

NAPHTHA FROM COAL A POTENTIAL NEW FEEDSTOCK

CONDENSATE AND NAPHTHA FORUM

MARCH 2012

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NAPHTHA FROM COAL

Naphtha has been produced from coal since the start of the industrial revolution in the 1780s. Today most of the naphtha produced from coal is as a byproduct in the production of coke for steel making. However, since the rise in the price of crude oil and crude oil derivatives over the past decade there has been increased interest in producing commodity products from non oil sources. This interest is spurred by concerns about energy security in a time of uncertain oil availability and price.

Despite its carbon intensity and moves by several jurisdictions to tax carbon emissions coal remains the principal alternative fuel source of interest because:

- Coal is widely available (most countries in the world have some coal)
- In many countries, reserves are vast (many billions of tonnes)
- Near surface coal is very easy to produce by open-cut methods
- the production cost can be very low (~ \$20/t or <**\$1/GJ** compared to oil about \$120/bbl or about **\$20/GJ**).

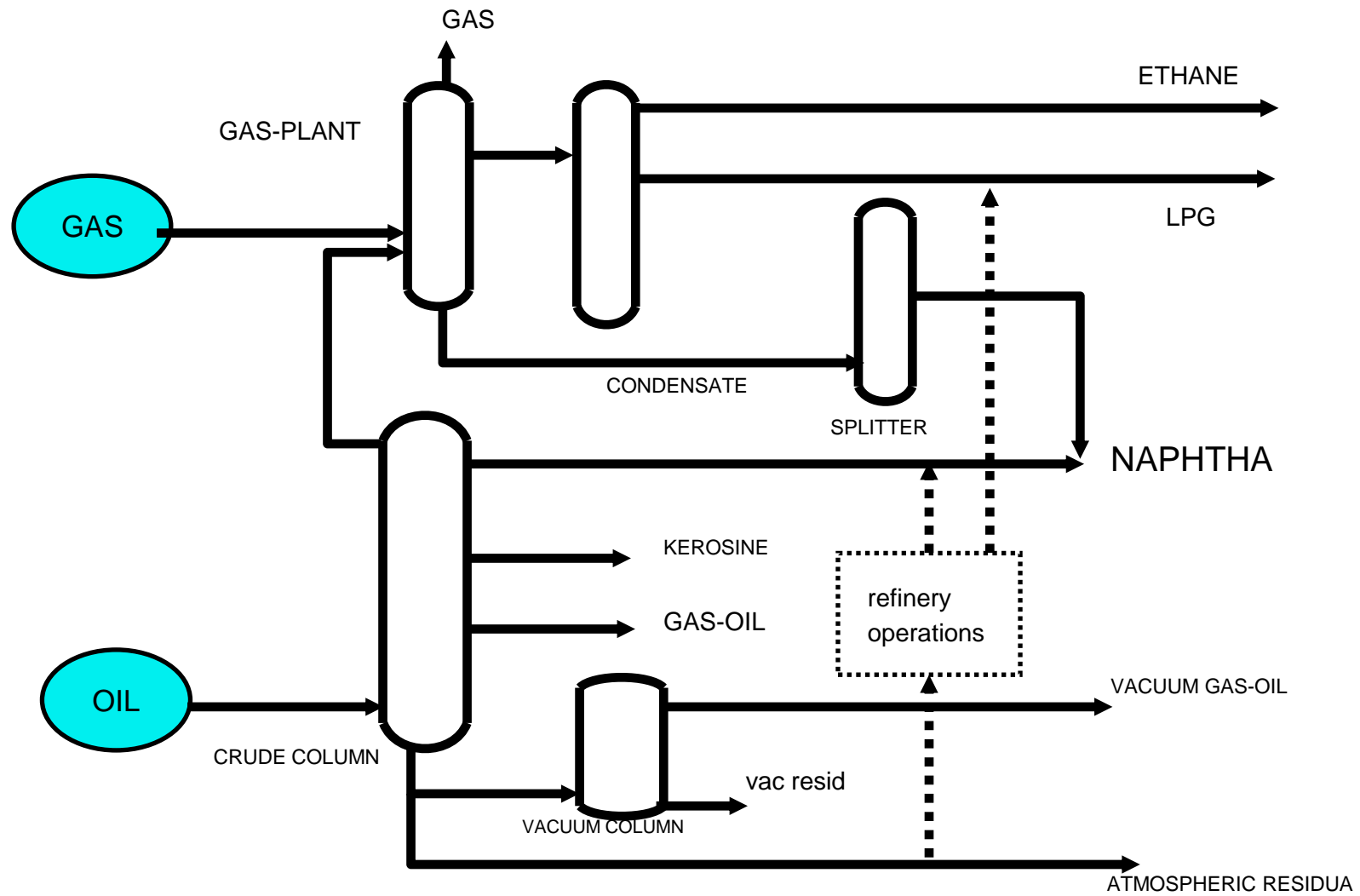
THE DIFFERENCE FACTOR OF 20 PAYS FOR A LOT OF CAPITAL AND CARBON CREDITS

In turning coal into products, naphtha is produced as byproduct the composition of which depends on the technology employed.

