

Baseline Design and System Analysis for Direct Coal Liquefaction

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Outline

- **Background and objectives**
- **Design basis**
- **Process description and options**
- **Comparison with one stage process**
- **Capital cost reductions**
- **Process simulation model**
- **Summary**

Background

- **Early studies developed commercial designs and cost estimates**
- **EDS, H-COAL and SRC processes**
- **Bechtel's Breckinridge project studied cost and economics of a commercial size H-COAL plant**
- **Breckinridge study has been updated several times**
- **This is an ongoing DOE sponsored study by Bechtel / Amcco**

Objectives

- **Conceptually design a commercial two stage direct coal liquefaction facility**
- **Study selected options**
- **Develop a process simulation model**
- **Develop capital and operating costs for base case and options**
- **Predict economics**

Base Case Design Basis

- **Wilsonville Pilot Plant Run 257E (Cat-Cat Reactor, Illinois Number 6, Burning Star Mine Coal)**

- **Reactor operating conditions**

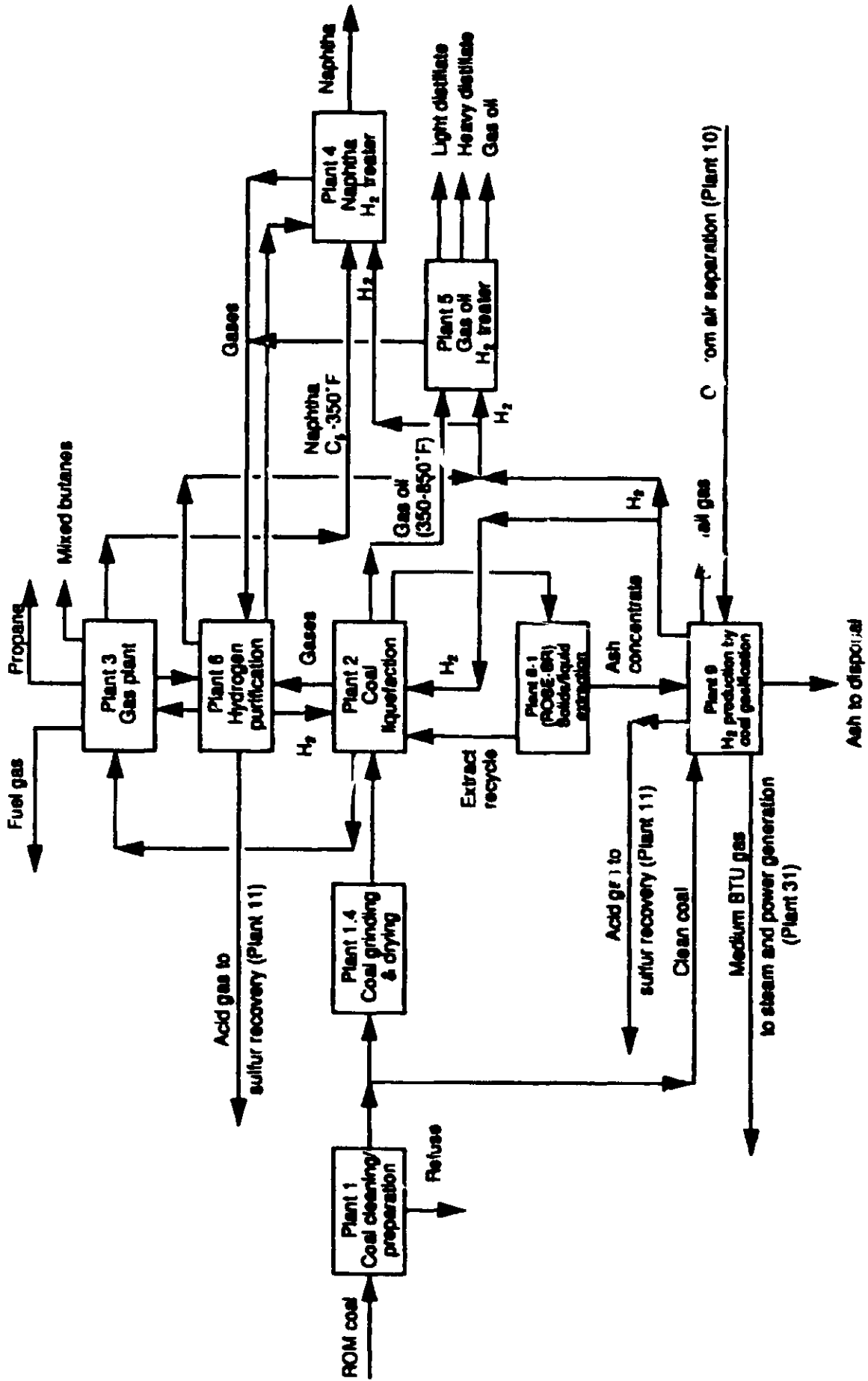
Coal feed
Rate, lb MAF/hr 1.26 MM
% Ash (MF) 11.5

