

sasol
reaching new frontiers



GTL Technology Advancements

World Petroleum Conference – ORYX GTL site visit

December 2011

Sven Godorr, Executive Manager Research and Technology

copyright reserved 2011, Sasol Technology (Pty.) Ltd.

Forward-looking statements

SASOL
reaching new frontiers



Sasol may, in this document, make certain statements that are not historical facts and relate to analyses and other information which are based on forecasts of future results and estimates of amounts not yet determinable. These statements may also relate to our future prospects, developments and business strategies. Examples of such forward-looking statements include, but are not limited to, statements regarding exchange rate fluctuations, volume growth, increases in market share, total shareholder return and cost reductions. Words such as “believe”, “anticipate”, “expect”, “intend”, “seek”, “will”, “plan”, “could”, “may”, “endeavour” and “project” and similar expressions are intended to identify such forward-looking statements, but are not the exclusive means of identifying such statements. By their very nature, forward-looking statements involve inherent risks and uncertainties, both general and specific, and there are risks that the predictions, forecasts, projections and other forward-looking statements will not be achieved. If one or more of these risks materialise, or should underlying assumptions prove incorrect, our actual results may differ materially from those anticipated. You should understand that a number of important factors could cause actual results to differ materially from the plans, objectives, expectations, estimates and intentions expressed in such forward-looking statements. These factors are discussed more fully in our most recent annual report under the Securities Exchange Act of 1934 on Form 20-F filed on 7 October 2011 and in other filings with the United States Securities and Exchange Commission. The list of factors discussed therein is not exhaustive; when relying on forward-looking statements to make investment decisions, you should carefully consider both these factors and other uncertainties and events. Forward-looking statements apply only as of the date on which they are made, and we do not undertake any obligation to update or revise any of them, whether as a result of new information, future events or otherwise.

1. **GTL Process and Technology Partners**

2. **Reforming and Air Separation**

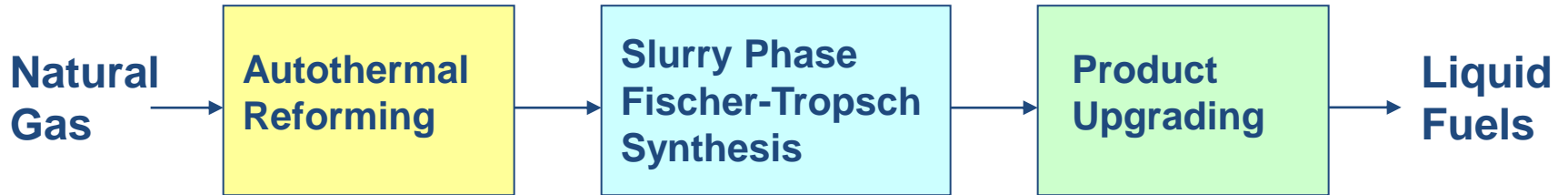
3. **Fischer-Tropsch Catalyst and Reactor**

4. **Environmental and Product**

The Sasol Slurry Phase Distillate (SPD™) Process



Technology Partners for ORYX GTL



HALDOR TOPSOE
 CATALYSING YOUR BUSINESS

SASOL
 reaching new frontiers

Chevron
 Human Energy

Shaw Stone & Webster, Inc.

BASF
 The Chemical Company

IHI

FOSTER WHEELER

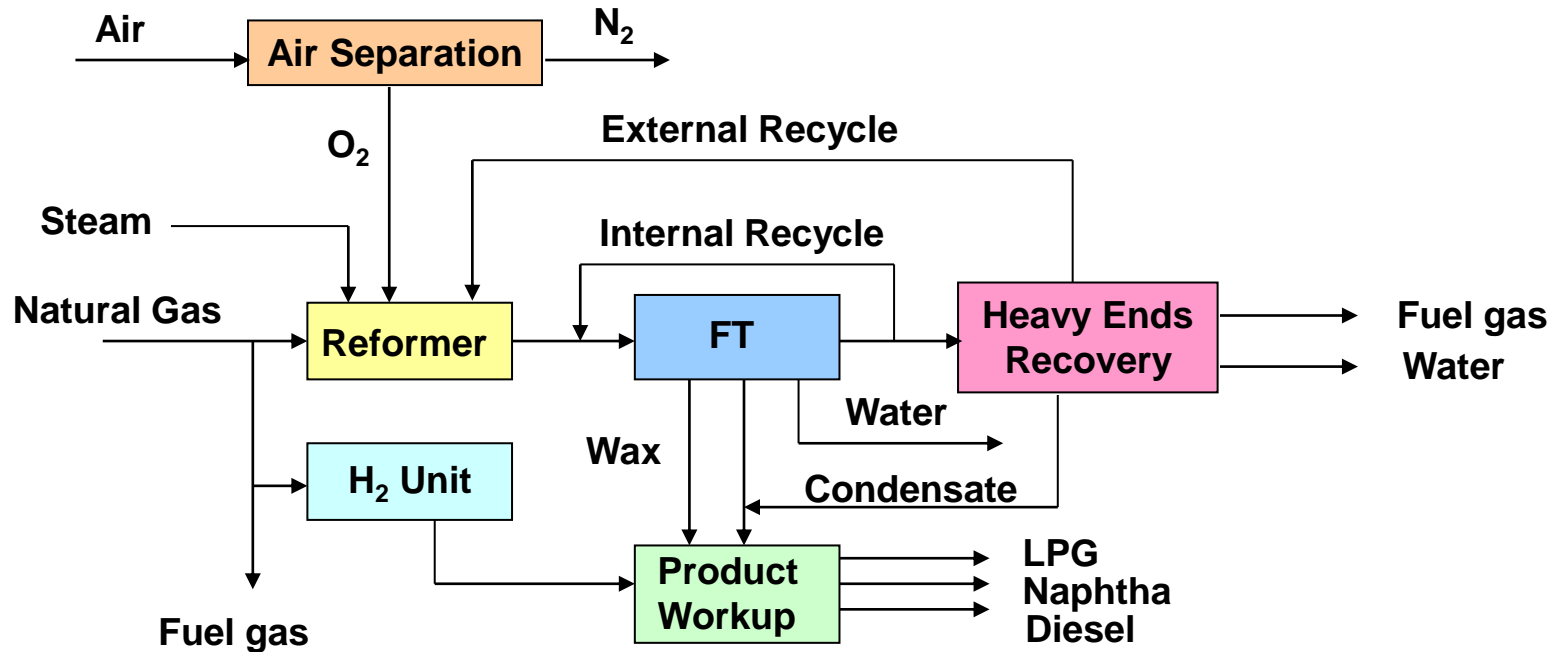
Technip

ORYX GTL
 QP - SASOL joint venture

The Sasol Slurry Phase Distillate (SPD™) Process

Gas to Liquids (GTL)

sasol
reaching new frontiers



Sasol has more than 55 years experience in development of Fischer-Tropsch catalysts, reactors and processes producing fuels, chemicals and power

