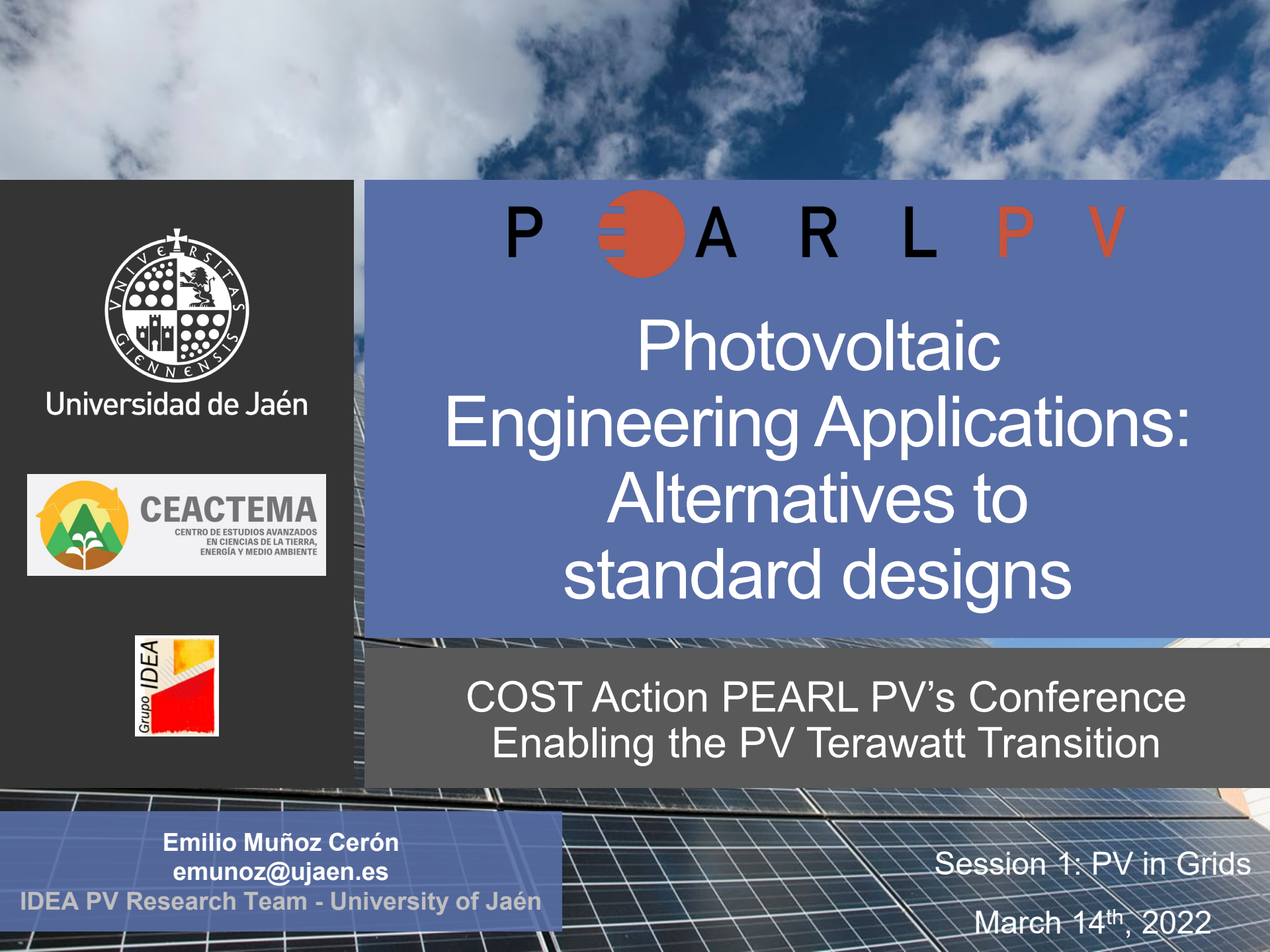


Universidad de Jaén

CEACTEMA
CENTRO DE ESTUDIOS AVANZADOS EN CIENCIAS DE LA TIERRA, ENERGÍA Y MEDIO AMBIENTE

Grupo IDEA

P A R L P V

Photovoltaic Engineering Applications: Alternatives to standard designs

COST Action PEARL PV's Conference
Enabling the PV Terawatt Transition

Emilio Muñoz Cerón
emunoz@ujaen.es
IDEA PV Research Team - University of Jaén

Session 1: PV in Grids

March 14th, 2022

Universidad de Jaén

Content

Photovoltaic Engineering Applications: Alternatives to standard designs

- Context (UJA PV Team and PV news)
- Infraestructure PV Integration
- Self-Consumption PV Design Tool

PV Team Context

CEACTEMA
CENTRO DE ESTUDIOS AVANZADOS EN CIENCIAS DE LA TIERRA, ENERGÍA Y MEDIO AMBIENTE

uja. Universidad de Jaén

Grupo IDEA

IDEA PV Research Team

Jaén (37º46'N; 3º47'W):

Annual mean daily irradiation:

