



SHELL COAL GASIFICATION PROCESS

An integrated solution for efficient coal-to-products value chains

Gasification India Conference
New Delhi, India
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Made by: Rob van den Berg, Technology Manager Gasification
Shell Projects & Technology

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Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

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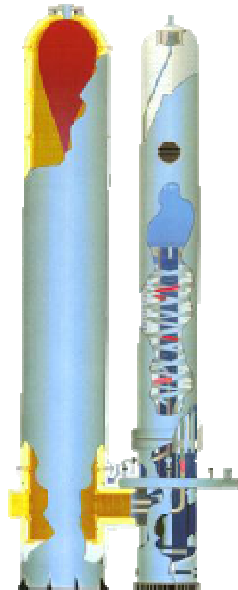
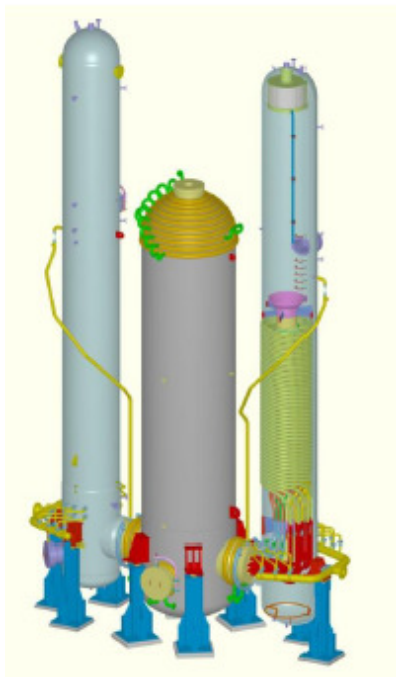
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Shell Gasification technology portfolio

SHELL GASIFICATION PROCESS (SGP)

with natural gas feedstock e.g. for GTL

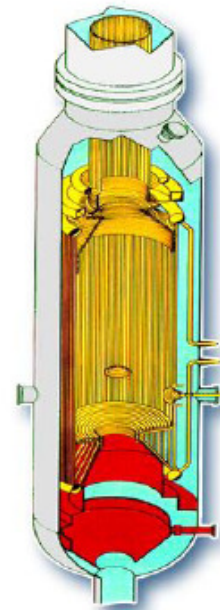
with residue feedstock e.g. for refineries



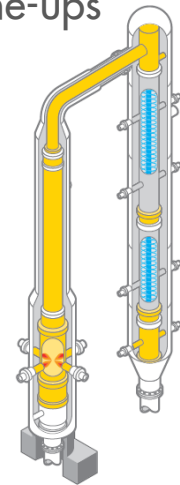
SHELL COAL GASIFICATION PROCESS (SCGP)

with solid feedstock (coal, petcoke and biomass) e.g. for chemicals, hydrogen and power generation

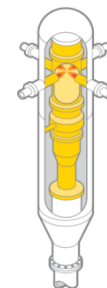
“One proven technology, two line-ups”



Syngas cooler



Bottom water quench



Residue gasification: from the bottom-of-the-barrel to light products

Proven track record since 1950s
>125 gasifiers in operation

Wide residue feedstock range from vacuum residue to highly viscous residues, such as thermal cracked residue, solvent de-asphalter residue; later retrofit to heavier feedstock possible

Safe and reliable operation: automated and fully safeguarded heat-up, start-up, shutdown sequences; reliability >99.5%

Extensive experience in start-up, operation and maintenance of own units and licensed units.

