Experiences of ISFOC on Concentration Photovoltaic

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ISFOC R&D Director

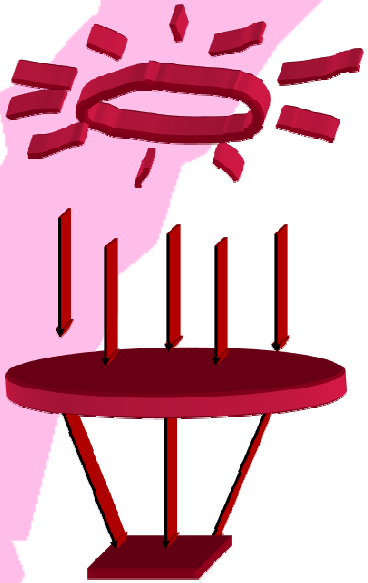
Workshop Florianopolis (Brazil) August 2011

Outline

- Concentration photovoltaic
- ISFOC
  - Creation
  - R&D plan
- First results
  - Degradation study
  - O&M issues
  - CPV and PV comparison
- CPV advantages
- Conclusions

Definition

The Concentration Photovoltaic (CPV) concentrates the radiation into the cell using an optical component

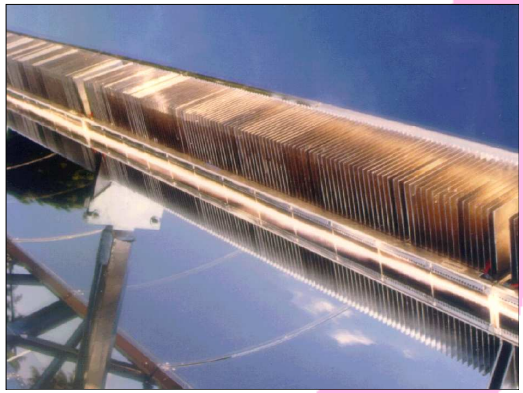


Advantages

- Cells much smaller than the traditional one => Less material needed
- Possibility to use a more efficient cell (III-V multijunction technology (40% instead of 20%)

Challenges

Only the direct radiation is used => A very accurate tracking is needed



High temperature on the cell

CPV types

- **Lineal concentrator**
  - Low and medium concentration
    - Example: Euclides (20-40x), Skyline (USA)

CPV types

- **Parabolic dish**
  - High concentration
    - Example: Solar System

CPV types

- **Integrated modules**
  - High concentration
    - Example: Concentrix (500X)

Cell

GaAs cell Advantage

The voltage drop due to the temperature is lower than in Si

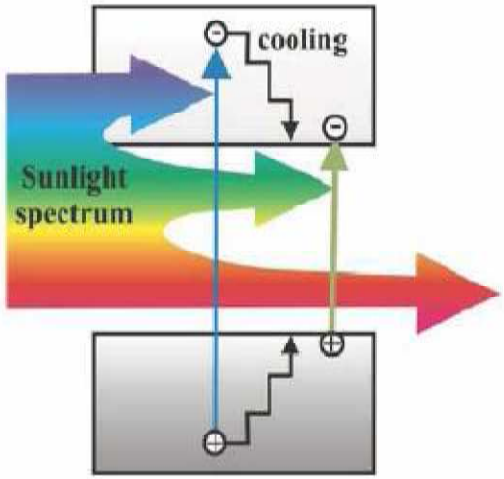
	E_G(eV)	V_{oc}(V)	V_{oc}/E_G(V/eV)	V_m(V)	qV- E_G(eV)	dV/dT(mV/°C)
Si (@ V_{oc})	1,12	0,65	0,580	-----	-0,47	-2,09
Si (@ V_m)	1,12	-----	------	0,55	-0,57	-2,42
GaAs (@ V_{oc})	1,43	1,00	0,699	-----	-0,43	-1,68
GaAs (@ V_m)	1,43	-----	------	0,87	-0,56	-2,12

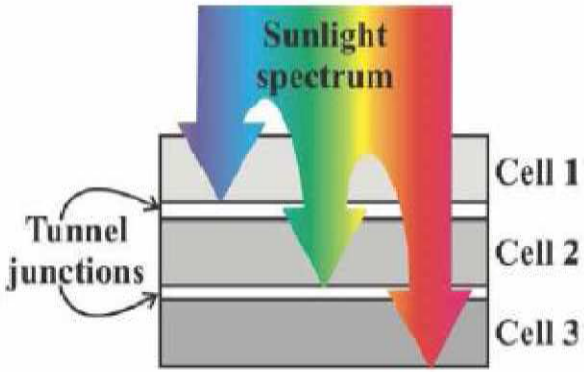
Courtesy C. Algora (IES - UPM)

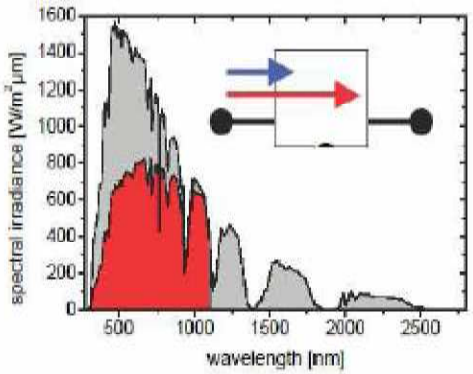
Cell

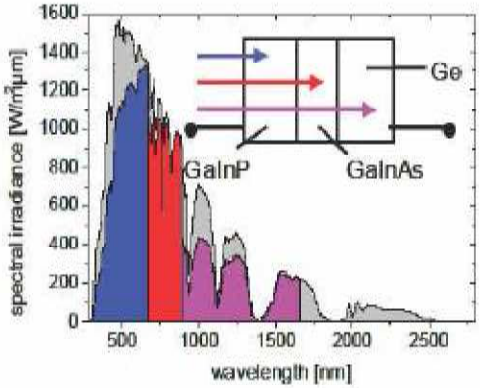
Multijunction cell: GaInP, GaInAs, Ge

Better use of the spectrum





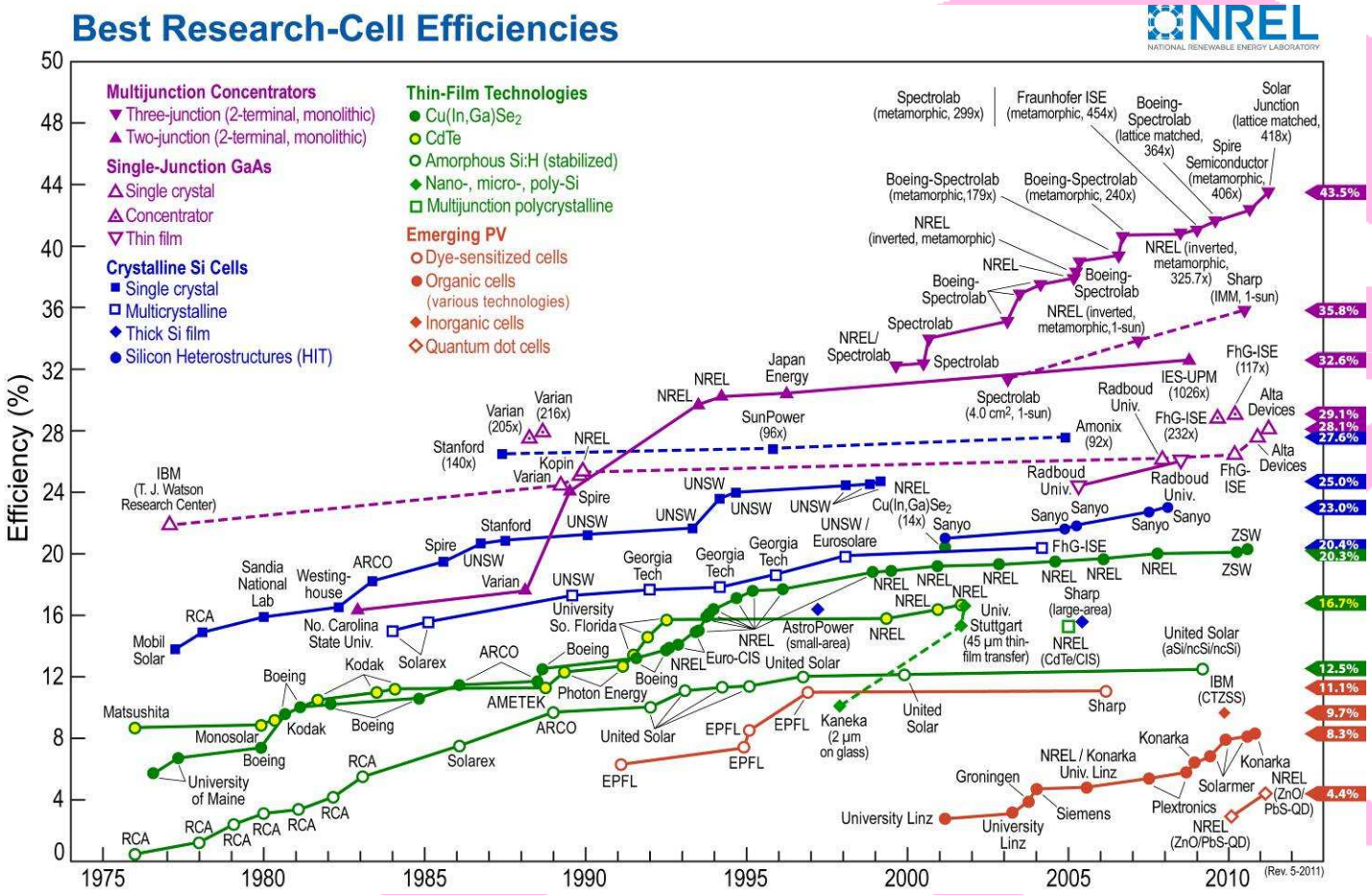




Courtesy A. Luque, Project CONSOLIDER - GENESIS FV

Cell

Record efficiency: 43,5% Solar junction (USA) May 2011



Best cell efficiencies progression (July 2011)
By Courtesy of NREL

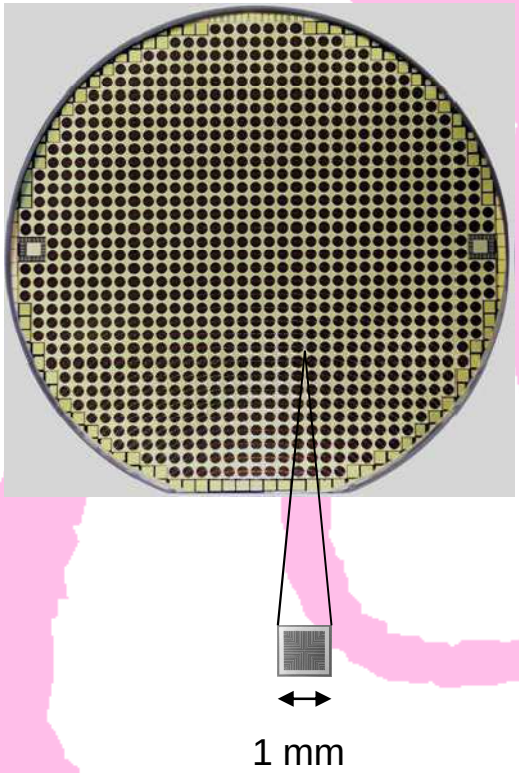
Cell

Lower size and serial resistance

The influence of the serial resistance is higher in CPV, therefore the cell should have a small Rs

$$I(T,C) = C \cdot I(T_0,1)$$

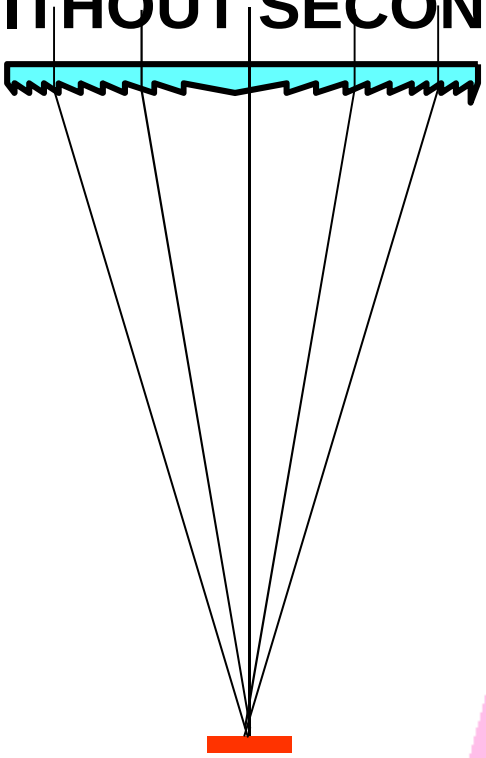
$$I = I_L - I_s\left[\exp\frac{q(V+IR_S)}{mkT} - 1\right]$$

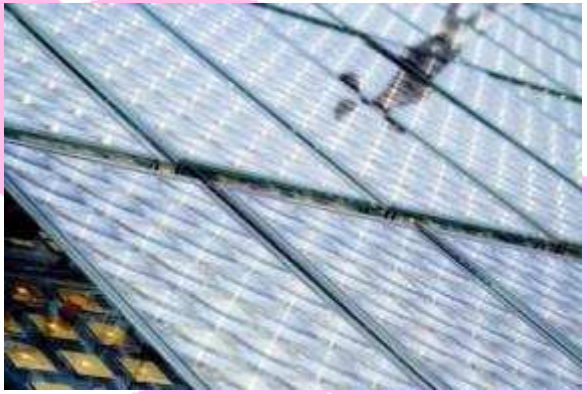


Optic

- **LENS: Fresnel**

WITHOUT SECONDARY OPTICS





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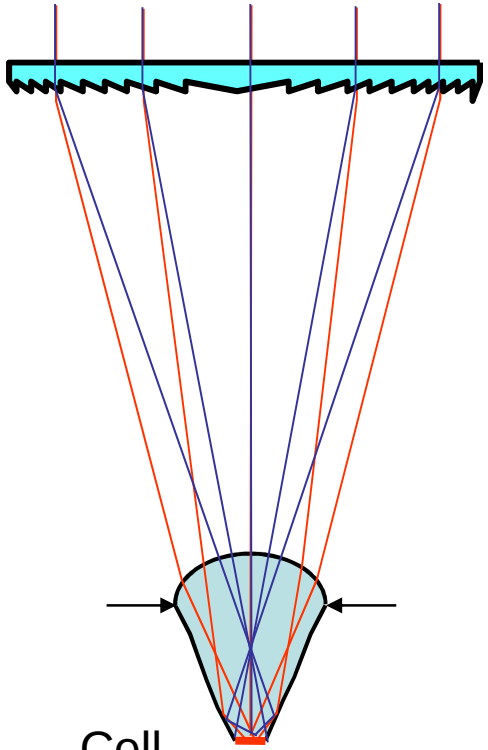
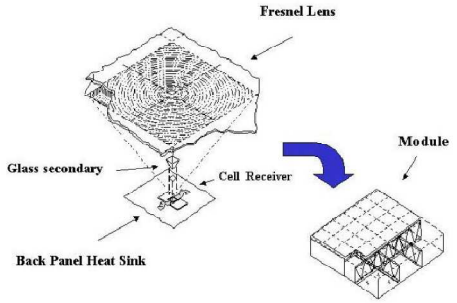
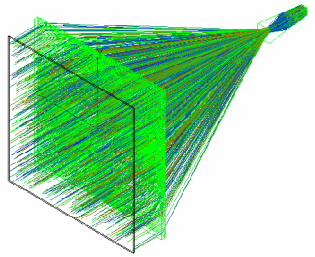


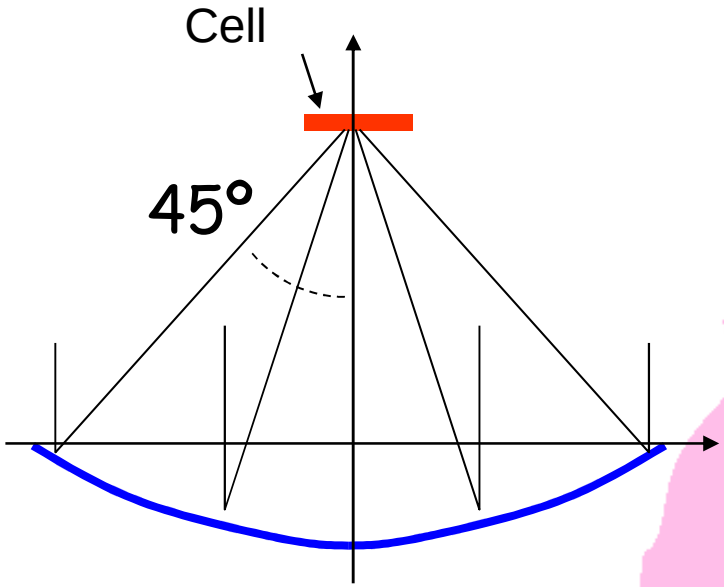


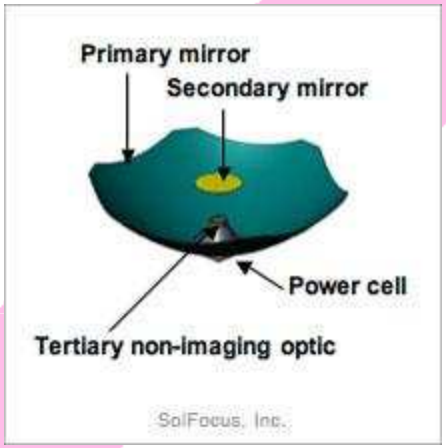


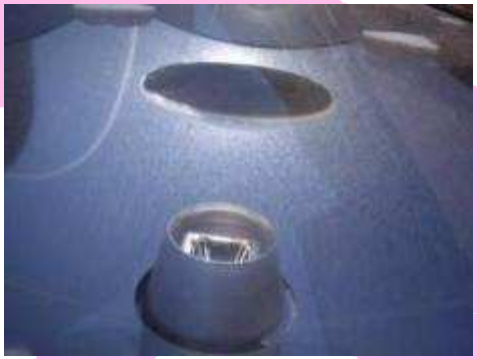
ISFOC

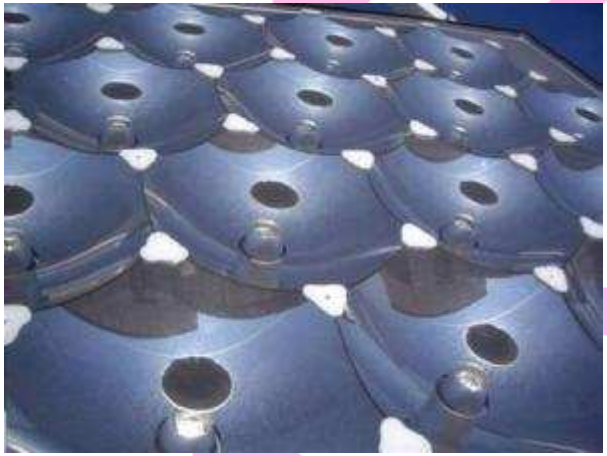
Optic

PARABOLA:



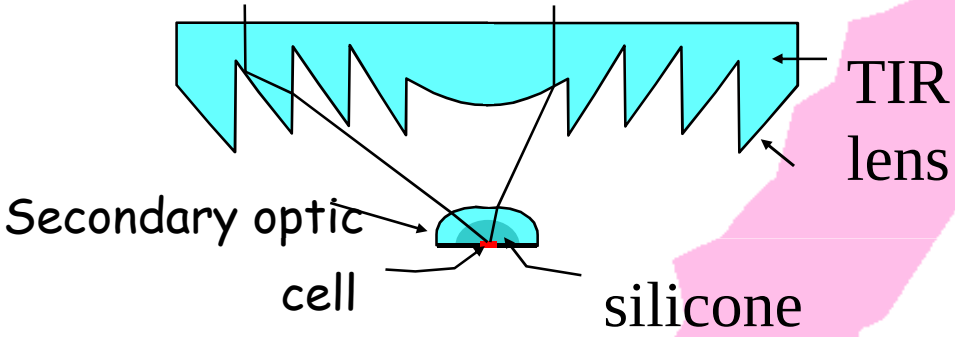


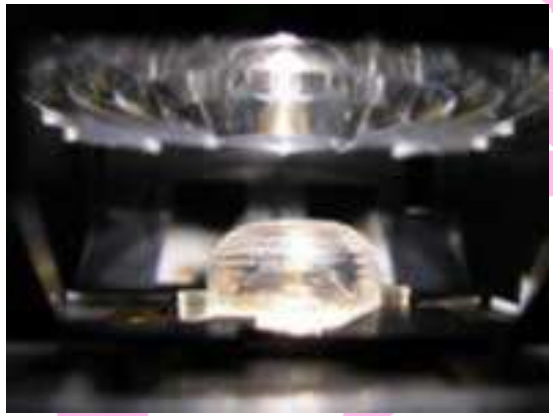




Optic

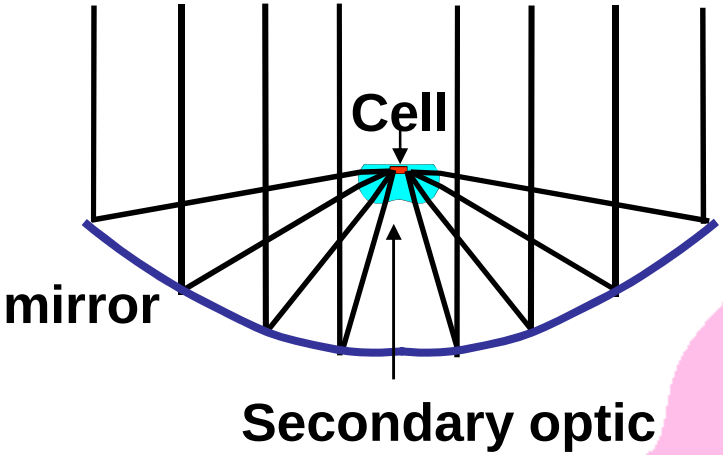
- **TIR: TOTAL INTERNAL REFLEXION**

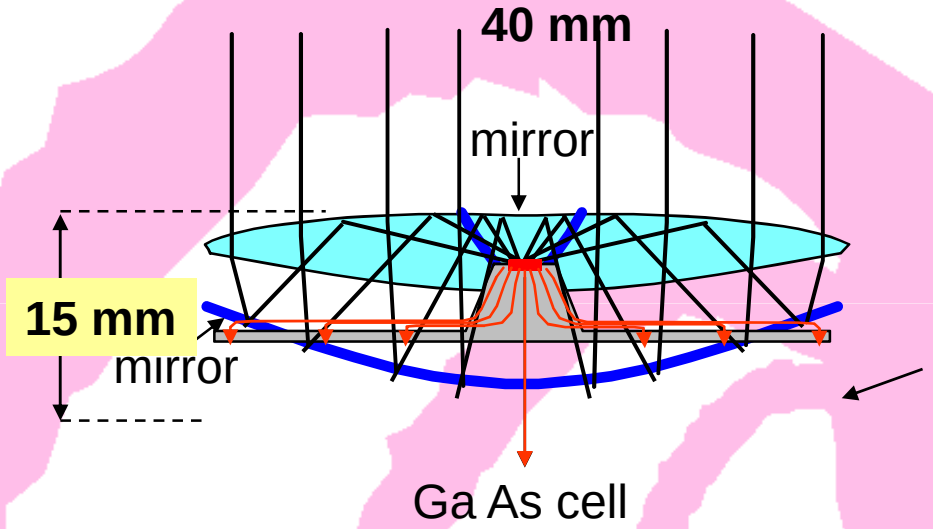


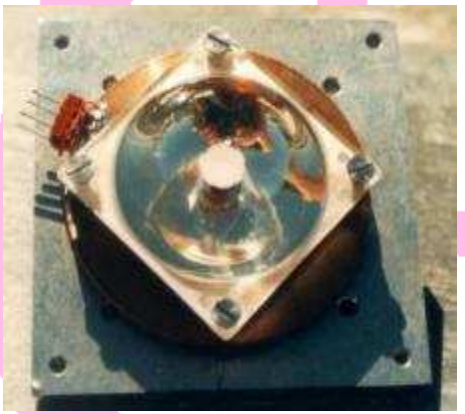


Optic

- New optical concepts(XR, XRI…)

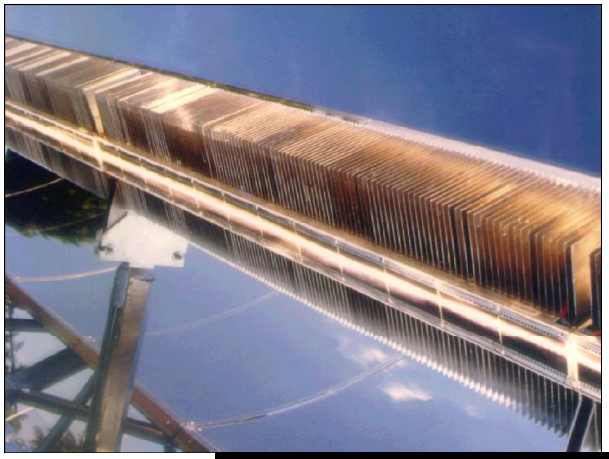


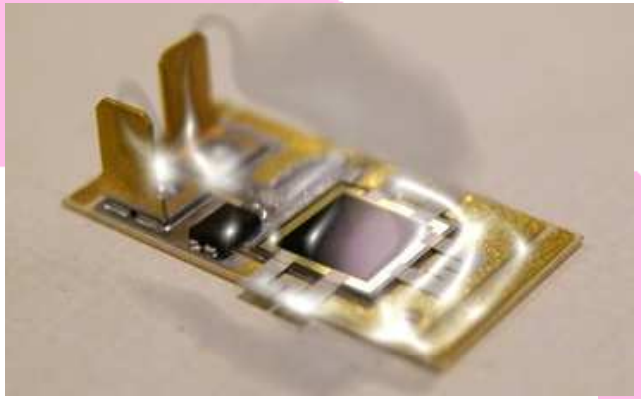


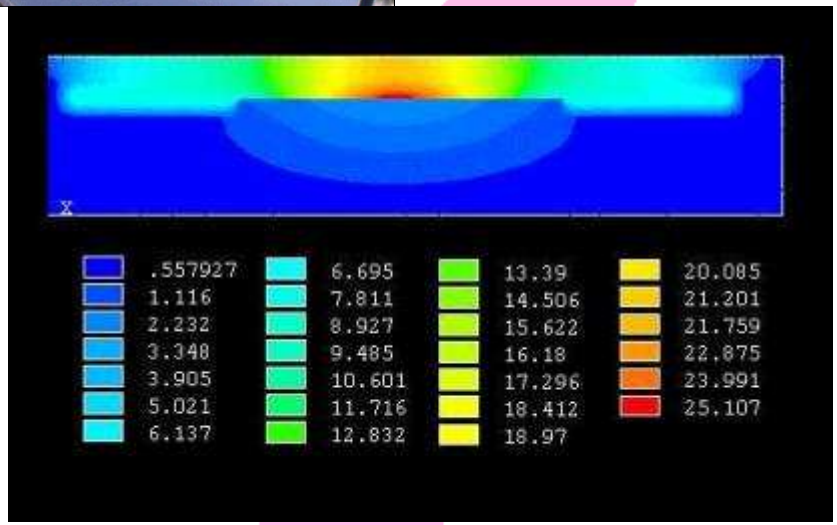


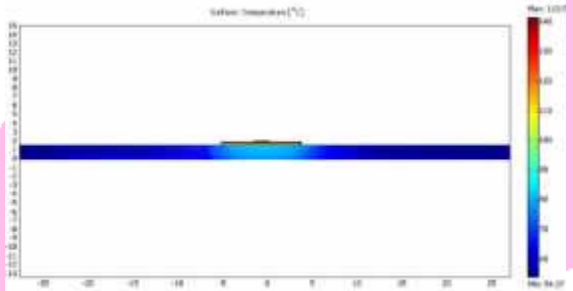
Heatsink

Passive refrigeration: Heatsink



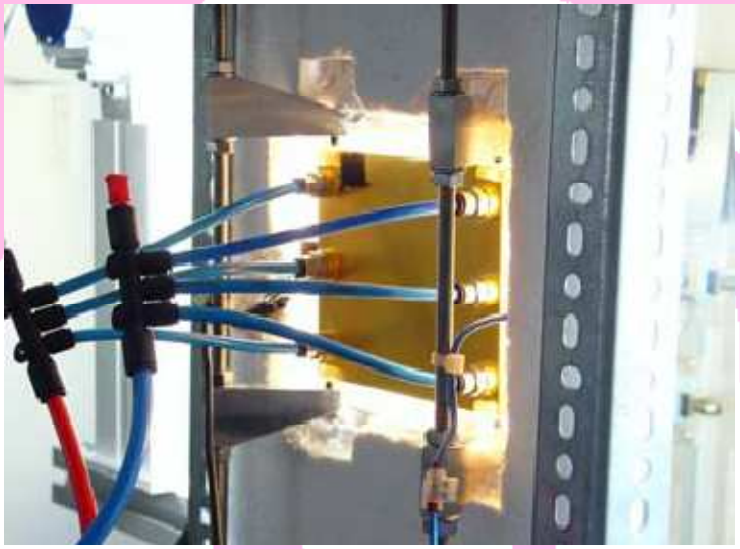






Heatsink

- Active cooling



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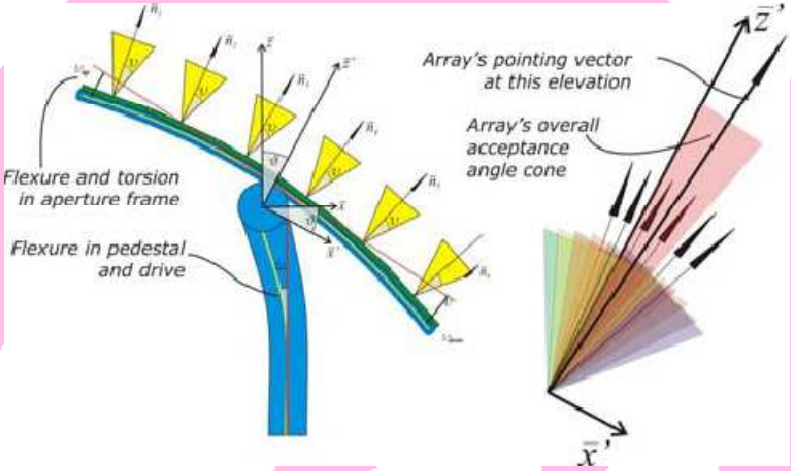
Trackers

