Rijksdienst voor Ondernemend Nederland

INTERNATIONAL POSITIONING OF THE DUTCH PV SECTOR

FINAL REPORT FOR PUBLICATION

JULY 2014

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Energy Indeed

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1 INTRODUCTION

The aim of this report is to explore the unique selling points (USPs) of the Dutch solar photovoltaic (PV) sector. The results of this exploration are meant to serve as input for the International Energy Programme (PEI) of the Netherlands Enterprise Agency (RVO.nl). This programme supports the Dutch Ministry of Economic Affairs (EZ) in the implementation of its international energy policy, with a focus on the BRIC-countries: Brazil, Russia, India and China. In line with this focus, most of the examples mentioned in this report relate to the BRIC-countries. Nevertheless, the results can also be used in relation to other countries. The report starts with an introduction about the Dutch international trade position (1.1), the status of the Dutch PV market (1.2), the Dutch Topsector policy (1.3) and the aim and method of the exploration (1.4).

1.1 International trade position

In international comparisons the Netherlands is often defined as one of the most attractive countries in the world for international trade. For instance, the country lists third in the Enabling Trade Index 2014 of the World Economic Forum (after Singapore and Hong Kong) and even first when it comes to its port infrastructure.[1]

In line with this position, international trade makes up an important share of the Dutch economy. In 2013, the country's export value reached an all-time record of 500 billion euros, equalling about 80% of the country's GDP. Within the EU, only Germany has a higher export value, meaning that the Netherlands leaves behind way larger countries like France, Spain, Italy and the United Kingdom.[2]

The trade from and to the Netherlands concerns many different sectors, with solar energy being no exception. For example, the Netherlands is an important exporter of PV production equipment, an important importer of PV panels and an extensive trader in solar related services. This report later provides several illustrations of these international trade relations.

1.2 PV in the Netherlands

The Dutch PV market is on the rise. In only two years time its installed capacity has increased fourfold to a total value of 722 MW at the end of 2013 (see Figure 1). About 90% of this capacity is installed at households.[3] Thanks to the net metering policy, these consumers can save around 0.22 euro per produced kWh, as long as they do not produce more electricity than they use on a yearly basis.

The business case of large-scale PV systems is generally weaker, but for these projects there are other incentives like the SDE+ subsidy (Stimulation Renewable Energy) and a reduced electricity tax for PV systems of local cooperatives. Besides, for companies there are fiscal incentives like the EIA (Energy Investment Tax-reduction) and KIA (Small-scale Investment Tax-reduction) to invest in PV.

[1] WEF (2014) – The Global Enabling Trade Report 2014. *World Economic Forum, 1 April 2014.*
[2] CBS (2014) – Nederland tweede exportland van Europa. *Centraal Bureau voor de Statistiek, 22 April 2014.*
[3] Website: www.polderpv.nl

In absolute terms, the market is still relatively small, but regarding its steady basis, it is believed to surpass yearly growth figures of some of the rather overheated FIT-markets soon. All in all, according to the European PV industry organization EPIA, the 'PV weather forecast' for the Netherlands looks sunny (see Figure 2).[4]

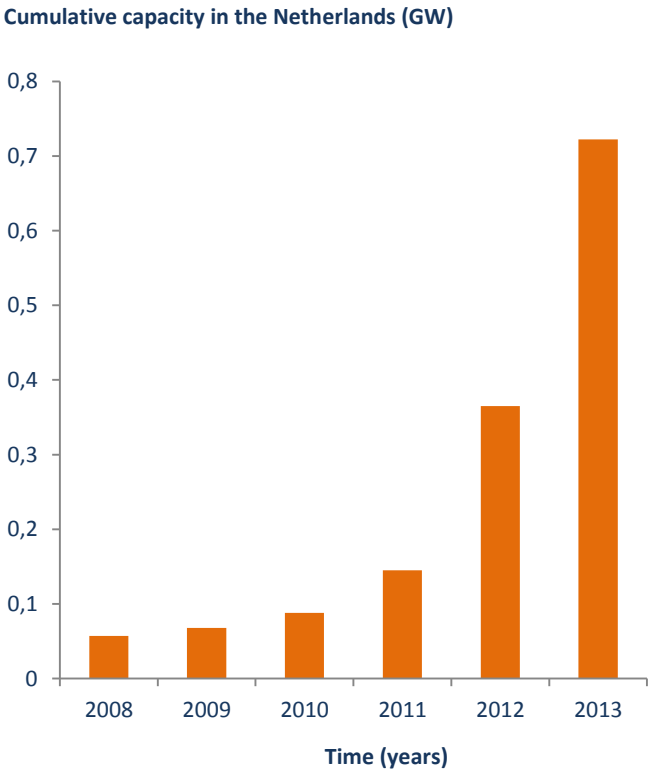

Figure 1 – *Cumulative PV capacity in the Netherlands in 2008-2013, with the preliminary estimate for 2013 (722 MW)*[5]

Figure 2 – *General political support situation for PV in European countries (early 2013)*

1.3 Topsector policy

Technology innovation in The Netherlands is stimulated by public-private partnerships with shared funding, to ensure a closer connection between research and development (R&D) and market deployment. Nine Topsectors (key areas for innovation) for economic growth are defined, including the Topsector Energy.

The public-private partnerships in the Topsector Energy are organised within seven Topconsortia for Knowledge and Innovation (TKI's). One of those TKI's is the TKI Solar Energy. The innovation contract of the TKI Solar Energy focuses on three main programme lines: PV systems and applications, wafer-based silicon PV technologies and thin film PV technologies.

[4] EPIA (2013) – Global Market Outlook For Photovoltaics 2013-2017. *European Photovoltaic Industry Association, May 2013.*
[5] CBS Statline (2014) – Hernieuwbare energie; capaciteit; zonne-energie; 2008-2013. *Visited on 25 June 2014*.

Currently, 28 TKI Solar Energy projects are in development: 14 on PV systems and applications, 8 on wafer-based silicon PV and 6 on thin film PV. In total, 105 Dutch organizations are involved with these projects, with a total project commitment of about 50 million euro. More information about these projects and organizations can be found on: www.tkisolarenergy.nl.

1.4 Aim and method

The aim of this report is to answer the following questions:

1. What are the USPs of the Dutch PV sector?
2. Where are they positioned in the PV value chain?
3. How can they be combined to create more interesting propositions?

The input for this report comes from a desk study, five direct interviews[6] and a panel session with twelve stakeholders from different parts of the Dutch PV sector on the 20th of June 2014 in Utrecht.[7] These activities have been performed in close collaboration with RVO.nl and the TKI Solar Energy.

[6] Interviews with Hein Willems (Solliance), Chiel Boonstra (Trecodome), Henk-Jan Wegman (Ubbink), Robert Jan van Vugt (Eternal Sun) and Oscar Goddijn (DSM).

[7] Panel session with Willem Vermeulen (Tempress), Theo Bosma (DNV GL), Chiel Boonstra (Trecodome), Otto Bernsen (RVO.nl), Rogier Blokdijk (FME), Jos Lenssen (HyET Solar), Wim Sinke (TKI Solar Energy), Michael van der Gugten (Smit Ovens), Fons van Pul (Pfixx Solar), Rudi Jonkman (Heliox), Marc Plaum (DSM) and Wijnand van Hooff (TKI Solar Energy).

2 VALUE CHAIN

As mentioned in the introduction, this report aims to find the USPs of the Dutch PV sector and their position in the PV value chain. As a basis for the latter, this chapter provides an impression of the PV value chain. It defines 11 segments (see Figure 3) and for each of these segments it describes the Dutch position and related collaborations.