Shell Pernis
1997
Cracked Residue



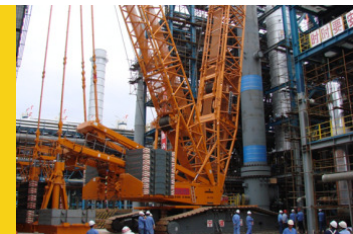
ENI Sannazzaro
2006
Residue/Asphalt



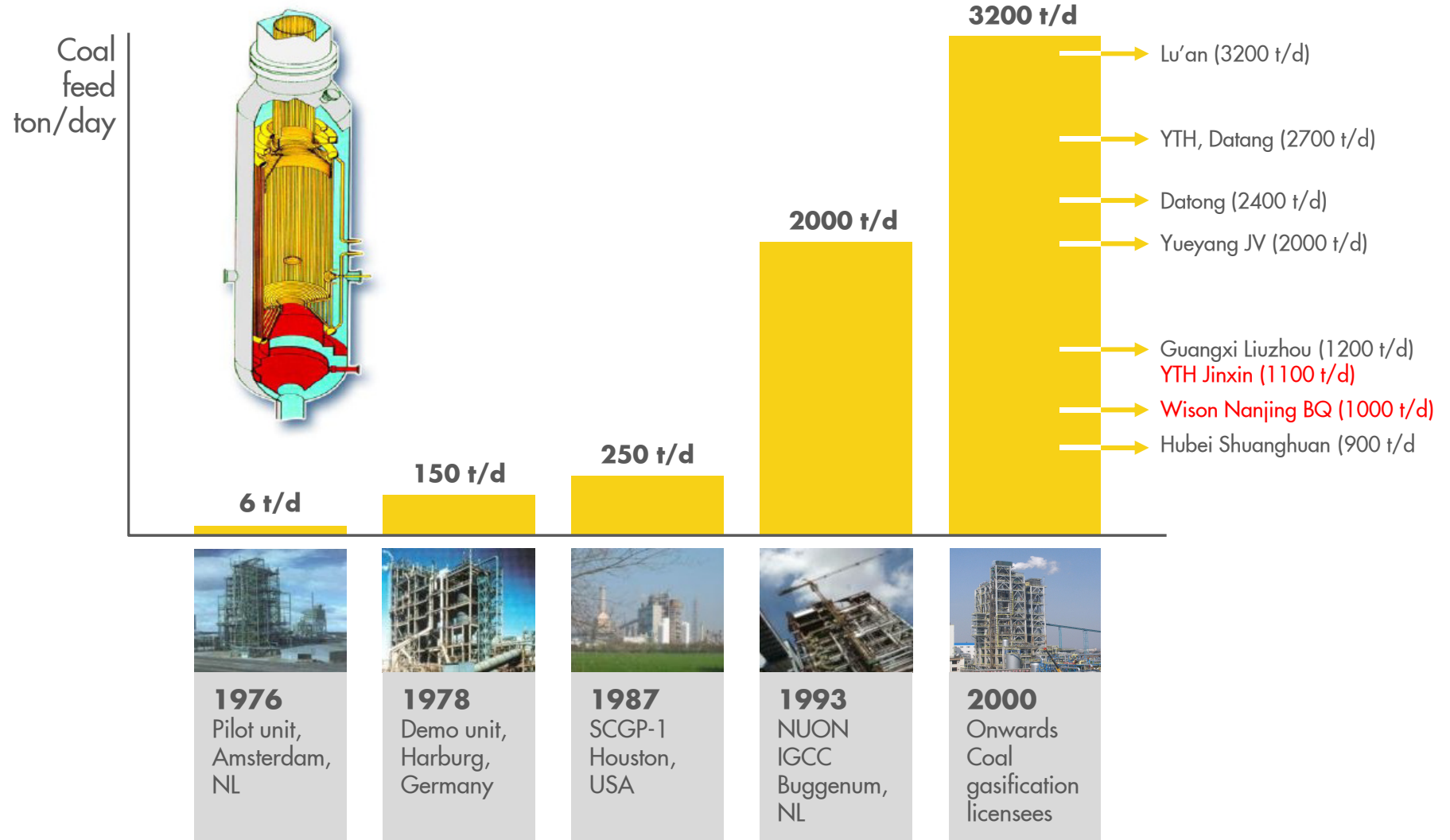
Nexen (Opti)
2008
Asphalt



Sinopec Fujian
2009
Asphalt



SCGP – A proven technology on an ever-increasing scale



SCGP licensing reference in China

- >15 years of commercialisation in China
- 22 license projects, 24 gasifiers in operation, 5 gasifiers to start-up



