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SASOL



Fischer-Tropsch (FT) and associated product upgrading by hydrocracking as a key process for sustainable aviation fuels



Slides presented at Jetscreen,
Brussels

26 November 2019

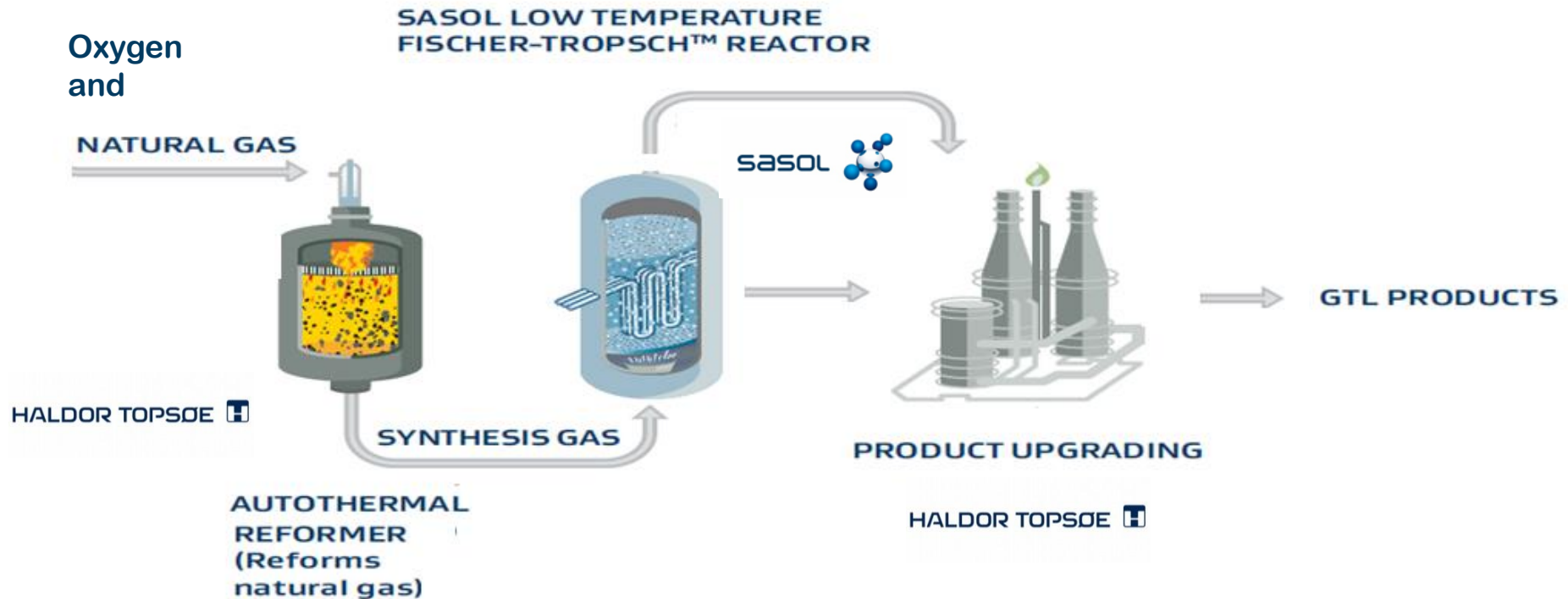
Durations (~20 mins)

Fischer-Tropsch (FT) is at the heart of the Sasol Processes

The GTL flow scheme



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Sasol has more than 50 years in integrating and developing FT technologies in GTL and CTL
Haldor Topsoe has been involved in synthesis gas generation for FT since the 90's

The GTL commercial reference

Sasol and Haldor Topsoe technologies successfully commercially used to generate FT products

- ORYXGTL ~ 34000 bbl/day
- EGTL ~ 34000 bbl/day
- UzGTL ~ 37500 bbl/day under construction