KEY ISSUES

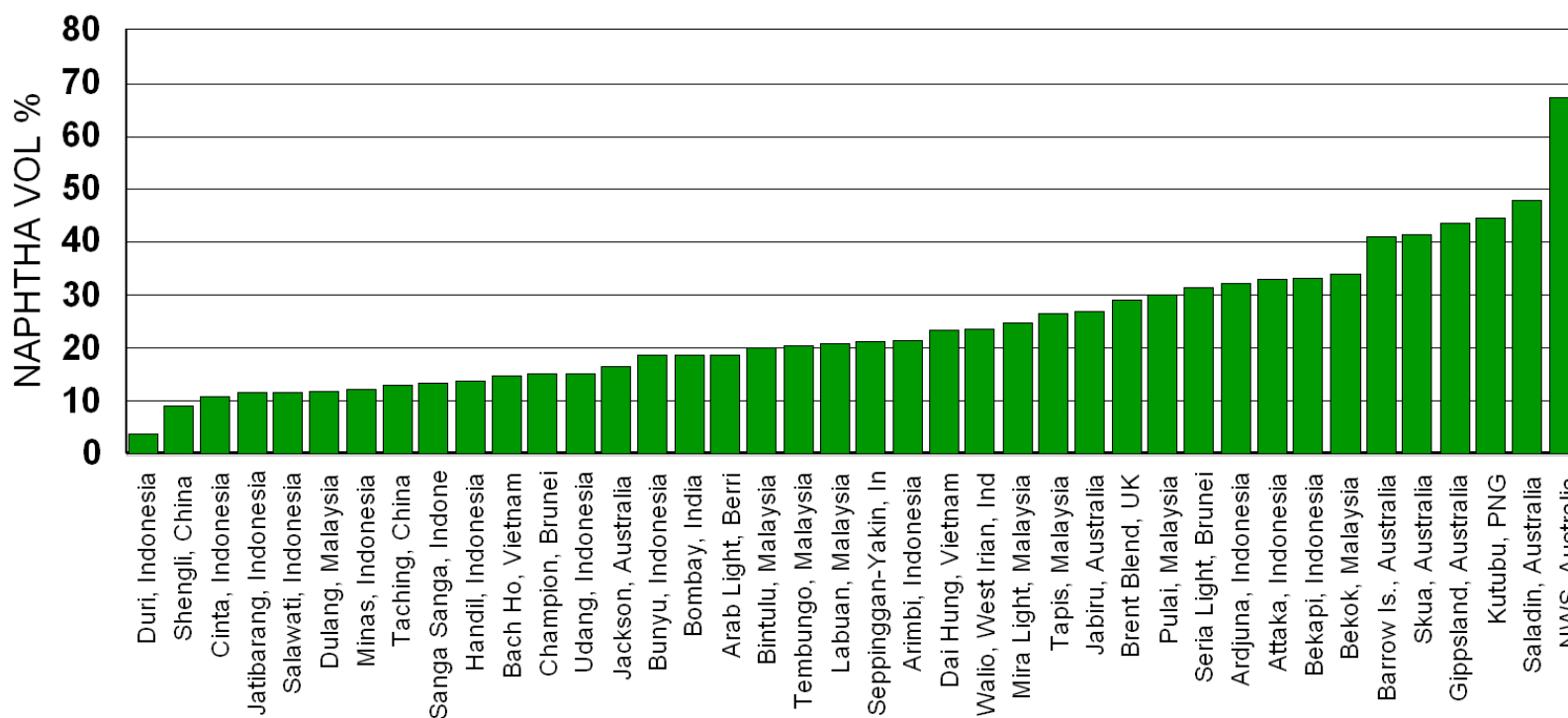
- TECHNOLOGY
- VOLUME AVAILABLE
- RAW COMPOSITION
 - ▶ SULPHUR
 - nitrogen
 - ▶ PARAFFINS
 - branching
 - ▶ NAPHTHENES
 - ▶ OLEFINS
 - ▶ AROMATICS
 - benzene
 - ▶ WATER SOLUBLE COMPONENTS
 - (ALCOHOLS, ALDEHYDES, KETONES etc)
- STABILITY
 - ▶ POST PRODUCTION TREATING
- USE

NAPHTHA FROM OIL & GAS



NAPHTHA FROM OIL

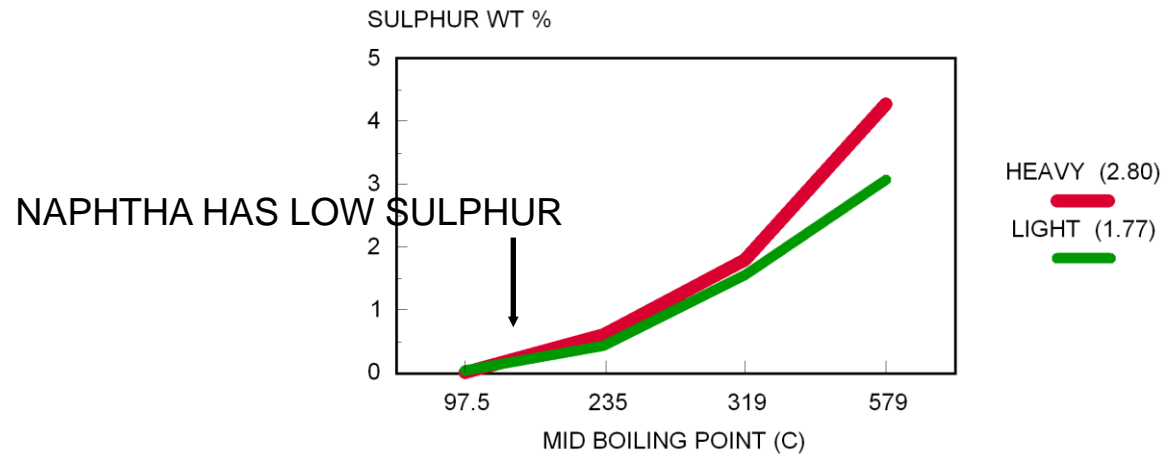
NAPHTHA CONTENT OF ASIAN EXPORT CRUDE OIL



NAPHTHA FROM OIL

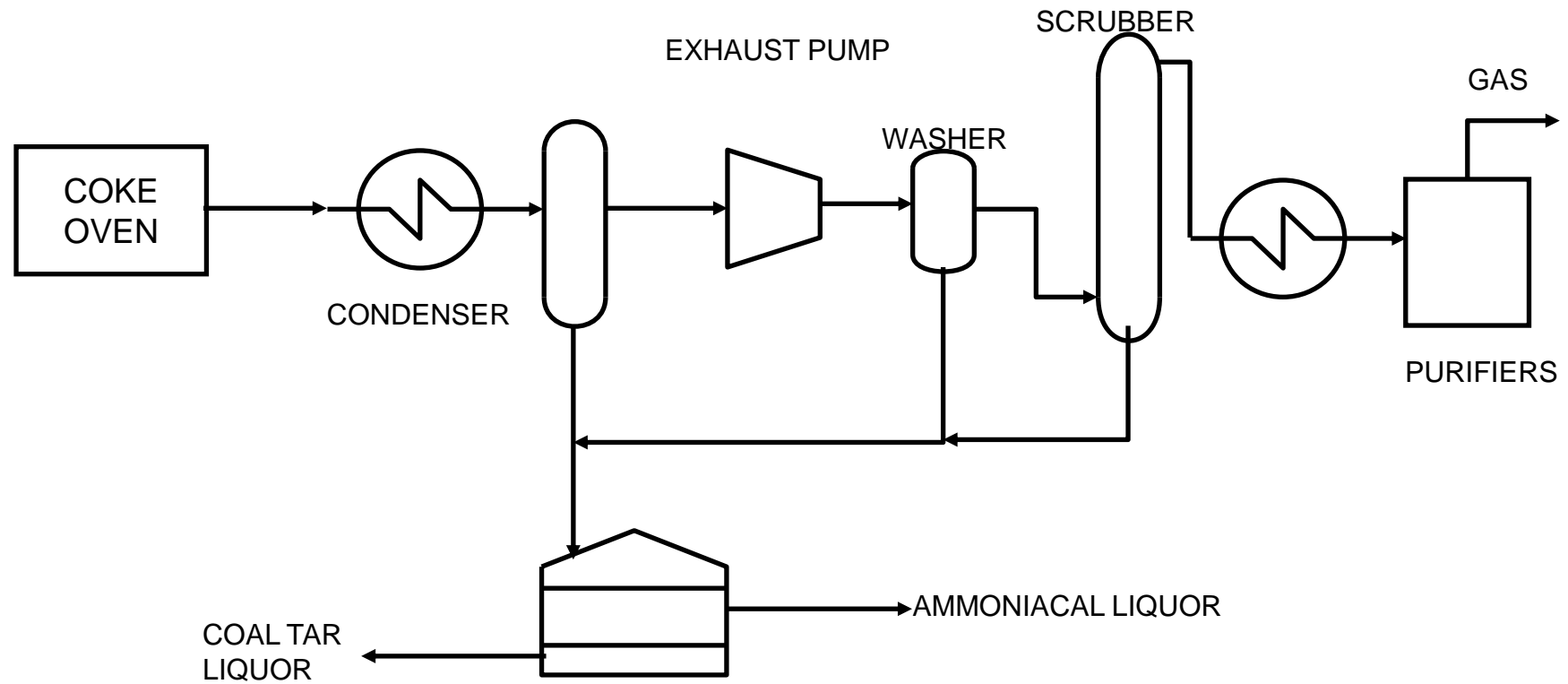
SULPHUR	LOW	< 0.5%	very low nitrogen
PARAFFINS	MODERATE	40% to 90%	high for Light Naphtha
BRACHED PARAFFINS	VARIABLE		depends on oil
OLEFINS	LOW	< 2%	
DIENES/ACETYLENES	NONE	0%	
NAPHTHENES	MODERATE	20% TO 70%	high for Heavy Naphtha
AROMATICS	LOW	3% to 20%	high for Heavy Naphtha
BENZENE	LOW	< 1%	
WATER SOLUBLE (oxygenates)	LOW	<1%	

