

The Future of Illinois Basin Coal Feedstock for Transportation Fuel Conversion

F.T. Sparrow

Director, Coal Transformation Laboratory

The Energy Center at Discovery Park

Purdue University

Indiana Society for Mining and Reclamation

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<http://discoverypark.purdue.edu/wps/portal/Energy>

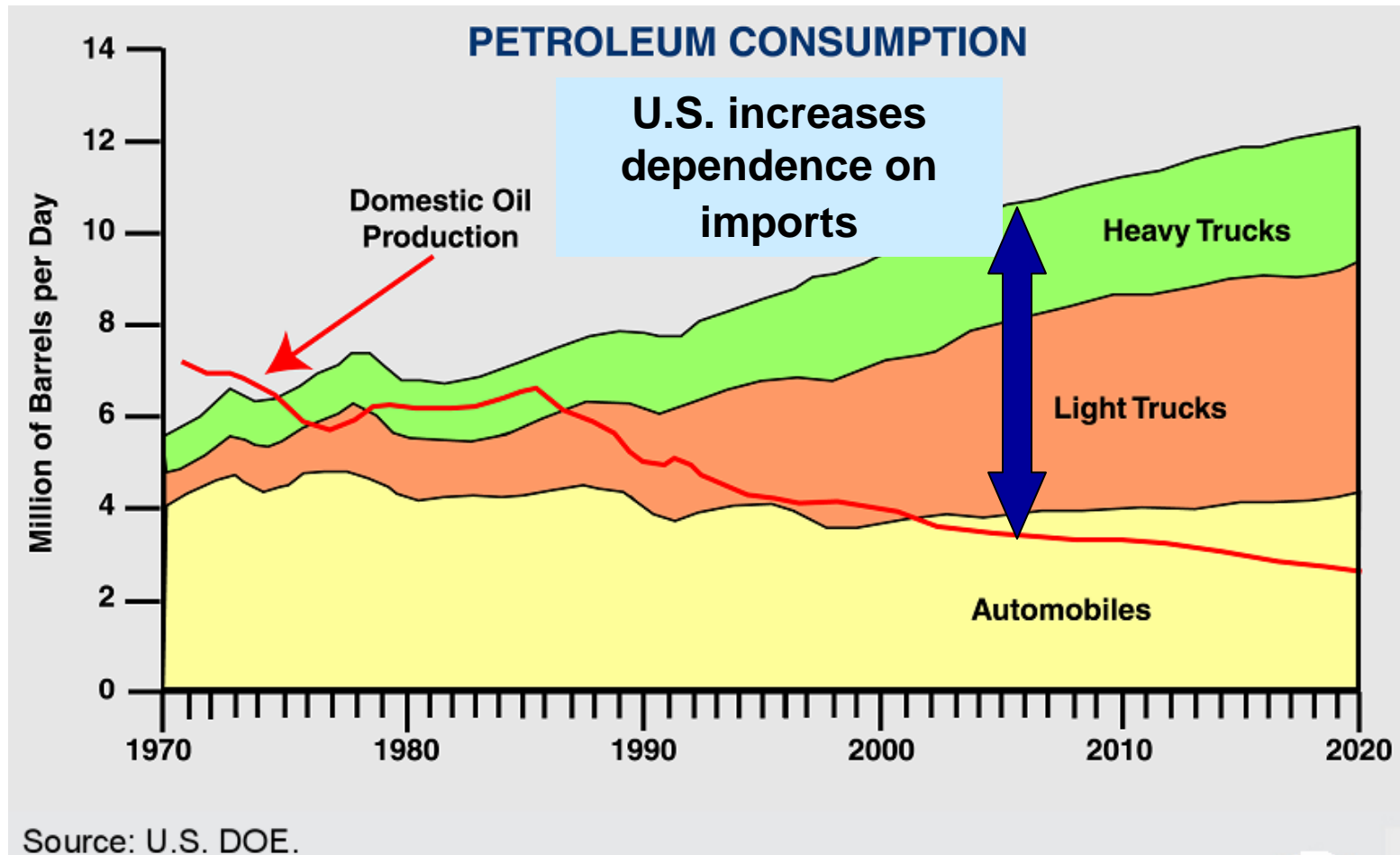
Here we go again....

“In 1980, Congress passed the Energy Security Act that created the Synthetic Fuels Corporation, another Carter proposal. Congress authorized \$20 billion in subsidies to promote the production of synthetic fuels from coal, tar sands, and shale oil reserves by private industry in an effort to reduce America's dependence on foreign oil. A single synthetic fuels plant was built at a cost of \$2.1 billion. In spite of these large expenditures, the Synthetic Fuels Corporation did not successfully produce an alternative fuel and never became a profitable venture. After seven years of failed efforts, President Reagan dissolved the corporation.”

