Green Energy Park

Solar R&D and testing

Arab-American Frontier Symposium

November 02nd 2017,
Rabat

IRESEN
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Solaire et en Energies Nouvelles

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The African context

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0.03 $ / kWh !

The African context

African emerging economies must bring reliable electricity

634* mio. people who currently lack access

Renewable energies are an adequate solution, especially distributed PV (high potential of job creation)

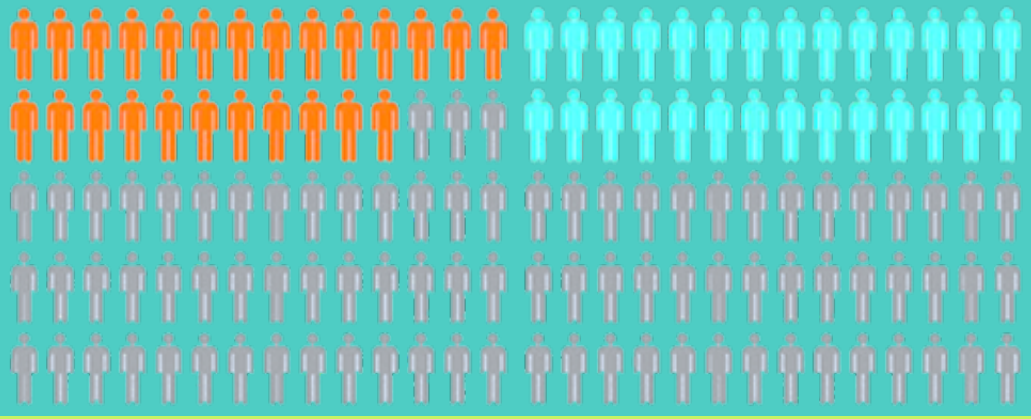
of the
7 Billion people
on Earth today,

legend
= 100 Million

2.5 Billion
have unreliable or no access to electricity

2.8 Billion
live in areas of high water stress

Highest percentage live in Africa!



Source: *AIE 2017

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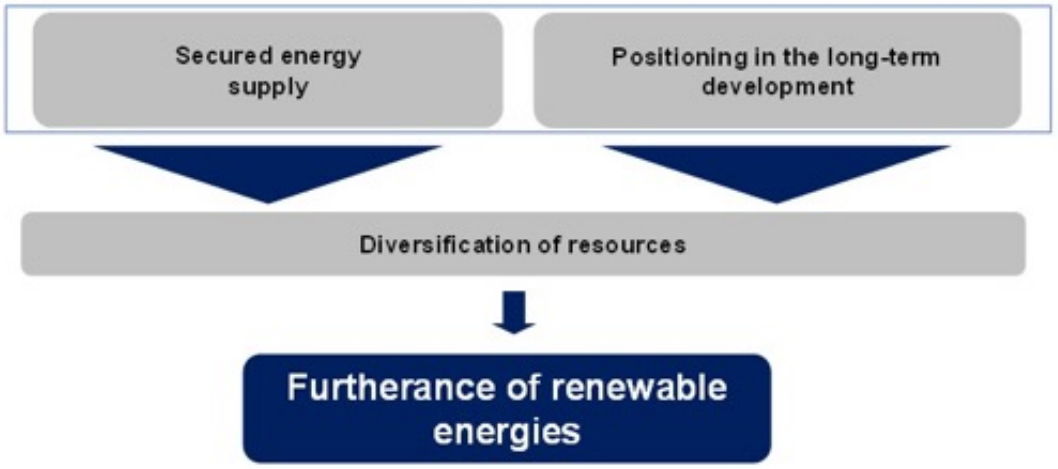
Moroccan national concept

GDP growth average of 5%

Electricity demand growth 6,5 %

Primar energy	Electricity
X 2 until 2020	X 2 until 2020
X 3 until 2030	X 4 until 2030



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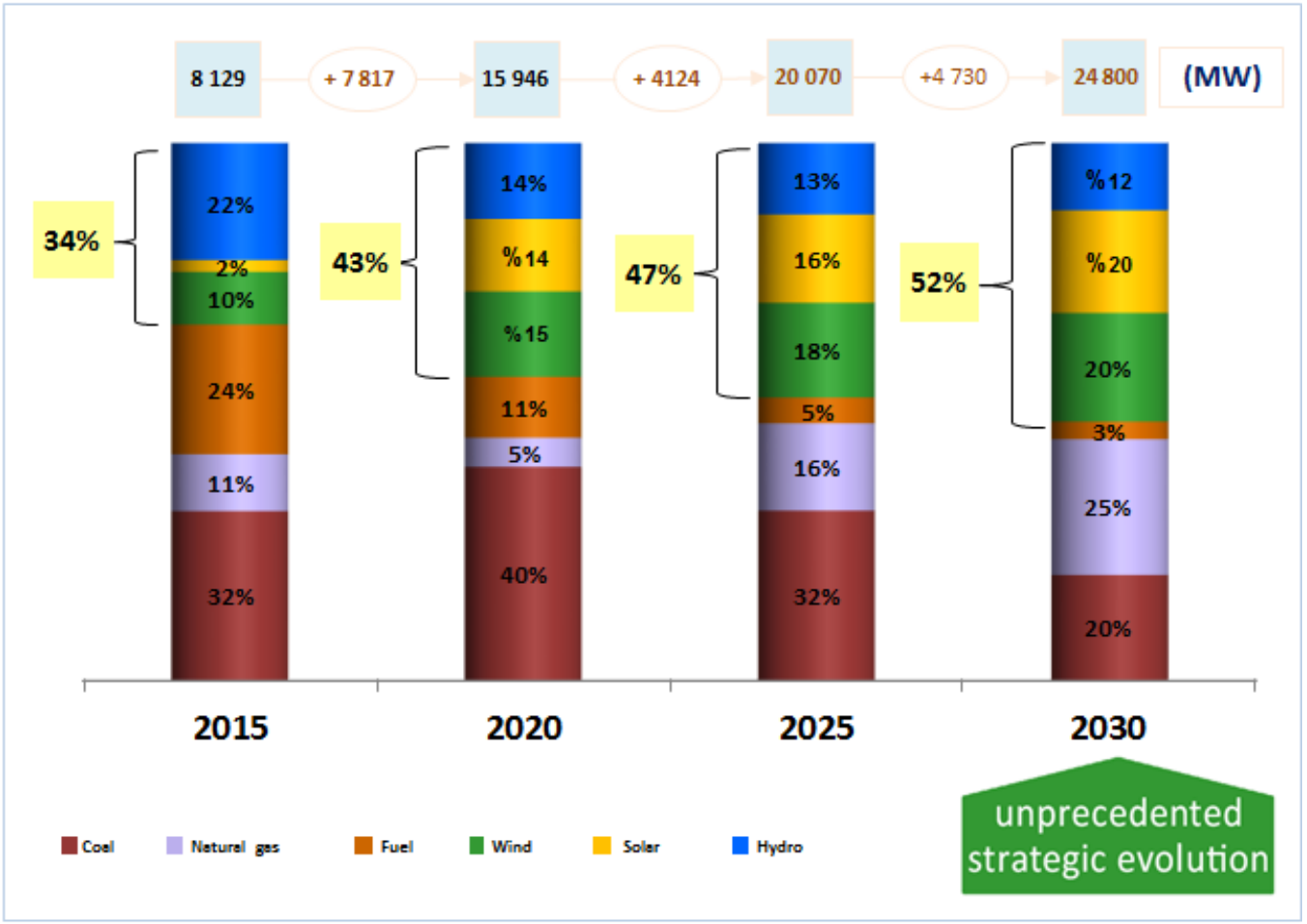
Moroccan national concept

Power mix evolution by 2030



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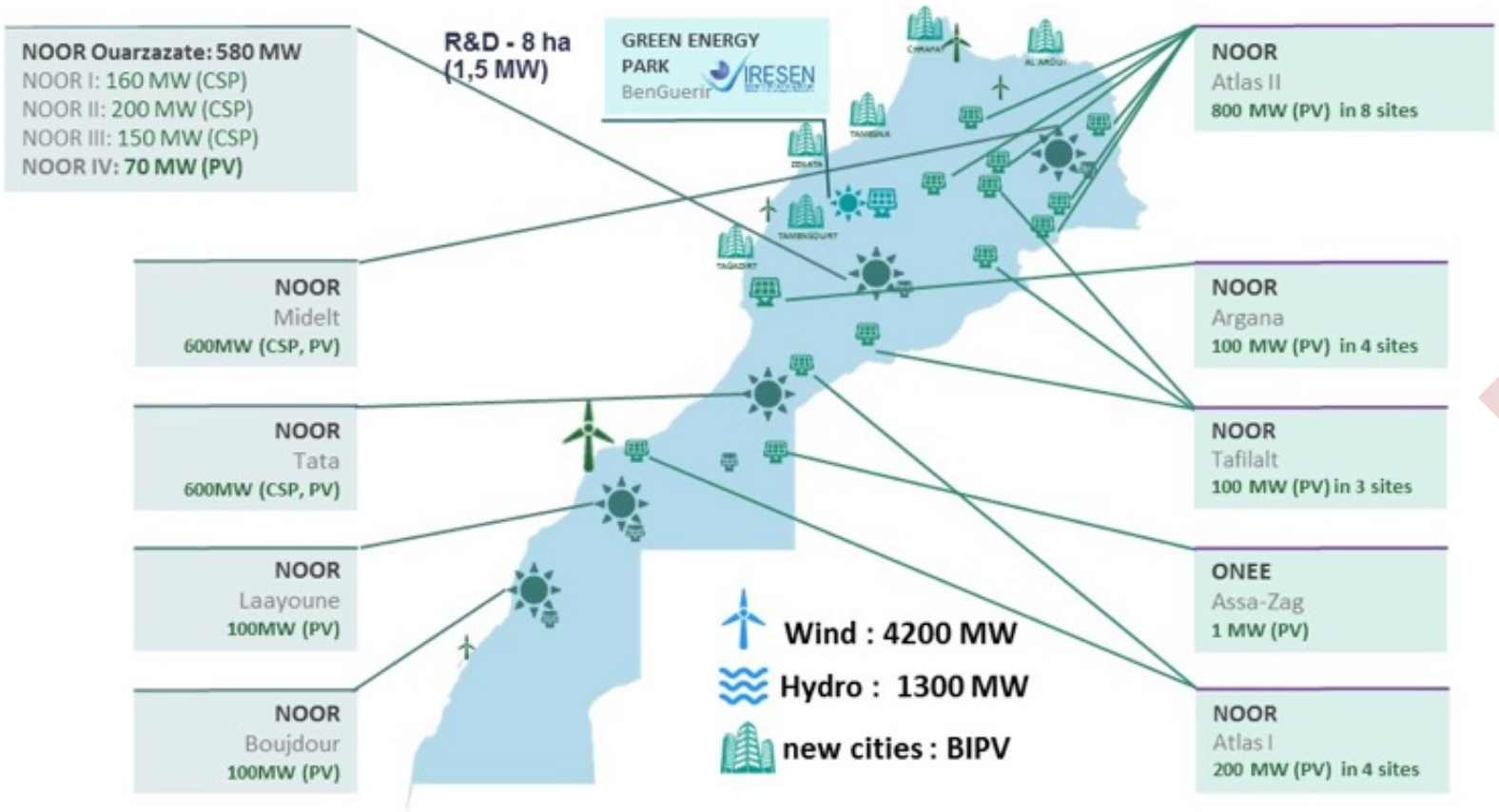
Moroccan national concept



