Shell Gasification & Clean Coal Energy

Shell Gasification – Leading Technology Across Multiple Applications

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GM Gasification & Hydrogen Manufacturing

KIVI, March 2010

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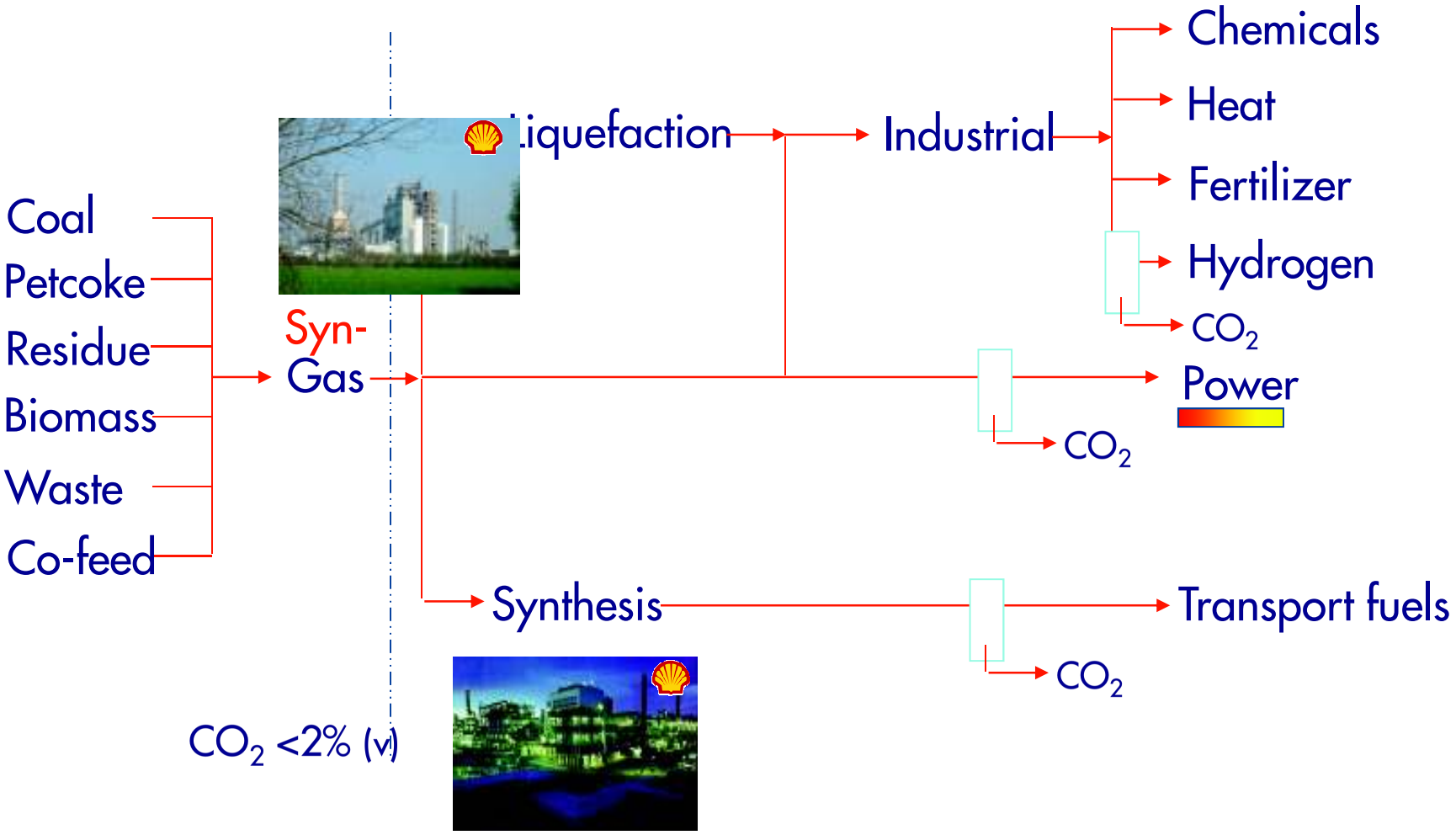
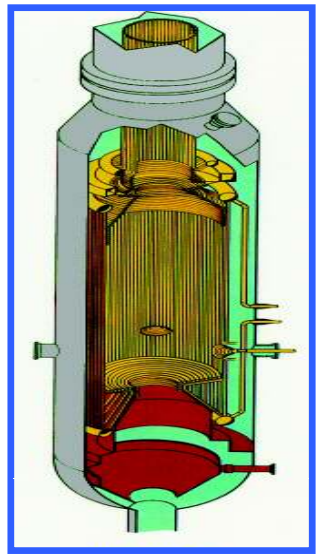
Syngas is fundamentally similar to Natural Gas, a business Shell knows well



Shell gasification processes – dedicated to feedstock

Liquid refinery residues
SGP

Coal and coke
SCGP



Differences

SGP: Non-slagging condition

SGP: Refractory lined gasifier

SGP: Liquid feed system

SGP: Fire tube boiler

SGP: Soot water handling

SCGP: Slagging condition

SCGP: Membrane wall gasifier

SCGP: Dry feed system

SCGP: Water tube boiler

SCGP: Solid slag handling

Coal gasification, from pilot plant to licensing in China

1956
- Start Shell oil gasification technology

1974
- Coal gasification demo facility in Amsterdam

1979
- Demo Unit Harburg, Germany

1987
- SCGP-1 Scaled-up Demo Unit USA

1993
- NUON IGCC 250MW Buggenum, The Netherlands

2006
- Start-up of 4 ammonia plants in China

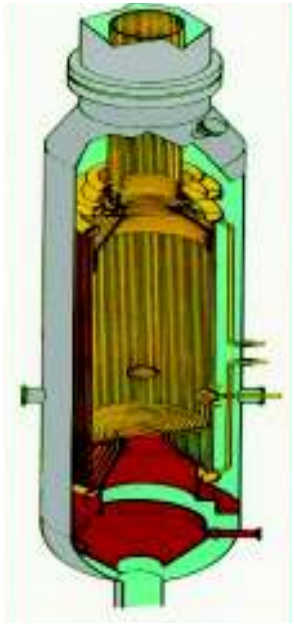
2006
- 50/50 JV with Sinopec & Shell, 2000 t/d ammonia plant in operation

2000-mid 2009
- 27 Licence deals around the world
- IGCC licence deals in the Netherlands, the UK and Korea
- Chemical licence deals in China, Vietnam and Australia
- Synthetic fuel licence deal in the US

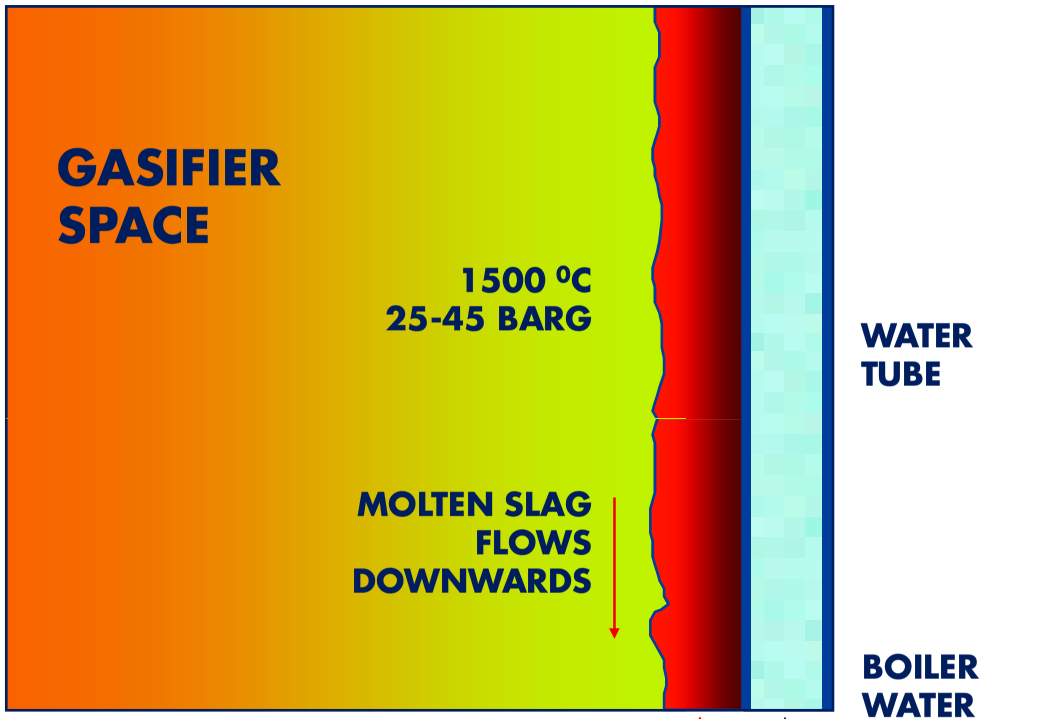
2008
- Start-up of 7 coal to chemical plants in China

2009 - onwards
- Multiple planned start-ups
- Ongoing R&D investments
- Constantly amassing learning and experience

