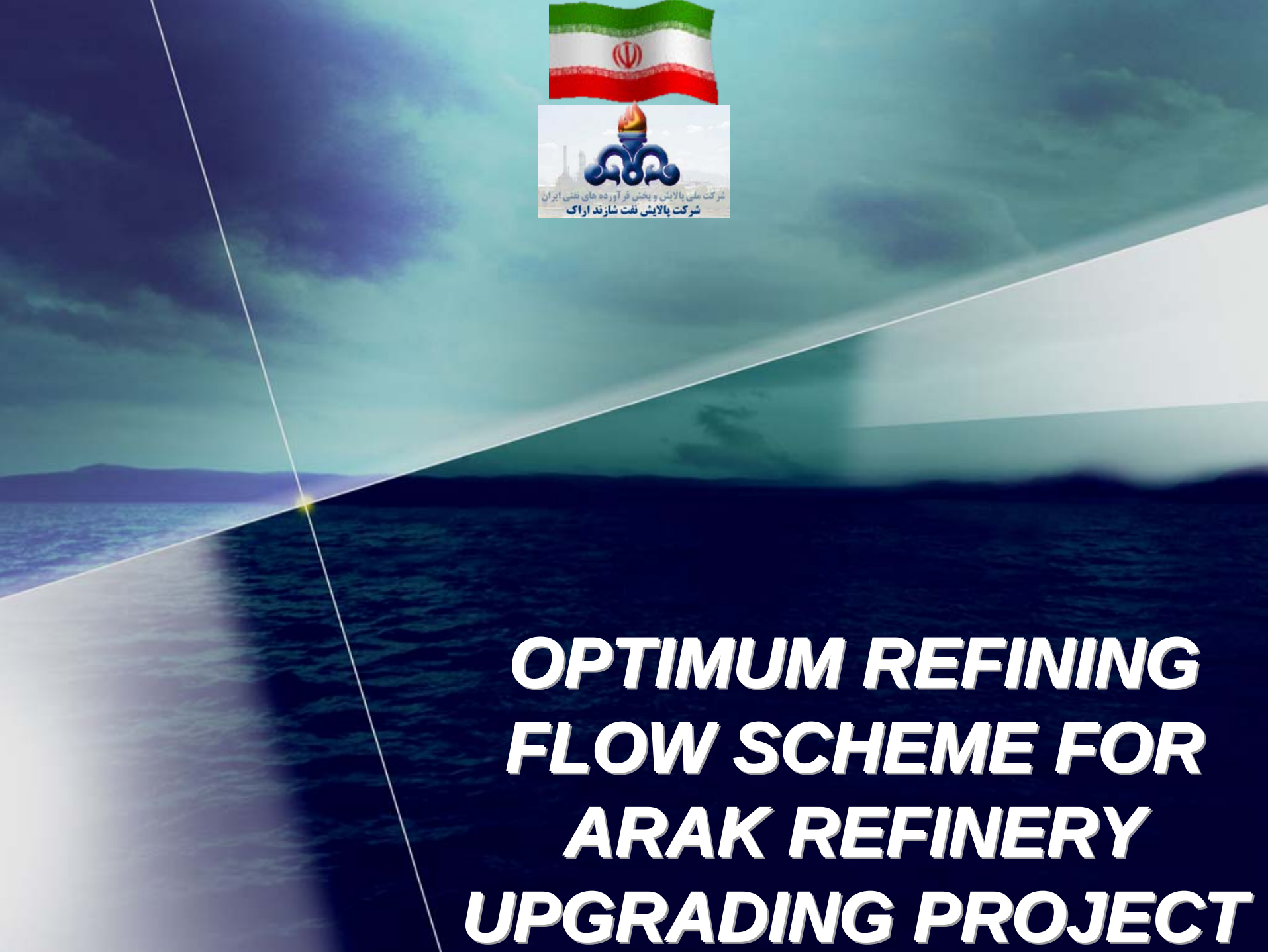


OPTIMUM REFINING FLOW SCHEME FOR ARAK REFINERY UPGRADING PROJECT

PRESENTATION OUTLINE

- Current market condition
- Proven residue conversion technologies
- Arak refinery current refining flow scheme
- Goals of project
- Different refining studied flow schemes

INTRODUCTION

Past

Residue upgrading investment less than expected:

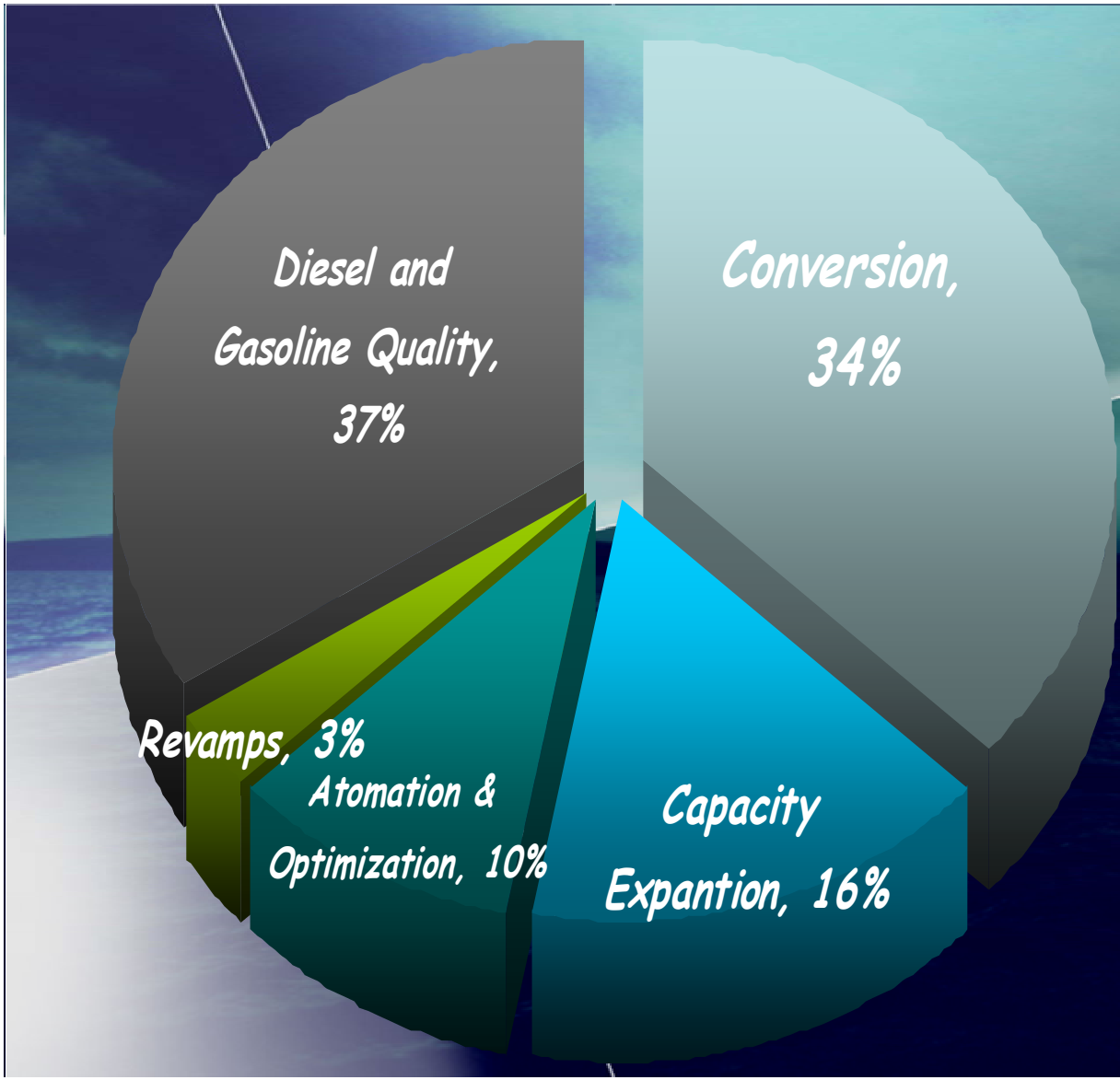
- Ligh crude availability
- Poor economic situation
- Slower than expected decline in fuel oil markets
- Higher capital costs and perceptions of unreliability

Now

More interest and investment due to:

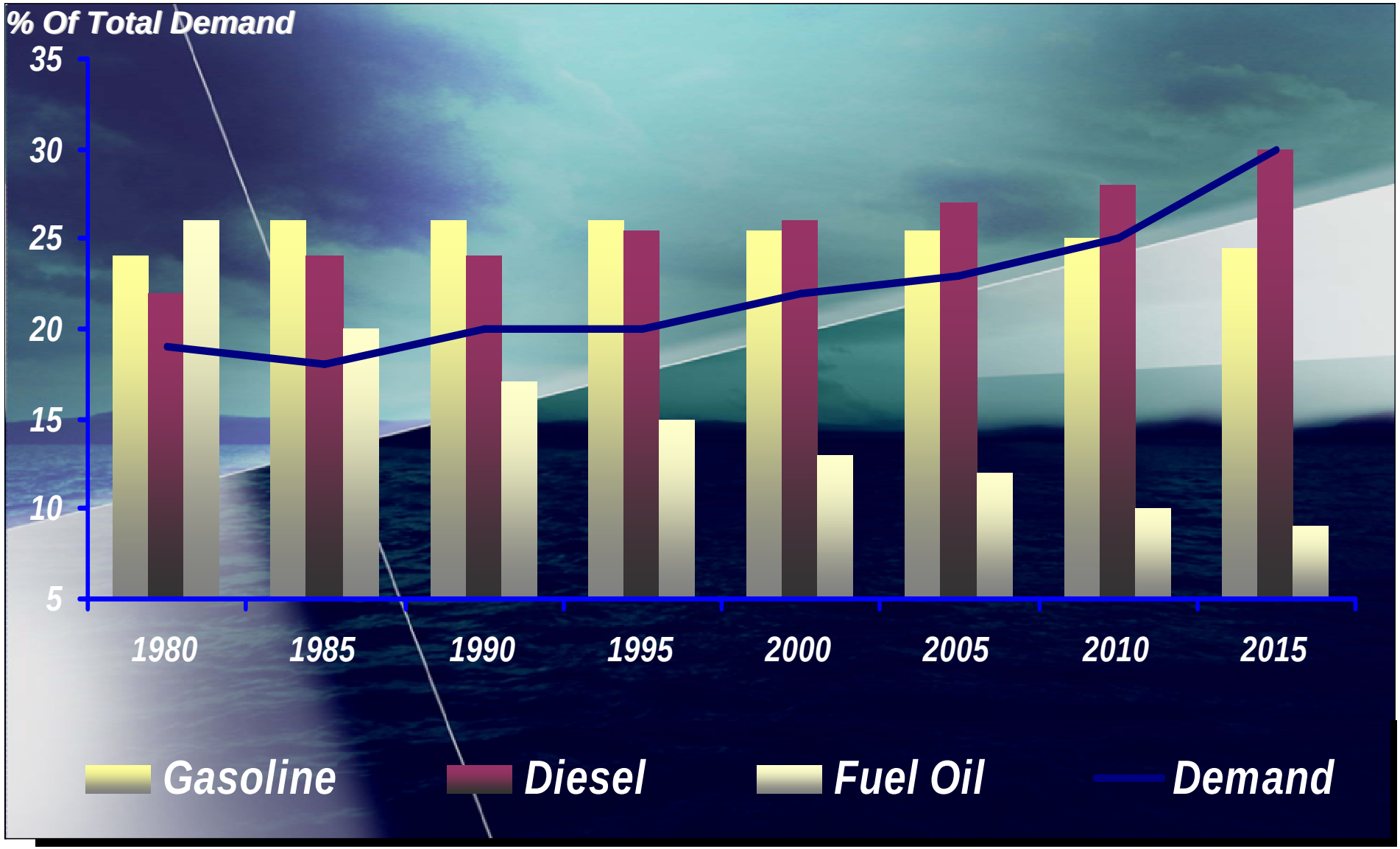
- Stringent product specifications and environmental
- Need for transportation fuels
- Continuing decline in fuel oil markets
- Technology improvement
- Improved economic conditions

REFINING INVESTMENT (2000-2005)



- residue upgrading importance,
- implementation challenges,
- challenges with technology providers.