16-08 Act
Autoproduction
- Production <50MW
- Agreement with ONEE

13-09 Act (2010)
Renewable Ener.
- Hydropower <12MW
- High Voltage

54-14 Act (2015)
Autoproduction
- Production >300MW
- Excess sold to ONEE

58-15 Act (2016)
Renewable Ener.
- Open to MV
- Open to LV
- Excess sold to ONEE (Max 20% per year)

Source: Ministry of Energy, Minining, Water and Environment, ONEE, MASEN, IRESEN, 2016

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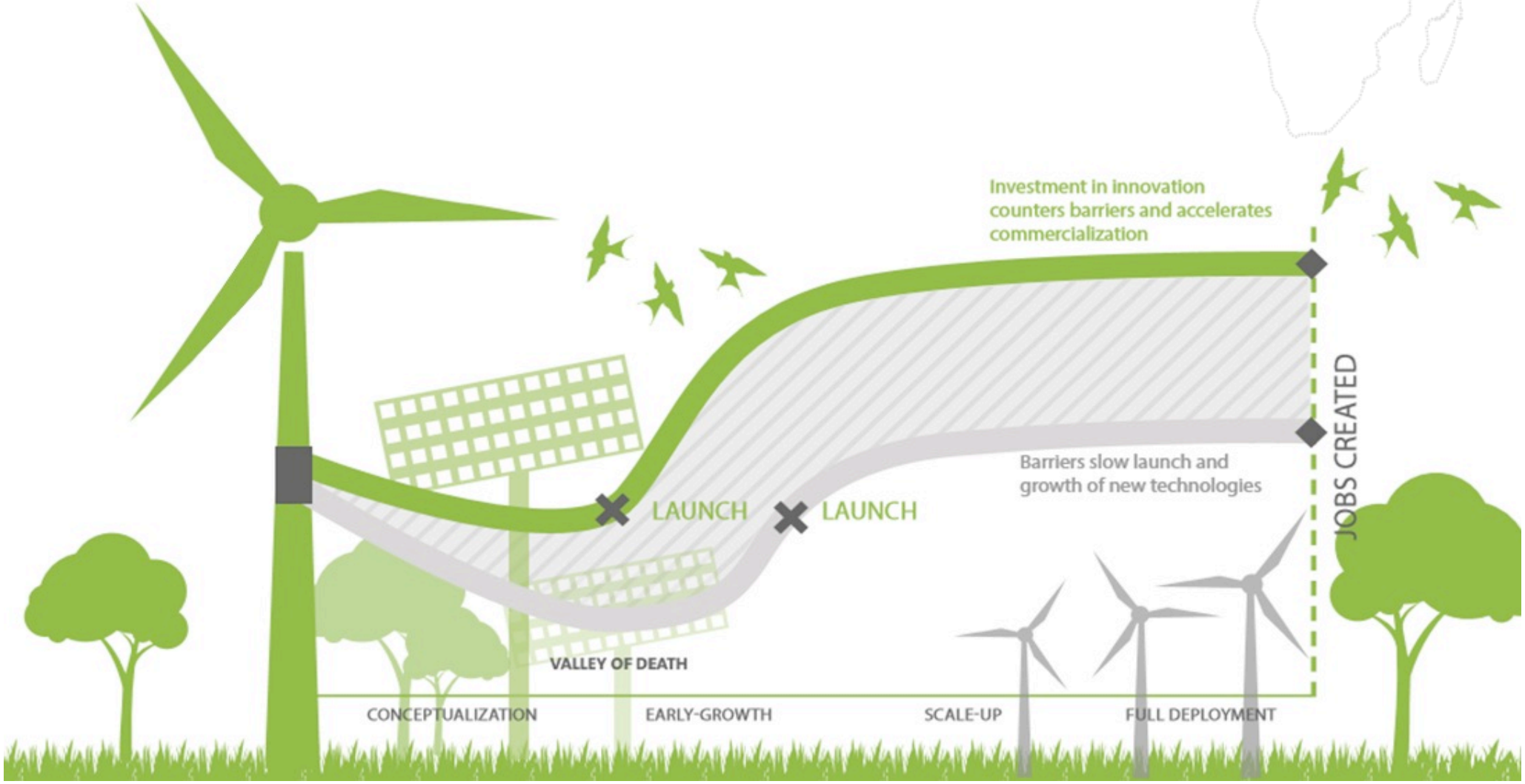
technology cooperation

Technology transfer



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1.

IRESEN
Introduction

IRESEN at a glance

Missions

IRESEN
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Created in 2011, the Research Institute for Solar Energy and New Energies (IRESEN) is at the heart of the **national energy strategy** in The Kingdom of Morocco, by its position in the fields of **applied research and innovation**.

FUNDING AGENCY

Financing of collaborative Innovative Projects

RESEARCH CENTER

Development of applied Research facilities

www.iresen.org

Roadmap

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I. Identify appropriate solar technologies for Africa

II. Developing next solar technologies, suitable to the local conditions

III. Protecting the local market: standardisation, certification

www.iresen.org

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Funding Agency

40 M€

2011-2017

Dedicated to support R&D & Innovation

2017-2023

80 M€

More Than 540

Researchers and PhD students supported

12

Laboratories

Created across Morocco

Labs created across Morocco

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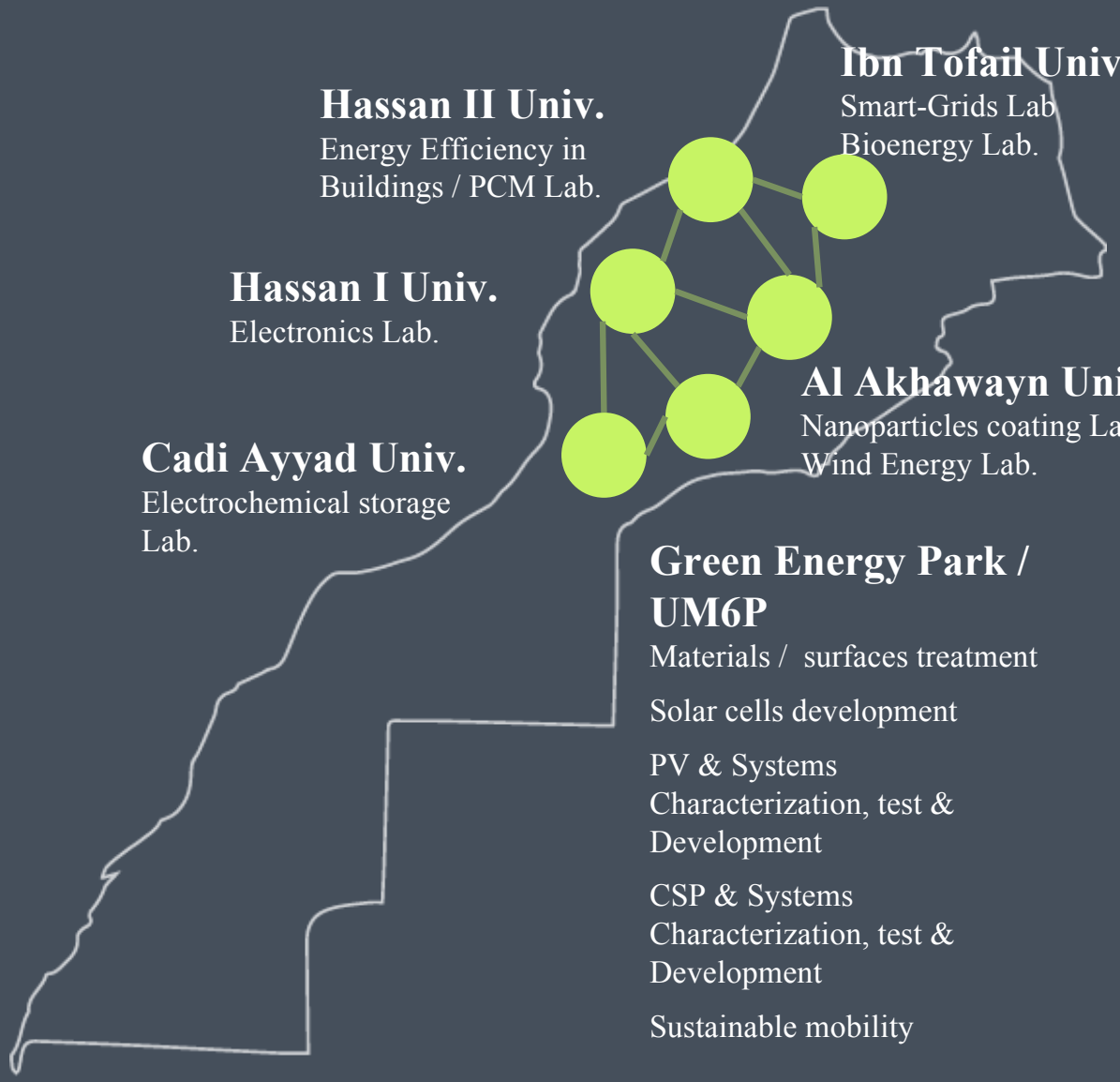
- Solar (Thermal, PV)
- Bio energy & Biomass
- Smart Grids & Green Cities
- Energy Efficiency & Storage
- Wind
- Sustainable Mobility



Hassan II Univ.
Energy Efficiency in Buildings / PCM Lab.