Reactor membrane wall design



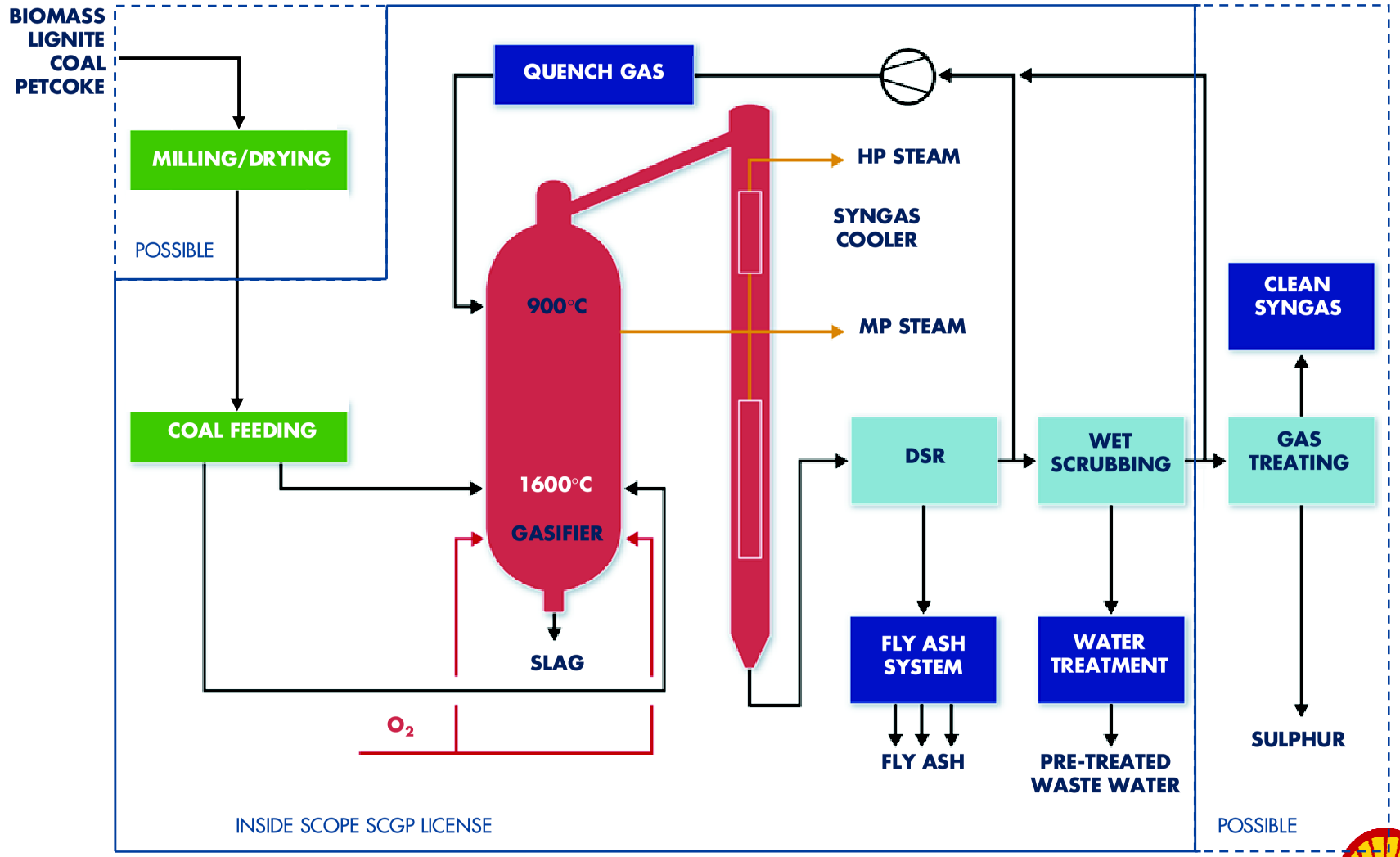
MEMBRANE WALL
PROTECTED BY SLAG LAYER



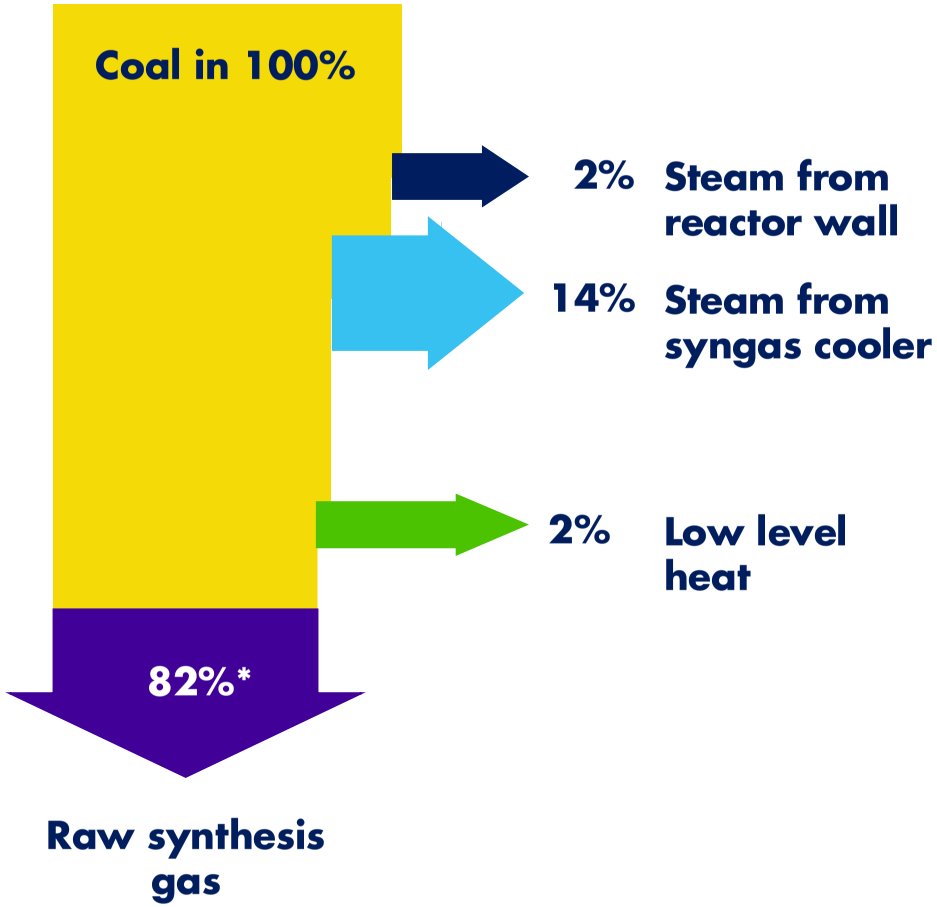
Advantages of design

- Less maintenance costs due to the long lifetime of the burners and the membrane wall design
- No thermal insulation, refractory lining in the gasification reactor
- Designed for life of reactor; no shutdowns for replacement or repairs under normal operating condition
- Burner lifetime in excess of 20,000 hours

Simplified flow scheme Shell coal gasification process



Our technology process offers an efficient way to produce syngas



- High efficiency due to the high temperature, lower oxygen use and high conversion compared to our competitors
- Carbon efficiency of over 99%
- Cold gas efficiency of 80-83% versus slurry gasifiers at 74-77%
- Virtually no efficiency penalty for sub-bituminous coal vs. bituminous coal.
- Very limited water use (only for wet scrubbing)

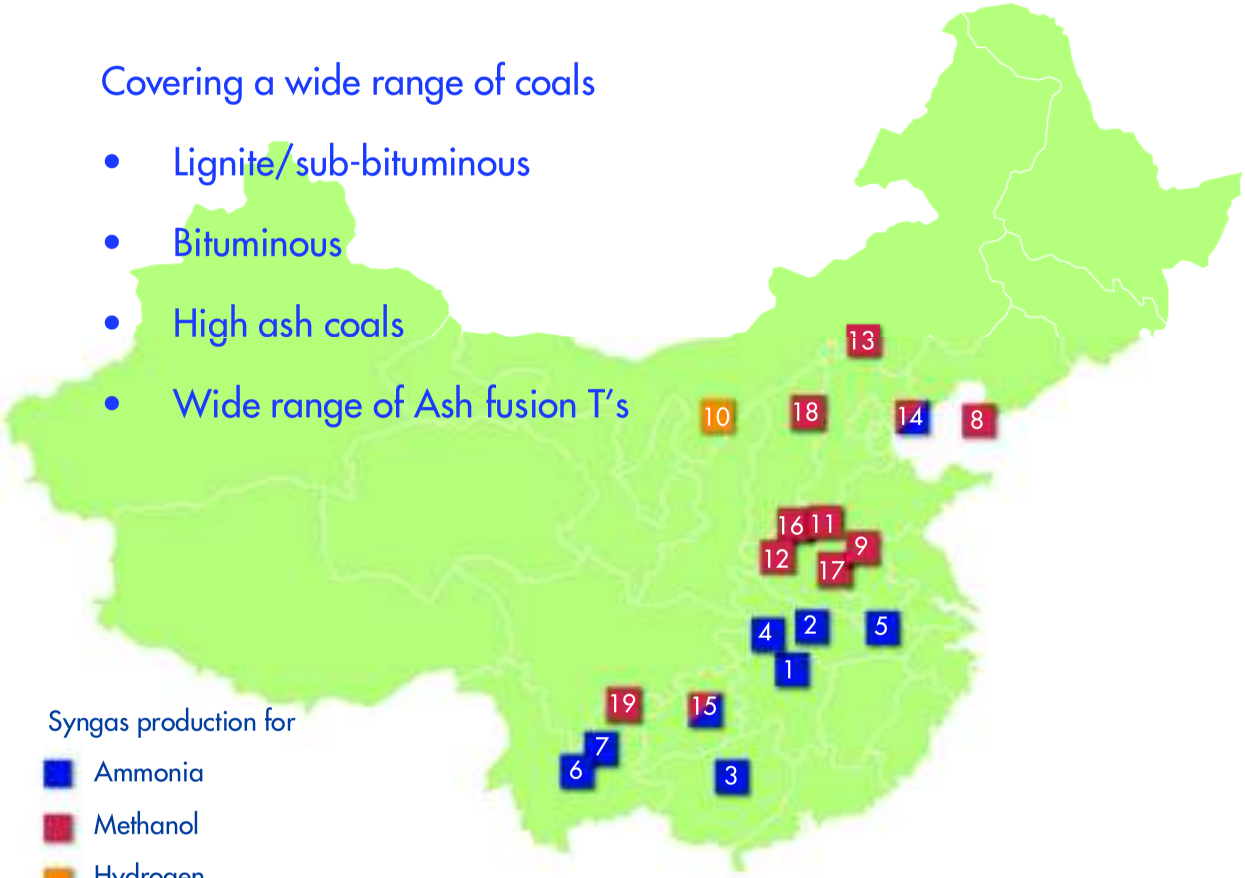
*The cold gas efficiency will vary slightly with the type of coal processed

Shell China coal gasification licences
Including its first equity investment

12 gasifiers started up in 2007-2009

Covering a wide range of coals

- Lignite/sub-bituminous
- Bituminous
- High ash coals
- Wide range of Ash fusion T's



