Technology Collaboration Programme
by IEA

International Energy Agency
Photovoltaic Power Systems Programme

Task 1 **Strategic PV Analysis and Outreach**

PVPS

National Survey Report of PV Power Applications in the Netherlands 2023

Rijksdienst voor Ondernemend Nederland

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems". In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks', that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Copper Alliance are also members.

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What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "Trends in photovoltaic applications" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report covering the year 2023. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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- **Data sources: Zon Monitor 2024 (RVO), CBS Statline 2024, PBL Eindadvies Basisbedragen SDE++ 2024, Solar Trendrapport 2024. De Nederlandse Bank (DNB) Van crisis naar kans: verduurzaming van woningen na de energiecrisis 22 april 2024.**
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COVER PICTURE

RVO Database, floating solar, project LimaGrain, Rilland.

TABLE OF CONTENTS

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Special thanks go out to my colleagues at the Netherlands Enterprise Agency (RVO) from the team Sustainable Energy for gathering the data and providing the necessary context.

1 INSTALLATION DATA

The solar PV Dutch market is defined as the market of all nationally installed solar PV applications, both roof top and ground mounted systems. A solar PV application consists of modules, a set up box, inverter, mounting system and all installation and electrical control components needed for its management. Other applications such as small mobile devices, outdoor applications, wearable PV, the use of organic PV and storage devices are not considered in this survey report.

This report covers only the solar PV systems actually installed during the calendar year of 2023. These statistics are piecemeal released during the course of 2024 by the Central Bureau Statistic (CBS). Earlier report thus might have diverging figures but always the latest CBS report is followed. In addition the Netherlands Enterprise Agency (RVO) gathers more detailed information for the subset of larger systems that used the SDE++ scheme and market & industry trends. A discussion of and guidelines (in Dutch) for the data gathering process by the CBS can be found in the following document “Onderzoek naar Productiefactoren” (CBS, 2022).

1.1 Applications for Photovoltaics

In 2023 the steady growth of solar installation in the Netherlands levelled off with 4,343 GWp installed capacity and no longer showed the accelerated growth pace of the last few years. Especially the larger solar system market segment fell behind as they are required nowadays to show there is capacity on the electricity grid before they can apply for the SDE++ scheme.

Uncertainty about the future of the net metering scheme and increasing grid congestion, causing involuntary curtailment, may have made prosumers more wary to invest in roof top solar applications. The business case of net metering is gradually being replaced by self-consumption which means that solar systems need to be more adjusted to the expected energy profile and take into account other measures around the house like isolation, heat pumps, home charging of electrical vehicles and home batteries.

While during the energy crisis electricity prices soared and peaked at the end of 2022, thereby stimulation solar PV installations, the energy prices in 2023 fell but did not return to the precrisis level. An analysis of the national bank (DNB 22-04-2024) shows that most home owners were able to finance investments in energy measures and lower their energy bills while a large part of the population, mostly tenants, were not.

In general, closing purchase power agreements (PPA’s) and installing local battery storage has helped mitigating the effects of increasing grid congestion. A national plan, coordinated by the government and grid operators (National Grid Congestion Action Programme), includes measures like cable pooling and new guidelines for frequency management.

Grid congestion has become not just a problem for the solar sector but for the Dutch society at large and it forces fundamental questions about the new and more decentralised electricity system and prioritization of the available grid connections.

The solar roof top market segment continues to be a main driver of solar deployment in the Netherlands. However, since more than half the privately owned houses already have installed solar PV, the major challenge for greening the building stock the coming years lies in the renovation market for business parks, public buildings, rentals and apartment blocks.

The ongoing debate on net metering in 2023 focused on the one hand on the costs and benefits for the hard to reach and lower income groups in Dutch society and on the other hand on the

lack of incentives in the scheme to benefit local grid congestion management while adding to the overall grid transportation costs for everybody.

Integrated solar application, like building integrated solar PV (BIPV) remains a relatively small market segment. Although many “market ready” BIPV systems are available, there is still room for innovation both business wise and technologically. The national production capacity for BIPV modules in the Netherlands is currently estimated at 100 MWp a year and ramping up with support of the national growth fund initiative SolarNL with two specific program lines on BIPV.

Although energy communities (collectives) are present in most municipalities and expanding their activities to other renewable energy sources. With 43 MWp installed in 2023 the amount accounts for 1% of the nationally total amount installed in 2023. (Source HierOpgewekt 2023)

Inshore floating systems are usually accounted for in the larger SDE++ scheme while offshore floating systems are still under development and not online yet. The government has set goals for achieving 3 GWp offshore floating systems on the North Sea around 2030.

Off-grid systems in the Netherlands are rare and mostly restricted to the transport infrastructure, weather stations, etc.

1.2 Total photovoltaic power installed

Information about installed capacity in the Netherlands is collected over the calendar year by the CBS from different sources and on a detailed municipality level. These figures change throughout the year as more information is coming in and are cross referenced.

Centralized systems in the Netherlands correspond to the SDE++ category of over 15 kWp and using a 3 x 80 Ampere connection to the grid. These can be ground mounted, floating or installed on buildings. Decentralized systems are considered those smaller than 15 kWp.