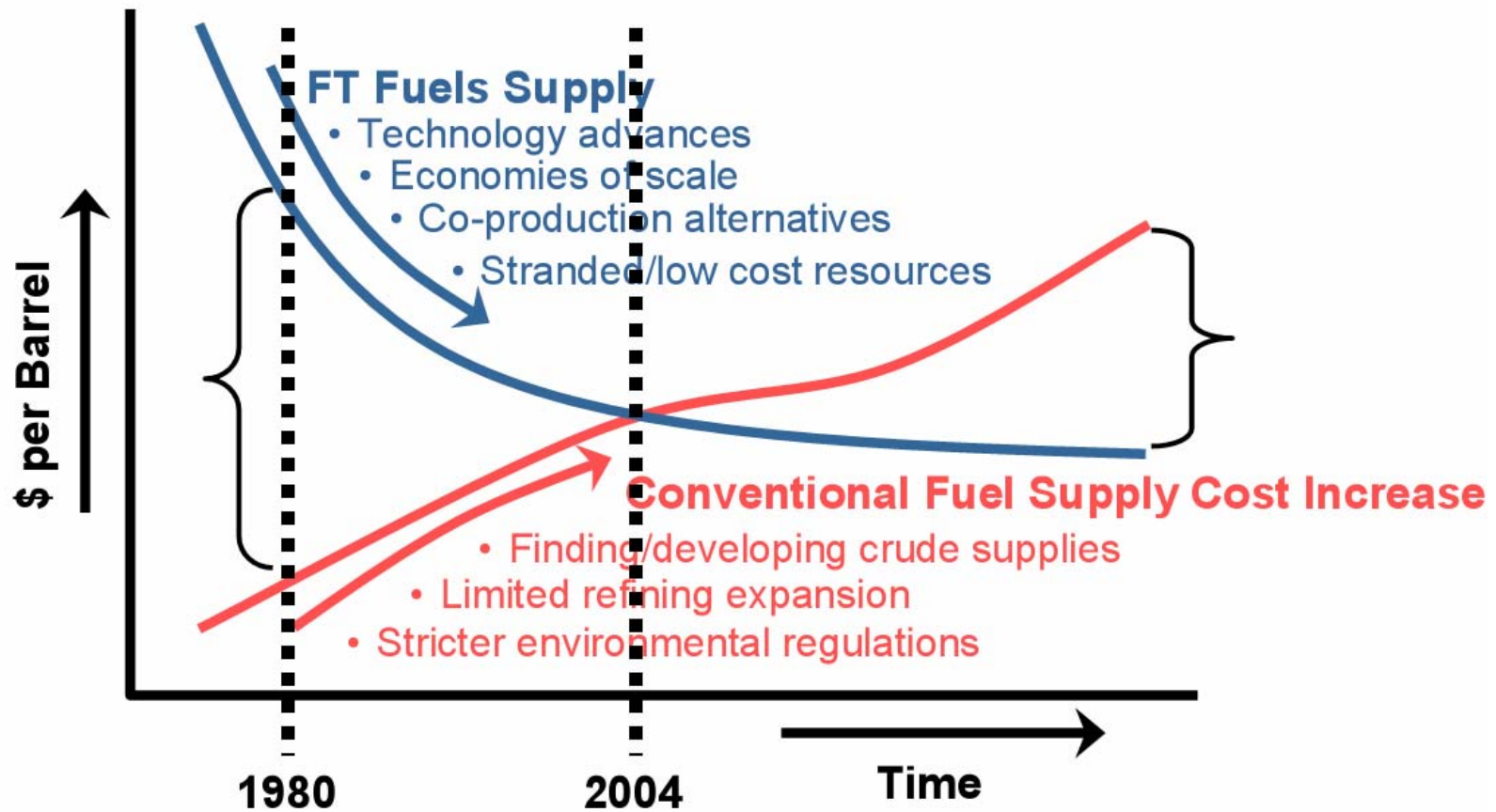
Source: National Environmental Trust, Failure of American Policies to Achieve Energy Independence,
<http://www.net.org/proactive/newsroom/release.vtml?id=27583>

Why again?