5.1 $kWh \cdot m^{-2} \cdot day^{-1}$

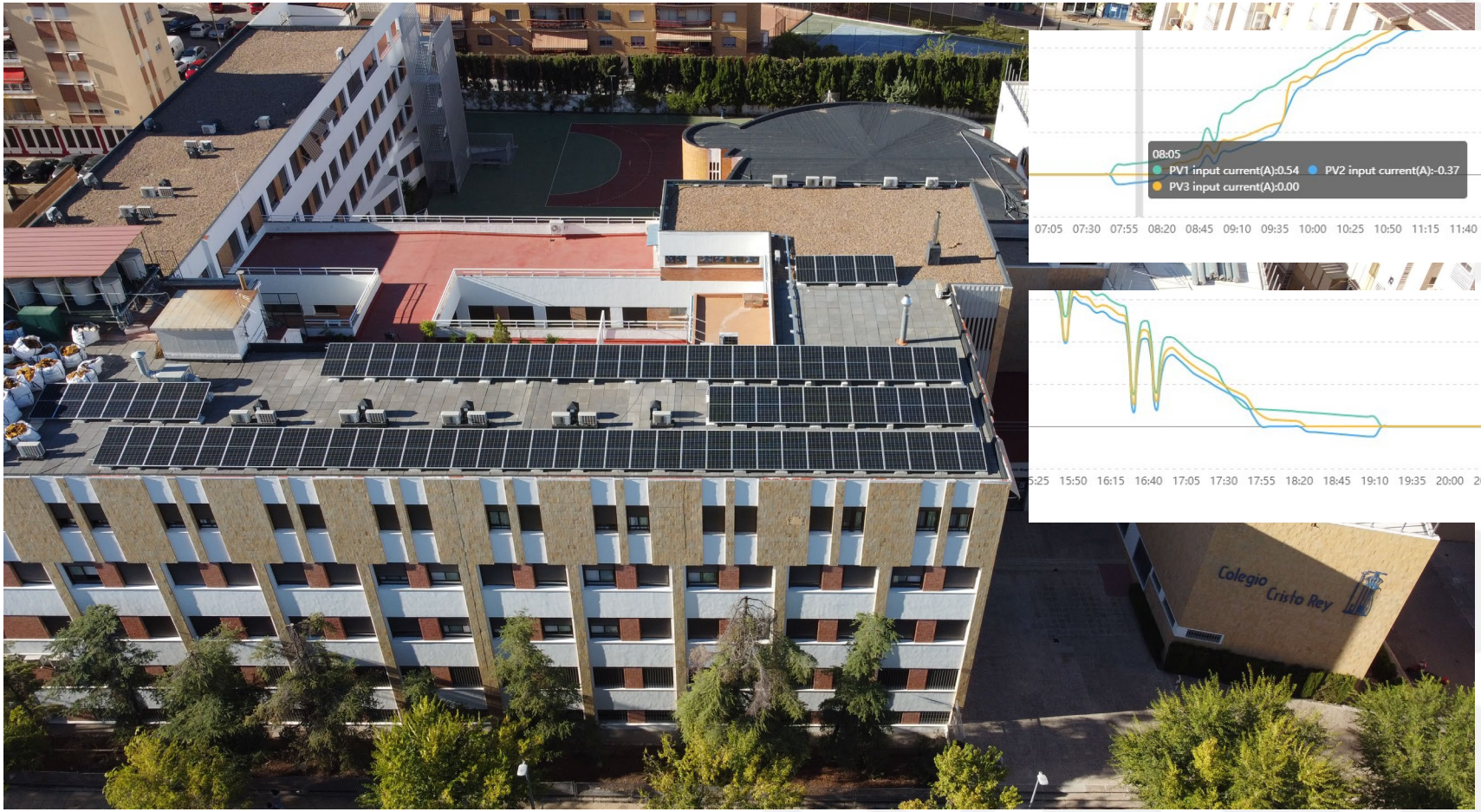
Continental-Mediterranean climate

PV Team Context

Engineering and Technical Assessment

IDEA PV Research Team

Grupo IDEA

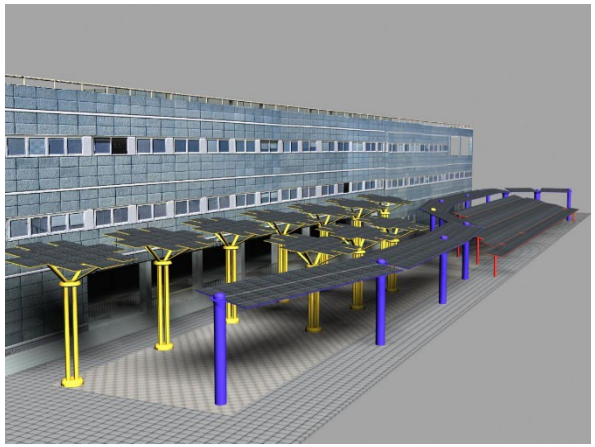


PV Team Context

Engineering and Technical Assessment

IDEA PV Research Team

Grupo IDEA



PV Integration

sd europe
SOLAR DECATHLON

uja.es

PV Team Context

Engineering and Technical Assessment

IDEA PV Research Team

Grupo IDEA

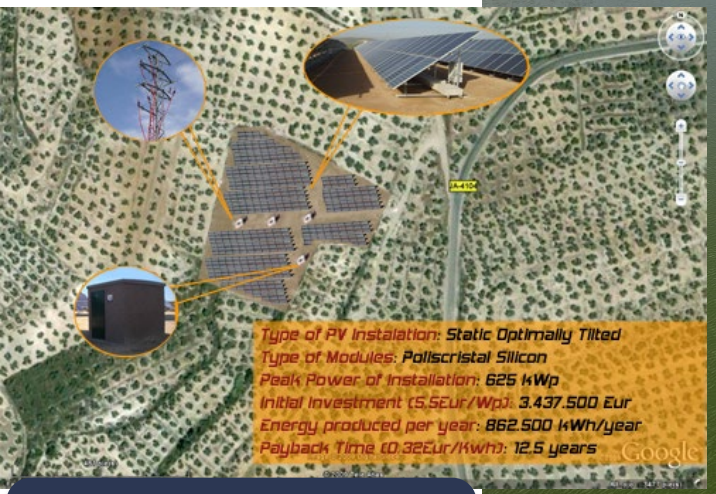
PV Integration

PV Team Context

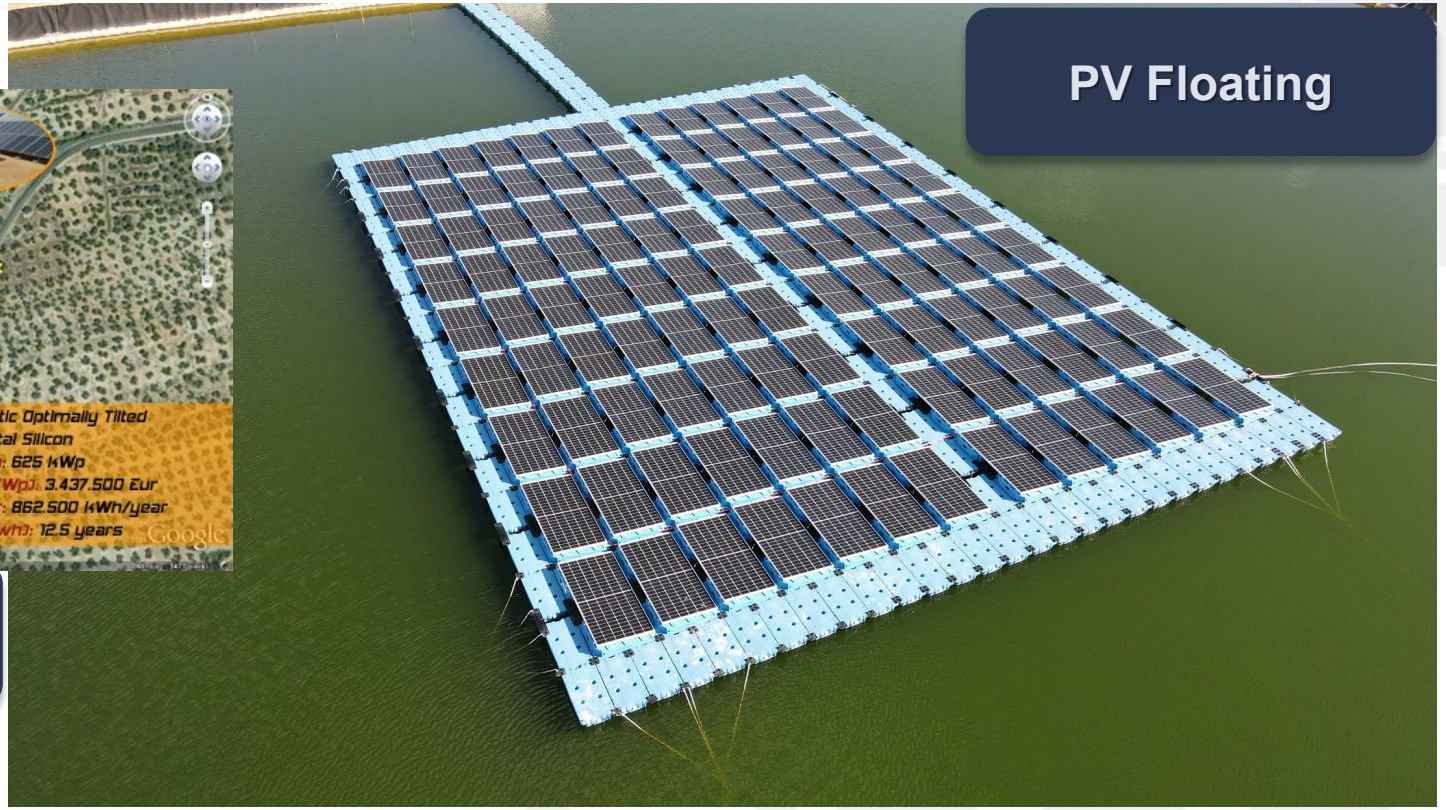
Engineering and Technical Assessment

IDEA PV Research Team

Grupo IDEA



PV at Marginal Lands



PV Floating

PV News

Los agricultores recelan del auge de las renovables por el uso de la tierra

Redacción 10/05/21

El auge de las energías renovables ha despertado recelos entre los agricultores y ganaderos de algunas zonas de España, que ven peligrar el uso de las tierras que necesitan para producir alimentos ante el avance de grandes parques eólicos o proyectos de placas solares.

El campo se rebela contra la 'invasión' de huertos solares

* *Agricultores y ganaderos crean plataformas ante la proliferación de proyectos*

Challenge

Land-Positive PV Solutions

Universidad de Jaén

Content

Photovoltaic Engineering Applications: Alternatives to standard designs

- Context (UJA PV Team and PV news)
- Infraestructure PV Integration
- Self-Consumption PV Design Tool

Context

Noise Barriers

Land-Positive PV Solution?

