



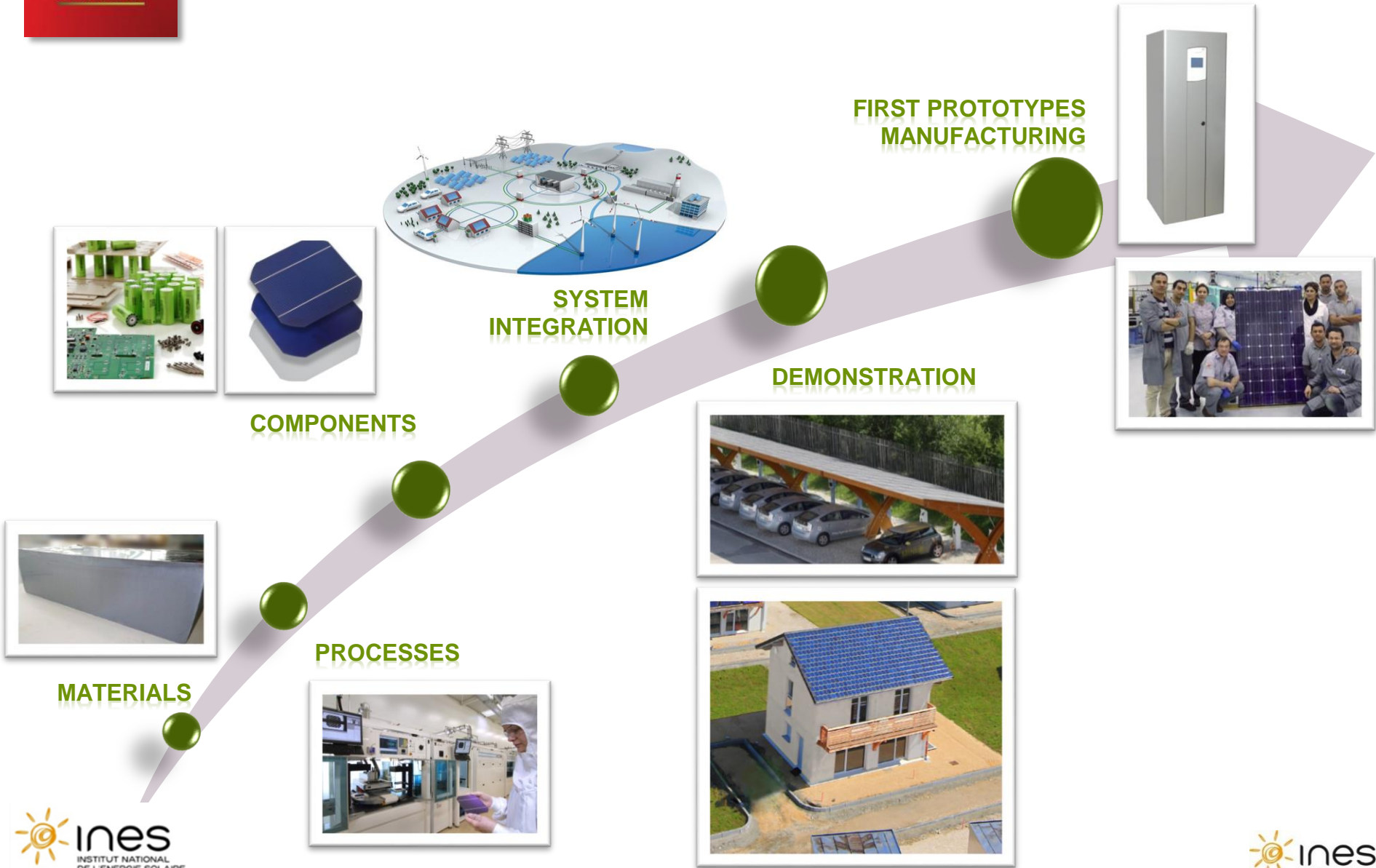
FIRST MONITORING RESULTS OF BIFACIAL SYSTEMS IN DIFFERENT CONFIGURATIONS

BIFIPV workshop –Miyazaki 29-30/09/2016

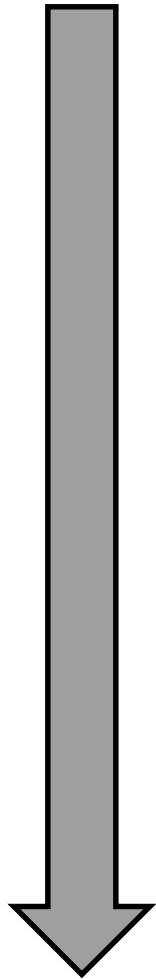
*Y. Veschetti, H. Colin, N. Chaintreuil, V. Soulima- Samouillo,
A. Plissonnier, P. Lefillastre, O. Wiss, M. Joanny, F. Al-Sharkarchi*

- **MOTIVATION IN BIFACIAL CONCEPT AT CEA-INES**
- **OUTDOOR MONITORING OF SINGLE BIFACIAL MODULE**
- **NEW BIFACIAL SYSTEMS PRESENTATION**
- **FIRST MONITORING RESULTS**
- **CONCLUSION & PERSPECTIVES**

INES: COVERING THE VALUE CHAIN



CEA-INES: STRONG INTEREST IN BIFACIAL



Cell level

- Development bifacial technologies (PERT & HJT)
- Industrialization
- Efficiency

Module level

- Development of bifacial module
- Efficiency
- Weight
- Certification
- Bifacial optimization

