a Sustainable Energy Future



Southern States Energy Board

The American Energy Security Study



Building a Bridge to Energy Independence and a Sustainable Energy Future

- **America now faces a crisis of historic proportion: a liquid transportation fuels crisis.**
- **America has the world's largest alternative liquid fuels resource base of coal, biomass, and oil shale to substitute for conventional oil imports.**
- **Exciting technologies are available to harness these resources in an environmentally respectful and economically rewarding manner.**

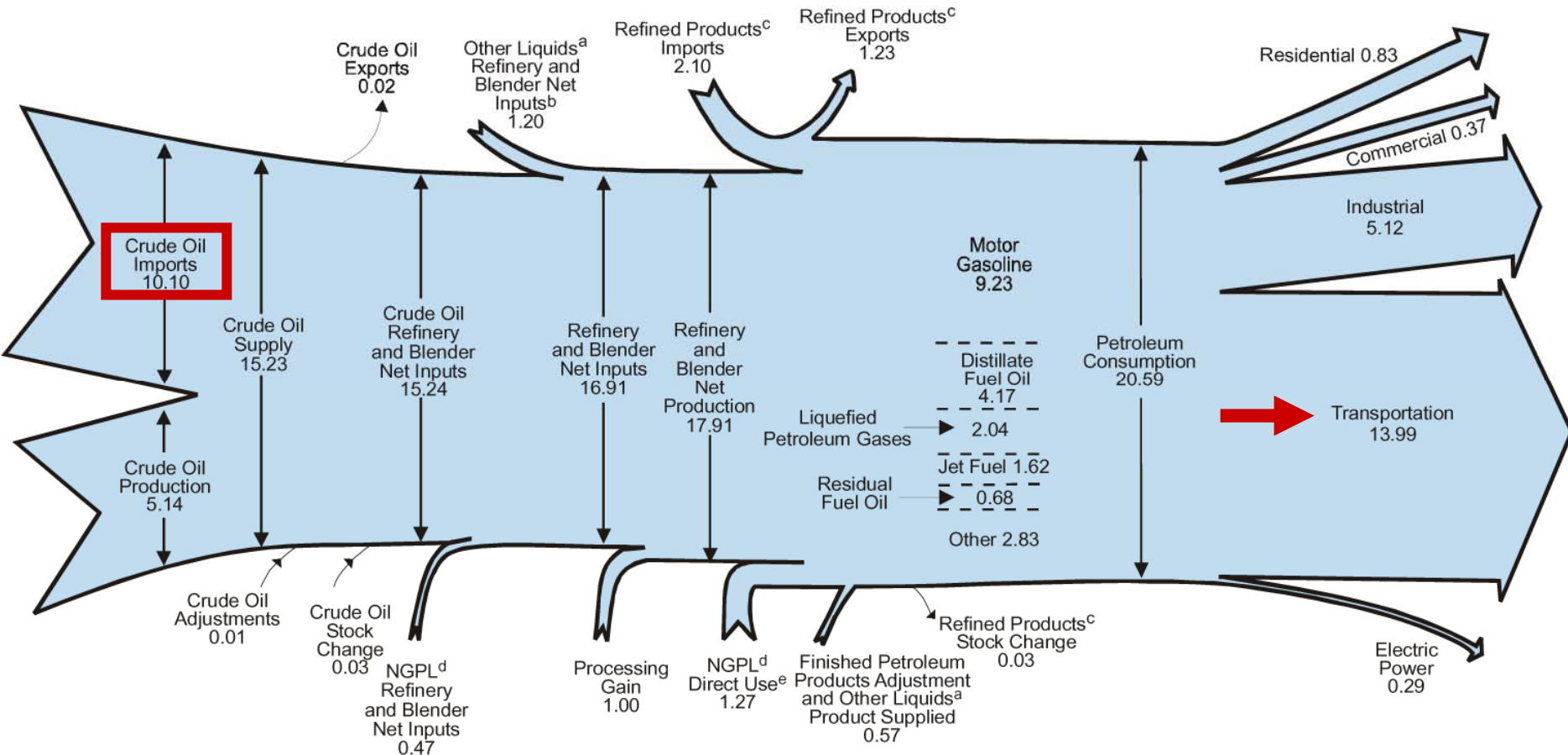
www.AmericanEnergySecurity.org

The liquid transportation fuels crisis!

- The U.S. consumes 21 million barrels of petroleum products per day, 58 % of which is imported.
- Oil accounts for 95 percent of the energy used in the U.S. transportation sector.
- At \$100 per barrel, we are exporting \$1.2 billion per day.

US Petroleum Flow - 2016

(Million Barrels per Day)



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America's alternative liquid fuels feedstocks.

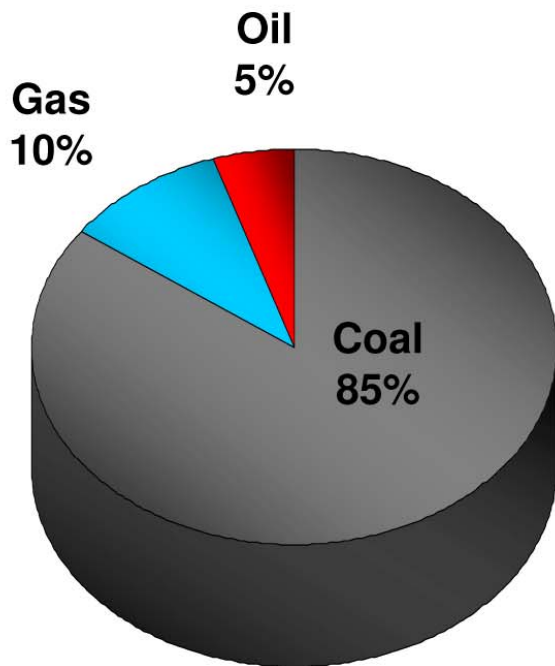
- **Coal** – of the estimated 500 billion tons in the continental US, we now use 1.1 billion tons per year to produce 49% of our electricity.
- **Oil Shale** – an estimated 2.1 trillion barrels of oil are locked up in US deposits.
- **Biomass** – Department of Energy studies show that biomass could supply 30% of our petroleum needs.

America's Most Abundant Resource

U.S. Fuel Resources

Years of Proven Supply

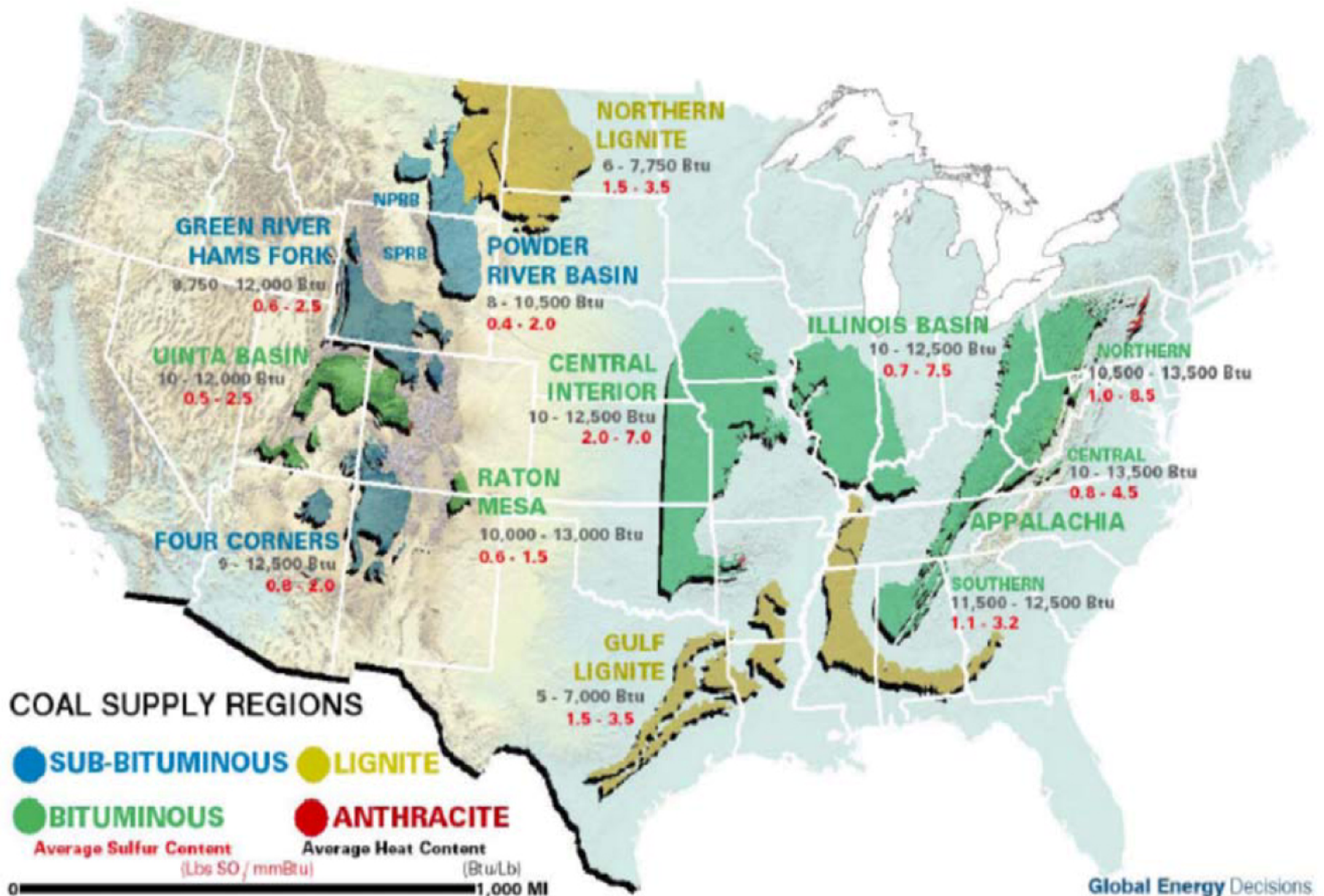
(at current consumption levels)



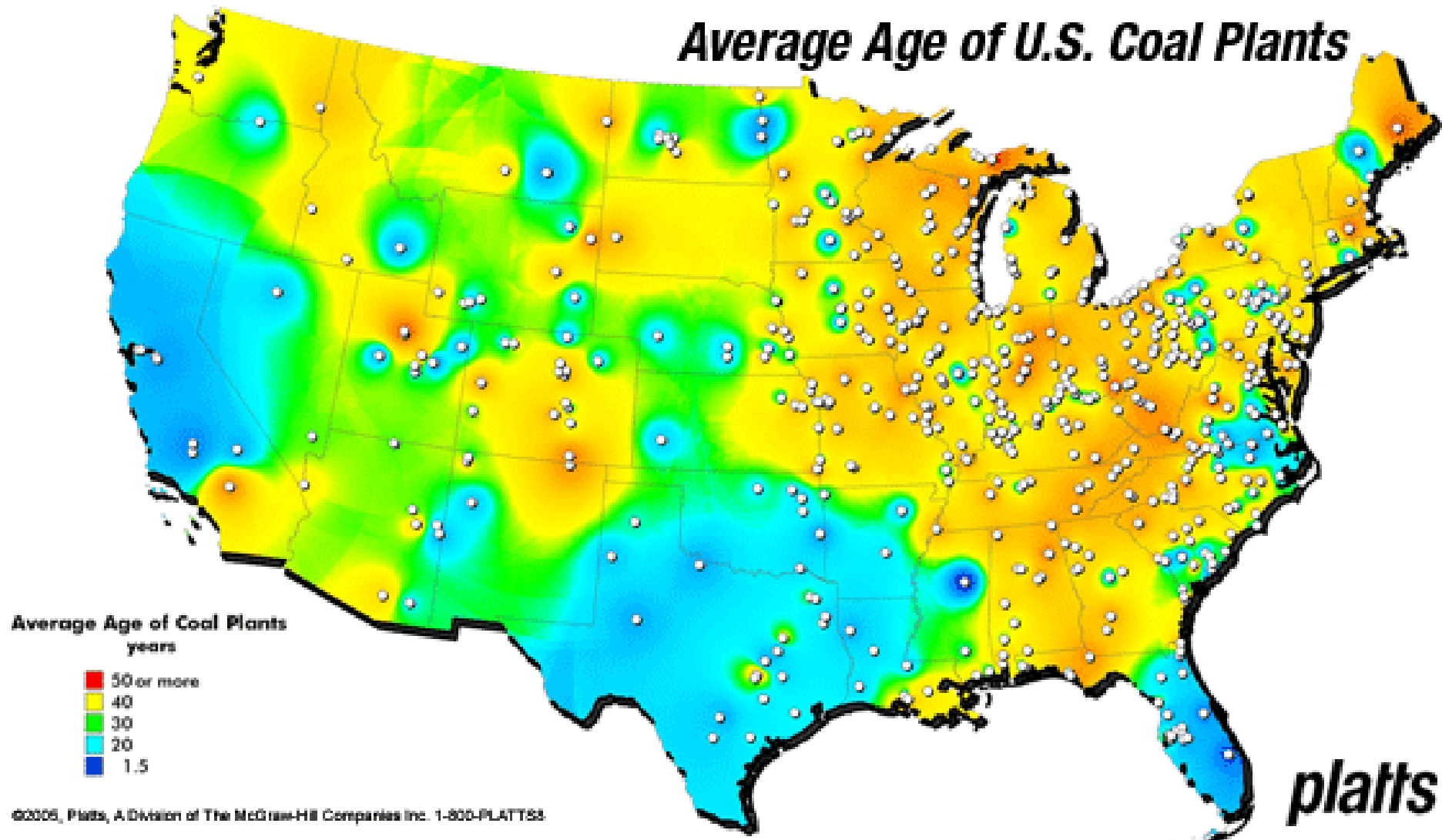
- 11.3 Oil
- 9.5 Natural Gas
- 258.0 Coal