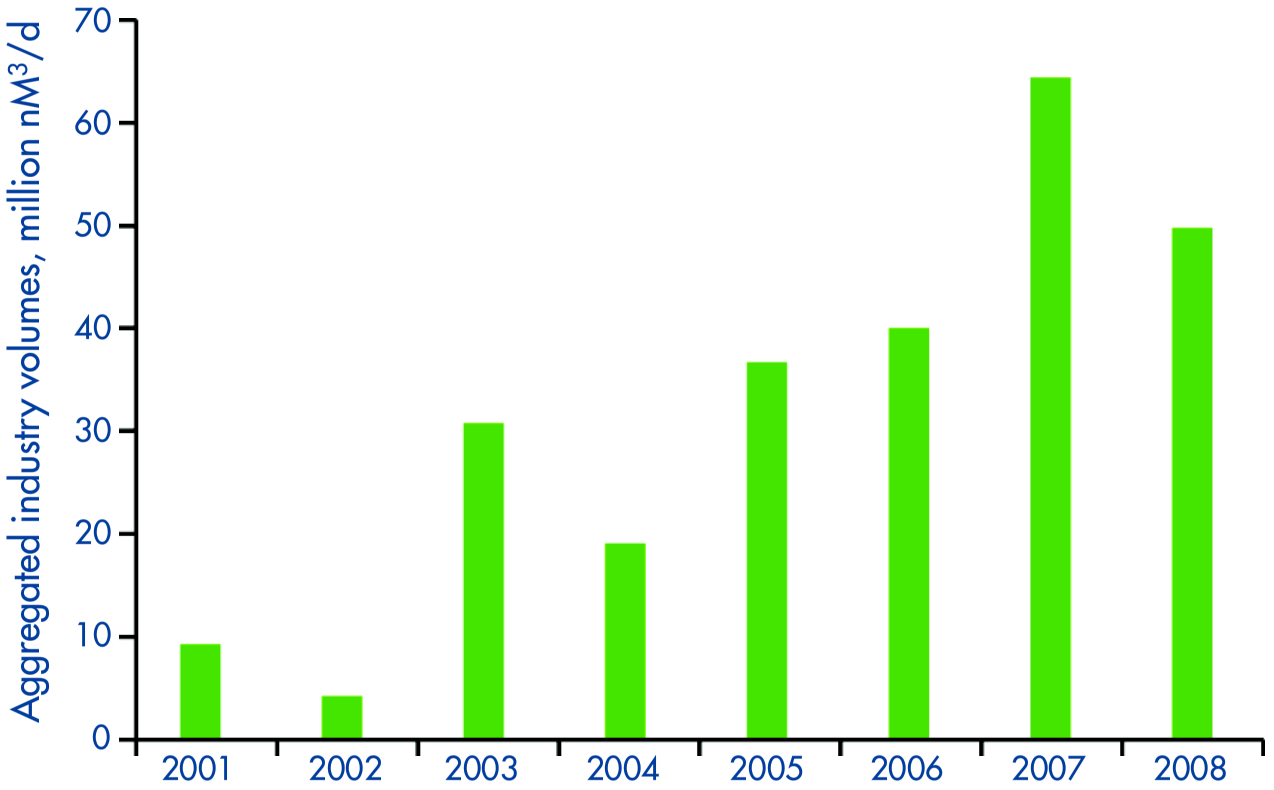
Syngas production for

- Ammonia
- Methanol
- Hydrogen

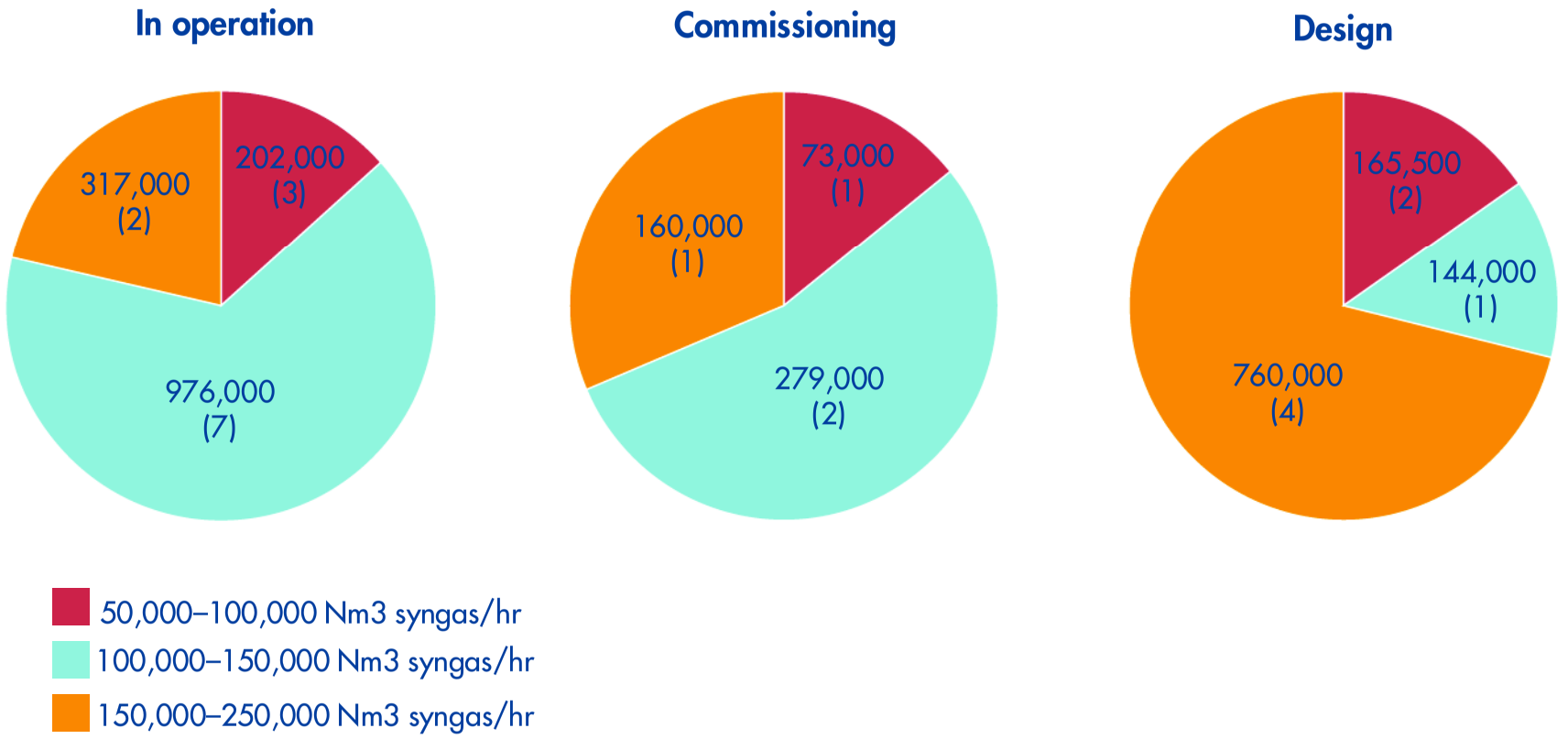
- **1 – Sinopec Shell Yueyang JV** 2,000 t/d ammonia
- **2 – Hubei Shuanghuan** 900 t/d ammonia
- **3 – Guangxi Liuzhou** 1,100 t/d ammonia
- **4 – Sinopec Hubei** 2,000 t/d ammonia
- **5 – Sinopec Anqing** 2,000 t/d ammonia
- **6 – Yunnan YunTianhua** 2,700 t/d ammonia
- **7 – Yunnan Zhanhua** 2,700 t/d ammonia
- **8 – Dalian Dahua** 1,100 t/d methanol
- **9 – Henan Longyu** 2,100 t/d methanol
- **10 – Shenhua DCL** 2 × 2,200 t/d hydrogen
- **11 – Henan Zhongyuan Dahua** 2,100 t/d methanol
- **12 – Henan Kaixiang** 1,100 t/d methanol
- **13 – Datang Power International** 3 × 2,800 t/d methanol
- **14 – Tianjin Soda** 2 × 2,000 t/d methanol/ammonia
- **15 – Guizhou Tianfu** 2,000 t/d methanol/ammonia
- **16 – Henan Hebi Zhongyuan** 2,700 t/d methanol
- **17 – Henan Longyu Phase II** 2,100 t/d methanol
- **18 – Datong Coal Mine Group** 2,400 t/d methanol
- **19 – Yunnan YunTianhua Phase II** 1,100 t/d methanol

Syngas projects in industry, in China

(1 gasifier string = 3-4 mln nm3/d)



SCGP is a proven technology on an ever-increasing scale



Beijing Gasification service center helping our customers with implementation

Accomplishments since kickoff in 2007:

- Successfully started up 12 coal gasifiers in China
- Successfully started up 3 Resid gasifiers in China (Fujian refinery)
- Extended service territory from China to Vietnam and Korea
- Organised the 4 global SCGP licensee conferences
- Commissioning, start-up and run-and-maintain support to 19 licensees
- Supporting reliability journey of client sites
- Setup of authorized vendors, incl maintenance and repair services

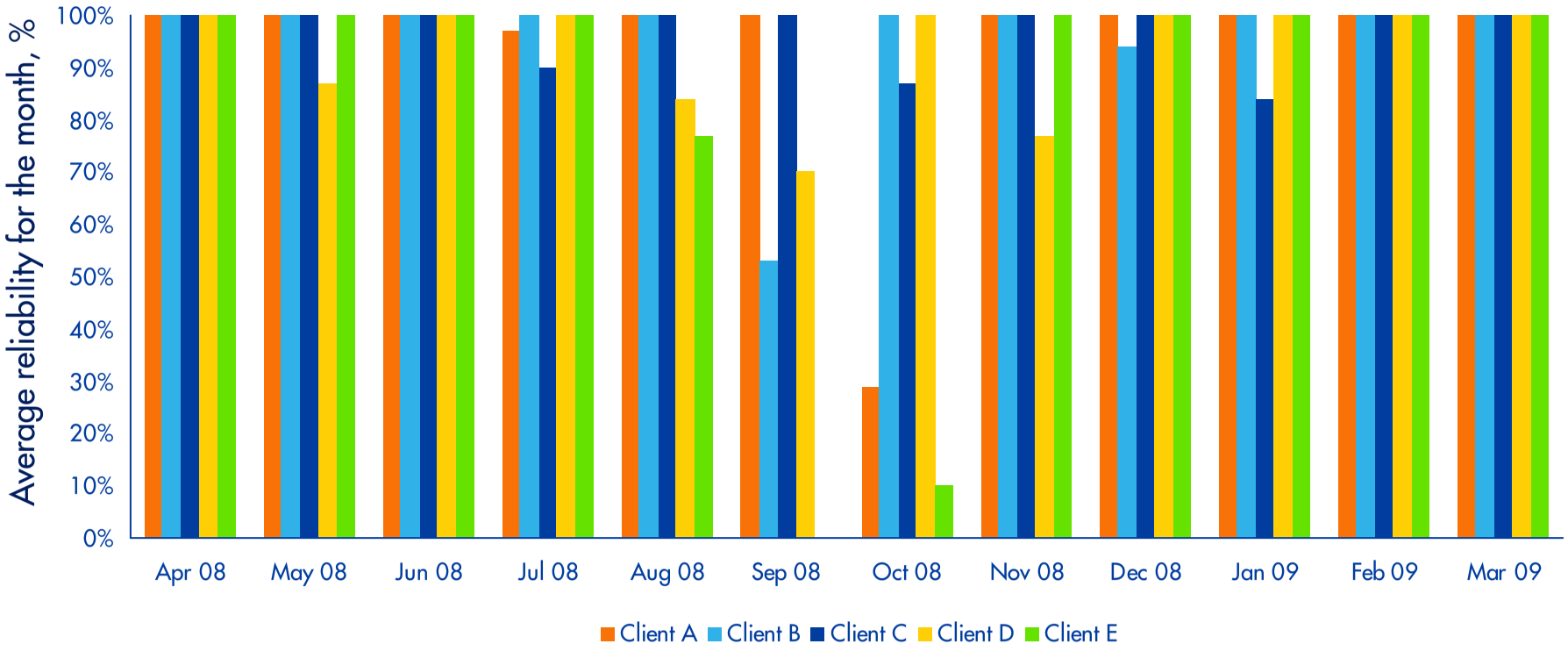
Shell services in coal gasification

- Licensing of the Shell Coal Gasification Process and related gas treating units
- Provision of Basic Design (Engineering) Packages, including integration and optimization work
- Review of detailed engineering documents and technical support during detailed engineering and gas treating
- Design of key (critical) equipment (e.g. gasifier internals)
- Operator training
- Support in commissioning, start-up and performance test runs
  (e.g. Mechanical Completion Inspection).
- After-sales technical and operational services tailor-made to customer requirements.
- Where appropriate, Shell can customize our contributions by including gas treatment and/or carbon capture and sequestration.





