
State of the Gasification Industry: Commercial Applications & Research and Development

ECUST OMB Technology Conference
Nanjing, 7th November, 2016

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Nanjing, November 2016

Overview

- Introduction
- Gasification database
 - Evaluations by different criteria
- Worldwide R&D activities
- Conclusions

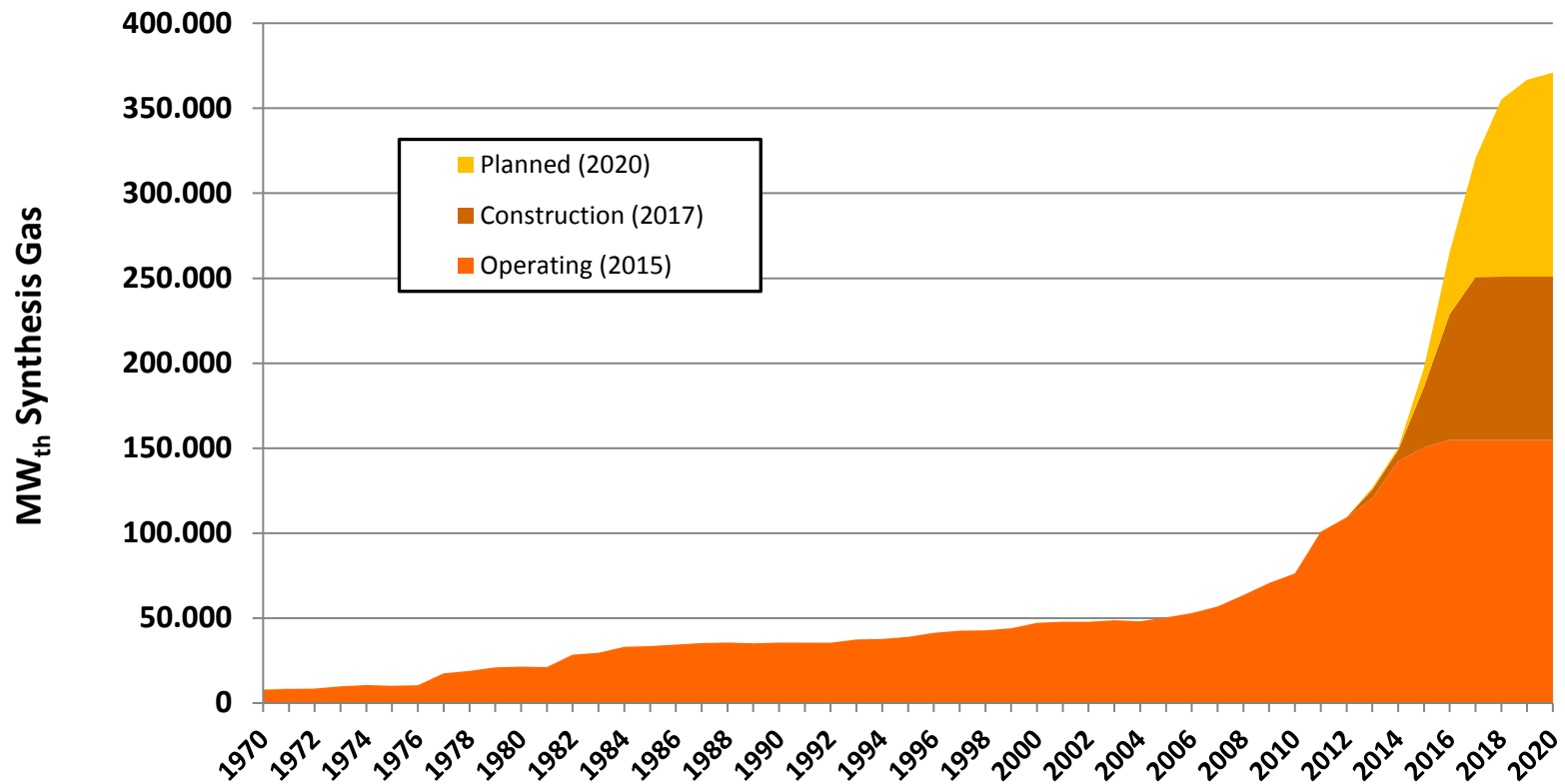
GSTC Gasification Database

- Maintained since 1999 by **Gasification and Syngas Technologies Council**
 - Total 1014 projects, 2559 gasifiers not counting spares, of which:

Commercial	Projects	Gasifiers	GWth Syngas
Operating	356	863	154
Construction	108	322	96
Planned	134	685	250
Total	598	1,870	370

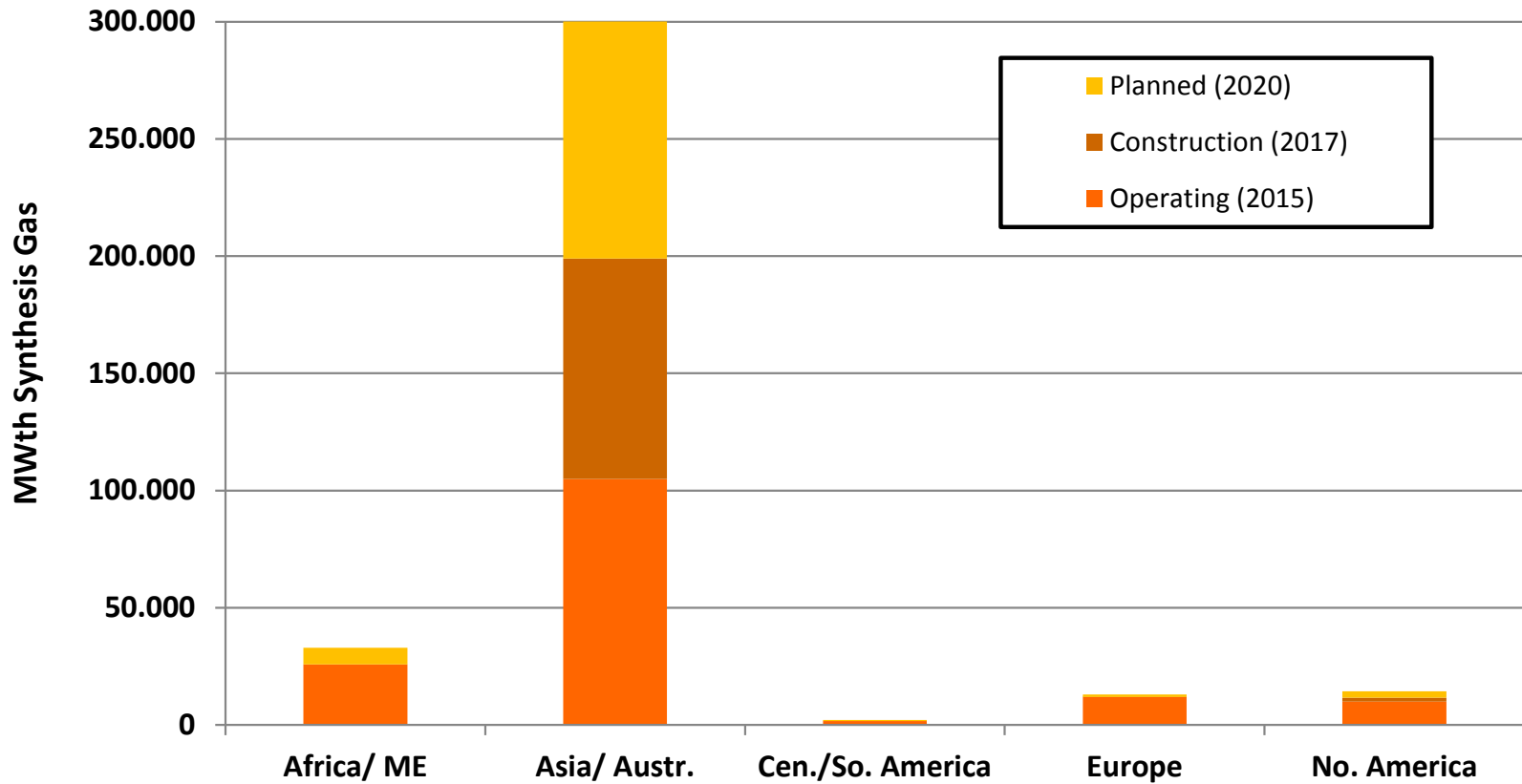
Note: Total database includes shutdown gasifiers, gasifiers never built or only in pre-planning stage, as well as pilot and demonstration gasifiers.