REFINERY PRODUCTS TREND



CURRENT MARKET CONDITION

- **Need to Produce Cleaner Products:**
  - Gasoline , Diesel Specifications
  - Refinery Fuel - Lower Sulfur
- **Significant Reduction in high Sulfur Fuel Oil Demand:**
  - Reduce HSFO Production
  - Substitute LSFO to HSFO
- **Limited availability of Low Sulfur Light Crudes**

Investment in Refinery Residue Processing

REFINERY PRODUCTS SPESIFICATIONS

Japan	1999	2000	2002
Unleaded Gasoline			
Sulphur, max. ppm	100	100	30
Benzene, max. %vol	5	<1	<1
MTBE, max. %wt	7	7	7
Diesel			
Sulphur,max.ppm	500	500	30
Cetane Index	50	50	50

Europe	Current	2005	2010
Unleaded Gasoline			
Sulphur, max. ppm	150	50	10
Total Arom, max. %v	42	35	*
Benzene, max. %vol	1	1	*
Oxygen, max. %wt	2.3	2.7	*
Diesel			
Sulphur, max. ppm	350	50	50
Cetane Number	51	*	*
Polycyclic Aromatics	11	*	*
Density (15°C, kg/m3)	845	*	*
Distillation Point (95%)	360	*	*

REFINERY CONDITION

- Existing Refinery Configuration
  - Capacity,Crude State
  - Degree of Residue,VGO Conversion
- Future Product Specifications
- Future Product requirements
  - Outlet for HSFO, Need for Power
- Impact of Future Power Price
- Current Product Quality
  - Gasoline,Diesel
- Impact of Financing Condition
- Identify possible residue upgrading options

RESIDUE UPGRADING TECHNOLOGY CHALLENGES

- Capital cost
- Quality of products
- Feedstock Limits
- Variety of potential options
- Operating Cost
- Other Emerging Technologies (GTL)

ROUTES TO RESIDUE UPGRADING

THERMAL PROCESS

- Visbreaker
- Delayed Coker
- Flixicoker
- Deep Thermal Conversion

→

- Low Selectivity Process
- Poor Quality Products
- No Catalyst

CATALYTIC CRACKING PROCESS

- R2R
- HOC
- RCC

→

- More Selectivity
- Medium Quality Products
- Due to catalyst no metal feeds
- Appropriate for VGO

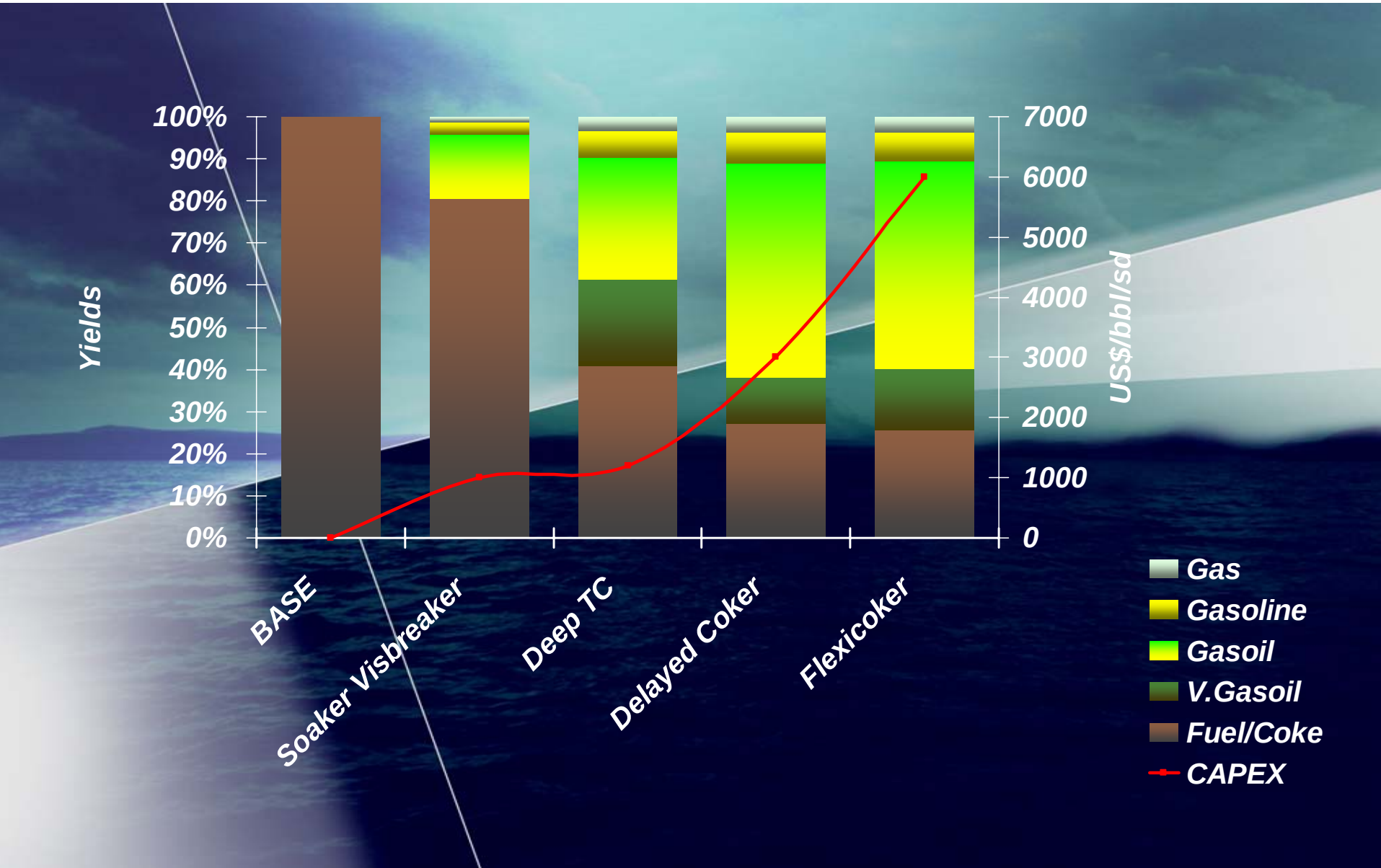
HYDROCRACKING PROCESS

- HYVAHL
- VRDS
- LC-Fining
- H-OIL
- HYCON

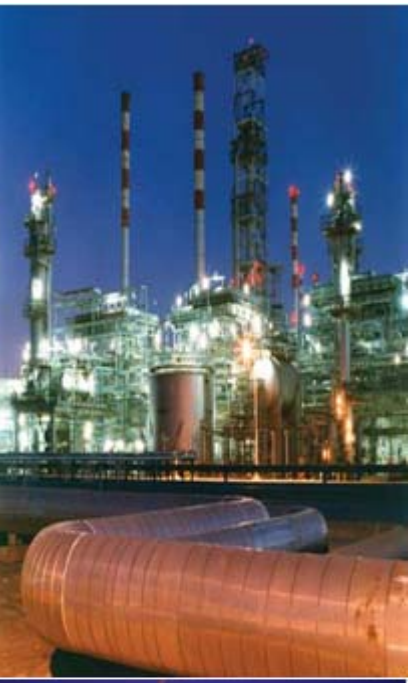
→

- Very high cracking selectivity
- Complete Conversion
- No Coke Production
- High Hydrogen Consumption

THERMAL CONVERSION RESIDUE UPGRADING



CARBON REJECTION TECHNOLOGIES MAJOR CHALLENGES



Solvent deasphalting

- Remove asphalts
- Increase gas oil yield from crude
- Make commercial asphalts from asphaltic crude unit bottoms
- Pitch utilization

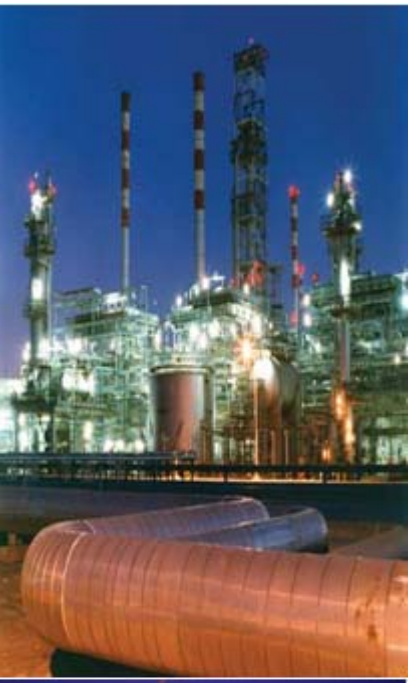
Catalytic cracking

- Make gasoline and distillates
- Try to minimize heavy fuel oil
- Medium severity cracking process

Coking

- Create light gasses and distillates
- Coke market

HYDROGEN ADDITION TECHNOLOGIES



Fixed Bed Process

- Improved catalyst and loading strategy
- In-line catalyst change
- Better Knowledge of Asphaltene chemistry

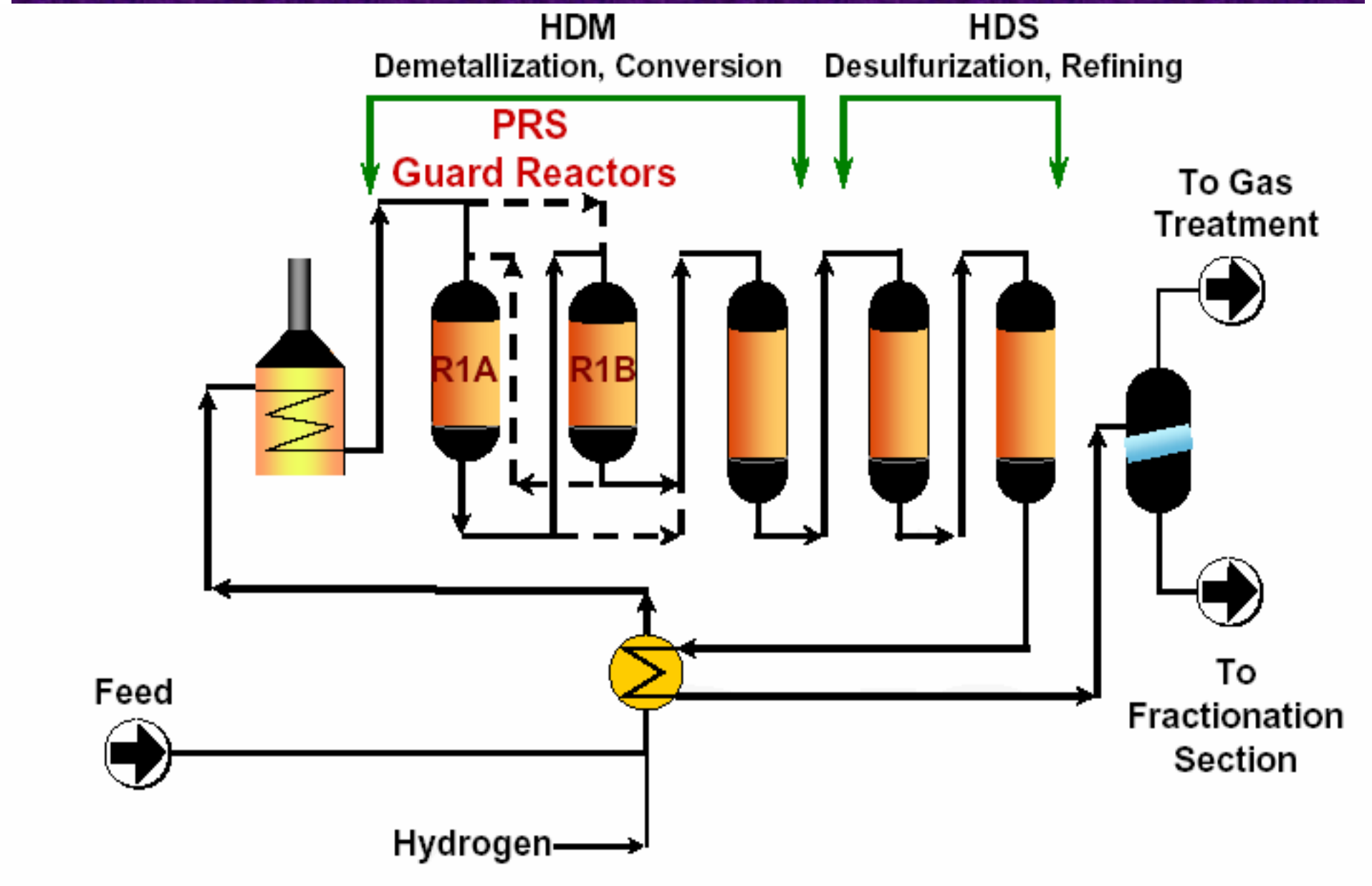
Ebullating Bed

- Second generation catalyst and catalyst rejuvenation
- New Reactor Design
- Hydroprocessing integration