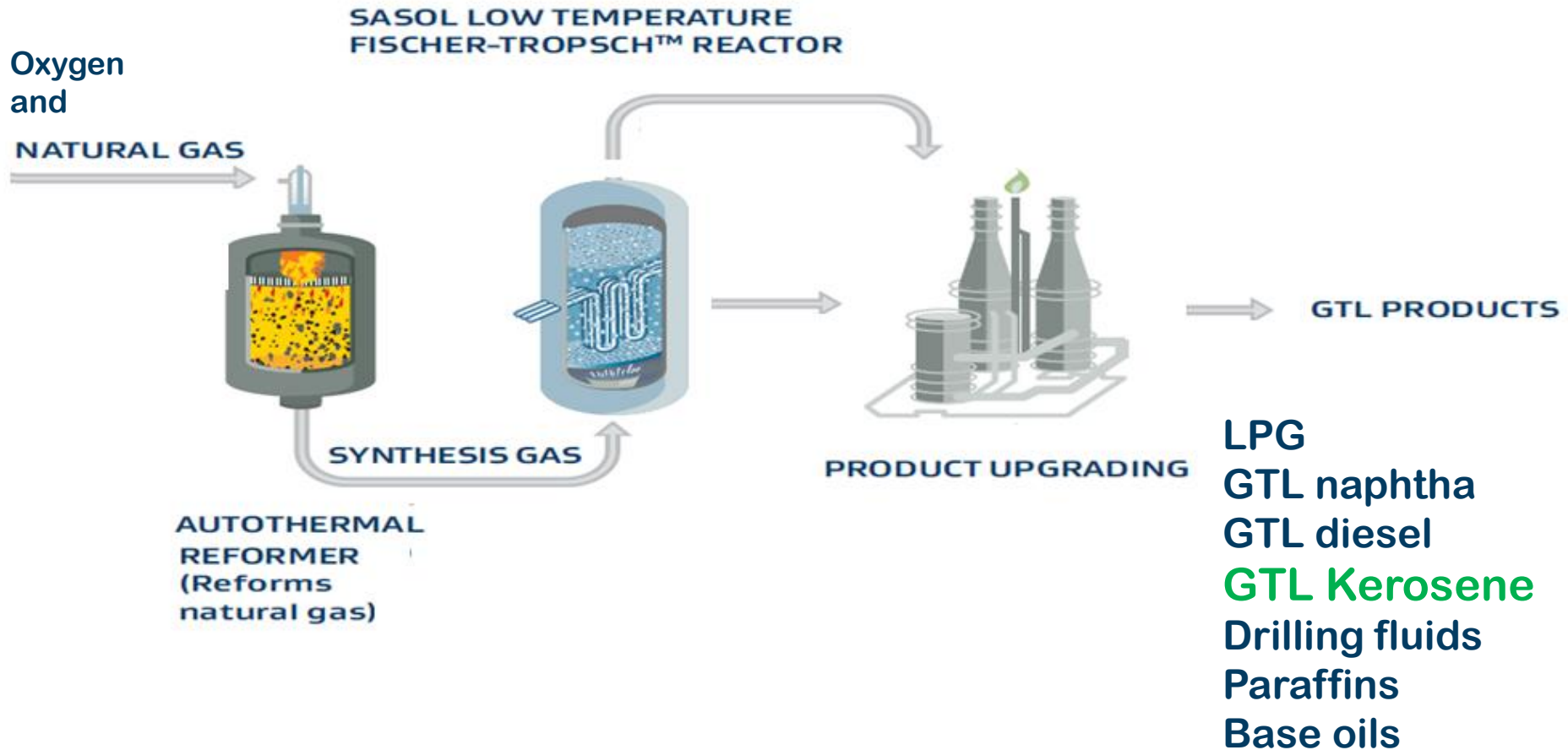


Images courtesy of ORYX GTL

Potential products from a Fischer-Tropsch (FT) based process



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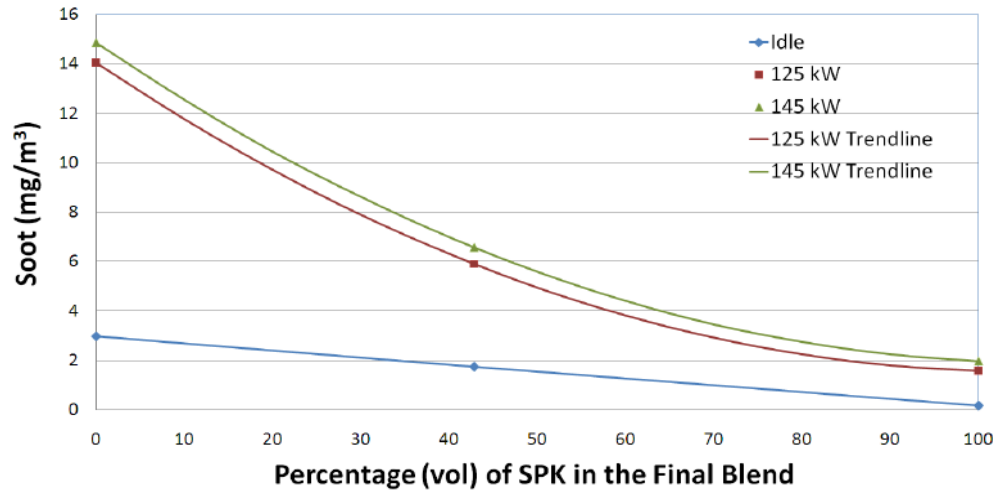


Benefits of Synthetic Paraffinic Kerosene (SPK) - 1



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Soot Emissions vs. SPK Concentration



