AGRIPV-ER SIRTA Experimental Setup Data Description

I. Introduction

The potential benefits of agriculture and solar photovoltaic (PV) infrastructure - called "agriphotovoltaic" (agriPV) - have been shown by research studies, and could benefit from the water-energy-food nexus. Many technical variations in agriPV are emerging and, given the complexity due to the number of variables at play, understanding and methodology work is still necessary to evaluate the advantages and limitations of each system on the nexus , to minimize possible negative environmental impacts and maximize its positive externalities.

Motivated by this context, an agriPV experimental platform was built at the SIRTA observatory, with 72 photovoltaic panels on solar trackers (east-west oriented) on an experimental plot of approximately 700 m2 (450 m2 in agriPV et 250 in test area). A complete device for electrical, meteorological, radiative, sun state and plant observation measures is deployed on this installation. More than 80 automatic measuring instruments collecting continuous data and multi-variable files are created to carry out interdisciplinary studies.

The SIRTA agriPV platform is a field for interdisciplinary research based on integrated experimental-numerical approaches, notably the study of the microclimate generated by an agriPV system, the study of the impact on plants and water as well as the optimization of the orientation of the solar panels. Other specific aspects such as the modeling of solar lighting, the study of PV performance and solar forecasting are part of the topics that can be addressed with this installation.

In fact, this platform is one of the rare agriPV initiatives carried out by academic actors and one of the demonstrator partners of the National Research Pole (PNR) on agriphotovoltaism, created by the INRAE in June 2023, with academic and industrial partners.

I. SIRTA observatory site

The agriPV experimental platform, due to the fact that it is housed at the SIRTA observatory (http://sirta.ipsl.fr), benefits from the reference measurements from SIRTA. The image below shows the main locations for the measurements considered.

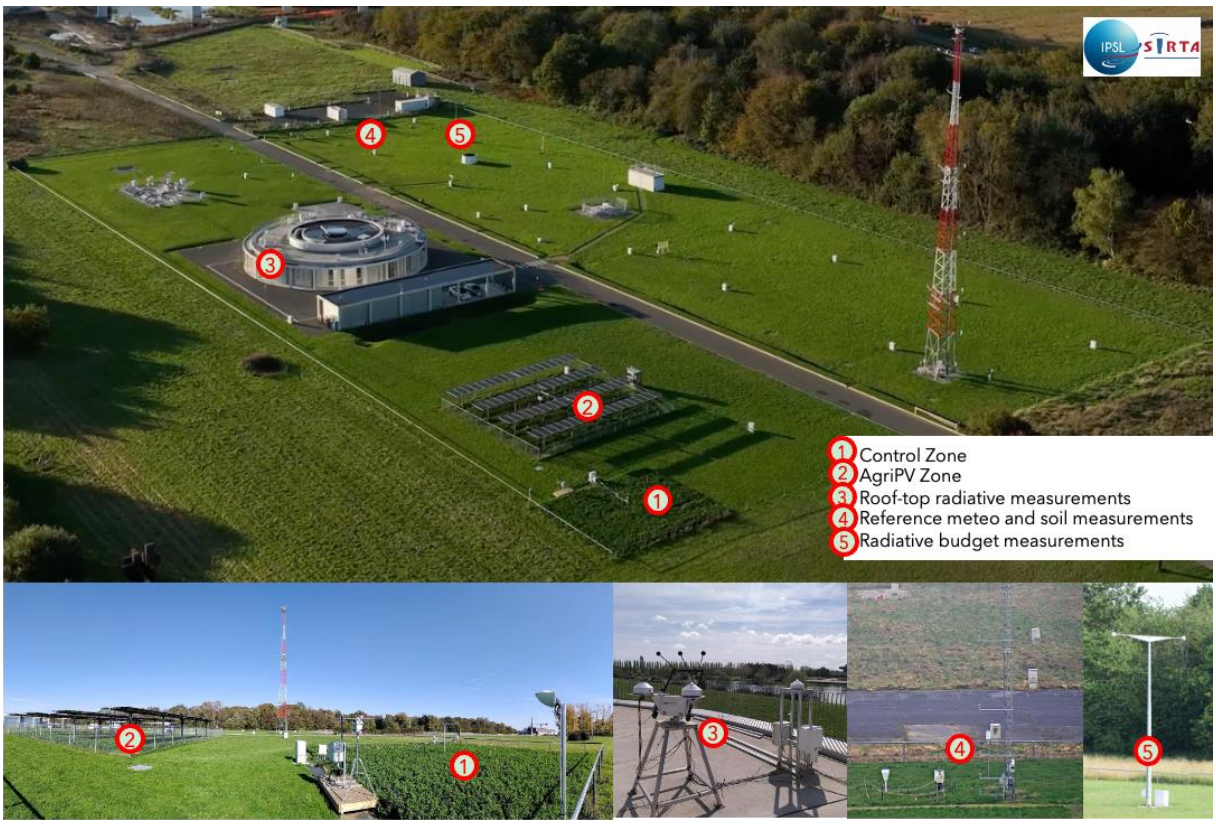


Figure 1 Views of SIRTA's research observatory with locations of measurements used for the agriPV data platform