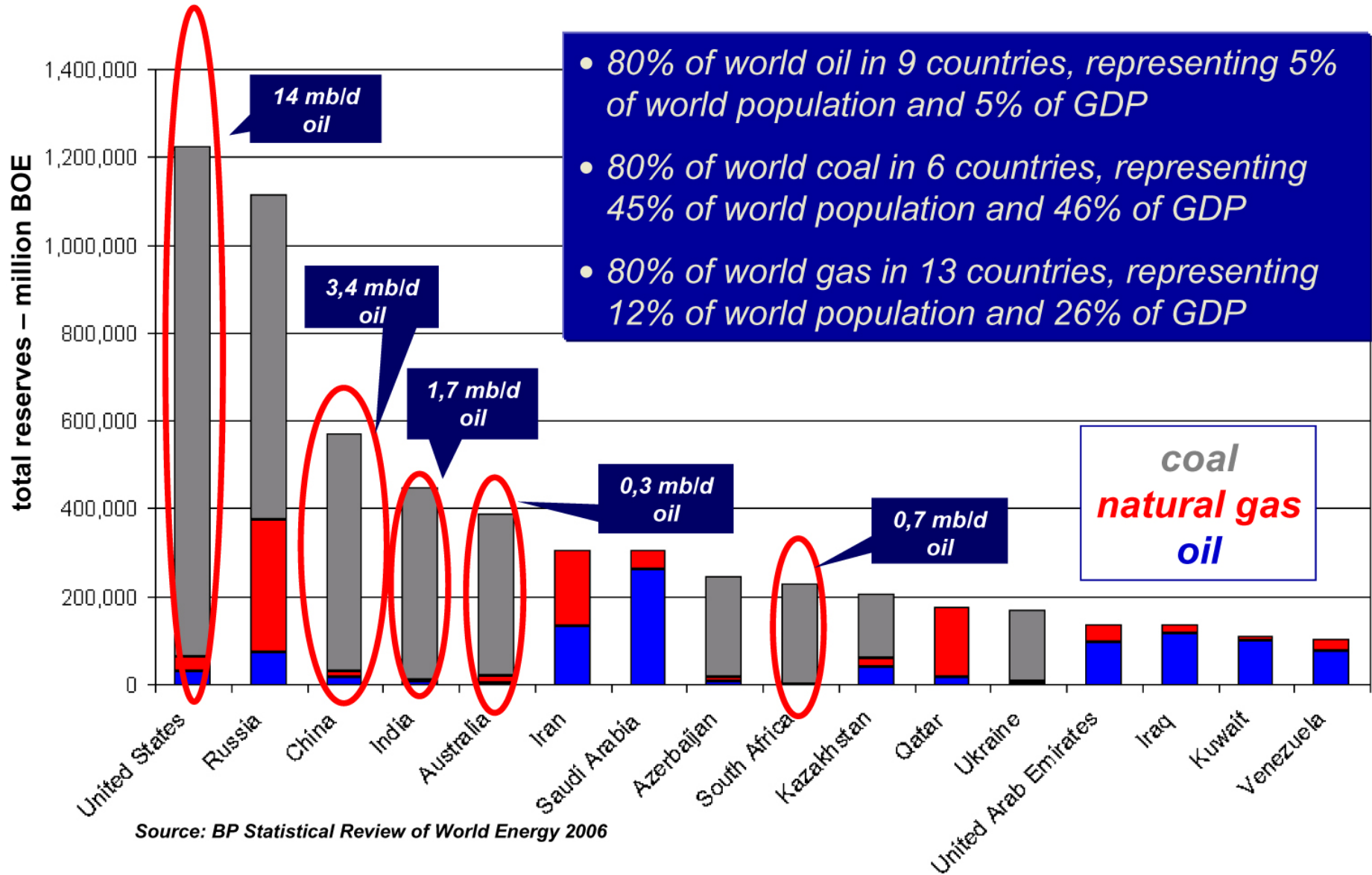
U.S. Coal Supply Regions



America's Aging/Polluting Coal Plants

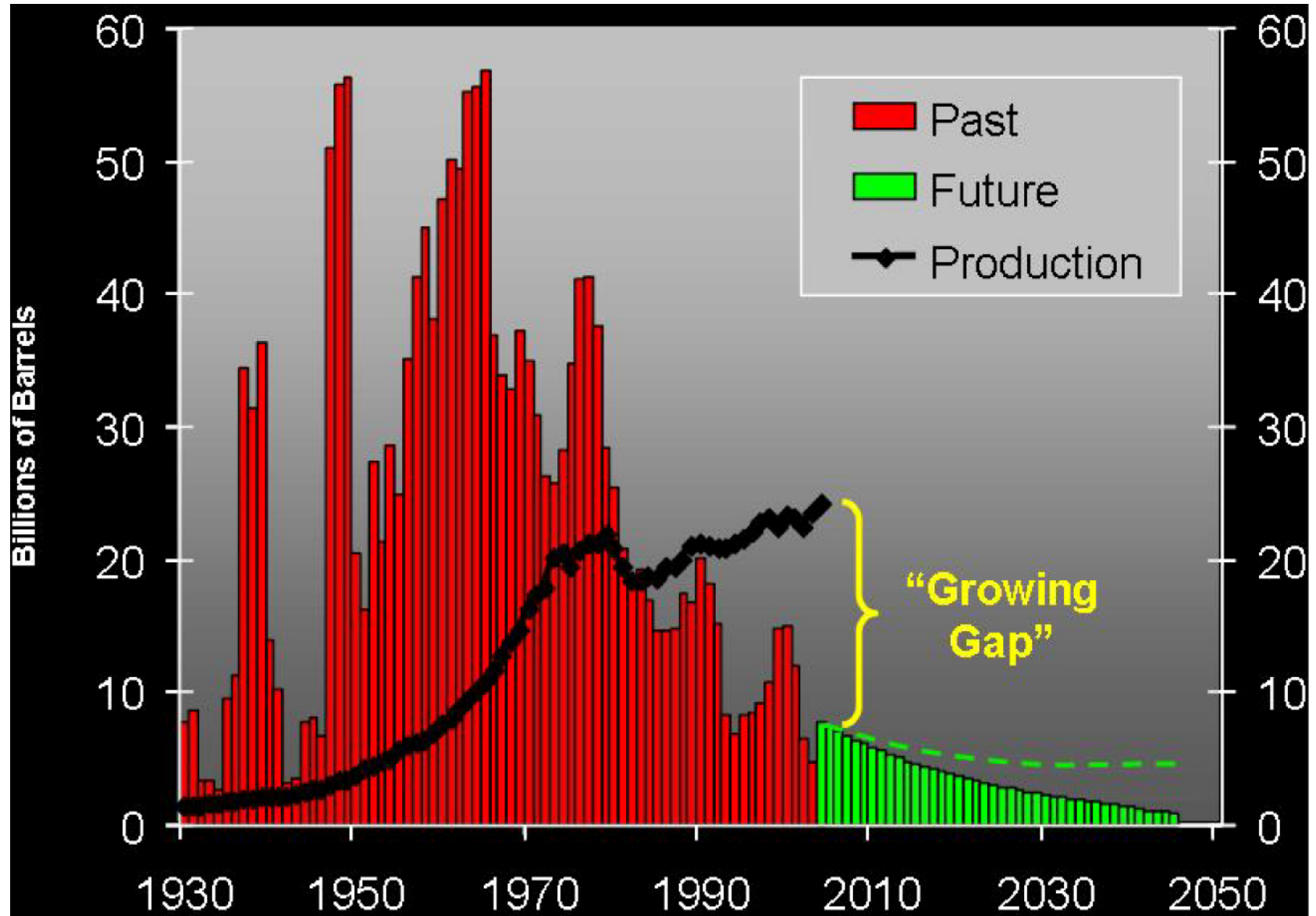


US Coal for Energy Security

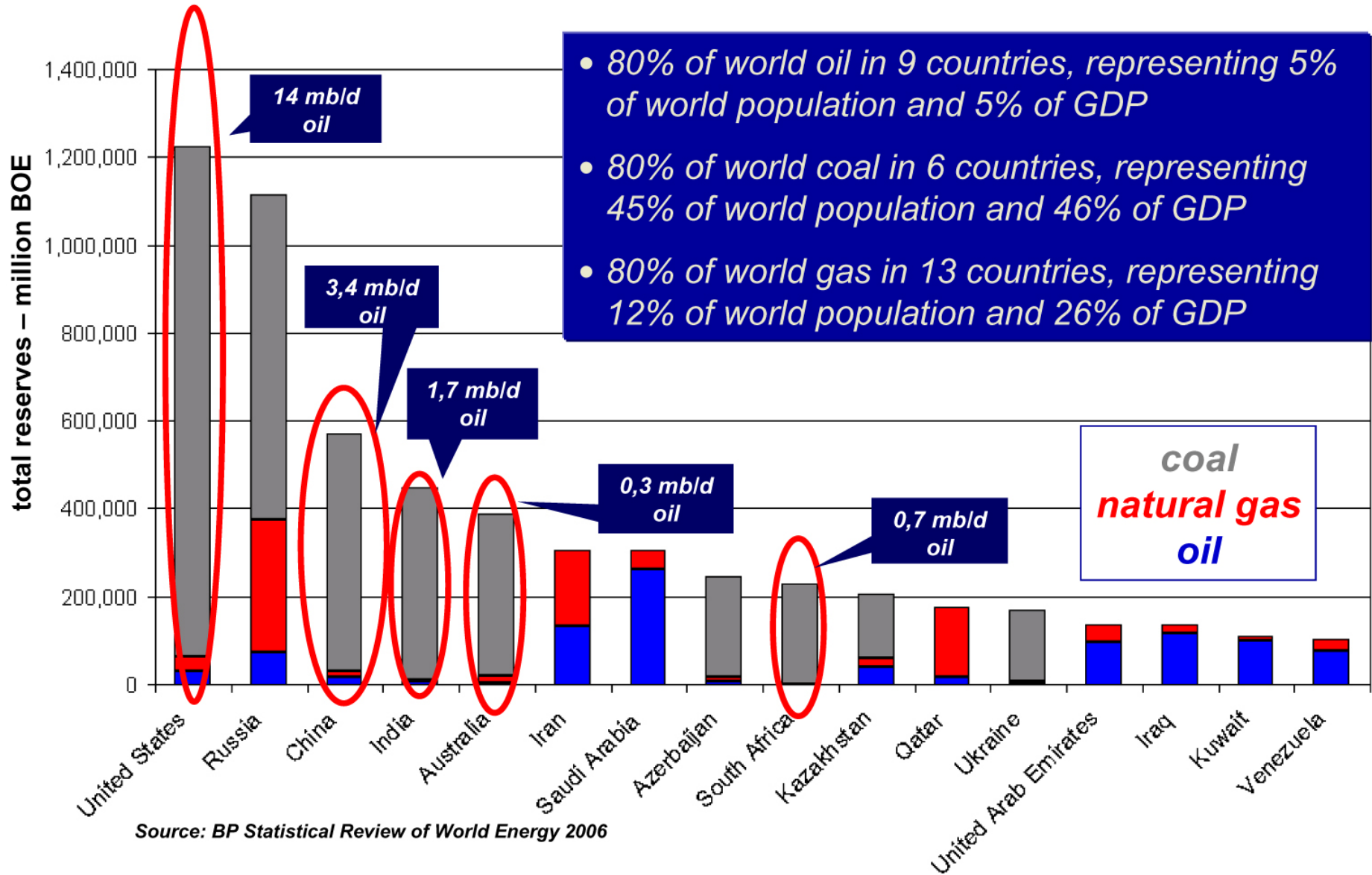


- 80% of world oil in 9 countries, representing 5% of world population and 5% of GDP
- 80% of world coal in 6 countries, representing 45% of world population and 46% of GDP
- 80% of world gas in 13 countries, representing 12% of world population and 26% of GDP

The World is consuming more oil than is being discovered.



US Coal for Energy Security

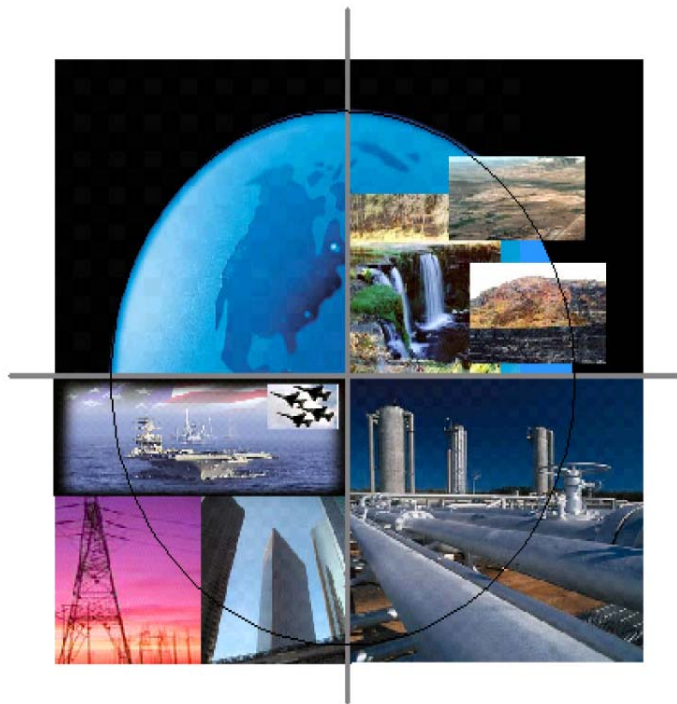


America has the world's largest alternative liquid fuels feedstocks.