Temperature, °F
First stage / Second stage 790 / 760

Catalyst space velocity,
lb MAF coal/hr/lb catalyst 1.12

Hydrogen consumption, wt% MAF 6.2

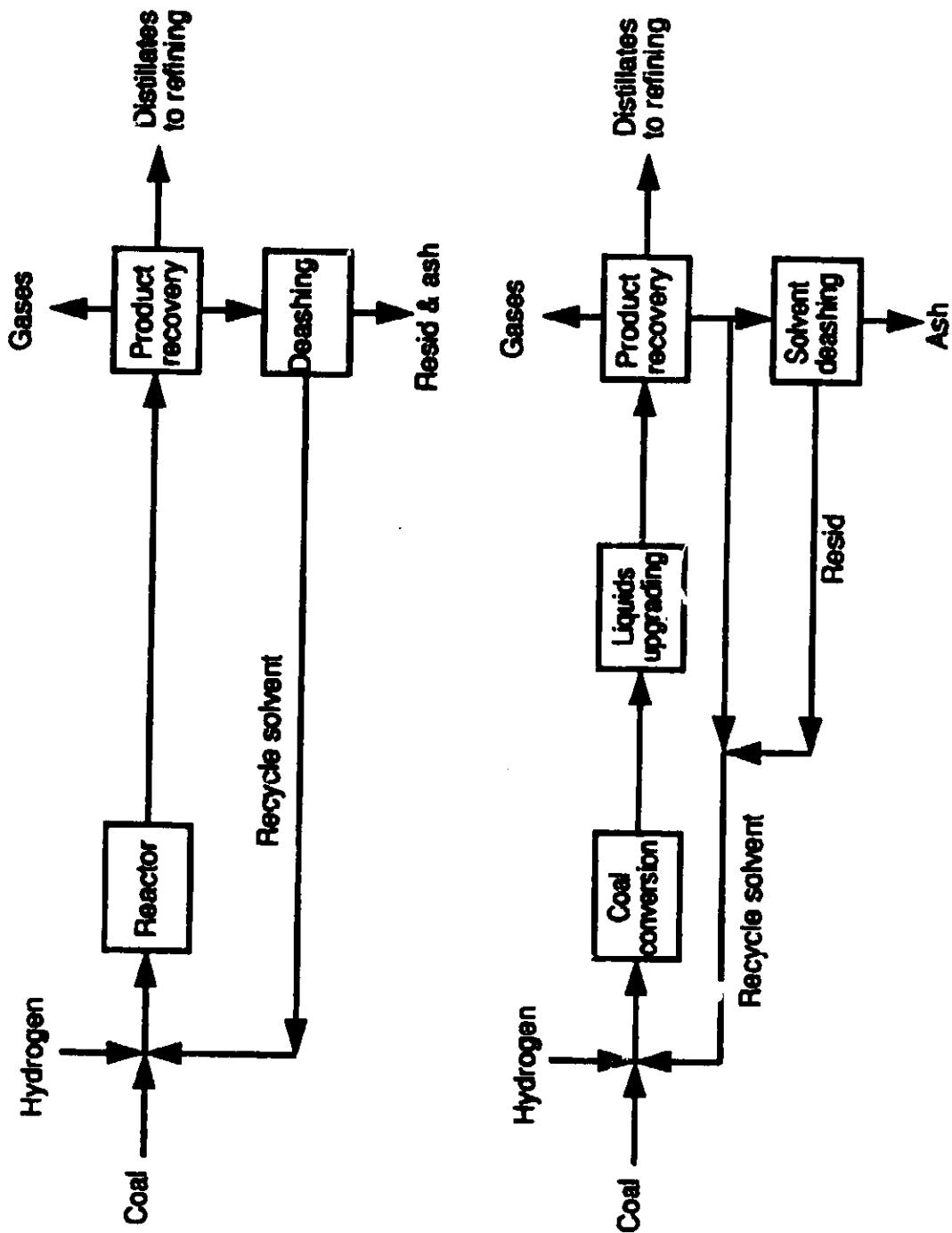
Simplified Block Flow Diagram



Options to Baseline

<u>Process</u>	<u>Variables</u>	<u>Base case</u>
Coal cleaning method	<ul style="list-style-type: none"> - Jig - Heavy media separation - Spherical agglomeration 	x
Reactor configuration	<ul style="list-style-type: none"> - Catalytic-catalytic - Thermal-catalytic - Catalytic-catalytic with vent gas separation 	x
Vacuum bottoms processing	<ul style="list-style-type: none"> - ROSE-SR - Fluid coking 	x
Hydrogen production	<ul style="list-style-type: none"> - Coal gasification (Texaco technology) - Steam reforming of natural gas 	x

