TECHNOLOGY FACTSHEET

TNO

WIND ONSHORE

Date of factsheet	19-8-2021
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Sector	Electricity generation
	Renewable
ETS / Non-ETS	ETS
Type of Technology	Renewable
Description	Onshore wind power is a mature technology, deployed worldwide. Asia, Europe and the United States show the highest total capacity. Wind turbines have grown significantly over the past decades, resulting in increased yield and at the same time cost reductions. 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. Usually, legal restrictions to tip height are in place, limiting the size of wind turbines. In order to benefit from further economies of scale, turbines are combined in wind parks. The turbine blades are driving a hub attached to an electric generator, located in the nacelle. The power is fed into the grid. Variability of the wind regime makes that the electricity supply capacity varies as well, from 0 MW in low wind or extremely stormy periods, up to maximum capacity at wind speeds within the design window. The yield of wind turbines strongly depends on the average annual wind conditions. Different wind classes require different turbine types. In this series of factsheets however, wind turbine characteristics do not vary in costs, but the main variable used is the yield, which depends on the regional wind speed. Six wind speed regions are defined for the Netherlands. The main information source for current onshore wind data is a meta study, performed in the Dutch subsidy scheme SDE++ (PBL 2021b). Future projections are based on combining projections from other reports with the SDE++ parameters.
TRL level 2020	TRL 9
	According to the Global Wind Energy Council (GWEC, 2021), 707 GW onshore wind and 35 GW offshore wind are cumulatively installed at the end of 2020 worldwide. For Europe, 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).

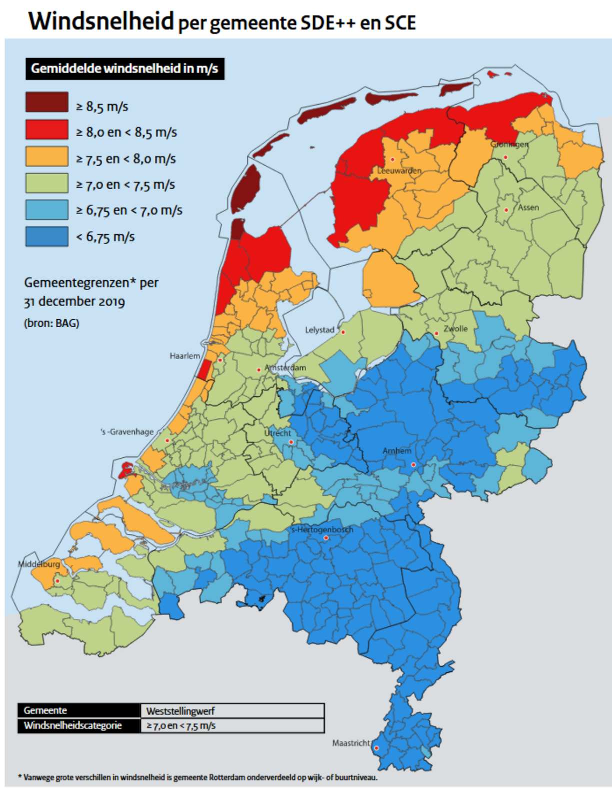
TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	MW		3-4								
			-			-			-		
Potential	NL	GWe	**Current**			**2030**			**2050**		
			4.16			11.00			15.00		
			4.16	–	4.16	11.00	–	11.00	8.00	–	16.00
Market share		%	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Capacity utlization factor	1.00										
Full-load running hours per year	2250 (2020), 2750 (2030) and 3000 (2050)										
Unit of Activity	PJ/year										
Technical lifetime (years)	20 year in 2020, 25 year from 2030 onwards										
Progress ratio											
Hourly profile	Yes										

Explanation

'Dutch onshore wind capacity in 2020 was 4159 MW. This is lower than the 6 GW agreed in the Energieakkoord voor duurzame groei (2013). PBL estimates in her Monitor concept-RES (PBL, 2021a), based on an analysis of the draft regional energy strategies (RES), that the cumulatively planned electricity production from wind is around 30 TWh by 2030. This value includes plans where no decision has been made between solar PV and wind. Assuming an average full load factor of 2750 hours per year by 2030 the anticipated onshore wind power capacity would be around 11 GW. In the report an analysis of the pipeline of wind projects is also presented. From this, PBL estimates a minimum realisation of approximately 6.6 GW (18.5 TWh) by 2030, based on projects currently under development. Various studies for the Netherlands report long term realisations for 2050, ranging from 5 to 16 GW onshore wind power. The potential is not so much constrained in terms of space available, but it is a matter of ambition and societal acceptance. For the factsheet document, total Dutch onshore wind power potential is put at 15 GW by 2050, at a future average of 3000 full load hours resulting in 45 TWh.

Wind speed category more than 8.5 m/s (dark red) gives approximately 450 MW (1.8 TWh) in 2050
Wind speed category between 8.0 and 8.5 m/s (red) gives approximately 1200 MW (4.4 TWh) in 2050
Wind speed category between 7.5 and 8.0 m/s (orange) gives approximately 2850 MW (9.6 TWh) in 2050
Wind speed category between 7.0 and 7.5 m/s (green) gives approximately 4350 MW (13.2 TWh) in 2050
Wind speed category between 6.75 and 7.0 m/s (light blue) gives approximately 1500 MW (4.1 TWh) in 2050
Wind speed category below 6.75 m/s (blue) gives approximately 4650 MW (11.8 TWh) in 2050
See the picture (RVO, 2021) for an indication of the average wind speeds throughout the Netherlands.



COSTS

	Euro per Functional Unit	Current			2030			2050		
Year of Euro	2015									
Investment costs	mln. € / MW	1.15			1.09			0.98		
		1.01	–	1.23	0.77	–	1.12	0.69	–	1.06
Other costs per year	mln. € / MW	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MW	0.011			0.010			0.009		
		0.010	–	0.012	0.008	–	0.012	0.007	–	0.011
Variable costs per year	mln. € / MWh	0.000			0.000			0.000		
		0.000	–	0.000	0.000	–	0.000	0.000	–	0.000

Costs explanation: For the year 2020 reference is made to PBL (2021b), which assesses in detail the costs of Dutch onshore wind power projects. The projection towards 2030 and 2050 is made based on multiple scenarios assessed in IRENA (2019), Ecofys (2018) and ETRI (2018). The minimum and maximum values have been based on data ranges observed in WindEurope (2021).

ENERGY IN- AND OUTPUTS

Energy carriers (per unit of main output)	Energy carrier	Unit	Current			2030			2050		
	Main output:	PJ	-1.00			-1.00			-1.00		
	Electricity		-1.00	–	-1.00	-1.00	–	-1.00	-1.00	–	-1.00
	Wind energy	PJ	1.00			1.00			1.00		
			1.00	–	1.00	1.00	–	1.00	1.00	–	1.00
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Energy in- and Outputs explanation											

MATERIAL FLOWS (OPTIONAL)

Material flows	Material	Unit	Current			2030			2050		
			-			-			-		
			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				-			-			-	
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
				-			-			-	
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
				-			-			-	
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
				-			-			-	
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Emissions explanation											

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										

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