Cumulative Capacity with Probable Increase



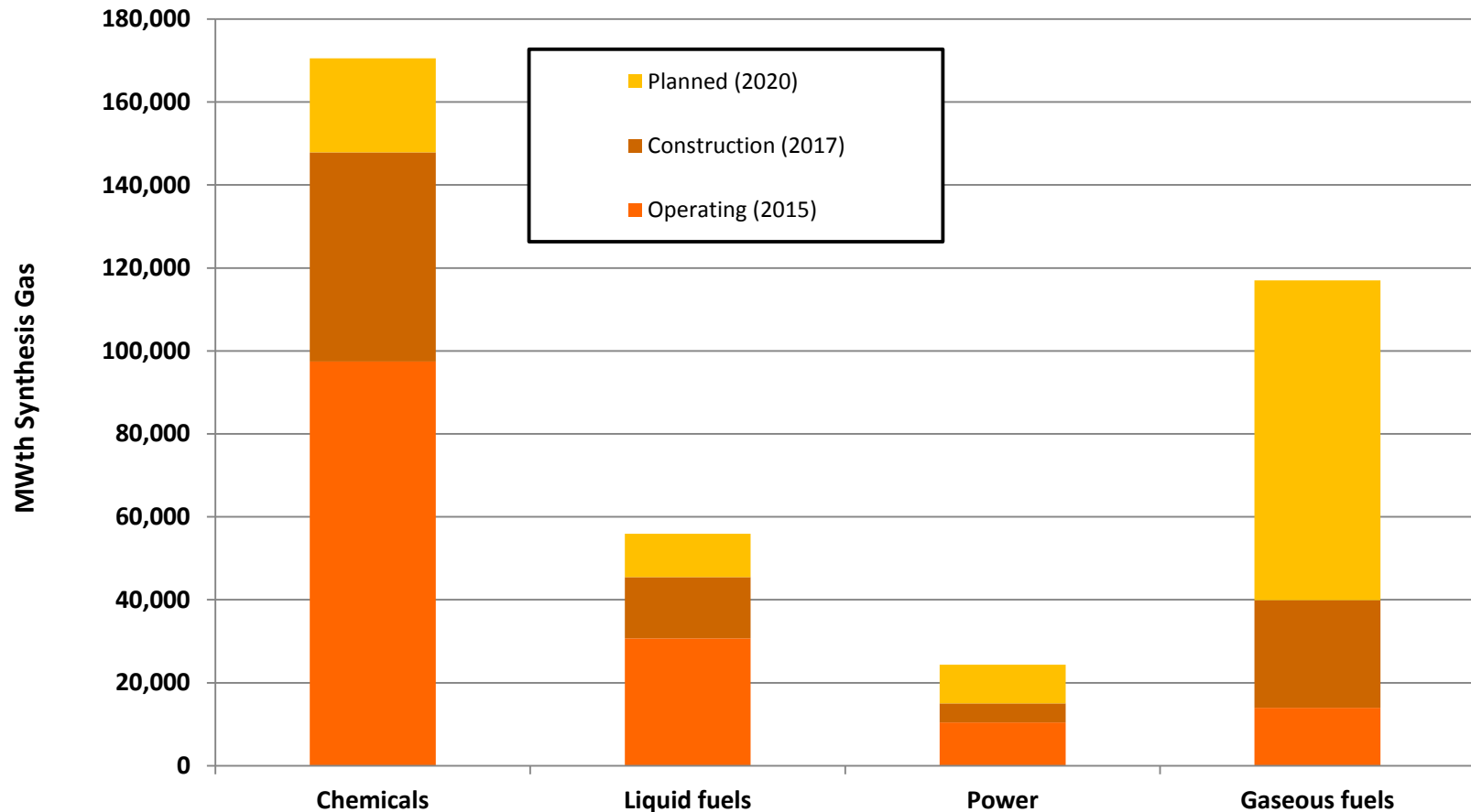
Source: GSTC Database, 2016

Gasification by Region



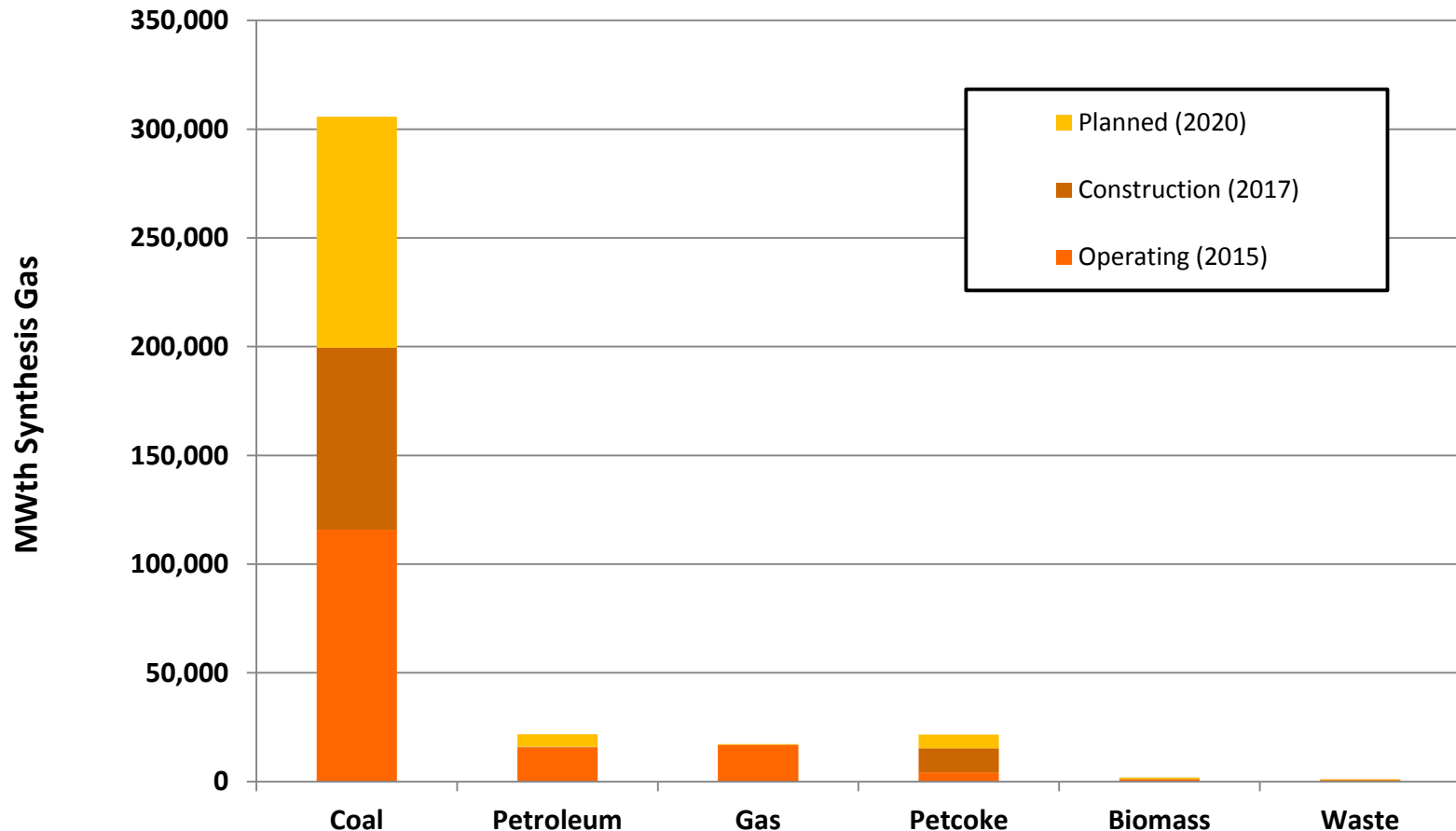
Source: GSTC Database, 2016

End Use Applications of Syngas