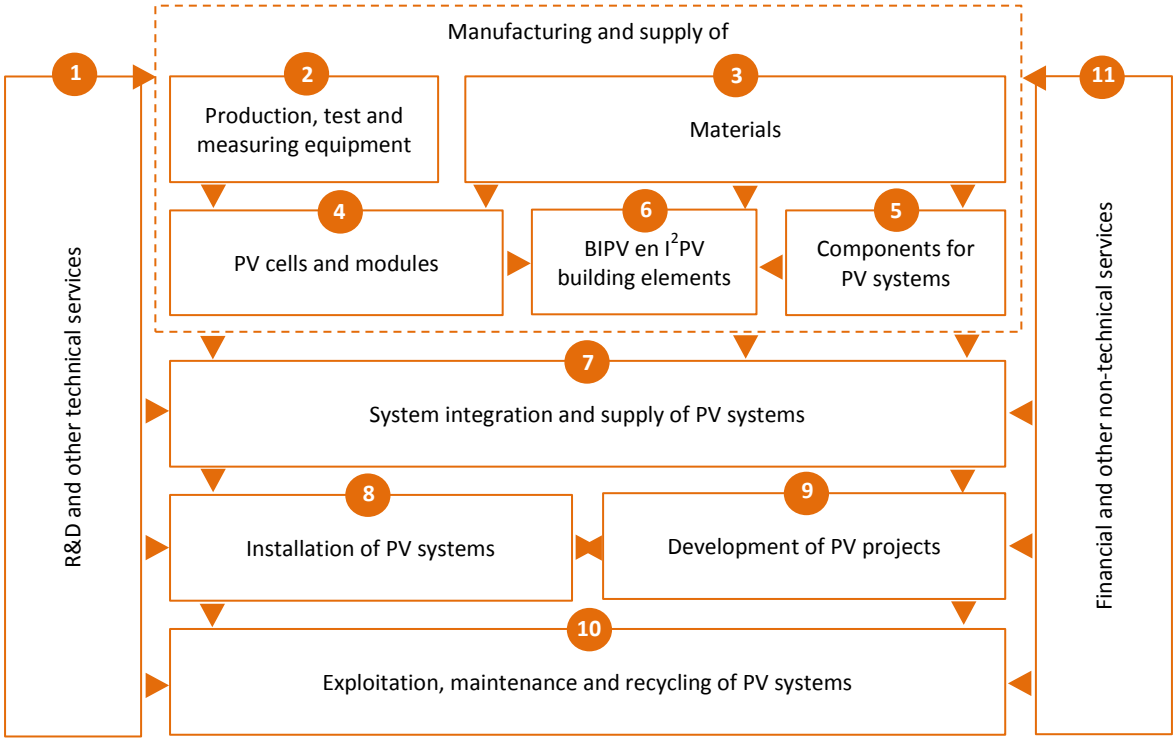

Figure 3 – *Schematic impression of the PV value chain*

2.1 R&D and other technical services

Description

The Netherlands is one of the world's leading R&D nations and among the very best in terms of R&D performance. In fact, the country belongs to the top 10 of R&D-spending nations in the world and, within that top 10, it ranks first in terms of the publication impact per research article. To a large extent, this top position is due to international collaboration.[8]

Also in the field of renewable energy, the Netherlands performs very well. On the list of patent requests in the field of renewable energy, the Netherlands lists 6th worldwide, with a 3.4 percent share.[9] ECN has the most requests and has an excellent reputation worldwide. Other Dutch organizations in this field are for instance TNO, AMOLF/FOM, the Dutch Polymer Institute and universities like the Delft University of Technology (TU Delft), TU Eindhoven, Utrecht University and Zuyd University of Applied Sciences (see also *paragraph 2.6*).

[8] Elsevier (2013) - The Netherlands – a top research nation. *By Harald Boersma, 2 May 2013.*
[9] NFIA (2009) – Holland, your gateway to a high-tech solar landscape. *Netherlands Foreign Investment Agency, July 2009*.

Besides R&D, there are also several Dutch companies who provide other technical services related to PV, like engineering, design, due diligence and other types of consultancy. Examples of these companies are DNV GL (former DNV KEMA), Royal HaskoningDHV, Ecofys, Arcadis, Grontmij, KIWA (certification institute), BDA and SGS.

Collaborations
The Dutch PV sector has bilateral relations with almost all important R&D institutes in Europe and with many others in other continents. This includes collaborations with for instance IMEC (Belgium), RWTH-Aachen (Germany) and NREL (USA).[10] In addition, there are numerous commercial collaborations with companies in for instance China, Taiwan and Japan. Together, these international collaborations have helped the Netherlands in building its current position as a small country with large contributions in the field of PV.[11] *Paragraph 3.1.1* elaborates on this point.

2.2 Production, test and measuring equipment

Description
Based upon its strong position in solar R&D and the semi-conductor industry, the Netherlands has some world-leading manufacturers of PV production machines. Examples of these companies are ASMI, Eurotron, Lamers HTS, Levitech, Meco, Roth & Rau B.V., Rimas, Smit Ovens, SoLayTec, Tempress and VDL Flow. Thanks to these companies, who are to a large extent complementary to each other, the Netherlands is in the global top 6 of PV production machine manufacturers, together with Germany, Japan, Korea, Switzerland and the USA.[12]

In addition, the Netherlands is moving forward in the field of test and measuring equipment. An example in this field is Eternal Sun. This Delft University of Technology (TU Delft) spin-off has developed solar simulation technology, which is now sold all over the world, especially in China and India. The company is positioned in both segment 1 and 2, as it provides test and measurement services as well as the equipment to do this in-house.[13] Examples of other Dutch companies in this field are Hielkema Test Equipment, XYZTEC and Celsian.

Collaborations
One of the reasons for the leading position in this segment might be the ability to work together, both with each other as well as with other segments. *Paragraph 3.1.1* elaborates on this point.

2.3 Materials

Description
The Netherlands has some large chemical companies like Akzo Nobel and DSM who supply materials to the PV industry. Over the past few years, especially the latter increased its focus on PV, for

[10] NREL (2009) – NREL teams with Dutch Energy Research Center. *National Renewable Energy Laboratory, News Release NR-1309, 28 May 2009.*
[11] Topteam Energie (2012) – Internationaliseringsoffensief. *April 2012.*
[12] FD (2013) – 'Made in Holland' speelt een cruciale rol in mondiale productielijnen zonnepanelen. *Henk Engelenburg, Financieel Dagblad, 17 May 2013.*
[13] Interview with Robert Jan van Vugt, quality manager at Eternal Sun. *Delft, 9 May 2014.*

instance by developing an anti-reflection coating for solar panels (Khepricoat) that can improve efficiencies up to 4% and by acquiring a Dutch start-up (Solar Excel) that had developed a foil that 'catches' sunlight using a unique light management technology. To increase the demand for these products, DSM has activities in other segments of the value chain as well. For instance, the company works on demonstration projects to proof the performance of their products. An example of such a demonstration project is the 1 MW PV system on top of one of their factories in India. Further, DSM has a strong position in R&D (segment 1) and it might take a step into PV recycling (segment 10).[14]

Next to the large companies mentioned above, there are several other Dutch companies that supply materials to the PV industry. Examples of those companies are C-Coatings, Resin Products & Technology B.V., RGS Development, SABIC Limburg, SPG Prints and Yparex.

Collaborations
DSM recently signed a three-year collaboration agreement with Solliance (see *paragraph 3.1.1*)[15] and the company is strongly involved with the NUON Solar Team (see *paragraph 3.2.2*). Further, most of the companies mentioned above are involved in TKI Solar Energy projects, thereby having relations with especially segment 1 and 2. These TKI projects concern themes like light management for thin film PV (including C-Coating), ecological concepts for solar cells and modules (including DSM), roll-to-roll production of organic PV (including SPG Prints) and low-weight BIPV modules (including Yparex, see *paragraph 2.4*).

2.4 PV cells and modules

Description
The Netherlands has a few manufacturers of PV products. Examples of these manufacturers are HyET Solar (thin film) and Solland Solar (crystalline silicon). The latter is in Italian hands, but its capacity in the Netherlands is expanding.[16] Further, there are several companies that aim to start production in the Netherlands in the next few years. These companies include Energyra, LineSolar, Peer+ and TULiPPS Solar.[17] Their focus is mainly on innovative products like high-performance modules, smart energy glass or durable low-weight BIPV modules.

There are also some examples of semi-Dutch joint ventures manufacturing PV products abroad, such as Parasol Energy Limited (Bangladesh) and Ubbink East Africa (Kenya). These joint ventures both have a strong focus on corporate social responsibility, paying special attention to for instance local employment, education, health insurance, safety conditions and usage of energy and water. In 2011 Ubbink East Africa implemented the first PV manufacturing plant in East and Central Africa. The company is now the leading PV company in that region.[18] [19]

[14] Interview with Oscar Goddijn, vice-president at DSM Advanced Surfaces. *Urmond, 22 May 2014.*
[15] Solliance (2014) – DSM joins Solliance CIGS research program for high performance solar modules. *Website news, 5 June 2014.*
[16] Solar Magazine (2014) – Solland Solar gaat Heerlense zonnecelproductiecapaciteit uitbreiden van honderd naar honderdvijftig megawatt. *Website news, 7 February 2014.*
[17] Solar Magazine (2014) – Nederland verwelkomt mogelijkerwijs zes nieuwe solar fabrieken tot 2017. *Edition March 2014, page 47.*
[18] PV Magazine (2011) - Ubbink opens East African PV module factory. *Website news, Becky Stuart, 31 August 31 2011*.
[19] Ubbink (2014) – About us. *Website of Ubbink East Africa, as visited on 27 April 2014.*

Collaborations

An interesting collaboration related to this segment is the SUMMIT-consortium, which is led by TULiPPS. In January 2014 this consortium received 4 million euro funding from the European Commission to build and demonstrate durable light-weight multi-functional PV modules and systems. Other members of this consortium are Uniresearch (segment 1), Eurotron (segment 2), Rimas (segment 2), Yparex (segment 3), Femtogrid (segment 5), TE Connectivity Nederland (segment 5), IBC Solar (segment 7) and, from abroad, Fraunhofer ICT and KIWA Italy.[20] Likewise, there is a multidisciplinary consortium led by TULiPPS is on Lightweight Rooftop Building-integrated PV (LiRoB).