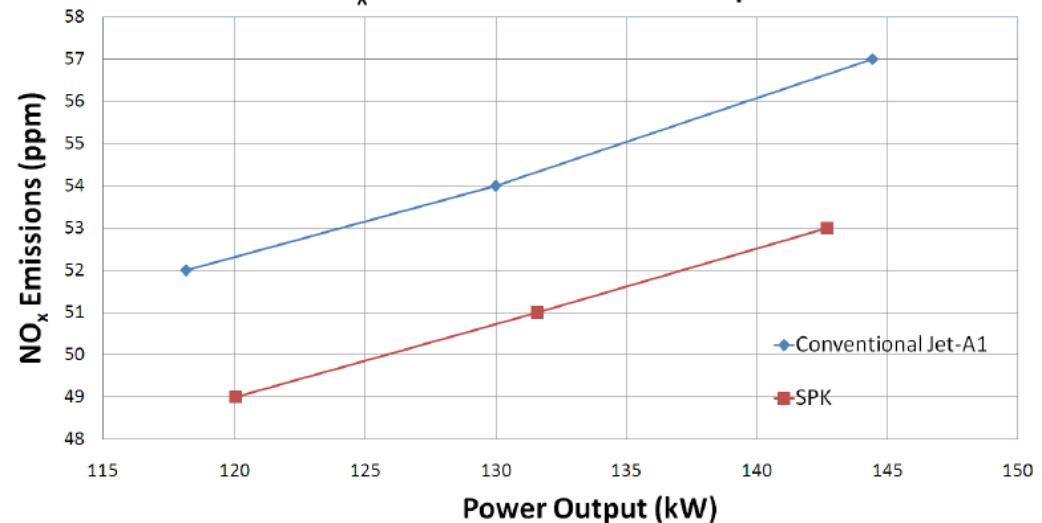
Emissions benefits:

High H/C ratio and very low levels of sulphur and aromatics ensure a more efficient and cleaner-burning combustion environment



T63
Test
Engine

NO_x Emissions vs. Power Output

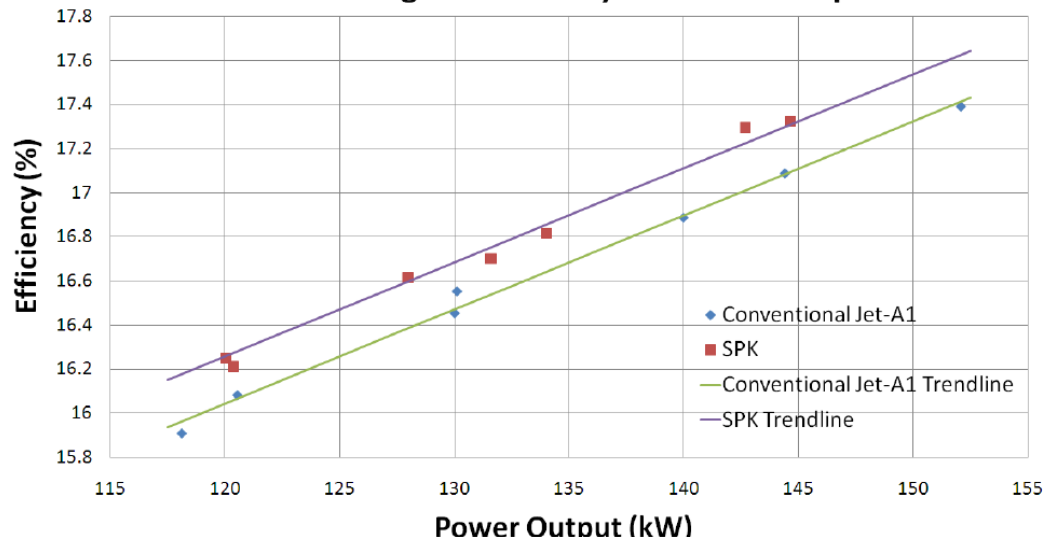


Benefits of Synthetic Paraffinic Kerosene (SPK) - 2



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Overall Engine Efficiency vs. Power Output



Data taken from Bester & Yates, GT 2009 - 6033



Jet Fuel Thermal Oxidation Tester

Additional benefits:

High H/C ratio ensures a more efficient and cleaner-burning combustion environment – also observed reduction in contrail formation (ECLIF)

