



HTI's Coal Process DCL Technology

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**China-US Coal Gasification and
Liquefaction Workshop, Beijing**

June 15-16, 2006

Presentation Outline

- 🔥 Coal-to-Liquids via Coal Liquefaction
- 🔥 HTI's Coal Process DCL Technology
- 🔥 Technology Applications
 - Philippine Hybrid DCL Project
 - Assam DCL Project
- 🔥 Concluding Remarks



Coal Chemistry

Direct Coal Liquefaction

Coal + Catalyst + Hydrogen \rightarrow Hydrocarbons (H_xC_y)

Indirect Coal Liquefaction

1. Gasification

Coal + Oxygen + Steam \rightarrow Syngas ($H_2 + CO$)

2. FT Synthesis

$H_2 + CO + \text{Catalyst} \rightarrow \text{Hydrocarbons } (H_xC_y)$

Coal Liquefaction Routes

Direct Coal Liquefaction

- **Partial** dismantling of the coal structure under high H_2 partial pressure
- Further hydrocracking of primary coal fragments
- Refining of coal liquids
- Products retaining ring structure

Indirect Coal Liquefaction

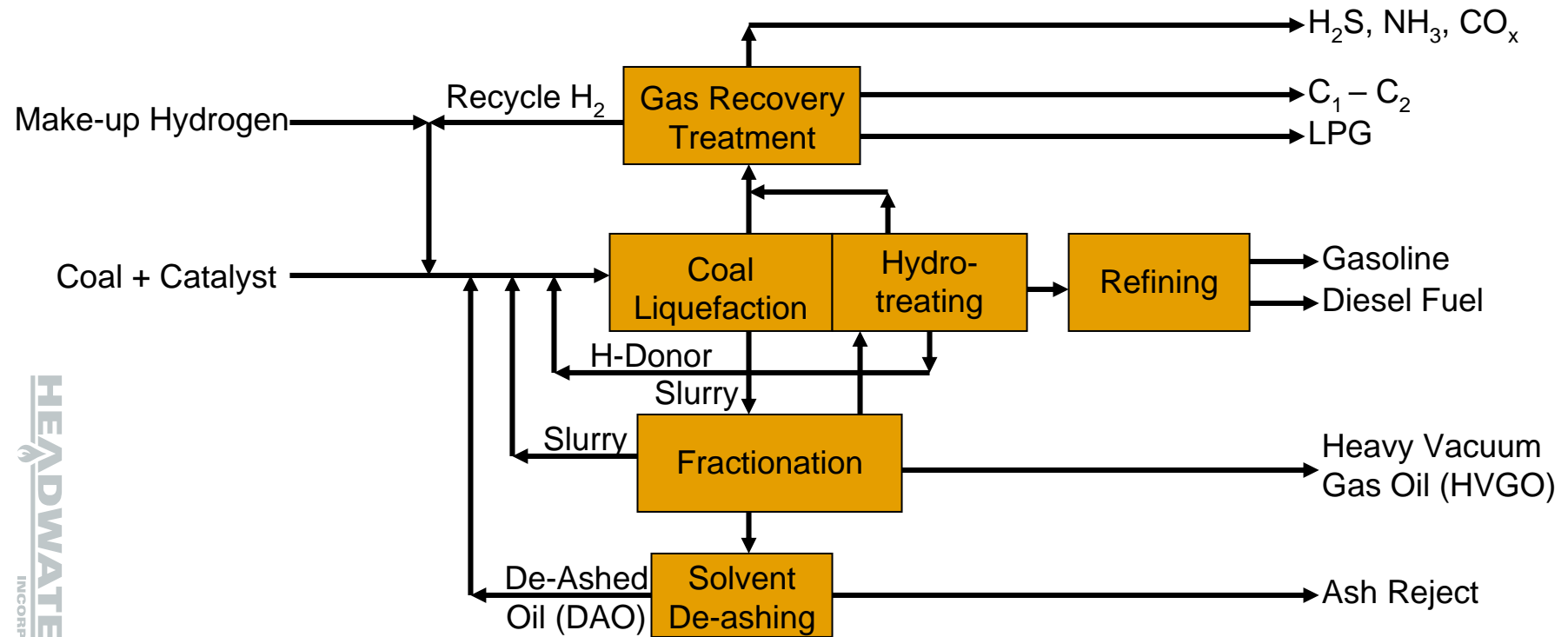
- **Complete** destruction of the ring structure in coal
- Gasification to produce syngas (H_2/CO)
- Removal of hetero-atoms (S, N) from syngas
- Catalytic synthesis of ultra clean paraffins
- Hydrogenation and wax hydrocracking

Key Features of HTI's DCL Technology

- 🔥 Fully Back-mixed reactor
- 🔥 Iron based catalyst with heavy end recycle
- 🔥 Inter-stage Vapor/Liquid Separation
- 🔥 Integrated Raw Product/Donor Solvent hydrogenation
- 🔥 Solvent de-ashing for high ash coal to improve distillate yield



