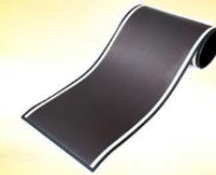
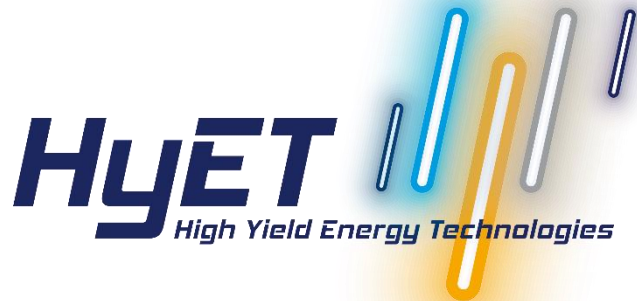


# *Cost-effective, low weight & flexible PV Solar modules*

Introduction HyET Solar  
2020

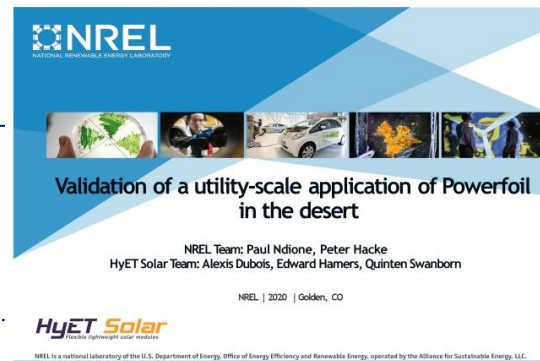


**HyET Solar**  
Flexible light weight solar modules



HyET Solar forms part of the HyET group of companies

# Key developments HyET Solar Powerfoil Q2 2020



1

## **NREL / Shell study concluded**

- Powerfoil @ 12% is cost (LCOE) equivalent to c-Si @ 18% for utility scale PV powerplants
- Reliability / durability characteristics of Powerfoil confirmed (stab. degradation < 1%/yr)

2

## **Commercial roll-out of Powerfoil ongoing; large market interest**

- LOI's to deliver more than 20 MW of Powerfoil in hand

3

## **Technology and further cost down roadmaps ongoing**

4

## **Expansion process of Arnhem factory started – capital raise ongoing !**

- First stage expansion to 40 MW/yr ready by Q2 2021
- Start second stage expansion to 300 MW/yr: Q4 2021

5

## **Plans for Indonesian license factory for Powerfoil signed with Pertamina**

- Start construction of 300 MW/yr capacity: Q4 2021



## ***Powerfoil® : Easy-to-integrate PV solar system***



**Powerfoil®**

★ IEC qualified

★ ASTM tested

**1**

***Flexible PV foils: enable installation on complex structures***

**2**

***Extreme low weight: no expensive reinforcements needed for existing rooftops, buildings and structures***

**3**

***High yield: higher diffuse light response during cloudy conditions. Superior temperature coefficient for hot climates***

**4**

***Low cost: USD 0.15/Wp (at scale), competitive for bulk scale markets***

**5**

***Sustainable: Based on fluorinated polymers, a-Si, SnO<sub>2</sub>; No exotic raw materials; Easy scalable production***

# *Powerfoil's unique properties allow for a wide range of applications unlike any other PV products today*

## Powerfoil vs conventional PV players

✓	Low module cost (with a strong further cost down potential: <\$ 0,15/Wp at scale)
✓	Very low system costs (BoS costs: 30 - 70% of conventional PV); will offset additionally required area costs, if any.
✓	High efficiency flexible product with a short term further technology roadmap to 20+%
✓	Unique application possibilities (due to low weight and full flexibility)
✓	Robust, environmentally friendly technology

### **Notes**

- *Cost levels, product and operational reliability have been ascertained by various due diligence investigations.*
- *The traditional disadvantages associated to thin film Si (a, mc Si) do not apply to Powerfoil because of a unique manufacturing process and very low system costs.*

# ***Powerfoil has significant energy yield advantage over conventional C-Si***

---

**1** ***Superior temperature coefficient***  
*(advantageous under tropical conditions: at 80C surface temperature Powerfoil loses 35.5% less power than c-Si panels)*