Ebullated bed VS Fixed bed

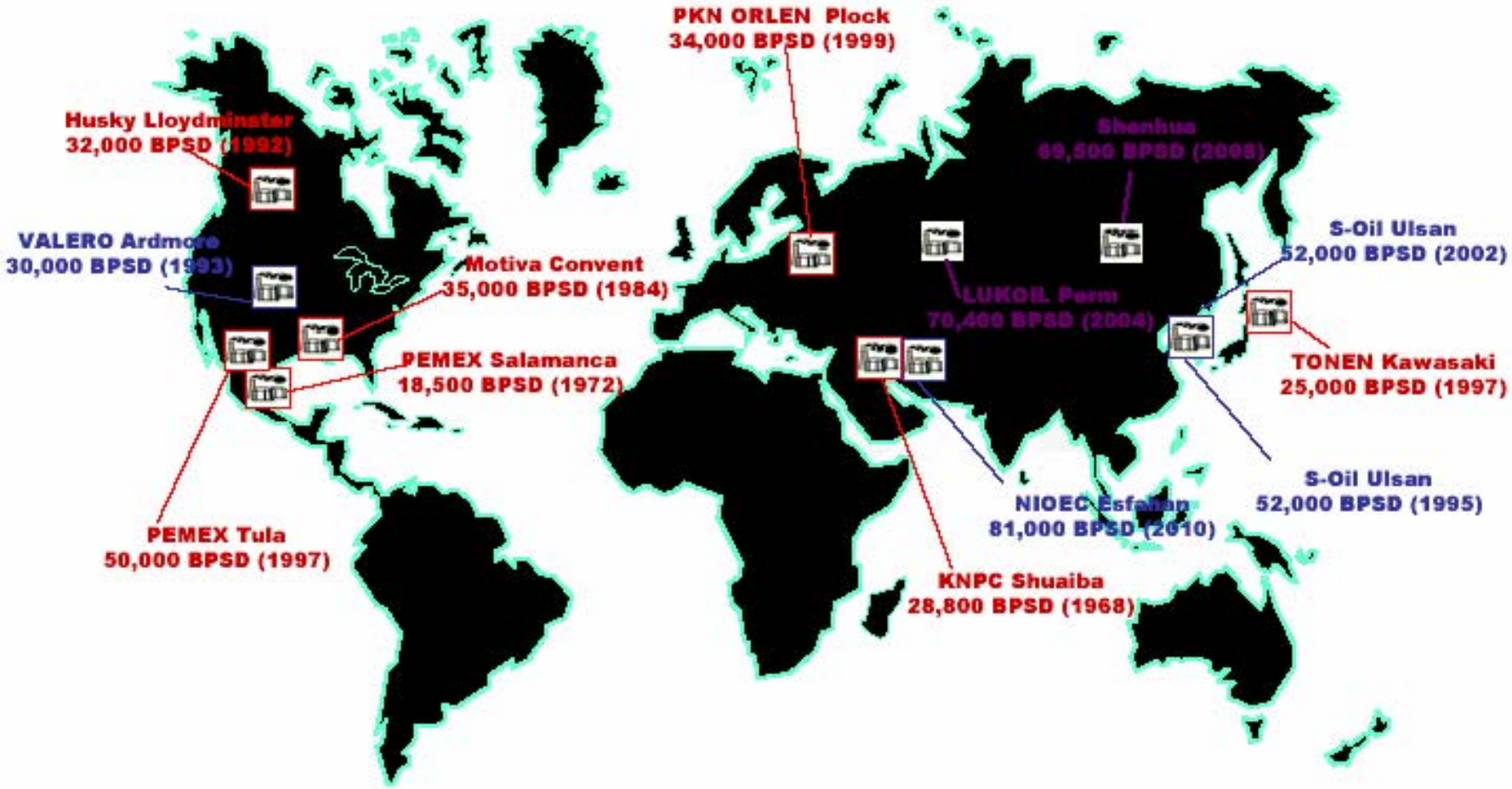
- ✓ یکنواختی درجه حرارت واکنشهای گرمازای سولفورزدایی
- ✓ قابلیت تصفیه خوراک حاوی 500ppm فلز
- ✓ قابلیت تصفیه وتبدیل خوراکهای فوق سنگین
- ✓ قابلیت تغییر درکیفیت خوراک ورودی
- ✓ عمر بالای کاتالیست

Typical Hyvahal arrangement



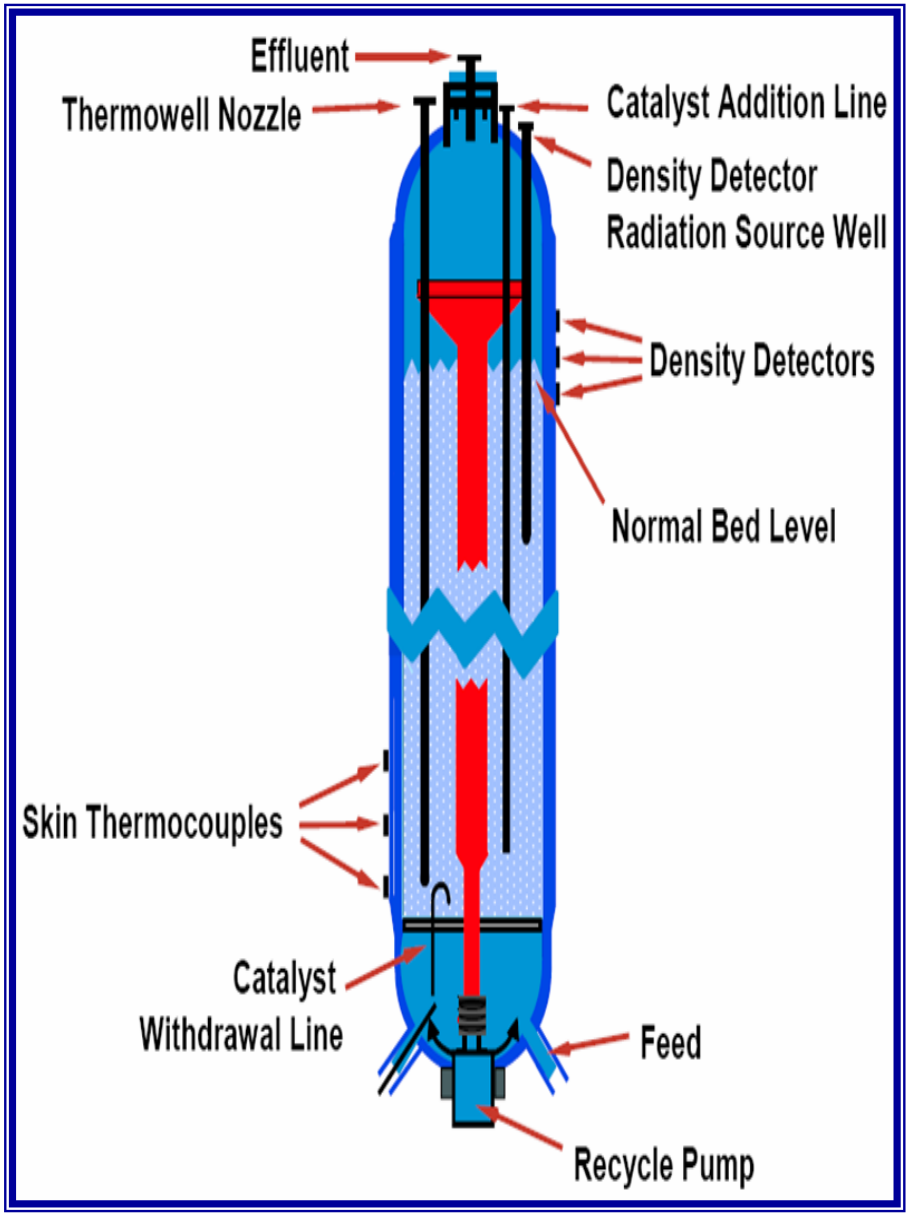

VRDS unit: 52000 BPSD
Guard Reactor R1A
Guard Reactor R1B
Main Reactor Section
P.R.S.