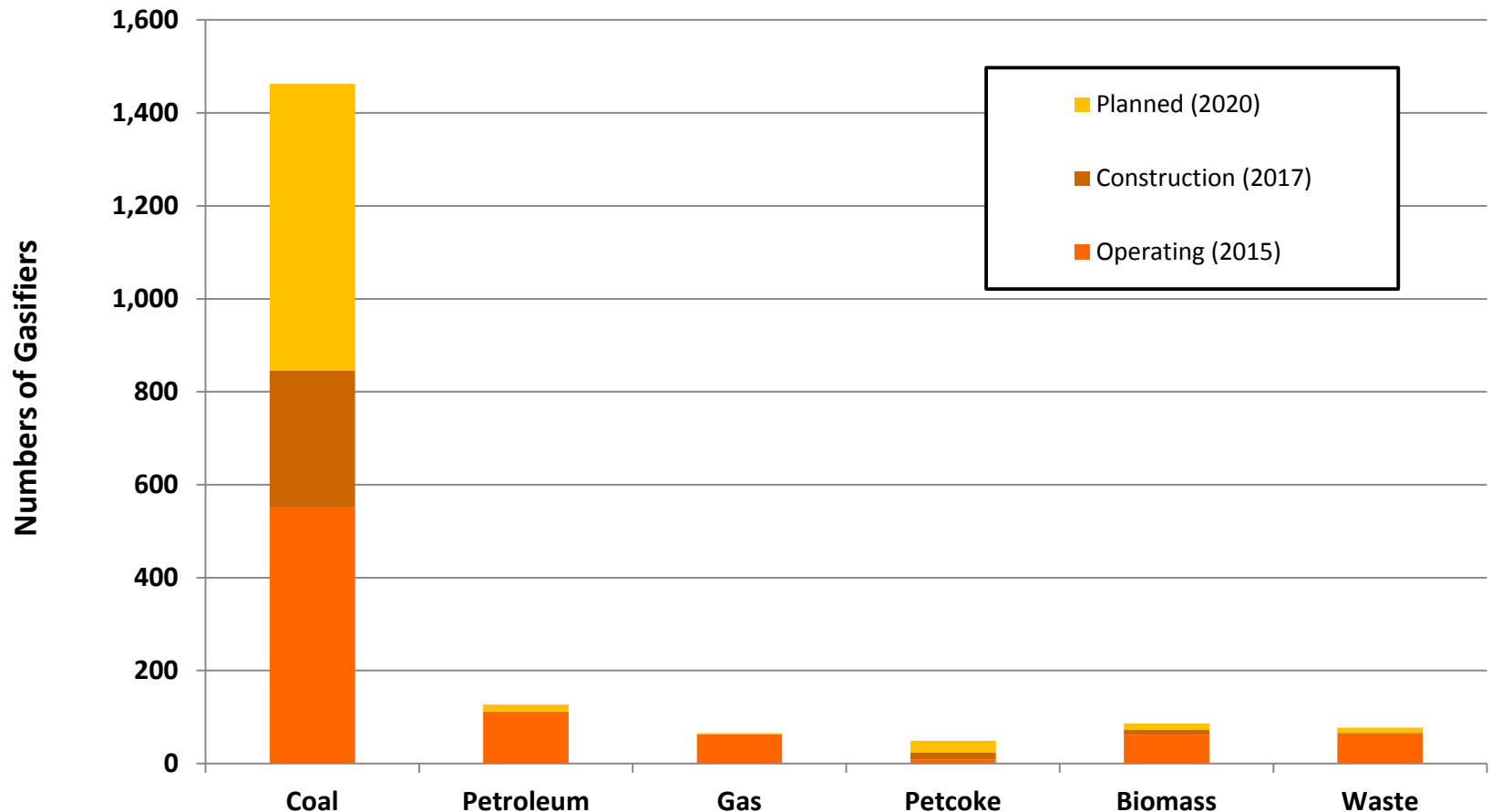
Source: GSTC Database, 2016

Primary Feedstocks for Gasification



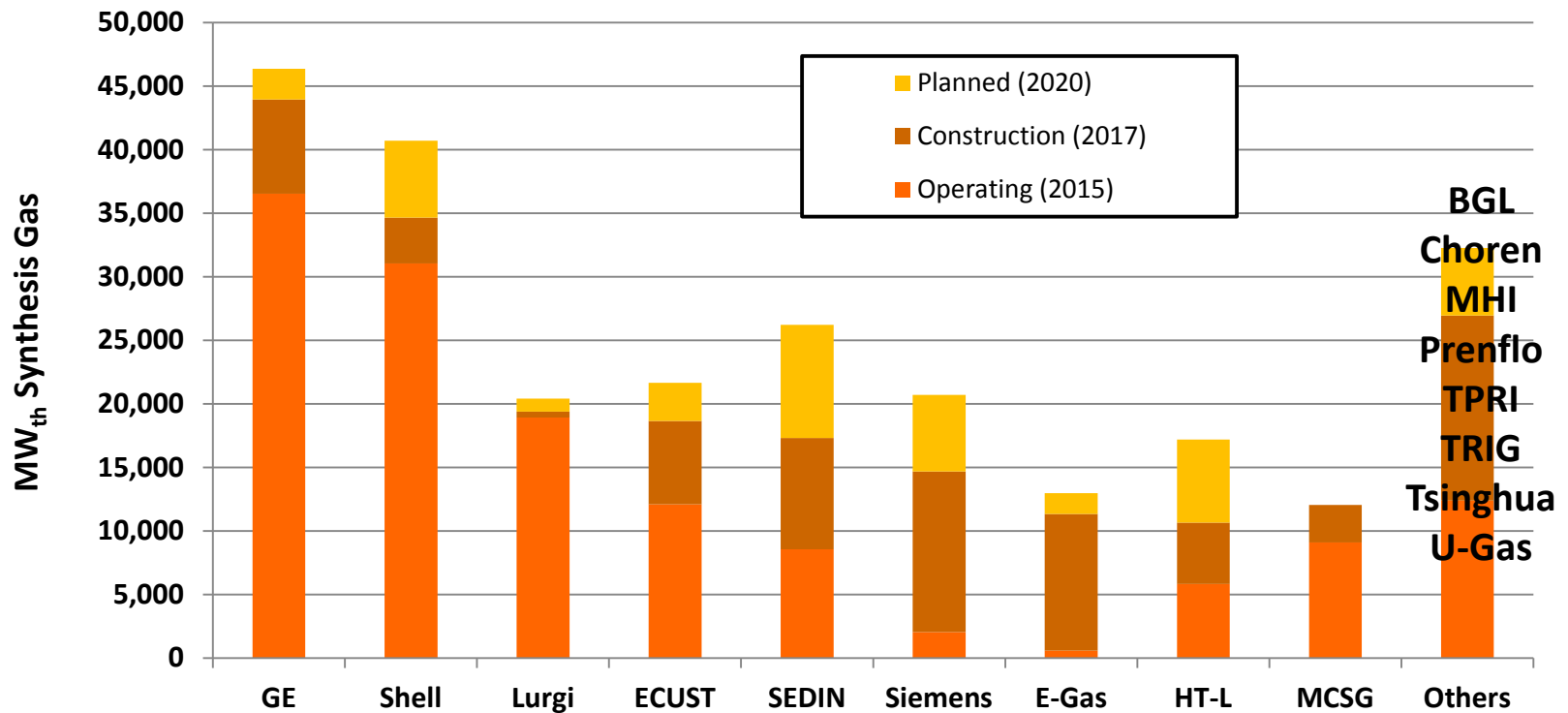
Source: GSTC Database, 2016

Number of Gasifiers by Primary Feedstocks



Source: GSTC Database, 2016

Gasification by Technology



