Sasol's Activities on Synthetic Fuels

2nd International BtL Congress

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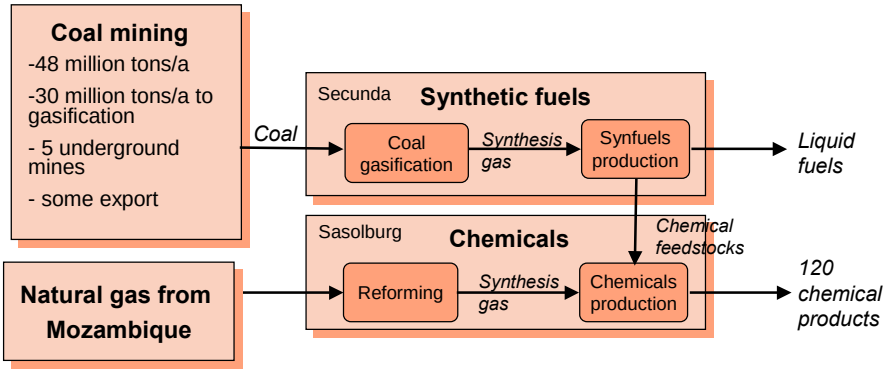
Contents

- Fischer-Tropsch (FT) processes and technology
- Sasol's position on BTL
- Biomass co-gasification with coal
- Current FT focus
- Conclusions

Sasol's Fischer-Tropsch based businesses:

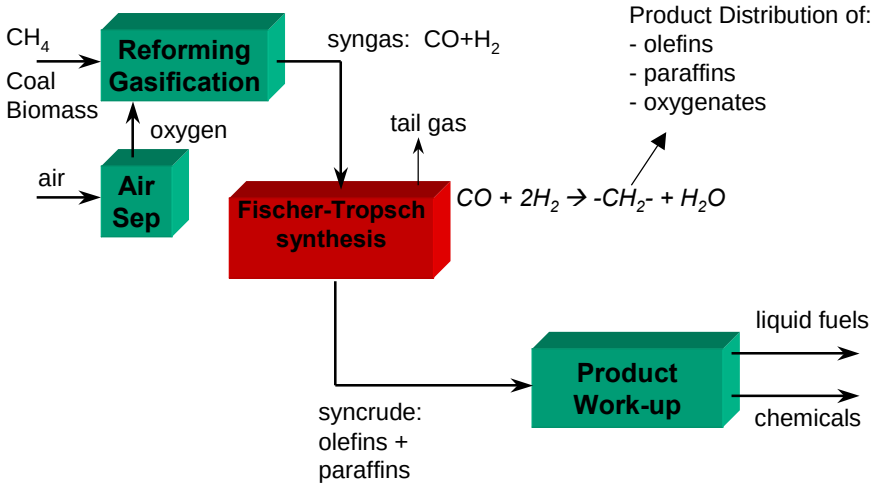
- Indirect FT-based liquefaction of coal to fuels and chemicals in South-Africa is the platform of Sasol's business
- Further global growth via GTL, CTL and enhanced chemicals production



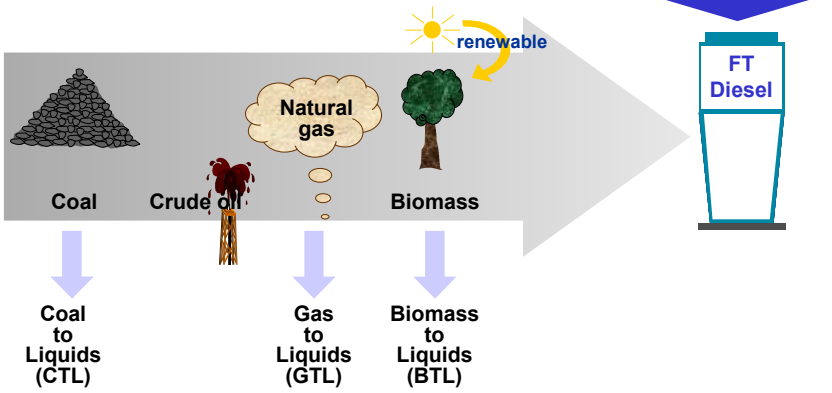
Syngas conversion via Fischer-Tropsch synthesis