HYVAHL REFERENCES

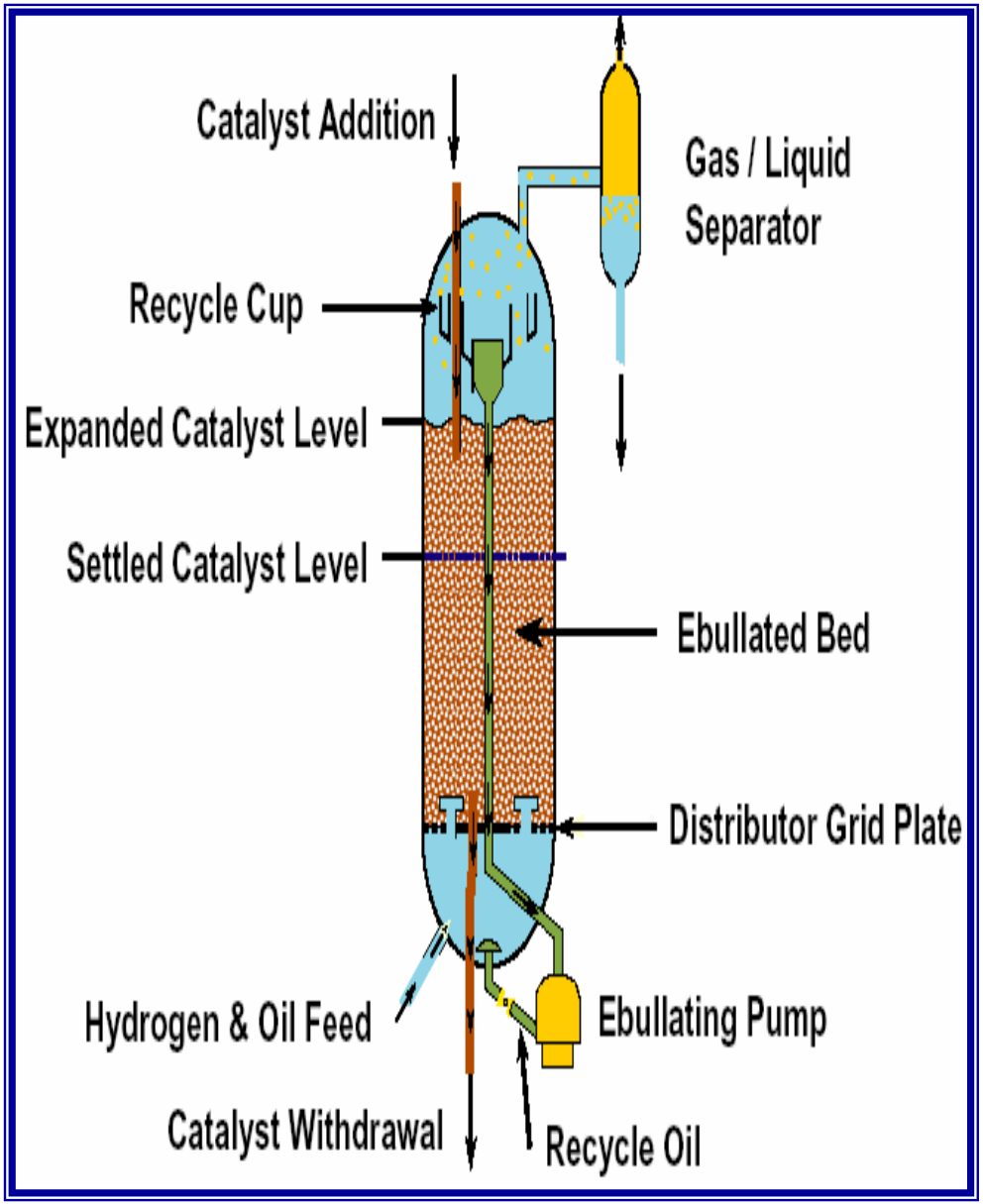


Current Total Capacity : 580000 BPSD

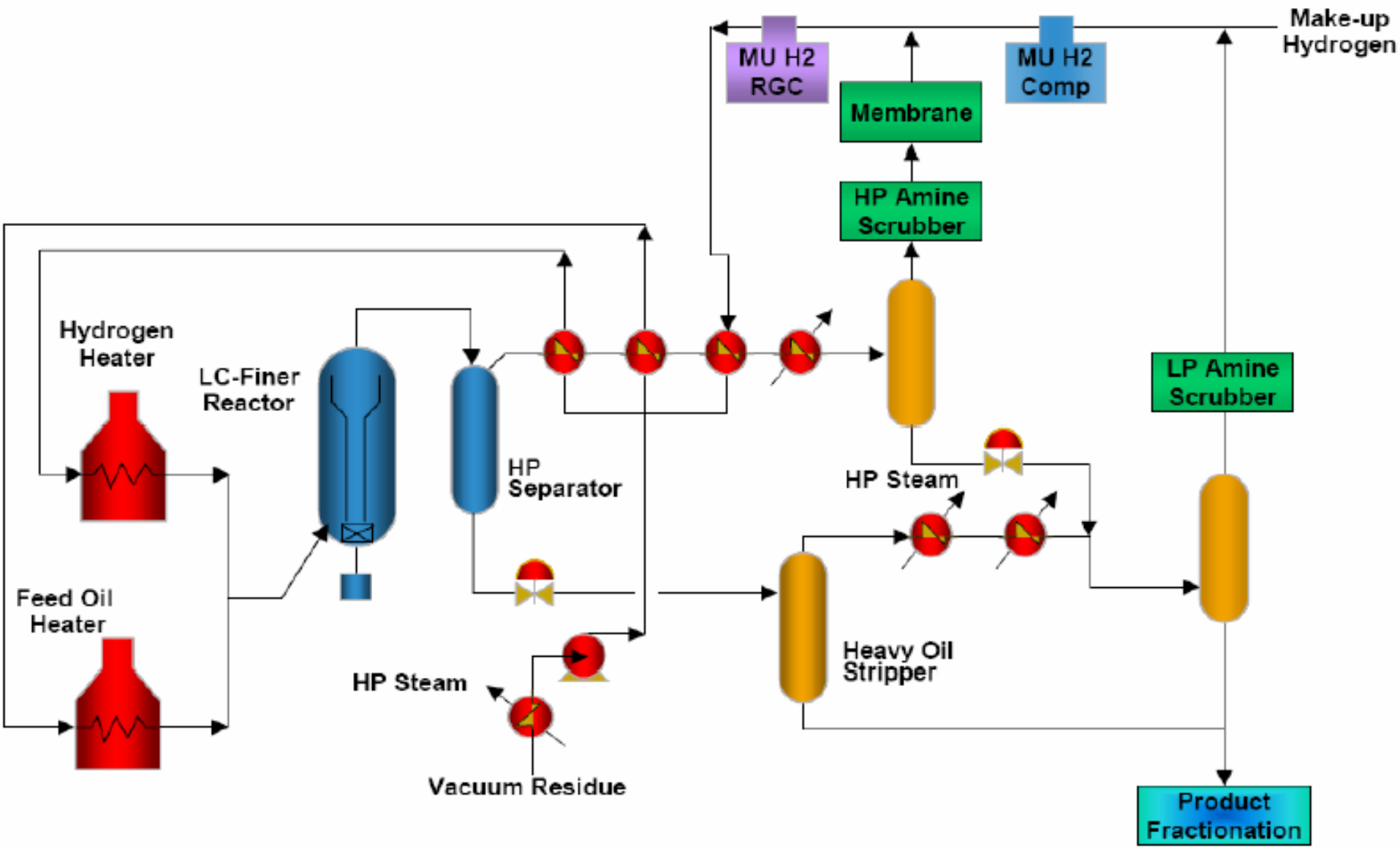
H-OIL



LC-FINER



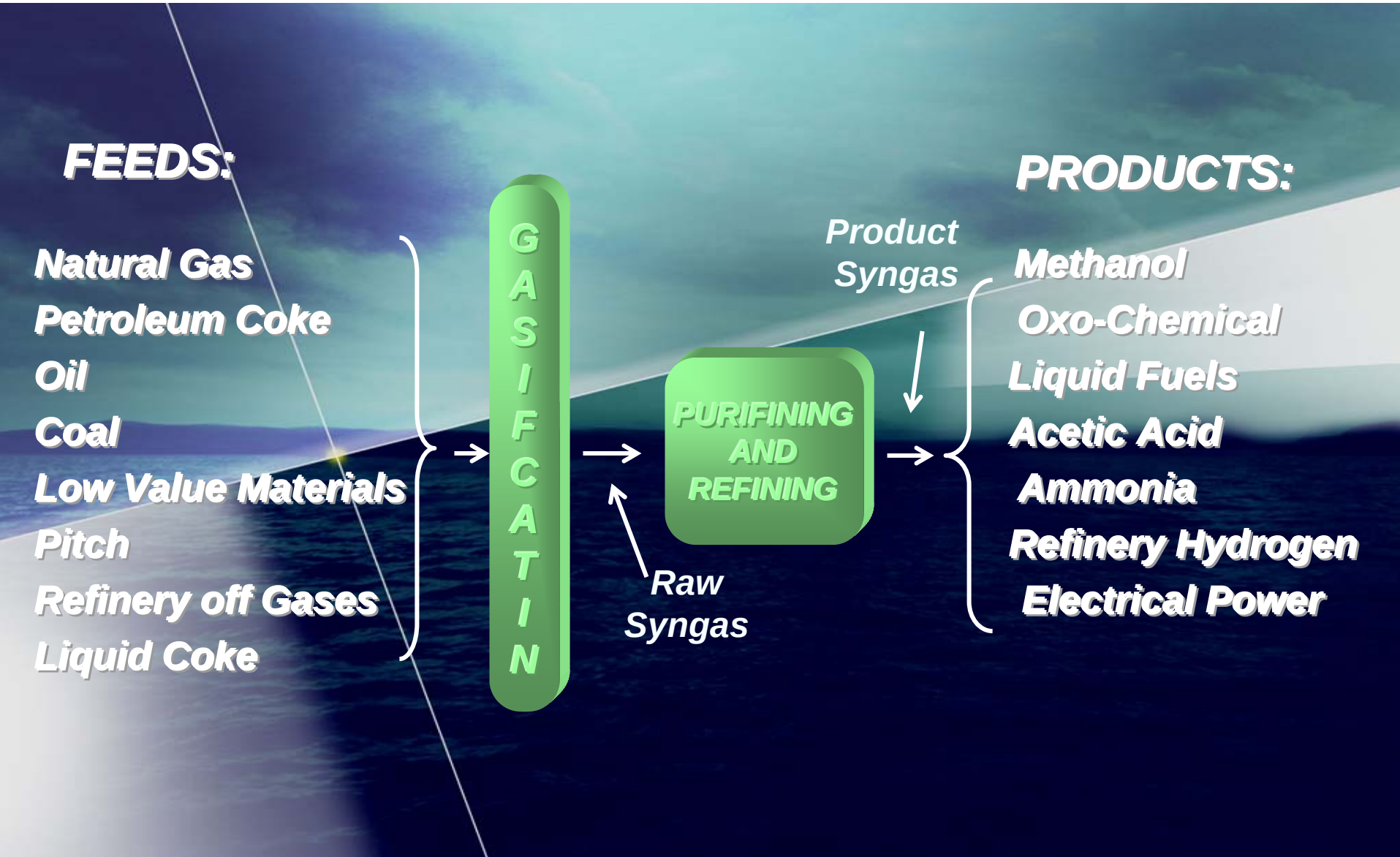
Lc-Fining flow diagram



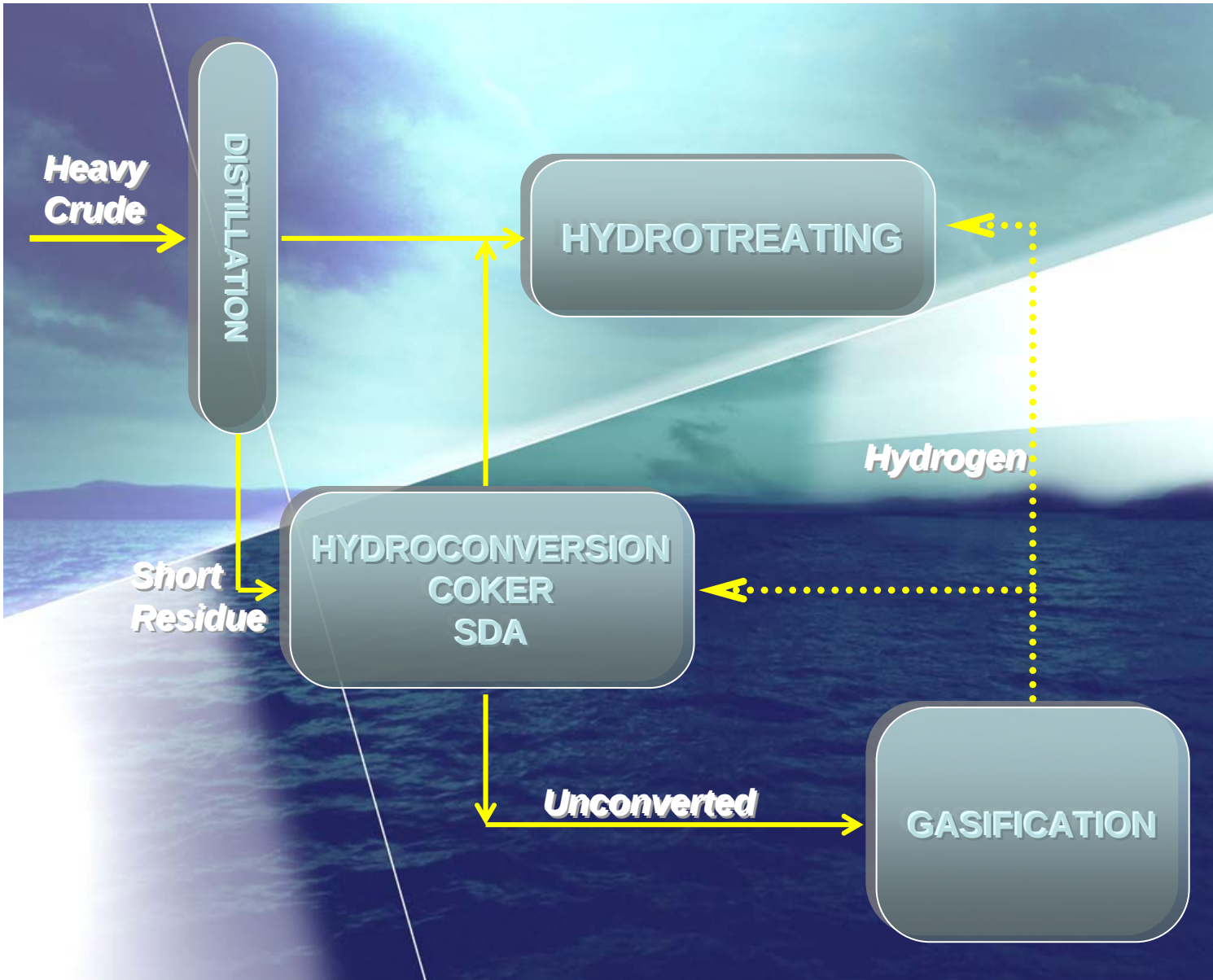
Lc-Fining operating range

Reactor Temperature	400-450 °C
Reactor Pressure	100-200 Bar
Conversion , vol% 525 °C+	40-92 %
Hydrogen Partial Pressure	71-170 Bar
Hydrogen Consumption	120-340 Nm^3/m^3
Desulfurization	60-95 %
Demetalization	70-98 %
CCR Reduction	40-75 %