Another interesting collaboration is the Memorandum of Understanding (MoU) on Dutch Solar Design Products in Kenya. This MoU was signed in November 2013 during a trade mission to Kenya by the Dutch Minister of Foreign Trade and Development Cooperation Lilianne Ploumen and the companies Ubbink (segment 4), Victron Energy (segment 5), Off-Grid Solutions (segment 7), S3C International (segment 9). By combining efforts, these Dutch players promote the use of high quality components, high quality system design and low threshold maintenance.[21]

2.5 Components for PV systems

Description

For roughly any component of a PV system, the Netherlands has a representative company. This includes for instance (micro-) inverters, power optimizers and storage systems (e.g. Mastervolt, Heliox, Femtogrid and Victron Energy), mounting systems (e.g. Esdec, Van Der Valk Systems, Freenergics Solar Supplies and Bosch Rexroth), monitoring systems (e.g. Plugwise and ReRa Solutions) and solar radiation measuring instruments (e.g. Kipp & Zonen). The latter exists since 1830 and has its equipment in operation at PV projects all over the world.

Collaborations

Three of the Dutch companies mentioned above collaborate in the so-called Module Level Power Management (MLPM) project. This project compares a traditional string solution (Mastervolt), a power optimizer solution (Femtogrid) and a micro-inverter solution (Heliox) in terms of energy production. Partner in this project is the Solar Energy Application Centre (SEAC), an independent research organization founded in 2012 by ECN, TNO and the Dutch solar sector organizations Holland Solar. According to SEAC, the MLPM project, which is also a TKI Solar Energy project, is unique in its design and implementation and it will lead to a better international position of the three participating companies.[22]

2.6 Building-integrated and infrastructure-integrated PV elements

Description

As one of the most densely populated countries in the world, an important aspect of PV in the Netherlands is the integration with the urban and infrastructural environment. Consequently, the

[20] TULiPPS (2014) – Long-Life, High-Efficiency PV Modules a Step Closer as Consortium Receives €4 mln Funding for Demo Program. *Press release, 15 January 2014.*
[21] Waka Waka (2014) – Dutch Solar Design Products in Kenya. *Website of Waka Waka, as visited on 27 April 2014.*
[22] Kostas Sinapis (2013) – Field Testing Module Level Power Management at SEAC. *YouTube, uploaded on 7 October 2013.*

Netherlands was one of the first countries to demonstrate a large number of PV systems fully integrated into a newly built zero-emission urban area, for instance in Parkstad Limburg (Wijk van Morgen), Amersfoort (Nieuwland, >1 MW) and Heerhugowaard (City of the Sun, >5 MW). When commissioned, the latter was even the biggest project in its kind worldwide.[23]

In line with this pioneering role, the Netherlands has a strong position in the development and supply of building-integrated PV (BIPV) and infrastructure-integrated PV (I^2PV) products. *Paragraph 3.3.1* elaborates on this point.

Collaborations
Many of the above mentioned organisations are involved in projects of the TKI Solar Energy and/or SEAC. In these projects, there is often a strong link with research organizations like ECN, TNO and universities (segment 1). In addition, SEAC is also involved in projects with PV system optimizers (segment 5) and the organization of the Solar Tours. These tours, organized together with RVO.nl, often take place during the European Solar Days in May in order to share experiences of remarkable and/or innovative PV projects in the Netherlands (not limited to BIPV and I^2PV).

Internationally, the Netherlands plays an active role on BIPV within the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS). In the past, the Netherlands had the leading role in the first IEA task about BIPV (Task 7) and currently the country is again leading in the preparation of a new task about this subject (Task 15). A definition workshop of this task will take place at the 29th EU PVSEC, this time being held in Amsterdam (September 22-26, 2014). The Centre of Expertise NEBER (New Energy Built Environment and Renewables)[24] leads these preparations.

2.7 Integration and supply

Description
Propelled by its favourable location at sea, its good infrastructure and its many harbours, such as the largest harbour of Europe (Rotterdam), the Netherlands has many PV trading companies. Examples of those companies are Energiebau Solar Power Benelux B.V., Energie-Unie, IBC Solar B.V., Libra Energy, Natec, Oskomera, Rexel, Solarclarity, SolarNRG and VDH Solar. Most of these companies offer solar panels as well as other solar system components, either as separate products or integrated into installation packs.

Several Dutch companies also integrate PV into buildings. Examples of those companies are BRS Building Systems, Hermans Techniek, Oskomera (mentioned above) and Scheuten. Further, PV is integrated in for instance infrastructure, electronic products and even fashion. *Paragraph 3.3.2* elaborates on this subject.

Collaborations
Some of the companies mentioned above have close collaborations with PV-installers and/or project developers (segment 8 and 9). These are described in the next two paragraphs.

[23] Top Sector Energy (2012) – Innovation Contract Solar Energy; Towards Green Jobs, Building Our Solar Future. *Wim Sinke and Albert Hasper, on behalf of the Innovation Table Solar Energy, 15 February 2012*.
[24] A Building Integrated High Tech Systems (BIHTS) programme, with partners like the Zuyd University of Applied Sciences.

2.8 Installation

Description
The Netherlands has hundreds of installation companies and until recently these companies were difficult to compare. However, by the end of 2012 the Netherlands introduced a certification system and three related courses (theory, mounting on the roof and electronics inside the building) for PV-installers, which allows them to proof their competences and distinguish themselves in the market. So far, respectively 243, 170 and 135 PV-installers have successfully followed these courses.[25] Based upon these certificates for individual PV-installers, there are also certificates for PV-installation companies. Examples of these certificates are the 'SEI-erkenning' (Stichting Erkenning Installatiebedrijven) and 'Zonnekeur Installateur', with the latter requiring the first. So far, 12 PV-installation companies are allowed to proclaim that they have the Zonnekeur Installateur.[26] With more and more attention for these certificates in tenders, both the individual certificates and company certificates are still increasing in numbers.

Collaborations
Some PV-installers work closely together with integrators and suppliers and/or project developers. Besides, these are strong mutual links between PV-installers, for instance in groups of one-person businesses. Almost all installers are united via UNETO-VNI, the sector association of installers and technical retailers. This organization has also played a role in the introduction of the certification system, together with for instance RVO.nl and the Dutch solar sector organization Holland Solar.

2.9 Project development

Description
Several PV trading companies are also project developers. Examples of these companies are IBC Solar B.V. Oskomera, SolarNRG and VDH Solar. Some of them also develop project abroad. An example of a Dutch project abroad is a 3.6 MW car park by Pfixx Solar at the airport of Aruba.[27]

Specifically, there are many Dutch organizations that develop PV projects in developing countries. This often concerns off-grid projects. Examples of Dutch companies involved in these projects are ETC Foundation, FRES, Rural Spark, Humana, PicoSol, S3C and SNV.

In the Netherlands, an interesting trend is the growing number of local (often non-profit) project developers, like local renewable energy cooperatives. These cooperatives often start on a voluntary basis, but a professionalization process is going on.

Collaborations
The local project developers mentioned above are united via e-Decentraal and HIER Opgewekt. The project developers in developing countries seem to be somewhat more fragmented. They sometimes collaborate with integrators and suppliers of PV systems (segment 7).

[25] Website: www.qbisnl.nl, *as visited on 13 June 2014.*
[26] Website: www.zonnekeur.nl, *as visited on 13 June 2014.*
[27] Solar Magazine (2014) – Pfixx Solar op Aruba gestart met aanleg 14.400 zonnepanelen parkeergarage luchthaven. *Website news, 27 February 2014.*

2.10 Exploitation, maintenance and recycling

Description

There are several Dutch project companies that offer PV systems including finance, exploitation and/or maintenance. Examples of these companies are Suniverse, Greenspread, Rooftop Energy and Slim Opgewekt. Variants include loan- and lease-concepts, in which the client pays off the PV-system for instance per year or per kWh. Also Dutch utility companies are more and more involved with the exploitation of PV systems. For instance, Eneco recently took over several PV-projects and now exploits PV-projects in Belgium (32 MW), France (12 MW) and the United Kingdom (10 MW).[28] Grid facilitator Alliander aims to play a supportive role in the planned exploitation of solar farms on for instance the Dutch islands Ameland (6 MW) and Texel.[29]

Regarding recycling, the Netherlands supports the introduction of collection points via PV Cycle. So far, the Netherlands has 22 collection points spread over the country.[30] Further, there are some Dutch companies that might play a role in PV recycling in the future. Example of those companies are GP Groot and Van Gansewinkel.

Collaborations

Naturally, this segment mainly collaborates with system integrators and suppliers, installers and project developers (segment 7-9). For recycling, a collaboration with for instance producers of PV-cells and panels (segment 4) might be interesting, but so far these have not been observed.

