TECHNOLOGY FACTSHEET

AUTOTHERMAL REFORMING (ATR) FOR HYDROGEN PRODUCTION WITH CARBON CAPTURE AND STORAGE (CCS)

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Sector	Hydrogen supply
ETS / Non-ETS	ETS
Type of Technology	Autothermal reforming
Description	Autothermal reforming (ATR) is the combination of both partial oxidation (POX) and steam methane reforming (SMR) in one reactor operating at 900-1150 degrees Celcius with energy efficiency lower than that of SMR. The typical reaction is given by the following equation: CH4+H20/2+O2/4 <-> CO + 5H2/2 The described ATR plant includes a carbon capture and storage (CCS) component.
TRL level 2020	

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range		
Capacity	MW		10,228		
			822	-	10,228
Potential	MW	NL	Unlimited		
			Min	-	Max
Market share	%		-		
			Min	*-*	*Max*
Capacity utlization factor	1.00				
Unit of Activity	PJ/year				
Technical lifetime (years)	10				
Full-load running hours per year	8,030				
Progress ratio	1.00				
Explanation	Jakobsen and Atland (2016) refer to a facility of 500,000 kg/day, corresponding to a capacity of 822 MW. NOE (2018) reports 89.6 TWh/year (used as main reference).				

COSTS

Year of Euro	2015									
	Euro per Functional Unit	Current			2030			2050		
Investment costs per year	mln. € / MW	1.20			1.20			1.20		
		1.20	-	1.40	1.20	-	1.40	1.20	-	1.40
Other costs per year	mln. € / MW	-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MW	0.04			0.04			0.04		
		0.04	-	0.07	0.04	-	0.07	0.04	-	0.07
Variable costs per year	mln. € / MW	-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Costs explanation	On one side, NOE (2018) reports on the costs of 10,678 million pounds for a 89.6 TWh/year hydrogen output facility (used as main reference for CAPEX). The above number is converted to eur/MW. On the other side, Jakobsen and Atland (2016) report on 972 million euros for a 500 t/day hydrogen facility. NOE (2018) report OPEX as 3% of CAPEX. Jakobsen and Atland (2016) consider 5% of CAPEX as OPEX.									

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Hydrogen	PJ	-1.00			-1.00			-1.00		
			-1.00	-	-1.00	-1.00	-	-1.00	-1.00	-	-1.00
	Electricity	PJ	0.05			0.05			0.05		
			0.04	-	0.05	0.04	-	0.05	0.04	-	0.05
	Natural gas resource (gas fields)	PJ	1.20			1.20			1.20		
			1.18	-	1.20	1.18	-	1.20	1.18	-	1.20
			-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Energy in- and Outputs explanation	NOE (2018) reports an efficiency of 79.7% and make a subdivision between electricity and natural gas inputs. Jakobsen and Atland (2016) give an overall efficiency of 82%, and describe a power input of 27.1 MW on a total energy consumption of 822 MW.										

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

	Substance	Unit	Current			2030			2050		
Emissions	CO2	Mton	-15.60			-15.60			-15.60		
			-15.60	-	-1.39	-15.60	-	-1.39	-15.60	-	-1.39
			-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
			-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
			-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Emissions explanation	The numbers specified are for Mton CO2 captured. The plant in the report from NOE (2018) has total emissions of 16 Mt/year and a capture rate of 96%, whereas the plant reported in Jakobsen and Atland (2016) has total emissions of 4,134 t/day and a capture rate of 92%.										

REFERENCES AND SOURCES

Camacho, Y. M., Bensaid, S., Piras, G., Antonini, M., & Fino, D. (2017). Techno-economic analysis of green hydrogen production from biogas autothermal reforming. Clean Technologies and Environmental Policy, 19(5), 1437-

Jakobsen, Daniel; Åtland, Vegar (2016). NTNU. Concepts for Large Scale Hydrogen Production.

NOE (2018). H21 North of England Report v1.0 - Northern Gas Networks