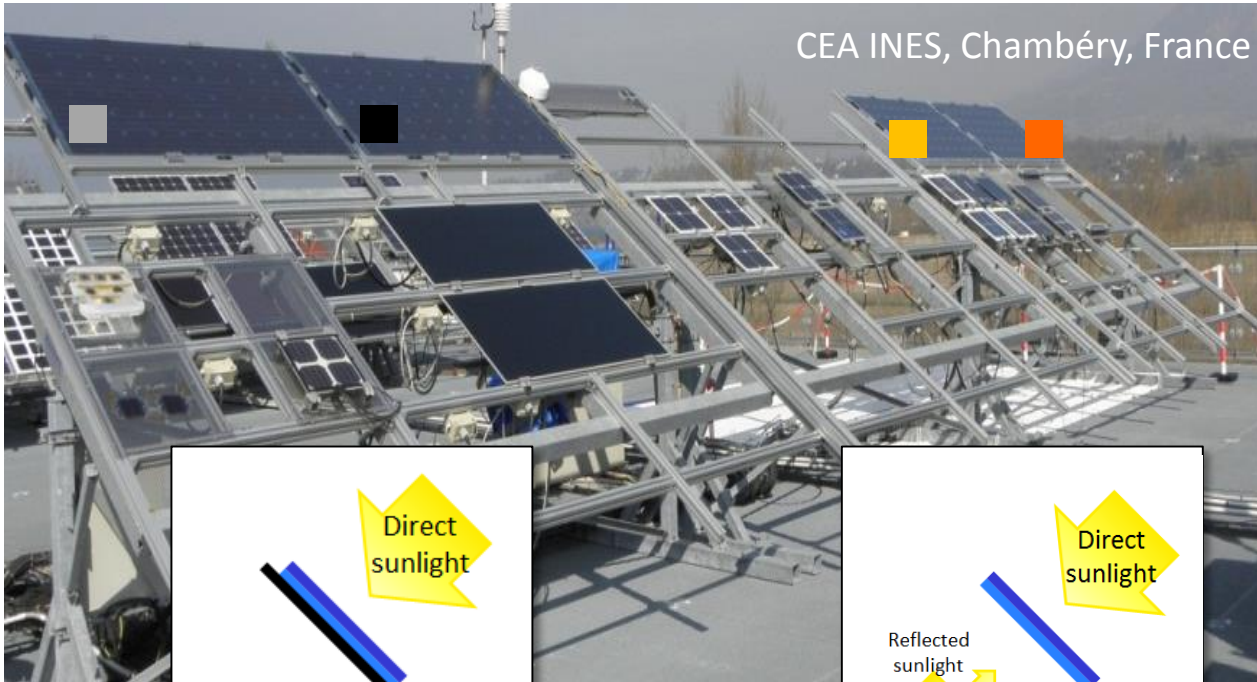


System level

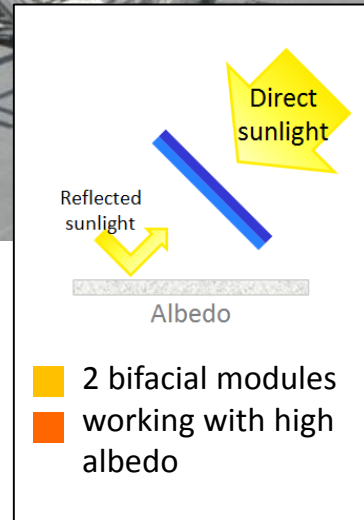
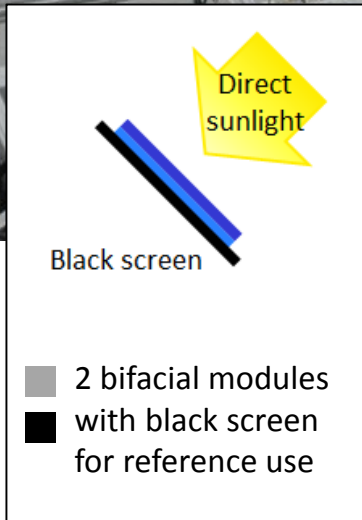
- Validation of bifacial technologies & potential
- I-V monitoring of outdoor single module
- New bifacial systems of 3KWp capacity (each)
- Development of a simulation tool

OUTDOOR BIFACIAL MODULE MONITORING

- Installed in 2015



CEA INES, Chambéry, France



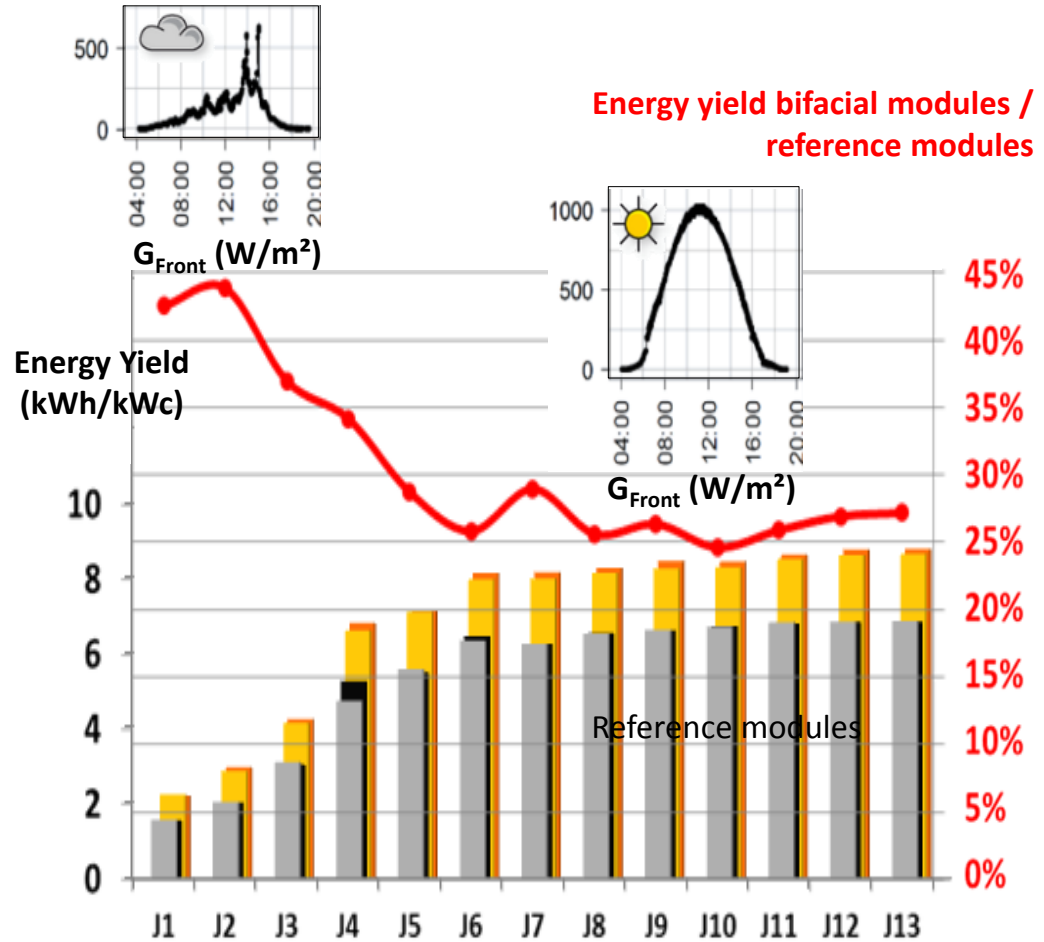
RENOLIT ALKORBRIGHT synthetic roofing membrane

