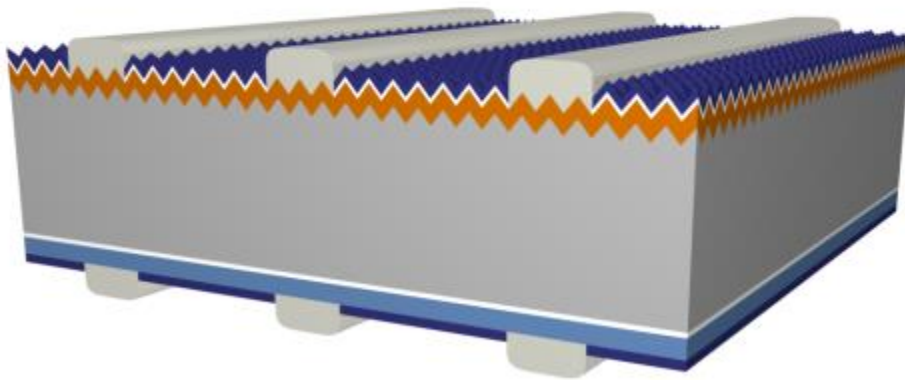


Poly-Si Passivating Contact Developments at Tempres: Outdoor Performance of TOPCon Modules



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*ECN.TNO

About Tempres



Equipment manufacturer, in Vaassen, the Netherlands, founded in 1981



Bifacial park (2017)



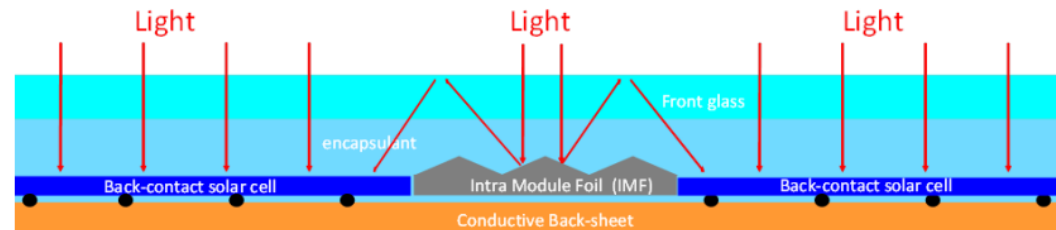
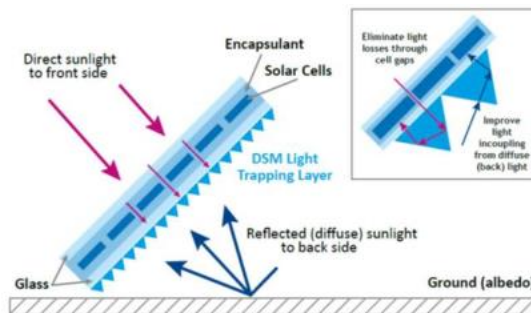
- 1428 bifacial PANDA modules
- East-West oriented
- 400 kWp (front side only)

Test site (2018)



- 24 mono- and bifacial modules
- South oriented
- 7 kW (front side only)

- Many new PV technologies have emerged:
 - **Cell concepts:** TOPCon, bifacial PERC+
 - **Interconnection technology:** use of $\frac{1}{2}$ cells, smart-wire interconnection, conductive back-sheets
 - **Module optics:** Intra module foil, light capturing ribbons, light trapping film



→ How do bifacial modules with such technologies perform in high-albedo conditions in the outdoors ?

Commercial modules (as reference):

- Mono- & bifacial PERC
 - Mono- & bifacial nPERT
 - Mono- & bifacial nPERT, smart-wire (SW)
 - Mono- & bifacial HIT
-
- Back contact modules: 3x MWT modules, 2x IBC Module
 - 1x PERC with $\frac{1}{2}$ cells

Home-built bifacial modules (ECN.TNO):

- Panda nPERT
- Panda nPERT, $\frac{1}{2}$ cells
- **TOPCon**

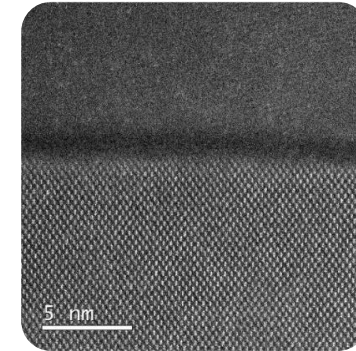
→ **All 24 modules have been flashed at ECN and Exasun**

