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State of the Gasification Industry – the Updated Worldwide Gasification Database

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Abstract:

The most recent gasification database was published in 2010 and provided information on 192 commercial real and planned gasification projects. This database has been updated and now includes over 280 additional projects, about half of which have been built over the last 5 years or are already under construction. The database includes not only coal and oil based units but also a considerable number of plants based on biomass and waste feedstocks.
This paper presents the results of the 2013 database update together with an analysis of trends that are derived from it. Information from the database is also available as a poster in the form of a world map.

Background and History of the Gasification Database

It is now fourteen years since the presentation of the first Gasification Database sponsored by NETL and GTC and prepared by SFA Pacific [Simbeck & Johnson, 1999]. Since that first issue of the database the world gasification industry has seen remarkable growth. The first issue included at total of 329 projects with 754 gasifiers. It included "many insignificant units included for completeness, but not worth mentioning." From this work 161 active operating or planned commercial projects covering 414 gasifiers were identified. The syngas output of these projects amounted to 42.7 MWth for projects already operating and 18.2 MWth for those in planning. The database has been updated at approximately three-year intervals. The initial update was performed in 2001 by SFA Pacific and from 2004 onwards updates were made by Childress Associates. The growth can be seen in the numbers of gasification projects and gasifiers with each update as shown in Table 1.

Table 1 Numbers of Gasifiers Included in Database Updates.

Update Year	Total Projects	Total Gasifiers	Real-Active Proj./Gasif.	Constr. Proj./Gasif.	Planned Proj./Gasif.	Real-Active MWth	Constr. MWth	Planned MWth
1999	329	754	128/366	n/a	33/48	42.7	n/a	18.2
2001	350	800	131/409	n/a	32/59	43.3	n/a	24.5
2004	391	841	117/385	n/a	38/66	43.0	n/a	25.3
2007	408	891	144/427	n/a	10/34	56.2	n/a	36.5
2010	463	990	192/505	11/17	37/76	70.8	10.9	40.4
2013	747	1741	234/618	61/202	98/550	104.7	63.4	84.0

2013 Update of Gasification Database Content

The database now includes a total of 747 projects, consisting of 1741 gasifiers (excluding spares), of which 234 projects with 618 gasifiers are active commercial operating projects. It covers 61 projects with 202 gasifiers under construction and a further 98 projects with 550 gasifiers in the planning phase. The output of operating gasifiers is 104.7 MWth with 63.4 and 84.0 MWth in the construction and planning phases respectively. Note that while the output of the 'planned' capacity has been adjusted using probability-of-realization factors, the number of gasifiers has not.

The main additions since 2010 come from

- Chinese projects. This includes some built prior to 2010 and not identified at the time, but most have come into service in the last few years. This reflects the dynamism of the Chinese economy over this period. It has also seen the introduction of a number of successful Chinese domestic new entrants into the technology suppliers market.

- Biomass and waste plants in Europe and USA. This is a reflection of the continued interest in renewable energy sources in these countries. Compared with coal or oil residue-fired units these are small, but numbers are increasing.

- Updating the status of existing entries. This includes reclassifying 'planned' projects to 'operating' status. But also planned projects that were ultimately abandoned have been removed. Some formerly operating plants have been shut down.

In addition, it has been decided to include underground coal gasification (UCG) projects in the database. With the exception of the Uzbek plant all current UCG operations to date are pilot plants and are therefore not visible in the statistics. The database now also includes two commercial units in planning.

Gasification Database Structure

The original Access platform for the database has proved robust and reliable. The same basic files have been maintained through several versions of Access released by Microsoft, so that the main focus has been on content update. Nonetheless there have been some minor improvements made to the structure also. The most important have been

- Plant shutdowns. In the past plants already shut down were eliminated from the active database evaluations. Plant shutdown dates have now been added so that the capacity of plants no longer running can still be considered during their lifetimes in the time scale presentation (Figure 1).
- In the past all planned projects were included in the evaluations. This tended to overstate the capacity projected for the years following the update, since not all the planned projects are realized. A realization probability has now been introduced for planned plants as suggested by Simbeck [2007]. The probability of project realization is necessarily subjective and does not always even apply to an individual project, but rather a group of projects in an individual market. The probability values, which have been assessed by Higman Consulting, are therefore not visible on a project-by-project basis, but have been built in to the summations presented later.
- For the summations, MW_{th} gasifier syngas output is retained as common metric. In most cases this number is estimated from gasifier feed or end -product rate. While

these estimates are inevitably inaccurate (often a gasifier is specified by coal tonnage input without a published figure for the heating value of the coal), the order of magnitude will be correct. It is assumed that when used for summations over- or underestimates on individual projects will balance, providing a good assessment of the total industry capacity.

Data Sources and Verification

The information included in the database comes from a multitude of source including journal articles, press releases, internet searches and the like. About two-thirds of the current database goes back to previous versions, so that acknowledgement to previous workers is due. The data has been made available to gasification licensors to verify the accuracy of the data collected. In some cases verification has been performed by contact with the owners.

Gasification Database Results

Gasification plants are becoming larger with each generation, and this is visible from Table 2, a list of the thirty largest projects operating or in planning. Although there is some growth in the size of individual gasifiers, most of these mega-plants achieve their capacity with multiple units.