Reliability of Chinese customers with initial start-up in 2006



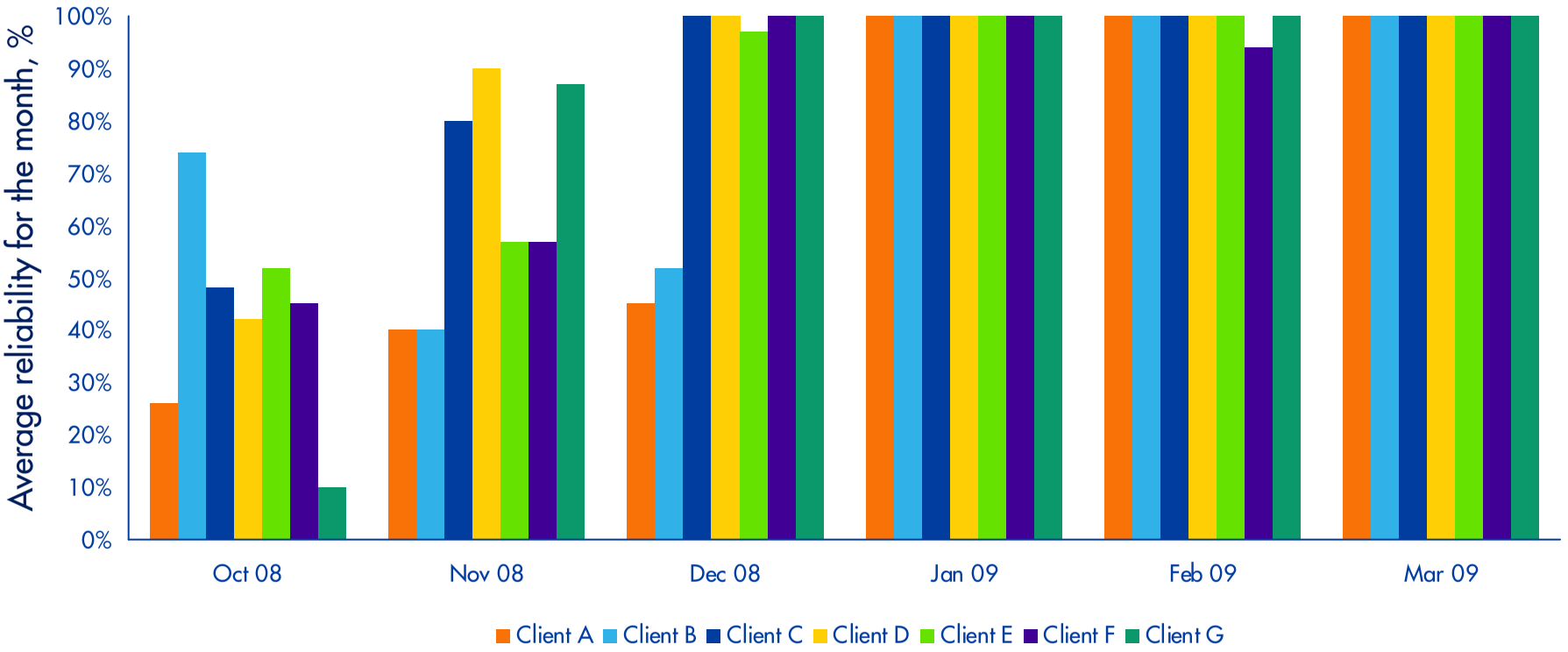
$$\text{Reliability} = \frac{\text{(actual on streamtime)}}{\text{(design on streamtime)}} \ 100\%$$

Inside scope: Everything within gasifier island battery limits including quench gas compressor etc.

Outside scope: Everything outside gasifier island battery limits so ASU, coal milling & drying, general utilities, power failures etc. are excluded

Source: China client monthly feedback

Reliability of Chinese customers with initial start-up in Q2 and Q3 2008



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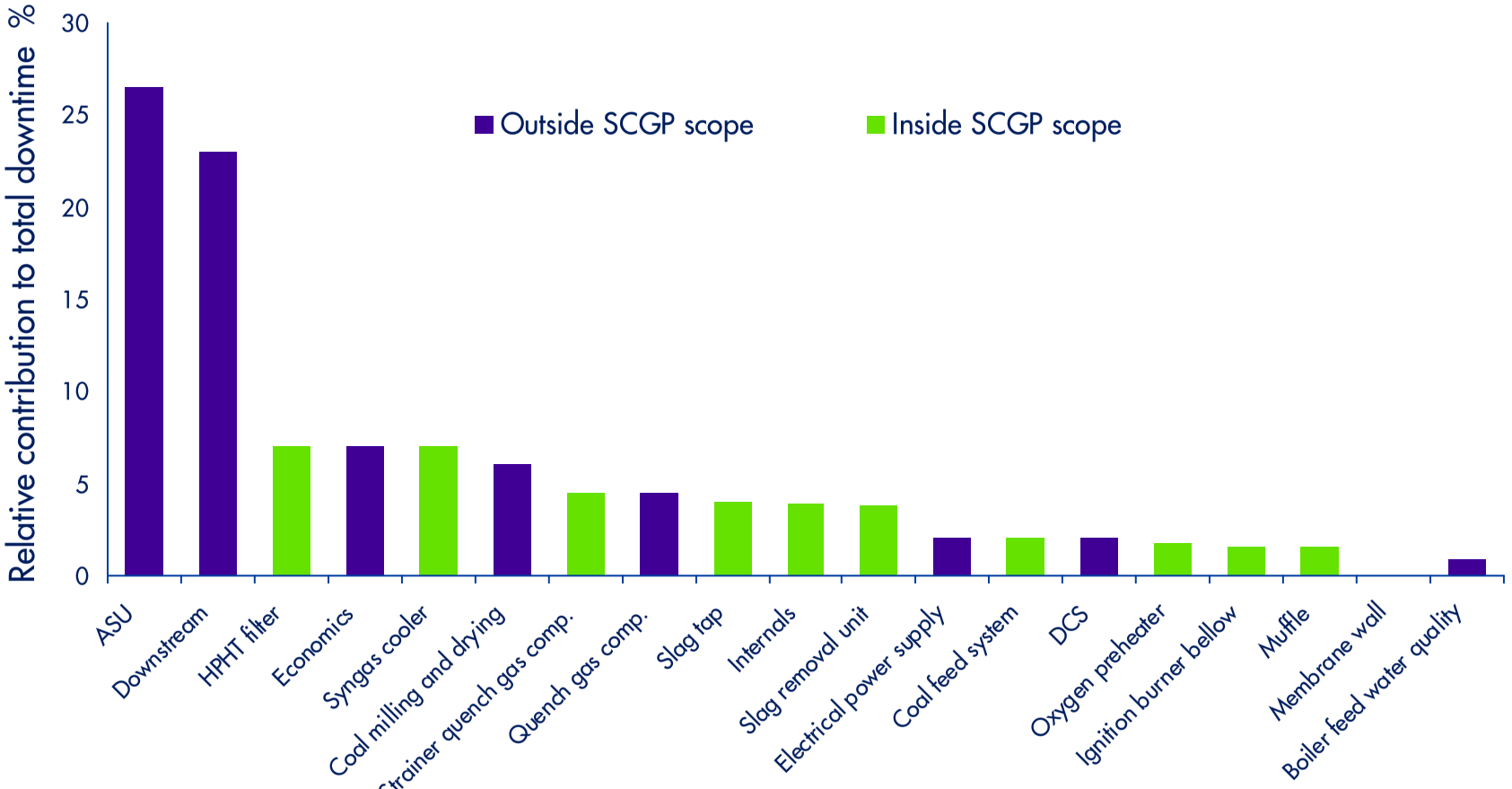
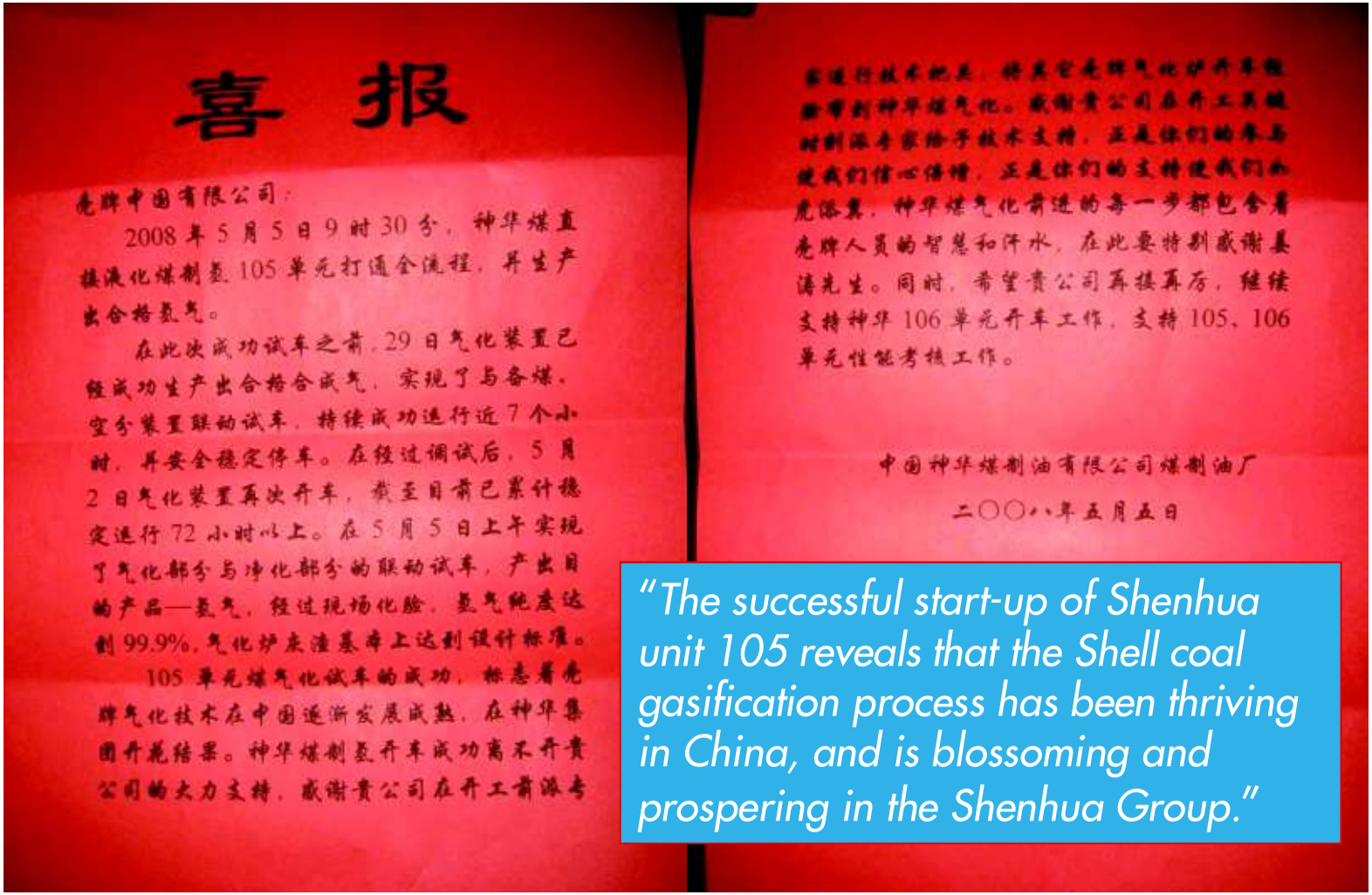
Source: China client monthly feedback

