TECHNOLOGY FACTSHEET

METHANOL TO PROPYLENE PROCESS

Date of factsheet	13-9-2021
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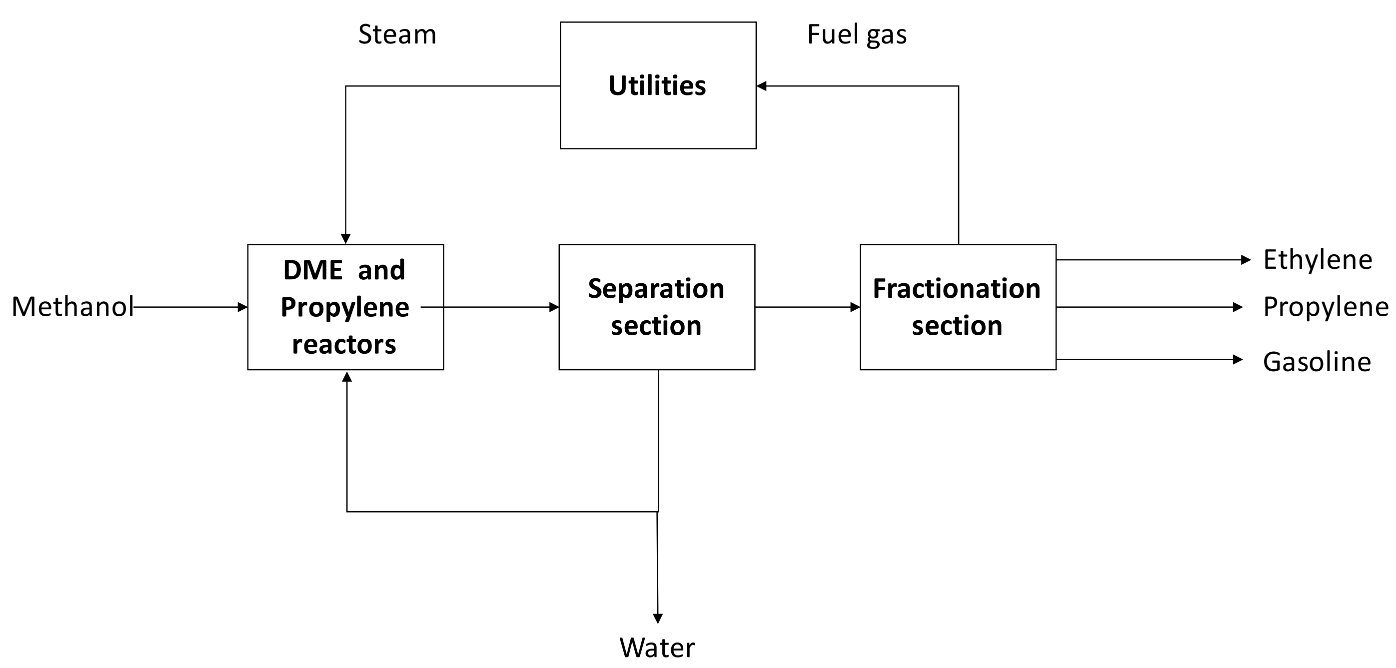
Sector	Industry: Petrochemicals
ETS / Non-ETS	ETS
Type of Technology	Alternative chemicals production
Description	The methanol-to-propylene (MTP) process converts methanol to propylene. Methanol is directed to a first reactor, known as dimethyl ether (DME) reactor, where methanol is converted to DME and water. This stream is fed to another reactor which converts the DME into propylene. This second reaction step takes place on a zeolite-based catalyst (ZSM-5) in a fixed bed reactor, which is different from the methanol-to-olefins (MTO) process. Also, the MTP® process can deliver LPG and gasoline as byproducts, which is not the case for the MTO technology. One important element of the MTP® process is the selective catalyst that is able to convert most of the methanol to propylene. Due to coke formation in the second reaction section, this step is normally executed in three reactors that operate in parallel. The coke formation results in carbon losses of less than 5%wt (Rothaemel, M. et al., 2016). One of them is kept in stand-by mode to remove the formed coke by introducing air. The first step reaction of DME production via methanol can be described by the following reaction: 2 CH3OH → CH3OCH3+ H2O The second step, the conversion of DME to mainly propylene, is described by the following reaction: 3 CH3OCH3 → 2 C3H6 + 3 H2O The product stream is directed to the separation section where water is removed and partially recycled to the reaction section and used as cooling media. After product conditioning, the product stream is directed to fractionation. There, the product stream is split up into the main product propylene and byproducts LPG, ethylene and gasoline (Jasper, S., El-Halwagi, M. M , 2015 & Zhao, Z. et al., 2020). Polymer grade propylene (concentration higher than 99.6%wt) can be produced via this technology (Rothaemel, M. et al., 2016).