Bifacial optimized mounting structure → no shadowing

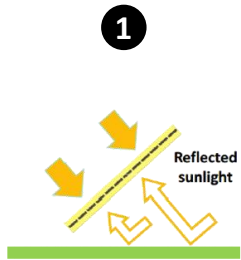
CEA bifacial modules: n-type, glass-glass, TPO Apolhya Solar® from **ARKEMA**



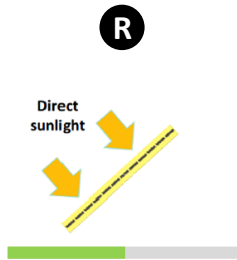
***M. Joanny, G. Razongle,
Bifacial PV modules:
Measurement challenges,
TUV workshop photovoltaic module,
Nov 2015, Cologne, Germany & silicon
PV, Chambéry, 2016***



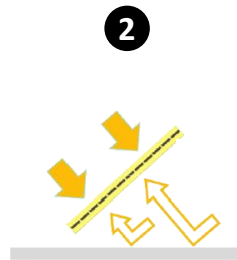
GENERAL DESCRIPTION OF BIFACIAL SYSTEMS



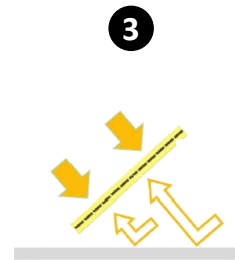
3 kWc
BIFACIAL 30° South
Portrait
albedo grass



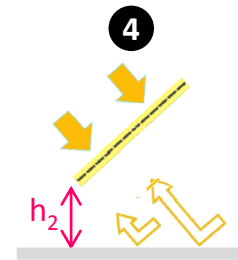
3 kWc
Monofacial 30° South
Portrait
No albedo



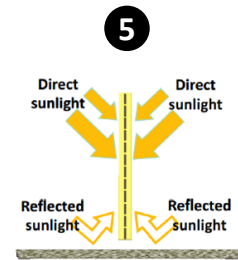
3 kWc
BIFACIAL 30° South
Portrait
Albedo: white rocks



3 kWc
BIFACIAL 30° South
Landscape
Albedo: white rocks



3 kWc
BIFACIAL 30° South
Landscape
Albedo: white rocks



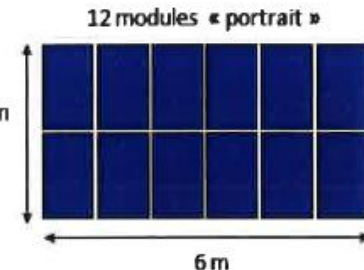
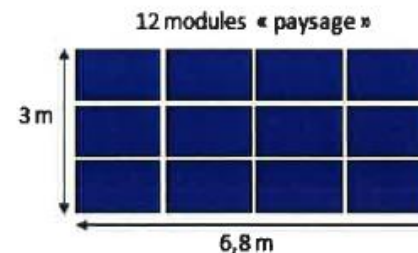
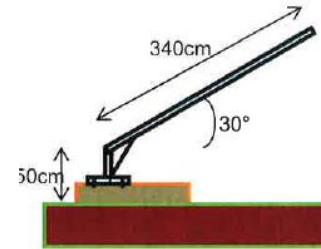
3 kWc
BIFACIAL vertical E/O
Albedo: white rocks

➤ Specific mounting structure

➔ Minimize shading on the rear side of modules

➤ Investigated parameters:

- Albédo: grass versus crushed white rocks
- **Modules height: h1 (0.6m) & h2 (1.6m)**
- Configuration: portrait versus landscape



