VALUE ADDED PETROCHEMICALS FROM PETCOKE

Petrochemical Conclave, July 29, 2017, Gandhinagar, Gujarat, India

Paul Koppel Ravi Ravikumar Sunil Singhal Nandkishor V Bhongale

FLUOR®

ML20160700-001.ppt

AGENDA

- The Case for Petcoke as Feedstock to Petrochems
- Gasification and Technology
- Example Projects

FLUOR®

PETCOKE?

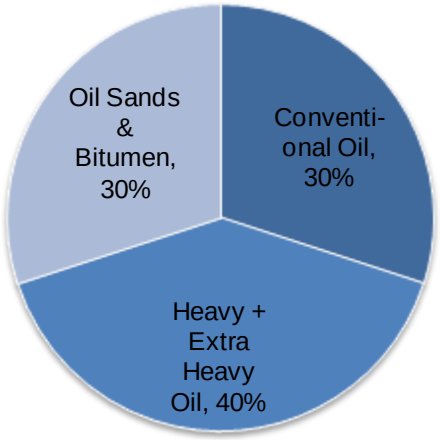
- Petroleum refinery byproduct of the coking process
- Types of petcoke:
  - Fuel grade – most commonly used as fuel; also gasification feed
  - Anode grade – used for electrodes in aluminum smelting process
  - Needle coke – used for electrodes in steel manufacturing
- Highest carbon, lowest hydrogen content and lowest value of potential petrochemical feedstocks
- Typical specifications of petcoke:

Category	Fuel Grade	Anode Grade	Needle Coke
Sulphur, wt%	4.0 – 7.0	1.0 – 3.0	0.1 – 0.8
Nickel / Vanadium, ppmw	200 – 3,000	50 - 200	<50
Calcium / Sodium, ppmw	50 - 300	20 - 100	<50
Volatile Hydrocarbons, wt%	9 - 14	7 - 9	5 - 7

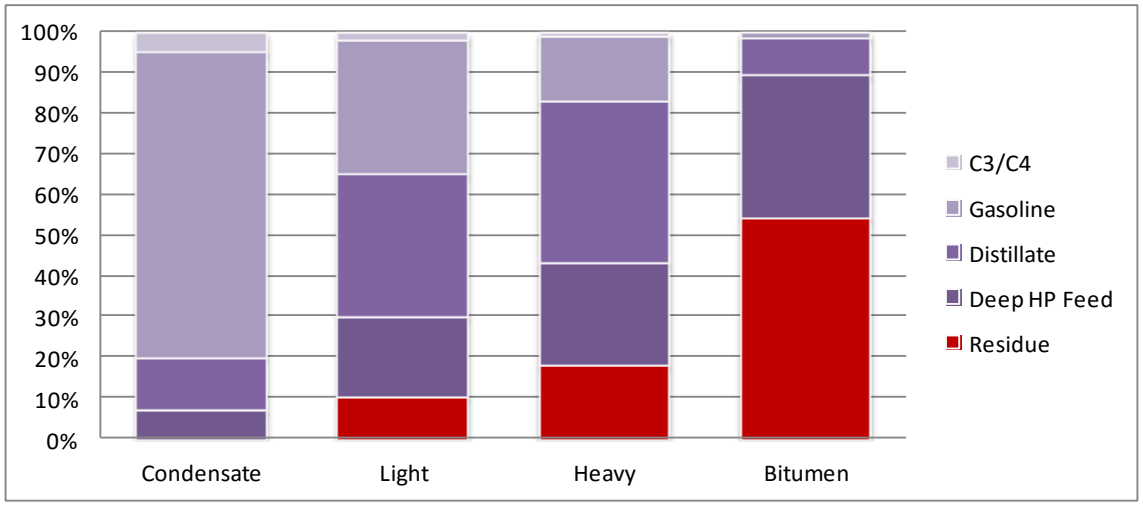
FLUOR®

WHY PETCOKE?

World Oil Reserves



Typical Refinery Yields By Crude Type



- Heavy crudes/bitumen have large residue content
- With time, conventional crude oil is depleting and the demand is fulfilled by heavy sour crude

FLUOR®

WHY PETCOKE?
Contd..