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Strategic Significance of America's Oil Shale Resource

Volume I Assessment of Strategic Issues



Office of Deputy Assistant Secretary
for Petroleum Reserves

Office of Naval Petroleum
and Oil Shale Reserves
U.S. Department of Energy
Washington, D.C.
March 2004



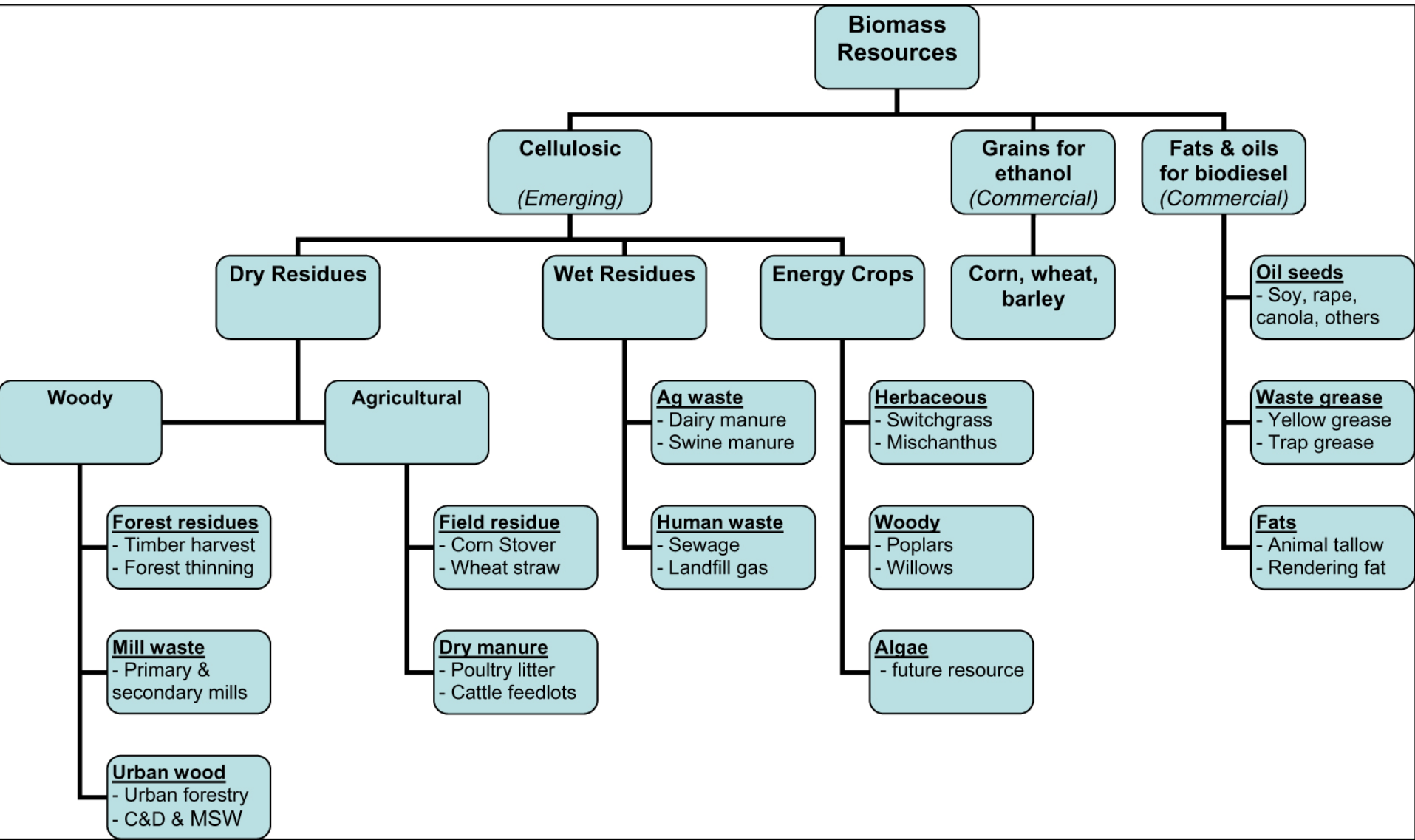
Let's keep the Petro-Dollars in America!



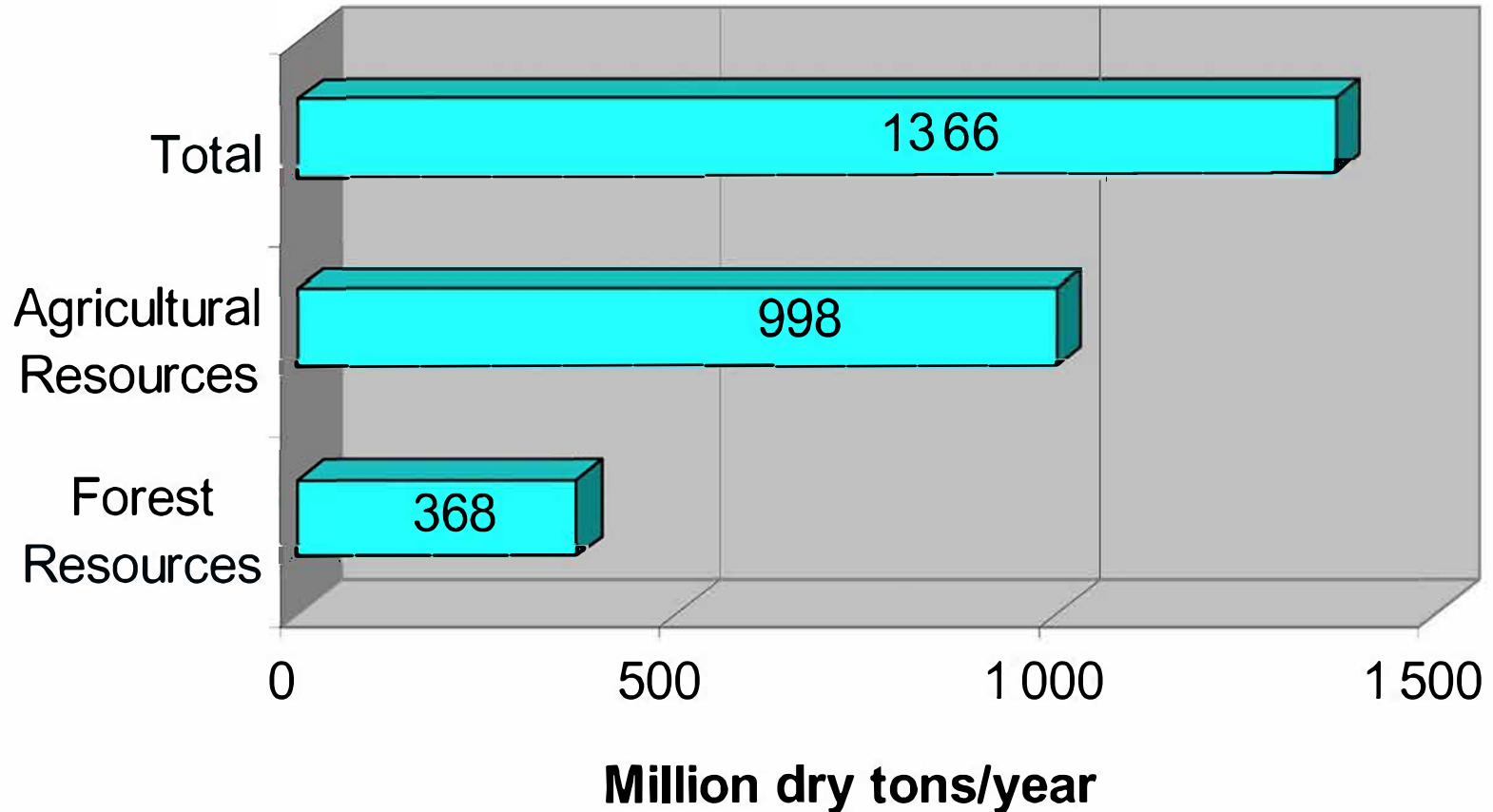
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- ✓ **Oil Shale** – an estimated 2.1 trillion barrels of oil are locked up in US deposits.
- **Biomass** – Department of Energy studies show that biomass could supply 30% of our petroleum needs.

US Biomass Feedstocks



Annual U.S. Biomass Potential



U.S. Biomass Potential (Source: ORNL, 2015)

America has the world's largest alternative liquid fuels feedstocks.

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www.AmericanEnergySecurity.org

Exciting technologies are available

- **Coal-to-Liquids**

- Gasification
 - Fischer-Tropsch
- } **ZEROS FT**

- **Oil Shale**

- In Situ
- Retort
- **ZEROS FT**

- **Biomass**

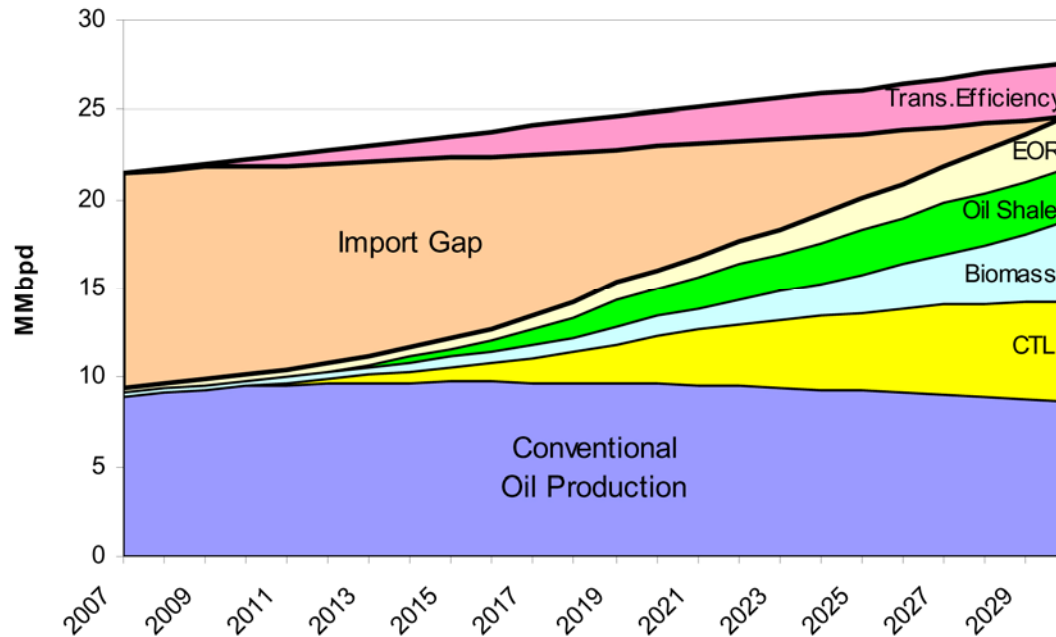
- Starches & Oils to Ethanol and Biodiesel
- Cellulosic Ethanol
- **ZEROS FT**





ZEROS = Security

The Path to U.S. Energy Security and Independence



ZEROS
Technology

**Patented integration of
technologies...**



ZEROS Integrated Technologies

➤ Gasification / Oxidation

- Rotary Kiln Gasifier
- Oxygen replaces air in gasifier (Air Separation Unit) zero Nox.

• Rankine Cycle

- Heat Recovery Steam Generated Electricity

• Fischer-Tropsch

- Liquid fuels – diesel, gasoline, jet fuel

• Gas Capture

- CO₂ capture and sale for Enhanced Oil Recovery

• Clean Water Production

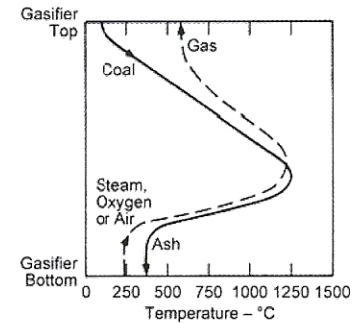
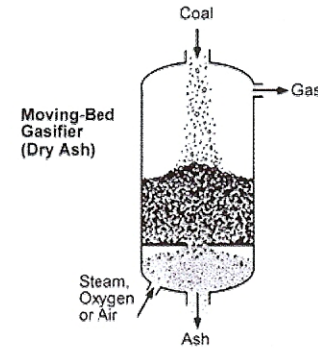
Gasification Technology



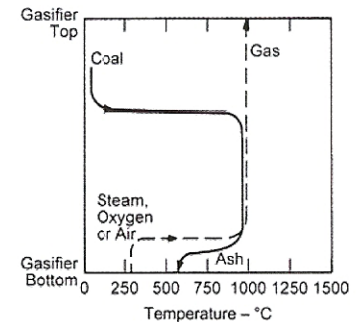
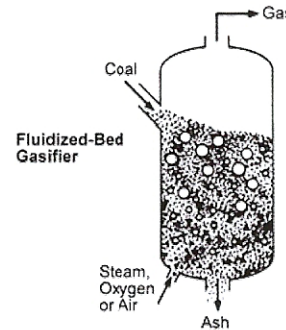
Shell Technology – 253 MW IGCC for Nuon
Buggenum, The Netherlands