The GTL process is an integrated mass and energy balance the comprises all of the unit operations found in Chemical Engineering Science



1. **GTL Process and Technology Partners**

2. **Reforming and Air Separation**

3. **Fischer-Tropsch Catalyst and Reactor**

4. **Environmental and Product**

Reforming and Air Separation

Heat Exchange Reforming Development

sasol
reaching new frontiers



- Methane Reforming is a key processing step for GTL - converts natural gas / methane into syngas feeding Sasol's Slurry Phase Reactor for the synthesis process
- Sasol and partners have a leading position with advanced heat exchange reforming technology - Sasol operates a commercial unit in Secunda
- Sasol is studying the application and accelerated commercialisation of exchange reforming for new GTL ventures to significantly improve the GTL value proposition



Reforming and Air Separation

Heat Exchange Reforming Impact



- **Improved efficiency**

- Overall carbon efficiency: up to 10%



- CO₂ footprint intensity: up to 30%



- **Lower Total Cost of Ownership (TCO)**

- For same oxygen requirement - GTL production capacity: up to 25%

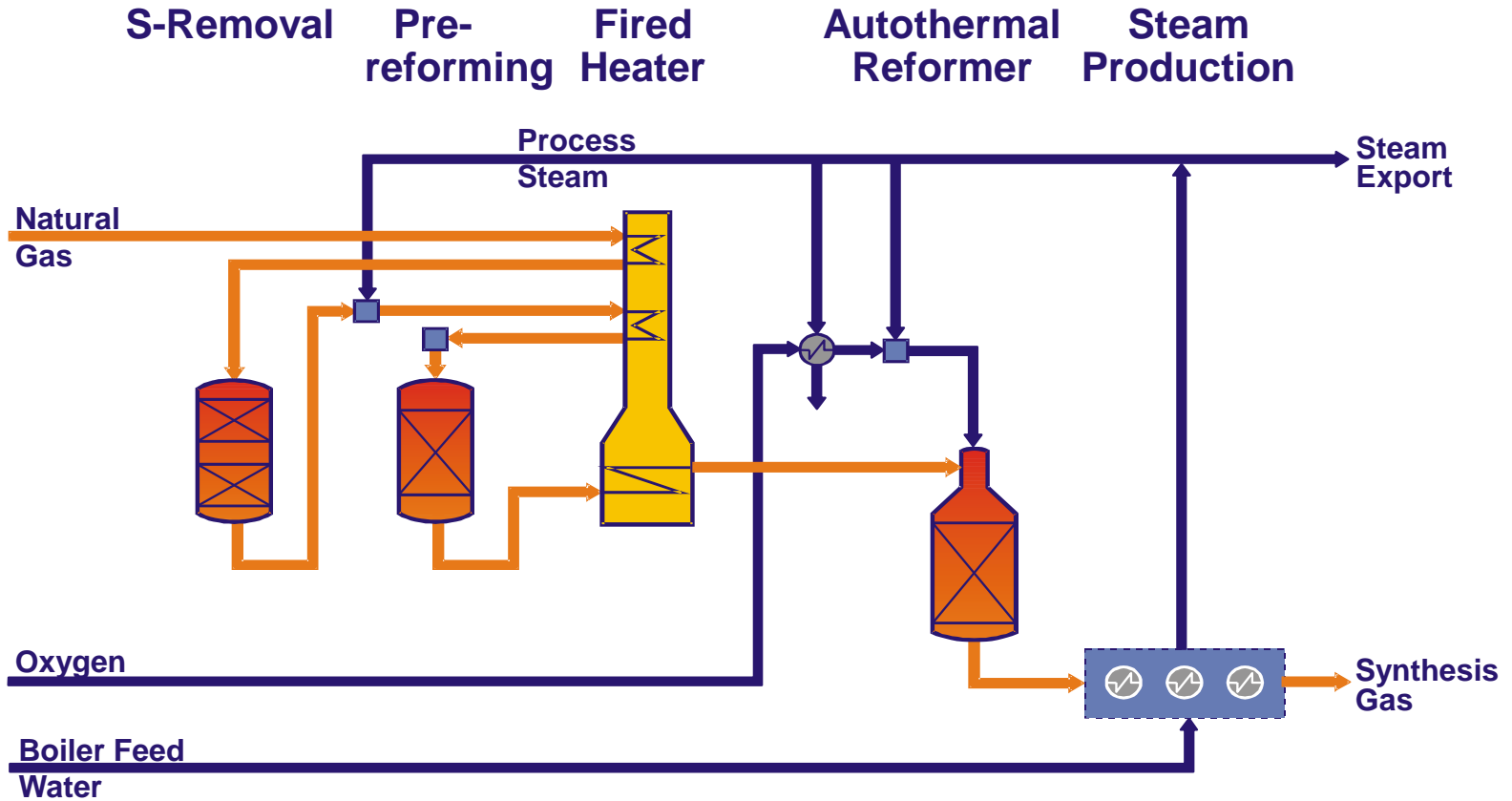


- Taking advantage of technology benefits and associated economies of scale - capital cost of syngas production