Figure 1 Yearly installed PV and accumulated capacity

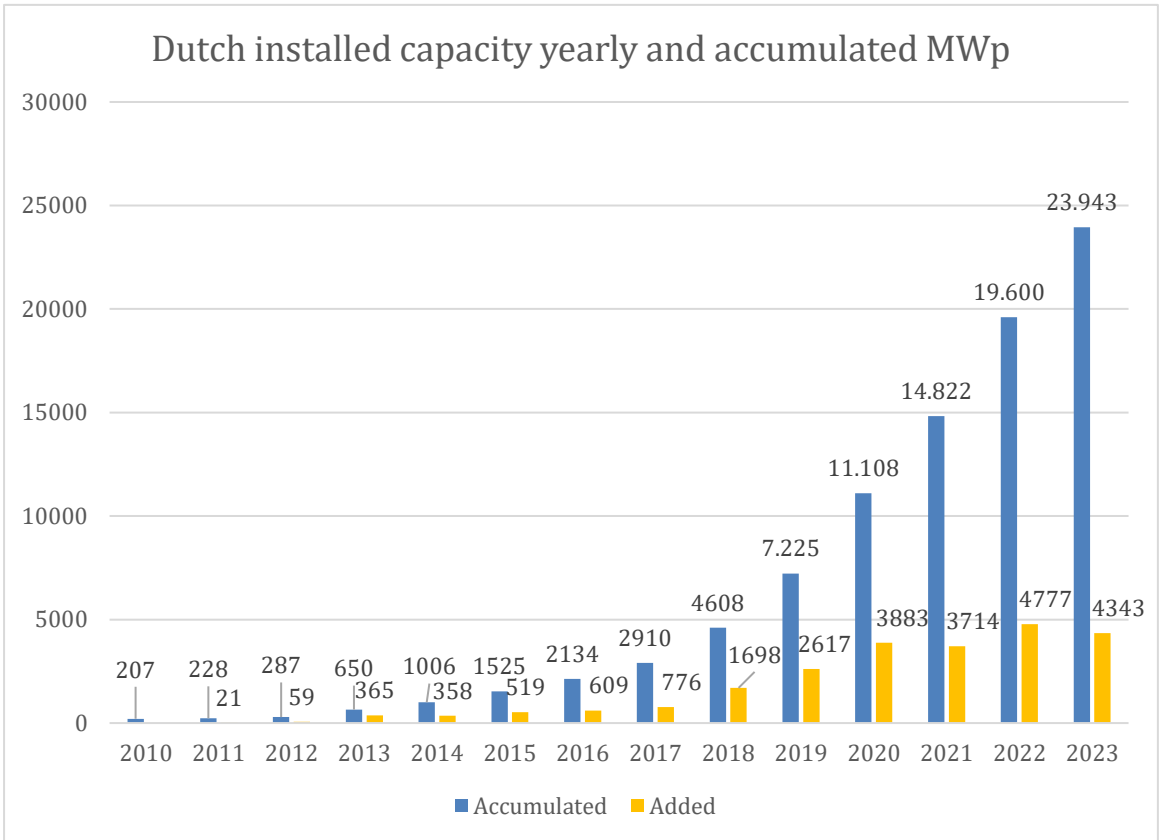


Table 1: Annual PV power installed during calendar year 2023

		Installed PV capacity in 2023 [GW]	AC or DC
	Decentralized	2.3	DC
	Centralized (systems > 15 Kwp)	2.1	DC
	Off-grid	0	DC
	Total	4.4	DC

Source CBS 02-09-2024:

The CBS reports PV installed capacity and uses the average irradiation (390.000 J/cm2) and full load hours yearly (875 kWh/kWp) in the Netherlands to calculate kWh in DC.

The official CBS information is updated during the following year as more information becomes available. Especially for smaller roof top systems this process is delayed and partly based on the (green) guarantees of origin issued by CERTIQ. In 2023 CERTIQ merged with VERTOGAS into VERTICER, servicing both the electricity and gas sectors.

Table 2: PV power installed during calendar year 2023

			Installed PV capacity [MW]	Installed PV capacity [MW]	All systems are reported in DC
Grid-connected	BAPV	Residential	2.178		DC
		Commercial			
		Industrial			
	BIPV	Residential	Estimated 100 MWp		
		Commercial			
		Industrial			
	Utility-scale	Ground-mounted	2.065		
		Floating			
		Agricultural			
Off-grid		Residential			
		Hybrid systems			
Total			4.343 GWp		DC

Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	NA
Is the collection process done by an official body or a private company/Association?	CBS Statline
Link to official statistics (if this exists)	RVO Zon Monitor 2024 Monitoring zonne-energie (rvo.nl) CBS Statline StatLine - Hernieuwbare elektriciteit; productie en vermogen (cbs.nl) Energieverbruik uit hernieuwbare bronnen gestegen naar 17 procent | CBS
Explanation of the method of data gathering by CBS can be found here:	Onderzoek naar productiefactoren zonnestroom in 2022 | CBS

Table 4: The cumulative installed PV power in 4 sub-markets

Year	Off-grid [MW]	Grid-connected distributed [MW] Small systems < 15 kWp	Grid-connected centralized [MW] (SDE category > 15 kWp	Total [MW]
2010	0	207	-	207
2011	0	228	-	228
2012	0	287	-	287
2013	0	650	-	650
2014	0	1.007	-	1.007
2015	0	1.530	-	1.530
2016	0	2.140	-	2.140
2017	0	2.621	289	2.910
2018	0	3.476	1134	4.610
2019	0	4.472	2.758	7.230
2020	0	5.674	5.436	11.110
2021	0	6.932	7.888	14.820
2022	0	9.549	10.051	19.600
2023	0	11.793	12.150	23.943

Source: CBS September 2024 and RVO Zon Monitor 2024

Table 5: Other PV market information

	2022
Number of PV systems in operation in your country	2.808.439
Decommissioned PV systems during the year [MW]	No numbers available
Repowered PV systems during the year [MW]	No numbers available

The amount of decommissioned solar panels in the Netherlands is slowly increasing up to 1.383 ton in 2023 of which only 51 ton is recycled. The source is (W)EEE register.