Average production loss for all Chinese SCGP customers in 2008



Source: China client monthly feedback

Key enablers – customer perspective



喜 报

壳牌中国有限公司：

2008 年 5 月 5 日 9 时 30 分，神华煤直接液化煤制油 105 单元打通全流程，并生产出合格氨气。

在此次成功试车之前，29 日气化装置已经成功生产出合格合成气，实现了与备煤、空分装置联动试车，持续成功运行近 7 个小时，并安全稳定停车。在经过调试后，5 月 2 日气化装置再次开车，截至目前已累计稳定运行 72 小时以上。在 5 月 5 日上午实现了气化部分与净化部分的联动试车，产出目的产品—氨气，经过现场化验，氨气纯度达到 99.9%，气化炉床渣碳含量上达到设计标准。

105 单元煤气化试车的成功，标志着壳牌气化技术在中国逐渐发展成熟，在神华集团开花结果。神华煤制油开车成功离不开贵公司的大力支持，感谢贵公司在开工前派专

[illegible] 技术把关，特别安排气化炉开车指导到神华煤气化。感谢贵公司在开工关键时刻派专家给予技术支持，正是你们的专业使我们信心倍增，正是你们的支持使我们如虎添翼，神华煤气化前进的每一步都包含着壳牌人员的智慧和汗水，在此要特别感谢聂涛先生。同时，希望贵公司再接再厉，继续支持神华 106 单元开车工作，支持 105、106 单元性能考核工作。

中国神华煤制油有限公司煤制油厂

二〇〇八年五月五日

"The successful start-up of Shenhua unit 105 reveals that the Shell coal gasification process has been thriving in China, and is blossoming and prospering in the Shenhua Group."

Key enablers – external perspective


·2· 综合新闻

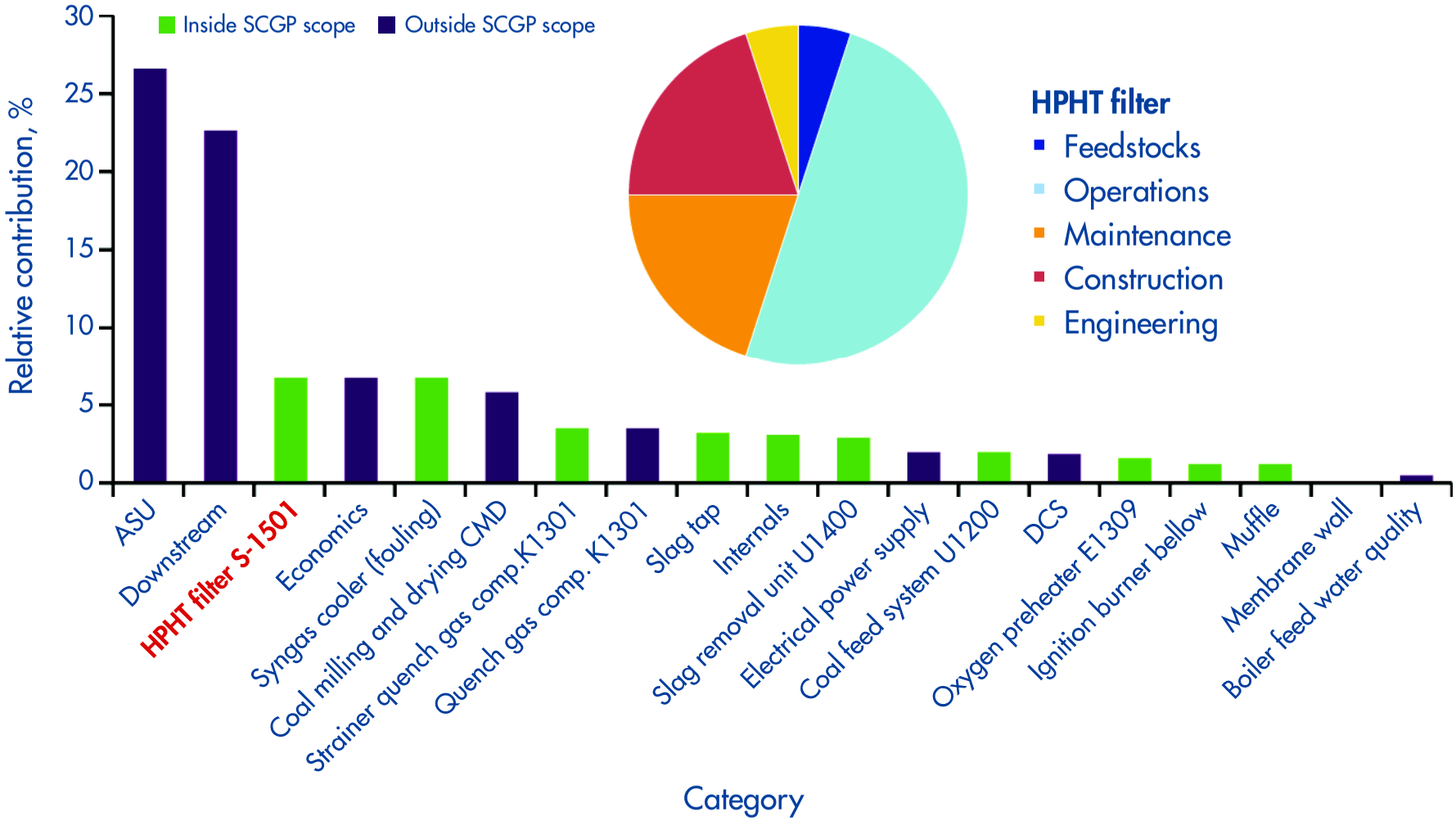
中原大化将二氧化碳气化剂技术成功用于甲醇生产

大力解决涉土领域突出问题

优质服务推开婚育文明花

"As one of the latest patents from Royal Dutch Shell plc, using carbon dioxide as carrier gas to transport pulverised coal (instead of nitrogen) demonstrates high efficiency, energy savings, etc."