Table 2 Top 30 Commercial Gasification Projects by Size

Gasification Plant/ Owner	Location	Gasification Technology	No. Gasifiers	MWth SG Output	Start-up Year	Feed/Product
Pearl GTL	Qatar	Shell	18 + 0	10936	2011	Natural Gas / FT Liquids
Yinchuan CTL Plant	China	Siemens	22 + 2	9300	2016	Coal / FT Liquids
Datang Ningxia SNG Plant	China	SEDIN	45 + 3	7125	2015	Lignite / SNG
Sasol Synfuels West	South Africa	Lurgi FBDB	40 + 0	7048	1977	Subbit. coal / FT liquids
Sasol Synfuels East	South Africa	Lurgi FBDB	40 + 0	7048	1982	Subbit. coal / FT liquids
CHNG Xinjiang SNG Plant	China	TPRI	7 + 1	6450	2014	Coal / SNG
Jamnagar Gasification Plant Phase I	India	E-Gas	6 + 2	5000	2015	Petcoke / Electricity
Jazan IGCC	Saudi Arabia	Shell	16 + 0	4465	2016	Refinery residue / Electricity
Yankunag Yulin CTL	China	OMB	8 + 0	3733	2015	Coal / FT Liquids
Yulin Methanol Plant	China	GE	10 + 4	3383	2015	Coal / Methanol
Inner Mongolia Chemical Plant	China	Shell	3 + 0	3373	2011	Lignite / Methanol
Yitai CTL Plant	China	OMB	4 + 1	2800	2014	Coal / FT Liquids
Yili SNG Plant	China	Siemens	7 + 1	2500	2015	Coal / SNG
Shenhua Ningxia Coal to Polypropylene II	China	SEDIN	14 + 2	2500	2015	Coal / Methanol
Xintian Yili SNG Plant	China	SEDIN	20 + 2	2500	2014	Coal / SNG
Lianyungang CTO Plant	China	Unspecified		2330	2015	Coal / Methanol
Shenhua Ningxia Coal to Polypropylene I	China	Siemens	5 + 0	1912	2011	Coal / Methanol
Great Plains Synfuels Plant	United States	Lurgi FBDB	12 + 2	1900	1984	Lignite / SNG
Qinghua Yili SNG Plant Phase 1	China	SEDIN	15 + 1	1750	2013	Coal / SNG
Xinjiang Guanghui Hami SNG Plant	China	SEDIN	12 + 2	1750	2013	Sub-bit. Coal / Methanol
Shenhua Baotou Coal-to-Olefins Plant	China	GE	5 + 2	1750	2011	Coal / Methanol
Zhungeer CTO Plant	China	Unspecified		1680	2014	Coal / Methanol

Yunnan MPG Plant	China	BGL	6 + 2	1680	2013	Coal / Methanol
ChinaCoal Fertlizer Plant	China	BGL	6 + 1	1680	2014	Coal / Ammonia
Fuxin SNG Plant	China	Unspecified		1670	2013	Coal / SNG
Hexigten SNG Plant	China	SEDIN	12 + 2	1670	2012	Coal / SNG
Gwangyang SNG	South Korea	E-Gas	3 + 0	1565	2014	Coal / SNG
Neimenggu Methanol Plant	China	SEDIN	11 + 1	1558	2015	Coal / Methanol
Rongxin Inner Mongolia Methanol Plant	China	OMB	2 + 1	1400	2013	Coal / Methanol
Weihe Pucheng Methanol Plant	China	GE	4+2	1400	2014	Coal/Methanol

Although the Pearl and Sasol Fischer-Tropsch facilities remain at the top or close to the top of this list, many of the subsequent projects are under construction and may be unfamiliar to many readers. In order to put some of these projects into a more familiar perspective, the top twenty operating plants are listed in Table 3.

Table 3 Top 20 Operating Commercial Gasification projects by size

Gasification Plant/ Owner	Location	Gasification Technology	No. Gasifiers	MWth SG Output	Start-up Year	Feed/Product
Pearl GTL	Qatar	Shell	18 + 0	10936	2011	Natural Gas / FT Liquids
Sasol Synfuels West	South Africa	Lurgi FBDB	40 + 0	7048	1977	Subbit. coal / FT liquids
Sasol Synfuels East	South Africa	Lurgi FBDB	40 + 0	7048	1982	Subbit. coal / FT liquids
Inner Mongolia Chemical Plant	China	Shell	3 + 0	3373	2011	Lignite / Methanol
Shenhua Ningxia Coal to Polypropylene I	China	Siemens	5 + 0	1912	2011	Coal / Methanol
Great Plains Synfuels Plant	United States	Lurgi FBDB	12 + 2	1900	1984	Lignite / SNG
Shenhua Baotou Coal-to-Olefins Plant	China	GE	5 + 2	1750	2011	Coal / Methanol
Hexigten SNG Plant	China	SEDIN	12 + 2	1670	2012	Coal / SNG
SARLUX IGCC Project	Italy	GE	3 + 0	1271	2000	Visbreaker residue / Electricity
ISAB Energy IGCC Project	Italy	GE	2 + 0	1203	1999	ROSE asphalt / Electricity
Sanwei Neimenggu Methanol Plant	China	GE	4 + 2	1167	2011	Coal / Methanol
Edwardsport IGCC	United States	GE	2 + 0	1150	2012	Coal / Electricity
Tianjin Chemical Plant	China	Shell	2 + 0	1124	2010	Coal /
Henan Jinkai	China	HT-L	4 + 0	1120	2012	Coal / Ammonia
Yunnan Methanol & DME Plant	China	BGL	4 + 1	1120	2011	Coal / Methanol
Bintulu GTL Plant	Malaysia	Shell	6 + 0	1032	1993	Natural gas / FT liquids
Long Lake Integrated Upgrading Project	Canada	Shell	4 + 0	1025	2008	Asphalt / H2
Leuna Methanol Plant	Germany	Shell	6+0	984	1985	Visbr4eaker residue/ Methanol
Shenhua Erdos DCL Hydrogen Plant	China	Shell	2+0	861	2008	Coal / Hydrogen
Fujian Refinery Ethylene Project	China	Shell	2+1	858	2009	Asphalt / Hydrogen and Electricity