*High **thermal** stability as shown by JFTOT break points*

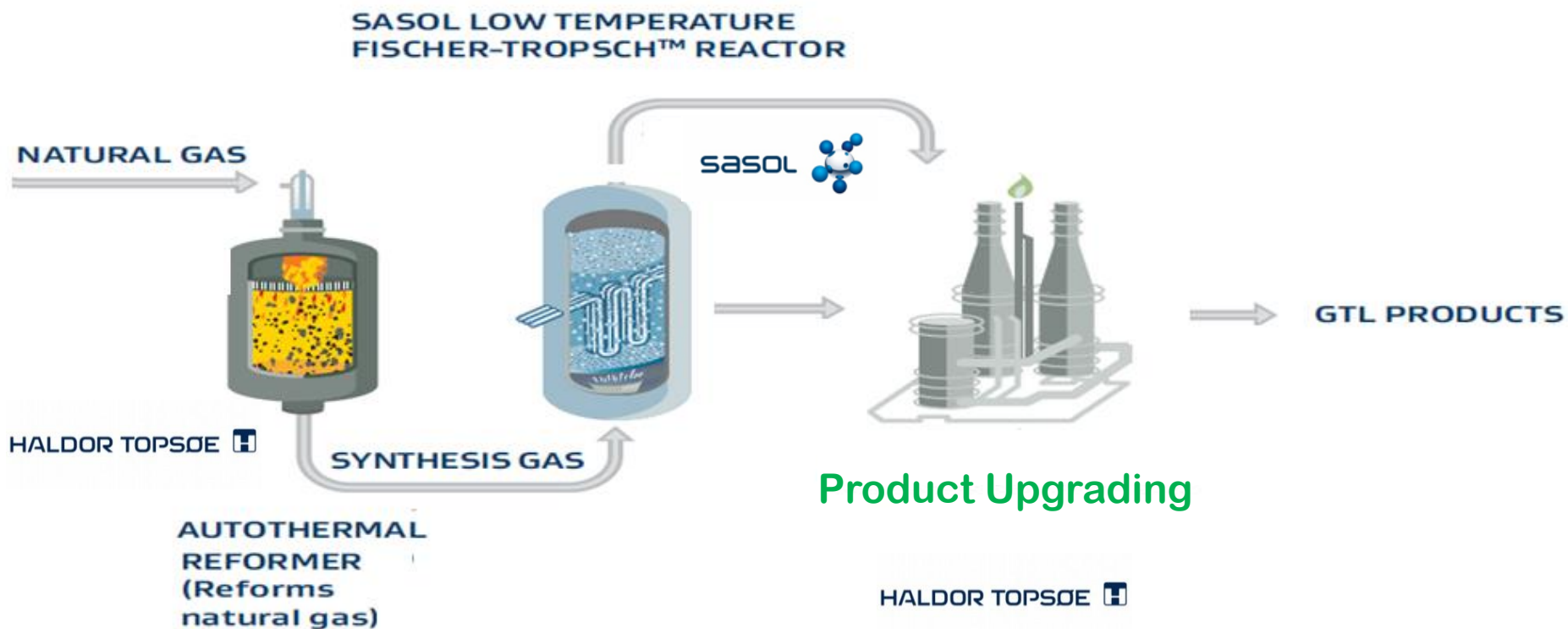


Product upgrading

What treatment is necessary to obtain Kerosene from FT derived material



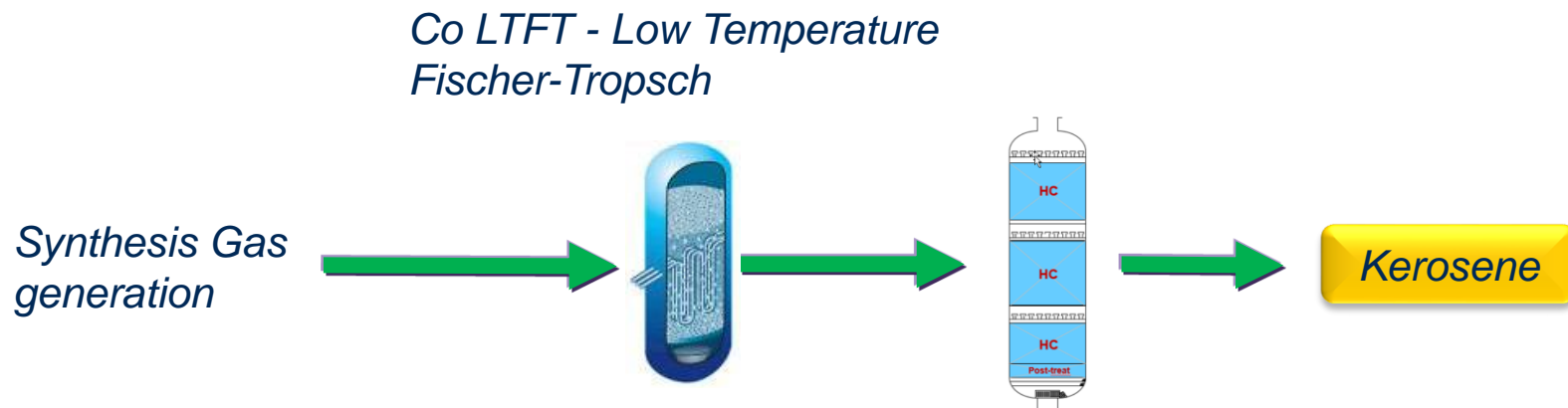
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Product upgrading

Topsoe hydroprocessing technologies for renewable jet

- FT upgrader technology for jet from
 - Natural gas
 - Municipal waste
 - Biomass/biogas
- In 2011, SPK produced with Topsoe HC technology was successfully used in a commercial flight
- Hydroflex™ technology for renewable jet
 - Feedstock flexibility:
 - Paper mill by-products (tall oil)
 - Vegetable oils (soy oil, rapeseed oil, used cooking oils)
 - Animal fats
 - Wood liquefaction products
 - Feedstock availability may be limited in certain areas



