



# Chemical Market Resources, Inc.

## **ALTERNATIVE FEEDSTOCKS** **For the Petrochemical Industry** **Status & Future**



**Alternative  
Feedstocks  
– Status &  
Future  
1/22**

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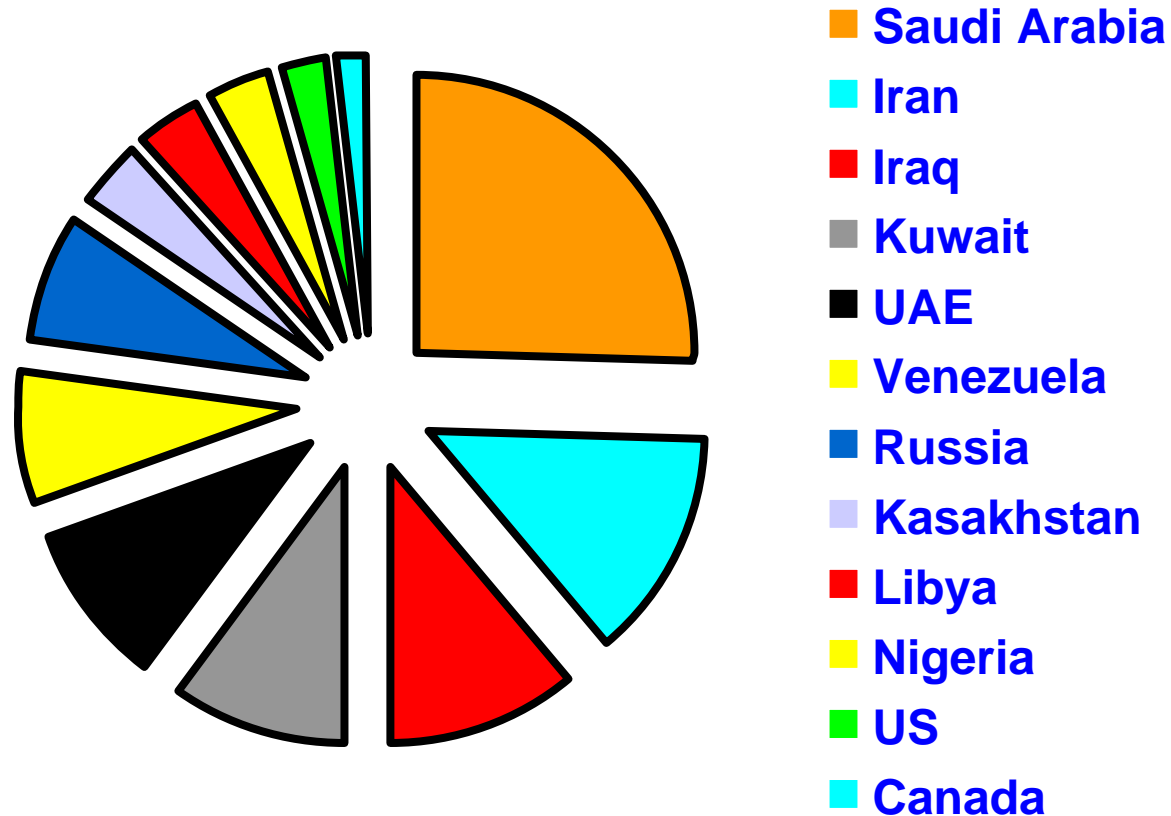
# Outline

- Introduction
- Status of current petrochemical feedstocks
- Overview of alternative petrochemical feedstocks
- Coal – Status & Future
- Natural Gas – Status & Future
- Biomass – Status & Future
- Conclusions