SULPHUR CONTENT AND CRUDE FRACTION
SAUDI ARABIAN CRUDES



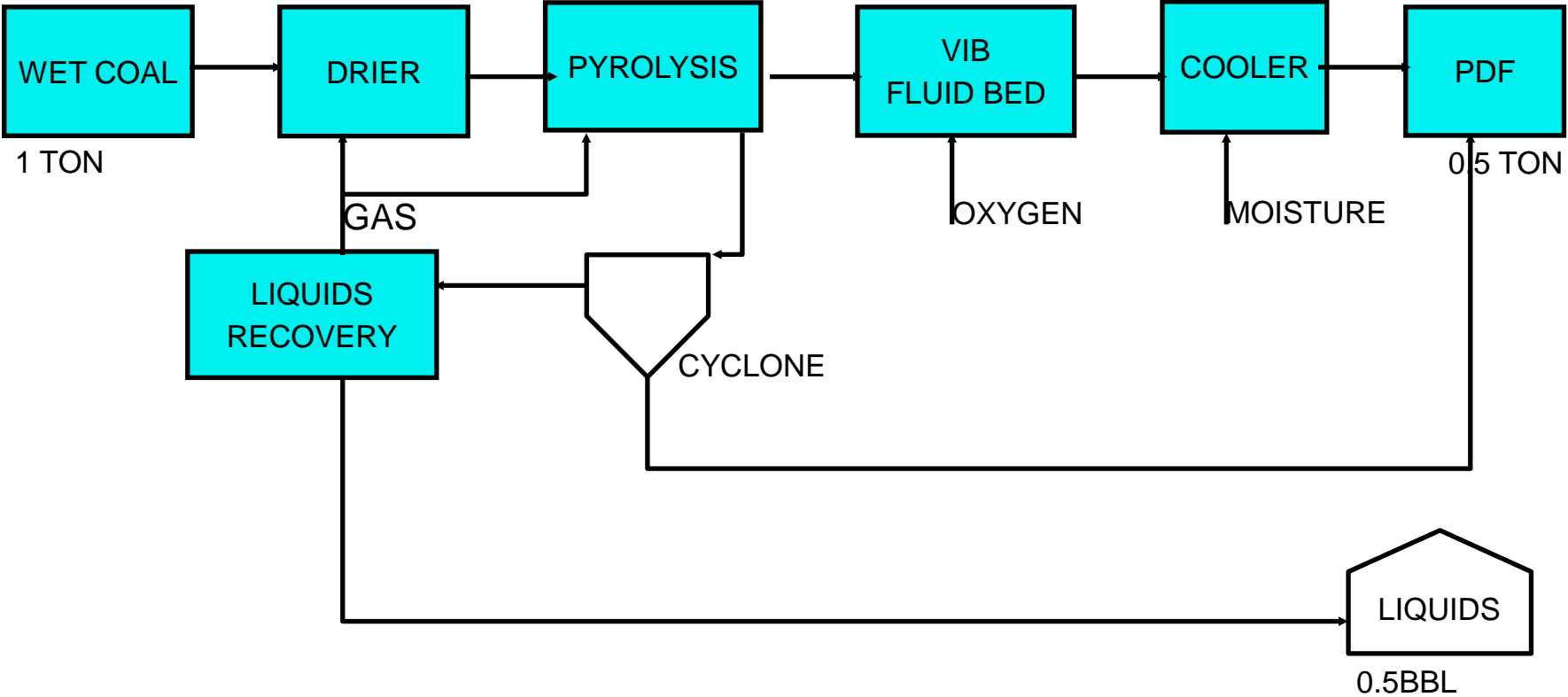
NAPHTHA BY COAL PYROLYSIS

A. COKE AND TOWN GAS



NAPHTHA BY COAL PYROLYSIS

B. LFC (Encoal)



NAPHTHA BY COAL PYROLYSIS

YIELD: ~ 0.1bbl NAPHTHA/t COAL

PRODUCT QUALITY IS COAL DEPENDENT

SULPHUR	HIGH	0.5 TO 1%	depends on technology Also contains nitrogen
PARAFFINS	LOW	<10%	
of which branched	VARIABLE		~ half of total
OLEFINS	LOW	<10%	
DIENES/ACETYLENES	HIGH	to 5%	
NAPHTHENES	MODERATE	~20%	
AROMATICS	HIGH	> 70%	many water soluble
BENZENE	HIGH	~ 5%	
WATER SOL	HIGH	>60%	phenols, cresols, xlenols