Table 6: PV power and the broader national energy market

	Data	Year 2023
Total (net) power generation capacities [GW] including nuclear	118.212	2023
Total renewable power generation capacities (including hydropower) [GW]	55.610	2023
Total electricity demand (net consumption) [TWh]	107.684	2023
New power generation capacities installed [GW]	6.875	2023
New renewable power generation capacities (including hydropower) [GW]	8.555	2023
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh]	19.993	2023
Total PV electricity production as a % of total electricity consumption	17,27%	2023
Average yield of PV installations (in kWh/kWp)	860 kWh	2023

Source: Electricity Balance Sheet; supply and consumption (CBS 2024)

1.3 Key enablers of PV development

Key drivers for decentralized PV deployment include the higher electricity demand caused by home charged electrical vehicles, heat pumps, increasingly air conditioning in the summer and the rising energy prices caused by not only the energy crisis but also higher transportation fees by grid operators.

All these trends align well with the solar PV energy profile during most of the year and improves the individual business cases. Only during the dark winter month's is there a national heating and storage problem. As such solar PV remains the main driver of the energy transition in decentralized systems and is within reach of most consumers. Barriers to these general economic and technical developments in the Netherlands are especially: split incentives for renewables in the build environment, a lack of energy ownership and the existing governance structure for grid expansion and investments, which did not anticipate clearly enough the accelerated growth of solar PV since 2014 and it's far reaching consequences.

In the category centralized power systems, solar PV is still outperformed by wind, which is mainly installed offshore at the North Sea. These offshore wind parks connect directly to the transmission network provided for by the national transmission operator TENNET. Increasingly, solar and wind parks are combined, using the existing cable connections. As such the increasing number of hybrid renewable energy parks has also become a driver for a specific form of solar PV deployment.

Electric cars (excluding fuel cell vehicles) estimated total 543.300 and new in 2023 around 100.000 (source IEA TCP HEV Annual Report). In 2023 a new collaboration agreement on a regional approach to national coverage of charging infrastructure was presented in October 2023.

The installation of heat pumps in the Netherlands accelerates after 2016 to a total of estimated 550.000 in 2022 and 100.000 installed yearly. (source IEA TCP HTP Annual Report 2023).

Figures for Battery capacity over 1 MWh are collected by the CBS since 2022. The total of this category amount to an estimated 1000 MWh in 2023. Data for smaller battery storage systems including home battery systems are not collected yet.

Table 7: Information on key enablers.

	Description	Annual Volume	Total Volume	Source
Decentralized storage systems In [MW, MWh or #]	Behind-the-meter battery storage systems, connected to the electric grid.	NA		IEA TCP STORAGE
Residential Heat Pumps [#]			Estimated 550.000	IEA TCP HTP
Electric cars [#]	Plug in Electrical cars	Estimated 100.000	Estimated 500.000 EV (not including hybrids)	IEA TCP HEV
Electric buses and trucks [#]	Plug-in Electric buses, light commercial vehicles, trucks and heavy duty vehicles	NA	Estimated 110.000	IEA TCP HEV
Hybrid Solar/Wind Parks	Hybrid Solar/Wind Cable Pooling	NA		

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 8: Typical module prices euro/wp residential

Year	Lowest price of a standard module crystalline silicon	Highest price of a standard module crystalline silicon	Typical price of a standard module crystalline silicon
2009	3	-	6
2010	2	-	3,2
2011	1,2	-	2,1
2012	0,9	-	1,5
2013	0,5	-	0,75
2014	0,62	-	0,8
2015	0,62	-	0,8
2016	0,57	-	0,78
2017	0,53	1,35	0,67
2018	0,35	1,15	0,55
2019	0,35	1,15	0,52
2020	0,3	1,15	0,47
2021	0,3	1,15	0,55
2022	0,35	1,3	0,57
2023	0,25	1,0	0,31

Source PBL

2.2 System prices

Table 9: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices euro/Wp]
Off-grid kW	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid.	NA
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	Est. 1,2
Residential BIPV 5-10 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected households. Typically, on villas and single-family homes.	NA

Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	Est 0,6
Small commercial BIPV 10-100 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	NA
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	Est. 0,6
Large commercial BIPV 100-250 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	NA
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	Est. 0,5
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	Est. 0,7
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	Est 0,5
Other categories existing in your country	Floating systems	NA

Source PBL

Table 10: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW **[euro/W]**	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[euro/W]**	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[euro/W]**	Centralized PV Grid-connected, ground-mounted, centralized PV systems 10-50 MW **[euro/W]**
2023	1,2	0,6	0,5	0,5

2.3 Cost breakdown of PV installations

The cost breakdown of a typical 5-10 kW roof-mounted, grid-connect, distributed PV system on a residential single-family house and a typical >10 MW Grid-connected, ground-mounted, centralized PV systems at the end of 2023 is presented in Table 11 and **Error! Reference source not found.**, respectively.

The cost structure presented is from the customer's point of view. it does not reflect the installer companies overall costs and revenues. The “average” category in Table 11 and **Error! Reference source not found.** represents the average cost for each cost category and is the average of the typical cost structure. The average cost is taking the whole system into account and summarizes the average end price for customer. The “low” and “high” categories are the lowest and highest cost that has been reported within each segment.