- One axis trackers: Only for low concentration

Trackers

Two axis trackers



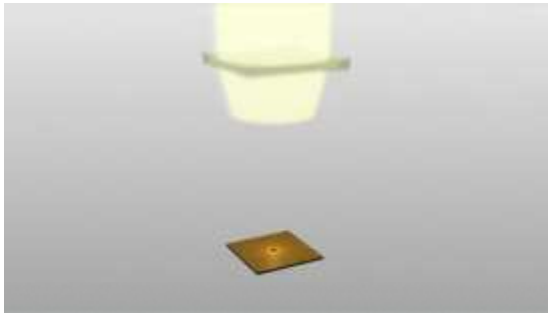
Trackers

- Other technologies

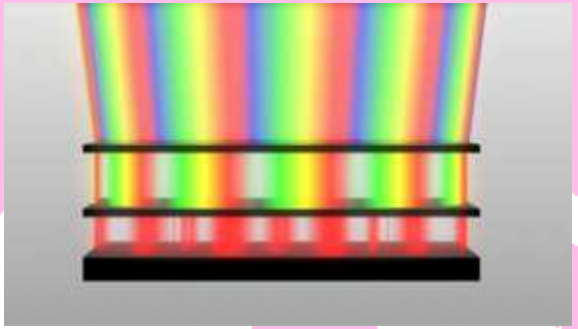
ISFOC

Module

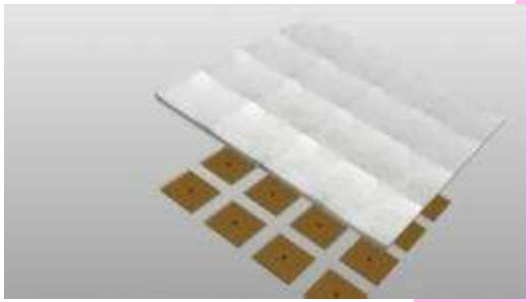
- Light into cell



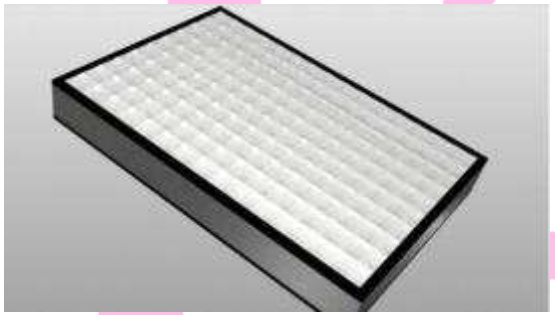
- Multijunction cell receives the light



- Cells with heatsink and lens



- Final module



Pictures by Courtesy of Concentrix

Launching ISFOC

UPM-IES

Castilla-La Mancha

MINISTERIO DE EDUCACIÓN Y CIENCIA

SIC

Instituto de Finanzas de Castilla-La Mancha, S.A.

ISFOC

ISFOC: Mission

To become a centre of reference that provides reliable information to the entire world on the power and productivity of commercial CPV systems.

Train a group of experts capable of promoting both high level research and local industrial development by means of setting up pilot photovoltaic concentration plants.

ISFOC

- FIRST PHASE: ISFOC Establishment
- First International call for tenders in 2006
  - 1,7 MW awarded to 3 companies
- Second International call for tenders in 2007
  - 1,3 MW awarded to 4 companies
- Construction of HQ Building and laboratories
- Recruitment of key personnel

- SECOND PHASE: Projects and Operation
- Operation and Maintenance of the power plants
- R&D plan deployment
- New projects

Manufacturers

Concentrix solar

500kW

SolFocus

500kW

isofotón

400kW

emcore
empower with light™

300kW

renovalia energy

300kW

Arima Eco Energy

300kW

sol3g

400kW

Infrastructures

Almoguera (Guadalajara)
SOLFOCUS
300 Kw

SolFocus

Puertollano (Ciudad Real)
HQ and 800kW
ISOFOTÓN
CONCENTRIX
SOLFOCUS

Puertollano 2
CONCENTRIX
300 Kw
Second Call for tenders

Concentrix solar

ISFOC

About ISFOC

1st and 2nd Phase ISFOC Project Installations (3MW)

Puertollano I

800kW installed and connected to the grid

Almoguera

300kW installed and connected to the grid

Puertollano II

300kW installed
600kW ready to hand over
700kW under construction

About ISFOC

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ISFOC

Castilla-La Mancha

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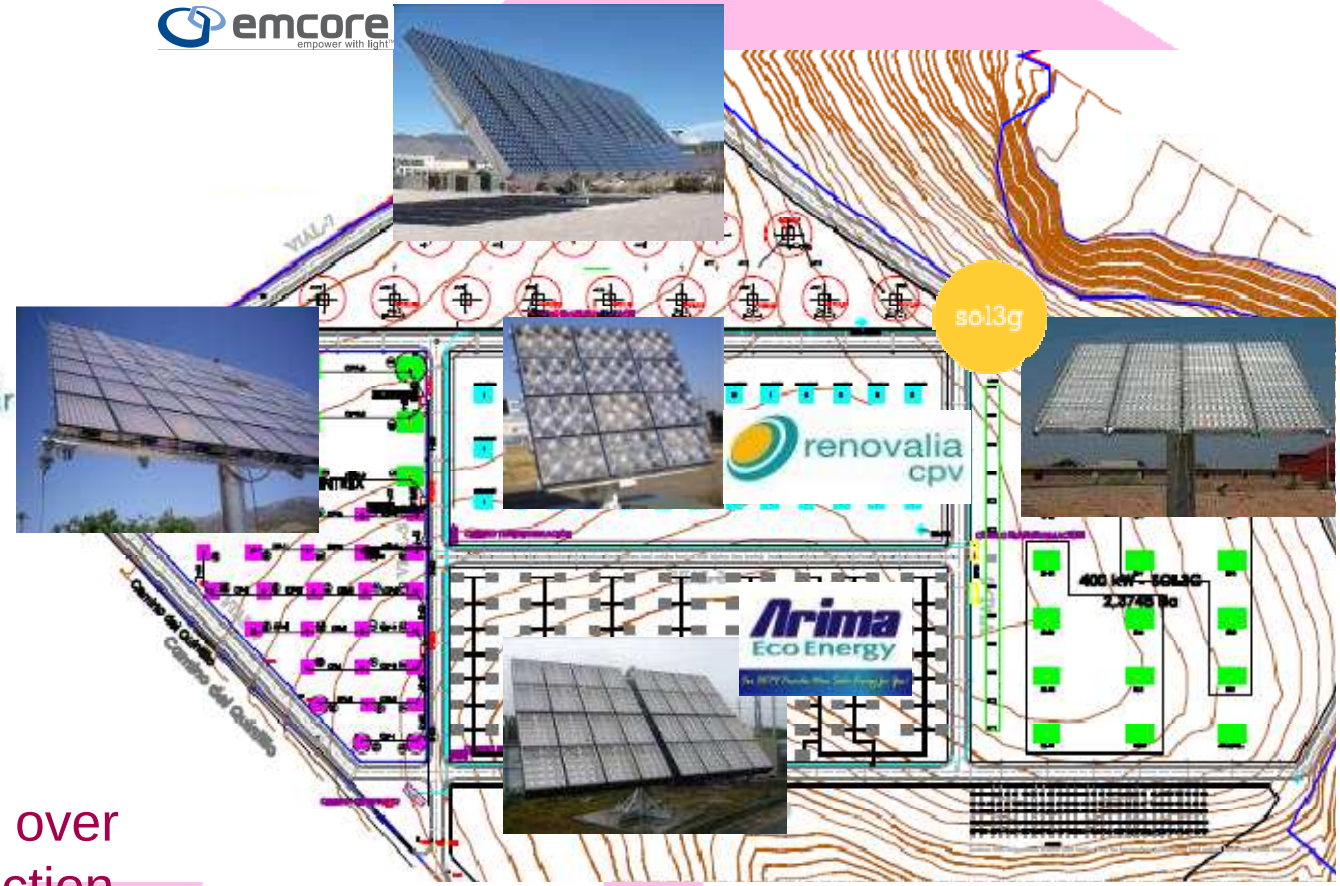
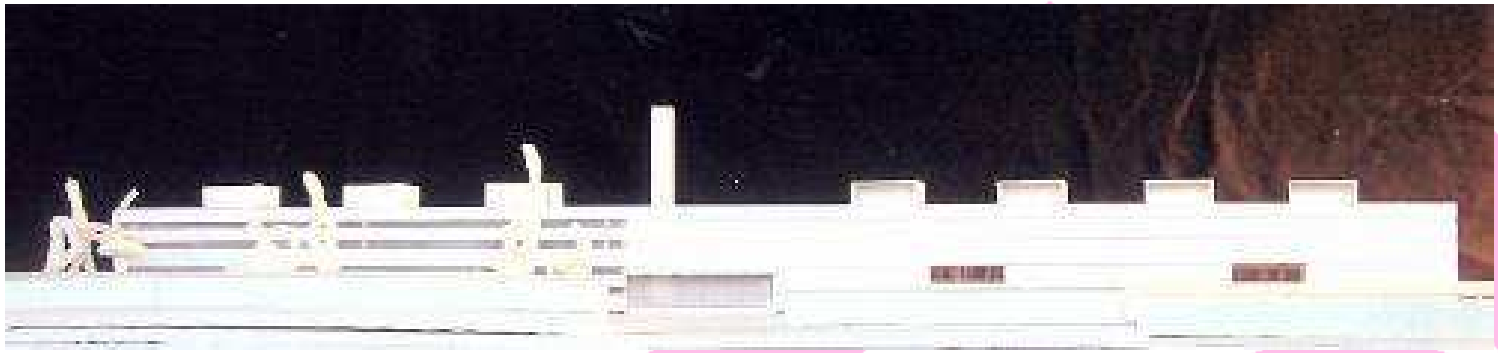


ISFOC

Castilla-La Mancha

Infrastructures – Puertollano I



Laboratories
Offices
Maintenance

ISFOC

Construction & Installations

Construction & Installations

Construction & Installations

Construction & Installations

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

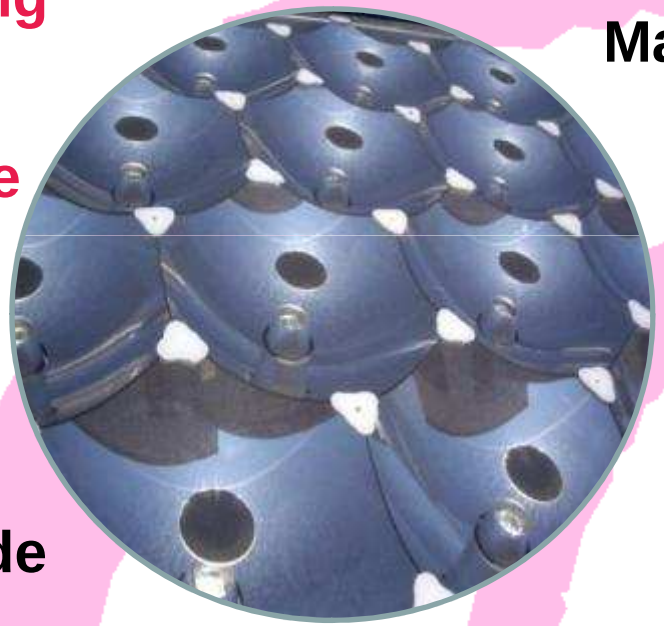
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



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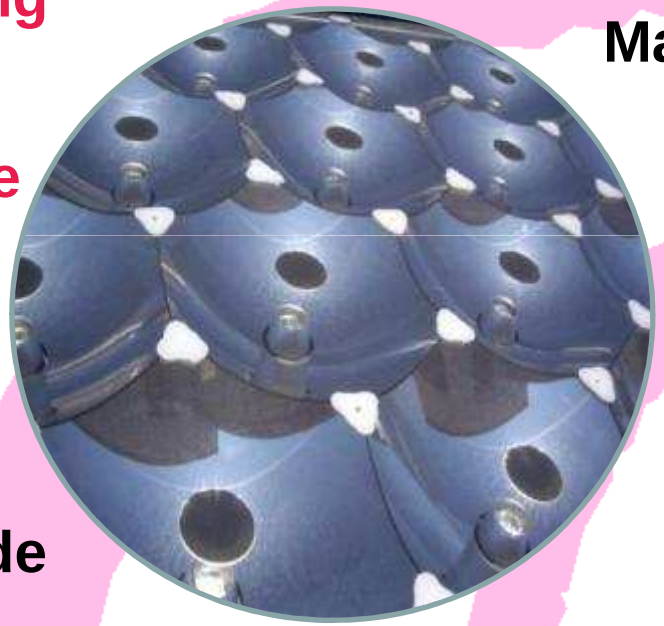


ISFOC

Life cycle

Design

Cell technology and size

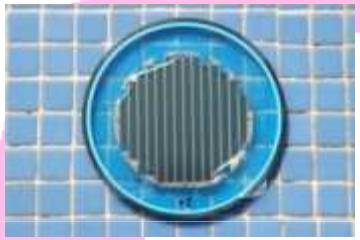
Optic technology

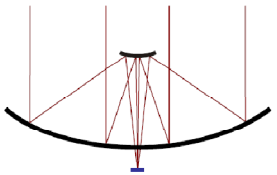
Acceptance angle

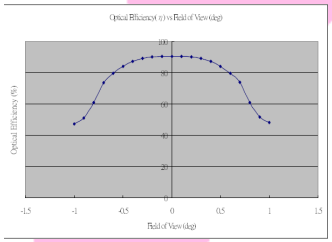
Tracker accuracy

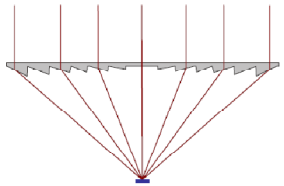
Electrical connection

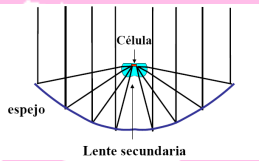
Electrical protection

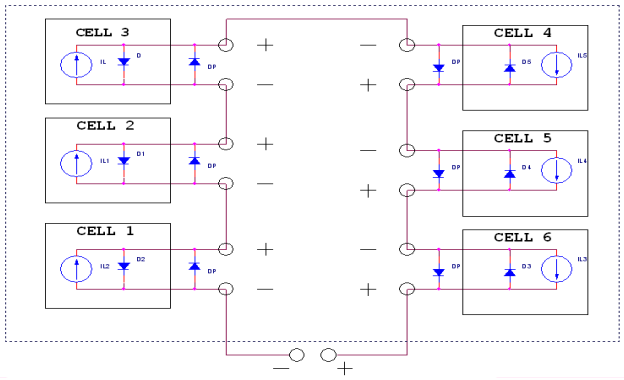












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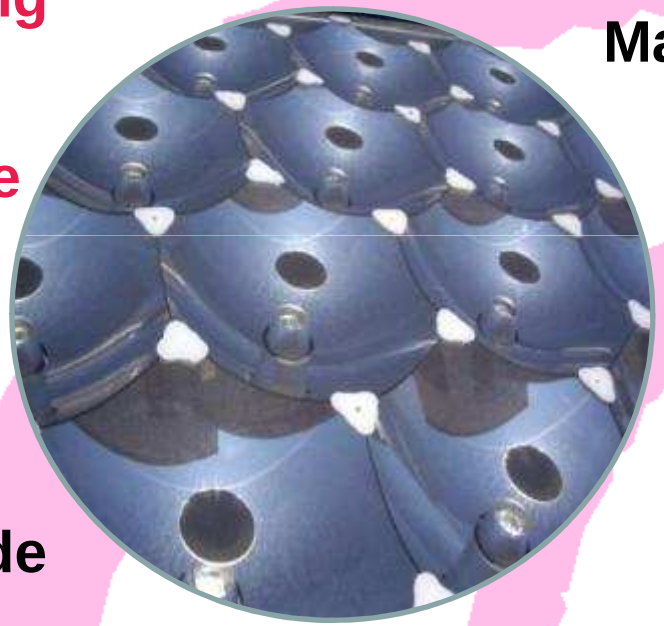

Life cycle

Manufacturing

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Module assembly

Standards

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Manufacturing

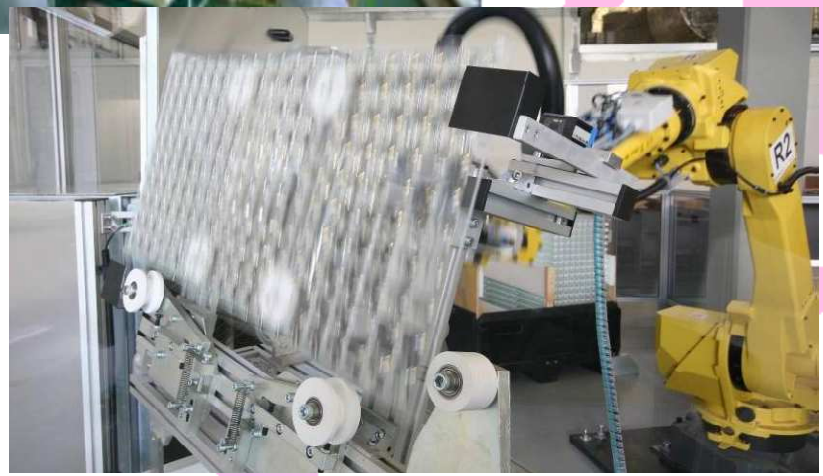
Cell testing

Optical tuning

Module assembly

Automation

Quality controls



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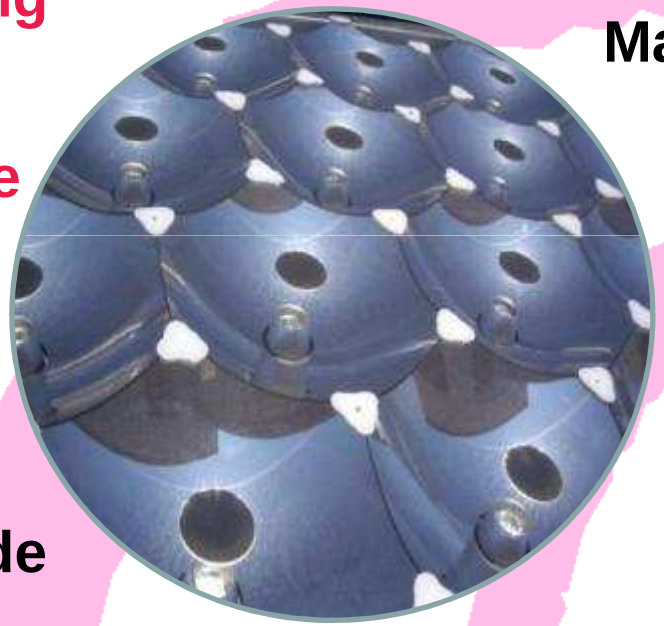

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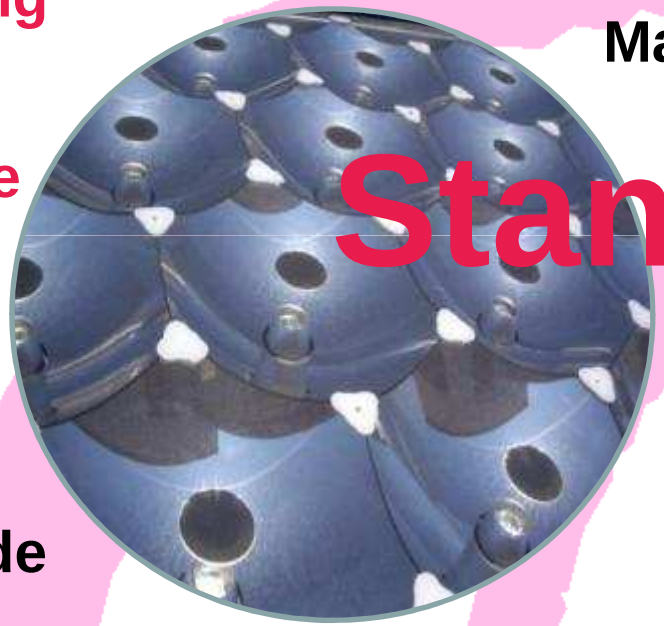

Standards

Life cycle

Standards

QUALIFICATION STANDARD: IEC 62108

ISFOC's partners must carry out the tests of the standard, before starting operation.

Only some accredited laboratories.

Most typical problems:

Watertightness

Electrical isolation

STANDARDS IN PROGRESS

CPV Modules rating

Energy rating

Tracker

Safety

Cells qualification

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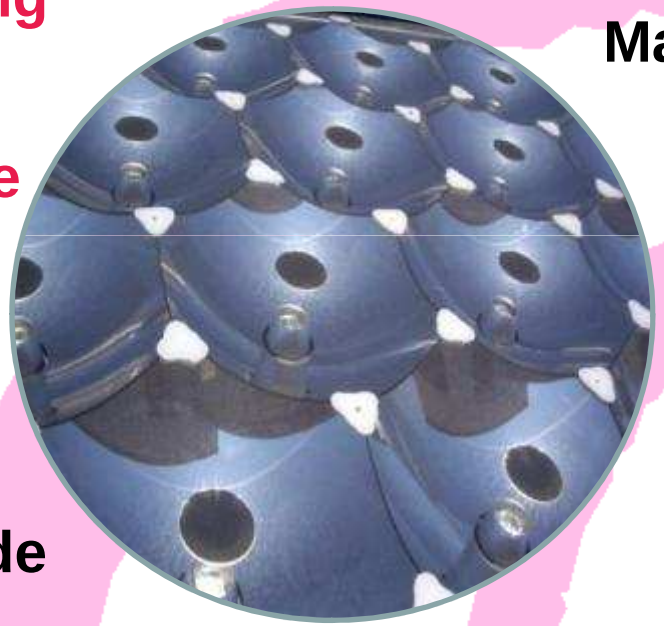
Operation & Maintenance

Recycling



Life cycle

Design

Manufacturing

Standards

Construction & Installations

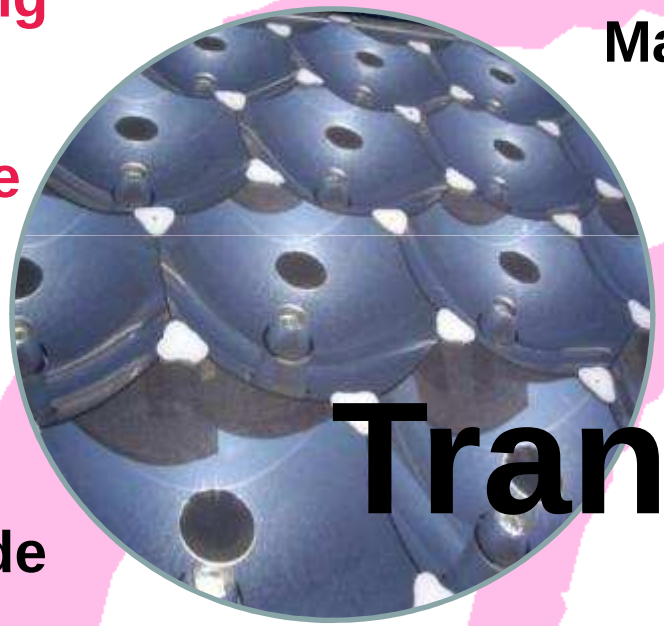
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Transport

Life cycle

Ready to be transported (temperature, presion...)

Dimensioned to be transported (to avoid special transport, cost...)