TOPCon module

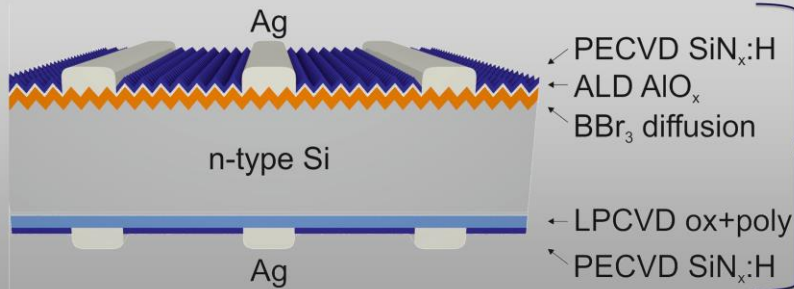


Bifacial TOPCon:

- Based *n*-type c-Si
- Poly-Si passivating contact at rear side
- In mass-production with 23.6% avg cell efficiency¹
- All deposition & diffusion steps can be done by Tempress



Poly-Si
SiO₂
c-Si base



- 60 cell module
- 305 Wp front power
- Bifaciality 85%
- Light capturing ribbons
- Light trapping film

¹ Trina solar, presented at latest EU-PVSEC Marseille

Dec 7th, 2017 – start constructing

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Status April 2018 – albedo 56%

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Climate data acquisition;

- **wind** (Thies Clima)
- **irradiance (front + rear), in plane**

Ingenieurbüro Mencke & Tegtmeyer GmbH

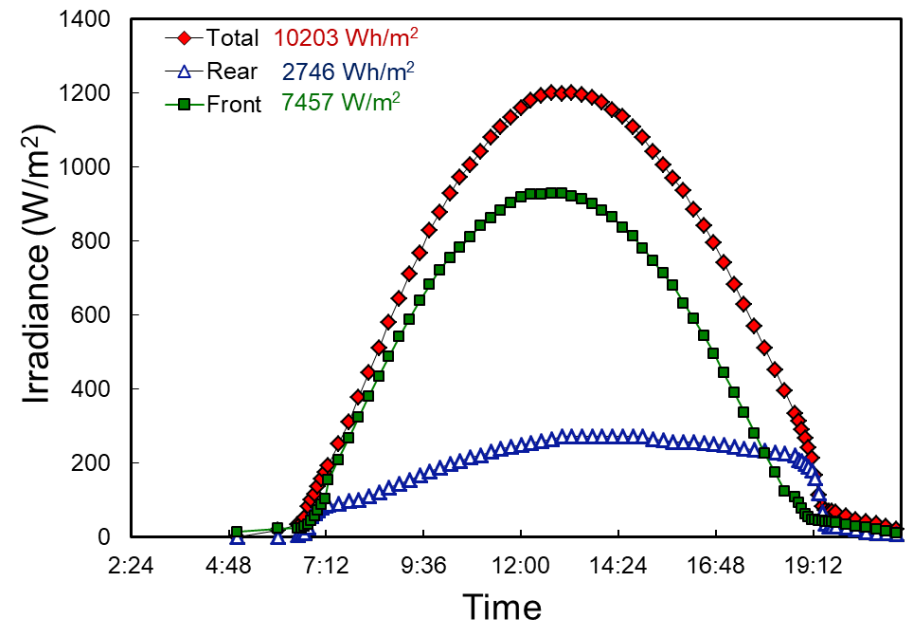
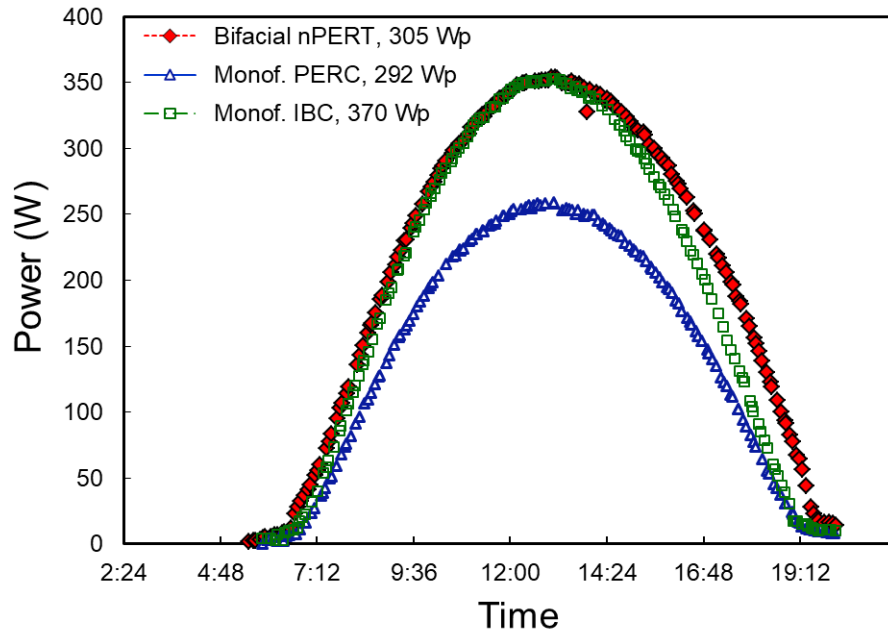
Inverters

- SolarEdge S505
- Heliox (2 modules)

Sunglasses required!