Product upgrading

Renewable jet production

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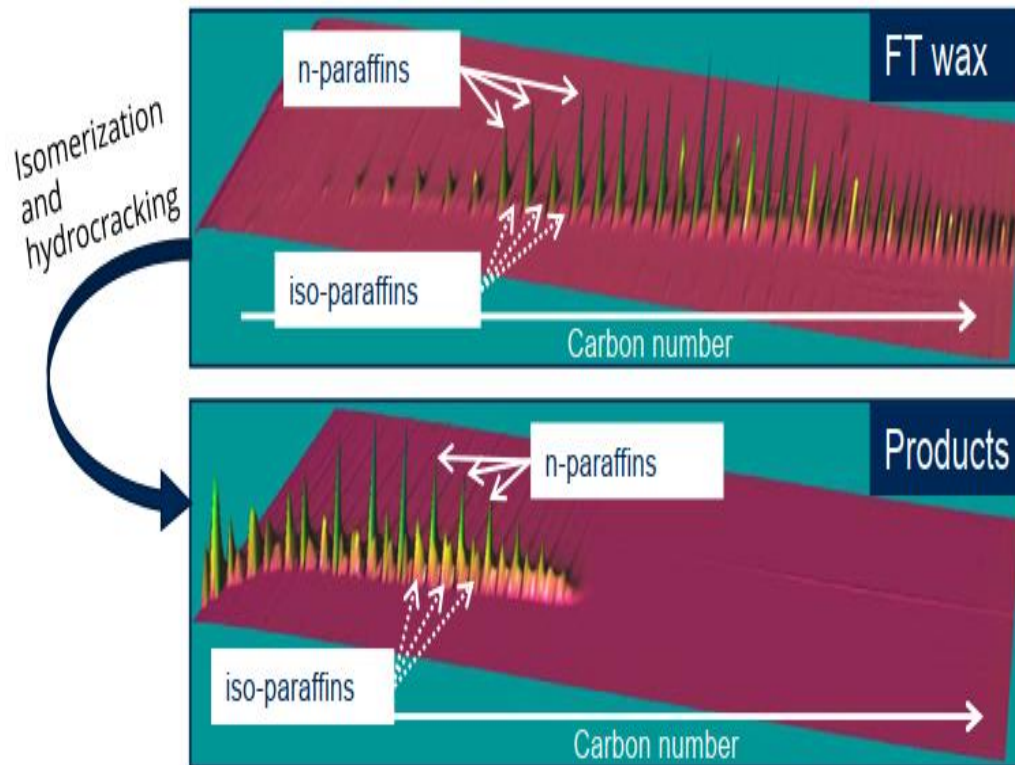


FT / Renewable produced jet feedstock consists of n-paraffins / triglycerides

Increased H₂ consumption

Critical product specifications

- Freeze point (max -40°C)
 - isomerization of n-paraffins
- End point reduction (max 300°C)
 - cracking of heavy molecules
 - oxygen removal
- Aromatics (max 0.5 wt.% in SPK)
 - formed on cracking catalyst
- Final jet blend aromatics:
 - min 8 vol%

