



Openbaar eindrapport Whooper

Gegevens project

- Projectnummer: TEHE119008
- Titel: Development of high-efficiency metal wrap-through silicon heterojunction PV modules
- Penvoerder en medeaanvragers:
Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek TNO
Stichting SIEC
GroenLeven
Eurotron B.V.
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Samenvatting van uitgangspunten, doelstelling en samenwerkende partijen

c-Si heterojunction (SHJ) solar cells have demonstrated record efficiencies. However, SHJ is not compatible with traditional module technology and has high metallisation cost due to low conductivity of the necessary silver paste. This has slowed down the introduction of SHJ in the market. Metal wrap-through, MWT, solar cell technology brings the front side metallisation through vias to the rear side of the solar cell, creating a fully back-contactable cell metallisation. Back-contact foil technology is the most efficient and elegant solution for interconnection, especially suited for the needs of SHJ. Recently, back contacted foil technology has made headways into the market improving on bankability and costs.

The goal of the WHOOPER project is the final development needed to combine the best of both industrial technologies, SHJ and MWT. Both lead to higher efficiencies and to improved manufacturability of highest efficiency cells and modules. With the combined technologies, an ultra-high efficiency mass manufacturable solar energy technology will become available, reducing overall kWh costs and opening up more difficult markets with these high efficiencies.

The WHOOPER consortium has five partners.

- ENEL-3SUN is the Italian manufacturer of SHJ solar cells and modules;
- Eurotron supplies production equipment and complete production lines for back-contact foil modules;
- GroenLeven is a solar park project developer;
- SIEC, Solar Innovation and Experience Center, based in Emmen, is an educational foundation;
- TNO is an R&D institute for applied research in the Netherlands. TNO coordinated the project.

Beschrijving van de behaalde resultaten, de knelpunten en het perspectief voor toepassing

The project consortium successfully integrated the MWT cell process steps with the regular cell manufacturing at 3SUN. WHOOPER modules were built on industrial equipment. This shows that the MWT-SHJ concept is applicable on an industrial scale. Reliability testing showed that the adapted module bill of materials was sufficient (and needed) to protect the MWT-SHJ solar cells.

Outdoor experiments were conducted at SIEC. Modules were installed in a standard south-facing fixed tilt system. For the reference MWT-PERC modules we found an energy yield of 940 kWh/kWp. In contrast, the WHOOPER modules performed at 990 kWh/kWp, a 5% increase. Although the WHOOPER module cost of ownership is 5% higher than the MWT-PERC module, the levelised cost of electricity is 7% lower. This is caused by a combination of higher power per module, more energy per Wp and consequently cheaper OPEX, more than offsetting the higher cost of the module per Wp.

A roof, resembling a typical farmyard barn, was built by local students using concepts from the circular economy. Modules on the roof heat up more than free-standing ground mounted modules. For the WHOOPER modules, this leads to a decrease in annual energy yield of 4%.

The biggest bottlenecks for MWT-SHJ technology for a significant share of the cell and module market are the higher capital costs for production equipment. Also, the conductive back sheet remains expensive, due to the copper layer. Replacing the copper layer with a cheaper conductor in combination with copper contact pads will reduce the module CoO.



The additional efficiency gain in combination with the lower temperature coefficient are the two main promises of WHOOPER modules. But to keep up with the ever decreasing prices of PV modules, more manufacturers have to convert to this technology. Nevertheless, we foresee substantial energy conversion improvements. Especially in the sunniest regions of Europe or for integrated installations with reduced heat transfer abilities.

Beschrijving van de bijdrage van het project aan de doelstellingen van de regeling (duurzame energiehuishouding, versterking van de kennispositie)

Regarding the energy transition, we have shown that WHOOPER modules have a higher power density than regular modules under standard test conditions. In addition, these modules produce more kWh per installed capacity at lower cost per kWh. That means that we can install more power per hectare, or need less area for the same installed capacity. To achieve the same annual energy conversion, we can even opt to install fewer panels, requiring even less area.

The knowledge position has strongly improved. The SIEC test field is the first outdoor installation in conditions identical to a regular Dutch solar park for MWT-SHJ modules. The information that was acquired and is still being gathered beyond the project end date, will give valuable insight on the behaviour of MWT-SHJ panels for more accurate yield forecasting, relevant for the day-ahead market, and to support the business case for future MWT-SHJ solar parks.