Reforming and Air Separation

GTL Synthesis gas generation - Current reference

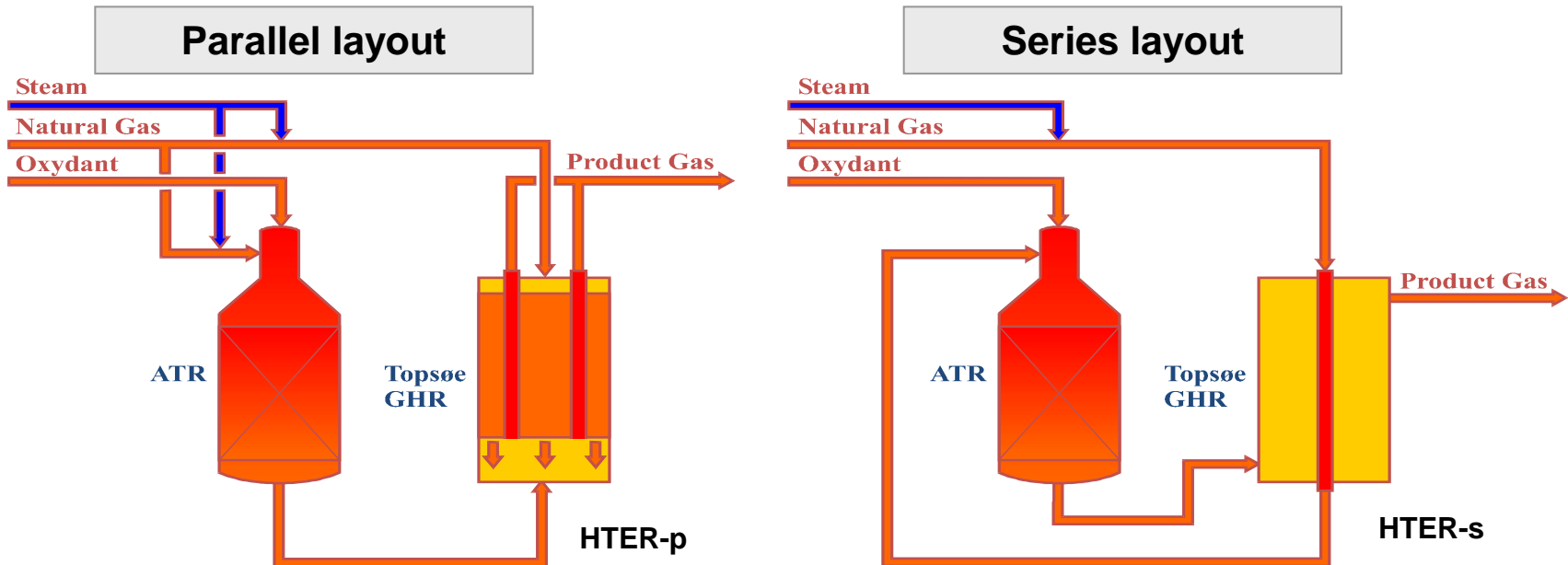


⇒ ORYX GTL a commercial reference for low steam to carbon ratio operation using Haldor-Topsøe ATR technology

Reforming and Air Separation

Haldor Topsøe Exchange Reforming (HTER)

SASOL
reaching new frontiers



- Increase in synthesis gas capacity from the same O₂ capacity
- Increase in plant-wide carbon efficiency

	Base Case	HTER-s
Plant-wide GTL carbon efficiency (%)	73-74	80



Much of the predicted efficiency benefit that HTER-s can bring could be realised, even with technology risk mitigation measures included

	Base case	HTER-s risk mitigated
Plant-wide GTL carbon efficiency (%)	~73	>78
Plant-wide GTL thermal efficiency (%)	~57	~61
Ton CO ₂ /bbl product	0.13	0.10

ITM Oxygen opens up further opportunities to improve thermal efficiency .



1. **GTL Process and Technology Partners**

2. **Reforming and Air Separation**

3. **Fischer-Tropsch Catalyst and Reactor**

4. **Environmental and Product**

FT Catalyst and Reactor Developments

GTL Research and Development

sasol
reaching new frontiers



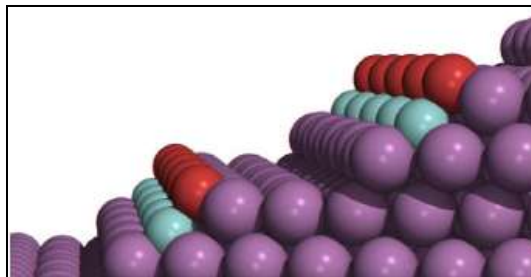
Reactor Demonstration Facilities in South Africa
Slurry Phase Design Reactor for Hydrocarbon Synthesis (400bpd) and Catalyst Testing Reactor (5bpd))

- Continued investment in R&D and leading edge innovation remains key
- Sasol has three R&D centers located in South Africa, the Netherlands and Scotland
- R&D facilities employ over 600 people with more than 120 of PhD graduates
- In both the High Temperature and Low Temperature hydrocarbon synthesis environments, Sasol has developed new generations of reactor technology
- Budget (FY2011/12): ~ US\$ 140 million

14 FT Catalyst Developments

Integrated Research Approach

SASOL
reaching new frontiers



Molecular modeling

Literature/
Academia



18 papers in 1990-2000,
20 papers in 2010!

Develop and
test hypothesis

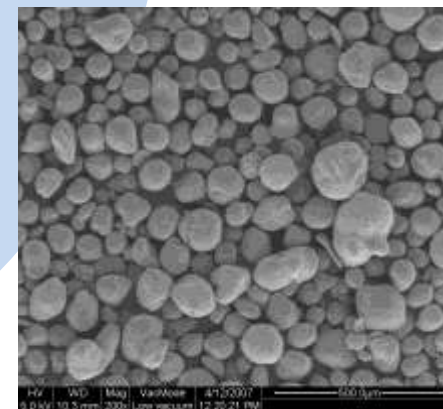
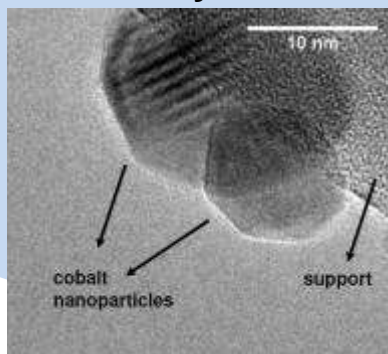
Advanced
characterization

Real catalyst
samples

Model systems



Synchrotron, Trieste



FT Catalyst Developments

Catalyst Deactivation Mechanisms



Primary deactivation mechanisms for GTL Co catalyst

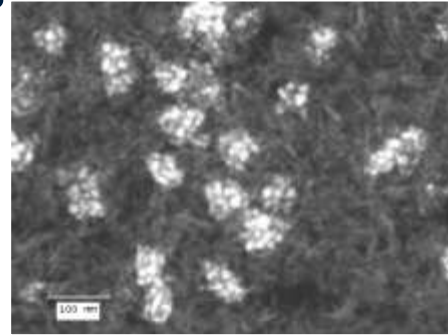
Sintering

- Co crystallites combine into “islands” reducing active area

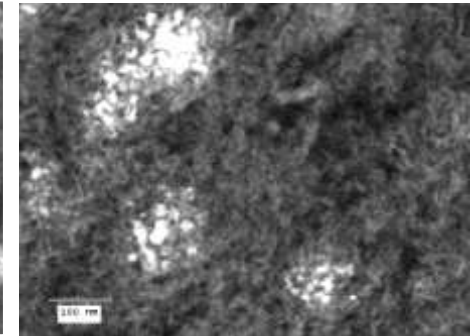
Carbon deposition

- Carbon covers active Co crystallites reducing active area

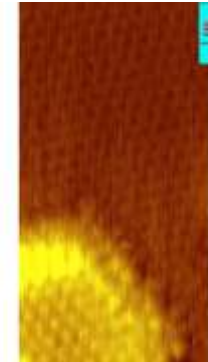
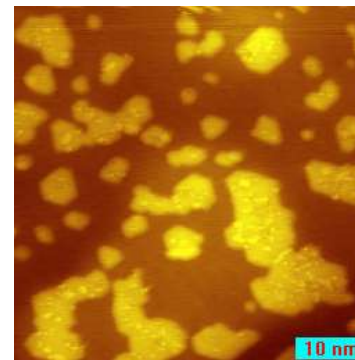
Transmission Electron Microscopy Images



Fresh catalyst



Operating catalyst



Scanning Tunnelling Microscopy
Images of polymeric carbon (graphene)

