TECHNOLOGY FACTSHEET

ADVANCED METHANOL TO OLEFINS PROCESS

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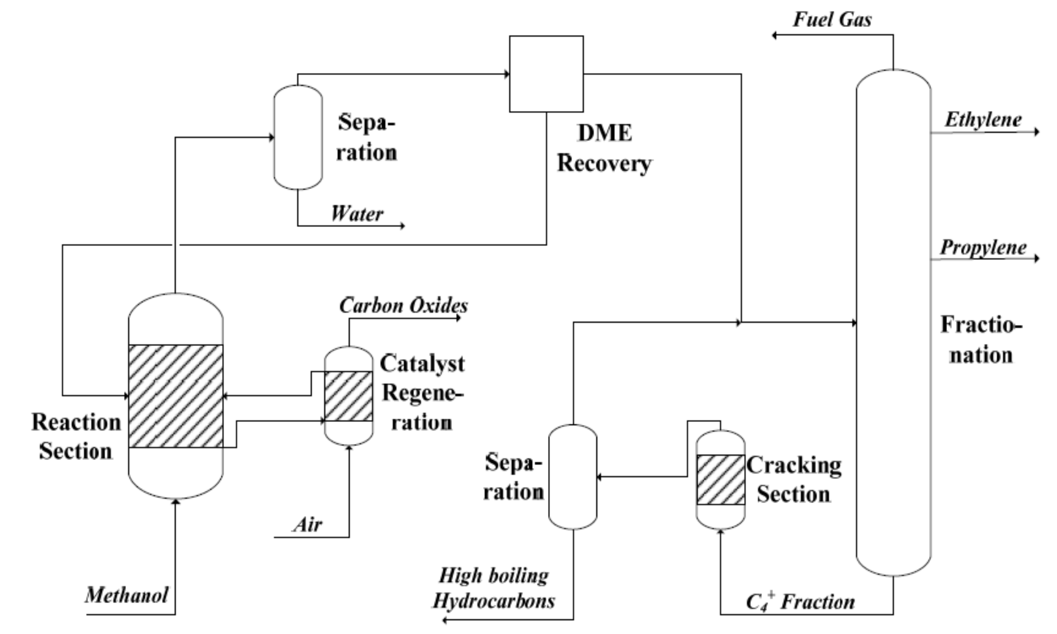
Sector	Industry: Petrochemicals
ETS / Non-ETS	ETS
Type of Technology	Alternative chemicals production
Description	This factsheet decribes the advanced methanol to olefins process, which is a combination of both licensed technologies UOP (Universal Oil Products)/Hydro Methanol to Olefins and Olefin Cracking Process (OCP) by Total. UOP/Hydro MTO technology consists of a methanol to olefin reaction, product purification and separation. The reaction for MTO can be described by two steps.The first step is the conversion of methanol to dimethyl ether (DME) and water: $2\ CH_3OH \rightarrow CH_3OCH_3 + H_2O$ The second step is the conversion of DME to both ethylene and propylene: $CH_3OCH_3 \rightarrow C_2H_4 + H_2O$ $3\ CH_3OCH_3 \rightarrow 2\ C_3H_6 + 3\ H_2O$ The production ratio between ethylene and propylene varies depending on the catalyst employed, the reaction conditions and the technology. Both reaction steps above occur in a catalytic fluidized-bed reactor. Coke formed via unwanted reactions can accumulate in the catalyst over time, which can reduce its performance. For this reason, portions of the catalyst are continuously removed from the reactor to a regeneration unit. The coke is removed from the catalyst with the help of air or oxygen in the regeneration reactor. The ratio between propylene and ethylene produced by the reaction can also be adjusted by the operational conditions: the range is 1.3 to 1.8. The product stream from the conversion reactor is fed to a separation section to remove water and to recover non-reacted DME. The olefin-rich stream is directed to a fractionation section in which the desired products ethylene and propylene are recovered. Residual gas and a stream that consists of medium boiling hydrocarbons are also recovered in the separation section. The hydrocarbon mix coming from the separation section is fed into a cracking reactor to provide another source for ethylene and propylene production. The cracking product is rich in olefins, which is sent to the separation section to recover ethylene and propylene. The byproduct from the cracking section is a mix of C4 olefins ('high boiling point hydrocarbons' in the picture) (Jasper, S., El-Halwagi, M. M , 2015).