Context

CEFRABID

Energía limpia procedente del desarrollo de infraestructuras de barreras acústicas viarias

Clean energy from road acoustic barriers infrastructure development

Partners

Główny Instytut Górnictwa (Polonia)
Coordinador del Consorcio

ML Systems (Polonia)

IBV – Fallast (Austria)

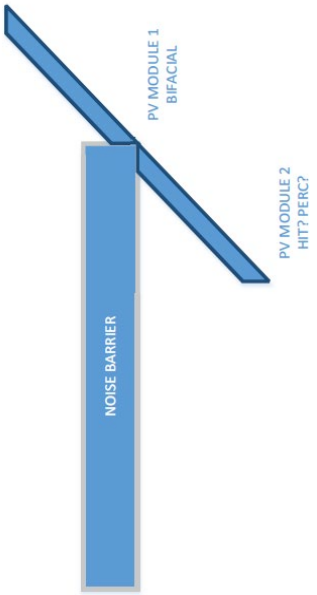
University of Cyprus (República de Chipre)

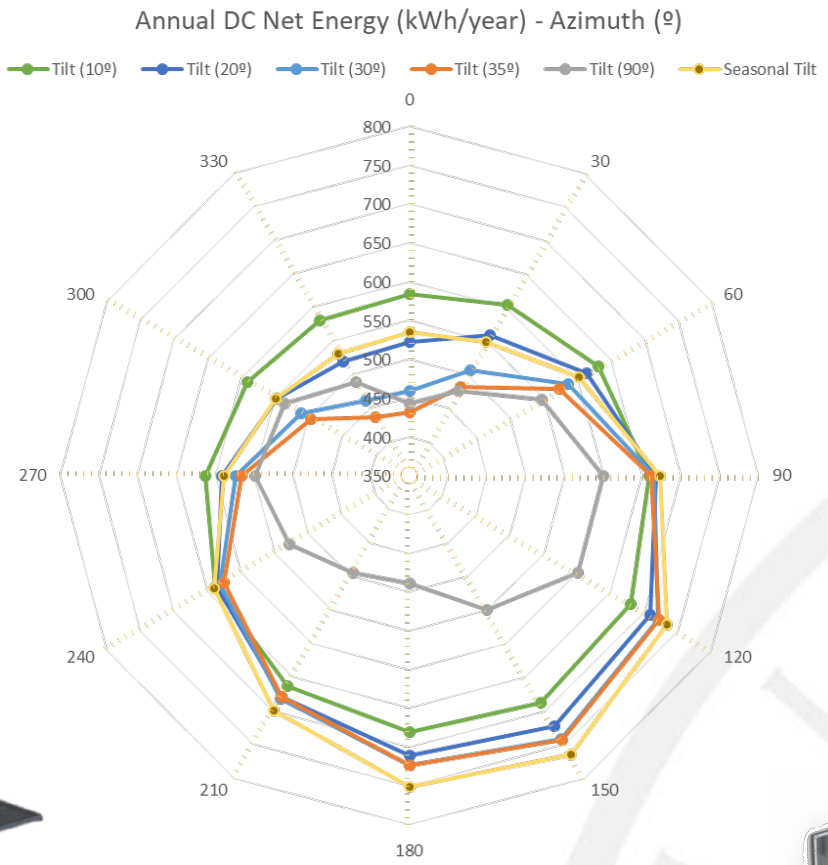
Universidad de Jaén

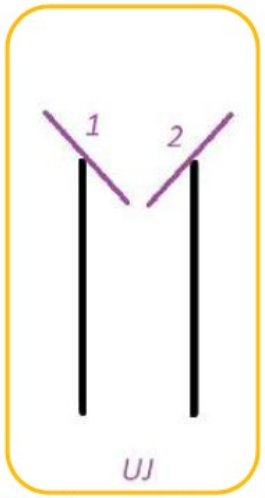
Funding Call / Agency

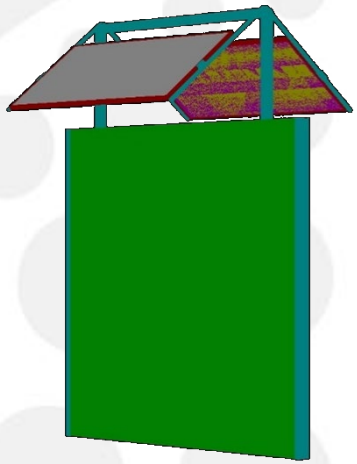
Proyectos de I+D+i «Programación Conjunta Internacional» 2018
(Proyecto: PCI2018-093082)