Good protection for transport (The modules are bigger and more fragile)

Transport

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

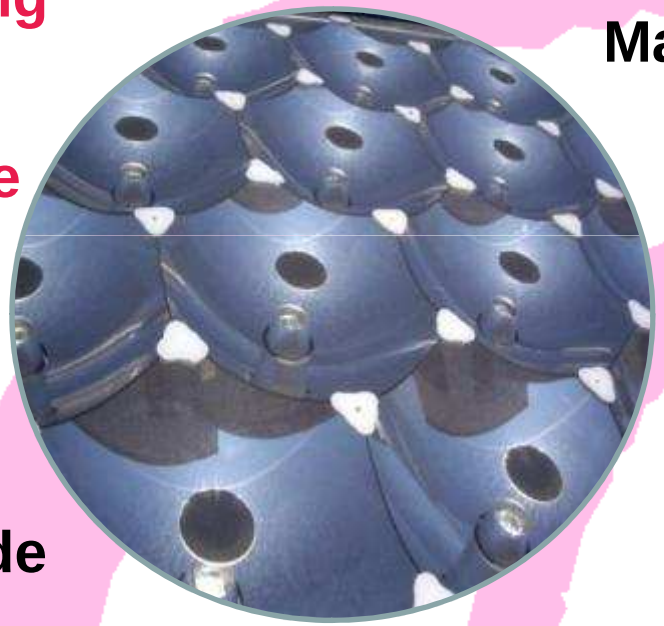
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



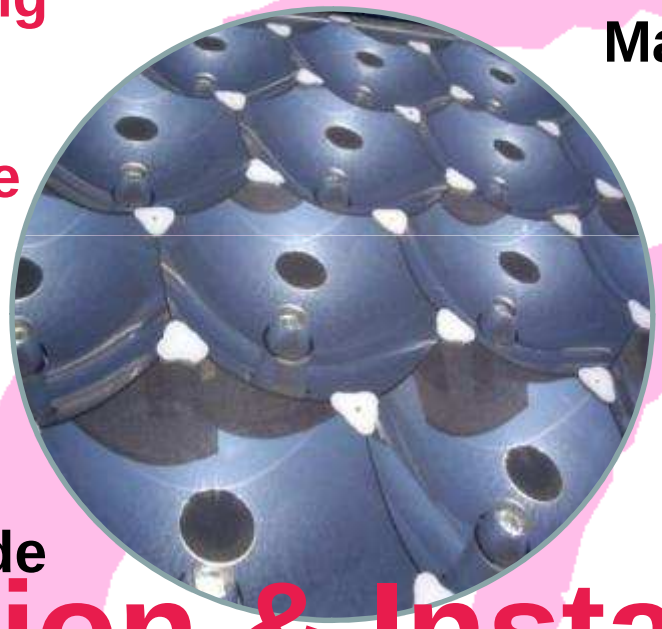
Life cycle

Design

Recycling

Manufacturing

Operation & Maintenance



Standards

Working mode

Transport

Not working mode

Construction & Installations

Module assembly

Life cycle

Paperwork!! PAPERWORK! PAPERWORK!!!
(permitting, licences, environmental agreement...)

Detailed project

Foundation (depending of the land)

Construction & Installations

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

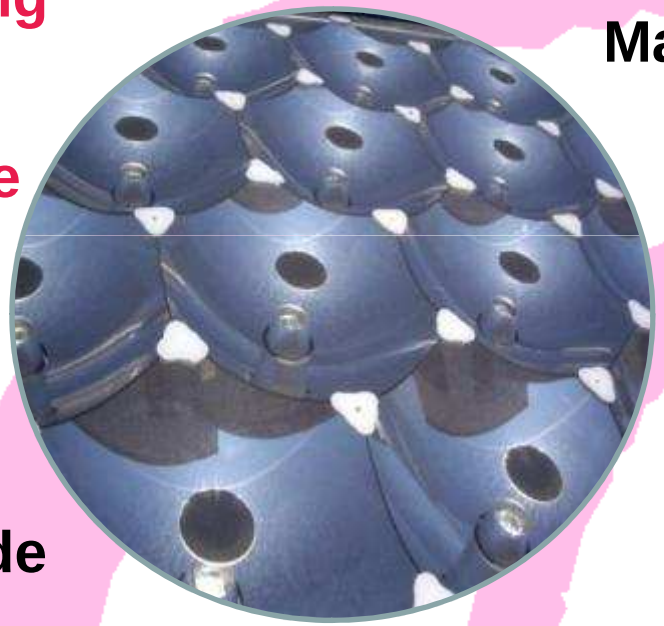
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

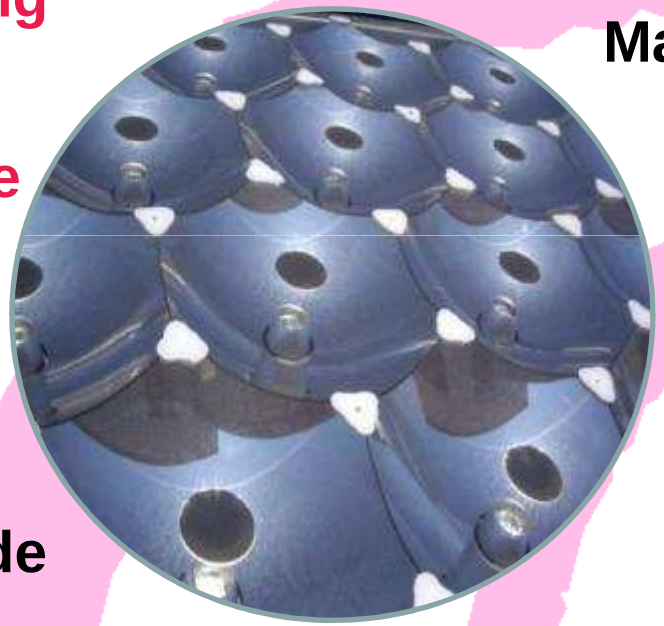
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



ISFOC

Location of the module assembly (on site or pre-assembly)

Alignment of the module on the tracker

Electrical connection

Module assembly

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

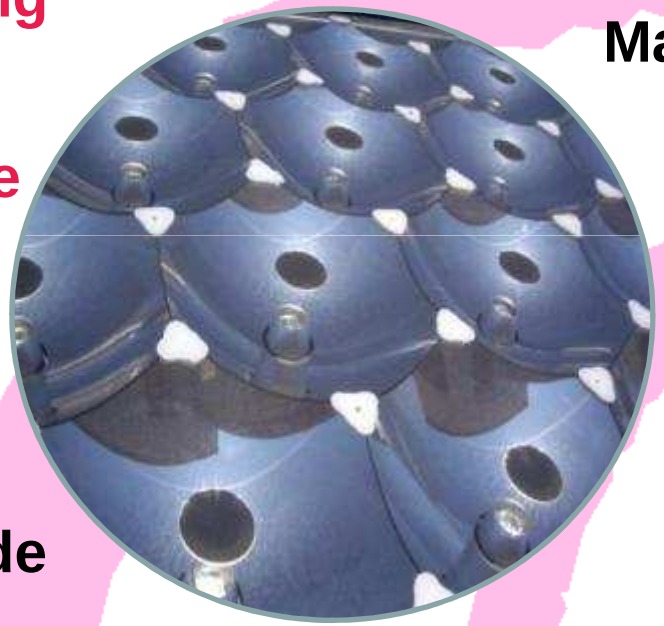
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

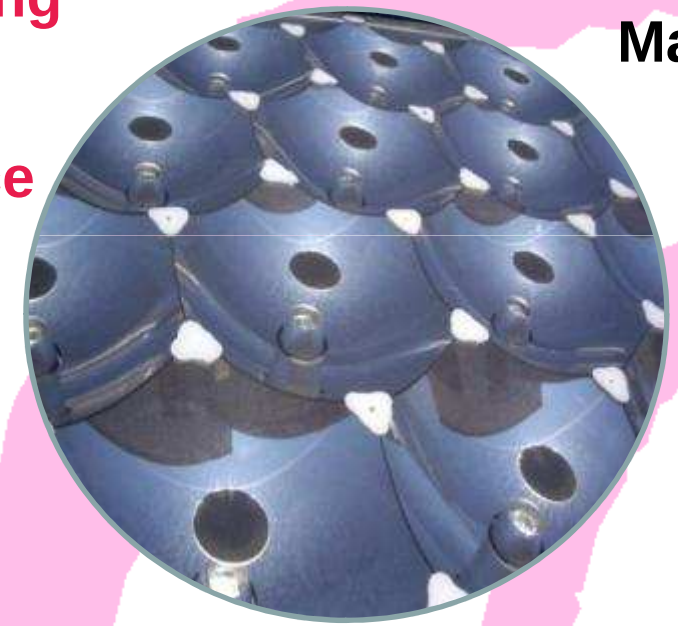
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



The system can be installed but not working (no electrical power, no grid connection, etc.)
Problems: Off axis, wind, no electrical input...

Not working mode

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

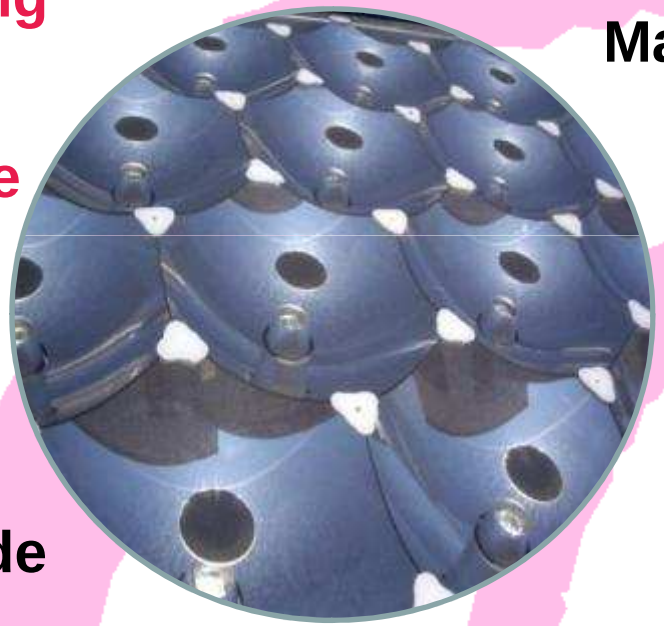
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

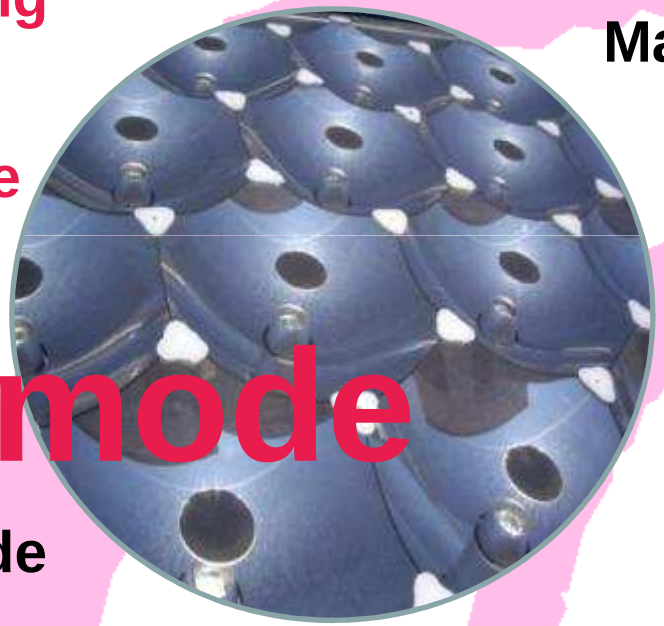
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Life cycle

Working mode

Energy production
Meteorological conditions
Control software
Data monitoring
Life duration

ISFOC

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

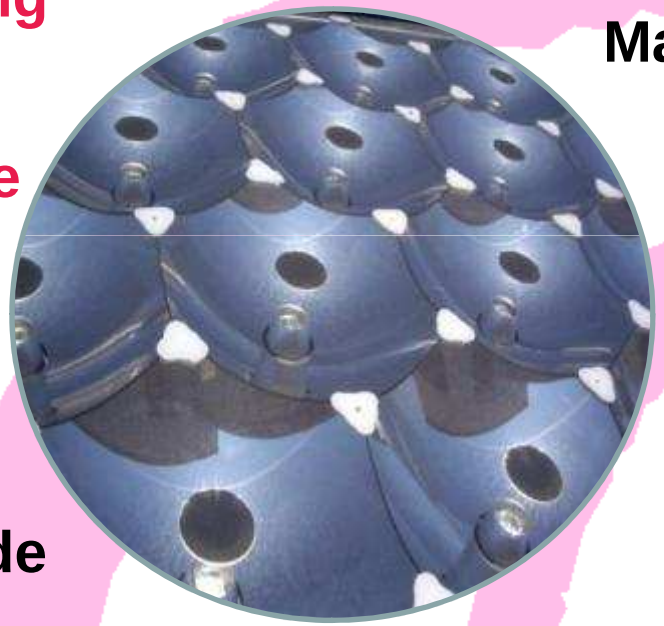
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling

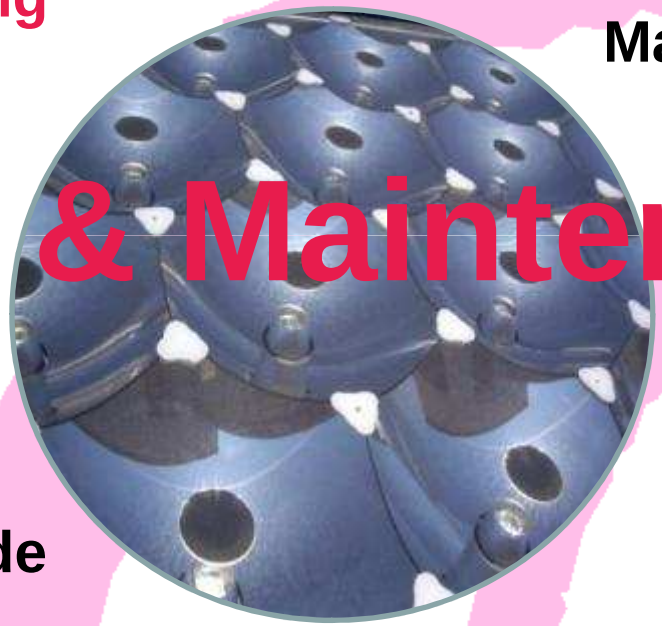


Life cycle

Design

Recycling

Manufacturing



Operation & Maintenance

Working mode

Transport

Not working mode

Construction & Installations

Module assembly

Operation & Maintenance

Standard Spare parts

Easy change

Easy cleaning

Monitoring

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

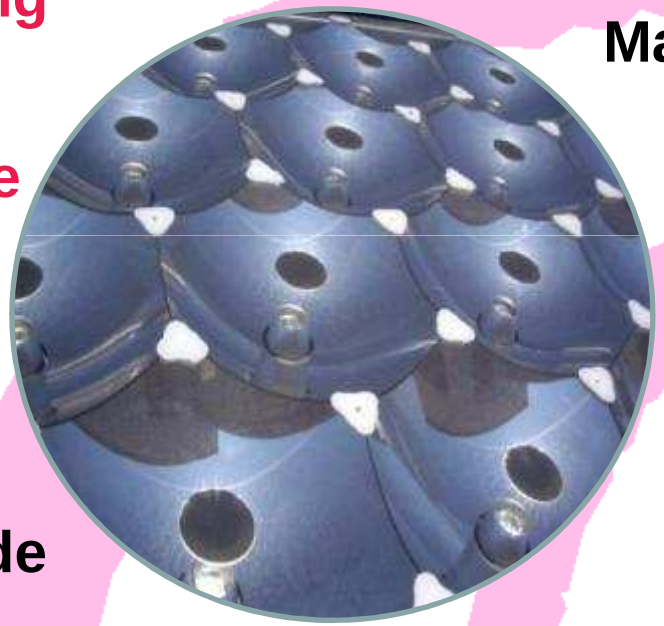
Module assembly

Not working mode

Working mode

Operation & Maintenance

Recycling



Life cycle

Design

Recycling

Manufacturing

Operation & Maintenance

Standards

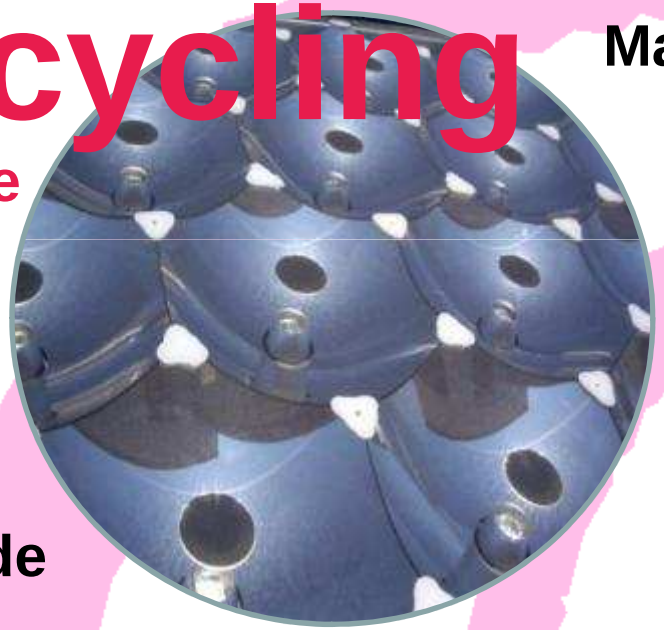
Working mode

Transport

Not working mode

Construction & Installations

Module assembly



Recycling

The CPV modules are easier to recycle

Traditional recycling

- Plastic
- Metal
- Glass

Life cycle

Design

Manufacturing

Standards

Transport

Construction & Installations

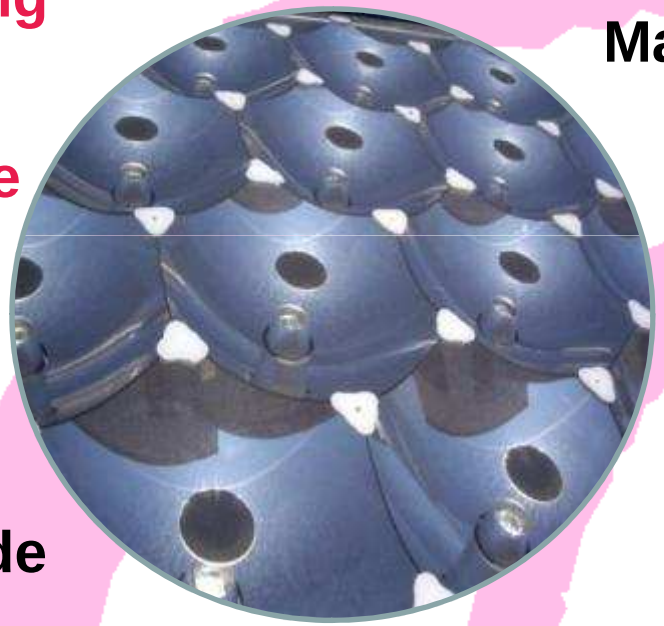
Module assembly

Not working mode

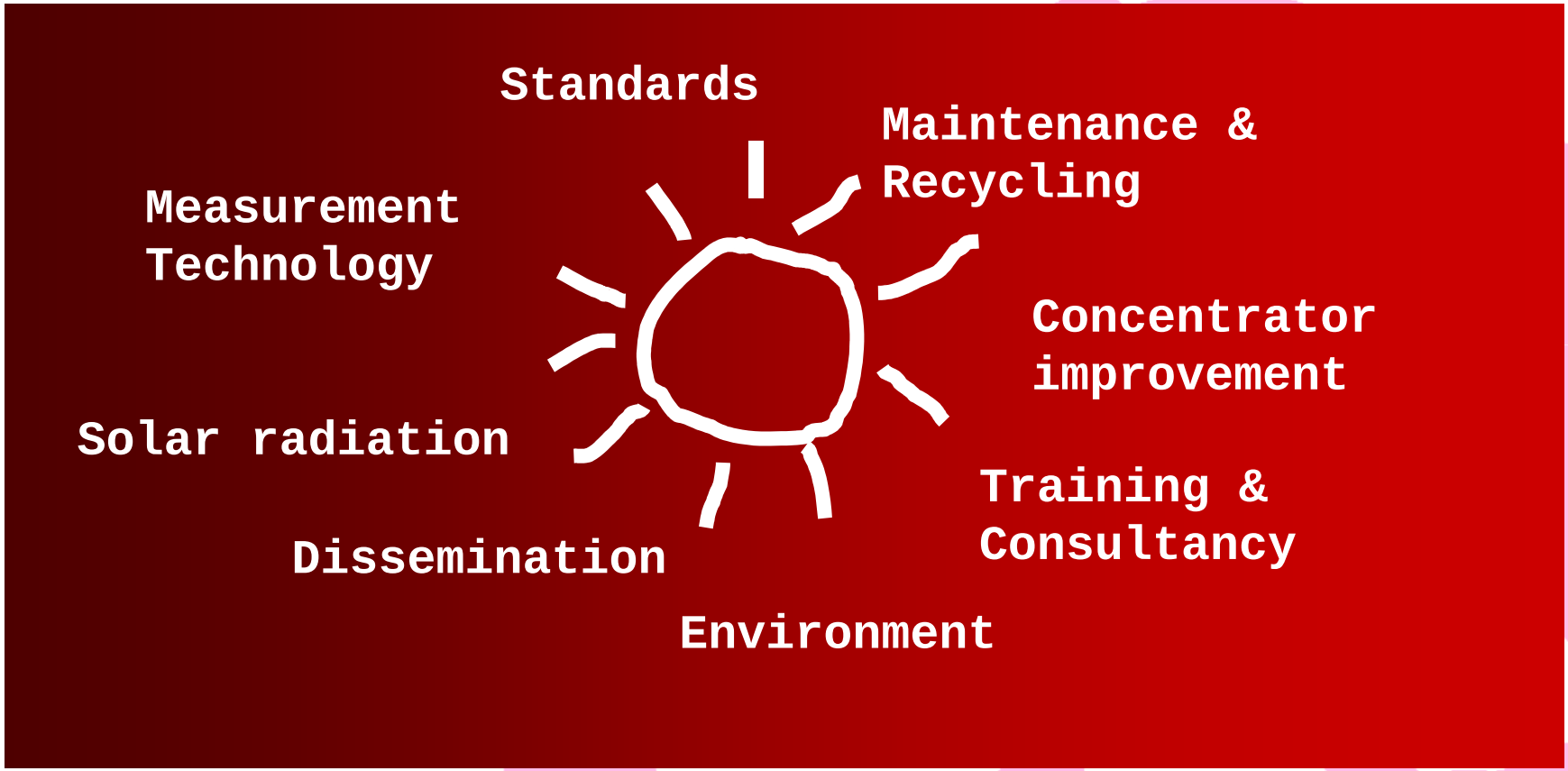
Working mode

Operation & Maintenance

Recycling



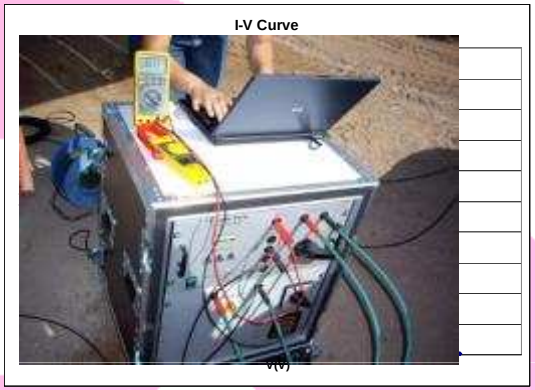
R&D plan

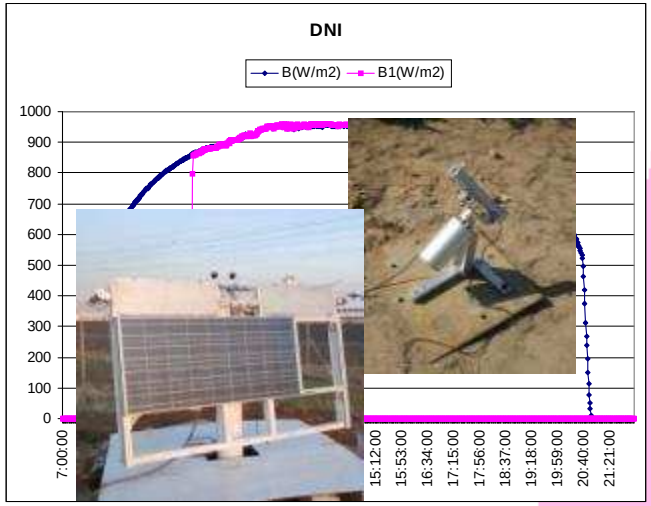

Standards
Maintenance & Recycling
Measurement Technology
Concentrator improvement
Solar radiation
Training & Consultancy
Dissemination
Environment

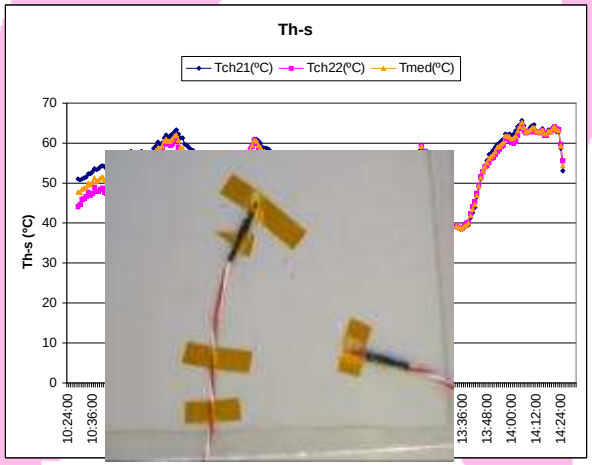
ISFOC'S METHOD

MEASURING EQUIPMENT

Power, I-V Curve	I-V Curve Tracer
DNI	2 pyrheliometer on independent tracker
Back plate temperature behind the cell	Thermal sensors (thermocouple, pt-100)



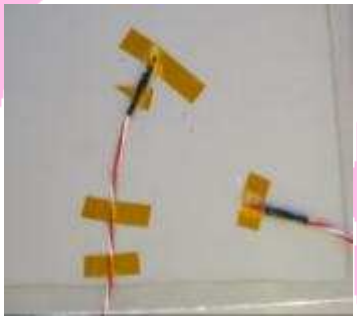




ISFOC'S METHOD

MEASURING EQUIPMENT

Power, I-V Curve	I-V Curve Tracer
DNI	2 pyrheliometer on independent tracker
Back plate temperature behind the cell	Thermal sensors (thermocouple, pt-100)
Wind speed and direction	Meteorological Station
Ambient temperature	Meteorological Station

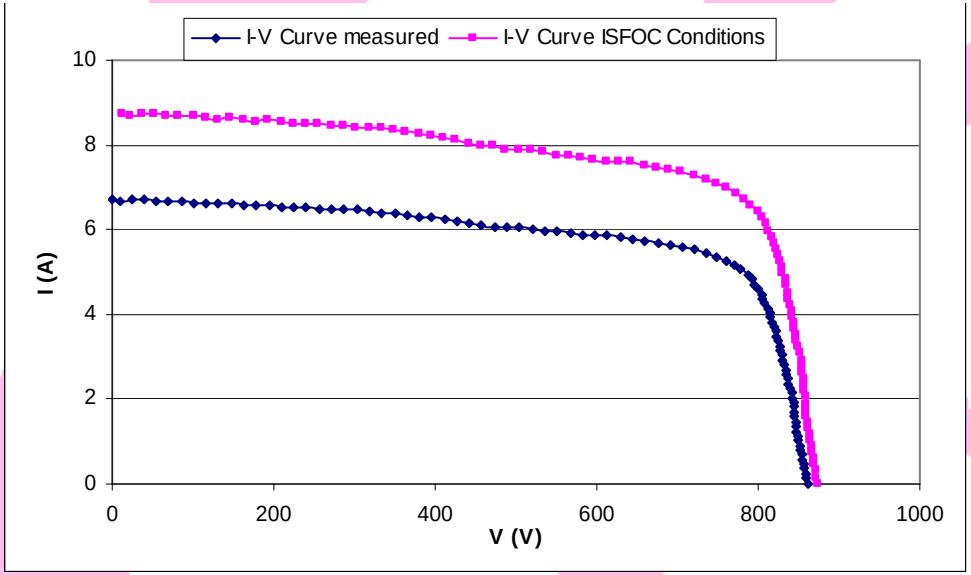


Normalization procedure

- **The results are translated to the standard conditions (850W/m2, 60ºC) with the following equations**

$$\Delta V_i = N\frac{0.0257\times(T_{oper}-T_{cel})}{297}\left[\ln\left(\frac{(I_{Lmea1}-I_i)(I_{Lmea2}-I_i)(I_{Lmea3}-I_i)}{I_{Lmea1}I_{Lmea2}I_{Lmea3}}\right)\right]+\left[N(E_{g1}+E_{g2}+E_{g3})-V_{ocmea}\right]\left(1-\frac{T_{oper}}{T_{cel}}\right)$$

$$I_2 = I_1 \cdot \frac{B_{oper}}{B_{mea}}$$



R&D: Meteorological stations

5 meteorological stations will be in operation across Castilla La Mancha

Three stations are working (direct, global and diffuse radiation, wind, temperature and humidity)

