Rijksdienst voor Ondernemend Nederland

Public final report Rodemo

Project details

- Project number: TEZ0214001
- Project title: Robust Desert-proof Modules RODEMO
- Project manager and participants:
  Project manager: TNO.ECN
  Participants:
  - DSM Advanced Surfaces, added partner (RVO agreement June 2017)
  - ECN Solar Energy merged with TNO. New entity name TNO.ECN (as of April 1st 2018)
  - Qatar Solar Energy, nominal partner
  - Eurotron BV resigned due to strategic reasons (RVO agreement June 2017)
  - Subcontractor Exasun BV
- Associated partners and test-sites:
  - Desert Technologies, Jeddah test- site, Saudi Arabia
  - EFFAT University, test- site at University in Jeddah, Saudi Arabia
  - Abdul Aziz University/Enerizon, Mecca test- site, Saudi Arabia
  - Nexo, New South Wales, Lightning Ridge, Glengarry test- site Australia
  - PUC- University Santiago test-site and Atacama test- site, Chili
- Project duration: 4.5 years: 01.01.2015 – 30.06.2019
- Date of publication public report: 30.09.2019

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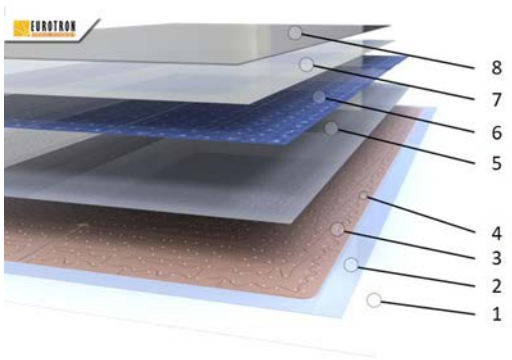
Project summary

Developing an intrinsically robust PV module, able to withstand harsh desert conditions, high temperatures, high irradiance and dust without fast reduction in power output is an attractive way to enhance module applicability. This especially holds when it can be realized without adding manufacturing complexity.

In addition, the module must be protected from degradation phenomena such as: delamination of encapsulant material due to exposure of UV light and high temperatures, damage from self-heating and hot spots or physical damage from sand storms.

The Rodemo project encompasses the module power output and reliability of back contact PV modules under desert conditions. Moreover, mitigation of soiling has been investigated by having modules equipped with an anti-soiling (low-soiling) coating.

Since regular polymer based back sheets, as applied in most commercial PV panels, can be prone to ageing by high levels of UV irradiation and elevated temperatures glass would be an attractive alternative since this material is not influenced by UV or high temperatures. Glass as a back sheet material has been introduced already (e.g. bifacial PV panels), but up to now not in combination with the back contact module concept. The project partners have investigated and developed a glass-glass module comprising new materials in combination with existing back contact technology of ECN.TNO and Eurotron. This technology is based on back contact cells interconnection on a patterned conductive back-sheet. Instead of a back-sheet, a conductive metal layer was sandwiched between a front and rear side glass plate. This novel module concept has been named back contact glass-glass and is designed for industrial , 60 cell full size modules. A 3D cross section of the glass/glass module is presented in Figure 1.



#	Description	Supplier	Type
8	Float Glass (ARC)	AGC	2,0 mm with ARC
7	Encapsulant frontside	STR	15585P/UF/HLT
6	Solarcells	QSE	MWT
5	Conductive adhesive	ECM	DB 1588-4
4	Integrated encapsulant	Eppstein	PVB 95 µm
3	Conductive backsheet foil	Eppstein	ContacFoil®
2	Encapsulant backside	STR	15580P/UF
1	Float Glass	AGC	2,0 mm

Figure 1 3D cross section of back contact glass- glass module

This project focused on the module power output and reliability of back contact PV modules in desert conditions. Hence, the aim was to determine a bill of materials (BoM), for the manufacturing and processing of 400 full size 60 cell test modules ready to be placed at different desert locations. LCOE for the modules were set to be below 0,14 euro/kWh (2015) with the emphasis to implement the technology into an industrial product. To assess the latter, the module concept has been tested and evaluated in a pilot production at ECN.TNO Subcontractor Exasun manufactured the bulk of the modules according to the BoM selected by ECN.TNO.

