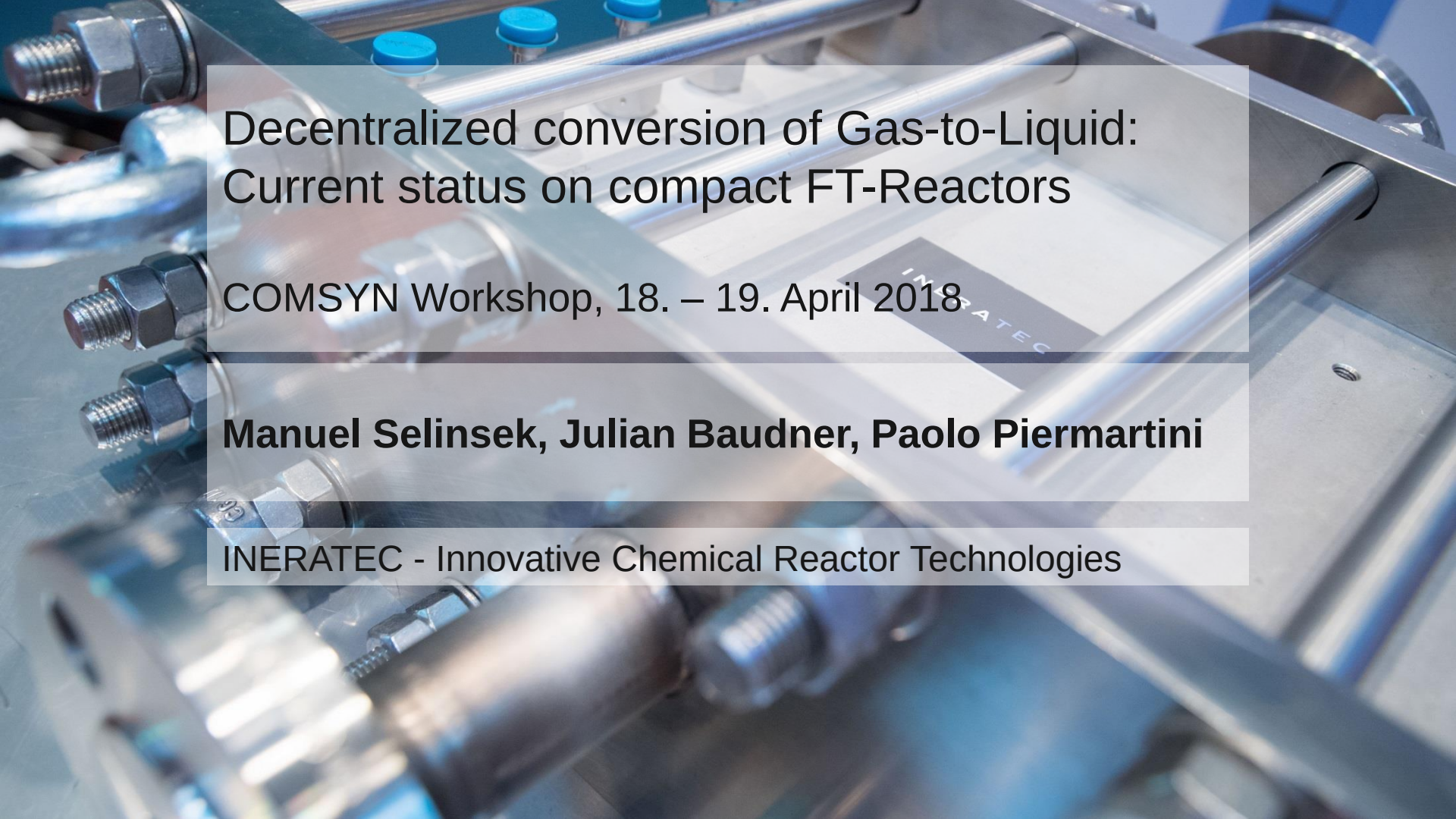




Decentralized conversion of Gas-to-Liquid: Current status on compact FT-Reactors

COMSYN Workshop, 18. – 19. April 2018

Manuel Selinsek, Julian Baudner, Paolo Piermartini

INERATEC - Innovative Chemical Reactor Technologies

Problem

We are Depending on Hydrocarbons Made from Oil and Gas



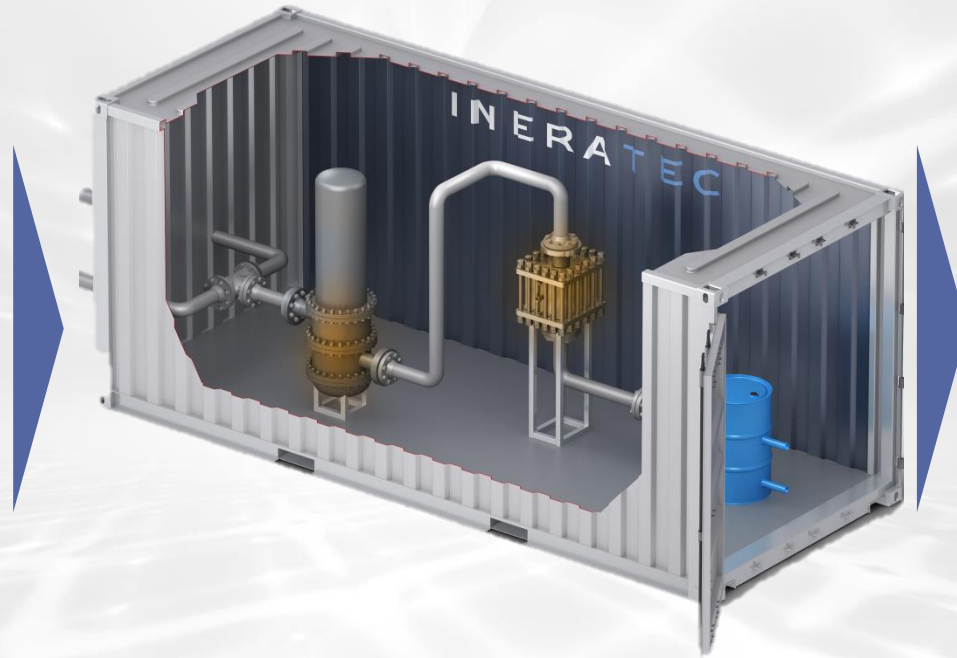
Technology

The Conventional Technology is not Suitable for Renewables



Power-to-X

Gas-to-X



Renewable
Fuels and Materials

Greenhouse Gas Recycling by INERATEC®

Technology

USP: Most Compact Chemical Reactor Technology in the World