2008 Reliability Chinese SCGP clients



Source : China client monthly feedback

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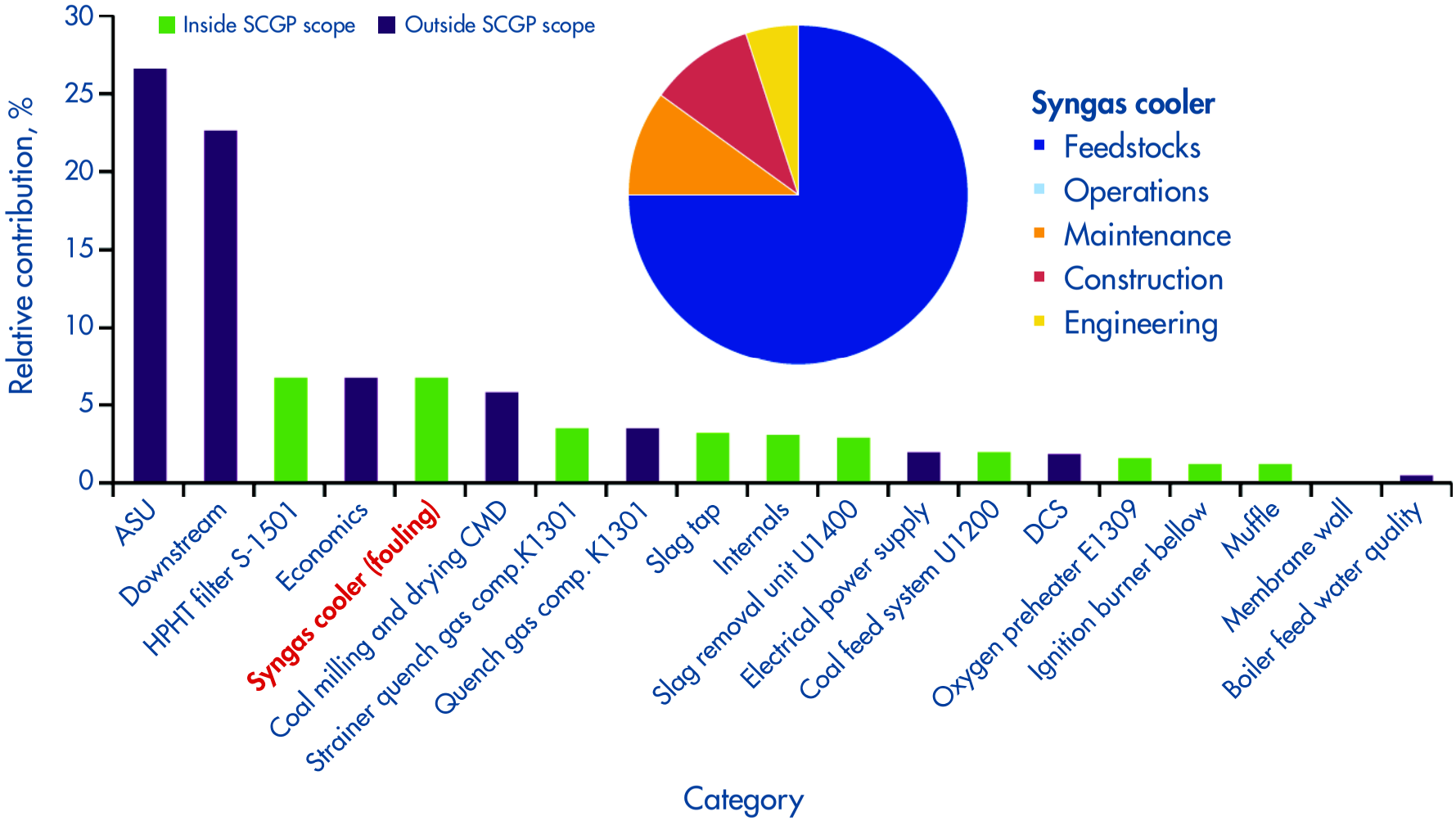
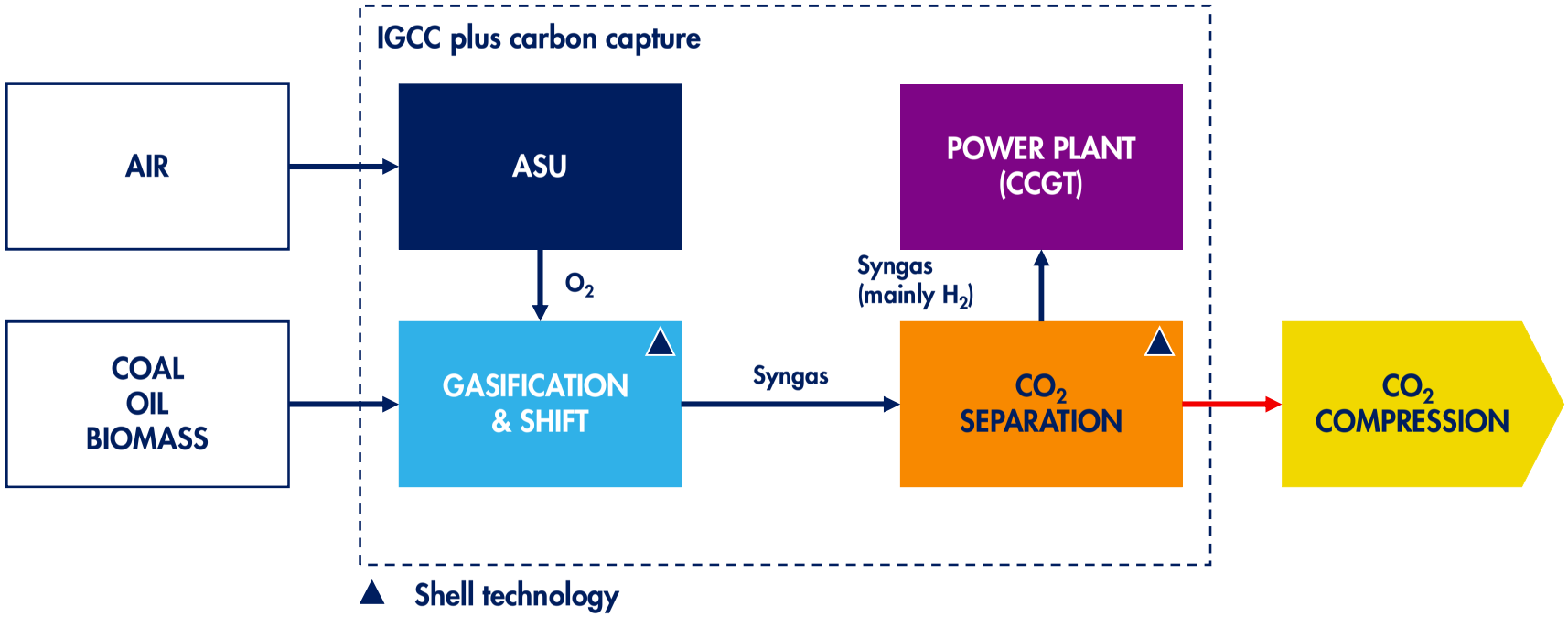


Source : China client monthly feedback

2008 and 2009 Licensee conferences in China, a platform for learning

Local vendors to manufacture key equipment

Power generation and carbon dioxide capture



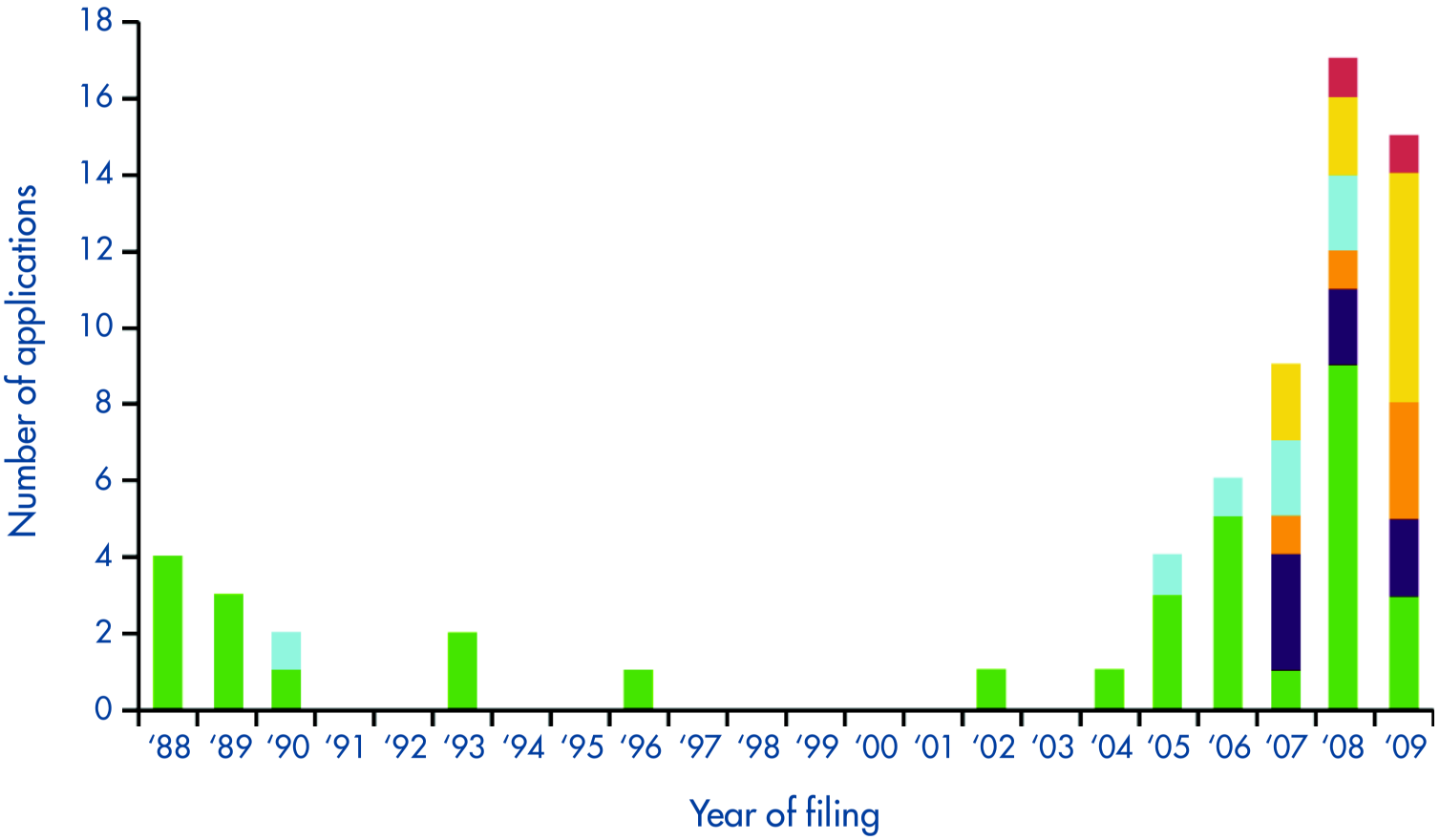
The Shell Coal Gasification Process allows CO_2 capture at high pressure

Kowepo IGCC Project

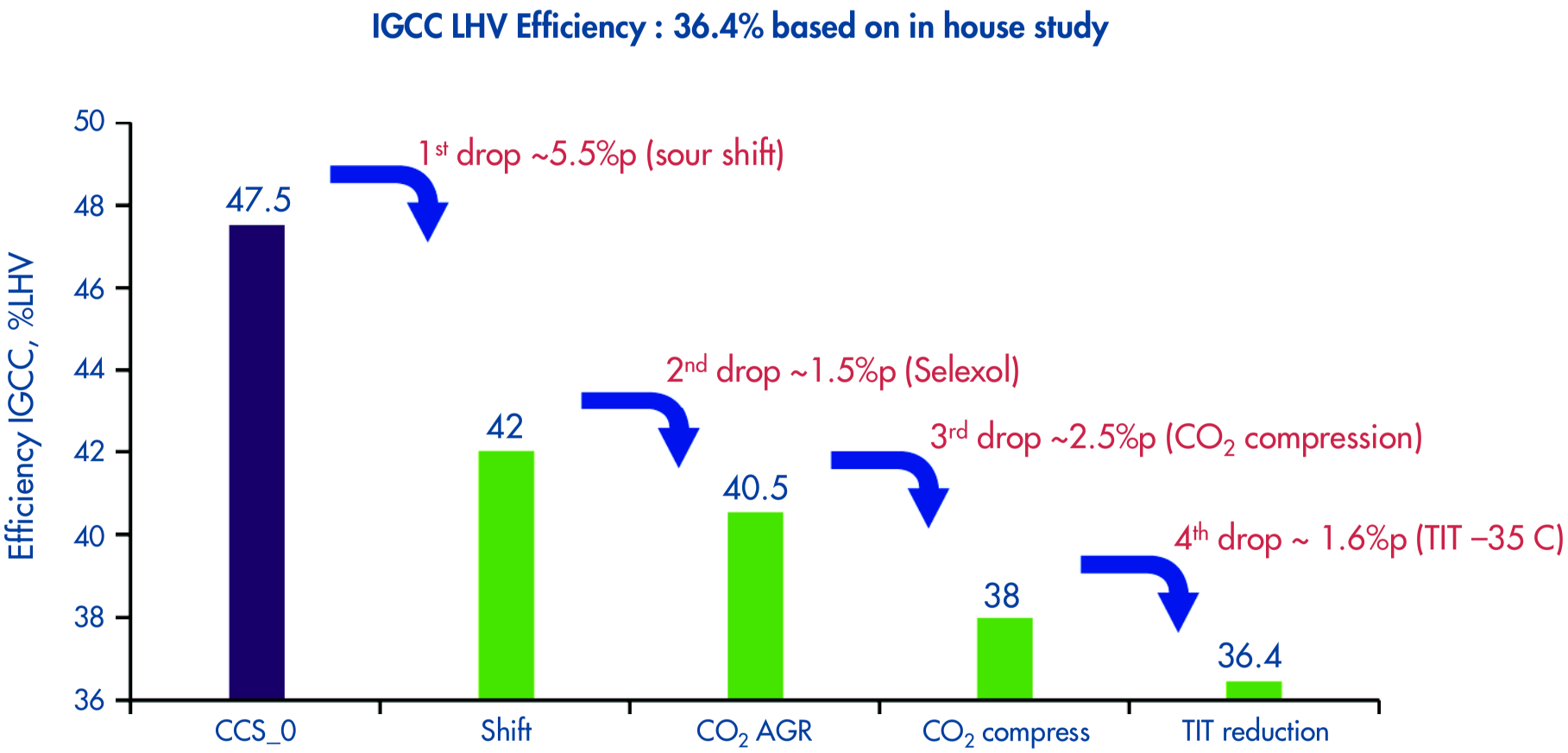
- The customer: Korea Western Power Co. Ltd
- The project: Taean IGCC #1 Power Plant
- The plant: 300 MW IGCC
- The location: Taean, Republic of Korea
- Shell's scope: Gasification & Gas Treatment