$CH_4 + ½\ O_2 \rightarrow CO + 2H_2$

$2C(s) + 2H_2O + ½\ O_2 \rightarrow CO + CO_2 + 2H_2$



Sasol's FT technology can be applied to different feeds

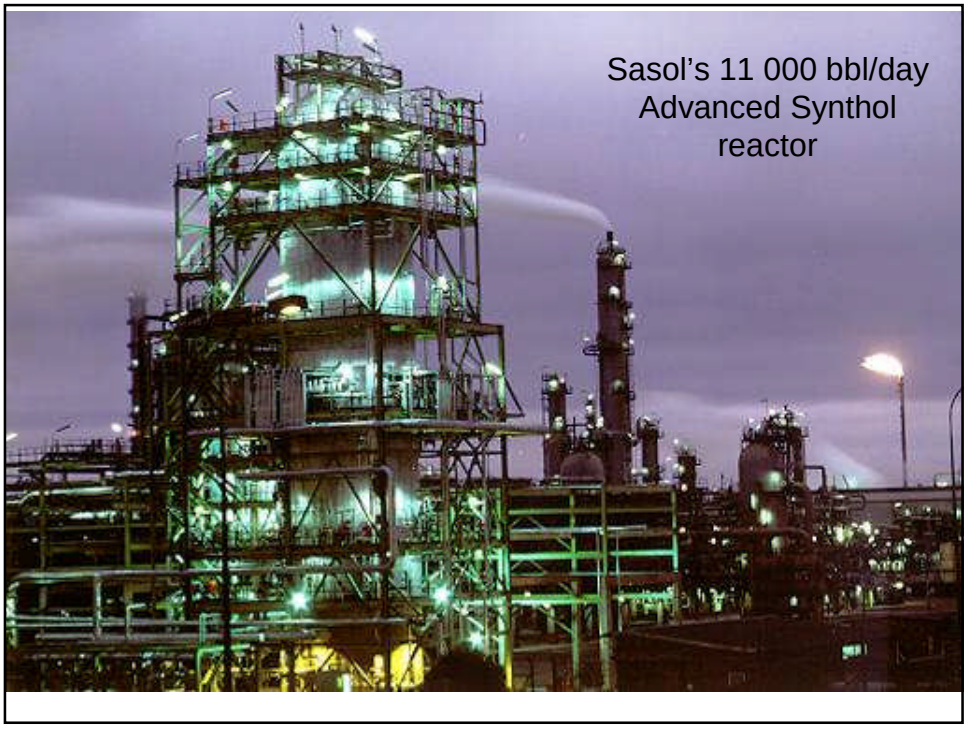


Sasol's Fischer-Tropsch technology development

Original 1950's technology for Fischer-Tropsch synthesis →

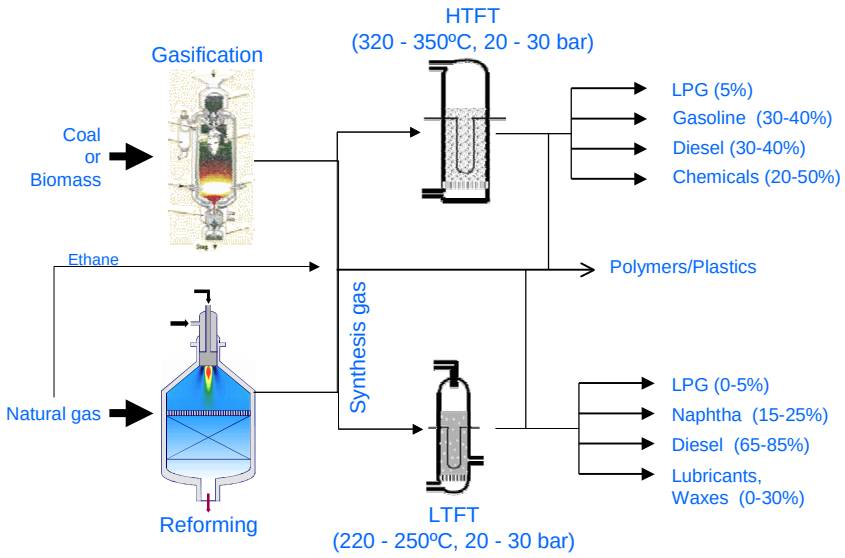
Advanced reactor technology developed by Sasol for the 21st century. →

High Temperature Processes Gas Phase Reactions and products Products - gasoline and light olefins	Low Temperature Processes Liquid phase reactor products Products - mostly diesel
The Sasol Circulating Fluidized Bed Reactor 1950 to present	The Arge Tubular Reactor Pre-WWII to present
The Sasol Advanced Synthol Reactor 1989 to present	The Sasol Slurry Phase Distillate Reactor 1993 to present

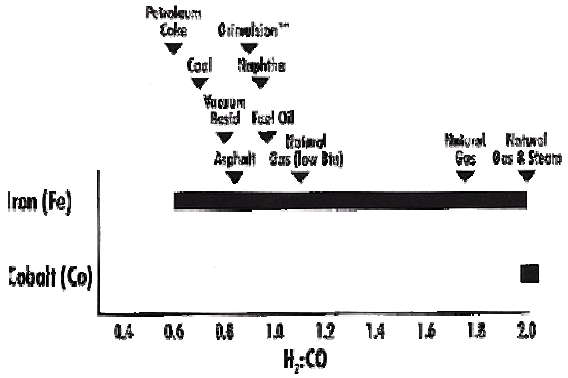


Sasol's Fischer-Tropsch technology offering

sasol
reaching new frontiers



Sasol's FT catalysts



M Dry & A Steynberg (Ed), *Fischer-Tropsch technology: Studies in Surface Science and Catalysis*

- GTL – LTFT with Co catalyst
- CTL – HTFT with fused Fe catalyst and LTFT with precipitated Fe catalyst

Sasol's position on BTL

- Sasol's interest in BTL stems from the fact that we are the world leader in FT technology, with over 50 years' commercial experience, and have both high-temperature and low-temperature FT offerings