In the project, all partners worked on various aspects of the back contact glass/glass module. ECN.TNO focused on the choice of materials in close cooperation with Exasun. Eurotron focused on mounting the copper conductor directly onto the rear glass of the module and to designing the glass- glass module concept. With respect to soiling mitigation, DSM has delivered and evaluated the coating materials. For the field testing of these novel modules a network of test sites was established at various desert locations. Manufactured modules were shipped, installed and tested in 3 countries involving a total of 5 different sites.

Deliverables of project partner Qatar Solar Energy were challenged as political circumstances prevented manufacturing of the modules at the Qatar factory. In addition due to strategic reasons the Dutch project partner Eurotron resigned from the project. In agreement with RVO and Eurotron, DSM was selected as new partner in exchange. Anti- soiling coating material, forming the task of DSM, received special attention which added a valuable product development to the running project. Manufacturing of 400 modules, a task of Qatar Solar Energy, was executed at subcontractor Exasun in the Netherlands. With respect to the testing, new associated partners from Saudi Arabia, Australia and Chili signed for prolonged module testing at their local desert test sites.

In summary 4 milestones out of 5 in the project plan have been achieved. The missing milestone 'Annual output determined on system level in Qatar' has been granted to the associated partners mentioned above. Monitoring of the test modules is in progress and measurement data has been collected from the test sites.

A limiting factor during the prototyping phase of the module development was the difficulty in obtaining structured conductive metal foils. Conductive metal foil producer Eppstein terminated production once ECN.TNO had thoroughly tested their materials as a positive candidate. In addition passing the IEC test for damp heat (DH)and temperature cycling (TC)took longer than expected as BoM material sets had to be changed in order to pass the test successfully. Final manufacturing of 400 back contact glass- glass modules at Exasun went without incident. However, severe delays occurred during export of the modules to the associated partner countries. Transfer to and through the local customs was a logistic challenge as the modules are of noncommercial nature. After successful field installation, data have been collected and provided on a continuous basis by the associated partners. In order to realize a useful data set ECN.TNO, Exasun and DSM are keen to prolong the measurement sessions in association with the partners in Saudi Arabia, Australia and Chile.

The installation and field tests at the associated partners location entailed extended media coverage, among those are the Atacama desert tests in Chili with Acciona the largest Chilean utility company and at EFFAT University of higher technical education for women in Saudi Arabia.

Promotion of the Dutch manufactured back contact glass- glass module in the countries of the associated partners led to first contacts with the manufacturer Exasun. The activities boosted the interest in this type of desert compatible high efficiency modules.

Associated partner benefits are present in the collaboration between EFFAT, Desert Technology, Abdul Aziz/Enerizon, PUC University Santiago, Nexo Australia and ECN.TNO. Building additional R&D capabilities for PV modules testing in desert areas is in the scope of the Industry and for example the targets set by the Saudi Arabia National Research Strategy. A contribution to the promotion of desert compatible module deployment of PV in Saudi Arabia/Australia/Chile was initiated by the Rodemo project. Exasun's promotion of PV module 'Made in the Netherlands' will support sales to the countries involved with further enhancing back contact module technology in general. DSM distributes anti- soiling coating to module manufacturers and uses field application on global scale.

Project results, highlights and bottlenecks

With respect to the technical results, highlights that can be mentioned are related to the development of the back contact glass-glass module. Progress was gained in all industrial aspects and for desert compatibility in particular. Among those aspects are Poly olefin based encapsulants tested for elevated temperature ranges and improvement of stability. On the manufacturing side, introduction of a curing frame developed for glass- glass modules lamination was adopted by the industry as a standard lamination technique. Anti-soiling coating applied to the glass- glass modules revealed an added value of this coating during field performance monitoring.

IEC testing was passed successfully and together with an optimized manufacturing progress this facilitates industrial implementation.