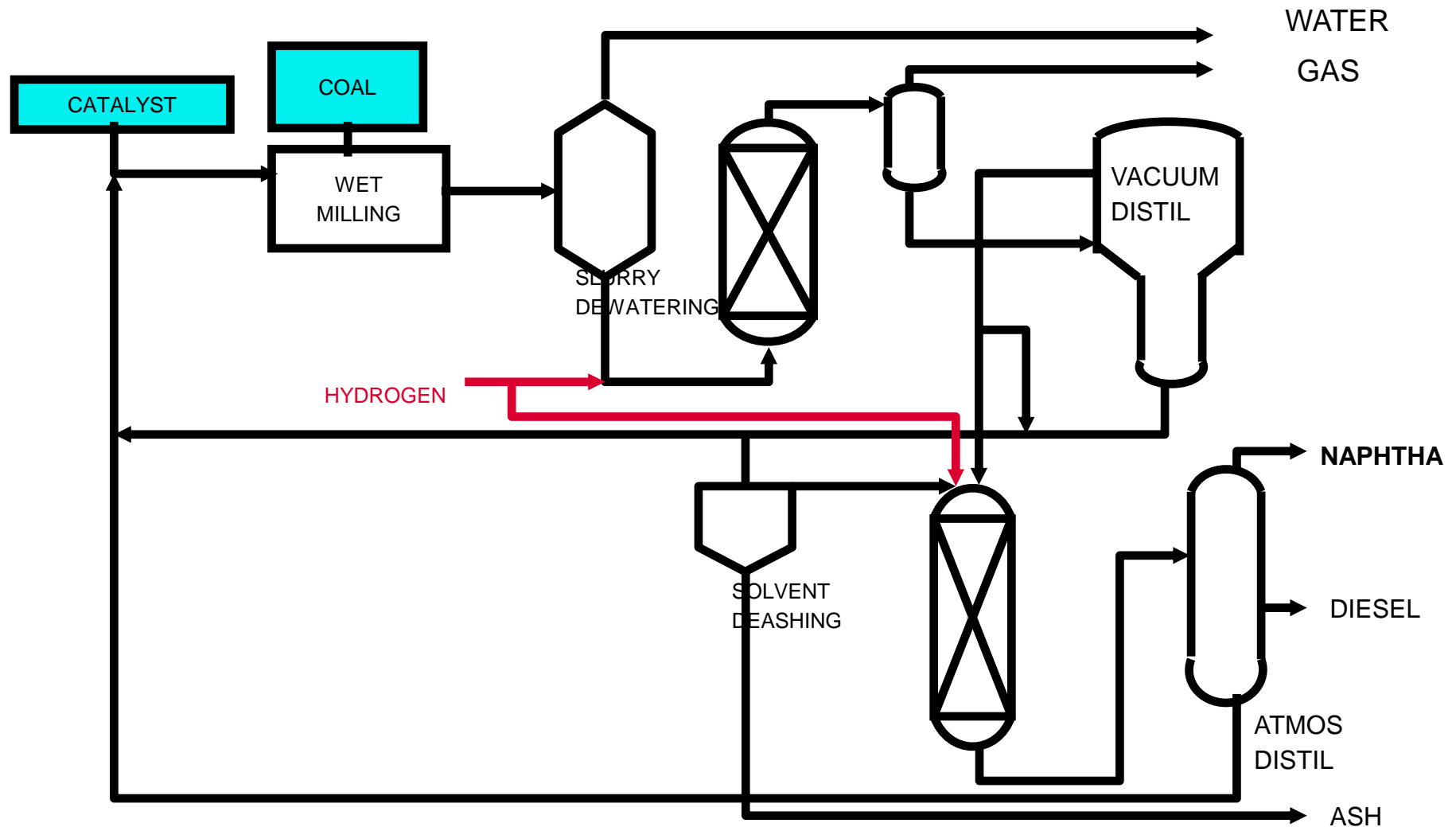
STABILITY: POOR

REQUIRES HYDROGENATION TO REMOVE DIENES

USE: WATER SOLUBLE COAL PRODUCTS

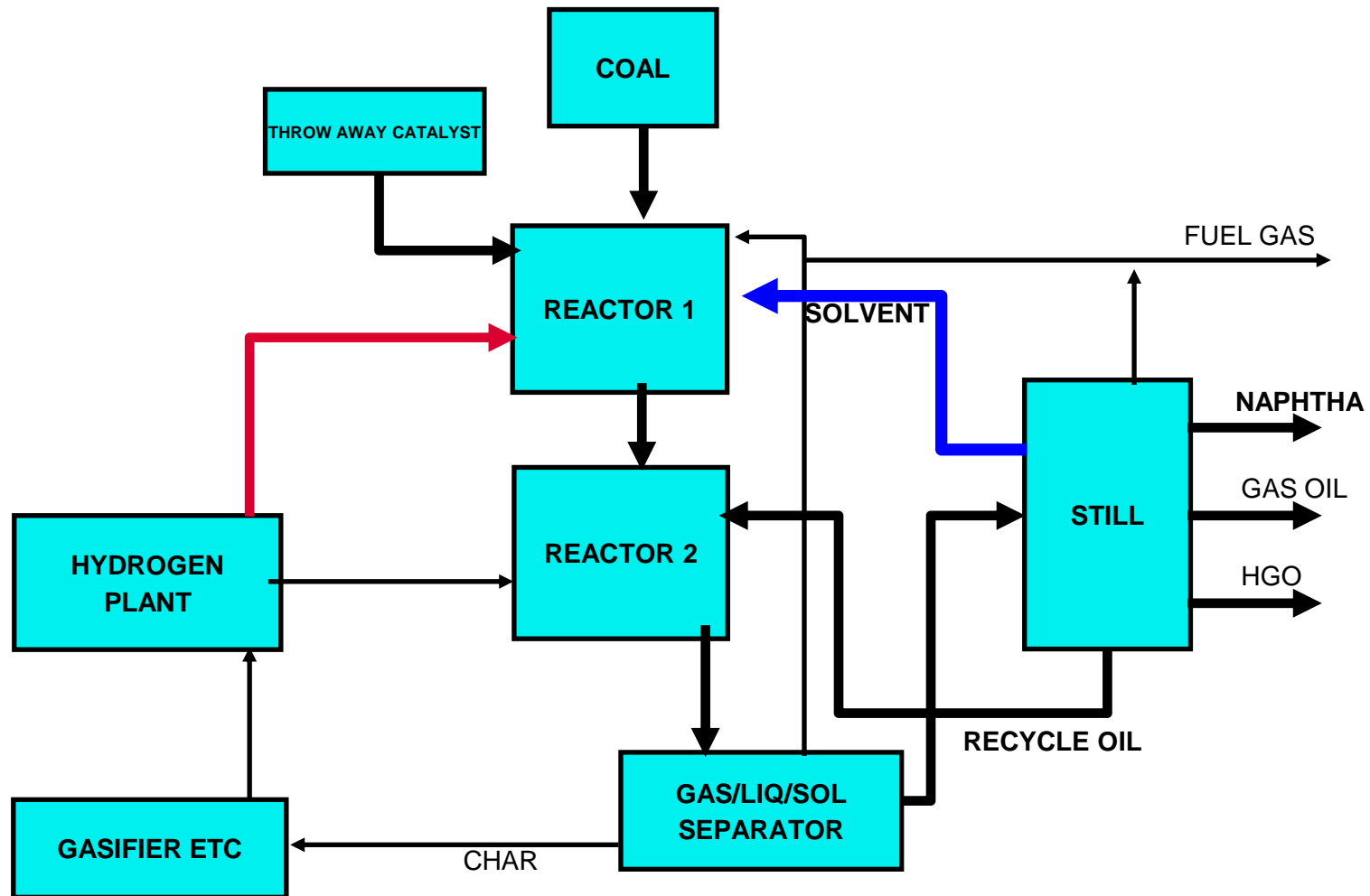
NAPHTHA BY COAL HYDROGENATION

B. NEDOL BROWN COAL HYDROGENATION



NAPHTHA BY COAL HYDROGENATION

C. DIRECT HYDROGENATION (HTI)



NAPHTHA BY COAL HYDROGENATION

YIELDS: 1t COAL 1.6 bbl naphtha (2.5 - 3.5bbl oil)

PRODUCT QUALITY IS COAL DEPENDENT:

BLACK COAL -> AROMATICS; LIGNITE -> ALIPHATIC

SULPHUR	MODERATE	0.5 TO 1%	depends on technology Also contains nitrogen
PARAFFINS	VARIABLE	<20%	depends on technology
of which branched	VARIABLE		
OLEFINS	LOW	<5%	multistage hydro-processes
POLYOLEFINS	NONE	0%	
NAPHTHENES	MODERATE	20% TO 50%	
AROMATICS	MODERATE	>30%	some data suggests 5%(?)
BENZENE	MODERATE	<5%	
WATER SOL (oxygenates)	VARIABLE	2 - 5%	depends on technology