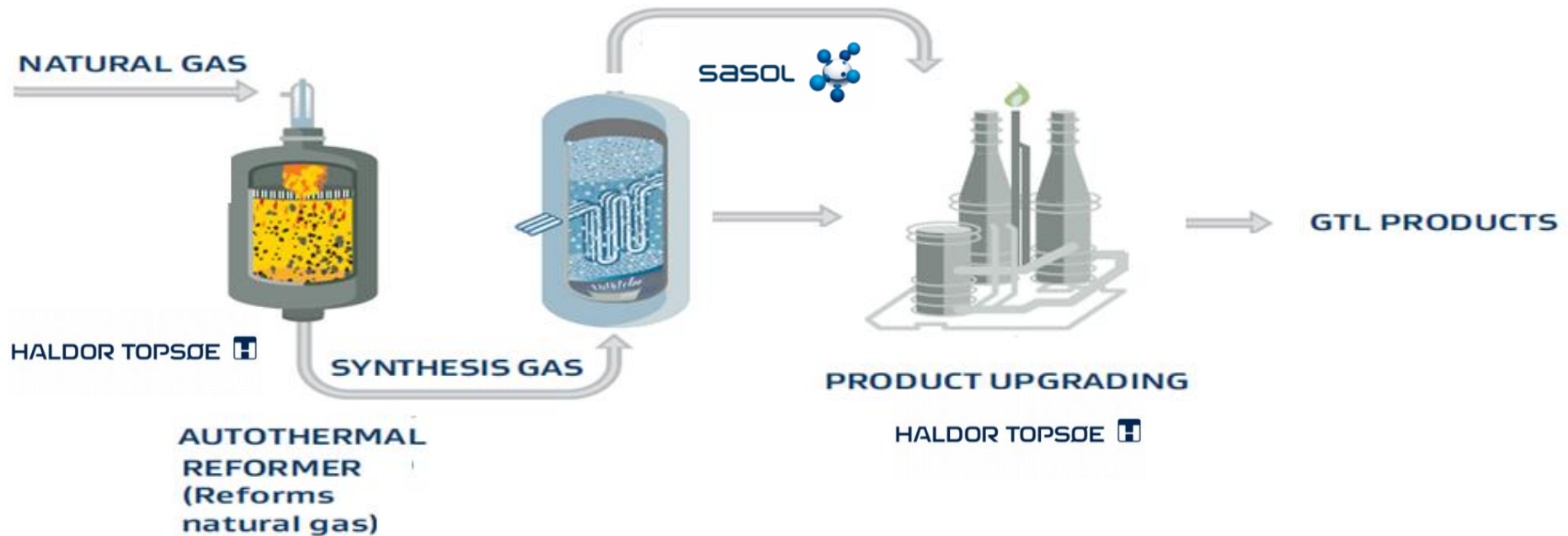


Fischer-Tropsch

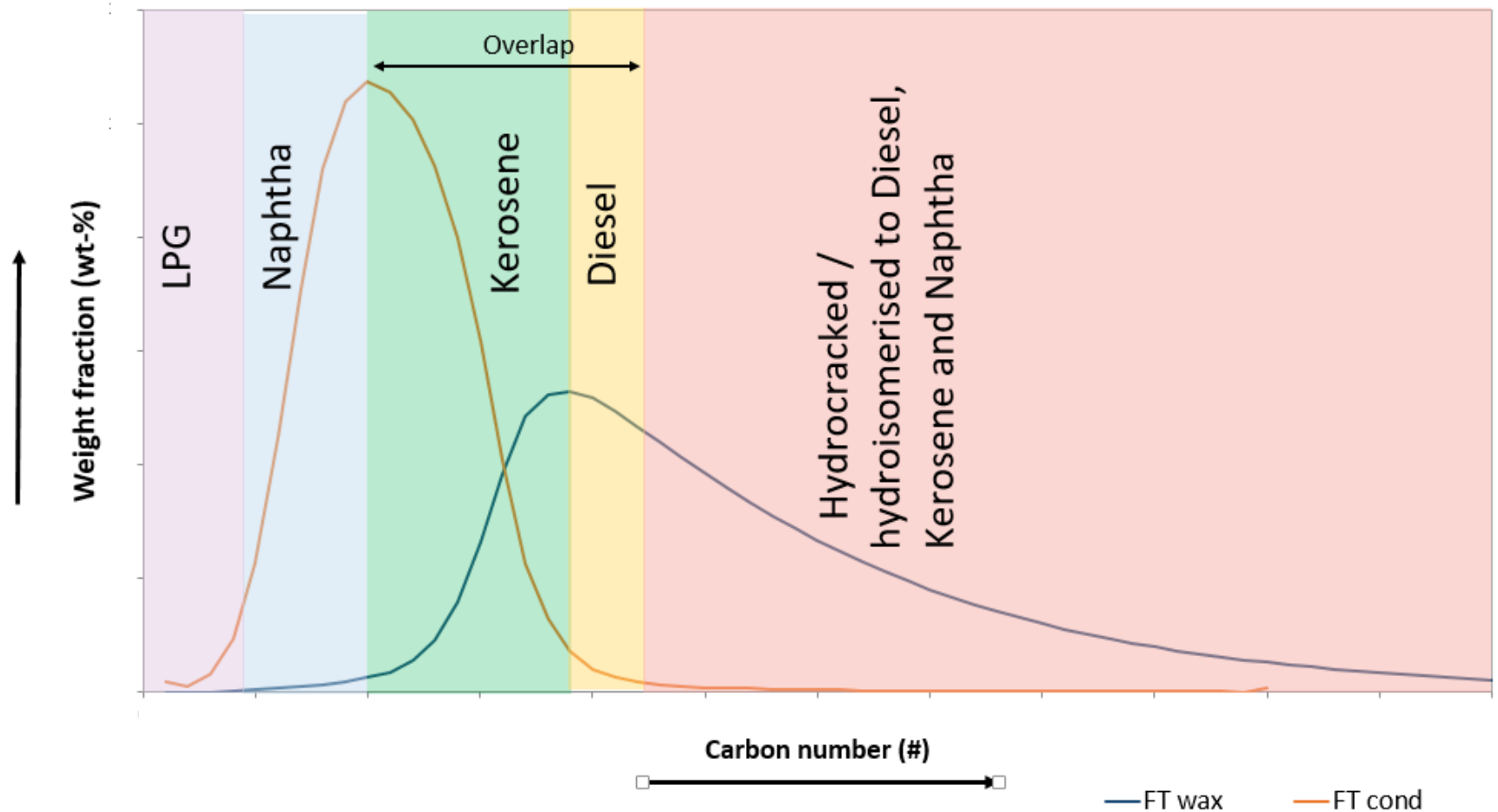


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Low Temperature Fischer-Tropsch™ Process