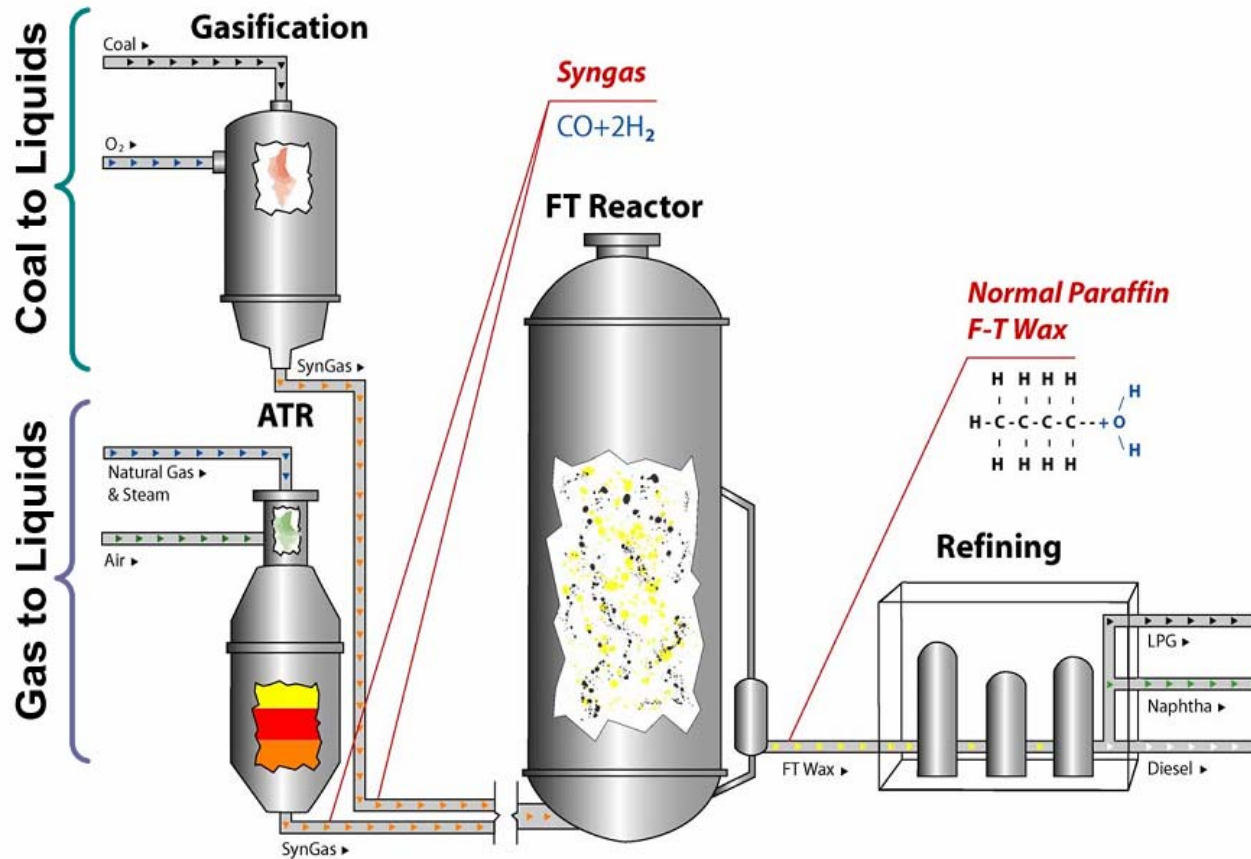
U.S. Dependence on Energy Imports



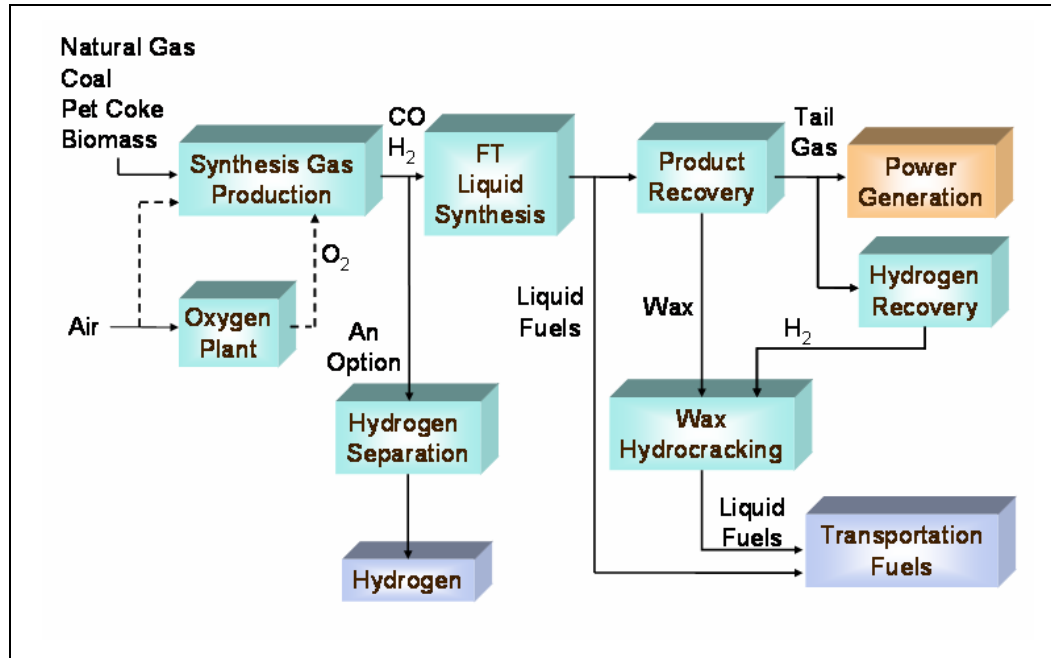
Conventional and Future Fuel Use



What process are we talking about?



