Integrated PV & Buildings, Infrastructure and water in The Netherlands

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Technical Chamber Cultural Center

Nicosia, Cyprus, November 2, 2018

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Outline

Introduction

- The Netherlands & Energy transition
- Status of PV in The Netherlands

Integration PV

- Buildings (roof, facade, window)
- Infrastructure /water
- IEA Task

Who is Zeger Vroon?

- Master: (86-90)
  Chemistry
  Universiteit Utrecht/Technical University Hannover
  (Storage) Phosphors (A. Meijerink and G. Blasse)

- Ph.D (91-95)
  Chemical Engineering
  Technical University Twente/Worcester(USA)
  Sol-gel synthesis and transport properties of zeolite membranes

- TNO (95-?)
  Inorganic Chemistry
  Optical coatings 0.4 fte
  (Eindhoven→ Geleen)

- Zuyd (10-?)
  Lector (Professor) (Solar)
  0.6 fte (since March 2014). BIPV
  (Heerlen)

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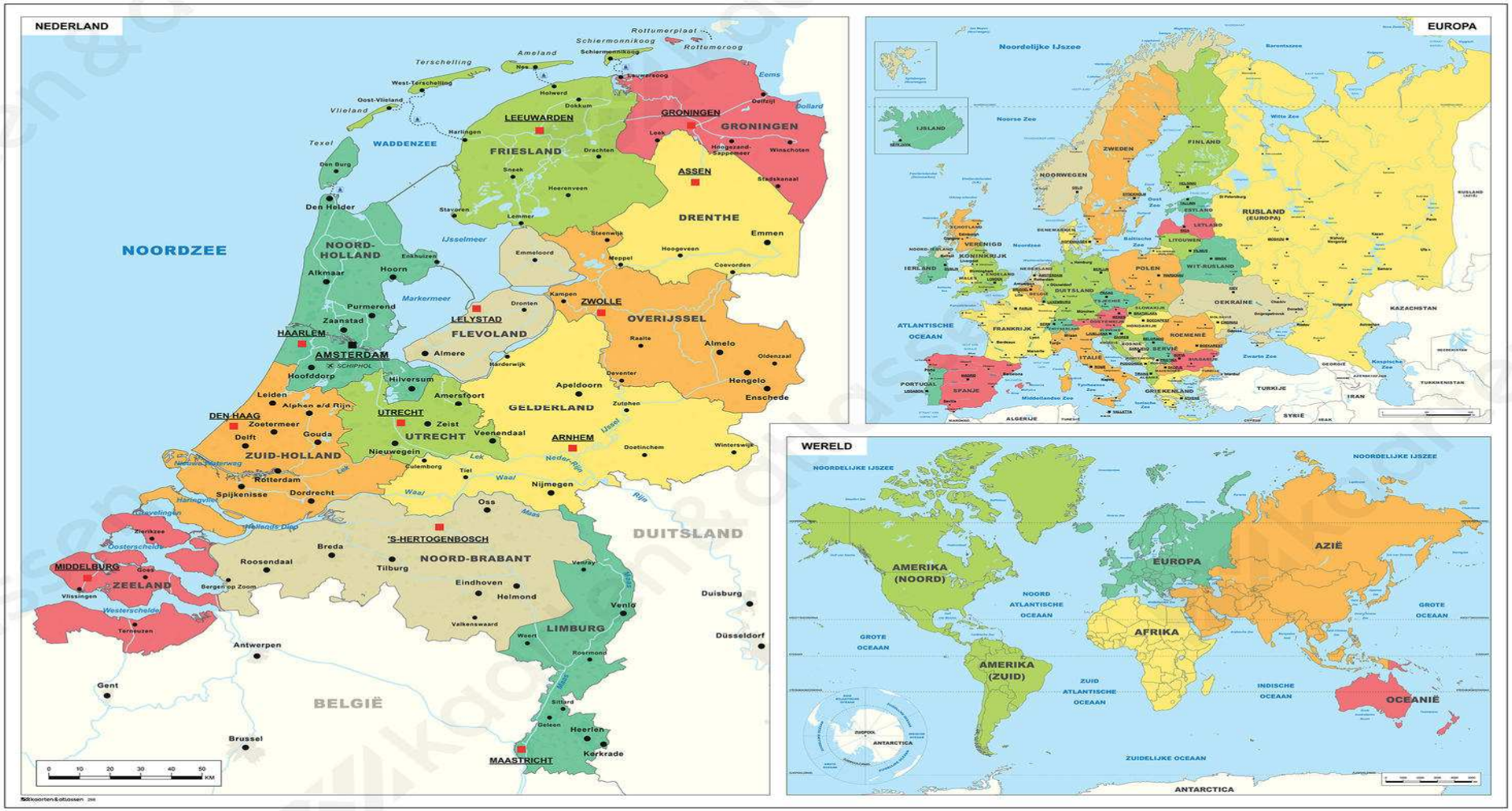
The Netherlands



The Netherlands

- Area: 41.500 km^2
  (120x350 km)
- Population 17.200.000
- Population density 425/km^2

- Climate **Cfb**

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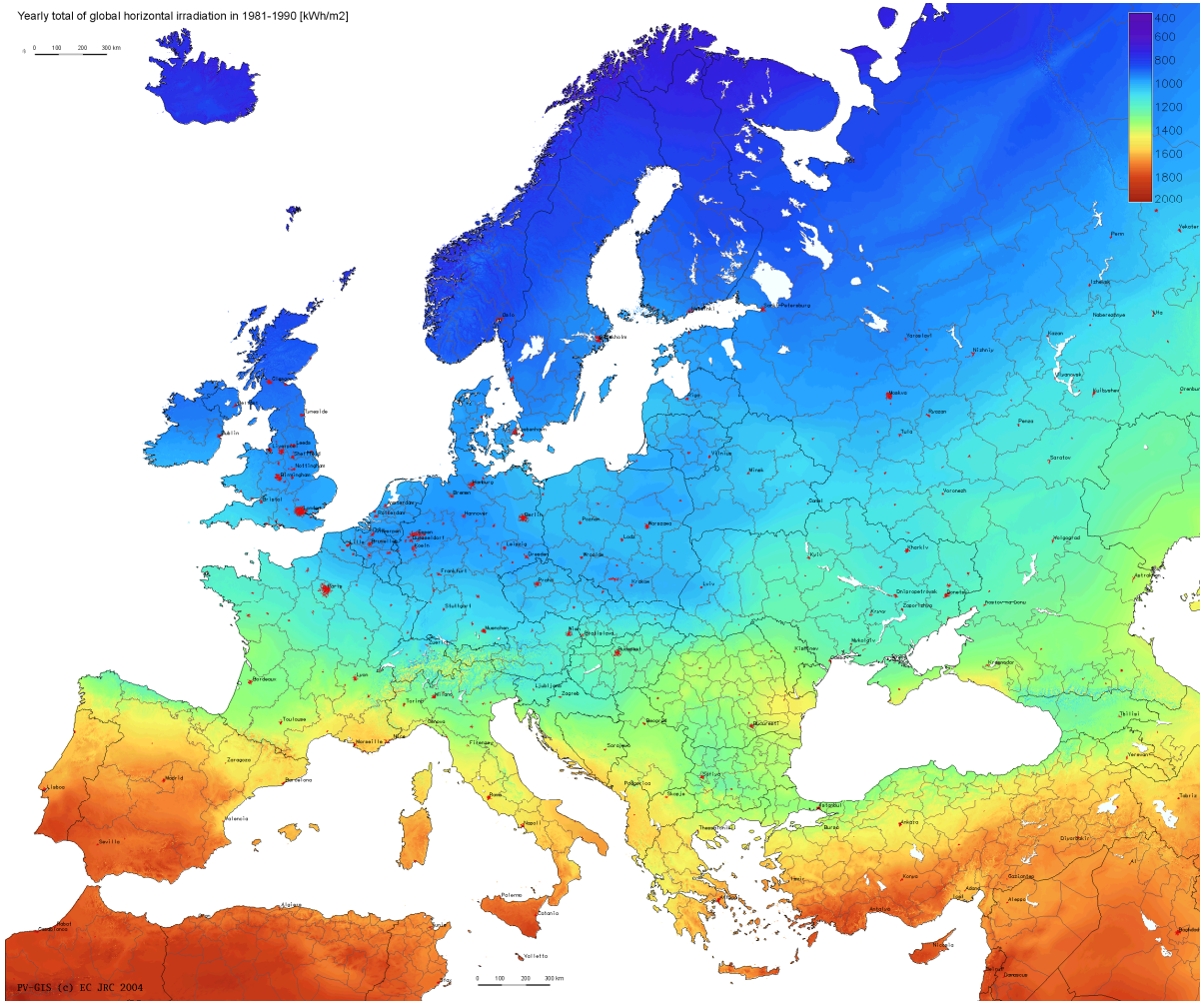
Europe



irradiation (kWh/m²·yr)	PV generation cost (€/kWh)
600	0.83
1000	0.50
1400	0.36
1800	0.28

insolation map: Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy (in press), http://re.jrc.ec.europa.eu/pvgis/

W. Sinke, [3]

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The Netherlands

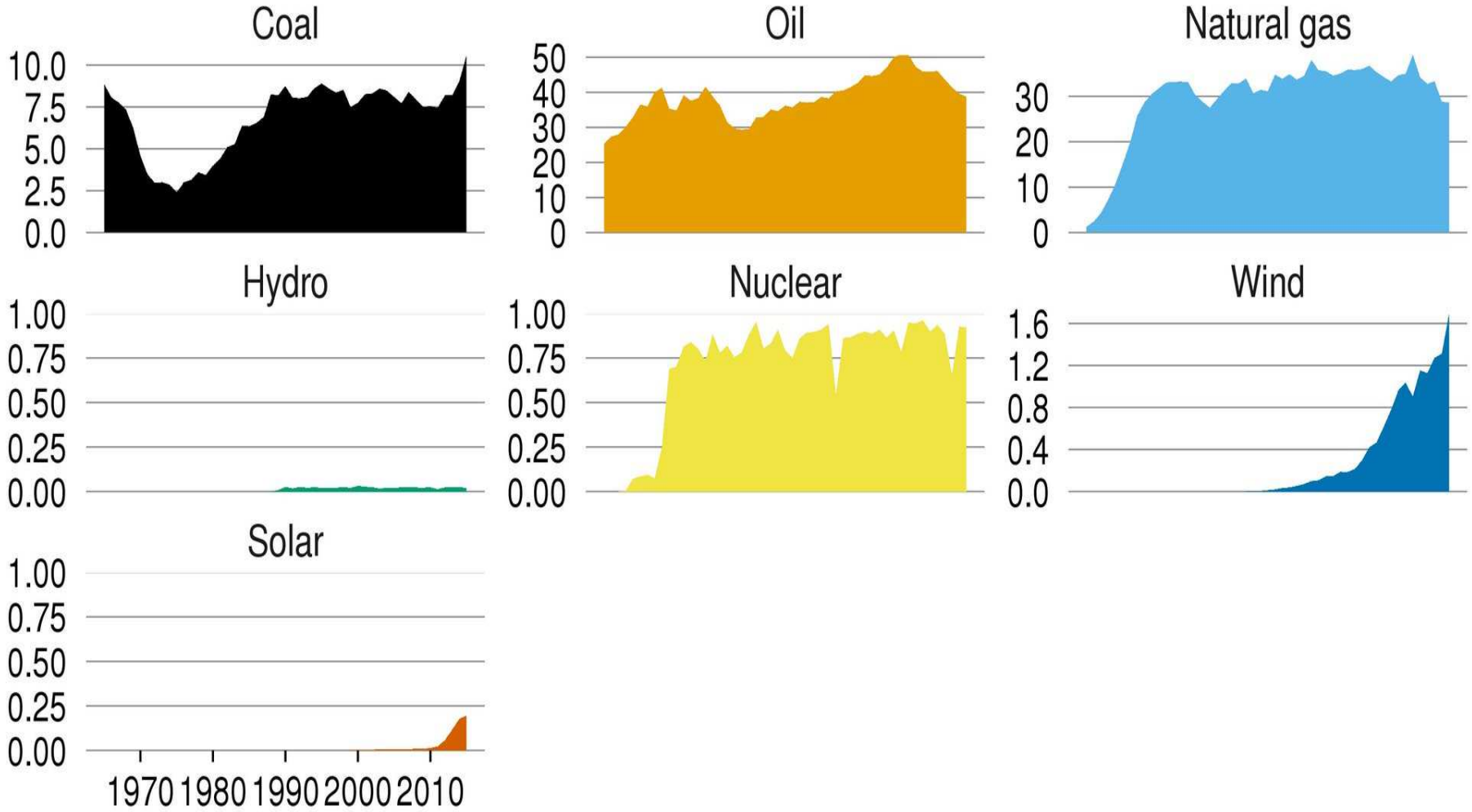
- **We have not a lot of space for the energy transition (integration)**

- Integrate with built environment, infrastructure, water.