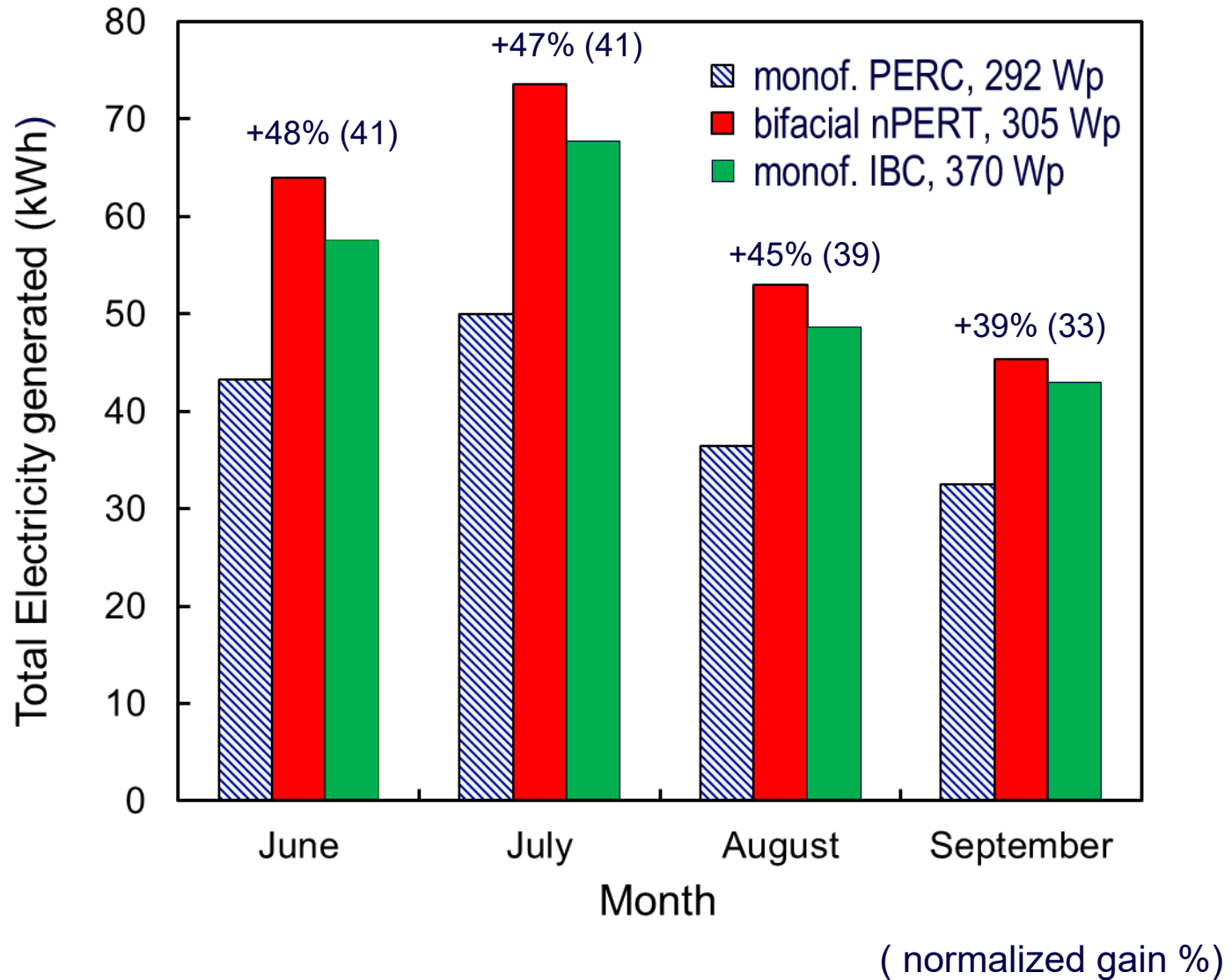


Results – Sunny day (1st of July)