Objectives:

- Verification of radiation models
- Castilla la Mancha radiation map

ISFOC

Meteorological stations status

Puertollano I (La Nava) meteorological station:

- 2 pyranometers for global radiation (horizontal)
- 2 pyranometers for diffuse radiation
- 2 pyrheliometers for direct beam radiation
- One pyranometer for global radiation in tracking surface
- One wind sensor for speed and direction
- One temperature and humidity sensor
- One Rain sensor
- One Visibilimeter
- One UV measurement equipment
- One portable spectroradiometer (Prede)
- One fix spectroradiometer (Instrument System)
- One set of Isotype cells (Fraunhofer Institute)
- One tracker of INSPIRA
- Meteorological Datalogger of Geonica

Meteorological stations status

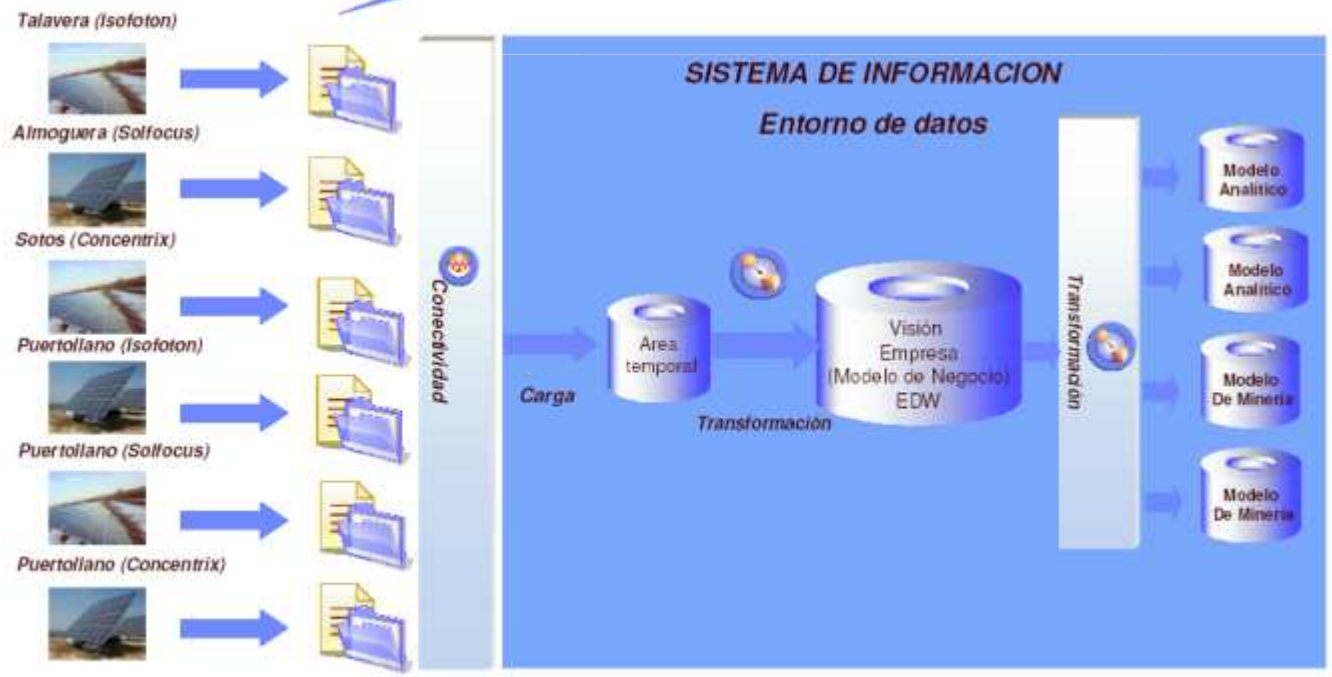
Puertollano I (La Nava) meteorological station:

ISFOC

R&D: Data base

Data base installations with meteorological and production data with all the information of the systems

Objective: Realization of a model of prediction of production



GOCPV


GOCPV
Gestión y Optimización de CPV
Directora I + D - ISFOC
frubio
Start
Help
Log out
Inventory
Maintenance
Reports
- Centers count.
- Plants counters
- Inversor product.
- Plant inverters
- Inversor check
- Meteorology
Información
GOCPV (V. 0.3)
Map
Ponferrada
Leon
Burgos
Logroño
Valladolid
Zaragoza
Salamanca
Alcalá de Henares
Madrid
Talavera de la Reina
Toledo
Cáceres
España
Spain
Valencia
Badajoz
Albacete
Alicante
Córdoba
Jaén
Murcia
Lorca
Sevilla
Huelva
Granada
Cartagena
Almería
Málaga
Cádiz
El Ejido
Marbella
Alboran Sea
Google
ISFOC Plants
National plants
|- La Nava, Puertollano
|- El Villar, Puertollano
|- Almoguera, Guadalajara
International plants
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GOCPV - Version 0.3
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GOCPV

GOCPV Gestión y Optimización de CPV

Ingeniero I + D - ISFOC
fgregorio

Start -- Production reports -- Plant meters

Help | Log out

- Inventory
- Maintenance
- Production reports
  - Center meters
  - Plant meters
  - Inverter product.
  - Plant inverters
  - SCP report
- Weather data

Power meter per plants

Date: September 2010

Imported/exported energy: Exportada

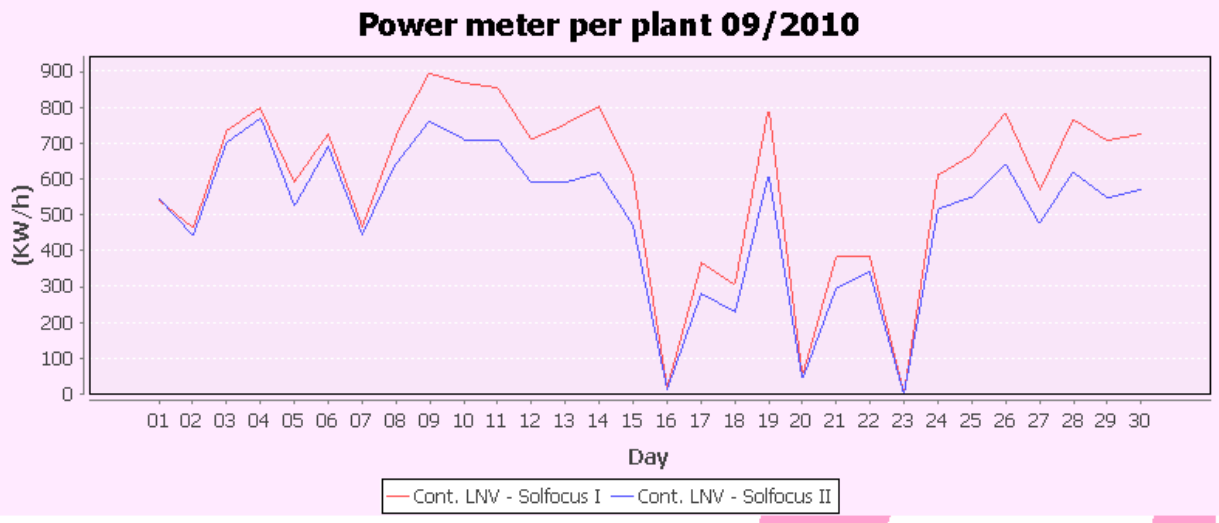
Data to show: Valores del contador de planta

Select the plants to report

- Almoguera
- El Villar
- La Nava

Show report

Power meter chart | Power meter data



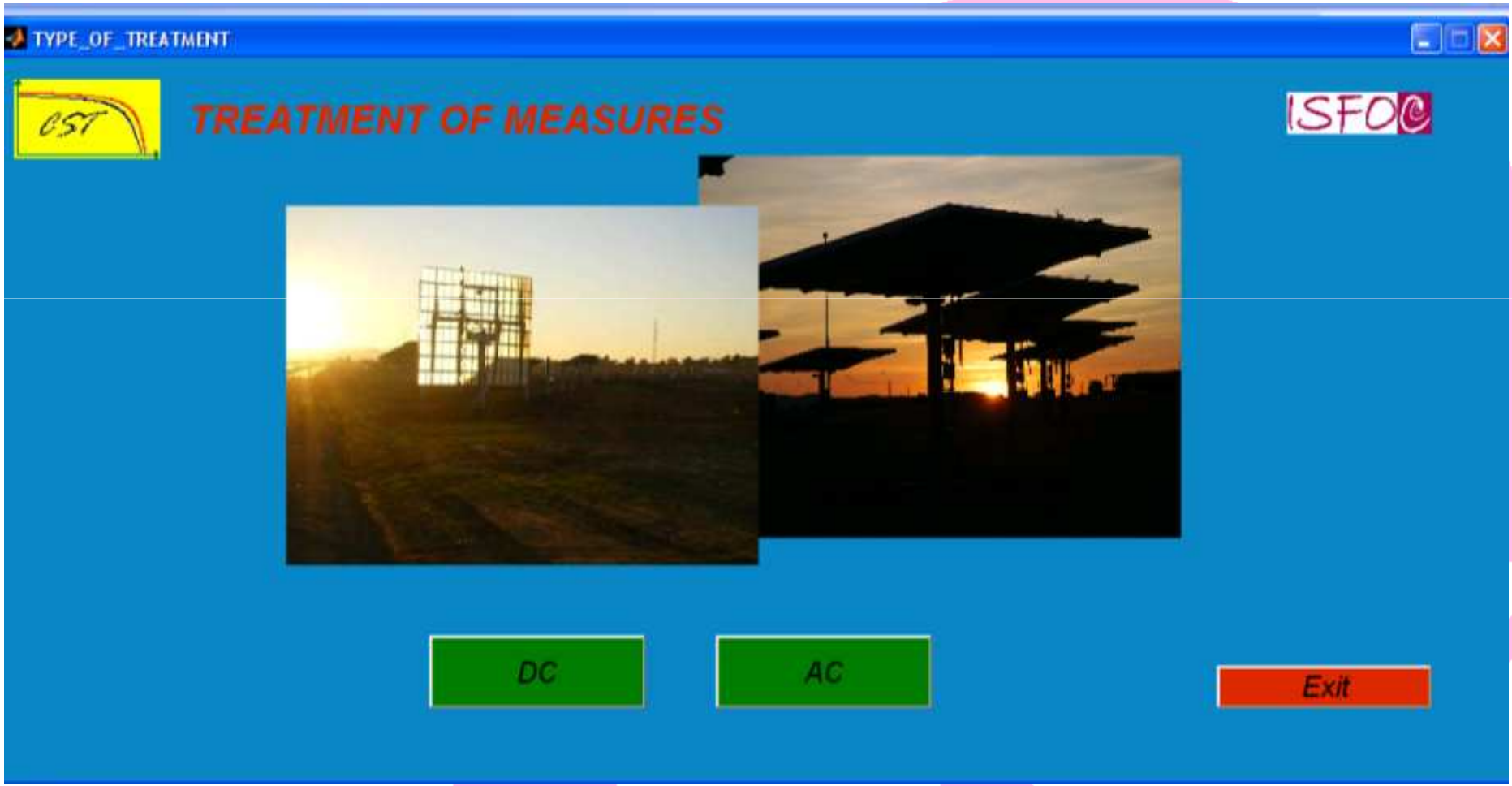
GOCPV - Version 0.34 | Aviso legal | Privacidad | Contacto | Accesibilidad

GOCPV


GOCPV
Gestión y Optimización de CPV
Ingeniero I + D - ISFOC
Start – Inventory – Devices
Help
Log out
Inventory
- Tech. Centres
- Divisions
- Subdivisions
- Devices
- Components
- Invent. explorer
- Invent.Hierarchy
- Calibrations
- Assignments
Maintenance
Production reports
Weather data
List of devices
Tech. centre
La Nava
Division
Plantas
Subdivision
Planta Concentrix I
Device group
Concentrador
Centre
Division
Subdivision
Device group
Code
Device desc.
La Nava
Plantas
Planta Concentrix I
Concentrador
CONC-111
Concentrador J - 111
CONC-115
Concentrador O - 115
Total 18 registros
Exportar: Excel | PDF
Copyright © ISFOC. Todos los derechos reservados
GOCPV - ISFOC - Diálogo de página web
General information
Concentrator info
Location
Photograph
Specific info of the concentrator
Photograph
Components of device (Panels)
Dimensions of the concentrator (x,y)
15
8
Concentrator area (m2)
34.3
Efective area (m2)
28.8
Concentrator power (KW)
5.4
Close

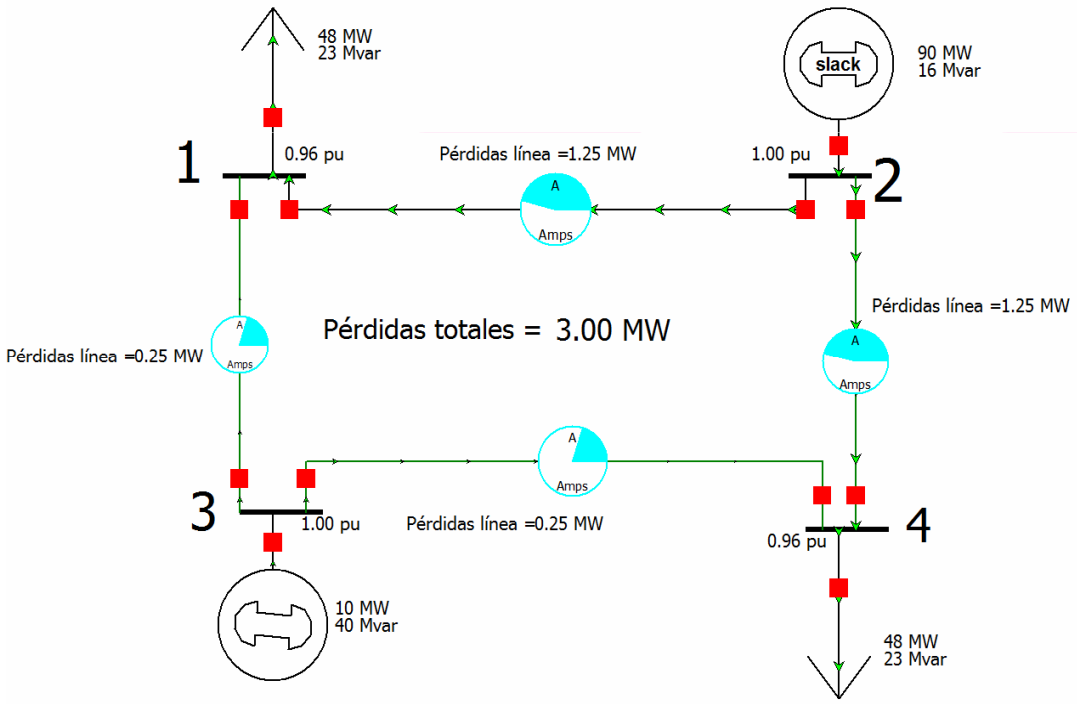
Software Development

Software tool for the CPV Plants Power Rating



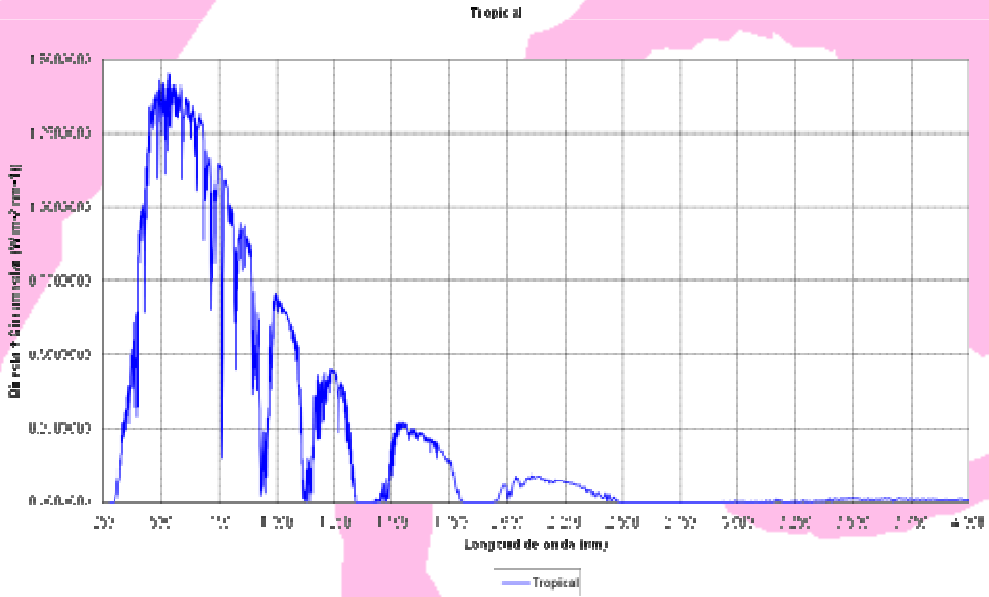
R&D: Grid impact

- Under study the technical and economical impact of the CPV on the grid in collaboration with the University of Castilla la Mancha.



R&D: Spectrum

- Spectrum project: To understand the influence of the Spectrum in the cell performance
  - Two spectroradiometer
  - Isotypes cells (Fraunhofer-ISE and IES-UPM)
- In collaboration with Abengoa, IES-UPM and INTA



R&D: Agriculture

- Agriculture project: Plants under sun and shadow conditions in collaboration with the University of Castilla la Mancha.

R&D: Cleaning

- Cleaning: Study of the way of cleaning.
  - Different frequencies
  - Different methodologies
  - Study of the power degradation depending of the time, rain and location

IEC tests

<u>QUALIFICATION STANDARD: IEC 62108</u>

ISFOC's partners must carry out the tests of the standard, before starting operation.

Today some accredited laboratories.

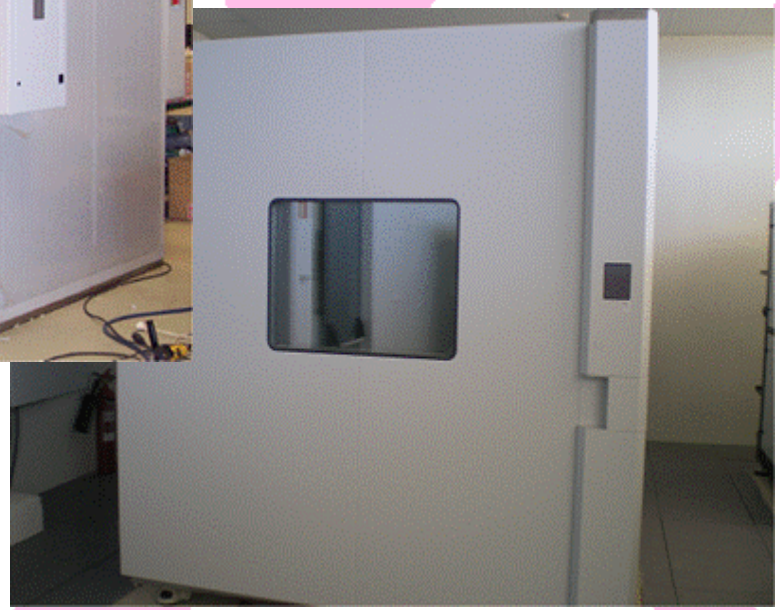
<u>Most typical problems:</u>

Watertightness

Electrical isolation

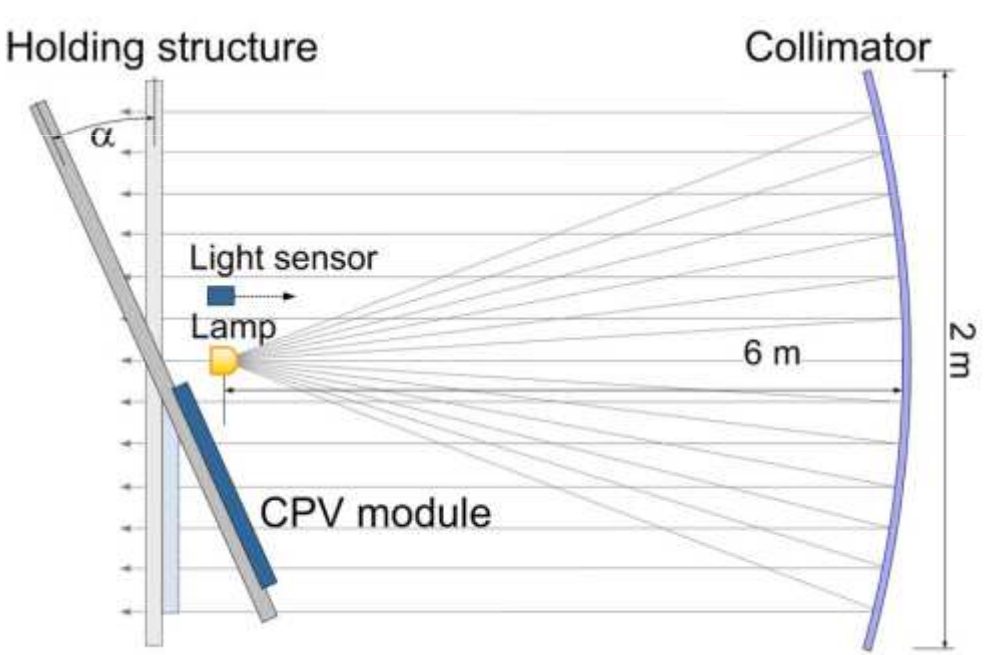
R&D: Laboratory

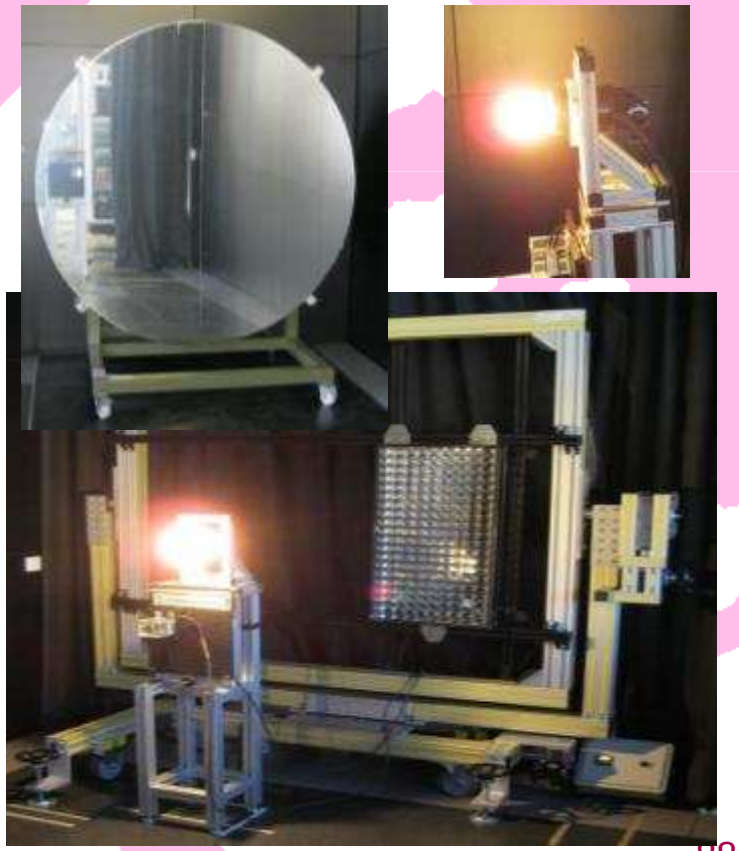
- Laboratory: ISFOC has installed a climatic laboratory to carry out all the IEC 62108 tests for validation purpose



R&D: Solar Simulator

- ISFOC has installed a Solar Simulator to characterize different modules of CPV technology.





R&D Projects: Current projects

A) SIGMASOLES PSE: Spanish project with 18 participants for CPV development

B) NACIR: European project. CPV Development, Installation in Egypt and Marocco, and validation

C) MASDAR: CPV installation in Masdar city, with analysis of the results

D) Collaboration projects: with partners

Sigmasoles: Subprojects

Subproject	Leader	Activities
TECHNOLOGICAL AREA:		
1. Cell development	IES (III-V)	Development of multijunction cells of 3 junctions, and validation
2. Optic development	LPI	Development of new concepts, prototypes and validation
3. Module development	**ISFOC**	Development of new modules, prototypes and validation
4. Tracker development	ALTRAN	Specifications, procedures, new desings
5. Plants and BOS	UJA	Inverter, electrical modelling, grid connection, grid impact, energy storage.
6. Field test	**ISFOC**	Field test preparation and installation. O&M and monitoring
EVALUATION AREA		
7. Quality & characterization	IES (ISI)	Caracterización, Calidad en producción, ensayos fiabilidad, normativa
8. Production model	**ISFOC**	Recurso solar, influencia en producción, base de datos, software modelo producción
MANAGEMENT AREA		
9. Management	ALTRAN	Management, Roadmap, Surveillance study, market study

European project NACIR: Activities

NACIR: European project of the FP7, coordinated by IES and together with Fraunhofer, Concentrix, Isofoton, ONE (Morocco) and NWRC (Egypt)

ISFOC Activities:

- Development of the measurement procedures
- Definition of the meteorological stations
- Measurements of the installations of Isofoton in Morocco and of Concentrix in Egypt.
- Development of a Data Base to analyse the data of all the locations.

MASDAR: R&D Activities

MASDAR: Bilateral project with MASDAR for the installations of 800 kW of CPV

Activities

- Call for tenders and contract definition
- Engineering Works supervision
- Training of the Masdar personal
- Evaluation and acceptation of the installed plants

-Definition and installations of the meteorological stations

-Development of a Data Base to analyze the data of all the locations.

NEW PROJECTS PRESENTED

- Spanish projects:
  - INNPACTO: (Innovation Ministry): 3 projects ("Sigmamodulos, Sigmatrackers, Sigmaplantas" presented with the technical coordination of ISFOC
- Others

Services

1) Development phase:
- Design review, FMEA, etc.

2) Characterization phase
- Indoor and outdoor characterization
- Outdoor performance study

3) Validation phase
- Pre-certification qualification tests
- Certification tests

4) Demonstration and comertial plants
- Solar resource and meteorology study
- Yield & production study
- Engineering
- Evaluation and follow-up of the demo plant
- Monitoring

RESULTS

- **RESULTS OF THE FIRST THREE YEARS OF OPERATION BY ISFOC**

Performance Degradation?

