IndianOil

Key Note Address by
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Refinery Challenges Related to Heavy Oils Processing in DCU/FCCU

Coking and CatCracking Conference
New Delhi, India: 2nd October, 2013

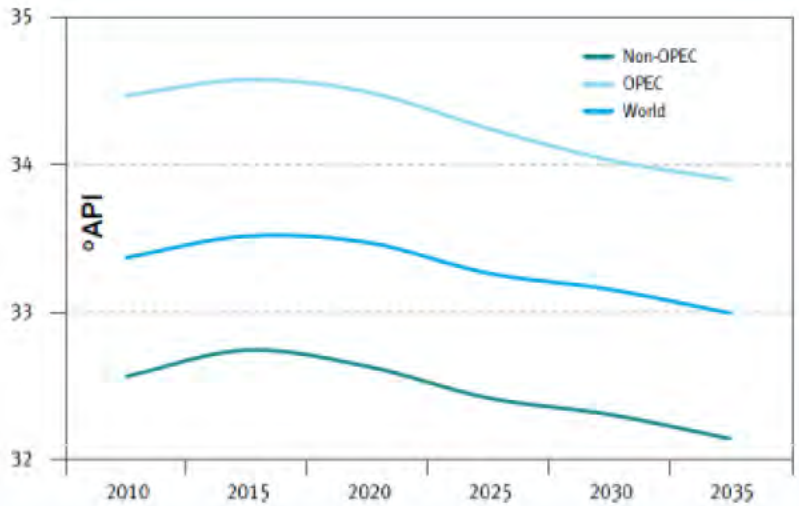
the Refining Community

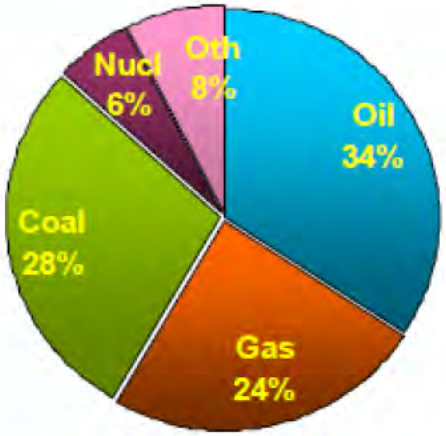
Content

- Global/ Indian oil scenario
- Residue upgradation through DCU
- Residue upgradation through FCC/ RFCC
- Alternate routes of Heavy oil processing

Global/ Indian oil scenario

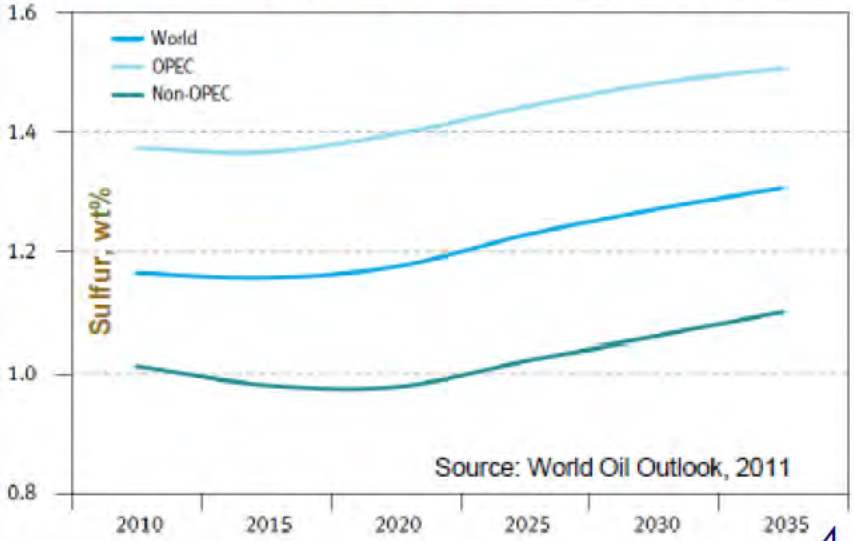
Deteriorating Crude Quality





World 2030

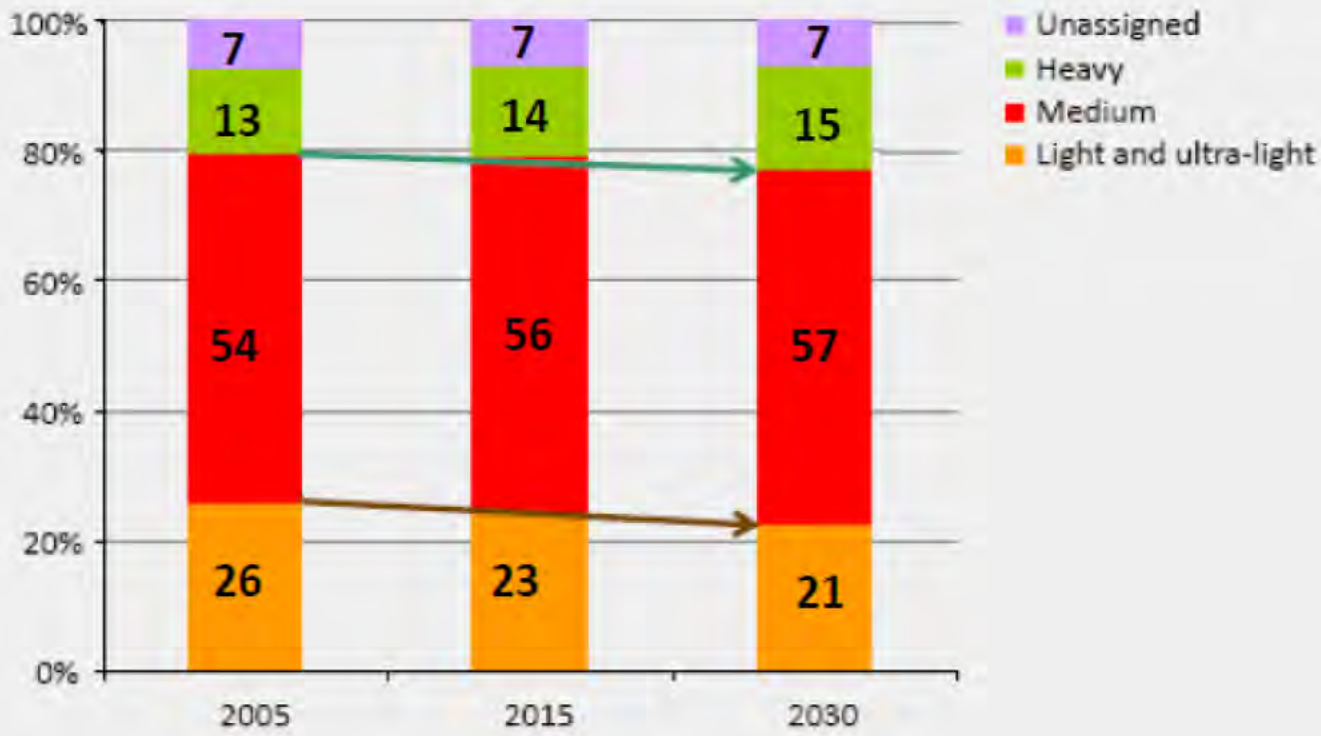
Source: BP Stat, 2009



During 2008 to 2030

- World energy demand increases from 12 to 17 btoe
- Share of oil continues to dominate 34.8 to 34%
- Average crude quality deteriorates due to decrease in sweet crude share