Worldwide Gasification Capacity and Growth

Figure 1 presents the growth of operating syngas capacity over time. In contrast to previous evaluations this includes the capacity of plants during their lifetime, but that have subsequently been shut down. This includes a number of notable plants such as the Sasol I facility in South Africa, which after about 50 years operation on coal, switched its feed to natural gas in 2004. However this has done little to change the overall picture. In 2010 the operating capacity was 70,000 MW_{th} syngas. This has now grown to about 100,000 MW_{th}. Though this is close to the figure projected in 2010, the data behind the figures is substantially different. As will be seen later, in 2010 considerable growth was predicted in the power sector, primarily in the USA. Actually the growth has been in chemicals, mainly in China.

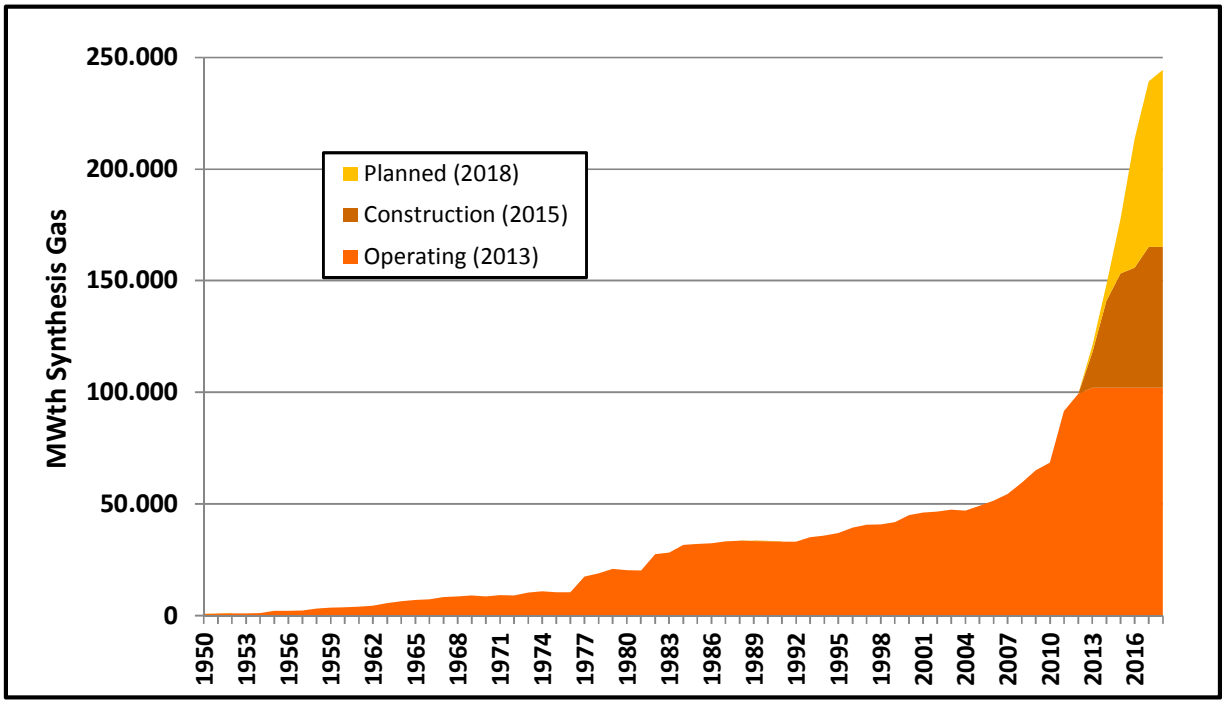

Figure 1 Cumulative Worldwide Gasification Capacity and Growth

Gasification by Location

The regional distribution of gasification plants is shown in Figure 2. Whereas in 2010 there had been a fairly balanced situation between Asia/Australia, Africa/ME and North America, the Asia/Australia capacity either operational or under construction is more than the rest of the world put together. This is mostly in China, though there is significant operating or planned capacity in India, Malaysia, Japan and South Korea. The next countries worldwide by syngas production are South Africa and Qatar with their Fischer-Tropsch units, as shown in Figure 3. A visual impression of the distribution of gasification plants around the world can be gained from the map in Figure 4. This was produced on the basis of an intermediate status of the update last year and will be available updated to 2013 in the near future.