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## World Oil Reserves



**Total 1,201, billion bbl, Jan 2006**

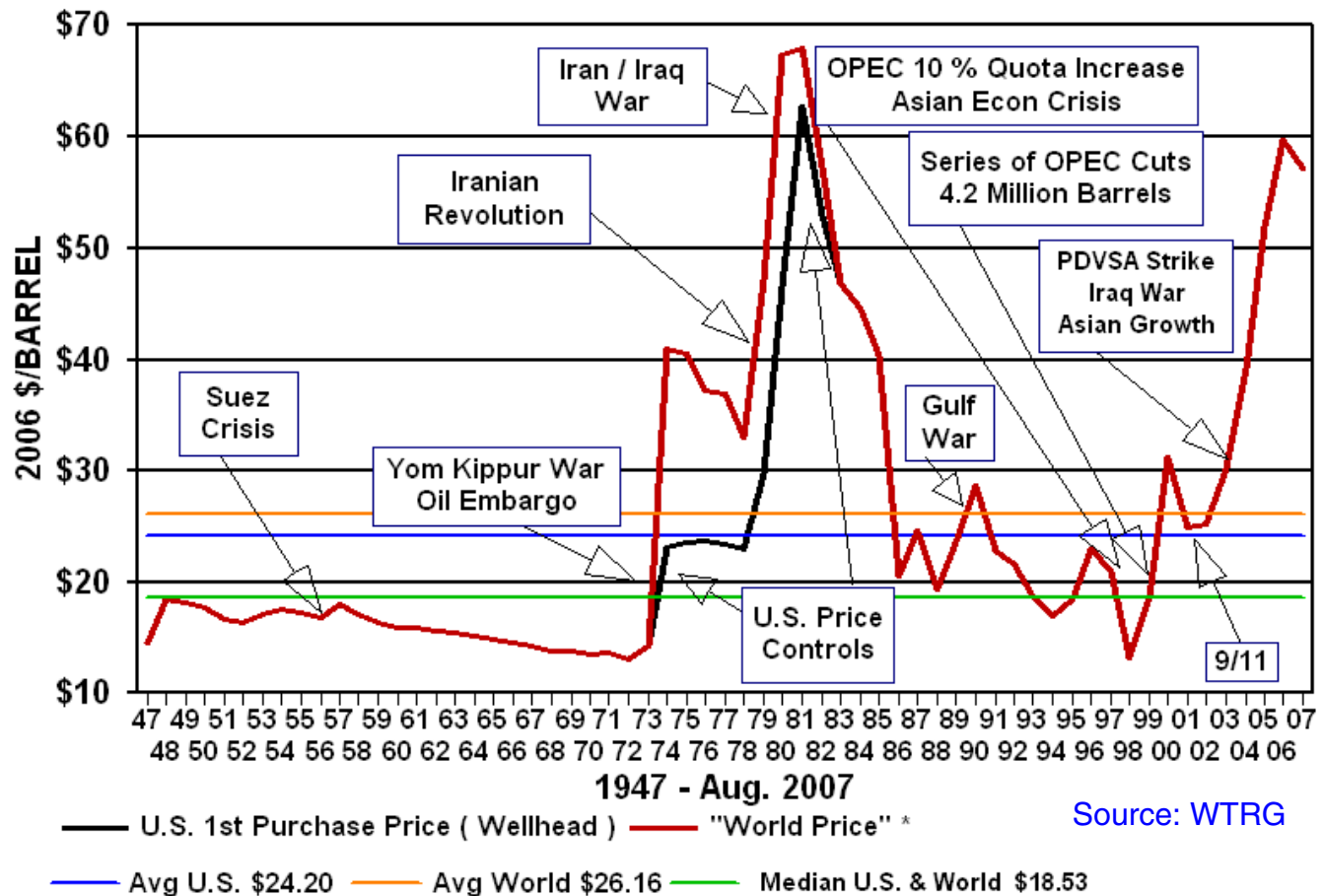


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# Status of Current Petrochemical Feedstocks

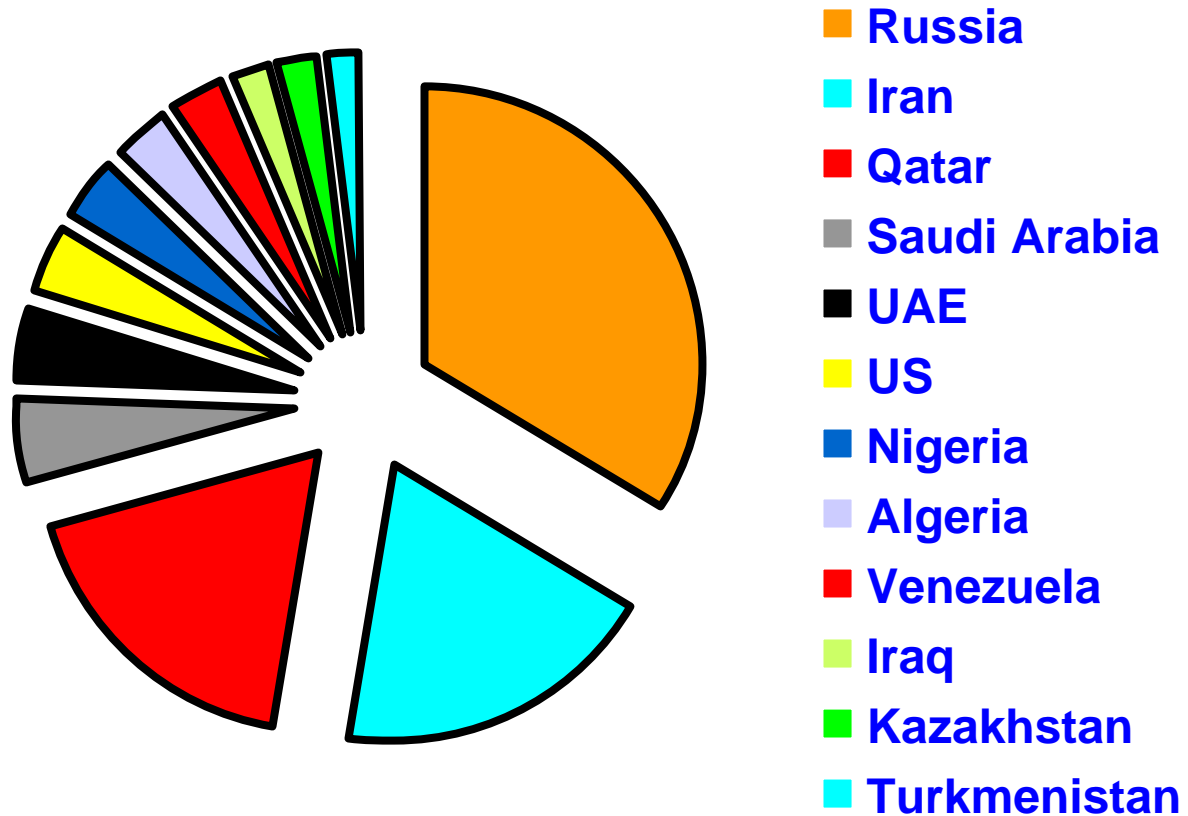
## Crude Oil (Naphtha)

- ✓ Physical quantity of reserves
- ✓ Price volatility
- ✓ Geopolitical situation



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## World Gas Reserves



- Recoverable reserves – 6,180 trillion cubic feet
- 80% of the proven natural gas reserves are stranded