Ibn Tofail Univ.
Smart-Grids Lab
Bioenergy Lab.

Hassan I Univ.
Electronics Lab.

Al Akhawayn Univ.
Nanoparticles coating Lab.
Wind Energy Lab.

Cadi Ayyad Univ.
Electrochemical storage Lab.

Green Energy Park / UM6P
Materials / surfaces treatment

Solar cells development

PV & Systems Characterization, test & Development

CSP & Systems Characterization, test & Development

Sustainable mobility

R&D Projects

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- Solar (Thermal, PV)
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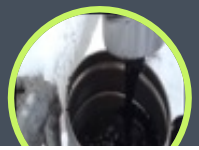
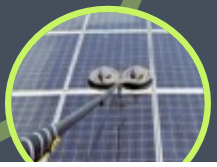


Solar heating of bitumen

Smart & sustainable Mobility

Synthesis of batteries based on local resources

Solar Cooling for chicken farm



New cleaning solutions for PV modules

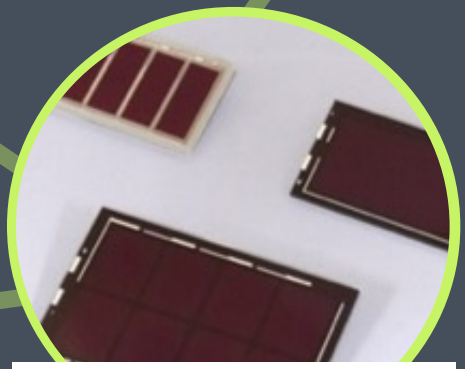
Solar Drying of phosphates

Solar food dryer

Pilot digester coupled with solar energy

Remote village Smart-Grid using Renewable Energies

Traditional public bath using solar and biomass



First Moroccan triple junction solar cell

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OCP

Every once in a while, a new technology, an old problem, and a big idea turn into an innovation

Dean KAMEN

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MOHAMMED VI POLYTECHNIC UNIVERSITY

2.

The Green Technologies Parks

R2I2M

dans l'écosystème de
L'UNIVERSITÉ MOHAMMED VI POLYTECHNIQUE

The identity

RESEARCH to INNOVATION to MARKET
R2I2M

TECHPARK

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other Universities

GREEN Technology **PARKS**

- Green Energy Park
- Green & Smart Building Park
- Bio Energy & Storage Park
- EWA Park
- new platform
- new platform

Green INNOVATION **BOOSTERS**

GREENSMEs & R&D units

Knowledge creation & dissemination → **Know-how creation & transfer** → **Technology development & validation** → **Start-Up Creation** → **Fully integrated technologies into African Market**

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other Universities

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- new platform
- new platform

Green INNOVATION **BOOSTERS**

GREENSMEs & R&D units

INNO project call
R&D

INNO booster call
Startups

Venture capital

GREEN TECHNOLOGY **PARKS**

Research 2 Innovation Network

Bio Energy Park
Bio energies & Storage

Green Energy Park
Solar Energies

Green & Smart Building Park
Energy Efficiency & Smart Grids

EWA Park
Nexus Water-Energy Agriculture

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GREEN Tech PARKS

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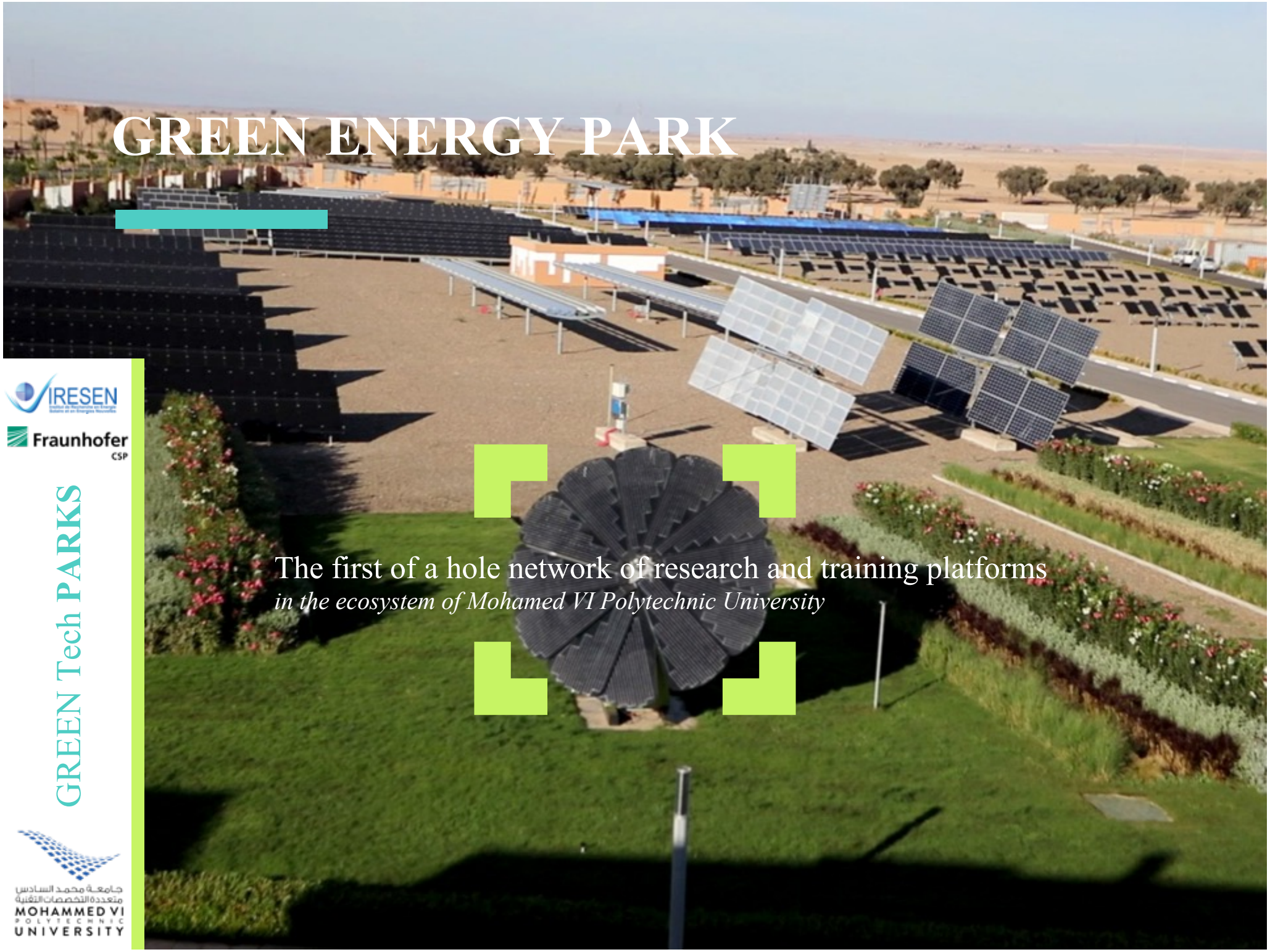
GREEN ENERGY PARK