Coal To Transportation Liquids, CTL



Coal → Gasification → Fischer-Tropsch

Synfuels: 1-2 barrels of oil per ton of coal

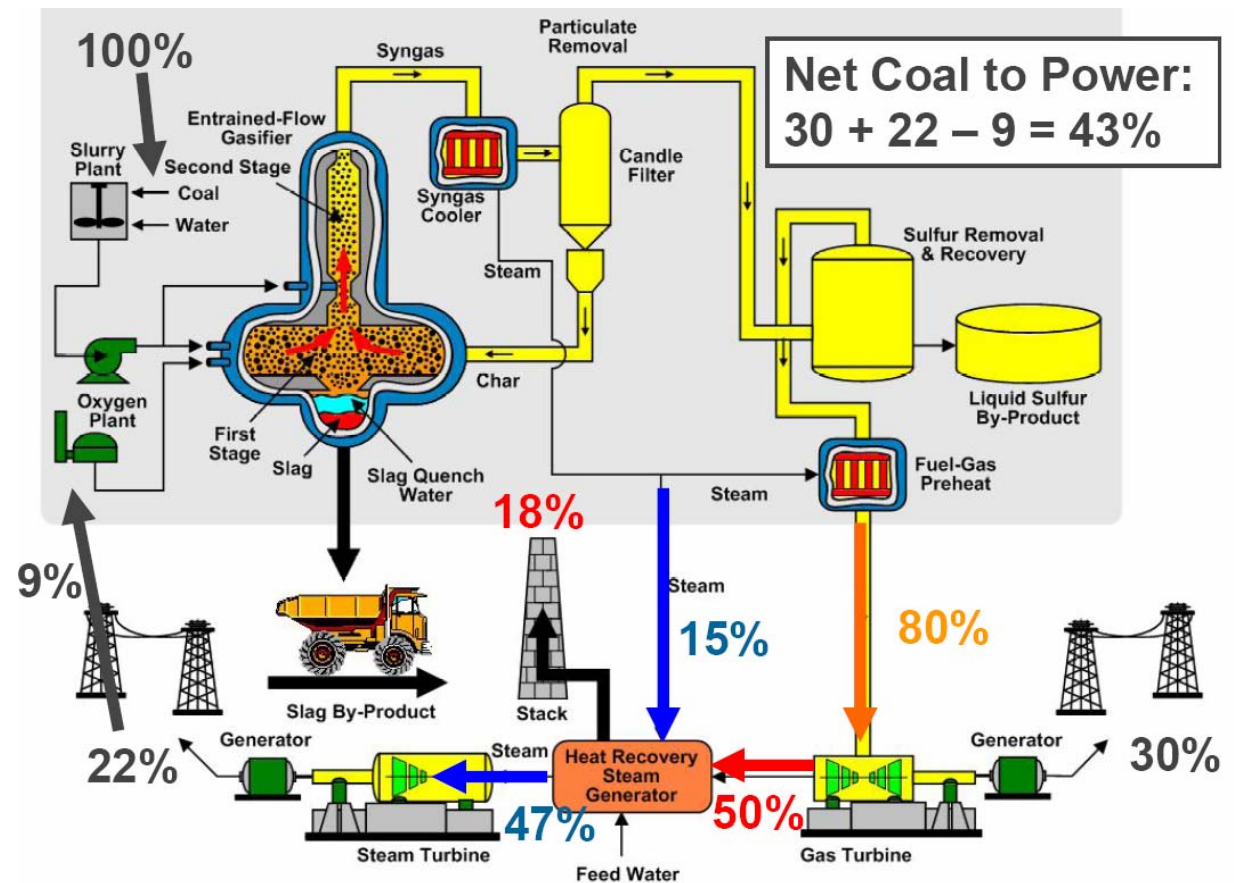
Other Synfuel Processes in the News

- Corn → ethanol (11 plants planned in Indiana-850 million gallons/yr.)
- Cellulosic Product → ethanol (needs development)
- Coal → gas
- IGCC;

Southwest Indiana Aims to be Home to Large Natural Gas Plant, October 27, 2006

PRESS RELEASE: EVANSVILLE, Indiana. Governor Mitch Daniels today announced there are plans to build a \$1.5 Billion coal gasification plant that would be the first in the country to make pipeline quality natural gas from coal beginning in 2008. The project will include a methanation process to produce pipeline quality substitute natural gas (SNG), which has an identical molecular structure to that of natural gas. It would produce 40 Billion cubic feet of pipeline quality SNG annually, which is enough to supply 15% to 20% of Indiana's residential and commercial gas demand. Its use is projected to save consumers more than \$3.7 Billion over the next 30 years versus the price of conventional natural gas.

IGCC Technology at Wabash



What can one ton of coal do?

- It can be used to generate 2100 kwh of electricity, which if sold at 6 cents/kwh, would add \$126 to the state's economy
- It can be used to produce 63 gallons of diesel fuel, which, if sold at 2.60/gallon would add \$165 to the state's economy- a 30% increase
- Further, the synfuel route appears to require 30% less capital investment

What would it take for Indiana to meet it's share of substituting 25% synfuel for crude oil?