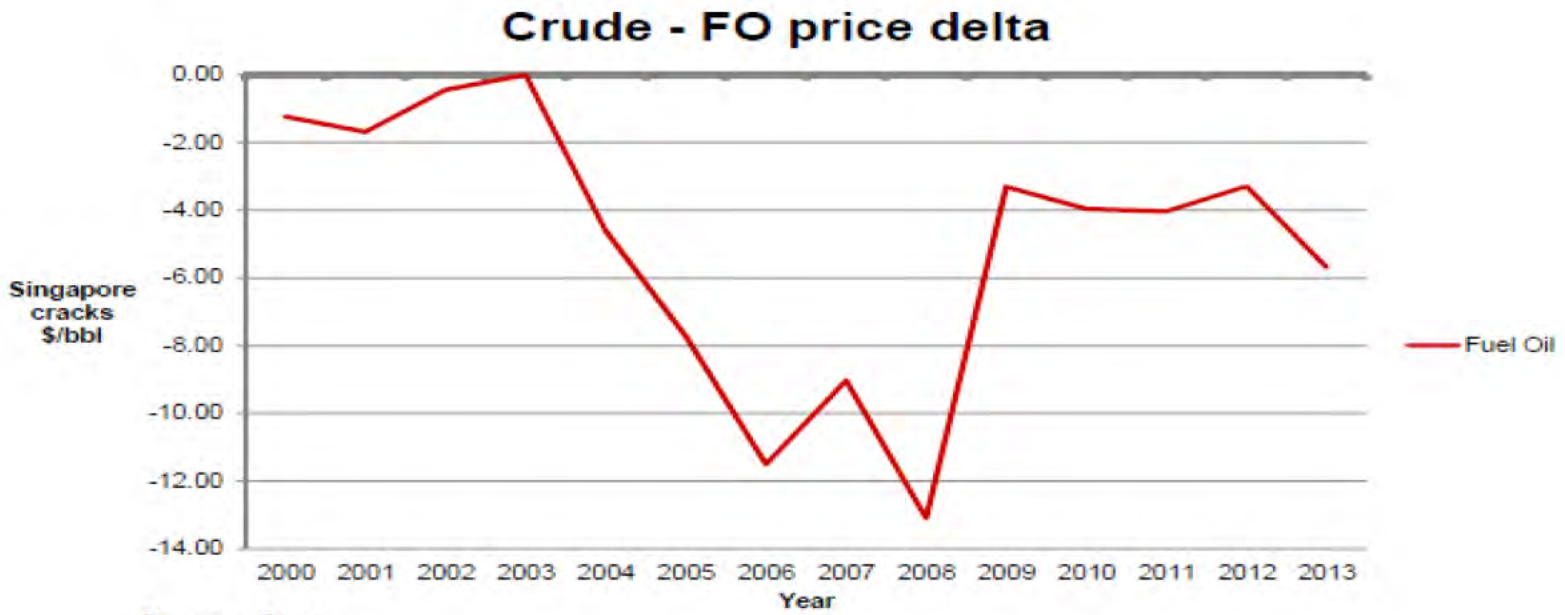
Deteriorating Crude Quality



© OECD/IEA - 2009

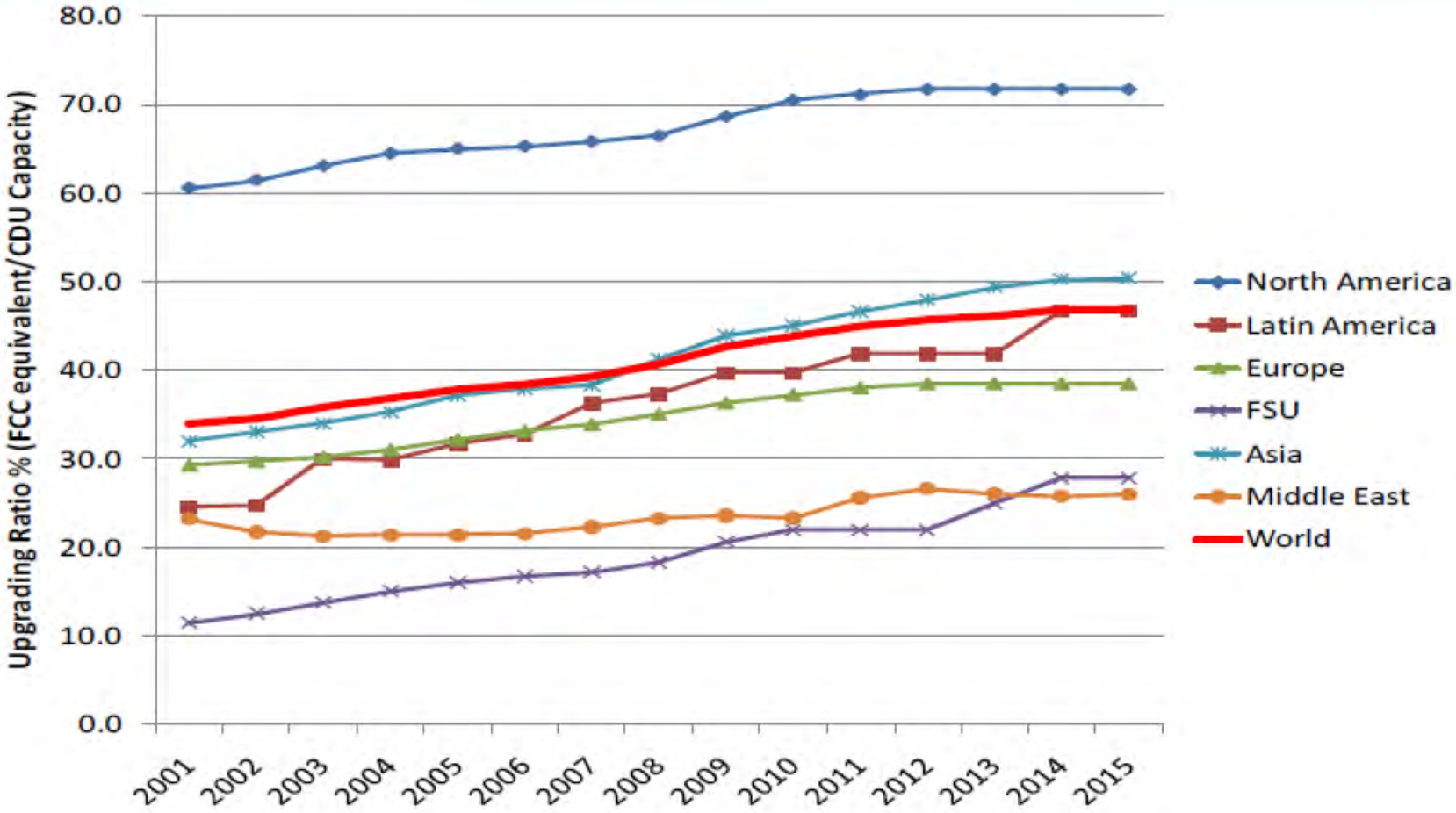
Product demand trend

- Eliminate fuel oil
- Maximize diesel + jet
- Minimize refinery products, priced lower than crude
- Maximize advantage crude feed
- Minimize opex
- Maximize sustainable margins