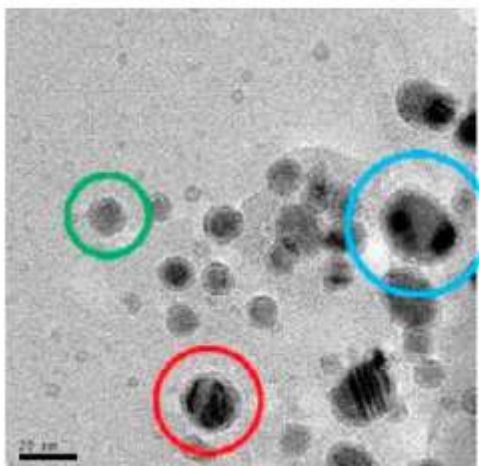
FT Catalyst Developments

Regeneration

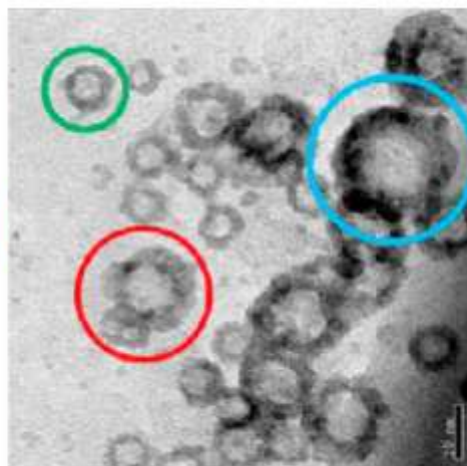
SASOL
reaching new frontiers



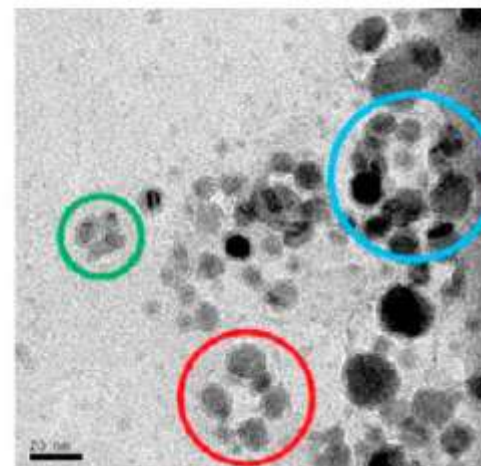
- Based on a fundamental understanding a 3 step oxidative regeneration process was developed on laboratory scale
- Successful regeneration process has been designed and scaled up to demonstration scale
- Regeneration increases the catalyst useful life, decreasing its effective cost and is a valuable tool for catalyst management



***Reduced + passivated
(represents spent)***



Reoxidized



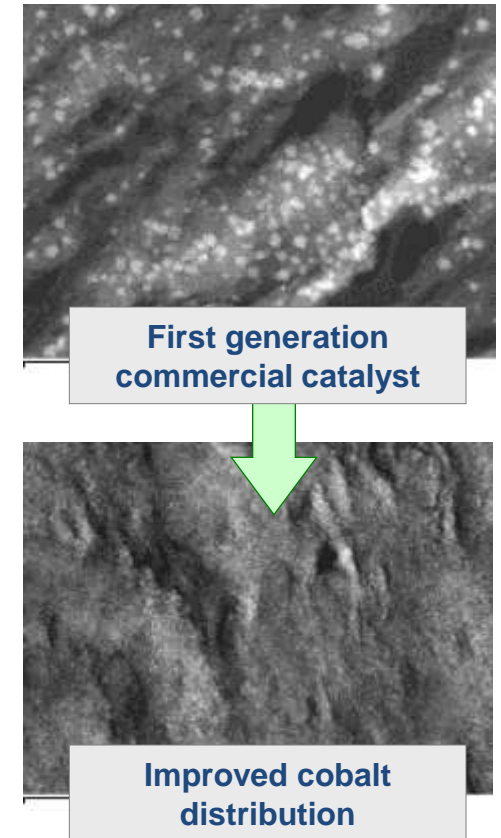
(Re-)reduced

FT Catalyst Developments

Next Generation



- **Better cobalt distribution allows improved catalyst activity and stability**
- **Improvements in alumina support**
 - Enhances catalyst mechanical and synthesis stability
 - Allows more severe hydrodynamic conditions
- **Next generation catalyst will lower GTL operating cost by**
 - Improving catalyst productivity
 - Allowing higher reactor intensities



FT Reactor Developments

Approach to Reactor Engineering

SASOL
reaching new frontiers

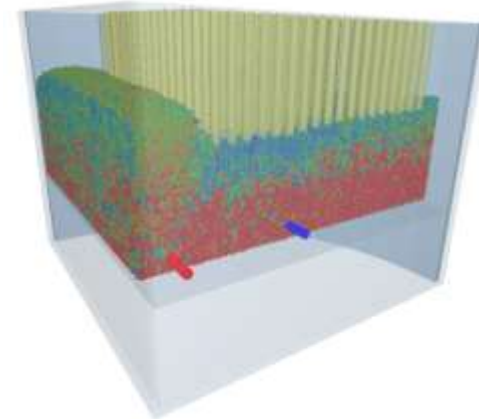
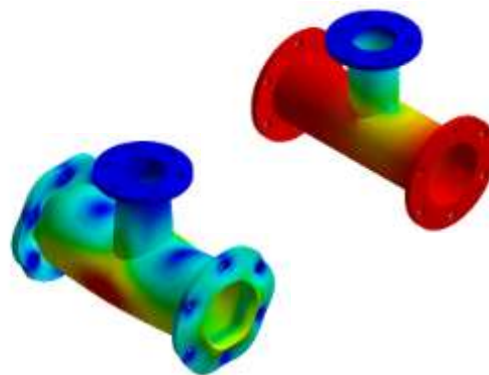
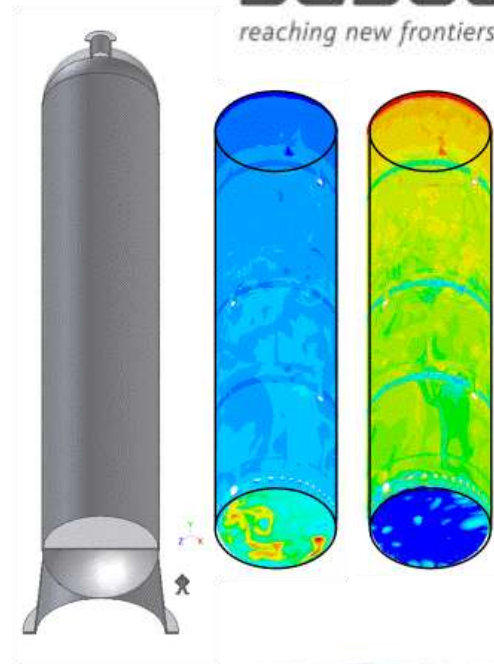