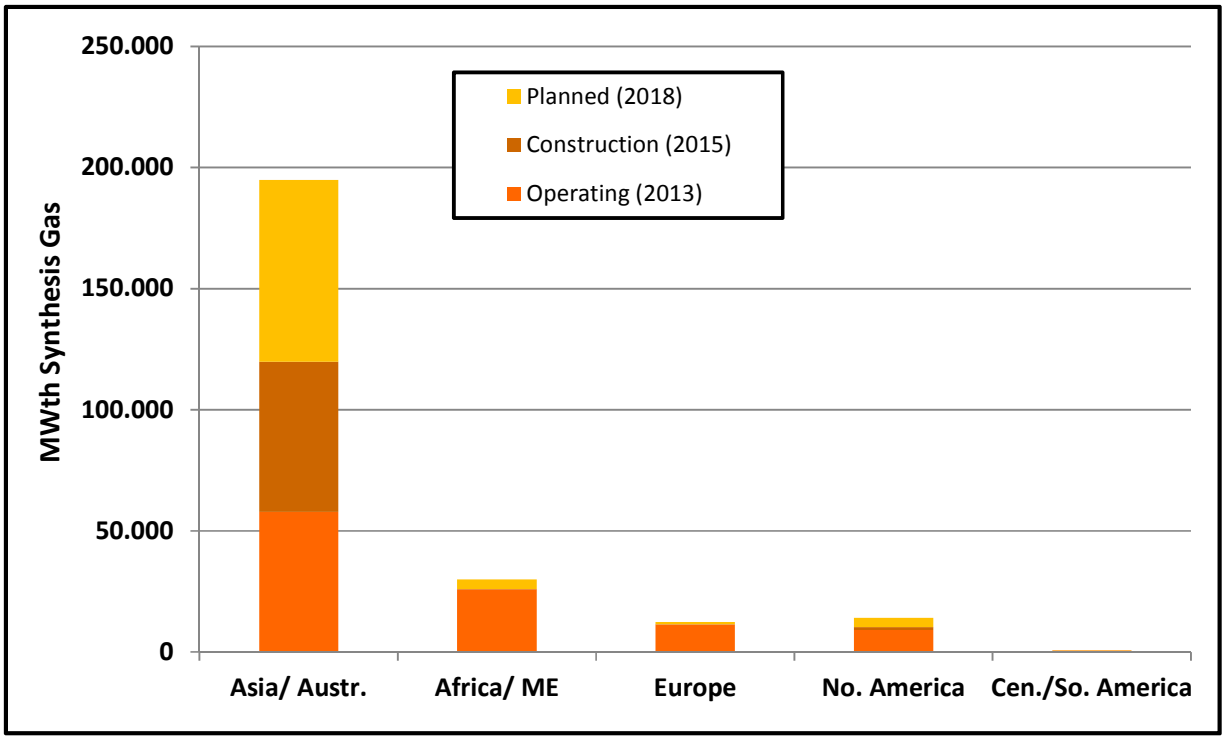

Figure 2 **Gasification Capacity by Geographic Region**

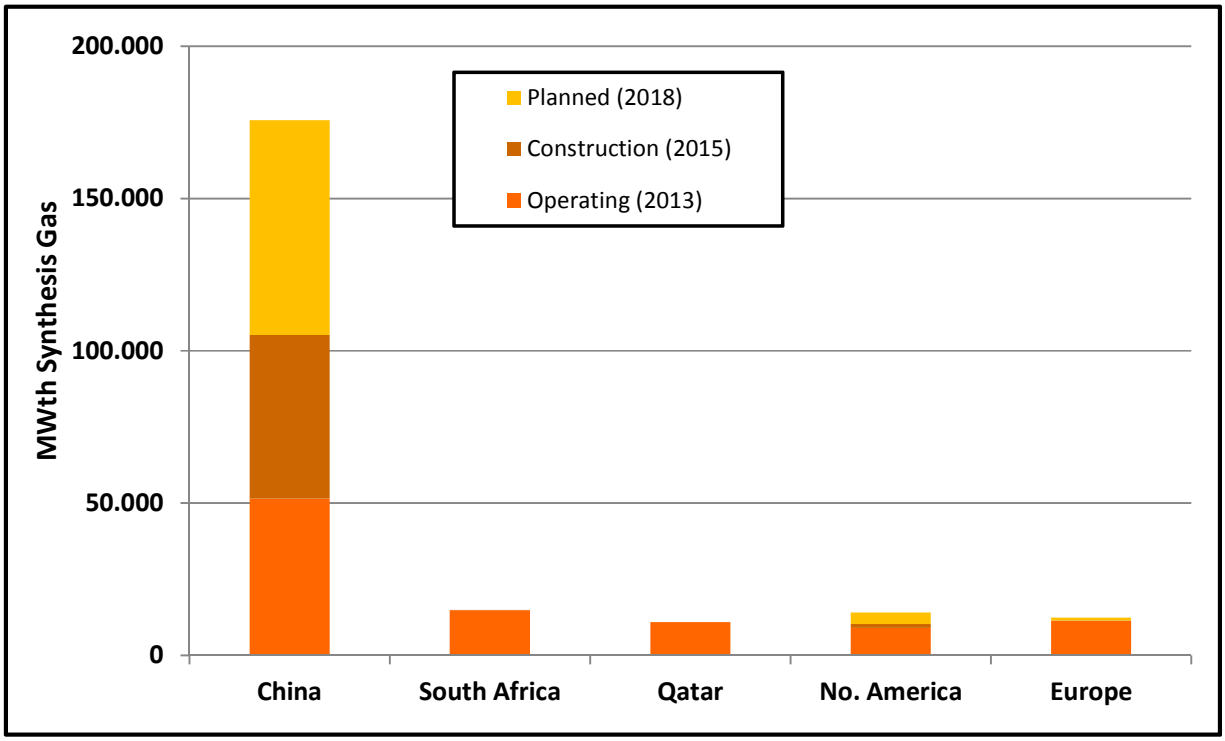

Figure 3 **Gasification Capacity in Selected Countries**

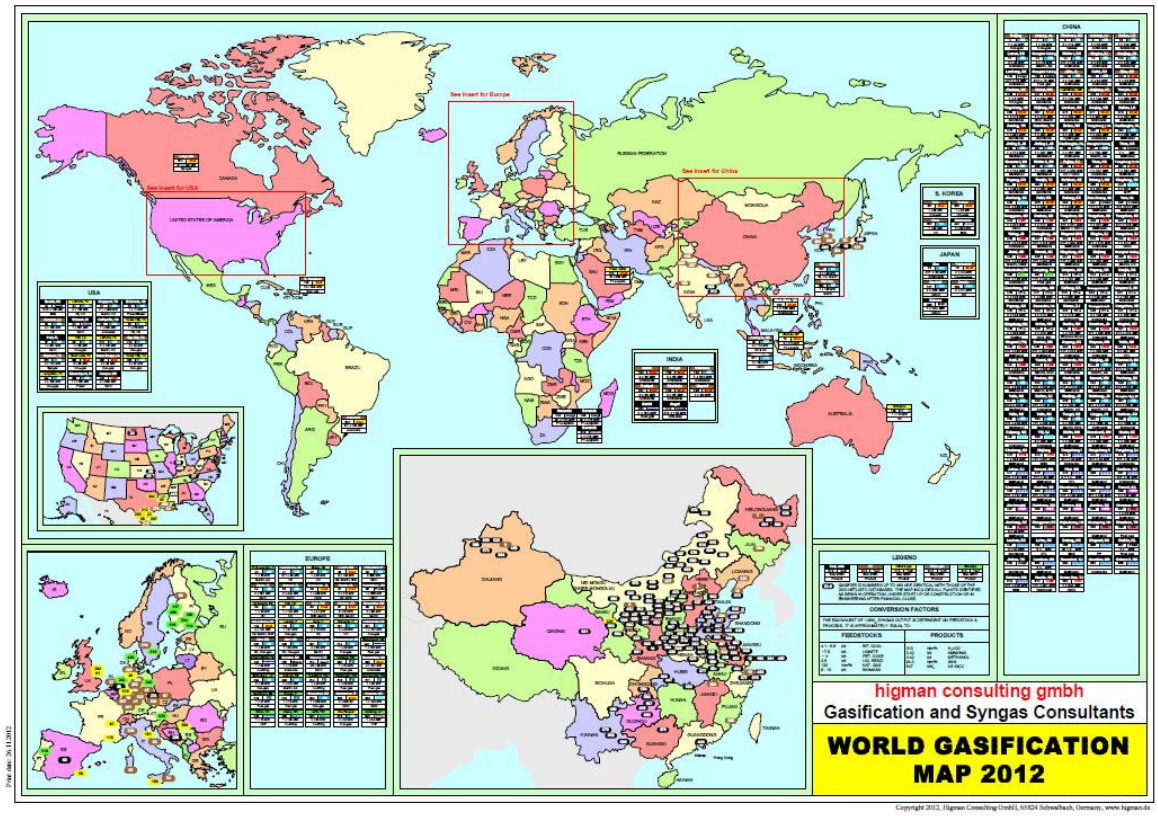

Figure 4 Map Showing Location of Operating Gasification Installations

Gasification by Application

Chemicals production remains the most important application of gasification, particularly if one looks at the current operating capacity shown in Figure 5. A recent study has determined that about 25% of the world's ammonia and over 30% of the world's methanol is now produced by gasification [Higman and Tam]. This compares with figures of about 10% in each case about ten years ago. These two chemicals remain by far the largest applications for gasification, though much of the methanol does not enter the market as such. Many of the larger methanol plants are captive units feeding derivatives manufacture such as acetyls or olefins on the same site. An interesting new chemical application is syngas-to-glycol with a number of plants under construction or just entering production. Syngas-to-ethanol is another chemical application that appears to have a promising future.

However synthetic fuels, both liquid and gaseous are becoming increasingly important. The operating liquid fuels capacity is dominated by just two plants, Sasol in South Africa and Pearl in Qatar. The power industry has disappointed compared with the 2010 projections. Many of the power projects were in the United States, where in the meantime the advent of shale gas has changed the market completely. But also the fact that the anticipated CO_2 legislation has failed to materialize in many countries has been a factor for the power sector. For chemicals, CO_2 removal is simply part of getting the chemistry right and is factored into the product cost. This is not realistic in the power industry if competitors can produce the same product (electricity) without it.

The picture for substitute natural gas (SNG) has changed significantly since the last publication of the database. For many years the Dakota Gasification plant was the single representative of this species. The high costs of importing LNG to many Asian countries has now brought a renaissance to this

product, with plants under construction in South Korea, India and China and many more planned, particularly in China's Inner Mongolia and Xinjian provinces.