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# Status of Current Petrochemical Feedstocks

## Objective

Alternative feedstocks for the production of petrochemicals and polymers



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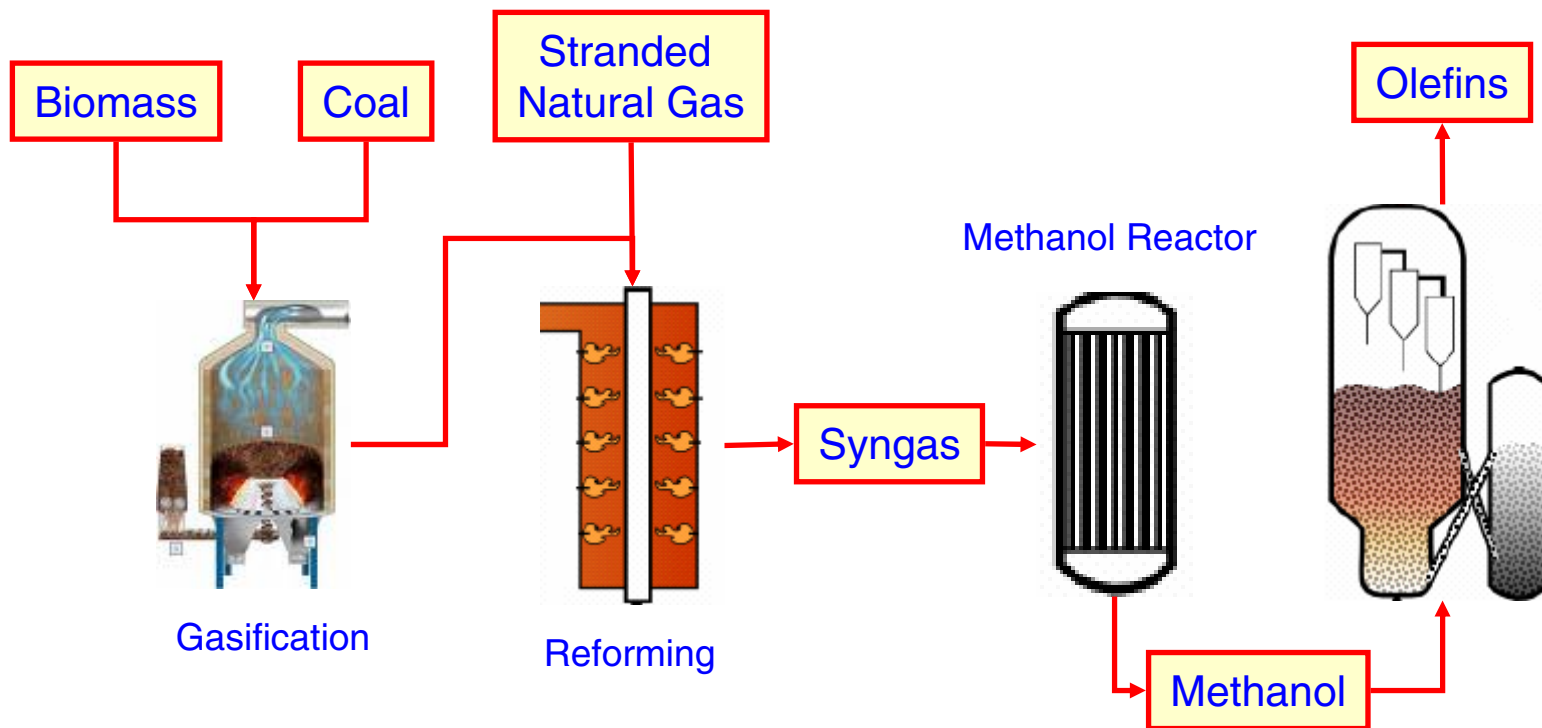


# Overview of Alternative Petrochemical Feedstocks

- ❑ **Significant emerging feedstocks for the petrochemical industry:**
  - **Coal**
  - **Stranded Natural Gas**
  - **Biomass**
  - **Unconventional resources – Oil sands**
  
- ❑ **Emerging Routes**
  - **New routes for production of traditional products (MTO, CTL, BTL...)**
  - **Development of new products (PLA, PHA ...) to replace traditional products**