Table 11: Cost breakdown for a grid-connected roof-mounted, distributed residential PV system of 5-10 kW

Cost category	Average [euro/W]	Low [euro/W]	High [euro/W]
Hardware			
Module	0,3	na	na
Inverter	0,05	na	na
Mounting material	0,1	na	na
Other electronics (cables, etc.)	0,2	na	na
Subtotal Hardware	**0,65**		
Soft costs			
Planning	-	na	na
Installation work	-	na	na
Shipping and travel expenses to customer	-	na	na
Permits and commissioning (i.e. cost for electrician, etc.)	-	na	na
Project margin	-	na	na
Subtotal Soft costs	**0,6**		
Total (excluding VAT)	**1,2**		

The cost breakdown for larger systems in the Netherlands follows different categories and has a specific method, see Planbureau Leefomgeving (PBL) “Eindadvies Basisbedragen SDE++ 2023”.

2.4 Financial Parameters and specific financing programs

Interest rates were on the rise in the whole of Europe in 2023 resulting in increasing capital costs for commercial installations. Many municipalities however offered lower rates provided by a special national fund for energy saving, matched by their own contribution. These rates are included below in table 13 for residential installations as the total budget cap is 65.000 euros.

Table 12: PV financing information in 2023

Different market segments	Loan rate [%]
Average rate of (green) loans – residential installations	3,6 - 4,1%
Average rate of loans – commercial installations	7,2 – 8,5 %
Average cost of capital – industrial and ground-mounted installations	7,2 – 8,5 %

2.5 Specific investments programs

Besides the SDE++ scheme other incentives exist but the tax (VAT) return scheme was discontinued early in 2023 and the tariff is now at 0% taxes on solar panels :

- SDE++ for solar systems larger than 15 kWp. A reversed auction system that compensates for the “unprofitable component” of renewable energy sources. The subsidy only covers the operational period of your project and compensates the difference between the cost price of the sustainable energy (or the reduction in CO2 emissions) and the revenue (if any).
- Net metering for smaller, often residential systems. The first 3000 kWh produced and fed into the grid are deducted from your energy bill against the same retail price. Lately energy companies have started to revise these arrangements within the limits of the existing contracts.
- The postal code (tax reduction scheme) ran until April 2021 and was adjusted to the SCE (subsidy cooperative energy). It is an operation subsidy where energy cooperatives and collectives of house owners are exempt from VAT.
- ISDE is an investment subsidy for SMEs up to 125/kWp.
- BOSA is an investment subsidy for sport accommodations.

2.6 Merchant PV / PPA / CPPA

Large scale commercial solar projects usually make use of the SDE++ scheme however around 18% of the projects in 2023 did not. The number has increased lately and is possibly caused by growing grid congestion. Especially business parks are affected and these can enter congestion management arrangements with the local grid operator and coordinated local production and demand in so called energy hubs and PPA’s.

While self-consumption remains the main driver in the Netherlands for smaller systems, the larger SDE++ category increasingly relies on such PPA’s constructions.

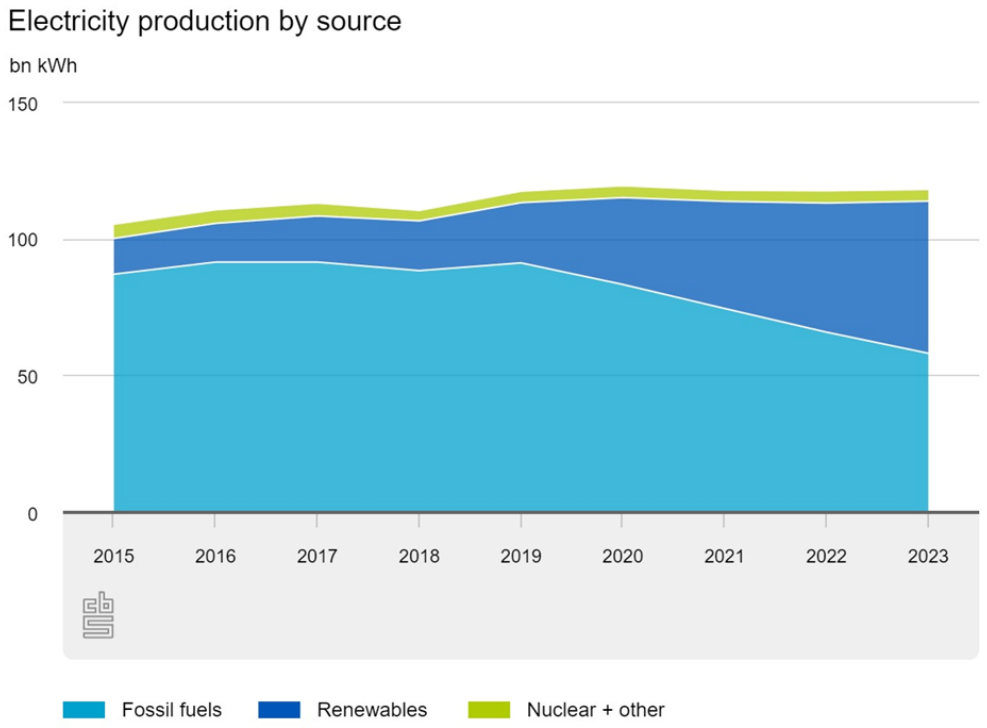
2.7 Additional Country information

The Netherlands has a population 17.88 million inhabitants on an area of 41,543 sq km, located at the mouth of four major rivers. The Caribbean Netherlands consists of the islands Bonaire,

St Eustatius and Saba. These are not included in this publication. Nevertheless around 20% of electricity production on the islands Saba and St. Eustatius comes from solar farms while on Bonaire wind farms are the dominant source of renewable electricity. A specific publication is provided by the CBS “The Caribbean Netherlands in Numbers”.