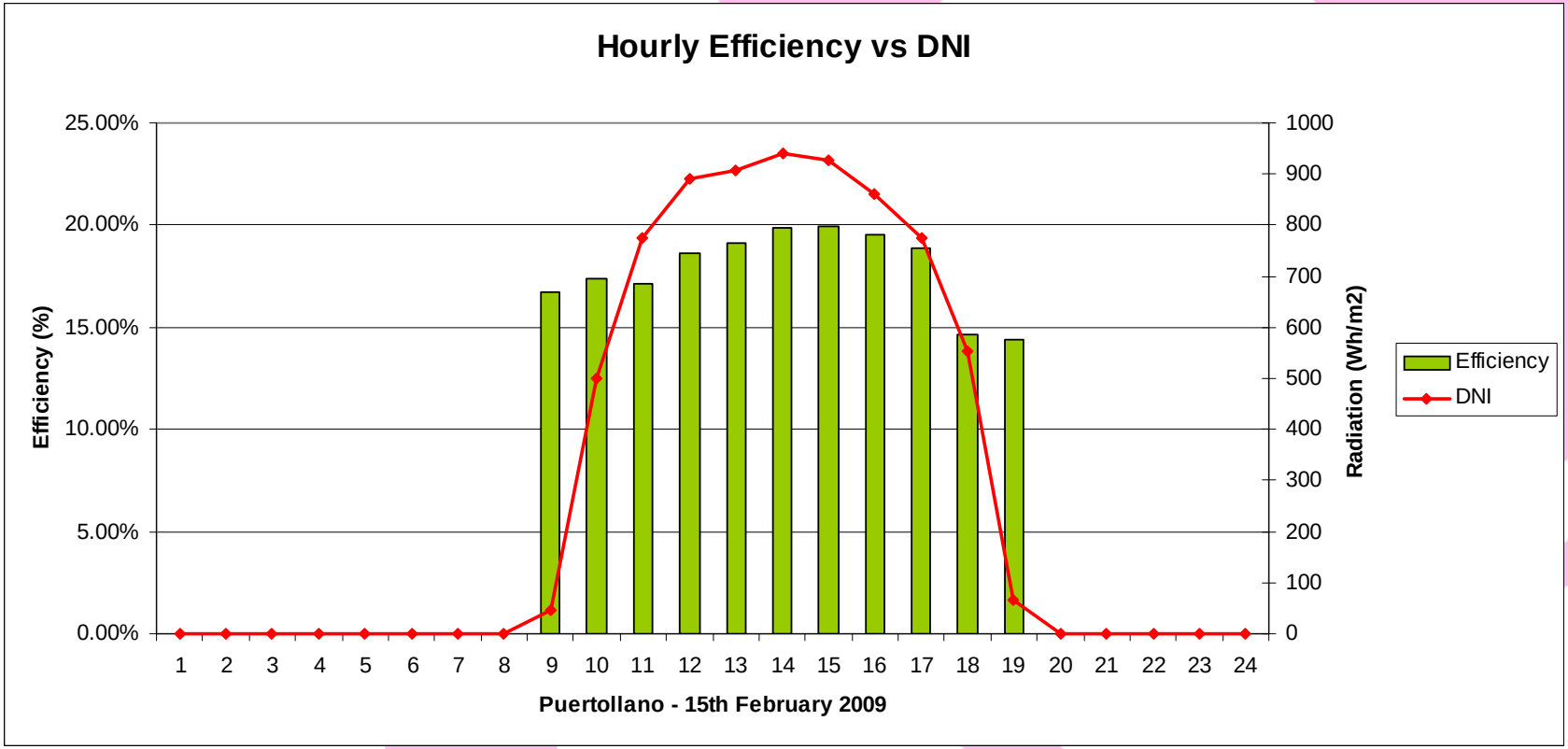
- **Is there performance degradation of the demonstration plants after two years of operation?**

- Method 1: Study of the production of a specific plant during sunny days in the different seasons, in the different years of operation, to verify if there is degradation of the performance
- Method 2: Efficiency of the plant during the whole year
- Method 3: Efficiency of a specific concentrator in different measurements

Method 1: Season Production follow-up

Winter production in 2009

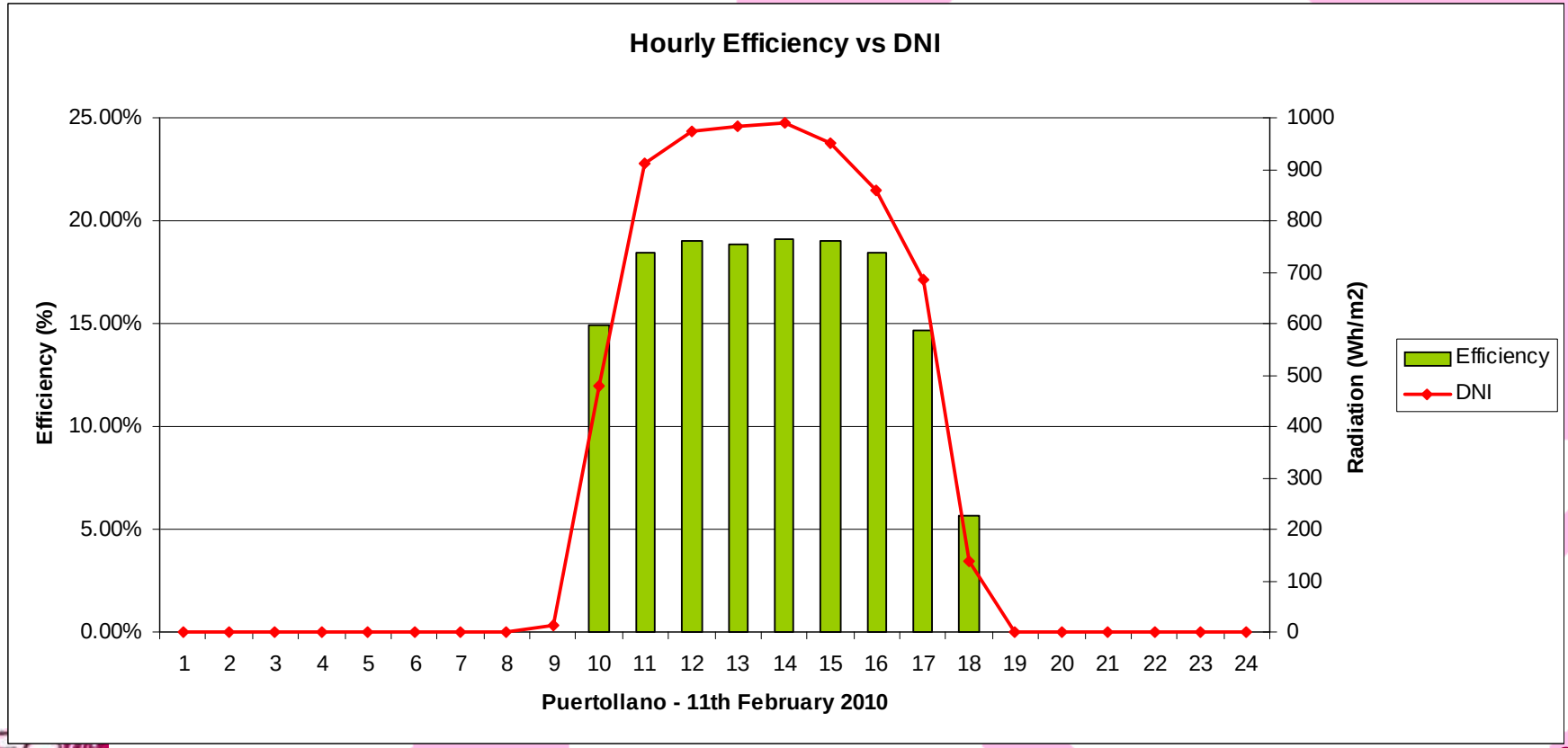
- Efficiencies until 19.9% in February 2009
-Temperatures between 0ºC and 15ºC



Season Production follow-up

Winter production in 2010

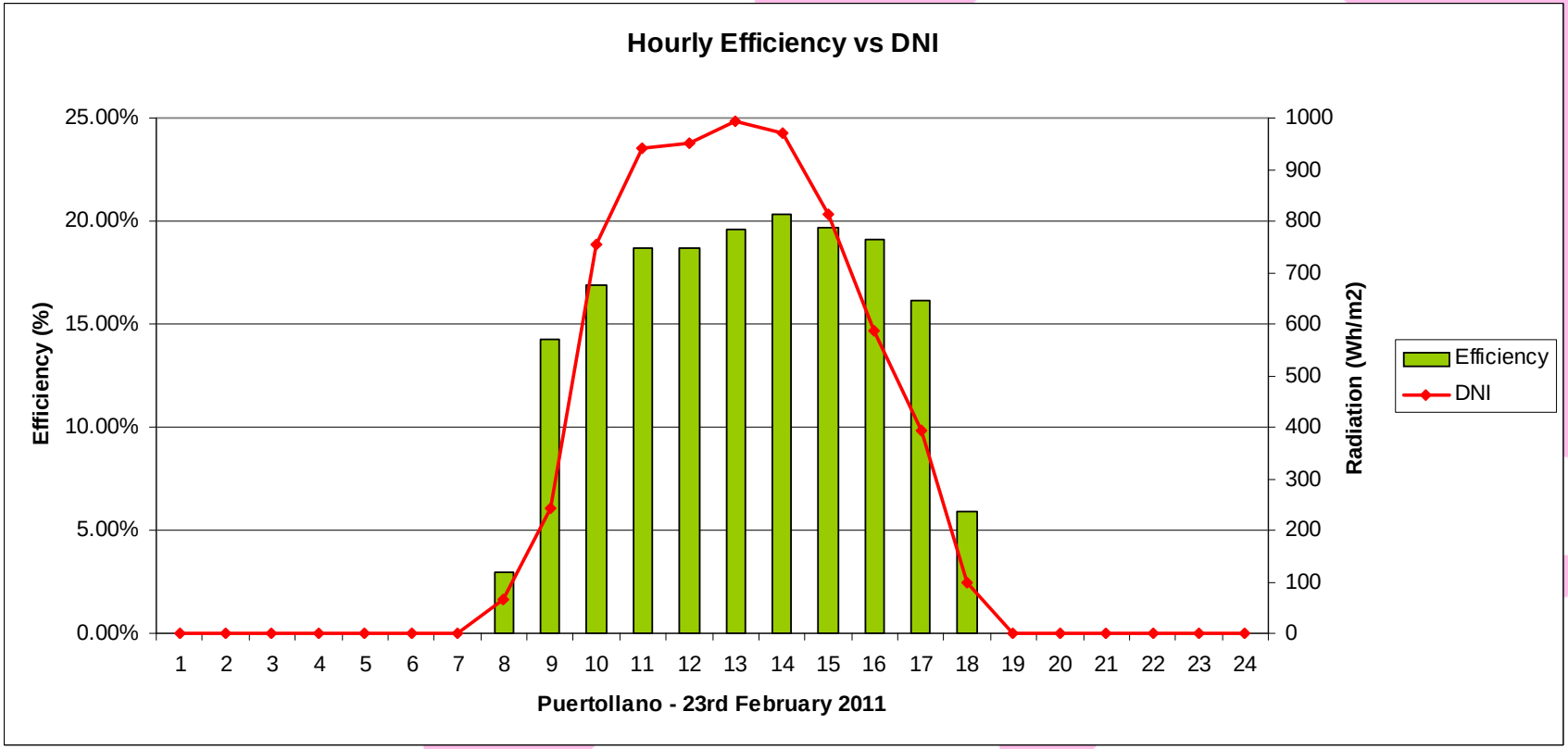
- Efficiencies until 19.0% in February 2010
-Temperatures between 2ºC and 7ºC



Season Production follow-up

Winter production in 2011

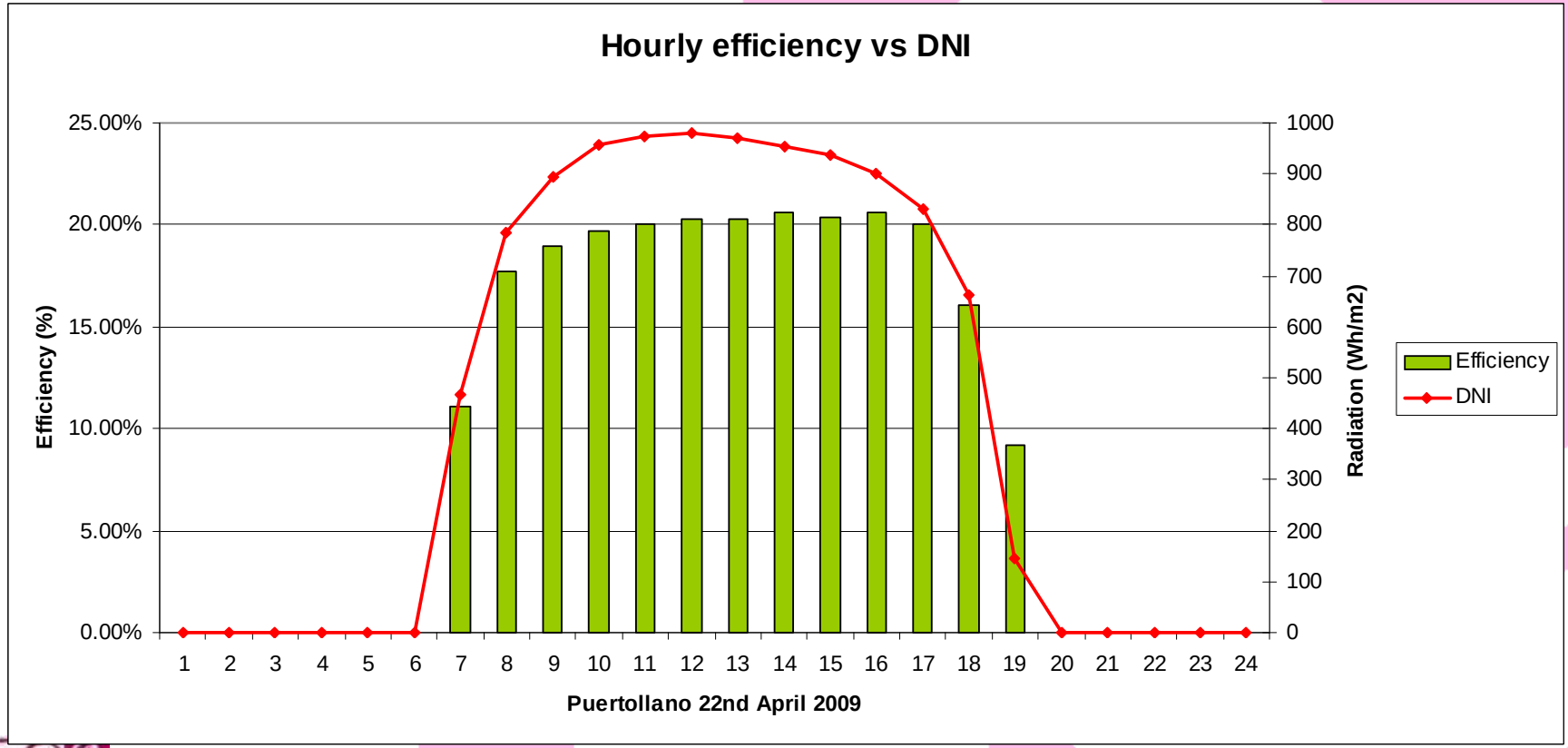
- Efficiencies until 20.0% in February 2011
-Temperatures between 3ºC and 17ºC



Season Production follow-up

Spring production in 2009

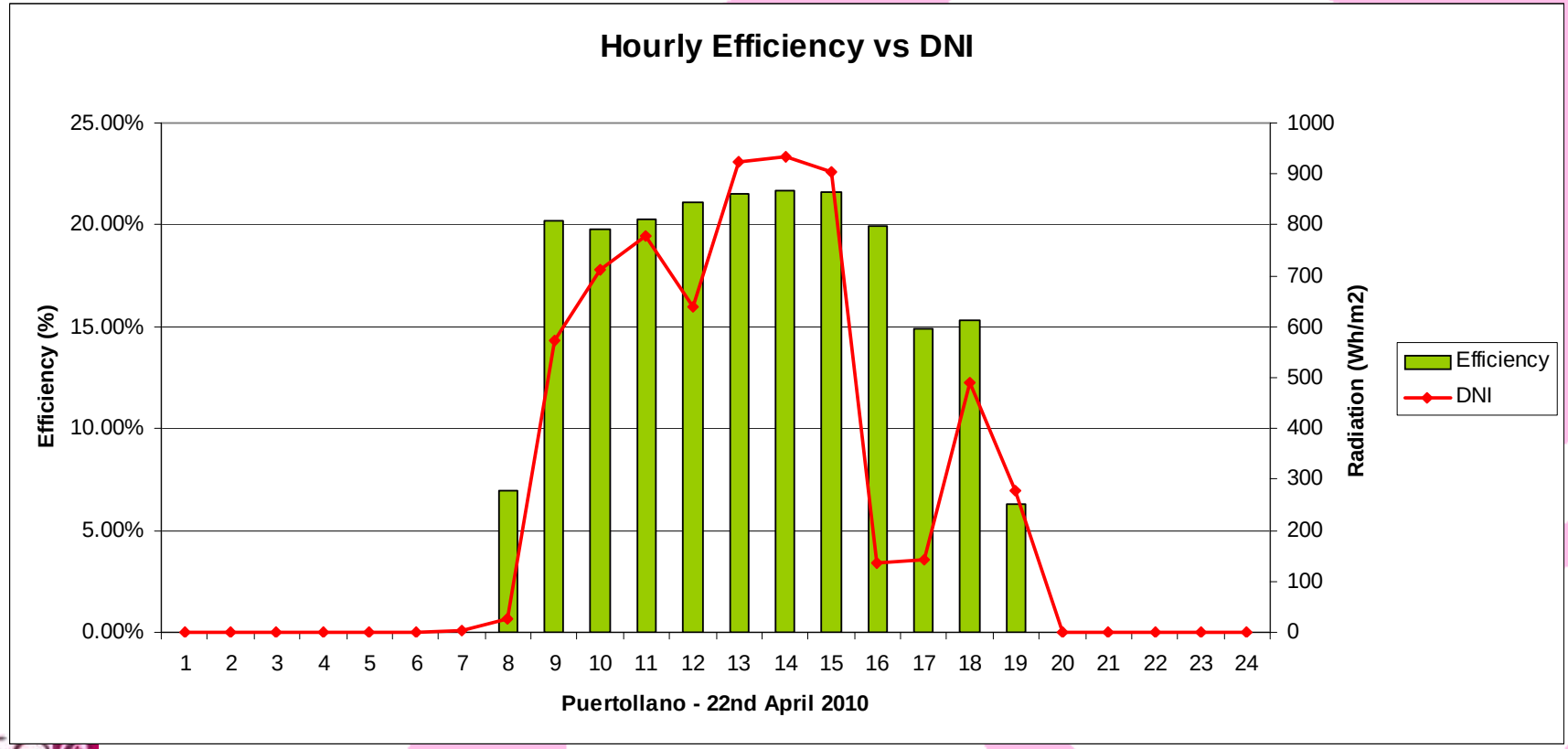
- Efficiencies until 20.6% in April 2009
-Temperatures between 8ºC and 20ºC



Season Production follow-up

Spring production in 2010

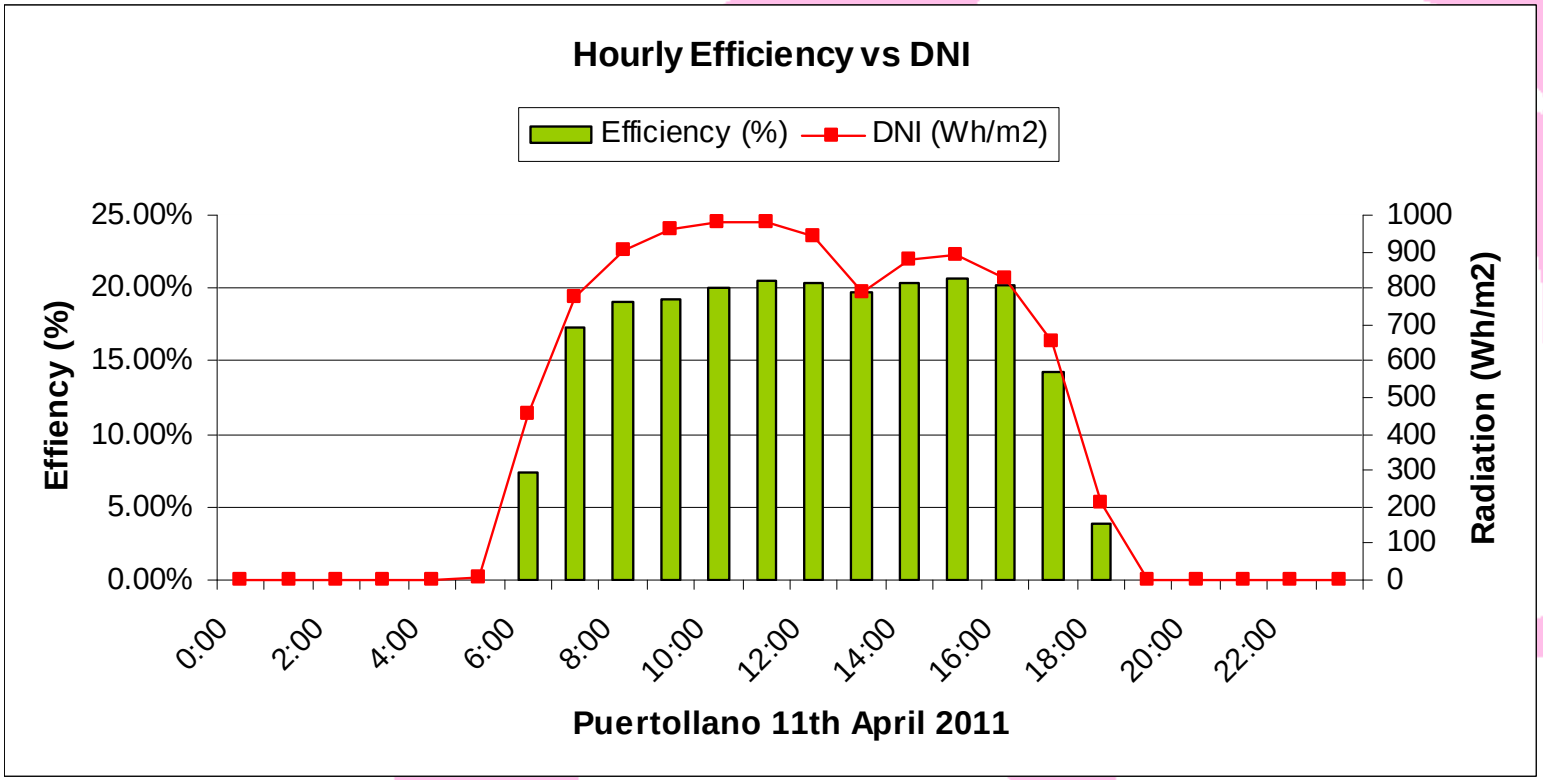
- Efficiencies until 21.7% in April 2010
-Temperatures between 12ºC and 19ºC



Season Production follow-up

Spring production in 2011

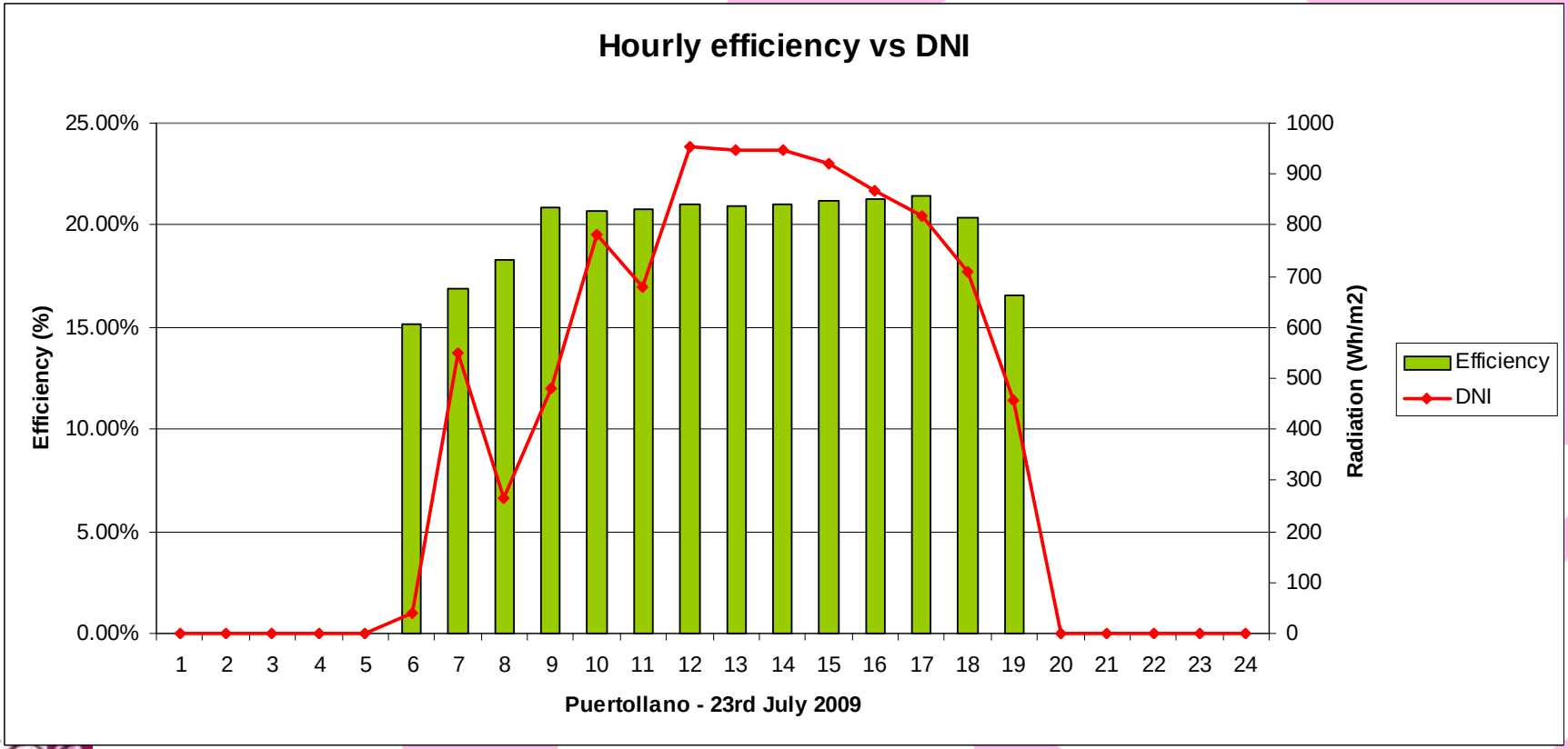
- Efficiencies until 20.7% in April 2011
-Temperatures between 12ºC and 20ºC