Not a lot of space for PV fields

The changing energy mix of Netherlands

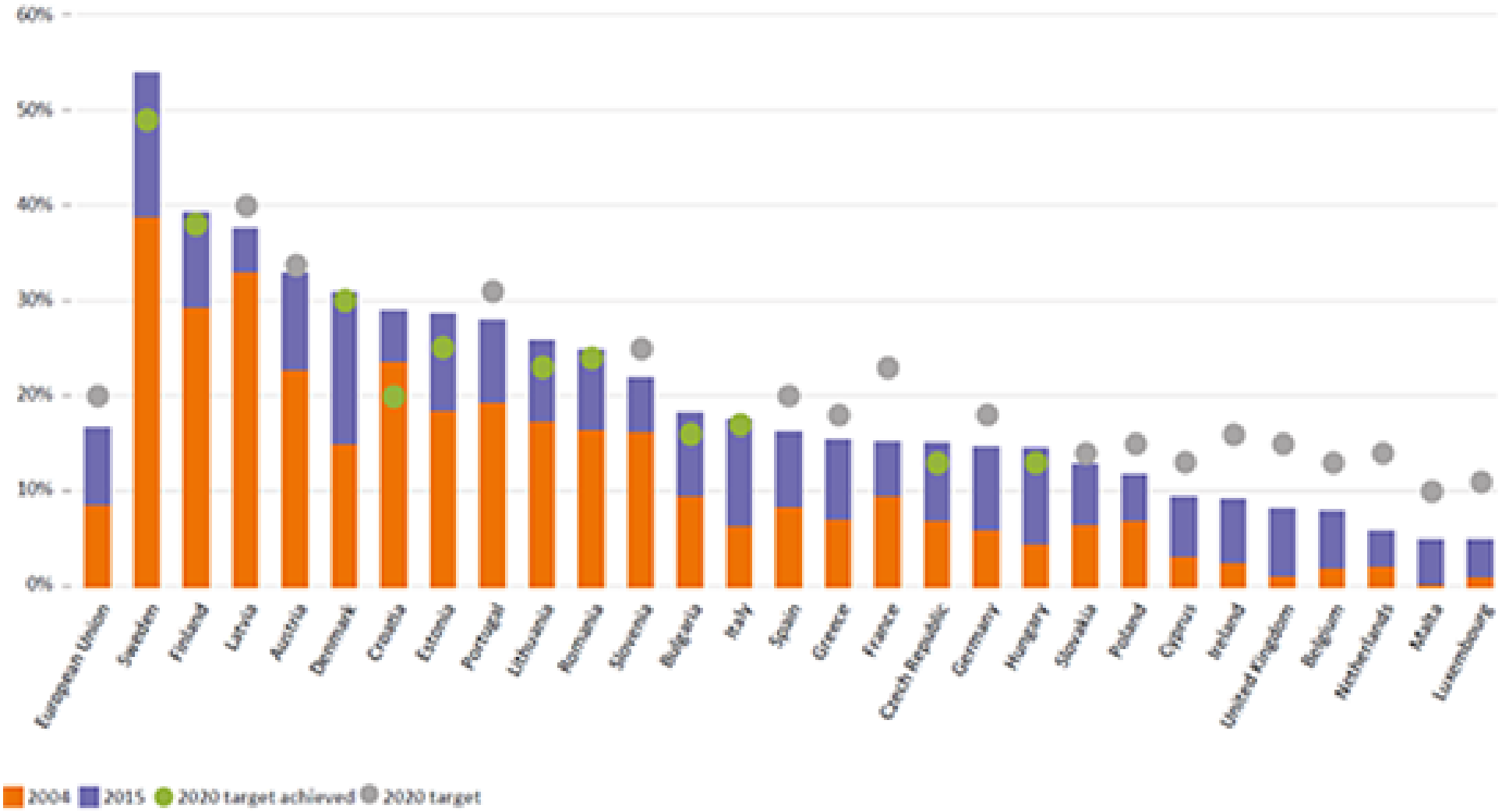
Primary energy consumption (Mtoe/year) (1965-2015)



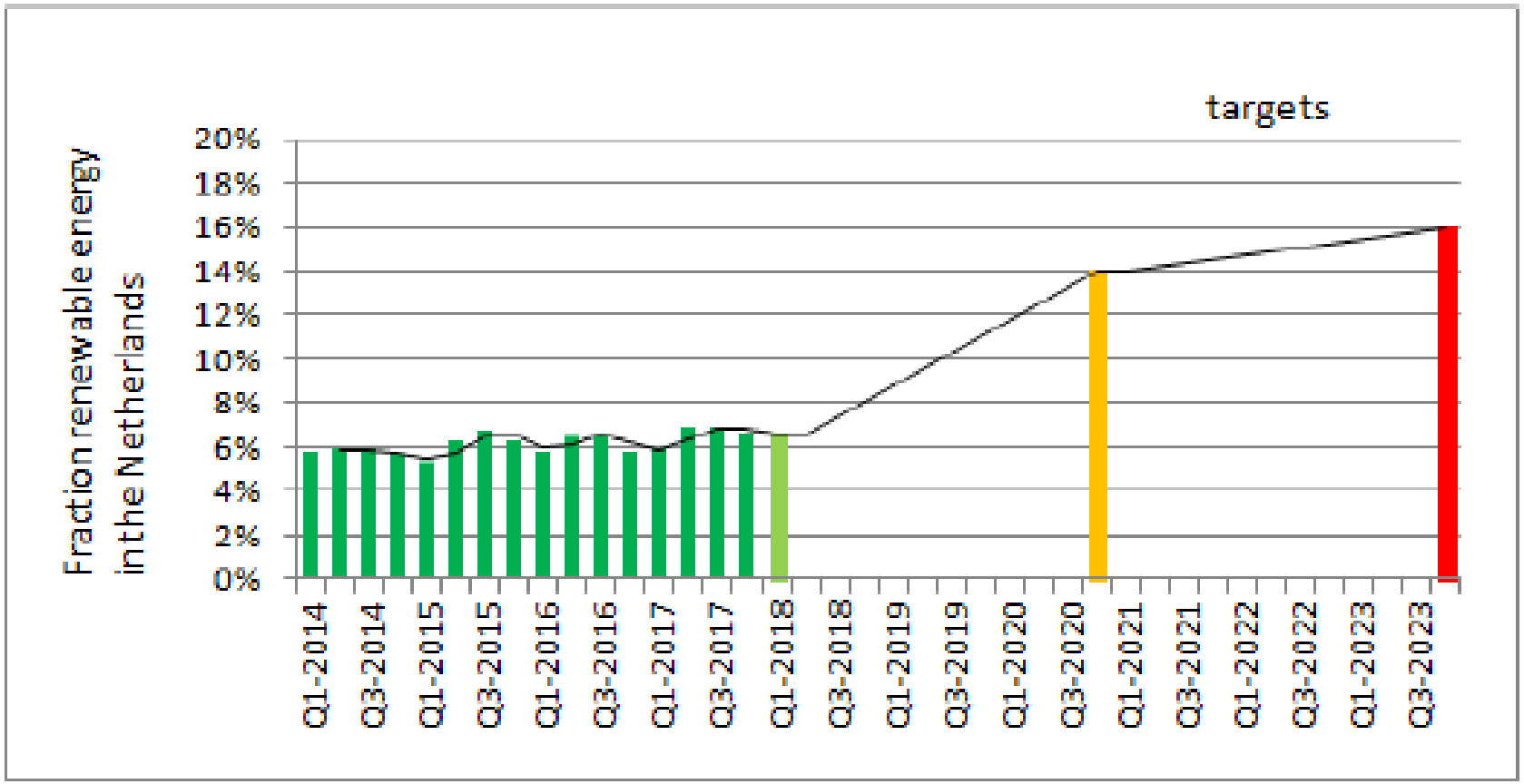
Data: BP Statistical Review of World Energy 2016 Figure: robert.wilson@strath.ac.uk

Note: Covers all energy uses including electricity, heating and transport. Does not include bioenergy

The Netherlands
Energy transition (2017)



Renewable energy (2018, targets)



The Netherlands

- High population density /good agriculture ground

→Not a lot of space for energy transition →

→Low amount PV fields

- Gas problem Groningen

→We have a big job to do in the Netherlands

Integration

- Buildings (BIPV)

Roof, Facade and Window

- Infrastructure (IIPV)

Solaroad and Noise barriers

- PV onto water (WIPV)

Floating PV

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Status PV in the Netherlands (2017/2050)

Type	2017 (GWp)	2050 (Expected) (GWp) [1]
PV Fields	0.1	45
PV & Buildings	2.4	90
PV & Infrastructure	0.05	33
PV & water	0	69
Other	0	1
Total	2.55 (0.3-0.4%)	237 (20-30 %)

SEAC report, (2017) [1]