Pre-Analysis





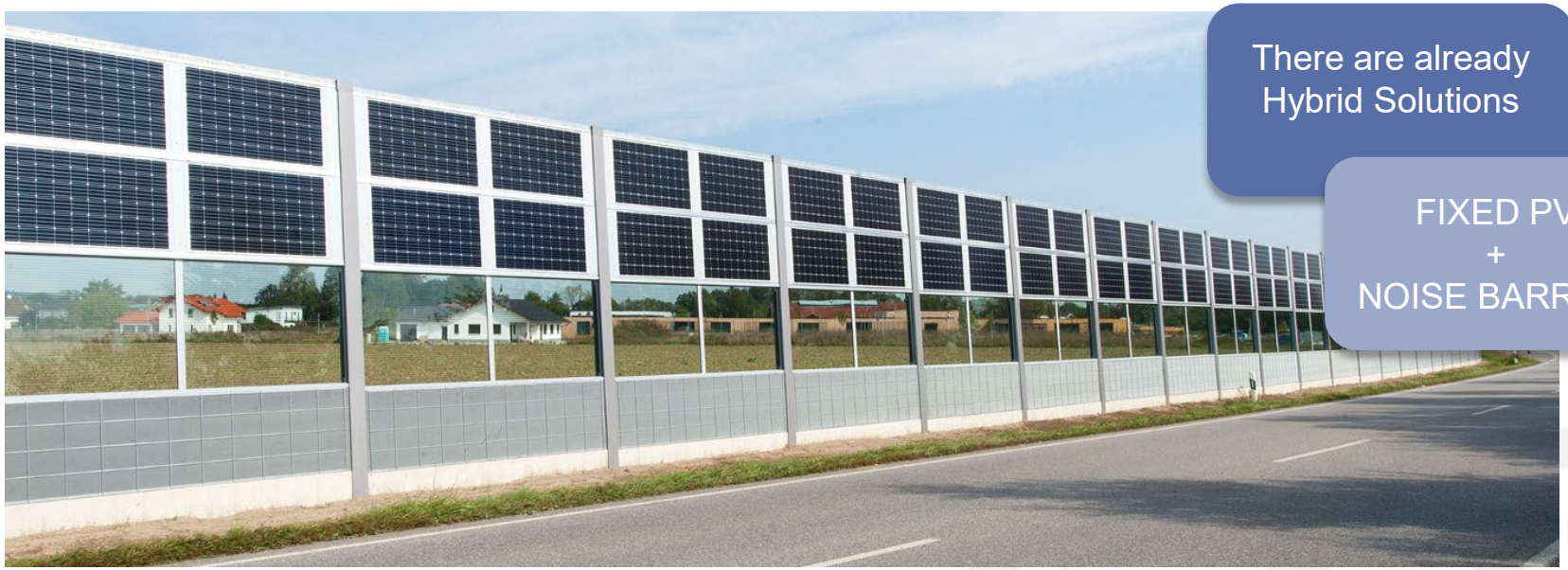




Preliminary simulations

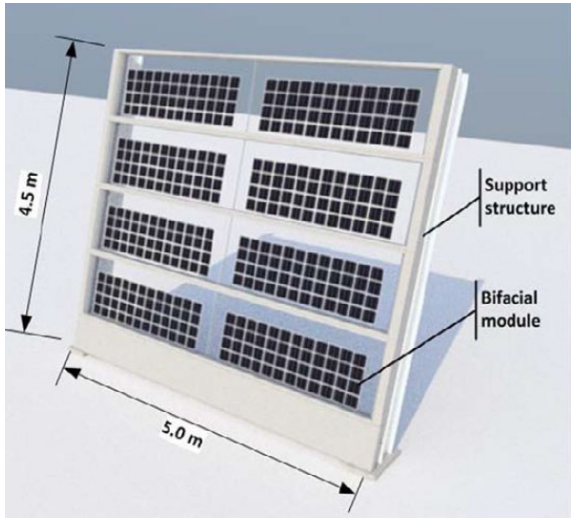
Pre-Analysis

Hybrid Solutions



There are already Hybrid Solutions

FIXED PV
+
NOISE BARRIER



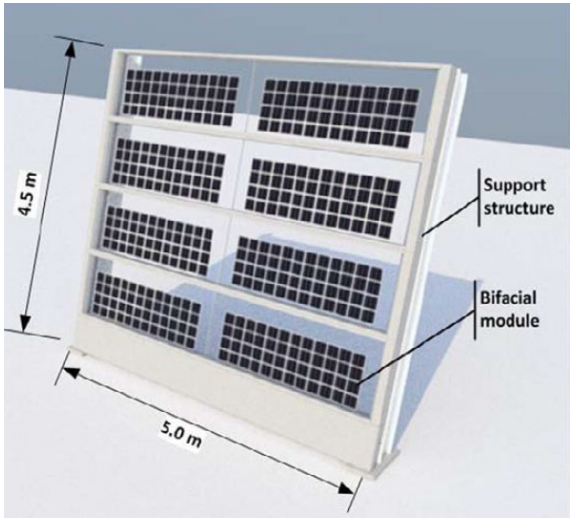
Pre-Analysis

Hybrid Solutions: ADVANTAGES

Acoustic Isolation +
Electrical (Green) Production

Land-Positive
PV Solution

Environmental Awareness



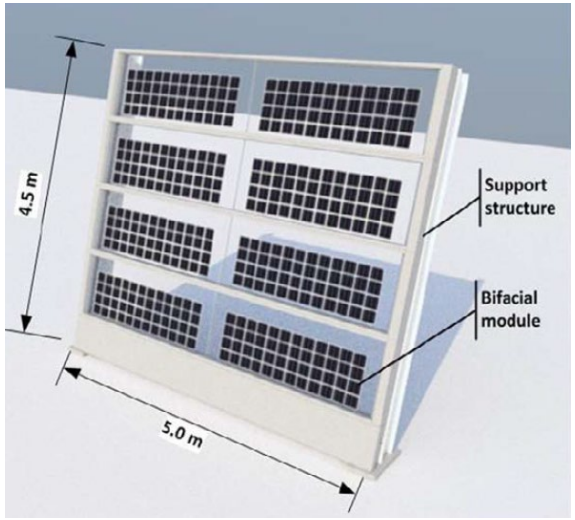
Pre-Analysis

Hybrid Solutions: LIMITATIONS

Lack of Standardization → Custom Designs (Noise Barriers and PV modules)

Limitation in System Orientation (Optimal in East-West Roads)

Limitation in Electricity Production



Pre-Analysis

Hybrid Solutions

Standardization
(Noise Barriers and PV modules)

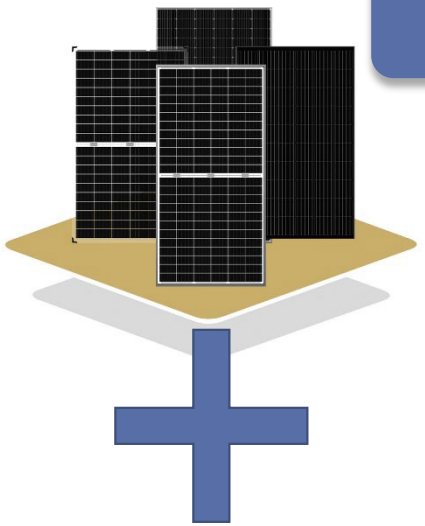
Minimise Azimuth Limitations

Maximise PV
Electricity Production

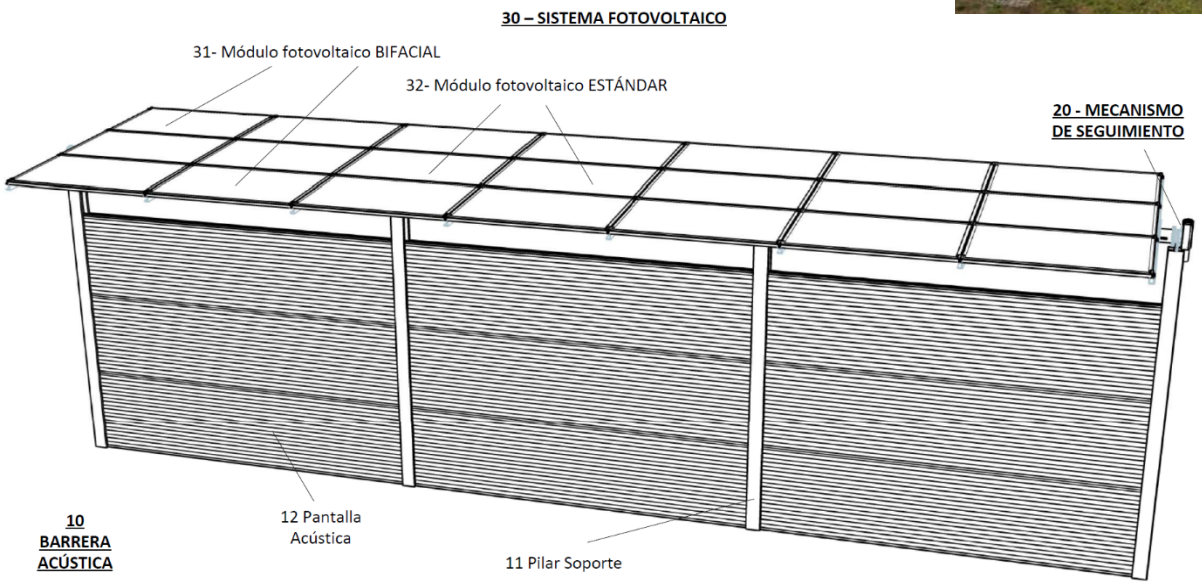
Technical Proposal

Noise Barrier (Standard)

PV module (Standard)



1 axis Solar Tracker (Standard)