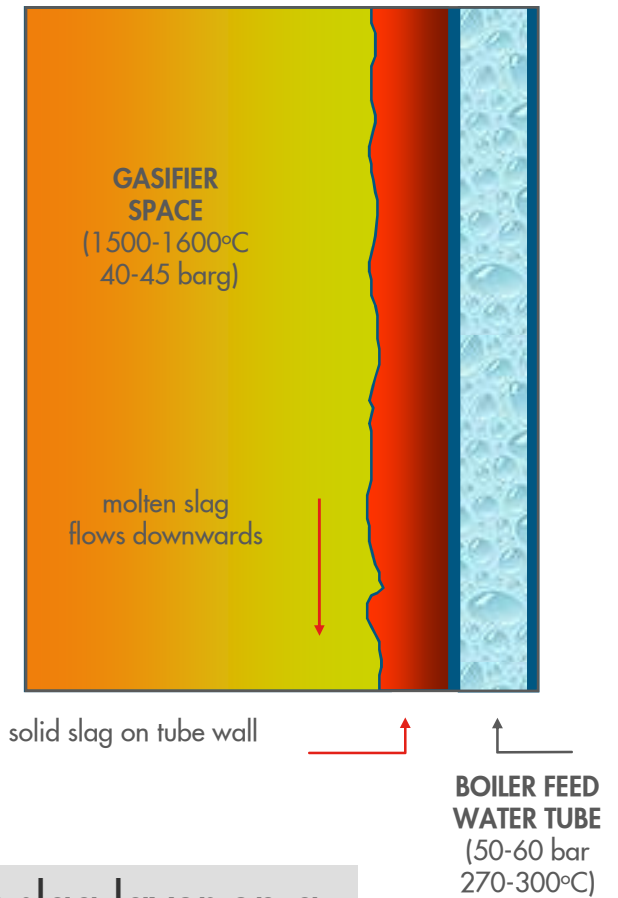
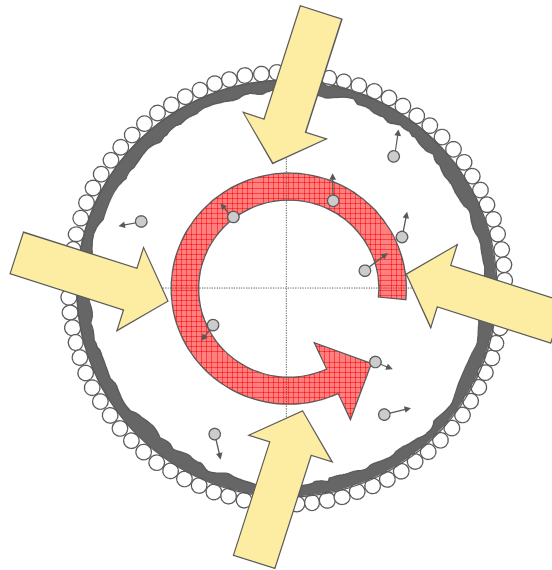
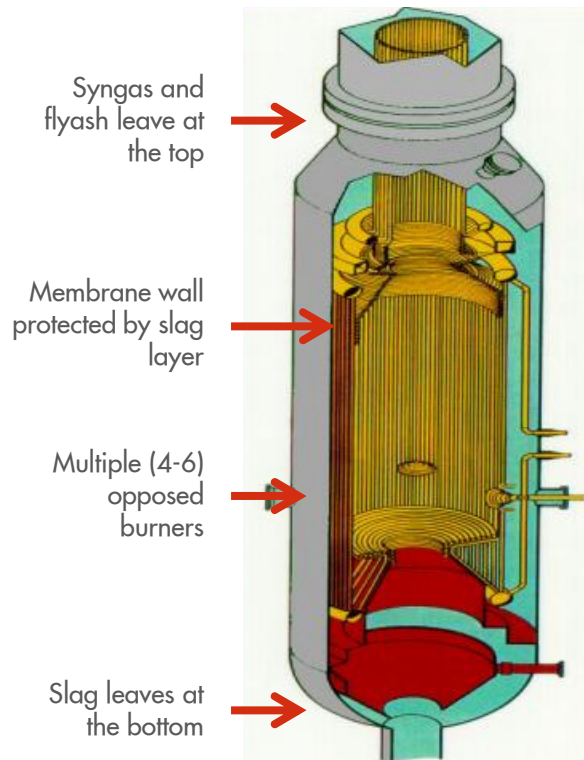
Pulverized coal intake capacity

- > 3,000 t/d
- > 2,000 t/d
- < 2,000 t/d

1	Lu'an	4 x 3,200 t/d	12	Sinopec Anqing	2,000 t/d
2	Datang International Power	3 x 2,800 t/d	13	Sinopec Hubei	2,000 t/d
3	Henan Hebi	2,700 t/d	14	Sinopec Shell Yueyang JV	2,000 t/d
4	YTH TianAn	2,700 t/d	15	Guangxi Liuzhou	1,200 t/d
5	Yunan Zhanhua	2,700 t/d	16	YTH ShuiFu	1,100 t/d
6	Datong Coal Mine Group	2,400 t/d	17	Henan Kaixiang	1,100 t/d
7	Shenhua DCL	2 x 2,200 t/d	18	Dalian Dahua	1,100 t/d
8	Henan Longyu	2,100 t/d	19	Henan Kaixiang II	1,100 t/d
9	Henan Zhongyuan Dahua	2,100 t/d	20	Wison Nanjing	1,000 t/d
10	Guizhou Tianfu	2,000 t/d	21	Yuntianhua Jinxin	1,000 t/d
11	Tianjin Soda	2 x 2,000 t/d	22	Hubei Shuanghuan	900 t/d