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Fraunhofer CSP

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The first of a hole network of research and training platforms

in the ecosystem of Mohamed VI Polytechnic University

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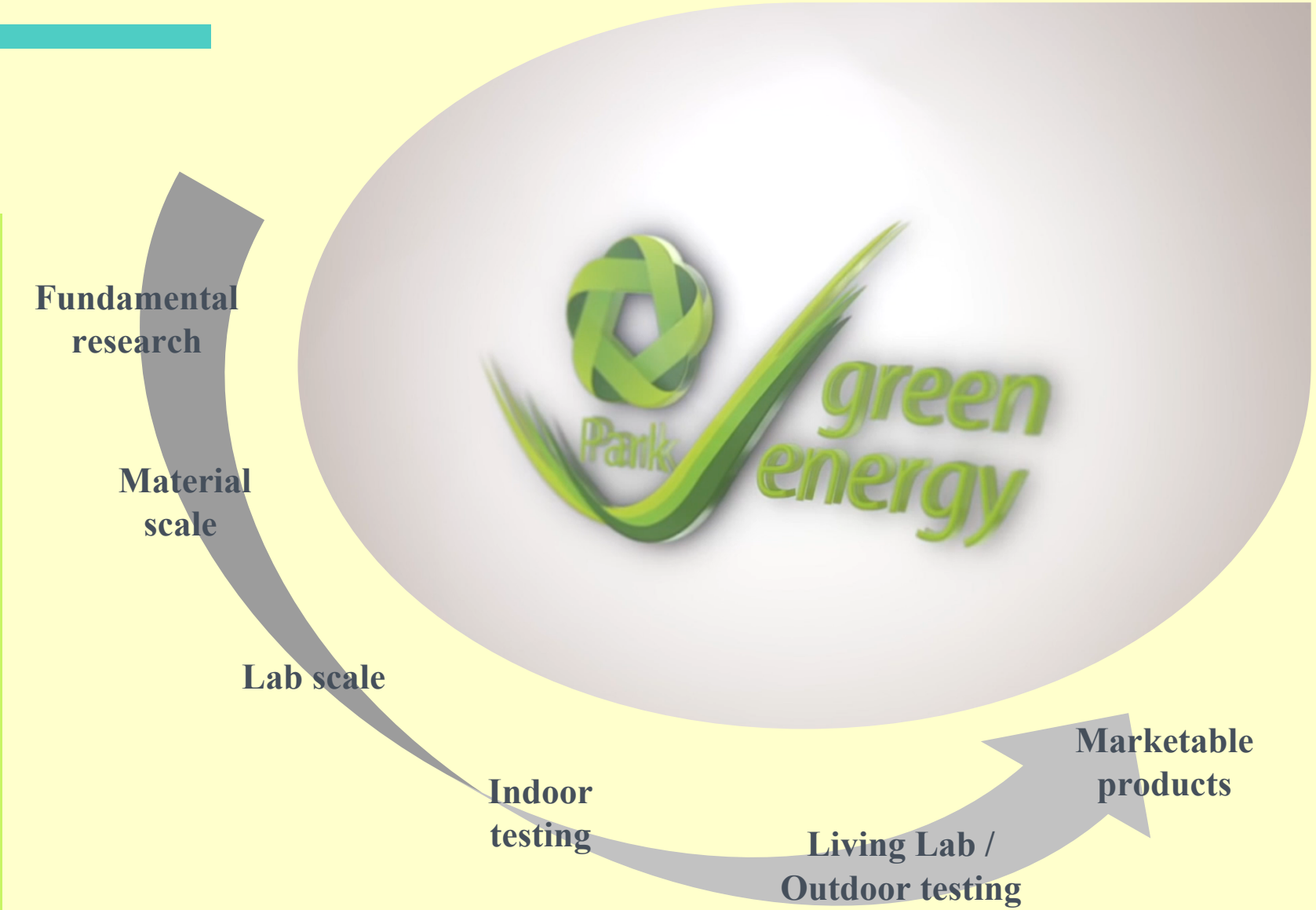
MOHAMMED VI POLYTECHNIC UNIVERSITY

Research to Innovation platform model



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Research to Innovation platform model

Joint PV outdoor test platform, combining a multitude of test-set-ups, in order to evaluate, characterize and validate PV modules in harsh weather conditions (First Solar, DSM, HQcells,..) -> assessment of PV technologies and development of **new adapted technologies for Africa** (**desert modules**)

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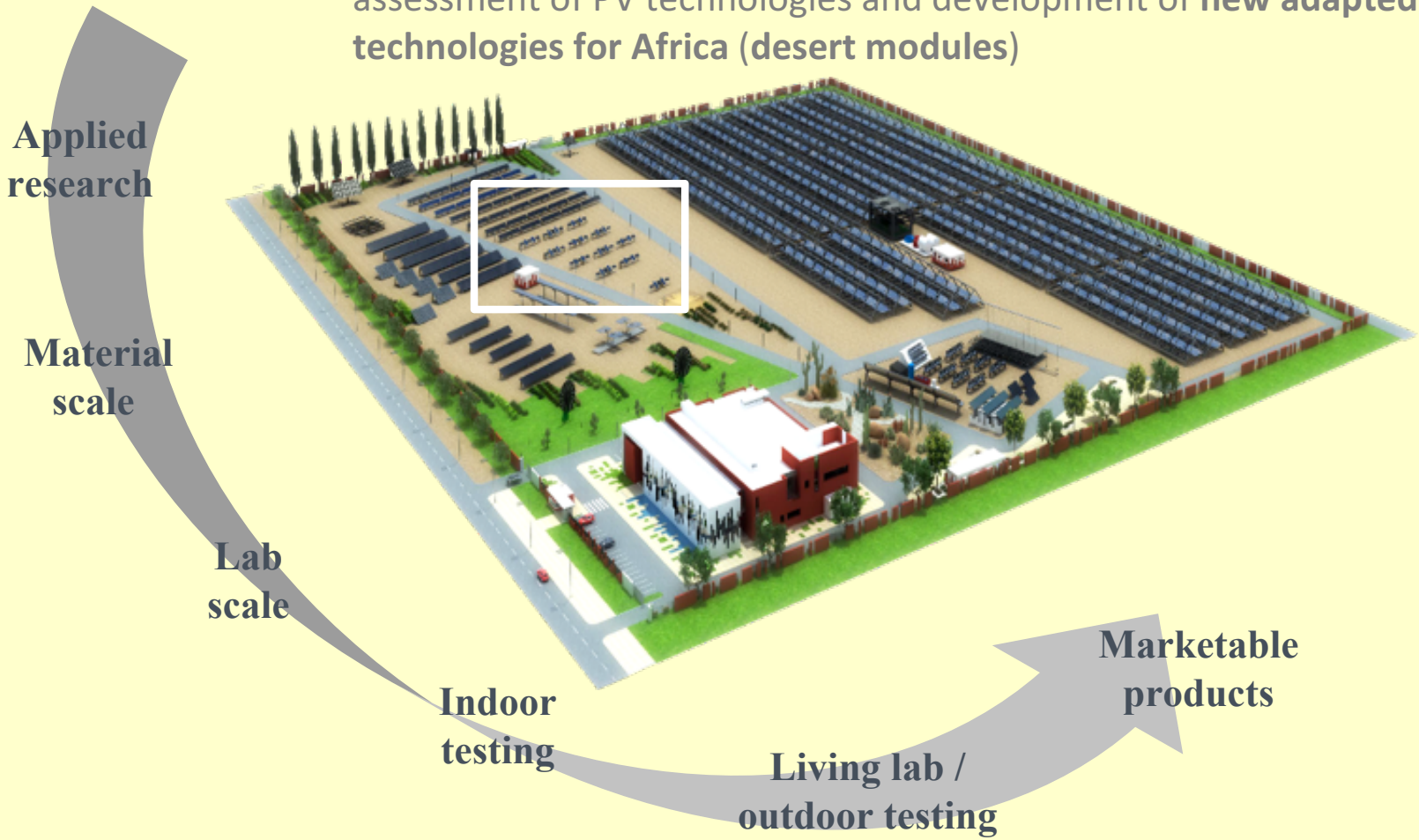
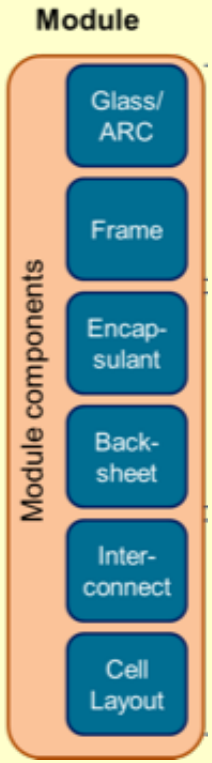


Challenges in desert conditions



Source: Fraunhofer CSP 2016 IRESEN 2016

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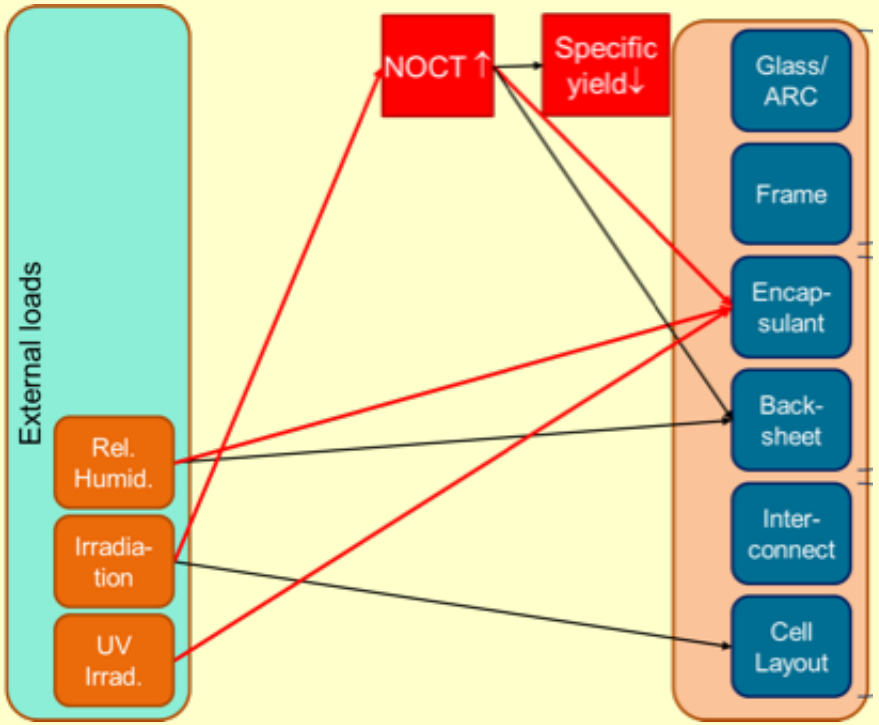
Challenges in desert conditions