Products from the Low Temperature Fischer-Tropsch™ Reactor and straight run destination



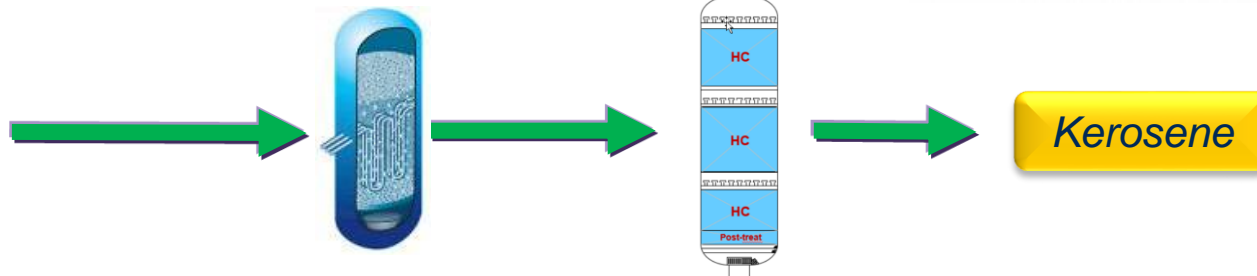
Sasol Low Temperature Fischer Tropsch (LTFT)TM Process



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Synthesis Gas can originate from multiple potential feedstocks

Co LTFT - Low Temperature Fischer-Tropsch



- Green Hydrogen
- CO₂
- Refuse gasification
- Biomass gasification
- Solar reforming
- Electric reforming

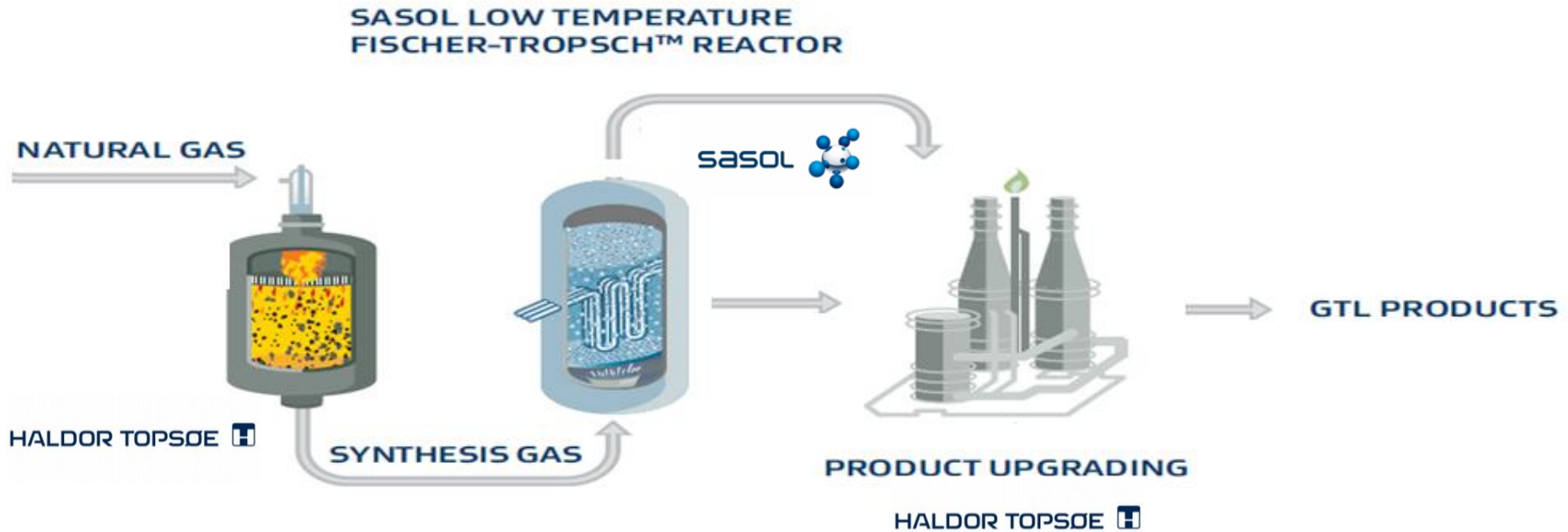
Sasol's FT technology can process synthesis gas generated from multiple sources if the syngas is

- sufficiently low in poisons, some cases may require cleanup steps
- In the appropriate H₂/CO ratio range, some cases may require adjustment

Synthesis gas generation



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Synthesis gas
generation

Topsoe eSMR technology

- Novel electrical steam methane reforming technology
- Significant power consumption reduction vs. electrolysis