- Indiana consumes 2.3 billion gallons of gas/year: 25% reduction would be 600 million gallons
- Meeting this goal would require:
 - A 30% increase in our corn production (230 million bushels)
 - A 60% increase in our coal production (20 million tons)
 - Conclusion reached in “Hoosier Homegrown Energy”: need both

Economic Growth From Hoosier Homegrown Energy



Indiana's Strategic Energy Plan

Goal: “Produce electricity, natural gas, and Transportation Fuels from Clean Coal and Bioenergy”

So: what is the state doing to encourage the use of coal as a feedstock for transportation fuels?

- **CCTR - The Indiana Center for Technology Research: created by S.B. 29 in 2003 to “encourage the use of Indiana coal in a economically and environmentally sound manner”**
- **CTL - The Coal Transformation Laboratory in Purdue’s Energy Center created in 2005 to “develop technologies for converting coal into combustible gases and liquids”**
- **CFA - The Coal Fuel Alliance created in August 2005 to further the objectives of the Obama / Lugar amendment to the 2005 Energy bill, aimed at increasing the use of Illinois basin coals as feedstock for transportation fuels**

CCTR Programs

- **General coal studies: IGCC, coal fines use, coal characterization, coke studies, coal transportation**
- **Coal to liquid studies**
 - I. **On-Going:**
 - **4 scoping studies: F/T production, use, environmental impact, policy**
 - **Contribution to Lugar / Purdue Summit**
 - II. **Proposed: F/T Production & use**

Policy Alternatives to Stimulate Private Sector Investment in Domestic Alternative Fuels

Wally Tyner

with assistance from Dileep Birur, Justin Quear,
and Jayson Beckman

- **For coal liquids or cellulose ethanol, one option would be a subsidy that varies with the price of crude oil – this option could be structured to function like a floor price for the domestic alternative**
- **Another option would be a purchase guarantee in which companies would bid for contracts to sell biomass or coal liquids**
 - **In this option, the government would not actually take possession of the product, but would resell in the market**

Our analysis to date has been done for a 60,000 b/d coal liquids plant with CO₂ sequestration

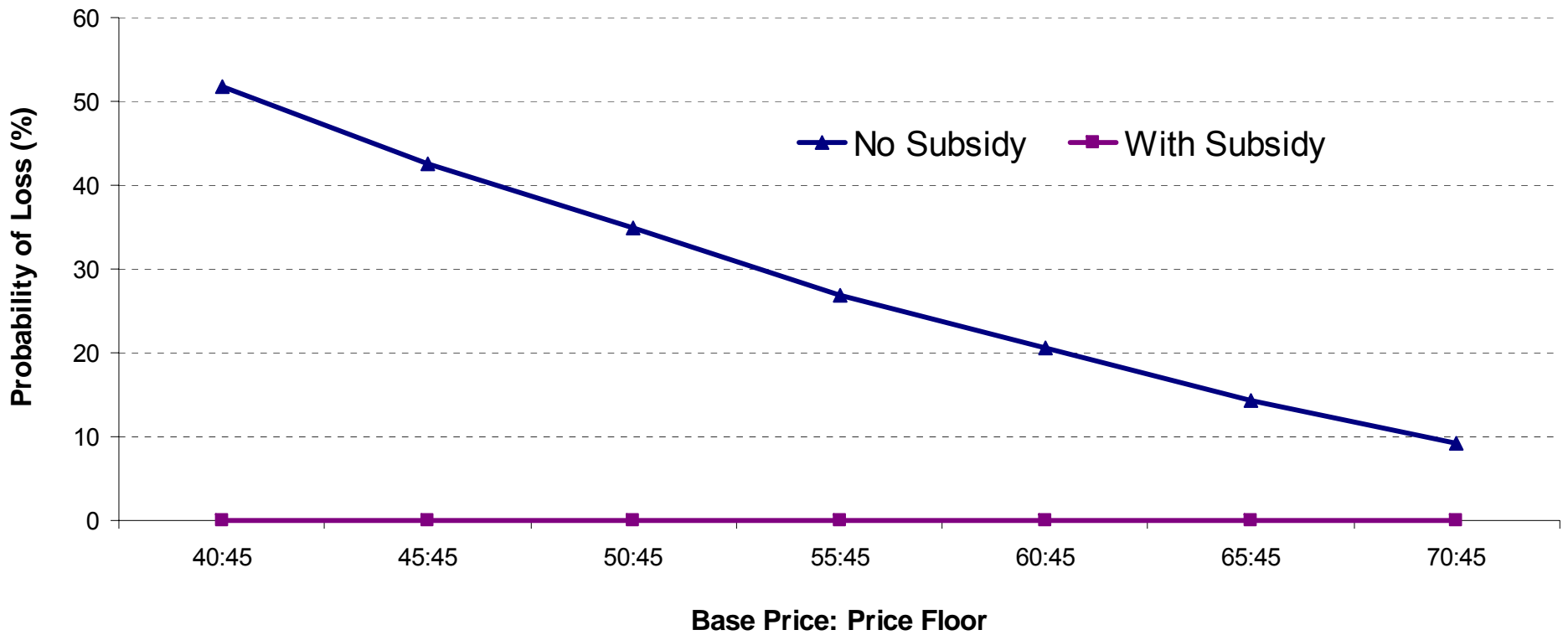
- **The capital cost of this plant is \$3.9 billion**
- **We use a total life of 25 years with an 8% debt rate, 15% return on equity, and 33% equity financing**
- **The plant uses Midwestern bituminous coal**