Measurements that are in particular interesting for the agriPV experimentation are (see locations and views in Figure 1) :

- The BSRN[1]-like roof-top radiative measurements: global horizontal irradiance (GHI), diffuse horizontal irradiance (DHI), direct beam normal irradiance (DNI), downwelling infrared irradiance (point 3 in Figure 1)
- The radiative budget measurements on a 10 m mast : upwelling and downwelling shortwave and longwave irradiance (point 5 in Figure 1)
- Air temperature, humidity, wind speed and direction and soil moisture and temperature (point 4 in Figure 1)

II. AgriPV zone: PV architecture description

The AgriPV project represents a cutting-edge integration of photovoltaic technology, utilizing 72 bifacial solar panels mounted on four single-axis trackers. Each row of 18 panels is connected to its own inverter and possess 2 different power capacities. The four PV rows are perfectly oriented in the North-South axis.

SPECIFICATIONS										
Module Type	JKM550N-72HL4-BDV		JKM555N-72HL4-BDV		JKM560N-72HL4-BDV		JKM565N-72HL4-BDV		JKM570N-72HL4-BDV	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax)	550Wp	414Wp	555Wp	417Wp	560Wp	421Wp	565Wp	425Wp	570Wp	429Wp
Maximum Power Voltage (Vmp)	41.58V	39.13V	41.77V	39.26V	41.95V	39.39V	42.14V	39.52V	42.29V	39.65V
Maximum Power Current (Imp)	13.23A	10.57A	13.29A	10.63A	13.35A	10.69A	13.41A	10.75A	13.48A	10.81A
Open-circuit Voltage (Voc)	50.27V	47.75V	50.47V	47.94V	50.67V	48.13V	50.87V	48.32V	51.07V	48.51V
Short-circuit Current (Isc)	14.01A	11.31A	14.07A	11.36A	14.13A	11.41A	14.19A	11.46A	14.25A	11.50A
Module Efficiency STC (%)	21.29%		21.48%		21.68%		21.87%		22.07%	
Operating Temperature(℃)	-40℃~+85℃									
Maximum system voltage	1500VDC (IEC)									
Maximum series fuse rating	30A									
Power tolerance	0~+3%									
Temperature coefficients of Pmax	-0.30%/℃									
Temperature coefficients of Voc	-0.25%/℃									
Temperature coefficients of Isc	0.046%/℃									
Nominal operating cell temperature (NOCT)	45±2℃									
Refer. Bifacial Factor	80±5%									

Figure 2 Datasheet with the electric PV module specifications for the Tiger Neo N-type 72HL4-BDV panels. Three types are present in the installation (555, 560 and 565 Wp). These are halfcell modules with 144 cells. Module size : 2278×1134×30mm

The following illustration describes the different modules in each row and their types.