The 3 Major Types of Gasification

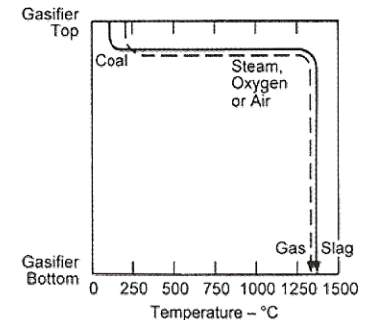
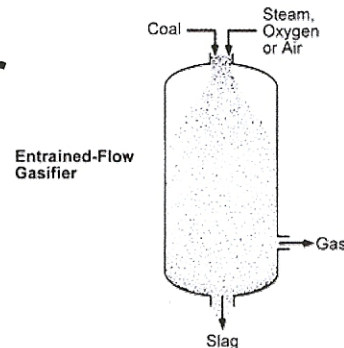
1. Moving-Bed Gasifier (e.g., Lurgi)



2. Fluidized-Bed Gasifier (e.g., KBR/Southern)



3. Entrained-Flow Gasifier (e.g., GE Energy, ConocoPhillips, Shell, Siemens)

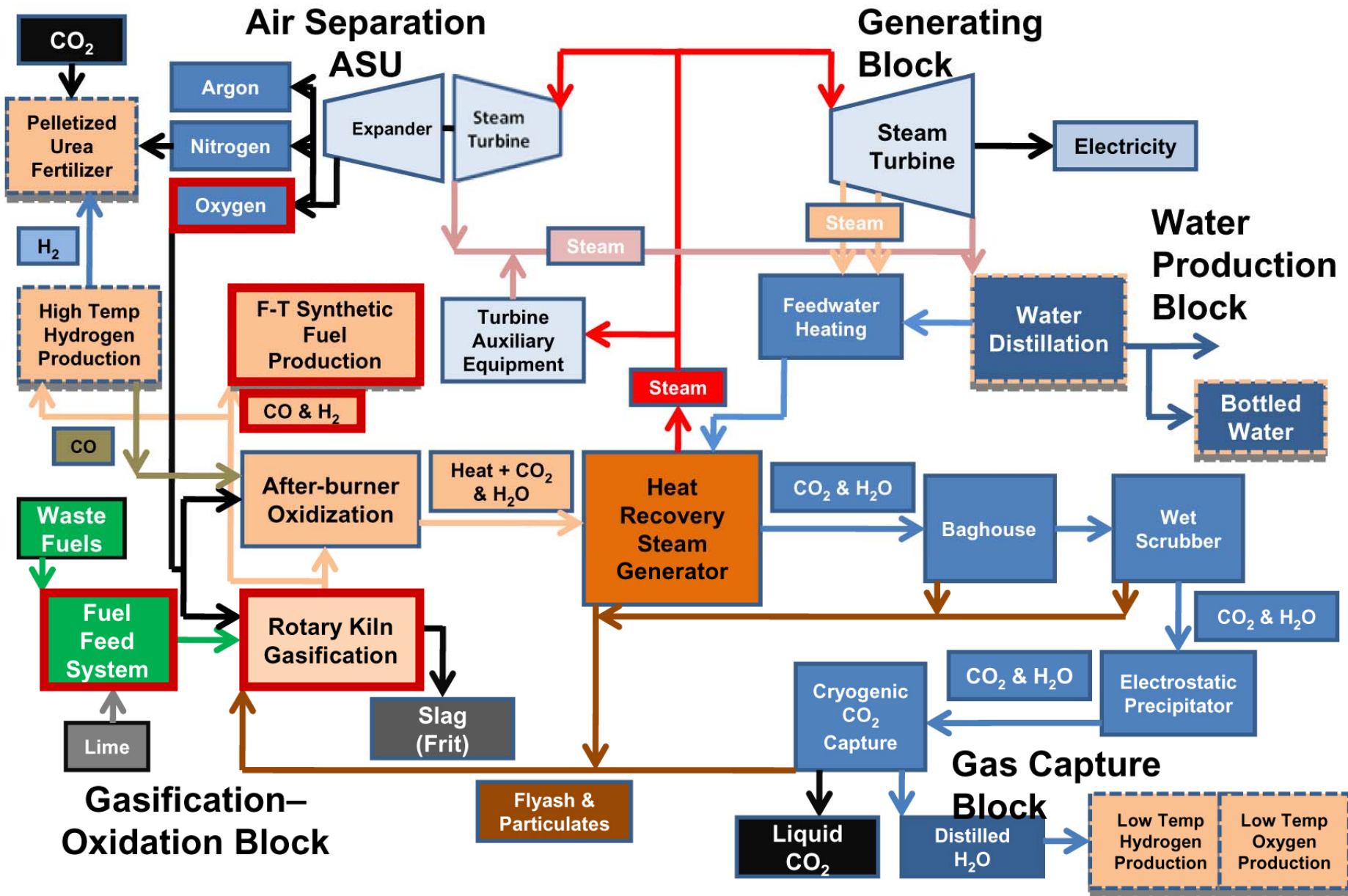


Rotary Kiln Technology

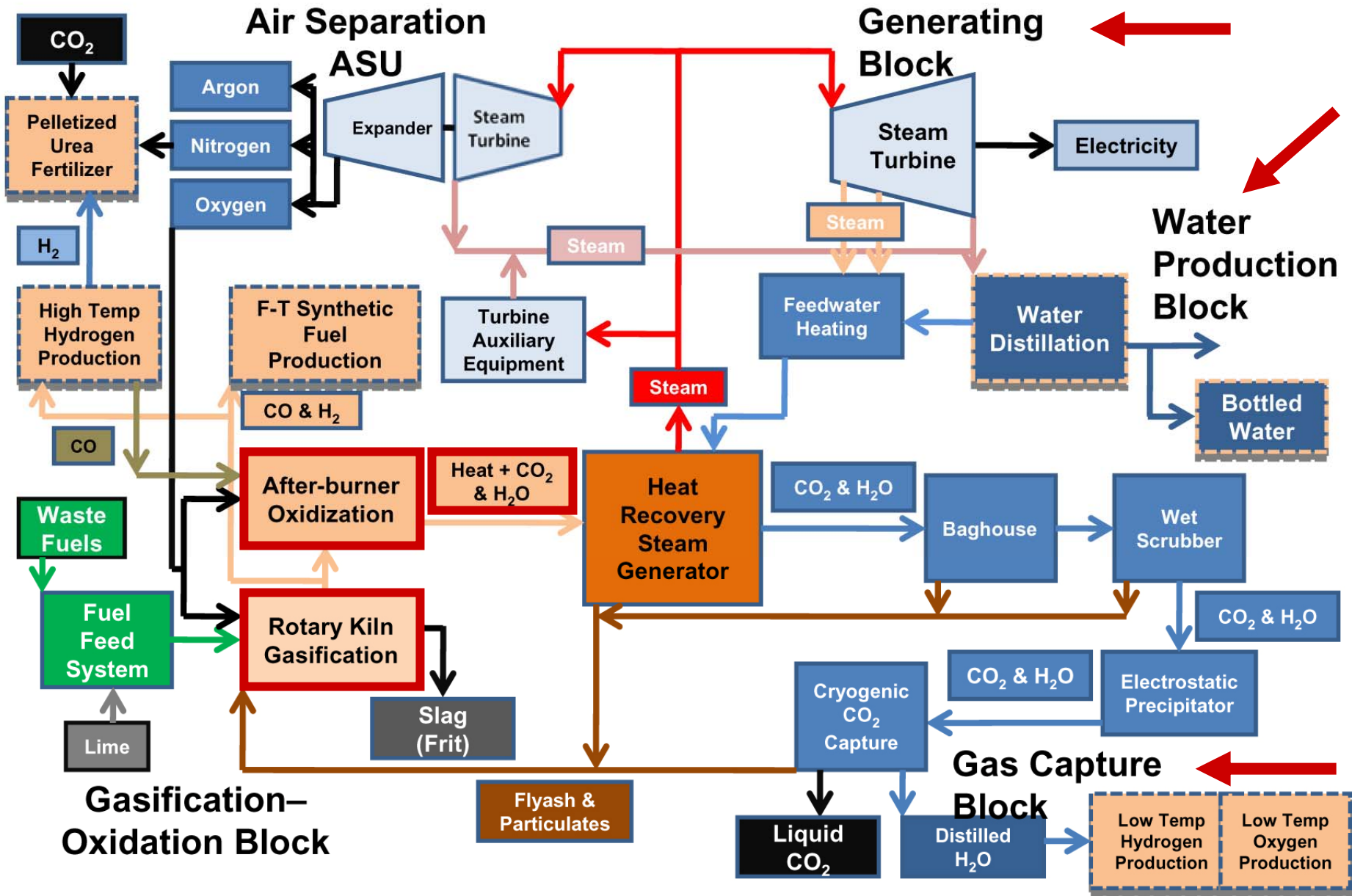


Metso Minerals designs and supplies both direct fired and indirect fired rotary kilns for a wide variety of applications. They have supplied over a thousand rotary kilns ranging in size up to 7.6 meters in diameter and 190 meters in length.