**2** ***Better spectral response***  
*(gives higher energy yield in humid atmospheres)*

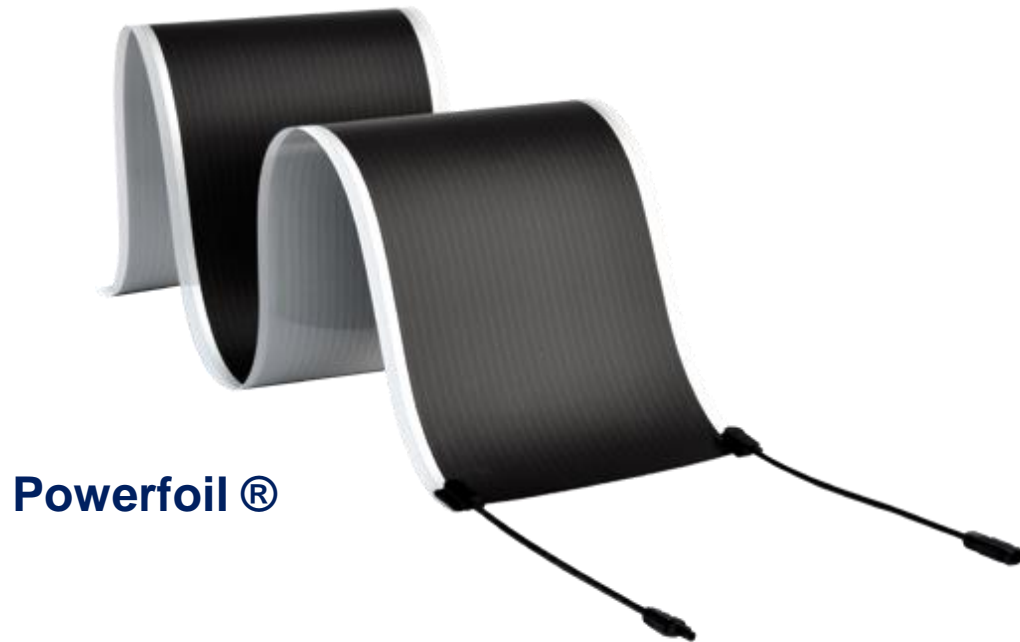
**3** ***Better low and diffuse light response***  
*(especially advantageous in cloudy climatic conditions)*

**4** ***Reduced soiling, resistant against erosion of sand & better snow-shedding***

**5** ***Linear shading***



# *Comparison of 12% Powerfoil with 18% c-Si*



# Powerfoil delivers lowest Cost of Energy

## Costs versus conversion efficiency: 3 use cases



RESIDENTIAL	C-Si 18%	Powerfoil 12%	COMMERCIAL	C-Si 18%	Powerfoil 12%	UTILITY SCALE	C-Si 18%	Powerfoil 12%
Power generated (MWh/yr)	2.464	4.060	Power generated (GWh/yr)	19.5	20.2	Power generated (GWh/yr)	178	182
Area utilisation (%)	40	95	Area utilisation (%)	67	97	Area required (ha)	83.3	105.1
LCOE (USD\$/kWh)	0.063	0.036	LCOE (USD\$/kWh)	0.0234	0.0209	LCOE (USD\$/kWh)	0.0253	0.0235





# Validation of a utility-scale application of Powerfoil in the desert

NREL Team: Paul Ndione, Peter Hacke  
HyET Solar Team: Alexis Dubois, Edward Hamers, Quinten Swanborn

NREL | 2020 | Golden, CO

**HyET Solar**  
Flexible lightweight solar modules

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

## ***Key conclusions NREL study carried out with Shell***

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### **Conclusions:**

1. Powerfoil @ 12% efficiency provides a more cost effective design for a 100MW PV Powerplant than traditional glass c-Si panels @ 18% efficiency.
2. Temperature increase caused by ground mounting: no significant power loss of Powerfoil modules
3. Powerfoil will withstand high temperature and high UV operating conditions in a desert environment