Photo courtesy of Kowepo

Shell clean coal energy related patent activity



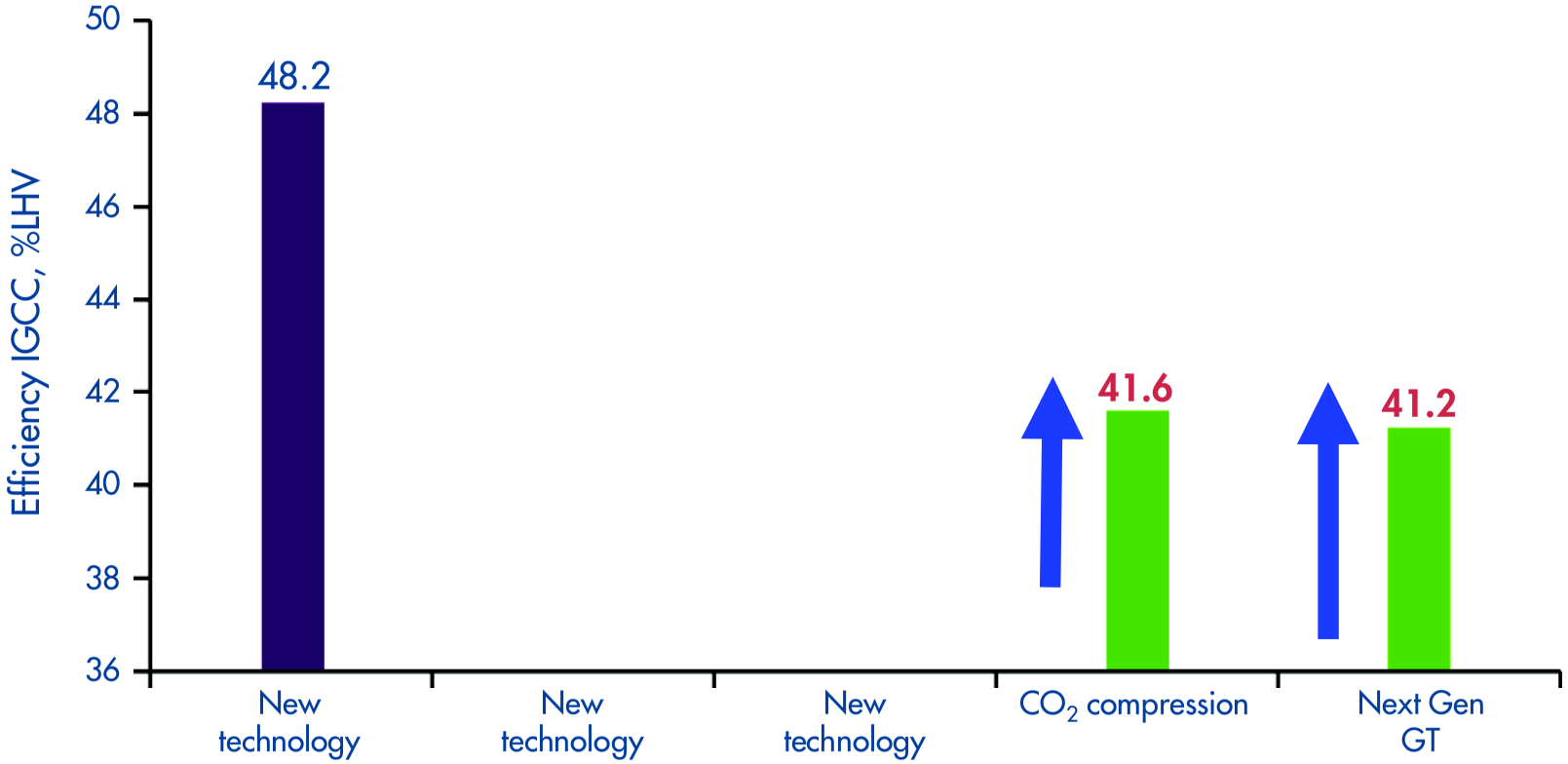
IGCC + 90% CCS today



El Cerrejon coal with CGE ~82%, MHI701F4, Selexol, Sour Shift

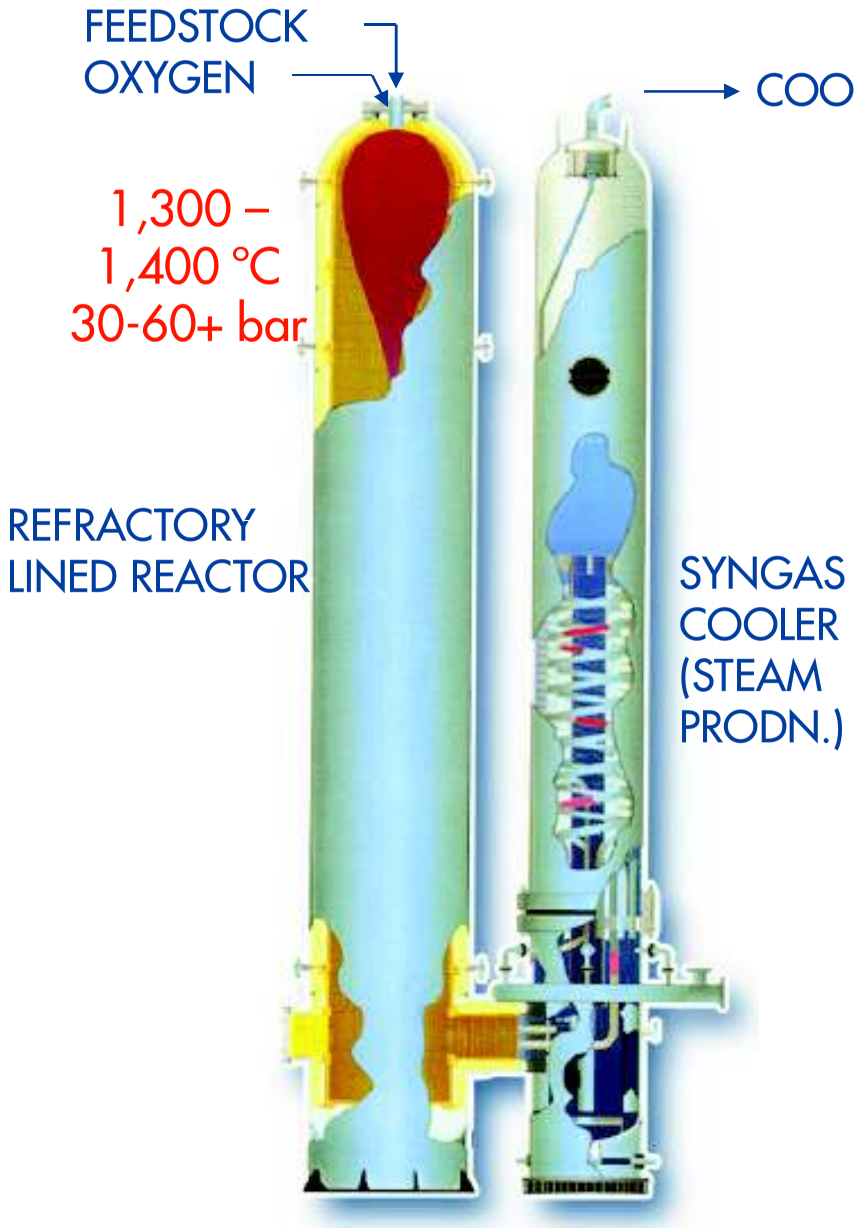
IGCC + 90% CCS tomorrow

4.5-5% LHV efficiency improvement potential for Future IGCC + CCS
Based on application of new technology
This widens the efficiency gap with post combustion CCS solutions



El Cerrejon coal: New IGCC technology

Shell Gasification Process (SGP) for Residue and NG



- LARGELY DEVELOPED IN 1950/60's ORIGINALLY FOR H2 PRODUCTION.
- OVER 60 BUILT.
- FEEDSTOCKS RANGING FROM NATURAL GAS (e.g. HYCON, SMDS, PEARL) TO ASPHALTS AND OTHER RESIDUES (e.g. FROM TAR SANDS).

ADVANTAGES:

- RELATIVELY LOW CAPEX.
- HIGH RELIABILITY.
- RELATIVELY HIGH THERMAL EFFY.
- SCALEABLE (THROUGHPUT AND PRESSURE).

LIMITATIONS:

- MAX. 0.4% ASH IN FEEDSTOCK.
- REFRACTORY / MOLTEN ASH REACTIONS, OVER TIME.