Technical Proposal

Technical Proposal installed at the University of Jaén Campus
12m x ~4m

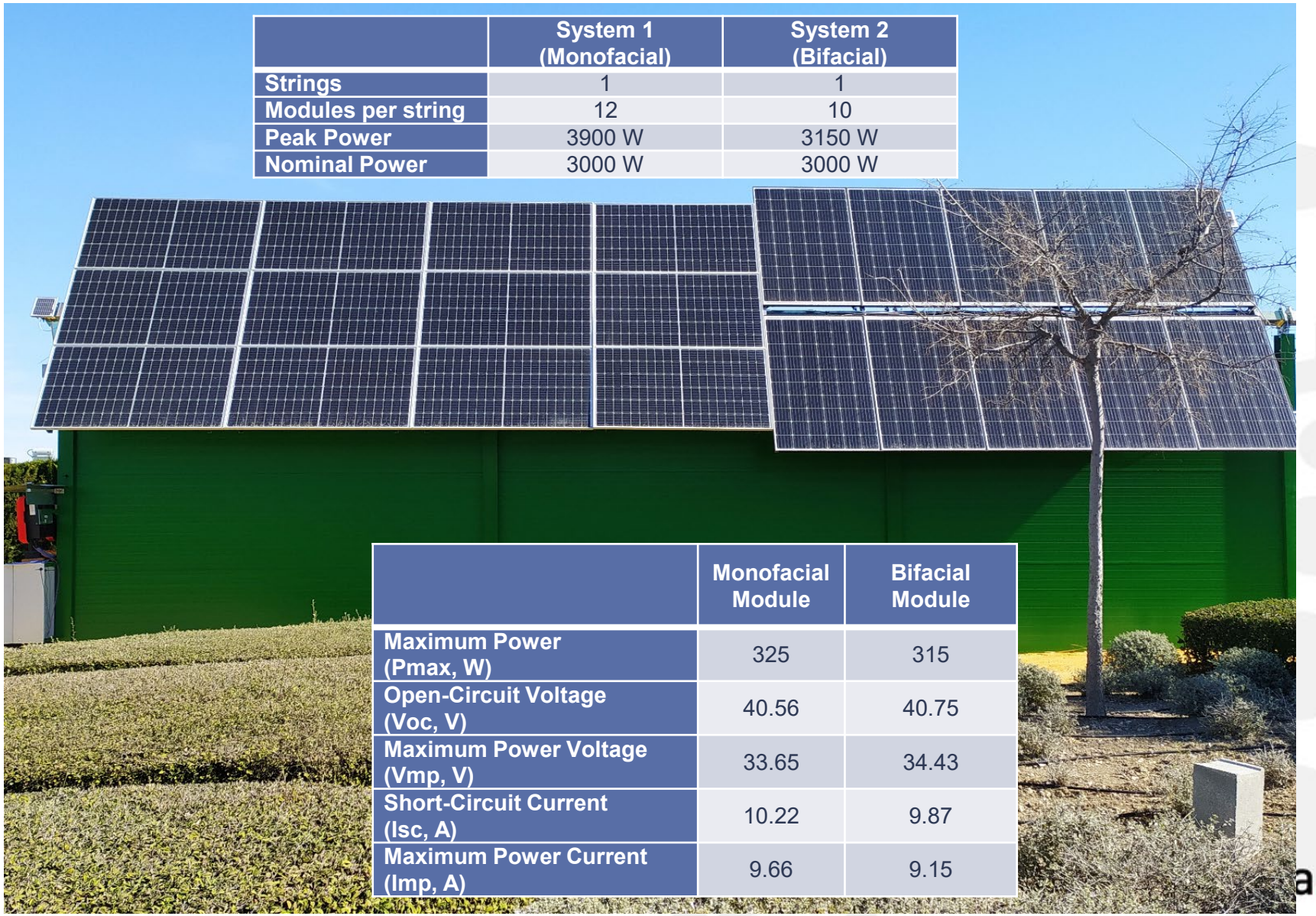
(Operating)

Technical Proposal

Technical Proposal

Technical Proposal

	System 1 (Monofacial)	System 2 (Bifacial)
Strings	1	1
Modules per string	12	10
Peak Power	3900 W	3150 W
Nominal Power	3000 W	3000 W



	Monofacial Module	Bifacial Module
Maximum Power (Pmax, W)	325	315
Open-Circuit Voltage (Voc, V)	40.56	40.75
Maximum Power Voltage (Vmp, V)	33.65	34.43
Short-Circuit Current (Isc, A)	10.22	9.87
Maximum Power Current (Imp, A)	9.66	9.15

Technical Proposal

UJAEN Design Advantages

Acoustic Isolation + Electrical (Green) Production

Land-Positive PV Solution

Environmental Awareness

Custom Designs (Noise Barriers and PV modules) ✗

Limitation in Azimuth Orientation (Optimal in East-West Roads) ✗

Limitation in Electricity Production ✗

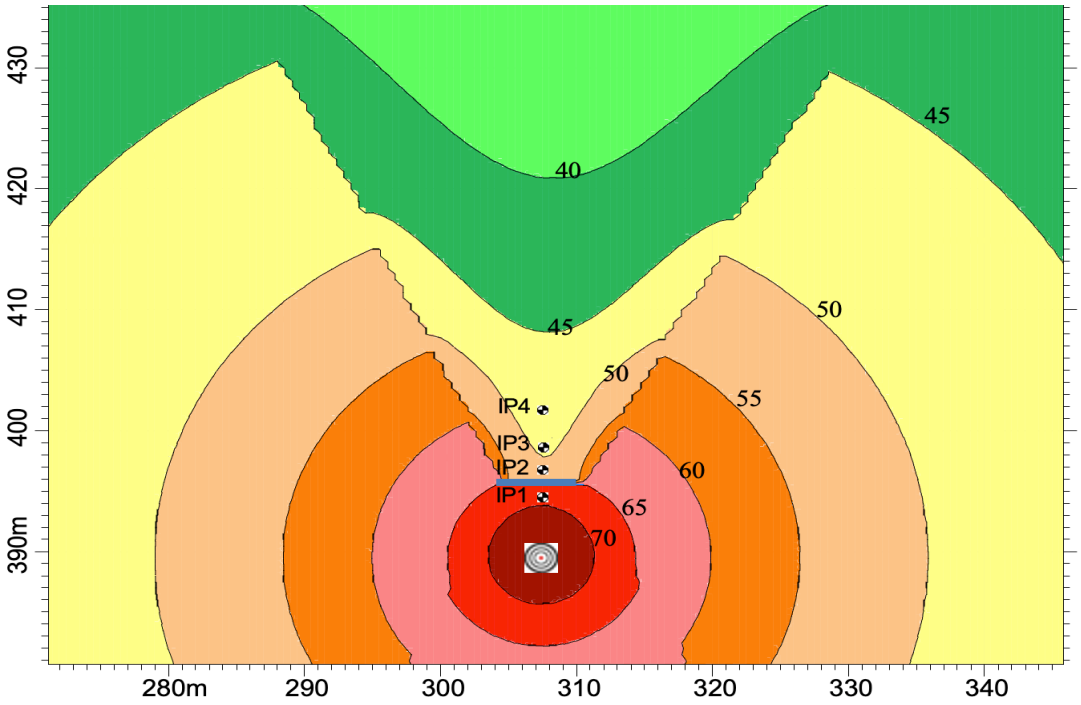
Standard Design (PV Modules, Noise Barriers and Tracker)

NO Azimuth Limitation (No Road Limitation)

Maximization of Electricity Production (Compared to fixed systems)

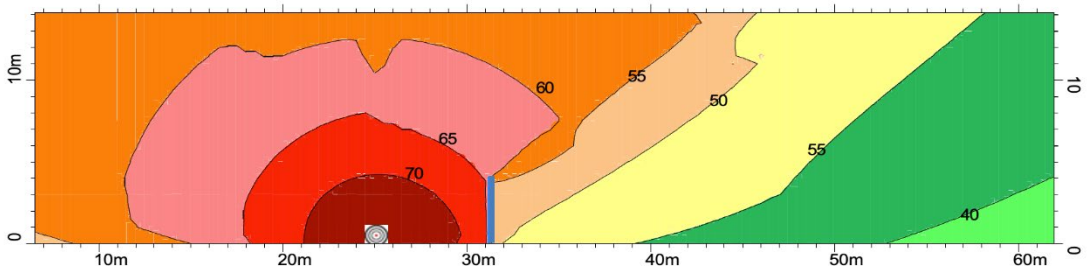
Preliminary Results

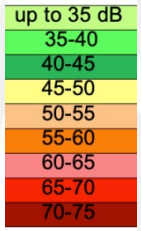
Noise Attenuation (Simulation)



Noise map

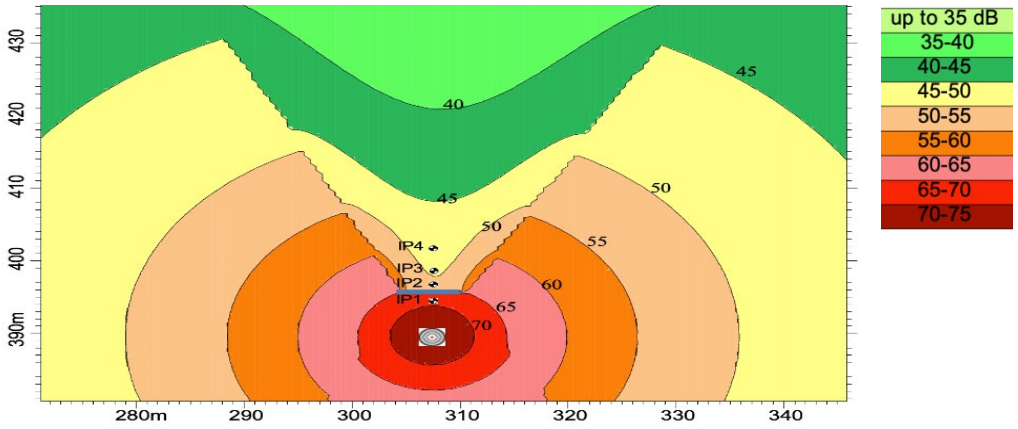
Scenario
- Short element
- Point sound source