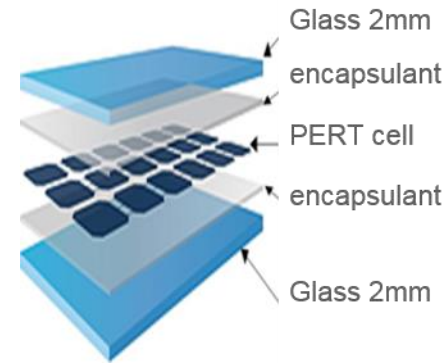
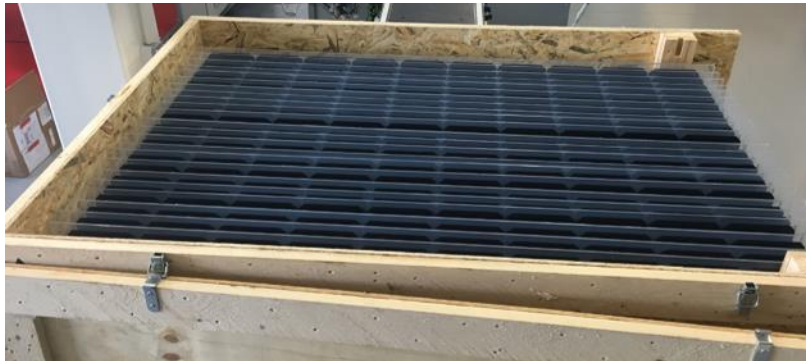
BIFACIAL MODULES FABRICATION



Assembly line



at CEA-INES

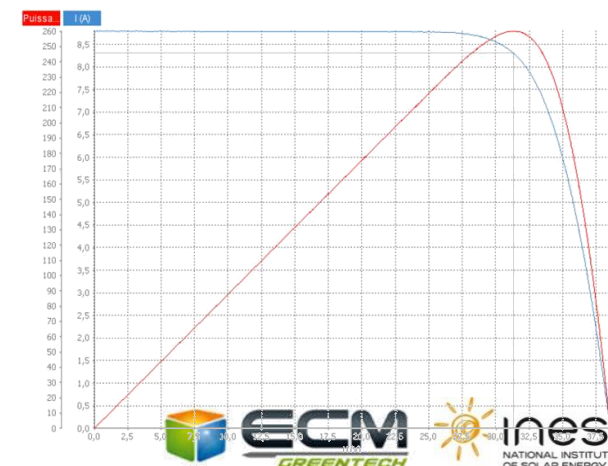
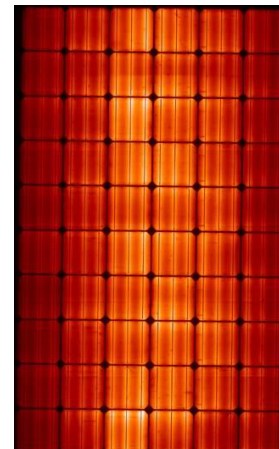


ARKEMA
INNOVATIVE CHEMISTRY

ARKEMA
INNOVATIVE CHEMISTRY

→ **60 fabricated modules:**

	Voc (V)	Isc (A)	FF (%)	P (W)	BF (%)
Average	38,5	8.8	76.7	260	90
STD	0,05	0,019	0,002	0,6	