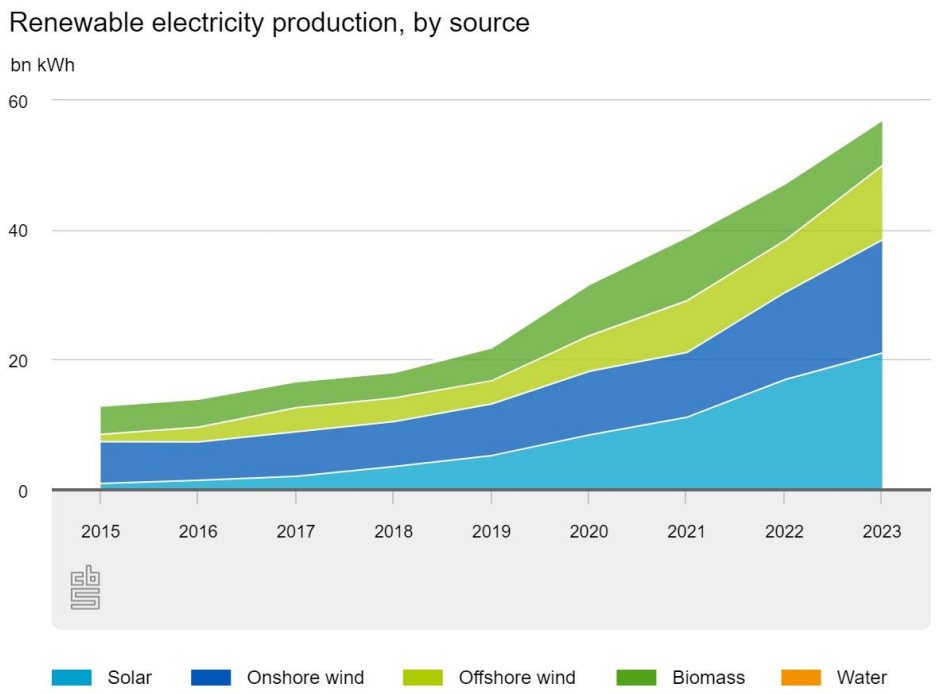
The total national electricity demand has been stable after the Covid epidemic at 107.684 TWh a year and the share of renewables has been steadily increasing as of 2019 to 17% in 2023, an increase of 2% compared to 2022.

Figure 2 Total yearly electricity production by source.



Solar PV takes 24% of this amount, wind 31%, biomass 34% and heat pums/geothermal 8%. The share of solar PV in the total electricity production in 2023 has risen to 16,5% total.

Figure 3 Total yearly renewable electricity production by source.



Source: Zon-Monitor 2024: [Monitoring zonne-energie]

Table13: Country information (Source CBS)

Retail electricity prices for a household [euro kWh]	0,43 average
Retail electricity prices for a commercial company [euro/kWh]	0,23 average
Retail electricity prices for an industrial company [euro/W]	na
Liberalization of the electricity sector	The electricity sector was liberalized in 1997. Retail was separated from distribution network ownership in 2009 and the publicly held energy companies were sold off.

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

Table14: Summary of PV support measures

Category	Residential			Commercial + Industrial			Centralized		
Measures in 2023	**Legacy**	**On-going**	**New**	**Legacy**	**On-going**	**New**	**Legacy**	**On-going**	**New**
Feed-in tariffs		-	-		-	-		-	-
Feed-in premium (above market price)		-	-		-	-		-	-
Capital subsidies		Y	-		Y	-		-	-
Green certificates		Y	-		Y	-		-	-
Renewable portfolio standards with/without PV requirements		-	-		-	-		-	-
Income tax credits	Y	-	-	Y	-	-		-	-
Self-consumption		Y	-		Y	-		-	-
Net-metering		Y	-		Y	-		-	-
Net-billing		-	-		-	-		-	-
Collective self-consumption and delocalized net-metering		Y	-		-	-		-	-
Sustainable building requirements		Y	-		-	-		-	-
BIPV incentives		-	-		-	-		-	-
Merchant PV facilitating measures					Y			Y	
Other (specify)		-	-		-	-		-	-

3.1 National targets for PV

Since the 2019 Climate Agreement, the Netherlands has legally binding national climate targets for 2030 and 2050. The original target was to reduce greenhouse gas emissions 49% by 2030 compared to 1990 levels and 95% by 2050. These targets cover all greenhouse gas emissions in the country and were set as legal requirements in the Climate Act in May 2019. In 2021, the Netherlands increased its climate ambitions and changed the 2030 target to 55% emissions reductions in line with the EU target, with the aim to introduce policies that enable a 60% reduction if possible.

The climate targets translate to greenhouse gas emissions levels at 103 Mt CO2-eq by 2030 and less than 11 Mt CO2-eq by 2050, compared to 221 Mt CO2 eq in 1990. In 2023, total emissions were 148 Mt CO2-eq.

Power and heat generation is the largest source of emissions, followed by industry, buildings, transport and agriculture. The power sector has decreased emissions the most in recent years, from 48 Mt CO2 eq in 2018 to 24 Mt CO2-eq in 2023, a reduction by half in five years.

Solar PV contributes a relative large share to the national climate goals and recently energy security. In 2023 17% (20,0 TWh) was generated as part of the total electricity production. The ambition is to generate 35,0 TWh in 2030. Key here is the division between large scale and small scale distribution, the planning process and the development of new markets.

This goal translates roughly to a 55% CO2 reduction and would open the way for a new phase of electrification, also of sectors not easily reached by solar and wind, and make sure the 2050 goals remain within reach.