- More heavy crudes → more residues → more petroleum coke
- International Maritime Organization lowering S spec of marine fuel from 3.5 to 0.5 wt% in 2020
  - Desulphurize or upgrade → more cokers
  - Carbon rejection / coker more prevalent than hydrogen addition / hydro-processing for residue upgrading
- Global petcoke production is growing due to increased refinery capacity and complexity
- Current global petcoke production capacity is ~120 MMTPA
  - North America produces ~45% of the global petcoke production total and exports to Europe/Asia
- Current Indian petcoke production capacity is ~ 16 MMTPA
  - India imported ~ 14 MMT petcoke in FY 2016-17

FLUOR®

CONSUMERS OF FUEL GRADE PETCOKE

- Cement production
- Boilers for power generation
- Gasification

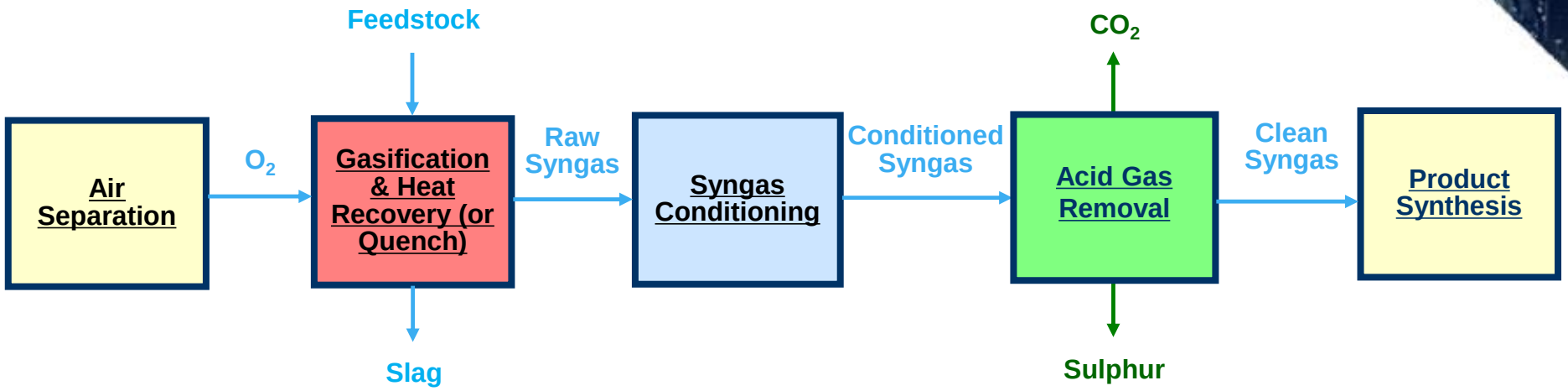
FLUOR®

ISSUES WITH DIRECT FIRING OF PETCOKE

- High SO_2 emissions due to high sulphur content – difficult to meet ever stricter emission limits even with best available post combustion control technologies
- Highest CO_2 emissions per MMBtu
- Heavy metals such as vanadium and nickel are present and can leach out from ash. A lined landfill may be required.
- High flame temperature generates higher thermal NOx – needs post combustion flue gas treatment
- Low reactivity – difficult to ignite.
  - Except for fluid bed boilers, must be blended
- For cement, permissible sulphur content in the clinker < 1.4wt% limits the use of some petcokes

FLUOR®

PETCOKE GASIFICATION



- Reaction of petcoke with oxygen and steam at high temperature to produce H_2 + CO synthesis gas
- Basic Gasification reactions:
  - Partial Oxidation $2\ C + O_2 \rightarrow 2\ CO$
  - Steam Gasification (Reforming) $C + H_2O \rightarrow CO + H_2$
  - Water Gas Shift $CO + H_2O \rightarrow CO_2 + H_2$
  - Methanation $3\ H_2 + CO \rightarrow CH_4 + H_2O$

FLUOR®

PETCOKE GASIFICATION
Contd..