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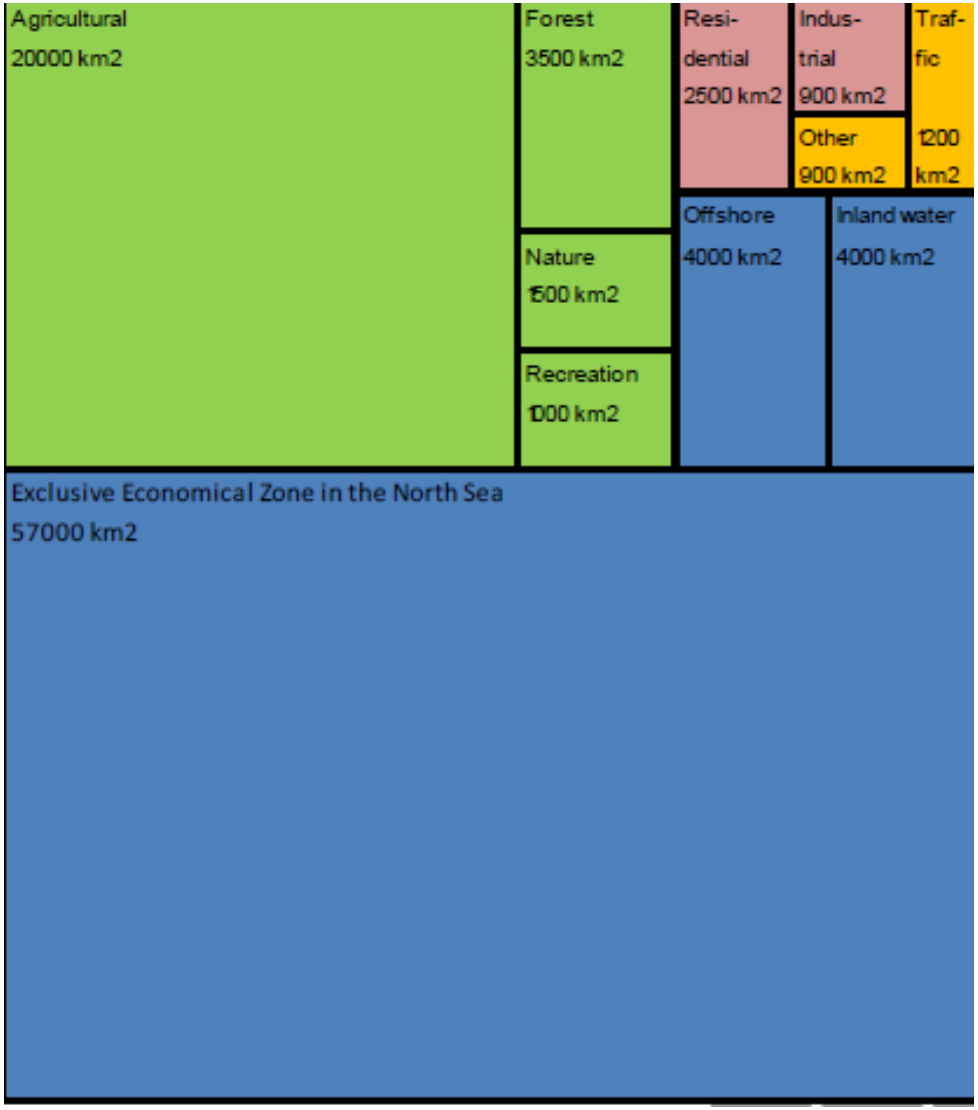
PV in The Netherlands (2017)

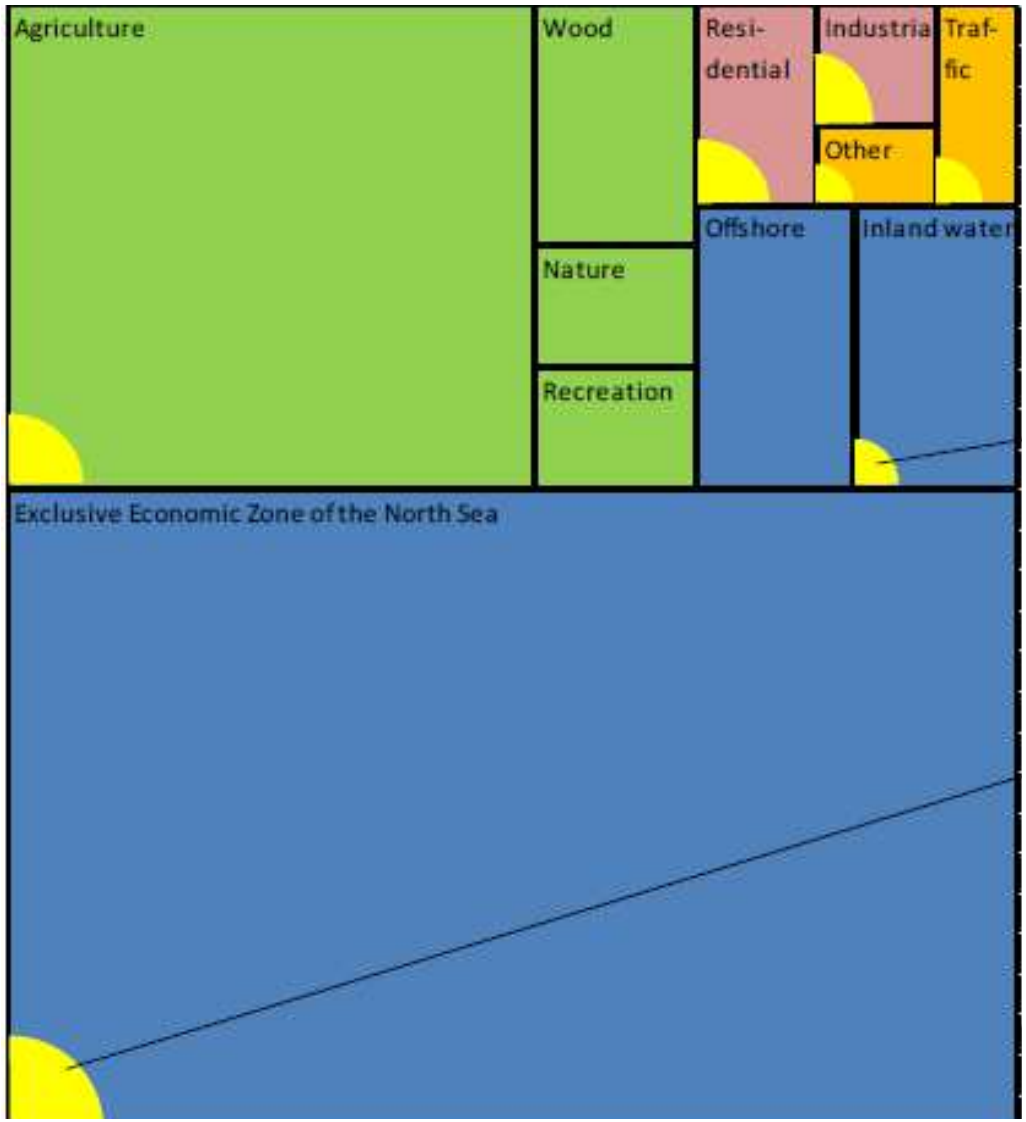
- Small amount of PV fields (< 5 %)
- BAPV (>95%)
- BIPV and other integrations (< 3%)

The Netherlands



[1] SEAC, report, (2017)

The Netherlands in 2050



[1] SEAC, report, (2017)

PV fields

- No → in fields
- Yes → Areas that can not be used for other functions (along highways, industrial areas, waste mountains, etcetra)

The Netherlands (Vision)

- PV fields → limited and/or only on not usable sites.
- BAPV → Good, non esthetical (windmill)
- BIPV → Important product

BAPV & BIPV

Two main techniques for PV in the building environment.

Built Applied PV

Built Integrated PV

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Definition BIPV

A BIPV module is a PV module and a construction product together, designed to be a component of the building. A BIPV product is the smallest (electrically and mechanically) non-divisible phovoltaic unit in a BIPV system which retains building related functionality. If the BIPV product is dismounted, it would have to be replaced by an appropriate construction product

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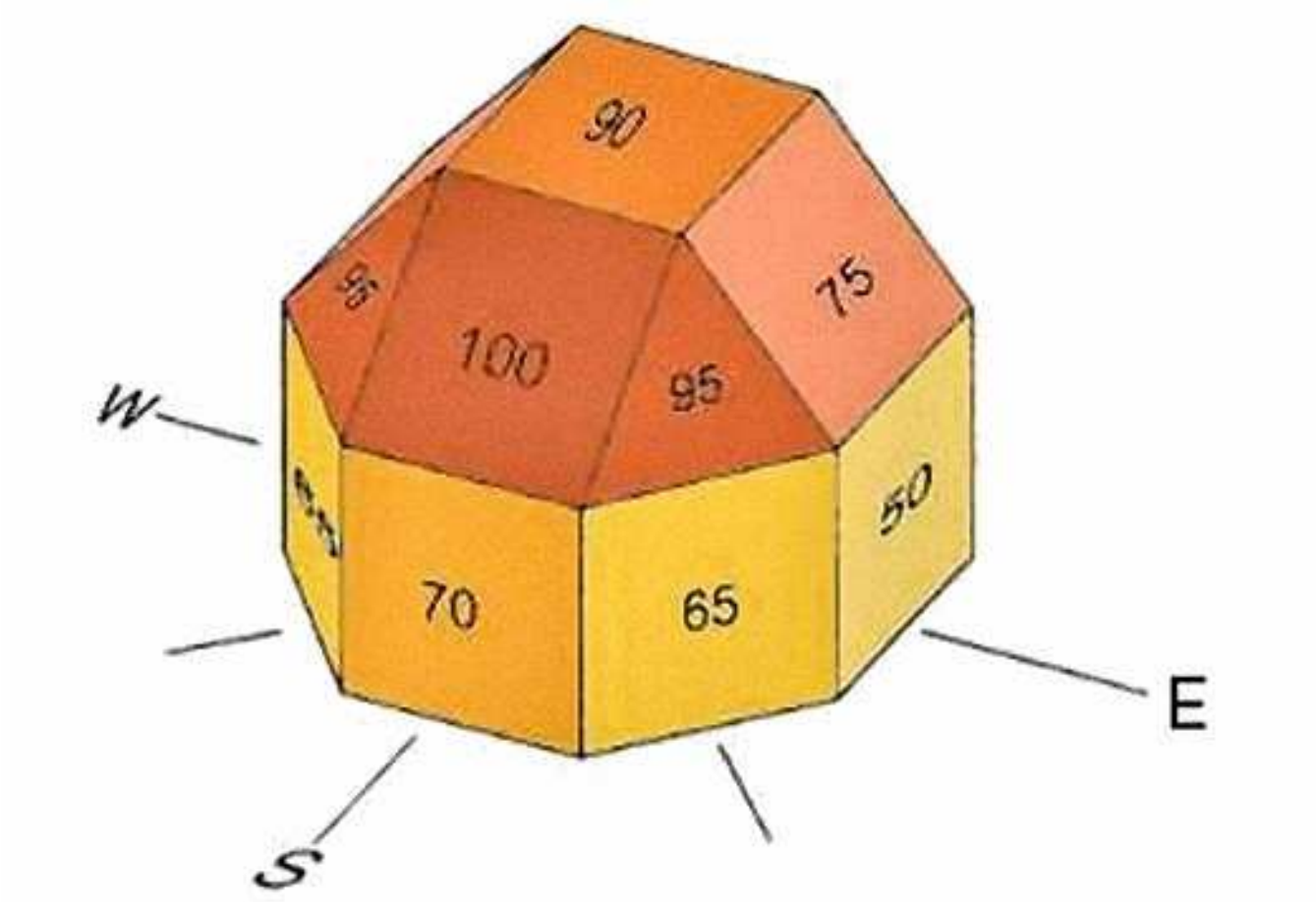
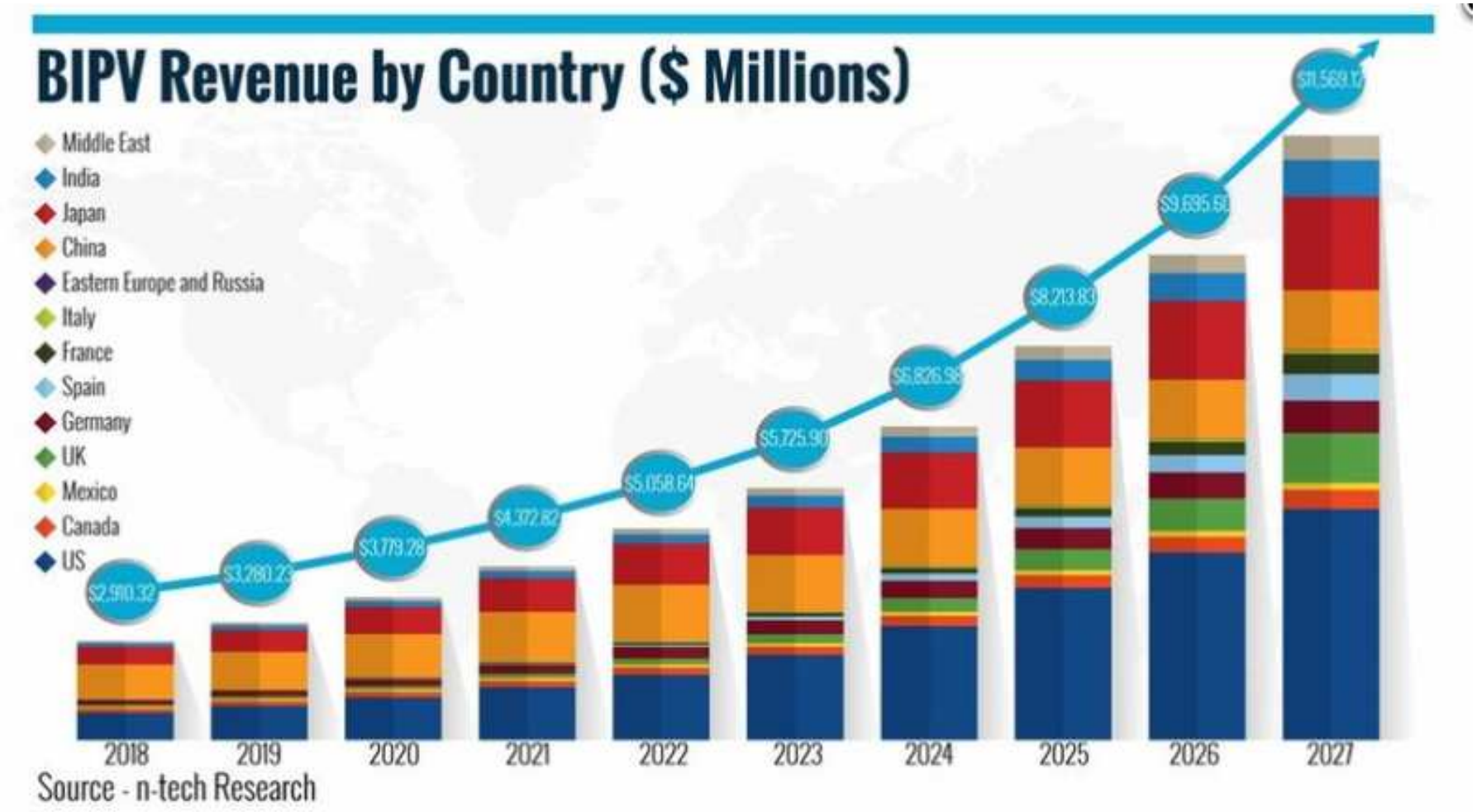
BAPV

