## **TECHNOLOGY FACTSHEET**



LIQUEFIED HYDROGEN S	STORAGE										
Date of factsheet	26-10-2020										
Author Sector	Gaby Janssen Hydrogen										
ETS / Non-ETS	Non-ETS										
ype of Technology	Storage	ie hudrogen in tenk	ic attractive u	hon a high volu	una atria ana ray	u donaitu ia ura	ntad Hawayar	an acceptial pr	art of this took	alaguis tha lie	auctorion
Description	Storage of liquefied or cryogenic hydrogen in tanks is attractive when a high volumetric energy density is wanted. However, an essential part of this technology is the liquefaction process which is expensive and requires 25-40% of the energy content of the hydrogen stored. Hydrogen has to be cooled down below -253°C to become liquefied. Moreover, liquefied hydrogen storage requires expensive (dewar) tanks which are designed to minimize heat transfer from the outside to the liquid, and often additional insulation of the tank and storage facilities is used. Still, losses due to boil-off of hydrogen are 0.1-0.5% per day. However, the operational pressure is low, < 10 bar, and after liquefaction the physical volumetric energy density of liquefied hydrogen is 2300-2950 kWh/m3. Tanks can therefore contain 0.1-100 GWh. Liquefied hydrogen is the preferred option when large amounts o hydrogen must be transported over long distances where no pipelines are available. Tanks can be loaded upon trucks or stored in ships. The investment costs for liquefied hydrogen storage consists of two parts, i.e. the costs of the tanks and the costs of the liquefaction process. The costs of the tanks scale with the amount of hydrogen that can be stored (expressed in in kg or GWh), the costs of the liquefaction scale with the maximum hydrogen flow (expressed in tons/day or MW_H2). Since costs of liquefaction are usually the dominant factor, here MW_H2 is used as the unit of capacity of the installation.										
RL level 2020	TRL 9										
ECHNICAL DIMENSIONS	Technology provided by Air Lique	uide, Linde and oth	ers.								
	Functional Ur	nit					Value and Ran	ge			
apacity	MW					34.70			24.70		
				34.70 Current			- 2030			34.70 <b>2050</b>	
Potential	-			-			-	-		-	
Market share		%	Min	-	Мах	Min	-	Мах	Min	-	Max
		/0	Min	-	Мах	Min	-	Мах	Min	-	Мах
Capacity utlization factor									1.00		
ull-load running hours per year Init of Activity	PJ/year							8	,000.00		
echnical lifetime (years)	і Јусан								25.00		
Progress ratio											
Hourly profile	No	uivalant to 25 to	f hudrogon /	/ This is hear -	n the Lower'	Heating Makes	of hydrogen	nich is 120 Mar //	a or 0 022 M414		
xplanation	The capacity of 34.7 MW is equ	arvalent to 25 tons o	nyurogen/day	y. This is based (	on the Lower I	neating value	or nyurogen wi	IICH IS 120 MJ/k	g of 0.033 MW	ли ку.	
OSTS ear of Euro	2015										
	Euro per Function	al Unit		Current			2030			2050	
nvestment costs	mln. € / MW			2.25			2.25			0.98	
Other costs per year	mln. € / MW		0.98	-	3.63	0.98	-	3.63	0.98		0.98
				-		Min	_	Мах	Min	-	Мах
			Min	-	Max						
	mln. € / MW			- 0.07			0.07	1		0.03	
	· · · · · ·		Min 0.03	0.07	0.11	0.03	0.07	0.11	0.03	0.03	0.03
excl. fuel costs) 'ariable costs per year	mln. € / The costs were derived assumir of the tanks at 800-10000 USD/	/MWh H2, assuming	0.03 <i>Min</i> city of 10 GWh ; 2828 €/MWh	0.07 - - hydrogen. For i H2. The specifie	0.11 Max nstallations w ed cost per M	0.03 Min ith different to W includes the	0.07 – – – – otal tank capac	0.11 Max ity, corrections nd decrease wit	Min must be made h increasing hy	– – – . Kearney estin /drogen flow. H	Max mates the cost Higher costs a
excl. fuel costs) /ariable costs per year	mln. € / The costs were derived assumir of the tanks at 800-10000 USD/ for a 5 tons/day liquefaction ins	/MWh H2, assuming stallation, lower for	0.03 <i>Min</i> city of 10 GWh ; 2828 €/MWh	0.07 – – hydrogen. For i H2. The specific or 2050 it is assi	0.11 Max nstallations w ed cost per M	0.03 Min ith different to W includes the	0.07 – – – otal tank capac liquefaction a will be at 50 to	0.11 Max ity, corrections nd decrease wit	Min must be made h increasing hy	- - . Kearney estin /drogen flow. H : are 3% of CAP	Max mates the cos Higher costs a
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REFERENCES A	EFERENCES AND SOURCES							
1	A.T Kearney (2014), Energy transition Institute, Hydrogen based energy conversion, 2014. https://www.kearney.com/web/home/insights/hydrogen.							
2	DOE (2019), Current Status of Hydrogen Liquefaction Costs, 2019. https://www.hydrogen.energy.gov/pdfs/19001_hydrogen_liquefaction_costs.pdf							
3	U. Cardella, L. Decker and H. Klein, Roadmap to economically viable hydrogen liquefaction. Int J Hydrogen Energy 42 (2017) p. 13329-38.							
4	https://hydrogeneurope.eu/sites/default/files/Hydrogen%20Europe_Green%20Hydrogen%20Recovery%20Report_final.pdf							
5	IDEALHY Consortium (2017). Hydrogen liquefaction report. FCH JU FP7-JTI Proj. Ref. 278177 D5.22.							
6	K. Ohlig and L. Decker, The latest developments and outlook for hydrogen liquefaction technology, AIP Conf. Proc. 1573 (2014) p. 1311-7.							
7	NREL (1998) - Amos WA. Costs of storing and transporting hydrogen (1998) NREL/TP-570-25106.							