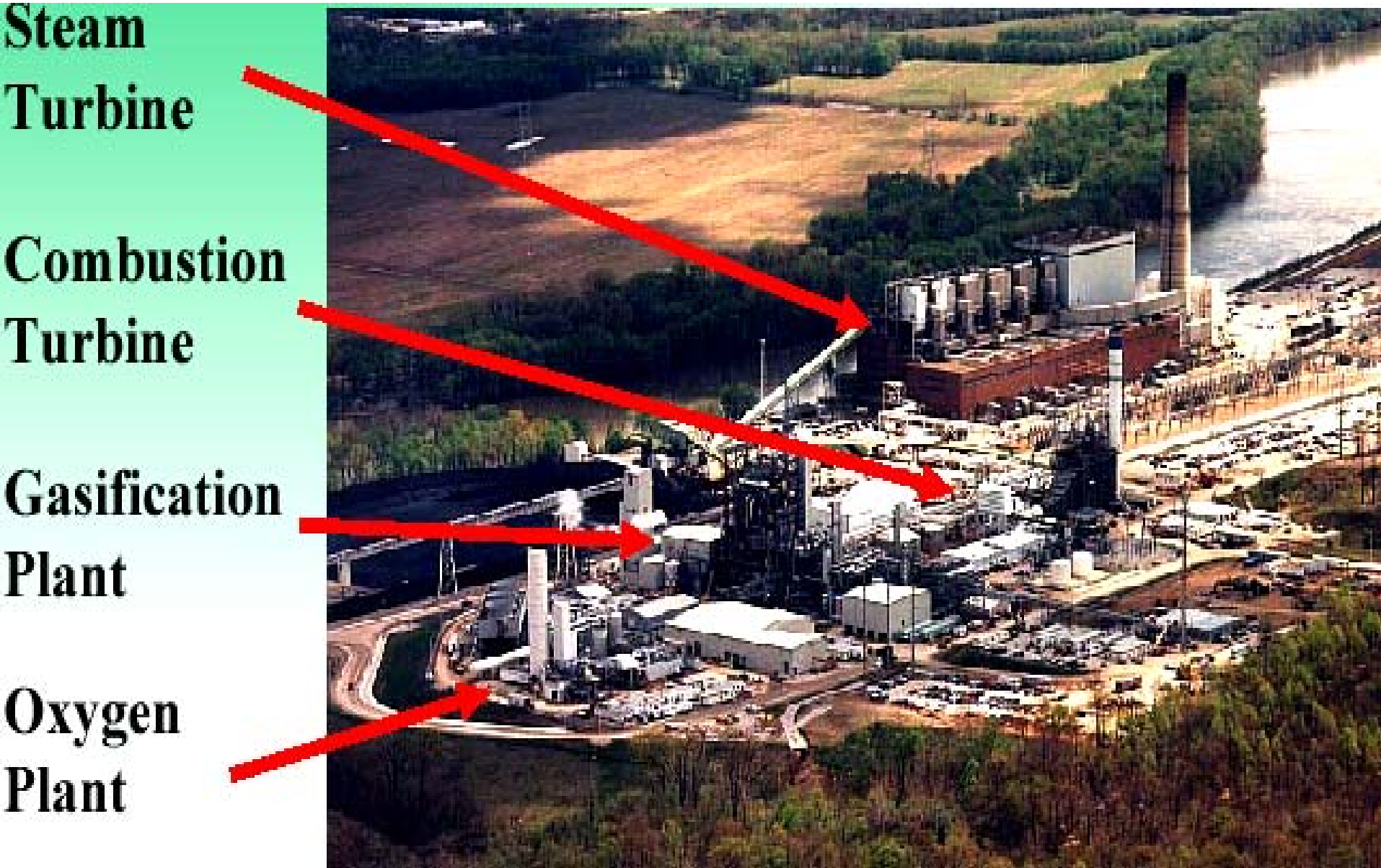
Gasification Feeds and Products



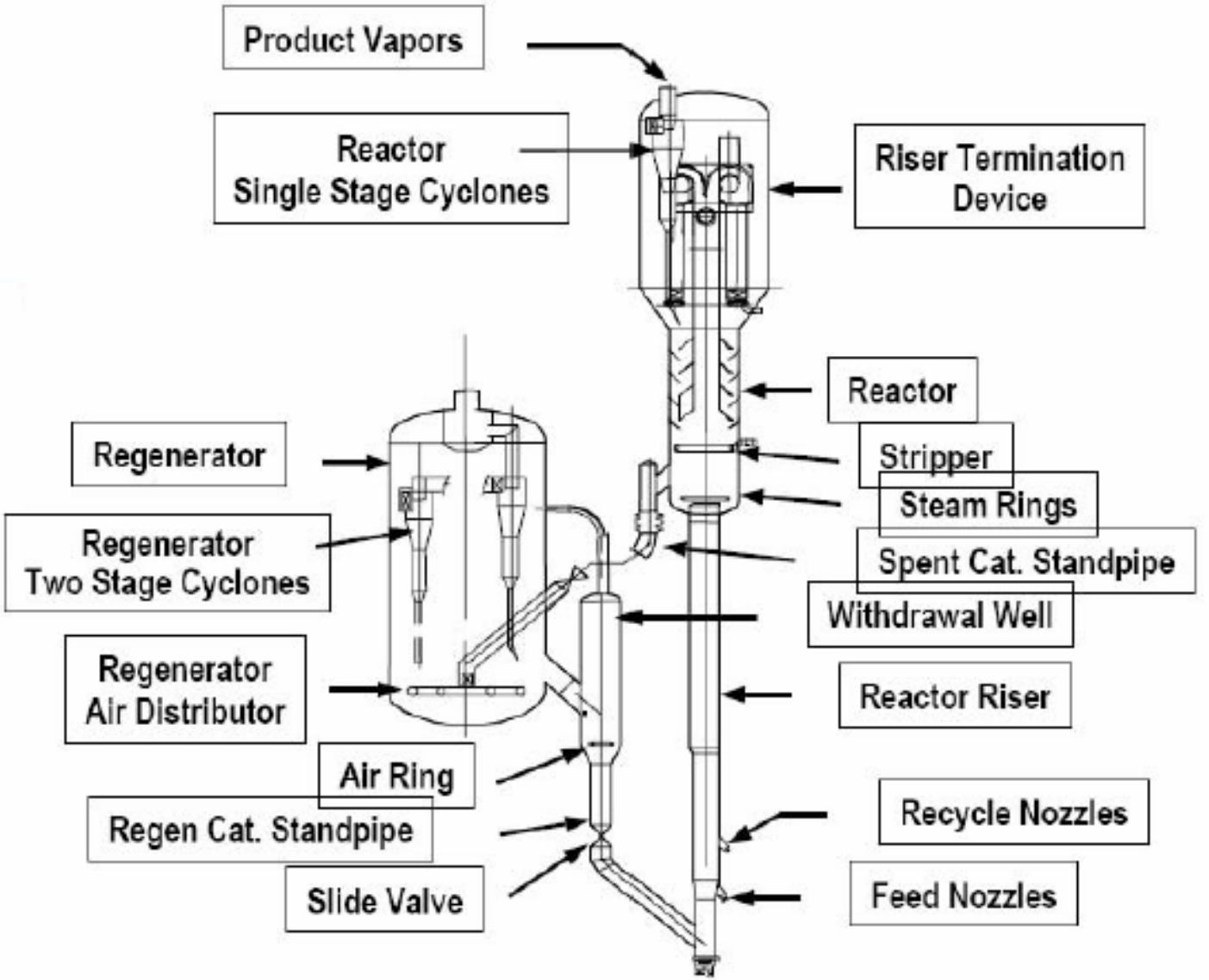
Rule of gasification in refineries



Gasification Plant



Residue Fluid Catalytic Cracking



BASE CASE

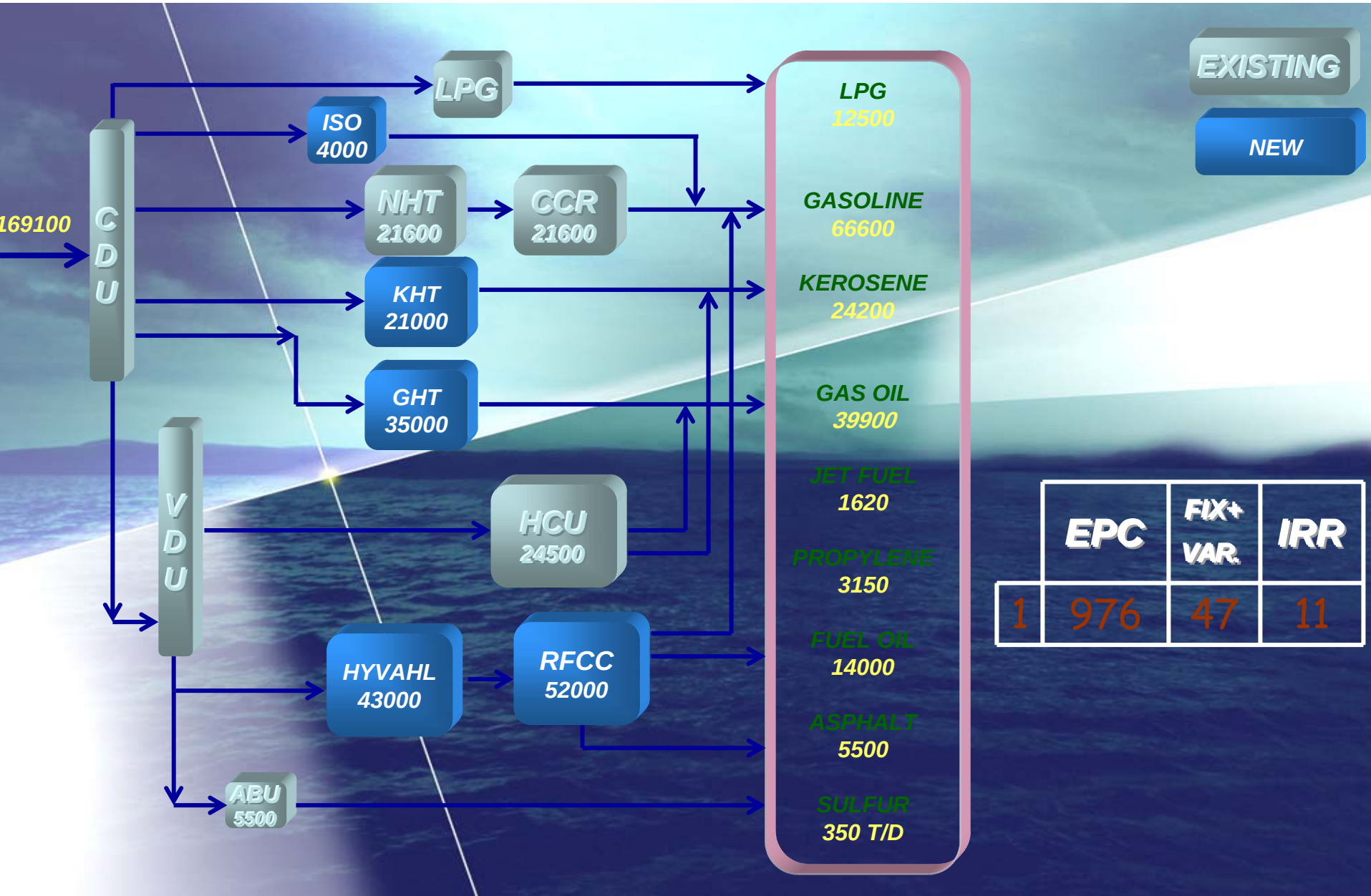
Units	Capacity (MBBL/D)
CDU	169.1
VDU	82
LPG	11.6
NHT	21.6
CCR	21.6
HCR	24.5
ABU	6
SRP	60 (Ton/D)

Product	BBL/D
LPG	6090
GASOLINE	29390
KEROSENE	26300
GAS OIL	47010
JET FUEL	1620
LUBE	2350
ASPHALT	6550
LSRG	1870
HSRG	1030
FUEL OIL	46520
SULFUR	60 (Ton/D)