TRL level 2020	TRL 8
	The methanol-to-olefin (MTO) process has a TRL of 8-9 and it is currently used in several locations in China, but so far it is not commercially deployed in Europe (Dechema, 2017). In China, the process is widely deployed with coal-based methanol as feedstock. In the early 1980s, Mobil Corporation discovered and developed MTO processes in the study of methanol-based gasoline (MTG) processes. Currently, the mainstream MTO technology around the world was developed by Honeywell International, Inc. (UOP). In 2008, Total built the world's first methanol to olefins/olefins cracking process in Feluy, Belgium, with a methanol capacity of 10 tons/day, where they applied the Honeywell UOP's MTO technology (Flowserve, 2019).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	kton		387.00								
			387.00			-			387.00		
Potential	EU	kton	Current			2030			2050		
			-			-			-		
			Min	–	Max	Min	–	Max	Min	–	Max
Market share		%	-			-			-		
			Min	–	Max	Min	–	Max	Min	–	Max

Capacity utlization factor	0.97	
Full-load running hours per year	8,550.00	
Unit of Activity	kton/year	-
Technical lifetime (years)	20.00	
Progress ratio	-	
Hourly profile	No	
Explanation	The capacity value is based on propylene production and reflects a typical commercial MTO plant with UOP/Total technology. Quite a significant expansion of this route is expected in the next years, the route will account for one fifth of all methanol used worldwide by 2021, mostly as a result of China's increasing demand for chemicals, according to new analysis from IHS Chemical (IHS, 2020). However, the methanol origin is majoritary fossil-based. The total technology potential in Europe is unknown.	

COSTS

	Euro per Functional Unit	Current			2030			2050		
Year of Euro	2015									
Investment costs	mln. € / kton	0.76			-			-		
		0.76	–	0.76	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	0.02			-			-		
		0.02	–	0.02	Min	–	Max	Min	–	Max
Costs explanation	Costs based on a plant capacity of 387 kta propylene. The CAPEX value considers all the units already described, excluding utilities (electricity and steam) production. The fixed operational costs were considered to be 3% of the CAPEX and the variable OPEX to be 2% of CAPEX. No specific future costs for this technology were found in literature, however, since it is already a commercially proven technology, the investment costs are expected to remain stable for the coming years.									

ENERGY IN- AND OUTPUTS											
	Energy carrier	**Unit**	**Current**			**2030**			**2050**		
Energy carriers (per unit of main output)	*Main output:* Methanol	PJ	3.94			-			-		
			3.94	–	3.94	*Min*	–	*Max*	*Min*	–	*Max*
	Heat	PJ	25.00			-			-		
			25.00	–	25.00	*Min*	–	*Max*	*Min*	–	*Max*
	Electricity	PJ	101.20			-			-		
			101.20	–	101.20	*Min*	–	*Max*	*Min*	–	*Max*
	Residual gases	PJ	-0.06			-			-		
			-0.06	–	-0.06	*Min*	–	*Max*	*Min*	–	*Max*
Energy in- and Outputs explanation	The mass and energy balances are based on Jasper, S., El-Halwagi, M. M (2015) and Zhao, Z et al. (2020) and reflect a 600 kta olefins (387 kta propylene) MTO plant. The residual gases are normally composed by ethane (55 wt%) and propane (45 wt%). The high boiling point hydrocarbons are composed by a mix of C4 olefins, its specific composition varies depending on the operational conditions of the OCP (olefins cracking process) section.										

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	CO2	Mton	0.06			-			-		
			0.06	–	0.06	*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, which is around 0.019 t coke/t propylene (considering carbon losses of 0.5%wt and process material yields from Zhao, Z et al. (2020) and Jasper, S., El-Halwagi, M. M (2015)). The emission factor of coke was considered to be 106.8 kg CO2/MJ (RVO, 2017). The value reflects the CO2 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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