Direct Liquefaction Process



DCL Background

- 🔥 Originally developed in Germany in 1917
- 🔥 Used to produce aviation fuel in WWII
- 🔥 US spent \$3.6 billion on DCL from 1975-2000
- 🔥 Headwater DCL licensed to China in 2002



Lawrenceville, NJ
30 bpd



Catlettsburg, KY
1800 bpd



Inner Mongolia, China
17,000 bpd

Other DCL Activities in Asia

- 🔥 Completed PFS on Assam coal for Oil India Limited (44,000 BPD, DCL Plant)
- 🔥 Completed Project definition on Philippine coals for H&W (60,000 BPD, Hybrid Plant)
- 🔥 Signed a new license on production of transportation fuels using lignite as feedstock (50,000 BPD, DCL plant)
- 🔥 Several enquiries from India, Indonesia, other Asian countries.



Commercializing CTL Technologies in U.S.

- 🔥 CTL projects are capital intensive (\$70,000- to \$120,000 per BPD)
- 🔥 CTL products are compatible with and perform similar to the petroleum-derived products
- 🔥 Economy of scale is critical to project economic (40,000 BPD + plant capacity)
- 🔥 CTL project economic is very sensitive to capex and world crude oil price
- 🔥 Planning to start FEED for a CTL project in North Dakota.