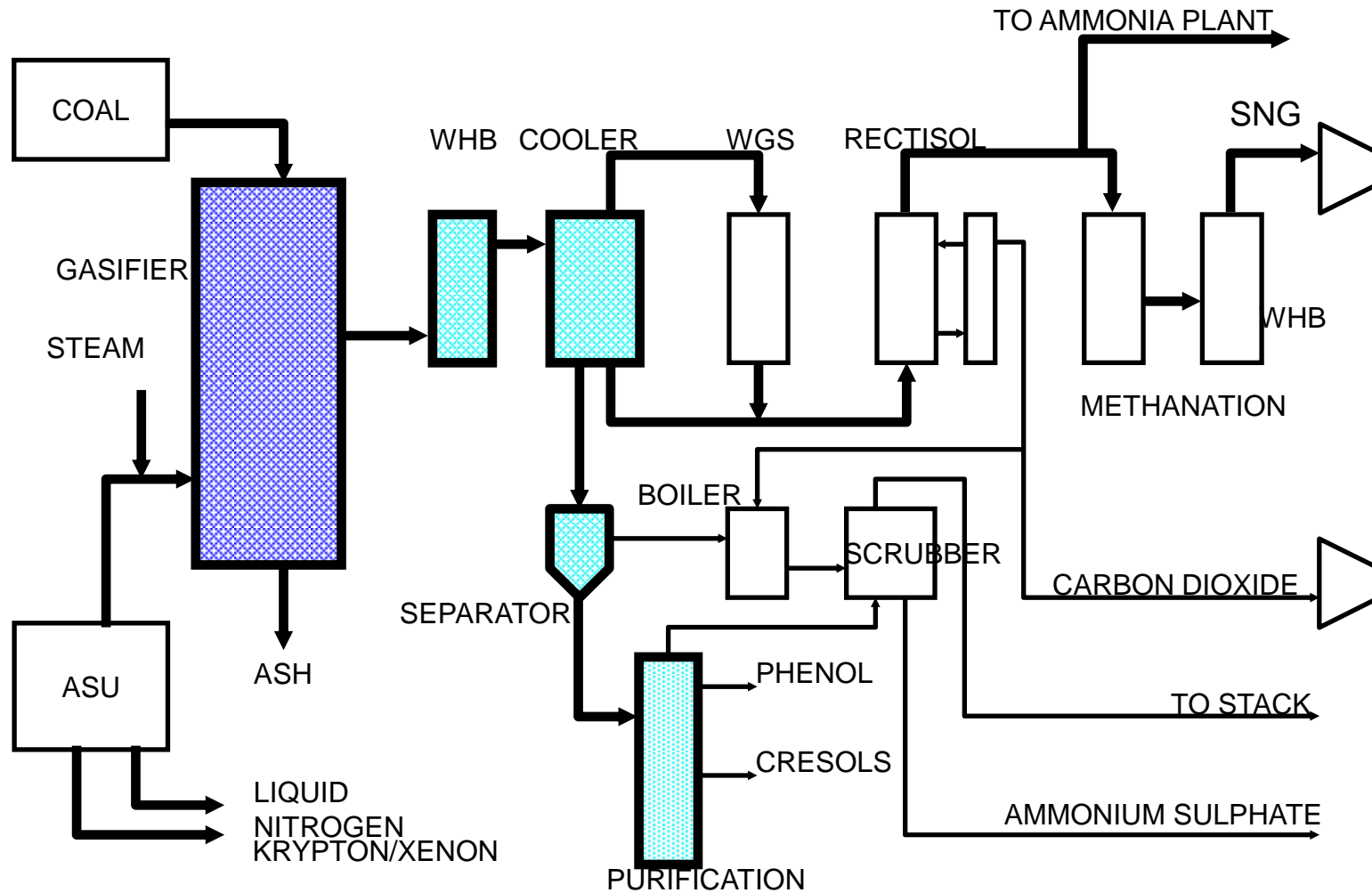
STABILITY: MODERATE

MAY REQUIRE FURTHER HYDROTREATMENT

USE: GASOLINE BLENDSTOCK (OCTANE>100)

NAPHTHA BY COAL GASIFICATION

DAKOTA COAL GASIFICATION



NAPHTHA BY COAL GASIFICATION LOW TEMPERATURE GASIFIERS - UCG

YIELD: 1t COAL - 0.03bbL OIL

PRODUCT QUALITY IS COAL DEPENDENT

SULPHUR	HIGH	0.5 TO 1%	depends on technology Also contains nitrogen
PARAFFINS	LOW	<10%	
of which branched	VARIABLE		~ half of total
OLEFINS	LOW	<10%	
DIENES/ACETYLENES	HIGH	to 5%	
NAPHTHENES	MODERATE	~20%	
AROMATICS	HIGH	> 70%	many water soluble
BENZENE	HIGH	~ 5%	
WATER SOL	HIGH	>60%	phenols, cresols, xlenols