Modular

Process simplification

Scalable

Load flexible

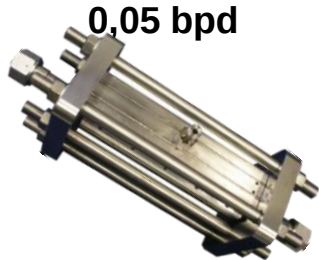
Technology

INERATEC FT Reactor Technology



0,0002 bpd

2011



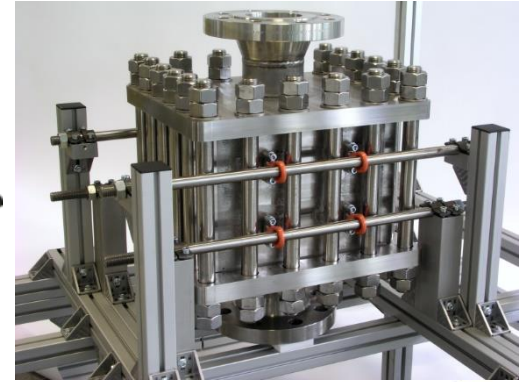
0,05 bpd

2014



0,2 bpd

2015



2 bpd

2018

	Catalytic activity (C ₅₊ per catalyst mass)	Reactor productivity (C ₅₊ per reactor weight)	Space time yield (C ₅₊ per reaction volume)
INERATEC®	2.1 g/gh	16.7 bpd/t	1785 kg/m ³ h
Velocys*	-	13 bpd/t	1600 kg/m ³ h
Oryx GTL – Sasol	-	8 bpd/t	20.6 kg/m ³ h
Literature Review	1.4 g/gh (Pat.) or 2 g/gh (Lit.)	-	-