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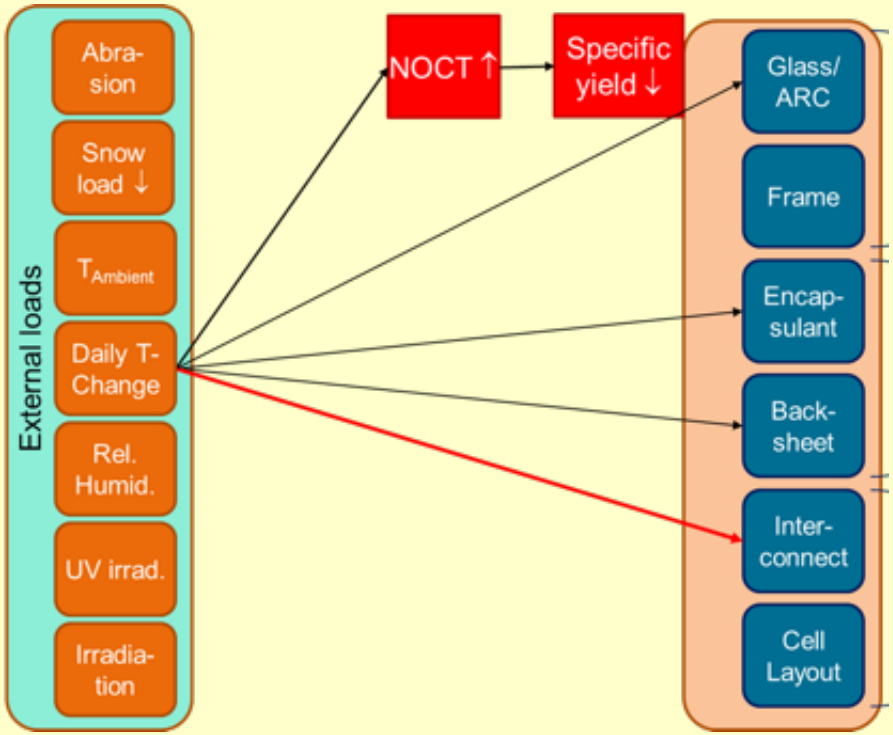
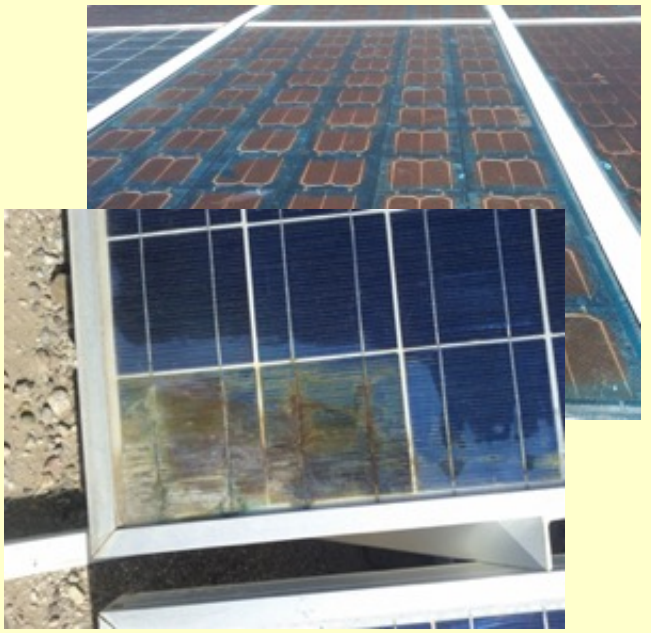
Challenges in desert conditions





Source: Fraunhofer CSP 2016 IRESEN 2016

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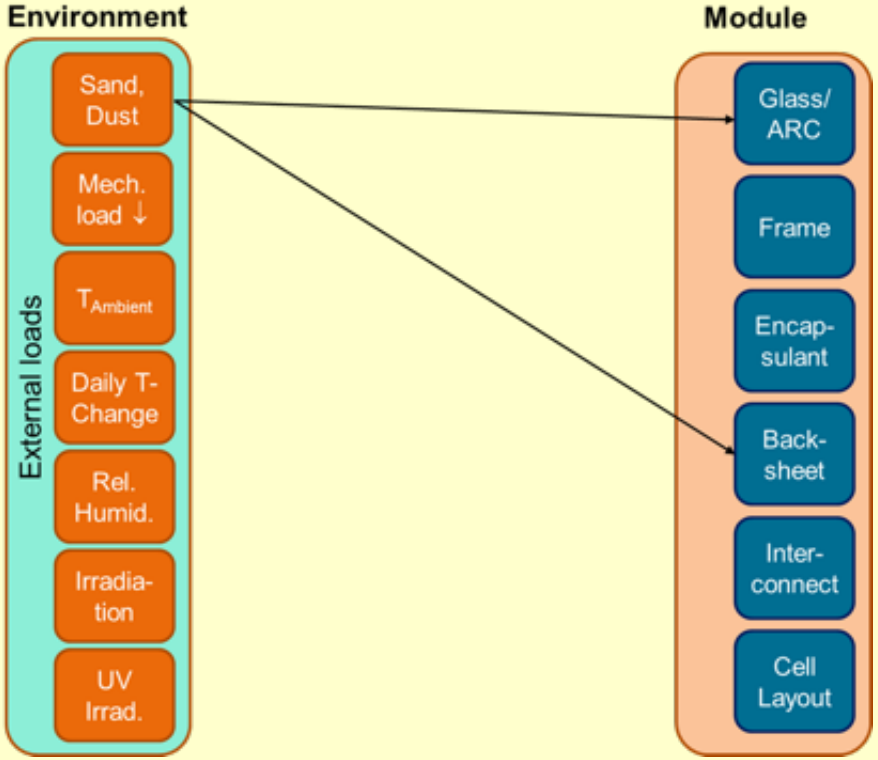
Challenges in desert conditions



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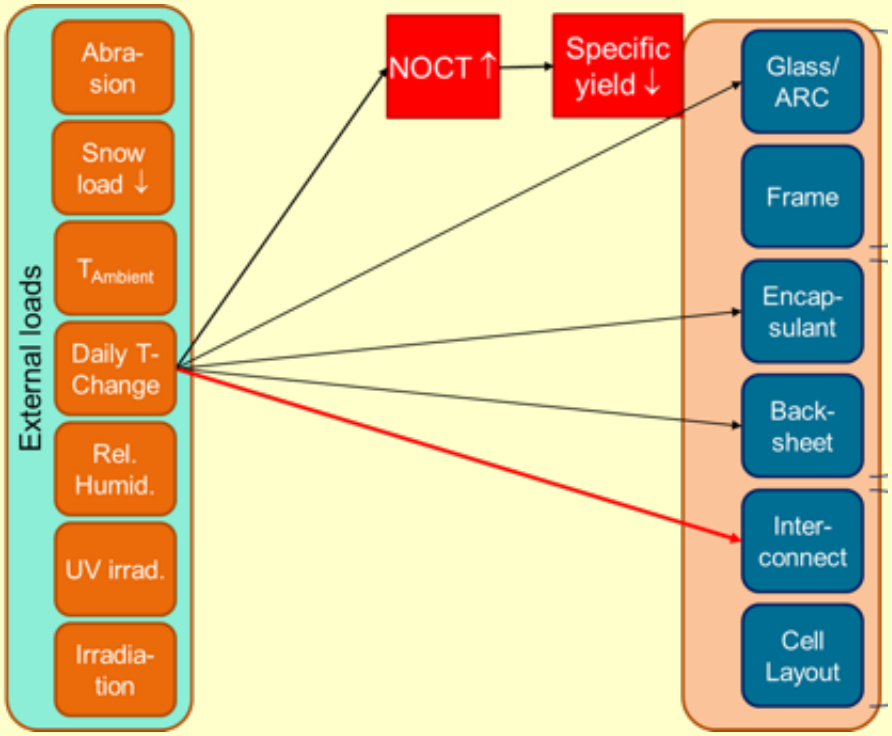
Challenges in desert conditions



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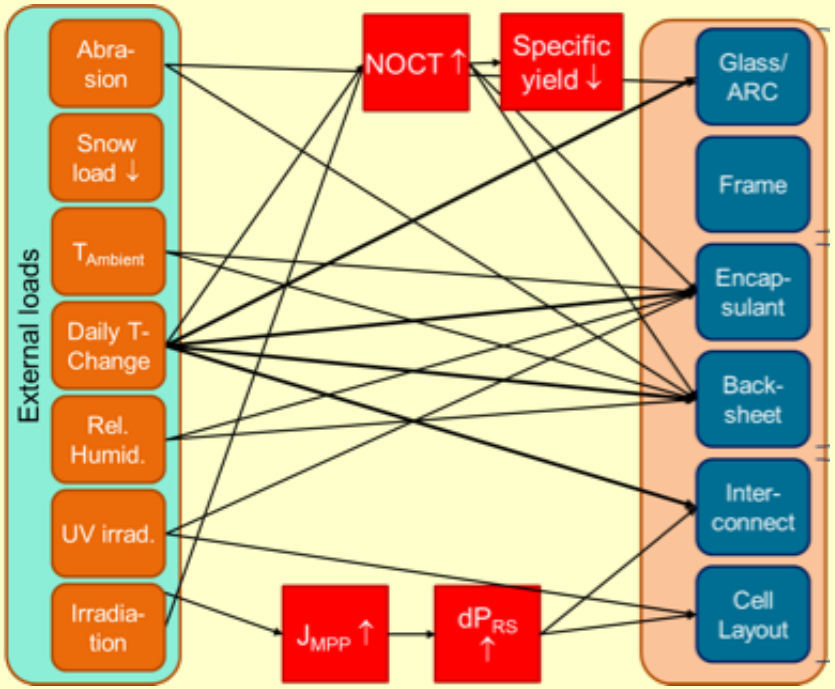
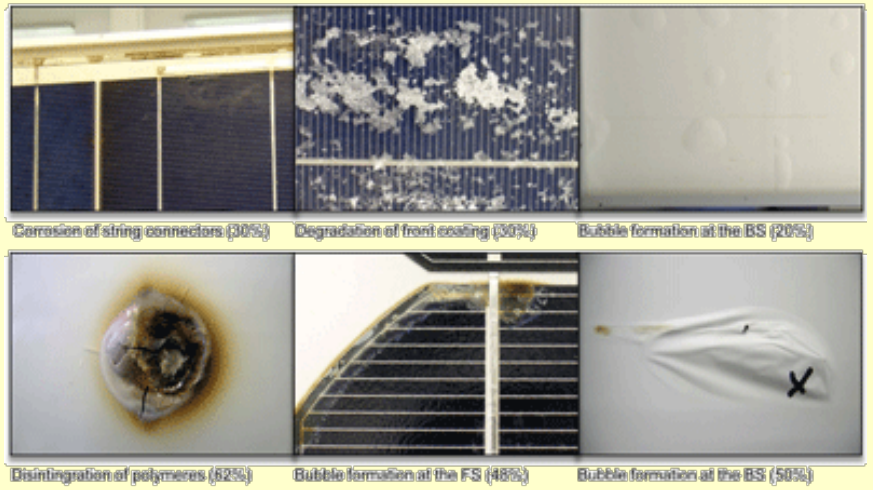
Challenges in desert conditions