Season Production follow-up

Summer production in 2009

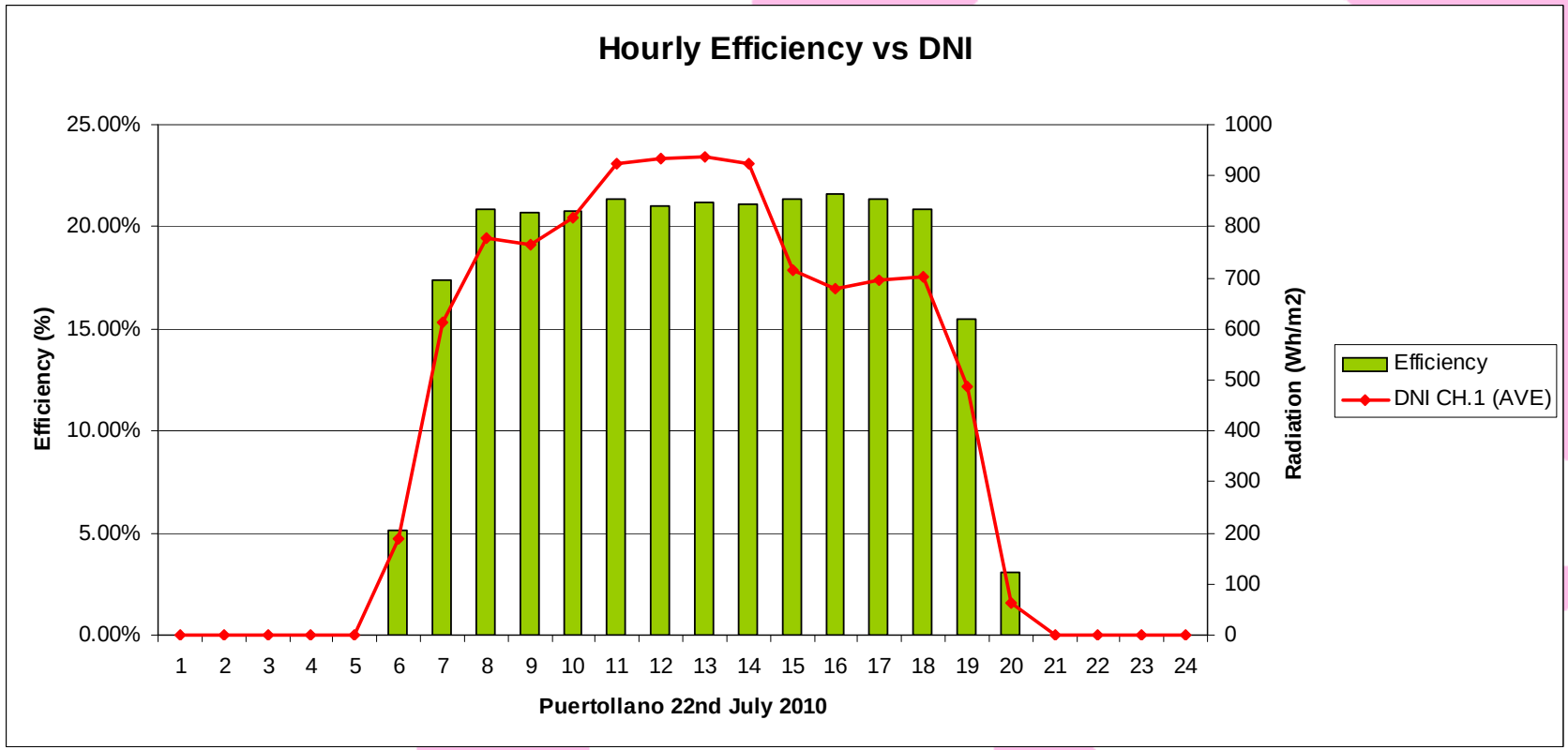
- Efficiencies until 21.4% in July 2009
-Temperatures between 20ºC and 32ºC



Season Production follow-up

Summer production in 2010

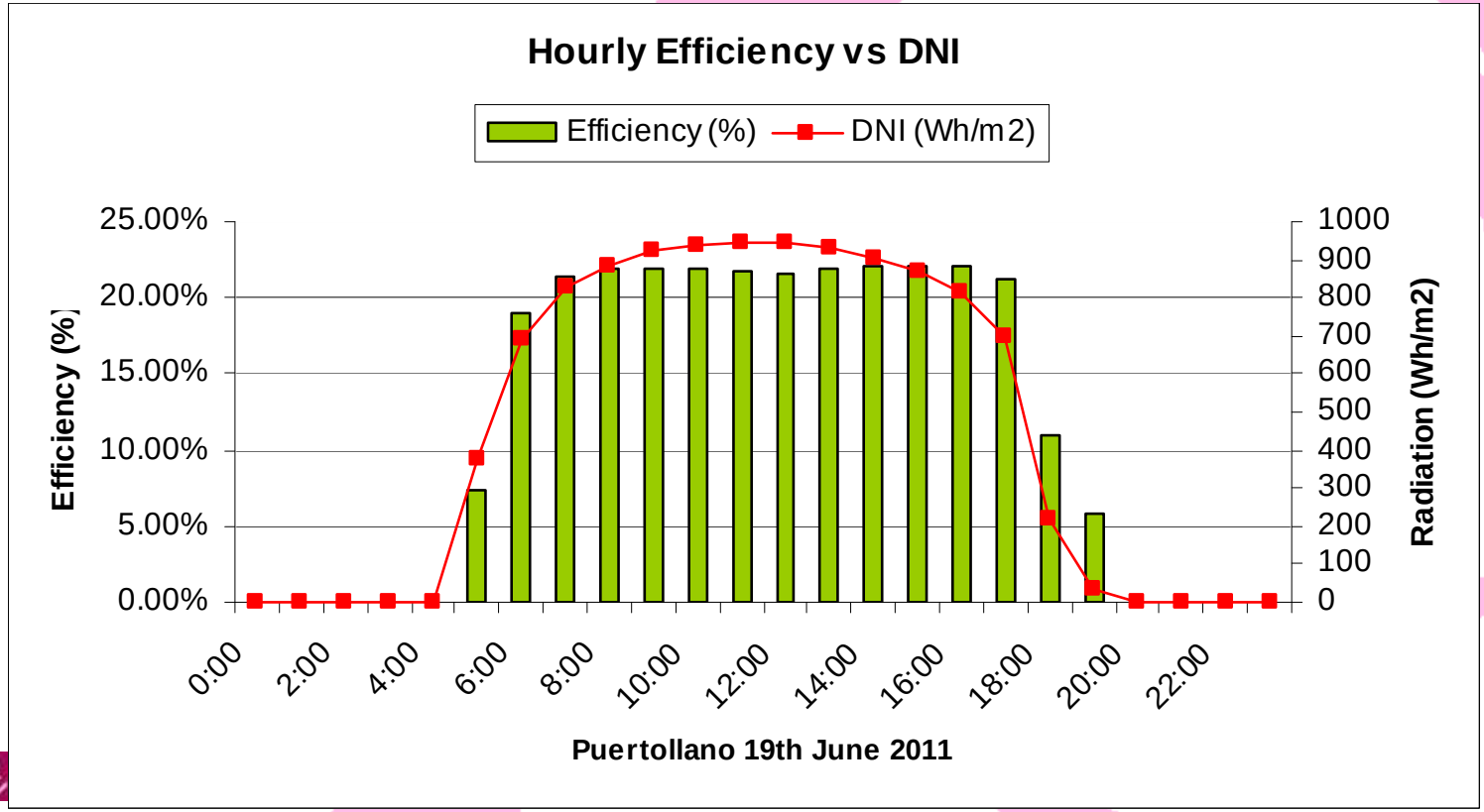
- Efficiencies until 21.5% in July 2010
-Temperatures between 21ºC and 32ºC



Season Production follow-up

Summer production in 2011

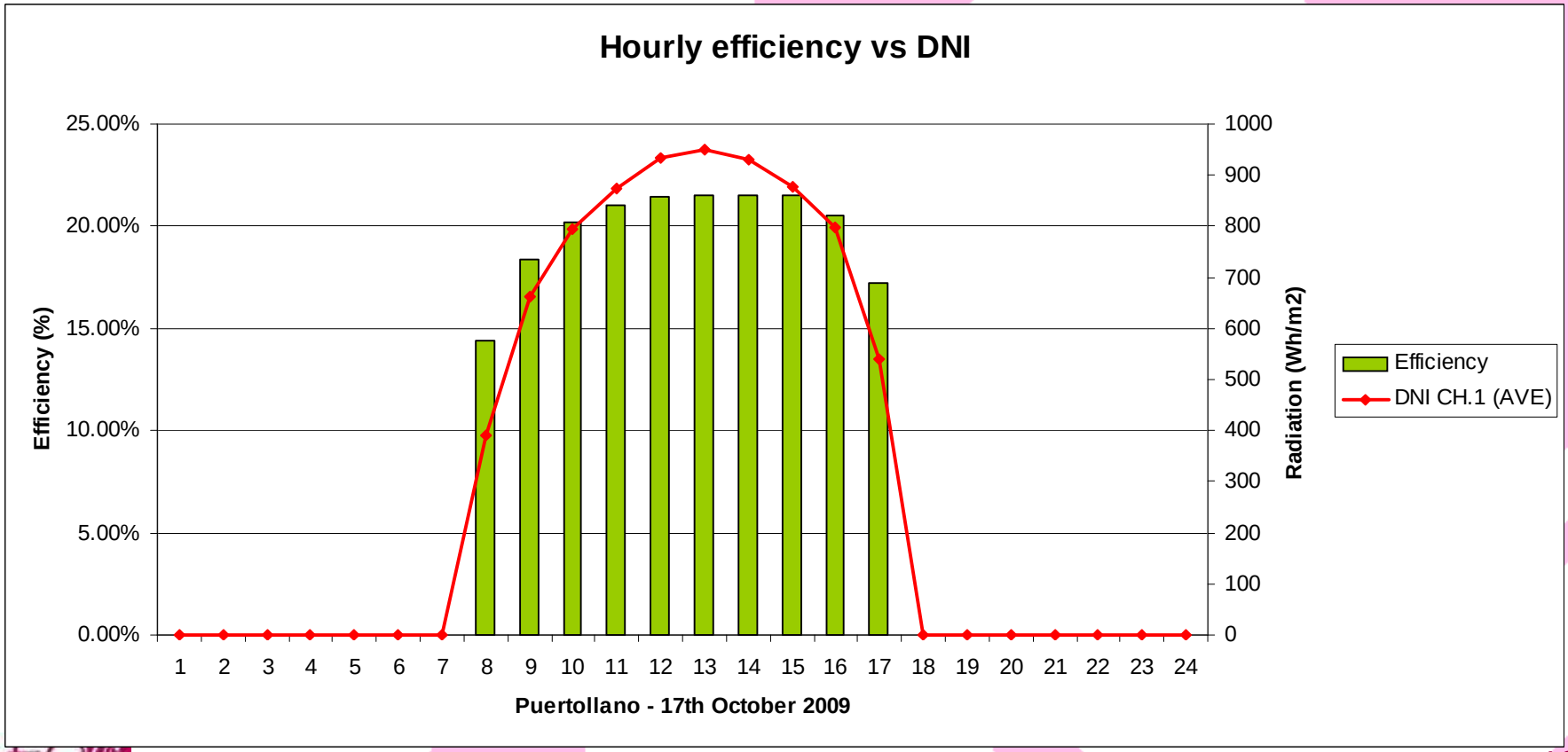
- Efficiencies until 22.1% in June 2011
-Temperatures between 17ºC and 34ºC



Season Production follow-up

Autumn production in 2009

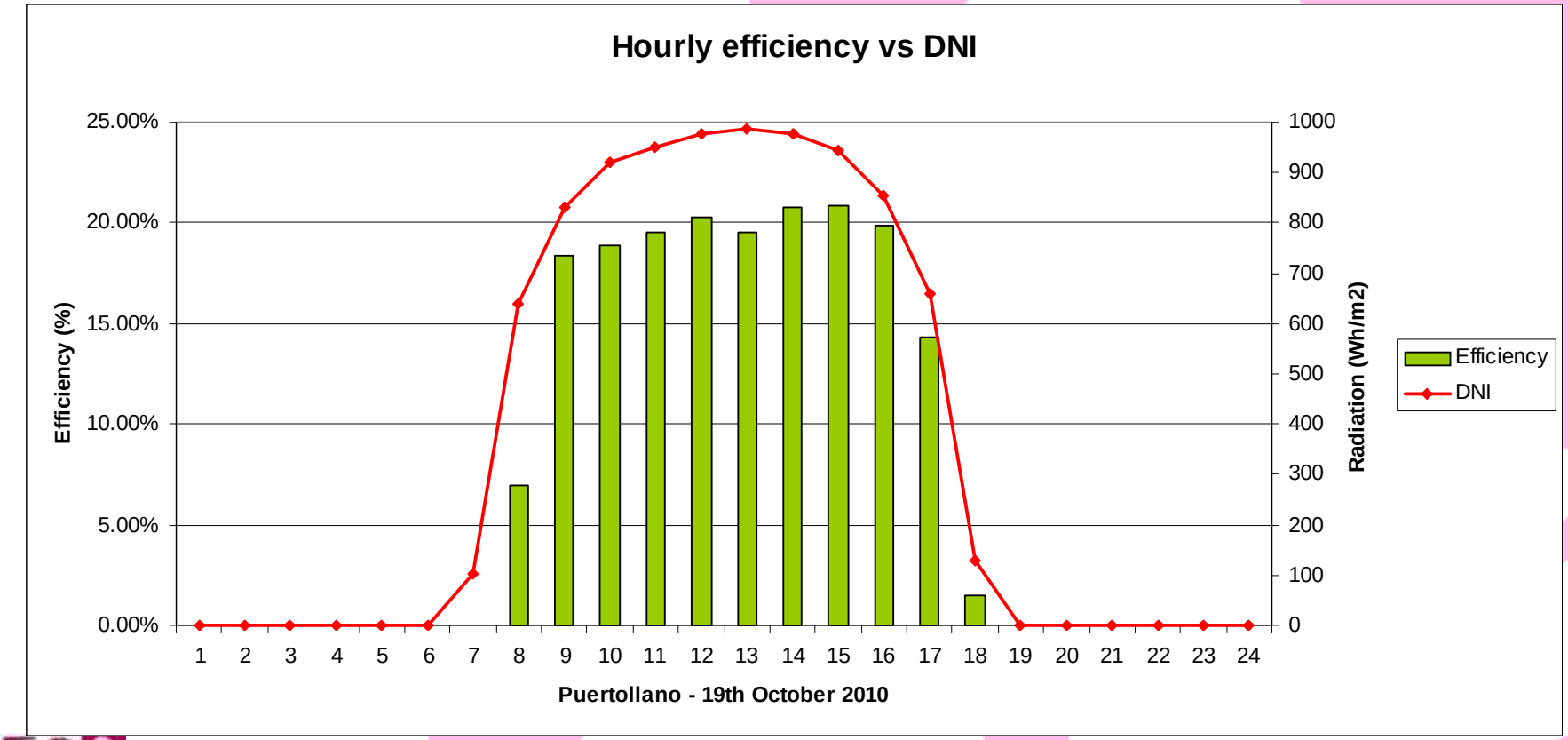
- Efficiencies until 21.5% in October 2009
-Temperatures between 7ºC and 22ºC



Season Production follow-up

Autumn production in 2010

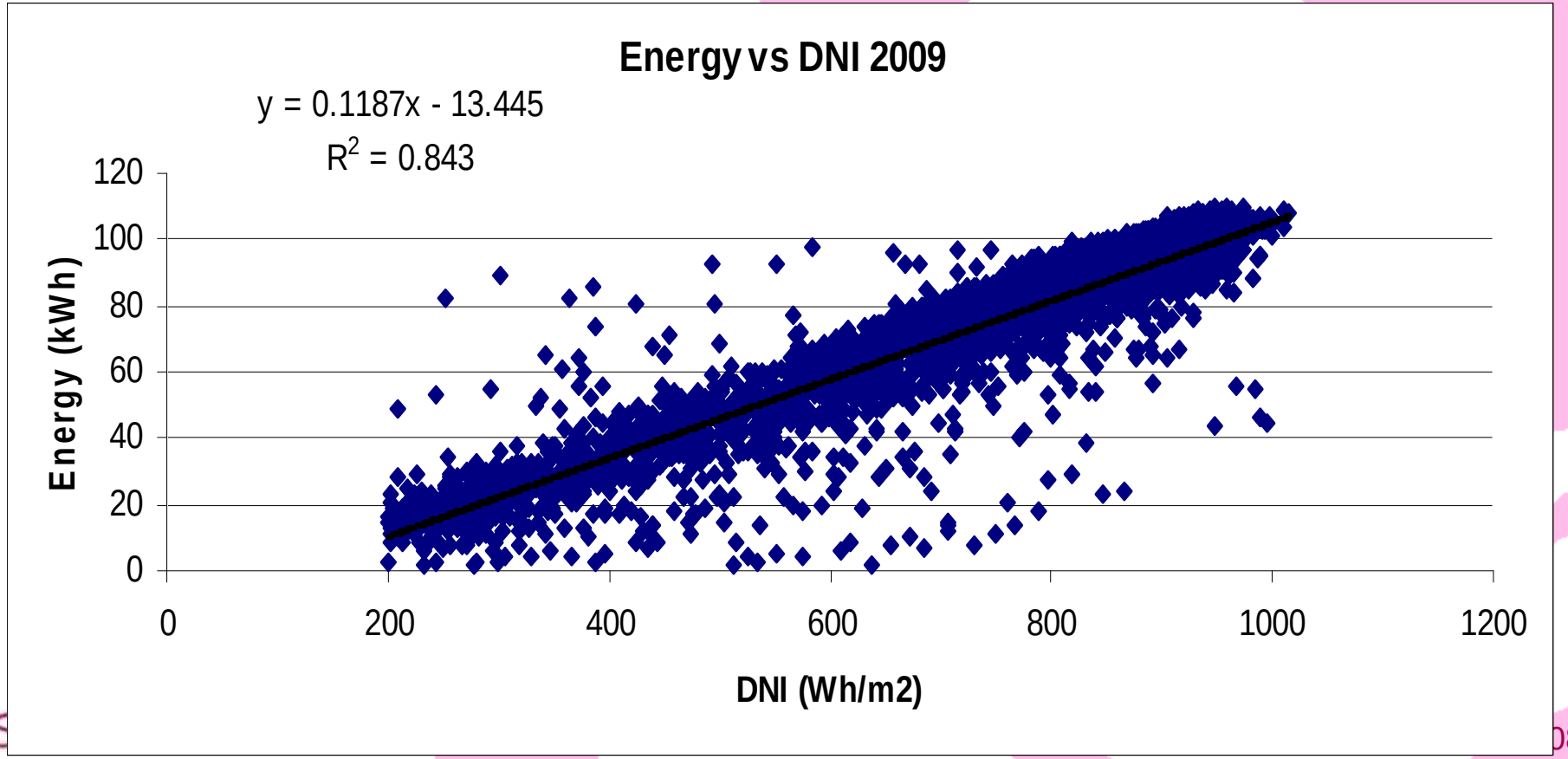
- Efficiencies until 20.7% in October 2010
-Temperatures between 3ºC and 19ºC



Method 2: Plant performance

Plant performance in 2009

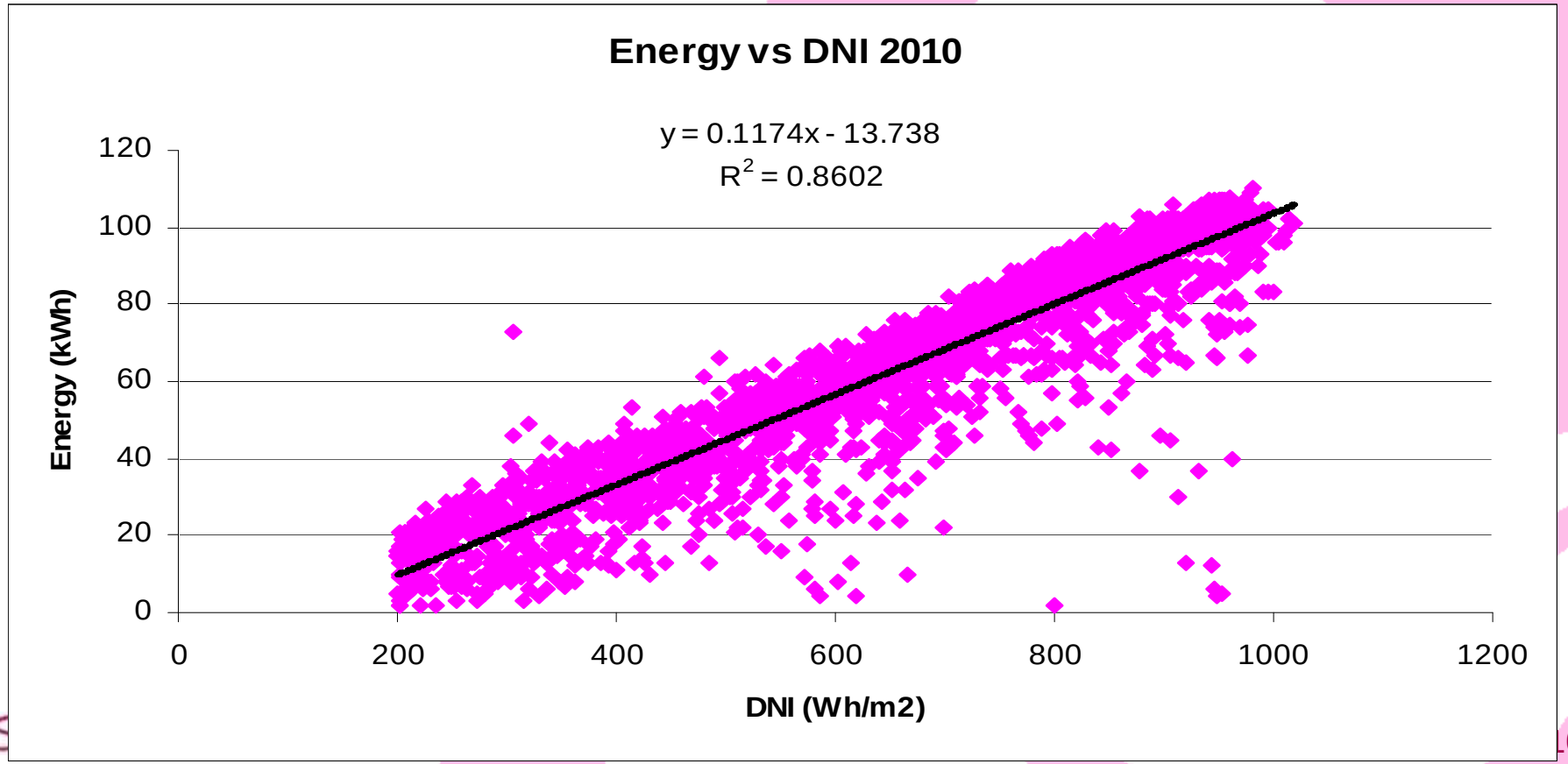
- Hourly data of Energy production vs DNI in 2009
- The efficiency is proportional to the slope



Plant performance

Plant performance in 2010

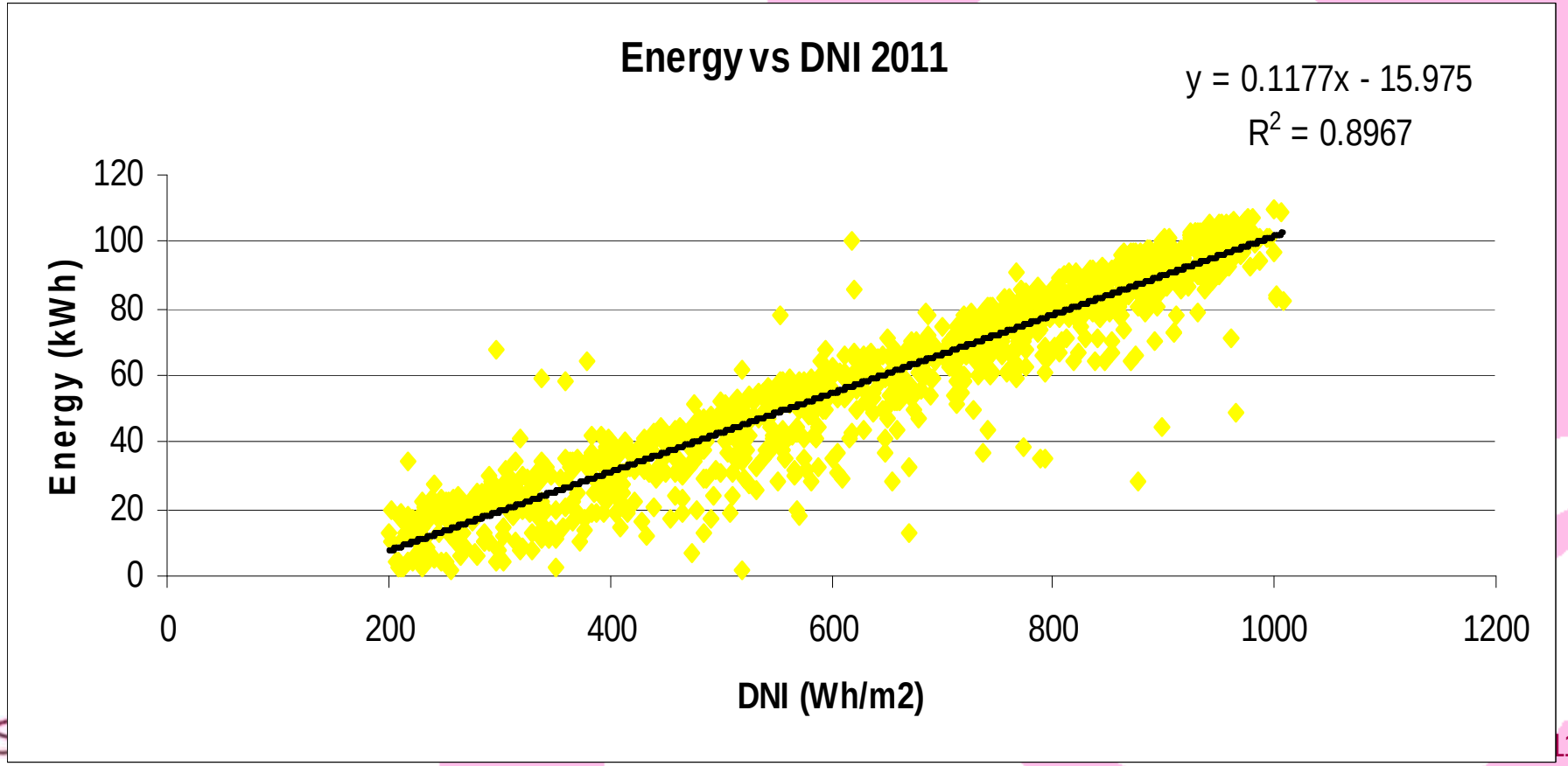
- Hourly data of Energy production vs DNI in 2010