S. LeViness, FT Product Manager, Presentation "Velocys Fischer-Tropsch Synthesis Technology – Comparison to Conventional FT Technologies", AIChE Spring Meeting, San Antonio, Texas/USA (30-Apr-2013)

"2012 Interim Results", Presentation to analysts of the Oxford Catalysts Group 2012, www.velocys.com

Business Model Engineering, Manufacturing and Sale of Turn-Key Chemical Plants



Engineering

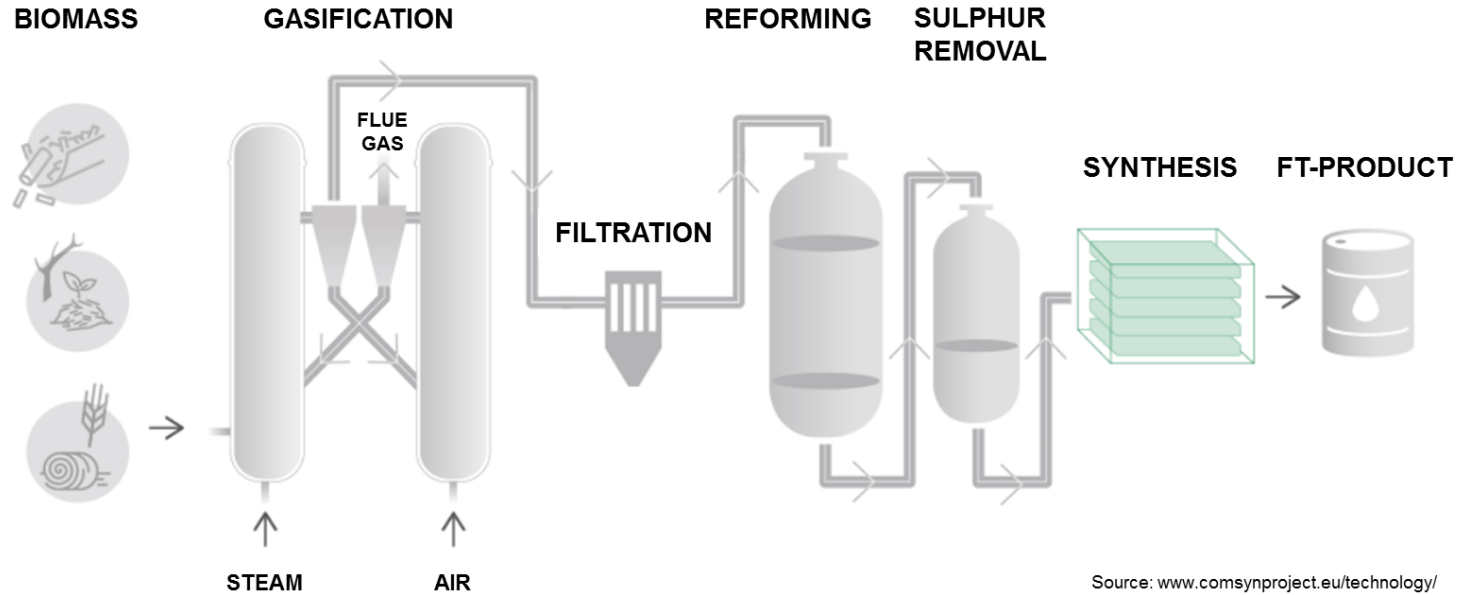


Plant construction



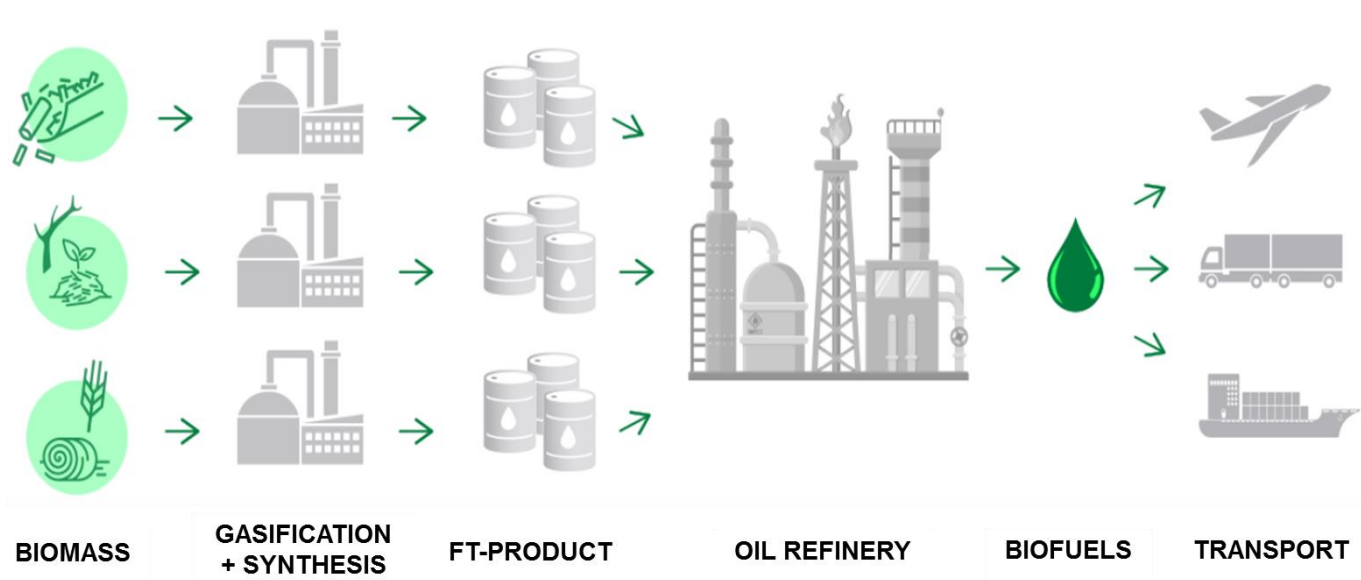
Commissioning & Services

Compact technology combining centralized and decentralized processes to develop competitive low carbon energy solutions



Source: www.comsynproject.eu/technology/

Compact technology combining centralized and decentralized processes to develop competitive low carbon energy solutions



Source: www.comsynproject.eu/project/

COMSYN Goals:

- Compact Gasification and Synthesis Process for Transport Fuels
- Production costs for transport fuels < 0,80€/l
- Capacity: 30 - 150 MW Feedstock Input, 10 - 50 kt/a FT-product (200 – 1000 bpd)

Main Objectives of the FT-Synthesis:

- Testing reactors with purified gas from gasification
- Optimizing the operating conditions for maximum paraffin yield
- Comparison of single and two-stage synthesis
- Design and establishing the manufacture process for reactor modules with 8 bpd size

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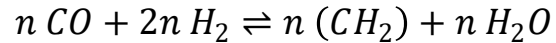
Main Objectives of the Synthesis Work Package:

- Testing reactors with purified gas from gasification
- Optimizing the operating conditions for maximum paraffin yield
- **Comparison of single and two-stage synthesis**
- Design and establishing the manufacture process for reactor modules with 8 bpd size

FT-Synthesis

- Exothermic, catalytic reaction (about 165 kJ/mol CO)
- $T = 210 - 240\text{ }^{\circ}\text{C}$
- $p = 15 - 30\text{ bar}$