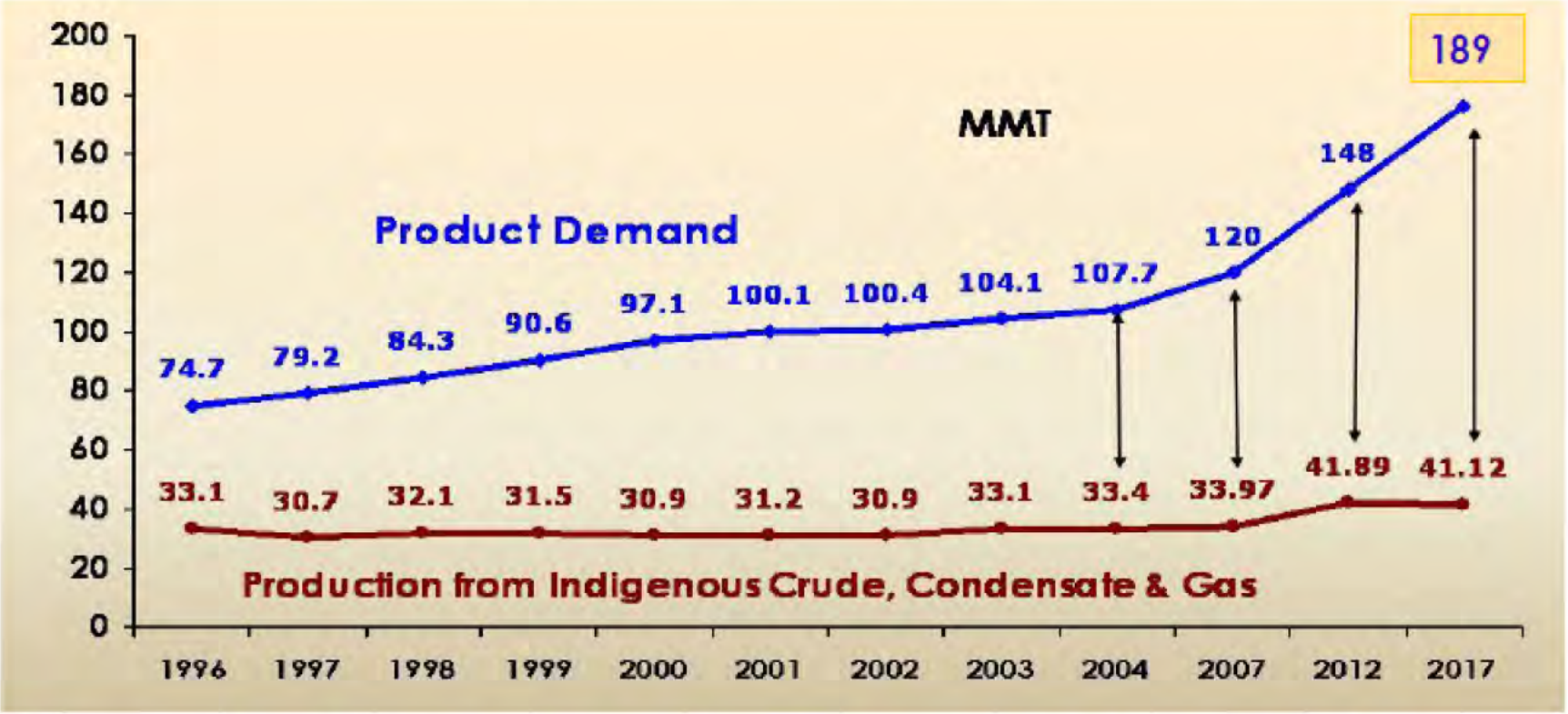
Source: Platts

Bottom of barrel upgradation



Source : FACTS September 2008

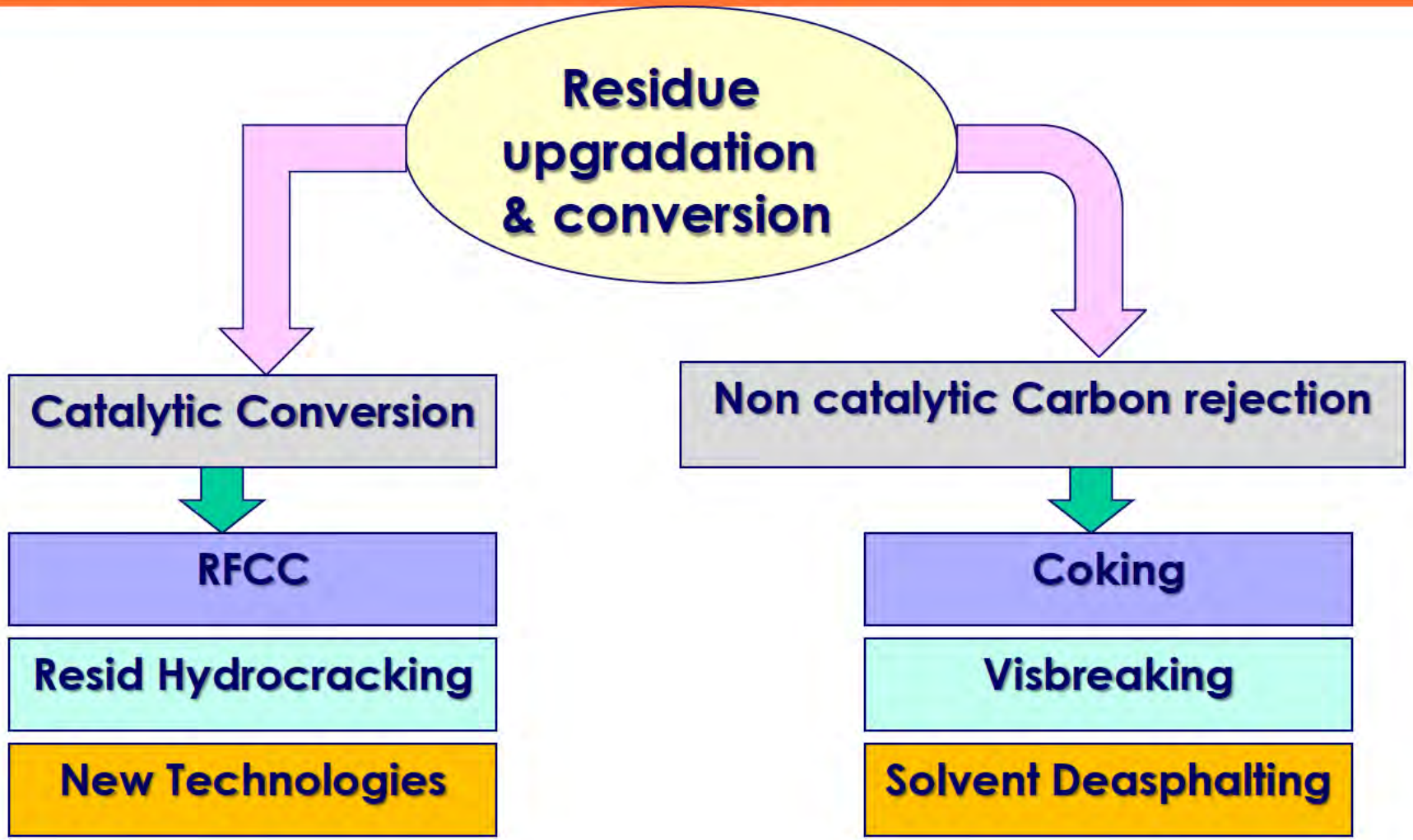
Widening gap in India – Product demand vs Indigenous crude availability