Uncertainty is incorporated in capital cost and future oil prices:

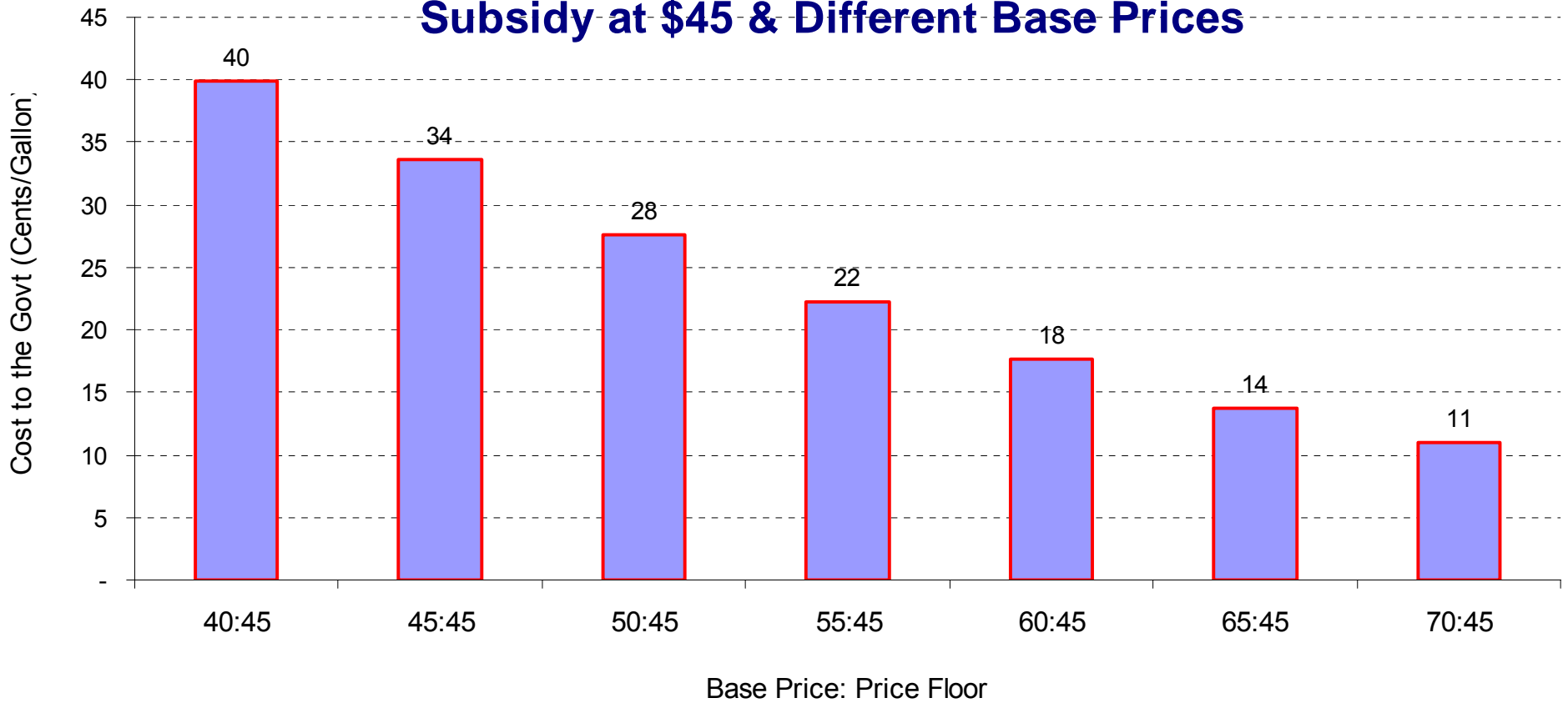
- **Oil price uncertainty was incorporated using price variability over the past 25 years (in inflation adjusted terms) and a range of base prices from \$40 through \$70**
- **The break-even cost of producing diesel fuels from this plant is estimated at a crude oil equivalent of \$43/bbl**

- **The simulations were done using a subsidy in the event the crude oil price in any given year falls below \$45**
- **So a crude price of \$45 becomes the floor for the plant, but in years with higher prices, market prices prevail**
- **In the graphs that follow, we present:**
 - **the probability of a loss at each base price with and without the subsidy, and**
 - **the expected government cost of the subsidy policy**