- If syngas of appropriate quality is available, we can guarantee our processes will deliver highly desirable synthetic fuels
- We are not actively pursuing BTL at this stage due to a number of concerns:
  - *Biomass gasification and gas cleaning technology needs further development*
  - *Consistent supply of biomass feedstocks delivered at an appropriate price*
  - *Scale of economy constraints (high capex per daily barrel)*
  - *Low fixed carbon content of biomass compared to coal*
  - *Need for long-term government subsidies*
- We believe co-gasification of biomass with coal may be a partial solution to these concerns

Sasol test work on biomass co-gasification with coal

- Aim of the test work was to evaluate the technical feasibility of co-gasification of alternative carbonaceous feedstocks with coal in a Sasol-Lurgi Fixed Bed Dry Bottom (FBDB) gasification process
- 9% blend of bark or bark/wood fibre pulp mixture with coal

Characteristics of FBDB gasifiers*

Advantages

- ✓ *Lump coal and limited grinding*
- ✓ *High ash content*
- ✓ *Coal with high ash flow temperature*
- ✓ *High "cold gas" thermal efficiency*
- ✓ *Low oxidant requirements*
- ✓ *Valuable co-products (e.g. tars)*
- ✓ *H_2/CO = 1.7-2.0 (suitable for FT)*