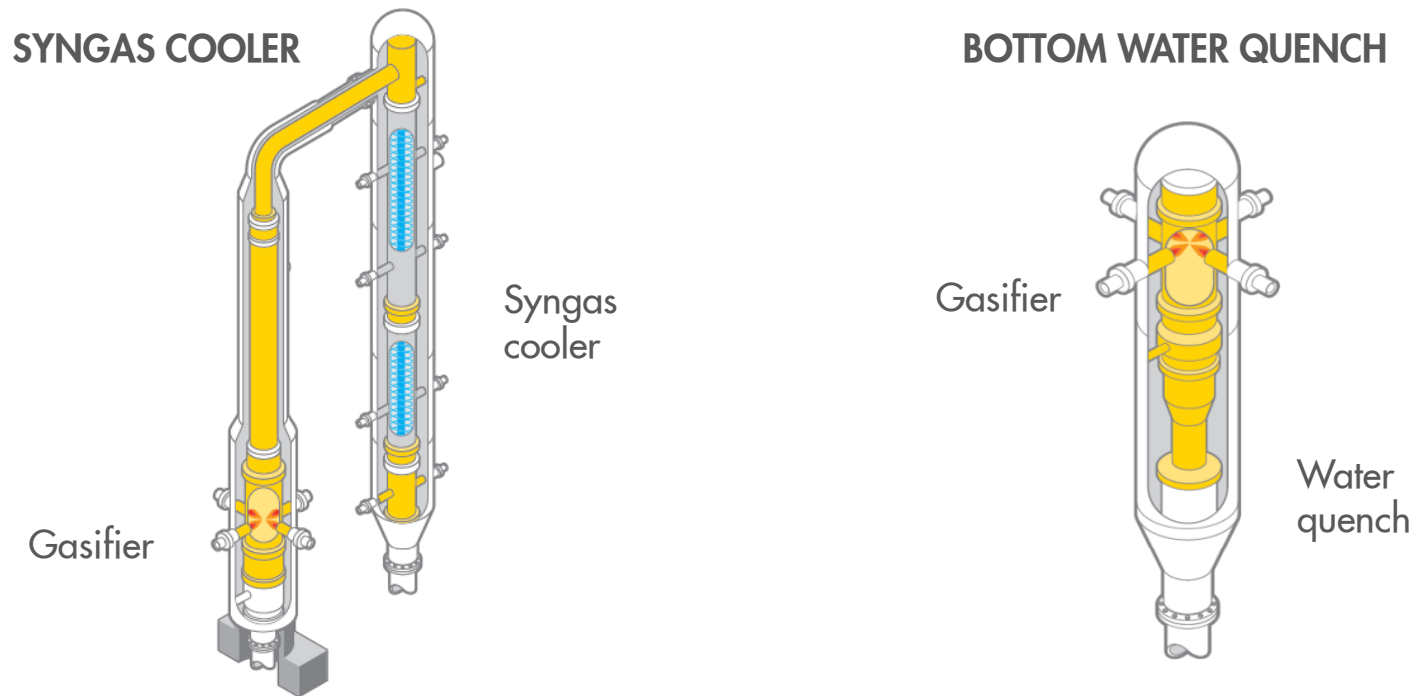
- 17 gasifiers with >2000t/d coal intake capacities
- Largest gasifier delivered 3,200t/d, start-up Q1 2017

Mature core of the technology: reactor and burners



Protection against high operating temperatures via a slag layer on a membrane (water) wall