Plant performance

Plant performance in 2011

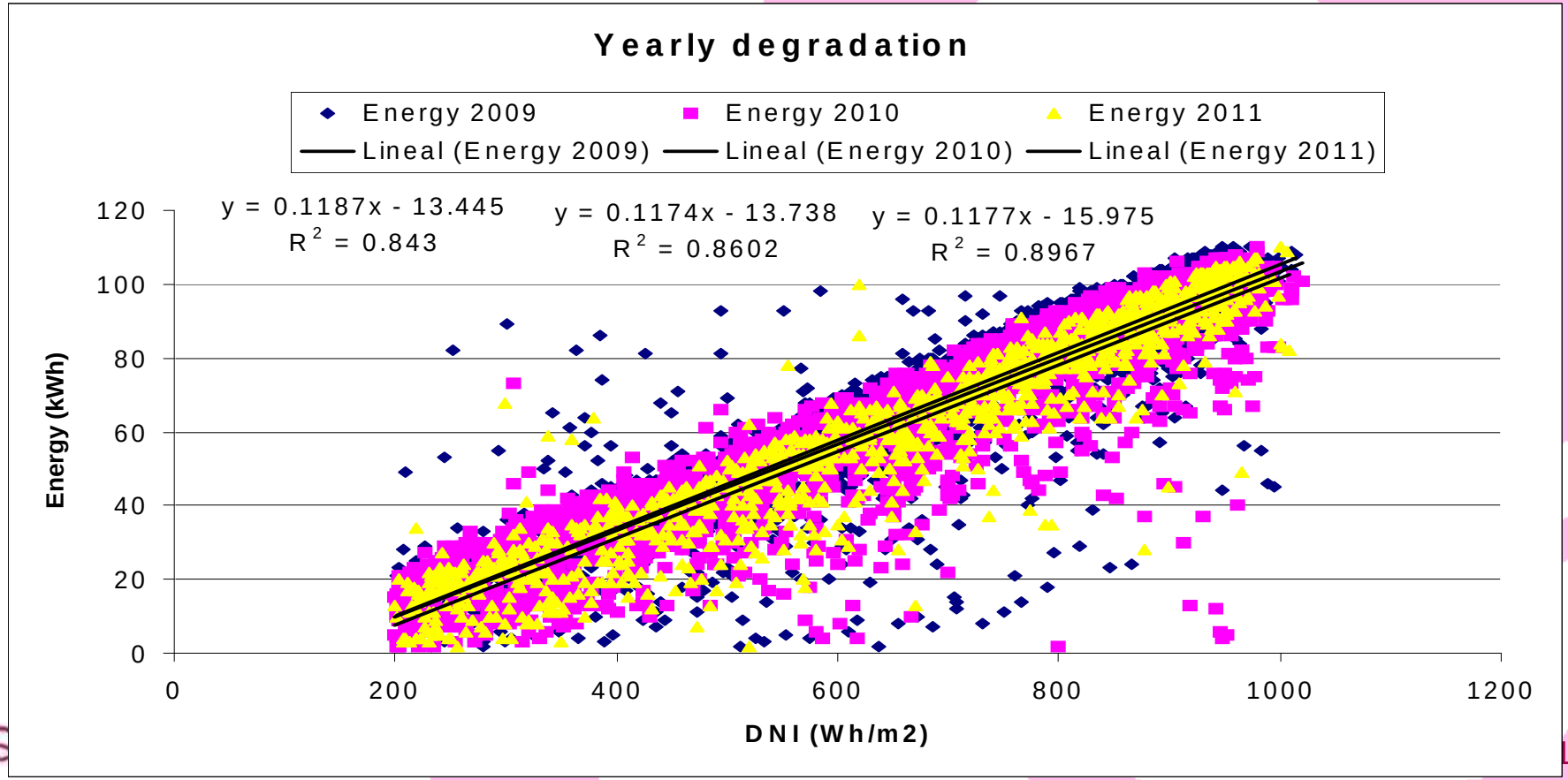
- Hourly data of Energy production vs DNI in 2011



Plant performance

Plant performance comparison

- Almost the same slope in the 3 years
- Only 0.84% difference between 2009 and 2011



Method 3: Concentrator Efficiency

- **Concentrator Efficiency after 3 years of production**

State	Date	Efficiency	Eff dif after 3 years	Cleanning difference
Dirty	11th July 2008	21.57%		
Clean	11th July 2008	23.08%		7%
Dirty	22nd March 2011	21.65%		
Clean	31st March 2011	22.72%	-2%	5%

Performance degradation

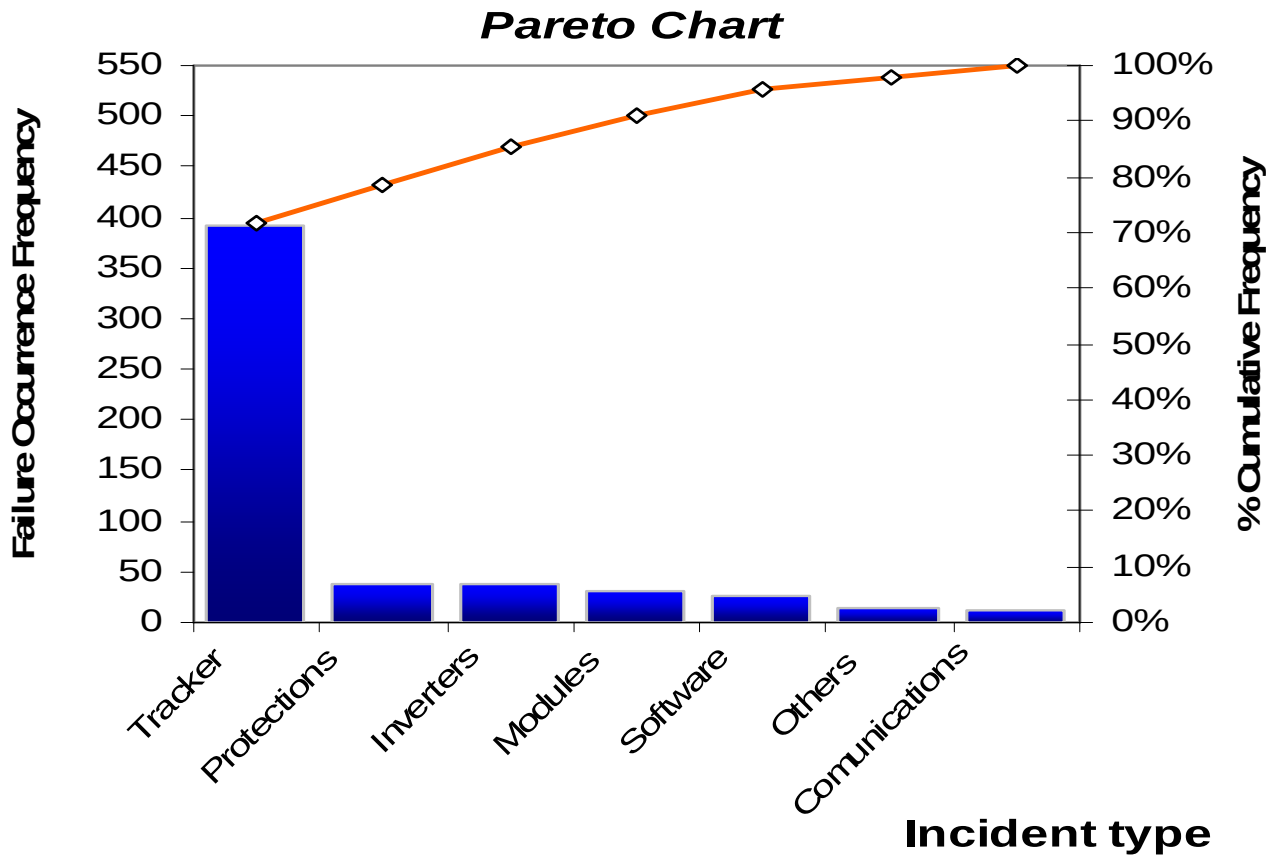
Conclusion

- No visible degradation in the analyzed plant after three years of operation
- No visible degradation in the analyzed concentrator after three years of operation

O&M issues

Operation and Maintenance issues by ISFOC

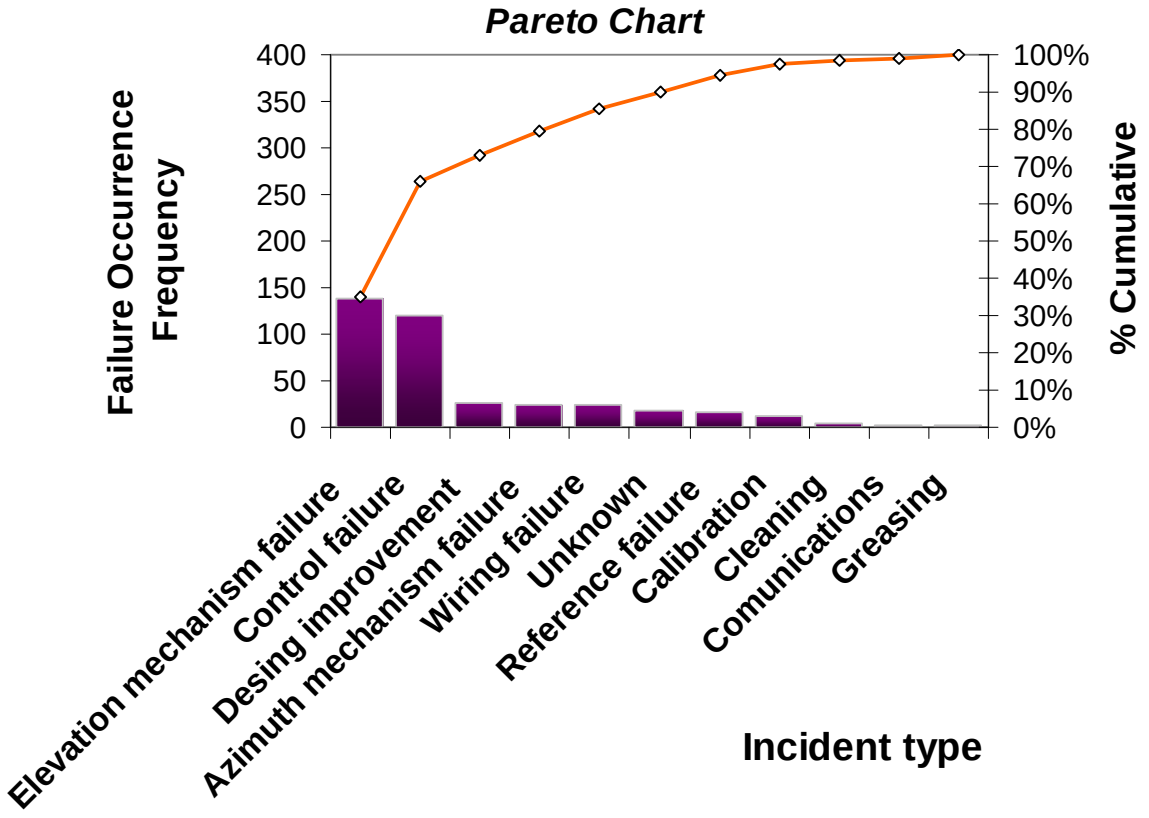
72% of the O&M issues comes from the trackers



O&M issues

Tracker issues explanation

The most important issues are elevation mechanism and control failures



Tracker issues

O&M issues

Tracker issues solutions

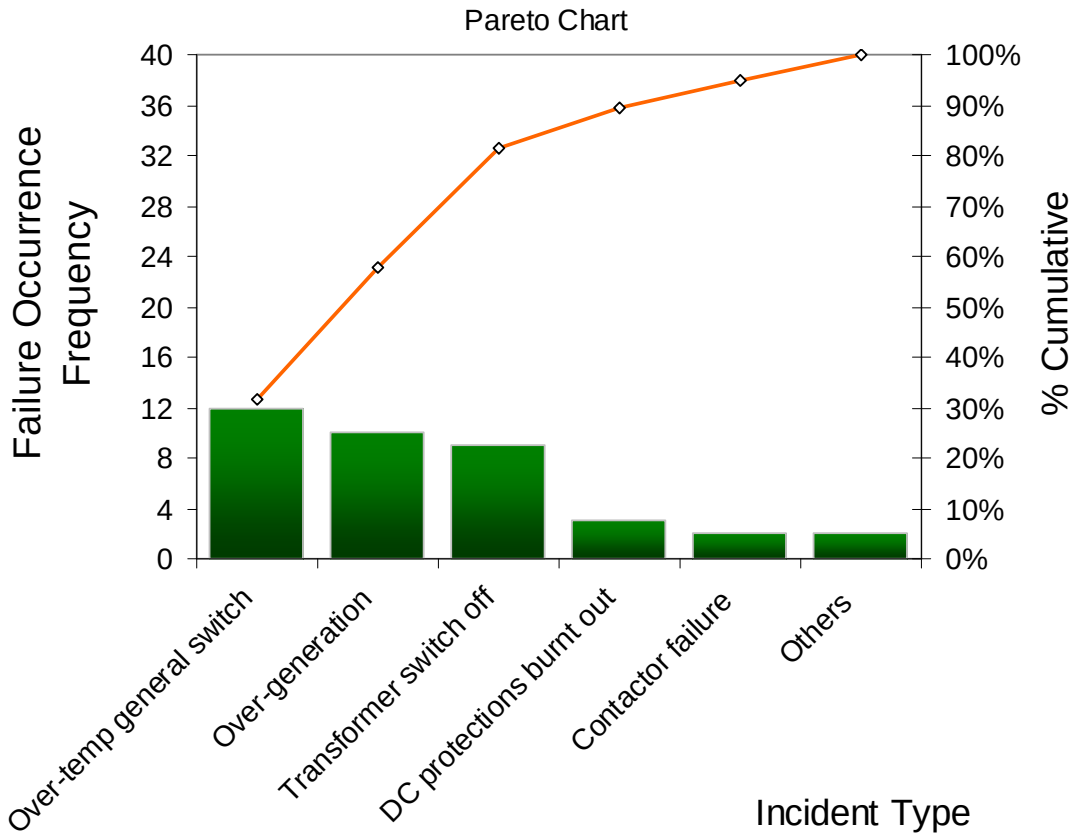
ISFOC, Spanish working group and IEC WG7 are working in new standards for tracker specification and qualification to improve the tracker's design

Most of the tracker issues by ISFOC have already been solved

O&M issues

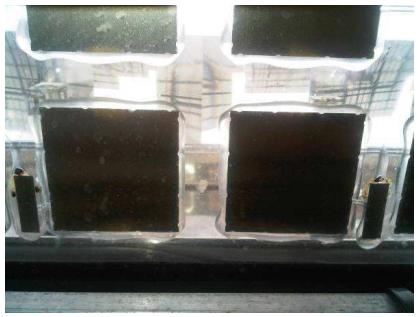
Protection and wiring issues explanation

The most important issues are linked with switches and overgeneration
Solution: Good design of the installations



O&M issues

- **Module issues: Very few modules found with minor issues generally not affecting production**



SOLVED IN THE PRESENT COMERTIAL GENERATION

O&M issues

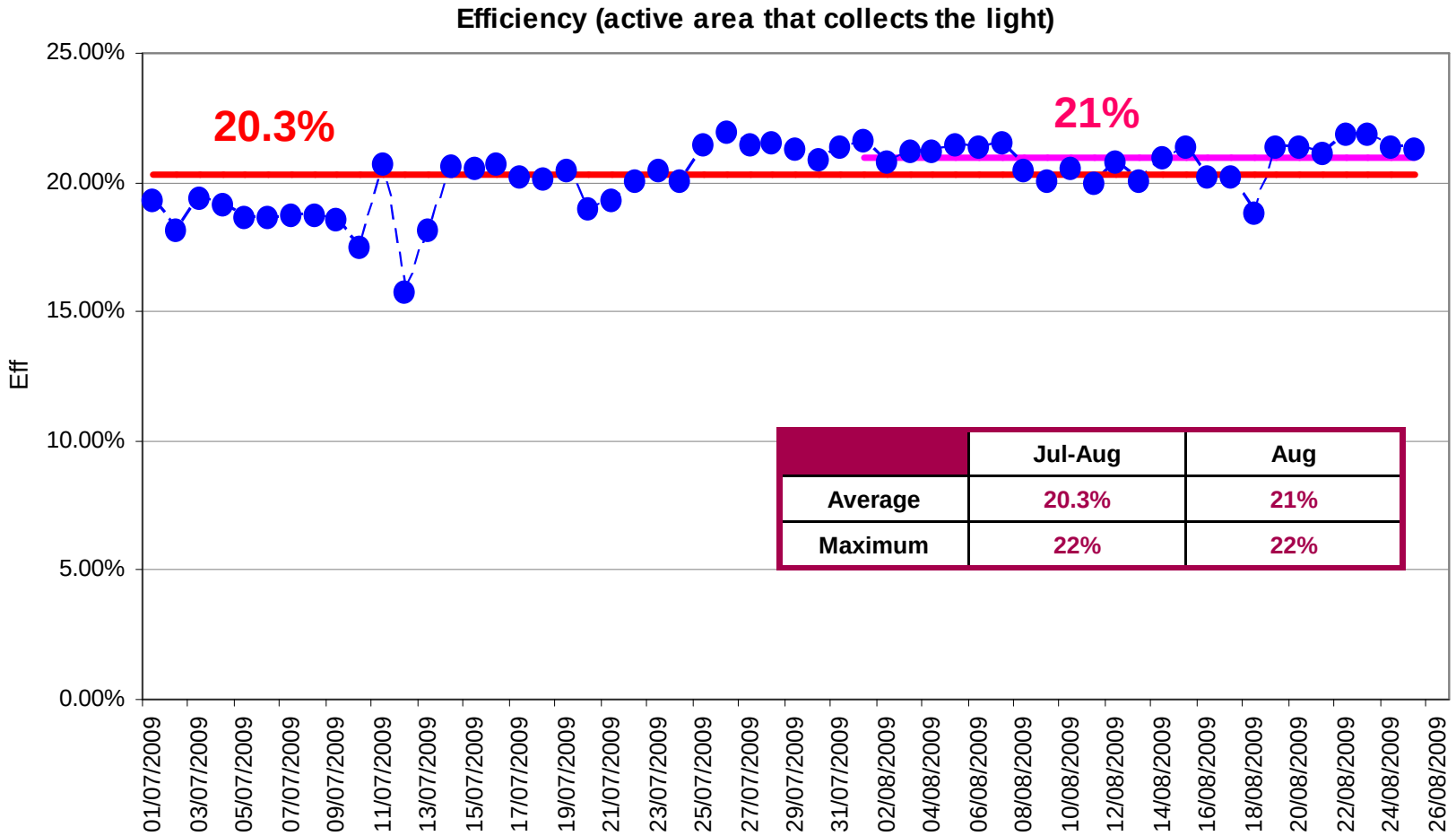
Conclusions

- Most of the Operation failures come from the trackers
- Many failures can be solved after reparation
- Qualification tests needed to avoid the tracker's failures
- Very few failures in modules, which can be solved with the experience in demonstration plants

Energy Production Data Analysis

Detailed analysis: Energy Production 1 CPV Plant (100kW)

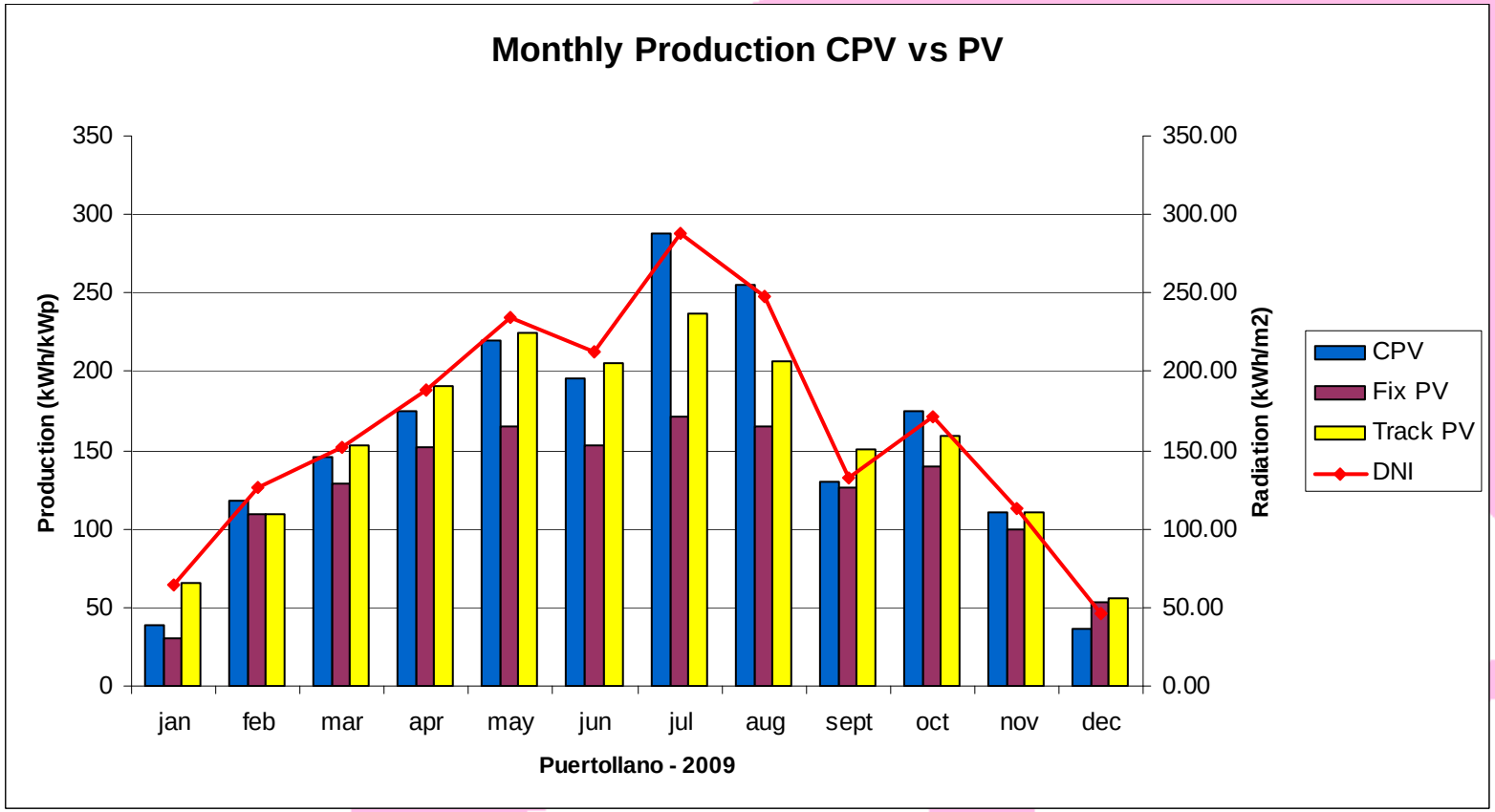
2009 data. July and August daily Energy generation



	Jul-Aug	Aug
Average	20.3%	21%
Maximum	22%	22%

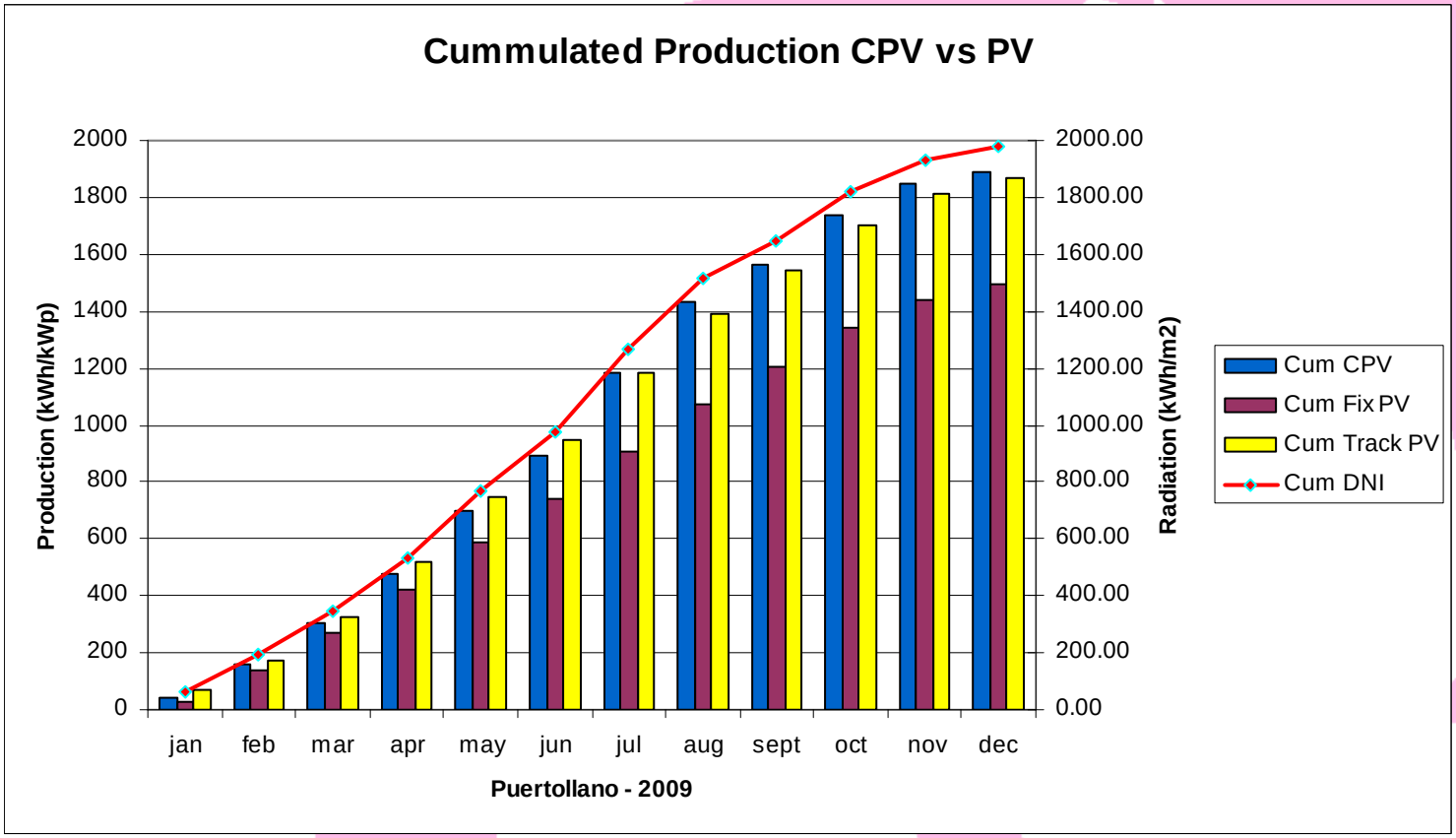
CPV vs PV production

- **CPV production much higher than tracked PV during summer in Puertollano in 2009**