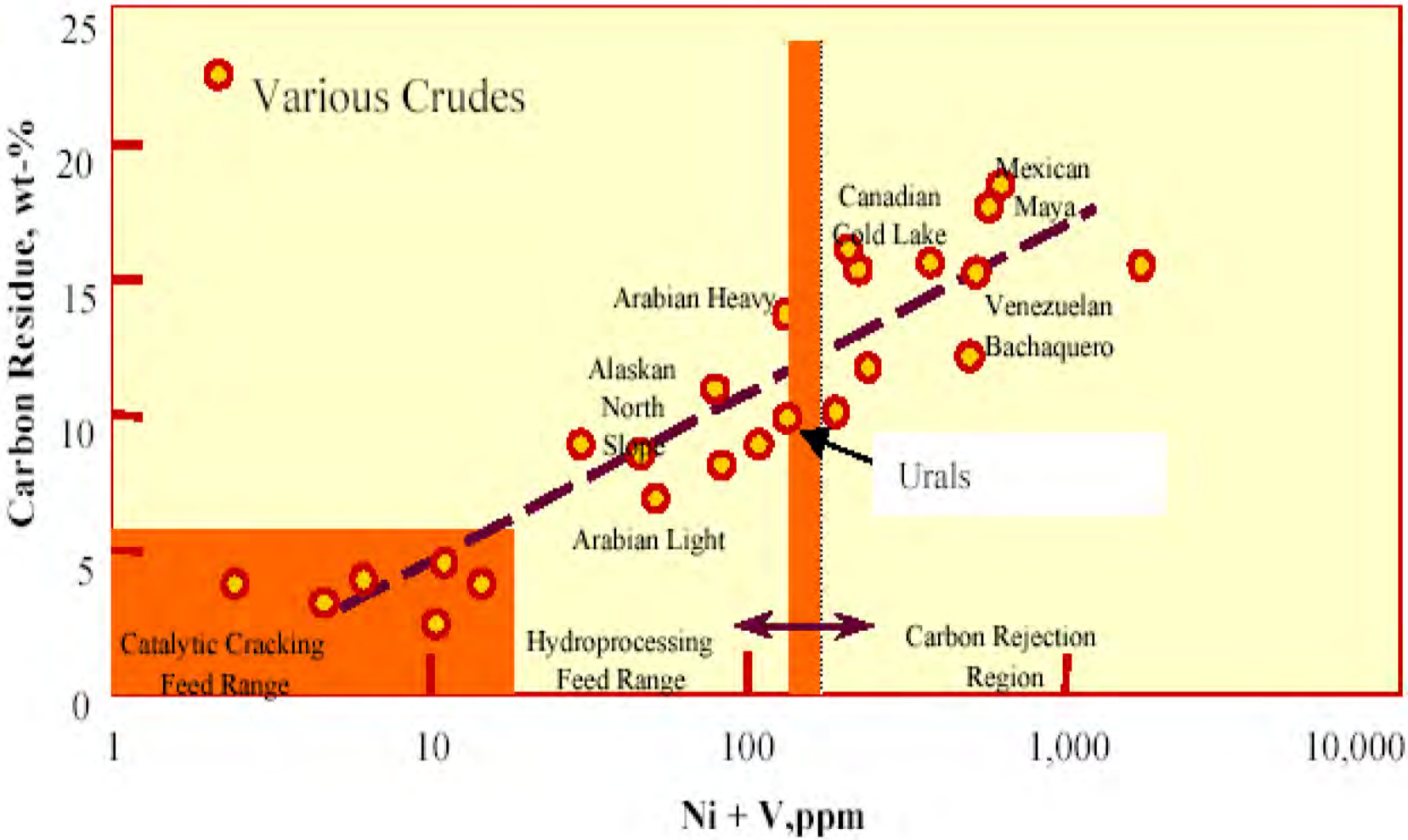
- Widening gap between product demand and crude production from indigenous sources; Heavy dependence on Imports
- Need for huge investments in refining, pipelines & Marketing infrastructure

Source: XIIth Plan Document

Routes for Residue Up gradation



Selection of upgrade route



Residue upgradation through DCU

Indian DCUs at a Glance

Refinery	Capacity (MMTPA)	Licensor	CCR, wt%		Coke yield, wt%	
			Design	Actual	Design	Actual
1. IOCL Guwahati	0.44	Romanian	6.5	5.86	17.7	13.2
2. IOCL Barauni-A	0.6	Russian/EIL	9.9	10.8	24	27.5
3. IOCL Barauni-B	0.5	Russian/EIL	5.75	10.2	13	25.3
4. IOCL Gujarat	3.7	Foster Wheeler	8.9/24/20	11.31	14.53/29.91/26.87	20.7
5. IOCL Digboi	0.17	EIL	5.6	6.31	19.1	16.3
6. IOCL Panipat	3.0	CB&I Lummus	24.07	21.16	28.82	29.6
7. IOCL Bongaigaon-A	0.5	EIL	5.75	5	13	12.6
8. IOCL Bongaigaon-B	0.5	EIL	5.75	4.8	13	13.2
9. NRL	0.357	EIL	19.2	12-19.0	28	
10. BORL	1.36	CB & I Lummus	22.3		27.65	18-28
11. EOL	6.0	CB & I Lummus	27.7		34.7	
12. HMEL	2.77	CB & I Lummus	25.6		31.56	
13. RIL-1		Foster Wheeler				
14. RIL-2	8.0	Foster Wheeler	25			
15. MRPL	3.0	CB&I Lummus				
16. IOCL Paradip	4.4	Foster Wheeler	26.8		33.1	

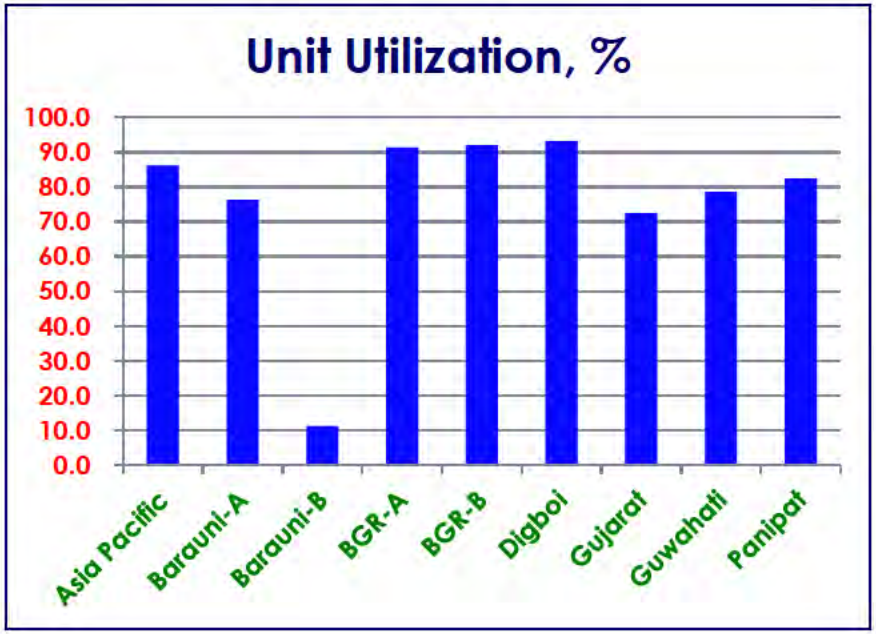
Performance factors of DCU

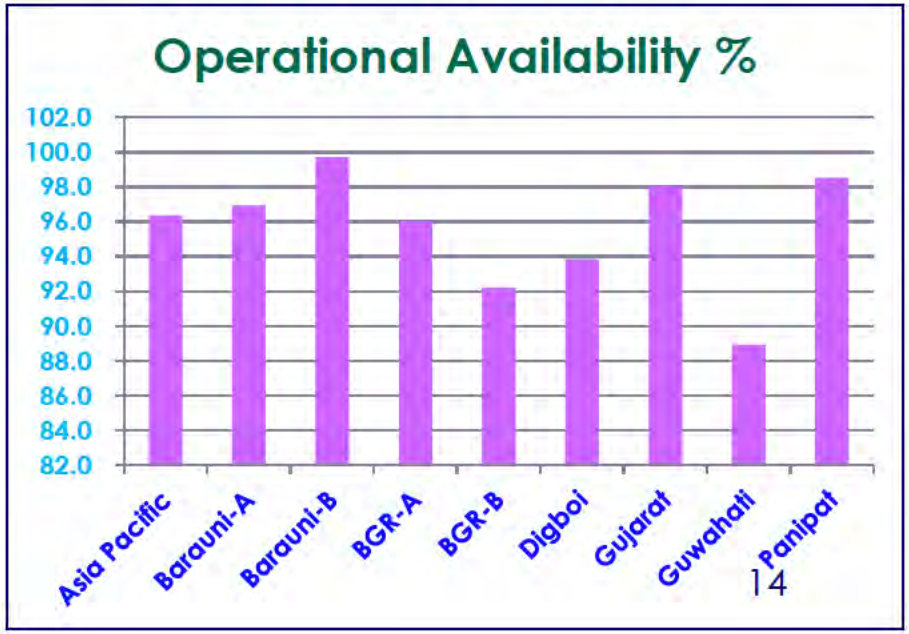
Refinery performance	Target
Availability	> 95%
Energy intensity index (EII)	< 85
Volumetric expansion	High
Net cash margin	High
GRM	≥ Singapore GRM