Integrated design tools

- Computational Fluid Dynamics
- Finite Element Analysis
- Discrete Element Modelling
- Design data from semi-commercial demonstration unit
- Hydrodynamic data from Cold Models

Analysis of commercial data

- 400 bbl/day FT Design Reactor
- 2 500 bbl/day Sasol Wax
- 16 000 bbl/day ORYX GTL



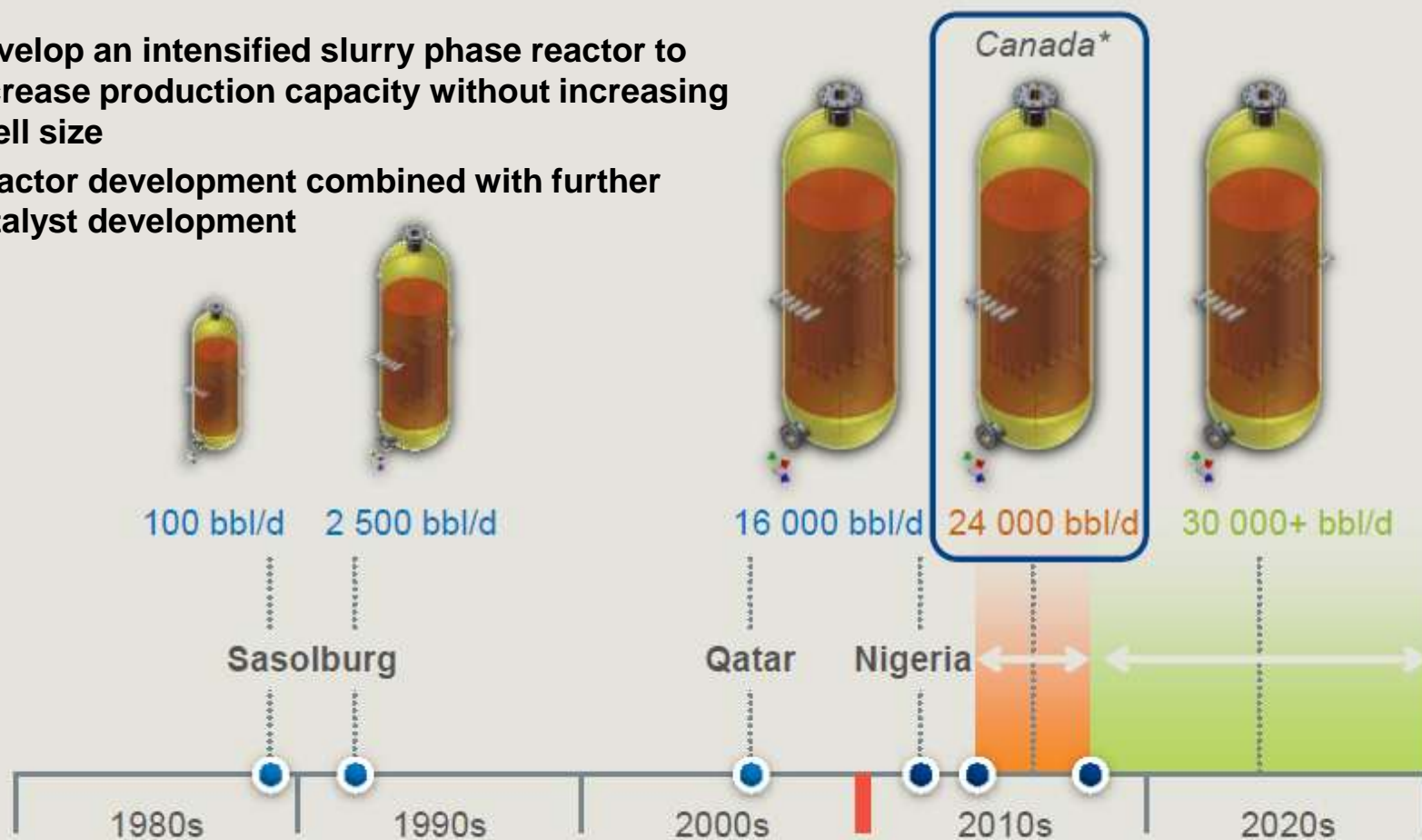
FT Reactor Developments

Reactor Intensification

SASOL
reaching new frontiers



- Develop an intensified slurry phase reactor to increase production capacity without increasing shell size
- Reactor development combined with further catalyst development



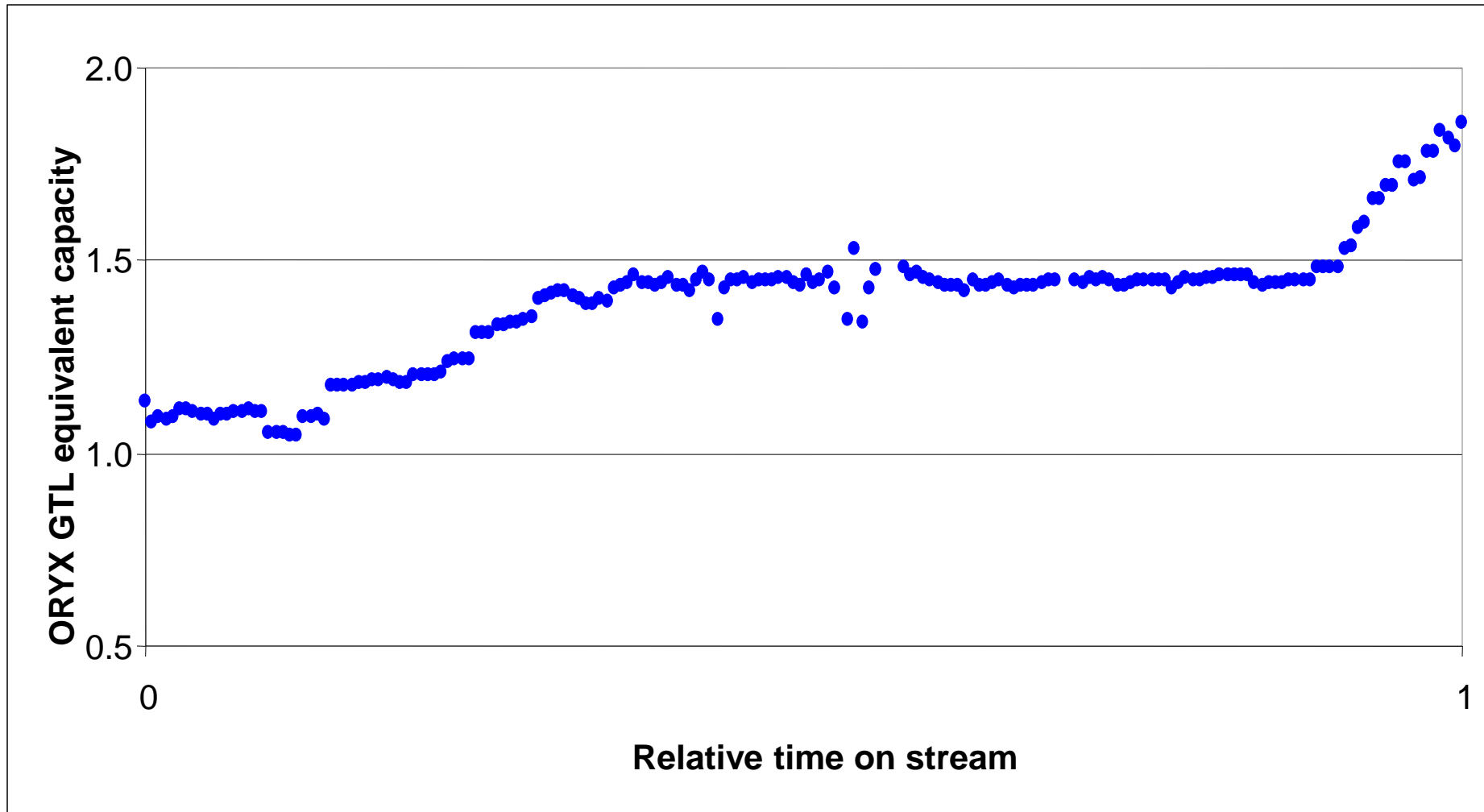
Enhanced performance through increased volumetric conversion efficiency