Comparison with One-Stage Process



Comparison With One-Stage Process

	<u>Breckinridge</u>	<u>Current study</u>
Feed coal	Kentucky/Illinois	Illinois, No. 6
Proposed plant location	Breckinridge, KY	Mine Mouth, Southern Illinois
Technology	Single stage H coal	Two-stage Wilsonville
Reactor temp. °F	850	790/760
Number of reactor trains	7 + 1	5 + 1
C ₄ ⁺ resid free liquids, wt% MAF coal	47	71

Comparison With One-Stage Process

	<u>Breckinridge</u>	<u>Current study</u>
Bottoms processing	Hydroclone + vacuum tower	ROSE-SR
H ₂ source	Gasification of vacuum bottoms	ROSE-SR ash concentrate + clean coal
H ₂ processing	Post gas plant (Cryogenic)	Prior to gas plant (PSA/membrane)
Product upgrading		
Naphtha	Hydrotreating/reforming	Hydrotreating
Distillate/gas oil	None	Hydrotreating
Treated water discharge	Zero	Permitted

Comparison With One-Stage Process

	Breckinridge design	Current design
Primary Liquefaction Yields, Wt% MAF coal		
H ₂ O, H ₂ S, NH ₃ , CO _x	13.8	14.0
C ₁ -C ₃	11.7	4.8
C ₄ -650°F	44.0	49.7
650-1000°F	3.0	--
650-850°F	--	21.4
Resid	--	0.0
Organics in ash-reject stream	33.0	16.3
H ₂ consumed	5.5	6.2
Coal SV, each reactor		
lb MAF/hr/ft ³ reactor vol	31.0	19.9
lb MAF coal/hr/ft ³ catalyst	--	39.2
Total catalyst replacement rate, lb/ton MAF coal	1.1	4.5

Capital Cost Reductions

- **Capital cost reductions have a strong impact on coal liquefaction economics**
- **Possible capital cost reduction approaches**
 - **Pretreating the coal**
 - **Reducing reactor volume / number of trains**
 - **Choosing a low construction cost area**
 - **Reducing hydrogen cost**
 - **Integrating with an existing refinery**

Process Simulation Model

- **Research guidance tool**
- **Principal yields**
- **Process economics**
- **Selected process options**
- **Base for future expansion**

Overview of Model

- **Elementally balanced**
- **Peripheral units**
 - **Simplified black box model**
- **Coal liquefaction plant**
 - **More rigorous model**
 - **Kinetic model**
 - **Individual reactor kinetics**
 - **Major operating parameters**
 - **Hydrodynamics**
 - **Major equipment sizes**

Simulated Plants

- Plant 1 - Coal cleaning and preparation plant
- Plant 2 - Coal liquefaction plant
- Plant 3 - Gas plant
- Plant 4 - Naphtha hydrotreater
- Plant 5 - Gas oil hydrotreater
- Plant 6 - Hydrogen recovery and purification plant
- Plant 8 - Critical solvent deashing (ROSE-SR) plant
- Plant 9 - Hydrogen production by coal gasification
- Plant 10 - Air separation (Oxygen) plant
- Plant 11 - Sulfur recovery plant
- Plant 38 - Ammonia recovery plant
- Plant 31 - Steam and power generation

Processing Options

<u>Process</u>	<u>Option</u>
Coal cleaning method	<ul style="list-style-type: none">- Jig- Heavy media separation- Spherical agglomeration
Reactor configuration	<ul style="list-style-type: none">- Catalytic-catalytic- Thermal-catalytic- Catalytic-catalytic with vent gas separation
Vacuum bottoms processing	<ul style="list-style-type: none">- ROSE-SR- Fluid coking
Hydrogen production	<ul style="list-style-type: none">- Coal gasification- Steam reforming of natural gas

Future Model Extensions

- Other coals
- Different catalysts and yield structures
- Other coal liquefaction reactor configurations
- Alternate downstream processing schemes
- New technologies
- Different economic scenarios

Summary

- **Developed conceptual baseline design**
- **Considered selected process alternatives**
- **Developing economics**
- **Developing process simulation model**
- **Provide basis for future studies**