Performance of IOCL DCUs

As per Solomon Study

Operational availability	Mostly >95%
EII	> 85
Max Coke Make, wt%	15-30
Feed CCR, wt%	5-22
GRM, &/ bbl	8-13





IOCL DCUs - Net & Gross Value Addition in 13-14

Value addition in IOCL DCUs
Gross value addition : 8 - 13 $/ bbl
Net value addition: 4 - 10 $/ bbl

Gross value addition = Realisation from product - cost of feed

Net value addition = Realisation from product - cost of feed - operating cost incl Fuel & loss

Improvement through operational measures minor hardware change

- Maximising t'put & on stream factor
- Reduction in Recycle Ratio & Coke drum pressure
- Reduction in Chamber Cycle time
- Regular online spalling of Heaters- to increase heater run length
- Propylene recovery from off gas
- Improved spray nozzle & trays in HCGO wash zone
- Filtration system for hot HCGO before processing in Hydrocracker.
- Stripping of CFO (in high pressure cokers) to recover gas oil/ modifying CFO zone trays.
- Heat integration/ maximising hot feed supply
- Improved coke cutting/ handling/ conveying systems
- Improved Heater metallurgy
- Coker additives for reduction in coke yield & increase of liquid yield

Improvement areas from outcome of Solomon Study

- Gap exists in Coke yield compared to top performers (Average coke yield = 1.47 X CCR, Top 10% Avg coke yield = 1.26 X CCR)
- Further improvement required in the factors affecting performance – Recycle ratio, pressure, coke VCM content etc
- Establish 97% Operational Availability as a top KPI
- Improvement plans to close yield gaps

Improvement through new projects/ technology

Production of needle coke

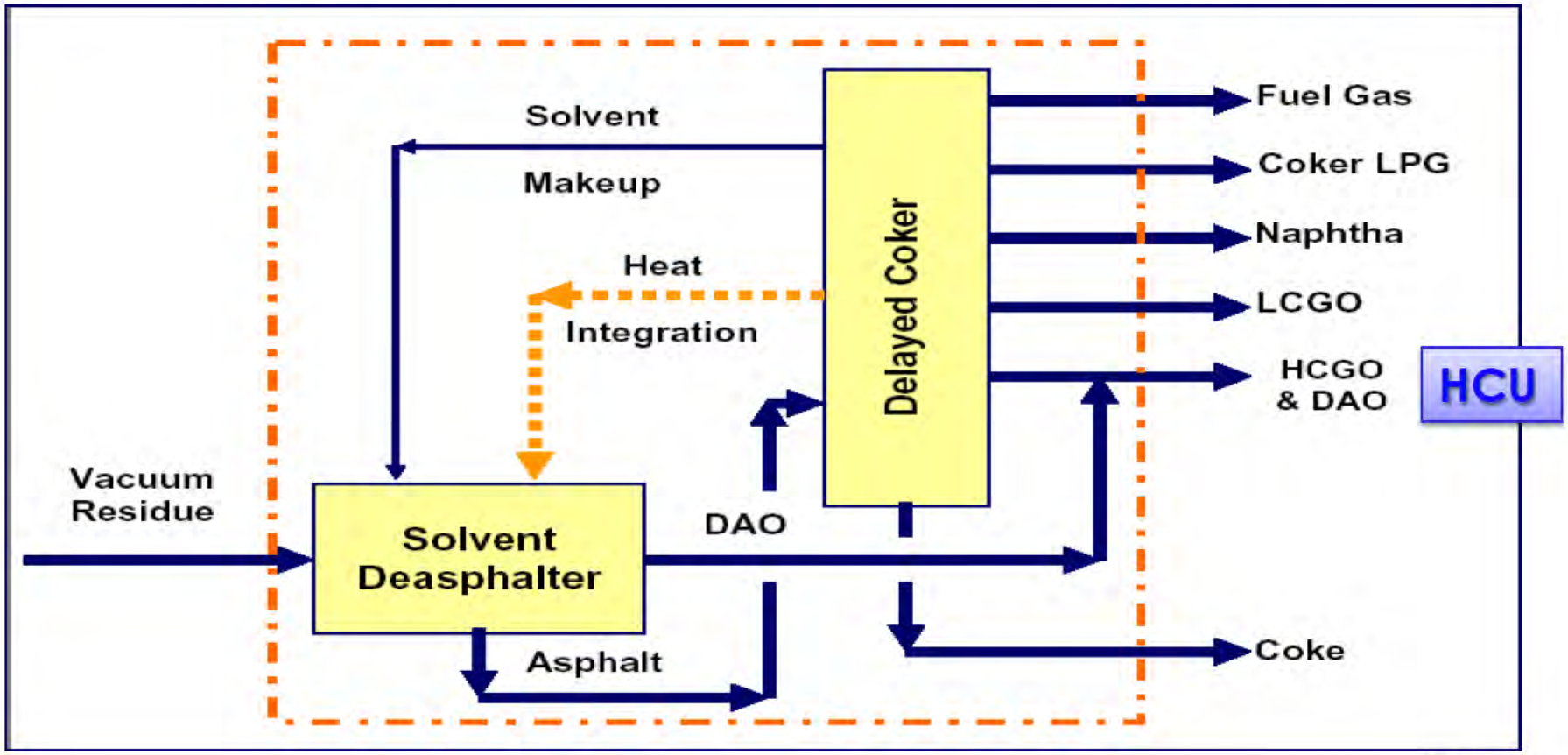
- High price (1500 $/ MT against 600 $/MT of normal graphite grade coke.
- Existing world production: ~ 750 TMTPA
- World wide Demand: ~1000 TMTPA
- Demand in India:
- Totally imported at present. Non-availability of sufficient qty of suitable feed
- Requirement:
  - LS CFO/ RFO
  - LS CLO
  - Feed BMCI- 105-135
  - Long kiln Calciner- kiln length > 165 feet

- Possible solution: Post Paradip refinery project commissioning.

Improvement through new projects/ technology: SDA – DCU- HCU combination

Installation of 3 cut SDA unit- routing VR to SDA, DAO to HCU and Asphalt to DCU

Issues: Capacity of HCU, DCU heater adequacy,



Residue upgradation through FCC/ RFCC

Indian FCC/ RFCC units at a Glance

S No.	Refinery	Capacity (MMTPA)	Type	Licensor	CCR, wt%	
					Design	Actual
1	IOCL Guwahati	0.1	INDMAX	IOCL R&D	4.46	3 – 3.5
2	IOCL Barauni	1.4	RFCC	SWEC	4.27	3 - 4
3	IOCL Gujarat	1 / 1.5	FCC	UOP	1	0.1
4	IOCL Haldia	0.7	RFCC	SWEC	4.06	3 – 3.5
5	IOCL Mathura	1/1.32/1.5	FCC	UOP/SWEC/Lummus	0.45	0.1 – 0.2
6	IOCL Panipat	0.7 / 0.85	RFCC	SWEC	1.5	1 - 2
7	HPCL Mumbai	0.4 / 0.95	FCC	EXXON		0.53
8	HPCL Vizag	0.4 / 0.95	FCC	EXXON		0.56
9	HPCL Vizag	0.97	FCC	UOP		0.33
10	BPCL Kochi	1 / 1.75	FCC	UOP/SWEC		0.6
11	BPCL Mumbai	0.85	FCC	UOP / SWEC		0.13
12	BPCL Mumbai	0.6 / 1.2	FCC	SHELL		0.41
13	CPCL	0.6 / 0.78	FCC	UOP		0.15
14	EOL Jamnagar	2.93 /3.36	RFCC	SWEC		0.68
15	HPCL Mumbai	1.456	FCC	UOP		
16	RIL-1	6/ 10	FCC	UOP		
17	RIL-2	10	FCC	UOP		
18	HMEL	2.22	DCC	Shaw stone & Webster		
19	MRPL	2.2	DCC	Shaw stone & Webster		
20	IOCL Paradip	4.17	INDMAX	Lummus technology Inc	0.1	-