2.11 Finance and other non-technical services

Description

Dutch financial services to the international PV-sector include investments in both companies and projects. Examples of the first include investments by Rabobank in SolarCity (USA)[31] and SunEdison (USA)[32] and by the Netherlands Development Bank (FMO) in Singyes Solar (China).[33] The latter also has project investments, for instance in an 8.5 MW project in Rwanda.[34]

Other Dutch organizations in this segment include banks like ASN and Triodos, foundations like the DOEN, IKEA and Shell Foundation, private investors like Voltiq and insurance companies like Solarif.

Collaborations

Through the investments mentioned above, there is a link with integrators and suppliers (segment 7) and project developers (segment 9). Via insurance companies there is also a link with the exploitation and maintenance of PV-projects (segment 10). Close collaborations are however not well-known.

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[28] Eneco (2014) – Meer zonne-energie beschikbaar voor Belgische klanten Eneco. *Website news Eneco.be, 28 April 2014.*
[29] Alliander (2014) – Onze initiatieven voor 2014; Jaarplan. *Page 17, Januari 2014.*
[30] Website: netherlands.pvcycle.org/collection-points/map, *as visited on 16 June 2014*.
[31] SolarCity (2012) - SolarCity and Rabobank Announce $42.5 Million Fund for Commercial Solar Projects. *Website news, 15 March 2012*.
[32] OPIC (2013) - SunEdison, IFC and OPIC Close $212.5M Project Financing arrangement for a 100 MWp Solar Power Plant in Chile. *Press release, 10 September 2013.*
[33] FMO (2013) – FMO invests in Singyes Solar. *Website news, 19 July 2013.*
[34] FMO (2014) – FMO invests in first utility scale solar project in Rwanda. *Website news, 17 February 2014.*

3 RESULTS

Based upon the interviews and the panel session, this chapter aims to answer the questions as stated in *paragraph 1.4*. Without pretending to be complete, it does so by highlighting three Dutch strengths: collaboration (3.1), high-tech solutions (3.2) and design (3.3). For each of these strengths, it provides a brief description, it shows examples and flagships and it comes up with suggestions for branding and combinations.

3.1.1 Collaboration: introduction

The Netherlands has an attractive climate for collaboration between companies. This can be found for instance in short travel distances (about two hours maximum), industry clusters and many consultative structures (the 'polder model'). The Dutch PV sector makes use of these opportunities. According to the stakeholders, multiple disciplines over the value chain are easily brought together and developments on different techniques are combined. Solution oriented, the sector develops consortia within the value chain and crosses sector borders. This leads to chain integration over multiple companies.

In the Dutch PV sector, such collaboration can especially be found between the Dutch manufacturing industry and research organizations (see *paragraph 3.1.2*). In fact, with a strong concentration around Eindhoven/Heerlen and sometimes with shared work places, these organizations can be seen as a *cluster*. Being part of such a cluster can have many advantages. For instance, via industry cross-overs, it can drive innovation, open new markets or spread risks. Therefore, it seems important to also present the cluster as such and to include as many relevant organizations as possible.

More and more, a development towards such a more 'inclusive' cluster is going on, with the recently signed collaboration between Dutch multinational DSM and Solliance being an example. Their enormous international network might open up doors for smaller organizations within the cluster. The same is true for other multinationals like Philips (see *paragraph 3.3.2*) and Heineken (see Figure 4). For these multinationals as well as small and medium enterprises (SMEs), it seems important to emphasize that they are all "part of the Dutch team".

"DSM, Philips and Heineken are all **part of the Dutch team**"

Figure 4 – *Many Heineken breweries have PV panels, for instance here in Den Bosch (1.5 MW) (© Heineken)*[35]

[35] Panel session: DSM ("We are all part of the Dutch team")

3.1.2 Collaboration: examples and flagships

The strong relation in the Dutch PV sector between the manufacturing industry and research organizations can for instance be found in the collaboration between ECN and Eurotron on Metal Wrap Though (MWT) technology (*back-contact alliance*, see Figure 5) and between ECN and Tempress on n-type technology (*n-Pasha alliance*). Both of these technologies are sold worldwide, for instance in China[36], Qatar[37] and the USA[38]. The latter is among others applied by the world's PV market leader Yingli (China).

Another remarkable, and probably unique collaboration in the field of PV is Solliance. This is an alliance between ECN, TNO, the Technical University of Eindhoven, IMEC, Holst Centre (both Belgium) and Forschungszentrum Jülich (Germany), working closely together with industrial partners to strengthen their regional position (in the Eindhoven-Leuven-Aachen triangle) as a world player in thin film PV. Examples of those partners are DSM, Roth & Rau B.V. and Smit Ovens. The latter is the main supplier of production equipment to the world's thin film market leader First Solar (USA).

An interesting example specifically related to test equipment is a recently started collaboration between Solliance partners ECN and TNO (both segment 1), Eternal Sun, Hielkema Test Equipment (both segment 2), and ReRa Solutions (segment 5) on the development of a unique climate chamber. This climate chamber is able to simultaneously test performance and degradation of all types of solar cells and mini-modules, thereby gathering information which is at the moment unattainable. The equipment is expected to become commercially available in the first half of 2015.[39]

Figure 5 – *Dutch technology inside: solar panel with backside contact technology of Eurotron (© Eurotron)*[40]

With Solliance focussing on thin film, there is another collaboration that focusses on the current dominant solar PV technology, crystalline-silicon. This collaboration is called the Silicon Competence Centre (SiCC), an initiative by ECN, AMOLF and the Delft University of Technology (TU Delft). Partners of this centre include Tempress, Eurotron, Levitech, Roth & Rau, DSM, Solar Electricity Development and the Utrecht University. Like several other PV collaboration projects in the Netherlands, the SiCC is also part of the TKI Solar Energy.

[36] PV Tech (2013) – Chinese start-up buys Eurotron back-contact module manufacturing line. *Mark Osborne, 12 Dec. 2013.*
[37] PV Tech (2013) – Eurotron to supply PV production line in Qatar. *Andy Colthorpe, 26 November 2013.*
[38] PV Tech (2013) – Boost for made-in-USA advanced PV cell manufacturing. *Finlay Colville, 30 December 2013.*
[39] Solliance (2014) – Eternal Sun and Solliance develop solar testing system which is unique in the world. *Website news, 11 February 2014.*
[40] Quote by Henk Kamp, Dutch Minister of Economic Affairs. *Website of the Dutch government, 24 November 2013.*

Collaboration in the Dutch PV sector is however not limited to the link between research organizations and the manufacturing industry. More and more, there are also links with other segments of the value chain. These links can for instance be found in the SUMMIT-consortium (see *paragraph 2.4*) and other TKI Solar Energy projects.

Finally, developments in the Dutch PV sector also seem to go hand in hand with smart energy programs and sustainable building concepts. This cross-sector collaboration ('total system thinking' or 'total system building') seems to be a strong brand for the Dutch PV sector as well. Examples of collaborations in this area are the Smart Energy Collective (a collaboration on smart grids including grid operators, energy suppliers, technology suppliers, service suppliers and companies in the building sector)[41], Built4U (an alliance between six specialists in sustainable building: Doorwin, Kingspan Unidek, Zehnder – J.E. Storkair, Trecodome, The Source Group and Van Aken Architecten) [42] and the PowerMatching City partnership (including Enexis, Essent, Gasunie, ICT Automatisering, DNV GL, TNO and several universities).[43]

3.1.3 Collaboration: position, branding and combinations

The stakeholders clearly indicate that being part of a team has advantages on the sectors worldwide position. It makes the relatively small companies stronger together.

In line with the examples in the previous paragraph, Figure 6 indicates the appearance of clusters within the PV value. It distinguishes very strong clusters (segment 1 and 2) as well as new clusters. Concerning the latter, segment 3 becomes more closely related with segment 1 and 2 (for instance via DSM) and segment 5 has developed its own clusters. Further, it indicates clusters that yet need development. These are segments that still need to be combined with other clusters (for instance segment 4 with 1 and 2) or segments that currently show only a few examples and need to develop more mass and international importance in the coming years.

The uniqueness of the collaboration and given examples can be combined and branded as:

1. PV Holland B.V. – One Multidisciplinary Technology Company of Companies;
2. Solar Panels Worldwide, Dutch Technology Inside;
3. Dutch Multinationals are Part of the Team;
4. Dutch Integral Solutions.