- Operating Conditions: 1400 – 1500°C and 30 – 85 barg
- Heteroatoms:
  - N converted primarily to N_2, NH_3, HCN
  - S converted primarily to H_2S, COS, CS_2
  - Many trace components (e.g. formic acid, chlorides, soot)
- Many trace components (e.g. formic acid, chlorides, soot)
- Syngas clean up and acid gas removal to condition gas for downstream catalysts and to meet environmental regulations
- Water gas shift to adjust H_2/CO ratio as required for end product
  - $CO + H_2O \rightarrow H2 + CO_2$

FLUOR®

PETCOKE GASIFICATION
Contd..

- Combustion or further processing of clean syngas to products
- Sulphur recovery as elemental sulphur or sulphuric acid
- Potential for CO_2 capture and use for CBM/EOR or sequestration
- Ash → vitrified slag → use in construction / unlined landfill
  - Potential for vanadium + nickel recovery from slag
- Gasification is a complex and challenging process
  - Project execution requires integration of technologies from several parties
  - Attention to trace components, corrosion and process control
  - Requires a highly qualified team with gasification experience

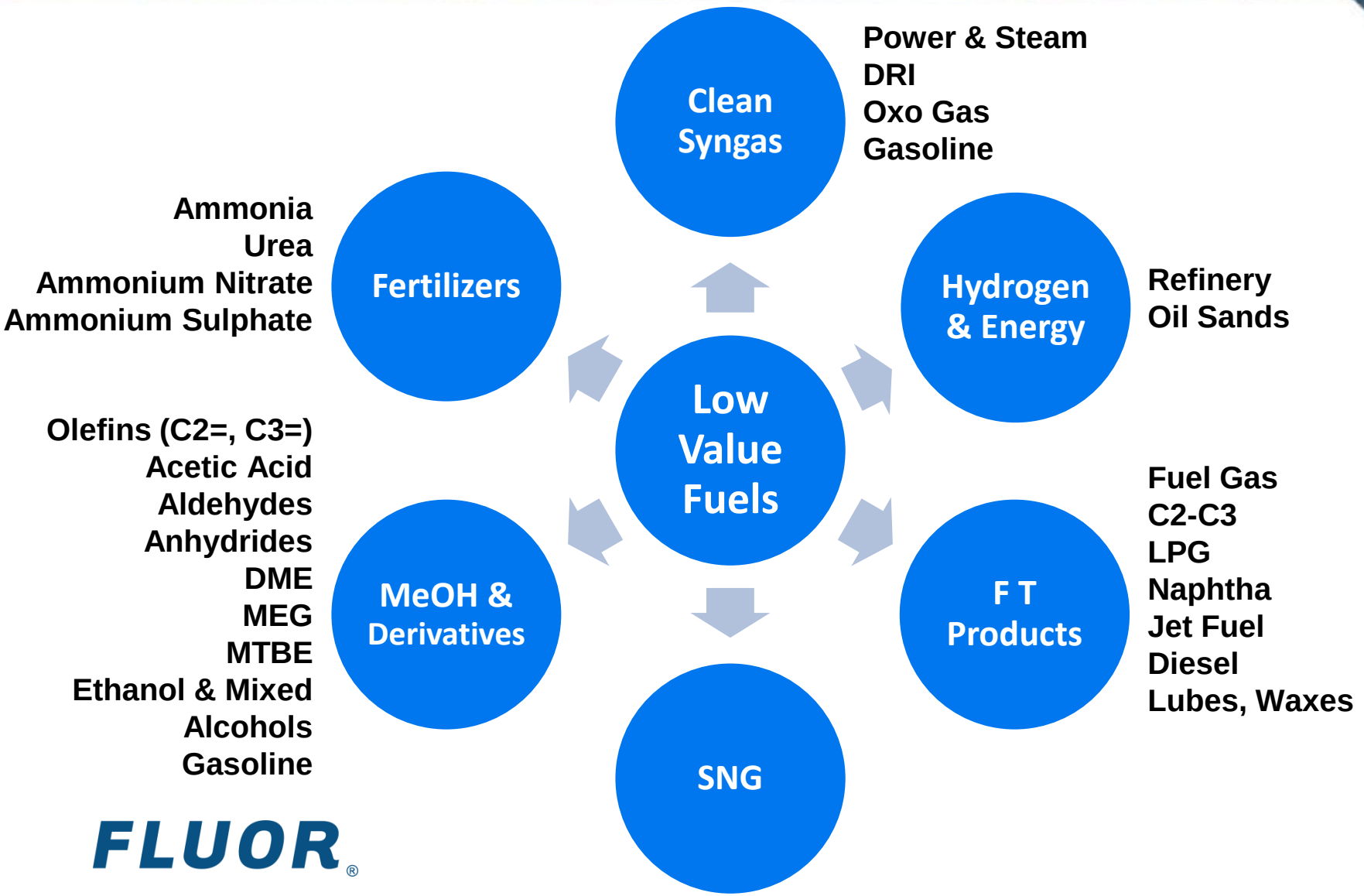
FLUOR®

TECHNOLOGY OPTIONS

- Commercially available petcoke gasification technologies:
  - GE – 100% petcoke or coal blend
  - CB&I (E-Gas) – 100% petcoke or coal blend
  - Shell – needs coal blend
  - Uhde PRENFLO – needs coal blend
  - Chinese technologies
- Technologies in development:
  - GTI (suitable for feeds with high ash melting point; more compact than conventional gasifiers; Industrial Demonstration Project with dry, high ash melting point coal in progress in China)

FLUOR®

GASIFICATION PRODUCT OPTIONS



FLUOR®

RELATIVE VALUE ADDITION FOR VARIOUS GASIFICATION PRODUCTS

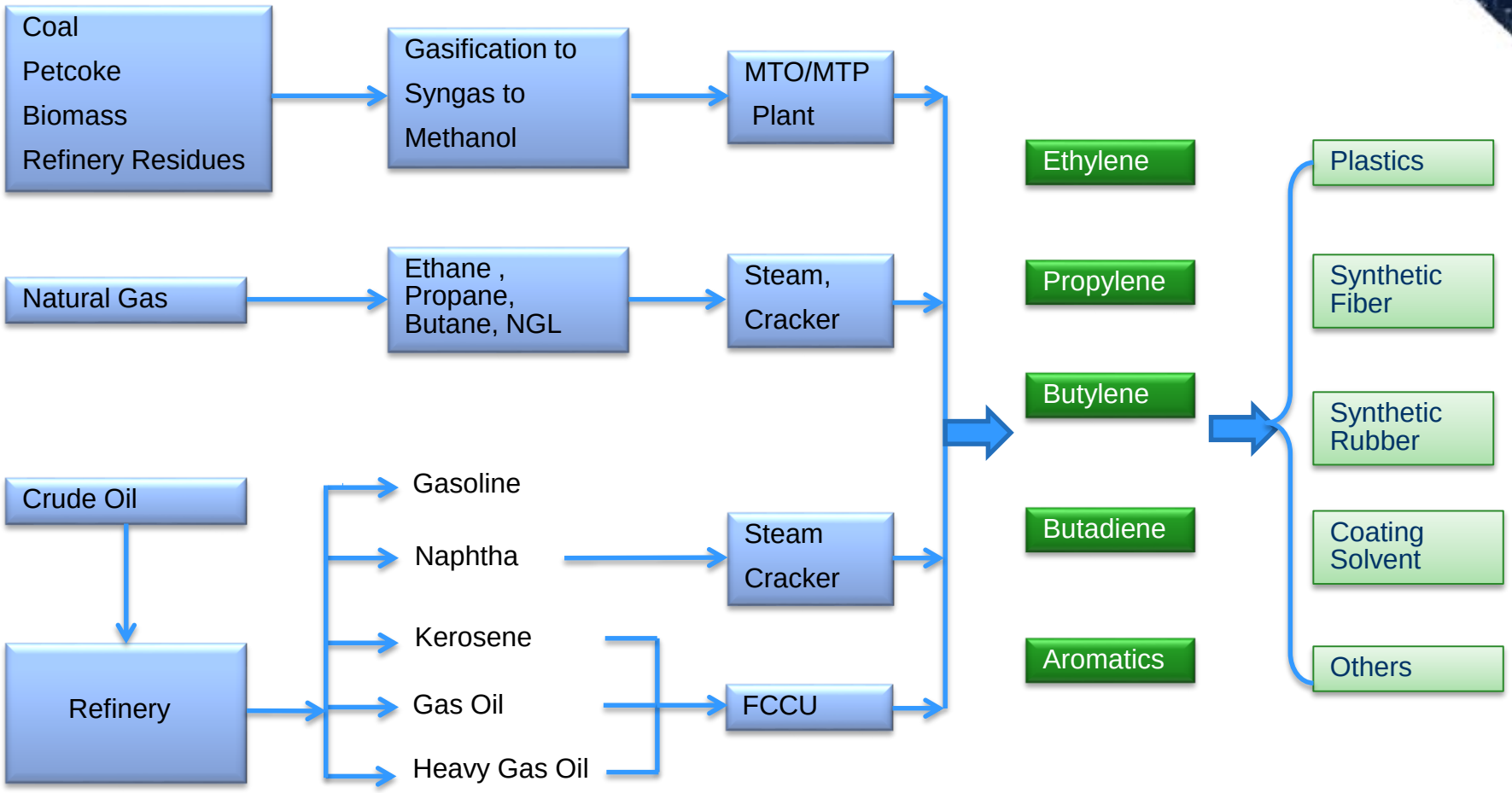
Relative Value Addition to Petcoke for Gasification Products