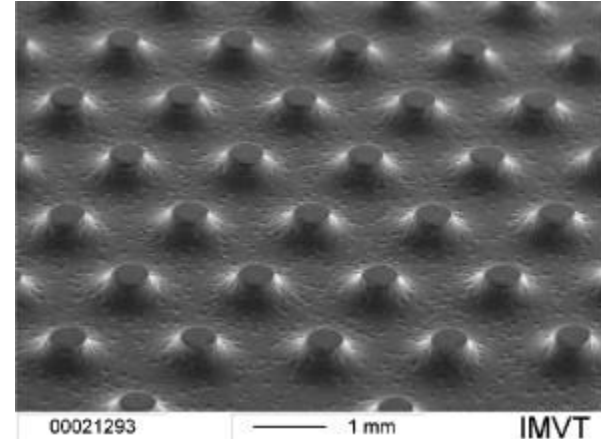
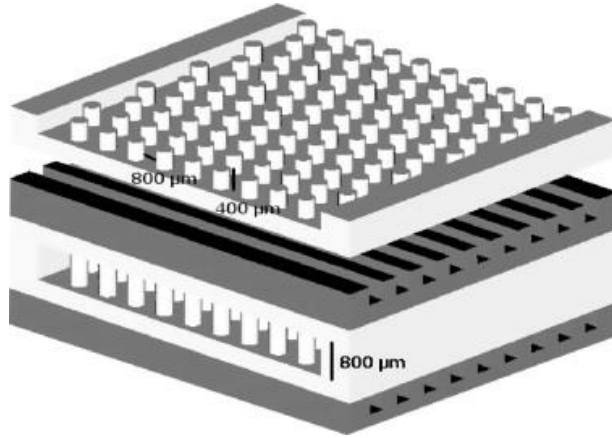
General reaction:



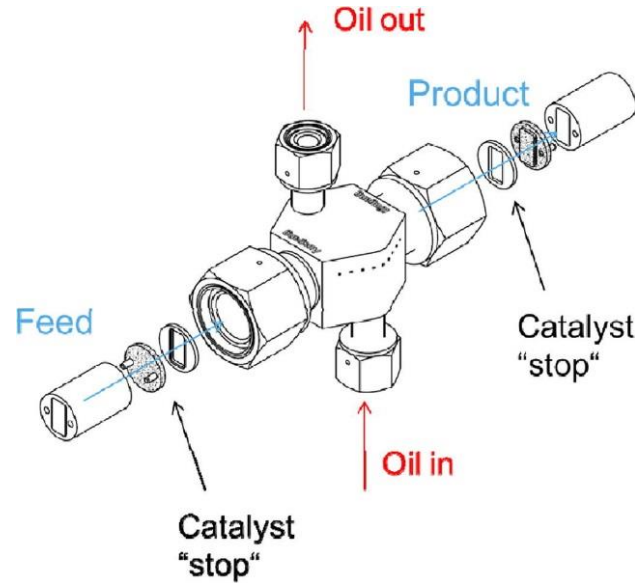
→ Predominantly saturated, aliphatic hydrocarbons ($\text{C}_1 - \text{C}_{60+}$ chains)



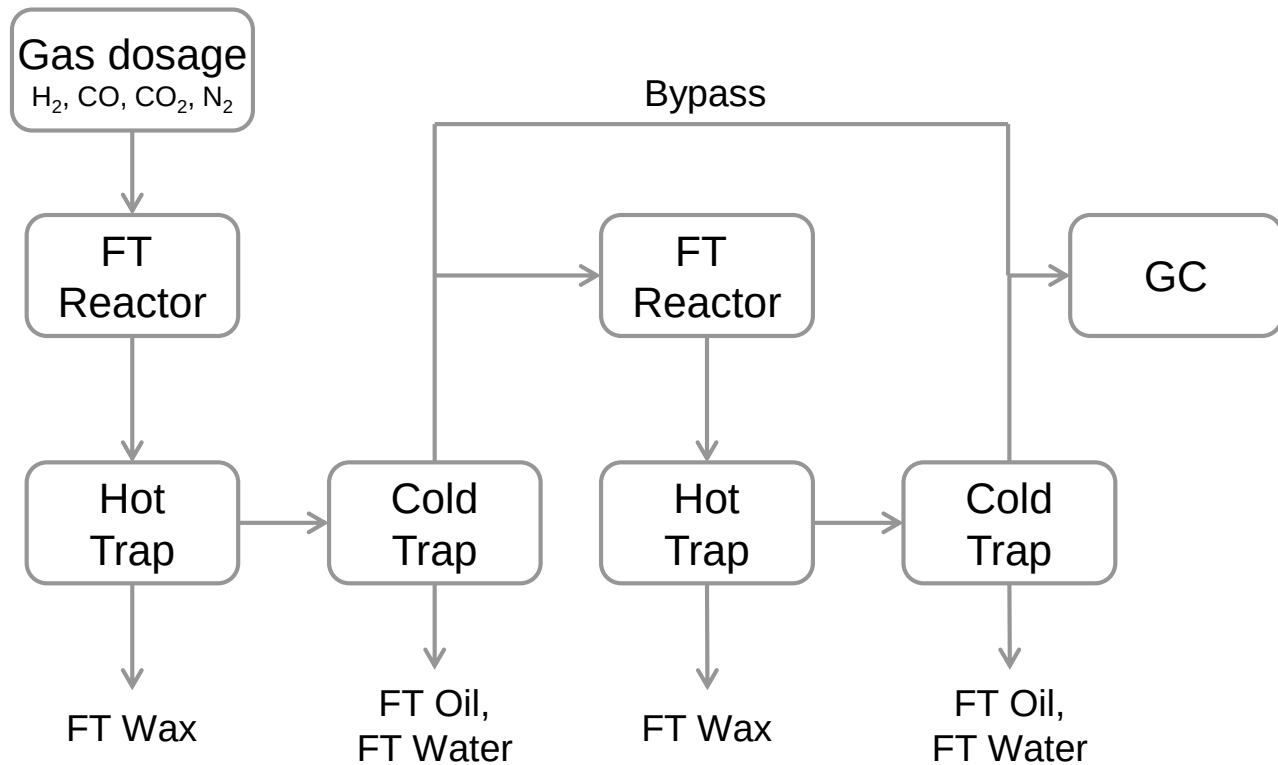
FT-Products: Liquid and Solid hydrocarbons.