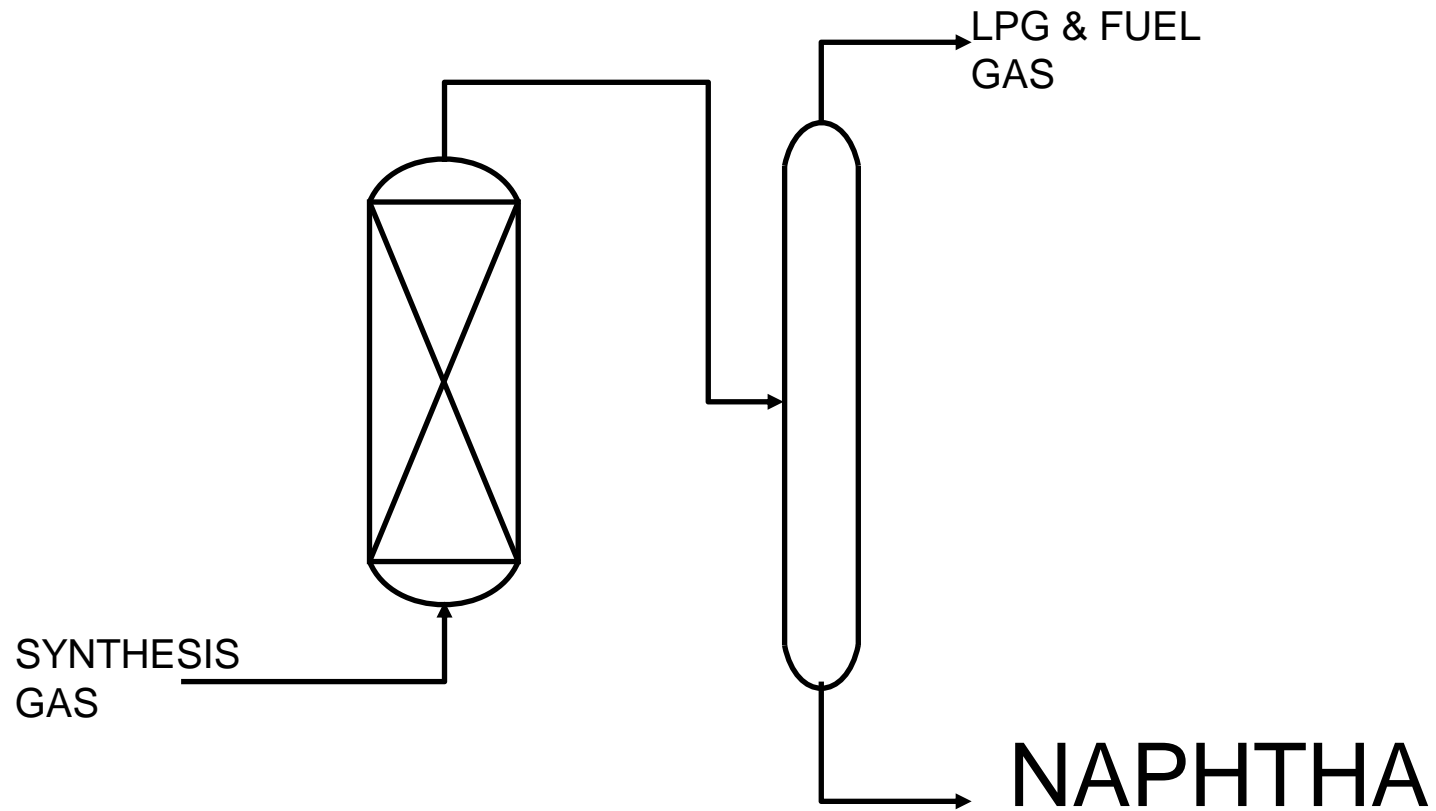
STABILITY: POOR

REQUIRES HYDROTREATMENT

USE: Oxygenates - coal chemicals

NAPHTHA BY FISCHER-TROSCH PROCESS

1. HIGH TEMPERATURE PROCESS



NAPHTHA BY HTFT PROCESS

HIGH TEMPERATURE REACTOR

YIELD: 1t COAL ~ 1.6bbi NAPHTHA (gasoline)

PRODUCT QUALITY INDEPENDENT OF COAL

SULPHUR	NONE	0%	no nitrogen
PARAFFINS	MODERATE	40 - 60%	
of which branched	HIGH		>50 % of paraffins
OLEFINS	HIGH	40 - 50%	
DIENES/ACETYLENES	LOW	<1%	
NAPHTHENES	MODERATE	<5%	
AROMATICS	MODERATE	<10%	
BENZENE	MODERATE	<2%	
WATER SOL	HIGH	3%	