# Overview of Alternative Petrochemical Feedstocks

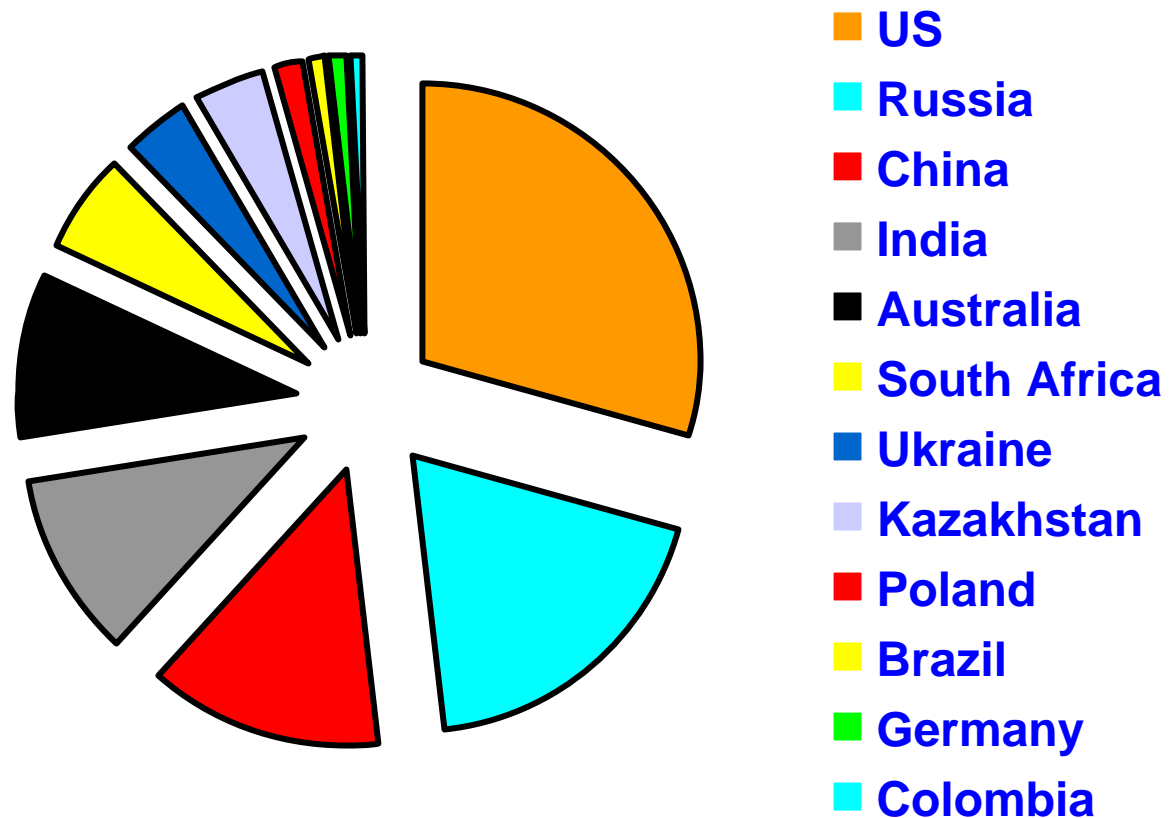


**Replacing the Traditional Crackers**

**Economics for Gas-to-olefin plants comparable to naphtha crackers**

# Coal – Status & Future

## World Recoverable Coal Reserves

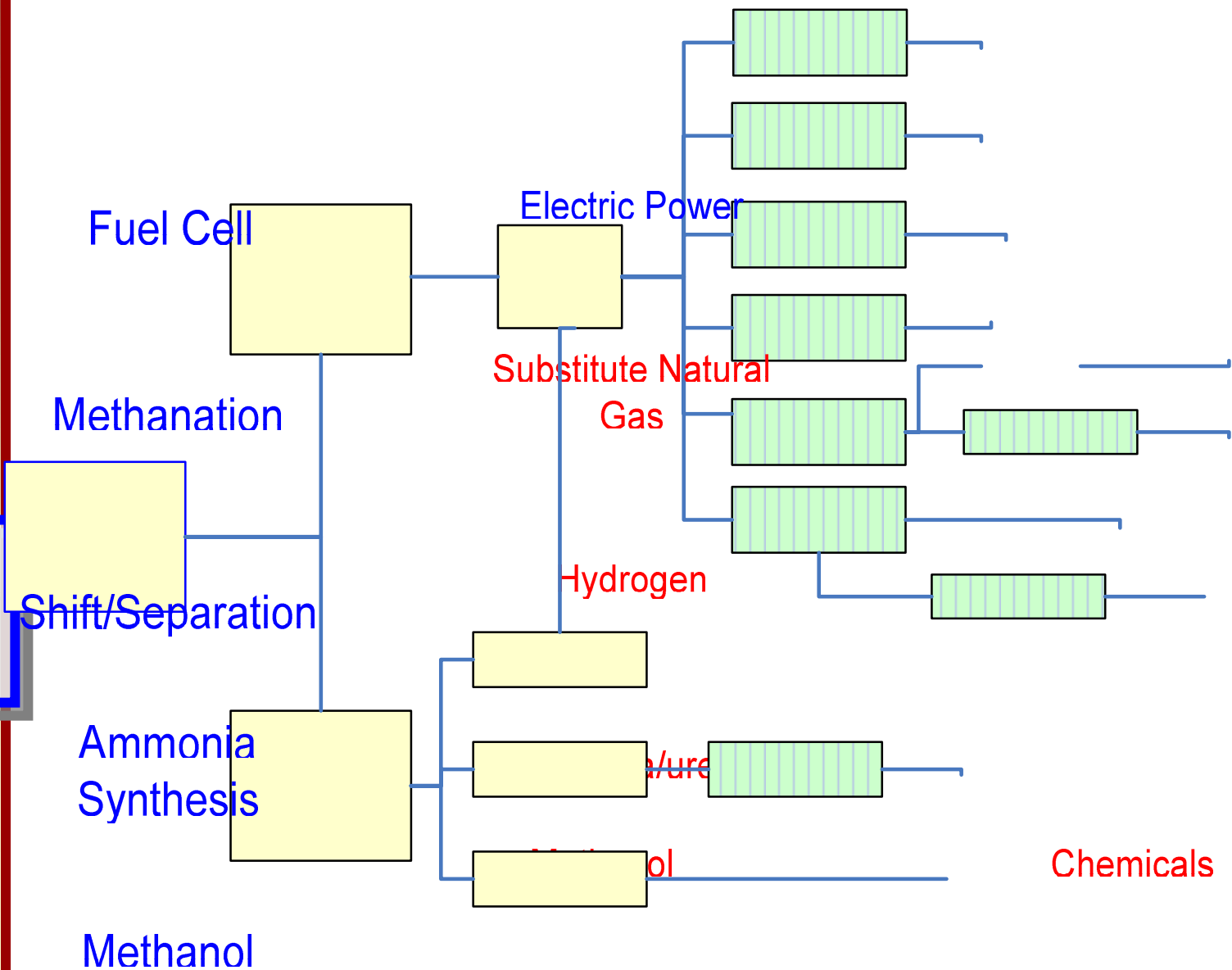


**Total 909 Billion Tons, Jan 2006**



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# Coal – Status & Future



# Coal – Status & Future

- ❑ Historically coal gasification research has been focused on fuels and power generation
- ❑ Current trend
  - ✓ Coal – Methanol – Chemicals/ olefins
  - ✓ Coal to Liquids (CTL)
- ❑ Regions with significant activity – China, Australia, South Africa, North America, India
- ❑ Past year has seen large coal chemical projects mushrooming in 19 of the 32 Chinese provinces
- ❑ Planned CTL projects in China, USA, Australia, India
- ❑ Key Companies – Sasol, Eastman, Syntroleum, ConocoPhillips and others



# Coal – Status & Future

## □ Coal – Chemicals

- Production of chemicals via the syngas and methanol route
- Methanol, DME – key products that would cater to the growing fuels market and downstream chemicals production