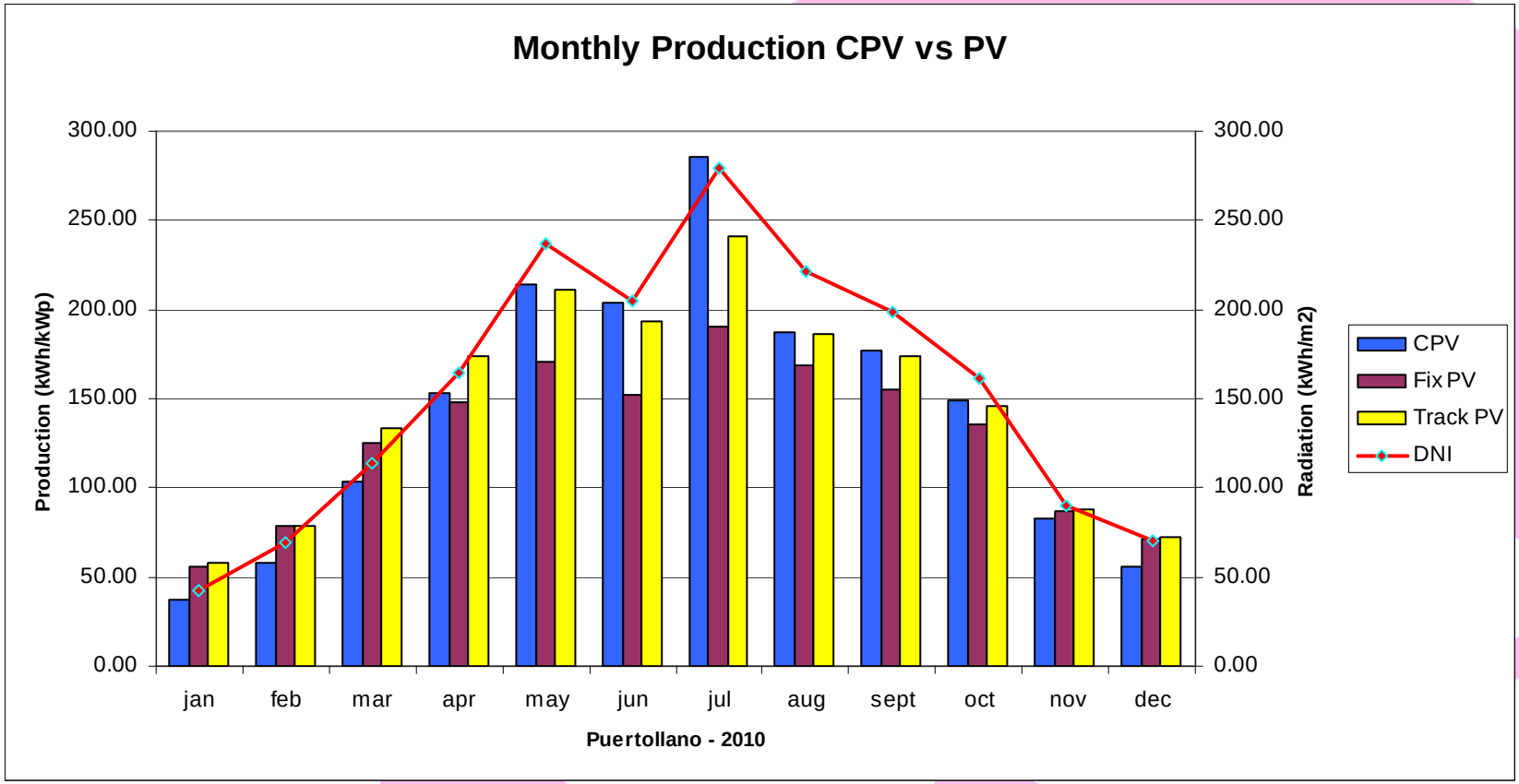
CPV vs PV production

- **Similar production for CPV and tracked PV in Puertollano in 2009**



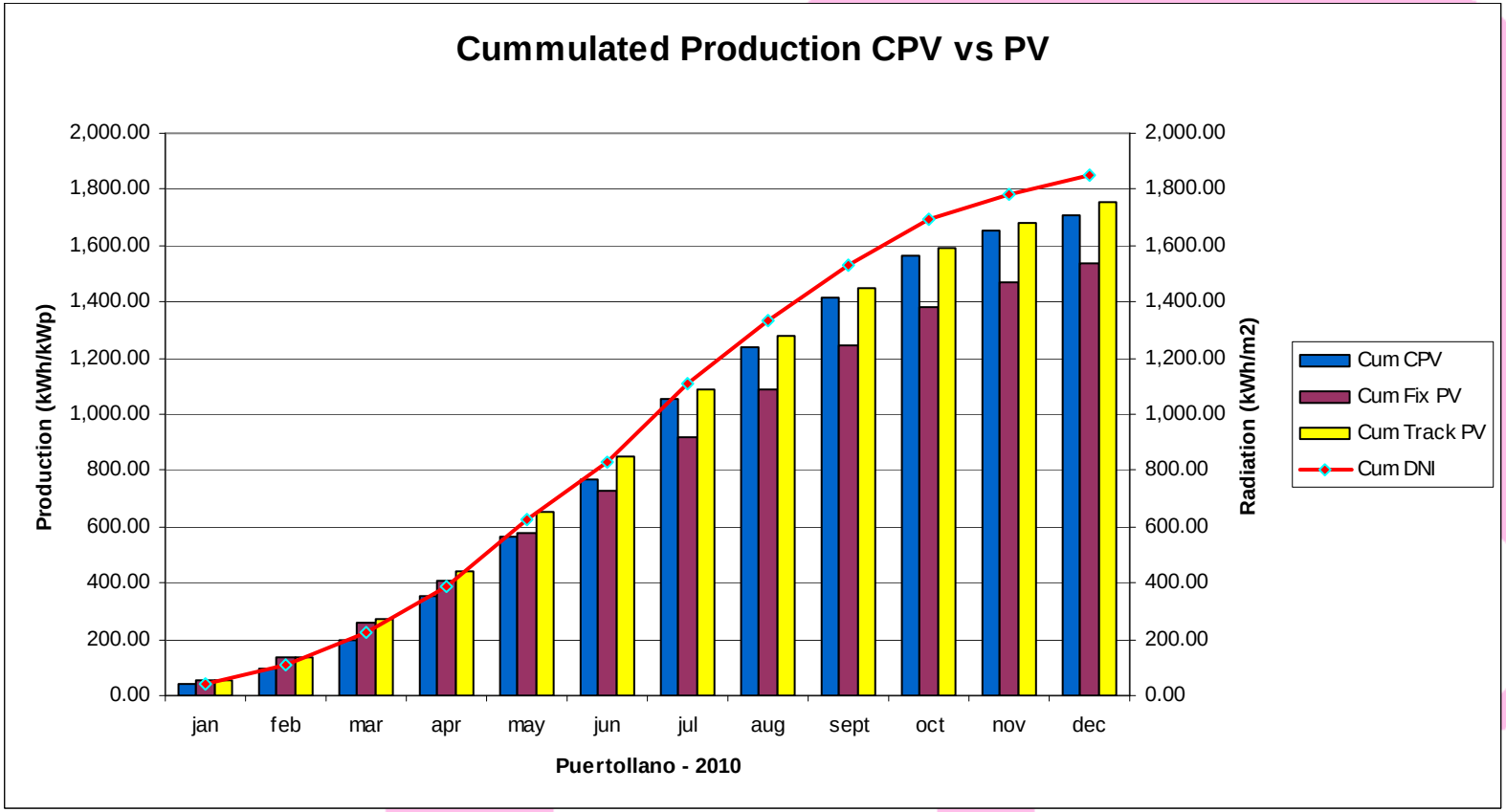
CPV vs PV production

- **CPV production higher than tracked PV during summer in Puertollano in the rainy 2010**



CPV vs PV production

- **Similar production for CPV and tracked PV in Puertollano in the rainy 2010**



Results: CPV – PV efficiency

- CPV efficiency increases with the DNI.
- PV efficiency decreases

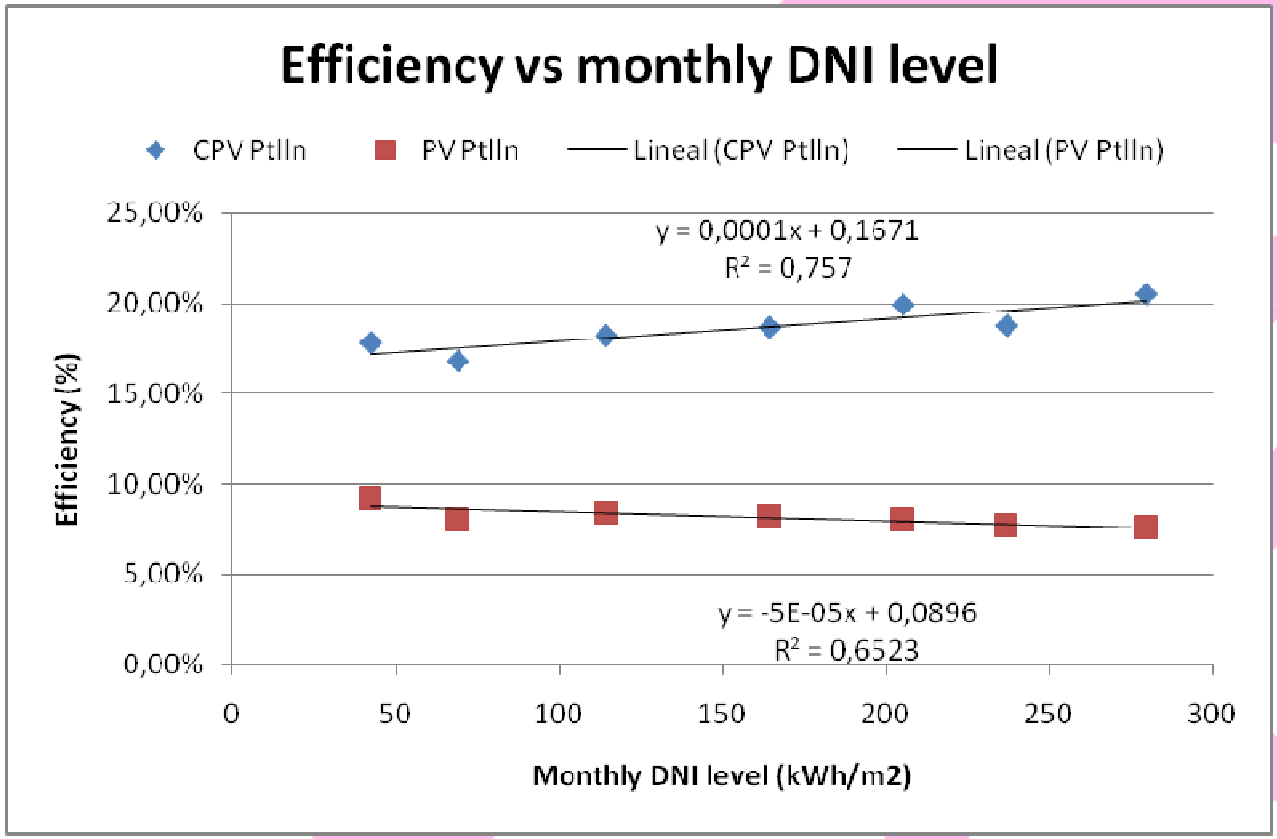


Figure 9: Monthly Efficiency versus DNI in Puertollano in CPV and tracked PV between the months of January 2010 and July 2010

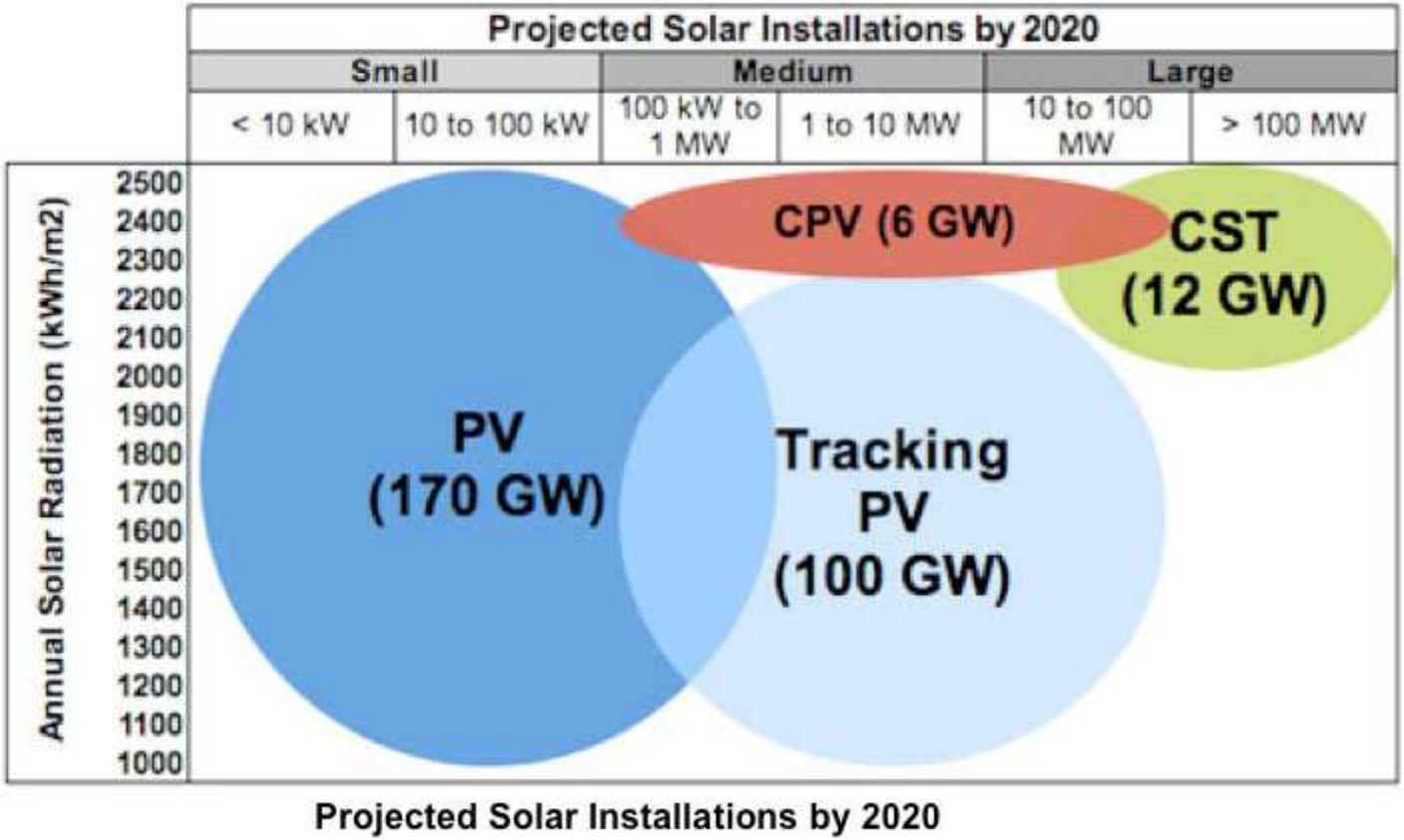
CPV vs PV

Conclusions

- Very similar production level between CPV and tracked PV systems in Puertollano, which is a medium sunny region, with the CPV rated at 850 W/m^2
- Fix PV has always less production than CPV and tracked PV systems
- Much better production of CPV in very sunny months

CPV market

CPV is desirable for high radiation location and all sizes plants



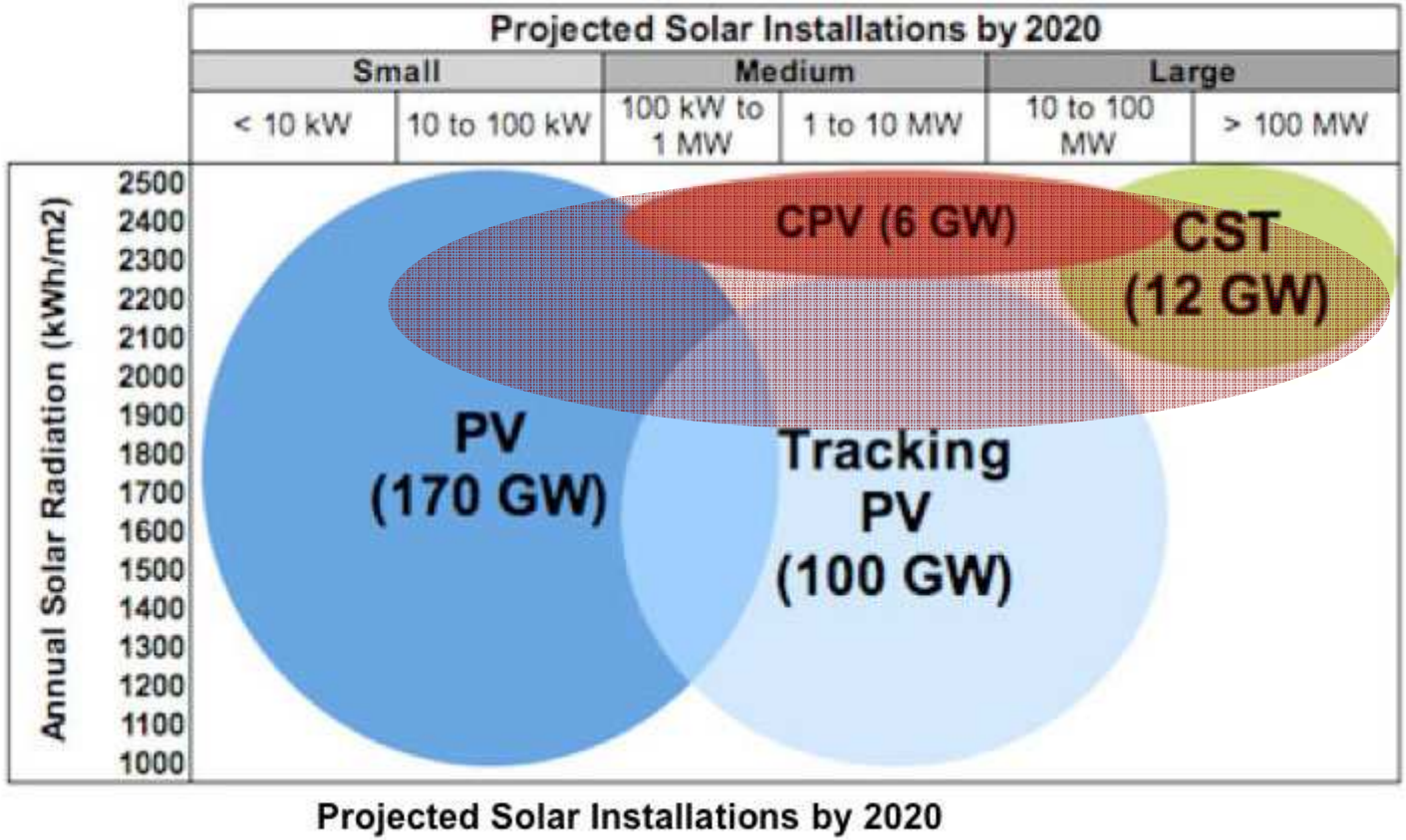
Projected Solar Installations by 2020

source: Prometheus Institute

ISFOC

CPV market

CPV is desirable for high radiation location and all sizes plants



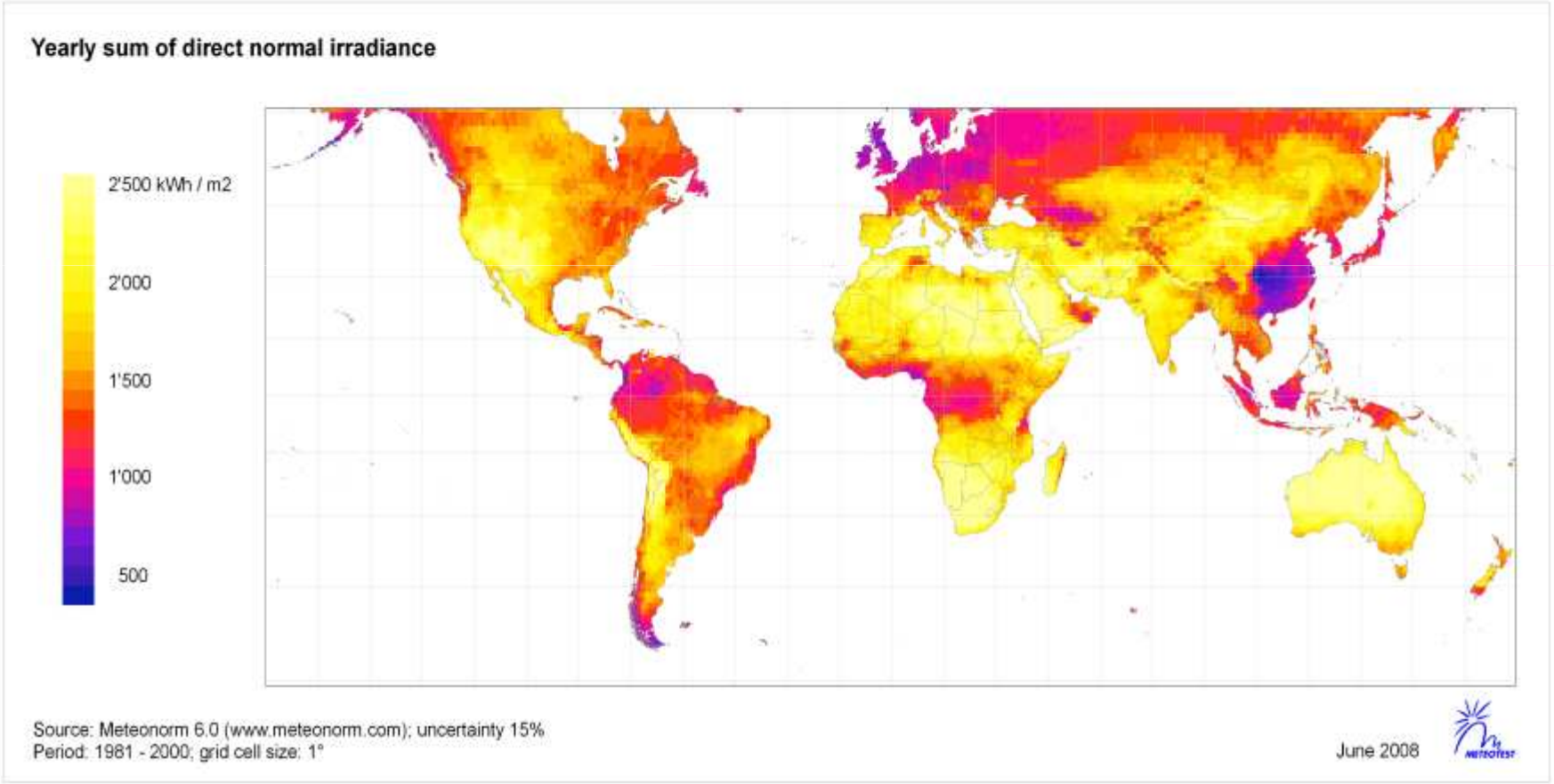
Projected Solar Installations by 2020

source: Prometheus Institute

ISFOC

DNI – Direct radiation map

Many high radiation locations in the world for CPV market



ISFOC

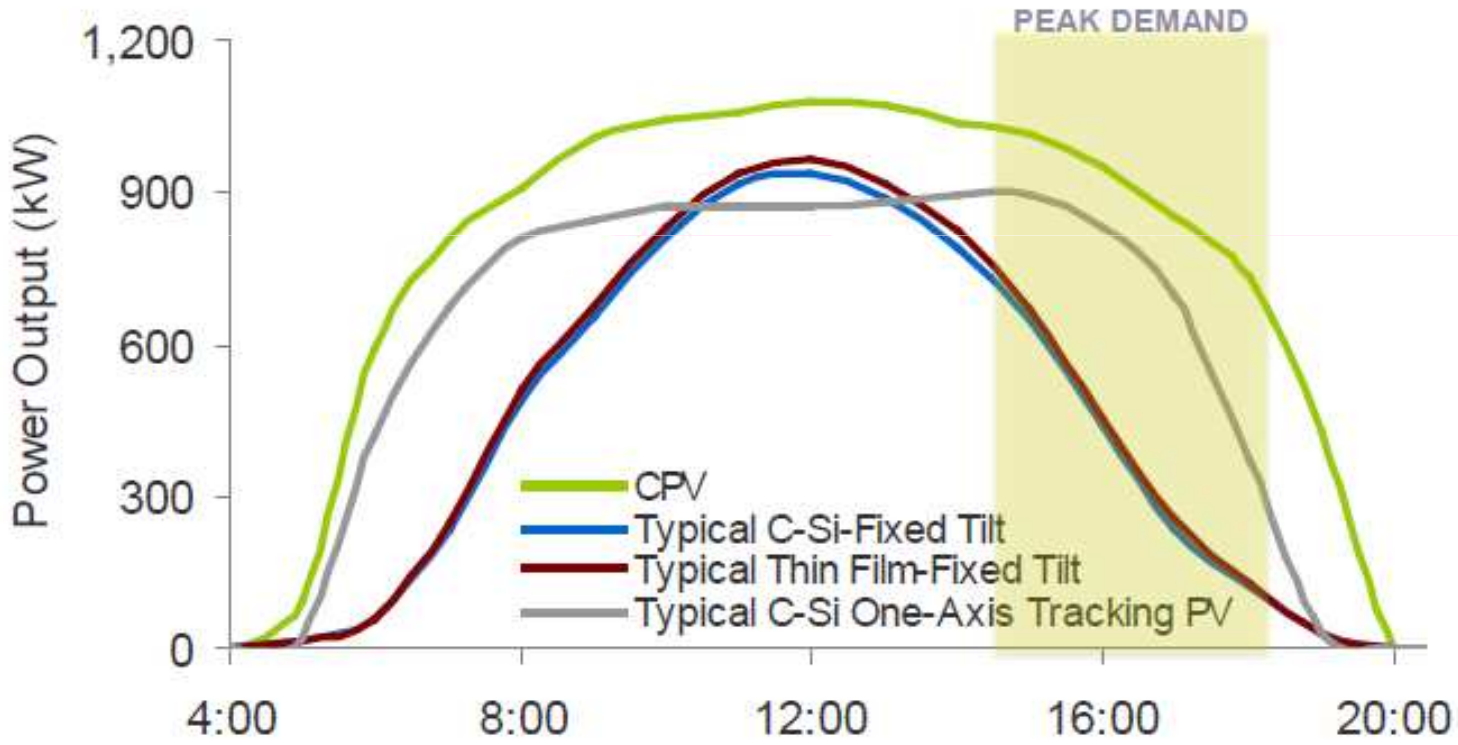
Other advantages

Enviromental advantages

- No Permanent Shadowing
- Minimal Impact to Land
- Dual Land Usage
- Flexible Layout Sites
- No Water Usage for Electricity Generation

Other advantages

Production during the peak demand



CPV situation

MANUFACTURERS	Company	On sun (MW)	Plants location
Abengoa Solar	Spain	1.2	Spain
Guascor foton	Spain	10.275	Spain
Isofotón	Spain	0.4	Spain
Renovalia CPV CS La Mancha	Spain	0	Spain
Sol 3G	Spain	1.4	Spain
Concentrix	Germany	1.76	0,5 Spain &world
Solfocus	USA	4.5	0,5MW Spain & 2MW USA
EMCORE	USA	1.65	Spain & China (1MW)
AMONIX	USA	0.61	USA
Arima ECO	Taiwan	0.33	Spain and Taiwan
Solar Systems	Australia	1.2	Australia
Opel	USA	0.4	Spain
Magpower	Portugal	0.1	Portugal
Everphoton	Taiwan		
Energy Innovations	USA		
Zenith Solar	israel	0.225	Israel
TOTAL		**23.32**	

CPV situation

CPV Companies	Company location
American CPV	USA
Amonix	USA
Boeing	USA
Concentrating Technologies	USA
Cool earth Solar	USA
Edtek	USA
EMCORE	USA
Energy Innovations	USA
Enfocus Engineering	USA
Entech	USA
GreenVolts	USA
IBM	USA
JX Crystal	USA
Opel International	USA
Pyron Solar	USA
Scaled Solar	USA
Semprius	USA
Skyline	USA
SolarTech	USA
Solfocus	USA
Soliant Energy	USA
SUNRGI	USA
Xtreme Energetics	USA
ZettaSun	USA
Menova	Canada
Morgan Solar	Canada
Zyrtech solar	Israel
Verilite	Israel
MST	Israel
Zenithsolar	Israel
Heliofocus	Israel

CPV Companies	Company location
Abengoa Solar	Spain
Concentralia	Spain
Guascor Foton	Spain
Isofoton	Spain
Renovalia CPV	Spain
Sol 3G	Spain
Soltec	Spain
Zytech solar	Spain
CPOWER	Italy
ENEA	Italy
Magpower	Portugal
Concentrix	Germany
Solar Tec AG	Germany
Absolicon	Sweden
Circadian Solar	UK
Silicon CPV	UK
Whitfield Solar	UK
Sichuan Zhonghan Solar Power Co. Ltd	China
ES System	Korea
Daido Steel	Japan
Sharp Solar	Japan
Arima ECO	Taiwan
Compsolar	Taiwan
Delta Electronics	Taiwan
Everphoton Energy	Taiwan
Spirox	Taiwan
Concentrating Solar Systems	Australia
Green and Gold Energy	Australia
Solar Systems	Australia

INTERNATIONAL CPV8 CONFERENCE

CPV8 Conference will be organized by ISFOC in 2012

Location: **Toledo (Spain)**

Date: **16th -19th April 2012**

CPV-8

8. International Conference on Concentrating Photovoltaic Systems

Conclusions

- Technology ready
- Life time cycle
- ISFOC Positioning
  - First installations and R&D plan
  - CPV production higher than PV production in sunny locations
  - Degradation study
- New CPV manufacturers
- CPV advantages
- CPV IS STARTING THE DEPLOYMENT WITH VERY BIG PLANTS!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ISFOC
THANKS FOR YOUR ATTENTION!!!