TECHNOLOGY FACTSHEET

STEAM METHANE REFORMING (SMR) FOR HYDROGEN PRODUCTION WITH SYNGAS CARBON CAPTURE

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Sector	Hydrogen
ETS / Non-ETS	ETS
Type of Technology	SMR-based hydrogen production with syngas CO2 capture
Description	Steam methane reforming (SMR) is a method that can be used for producing hydrogen from natural gas. This is achieved in a processing device called a reformer which reacts steam at high temperature with the gas. SMR uses the endothermic reaction $CH_4 + H_2O \rightleftharpoons CO + 3H_2$. The reaction is carried out at an activation energy of 206 kJ/mol and temperatures of 500-900 degrees Celsius [3]. In this SMR plant, a COGEN plant is running to export a relatively small fraction of the energy involved to the electricity grid. In this case, capturing CO2 from the shifted syngas using MDEA increases the natural gas consumption by .46 MJ/Nm3 H2 and avoids 54% of CO2 emissions.
TRL level 2020	TRL 9
	IEA (2017) reports 100.000 Nm3/h. at 10,8 MJ/Nm3, this translates to a capacity of precisely 300 MW hydrogen energy output. Progress ratio is found in Thomas (2009)

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range		
Capacity	MW				*300.00*
			300.00	*-*	*300.00*
Potential	MW	NL		*unlimited*	
			-	*-*	*-*
Market share	%				
			Min	*-*	*Max*
Capacity utlization factor	1.00				
Unit of Activity	PJ/year				
Technical lifetime (years)	25.00				
Full-load running hours per year	8,322.00				
Progress ratio	0.95				
Hourly profile	No				
Explanation	IEA (2017) reports 100.000 Nm3/h. at 10,8 MJ/Nm3, this translates to a capacity of precisely 300 MW hydrogen energy output. Progress ratio is found in Thomas (2009).				

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs per year	mln. € / MW			0.88			0.88			0.88
		0.88	-	1.16	0.88	-	1.16	0.88	-	1.16
Other costs per year	mln. € / MW			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MW			0.03			0.03			0.03
		0.03	-	0.07	0.03	-	0.07	0.03	-	0.07
Variable costs per year	mln. € / MW			0.25			0.25			0.25
		0.25	-	0.25	0.25	-	0.25	0.25	-	0.25
Costs explanation	Data in NTNU (2016) is based on a different size plant, and the numbers here are scaled to represent the same size plant as in IEA (2017). All costs excluding fuel costs. Sinnot (2009) finds a higher (per kg H2 output) value for investment costs, which can at least in part be explained by the use of data for a smaller size plant. In these figures, the OPEX costs amount to 3,6% of the CAPEX costs. Conventional plants (such as SMR) benefit from economy of scale, so you can use a scale-up factor of 0.8 (Sinnott et al., 2009) when estimating the cost of a larger scale plant. Due to lack of data, there is an implicit assumption here the same scaling factor can be applied to this plant, including its CCS component. All values based on LHV. Variable costs include here raw water make-up, catalysts and chemicals. Cost developments are taken relative to base year, and are found in Vita (2018). Cost for CO2 capture are included.									

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:*	PJ			-1.00			-1.00			-1.00
	Hydrogen		-1.00	-	-1.00	-1.00	-	-1.00	-1.00	-	-1.00
	Electricity	PJ			-0.03			-0.03			-0.03
			-0.03	-	0.00	-0.03	-	0.00	-0.03	-	0.00
	Natural gas resource (gas fields)	PJ			1.47			1.47			1.47
			1.47	-	1.47	1.47	-	1.47	1.47	-	1.47
		PJ			-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Energy in- and Outputs explanation	Production of hydrogen; 10^5 Nm3/h give 10,8*10^5*24*365*0,95 MJ = 8,99 PJ/y. The 0,95 factor is to account for active running hours per year. Other numbers are taken from IEA (2017) and NTNU (2016) and scaled accordingly. The NTNU study reports on an energy efficiency of 0,82, but based on their own reported values of in,- and outlet I find an energy efficiency of 0,96. A plant with an average power of 300*0,95 MW gives 8,99 PJ/year, and so all numbers are scaled by 8,99 to give a per PJ result. The 0.95 factor accounts for the utilization rate.										

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			-0.04			-0.04			-0.04
			-0.04	-	-0.04	-0.04	-	-0.04	-0.04	-	-0.04
					-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
					-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
					-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Emissions explanation	IEA (2017) reports 0,8091 kg CO2/Nm3 hydrogen for the case without CCS. This gives 24*365*10^5*0,8091*0,95 kg or 0,675 Mton/year. In the OPERA model, these emissions are calculated from the fuel input. For the purpose of this factsheet, all carbon emissions that are avoided due to CCS are written down as negative. With CCS the number is extrapolated from that with IEA (2017) data. A plant with an average power of 300*0,95 MW gives 8,99 PJ/year, and so all numbers are scaled by 8,99 to give a per PJ result. The 0.95 factor is to correct for utilization percentage.										

OTHER

		Current			2030			2050		
Other				-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

REFERENCES AND SOURCES

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