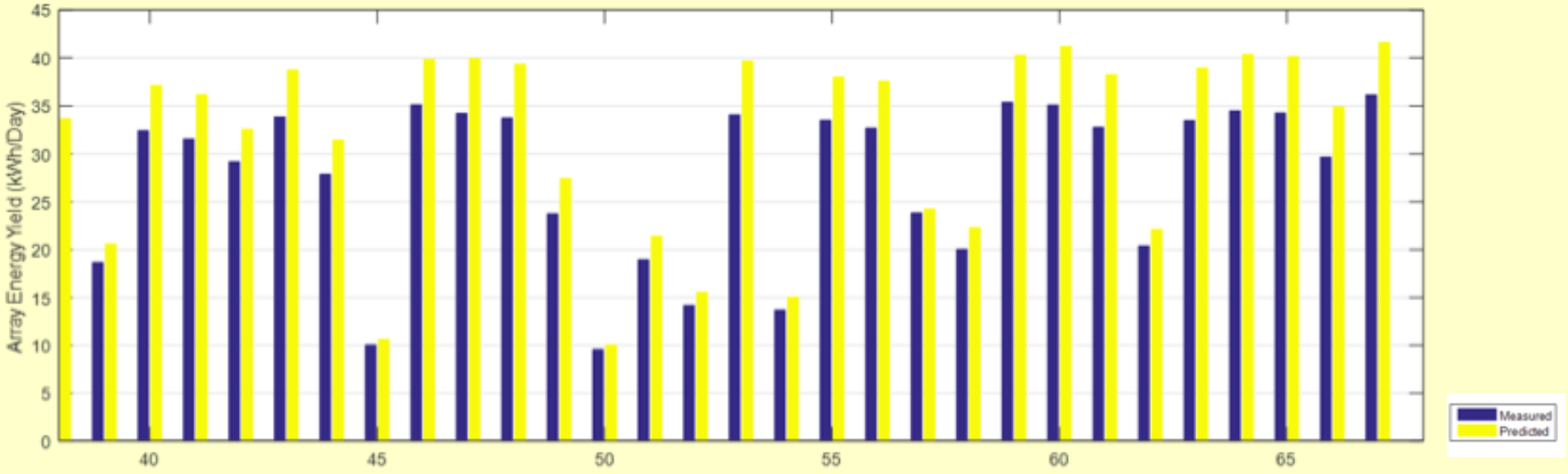




Source: Fraunhofer CSP 2016 IRESEN 2016

Challenge: Degradation

- comparison of monitored and simulation values 20 kWp PV system performance in the GEP



- The average of energy losses per month due to this degradation is around **150 kWh/Month** for thin film PV system, which makes the real monthly measured energy yield **15% less than the expected monthly energy yield**.

Source: Fraunhofer CSP 2016 IRESEN 2016

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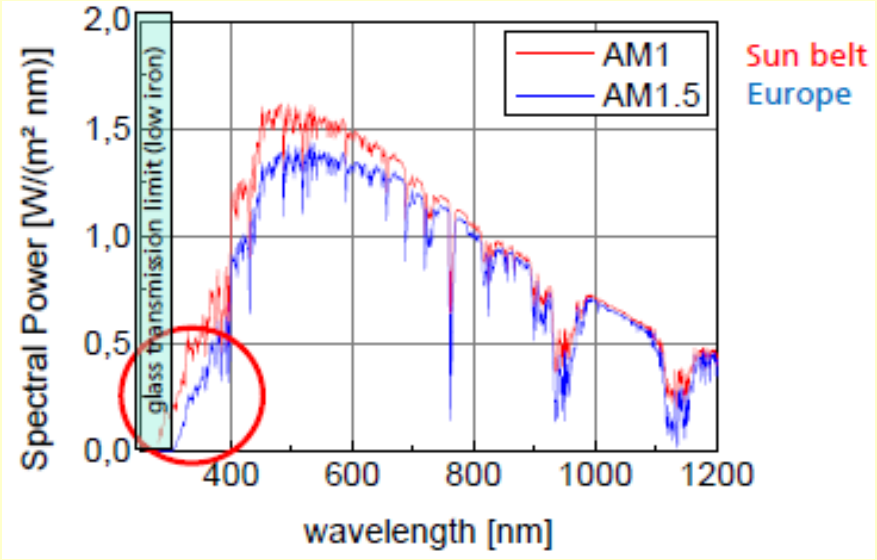
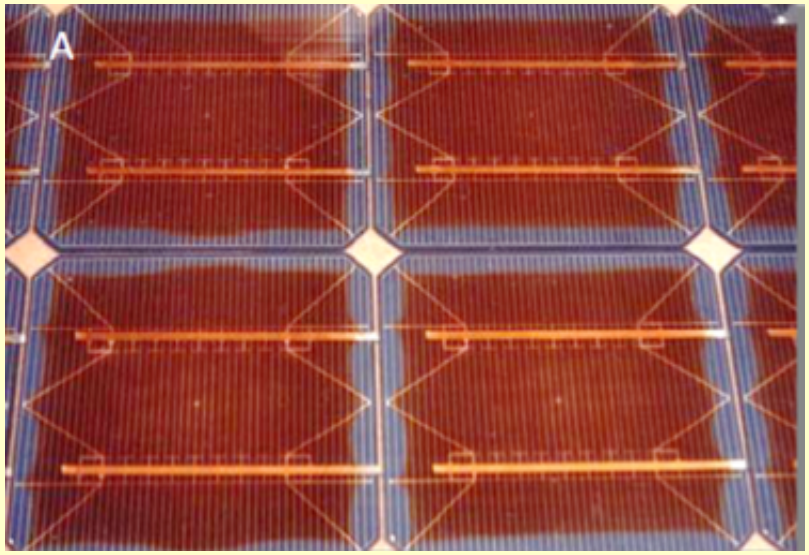
Challenge: UV

- PV modules under UV influence





Discoloration of EVA under UV influence

- 2x annual irradiation dose
  2x UV power in sun belt regions
  = **4x UV** dose compared to
- Rough estimation:

Does **20 years** in moderate climates correspond to approximately **5 years** in sun belt areas?

Source: Fraunhofer CSP 2016 IRESEN 2016

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Soiling effect on the PV systems

- soiling impact on two PV systems (Monocrystalline & Amorphous) has been investigated.

Type of technology	Amorphous	polycrystalline
Number of modules in series/string	8	23
The modules nominal power	135 Wp	240 Wp
Number of string	2	2
The open circuit voltage Voc	61,3 V	37,3 V
The short circuit current Isc	3,41 A	8,3 A
The maximum voltage V_{mpp}	47 V	30,1 V
The maximum courant I_{mpp}	2,88 A	7,9 A

- Both system are composed with two strings each.
- For the experiment period and for each technology, one string was cleaned twice a week and the other left without cleaning.
- The soiling impact can be visualized by calculating the difference between the energy produced from the clean and the soiled string: $\Delta E = E_{clean} - E_{soiled}$