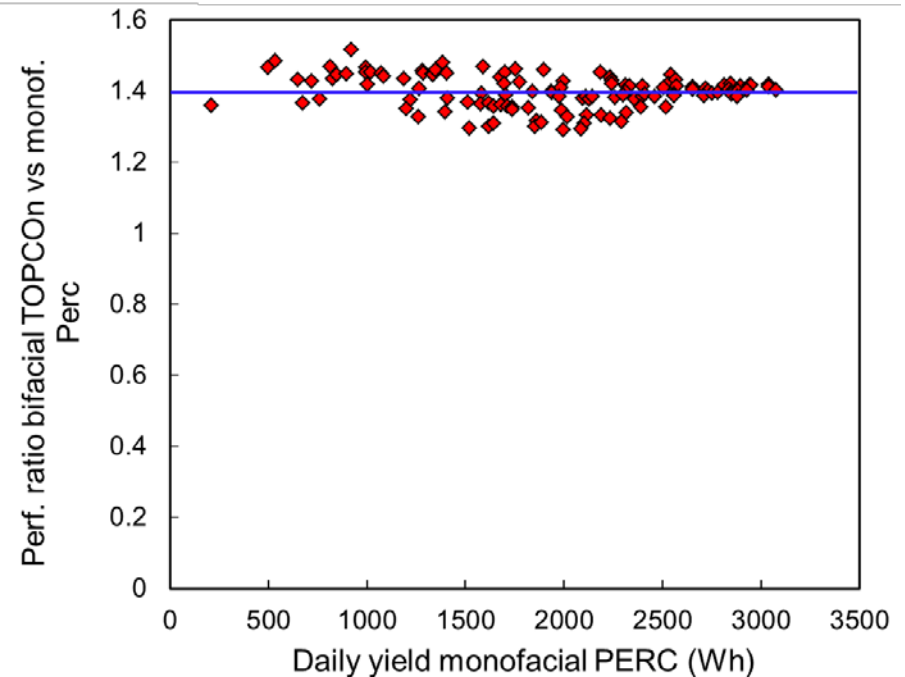
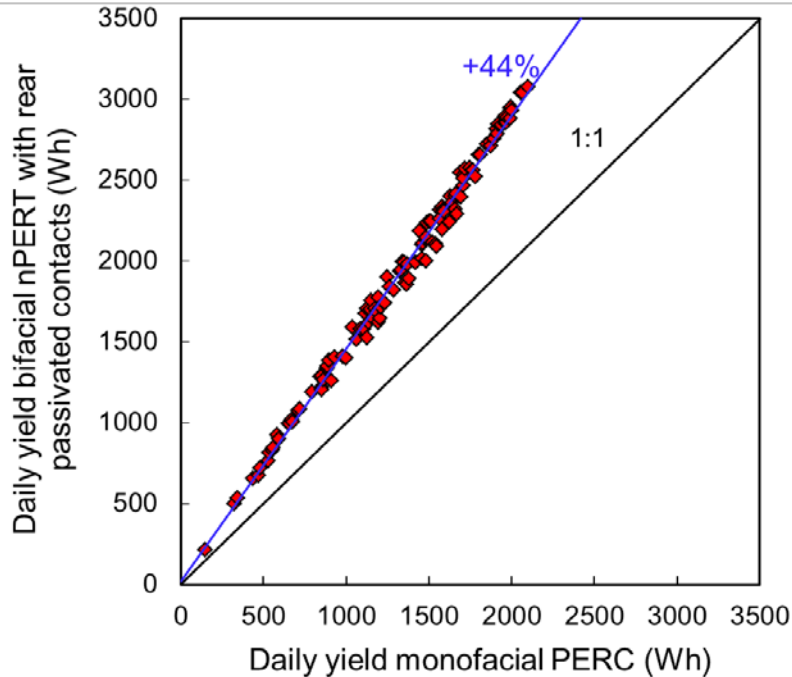


- Bifacial TOPCon module shows 40% higher specific energy yield (kWh/Wp) than monofacial PERC, 353 Watt reached.
- 36.8% extra irradiance from the rear side

Results - Monthly



Influence of the weather



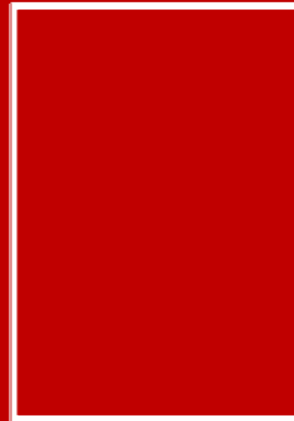
- Raw data of 122 days (June - Sept 2018)
- TOPCon: 39% avg. higher specific yield than monofacial PERC (varies between 29 and 51% day by day)

Analysis from June-September shows:

1. All monofacial modules have comparable specific yields (dev. <10%)
2. Bifacial TOPCon has very high specific yields (39% higher than standard monofacial PERC)
3. Bifacial TOPCon modules generated most electricity of all 60 cell (equivalent) modules.



■ THANK YOU FOR
YOUR ATTENTION.



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