TECHNOLOGY FACTSHEET

FISCHER-TROPSCH FUEL PRODUCTION

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Sector	Industry: Petrochemics
ETS / Non-ETS	ETS
Type of Technology	Production
Description	Mixing CO with H2 (provided from external sources) provides the syngas which can be used in a Fischer–Tropsch (FT) plant to produce FT synthetic fuels. The syngas is converted in the FT reactor into a mixture of hydrocarbons. The crude FT oil exists typically (e.g. Shell's Middle Distillates Synthesis) out of long chain waxy molecules and is subsequently upgraded by a hydro-isomerisation and hydrocracking step (mild conditions of temperature and pressure) and distillation to produce the desired, lighter products. Although the mixture of produced hydrocarbons may vary depending on the process and conditions, we here assume that the energy use and costs remain the same. As desired, the process produces either a high share of diesel (diesel mode) or kerosene (kerosene mode). This results for diesel mode in 60% (energy) diesel, 25% (energy) kerosene and 15% (energy) other oil products, and for kerosene mode in 25% diesel, 50% kerosene, and 25% other oil products. [Schmidt 2016a, Schmidt 2018, Ansorge]
TRL level 2020	TRL 9 The FT process is developed one century ago and applied at commercial scale ranging from 15000-260000 bbl/d. Typically the syngas is produced by natural gas reforming or the gasification of coal [Shell's Pearl GTL plant]. To start from CO2, RWGS (or another CO production route) is required (not integrated in this factsheet) to produce the CO. Such technology has been demonstrated, but not at full commercial scale (TRL 7). An alternative to produce syngas is by co-electrolysis of water and CO2 in high temperature electrolyzers, which is also a technology that is not fully mature (TRL 6). Here we only assess the FT reactor and upgrading, which is (starting from syngas) operated at full commercial scale, i.e. TRL 9. For small scale FT plant implementation some development may be required to adjust these to the upstream syngas production step.

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	PJ		10								
			0.17			-			570.00		
			Current			2030			2050		
Potential	EU	PJ	0.50			2,472			8,816		
			0.30	–	0.50	2,472	–	2,472	4,610	–	14,991
Market share	EU	%	-			16.59			64.25		
			-	–	-	16.59	–	16.59	39.46	–	86.15

Capacity utlization factor	1.00
Full-load running hours per year	8,322
Unit of Activity	PJ/year
Technical lifetime (years)	25
Progress ratio	0.90
Hourly profile	No
Explanation	The potential is very high if the full amount of hydrocarbon fuels currently used is considered. We depict the average projection of Siegemund et al. (2017), who made an estimate of the potentials for the European transport sector based on various assumptions. We assume that the process runs continuously (based on constant supply of H2 and CO). The progress ratio is derived from Detz (2018) (FT plant), which might be conservative as a smaller scale FT plant is a rather novel technology and may follow a different learning curve than conventional FT technology, especially if modular designs are developed integrated with rWGS/electrolysis.

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	mln. € / PJ	30.00			13.00			10.00		
		13.00	–	37.00	10.00	–	15.00	9.00	–	11.00
Other costs per year	mln. € / PJ	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / PJ	1.20			0.52			0.40		
		0.65	–	1.85	0.45	–	0.60	0.40	–	0.45
Variable costs per year	mln. € /	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Costs explanation	The capex for the FT plant (synthesis and upgrading processes) ranges between 14 and 53 Meuro/PJ fuel output for a 3 PJ capacity plant (9 studies), while it is 10-37 Meuro/PJ for a 10 PJ plant We selected a value of 30 Meuro/PJ for 2020. For a 10 PJ plant in 2030, the costs are projected in 3 studies to go down to 10-15 Meuro/PJ, while further reductions are expected for 2050: 9-11 Meuro/PJ (4 studies). We select 13 Meuro/PJ for 2030 and 10 Meuro/PJ for 2050. O&M ranges between 3-5% of which we selected 4% from the investment costs.

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Synthetic fuels	PJ	-1.00			-1.00			-1.00		
			-1.00	–	-1.00	-1.00	–	-1.00	-1.00	–	-1.00
	Electricity	PJ	0.02			0.02			0.02		
			0.02	–	0.02	0.02	–	0.02	0.02	–	0.02
	Hydrogen	PJ	0.91			0.91			0.91		
			0.79	–	0.92	0.91	–	0.91	0.91	–	0.91
	CO	PJ	0.53			0.53			0.53		
			0.46	–	0.53	0.53	–	0.53	0.53	–	0.53

Energy in- and Outputs explanation	The difference in energy and mass ratios between diesel, kerosene, and oil products is neglected because the error is small (typical LHV of these fuels is 43 MJ/kg) and the values depend on the exact composition of the synthetic hydrocarbon fuel produced by the chemical reaction. At diesel mode, the process produces 1 PJ of hydrocarbon products of which 0.6 PJ diesel, 0.25 PJ kerosene, and 0.15 PJ other oil products. At kerosene mode, the process produces 1 PJ of hydrocarbon products of which 0.25 PJ diesel, 0.50 PJ kerosene, and 0.25 PJ other oil products. We assume a carbon efficiency of 88% from CO to products for 2020. Although the carbon efficiency may slightly improve after development over time, we here assume it remains constant towards 2050.

MATERIAL FLOWS (OPTIONAL)

	Material	Unit	Current			2030			2050		
Material flows	Water	Mton	-0.03			-0.03			-0.03		
			-0.03	–	-0.03	-0.03	–	-0.03	-0.03	–	-0.03
	Heat produced	PJ	-0.33			-0.33			-0.33		
			-0.33	–	-0.33	-0.33	–	-0.33	-0.33	–	-0.33

Material flows explanation	The reaction between hydrogen and CO produces FT fuels, heat, and water. 2 mol H2 + 1 mol CO -> 1 mol ~CH2~ + 1 mol H2O. Besides 1 PJ of fuels, we assume that around 0.33 PJ of high grade heat can be produced by the exothermal process and combustion of waste products after extraction of internal heat use for upgrading and purification. Water is another byproduct, typically around 0.03 Mt/PJfuel of process water is produced.

EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)

	Substance	Unit	Current			2030			2050		
Emissions	CO2	Mton	-0.01			-0.01			-0.01		
			-0.01	–	-0.01	-0.01	–	-0.01	-0.01	–	-0.01
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Emissions explanation	The carbon conversion efficiency to fuels is 88%, the remaining 12% is converted into fuel that is not a FT fuel output (e.g. ethane/methane) and is used as purge gas and burned with air/oxygen to produce CO2 in a flue gas.

OTHER

Parameter	Unit	Current			2030			2050		
			-			-			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Explanation										

REFERENCES AND SOURCES

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