Although the innovation policy for the energy sector does not mention specific targets for specific technologies such as PV, some specific policies for solar were announced to adjust to the changed circumstances:

1. A strong preference for deploying solar panels on the available roof tops
2. Nature reserves and agricultural ‘open field” systems are to be avoided
3. The multifunctional use of existing terrain and surfaces
4. The use of federal land adjacent highways, railways, dredging depots etc.
5. In addition the Minister of Economic Affairs & Climate launched plans to install 3GW of floating solar on the North Sea around the year 2030

The number of involved ministries has also increased recently and regional governments play an important role for assigning the scarce spaces, planning, granting permits etc.

Grid congestion has increased substantially in 2023 and new, large scale solar parks need to show there is capacity on the grid first before they can apply for the SDE++ scheme. Additional measures are promoted together with the grid operators to address the urgent situation which include power plant design, cable pooling, load shifting, both passive and active curtailment and the increasing use of storage facilities.

Additional funds are freed in 2023 by the state owned grid operators for grid reinforcement as a long term strategy.

In 2023 specific attention is paid by the innovation programs to the circularity and life span of solar panels.

3.2 Direct support policies for PV installations

Several direct support schemes are in place and together with the historical decline in solar panel prices, these have caused solar PV to row rapidly in the Netherlands over the last ten years. Some changes however are discussed, considering a more even roll out and avoid over stimulation. Most importantly among these for smaller systems is the net metering scheme.

While in previous years the phasing out of the net metering scheme was announced by the government, this public debate still continues and focuses on the different business cases for solar energy and the return on investments for the end users. After some discussion the tax (VAT) return scheme on solar applications was stopped in 2023 and the tariff set to zero.

Support schemes in the Netherlands:

- SDE++ for solar systems larger than 15 kWp.
- Net metering for smaller and often residential systems.(< 12 kWp)
- Postal code (tax reduction scheme) until 2021 was adjusted to the SCE (subsidy cooperative energy).
- ISDE for SME's for energy saving measures. There are no ISDE subsidies for individuals regarding solar panels.
- EIA is a (green) tax reduction scheme for SME's.
- Cheap green loans in many municipalities but only if they are signed up to a national fund.

3.2.1 Mandatory solar

There are no mandatory measures for BAPV solar PV in the Netherlands other than the BENG norm for newly build houses which have to almost energy neutral. This implies often the installation of a certain amount of solar PV depending on the energy profile of the finished house and installations. For BIPV there are no effective building codes or other measures that make the installation of BIPV mandatory or beneficial in the Netherlands.

3.2.2 Description of support measures

- The SDE++ scheme for larger systems (> 15 kWp) plays an important role in the development of solar park. Almost 47% of the total installed capacity in 2023 was realized with the SDE++ scheme and around 84% of the larger PV systems. The SDE++ scheme is a subsidy for exploitation. This implies that the subsidy is received over the period of exploitation of the solar park and depends on the market prices and the realized amount of solar power. There exist several general categories and it is in essence a reversed auction system, the cheapest technology prevails within that category, in this case renewable electricity. Every technology has its own base prices which correspond to the production costs or the reduction of CO2 emissions. The base prices are also the maximum amount of subsidy which can be received. This means that in case market prices are high enough, no subsidy is received, while in case of low market prices additional subsidies are received.

- The net metering scheme deducts the yearly kWh generated solar power from the yearly consumed kWh from the grid.

- The EIA is a green tax reduction scheme for SME's.

- The SCE is another exploitation subsidy for energy communities and associations of house owners.
- The ISDE is an investment subsidy for house owners or commercial users such as housing associations.
- BOSA is an investment subsidy specially for sporting accommodations.
- The cheap loans for improvements to your home come from a green national fund in which municipalities can participate.

3.2.3 BIPV development measures

While there is an energy label in place for buildings in general and measures exist to reduce the dependency on natural gas in the build environment, there are no policies in place to incentivize or mandate building-integrated PV in the Netherlands.

On the contrary, it was found in the recent IEA PVPS task 15 report "*Analysis of the Technological Innovation System for BIPV in the Netherlands 2024*" that these measures, including the BENG norm for newly build houses, even negatively affect the implementation of BIPV in favor of regular solar PV installations.

Photo courtesy of Kameleon Solar

3.2.4 Merchant PV development measures

As mentioned above PPA's and CPPA's are increasingly used to balance local supply and demand. Increasing grid congestion is one of the main drivers for this development but also the matching of entities with complementary energy profiles

3.3 Self-consumption measures

Table 15: Summary of self-consumption regulations for small private PV systems in 2023

PV self-consumption	1	Right to self-consume	Y
	2	Revenues from self-consumed PV	N
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	Y
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Y
	5	Maximum timeframe for compensation of fluxes	N
	6	Geographical compensation (virtual self-consumption or metering)	N
Other characteristics	7	Regulatory scheme duration	N
	8	Third party ownership accepted	Y
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	N
	10	Regulations on enablers of self-consumption (storage, DSM…)	Y
	11	PV system size limitations	N
	12	Electricity system limitations	Y
	13	Additional features	

3.4 Collective self-consumption, community solar and similar measures

Collective self-consumption does exist in the form of the above mentioned SCE subsidy scheme, of which more than half finds its way to rental homes by means of the social housing associations. However the budget is maximized and relatively few people use the scheme.

In the original net-metering scheme (without a digital meter) the distinction between self-consumption and no consumption was not even made.