Product Options



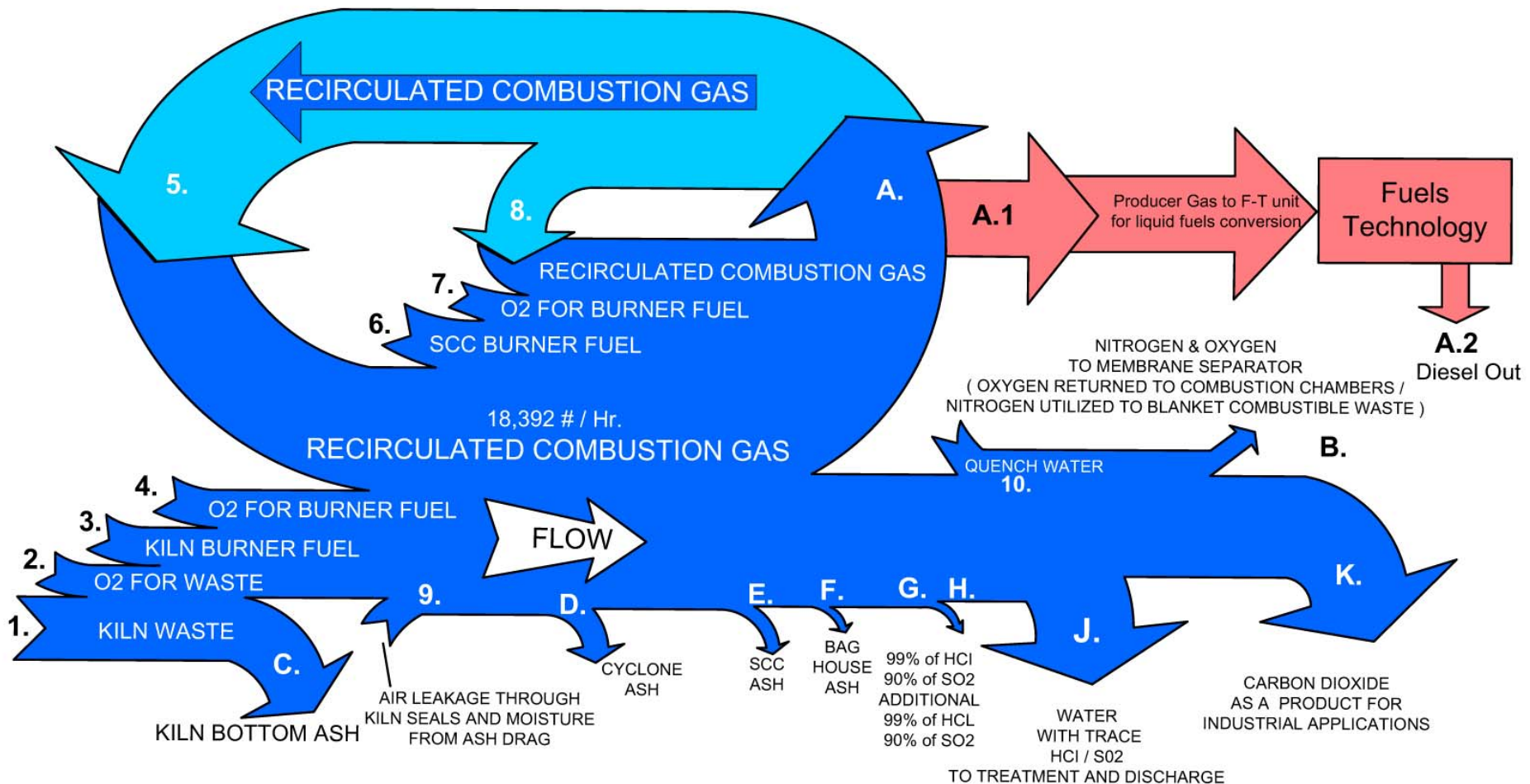
Product Options





ZEROS

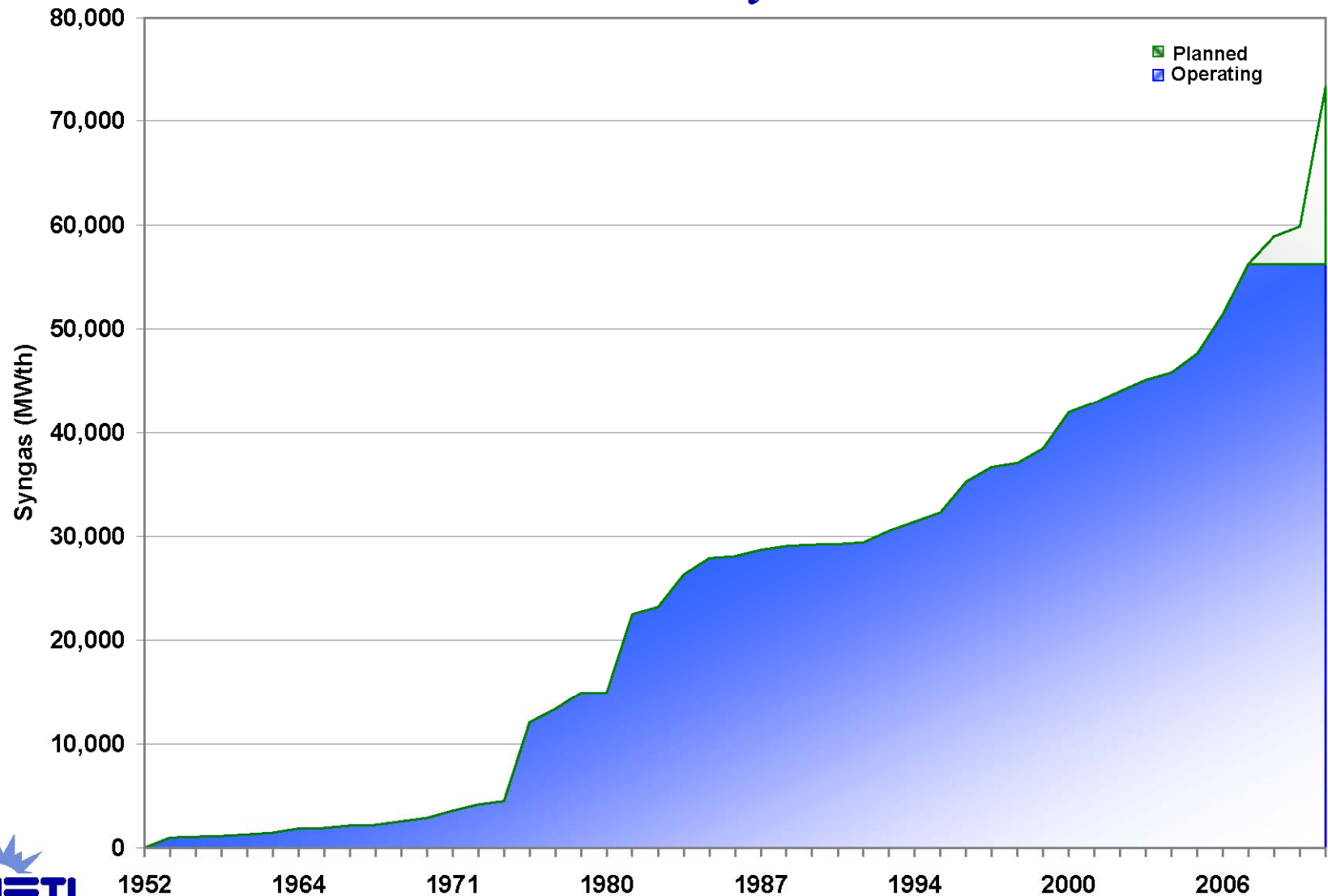
Mass - Balance



"ZEROS" Zero-emission Energy Recycling Oxidation System - MASS BALANCE DIAGRAM

Worldwide Gasification Capacity and Planned Growth

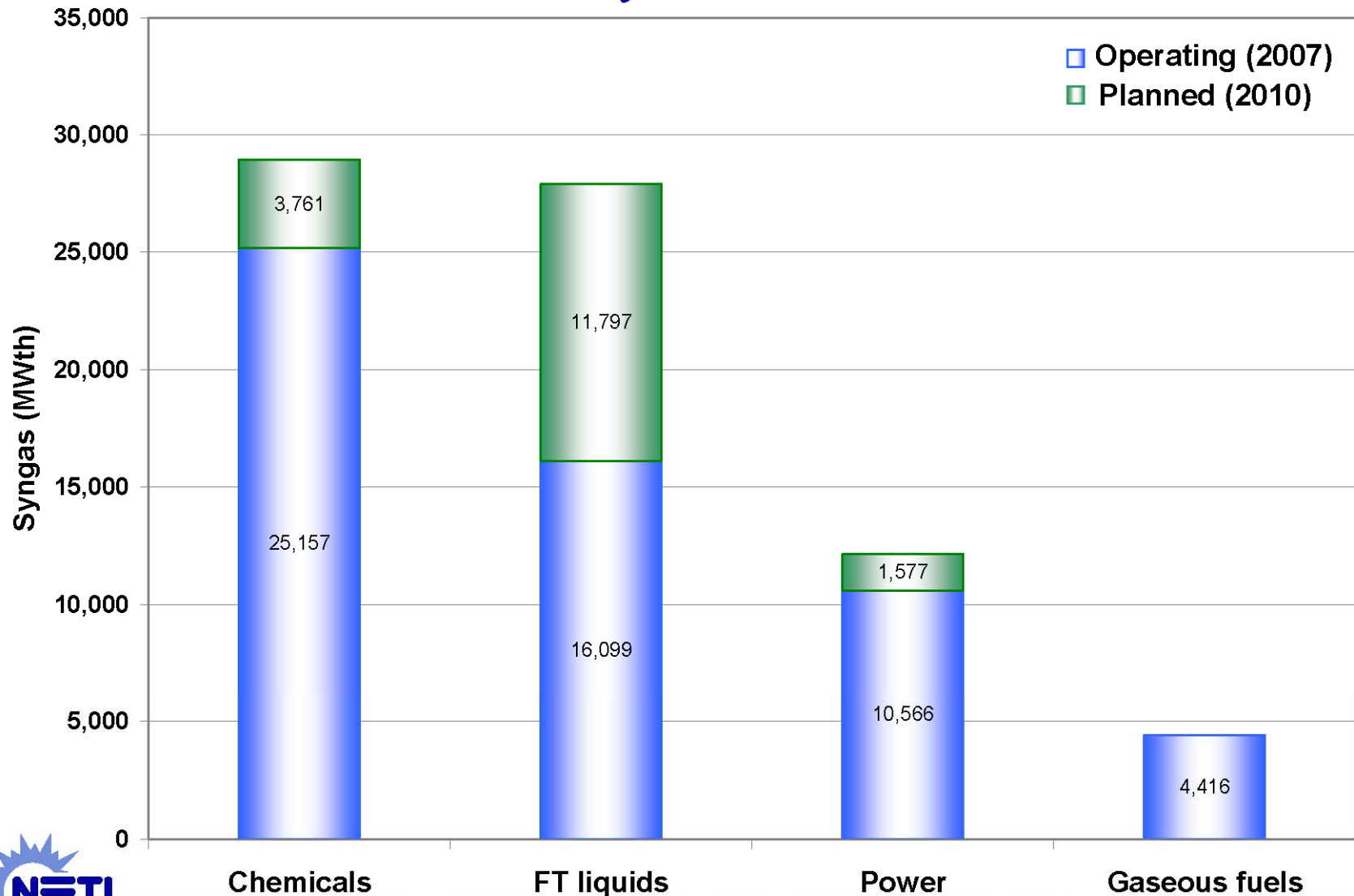
Cumulative by Year



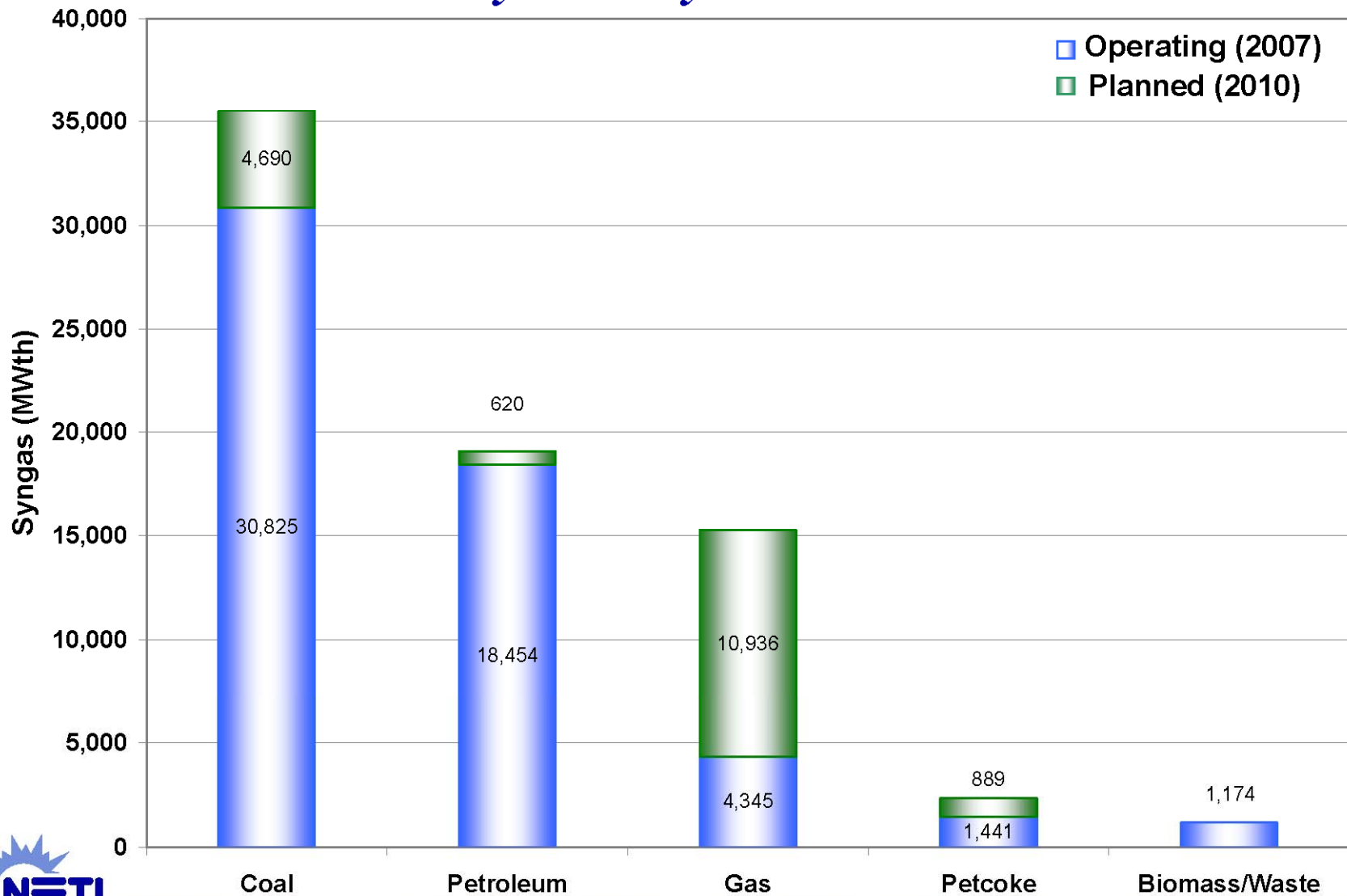
Worldwide Gasification Capacity and Planned Growth *by Technology*



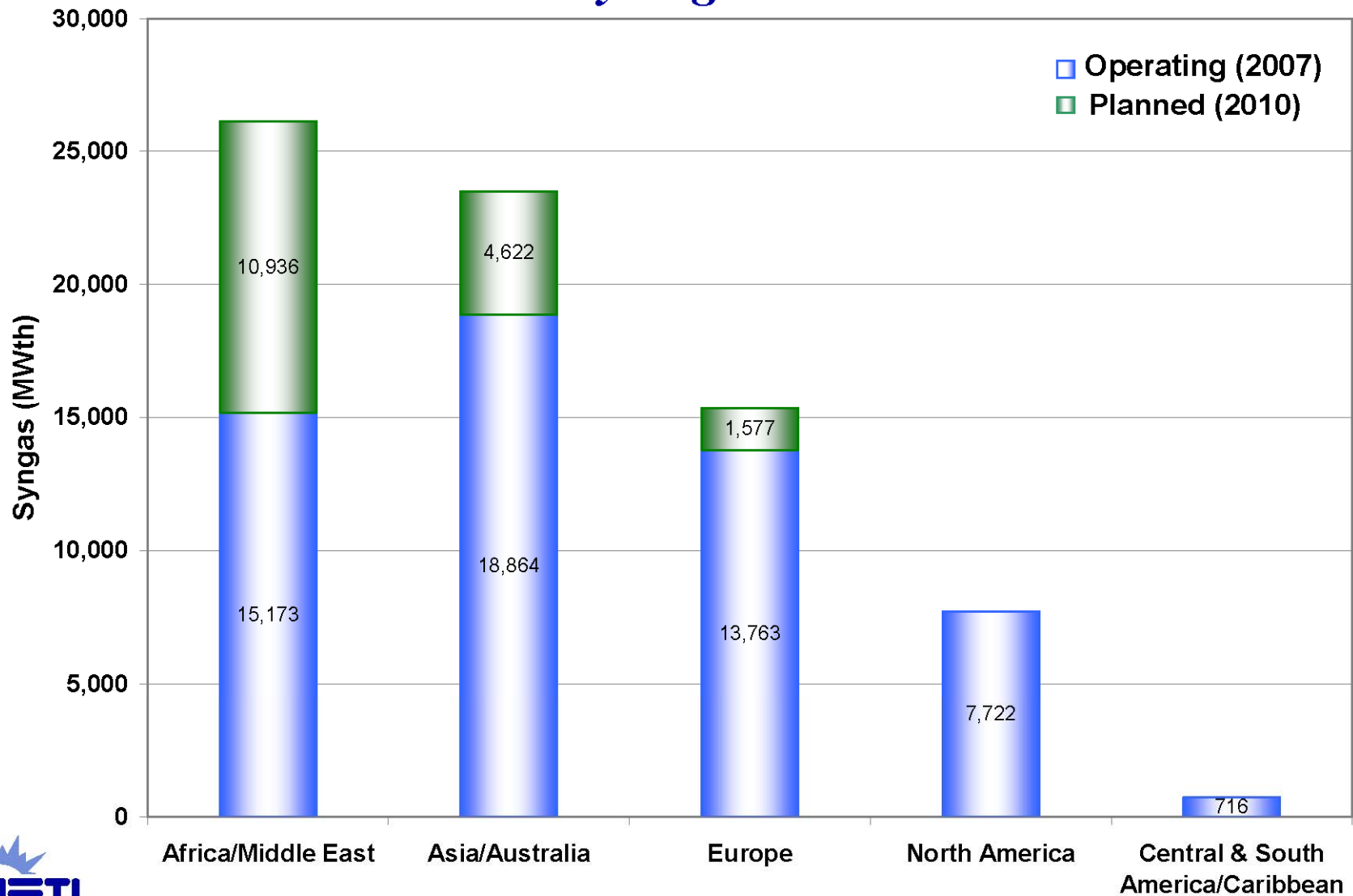
Worldwide Gasification Capacity and Planned Growth *by Product*