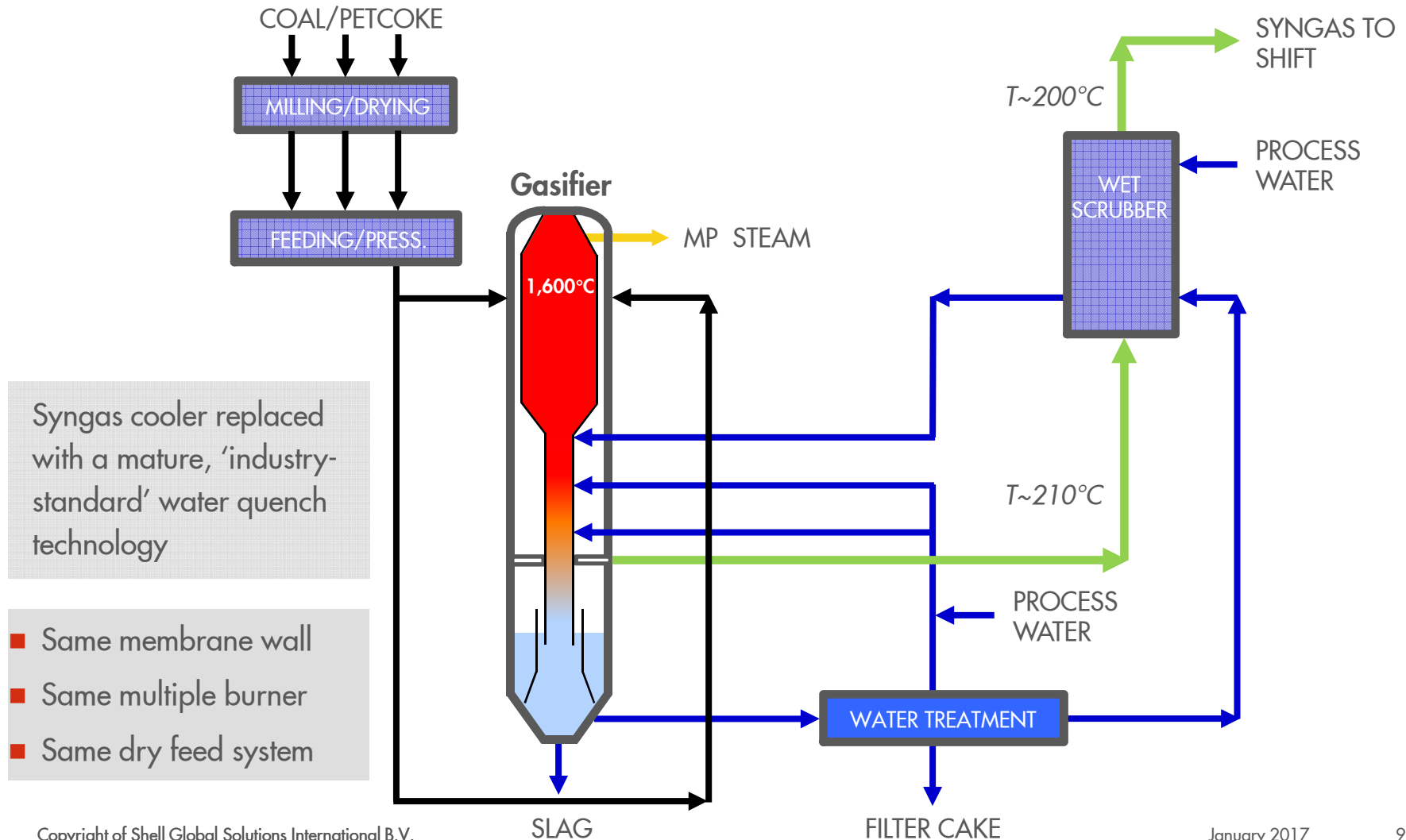
Shell Coal Gasification: a single proven technology, two line-ups



- Industrially proven, mature technology
- Carbon efficiency >98-99%
- Highest energy efficiency, lowest consumption
- High-level steam as a very useful 'byproduct'
- Low water consumption, less wastewater to treat: environmentally friendly