3.5 Tenders, auctions & similar schemes

The SDE++ scheme mentioned above is essentially a reversed auction system. It is important to note that the table below shows the realized solar parks in MWp, which differs from the granted number of SDE++ projects. The main reasons for not realizing solar plants are; problems with the roof constructions, obtaining private financing, increasing construction costs and grid congestion. In 2023 a total of 1.650 MWp was cancelled.

Table 16: Yearly realized capacity MWp 2023 by SDE++ category

Years/realized projects in MWp	Between 15kWp and 1MWp)	Building mounted (>1MWp)	Not building related (>1MWp)
2017	171	51	60
2018	398	51	395
2019	779	150	495
2020	989	423	1026
2021	779	446	898
2022	552	462	1065
2023	250	355	967

Source: RVO ZonMonitor 2024

3.6 Other utility-scale measures including, floating and agricultural PV

The inland larger floating systems are included in the SDE++ category for solar and so are systems on agricultural land. Integrated Agri-PV systems and offshore floating PV systems are under development and very much part of the innovation agenda.

3.7 Social Policies

As mentioned, BOSA is an investment subsidy for sport accommodations. This can be considered as an incentives with social goals.

For schools the available subsidies are part of the “climate control” for schools, and were stopped in 2023. Around only half of the schools with suitable surfaces have installed solar panels.

Energy coaches are made available on a municipality level who advise concerning easy to implement energy saving measures and the benefits of solar panels. In addition, cheap green loans are available in many municipalities but only if they are signed up to the national fund.

No other specific measures are in place to address so called “energy poverty” in the Netherlands.

3.8 Retroactive measures applied to PV

No retroactive measures were applied in 2023.

3.9 Indirect policy issues

3.9.1 Rural electrification measures

Measures for rural electrification are absent in the Netherlands.

3.9.2 Support for electricity storage and demand response measures

The are no specific incentives for battery storage at home in the Netherlands. The already mentioned EIA scheme covers various technologies among which battery storage.

3.9.3 Support for encouraging social acceptance of PV systems

The economic and social aspects solar PV deployment were already mentioned.

In addition the esthetical aspects of solar in the landscape and built environment are addressed with technology and design innovations. Spatial Integration of solar PV is high on the agenda of local governments.

3.9.4 Other support measures

The combination of solar PV together with other measure like battery storage and EV's are mentioned above as drivers of solar PV but not stimulated as a package together with demand response measures.

The climate goals are national goals for each country and international compensation follows mostly the international emission trading scheme or ETS.

3.10 Financing and cost of support measures

The SDE++ scheme is paid for by a levy on the energy prices and since 2023 these are part of the energy taxes paid to the government. The additional amount has been around 3 euro cent to the electricity prices over the last few years

The net-metering scheme is subject to a negotiation between the prosumer and the energy supplier, supervised by the national regulator. The amount of kWh consumed and produced are levelled without paying additional taxes.

3.11 Grid integration policies

Grid integration, connection and access to the grid are integral part of the energy law and supervised by the national regulator Autoriteit Consument & Markt (ACM). The recent and increasing grid congestion has raised many question and the current situation is under revision.

4 INDUSTRY

4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

The Dutch solar industry took a hit in 2023 with several bankruptcies and take overs caused primarily by the low module prices. At the same time new start up entered the field with innovative products. New startups and spin offs appear each year, especially in thin film deposition technology and companies targeting new market segments. Examples of these are Morphotonics, with experience in nano-imprint and microreplication, SALD and SparkNano are both specialized in Spatial ALD technology.

In 2023 the National Growth Fund proposal Solar NL was granted with 300 Million government support. It aims to develop national high efficiency solar cells and light weight modules production for niche markets. It contains three program lines;

- High efficiency hetero junction cells
- Flexible solar foils and perovskites
- Custom made light weight applications (BIPV and VIPV)

See website SolarNL – National Dutch PV research, innovation and industry program

In addition circular design for solar panel is being stimulated by subsidy grants and new ways for recycling or refurbishing panels that have reached end of life.

No silicon feedstock is produced in the Netherlands but plans exit to start up production.

Table 12: Silicon feedstock, ingot and wafer producer's production information for 2023

Manufacturers	Process & technology	Total Production	Product destination	Price
	Silicon feedstock [Tonnes]	0		
	sc-Si ingots. [Tonnes]	0		
	mc-Si ingots [Tonnes]	0		
	sc-Si wafers [MW]	0		
	mc-Si wafers [MW]	0		

4.2 Production of photovoltaic cells and modules (including TF and CPV)

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

In 2023 most manufacturers of PV Modules in the Netherlands had a focus on circular design with a lower carbon footprint, light weight panels and/or BIPV products. There are no producers of solar cells.

Total PV cell and module manufacture together with production capacity information is summarised in Table below.

Table 13 : PV cell and module production and production capacity information for 2023

Cell/Module manufacturer	Technology	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Totals	Csi/Asi/CIGS	**0**	**200**	**na**	**na**

4.3 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. In the Netherlands additionally machinery and equipment manufacturers play an important role in the innovation process for both crystalline and thin film technologies.

Table 19 : Overview of the major companies, although the list is not exhaustive.