# Vopak projects in operation


## VOPAK Vlaardingen Powerfoil

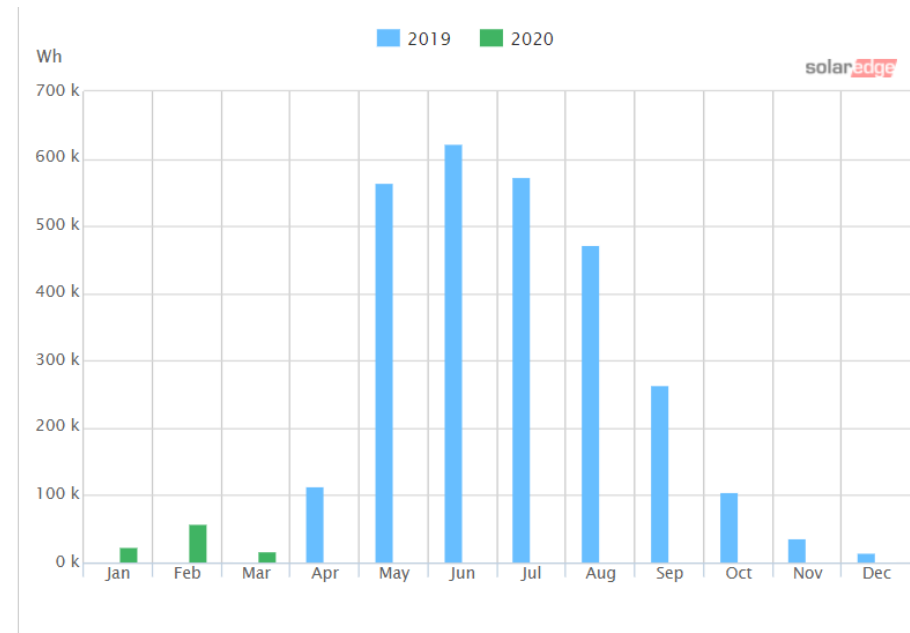
- Powerfoil 330 installed on 1 tank roof top (6 kWp)
- Producing continuously for >11 months
- Electricity produced 2.87 MWh
- Powerfoil potential = 330 MWh/tank/yr
- Powerfoil is ATEX certified Thin Film Solar system



**Environmental Benefits**

 CO2 Emission Saved  
**1,124.18 kg**

 Equivalent Trees Planted  
**3.76**





## ATEX I Certified Product

- Can be used in explosive atmospheres
- Ideal for tank applications
- In discussions with Enphase for integrated ATEX certified micro-inverters





# Technology roadmaps in place to further streamline production process and to achieve higher efficiencies

## Technology roadmap

All largely possible to manufacture with existing factory equipment

**HyET Solar**  
Flexible light weight solar modules

**TU Delft**  
Delft University of Technology

**TNO** innovation  
for life

**ECN**  
Your energy. Our passion.

### Future

Future technology generations (Si & Roll to Roll based) to guarantee continued leadership

### 2020

Tandem junction  
amorphous/microcrystalline Si  
(opt. current processes): 12%

### 2022

Triple junction  
amorphous/microcrystalline / TF c-Si: 15 + %

### 2023

Tandem junction  
microcrystalline/perovskite:  
25 + %

### 2021

Tandem junction  
amorphous/microcrystalline  
(NG - SiH<sub>4</sub>/SiF<sub>4</sub>): 13 + %

### 2022

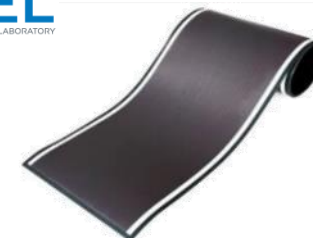
Triple junction  
amorphous/microcrystalline /  
SiGe: 18 - 20%

**NREL**  
NATIONAL RENEWABLE ENERGY LABORATORY

### Now

- Single junction amorphous Si: approx. 8%
- Tandem junction amorphous / microcrystalline Si: approx. 11%

**SOLLIANCE**





*Thank you for your attention!*

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