TARGETS

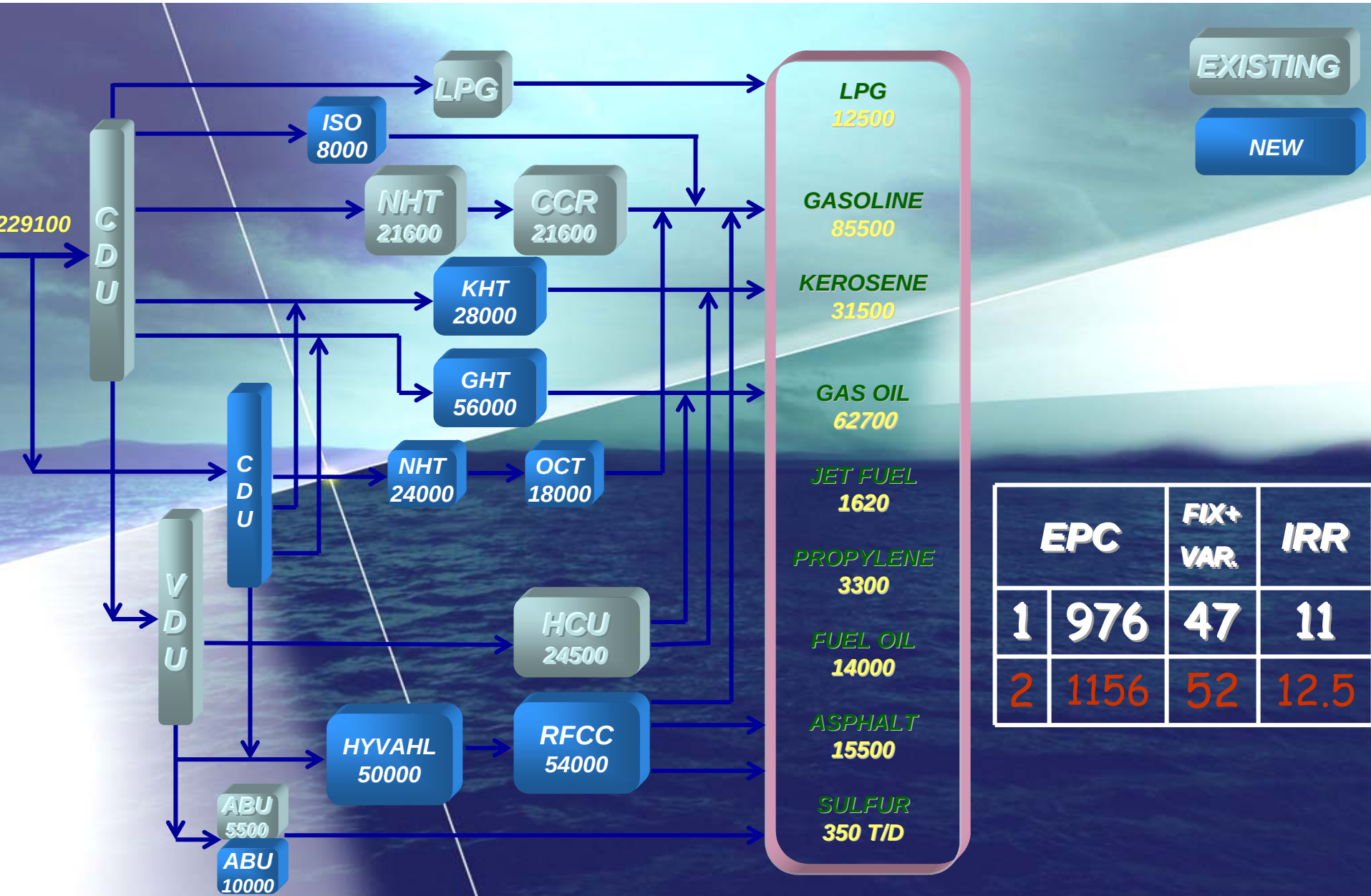
- ✓ Capacity increase from 169100 to 250000 BPSD
- ✓ Fuel oil reduction
- ✓ Gasoline increase
- ✓ Product specification upgrading to Euro 2005
- ✓ Environmental consideration
- ✓ Polymer grade propylene production
- ✓ Crude type change from 100% Ahwaz light to blend of 55% Ahwaz and 45% heavier crude

CASE – 1 : 169100 BPSD



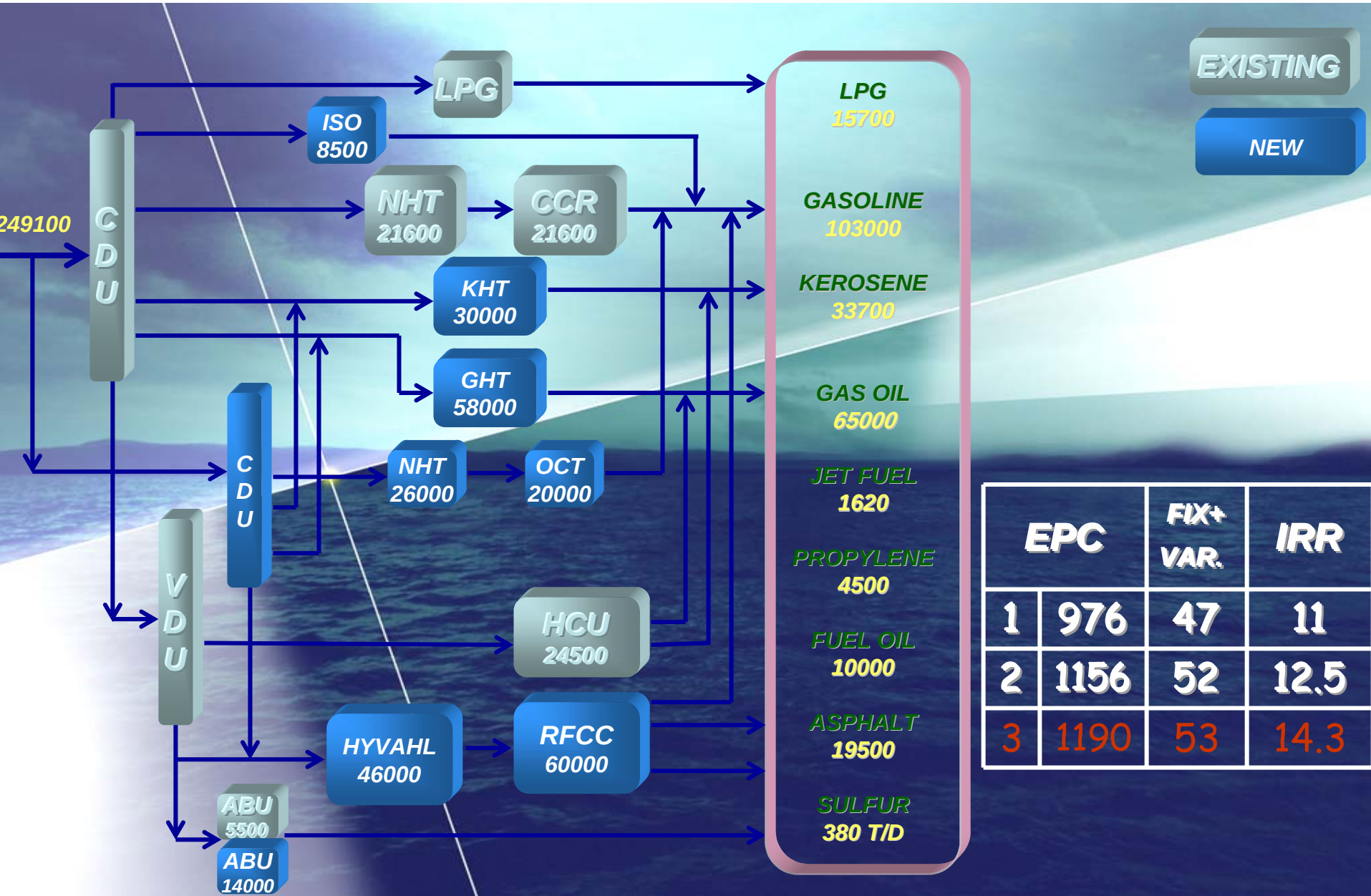
	EPC	FIX+ VAR.	IRR
1	976	47	11

CASE – 2 : (169100 + 60000) BPSD



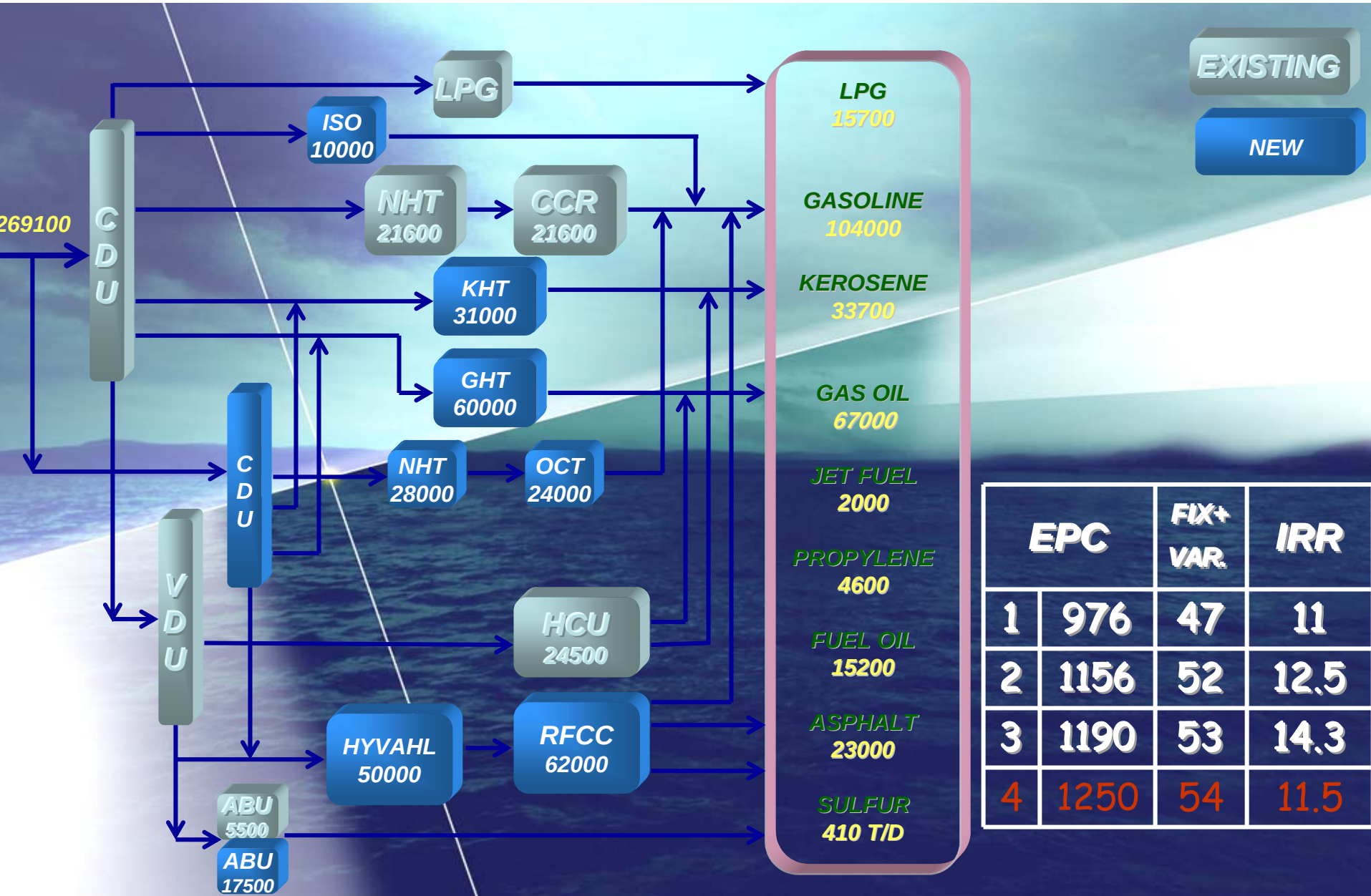
EPC		FIX+ VAR.	IRR
1	976	47	11
2	1156	52	12.5

CASE – 3 : (169100 + 80000) BPSD



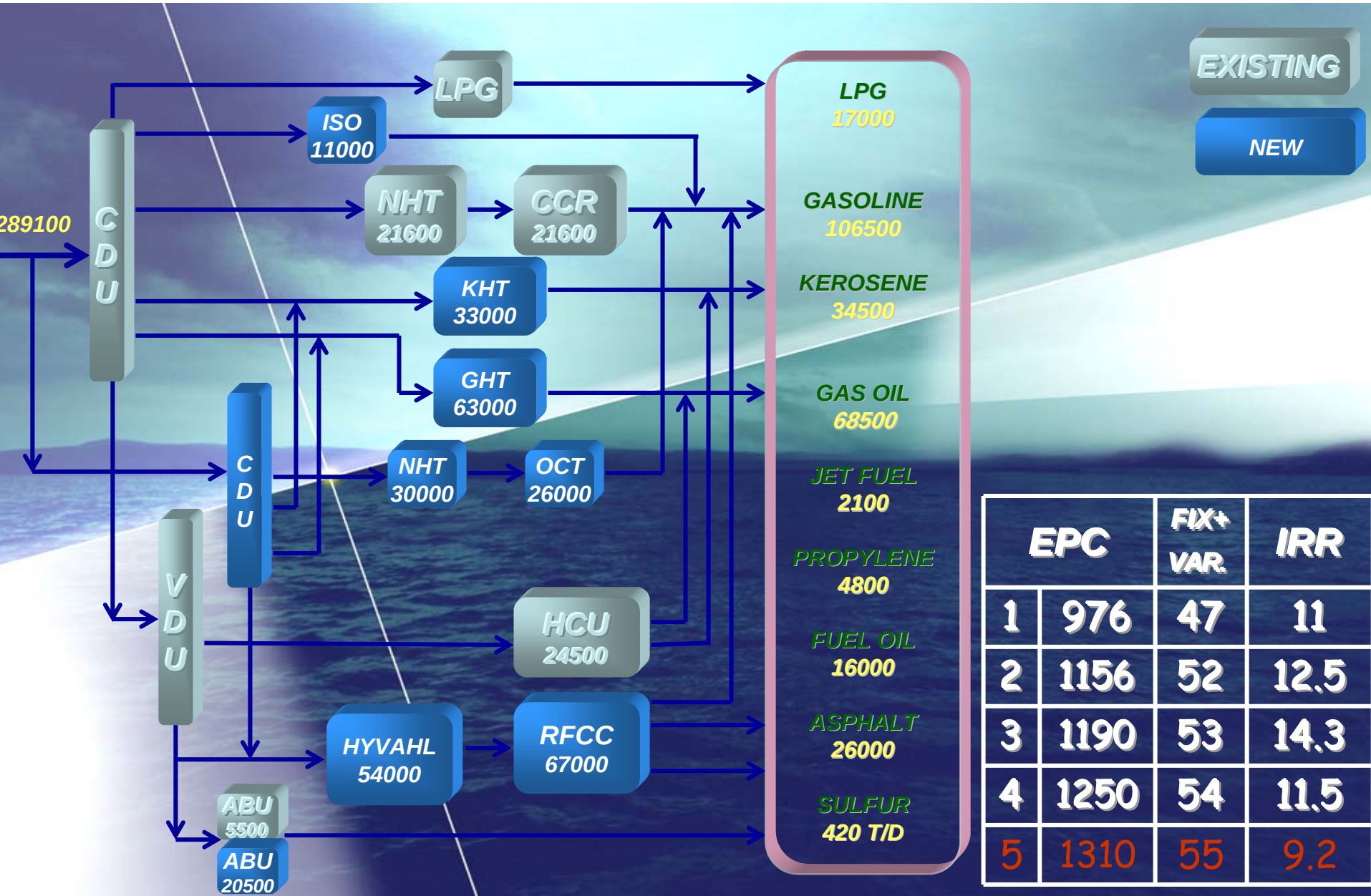
EPC		FIX+ VAR.	IRR
1	976	47	11
2	1156	52	12.5
3	1190	53	14.3