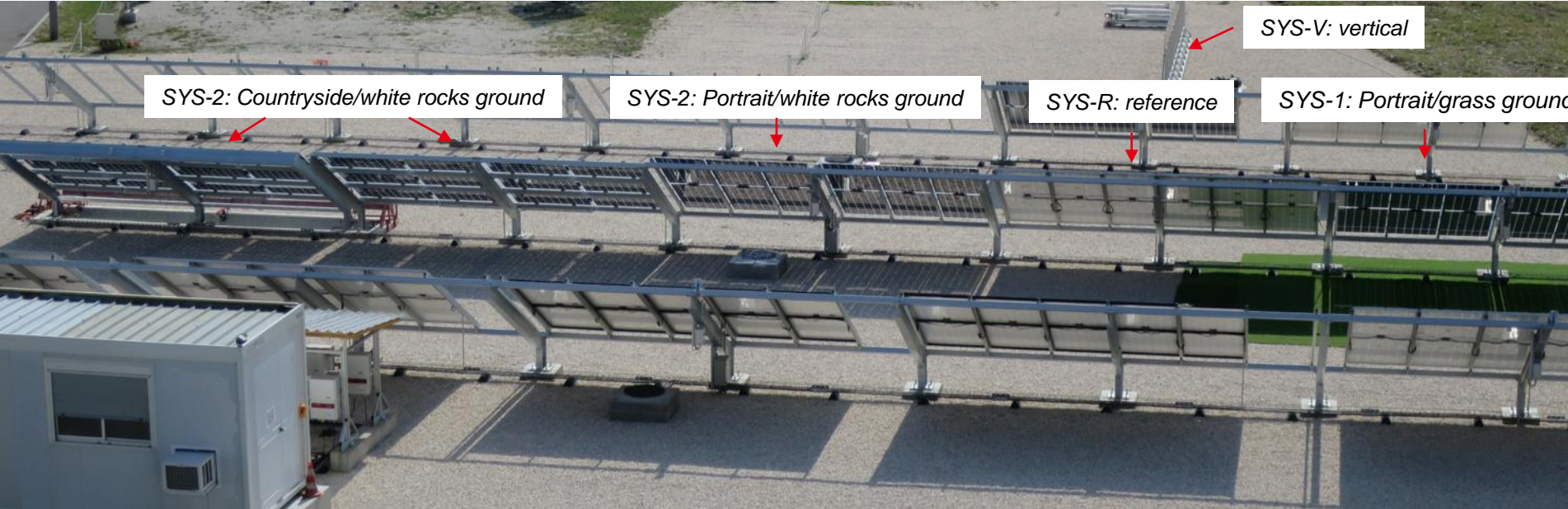




SYSTEM OVERVIEW

Operational since 01-sept-2016

May 2016



SYS-2: Countryside/white rocks ground

SYS-2: Portrait/white rocks ground

SYS-R: reference

SYS-1: Portrait/grass ground

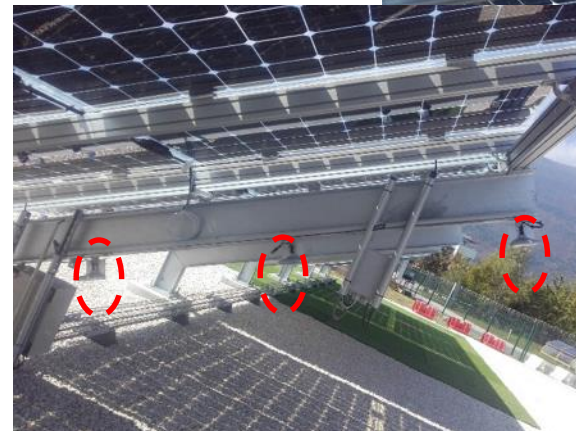
SYS-V: vertical

SYSTEM OVERVIEW



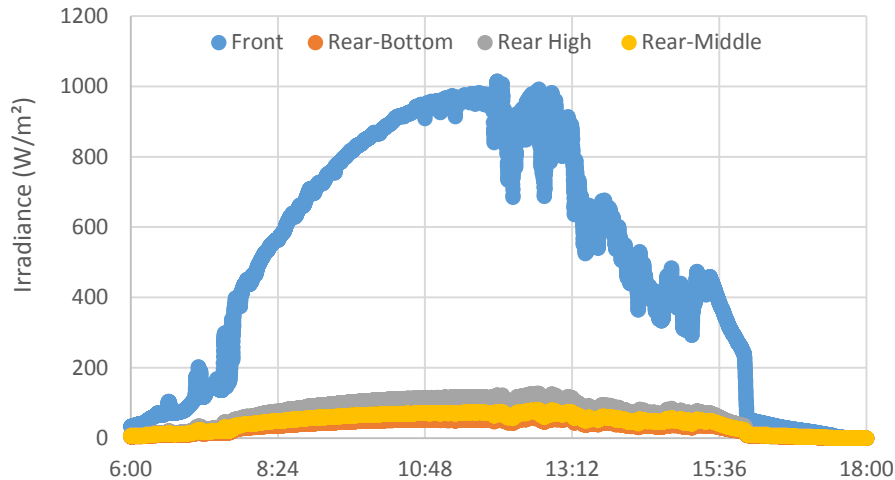
SUB-SYSTEM DESCRIPTION

- 12 modules (Peak Power ~ 3120Wp) in series
- Identical cabling length for each system
- DC/AC monitoring
- Tilted reference cells IKS SET Sensor
→ Front side and rear side (3 positions)
- Horizontal pyranometer
- FRONIUS IG+ 50V1 inverter (4KW nominal output)
- Module temperature sensor.
- Reference systems with mc-Si modules (260W)
- **Output datas:**
 - DC/AC productions (/5s)
 - Performance ratio (PR)

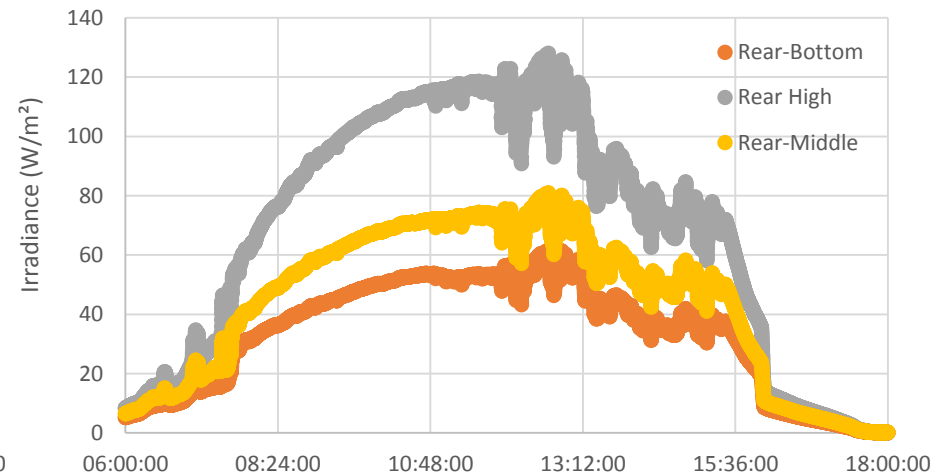


IRRADIANCE MEASUREMENTS

Front & Rear irradiance 2016-09-22



Rear irradiance 2016-09-22

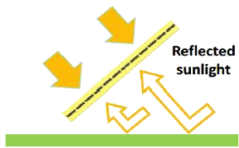


- Rear irradiance variation with the position of the reference cell
- In this example, $G_{rear} = 6\%$ to 13% of G_{front}