With an eye on the future, the stakeholders indicate the wish and need to continue to develop these clusters. This is important for instance to be able to keep working on integral solutions, which are believed to become more important. This concerns for instance the integral quality and sustainability of PV products.[44]

If the PV Holland B.V. wants to position itself internationally as one multidisciplinary company of companies, it is important according to the stakeholders that existing clusters are maintained and

[41] Website: www.smartenergycollective.com
[42] Website: www.built4u.nl
[43] Website: www.powermatchingcity.nl
[44] Panel session: ECN

strengthened[45], that more bilateral collaboration is stimulated[46] and that more clusters in European context are developed.[47]

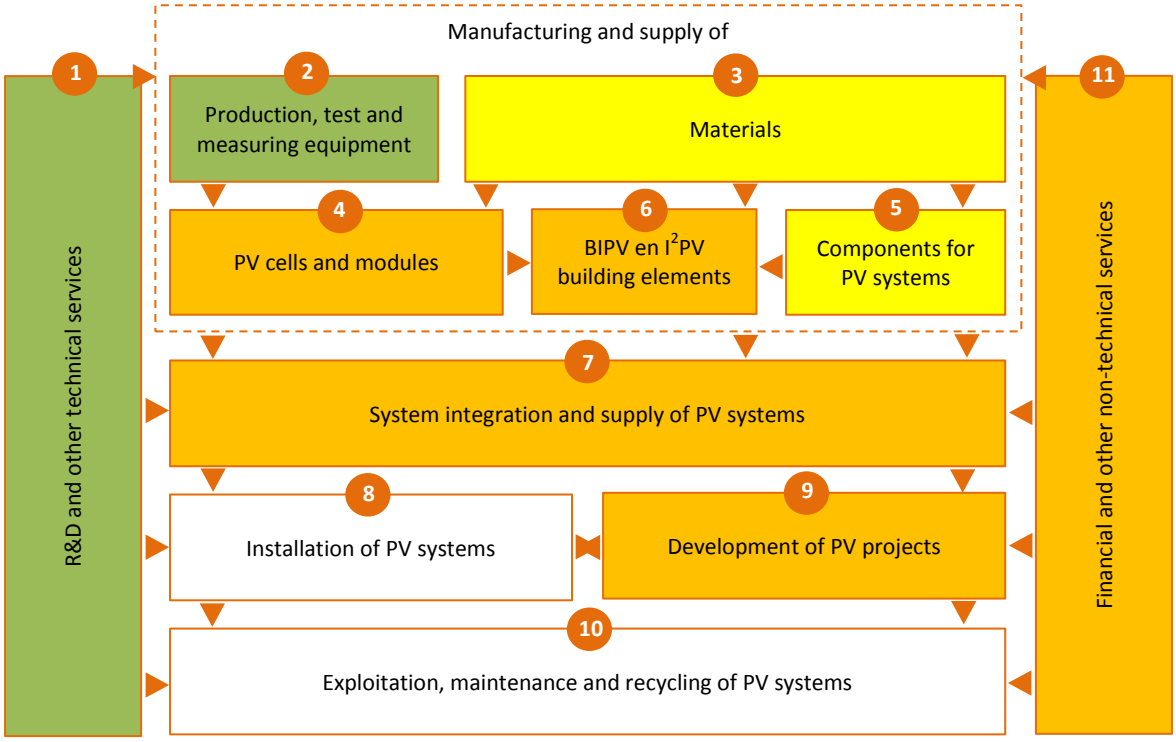


Figure 6 – *PV value chain with indication of very strong clusters (green), new clusters (yellow), clusters that need more development (orange) and clusters that hardly have an international relation (white)*

3.2.1 High-tech: introduction

The stakeholders indicate that quality, stability, reliability and innovation are strengths of products developed by the Dutch PV sector. The stakeholders also indicate that internationally, Dutch products are associated with these qualities.

These strengths seem to have a strong relation with the development of high-tech in the Netherlands. In general, Dutch companies and knowledge institutes in the high-tech sector are renowned for their technological excellence and among the world's best in their market segments and niches. These properties make the Netherlands an excellent 'place to be' for technical solutions to societal challenges in the areas of mobility, health, renewable energy, security, and the climate change.[48]

The high-tech part of the Dutch PV sector is no exception and a frontrunner in many ways. Concepts and ideas are developed and put into practice, leading to unique or first-of-a-kind solutions. In order

[45] Panel session: Hyet Solar
[46] Interview with Robert Jan van Vugt, quality manager at Eternal Sun.
[47] Interview with Chiel Boonstra, owner of Trecodome.
[48] Website: www.hollandhightech.nl/int/

to stay a frontrunner, there is a need for continuous innovation.[49] The Dutch PV sector knows this and is capable to put this into practice. The continuous innovation is a need for the sector to stay a frontrunner in the international top of solar technology development.

As 'economy' is in the DNA of the Dutch[50], quality, reliability and stability are translated into innovative products that focus on 'high efficiency, low costs'. The latter refers to low total cost of ownership, which includes quality and performance aspects of products.

Finally, Dutch products and services are also known for their flexibility and their alignment with the wishes of clients. The continuous effort for innovation and development of new products gives the flexibility to design and develop products on-demand. An example in this respect is the development of the solar simulation system of Eternal Sun (see Figure 7). The solar simulation solutions are innovative, reliable and practical in use.[51] A unique quality of Eternal Sun is their flexibility and support in customer solutions. They provide highly accurate solar simulation up to any size.

"Product, service and support **on demand**"

Figure 7 – *Flexibility with solar simulation solutions (© Eternal Sun)*

3.2.2 High-tech: examples and flagships

Paragraph 3.1.2 already shows some Dutch high-tech examples inside PV products ('Dutch technology inside'). This paragraph adds some other high-tech PV examples: Dutch champions in solar racing, Dutch PV space, the Dutch PV track-record and Dutch live demonstration projects.

Dutch champions in solar racing

Every two years, teams from all over the world compete against each other in World Solar Challenge. This challenge concerns a car race over a distance of more than 3,000 kilometres, from Darwin (North-Australia) to Adelaide (South-Australia), fuelled by nothing other than solar energy. Since its first edition in 1987 the race has been won by teams from the United States, Switzerland, Japan, Australia and The Netherlands. Since the turn of the century however, the Dutch have been dominant, winning 5 out of the 7 editions.[52]

[49] Panel session: Smit Ovens
[50] Panel session: Tempress
[51] Website: www.eternalsun.com/about_us/eternal-sun/
[52] Website: www.worldsolarchallenge.org

"Since the year 2000, the Dutch won **5 out of 7** World Solar Challenges"

Figure 8 – *Nuna 7 at the World Solar Challenge 2014 (© Hans-Peter van Velthoven)*

In all cases, these victories were reached with a car named Nuna. The first edition of this car (Nuna 1) won in 2001 and the latest edition (Nuna 7, see Figure 8) won in 2013. The car is the result of a collaboration between a bunch of Dutch organizations, including Nuon, TU Delft and DSM, who aim to show the world the possibilities of high-end technologies and renewable energy. For that purpose, the car also travels to places outside Australia. For instance, in September 2014 the car will take in the Sasol Solar Challenge from Pretoria to Cape Town (South-Africa).[53]

Still, the Nuna is not the only Dutch icon in solar racing. Since 2013 the World Solar Challenge also has a Cruiser Class, which was won by a car from the Technical University of Eindhoven. This car named Stella is the world's first solar family car.[54] Further, the Netherlands organizes the world championship for solar powered boats, called the Dong Energy Solar Challenge. The route of this challenge is the same as the route of a famous Dutch skating event in the province of Friesland: the 'Elfstedentocht'.[55]

Dutch PV in space

Just outside Leiden you can find a special subsidiary of the European Space Agency (ESA). This subsidiary, called Dutch Space, supplies solar energy systems to about two-third of all ESA missions, including all Galileo satellites commissioned to date. For the solar energy systems of these satellites, the company can be seen as the prime contractor: it does not build the solar panels in house, but – supported by a network of partners – it does perform the panels' design, engineering management, assembly and testing.[56]

A remarkable project of Dutch Space is the solar energy system of Rosetta (see Figure 9). This spacecraft was launched in 2004 and it is the first spacecraft to fly close to Jupiter. Since its launch, it has travelled to places as far as 800 million kilometres from the sun, where solar intensity is only about 4% and where temperatures are about -270°C. Because of these extreme circumstances, the efficiency and reliability of the solar energy system are crucial. In January 2014, the spacecraft hit the world news, as it had successfully awoken from a planned hibernation of almost three years.[57]

[53] Website: www.nuonsolarteam.nl
[54] Website: www.solarteameindhoven.nl
[55] Website: www.dongenergysolarchallenge.nl
[56] ESA (2014) – Dutch company powering Galileo. *Press release of the European Space Agency, 24 March 2014*.
[57] Dutch Space (2014) – Ruimtesonde Rosetta ontwaakt. *Press release of Dutch Space, 17 January 2014.*

"**Two-third** of the European satellites has a solar energy system from Dutch Space"