Worldwide Gasification Capacity and Planned Growth by Primary Feedstock

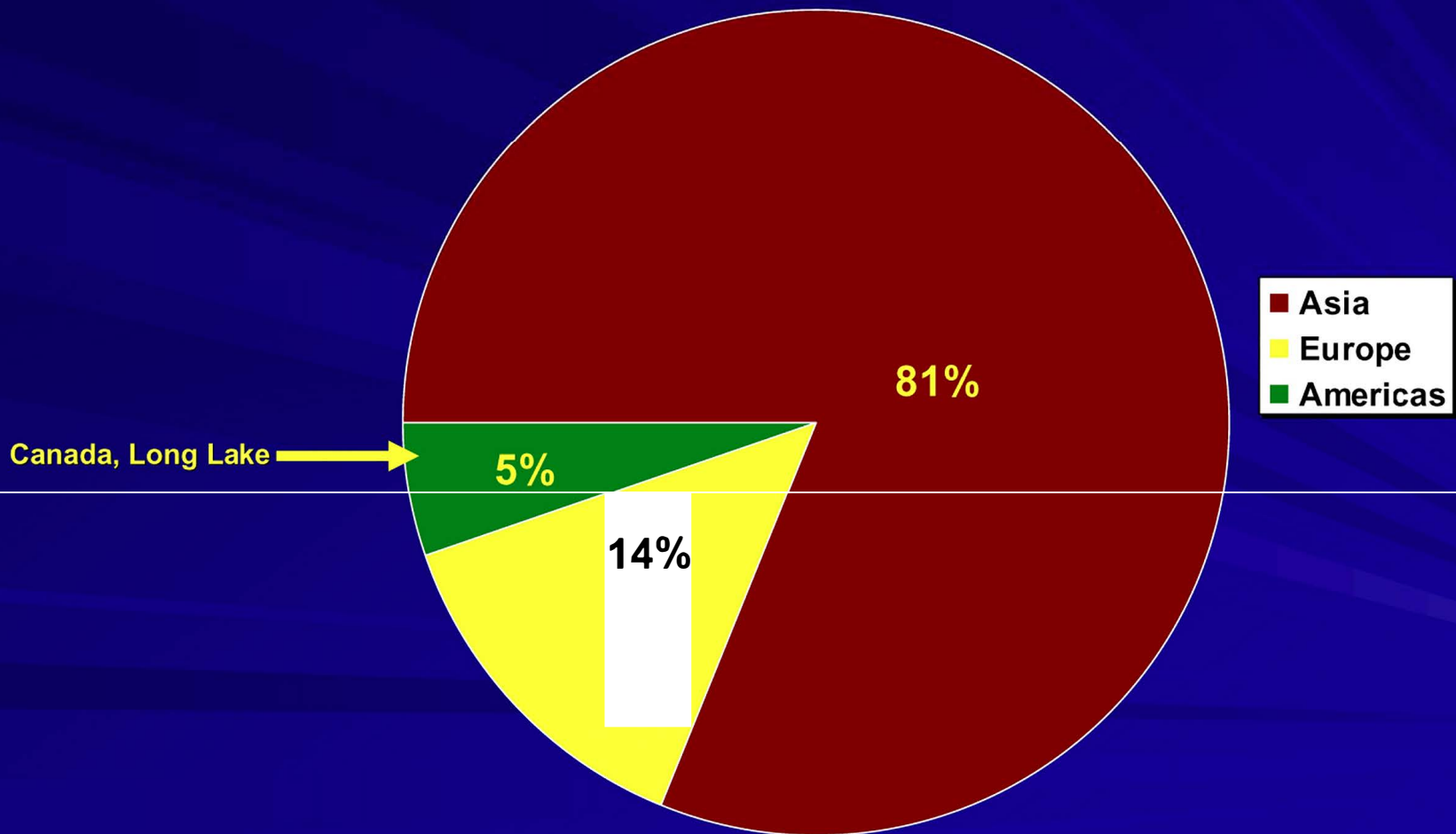


Worldwide Gasification Capacity and Planned Growth *by Region*





Shares of Growth in World Gasification Capacity

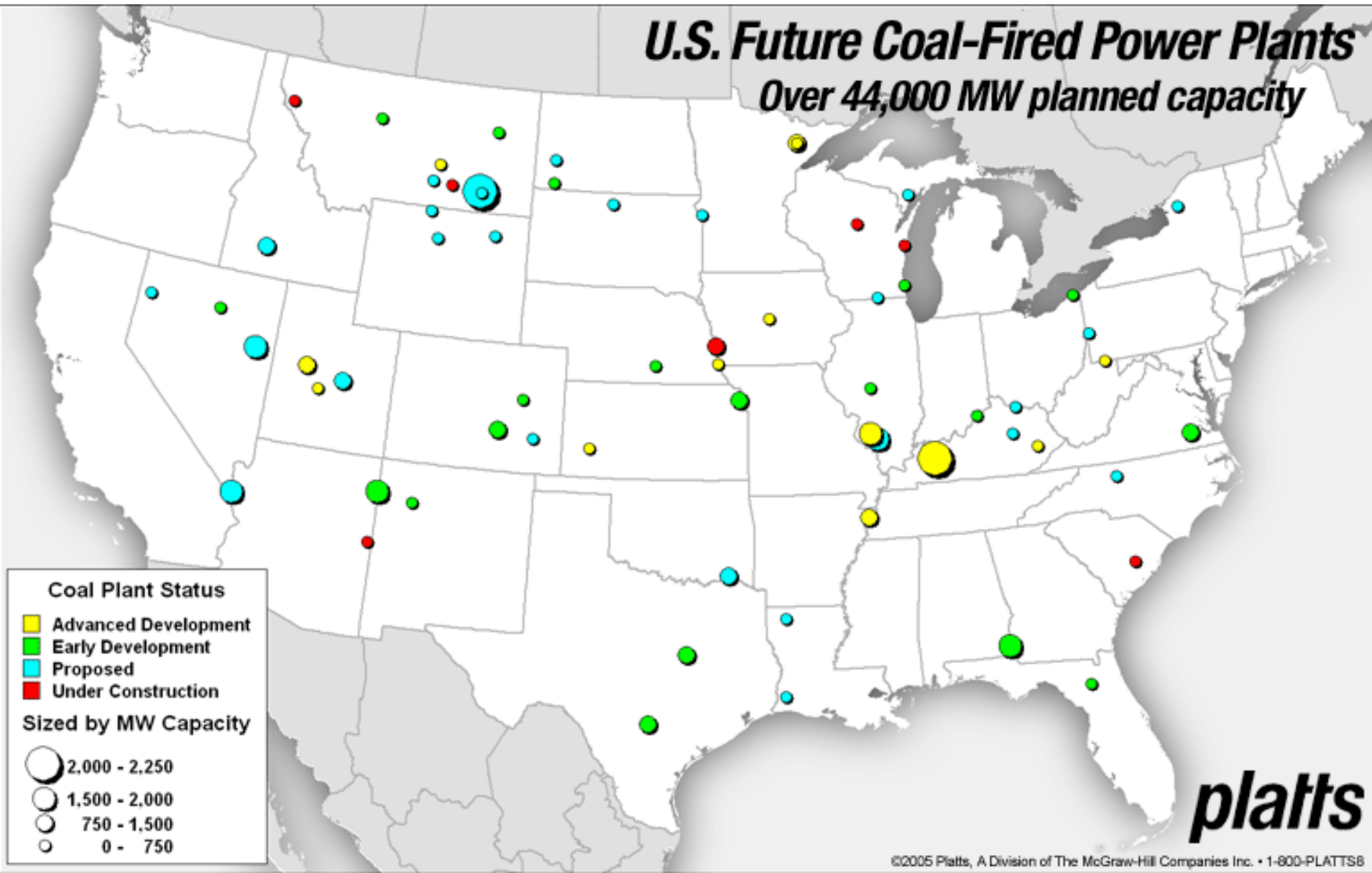
2004-2010
(without Pearl GTL)



2004-2014 Gasification Scoreboard

	China	29
	U.S.	0

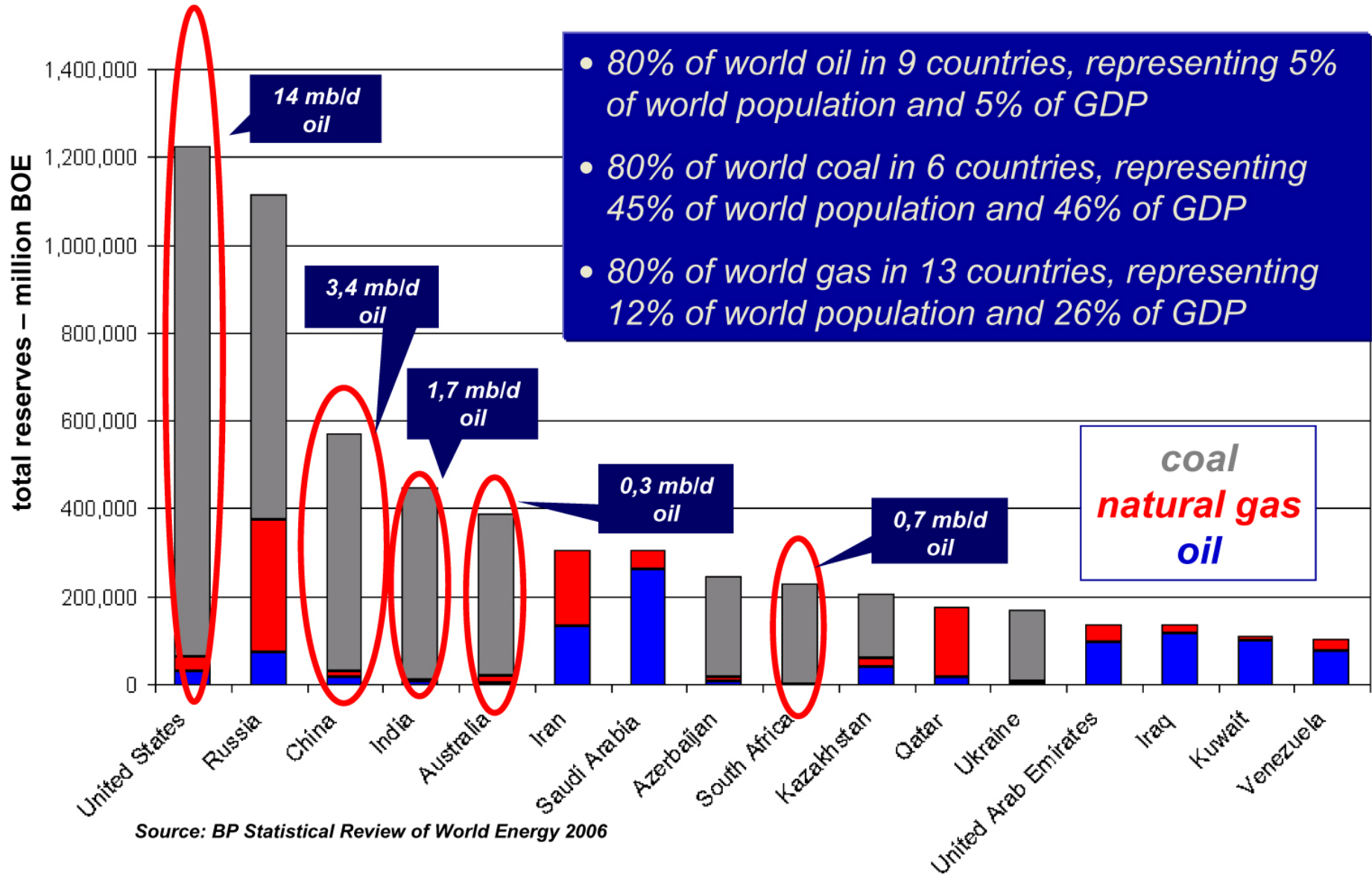
More of the same?



U.S. Gasification Outlook

- No new gasification-based plant has started up since 2012.
- Challenges posed by:
 - High/rising construction costs, project finance, lower cost competition in power market, uncertainty about future public policy incentives/regulations.
 - Anti coal attitudes, even when employing “clean” technologies (e.g. IL Sierra Club v. Taylorville IGCC)
- However, high degree of interest in new plants due to:
 - Oil/gas prices and price expectations,
 - More stringent criteria pollutant control requirements,
 - Growing consensus that CO₂ controls are on the horizon.