Number of PV modules >	11.000.000
Payback time less than	7-10 years
Kwh price in 20 years	0.10-0.13 Eur/kWh
Interest house owners:	5-8 %

PV on the house



International Energy Agency



Zuyd & Research

- Built environment (BIPV)

Roof (2011-2018)

Facade (2013-2018)

Window (<2017)

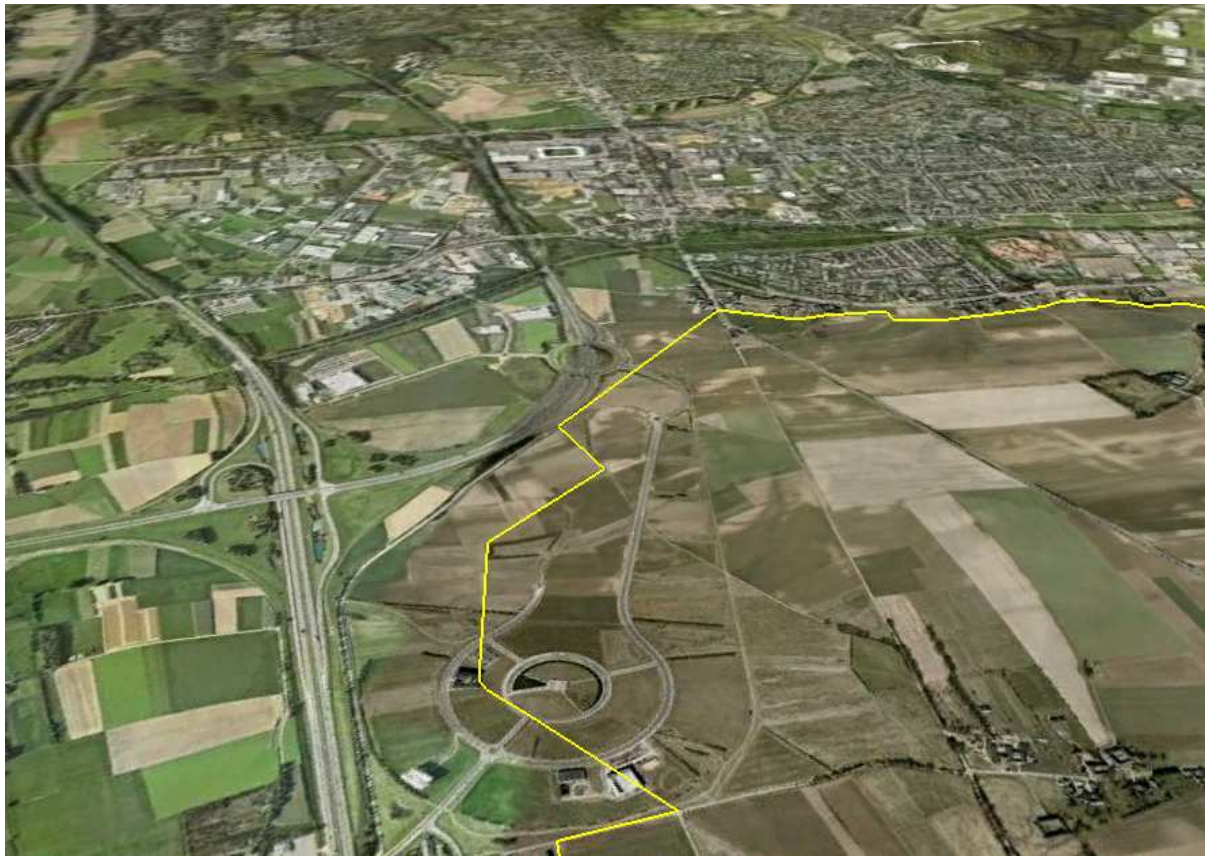
- Infrastructure (IIPV)

Solaroad and Noise barriers (>2018)

Zuyd&Research

- Validation and demonstration of integrated PV products and energy storage products for Buildings

Demonstration & Field test
District of Tomorrow



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Realized BIPV projects at Zuyd

Kerkrade-west
(Bestaande wijk van morgen)

Heem wonen → renovation
152 houses → new building envelop with PV
F → A++

BIPV

Modules

- Color
- Size
- Curved
- Transparent

BIPV
(Roof)

Integrated

Colour	Black/blue → Colors
Shape	Rigid → Flexible
Size	Rigid → All sizes

Built environment (Roof, integrated)

BEAUsolar

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Built environment (Roof, integrated)

AERSPIRE
Aesthetic Energy Roofs

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Built environment (Roof, integrated)

SCX SOLAR
connected to the sun

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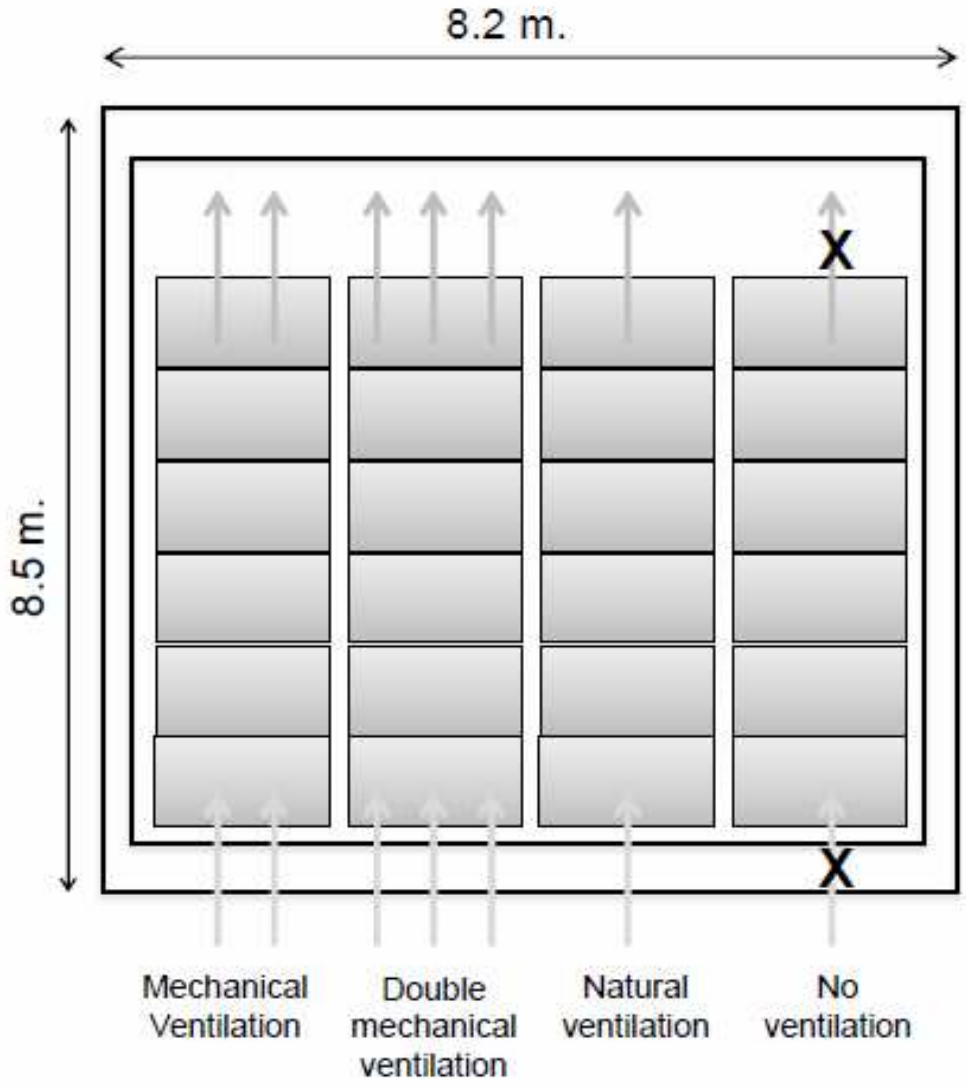
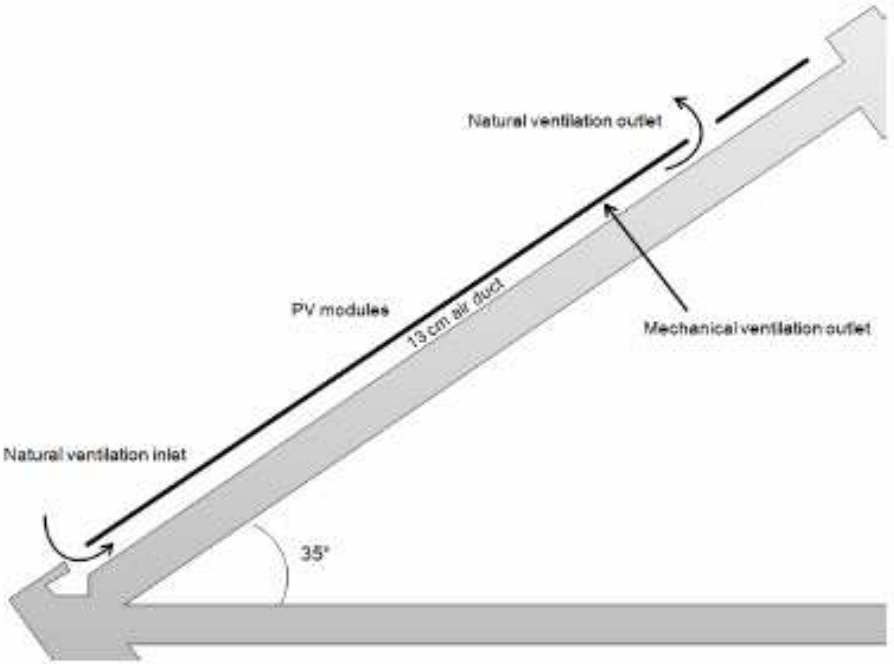
Building 1
Bent to the sun

Of dit?