Product / Commodity	Price, $/MMBtu	Market Price[1]
Petcoke	2.7 - 3.0	$ 80 - 90 / MT
Methanol	21 - 22	$ 400 - 420 / MT
Ethanol	41	$ 1032 / MT[2]
Ethylene	29	$ 1320 / MT
Propylene	26	$ 1125 / MT
Acetic Acid	42	$ 515 / MT
MTBE	25	$ 825 / MT
Ammonia	23 - 25	$ 400 - 440 / MT
Urea	35 - 38	$ 300 - 330 / MT
Naphtha	11	$ 485 / MT
Petrol (Gasoline)	12.9	INR 28 / Ltr[3]
Diesel	11.2	INR 28 / Ltr[3]
SNG	8 / 12	LNG Landed / Gate Price
Hydrogen	16	Based on $8 natural gas price

1. Indicative market prices in India
2. Delivered price at Oil Marketing Companies' (OMC's) depots
3. Refinery gate price

FLUOR®

PETROCHEMICAL FEEDSTOCKS



FLUOR®

KEY DRIVERS

- Less costly vs Petroleum and NG derived feedstocks
- Low feedstock cost → high value added → supports higher CAPEX.
- Higher value added → improved margin certainty
- Tightening marine fuel sulphur specifications will result in more cokers and increased global and Indian supply of petcoke
- More environmentally friendly than other uses
- Indian government's emphasis on Methanol Economy
  - NITI Aayog proposal to allow 3% methanol blending in gasoline
  - Opportunity to address current net imports of methanol in India

FLUOR®

KEY DRIVERS…

- Ethanol blending up to 10 vol% is being encouraged in transport fuels
- Declining direct use of petcoke as fuel due to environmental regulations
- If included in petcoke producing refinery,
  - save on shipping and benefit from integration synergies
  - H_2 requirement for the refinery can be met by the syngas produced from the Petcoke Gasification
- Projected increased supply and decreased demand should lead to long term pricing weakness
- Gasification and syngas processing are complex and requires design, operations and maintenance diligence.