ZEROS & Coal for Energy Security





ZEROS Integrated Technologies

✓ Gasification / Oxidation

- Rotary Kiln Gasifier
- Oxygen replaces air in gasifier (Air Separation Unit) zero Nox.

➤ Rankine Cycle

- Heat Recovery Steam Generated Electricity

• Fischer-Tropsch

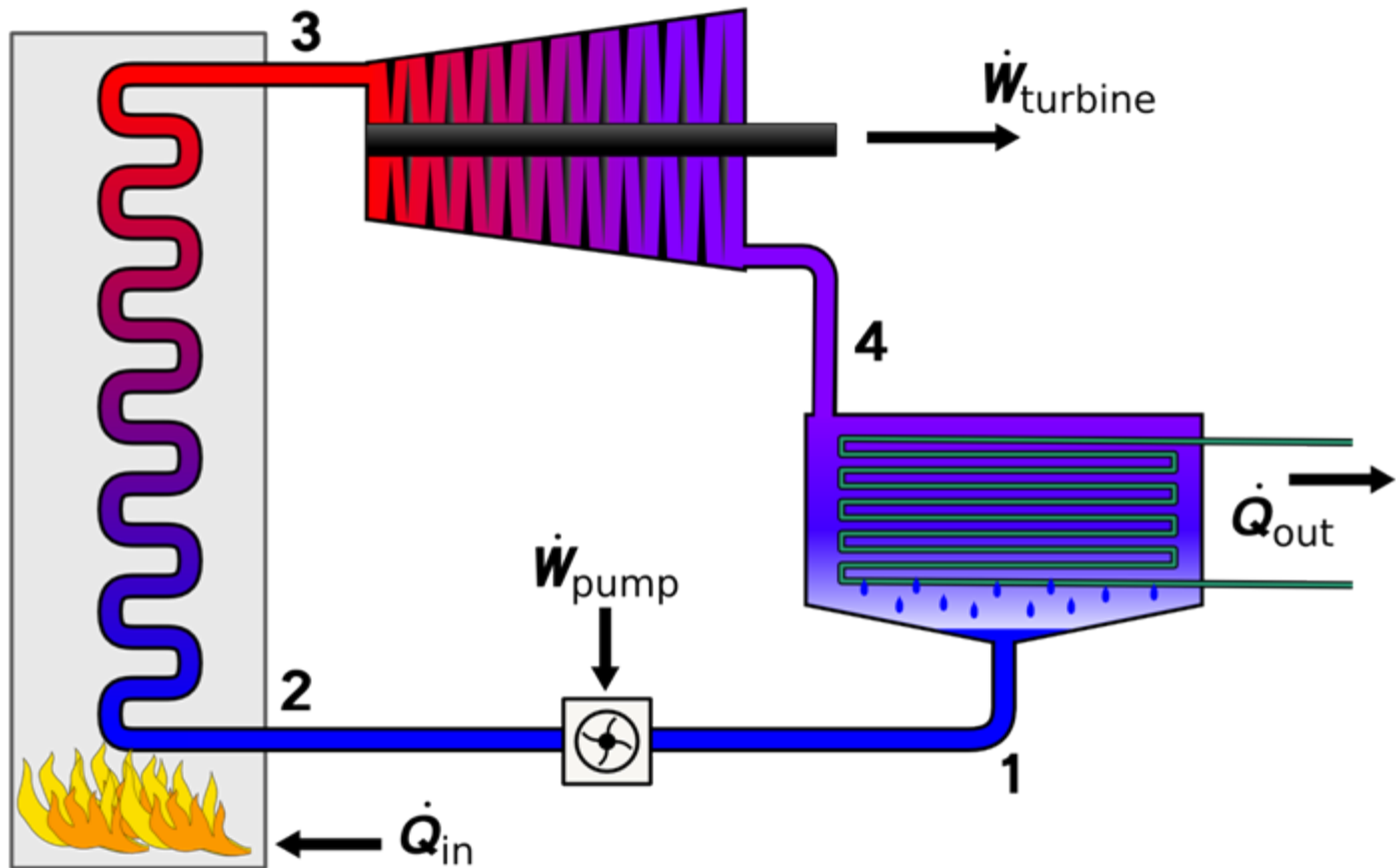
- Liquid fuels – diesel, gasoline, jet fuel

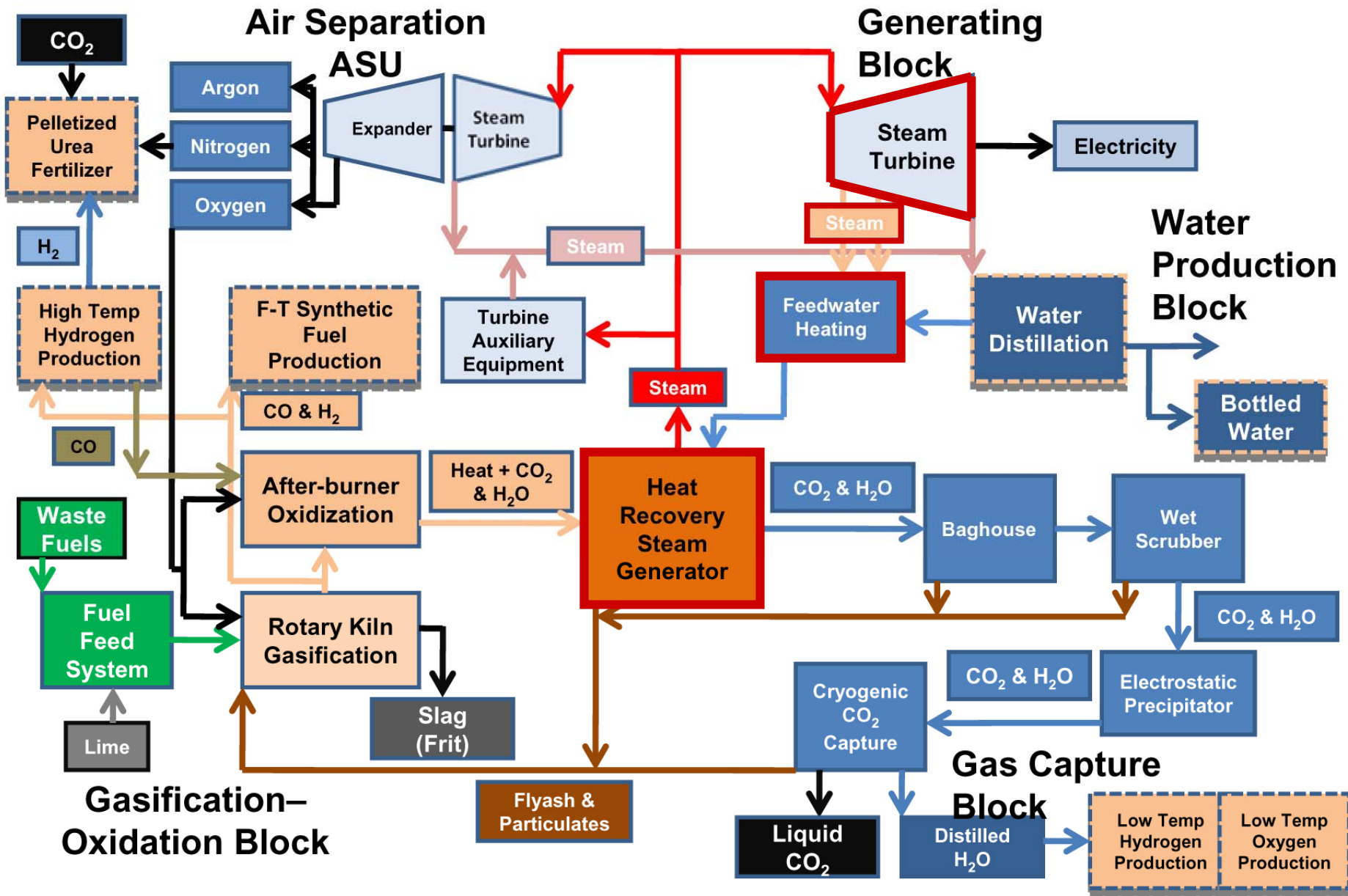
• Gas Capture

- CO₂ capture and sale for Enhanced Oil Recovery

• Clean Water Production

Rankine Cycle Technology







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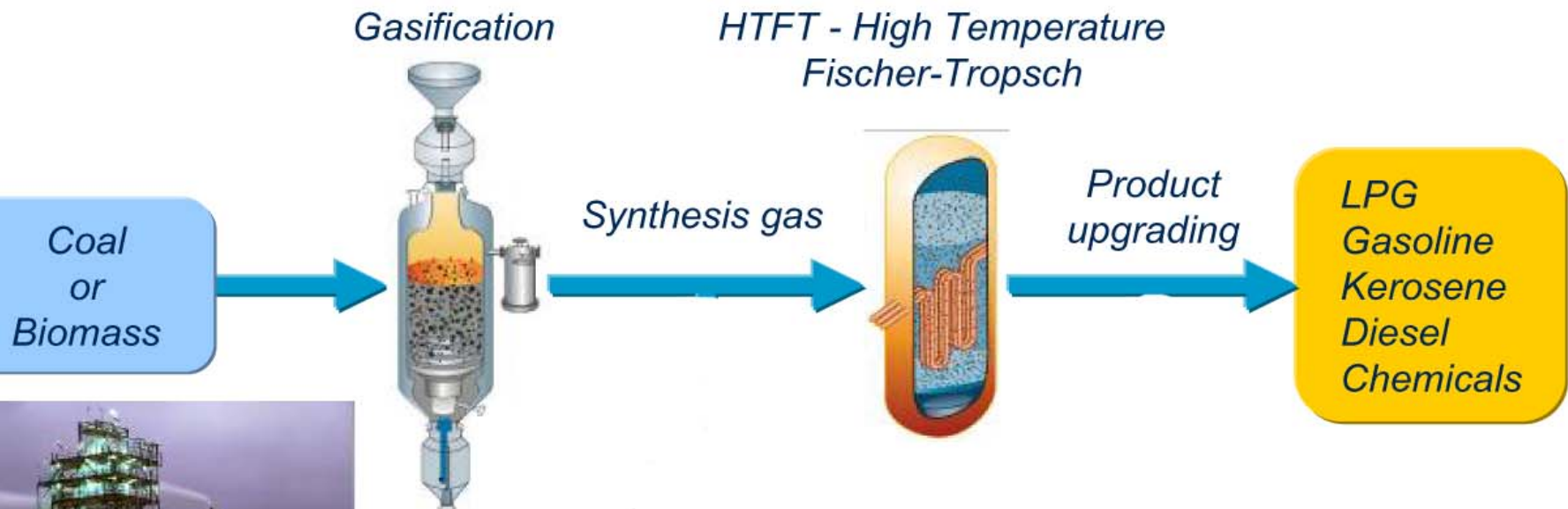
• Clean Water Production

Fischer-Tropsch Technology

- Invented in petroleum-poor but coal-rich Germany in the 1920s, to produce liquid fuels.
- Used by Germany and Japan during World War II to produce ersatz fuels.
- Germany's annual synthetic fuel production reached more than 124,000 barrels per day from 25 plants in 1944.
- Currently, only a handful of companies have commercialized their FT technology.

Sasol FT in South Africa

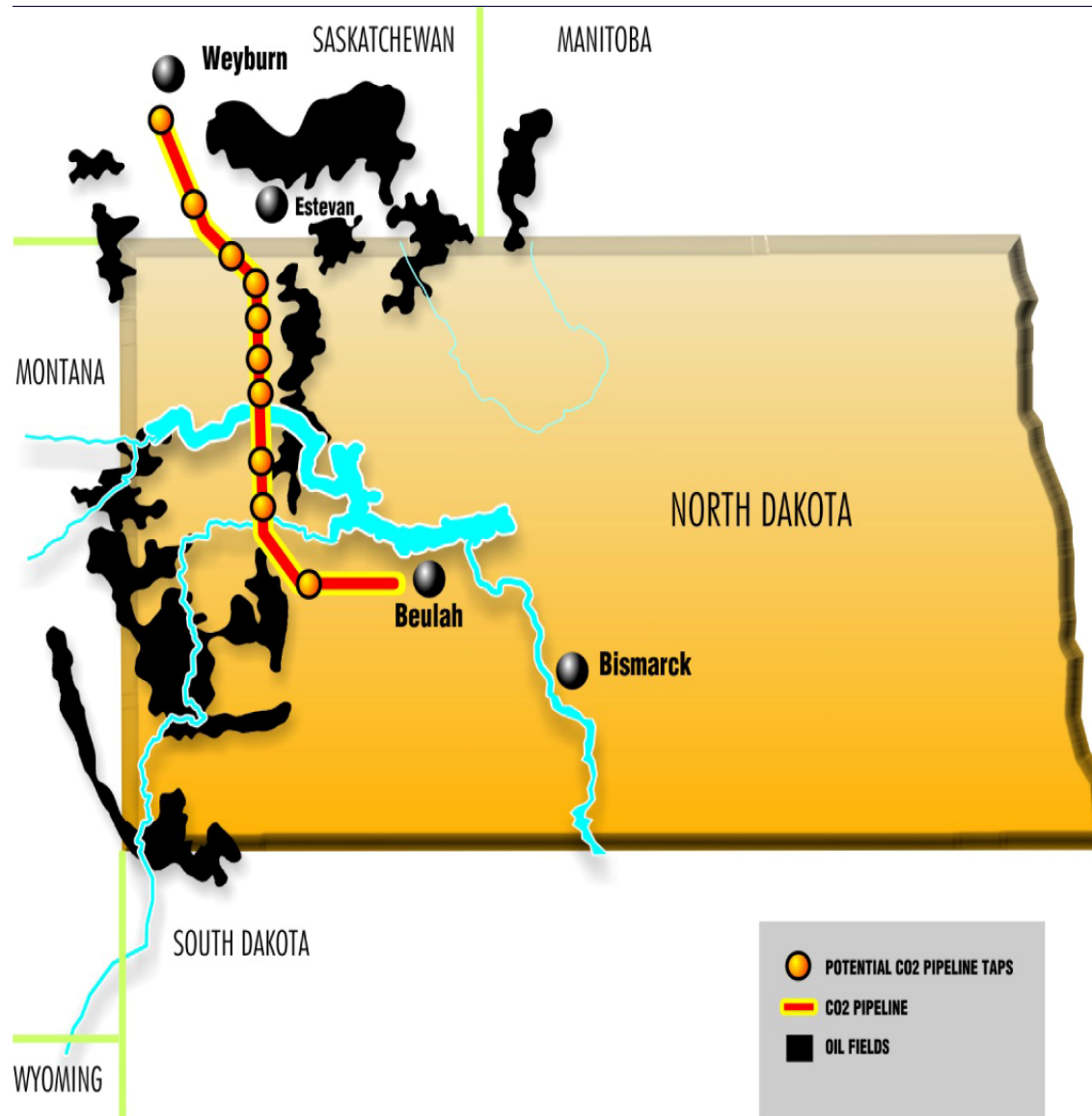
- Produces 150,000 Bbl/day at their Secunda Plant.
- Has produced 1.5 billion barrels since August, 1955.