- Syngas to methanol/ DME: Lurgi, Haldor Topsoe, Davy Process Technology
  - Well known technology; mega methanol plants operating currently
- Methanol to olefins/ gasoline: Lurgi, UOP, ExxonMobil, Dalian Institute of Chemistry and Physics
  - Technology will be commercialized in China by 2009

## □ Coal Liquefaction

- Capital costs estimated as USD 3.5–4.5 billion
- Sasol – key proponent of the technology
- Shenhua China Coal Liquefaction Corp. constructing 20,000 bpd plant additional 180,000 bpd planned – will be the world's largest single train liquefaction plant
- Bench and pilot facilities at Rentech, Headwaters, Syntroleum, and ConocoPhillips

# Coal – Status & Future

## □ Issues

- High capital and operation costs
- Energy price volatility
- Some of the technology (direct liquefaction, MTO) is yet to be proven commercially
- **Finally – how clean are these coal technologies??**

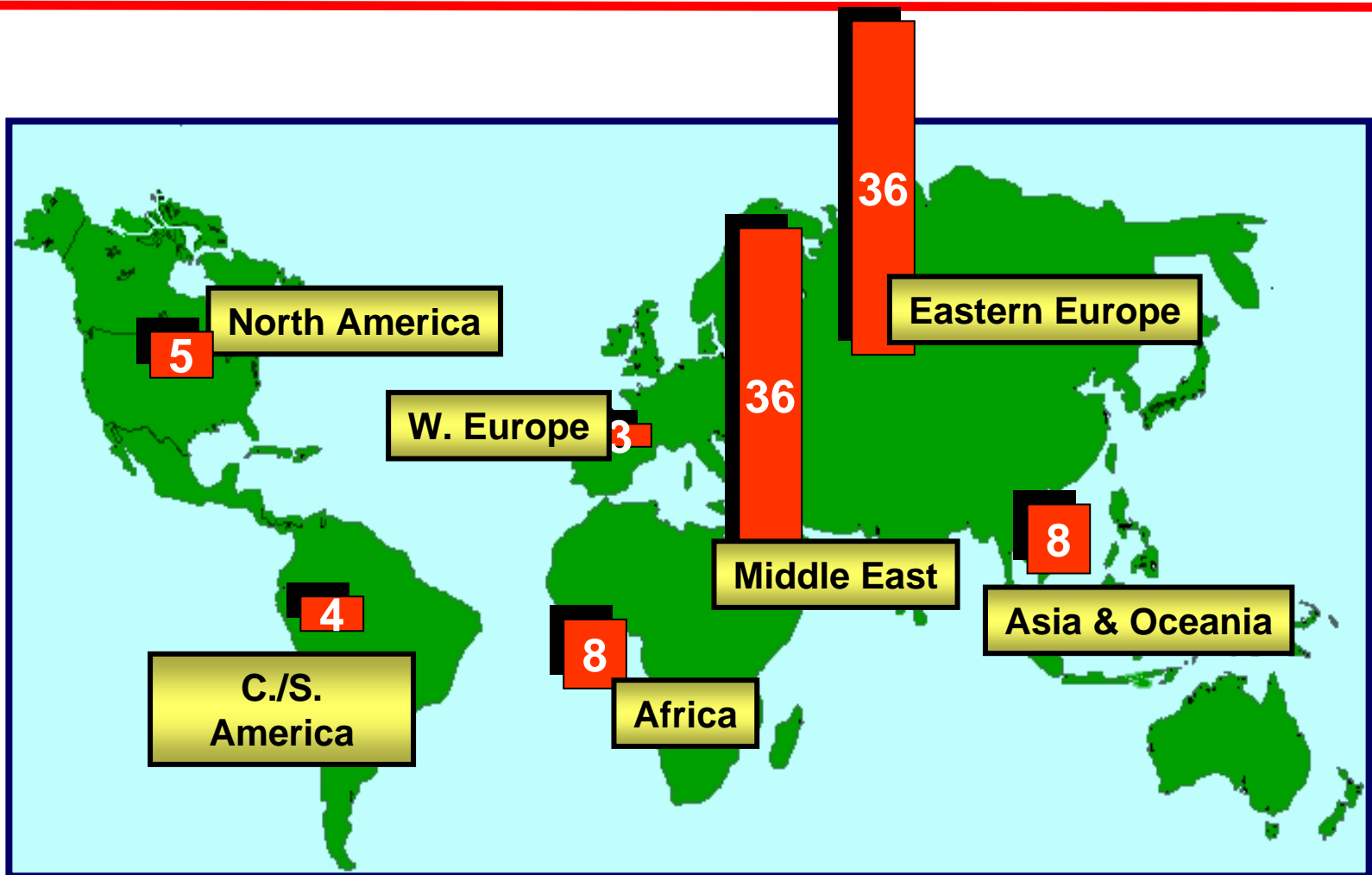


**Companies focusing on development of clean coal technologies for the future**



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# Stranded Natural Gas – Status & Future