Limitations

- × *Limited ability to handle excessive fine coal*
- × *Broad particle size distribution (PSD) can lead to coal segregation and channel burning*
- × *Pressure drop can limit gas throughput*
- × *Relatively high steam consumption*

***Sasol Lurgi Technology Company (Pty) Ltd proprietary technology**

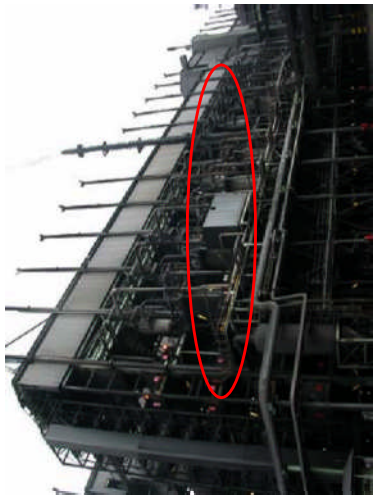
Bulk and pulp characteristics

	Liquid hydrocarbon fraction (air dried basis)	*Ash (air dried basis)*	*S (dry ash free)*	*Ash Fusion Temp (˚C)*
Bark	15	3-35	0.2	1200 to 1400
Pulp	4	<10	0.4	
Sasol coal	3-5	22-30	1-2	1300 to 1500

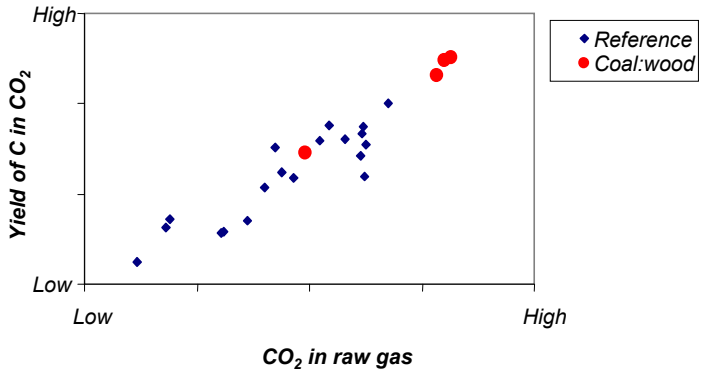
- Liquid hydrocarbon fraction includes methanol, acetic acid, proprionic acid and methyl acetate