With respect to the technical results, highlights that can be mentioned are:

- Scaling up of the back contact glass- glass module from 4 cell minimodules to full size 60 cells including BoM;
- Minimodules and full size passed specific/beyond IEC tests based on IEC 61215 approval;

- UV testing passed at elevated temperatures of 100°C conform IEC 62892 (draft) desert test;
- Manufacturing of 400 full size glass- glass back contact modules for field test;
- Prolonged field tests at different desert test sites;
- Investigation on anti- soiling behavior during laboratory tests;
- Understanding the potential of IR coatings for module desert application;
- First field test results demonstrate feasibility of using Dutch manufactured glass-glass modules in desert areas.

Contribution to program targets

This project was part of the TKI Urban Energy program line 2.4.17 PV program. It contributed to its target to develop an intrinsically robust PV module able to withstand harsh desert conditions (high temperature, high (UV) irradiance, dust) without fast reduction in power output in the field and without adding manufacturing complexity.

Rodemo has catalysed the development of glass-glass back contact modules to get closer to industrialization. Production of these modules at Exasun is a clear indication of the viability of this module type. Several spin off's resulted from this project. Copper cold spray proof of principle tests done in WP1 lead to a further research in the field and patenting of the technology with respect to low cost metal conductive concepts for back contact applications. Next to the Rodemo field tests, DSM extended testing of AS/AR coating on a global scale. AS/AR coating, meanwhile an industrial product is ready to be launched as a market product.

The development of desert compatibility of the Rodemo modules is proceeding at present and is closely followed by Institutes and customers in the MENA region. Chilean utility Acciona has started a test field with the Rodemo glass-glass back contact modules operated by the University of Santiago de Chile.

For Exasun new contacts to extend the business to Saudi Arabia and Chile were established. Glass- glass back contact modules for desert applications can support sales for Exasun in the MENA region, Chile and neighboring countries. The production of back contact glass- glass modules supports PV panels 'Made in the Netherlands'.

Spin-off

The Rodemo project has been a substantial promotor in bringing the back contact glass-glass module to industrialization, and its TRL has progressed from about 6 to 9. During the Rodemo project the processing of the glass-glass module has been further refined and adequate materials were selected for the BoM. Module power output of up to 300 W was reached and could fulfill the requirements of the IEC 61215 DH and TC test. In addition mini module tests were conducted at ITRI regarding the IEC desert tests 62892 with elevated UV load and temperatures.
Copper cold spray tests have resulted in a patent of the technology with respect to low cost metal conductive concepts for back contact applications.

Publications

Date	Title	Authors	Conference/medium
11-06-2019		Prof Malak Alnory Effat University, Martin Spath & Jan Bultman ECN.TNO	Printed press release: Al Watan OKAZ Al Madian Online press release: Rawafed https://www.rwifd.com/?p=303082

			Roaa News http://roaanews.com.sa/archives/423895 Therban http://www.thrban1.net/news.php?action=show&id=20065
		Prof Rodrigo Escobar, University Santiago Chile	Report: Inspección y evaluación de sitios en unidades del Ejército de Chile para instalación fotovoltaica de 15kWp Press release: Acciona utility test field at Atacama desert PhD work PUC Andrea publications
		DSM	Workshop Soiling effect on PV modules, 5-7 May 2016, Dubai. Dr. I. Bennett 2017 Photovoltaic Reliability Workshop (PVRW), 28 February - 2 March 2017, Lakewood, Colorado. Dr. N. Voicu Desert PV Module workshop, 9-10 May 2017, Doha, Qatar H. Schoot AS- AR product launch SNEC Shanghai, China 2018

Patents

Copper cold spray	ECN.TNO	Patent nr EP2994941	Description SOLAR PANEL AND METHOD FOR MANUFACTURING SUCH A SOLAR PANEL

Extra copies of this report

Digital copies of this report can be requested via the below mentioned contact persons.

Rijksdienst voor Ondernemend Nederland

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Subsidie

“Het project is uitgevoerd met subsidie van het Ministerie van Economische Zaken, Nationale regelingen EZ-subsidies, Topsector Energie uitgevoerd door Rijksdienst voor Ondernemend Nederland.”