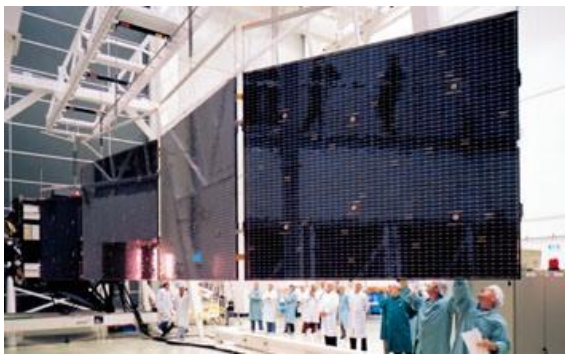


Figure 9 – *Dutch Space solar panels for Rosetta during test (© ESA)*

Another interesting Dutch company working with PV in space is ISIS (Innovative Solutions In Space). This spin-off of the Delft University of Technology (TU Delft) develops and produces satellites with the size of a milk carton (see Figure 10). For many purposes, these so-called nano-satellites are a cheap alternative for their larger brothers, for instance to track ship movements or to test solar cells. One of ISIS's latest products in space is the Delfi-n3Xt. This nano-satellite was launched from Russia in November 2013 and has an innovative technique to keep its solar cells oriented towards the sun.[58]

"Satellites with the **size of a milk carton** testing solar cells in space"

Figure 10 – *Triton satellite of ISIS (© ISIS)*

Dutch experience and track-record

Already in the 1950s, when Bell Telecom Laboratories introduced the world's first solar panel, Dutch scientists at Philips were working on solar energy research.[59] A few decades later, in 1979, the first PV factory in the Netherlands was built and Dutch implementation of PV started to take off. In the 1980s, this included the implementation of the first 'large' PV-system of 50 kW in Europe (Terschelling), an autonomous solar powered house (Castricum), solar powered buoys (by 'boeienkoning' Peter Zaadnoordijk) and rural PV projects in Indonesia. Later, the Netherlands also became responsible for the world's first large urban PV projects (see *paragraph 2.6*). Taken together, these early PV movements might be interesting to include in a branding strategy about Dutch PV, in order to show the country's rich experience and track-record in PV.

[58] TU Delft (2013) – TU Delft lanceert satelliet Delfi-n3Xt. *Press release of TU Delft, 21 November 2013.*
[59] Lysen (2006) – Fifty years of solar PV in the Netherlands. *Erik Lysen, Dutch Solar Cell R&D seminar, 27 September 2006.*

Dutch live demonstration projects

Finally, The Netherlands is not only a small, but also a densely populated country with an excellent infrastructure. Therefore, the country seems to be an ideal place to demonstrate and test urban PV solutions. This live demonstration is already done at several places, for instance in Parkstad Limburg, Amersfoort and Heerhugowaard (see *paragraph 2.6* and Figure 11), in Eindhoven (see *paragraph 2.5*: MLPM project) and in Hoogkerk (see *paragraph 3.1.2*: PowerMatching City), with the latter being claimed as the world's first live demonstration of smart grids and integral energy services in a residential area (40 houses).[60]

Figure 11 – *Demonstration of a zero-emission area: City of the Sun (>5 MW PV) in Heerhugowaard (© Cees Bakker)*

3.2.3 High-tech: position, branding and combinations

The stakeholders clearly indicate that Dutch technology is associated all around the world with 'high standard' technology. In fact, quality, reliability and innovation are named as strengths in all the segments of the value chain. Nevertheless the total economic value and international impact differs per segment. Although this research did not quantify the international impact per segment, the given examples provide an indication of the *current* international impact of the different segments. Accordingly, Figure 12 indicates the segments that currently have a high international impact (segment 1 and 2), a medium international impact (segment 3, 4, 5 and 6) and a small international impact (segment 7 and 9). Especially the latter segments still have a large potential to increase their international impact, for instance live demonstration projects.

The uniqueness of the Dutch technology and given examples can be combined and branded as:

1. Holland High-Tech;
2. Dutch Sustainable Products: Reliability, Quality & Stability;
3. Dutch Experience & Track Record;
4. Dutch Continuous Innovation;
5. Dutch High Efficiency & Low Cost solutions;
6. Dutch Flexibility;
7. Holland Demo-Lab (potentially strong in the future);

For the development of future combinations, the stakeholders indicate that the continuous effort to innovate is the most important factor to stay ahead or even to survive in the international context.

[60] Essent (2013) – Internationale primeur met energieconsument van de toekomst. *Website news, 18 June 2013.*

In line with that, copying of products and increased innovations speeds of some countries were indicated as threats. Nevertheless, the stakeholders agree that, if the strong industrial and technological basis of the Netherlands will be maintained, innovation will continue and new technology waves will rise.[61] This must be supported with development of innovation roadmaps.

Further, the stakeholders indicate that if the demand for flexible sized PV panels arises, the Dutch PV sector can swiftly and easily adapt to this need.[62]

Finally, the stakeholders admit that the relative small home-market for PV is a weakness. However, as the Dutch PV market will always be small in absolute numbers, it is more important that the sector continues to develop large demonstration projects. The Netherlands has a unique potential to develop a high-tech theme park: *Holland Demo Lab*. The PV sector already shows good examples of testing and live demonstration, but the meeting suggests that more demonstration projects with international appeal are needed to enhance the position of the Dutch PV sector. Or, as someone said during the meeting: "Holland *is* the demo". Important developments in the mid-term future are for example the mission of "Duurzaam Texel" and the municipality of the island of Texel to become self-sufficient and climate neutral in 2020. Another relevant and recently launched concept in this respect might be *'Holland: Sustainable Urban Delta'*. This concept aims to position the Netherlands as a solver of societal challenges in large delta cities. These challenges include renewable energy, recycling of raw materials, water- and air quality, mobility and food security.[63]

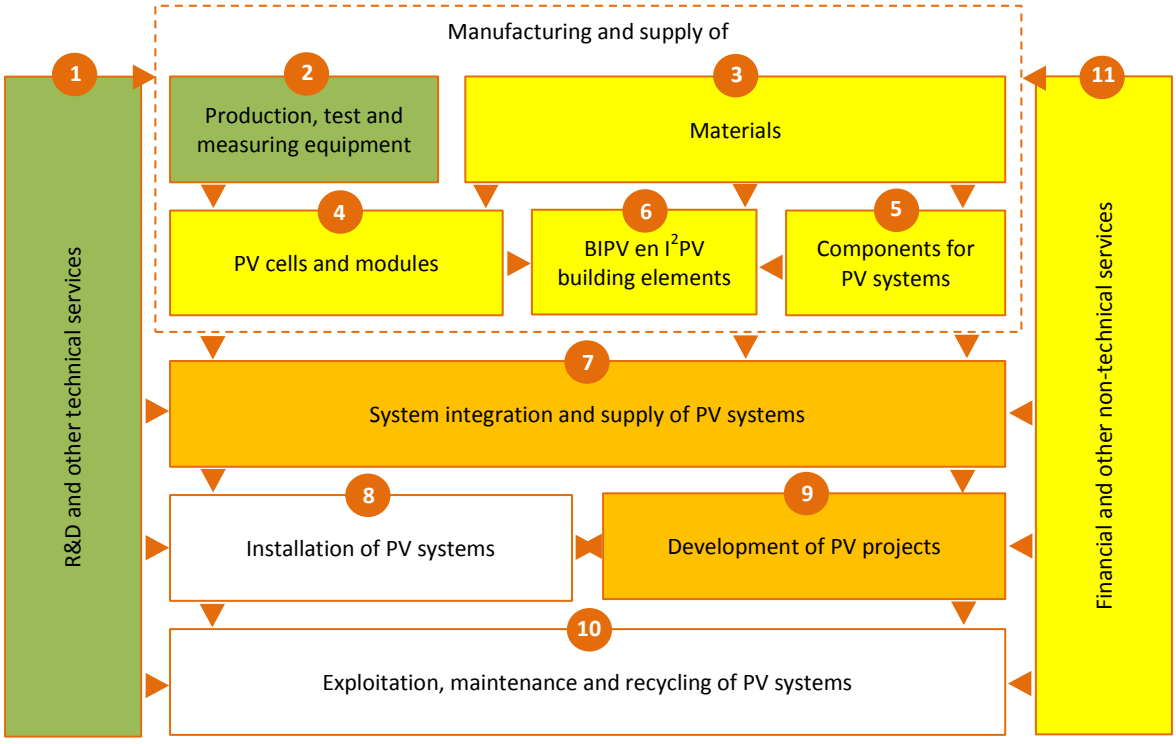


Figure 12 – *PV value chain with indication of the current international impact per segment: high (green), medium (yellow) and small (orange) – Especially the latter segments still have a large potential to increase their international impact. Segments with hardly an international relation are white.*

[61] Panel session: RVO.nl
[62] Panel session: Smit Ovens
[63] FME (2014) – Succesvolle lancering 'Holland, a Sustainable Urban Delta'. *Website news, 11 April 2014.*

3.3.1 Design: introduction

Dutch Design is a very strong brand abroad, embodying innovation, creativity and business acumen. Examples that are often mentioned in this context are building designs and architecture of Rem Koolhaas, consumer product designs of Philips and fashion designs of Victor & Rolf. Although these examples might seem to have little relation with the PV sector, the relation between Dutch Design and PV appears to become more and more prominent. In fact, examples of Dutch Design nowadays also include solar powered buildings, electronic products and even solar powered dresses.