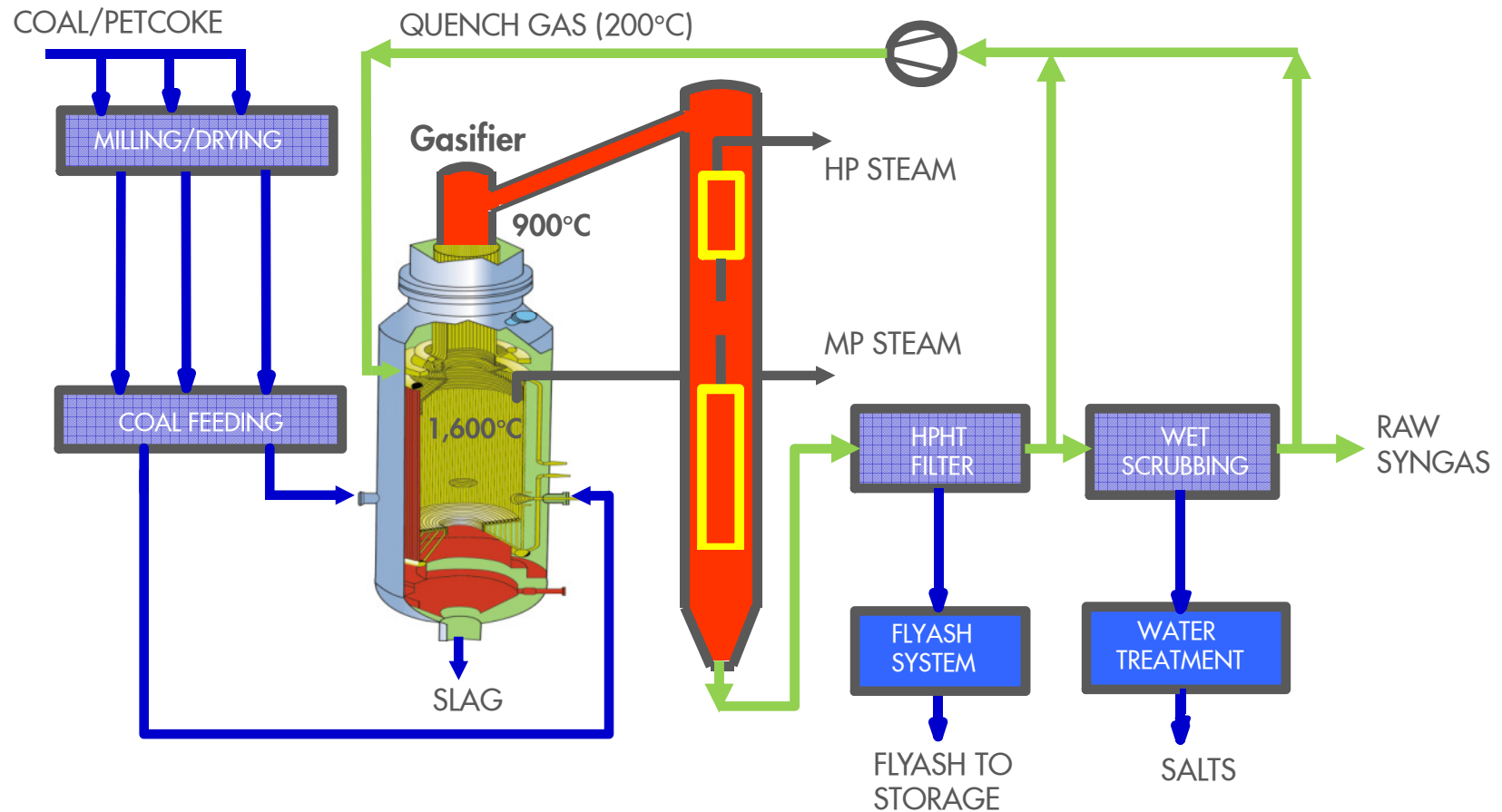
- Same basic design as syngas cooler line-up
- Carbon efficiency >98-99%
- Simplified line-up, reduced Capex
- Even wider coal flexibility
- Easier operation and maintenance (less equipment)

Bottom Quench technology: a simplified line-up



SCGP – Syngas cooler process line-up

SCGP line-up with Syngas Cooler (SGC) offers high efficiency and small environmental footprint

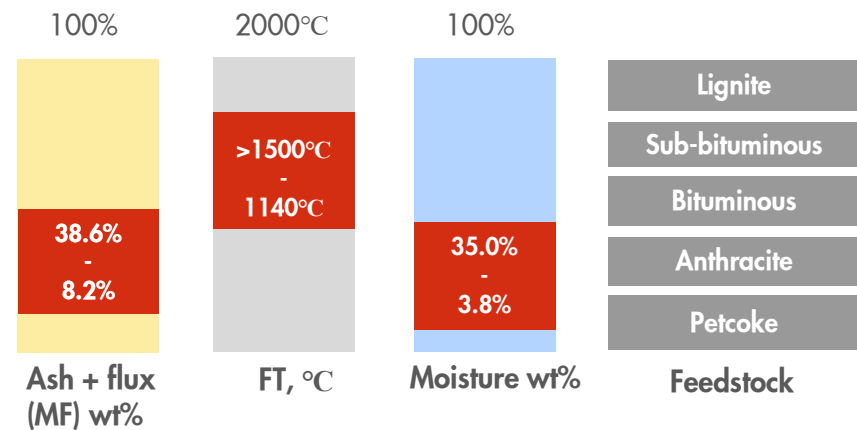


Performance and reliability: wide coal suitability

FEED FLEXIBILITY

- Handled over >150 different kinds of coal incl. challenging feedstocks like lignite and petcoke
- Four projects successfully used petcoke blended with coal, with one reaching 328 days at full operation load
- Based on extensive operating experience, several modelling tools were developed to confidently assess novel coals and optimise coal blends