CASE – 4 : (169100 + 100000) BPSD



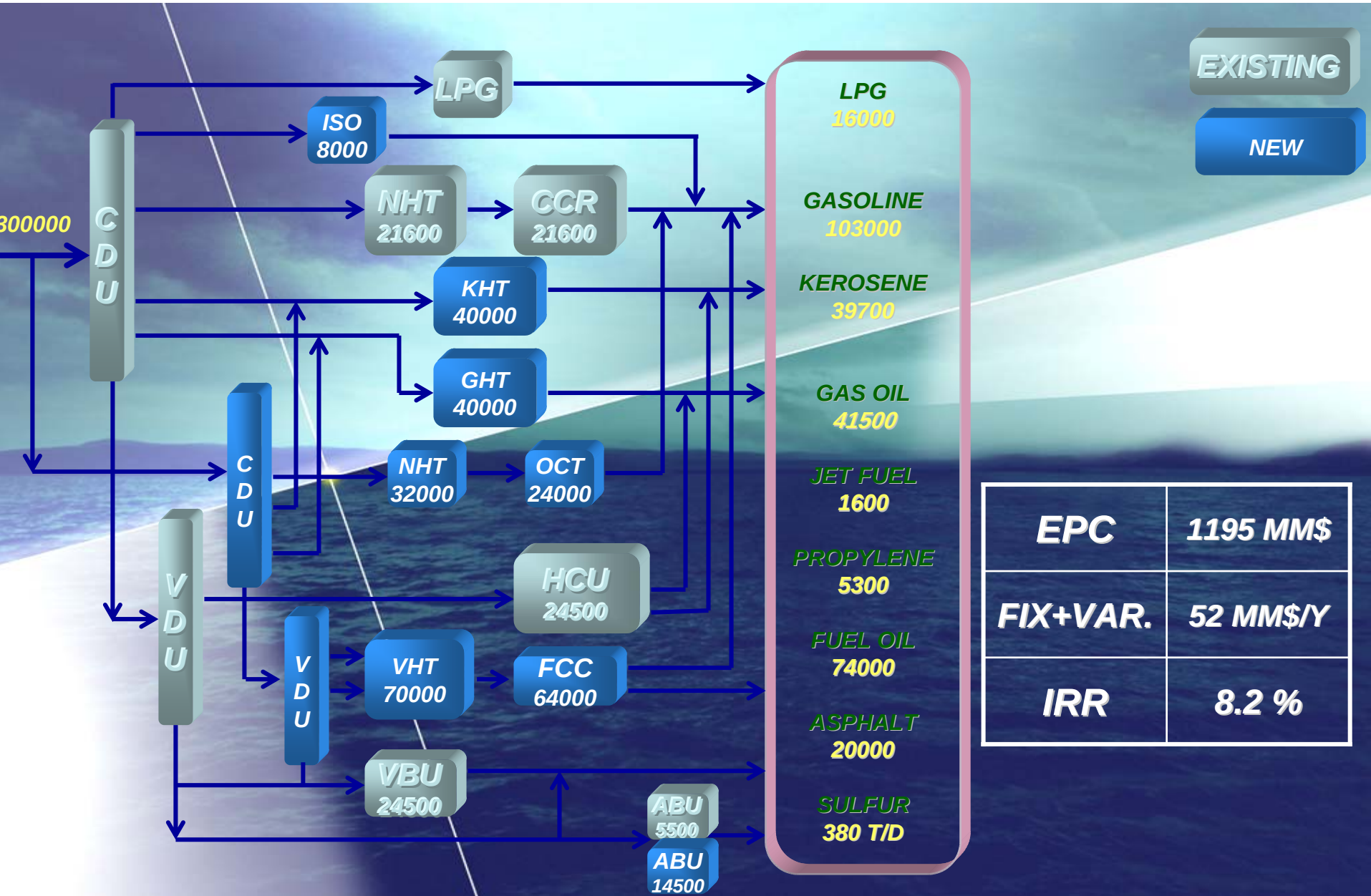
EPC		FIX+ VAR.	IRR
1	976	47	11
2	1156	52	12.5
3	1190	53	14.3
4	1250	54	11.5

CASE – 5 : (169100 + 120000) BPSD



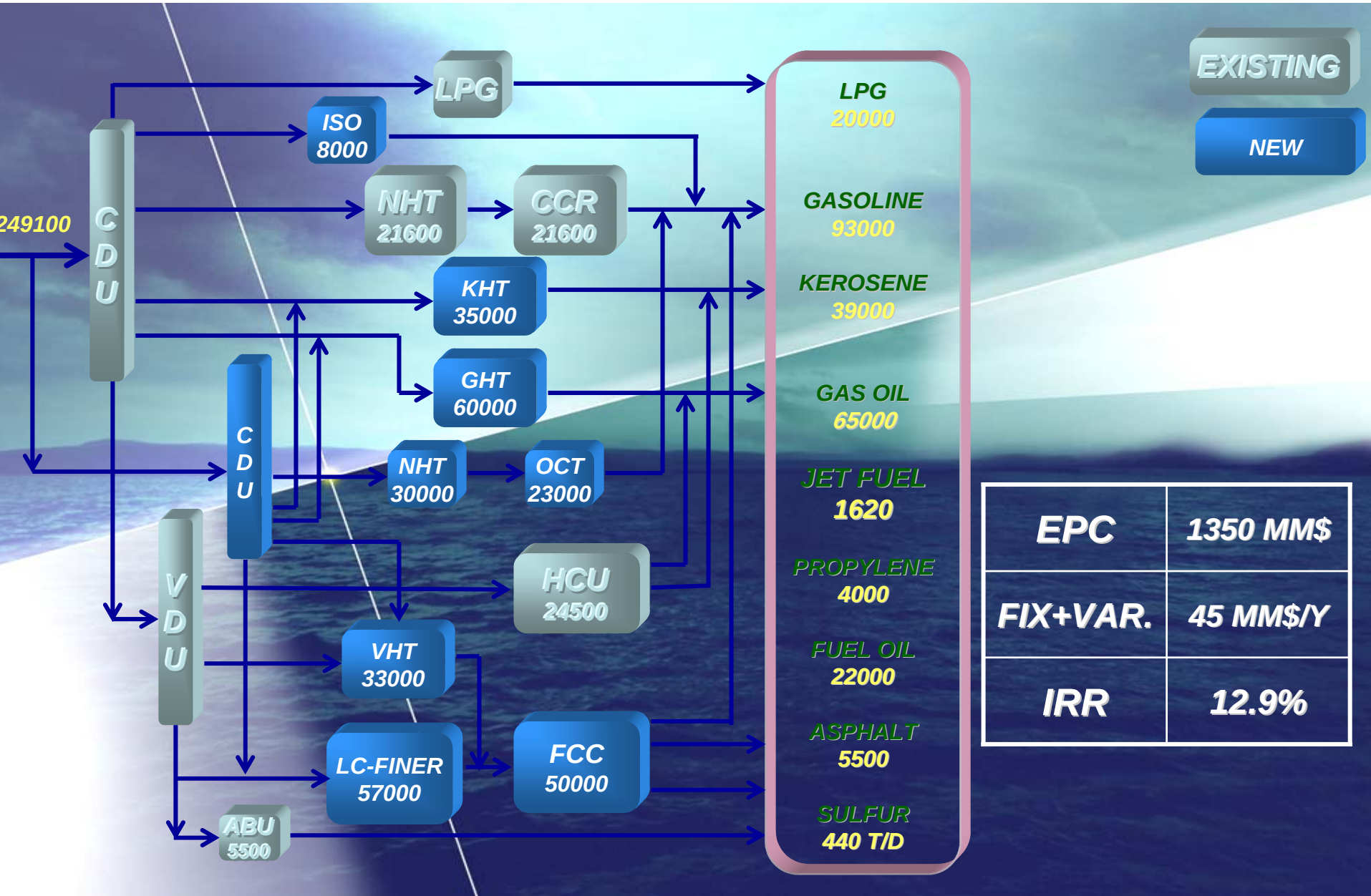
	EPC	FIX+ VAR.	IRR
1	976	47	11
2	1156	52	12.5
3	1190	53	14.3
4	1250	54	11.5
5	1310	55	9.2

CASE – 6 : (150000 + 150000) BPSD



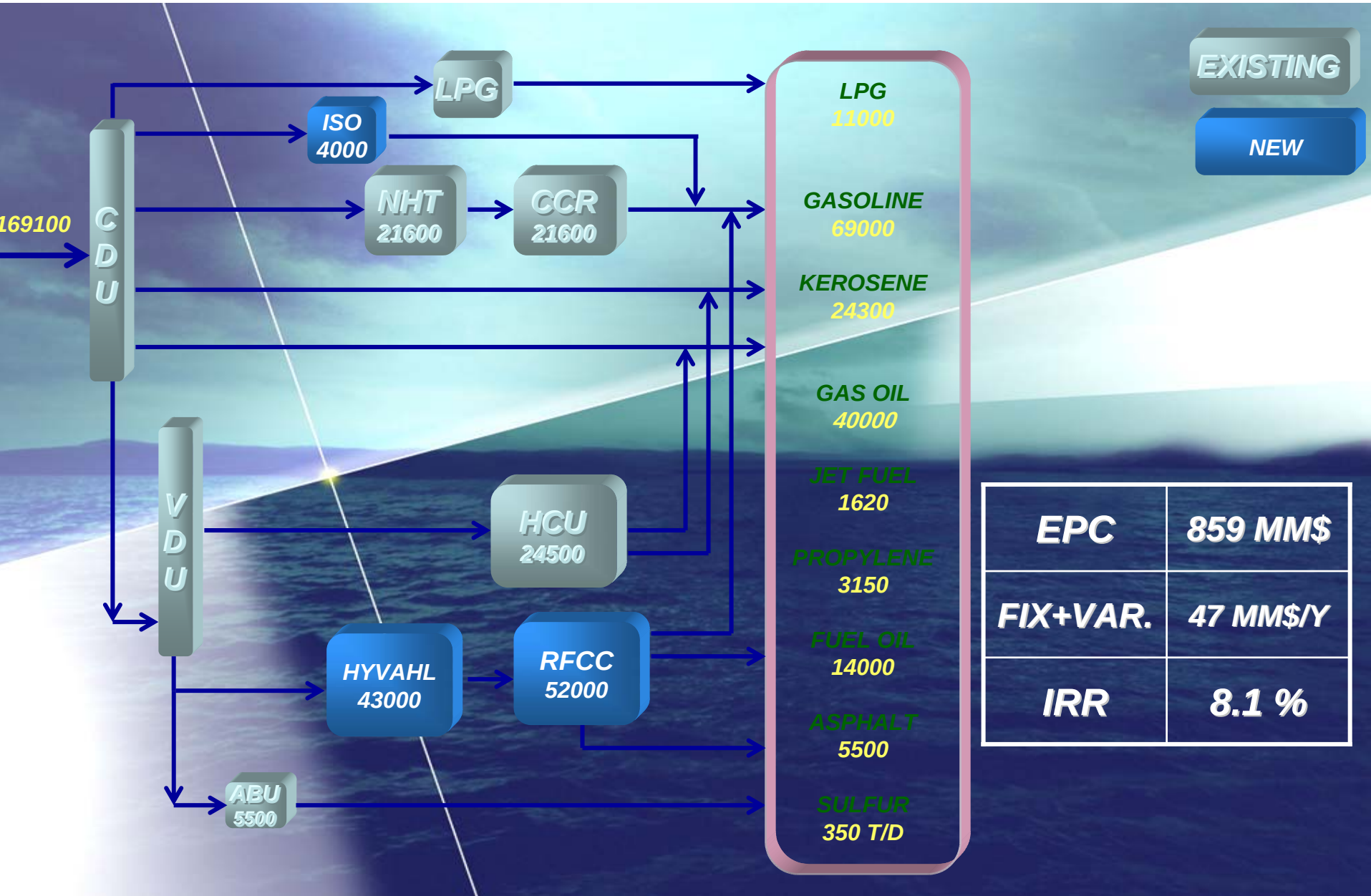
EPC	1195 MM$
FIX+VAR.	52 MM$/Y
IRR	8.2 %