In the cell and module processing, we developed and fine-tuned several laser processes for “drilling” the vias and isolating the vias, with “front side polarity”, from the rear side polarity. We compared the laser isolation with processes involving wet chemistry and screen printing. These processes can also be applied for other back-contact cell concepts.

Back-contact foil module concepts need a process step to deliver electrically conductive material, e.g. conductive adhesive or low temperature solder, that interconnects the cell metallisation with the patterned conductive foil. Typically, this is done by stencil printing on the conductive foil. To allow smaller contact pads and less conductive material consumption, printing on the cells is considered as an alternative. In WHOOPER we investigated and fine-tuned inkjet printing as an alternative method to deposit smaller amounts of conductive material with more precision.

Spin off binnen en buiten de sector

None (yet).

Overzicht van openbare publicaties over het project en waar deze te vinden of te verkrijgen zijn

Several (online) media outlets have reported on the WHOOPER project. We’ve also presented our results at international conferences and were invited to presented at the Back-contact Workshop.

- Start of project press release picked up by international and national media (selection):
<https://taiyangnews.info/whooper-project-to-combine-hjt-with-mwt/>
<https://solarmagazine.nl/nieuws-zonne-energie/i21723/tno-en-nederlandse-bedrijven-ontwikkelen-nieuw-zonnepaneel-whooper>
<https://www.tno.nl/en/about-tno/news/2020/6/tno-teamsup-to-realize-innovative-mass-manufacturable-solarmodule/>
<https://innovationorigins.com/nl/combinatie-van-technologieen-maakt-tnos-whooper-zonnepaneel-extra-efficient>



<https://www.pv-magazine.com/2020/06/24/heterojunctionmwt-solar-module-based-on-23-efficient-cells/>
<https://duurzaam-actueel.nl/innovatief-zonnepaneel-voorgrootschalige-productie-op-komst/>

- Oral presentation
High efficiency Silicon Heterojunction Metal Wrap Through produced in industrial pilot line
Marina Foti et al. IEEE PVSC 49 (2022), Philadelphia, PA
<https://doi.org/10.1109/PVSC48317.2022.9938473>
- Poster presentation
Up to 5% power gain of silicon heterojunction metal wrap through laminates produced in industrial pilot line
Marina Foti et al. WCPEC-8 (2022), Milan, Italy
<https://userarea.eupvsec.org/proceedings/WCPEC-8/3DV.1.8/>
- Officiële opening SIEC op 28 september 2022
Met o.a. een ingezonden video van Bas van Aken, TNO, en rondleiding langs de Whooper panelen en de dakopstelling.
<https://solarmagazine.nl/nieuws-zonne-energie/i28149/solar-innovation-and-experience-center-bij-zonneparkoranjepoort-opent-deuren>
- Invited talk
Low cost back contact HJT and options for tandem devices
Gianluca Coletti, 10th Back-contact workshop (2022),
- News article:
<https://solarmagazine.nl/nieuws-zonne-energie/i36397/project-van-de-week-whooper-zonnepalen-klaar-voor-marktintroductie>
- RVO praktijkverhalen
<https://www.rvo.nl/praktijkverhalen/onderzoek-toont-voordelen-nieuwe-zonnepanelen>
- Press release SIEC at project closing
[Belangrijke rol Solar Innovation and Experience Center Emmen bij ontwikkeling Whooper: een nieuwe generatie zonnepanelen - Kijk op het Noorden](#)

Meer exemplaren van dit rapport

Meer exemplaren van dit rapport kunnen digitaal worden verkregen via het hieronder genoemde contact.

Contact voor meer informatie

Meer informatie over dit project kan verkregen worden via:
Bas van Aken, bas.vanaken@tno.nl

Subsidie

Het project is uitgevoerd met subsidie van het Ministerie van Economische Zaken en Klimaat en het Ministerie van Landbouw, Natuur en Voedselkwaliteit, Nationale regelingen EZK- en LNV-subsidies, Topsector Energie uitgevoerd door Rijksdienst voor Ondernemend Nederland.