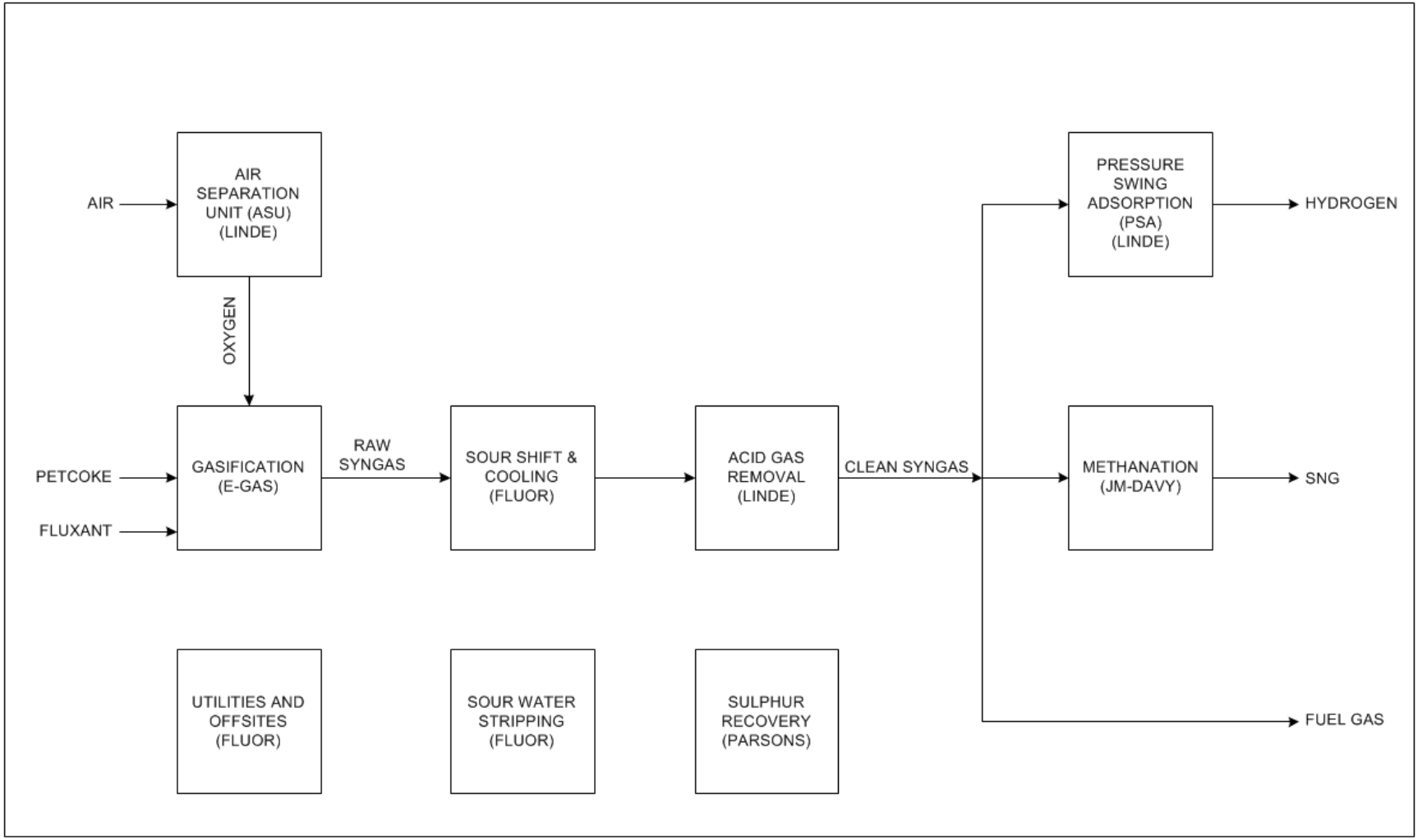
FLUOR®

SUCCESS STORIES

- 10+ petcoke-based gasification plants built worldwide
- World's largest petcoke based gasification plant is in the commissioning phase at Reliance's Jamnagar, India Refinery
- Lake Charles Methanol Gasification Plant – FEED near complete; detailed engineering expected to kick off in 2017 Q4
- While challenging, several gasification projects have been successful. Must employ best technologies and employ gasification experienced design engineers. Don't learn on the job.