→ Not being used so far in the data analysis

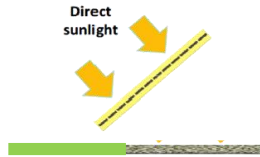
BEHAVIOUR FOR VARIOUS WEATHER CONDITIONS

1



Portrait
albedo grass

R



Monofacial
Portrait

2



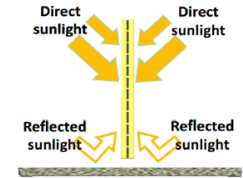
Portrait
Albedo: white rocks

3

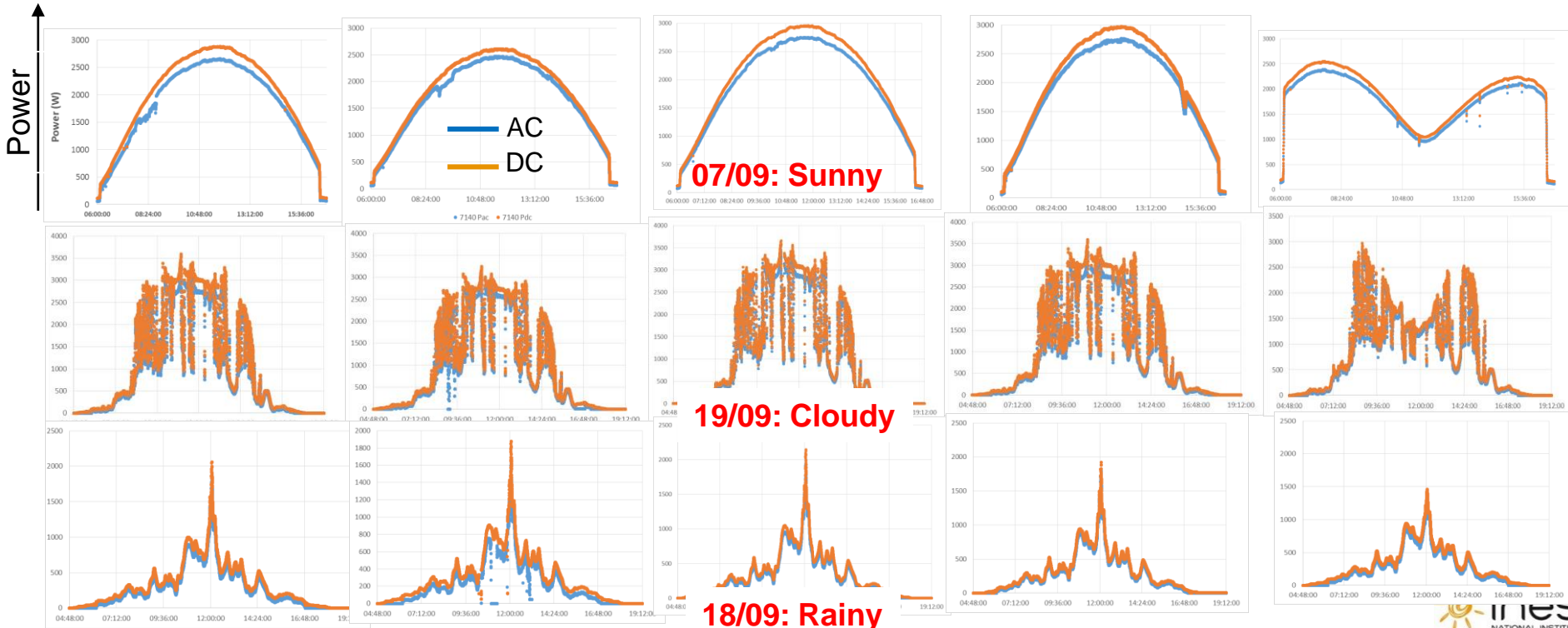


Landscape
Albedo: white rocks

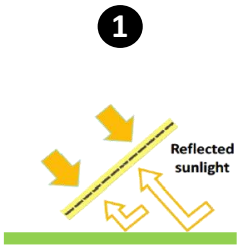
V



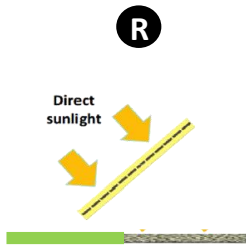
vertical E/O
Albedo: white rocks



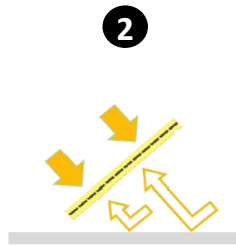
DAILY PRODUCTION FOR SUB-SYSTEMS



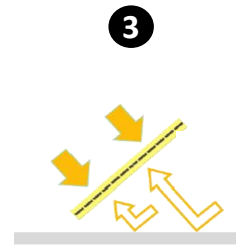
Portrait
albedo grass



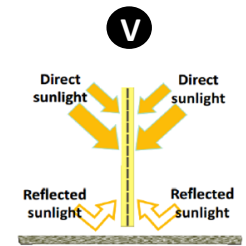
Monofacial Portrait
No Albedo



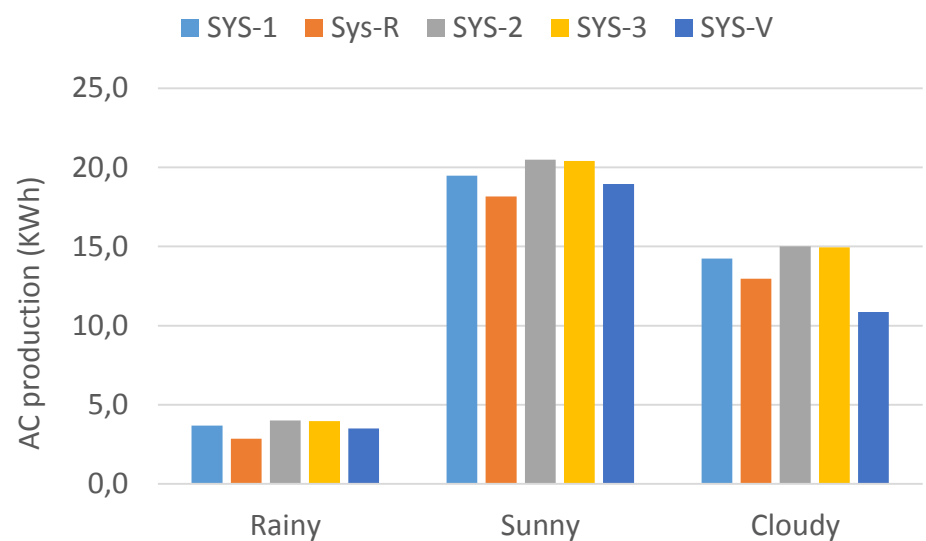
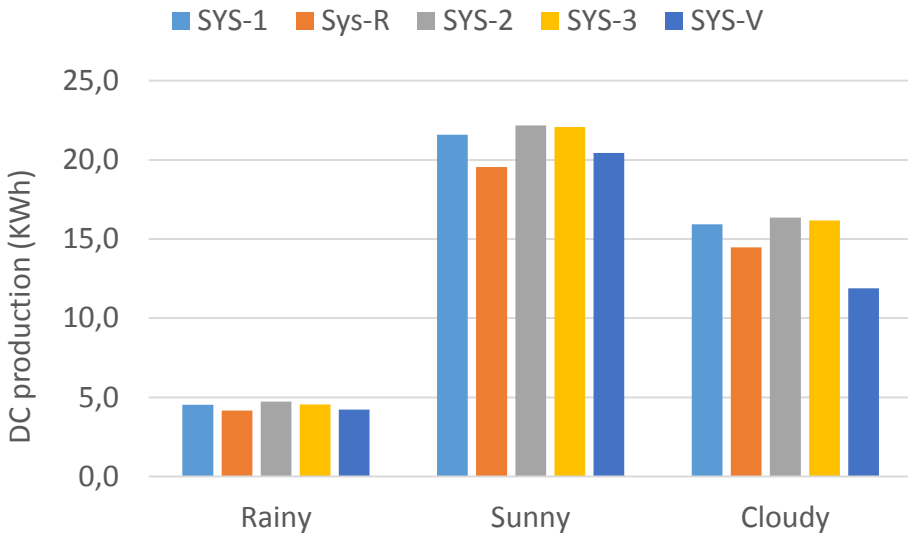
Portrait
Albedo: white rocks