Coal + Bark

Coal + Bark + Pulp

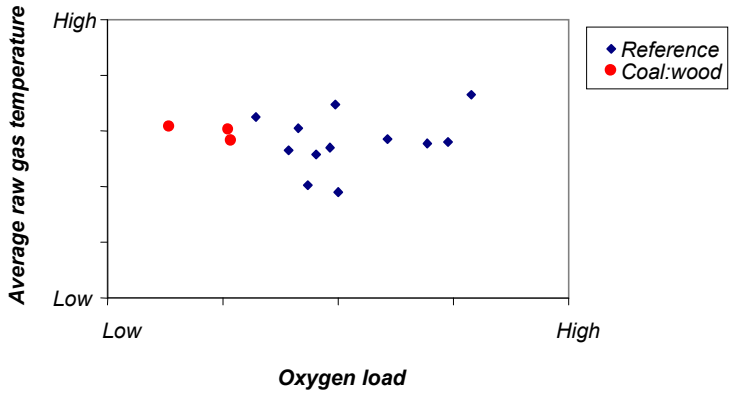


CO_2 production



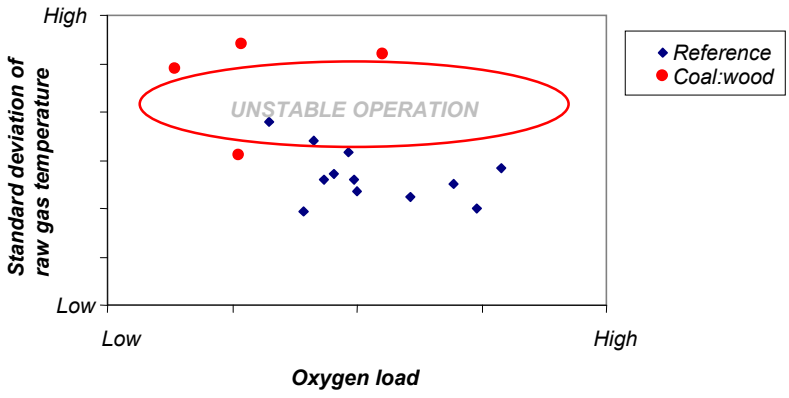
- High CO_2 production due to higher volatiles and inherent moisture content of biomass.
- Greater moisture promotes the water-gas shift reaction leading to CO_2 generation

Operating stability – raw gas temperature



- Gasifier temperature can be controlled
- Lower oxygen load is due to the fact that biomass co-feeding places a constraint of the quantity of feed to the gasifier due to its bulky, low density nature

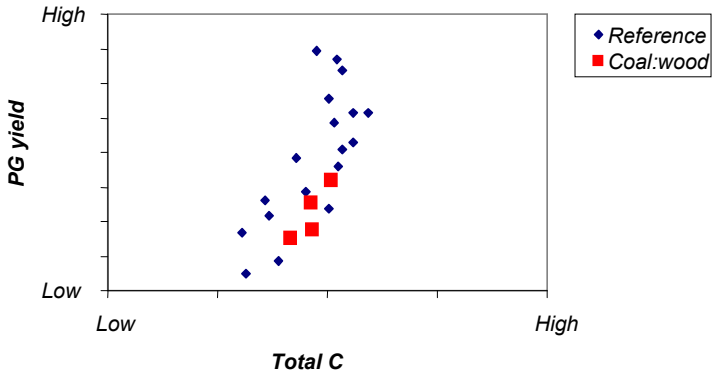
Operating stability - raw gas temperature



- Unstable operation due to lower feed rate at same oxygen load compared to coal and high volatiles content of biomass

Pure gas yields

Pure gas = syngas after purification remove CO_2 and sulphur



- Can achieve the same pure gas yield for the total carbon fed into gasifier
- However, to get the same rate of pure gas production, need to feed raw material faster

Results

- Biomass can be co-gasified in a Sasol-Lurgi gasifier. Based on the increased standard deviation of the raw gas outlet temperature, it was concluded that the coal/wood blend was gasified with less stability compared to gasifier operation with typical coal
- However, more stable operation was obtained when the oxygen load was reduced by increasing the steam/oxygen ratio. This led to higher CO_2 in raw gas concentrations
- The issues of decreased operating stability, high gasifier outlet temperatures, lower carbon efficiency and higher CO_2 production would have to be addressed
- Pelletisation of biomass may offer a solution to address the density issue with biomass, maintain feed rates and allow stable operation.
- With <10% wood, no significant changes in steam, oxygen, gas liquor, high pressure boiler feed water and other parameters were observed during coal/wood tests in comparison with results obtained during reference tests with coal only
- The addition of 9% bark and pulp did not have a significant effect on pure gas yields in comparison with reference tests
- Tar composition slightly affected, but the significance not clear
- Effect on downstream processes not quantified and unknown