[1] Baseline Surface Radiation Network (BSRN) : https://bsrn.awi.de/

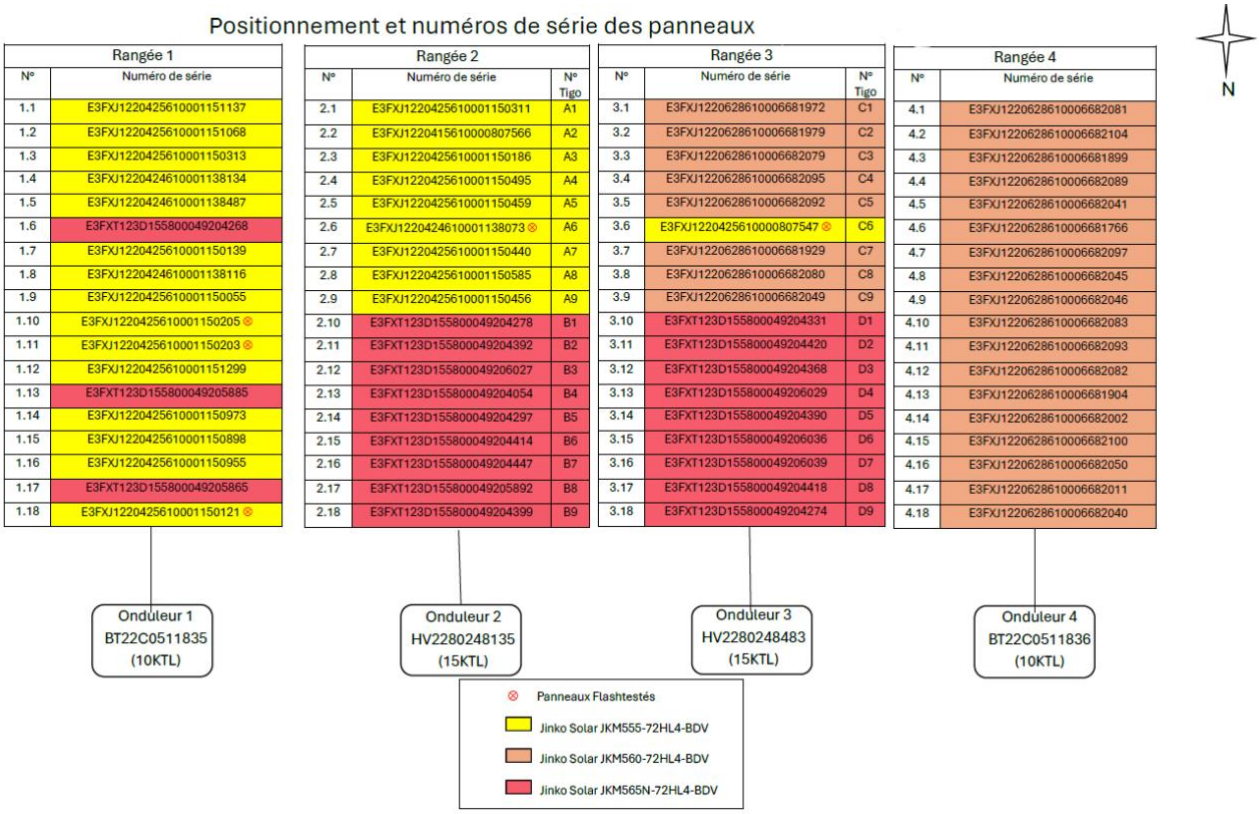


Figure 3 Photovoltaic module layout on the AgriPV zone

III. Electric system measurements (Enspire)

We have installed reference cells type Si-RS485TC-T-Tm-MB on the 2nd row and more precisely on module number 8 (no : 2.8) . we have chosen to place two reference cells pointing upwards in order to measure the downwelling radiation while the other two are downwards measuring the upwelling radiation (figure 3) .

Figure 4 Position of reference cells

These reference cells used PT100 temperature sensors to measure the temperature of the PV modules, these sensors were attached to three PV modules (Figure 4).