Field Test 1 – technical layout



Top view (no scale)



Vertical section (no scale)

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ZUYD

Field Test 1 – PV output 2013-2015

Segment 1: 1 x mechanical ventilation
Segment 2: 2 x mechanical ventilation
Segment 3: natural ventilation
Segment 4: no ventilation

TU/e ZUYD

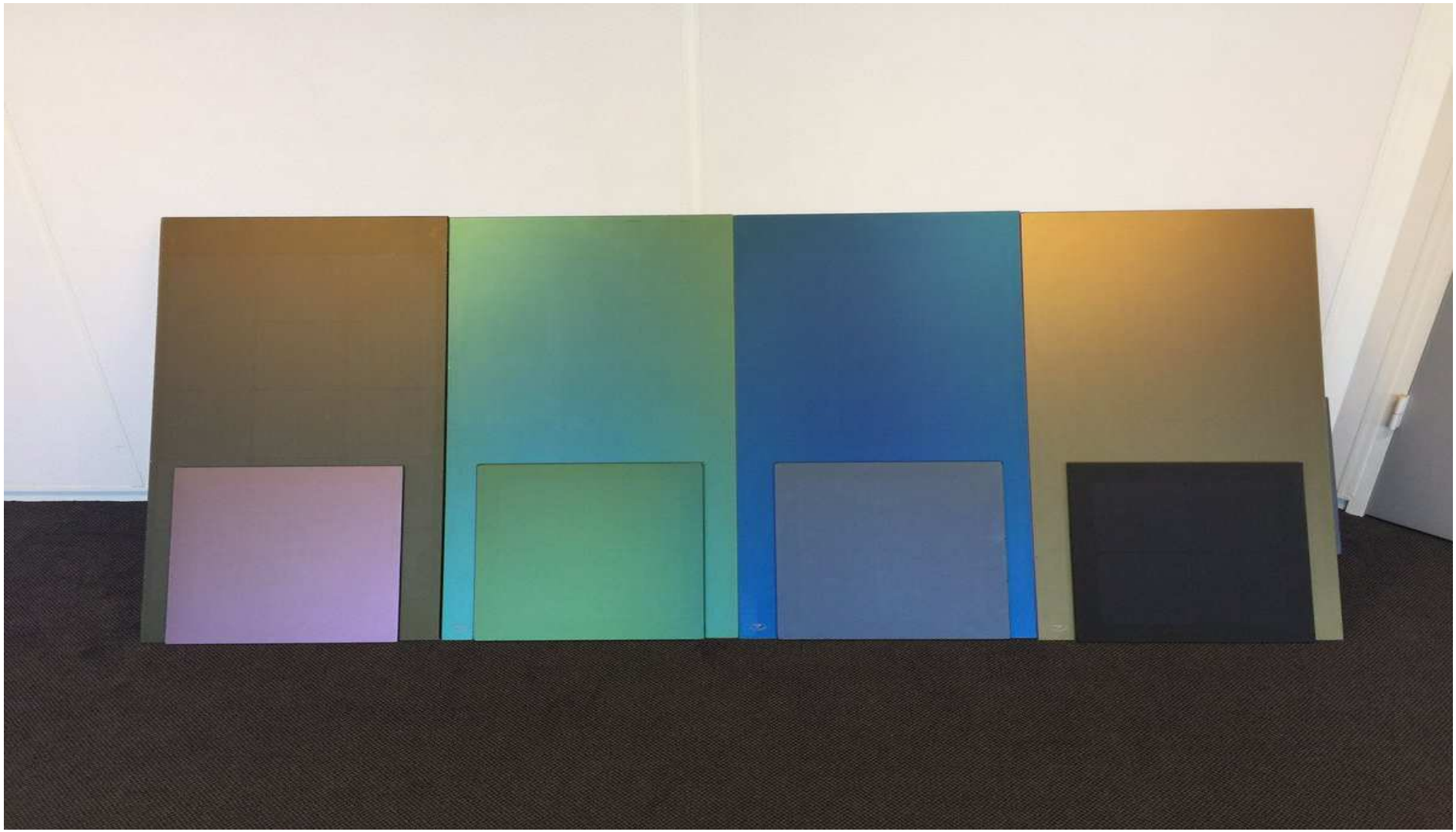
209 Wp	197 Wp	169 Wp	112 Wp
213 Wp	213 Wp	183 Wp	92 Wp
196 Wp	196 Wp	195 Wp	124 Wp
170 Wp	139 Wp	200 Wp	160 Wp
167 Wp	194 Wp	176 Wp	185 Wp
198 Wp	na	208 Wp	199 Wp

Wp per string (modules 1-5):

A: 955 Wp
B: 939 Wp
C: 923 Wp
D: 673 Wp

TU/e ZUYD

Avancis

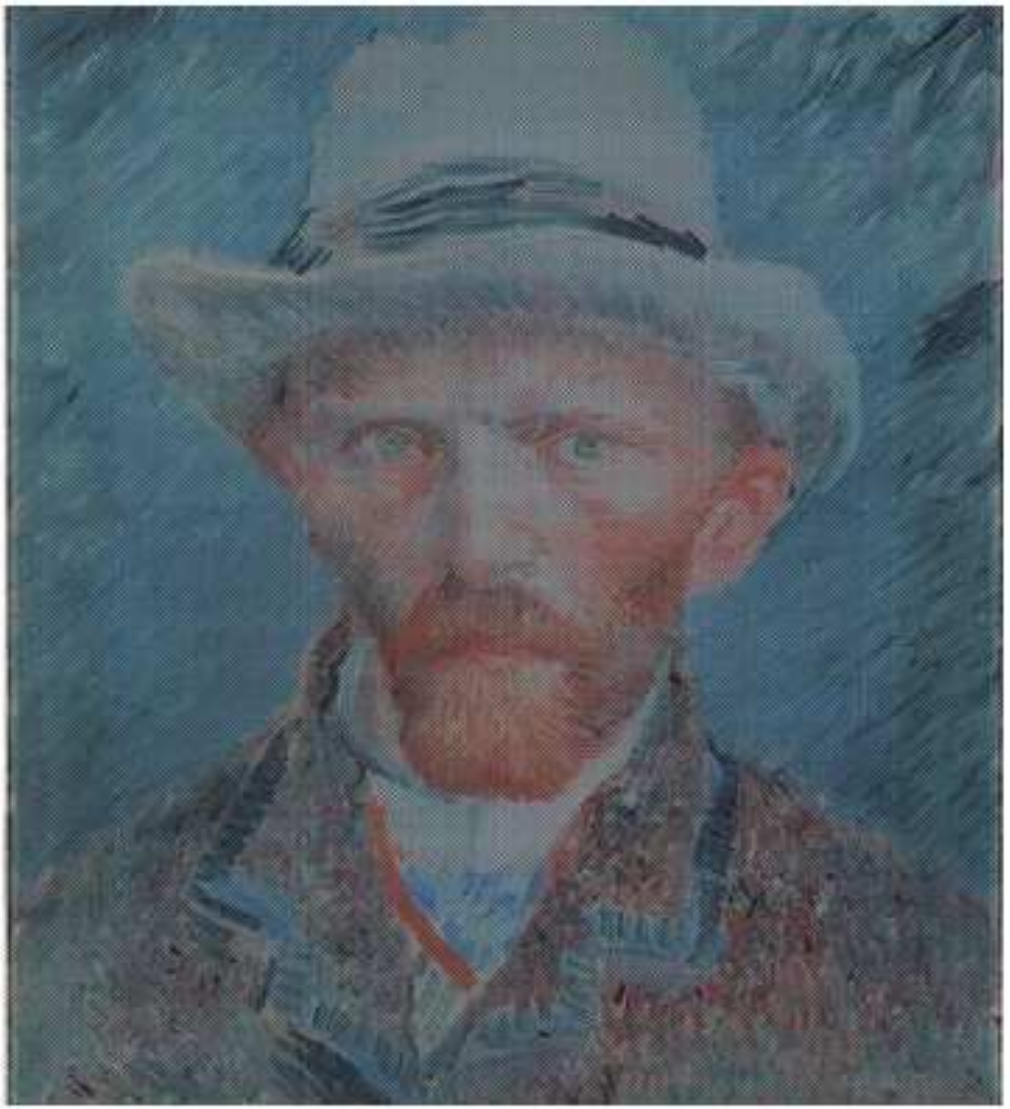


Avantis

(Last week, Glasstec)

Kameleon Solar

Kameleon Solar



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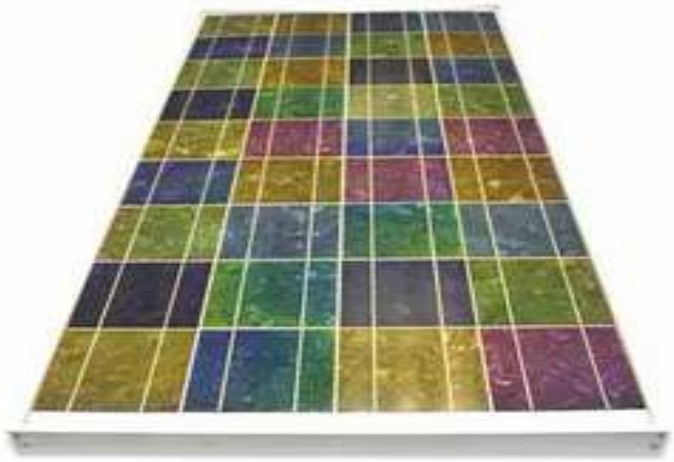
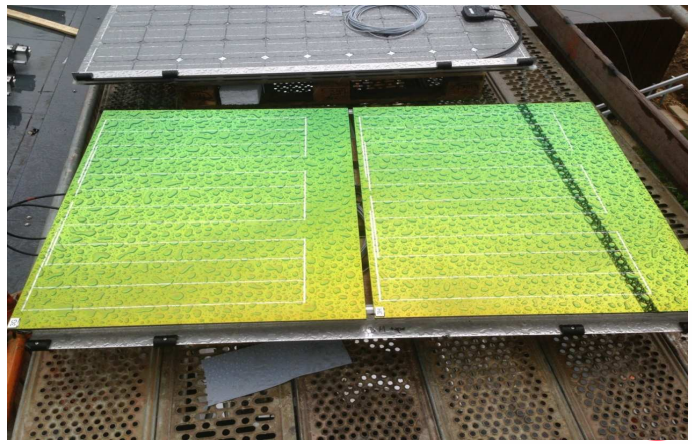
Colored solar modules