Resid processing – Desired FCC configuration

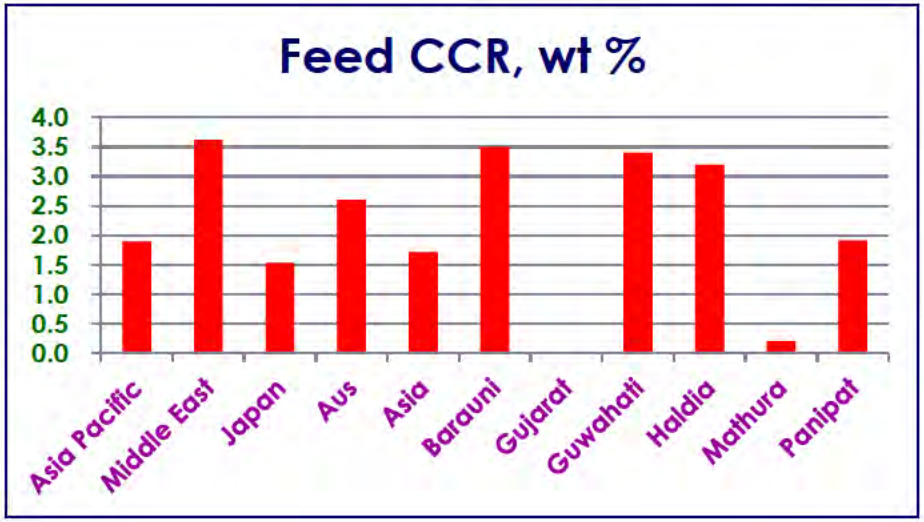
CCR Level	
< 2 wt%	FCC with one Regenerator – Partial / Full burn
2 – 5 wt%	RFCC with two Regenerator – Partial and Full burn
>5 wt%	RFCC with two Regenerator + Cat Cooler, Indmax, DSC
Metal (Ni + V)	
<2 ppm	No metal passivation required
2 - 10 ppm	Ni passivation + V trap
10 - 35 ppm	Ni passivation + V trap + Cat withdrawal
< 50 ppm	Feed Hydrotreatment (VRDS)
> 50 ppm	Indmax

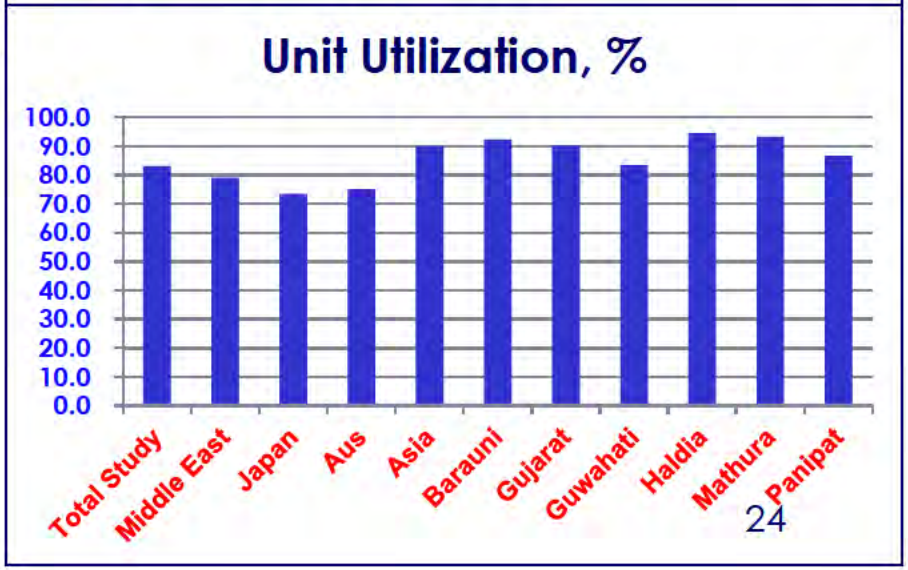
Resid processing – Challenges in RFCC

Cause	Effect	Outcome
Nickel	More Hydrogen, Gas & Coke	High Dry gas
Vanadium	Zeolite Distruction	High catalyst make up
Basic Nitrogen	Zeolite Acidity Neutralization	Low conversion
Condrason residue / Big Molecules	Poor accessibility / diffusion to/from catalyst pores Temporary deactivation of catalyst by coke Poor strippability of catalyst High Regen temp. & low Cat/Oil ratio	Low conversion
Aromatics	Difficult to crack, more Coke	Low Conversion
Sulfur	Higher SOx emission & High Sulfur in Products	Flue gas / product treatment units

Performance of IOCL FCC/ RFCC units: Solomon study

- Operational availability: 90-95% (Asian avg-95)
- EII: 100-200 (Asian avg-94)
- Feed CCR: <3.5 wt%
- MDA: 0.7-1.3
- GRM: 30-35 $/ bbl





IOCL FCCUs - Gross Value & Net value Addition

Value addition in IOCL FCC / RFCC units
Gross value addition : 30- 35 $/ bbl
Net value addition: 22-30 $/ bbl

Gross value addition = Realisation from product - cost of feed

Net value addition = Realisation from product - cost of feed - operating cost incl Fuel & loss

Improvement through operational measures - minor hardware change

- Use of Ni Passivator for reduction of DG & increase of liquid yield
- Use of new regenerator design & structured packing in Stripper
- Recovery of LCO range product from CLO
- Processing of DAO replacing VR
- Reduction of CLO using RUA
- New catalyst designs with increased contaminant resistance, increased hardness, increased distillate selectivity
- Better regenerator designs which provide optimum catalyst activity, minimise NOX, lower catalyst loss, operational flexibility, mechanical integrity & low investment.
- New Catalyst Cooler designs
- New Flue Gas scrubbing system designs – Reducing particulate, SO2, SO3 & NOX in a single vessel.
- Riser Termination Devices, new designs of feed injector nozzles, Stripper internals
- Third stage Separator (TSS) – Cyclonic Separator to remove catalyst fines from regenerator flue gas.

Improvement areas from outcome of Solomon Study

- Yield gap to be measured by the Modified Dynamic activity vs Feed UOP K and improvement plans to be made to close yield gaps.

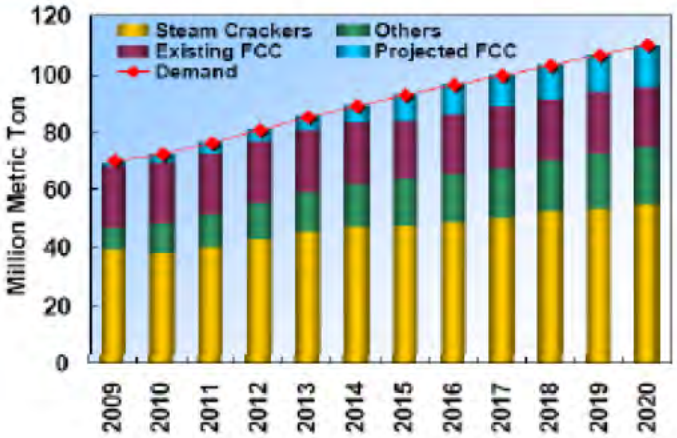
- Further improvement required in the factors affecting performance – Reactor hardware, steam rates, temperature, catalyst etc.