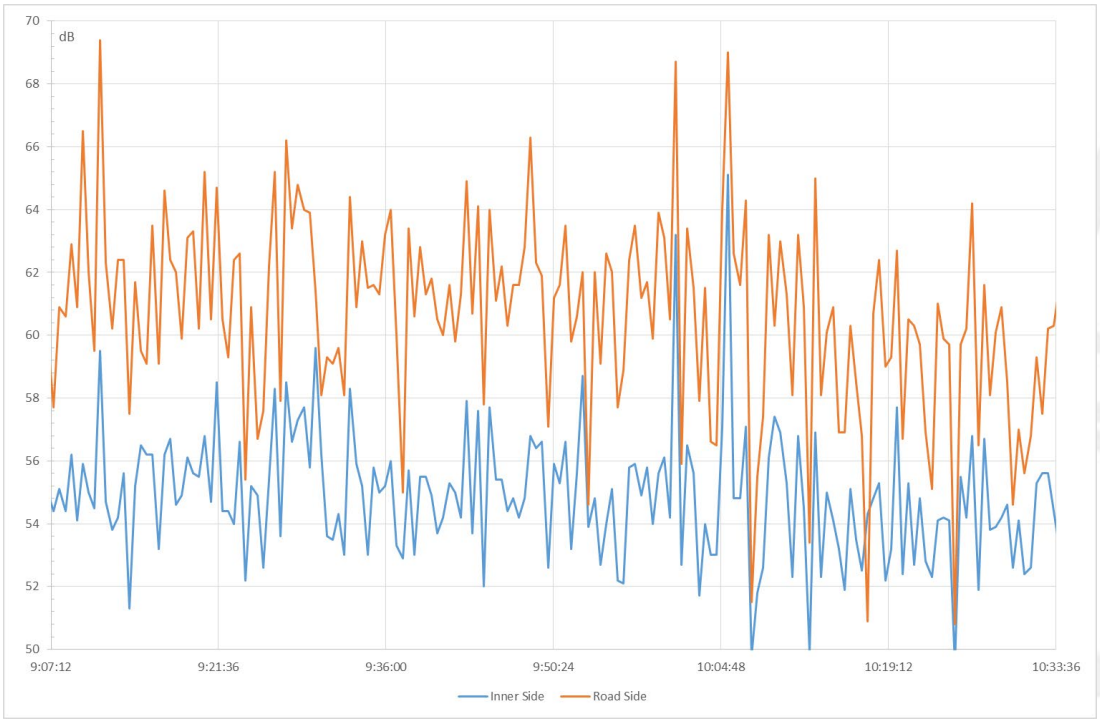


Preliminary Results

Noise Attenuation (Simulation + Measurement)



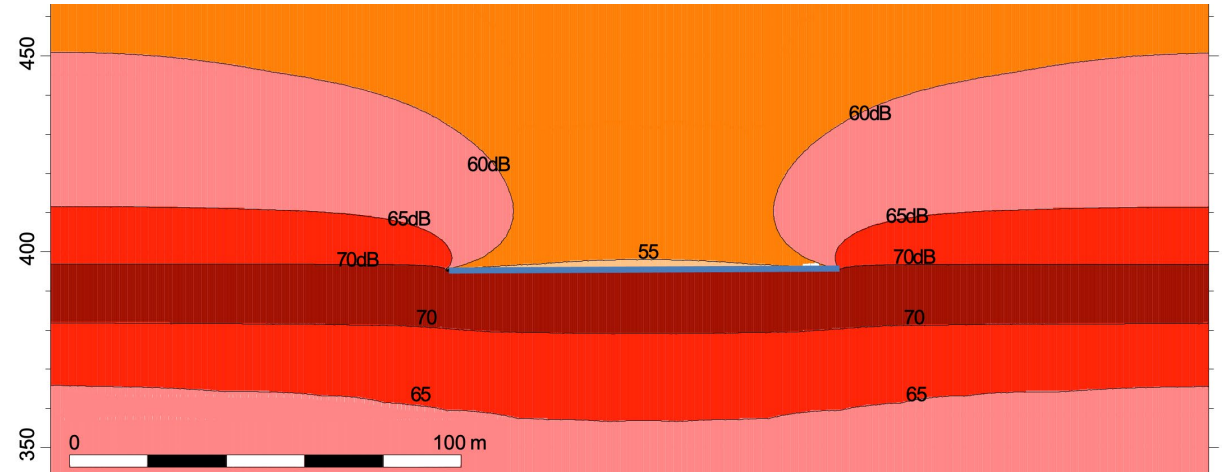
Noise map



Scenario
- Short element
- Point sound source

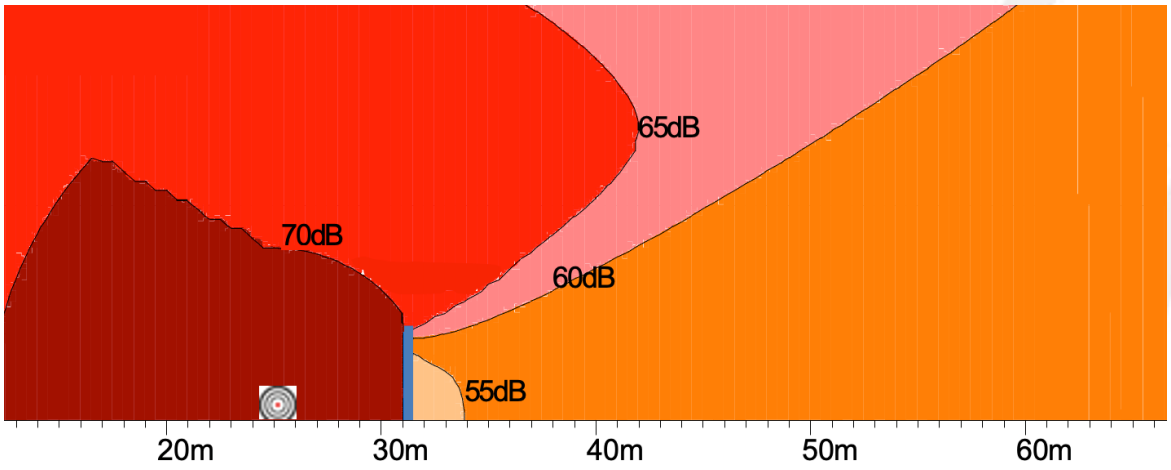
Preliminary Results

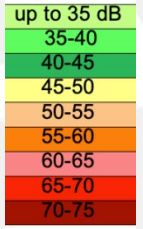
Noise Attenuation (Simulations)



