

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 / Amoco

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

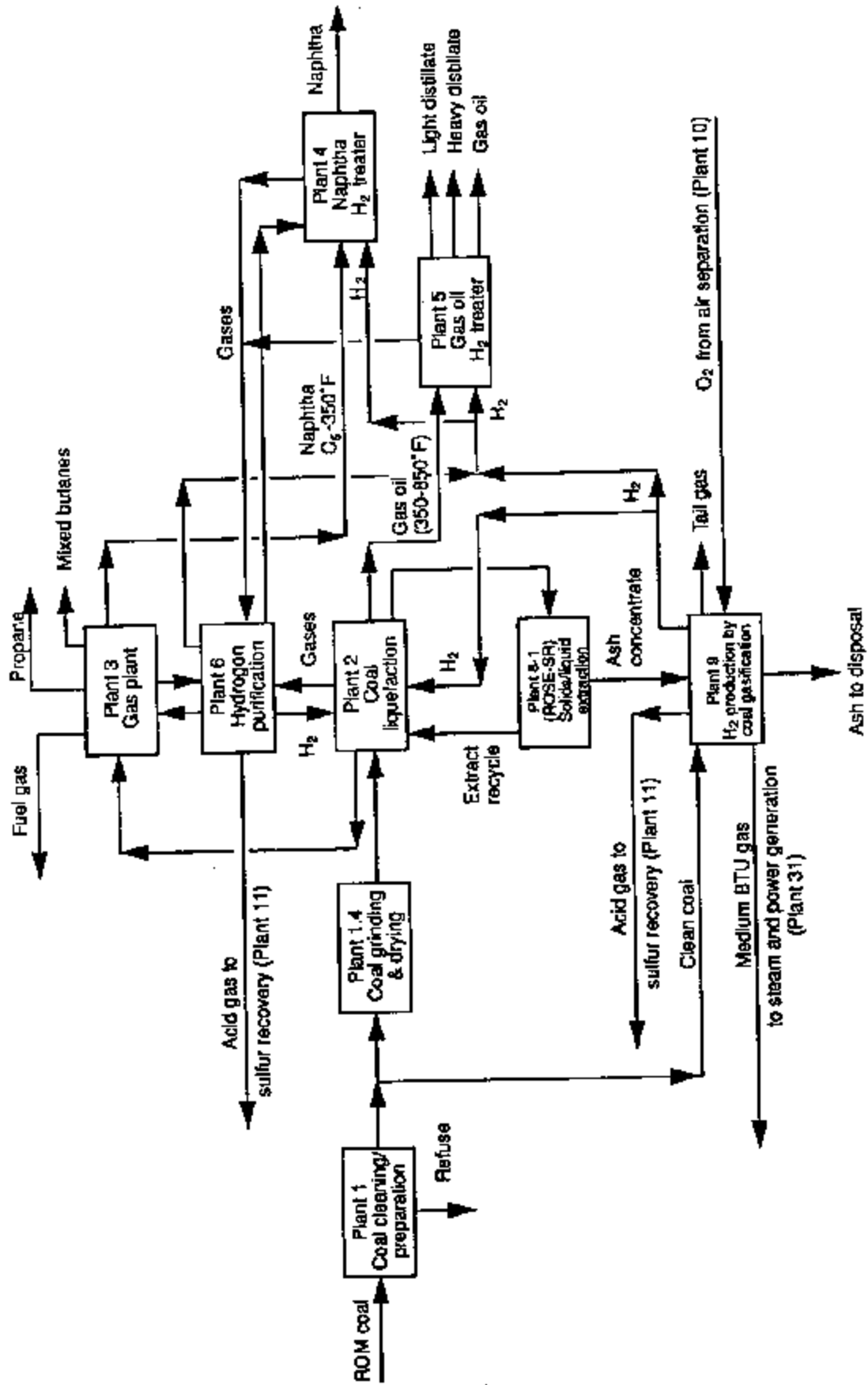
Base Case Design Basis

- 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