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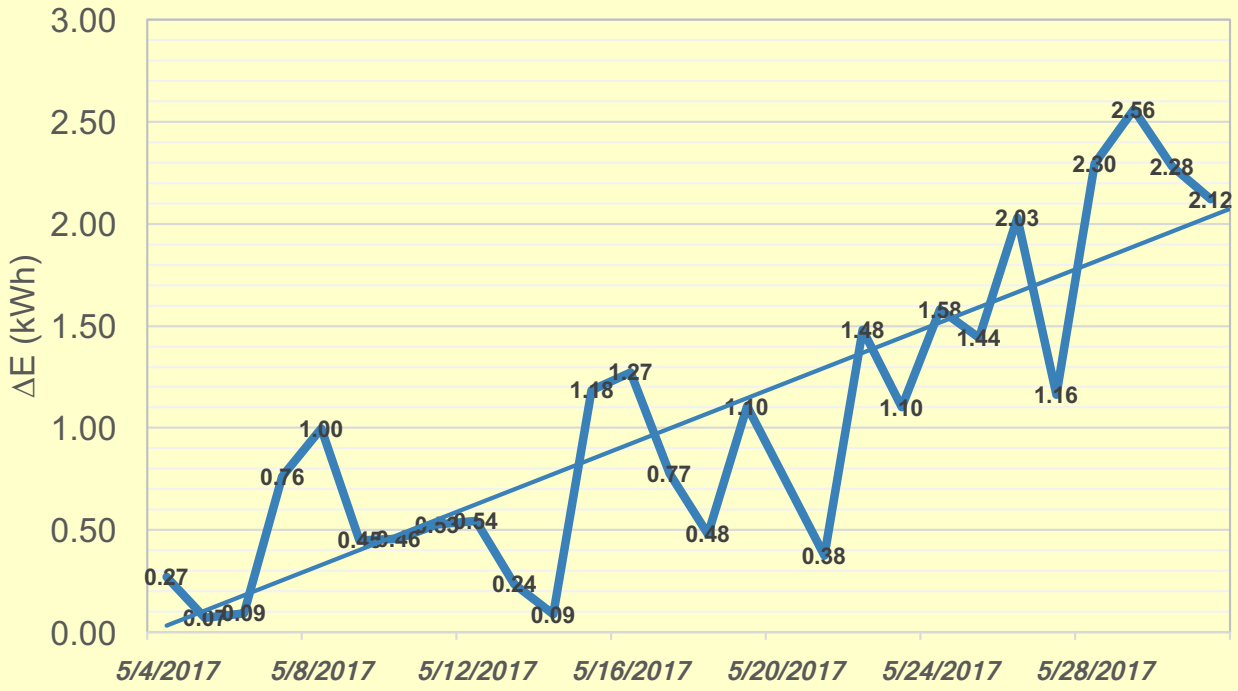
Soiling effect on the PV systems

- From May the 2th to the 31st the soiling impact on two PV systems (**Monocrystalline** & Amorphous) has been investigated.

- For the **monocrystalline system**, the difference in energy (ΔE) between the cleaned and the soiled strings keep increasing with time.

- During the **29th of May** the energy loosed due to soiling reaches **~ 2.5kWh which is the equivalent to 41% loss** from the system's production.



- The **average energy drop due to soiling was of 1.03kWh during the whole exposition period**. Which is the equivalent of **18.6%** loss from the system's production.

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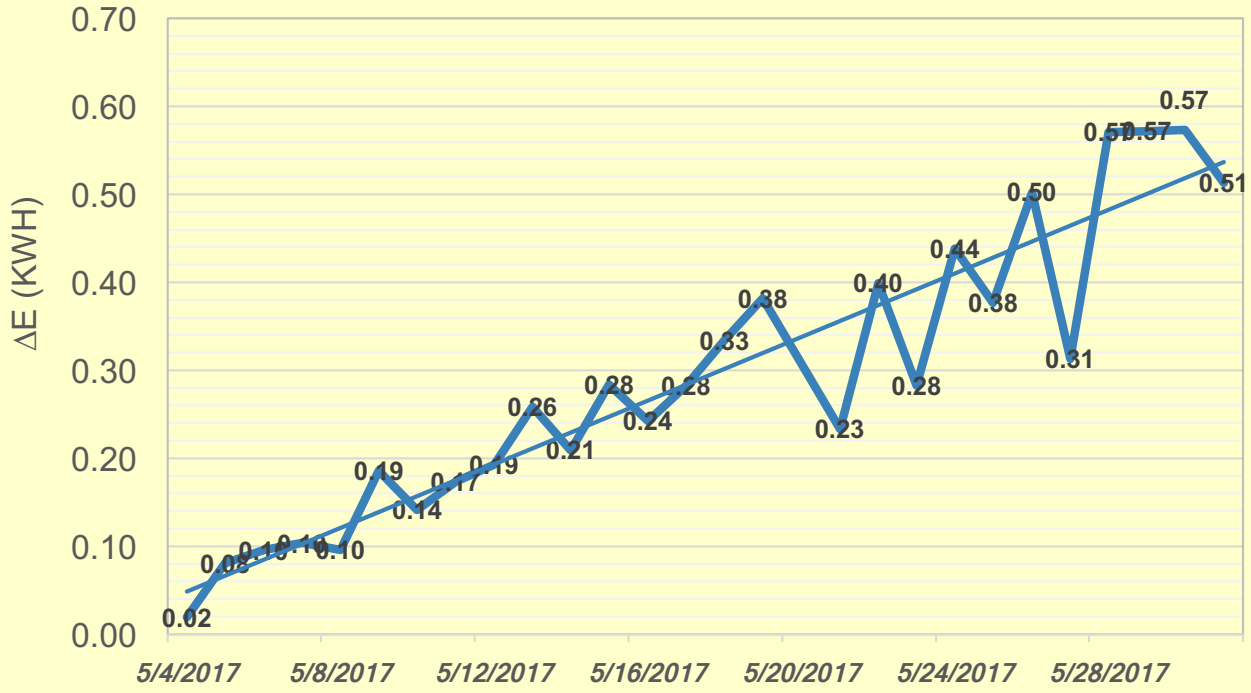
Soiling effect on the PV systems

- From May the 2th to the 31st the soiling impact on two PV systems (Monocrystalline & **Amorphous**) has been investigated.

- For the **Amorphous system**, the difference in energy between the two strings is increasing with time, but it's not so high (~0.5kWh).

- For the 27th the 28th and the **29th of May** the energy loosed due to soiling reaches **~ 0.57kWh. This is equivalent to 9.1%** of the system's production.



- The **average energy loss during the whole exposition period was of 0.29kWh due to soiling.** This is equivalent to **4.9%** of the system's production.

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Soiling effect on the PV systems

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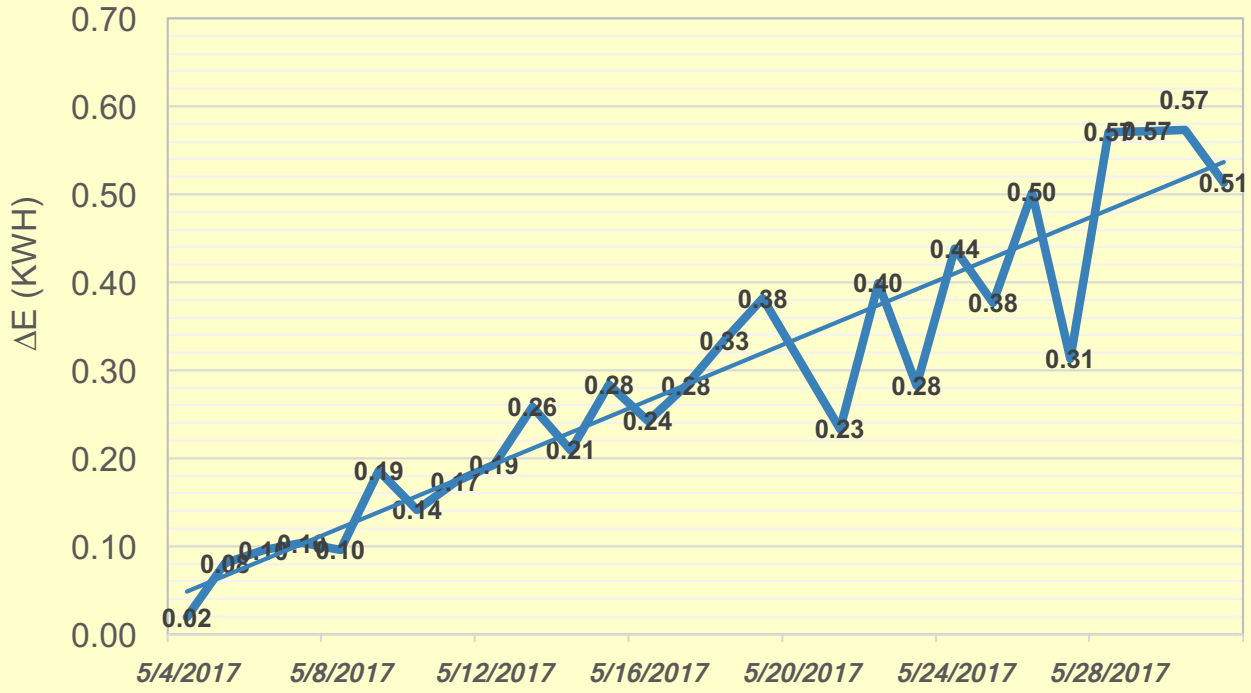