- Establish 97% Operational Availability as a top KPI

LPG/ Olefin Maximisation from FCC/ RFCC

Projected growth rates

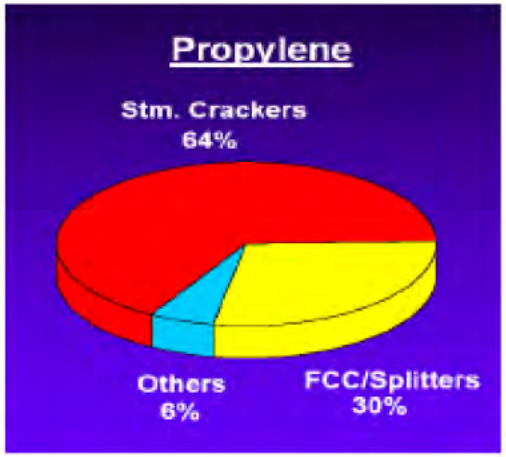
- Propylene Demand in India is 8.6 % against 4.0% of world
- LPG Demand in India is greater than10% against 3.5 % of world
- Growing gap between propylene demand and supply from steam cracker



Data Source: CMAI Feb 2010

FCC route

- Conventionally operates in Diesel/Gasoline mode
- Need of the hour is to produce higher olefins (propylene/butylenes) and LPG
- Flexibility available through
  - Increased operational severity
  - Modified/improved catalyst formulations
- New FCC technologies for light olefins



Olefin Maximisation Technologies

Process Name	Developer/Licensor	Propylene Yield, wt%	Remarks
Deep Catalytic Cracking (DCC-I and DCC-II)	RIPP-Sinopec/Stone Webster	14.6-28.8	Commercialized, several plants in and outside China.
Catalytic Pyrolysis Process (CPP)	RIPP-Sinopec/Stone Webster	24.6	VGO and heavy feeds, commercial trials in China.
High-Severity FCC (HS–FCC)	Nippon/KFUPM/JCCP/Saudi Aramco	17-25	Downer, high severity (temperature, C/O), 500 BPD cold flow model.
Indmax	Indian Oil Co./ABB Lummus	17-25	Upgrades heavy cuts at high C/O 15-25.
Maxofin	ExxonMobil and KBR	18	Variations with Superflex to increase propylene
NEXCC	Fortum	16.1	High C/O, short contact time, multi-port cyclones.
PetroFCC	UOP	22	Additional reaction severity along with RxCat design.
Selective Component Cracking (SCC)	ABB Lummus	24	High Severity operation (temperature, C/O)
High-Olefins FCC	Petrobras	20-25	Downer, high temperature, C/O.
Ultra Selective Cracking	IFP/Stone Webster/Total	NA	200 BPD downer Demo unit

Source: The Arabian Journal for Science and Engineering, Volume 33, Number 1B, April 2008

Alternate routes of Heavy oil processing

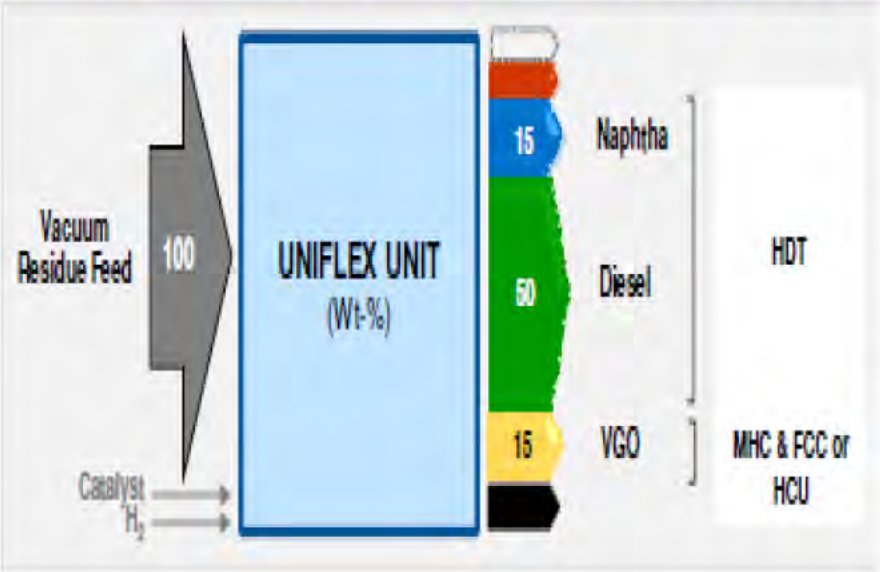
Ebullated vs Slurry Hydrocracker

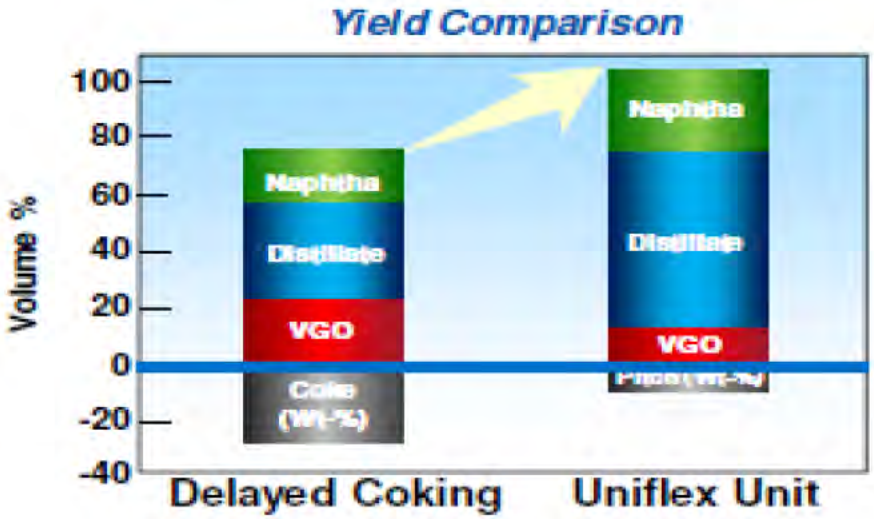
Resid hydrocracker		
Resid hydrocracker	**Ebullated**	**Slurry**
Conversion, %	75	95
Volume gain	Medium	High
Diesel selective	No	Yes
Fuel oil	Yes	No
Commercial	Yes	No
Licensor	Axens, CLG	Eni, KBR, UOP

Resid Processing – Upcoming Technologies

UOP UNIFLEX™ Process

- Similar to Hydrocracking
- Once through liquid catalyst
- 90% conversion with max Diesel & min VGO
- Product streams requires further treatment