Philippine Hybrid CTL Plant

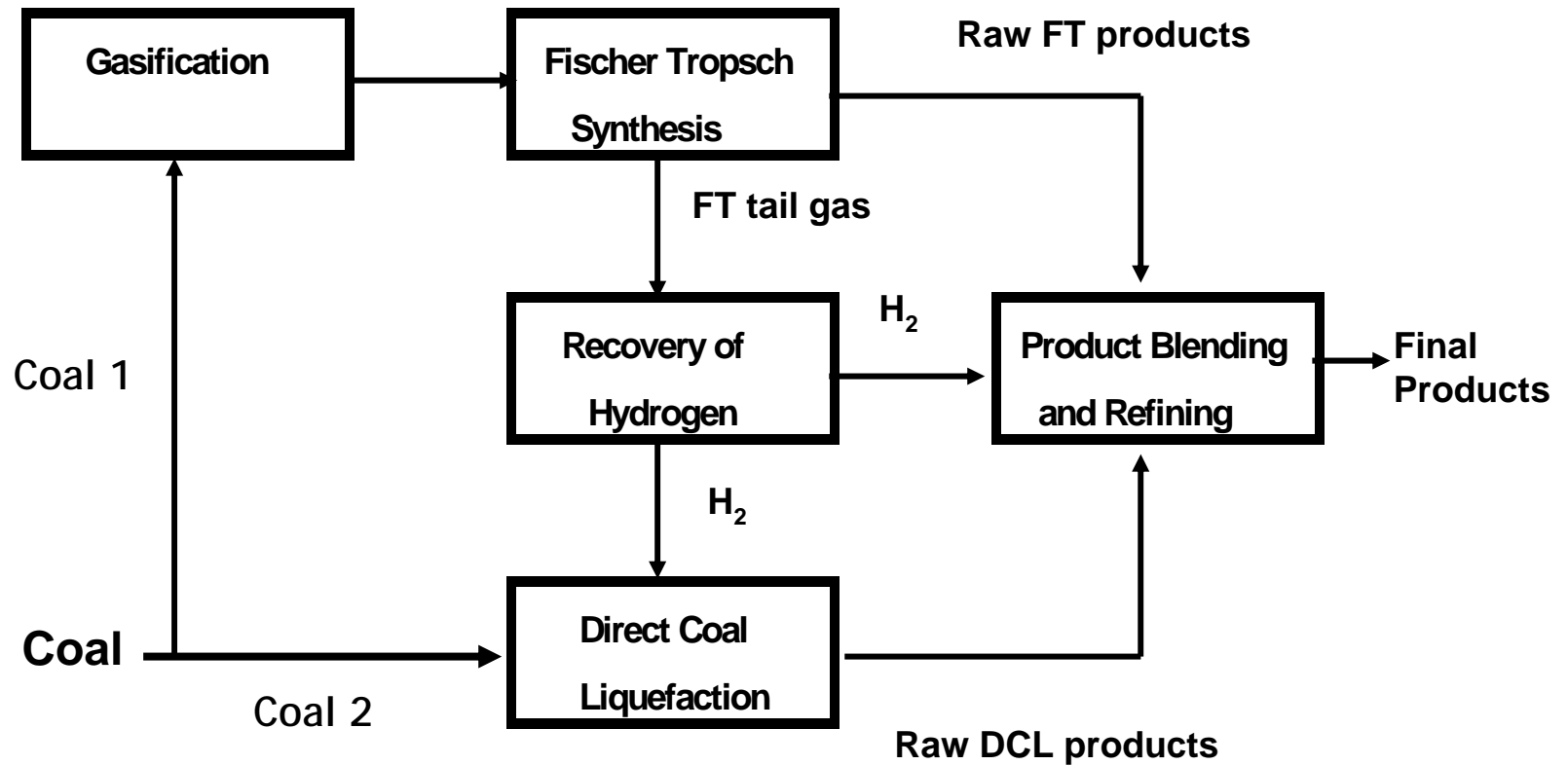


Basis for the Philippine Hybrid Plant

- 🔥 Plant location closer to market
- 🔥 Flexibility in coal feed
 - Low quality coal for syngas production
 - Higher quality coal for direct coal liquefaction
- 🔥 Products blending to reduce refining cost
- 🔥 Process integration to maximize heat utilization
- 🔥 Self sufficient in energy requirement
- 🔥 Large power generation not required



Hybrid Plant - Block Flow Diagram



Coal Feed Rates to Hybrid Plant

Total feed rate: 23,000 coal short ton/day (maf basis)

- Lignite A: 9,400 stpd
- Lignite B: 7,900 stpd
- Sub-bituminous: 5,800 stpd

Products (BPSD):

C3/C4	11,200
FT Naphtha	11,500
DCL Naphtha	15,600
FT Diesel	13,400
DCL Distillate	6,500
DCL VGO	<u>2,800</u>
Total Liquids	61,000

By-Products:

Sulfur - 520 stpd; Net Power - 67 MW



Capital Investment (million 2005\$)

Major Units	million, 2005\$
Syngas/H ₂ production	1,260 (66%)
Direct Coal Liquefaction	330 (17%)
FT Synthesis & Product Upgrading	<u>330 (17%)</u>
Total ISBL	1,920 (100%)
OSBL (35% of ISBL incl. power block)	660
Power Block	<u>270</u>
Total EPC Cost (USGC location)	2,850
Total EPC Cost (Philippine location)	2,760
Contingency (25%)	690
Owner's cost	420
Interest during construction	<u>330</u>
Total Project Cost	4,200

IRR Sensitivity

Parameter	+20%	Base IRR	-20%
EPC	29	38	48
Fuel Revenue	49	38	22
Coal Price	34	38	41

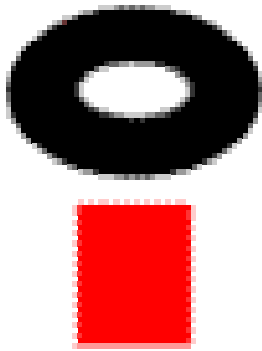
Other major assumptions:

330 days on-line, 15% equity, capacity-51%, 1st yr; 81%, 2nd yr.

fuels price April/2005 FOB Philippines price; Crude price- \$43 to 50 per bbl.



Liquefaction of Assam Coals



Oil India Limited

HEADWATERS
INCORPORATED



Performing of Assam Coal

- 🔥 Assam coals have a high reactivity for direct coal liquefaction (>98% conversion)
- 🔥 Potential distillate yield into the range of 73 to 77 s% maf coal
- 🔥 Requires effective hydrogen transfer system to match with the high reactivity of Assam coals
- 🔥 Action Plans:
 - License arrangement including a process warranty pilot plant test to generate design basis
 - Develop basic engineering design for better investment cost estimate
 - Develop product upgrading strategy for coal liquids



Assam DCL Complex Summary

🔥 Feed Coal: 10,419 Tons/d

- 7,000 T/d DCL
- 3,420 T/d H₂ production (Gasifier)

🔥 Products

- LPG 341 T/d (3,971 bbl/d)
- Naphtha 1,660 T/d (14,077 bbl/d)
- Kerosene 600 T/d (4,744 bbl/d)
- Diesel 2,804 T/d (21,379 bbl/d)
- Total C₃+Liquid Products 44,171 bbl/d



Economic Analysis Summary

- 🔥 44,000 BPD DCL Plant
- 🔥 CAPEX = US\$2.16 billion
- 🔥 Annual Revenue = US\$1,139 million
- 🔥 Annual Expenses = 471 million
- 🔥 Income before state tax = 668 million
- 🔥 1/3 Equity
- 🔥 IRR of 30 % (\$50/ton); 23% (*\$90/ton*)
- 🔥 \$962 Million NPV @ 12% Discount Rate



Concluding Remarks

- 🔥 CTL is a viable option to monetize coal reserve
- 🔥 CTL technologies are commercially-ready
- 🔥 Economy of scale and crude oil price are critical to CTL project viability
- 🔥 Government assistance in project finance is needed for the first generation CTL plants
- 🔥 Government guarantee on CTL product floor prices is essential
- 🔥 Future R&D efforts on plant efficiency and cost reduction are needed