CASE – 7 : (169100 + 80000) BPSD



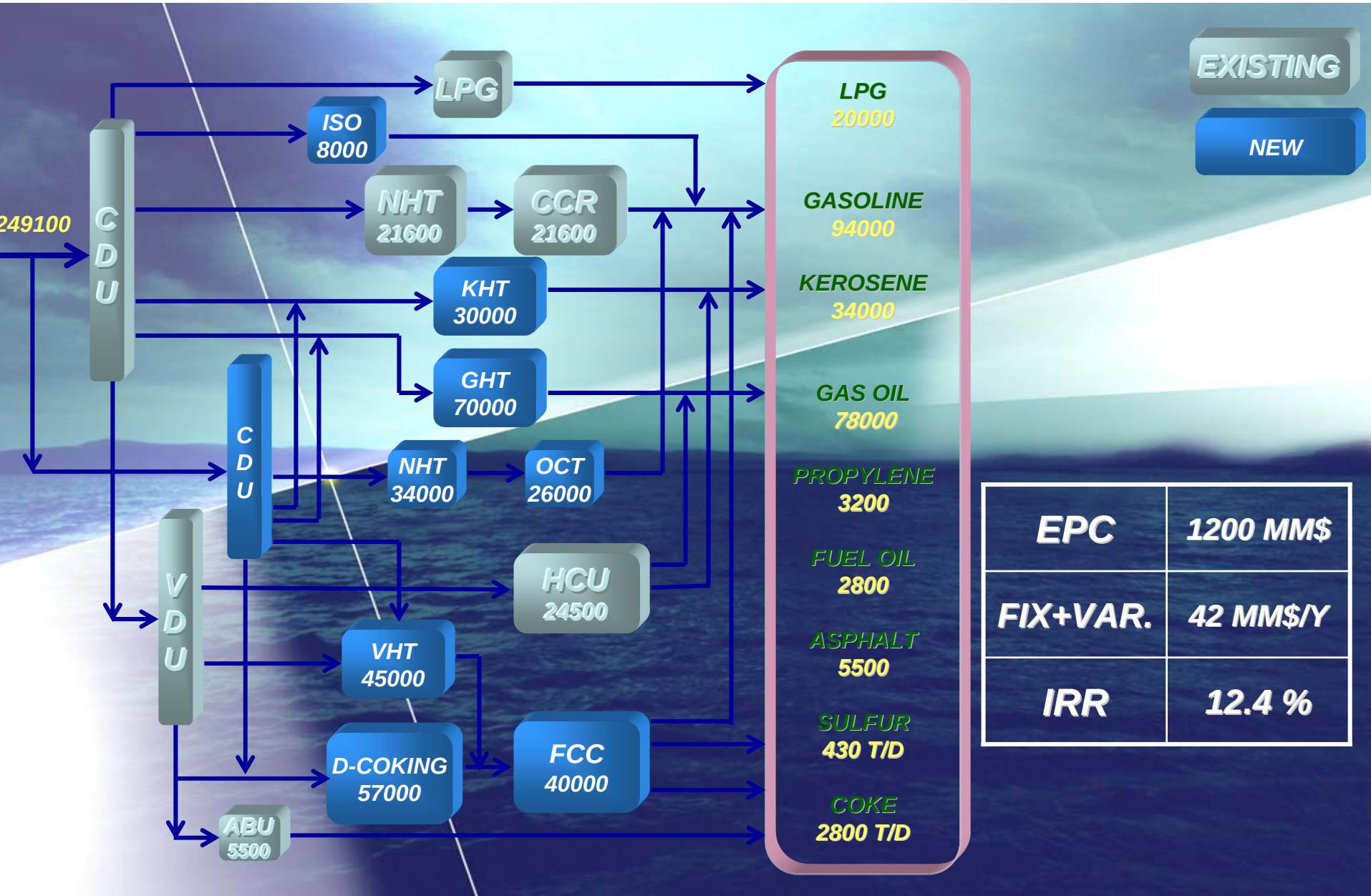
EPC	1350 MM$
FIX+VAR.	45 MM$/Y
IRR	12.9%

CASE – 8 : 169100 BPSD



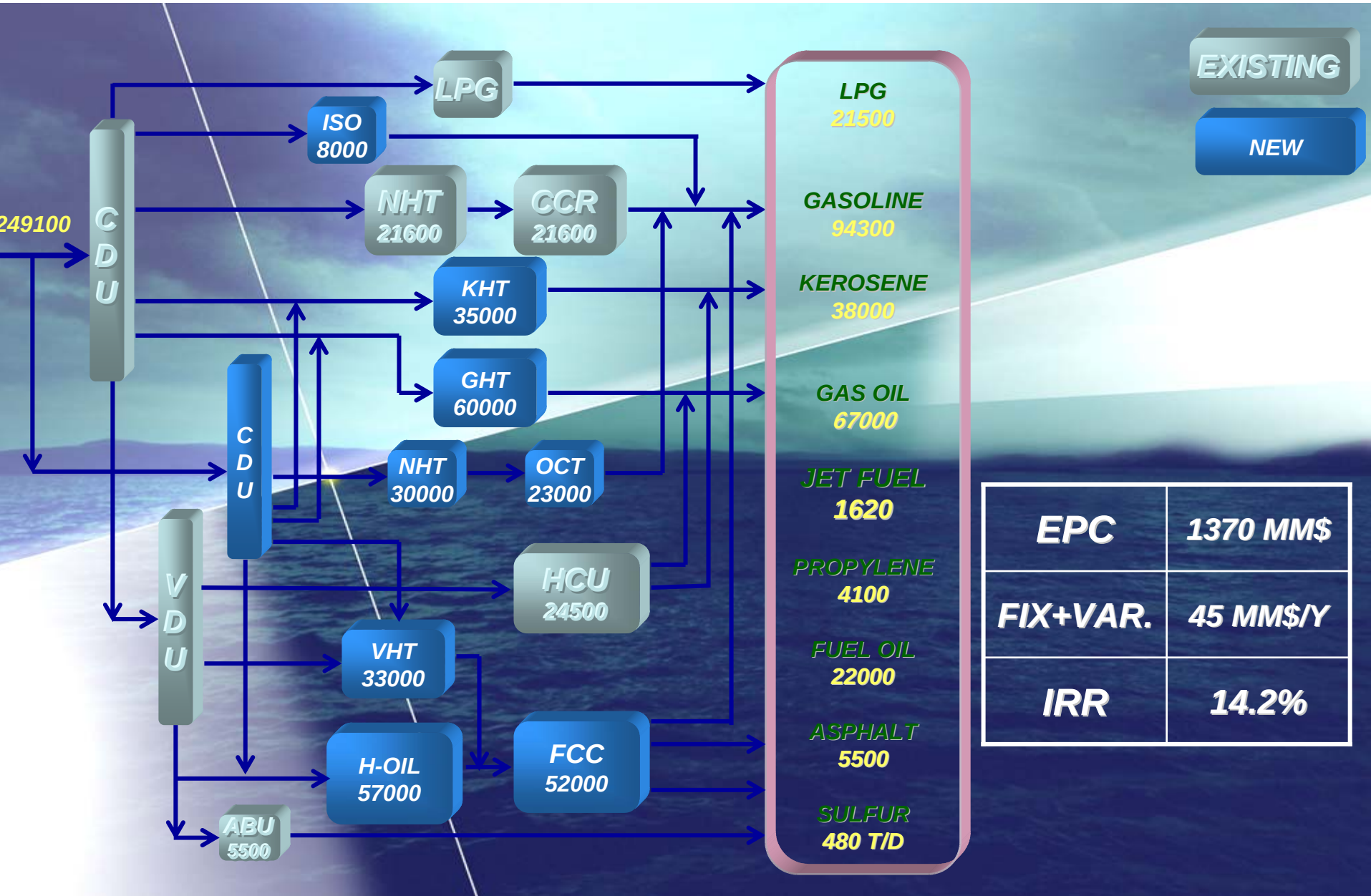
EPC	859 MM$
FIX+VAR.	47 MM$/Y
IRR	8.1 %

CASE – 9 : (169100 + 80000) BPSD



EPC	1200 MM$
FIX+VAR.	42 MM$/Y
IRR	12.4 %

CASE – 10 : (169100 + 80000) BPSD



EPC	1370 MM$
FIX+VAR.	45 MM$/Y
IRR	14.2%

FINANTIAL CALCULATION

i=annual rate of return (as a fraction)
S=annual cash flow (net after-tax+depreciation)
I=investment
T=life of facility (years)

$$i=S/T - i/((1+i)^T-1)$$

- ✓نوسانات قیمت نفت خام وفرآورده ها حداقل با میانگین هفت ساله درنظر گرفته شود
- ✓هزینه نقل وانتقال فرآورده ها ونیزهزینه انتقال واردات وصادرات درنظرگرفته شود
- ✓حساسیت عوامل تاثیرگذاربردرآمد سالیانه در نظرگرفته شود

SUMMERY

CASE	1	2	3	4	5	6	7	8	9	10
NEW CDU	-	60	80	100	120	150	80	-	80	80
NEW VDU	-	-	-	-	-	65	-	-	-	-
KHT	21	28	31	34	38	36	36	-	30	35
GHT	35	50	53	58	63	33	58	-	70	60
OCT	13	18	20	24	27	24	23	12	26	23
ISO	5	8	8.5	10	11	8	8	4	8	8
VHT	-	-	-	-	-	72	33	-	45	34
FCC	-	-	-	-	-	67	50	-	40	52
LC-FINING	-	-	-	-	-	-	57	-	-	-
HYVAHL	43	52	67	75	84	-	-	43	-	-
DELAYED COKING	-	-	-	-	-	-	-	-	57	-
H-OIL	-	-	-	-	-	-	-	-	-	57
RFCC	52	72	94	104	115	-	-	52	-	-
ABU	-	10	6	6	6	10	-	-	-	-
IRR%	11	12.5	14.2	11.5	9.2	8.2	12.9	8.1	12.4	14.2

الگوی نهایی طرح توسعه پالایشگاه اراک

No.	New Units	Capacity (BSPD)	Licensor
1	CDU	80,000	----
2	NHDT	33,000	Axens
3	CCR	20,000	Axens
4	Gas Oil HDT	53,000	Axens
5	Kerosene HDT	31,500	Axens
6	Isom.	8,500	RIPI
7	Residue HDMS	69,180	UOP
8	RFCC	94,387	UOP
9	H2 Plant	2X67.5 MMCF/D	Technip
10	Amine & SWS	SWS 5000 TPD	----
11	SRU	2X320 TPD	KTI
12	PrimG	50500	Axens
13	LPG Merox	28105	UOP
14	Propylene Recovery	28105	UOP

NIORDC 2010

Refinery	Nominal Capacity (KBPD)	Increased Capacity (KBPD)
Bandar-Abbas	232	640
Tehran	225	250
Esfahan	200	376
Arak	150	250
Abadan	140	200
Tabriz	100	110
Shiraz	40	60
Lavan	20	30
Kermanshah	15	22
Condensate Ref.	-	360
TOTAL	1122	2298

میزان تولید بنزین پس از انجام طرحهای توسعه پالایشگاهها

Refinery	Existing (BPD)	After expansion and products upgrading (BPD)
Arak	29300	105000
Esfahan	43000	118000
Tehran	41000	74000
Tabriz	24800	61000
Total	138100	358000