1. Coating on top of silicon cell
2. Thin film technology (OPV)
3. Coating/foil on front glass substrate of module





Coloured Solar Cells

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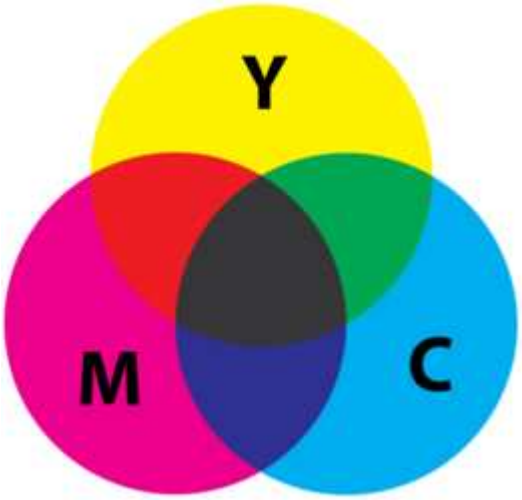
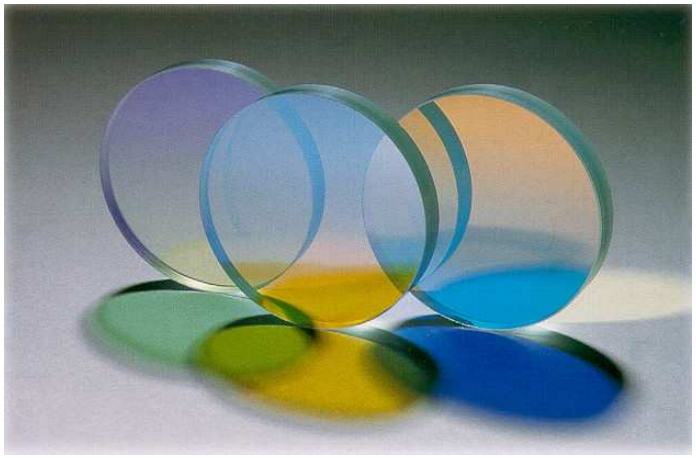
Creating colour

– Paint
– Colour filter
– Selective reflective coating

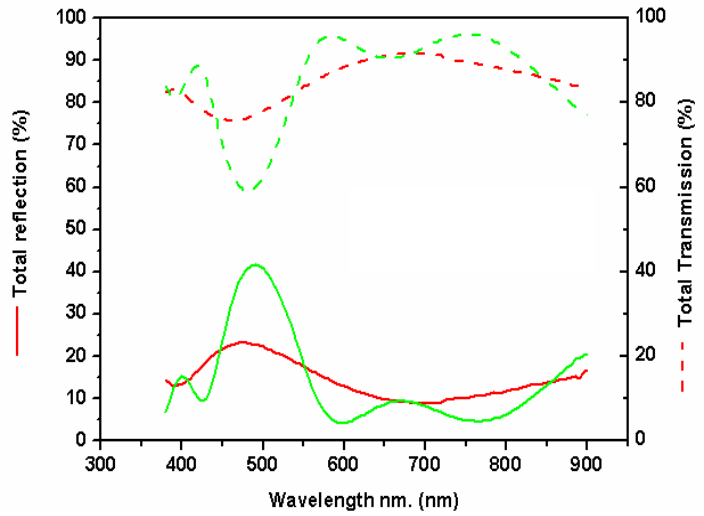
	Transmission	Reflection
Paint	--	++
Colour Filter	+/-	+/-
Selective reflective coating	++	+





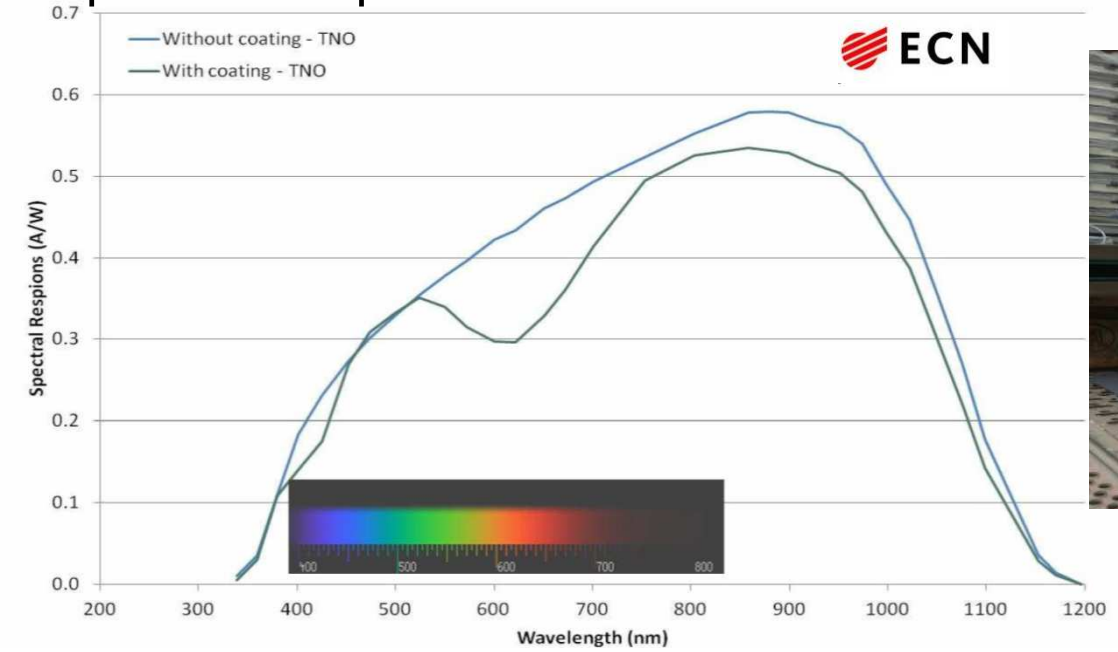
Selective reflective coatings (1)

- Working principle
  - Creation of interference stack
  - Reflection and colour can be adjusted
  - Stack applied on PV panels



Selective reflective coatings (Spectral response)

Spectral Response



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Preparation of colored solar modules (Scale up)

- Size: 81.35 x 98.80 cm (half of a standard module).
- Preparation at Prinz-Optics and Soltech
- Cells: 6x4 (24).
- I-V test: Efficiency about 10% less than standard modules.

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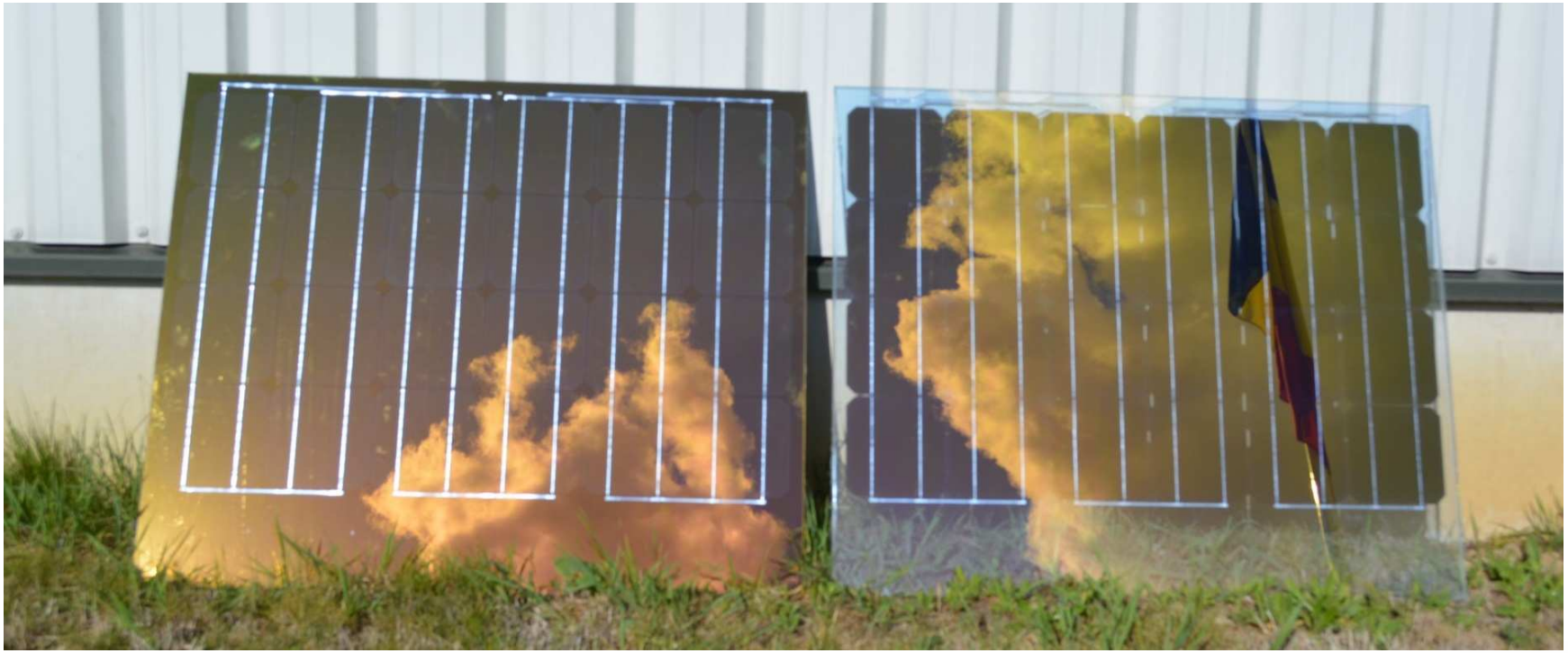
Preparation of colored solar module

(24-cells colored modules with black and transparent EVA)



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BIPV roof

Properties of the colored BIPV solar roof

- Number of colored modules: 8
- Number of colored modules: 4 (black EVA)
- Number of colored modules: 4 (transparent EVA)
- Number of standard modules (100x160 cm): 36
- Orientation 190°
- Inclination 12°
- 9840 Wp total