Source: GSTC Database, 2016

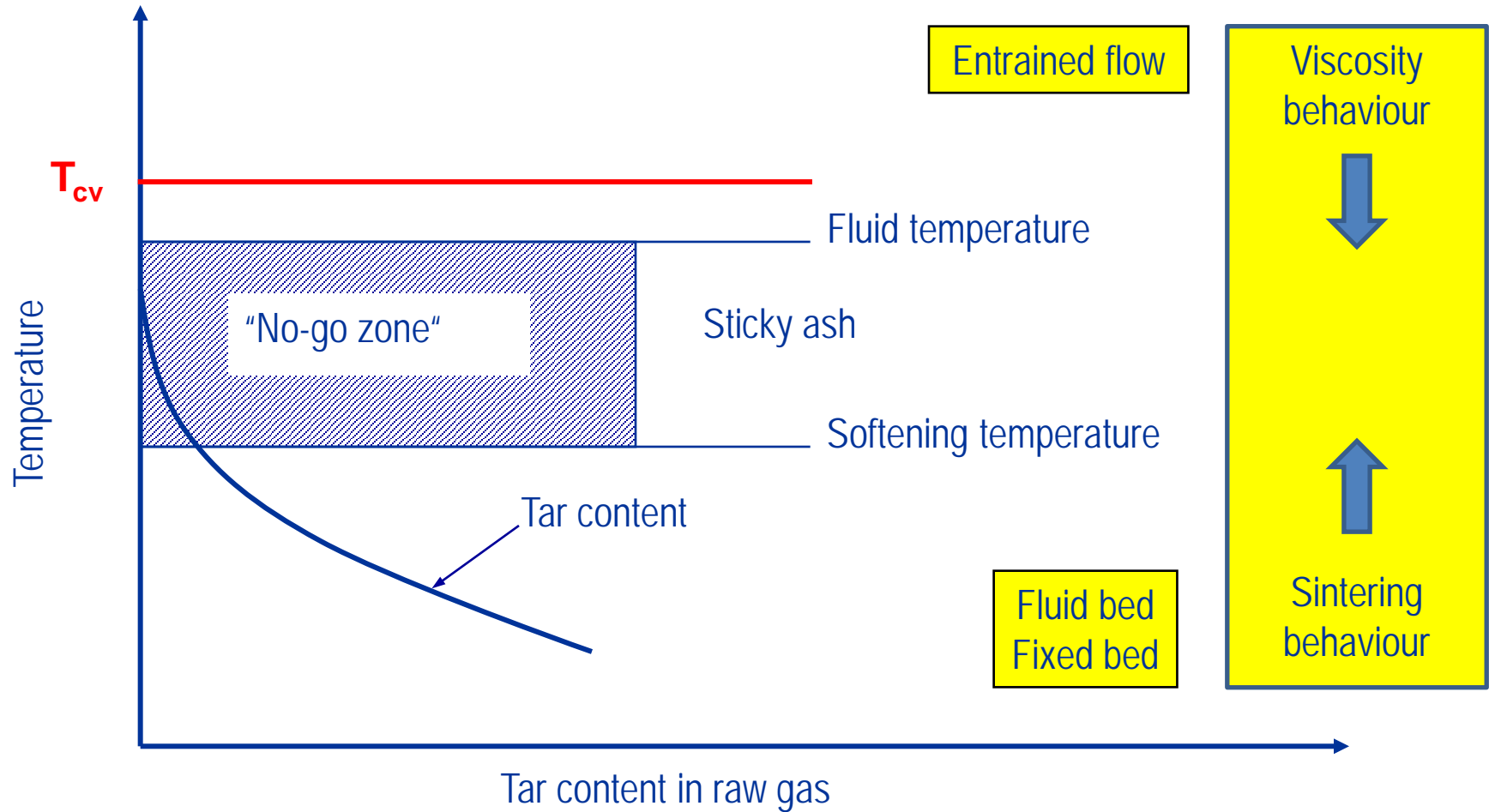
Current R&D Areas for Coal-to-Chemicals

- Coal Properties Relevant to Gasification
- Coal Preparation and Feeding
- Gasification Reactors
- Contaminant Species in Raw Syngas
- Syngas Coolers
- Primary Gas Cleaning
- Alternative Configurations
- Gas Treating
- Chemicals from Syngas

Coal Reactivity

- No clear standard, so difficult to compare results.
- Usually measured at atmospheric pressure with CO₂ or steam atmosphere.
- Gasifiers operate at medium to high pressure in syngas atmosphere (recycled CO present in gas).
- Char preparation is also critical.
- Much published work is routine analysis, but some fundamental work is being carried out.
 - CSIRO, AUS; Calgary, CA; INCAR, ES; ICC, CN