Probability of Loss With and Without the Floor Price Subsidy at \$45



Government Cost of a Floor Price Based Subsidy at \$45 & Different Base Prices



The bottom line is that with base prices ranging between \$55 and \$70 per barrel, the expected cost to the government would range between 11 and 22 cents per gallon of fuel produced

- **Of course, if oil remains above \$45, the actual cost would be zero**
- **So if the national security cost of imported oil is greater than 11-22 cents per gallon, the nation would benefit from this policy**

Purdue's CTL Program

- Aimed at finding mix of FIT fuels and engine designs which results in lowest cost to users
- Three areas of interest
 - Diesel
 - Combustion turbine
 - CO₂ reduction

FT Diesel Fuels Research

- **Integrated program focusing on fuel modification and engine and after-treatment designs will maximize benefits of utilizing FT fuels. This plan has been developed as part of the initial scoping study**
- **Existing engine test facilities will have to be upgraded to carry out integrated fuels and engine research, provide the level of detail required to maximize the benefits from both components, and provide realistic economic assessment**

Diesel Engine Test Facility

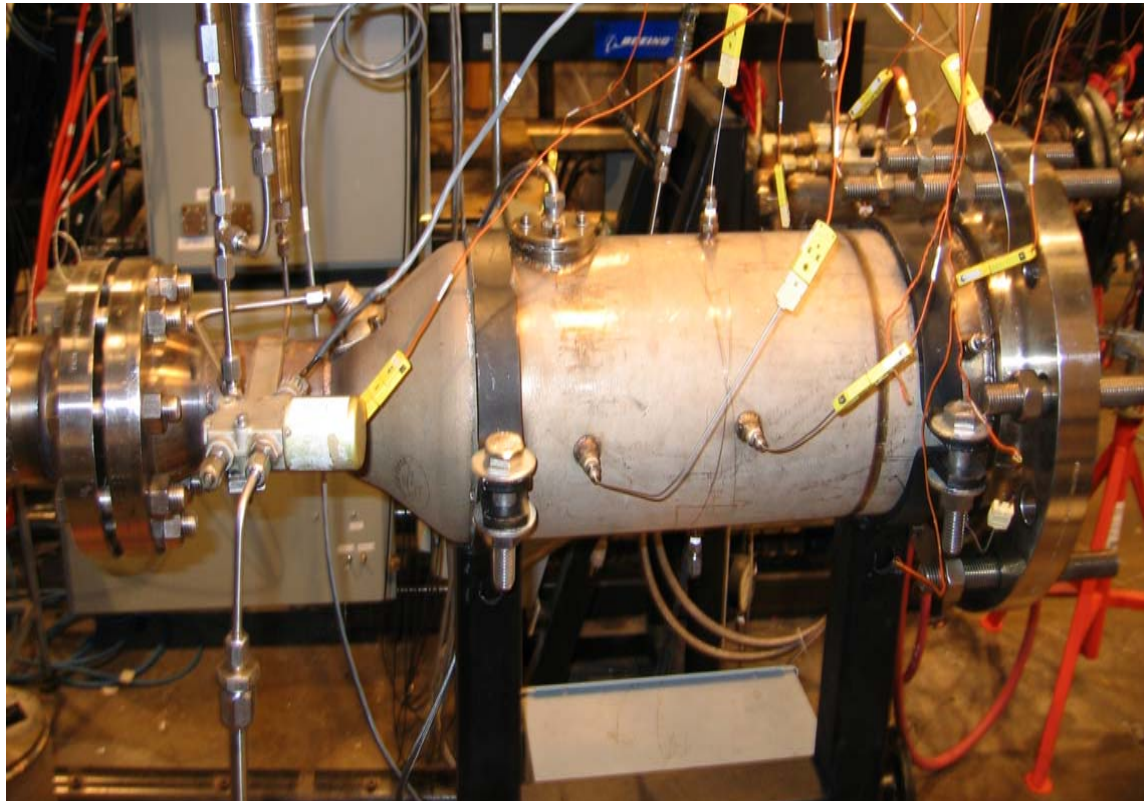


- **October 2002
Certified ISB 5.9 L
Cummins Diesel –
EGR & VGT (with
Cummins Calterm
II 7.63)**
- **800 hp Eddy
Current
Dynamometer w/
Dyn-Loc IV
Controller**

FT Fuels Utilization in Aircraft Gas Turbines

- **Use of FT fuel as an endothermic coolant for aircraft systems – endotherms and coking behavior must be investigated**
- **Particulate generation – investigation of sooting behavior of FT fuels and blends with JP8 – low aromatic content may lead to lower soot emissions**
- **Atomization, mixing, ignition properties of FT fuels and fuel blends will be studied in High Pressure Lab gas turbine combustor facility**

Gas Turbine Combustor Facility



- Air flow at 950 deg F inlet temperature at 9 lbm/sec and 700 psi
- Recently upgraded emissions monitoring system, state-of-the-art FTIR and flame ionization detector installed

Obama-Lugar Amendment

Three Universities (Southern Illinois University, Purdue University, and University of Kentucky) of the “Coal Fuel Alliance”, are to