Topsoe Re-Shift™ technology

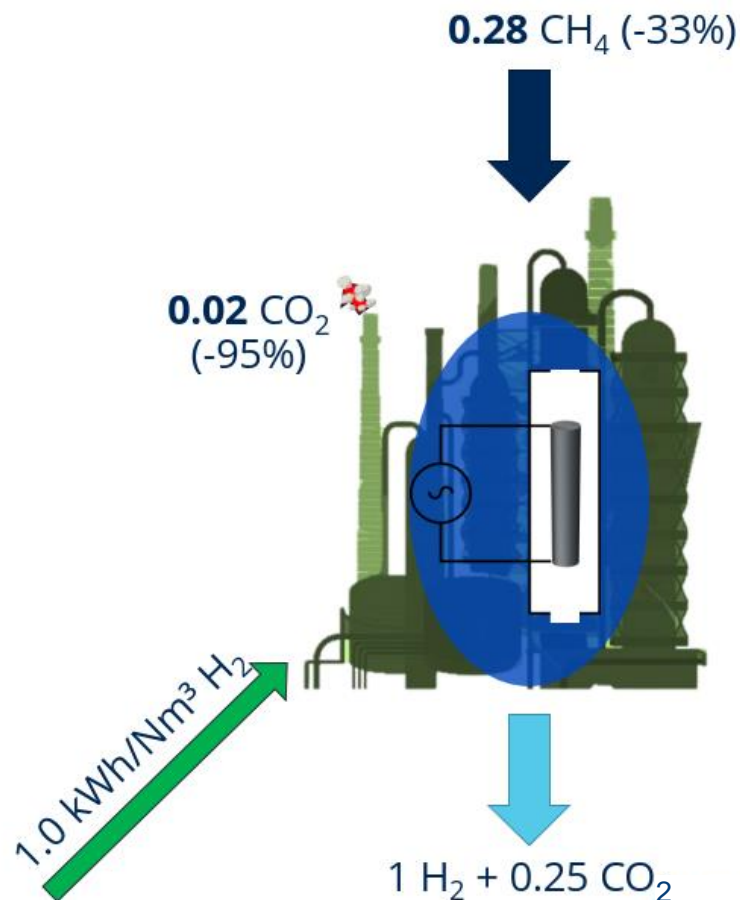
- CO₂ reforming to CO rich syngas



Novel green syngas and H₂ generation for FT technology and product upgrading

eSMR demonstration plant employed to produce Biogas to MeOH (DK)

Electric reformer



Together Sasol and Haldor Topsoe can supply technologies to produce kerosene from a multitude of feedstocks



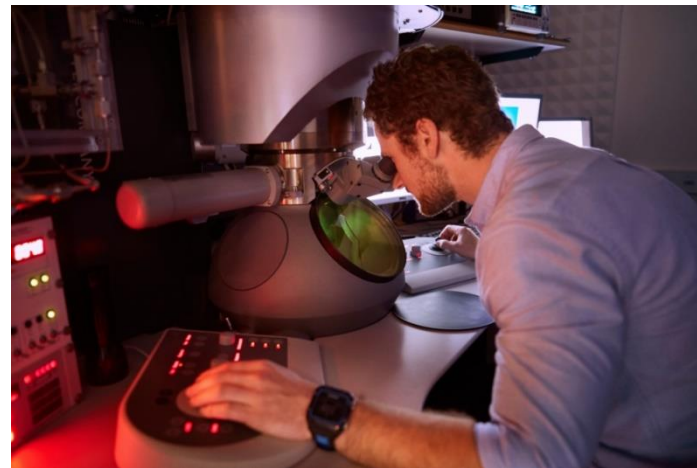
Low Temperature Fischer-Tropsch™ Process



- Sasol and Haldor Topsoe have extensive expertise in catalytic systems and supply catalyst into developing technology spaces
 - Syngas generation (Syncor™, steam reforming) by Haldor Topsoe
 - Hydrogen production (Syncor™, steam reforming) by Haldor Topsoe
 - Fischer Tropsch (Low Temperature) by Sasol
 - Refining including refining of biofeedstocks (Hydrocracking, Hydroflex™) by Haldor Topsoe



Sasol LTFT microreactors for catalyst testing



TEM microscope at Topsoe R&D for in-situ studies

Questions ?

GTL Kerosene

Sasol history with synthetic aviation fuel



- **Synthetic aviation fuels have been a feature of South African aviation for many years in terms of a performance and reduced emissions**
 - GTL kerosene has the potential to surpass anything so far achieved
 - GTL kerosene has been approved for use up to 50% as blend stock



- In September 2010, the world's first commercial flight using Sasol's fully synthetic jet fuel took to the sky. A Boeing 737 flew from Lanseria, Gauteng to the Africa Aerospace and Defence expo at Ysterplaat, Western Cape and back to Lanseria
- Sasol was the first company to:
 - Gain international approval for semi-synthetic jet fuel
 - Supply semi-synthetic jet fuel for commercial use
 - Gain approval for fully synthetic jet fuel

The first passenger flight in September 2010 using fully qualified and endorsed Sasol synthetic jet fuel