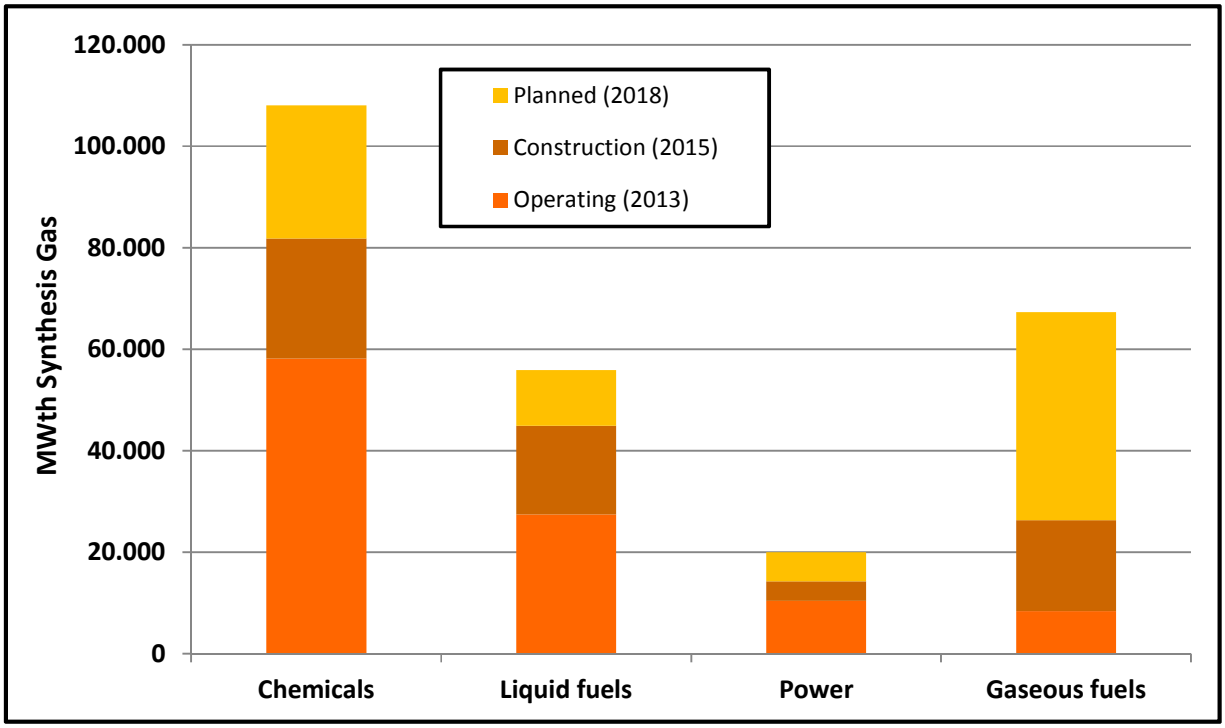

Figure 5 Gasification by Application

Gasification by Primary Feedstock

There had been a time when the use of coal and oil as a gasification feedstock was of the same order of magnitude. However with the price of crude oil at about $100/bbl, it is not surprising that coal has come to dominate the feedstock market. In fact, there are quite a number of oil gasifiers among those that have been shut down since the first issue of this database in 1999. In many cases it is simply no longer economic to use oil products as a feedstock for ammonia. Coal is now the dominant feedstock and as shown in Figure 6, it is clear that this will continue to be so.

The gas feed capacity is largely that in the Bintulu and Pearl GTL plants. It does however include a number of much smaller plants for the production of CO-rich synthesis gas, where gasification technology can be competitive with steam reforming.

There is only a small capacity shown for plants that were designed for petroleum coke feed. One should not forget however that a number of plants originally designed for coal feed have been able to take advantage of their ability to process the cheaper petcoke feed. The Polk and Wabash IGCCs in the USA are examples.

Looked at on the capacity scale in Figure 6, biomass gasification appears negligible. Biomass and waste gasification projects tend to be small because of the high cost of bringing a large amount of biomass to a single point of use. When looking at the same feedstock classifications, but with the number of gasifiers as the metric as in Figure 7, then one can see that there are more projects than for natural gas or petroleum coke feed. Nonetheless the dominance of coal as feedstock does not change.