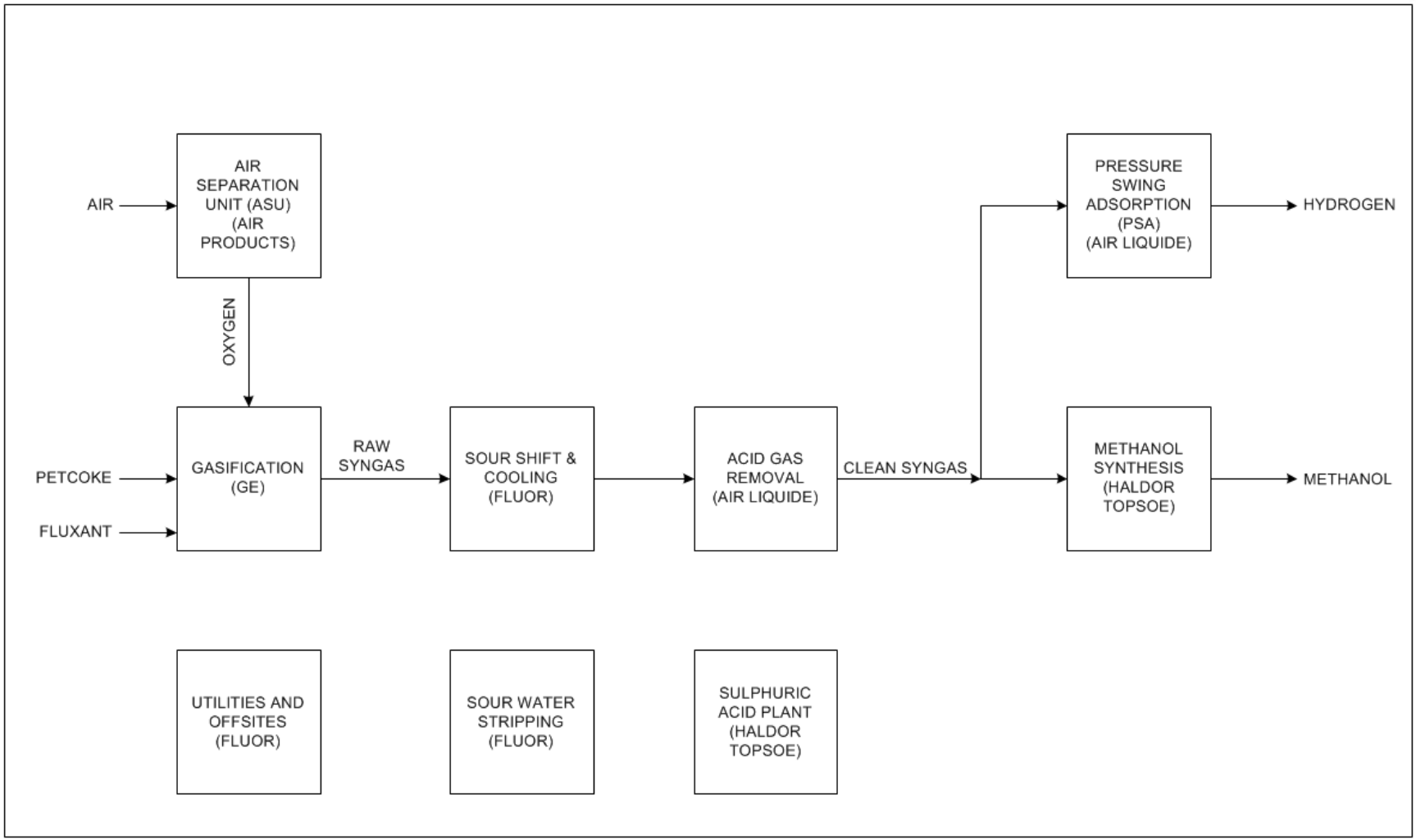
FLUOR®

Reliance Jamnagar Gasification Project



FLUOR®

Lake Charles Methanol Project



FLUOR®

FLUOR GASIFICATION EXPERIENCE

Client	Location	Scope	Feed	Products	Technology	Completed
Lake Charles Methanol	Louisiana	FEED, EPFC	Petcoke	Methanol	GE	Ongoing
Reliance Industries	India	E, P and PM Support	Petcoke, Coal	Hydrogen, SNG, Power	CB&I E-Gas	2017
Celanese / IOCL	India	Pre-FEED	Petcoke, Coal	Ethanol, Power	Confidential	2015
Pertamina	Indonesia	Pre-FEED	MSW	Power	Solena	2014
Confidential	Indonesia	Pre-FEED	High Moisture Indonesian Coal	SNG, Urea, CO_2	Confidential	2012
Jindal SynFuels	India	Pre-FEED	High Ash Indian Coal	FT Liquids, Ammonia	Confidential	2012
Reliance ADAG	India	Pre-FEED	High Moisture Indonesian Coal	SNG, Power	Confidential	2012
MAK	Mongolia	Pre-FEED	High Moisture Brown Coal	MTG, Power	Confidential	2012
Fulcrum Sierra BioFuels	Nevada	FEED Refresh, EPC	MSW	Ethanol, Power	InEnTech (IET)	2012
OPTI Canada Phase II	Alberta	FEED	Residue	Hydrogen, Power, CO_2	Shell	2012
Rentech	California	FEED	Woody Waste	FT Liquids, Power	Rentech SilvaGas	2011

FLUOR®

FLUOR GASIFICATION EXPERIENCE

Client	Location	Scope	Feed	Products	Technology	Completed
Summit	Texas	FEED	Coal	Urea, Power, CO_2	Siemens	2011
Swan Hills	Alberta	Pre-FEED, FEED	Deep Unmineable Coal	Power, CO_2	Swan Hills In-situ Coal Gasification	2011
MSEZL	India	Pre-FEED	Petcoke	Acetic Acid, Hydrogen, Power	Confidential	2010
Eastman	Texas	FEED	Petcoke	Hydrogen, Methanol, Ammonia, CO_2	GE	2009
Confidential	Montana	Pre-FEED	Coal	Urea, Power, CO_2	Siemens	2009
Valero	Texas	Pre-FEED	Petcoke	Hydrogen, Power, CO_2	ECUST	2009