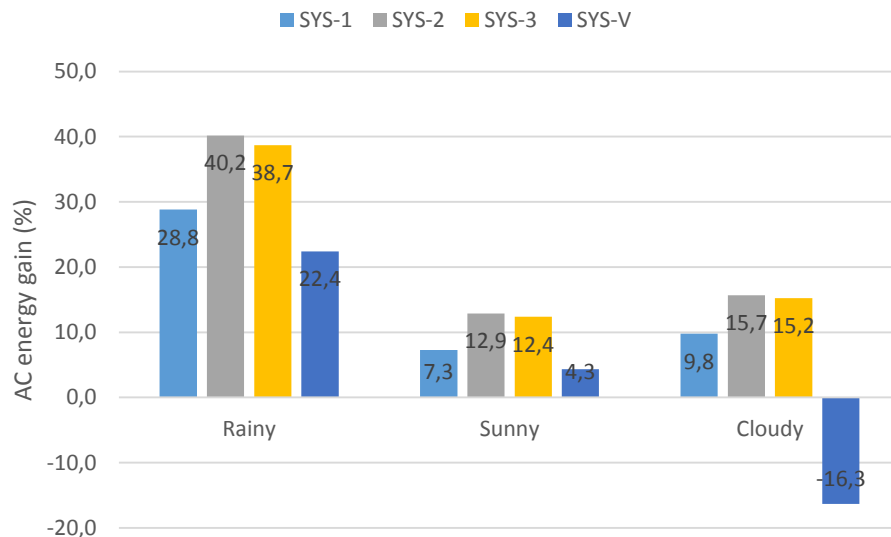
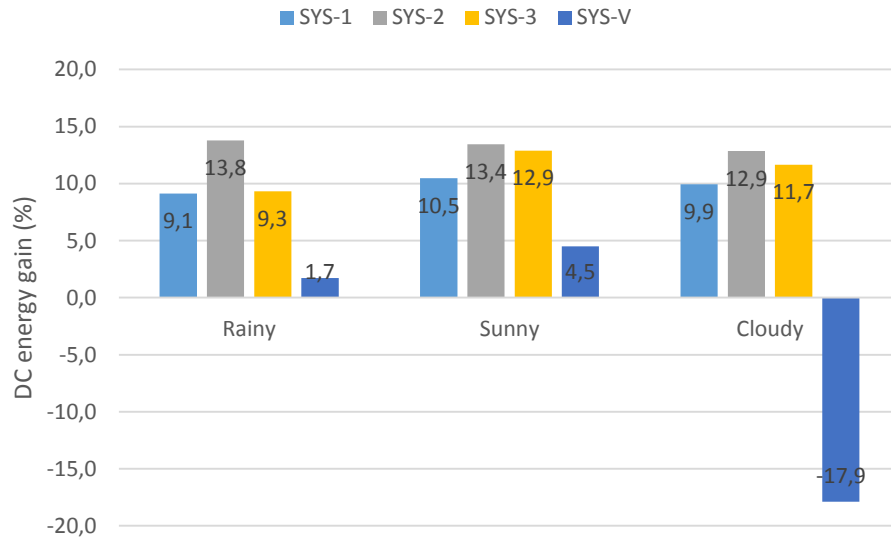
Landscape
Albedo: white rocks



vertical E/O
Albedo: white rocks



DAILY ENERGY GAIN VS REF SYSTEM



Reminder:

SYS-1 = Portrait/grass ground

SYS-2 = Portrait/white rocks ground

SYS-3 = Country/white rocks ground

SYS-V = Vertical/white rocks ground

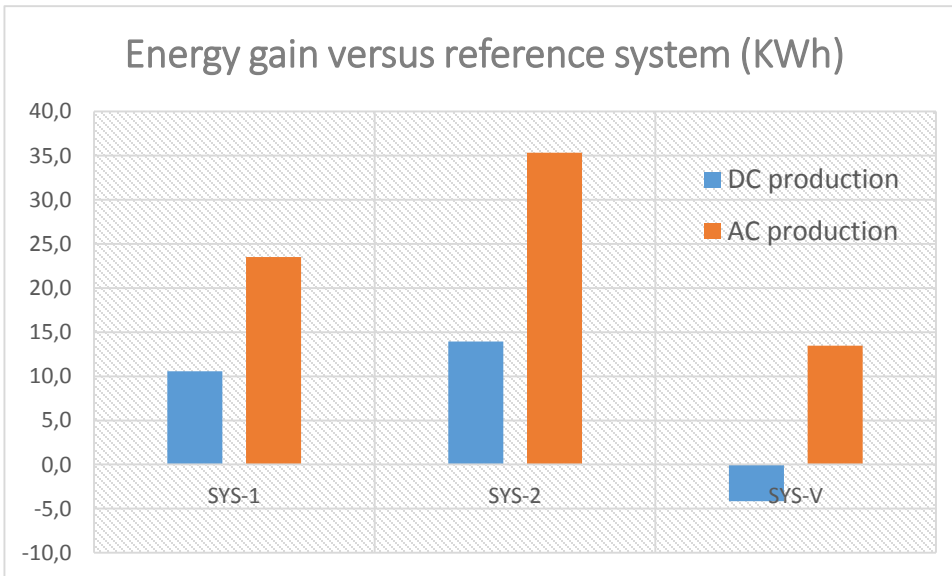
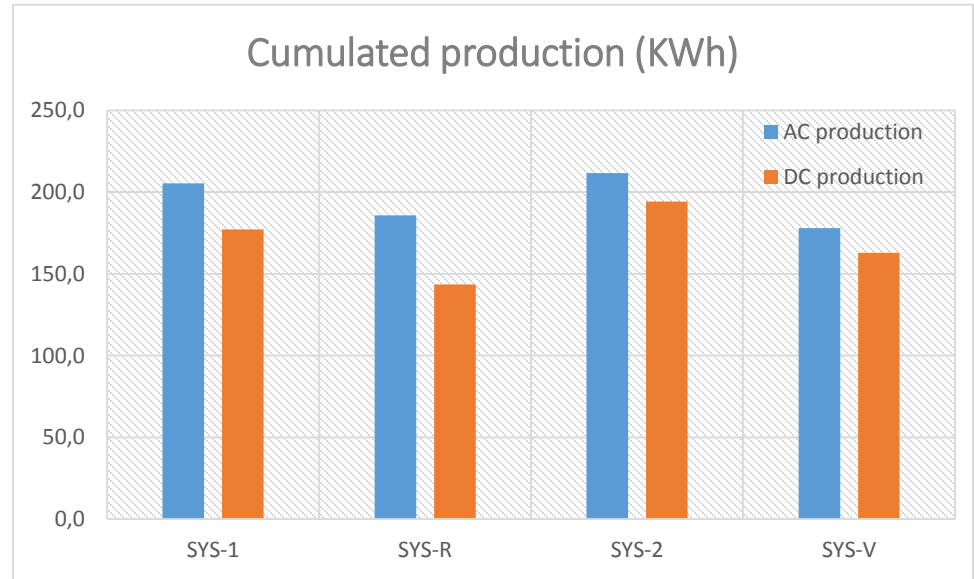
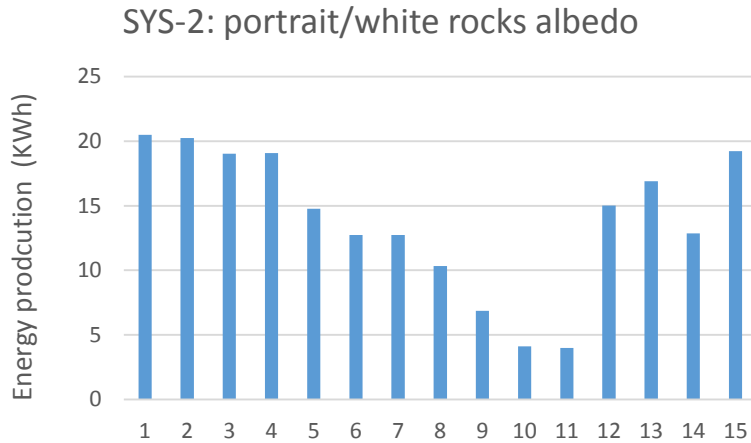
- DC gain ~ 12 – 14% for best albedo
- DC gain ~ 10% for grass ground
- More variation in vertical system gain

- AC gain ~ 12 – 40% for best albedo
- AC gain ~ 7% - 29% for grass ground
- More variation in vertical system gain

Inverter sensitivity

→ Not optimized for reference and vertical systems

ANALYSIS OVER 15 DAYS PERIOD



- AC gain ~ 35% for best albedo
- AC gain ~ 23.5% for grass ground
- AC gain ~13.5% for vertical system
- DC gains more limited (up to 14%)

Large influence of inverter

CONCLUSION & PERSPECTIVES

Summary:

- INES bifacial 3KWp systems can lead to a broad range of investigations
- Partially operational since 01/09, still requires a deeper data analysis

First results:

- High influence of the inverter dimension
- Related to the first results, the bifacial gain is:
 - ~ 14% with crushed white rocks
 - ~ 10% with synthetic grass

Perspectives:

- Inverter or modules adaptations.
- Long-term monitoring (week, month, year)
- Variation of albedo (black/white plastic sheets)
- Comparison of different bifacial modules technologies
- Albedo measurements
- Influence of rear shading and module height
- I-V monitoring of single module
- Validation of simulation tool
 - Simulation of module I-V curve
 - Simulation of systems

MERCI POUR VOTRE ATTENTION

THANKS FOR YOUR ATTENTION

Acknowledgements:

- ***A. Roisin, J. Mattei,
A. Biron (CEA) for
bifacial system
fabrication***

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Public Banc) for
financing BIPPP
national Project**



Commissariat à l'énergie atomique et aux énergies alternatives
Alternative Energies and Atomic Energy Commission
17 av des martyrs 38000 GRENOBLE France
<http://liten.cea.fr>

Établissement public à caractère industriel et commercial
Public establishment with commercial and industrial character
RCS Paris B 775 685 019

INES Site
Institut National de l'Energie Solaire
National Solar Energy Institute
50 avenue du lac Léman
73375 Le Bourget-du-Lac France
+33 4 79 79 20 00