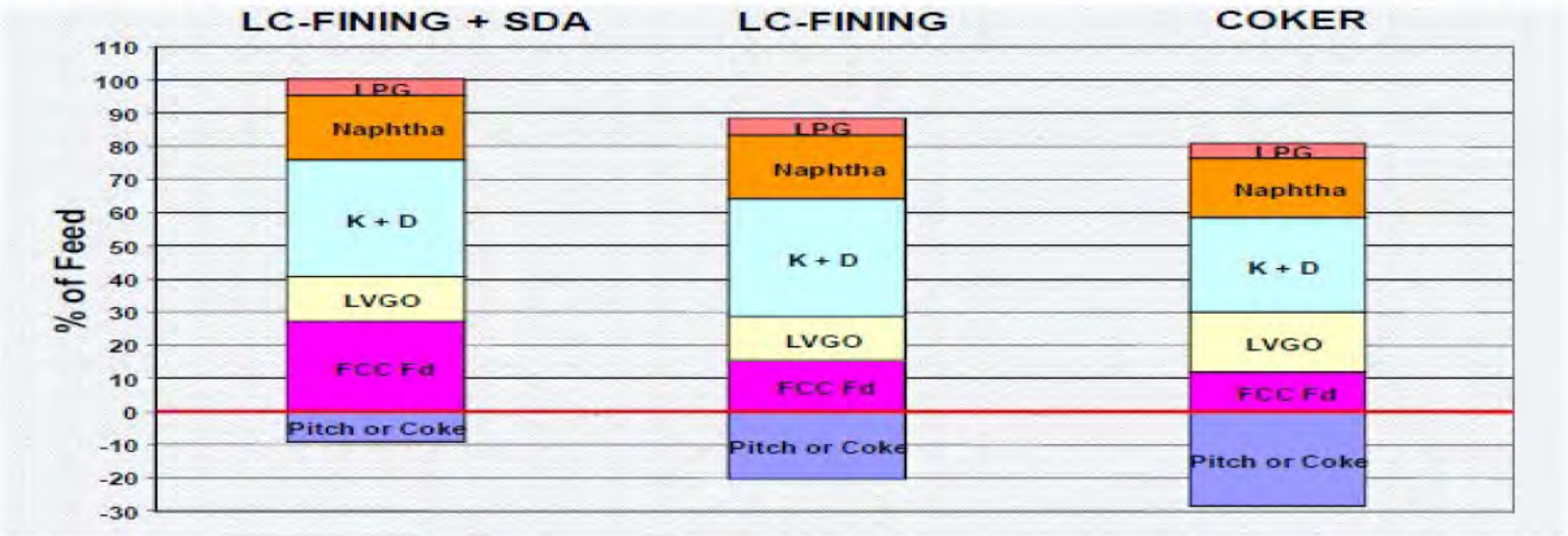


Source: UOP

Resid Processing – Upcoming Technologies

CLG LC - FINING Process

- Ebullated bed resid hydrocracking process
- Isothermal reactor operation
- Catalyst added & withdrawn onstream (extending unit run length)
- Recent advances in LC-FINING (LC-MAX, Hybrid Slurry & VRSH) can further increase resid conversion
- LC MAX is new multi-stage LC-FINING with solvent de-asphalting.

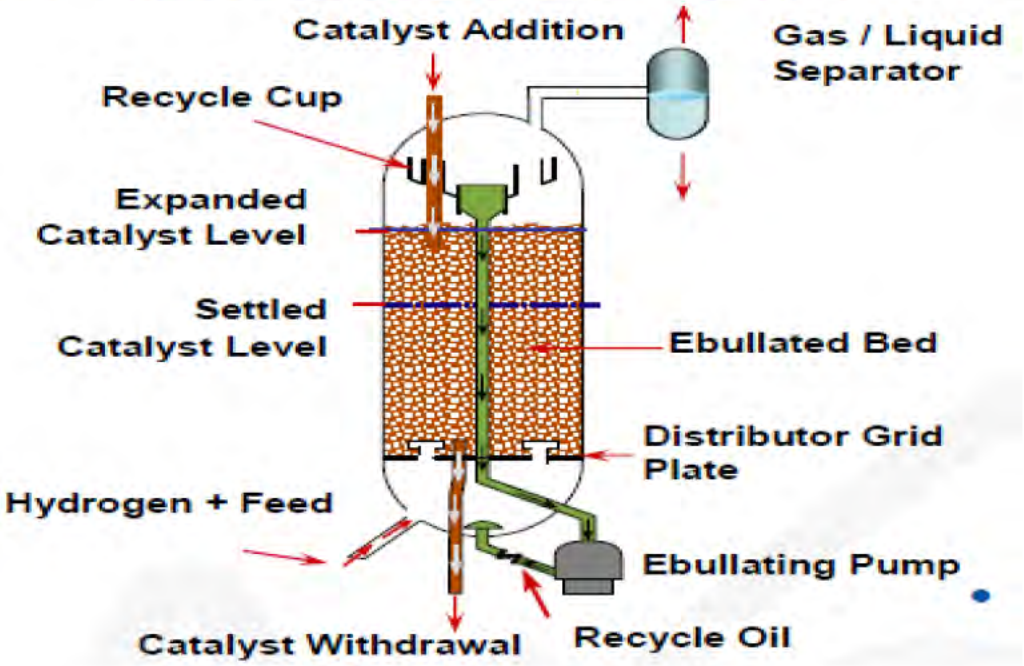


Source: CLG

Resid Processing – Advanced Technologies

Axens H-OIL Process

- Ebullated bed residue & distillate hydrocracking process
- 40-80% conversion for residue hydrocracking
- Feed stock – VR for reside HC & HVGO/DAO for Distillate HC
- Online addition/ withdrawal of catalyst



Source: Axens

Thank you

GRM of Indian DCUs

:Reliance, Jamnagar

: Essar, Vadinar

⇑ **Above**

Singapore GRM

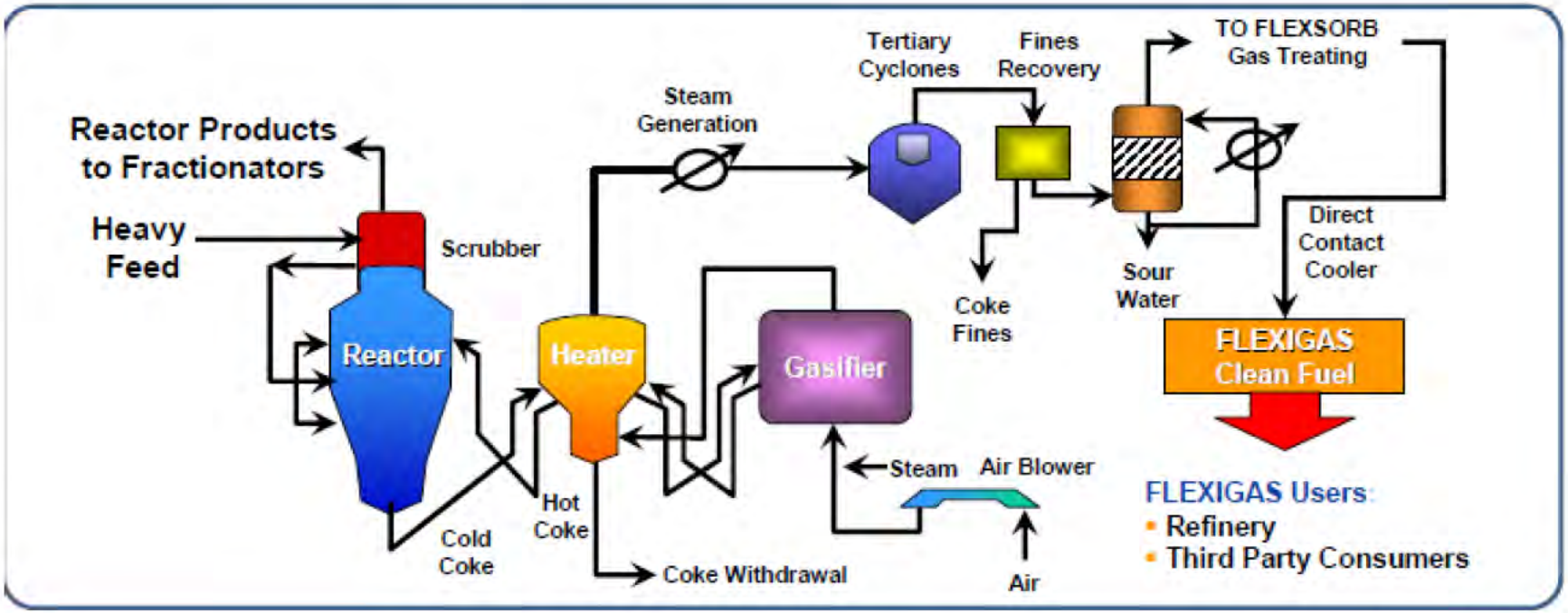
⇓ **Below**

Other Indian refineries

: IOC, BPCL, HPCL, MRPL

Improvement through new projects/ technology: EXXON FLEXICOKING™

- Continuous fluid bed process with integrated coke gasification
- Same liquid yield as Delayed Coking
- Coke gasified in integrated Steam Air Gasifier
- Produces Clean CO/H2 Fuel Gas Product Instead of Coke



Source: EMRE