TECHNOLOGY FACTSHEET

TNO

Date of factsheet												
	17-8-2021											
Author	Luuk Beurskens											
Sector	Electricity generation											
ETS / Non-ETS	ETS											
Type of Technology	Renewable											
Description	Offshore wind power is a mature technology, deployed mainly in Europe and Asia. To produce more power against lower costs, wind turbine rotors have grown significantly over the past decades. The larger the diameter of a wind turbine rotor, the larger the swept area, which increases quadratically with the length of a blade. This makes upscaling both technically and economically attractive. The issue of landscape integration for onshore wind is an important barrier, which is much less relevant for offshore wind power. On the other hand, for offshore wind the impact on the marine environment is a point of attention. Offshore wind power benefits from economies of scale by increasing wind turbine capacity. Another offshore advantage is that maritime wind speeds on average are higher than continental wind speeds. Offshore wind turbines are combined in large wind parks, and three main approaches exist for locating the offshore wind turbines: attached to the seabed through a monopile, through a tripod or similar construction, or floating. For the typical Dutch North Sea circumstances, monopiles are commonly used. In offshore wind turbines, just like onshore, the turbine blades are driving a hub attached to an electric generator, located in the nacelle. The electricity is led to a power substation, from where the undersea cable is connected to the onshore electricity grid. The connection is often very long, from a few kilometers to several tens of kilometers, or above 100. Besides water depth and distance to shore, operation and maintenance costs are relatively high for offshore wind power, making maintenance concepts and strategies an important aspect of offshore wind power operation. The yield of wind turbines depends on the average annual wind conditions.											
TRL level 2020	TRL 9 According to the Global Wind Energy	2 Council (GWF)	C. 2021), 707 G	W onshore win	d and 35 GW of	fshore wind are	e cumulatively	installed at the	end of 2020 wo	orldwide. For Fi	Irope GWEC	
	estimates 194 GW onshore wind and 25 GW offshore wind (both 2020). For the Netherlands, Statistics Netherlands (CBS, 2021) estimates the offshore wind capacity by the end of 2020 to be 2460 MW (electricity generated in 2020: 4985 GWh, normalised). Dutch capacity for onshore wind in 2020 was 4159 MW (normalised electricity generated in 2020: 8960 GWh).											
TECHNICAL DIMENSIONS												
	Functional Unit					V	alue and Rang	e				
Capacity	MW						10 MW (2020)					
	NL	GWe		Current			2030			2050		
Potential			2.46	2.46	2.46	11 50	11.5	11 50		108 GW		
Market share		%	2.40	-	2.40	11.50	-	11.50		-		
Capacity utlization factor			iVIIn	-	IVIax	IVIIN	-	1.00	IVIIN	-	IVIAX	
Full-load running hours per year	4735 hrs/year according to TNO (20	21)										
Unit of Activity	PJ/year											
Technical lifetime (years)	For 2020: 20 years. For 2030 and 20	50: 30 years										
Progress ratio	Voc											
	GW offshore wind in 2050, 170 TWh wind by 2050. The potential for offsh technical optimisation (10 MW/km2) are 10 MW in 2020 and 20 MW for th) and one in wh hore wind on th , accepting high he period after	nich the Nether ne Dutch contin her losses and l 2030. From 20	lands could be s iental plateau is higher costs (DI 130 onwards, life	self-sufficient in s even larger: 10 NV, 2020). For t etime for offsho	a renewable ele 08 GW when eco he potential tho pre wind power	ctricity by 2050 onomical optim e economical o is estimated 30	 The latter sce lisation is applic ptimum is selec years, increas 	nario assumes ed (6 MW/km2) ted: 108 GW. A ing from 20 yea	/2 GW (325 TW), and 180 GW I Assumed turbin ars in 2020 (Bul	(h) offshore based on e capacities der 2021).	
COSTS												
Year of Euro	2015											
Investment costs	Euro per Functional Un	it	Current		2030							
				2 27 (1 42)			2030			2050		
Other costs per year	mln. € / MW		-	2.27 (1.43)	-	-	2.40 (1.62)	-	-	2050 2.21 (1.49) -	-	
			- Min	2.27 (1.43) - - -	- Max	- Min	2,40 (1.62) - -	- Max	- Min	2050 2.21 (1.49) – –	- Max	
Fixed operational costs per year (excl. fuel costs)	mln.€/ MW		- Min 0.0210	2.27 (1.43) - - 0.0234 -	- <i>Max</i> 0.0257	- <i>Min</i> 0.0184	2.40 (1.62) - - 0.0234 -	- <i>Max</i> 0.0291	- <i>Min</i> 0.0171	2050 2.21 (1.49) - - 0.0224 -	- Max 0.0288	
Fixed operational costs per year (excl. fuel costs) Variable costs per year	mln. € / MW mln. € / MWh		- Min 0.0210 0.000011	2.27 (1.43) - - 0.0234 - 0.000012 -	- <i>Max</i> 0.0257 0.000013	- <i>Min</i> 0.0184 0.000005	2.40 (1.62) - - 0.0234 - 0.000006 -	- <i>Max</i> 0.0291 0.000007	- <i>Min</i> 0.0171 0.000005	2050 2.21 (1.49) - - 0.0224 - 0.000006 -	- <i>Max</i> 0.0288 0.000007	
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EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)													
	Substance Unit			Current				2030		2050			
Emissions					-			-			-		
				Min	-	Max	Min	-	Max	Min	-	Мах	
					-			-			-		
				Min	-	Max	Min	-	Max	Min	-	Мах	
					-			-			-		
				Min	_	Max	Min	_	Max	Min	_	Max	
					-	-		-			-	-	
				Min	-	Max	Min	-	Max	Min	-	Max	
Emissions e	explanation												
OTHER				_									
	Parameter Unit		Current			2030			2050				
				-	1		-			-			
				Min	-	Max	Min	-	Max	Min	_	Мах	
					-	1		-			-		
			Min	-	Max	Min	-	Max	Min	_	Max		
					-	1		-			-		
				Min	-	Max	Min	-	Max	Min	-	Max	
					-			-			-		
				Min	-	Max	Min	-	Max	Min	-	Max	
Explanation)												
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