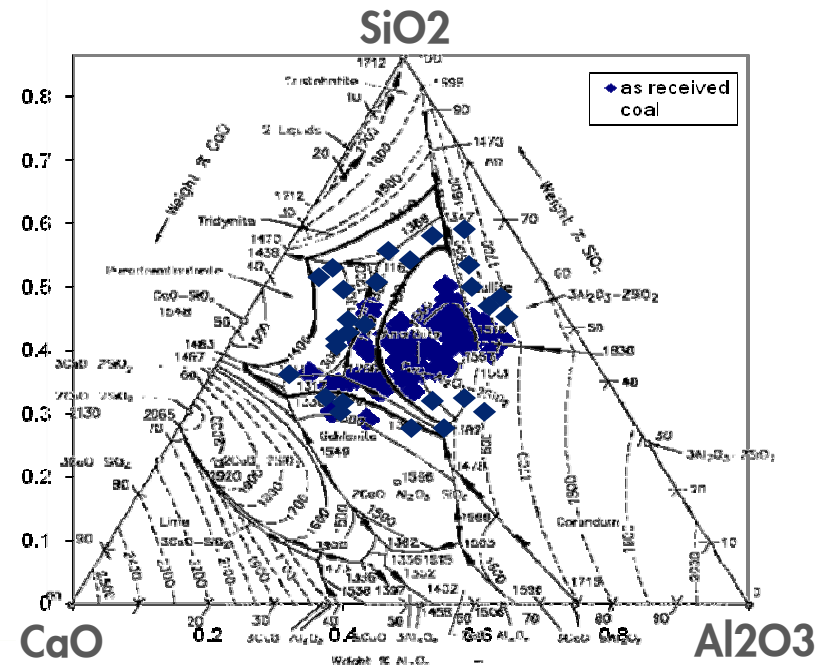
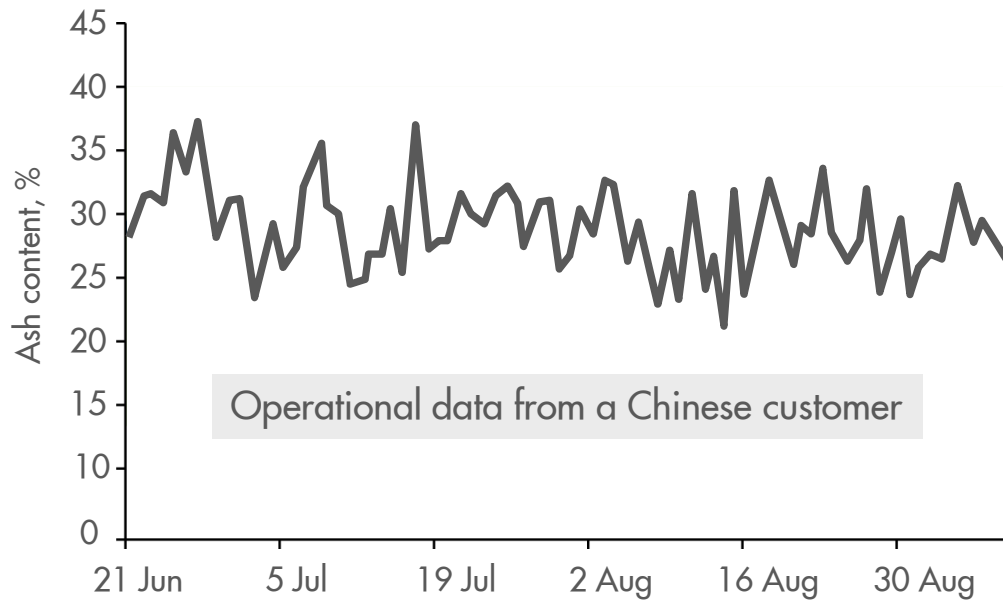
Property range of feedstocks operated in SCGP



Broad operating experience on many different kinds of coal

FEED FLEXIBILITY

- Handled over >200 different kinds of coal covering the whole reactivity spectrum from lignite to anthracite, ash contents from 6-37%
- Four projects successfully used petcoke blended with coal, with excellent operational results



DEEP INSIGHT IN PROCESS

- Based on extensive operating experience, several modelling tools were developed to confidently assess novel coals and optimise coal blends

Example of actual operation of a Chinese customer



Rich operational experience on petcoke/coal blends



Tianfu was the first dry-feed gasification plant in China that successfully demonstrated petcoke/coal blending

Now four SCGP plants in China have operational experience on petcoke

1987

2010

NOW

Gasified 100% petcoke in SCGP-1 plant in Houston US

Characteristic	Unit	Petcoke	Sub-bituminous coal
Moisture	wt%	6.23	19.0
Total sulphur	wt%	6.94	0.22
Heat content (HHV)	MJ/kg	35	21.5
Proximate analysis received			
Ash	wt%	0.34	7.6
Volatile material	wt%	12.88	46.8
Fixed carbon	wt%	86.78	45.6
Ultimate analysis (dry)			
C	wt%	89.45	65.6
H	wt%	2.8	4.53
N	wt%	0.05	0.83
Cl	wt%	0.01	0.1
S	wt%	7.48	0.18
Ash	wt%	0.2	7.61
O ₂	wt%	0.01	21.15



Petcoke blending gives good operational performance and reliability: YZH operated continuously for 291 days and Tianfu for 186 days. Annual longest accumulated running days: 341.