TRL level 2020	TRL 8
	In the late 1990s the development of the so-called MTP® (methanol-to-propylene) process, a Lurgi Technology (by Air Liquide Global E&C Solutions) started. After several tests in pilot scale, a demonstration unit was built with the MTP® technology in Norway, as a side-stream plant of a Statoil methanol plant using natural gas as feedstock. The demo unit was operated from January 2002 to April 2004. The first MTP® plant started up in China in 2010 and two more units followed in line (with a capacity of 470 kta propylene each), their feedstock is coal-based methanol. The MTP® technology is currently fully commercialized and other plants with the Lurgi technology were constructed worldwide (Rothaemel, M. et al., 2016).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	kton		570.00								
			570.00			-			570.00		
			Current			2030			2050		
Potential	Global	kton	9,500.00			-			-		
			9,500.00	–	9,500.00	Min	–	Max	Min	–	Max
Market share		%	-			-			-		
			Min	–	Max	Min	–	Max	Min	–	Max

Capacity utlization factor	0.91	
Full-load running hours per year	8,000.00	
Unit of Activity	kton/year	-
Technical lifetime (years)	20.00	
Progress ratio	-	
Hourly profile	No	
Explanation	The capacity value is based on propylene production. The global propylene industry is expected to expand with the construction of many MTP plants in China. Globally there are currently 19 MTP plants, most of which are situated in China, which use methanol feedstock derived from domestically available coal. Since China has one of the largest coal reserves in the world, producers can readily obtain coal for propylene production. It is forecasted that China will build 13 more MTP plants in the next five years (Recycling Portal, 2018). However, the methanol feedstock can come from renewable sources, such as bio-gas and green electricity via electrolysis. Regardless of the source of methanol, the MTP process keeps the same configuration. The current global capacity potential was calculated assuming that the 19 MTP plants mentioned present an average capacity of around 500 kta.	

COSTS

Year of Euro	2015								
	Euro per Functional Unit	Current			2030			2050	
Investment costs	mln. € / kton	0.56			-			-	
		0.56	–	0.56	Min	–	Max	Min	– Max
Other costs per year	mln. € / kton	-			-			-	
		Min	–	Max	Min	–	Max	Min	– Max
Fixed operational costs per year (excl. fuel costs)	mln. € / kton	0.02			-			-	
		0.02	–	0.02	Min	–	Max	Min	– Max
Variable costs per year	mln. € / kton	0.01			-			-	
		0.01	–	0.01	Min	–	Max	Min	– Max
Costs explanation	Costs based on a plant capacity of 570 kta propylene. The CAPEX value considers all the units already described, excluding utilities production. The fixed operational costs were considered to be 3% of the CAPEX and the variable OPEX to be 2% of CAPEX.								

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Methanol	PJ	3.37			-			-		
			3.37	–	3.52	Min	–	Max	Min	–	Max
	Heat	PJ	13.41			-			-		
			13.41	–	13.41	Min	–	Max	Min	–	Max
	Electricity	PJ	246.32			-			-		
			246.32	–	246.32	Min	–	Max	Min	–	Max
	LPG	PJ	-0.07			-			-		
			-0.08	–	-0.07	Min	–	Max	Min	–	Max
Energy in- and Outputs explanation	The mass and energy balances are based on Rothaemel, M. et al. (2016) and Zhao, Z et al. (2020), they represent a 470-570 kta propylene plant. The losses via coke formation were considered to be around 0.5%wt of the total methanol input.										

MATERIAL FLOWS (OPTIONAL)

	Material	Unit	Current			2030			2050		
Material flows			-			-			-		
			Min	–	Max	Min	–	Max	Min	–	Max
			-			-			-		
			Min	–	Max	Min	–	Max	Min	–	Max
Material flows explanation											

EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS))											
	Substance	**Unit**	**Current**			**2030**			**2050**		
Emissions	CO_2	kton	0.05			-			-		
			0.05	–	0.05	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Emissions explanation	Emissions consider coke burning for the reactor regeneration. It was calculated based on the ratio between coke and propylene formed, which is around 0.017-0.018 t coke/t propylene (considering carbon losses of 0.5%wt and both sources for the process material yields: Rothaemel, M. et al. (2016) and Zhao, Z et al. (2020)). The emission factor of coke and its LHV value were considered to be 106.8 kg CO_2/MJ and 28.5 MJ/kg, respectively (RVO, 2017). The value reflects the CO_2 emissions per kton of propylene produced. The utilities production emissions are outside the scope of this factsheet.										
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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