Ash melting point issues



Coal Ash Properties Relevant to Gasification

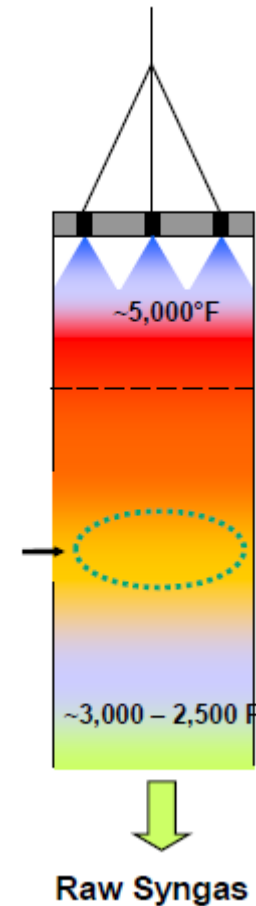
- **Ash melting point prediction with FactSage**
 - ECUST, CN; Sheffield, UK
- **Slag viscosity prediction**
 - CSIRO, AUS; ECUST, CN
- **Sintering studies**
 - North West University, ZA; Sasol, ZA; ICC, CN
- **Char-Slag transition**
 - Utah, US
- **Other issues include kinetics and ash surface tension**

Gasifier feeding

- Existing processes can all benefit from improvement
- **Slurry feed: increase coal content of slurry**
 - ECUST, CN; SCUT, Guangzhou, CN; Zhejiang University, CN; KIER, KR; CSIR, Bhubaneswar, IN
 - EPRI, US
- **Dry feed**
 - ECUST, CN; Shell, NL
 - North West University, ZA (breakage losses for fixed beds)
- **Solids pumps**
 - GE (Stamet); GTI R-Gas (Rocketdyne); Synfuels China, Freiberg

Gasification Reactors

- Generally proprietary development with limited release of information.
 - Lurgi Mark Plus (DE)
 - Shell Hybrid (NL/CN)
 - GTI R-Gas (Rocketdyne) (US)
 - Tsinghua (CN)
 - ECUST Dry Feed
 - ECUST SE (CN)
 - Uhde Prenflo PDQ (DE)
 - CB&I ESTR (US)



Trace elements in coal

- **Partitioning**

- (Entrained flow) CSIC, Barcelona, ES;
- (Fixed bed) North West University, ZA ; Sasol,ZA;
Taiyuan University of Technology,CN

- **Removal at higher temperatures**

- (Hg) NETL, US; RTI, US
- (As) NETL, US; RTI, US; FZ Jülich, DE
- (Se) RTI, US
- (Alkalis) FZ Jülich, DE

Other systems

- **Catalytic gasification process**
 - Original work by Exxon 1978 - 1981
 - Now pursued by Great Point Energy
 - Other work by CRIEPI, JP; ECUST, CN; NIAIST, JP
- **Chemical Looping**
 - Elegant solution for CO₂ capture, but much work still to be done.
 - Easiest application is combustion of gaseous fuel. Concepts for solid fuels are being developed.
 - Chalmers, SE; Ohio State, US; CSIC, ES; TU Vienna, AT

Gas treating – RTI HT Desulfurization

- Adsorption of sulfur species on zinc oxide in transport reactor at over 230°C
- Regeneration by combustion of sulfur species to SO₂
- Tested at 0.3 MW_e with real syngas under industrial conditions
- Demonstration at 50 MW_e for Polk IGCC now completed



Source: Gupta, GTC 2009

Chemical from Syngas

- Ammonia
- Hydrogen
- Methanol
 - and derivatives (DME, Olefins, Aromatics, Gasoline etc.)
- Ethanol
- Oxo-alcohols
- MEG
- SNG
 - and LPG
- Fischer-Tropsch liquids

Conclusion

- Gasification industry is growing fast – particularly in China.
- Chemicals synthesis is most important application.
- R&D is continuing at fundamental level in many parts of the world.
- Improved understanding at fundamental level will help industry to improve performance.