3.3.2 Design: examples and flagships

"Adding a taste of **Dutch Design** to BIPV-projects all over the world"

Figure 13 – *Energy Flower in Wuhan, designed by Soeters Van Eldonk and project management by Grontmij (© Grontmij)*

Dutch architecture is known to be innovative and daring.[64] Several Dutch architects are applying building-integrated PV (BIPV) in their designs. Tjerk Reijenga (BEAR-iD) is an example of such an architect, having applied BIPV in Dutch projects like the City of the Sun (Heerhugowaard) and ECN's R&D centre (Petten) as well as Chinese projects like the R&D Centres of Trina Solar (Changzhou and Shanghai) and Philips (Shanghai).[65] Another remarkable Dutch BIPV-example in China is the extremely efficient Energy Flower, designed by Soeters Van Eldonk and with project management by Grontmij (see Figure 13).[66]

"**Dutch aesthetic** solutions and modular concepts"

Figure 14 –*Aesthetic Energy Roof (© AERspire)*

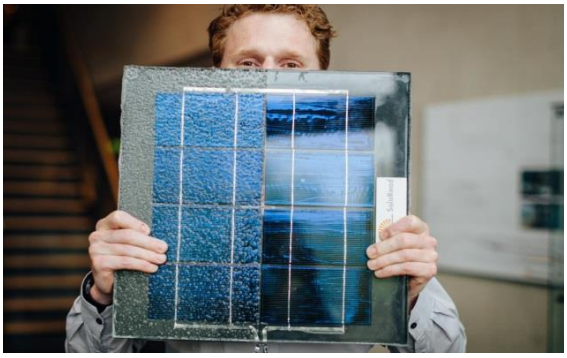
[64] Website: www.holland.com/global/tourism/blogs/dutch-design-and-architecture.htm
[65] Website: www.bear-id.com/type/solar
[66] Website: www.soetersvaneldonk.nl/nl/architectuur/duurzaam/wuhan.html

A related development is the design of BIPV and I^{2}PV elements. Dutch examples in the first category are BIPV-modules (e.g. TULiPPS), solar roofs (see Figure 14) (e.g. AERspire, Ballast Nedam, Comuth, Dimark Solar, SCX Solar, SolarTech, Stafier Solar, Synroof, Ubbink and Zonnepanelen Parkstad), solar glass-products (e.g. BRS Building Systems, Peer+, Scheuten and TU Delft) [67] and even solar *skins* to diminish the electricity bill of old houses (e.g. Prêt-à-Loger, see Figure 15).[68] The development of products in this field has been supported by the SBIR-IPZ programme, a national programme on innovative systems for integration of PV in the built environment.[69]

"Meet the daring character of **Dutch creativity** in products with PV"

Figure 15 – *Solar skins (© Prêt-à-Loger)*

Dutch examples in the second category are the design and implementation of solar street lights by Kaal Masten[70] and a solar road by TNO, Imtech, Ooms Civiel and the Province of Noord-Holland (SolaRoad). [71] The latter will be implemented in Krommenie in autumn 2014, which is pretended to become the world's first road that generates electricity with solar cells (see Figure 16). Other Dutch examples of I^{2}PV-elements include innovative solar powered sound walls (Solar Highways by Rijkswaterstaat)[72] and solar powered bus stops (ATC Solar Curve Bus Stop by Studio Mango).[73]



"The world's first road that generates electricity with **solar cells**"

Figure 16 – *SolaRoad, developed by TNO, Imtech, Ooms Civiel and the Province of Noord-Holland (© SolaRoad)*[74]

[67] Holland Trade (2013) – Dutch power-generating windows win CleanTech challenge. *ID: 5235, May 2013.*
[68] Inhabitat (2014) - Dutch Students Design Revolutionary Solar Power 'Skins'. *Nicole Jewell, online publication, 3 May 2014*.
[69] RVO.nl (2014) – Bouwen op zonne-energie. *Netherlands Enterprise Agency, 14 April 2014.*
[70] Solar Tribune (2013) – Dutch company develops solar street lights. *Solar Technology News, 16 October 2013.*
[71] Website: www.solaroad.nl
[72] Rijkswaterstaat (2014) – Rijkswaterstaat start Solar Highways project. *Website news, 15 April 2014.*
[73] Website: www.studiomango.nl/portfolio-items/atc-solar-curve-electric-buss-charging-station
[74] Quote by Suzanne van Kooten, Director of Innovation Energy Efficiency at TNO. In: Bleijenberg (2014) – SolaRoad, de weg die zonlicht omzet in elektriciteit (vimeo.com/91641192). *Video uploaded in April 2014*.

In the category of electronic products, Philips is designing and distributing solar powered lights like the Uday. These lights are mainly distributed in developing countries. Another example in this field is the smartly designed WakaWaka, which is promoted as “the most efficient solar light in the world”. According to the product website, it can provide 16 hours of light after one day of charging. The WakaWaka has already impacted the lives of more than 400,000 people, particularly in disaster areas in for instances Haiti, the Philippines and Syria.[75]

Finally, solar PV also finds its way to other areas of design. For instance, in 2014 the Dutch fashion designer Pauline van Dongen hit the international news with her ‘Wearable Solar’ project: a coat and a dress designed with thin film solar cells. Likewise, Dutch Design examples include a solar-powered DJ-table for kids to play with in public areas (the Fono by Yalp), a solar-powered ice cream cart (the Sustainable Ice-cream Cart by Springtime, IJs&Zopie and Odenwald Organic) and, last but not least, solar-power cars. The next chapter elaborates on the latter.

3.3.3 Design: position, branding and combinations

The stakeholders agree that ‘Dutch Design’ is an international recognized strength and that the relation with PV becomes more and more prominent.

On this issue, the PV sector overlaps with other sectors. Clearly, these are at least the design, (city-) architecture and building sector. This combination is believed to have a large potential for strong development in more segments of the PV value chain. This is indicated in Figure 17, showing that segment 6, although currently mainly focussed on the Dutch home market, is the most developed segment in relation to design. The figure also indicates the segments that need to develop in the future. These are segments 1, 2 and 4 in combination with segment 5 for new product development and segments 7, 8 and 9 in combination with for instance the architecture and building sector.

The uniqueness of the Design in relation to the PV sector can be branded as:

1. Dutch Design meets PV;
2. Dutch Creativity with PV;
3. Dutch Sustainable Architecture;
4. Dutch Aesthetic BIPV Solutions.

For future development, the stakeholders indicate the importance to collaborate and integrate more with European clusters in relation to sustainable building development.

[75] Website: www.waka-waka.com

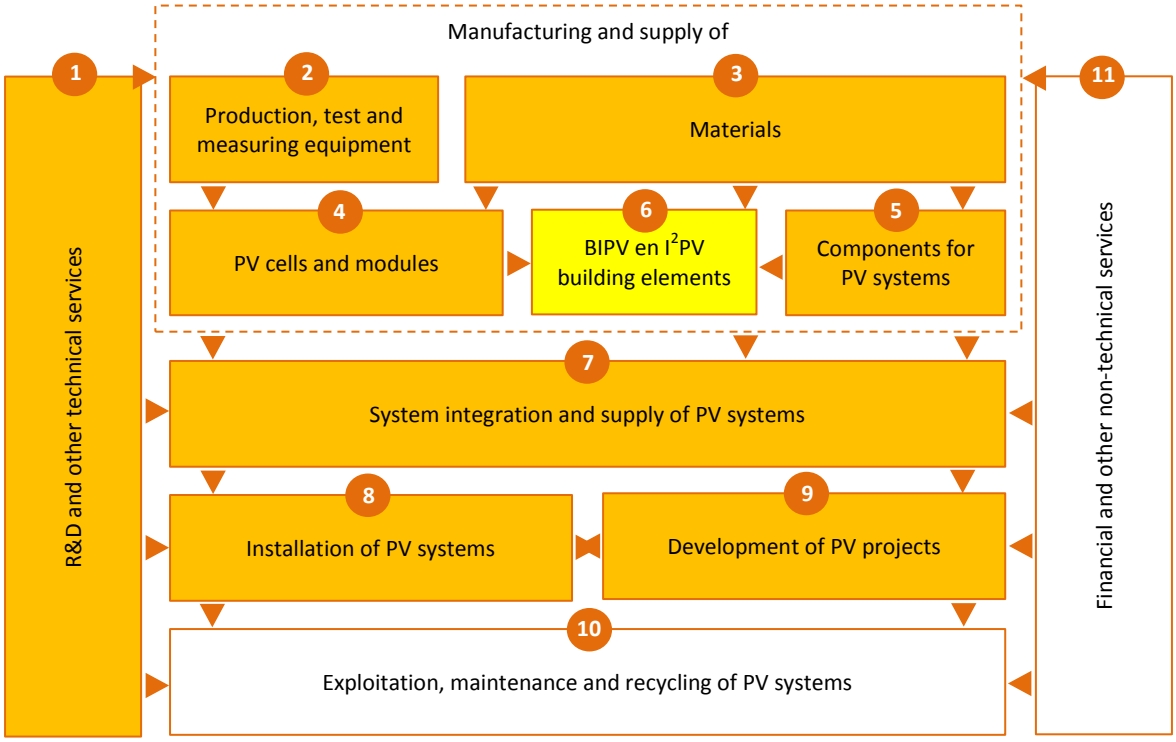


Figure 17 – *PV value chain with indication of segments with strongest relation to design (yellow), segments with a weaker relation but with growth potential (orange) and segments with hardly any relation (white)*