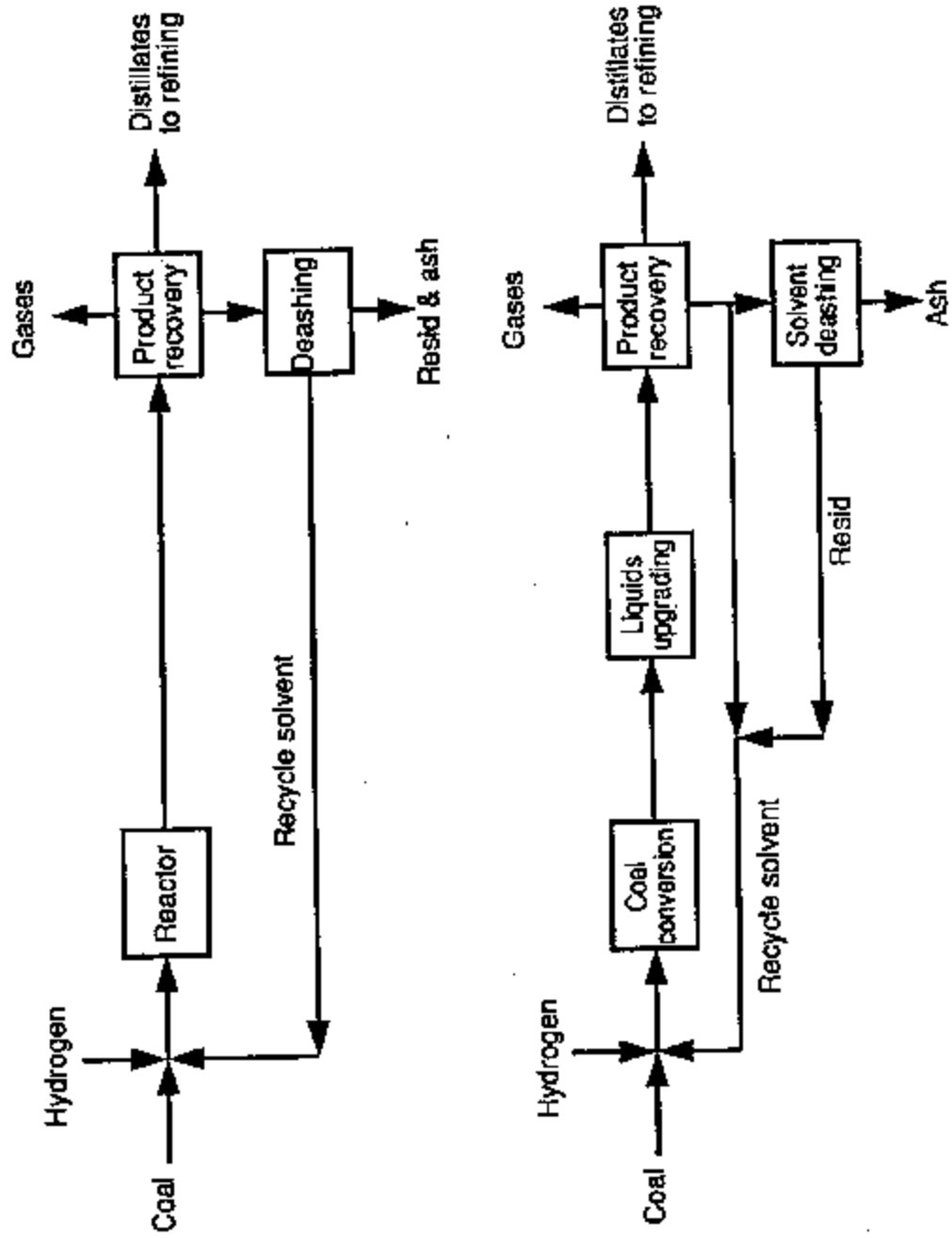
Simplified Block Flow Diagram



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

	<u>Breckinridge design</u>	<u>Current design</u>
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