Noise map

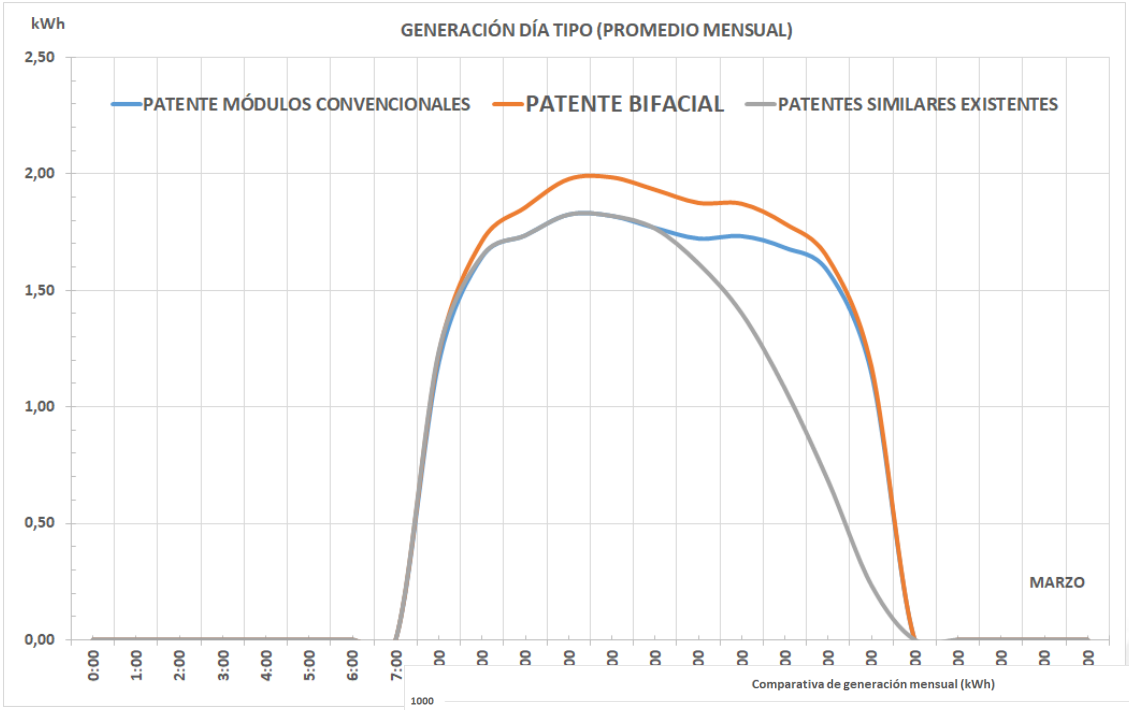
Scenario
- Long element
- Linear sound source

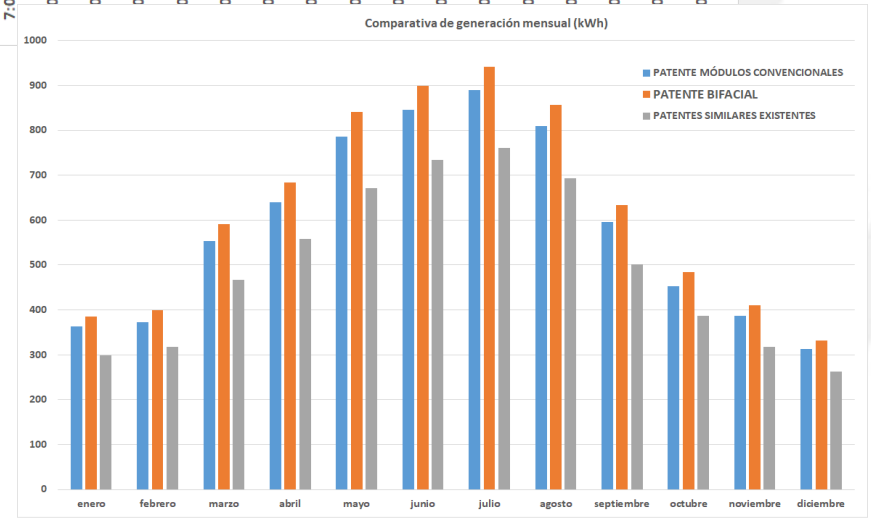




Preliminary Results

Energy Improvements (Simulations)

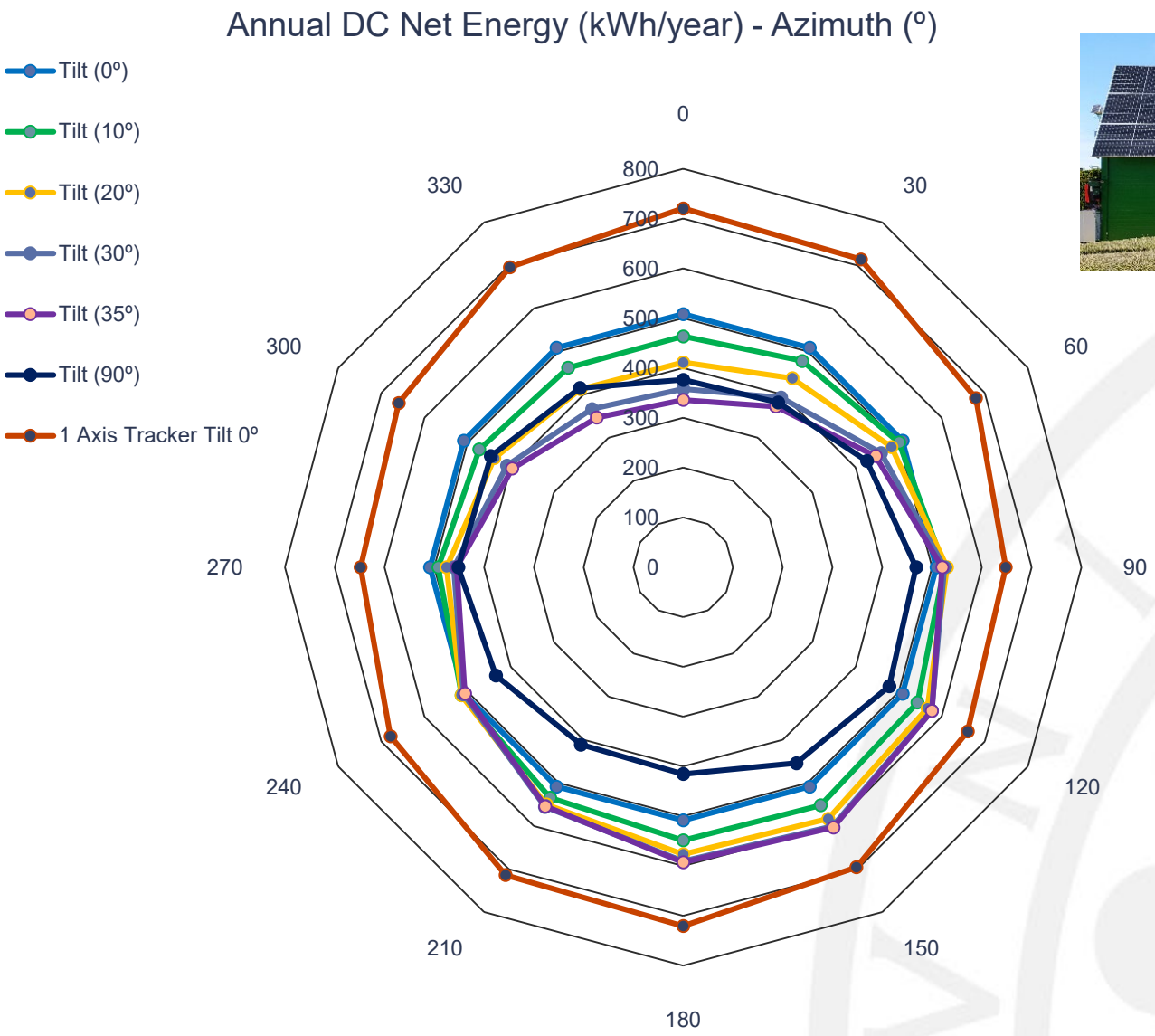




Improves power generation potential over any existing alternative

Preliminary Results

Energy Improvements (Simulations)



Improves power generation potential over any existing alternative under different orientations