* Feasibility study

FT Reactor Developments

Reactor intensification demonstration data

SASOL
reaching new frontiers



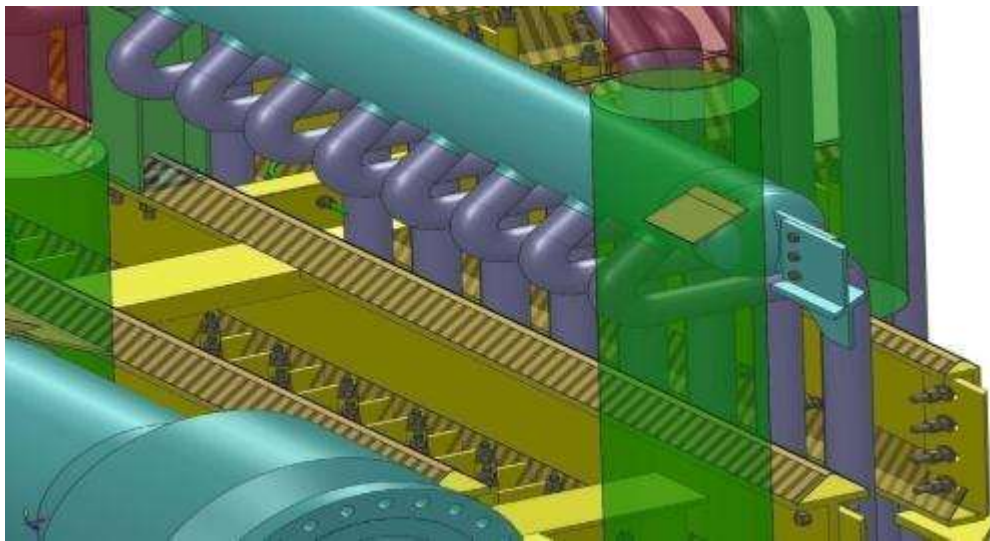
FT Reactor Developments

Intensified reactor engineering

SASOL
reaching new frontiers



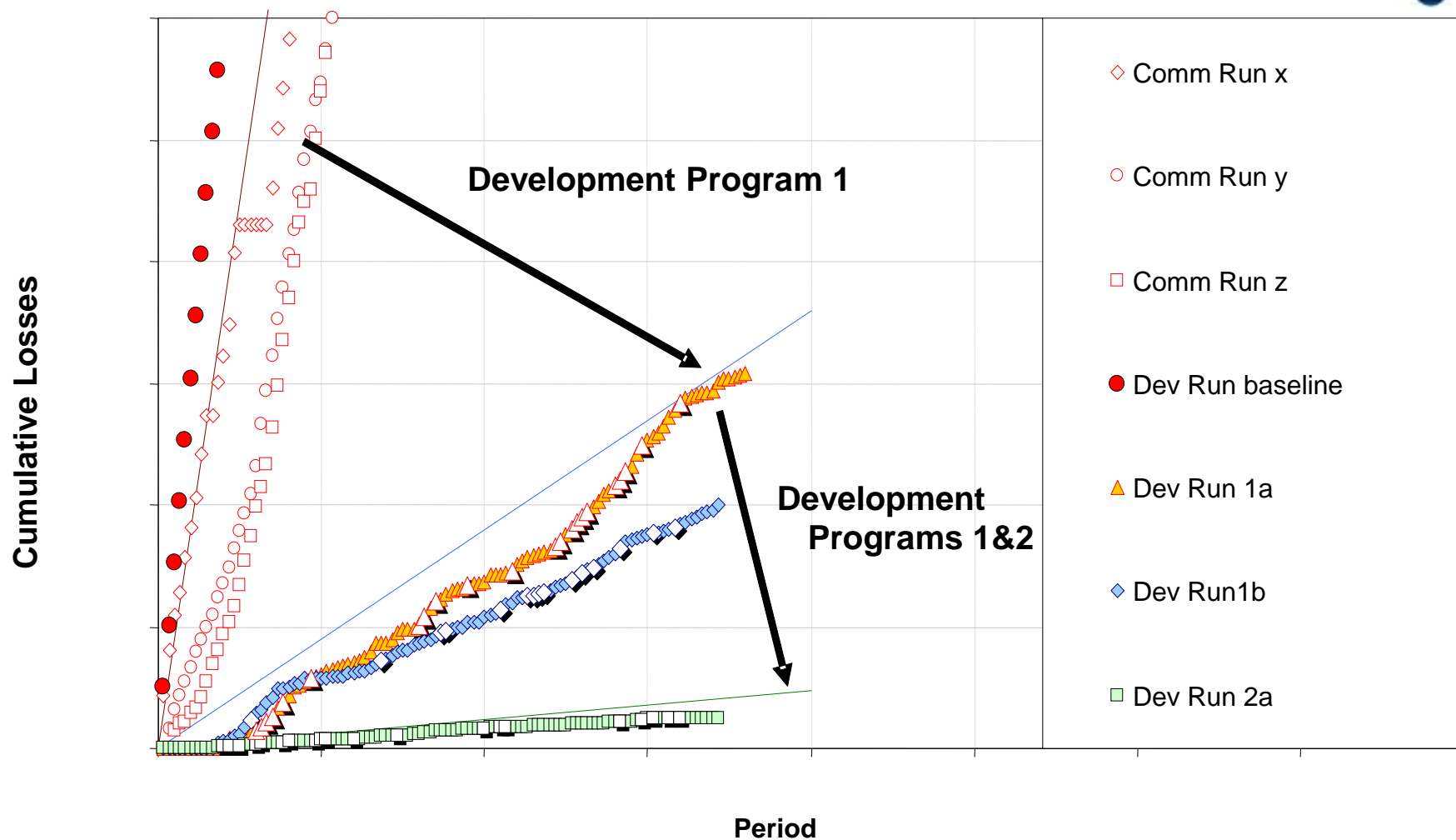
- Concept demonstrated on a semi-commercial scale
- Conceptual study completed
- Full 3D model developed
 - Checked manufacturability
 - Clashes
- Generic mechanical checks done
- Process checks completed
- Reactor now ready to be offered commercially
- Reactor Capital saving of approximately 25% per bbl