Machinery production equipment	Material suppliers	Junction box/inverters	Sub-structures	Modules/Integrated PV products	
Smit Thermal Solutions	Endurans	Taylor	Valk Solar systems	Exasun-Wienerberger	Kameleon Solar
Levitech	Sabic	Solned	Solarstell	Energyra	Lightyear
Tempress	Scheuten	Delta	Esdec	Solarge	Im-efficiency
Solmates	Yparex	Sofar Solar	Easyfix solar	Solinso	Mito Solar
Mat-tech	Akzo Nobel	Solar Edge	**Alius**	Elsun	FlexSol
Morphotonics	C Coatings	Sungrow		Hyet Solar	Solar Visuals
EternalSun	Resin	Huwai		Oceans of Energy	ZigZag Solar
Spire	RGS Development	Mastervolt		Solar Duck	Studio Solarix
VDL	SPG Prints & Yparex			Escom	Wattlab
Eurotron	DSM			Duramotion	Robisol
Sald	Flexipol Composites			SMA Solar Technology	GSE Integration
SparkNano	Compoform				Skipps
	Taylor Technologies				Tulipp Solar

Similarly to the wider European picture, many Dutch machines and equipment manufacturers have shifted their production to more profitable sectors or gone out of business in the recent past. Eternal Sun and Eurotron are examples of Dutch companies still active in this value chain section and joined each year by new innovative startups.

The Netherlands does not house any companies that produce metallurgical- and polysilicon ingots, wafers and cells. Instead, Dutch module companies focus more on specific niches, while sourcing their bulk material (mostly) outside Europe. These niches address the demand of a densely populated country, seeking to optimize space and energy return while expanding solar capacity to reach national climate goals.

5 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

5.1 Labour places

Table 20: Estimated PV-related full-time labour places in 2022 and 2023

Market category	Number of full-time labour places
Research and development (not including companies)	3%
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	7%
Distributors of PV products and installations	84%
Others including mainly maintenance and cleaning	6%
Total	**EST 42.550 FTE**

The business value calculated as installed capacity multiplied by price watt.

Table 21: estimation of the value of the PV business in 2023 (VAT is excluded)

Sub-market	Capacity installed [MW]	Average price [euro/W]	Value
Off-grid	na	na	-
Grid-connected distributed	2,300	1,2	2.760 mln
Grid-connected centralized	2,100	0,6	1,260 mln

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

The Netherlands have one transmission operator Tennet and several regional distribution operators; Enexis Coteq, Enduris, Enexis, Liander, RENDO, Stedin and Westland Infra. The off shore sector is mainly provided for by Tennet and so are the mainly interconnections with neighbouring countries.

The energy transport infrastructure is state owned by the central government while the energy suppliers have become completely unbundled and there is no overlap or degree of government ownership. This is different from many other European countries were governments still play a major role in energy generation. Since every household and company in the Netherlands is also connected to the gas infrastructure there is a separate state owned operator for the gas infrastructure, the Gasunie. The regulator ACM controls the energy market, including grid operators, and establishes energy codes in addition to the existing energy law.

For balancing purpose the grid operators of both electricity and gas work closely together. The smart meter roll out in the Netherlands was delegated to the regional grid operators who own the installed meters and which are regulated by the ACM and AP (authority personal/private data) together.

Storage capacity is very limited in the flat country and one of the main focus points of policy together with the increasing grid congestion. Additional measures were promoted to address this urgent situation which include: power plant design, cable pooling, load shifting, passive and active curtailment and the increasing use of storage facilities. Additional funds are freed in 2023 by the state owned grid operators for grid reinforcement although this will not solve the already existing back log in solar projects which cannot be connected in the short term. For the future roll out of solar and reaching the climate goals in the Netherlands these new powerlines and storage capacity are essential.

In 2023 a new energy law was prepared to replace the current separated electricity and gas energy laws and implement the EU Clean Energy Package (2019/944).

6.2 Interest from electricity utility businesses

Most larger energy suppliers are involved in renewable energy generation and incorporate the purchase of solar panels or rental PV systems in their customer services.

Developers of solar parks include international energy companies like Stattkraft, Engie, Vattenfall, Eneco and Shell.

6.3 Interest from municipalities and local governments

Since 2019 part of the implementation of the “energy transition” has been delegates to 30 “renewable energy regions” or RES regions in the Netherlands. This includes primarily the planning of renewable energy sources and storage in the densely populated areas and multi-functional land use. The thirty regions are supported by the provinces and several national programs. Each municipality retains its own responsibilities but collaboration is made easier beyond the township boundaries. A detailed yearly review can be found in the PBL publication Monitor RES 2024.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

In 2023 the Netherlands became the world champion for a short while with the amount of solar panels per capita (1.280 WP/inhabitant). The country will probably be overtaken in the following years as the available space in the densely populated country is limited and grid congestion is still increasing. Still, new markets are explored to incorporate integrated PV products and an ambitious plan for offshore floating has been launched.

In 2023 also the Growth Fund proposal SolarNL was granted to stimulate national production of solar cells and panels. The main topics covered in the proposal are Si HJT cells and modules, flexible solar foils and lightweight/integrated PV.

7.2 Prospects

Beside reaching the Climate Goals, the geopolitical uncertainty in Europe has become and will remain, an important driver for the production of renewable energy and a higher degree of energy independence in the Netherlands. The Netherlands also form an important energy hub for both gas and power markets in North Western Europe. The total energy mix remains heavily influenced by energy imports and exports especially to and from its direct neighbors Germany, Belgium, Norway and the UK.

The expectation for next year is that accelerated growth in the existing solar markets will level off caused by the mentioned saturation of the roof top market and increasing grid congestion. The relatively high energy prizes and ever lower prices for solar panels will offset these negative trends to some extent. The combined expected result is that the number of negative electricity prices on the day ahead market will grow in 2024.

The growing investments in the power grid and storage capacity will need time to address these issues. New markets will be developed however in transport, offshore, agriculture and the production of green hydrogen. For the build environment the main challenges remain: apartments blocks, renovation of the building stock and social housing.

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