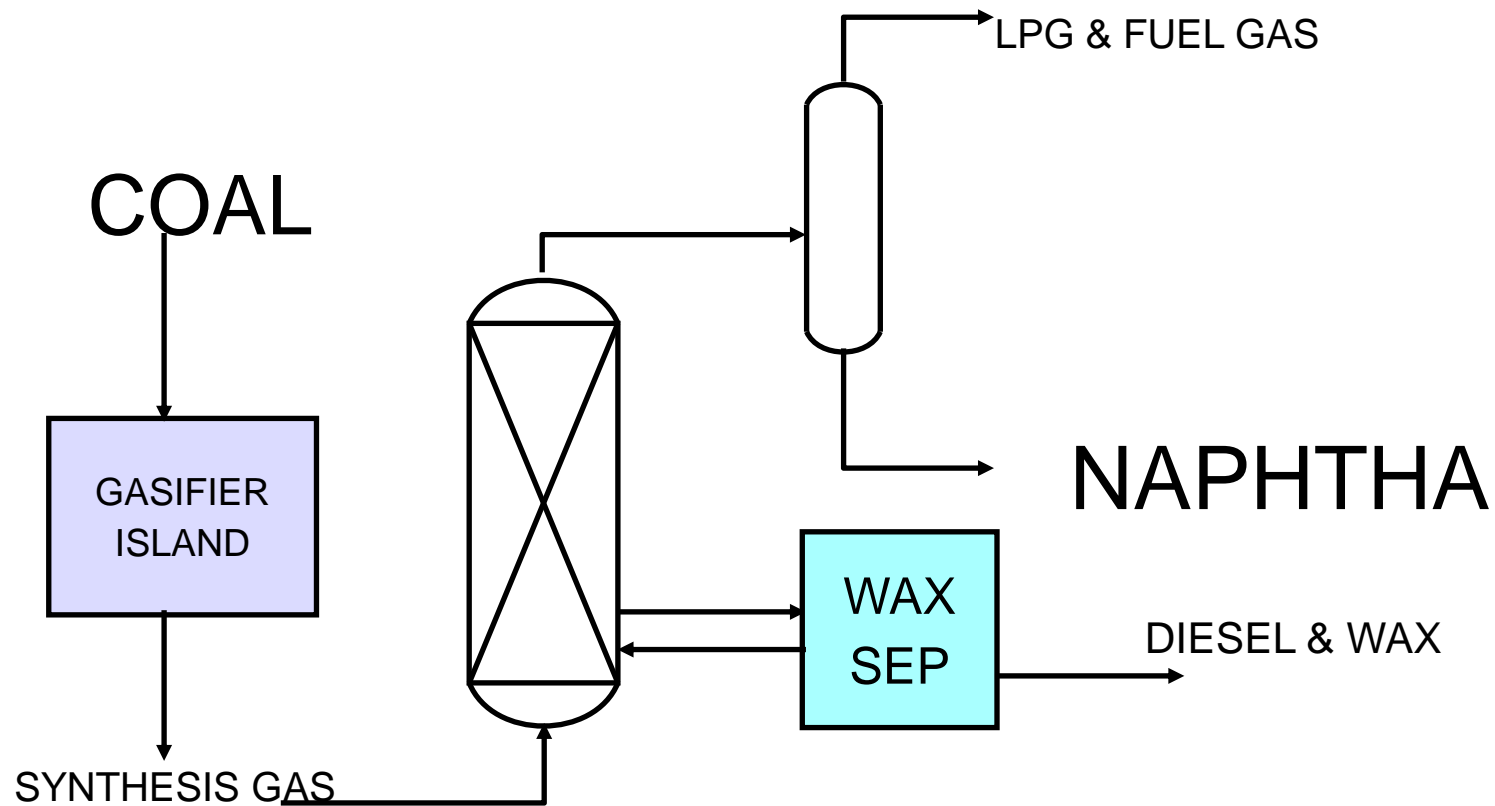
STABILITY: MODERATE

MAY REQUIRE FURTHER HYDROTREATMENT

USE: GASOLINE BLENDSTOCK

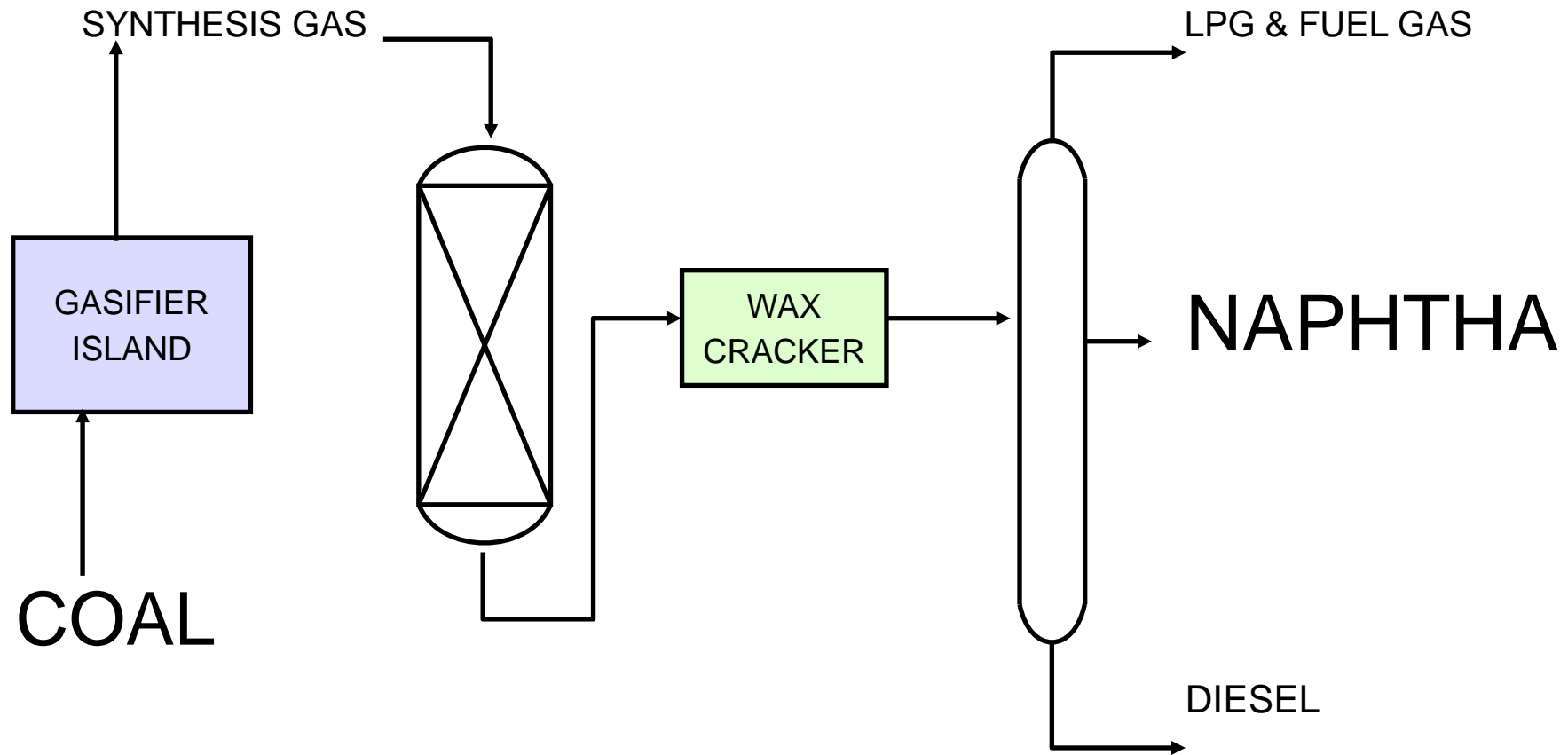
NAPHTHA BY FISCHER-TROSCH PROCESS

2a. LOW TEMPERATURE SLURRY PROCESS



NAPHTHA BY FISCHER-TROSCH PROCESS

2b. LOW TEMPERATURE FIXED-BED PROCESS



NAPHTHA BY LTFT PROCESS

LOW TEMPERATURE REACTOR

YIELD: 1t COAL ~ 0.8 bbl NAPHTHA (2.5 BBL/OIL)

PRODUCT QUALITY INDEPENDENT OF COAL

		RAW	HYDROGENATED	
SULPHUR	NONE	0%		No nitrogen
PARAFFINS	HIGH	~90%	~70%	
of which branched	LOW	~15%	~30%	depends on severity
OLEFINS	LOW	<10%	0%	
POLYOLEFINS	NONE	<0%	0%	
NAPHTHENES	LOW	<5%	<5%	
AROMATICS	LOW	<3%	<3%	
BENZENE	VERY LOW	<0.5%	<0.5%	
WATER SOL (acids)	LOW	<1%	0%	Raw product high TAN No.