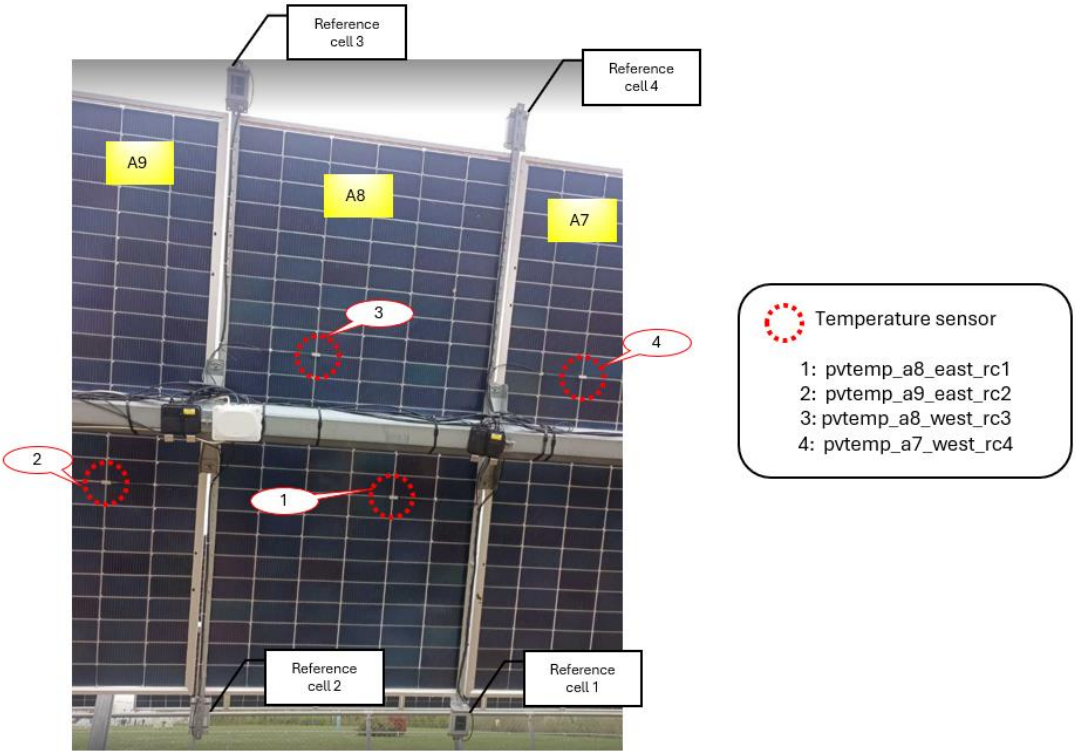


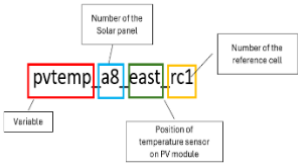
Figure 5: Position of temperature sensors

All the data from the inverters, reference cells and the meter are collected by a Smart logger accessible via a web interface called Enspire.

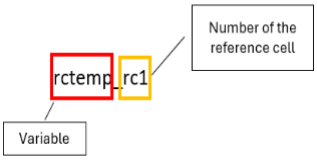
- Time (UTC)

For reference cells :

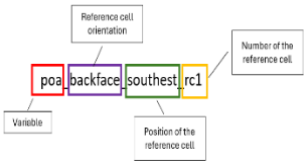
- Temperature of the PV modules (°C): Four variables one for each reference cell in the following format :



- Temperature of the reference cell (°C) in the following format :



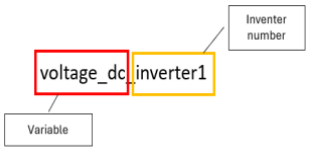
- Irradiance (w/m²) in the following format :



For the inverters :

- The ac and dc data for :
  - Voltage (V)
  - Current (I)
  - Power (KW)
- Inverter temperature (°C) , variable name :temp
- Energy daily (KWh)

All variable names have the format below :



IV. PV module level data (Tigo)

In order to study the PV module performance, we have equipped each PV module on the second and third row with an optimizer of type Tigo TS4-A-O .

This will generate another data file called Tigo, which gives details of every PV module in the two rows.

The figure below illustrates the PV number of panels associated with the optimisers.

Row 2	
N°	N° Tigo
2.1	A1
2.2	A2
2.3	A3
2.4	A4
2.5	A5
2.6	A6 ⊗
2.7	A7
2.8	A8
2.9	A9
2.10	B1
2.11	B2
2.12	B3
2.13	B4
2.14	B5
2.15	B6
2.16	B7
2.17	B8
2.18	B9

Row 3	
N°	N° Tigo
3.1	C1
3.2	C2
3.3	C3
3.4	C4
3.5	C5
3.6	C6 ⊗
3.7	C7
3.8	C8
3.9	C9
3.10	D1
3.11	D2
3.12	D3
3.13	D4
3.14	D5
3.15	D6
3.16	D7
3.17	D8
3.18	D9

⊗ Panneaux Flashtestés

Jinko Solar JKM555-72HL4-BDV

Jinko Solar JKM560-72HL4-BDV

Jinko Solar JKM565N-72HL4-BDV

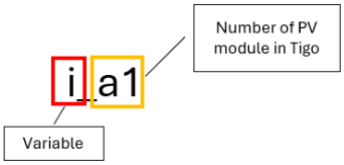
Figure 6: Number of PV modules detailed for Tigo

Data of tigo :

For each panel on the two rows we collect the following data :

- Time (UTC)
- Voltage (V), variable name : v
- Current (I), variable name : i
- Power (W) , variable name : p

All variable names have the format below :