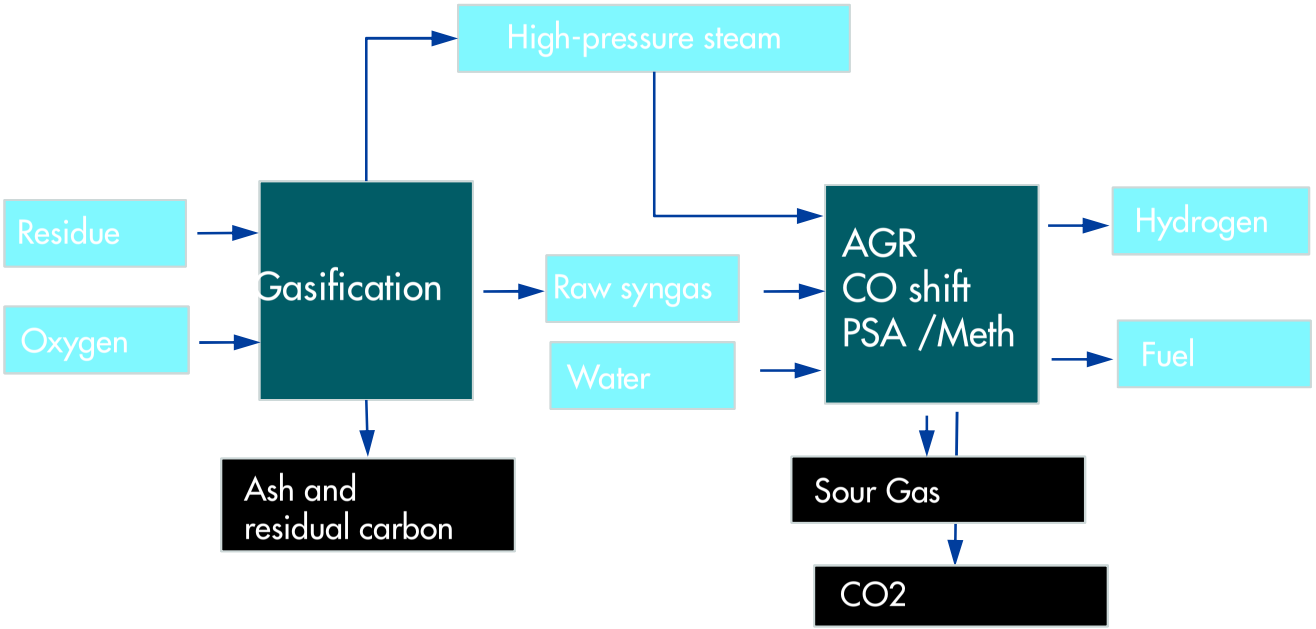
We are facing Challenges in Resid Upgrading...

- Feedstock issues, including availability and quality
  - Synthetic, heavy and sour, high TAN crudes
- Ever-changing specifications and regulations
  - Mandates on product quality and emissions
- Product Demand
  - Increasing demand of all products, except Fuel Oil
  - Projected MFO/HFO over supply & diesel shortage
  - MFO/HFO specifications expected to get tougher

From

To

SGP downstream integration for H2 + Power

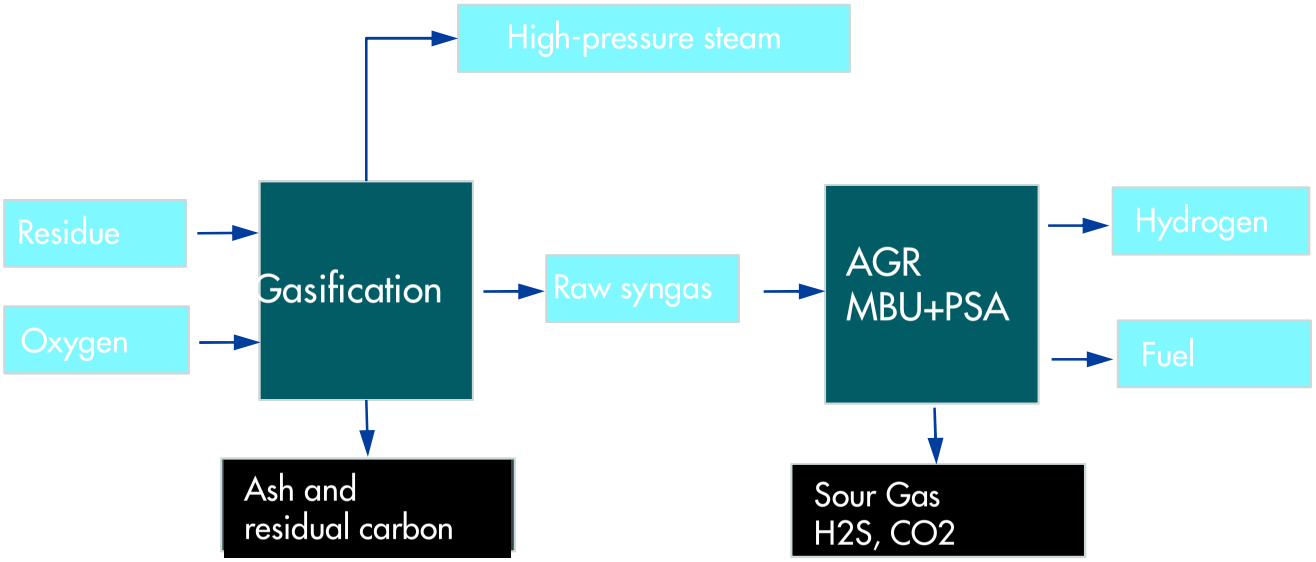


Shell Pernis
1997
Thermal Cracked Residue
3 x 550 t/d

Fujian
2009
SDA residue
3 x 1200 t/d

CO-shift for high hydrogen product yield, less fuel

SGP downstream integration for H2 + Power

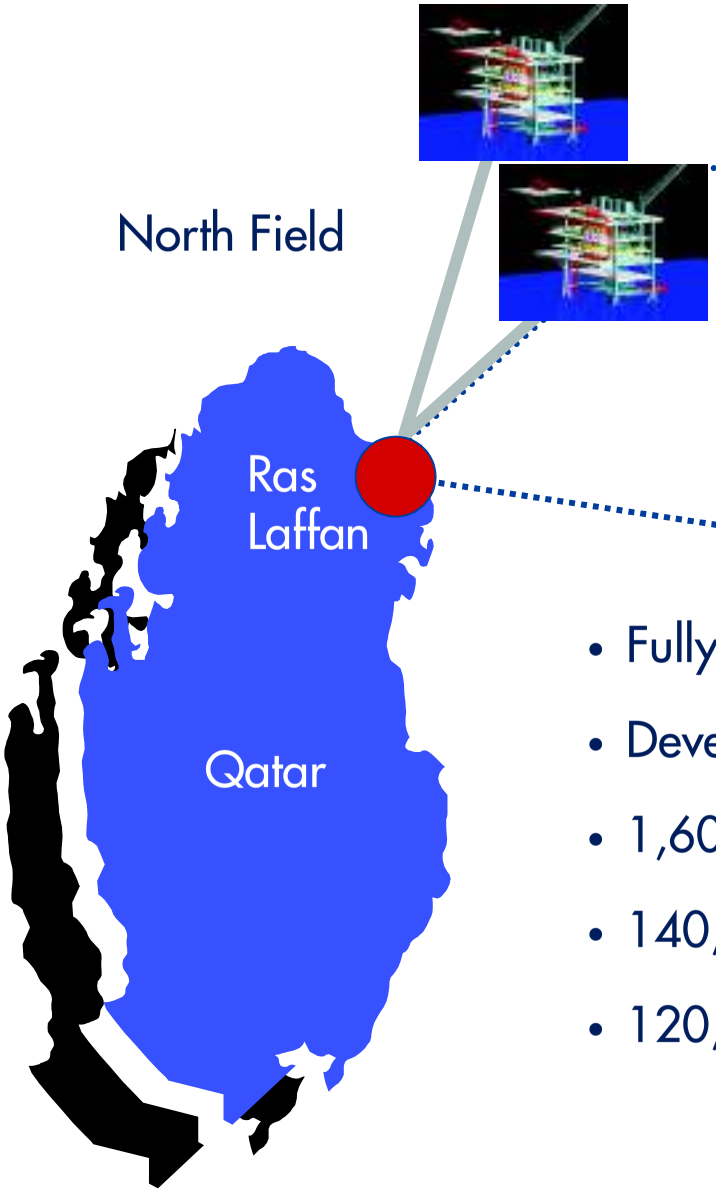


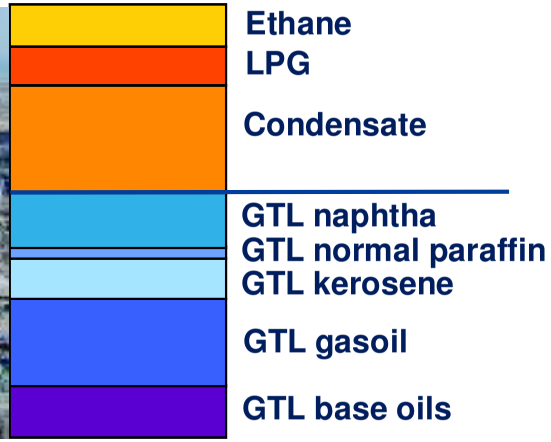
ENI Sannazzaro
2006
TC /SDA residue
2 x 600 t/d

Nexen (Opti)
2008
TC/SDA residue
4 x 1033 t/d

Membrane for lower hydrogen product yield, more fuel

Pearl GTL – project overview





- Fully integrated project "from reservoir to market"
- Development & Production Sharing Agreement
- 1,600 MMscf/d well head gas
- 140,000 b/d capacity for GTL products
- 120,000 boe/d upstream products

A world-scale project

- Contributes to Qatar's vision of becoming GTL Capital of the World
- World's largest GTL plant
- World's largest producer of premium quality base oils
- World's largest oxygen capacity built at one time
- World's largest system for full recovery of industrial process water

QATAR: PEARL GAS TO LIQUIDS PROJECT

2007 – SITE PREPARATION

2009 – INSTALLATION WELL UNDERWAY

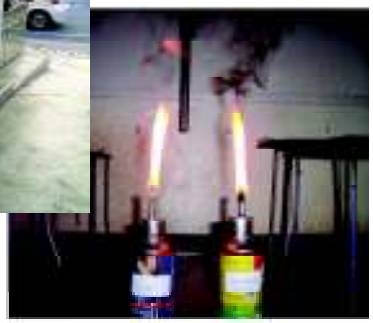
GTL products: value and versatility

GTL Naphtha used as premium feedstock for olefins

GTL NP – a cost effective detergent feedstock

GTL Baseoils – feedstock for high quality lubricants

GTL Kerosene marketed at selected outlets in Japan



Trialled in Kenya for cooking & lighting

Unbeaten at Le Mans 3 years in a row

Official fuel Davos 08

Shanghai Bus Trial

Successful trial on 1st Feb 08 of GTL Jet Fuel on A380 flight from Filton to Toulouse

Shell Gasification - Conclusion

- Requires an integrated approach
- SGP can process virtually all refinery oil residues
- SGP using NG is key to large scale GTL applications
- Enables refiners to use heavier crudes
- Can help refiners enhance their yield of high-value products, meeting stringent specifications

Tailor-made solutions are integrated into existing complexes

Shell Coal Gasification - Conclusion

- 40 years' experience in research and development, design and operation
- Highest coal to CO + H_2 yield, and minimum O_2 consumption
- Demonstrated a wide range of feedstocks
- Proven on ever-increasing scale
- Proven reliability performance and low maintenance costs
- High degree of automation supports smooth start-up
- Cheaper CO_2 disposal through carbon capture and storage
- 19 licences in China, 4 new deals in the last 8 months, 26 deals globally
- New Technology development would enable IGCC+CCS at 40+% efficiency


Thank you
Buggenum Plant, The Netherlands,
courtecy Nuon