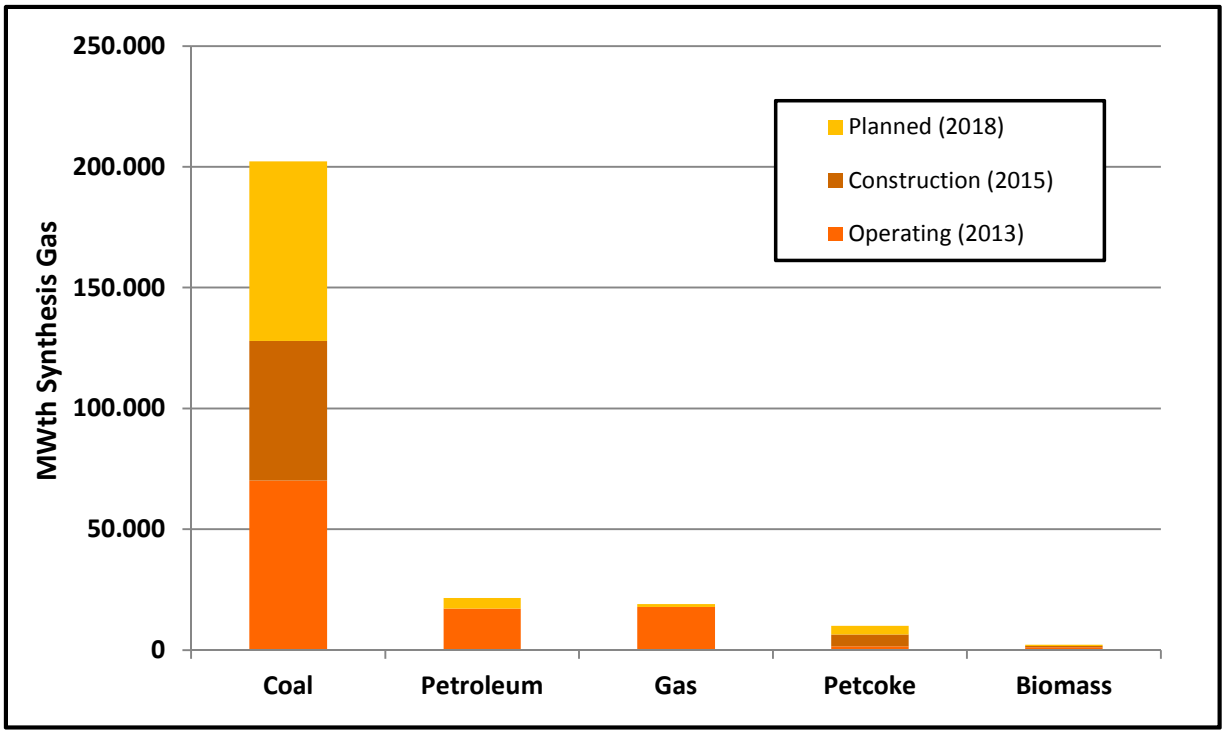

Figure 6 Gasification by Primary Feedstock

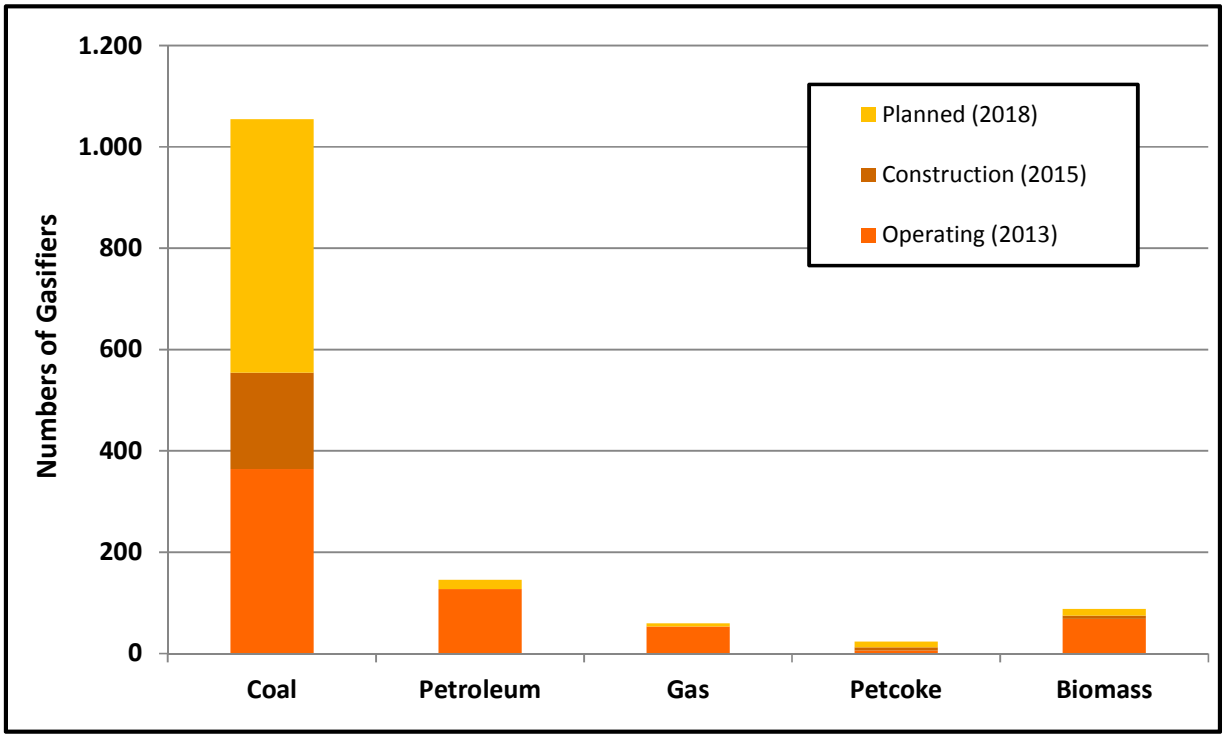

Figure 7 Numbers of Gasifiers by Primary Feedstock

Gasification by Technology

The 2010 version of this database saw the first entry of a Chinese process (ECUST's OMB) into the analysis by technology. The development of the market in China has also seen additional processes from Chinese licensors such as Changzheng Engineering (CECO), Northwest Research (MCSG), and

SEDIN making their mark. Nonetheless, the leading players remain GE and Shell, both of which also have a considerable number of projects n the pipeline. Figure 8 and Figure 9 show the situation by capacity and numbers of gasifiers (excluding spares).