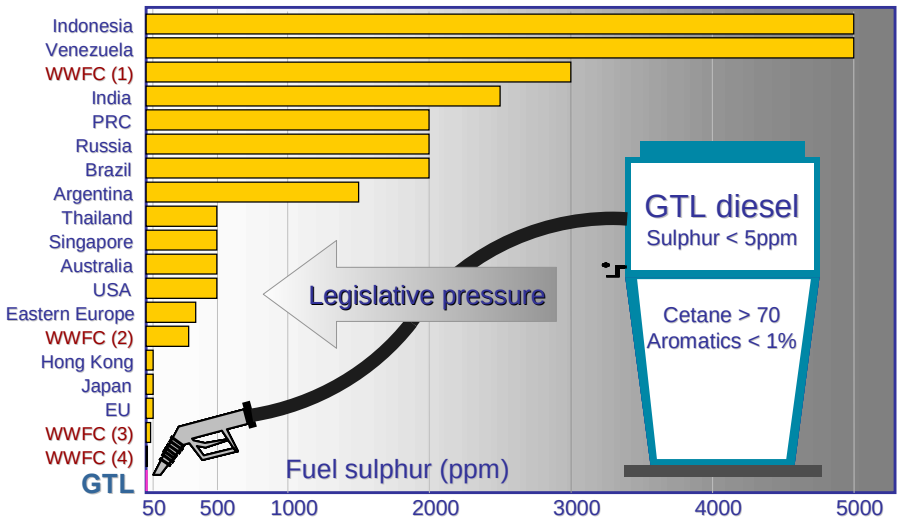
Our current FT focus

- Although co-gasification of biomass is technically feasible, further development and implementation at Secunda has not proceeded because:
  - *Lack of availability of suitable biomass (1% co-blend requires 265 ktpa biomass)*
  - *High delivered cost of biomass vs coal*
  - *Low volumetric density of biomass places a constraint on the raw material feeding system to the gasifiers*
  - *This and the lower fixed carbon content of biomass means a reduction in syngas production*
- Thus, our focus is on GTL and CTL

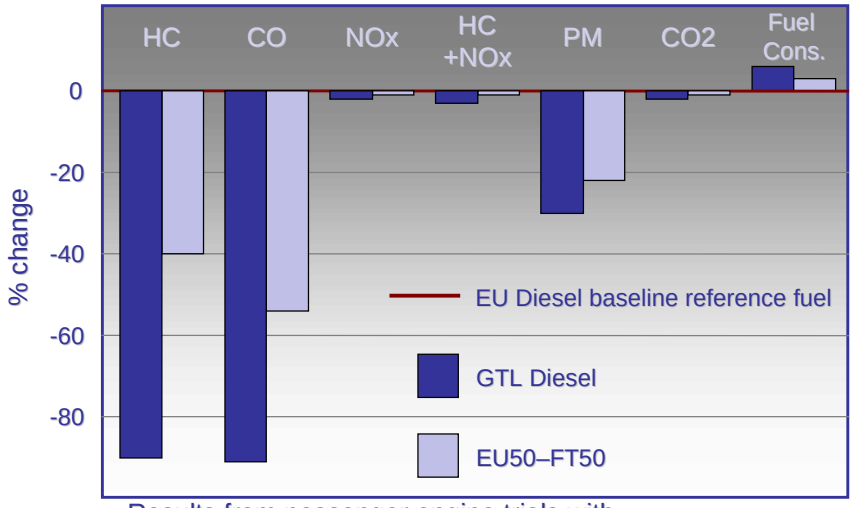
Properties of GTL products

GTL Diesel	GTL Naphtha
Ultra low sulphur - <5 ppm	Ultra low sulphur content
Highly paraffinic	High in paraffins
Low aromatics - <1% total	*Very low aromatics*
Very high cetane number - >70	*Low octane number*
Lower density - ~0.77 kg/l	High hydrogen content
Good cold flow properties	Highly linear molecules
Compatible with existing materials used in engines	Ideal for cracker feedstock
Environmentally superior product	

