TECHNOLOGY FACTSHEET

SOLAR PV, ROOFTOP 15 kWp - 1 MWp, ORIENTED SOUTH

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Sector	Buildings
ETS / Non-ETS	Non-ETS
Type of Technology	Renewable
Description	Solar photovoltaic (PV) systems convert solar irradiation into electricity. Various types of solar conversion technology types are currently on the market, each differing in terms of costs and efficiency. Examples of such variants comprise crystalline and multi-crystalline silicon PV (mainstream technology), as well as thin film PV (less common technology). This factsheet for solar PV focuses on mainstream technology. The solar modules generate direct current (DC). The DC might be used for off-grid applications, combined with an electricity storage system (i.e. battery), but these systems will not be addressed in this factsheet: off-grid systems are considered niche markets where different pricing mechanisms occur. The major contribution for the Netherlands is expected to be in grid-connected systems. In these, DC from the modules is converted to alternating current (AC) by an inverter. A PV mounting structure allows to fix the panels in the right position: usually a fixed tilt angle and a fixed orientation, although sun-tracking systems are also possible (but in the Netherlands currently more expensive in terms of electricity generation costs). There are three main spatial layouts: firstly a south-facing system, tilted at 30 to 40 degrees, for high energy generation during the year, characterised by high power peaks (at noon) during summer. Secondly, systems may be oriented towards both east and west at a smaller tilt. Advantages of these systems are that more peak capacity can be installed on the available surface (higher kWp/m2) and that the power peak during summer is smaller, with a more balanced power generation during the day as a result. For the Netherlands, these two layout variants are the most common, and both can be realised on rooftops and in field installations. Solar tracked systems comprise a third system type, which maximise electrity generation by actively adjusting the inclination angle and orientation. This type of system may be applied in solar fields, at a higher investment cost and more operational expenses, plus more land use due to the wider spatial requirements. Other variants of solar PV applications exist as well, such as floating PV or facade PV, integrated in buildings. These types generally are more expensive, although cost reductions are certainly to be expected. The photovoltaic module is an important component determining the total system cost, but as module costs have been decreasing rapidly over time its relative importance in system costs is reducing, and other components are receiving more weight. Examples of other components are inverter costs, construction material and installation labour. This latter component is an important factor, which can be reduced by increasing the project scale and by moving from rooftop to ground based installations. To estimate PV potentials, multiple methods exist, from bottom-up to top-down approaches. Bottom-line however, is that a large potential is existing, and possibly that system balancing constraints are more limiting than physical space. In the technology factsheets, five solar PV system types will be addressed: household rooftop systems (typically 2-10 kWp, on sloped roofs or on flat roofs), large rooftop systems (reference size 250 kWp, generally flat roofs), multi-MW rooftop systems (reference size 5 MWp, flat roofs) and multi-MW solar PV fields (reference size 10 MWp, ground-based). Also, floating PV is addressed indicatively. Note that for all layouts two orientations are defined: South and East/West. The difference lies in the respective value of the full-load hours and expenses for surface rents. In this factsheet, data is presented for a typical 250 kWp system (approximately 900 modules), on a South-facing rooftop with a fixed tilt, inclined.
TRL level 2020	TRL 9
	Many systems are operational worldwide. See CBS (2018) for the Dutch realisations.

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	MW		0.25								
			Min			-			*Max*		
Potential	NL	MW	Current			2030			2050		
			2,000			5,000			15,000		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Market share		%	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Capacity utlization factor	1.00
Full-load running hours per year	920
Unit of Activity	PJ/year
Technical lifetime (years)	25
Progress ratio	
Hourly profile	
Explanation	The reference system assumed here is a 250 kWp system on a flat roof in utility buildings. The total PV installations for 2020 are assumed to represent around 8 GWp, based on the latest CBS figures (4,3 GWp for 2018), with a continuing growth up to 2020. Note that all potential data have been broken down into capacity range sectors, and that this potential may be filled either with South oriented systems, or with East/West oriented systems. For 2030, the assumed cumulative PV capacity potential in the Netherlands is 30 GWp, based on PBL (2019) (22 GWp on buildings) and Gasunie 2018 (8 GWp ground based potential). For the period up to 2050, the building sector may cover 66 GWp (50 TWh), of which 41 GWp in the residential sector and 25 GWp in the utility sector. Ground-based potential may amount to 34 GW (Gasunie 2018). Solar PV technology has been coming down rapidly in investment costs and electricity generation cost over the past years, and it is expected that it will continue to reduce further. The full-load hours are averaged over the lifetime. An annual efficiency degeneration of 0.64% makes that full-load hours for South-oriented systems decrease from 990 kWh/kWp in year 1 to 849 kWh/kWp in year 25 (rounded average: 920 kWh/kWp). For East/West-oriented systems, the reduction goes from 890 kWh/kWp in year 1 to 763 kWh/kWp in year 25 (rounded average: 820 kWh/kWp). The conversion efficiency improvement that is expected results in smaller modules for similar capacity ranges, which is one of the drivers for cost reduction.

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	mln. € / MW	0.663			0.523			0.350		
		0.639	–	0.686	0.467	–	0.579	0.235	–	0.466
Other costs per year	mln. € / MW	0.001			0.001			0.001		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MW	0.0163			0.0157			0.0150		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Variable costs per year	mln. € / MW	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Costs explanation	The investment costs are taken from public reports (PBL, 2018 and PBL, 2019). These studies aggregate multiple information sources and various checks are performed with market data. The range results from the cost estimates that are defined in seasonal intervals. Future costs were estimated by applying the projected cost decrease as reported in FhG-ISE (2015), albeit with a newly calibrated starting point for the year 2020, for which detailed estimates exist from SDE++ (2019). For comparison purposes: the widest investment cost range according to this report is 757-892 €2014/kWp in 2020 to 278-606 €2014/kWp by 2050. The fixed operational costs reported are taken from SDE++ 2020 (2019) and cover the O&M, metering, insurance and taxes (time-dependent, correlated to investment cost development), connection costs. Under 'Other costs' some of the cost components missing in the SDE+ were added: costs for societal support, asset management and land or roof lease (these three cost components are not considered in SDE+, which is a result of the chosen system boundaries of the scheme). All information is based on publicly available data.

ENERGY IN- AND OUTPUTS											
Energy carriers (per unit of main output)	**Energy carrier**	**Unit**	**Current**			**2030**			**2050**		
	Main output: Electricity	PJ	-1.00			-1.00			-1.00		
			-1.00	–	-1.00	-1.00	–	-1.00	-1.00	–	-1.00
	Solar 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	Solar in = 1 and electricity out = -1.										
EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)											
Emissions	**Substance**	**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*
Emissions explanation											

REFERENCES AND SOURCES

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