V. Tracker system measurements (Zimmermann)

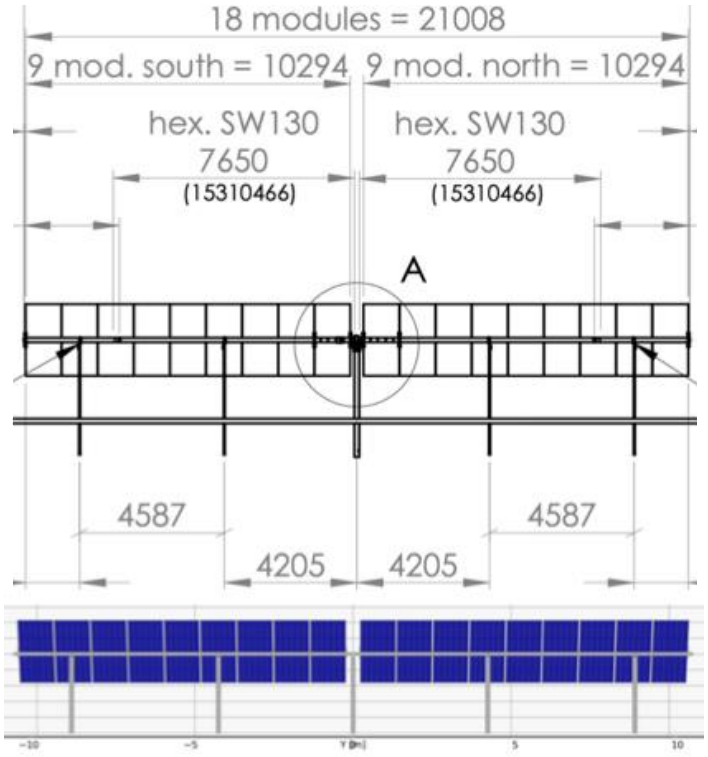


Figure 7 Sizes of each PV module tracking row. The torque tube is installed 2.5m above the ground

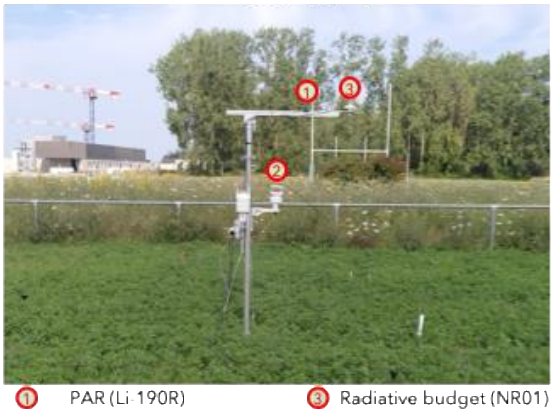
Figure 8 View of the tracking system elements and measurement sensors

VI. Radiative and meteorology measurements (meteorad and meteoradref)

Meteorad

① PAR (Li-190R)
②② Meteo station (wind, temp, RH, rain, GMX-550)
③ Radiative budget (CNR4)
④ PAR (CBE-80)

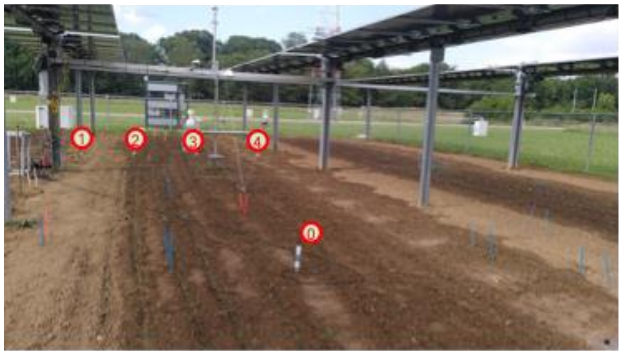
Meteoradref



① PAR (Li-190R)
② Meteo station (wind, temp, RH, GMX-550)
③ Radiative budget (NR01)

VII. Soil temperature and humidity (meteosol and meteosolref)

Meteosol



0 Soil moisture profile (10,20,30,40,60,100 cm) (PR2)
1 2 3 4 Ground temperature and humidity (ML3)

Meteosolref

0 Soil moisture profile (10,20,30,40,60,100 cm) (PR2)
1 2 3 4 Ground temperature and humidity (ML3)

VIII. Sonic anemometer measurements (meteo2)

1 Metek sonic anemometer 1,2 m agl

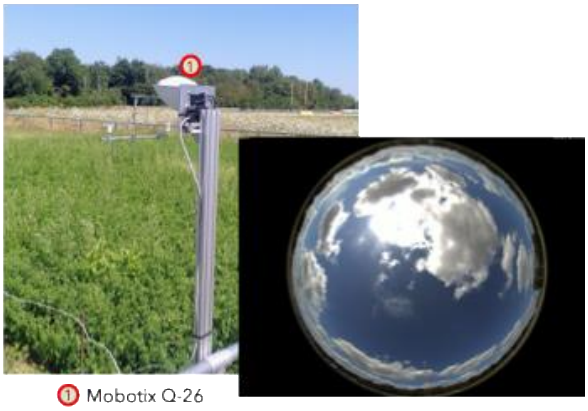
2 Metek sonic anemometer 3,5 m agl

IX. Sky imagers (Mobociel and mobosol)

Mobosol

1 Mobotix Q-26

Mobociel



1 Mobotix Q-26

X. Acknowledgements

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