Source: GTI; values in percentage



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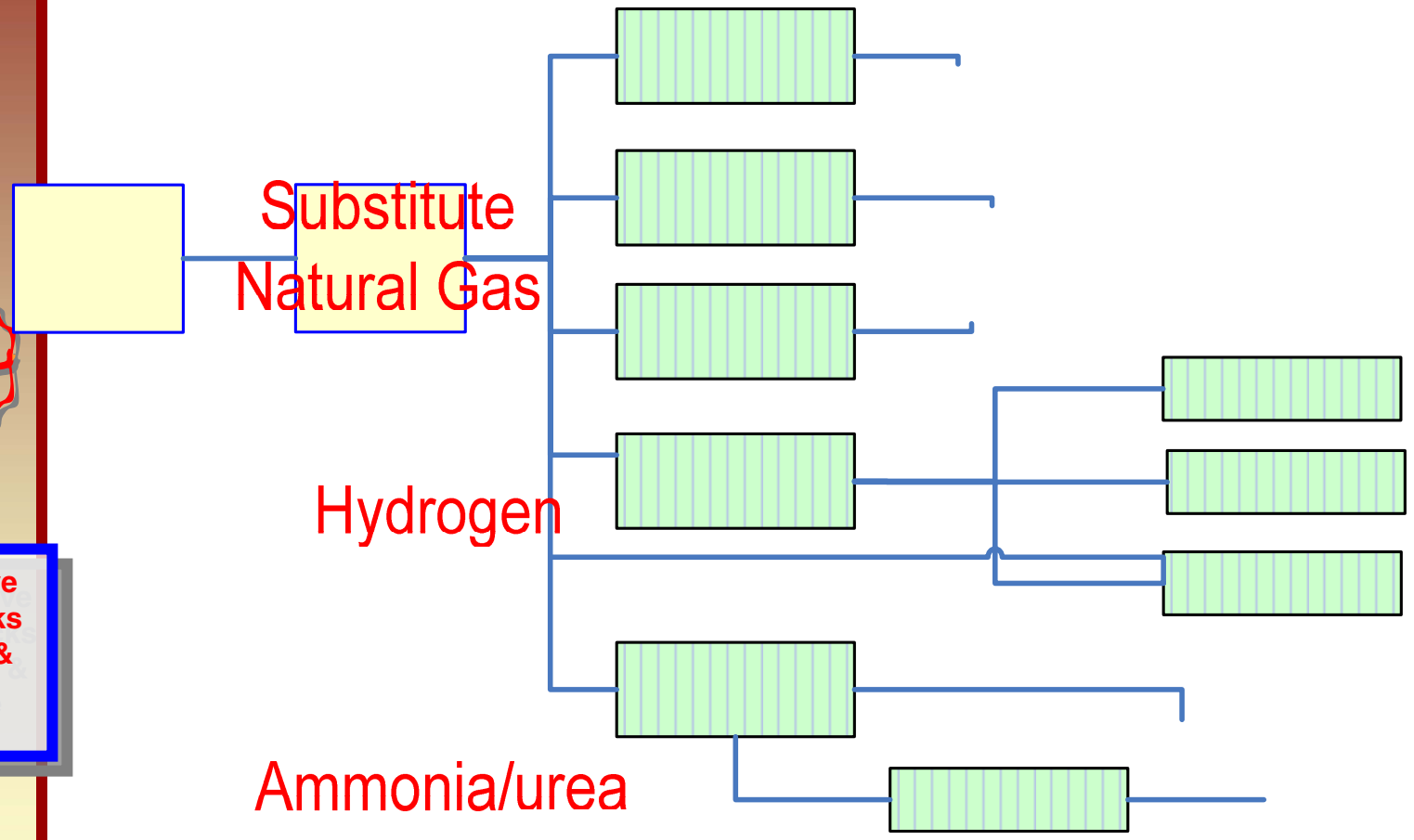
# Stranded Natural Gas – Status & Future

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MTO /MTP

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# Stranded Natural Gas – Status & Future