GTL diesel exceeds new fuel quality demands

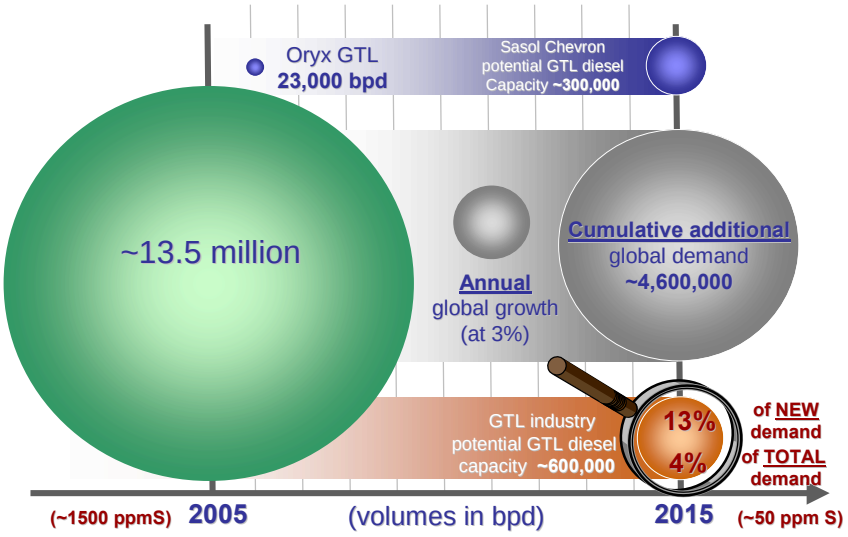


GTL diesel helps to meet new air quality demands

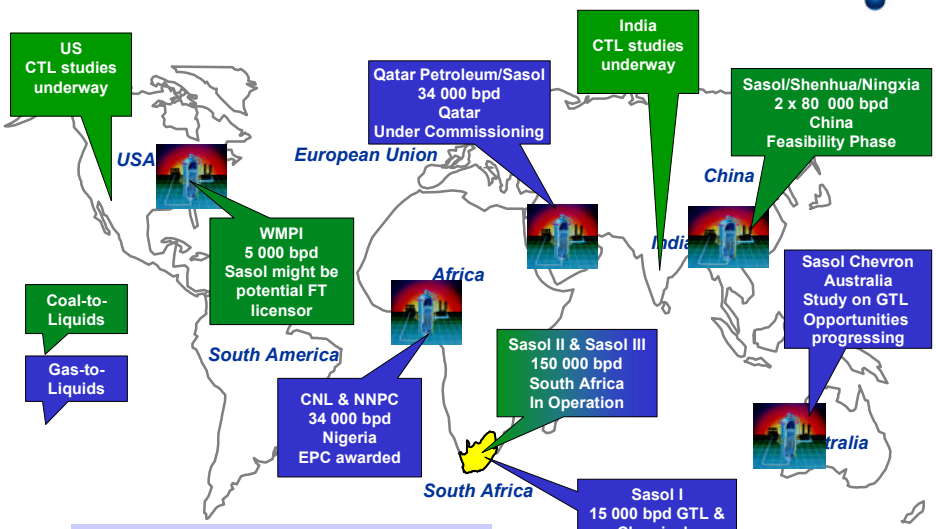


Results from passenger engine trials with DaimlerChrysler

GTL will help meet diesel demand growth



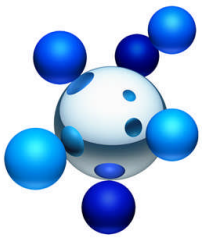
Sasol's Current Global FT Activities



Sasol operates the world's only commercial scale CTL Facility and is currently commissioning a commercial scale GTL facility.

Conclusions

- Sasol is uniquely positioned to offer Fischer-Tropsch solutions to the world
  - *50 years of proven commercial experience in indirect coal liquefaction.*
  - *Expertise enabling a "running plant" project approach*
  - *Expertise in marketing of FT derived fuels.*
  - *The ability to develop a viable commercial XTL projects rapidly.*
- Number of factors creating opportunity for alternative fuel sources
  - *High oil prices*
  - *Political instability in the Middle East*
  - *Countries with the strategic need and ability to invest in security of energy supply*
- Expansion of the number of commercial GTL and CTL plants in the world is a step along the path to BTL
- Experience gained around the world from implementation of GTL and CTL will prove invaluable for the commercialisation of BTL in the future, once the issues have been solved



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