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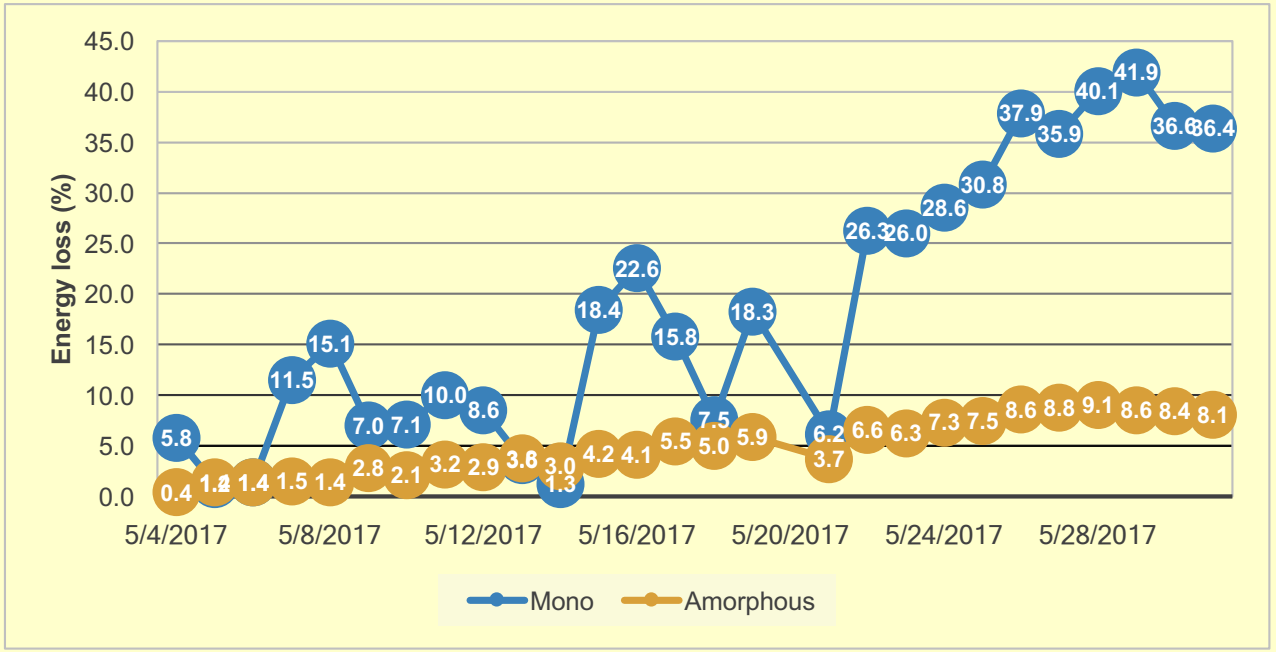
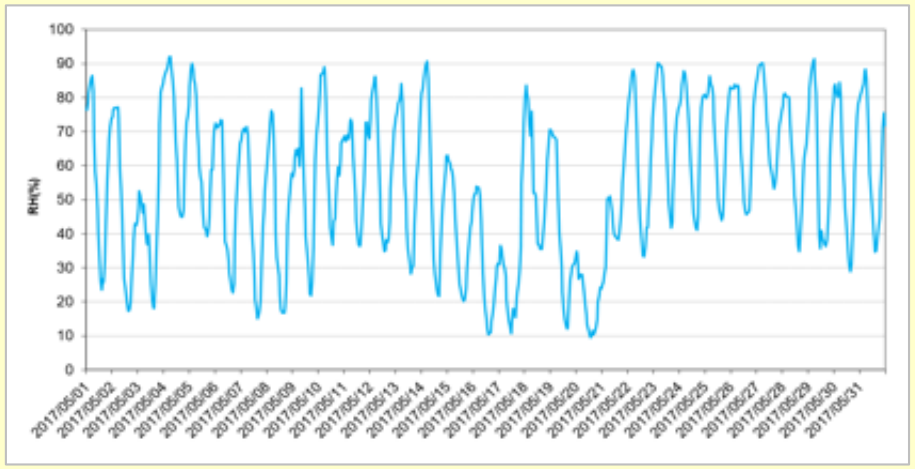
Soiling effect on the PV systems

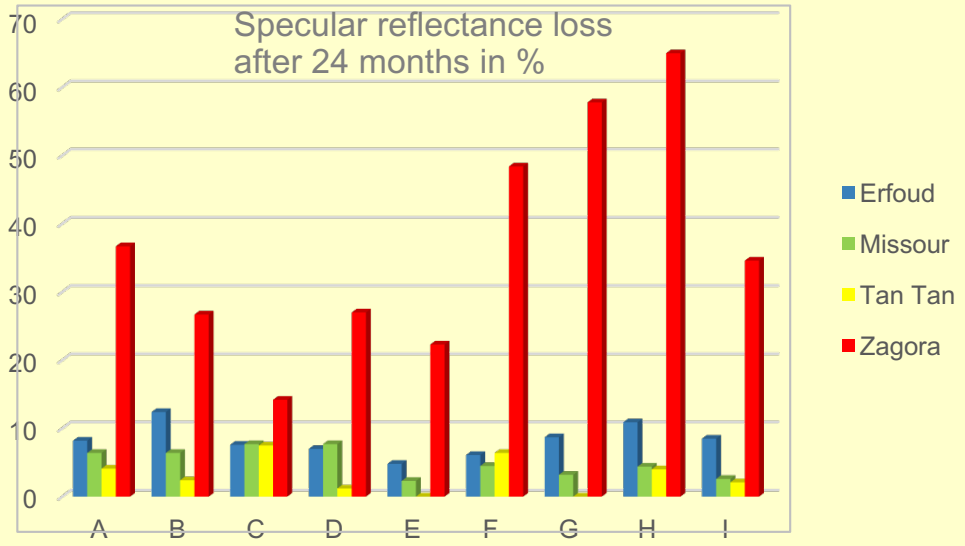
- The difference in the energy losses between the technologies can be explained by the humidity variation between the day and the night, and the modules temperature.
- The Monocrystalline modules are sensible to the temperature, which contribute to the evaporation of the dewdrops on the surface. This causes an agglomeration and cementation of the dust on the surface, thus a high energy loses.





Technology	Mono	Amorph
Max. energy loss	41.9%	9.1%
Average energy loss	18.6%	4.9%

Outdoor Exposure- Moroccan & African Sites



Location	Latitude	Longitude	Max Temperature [°C]	Min Temperature [°C]	Mean Temperature [°C]	Yearly sum solar irradiance GHI [kWh/m²]	Mean wind speed [m/s]	Mean relative humidity [%]
Missour	32,86°N	-4,11°E	40,6	-1,8	18	2023	3,6	48,1
Erfoud	31,49°N	-4,22°E	44	-3,1	22,2	2044	3,1	30,1
Zagora	30,27°N	-5,85°E	45,3	-0,6	23,9	2174	3,8	23,4
Tan Tan	28,5°N	-11,32°E	32	9,2	18,8	1856	4,4	82,9
Yamoussoukro	6,798°N	-5,275°E	39,44	13,07	26,20	1652	2,4	75,5

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GREEN & SMART BUILDING PARK

IRESEN

GREEN Tech PARKS

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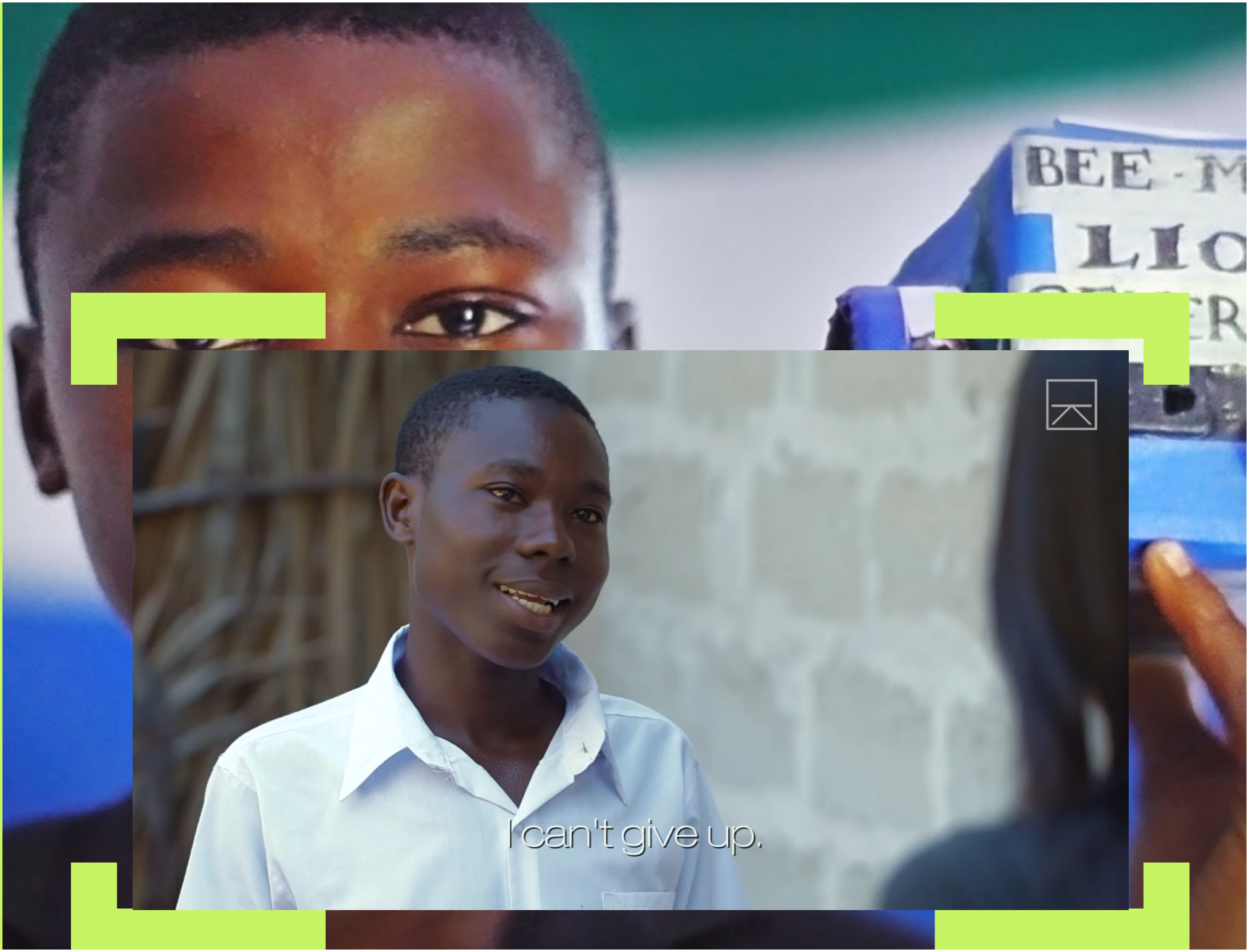
Testing, training and research platform is dedicated to research and development in the field of green buildings, energy efficiency, Smart grids and electrical mobility.

What Does a Smart African City Look Like?


TECHPARK
THE GREEN INNOVATION NETWORK
Developing adapted green technologies to help the African Dream happen


I can't give up.

ikken@iresen.org

Thank you

Developing adapted green solutions for the wealth of the future Africa

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