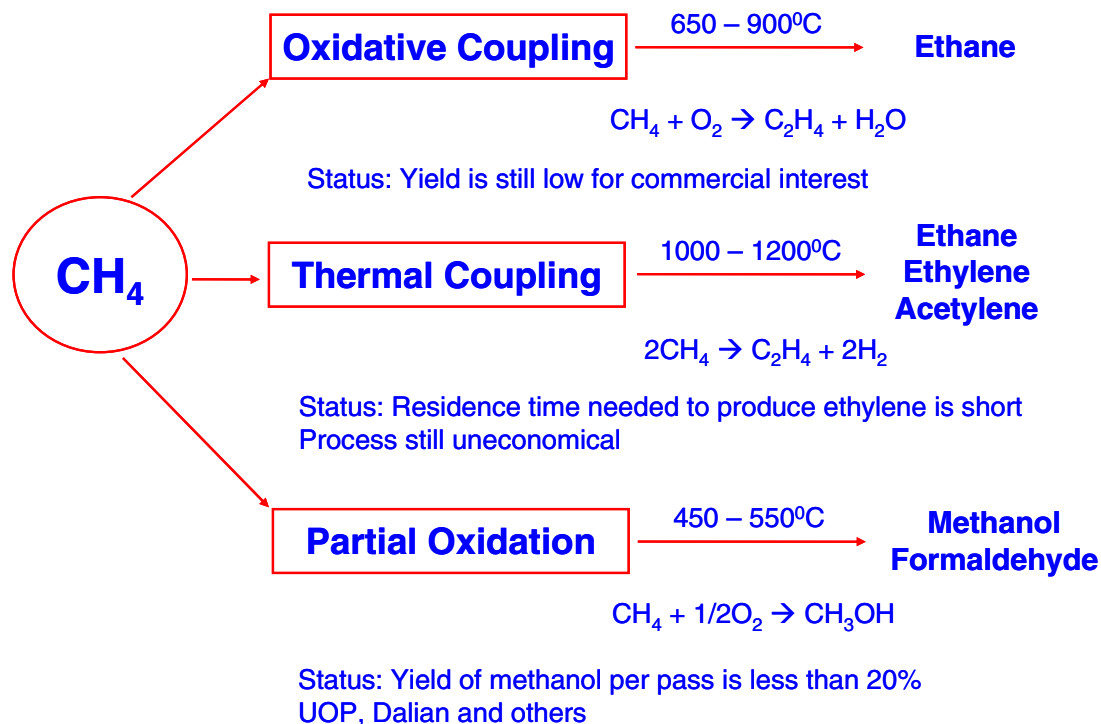
- ❑ Nearly 79% of the world gas reserves are “stranded”
- ❑ Routes to monetize these natural gas reserves
  - ✓ Mega-methanol (gas-to-methanol), Methanol-to-chemicals/olefins (MTO)
    - Operating world scale methanol plants in South America, Iran
    - Total mega methanol capacity by 2010 (if all announced capacity comes on-stream) is ~20 million tons annually
    - MTO/ MTP technologies on the verge of commercialization
  - ✓ Gas-to-liquids (GTL)
    - Sasol’s Oryx GTL (operating) and Shell’s Pearl GTL (under construction) – prominent world scale GTL facilities
    - Recent focus on GTL – escalating costs of GTL plants (Exxon decide not to go through with planned GTL in Qatar); production problems at Oryx GTL plant
  - ✓ LNG
    - 24 LNG Liquefaction (Export ) Terminals
    - 60 Regasification (Import) Terminals
    - LNG imports in the U.S. alone are expected to increase at an annual rate of 16% by 2025



□ Future directions for utilization of gas reserves:

- ✓ Methanol/GTL FPSO – StarChem, MEO Australia
- ✓ Direct Methane conversion routes – Dow, academic institutes
- ✓ Development of unconventional gas reserves
  - ✓ Coalbed methane, Methane hydrates, Compressed natural gas (CNG) transport