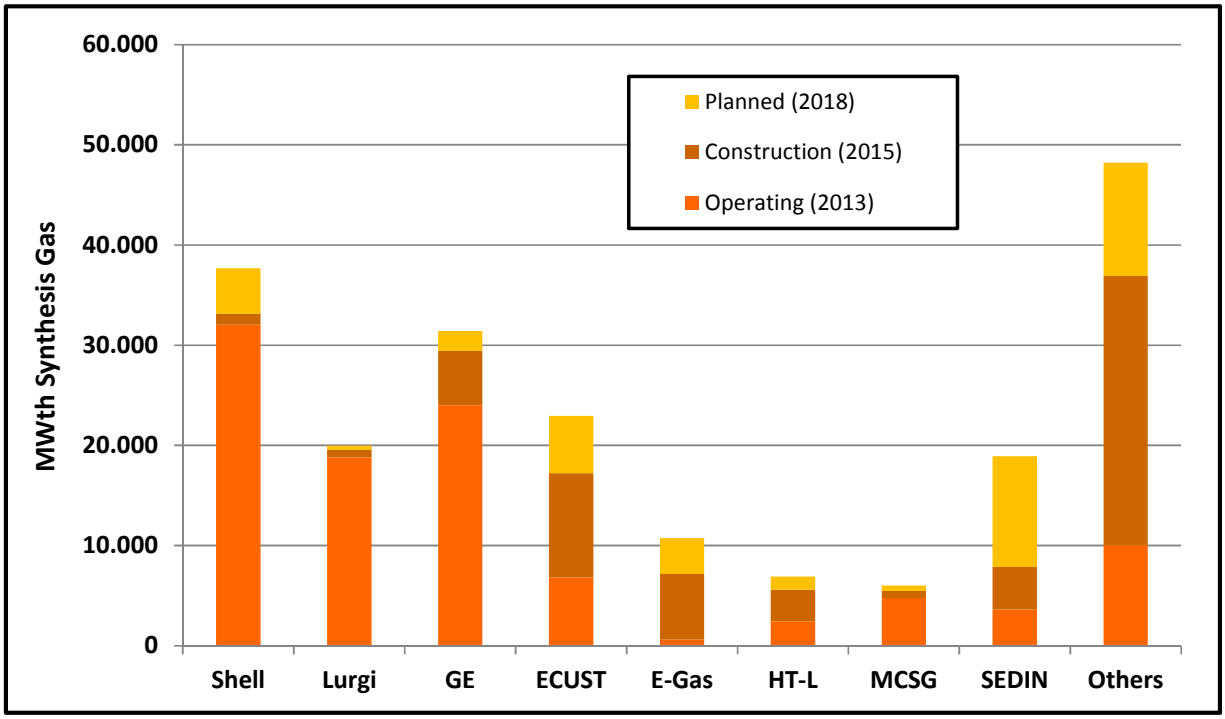

Figure 8 Gasification by Technology

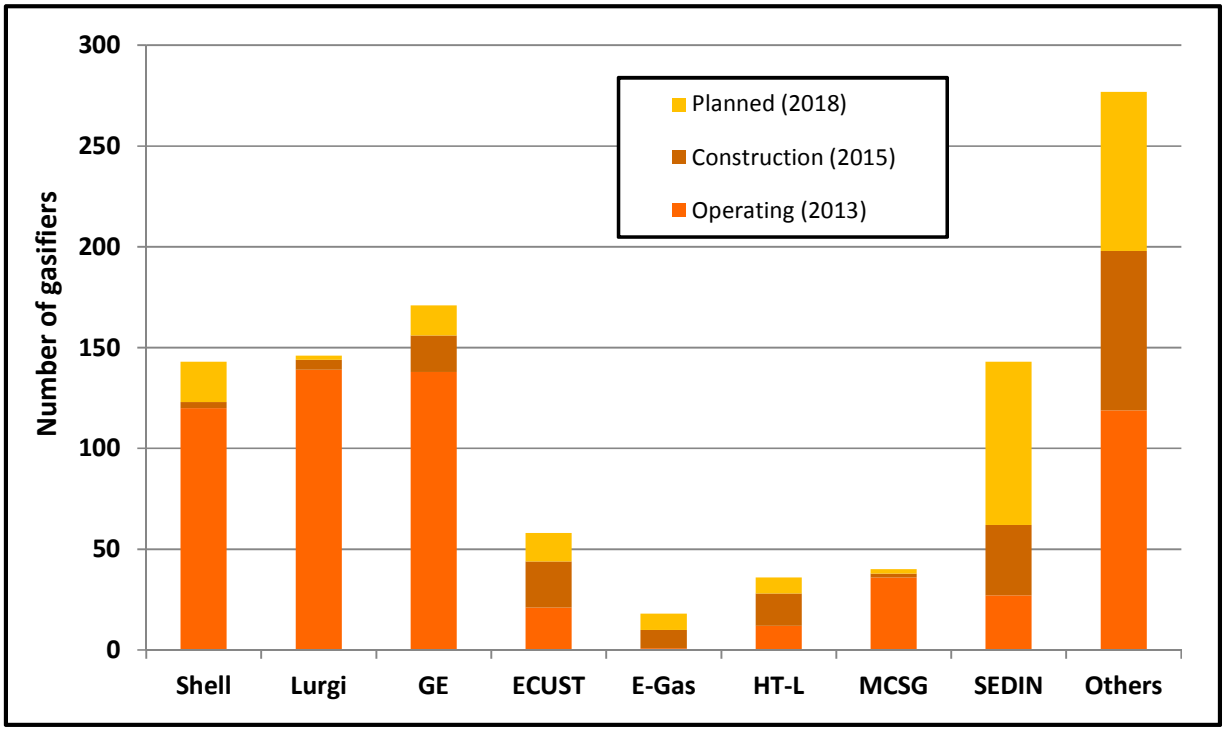

Figure 9 Numbers of Gasifiers by Technology

Conclusions

Gasification capacity continues to grow on a worldwide basis. While the majority of this growth is in Chinese coal-to-chemicals plants reflecting the dynamics of that market, other markets such as SNG in Korea and India are also developing. The development of 'mega-plants', particularly for such products as Fischer-Tropsch liquids, SNG and methanol-to olefins, but also in large refineries such as Jamnagar and Jazan, is also an important influence on the growth of gasification capacity worldwide.

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