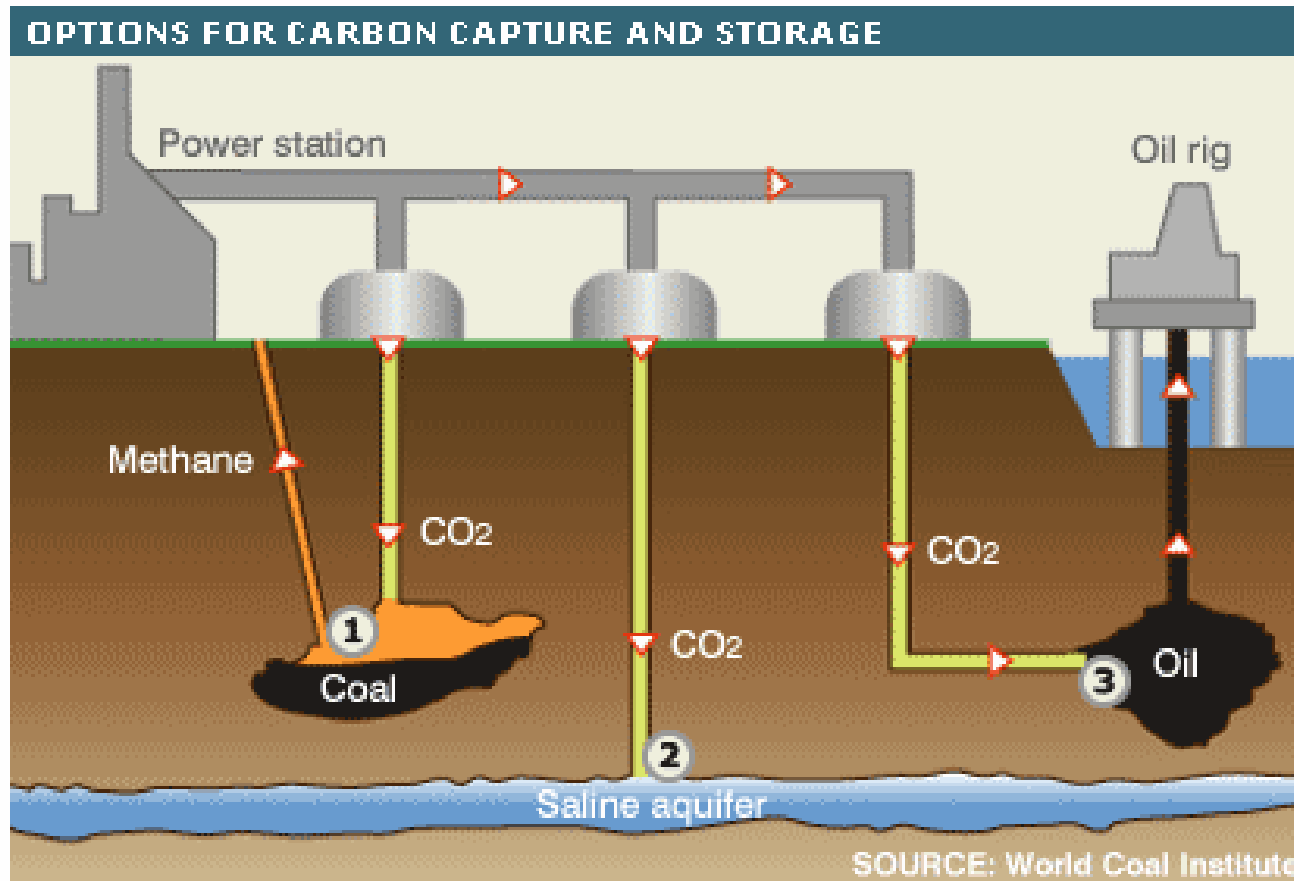
“...evaluate the commercial and technical feasibility of advanced technologies to convert Illinois Basin coals into Fischer-Tropsch, (FT) and other transportation fuels”

- **\$85M authorized for research and a test center from DOE**
- **DOE has immediate need for 400,000 bbls/day for their own use**

What are the challenges that must be overcome before coal to liquids becomes a reality?

- 1. Uncertainty regarding crude oil prices-oil at \$70, make a bundle: oil at \$40 loose your shirt.**
- 2. Reducing the cost of conversion process: some uncertainty remains.**
- 3. Global warming: coal releases more CO₂ than other fuels. CO₂ injection? CO₂ conversion?**
- 4. Why not focus on renewables, not coal, for synfuel?**
- 5. Usage in engines-who will certify fuels?**

CO₂ The Huge Challenge



CO₂ Capture & Sequestration

Is there something better?

1. CO₂ pumped into disused coal fields displaces methane which can be used as fuel
2. CO₂ can be pumped into and stored safely in saline aquifers
3. CO₂ pumped into oil fields helps maintain pressure, making extraction easier

Conclusion:

- **Don't quit your day job mining coal to generate electricity**
- **The future of Coal to Liquid holds great promise**