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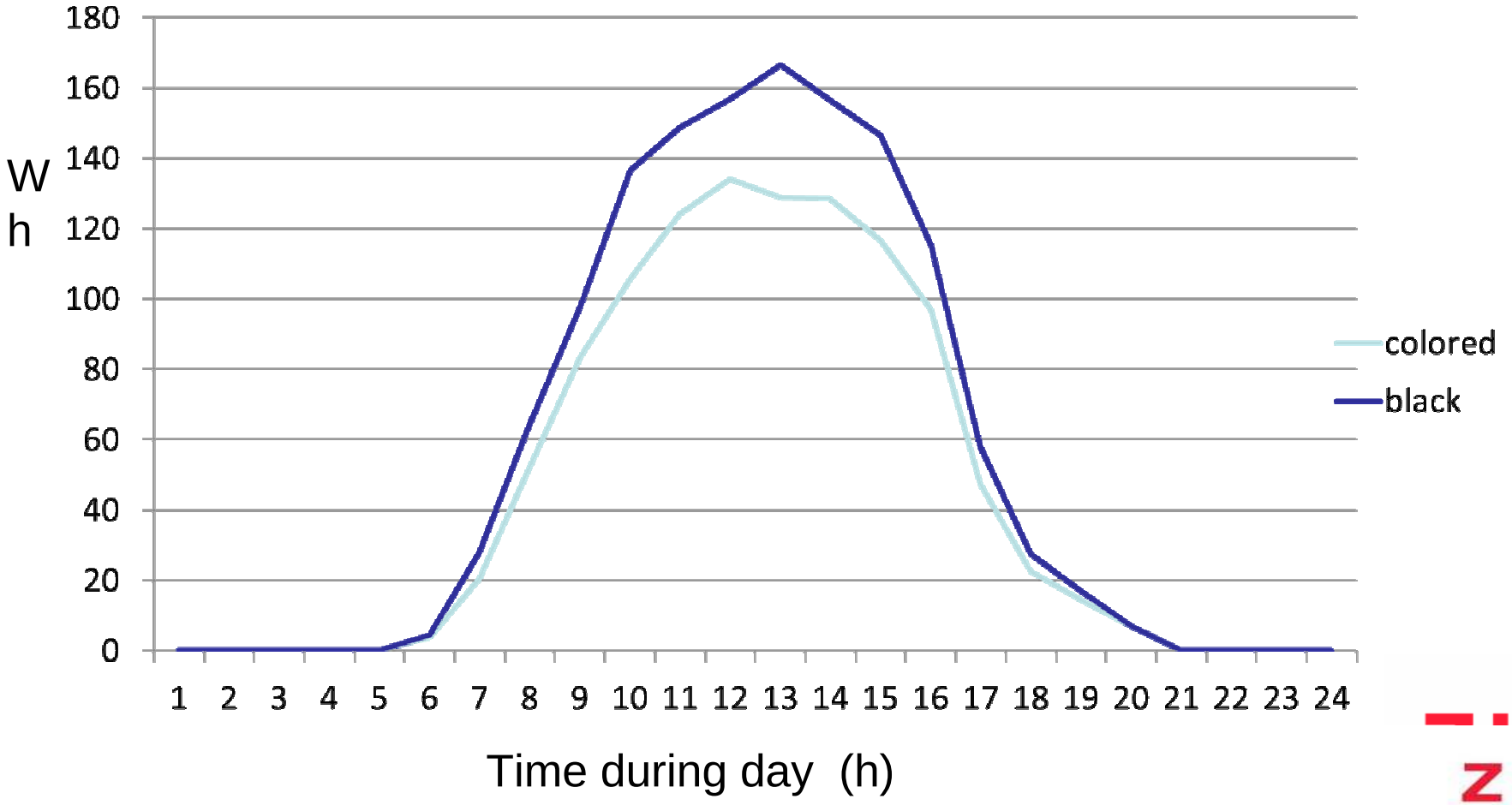
BIPV roof

(average hourly PV output (Wh) of colored vs black modules with 80% compensation for difference between 48 and 60 cells) over 1 day.)



Zuyd University of Applied Sciences

BIPV roof

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Field test

- Reliability colored coating good
- Less than 20 % loss due to colored coating
- Different colors can be obtained.
- Building companies like the green-yellow color

Demo 1
Out with asbestos, in with solar panels

Challenge

- > 10 km2 in Limburg (> 100 km2 asbestos roofs in the Netherlands)
- Asbestos must be removed before 2024.

- 30-40% of the asbestos roofs is with low construction. PV panels are heavy.

- > 3 km2 in Limburg (> 30 km2 asbestos roofs in the Netherlands)
  Thin film
  Improve roof construction

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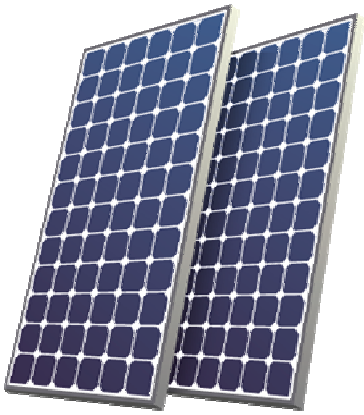
District of tomorrow
(Building 4,Why thin film?)



•≈ 20 kg

•≈ 3-7 kg

•Mounting frame

•Peel and Stick

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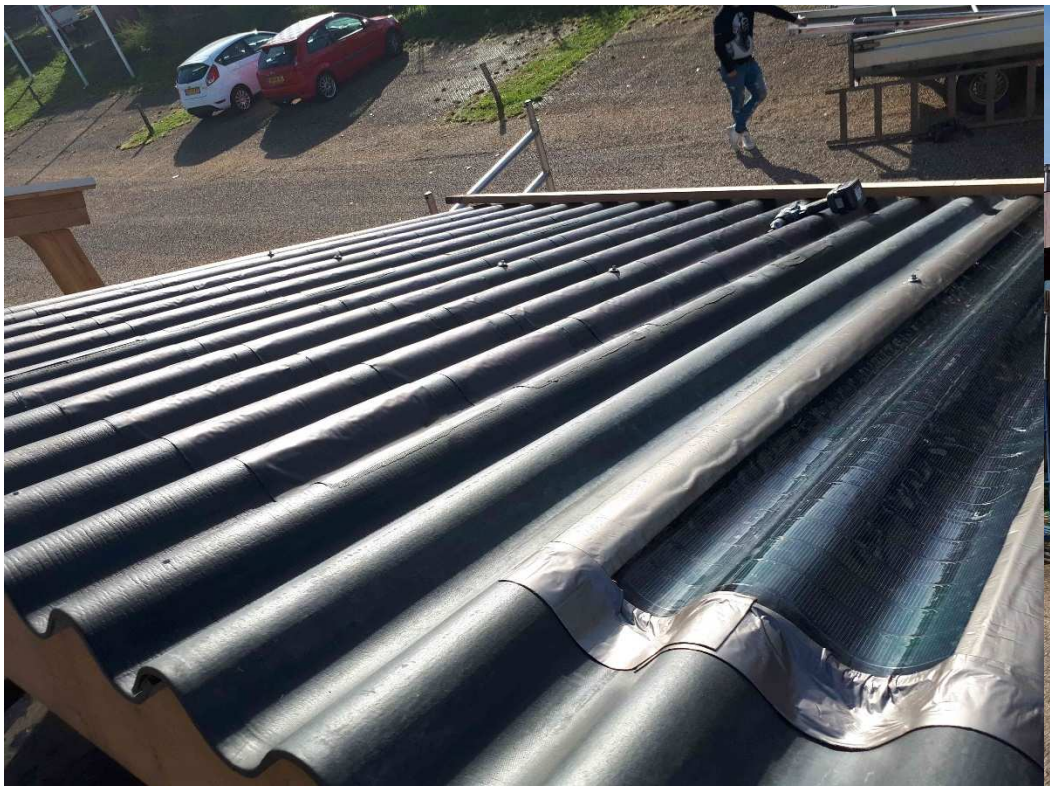
Hyet Solar BV

Products: PowerFoil115: Single junction (a-Si:H)
PowerFoil165: Tandem junction (a-Si:H/µc-Si:H) modules (n=10%)

Eternit

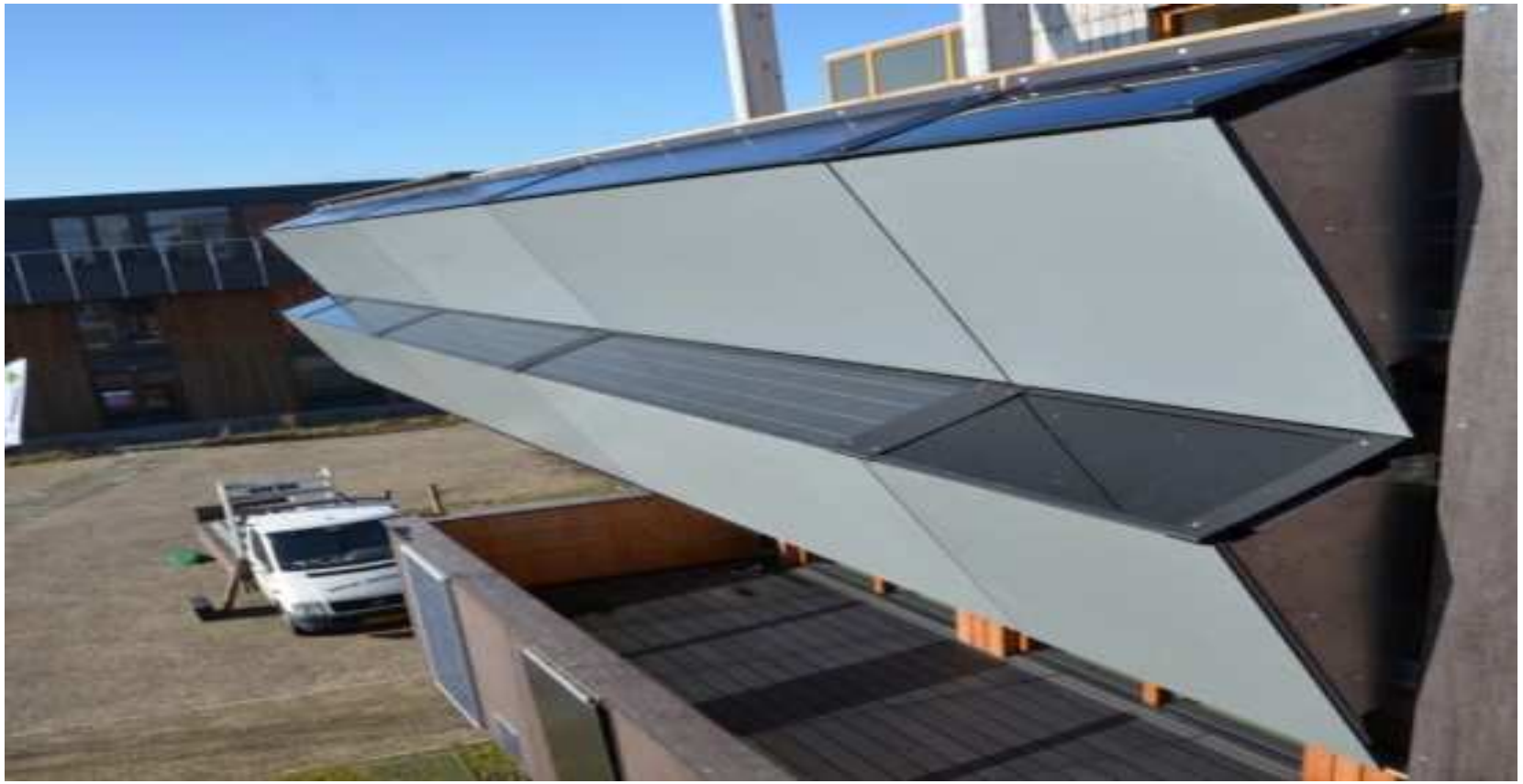
Monday Oktober 8
(Building demo 1)

Monday Oktober 8
(Building demo 1)



Facades

Zigzag solar



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Zigzag solar
(Q park Heerlen)

Solowall (SCX Solar)

Solowall (SCX solar)

PV &Windows
(Transparant PV)

Integrated PV window

PHYSEE

665 × 374Op afbeeld

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Physee

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- **Physee (Projects in the Netherlands)**

OPV (Lifetime)

PV & infrastructure

Solaroad

Noise Barriers

Solaroad, infrastructure

Solaroad, infrastructure

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Solaroad Living Lab
Facts & Figures

- Location : Krommenie
  (15 km from Amsterdam)

- Cycling path : 70 m long and 3.5 m broad
- Half cycling path with PV solaroad (70x1.75 m)