4 CONCLUSIONS AND RECOMMENDATIONS

The final chapter of this report answers the research questions (4.1 and 4.2) and summarizes the results in a SWOT-diagram (4.3), including the Dutch PV sector's strengths (S), weaknesses (W), opportunities (O) and threats (T). These points are based upon the direct interviews and the panel session. The final paragraph lists some final recommendations (4.4).

4.1 What are the USPs of the Dutch PV sector?

Well-known strengths of the Dutch economy are collaboration, innovation, creativity, design and reliable high-tech solutions focusing on 'high efficiency, low costs'. But how do these strengths express themselves when it comes to PV? Without pretending to be complete, the report answers that question by highlighting three strengths and showing examples.

Collaboration – The Netherlands has a strong position in the manufacturing and supply of production equipment for the PV industry. An important reason for this strong position is believed to be the close relation with research organizations. This relation can be found in alliances (for instance ECN-Tempress, ECN-Eurotron and Solliance) and regional clusters (for instance around Eindhoven).

High tech solutions – The Netherlands has a long track record with innovative products, pioneering demonstration projects and examples that show the country's technological excellence. In general, Dutch high-tech products are associated with quality and reliability and Dutch high-tech services are believed to be flexible and client-oriented.

Design – The Netherlands has a strong position in design ('Dutch Design'). This includes the design of buildings, building-elements, infrastructure elements and consumer products with integrated PV. In line with this, the Netherlands has some eye-catching products and projects with the design of aesthetic PV products, sustainable buildings and cities.

4.2 Where are they positioned in the PV value chain and how can they be combined?

Referring to the value chain as shown in Figure 3, the first two strengths are mainly related to segment 1 (R&D and other technical services) and 2 (production, test and measuring equipment). Nevertheless, the report shows that there are linkages with other parts of the value chain as well. It is therefore argued that the Dutch PV sector can (and maybe, should) be presented as *one cluster* or *one multidisciplinary company of companies*.

The third strength mainly relates to segment 6 (BIPV en I^2PV building elements) and 7 (system integration and supply of PV systems). Again however, there are linkages with other parts of the value chain. An example of that is the SUMMIT-consortium, in which Dutch organizations from roughly segment 1-7 work together on low-weight BIPV-modules. It is also argued that the Dutch PV sector can (and maybe, should) integrate more in the (European) building and architecture sectors.

4.3 SWOT

Although the aim of the report is to discuss the strengths of the Dutch PV sector, some stakeholders also express their opinion about the weaknesses, opportunities and possible threats of the sector. Figure 18 summarizes some of those points in a SWOT-diagram.

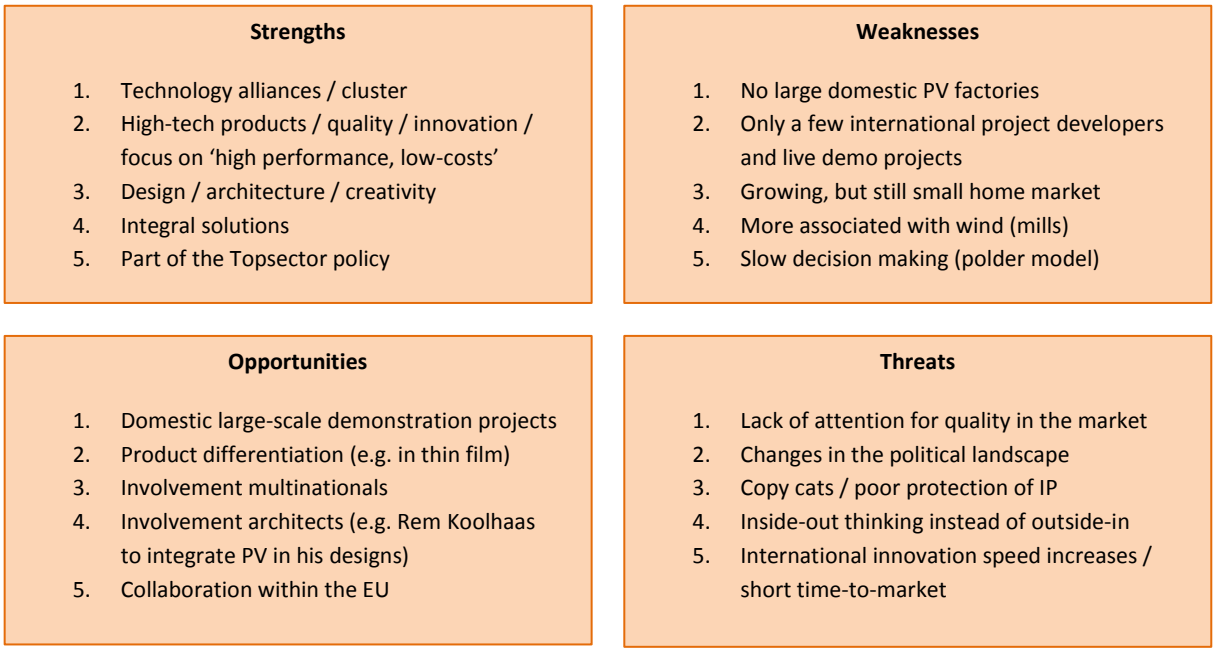


Figure 18 – *SWOT-diagram*

4.4 Recommendations

In brief, stakeholders come up with the following recommendations:

- Brochure – This report could perfectly serve as input for an international brochure about the Dutch PV sector. Such a brochure could for instance be used at international conferences, by Dutch embassies and of course by the sector itself. It is recommended to pay special attention to the lay-out of the brochure.
- Quantification – Another important next step could be a quantification of the results. This step would be very helpful in order to illustrate the size of the Dutch PV sector en thereby to underpin and/or sharpen the mostly qualitative results of this report. It is recommended to do this quantification on such a level that no confidential data is exposed.
- Geographical focus – Thirdly, the report does not yet indicate which countries or regions are the ones to focus on. This might be an interesting follow-up question.
- Other sectors – Another recommendation is to learn from other Dutch sectors and their international positioning. An inspiring example might for instance be the Dutch water sector.
- Website – A final suggestion is to build a special website for the positioning. Besides RVO.nl and the TKI Solar Energy, this might be an interesting suggestion to discuss with for instance Cleantech Holland/FME-CWM and the Dutch solar sector organization Holland Solar.

APPENDIX – ABBREVIATIONS

In this report the following abbreviations are used (see Table 1).

BIPV	Building-Integrated PV	**MW**	Megawatt
BRIC	Brazil-Russia-India-China	**MWT**	Metal Wrap Through
ECN	Energy research Centre of the Netherlands	**NREL**	National Renewable Energy Laboratory (USA)
ESA	European Space Agency	**PEI**	International Energy Programme
EU	European Union	**PV**	Photovoltaic
EZ	Economic Affairs	**PVPS**	Photovoltaic Power Systems Programme
FIT	Feed-In Tariff	**R&D**	Research & Development
GDP	Gross Domestic Product	**RVO.nl**	Netherlands Enterprise Agency
GW	Gigawatt	**SDE**	Stimulation Renewable Energy
I^2PV	Infrastructure-Integrated PV	**SEAC**	Solar Energy Application Centre
IP	Intellectual Property	**SiCC**	Silicon Competence Centre
ISIS	Innovative Solutions In Space	**SME**	Small or Medium Enterprise
kW	Kilowatt	**TKI**	Topconsortium Knowledge & Innovation
LED	Light Emitting Diode	**TU**	Technical University
MLPM	Module Level Power Management	**USA**	United States of America
MoU	Memorandum of Understanding	**USP**	Unique Selling Point

Table 1 – *Abbreviations*

COLOPHON

Title

International positioning of the Dutch PV sector

Version

Final

Date

July 2014

An assignment of

Netherlands Enterprise Agency (RVO.nl), International Energy Programme (PEI)

A production of

Atrivé and Energy Indeed, in consultation with the TKI Solar Energy

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