FT Catalyst and Reactor Developments

Catalyst losses: Catalyst and Process improvements

sasol
reaching new frontiers





1. **GTL Process and Technology Partners**

2. **Reforming and Air Separation**

3. **Fischer-Tropsch Catalyst and Reactor**

4. **Environmental and Product**

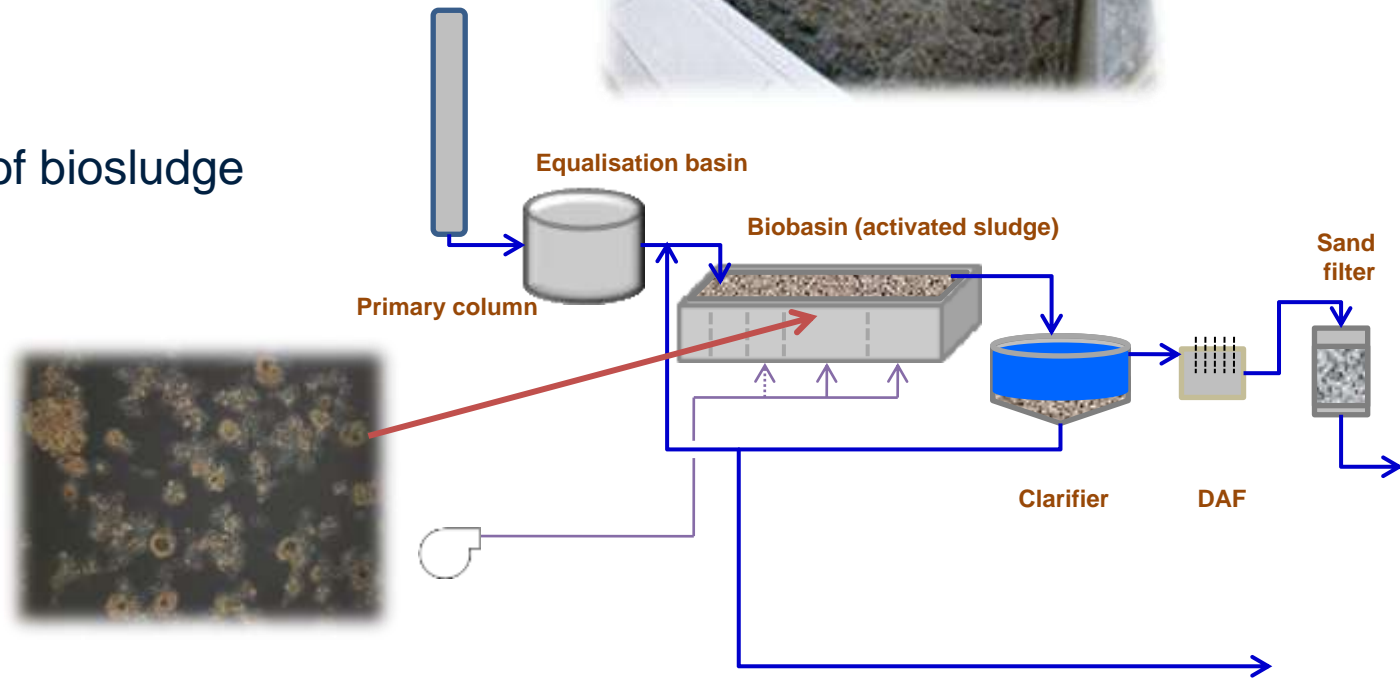
Environmental

Yesterday – activated sludge

SASOL
reaching new frontiers



- Currently installed at ORYX GTL (2006)
- Not a ZLED design
- Robust
- Large amount of biosludge produced
- Large footprint



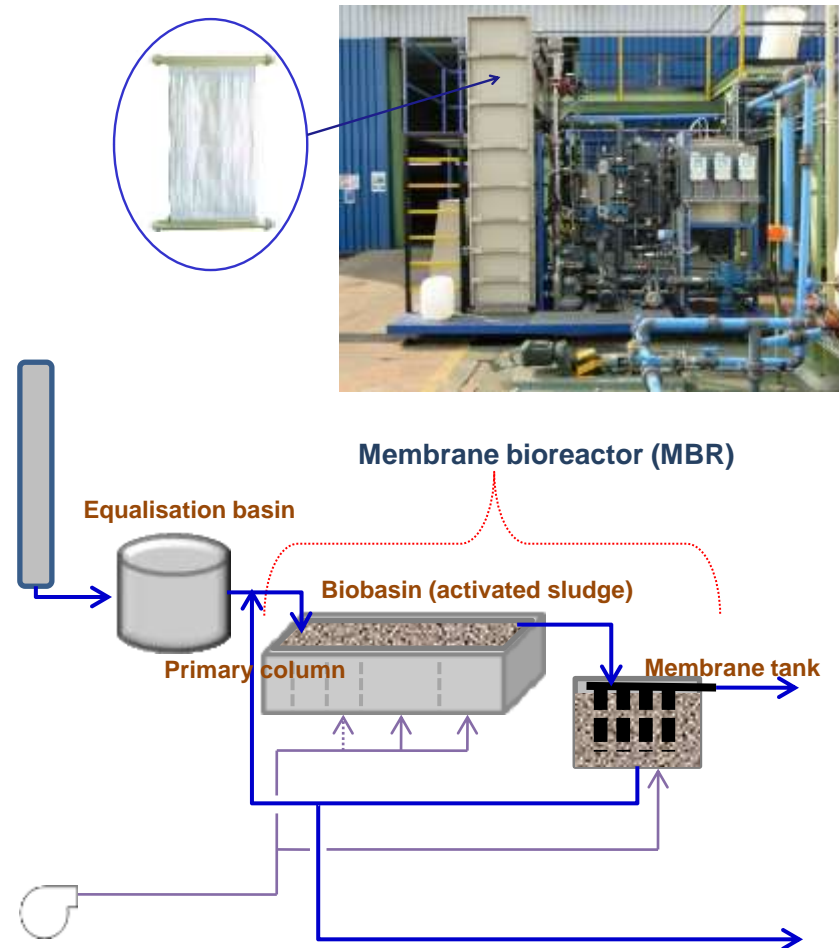
Environmental

Today – Membrane bioreactor (MBR) process

SASOL
reaching new frontiers



- Current GTL effluent treatment technology offering
- High quality produced water enables ZLED design
- 5-10% less biosludge produced
- 30-40% footprint reduction
- 20-30% cost reduction