Rune Myrstad, Sigrid Eri, Peter Pfeifer, Erling Rytter, Anders Holmen, Catalysis Today, Volume 147, 2009, Pages S301-S304, <https://doi.org/10.1016/j.cattod.2009.07.011>.



Paolo Piermartini, Tim Boeltken, Manuel Selinsek, Peter Pfeifer, Chemical Engineering Journal, Volume 313, 2017, Pages 328-335, <https://doi.org/10.1016/j.cej.2016.12.076>.



Picture of 2-Stage FT test rig for COMSYN

FT-Synthesis Comparison of single and two-stage synthesis: Initial Experiments

Operation Mode	$\dot{V}_{\text{total}}$ [Stdml/min]	y_{H_2}	y_{CO}	y_{CO_2}	y_{N_2}	H_2/CO	p_{total} [bar]	T [°C]
1-Stage	1226,7	63,5%	33,4%	0%	3,1%	1,9	20	220
1-Stage	613,4	63,5%	33,4%	0%	3,1%	1,9	20	220, 230, 240
2-Stage	1226,7	63,5%	33,4%	0%	3,1%	1,9	20	220, 230, 240

FT-Synthesis Comparison of single and two-stage synthesis: Initial Results

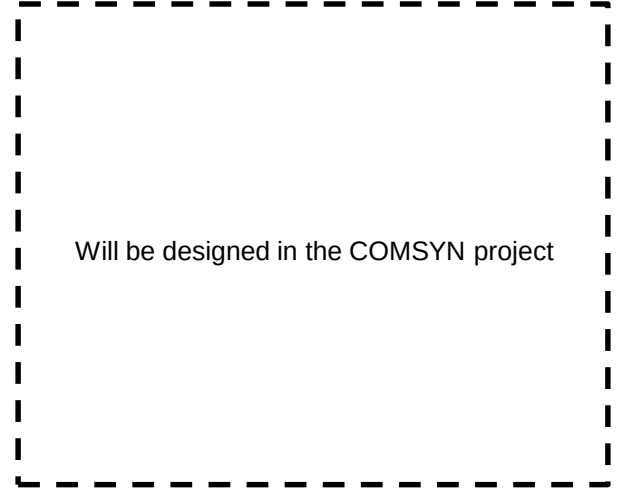
- Lab scale setup operational and functional
- Applying a 2nd stage leads to
 - Increased CO and H₂ conversion
- Intermediate product condensation leads to:
 - Changes in selectivity
 - Changed selectivity behavior over temperature



Lab Scale
0,0002 bpd



Pilot Scale
0,05 bpd



Production Scale
8 bpd

Thank you for your attention



INERATEC



wood.





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