OPTI Canada	Alberta	FEED, EP	Residue	Hydrogen, Power	Shell	2008
Valero	Delaware	EP	Petcoke	Power, Steam	GE	2008
Steelhead	Illinois	FEED	Coal	SNG	CB&I E-Gas	2006
Total	France	FEED	Residue	Hydrogen, Power	GE	2004
ISAB	Italy	Owner's Eng.	Residue	Hydrogen, Power	GE	1999
Great Plains	North Dakota	Owner's Eng.	Coal	SNG	Lurgi	1988
Shell	Netherlands	FEED, EPCM	Residue	Hydrogen, Power	Shell	1997
Texaco	Kansas	EPCM	Petcoke	Power, Steam	GE	1996
Motiva	Louisiana	EP	Residue	Hydrogen	GE	1985
Eastman	Tennessee	C	Coal	Chemicals	GE	1986
Sasol	South Africa	EPCM	Coal	FT Liquids, Chemicals	Lurgi	1980

Note: Constructed plants in red

FLUOR®

CONCLUSIONS

- Increased supply / Decreased demand for petcoke
- Petcoke utilization → High value products
- Maximum economic benefits from petcoke
- Syngas produced from gasification can be processed to give a wide variety of products depending upon market conditions and economic / strategic considerations. Retain gasification / syngas and marketplace consultants early to configure the optimum facility.
- Byproducts sulphur, H_2SO_4, CO_2, Slag, N_2, Ar can provide additional revenue
- Gasification offers reduced air emissions and carbon footprint, a key concern in the wake of new stricter emissions norms

FLUOR®

Stay Connected..

Paul Koppel	Ravi Ravikumar	Sunil Singhal	Nandkishor V Bhongale
Paul.Koppel@fluor.com	Ravi.Ravikumar@fluor.com	sunil.singhal@fluor.com	Nandkishor.V.Bhongale@fluor.com
+1.832.472.6932	+1.949.349.7481	+91.124.457.0700 Extn. 1649	+91.124.457.0700 Extn. 3295

http://www.fluor.com

http://www.linkedin.com/company/fluor

@FluorCorp

http://www.youtube.com/user/FluorCorporation

FLUOR®