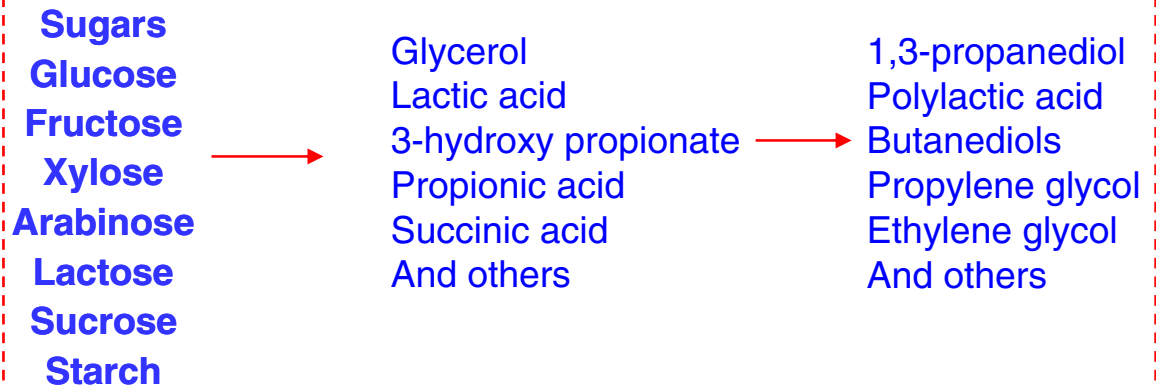
## Direct Methane Conversion Routes



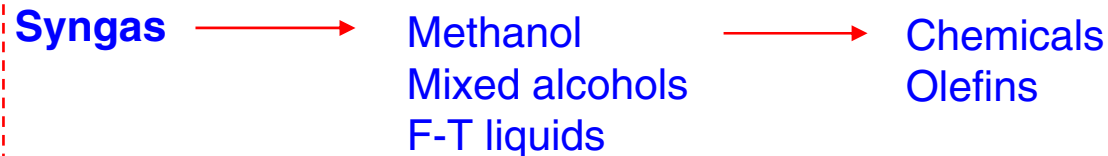
# Biomass – Status & Future

**Biomass**

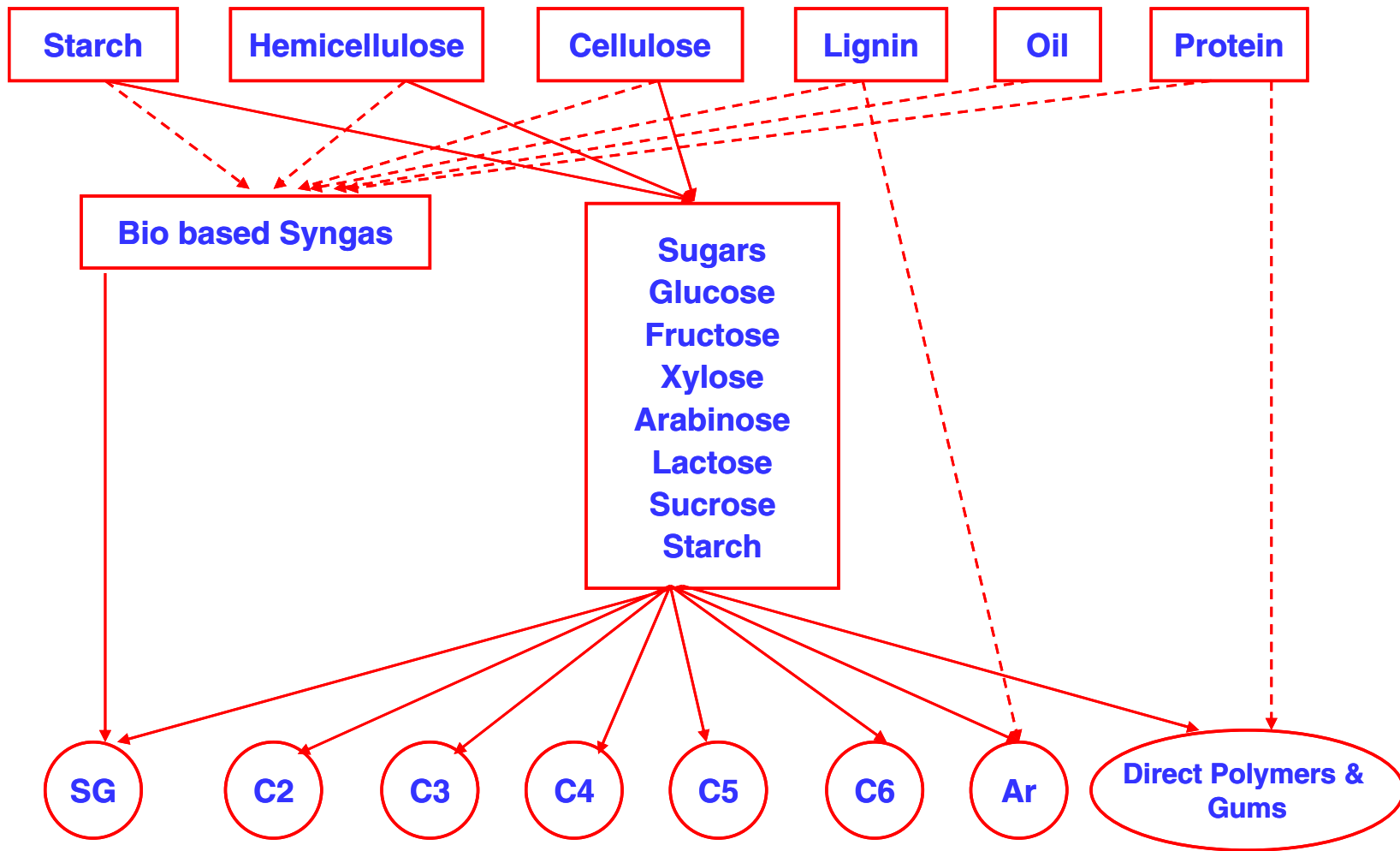
## Biochemical Route



## Thermo-chemical Route



# Biomass – Status & Future



Source: DOE



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# Biomass – Status & Future

## □ Biomass – biochemical route:

- Products replacing traditional polymers/chemicals
  - Biopolymers available in or created in plants/ organisms – e.g.: cellulose, soy protein, starch, etc
  - Biopolymers that can be produced from renewable natural sources – e.g.: lactic acid from corn, potatoes, etc., and triglycerides from vegetable oils
- Specific products include polylactide (PLA), polyhydroxyalkanoate (PHAs), polytrimethylene terephthalates (PTTs from 1,3-propanediol), Polyurethane, Polyamides, etc
- NatureWorks LLC, Teijin, Metabolix, Novamont, DuPont, Cereplast and others
- Applications as replacement or blends with petroleum based polymers – packaging, textiles, automotive parts
- Focus for future: Improving the following characteristics to find increased applications
  - Price – currently higher than petroleum based polymers
  - Mechanical/ Impact resistance
  - Heat resistance



# Biomass – Status & Future

- Biomass – thermo-chemical route:
  - Production of traditional chemicals via the syngas route
  - Biomass gasification is currently in the developmental stages
  - Primary focus of this route is in the production of methanol, DME and ethanol for fuel use
  - Biorefinery concept being popularized
    - Biomass – syngas – methanol – olefins
  - Several companies in Europe and USA working on commercializing the thermo-chemical route – the key driver being the development of alternative fuels

# Conclusions

- ✓ Volatile and high prices of crude and environmental concerns have spurred the evaluation of alternative feedstocks for the petrochemical industry
- ✓ Gradual shift in global centers of production from consuming countries to countries with feedstock advantage
- ✓ Breakthrough and improved economical technologies required for the new feedstocks to compete with petroleum feedstock
- ✓ Are we witnessing history repeat itself (70s oil embargo)??
- ✓ Please subscribe to our biweekly global strategic analysis newsletter **Alternative Feedstocks** to remain informed about the developments in this dynamic area of the petrochemical industry