STABILITY: GOOD

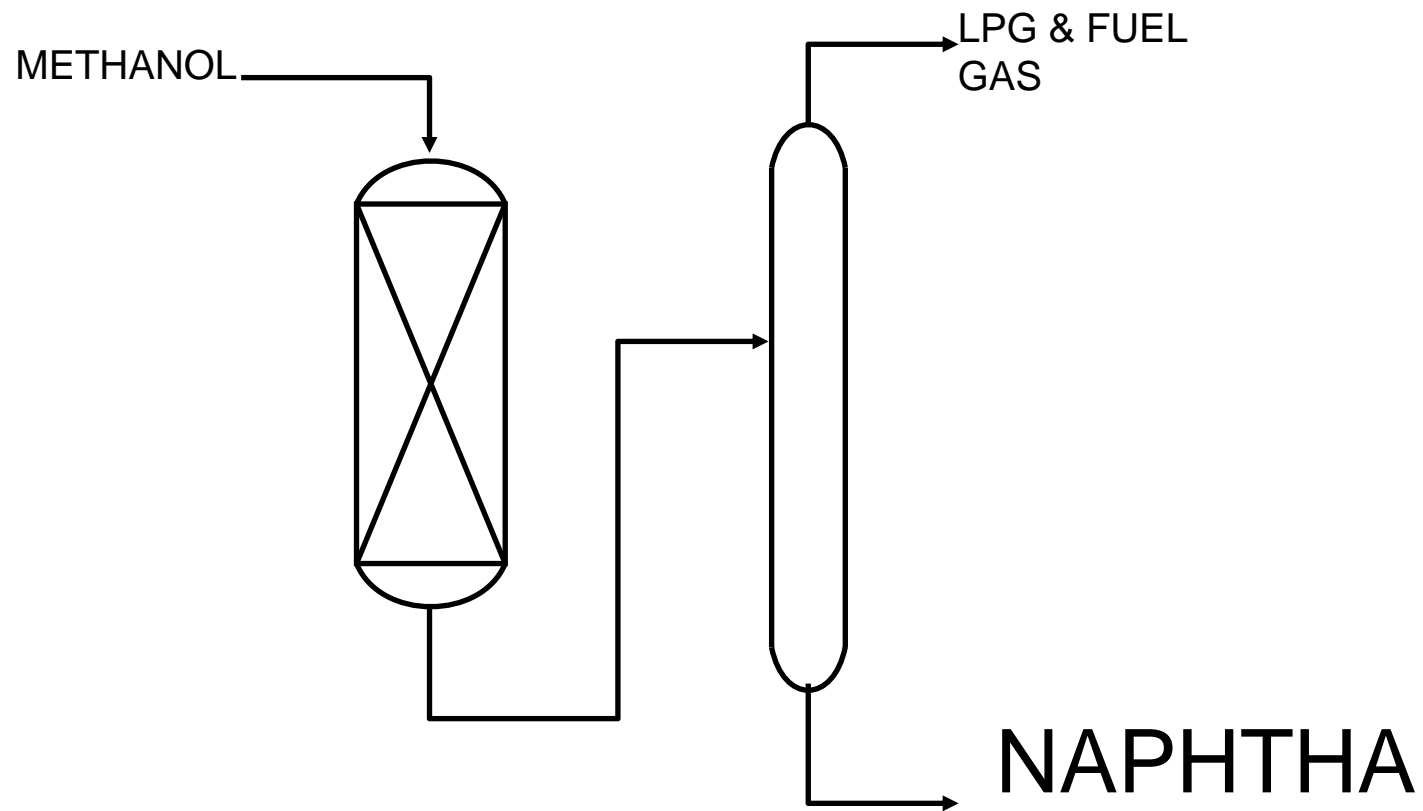
RAW PRODUCT IS HYDROGENATED TO ELIMINATE OLEFINS AND OXYGENATES

HYDROGENATION CAN CAUSE ISOMERISATION WHICH INCREASES CHAIN BRANCHING

USE: Petrochemical cracker feed

NAPHTHA BY METHANOL CONVERSION

1. METHANOL TO GASOLINE (MTG)



NAPHTHA FROM MTG PROCESS

YIELD: 1t COAL ~ 2.0bbbl NAPHTHA (gasoline)

PRODUCT QUALITY INDEPENDENT OF COAL

SULPHUR	NONE	0%	no nitrogen
PARAFFINS	MODERATE	~30%	
of which branched		>90%	
OLEFINS	MODERATE	~15%%	Mostly C4 and C5
POLYOLEFINS	NONE	<%	
NAPHTHENES	LOW	<5%%	
AROMATICS	MODERATE	~30%	Durene in raw product
BENZENE	LOW	<1%	
WATER SOL	LOW	<1%	

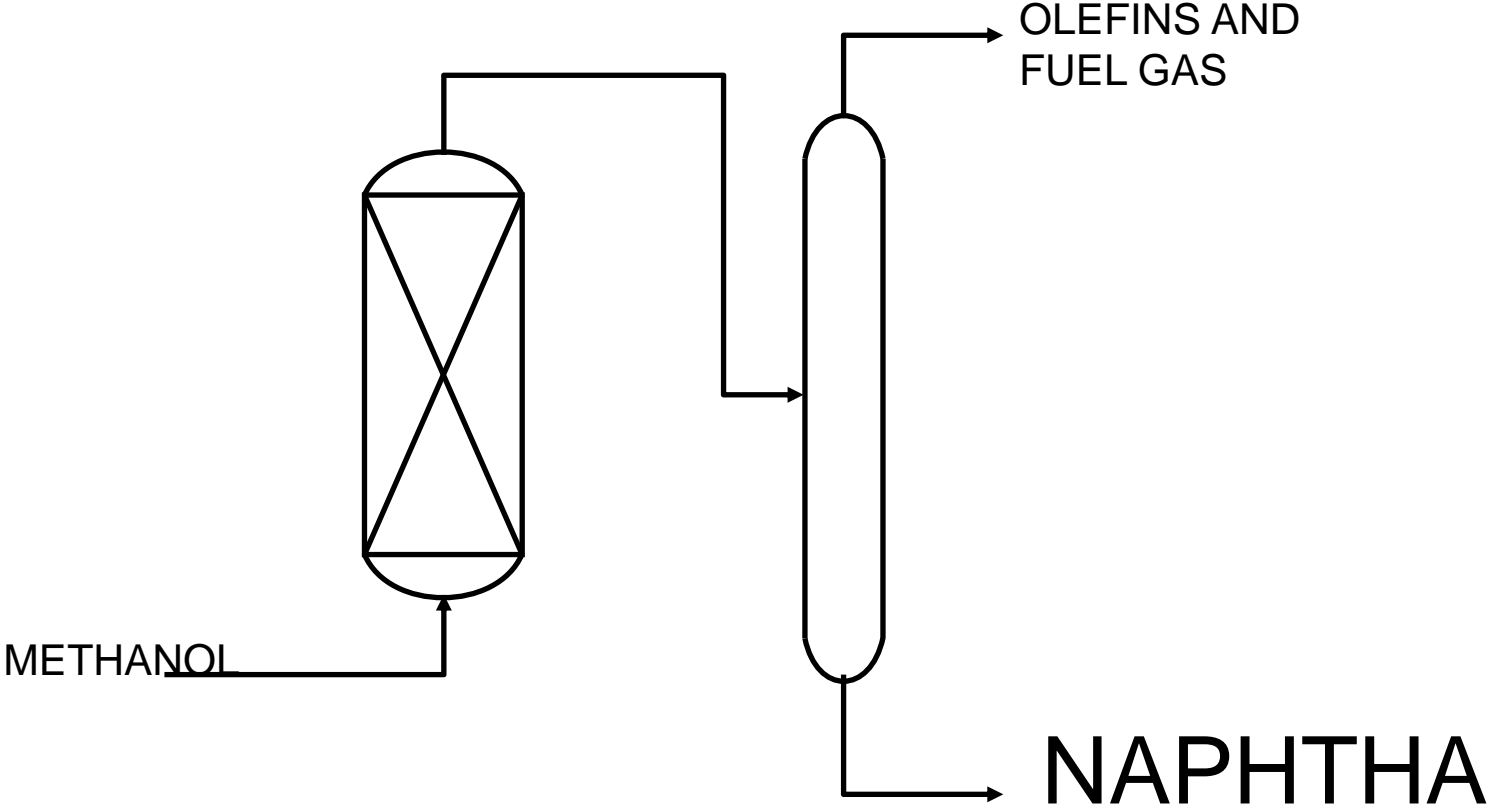
STABILITY: GOOD

HEAVY FRACTION HYDROTREATED TO REDUCE DURENE

USE: Gasoline (92 RON)

NAPHTHA BY METHANOL CONVERSION

2. METHANOL TO OLEFINS (MTO)



NAPHTHA FROM MTO PROCESSES

YIELD: 1t COAL ~ 0.5bbbl NAPHTHA

PRODUCT QUALITY INDEPENDENT OF COAL

		ZSM-5 Catalysts	Mol. Seive Catalysts	
SULPHUR	NONE	0%	0%	no nitrogen
PARAFFINS	MODERATE	~30%	~ 30%	
of which branched	HIGH	>90%	>90%	
OLEFINS	HIGH	>50%%	>50%	Mostly C4, C5, C6
POLYOLEFINS	NONE	0%	0%	
NAPHTHENES	LOW	<5%%	<5%	
AROMATICS	VARIABLE	~30%	<5%	high p-xylene for ZSM-5
BENZENE	LOW	<1%		
WATER SOL	LOW	<1%	<1%	some ethers and acids possible

STABILITY: GOOD

USE: Gasoline blendstock

OXYGENATES may need to be extracted