- 54 modules, 16 kWp, 80 cells/module

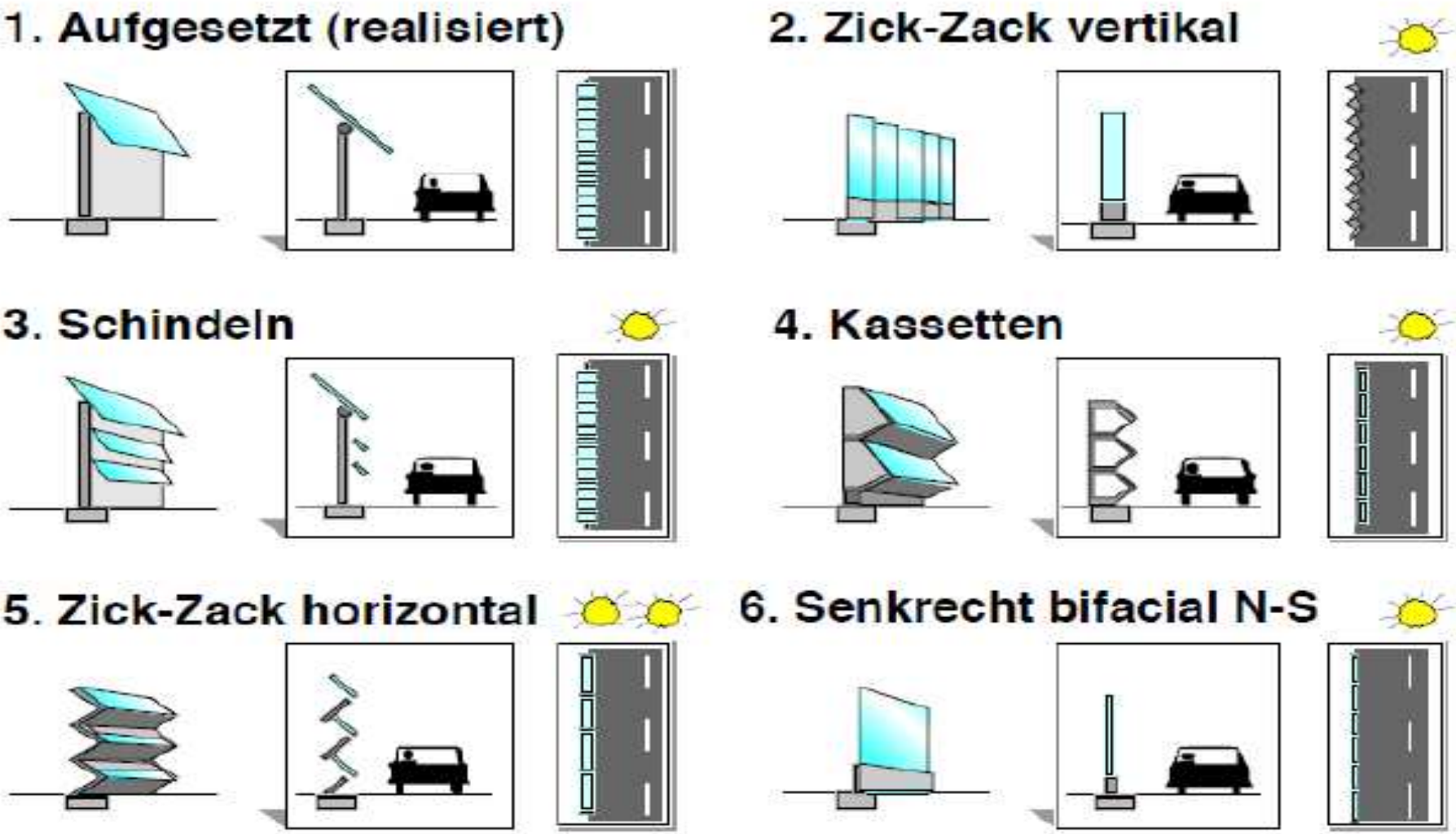
Solaroad

2014-2018	Zuyd not involved
2018-2022	Rolling Solar - New product with CIGS in stead of silicon - New types of encapsulants

Noise barriers

Country	City	Road/Railway	Rated power (kWp)	Tilt	Azimuth	Year	Location known	Material	Owner/Builder
Switzerland	Chur	A13	100	45°		1989		c-Si	TNC AG
Austria	Seewalchen	A1	40		160°	1992			Oberöstereichische Kraftwerke
Germany	Rellingen	A23	30		200°	1992			TST (DASA)
Switzerland	Gordola	Rail	103		200°	1992	X		TNC AG
Germany	Saarbrücken	A620	60			1995			Stadtwerken Saarbrücken
Switzerland	Giebenach	A2	100	45°		1995			TNC AG/ Kanton Basel
Netherlands	Utrecht	A27	55	50°	245°	1995	X	c-Si	RWS
Netherlands	Ouderkerk a/d Amstel	A9	220	50°	200°	1996	X	c-Si	Shell & ENW / EU Commision
Germany	Inning am Ammersee	A96	30			1997			TNC GmbH, Bayernwerk, BMFT
Switzerland	Zurich (Aubrugg)	E41	10	90°	80°	1997	X	c-Si	Uitbreiding door TNC in 2004
Switzerland	Zurich (Walliselen)	Rail	9.6	45°	200°	1998	X	c-Si	TNC
Switzerland	Zurich (Brütisellen)	A1	10	90°	140°	1999	X	a-Si	TNC
France	Fouquières-lès-Lens	A21	63	45°	170°	1999	X	c-Si	
Germany	Sausenheim	A6	100			1999			
Austria	Gleisdorf	A2	101			2001			
Switzerland	Safenwil	A1	80	45°	170°	2001	X	c-Si	IG Solar Safenwil
Germany	Emden	A31	53	90°	180°	2003	X	multi	Straßenbauamt Aurich/Energiever
Germany	Freising (Munich)	A92	600	45°	180°	2003-	X	c-Si	
Germany	Vaterstetten	Rail	180		210°	2004		a-Si	Phoenix Solar
Germany	Freiburg	B31	365			2006			TNC, aluminium: Van Campen
Germany	Großbettlingen	313	28			2006			
Australia	Melbourne	40	24	90°	180°	2007	X	a-Si	
Germany	Töging am Inn	A94	1000	45°	210°	2007	X		
Switzerland	Melide (Lugano)	A2/rail	123	45°	220°	2007	X	c-Si	Suntechnics Fabrisolar AG
Switzerland	Münsingen	Rail	14	90°	80°	2008	X	c-Si	TNC
Italy	Marano d'Isera (Trento)	A22	730	*	140°	2009	X	c-Si	IrisLab/Autobrennero A22
Germany	Aschaffenburg	A3	2065	45°	150°	2009	X	c-Si	Evergreen solar GmbH
Italy	Oppeano (Verona)	SS434	833	45°	210°	2010	X	c-Si	
Germany	Bürstadt	B47	283	60°	150°	2010	X		
Germany	Biessenhofen (Bayern)		90	45°	180°	2010	X		Rau Lärmschutzsysteme
Germany	Wallersdorf	A92	1000	45°	150°	2010	X		Apfelböck Ingenieurbüro GmbH
Germany	Polling	Rail	1200	45°	210°	2012	X	c-Si	Exaphi GmbH
Germany	München	Rail/road	7.5	90°		2013			Kohlauer

Types of noise barriers



SONOB project
(SOlar NOise Barriers)

- Dutch Highways: 750-800 km Noise Barriers

Noise Barriers are needed a lot due to highways, close to highways

- Heijmans → tested special Solar Noise Barriers

→ Luminescent solar concentrators

→ Bificial solar panels

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Noise Barriers

2014-2018	**Zuyd not involved**
2018-2022	**Rolling Solar** **New product with CIGS in stead of silicon**

PV & water
(Floating solar/Marine solar)

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PV & water

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PV & water


Geïnstalleerd vermogen (kWp)
Drijvende PV wereldwijd
1677
6670
41160
75308
115308
< 2014
2014
2015
2016
2017

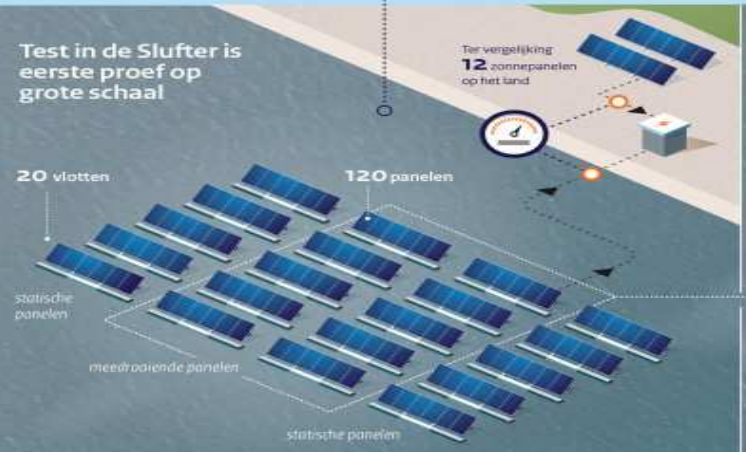
Energie op water

Proef drijvende zonnepanelen

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

Nederland staat voor een enorme opgave om doelstellingen voor duurzame energie te halen. Het kabinet streeft naar **14%** duurzame energie opwekking in 2020. Samen met andere overheden, bedrijfsleven en kennisinstellingen werken we aan innovatieve oplossingen, zoals drijvende zonnepanelen, om deze energiedoelstellingen te behalen.

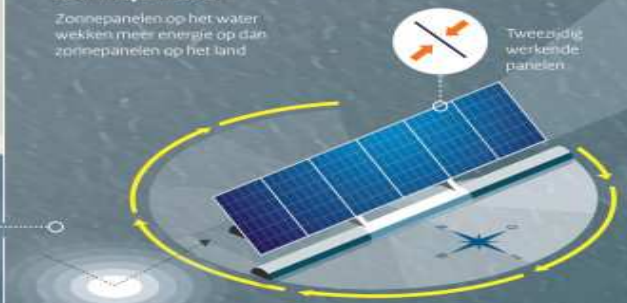
Test in de Slufter is eerste proef op grote schaal



De proefinstallatie van Sunfloat zal een jaar lang aan weer en wind in de Slufter worden blootgesteld

Voordelen drijvende zonnepanelen

Zonnepanelen op het water wekken meer energie op dan zonnepanelen op het land



Reflectie van het zonlicht op het wateroppervlakte
+10% rendement

Passieve koeling door water oppervlakte
+10% rendement

Met de zon meedraaien
+18% rendement

Toekomst

Bij een geslaagde test is de Slufter geschikt voor het plaatsen van minimaal **400.000** panelen

Hiermee kunnen we voor minimaal **25.000** gezinnen stroom opwekken

Port of Rotterdam

Sunfloat®

PV & water

IEA PVPS Task 15

Enabling Framework for BIPV acceleration

It is not about a 'grand vision' on BIPV or reaching 'grid parity', it is about the basic conditions for upscaling niche markets and products.

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IEA PVPS Task 15 Subtasks

Subtask A – BIPV database

Subtask B – BIPV business cases

Subtask C – BIPV regulatory issues

Subtask D – BIPV environmental issues

Subtask E – BIPV R&D activities

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IEA PVPS Task 15 Countries

1. Austria
2. Australia
3. Belgium
4. Canada
5. China
6. France
7. Germany
8. Italy
9. Japan
10. Korea
11. Norway
12. Singapore
13. Sweden
14. Switzerland
15. The Netherlands

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Conclusions

- Netherlands need to integrate PV with other functions.
- Prototypes of BIPV enough. WIPV and IIPV are coming
- BIPV products produced on large scale not present→ price issue