RELIABILITY DATA 2016

	产量 Capacity (Nm ³ /hr) CO+H ₂	可靠性 Rt (%) (Note 1)	累计运行天数 Acc. Run days	最长运行天数 Longest cont. run (days)	平均氧负荷 Average O ₂ load (%)
1	140,000	100	348	196	94
2	140,000	98.4	347	234	97
3	70,000	100	336	207	100
4	140,000	100	336	171	101
5	140,000	96.7	335	167	96
6	140,000	95.6	331	173	100
7	70,000	87.4	320	117	89*
8	70,000	88.0	317	88	88
9	70,000	97.3	316	212	103
10	140,000	98.6	315	131	94
11	140,000	97.5	315	178	76*
12	140,000	97.8	313	208	75*
13	140,000	90.7	307	127	91
14	140,000	96.4	300	254	77*
		96%	*) Limited by downstream demand		

Top quartile operation performance in 2016

SAFE OPERATION

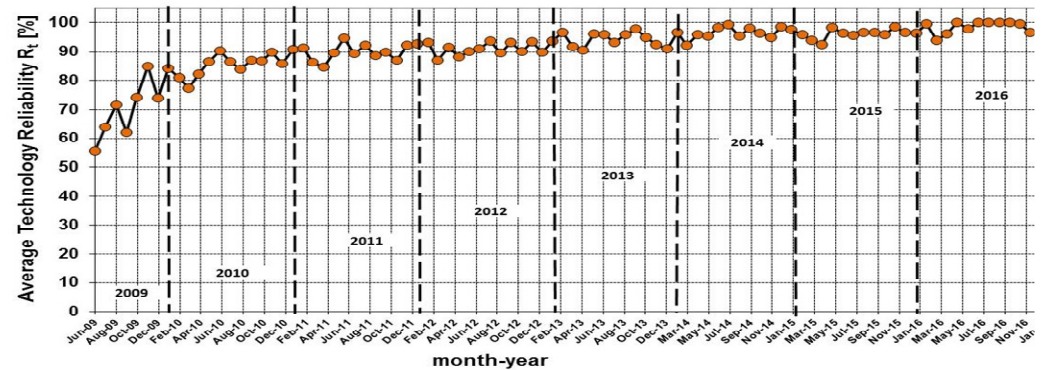
- Dongting JV achieved 10 million man-hours without LTI on December 25, 2015 (since 9th Feb 2006)

HIGH RELIABILITY

- Overall SCGP plant reliability in 2016 is **96.3%**: 14 plants clocked more than 300 accumulative running days, the longest one 348 days



AVERAGE TECHNOLOGY RELIABILITY



LATEST START-UP: ANOTHER SCGP-BQ

- Jinxin coal to ammonia/fertilizer plant in Inner Mongolia successfully started up in June 2016, reached 90% load, and produced on-spec end-use product within the first month of operation. First BQ operation on lignite

SCGP - SGC Korea Western POver (KOWEPO) IGCC project

- The first IGCC project in South Korea, located in Taean, approximately 150 km south-west of Seoul, started-up end of 2015.
- IGCC is supported as new energy under the Korean government Renewable Portfolio Standard.
- Gasification (a single SCGP unit)
 - Feedstock: 2,650 ton/day sub-bituminous coal
 - Syngas capacity: 175,000 Nm³/hr CO+H₂
- IGCC power output 380 MW (gross), net efficiency 42% HHV, with good air quality emissions of
 - SO_x < 15 ppm
 - NO_x < 30 ppm
 - Dust < 1 mg/Nm³



Looking to the future

- **Shell's world-class gasification technologies** can contribute to a cleaner energy future.
- **Continuous improvement** has seen the reliability of Shell's gasification technologies steadily improve in recent years.
- Shell has a **strong, global reference list** in gasification
- **Coal gasification offers a single proven technology in two line-ups:** SCGP syngas cooler and bottom water quench depending on your business objectives.
- Our **dedicated gasification technical and services team** offers comprehensive and experienced support.



Thanks for your attention