Great Plains Synfuels Plant Produces 54 BCF/yr of Methane From 6 million tons of North Dakota Lignite



CO₂ is piped 205 miles for Enhanced Oil Recovery





FT fuels-according to the US DOE

- Taking credit for the value of CO₂, sold power, naphtha, and other products, and any premium for the high quality fuel, F-T liquids could compete with oil at a crude oil price of \$41 to \$61/ Bbl.
- Volumes of captured CO₂ may be injected into oil reservoirs to increase oil recovery or into coal seams to enhance coal bed methane production.
- The F-T process produces superior quality diesel fuel that has virtually no sulfur, very low aromatic content and a high cetane number.



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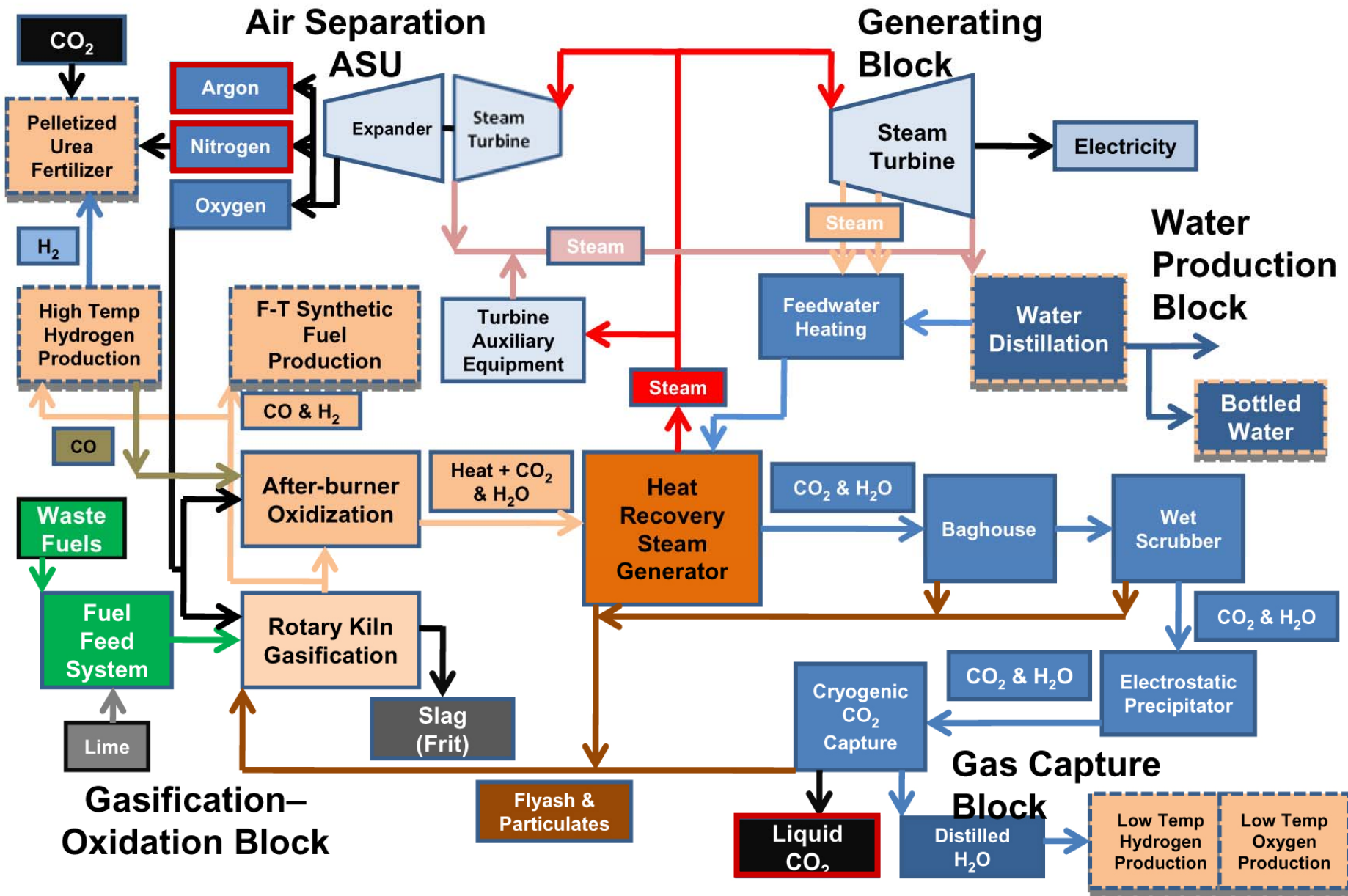
➤ Clean Water Production

Gas Capture Technology



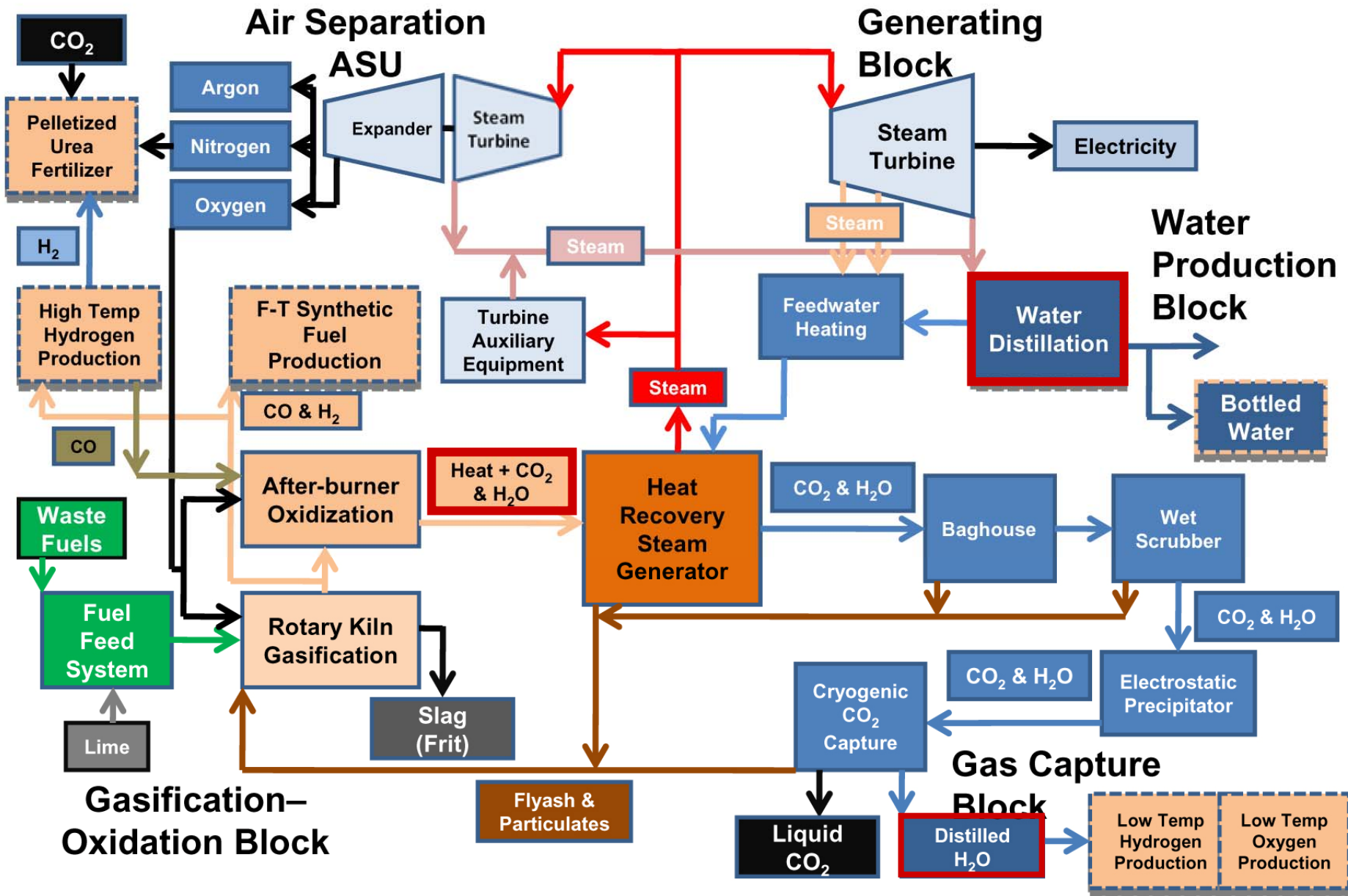
Air Products – Martinez, CA Hydrogen Plant

Product Options



Clean Water Production

- Zero water required by system.
- Distilled water is a by-product of the after-burner oxidation.
- Example – Coal to Synthetic Diesel & Power Plant (32 million gallons + 50 MW gross – 32.71MW net) produces 124 million gallons of pure distilled water.



Technology Comparison

Waste to Energy / Alternative Energy Technologies

	Incineration	Gasification (IGCC)	Pyrolysis	Plasma	Gasification-Oxidation
Capital Costs	Medium	High	Medium	Medium	High
Operating Costs	Medium	High	Medium	Medium	High
Maintenance Costs	Medium	High	Medium	Medium	High
Fuel Flexibility	Good	Low	Medium	High	High
Biomass / MSW	High	Good	Good	High	High
Coal Fuels	Medium	High	High	High	High
High Sulfur Fuels	Medium	Excellent	Medium	Excellent	Excellent
Base Emission Level	High	Good	Medium	Good	None
Stack Gas Cleanup Rqmts	High	Medium	Medium	Medium	Low
Heat Rate	Medium	Good	Medium	High	Good
Water Requirements	Low	High	Low	None	None
Current CO ₂ Capture	None	None	None	None	100%
Electrical Production	High	High	High	High	High
Hydrogen Production	None	High	None	High	High
Nitrogen Production	None	High	None	None	High
Argon Production	None	High	None	None	High
Sulfur Capture Capable	None	High	None	Medium	High
Non-Hazardous Slag	Medium	High	Medium	High	High
Non-Hazardous Ash	Medium	High	Medium	High	High
Produces Water	None	None	None	None	High
Water Distillation	High	High	High	High	High
F-T Diesel Capable	None	High	None	None	High
Pelletized Urea Capable	None	High	None	None	High

The background of the image is a dense, overlapping collage of US dollar bills. The bills are shown at various angles, creating a sense of movement and abundance. The colors are muted, with a greyish-green tint. The text 'ZEROS Economics' is centered over this background.

ZEROS Economics

Chambers Fuel & Energy Organic Waste ("MSW")

Chambers Fuel & Energy, LLC CoGen Refinery
Pro Forma Investment Summary - Typical Plant (\$ 000's)
December 24, 2017

Capital Cost	\$618,546	
Synthetic Diesel/Jet Fuel Production	40,000.000	million gallons / year
Wholesale Diesel Price	\$2.95	per gallon
Diesel Product Cost	\$0.41	per gallon
Power Production	744,600	MWh's
Wholesale Power Price	\$120.00	per MWh
Diesel/Jet Fuel Sales	\$118,000	42%
Power Sales	\$89,352	32%
By-Products Revenues (CO2, Nitrogen, Argon, Ash)	\$74,809	27%
Total Annual Sales	\$282,161	
Equity	\$617,927	
Financing - Loan to Value	0%	
Interest Rate	8.00%	
Term	20	years
DSCR Initial	3817.94	
DSCR Average	4267.37	
Tax Rate	25%	
Ten Year MACRS		
Benefit / Cost Ratio	3.63	
Discount Rate	6%	
Per Year After-tax Return on Capital	32.4%	
Per Year After-tax Equity IRR	32.4%	



Leading the Way to American Energy Security

- **Patented Gasification / Oxidation Method & System**
 - **Integration of established technologies**
 - **Constructed with off-the-shelf equipment & controls**
 - **Fuel & Output Flexible**
 - **High Efficiency = High Investment Returns**
 - **Zero emissions**
 - **Zero waste streams**
 - **Zero water demand**
- } = **No Environmental Permit Issues**
- **Clean water production**
 - **Much shorter permitting time & less permitting risk**



For American Energy Security



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