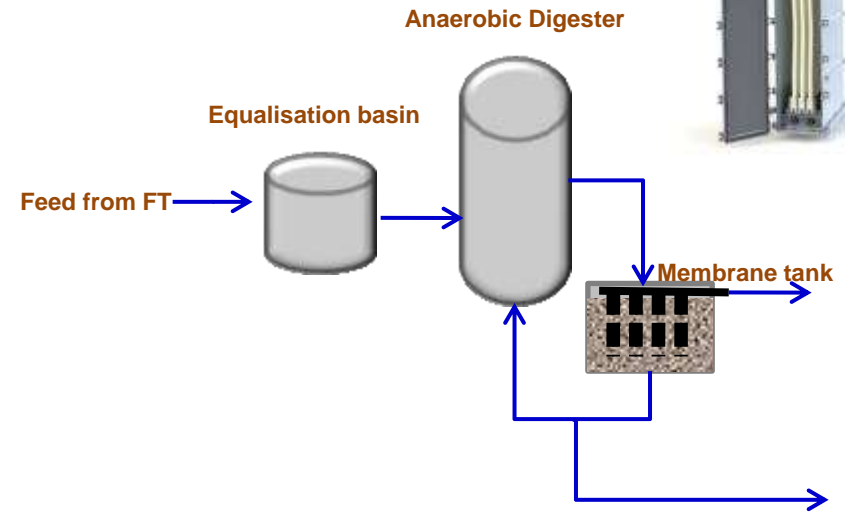
Environmental

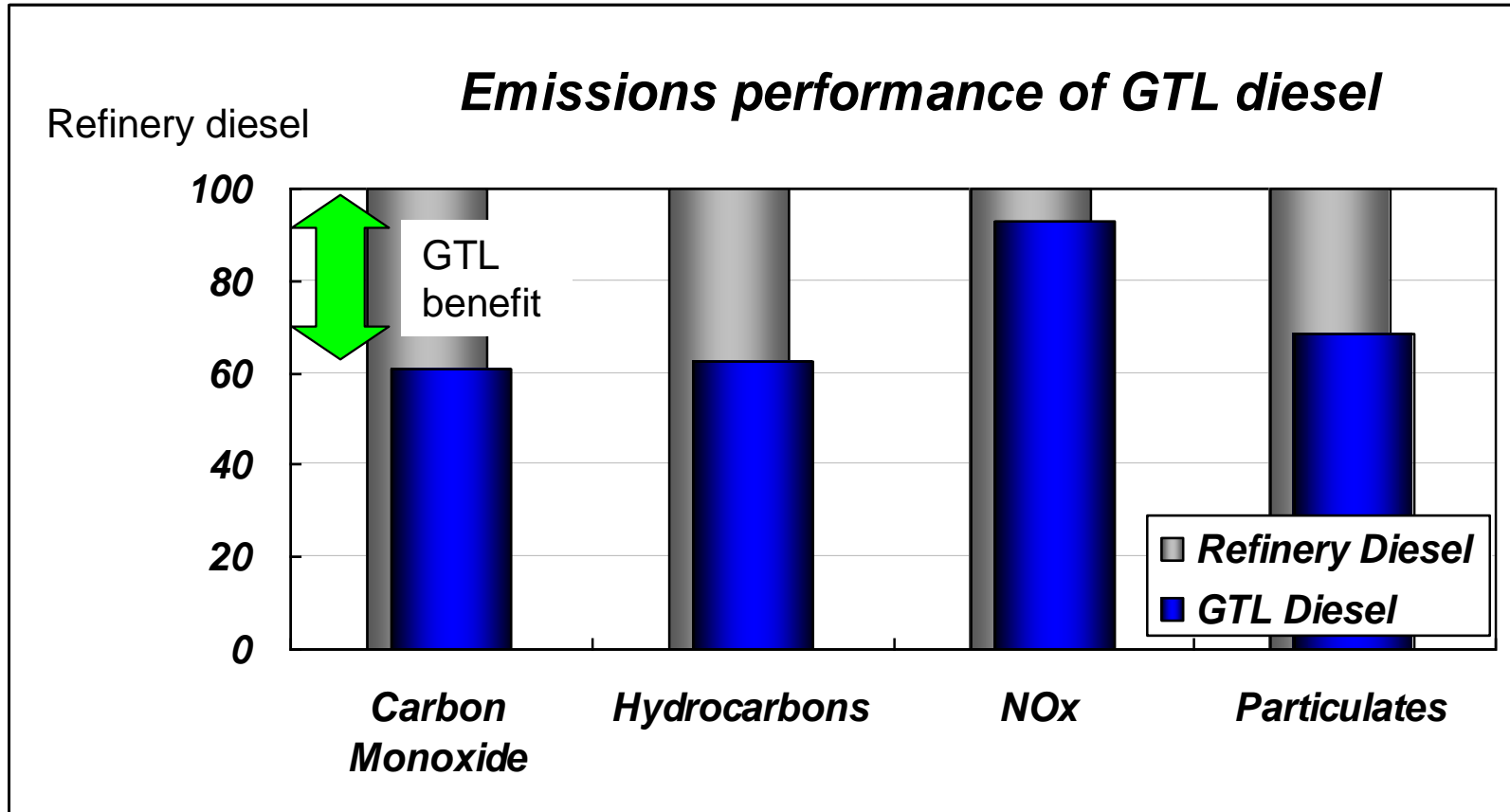
Tomorrow – Anaerobic membrane bioreactor (AnMBR) process

SASOL
reaching new frontiers



- Future GTL effluent treatment technology
- Feed directly from FT
- Further footprint reduction
- 20-30% further cost reduction
- Large energy reduction in removing primary column
- Organics in feed converted to biogas and re-used





- Substantial benefits even against Euro V type fuels
- Benefits also realised in blends

Ref: STFR

“Greenhouse Gas Emission Evaluation of the GTL Pathway”
American Chemical Society Journal Environmental Science & Technology

Product

Increased value to product slate

SASOL
reaching new frontiers



- Increase diesel yields
 - Alternative Product Work-up technology suppliers
 - Improved hydroprocessing catalysts/technology
 - Oligomerisation/Alkylation technologies

- Jet Fuel / Kerosene
 - Technology available

- Wax Extraction / Chemicals / Base Oils – Value Adds
 - Suite of technologies available – require appropriate business opportunity



🌟 Sasol is well positioned, with our partners in

- Technology Development
- Optimized Operating Facilities
- Business Development

to secure sustained increased in the value of
commercializing GTL

SASOL
reaching new frontiers



Sven Godorr
Office: +27 11 344 0045
sven.godorr@sasol.com
www.sasol.com