Preliminary Results

Utility Model

MINISTERIO DE ENERGÍA, TURISMO Y AGENDA DIGITAL

Oficina Española de Patentes y Marcas

Licensing the Utility Model

Collaborate in future projects based on this proposal

Nº SOLICITUD: **U202032453**
Nº PUBLICACIÓN: **ES1258189**
TITULAR/ES:
UNIVERSIDAD DE JAÉN

FECHA EXPEDICIÓN: 25/02/2021

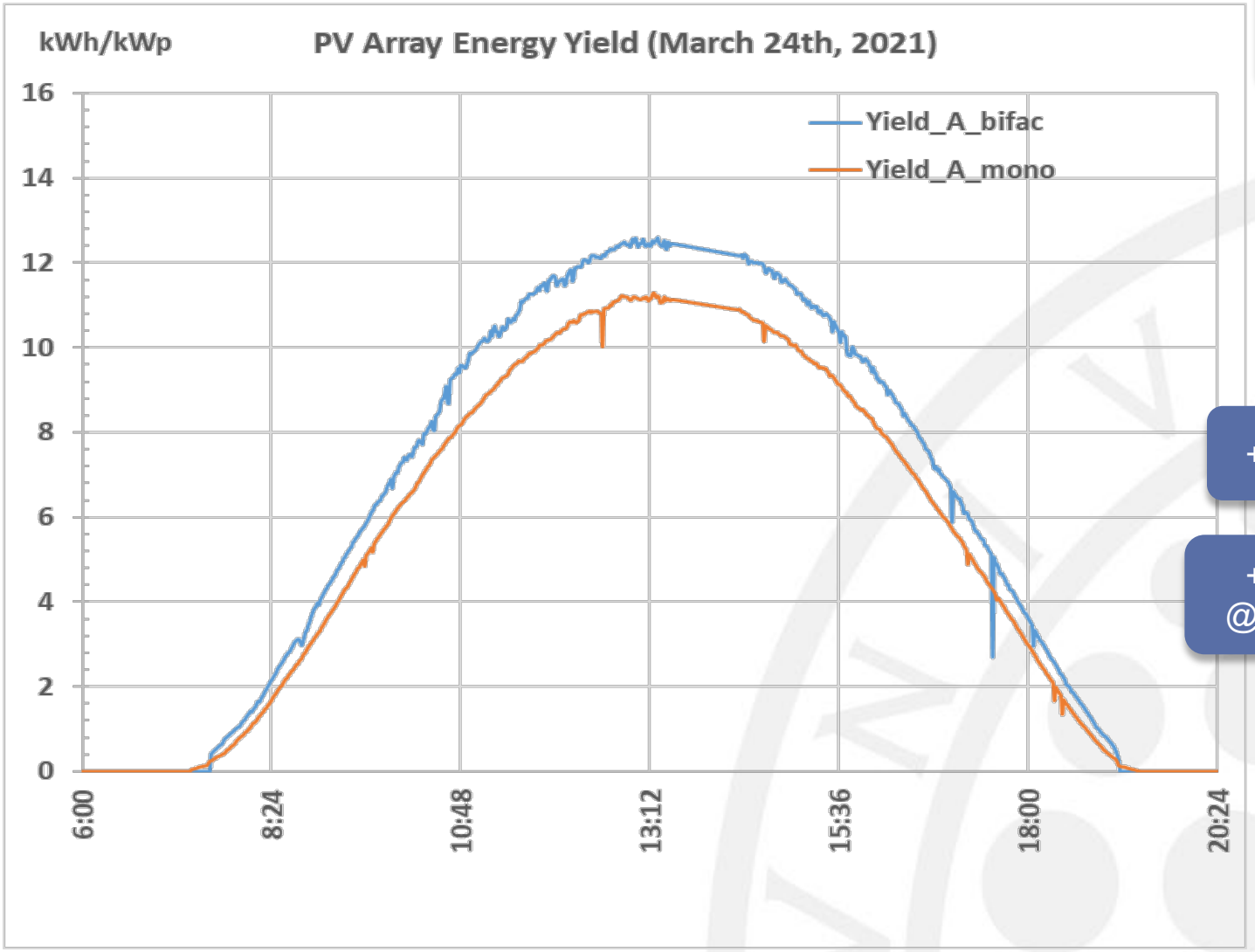
TÍTULO
DE
MODELO DE UTILIDAD

Cumplidos los requisitos previstos en la vigente Ley 24/2015, de 24 de julio, de Patentes, se expide el presente TÍTULO, acreditativo de la concesión del Modelo de Utilidad.

Se otorga al titular un derecho de exclusiva en todo el territorio nacional, bajo las condiciones y con las limitaciones en la Ley de Patentes. La duración del modelo de utilidad será de **diez años** contados a partir de la fecha de presentación de la solicitud (11/05/2020).

R&D Results

Bifacial PV Characterisation



Bifacial vs Monofacial

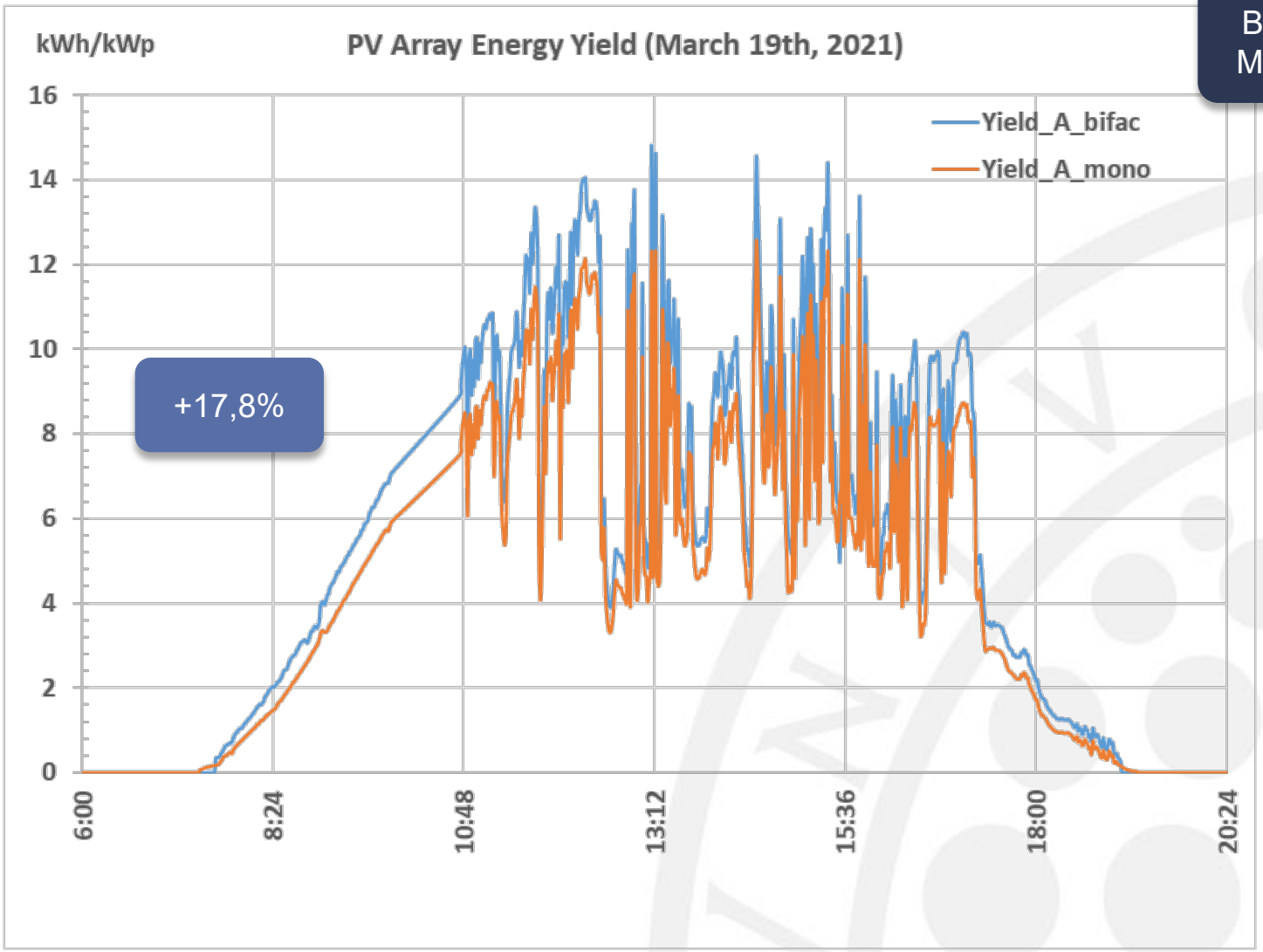
+14,5%

+21,5% @Max Diff

R&D Results

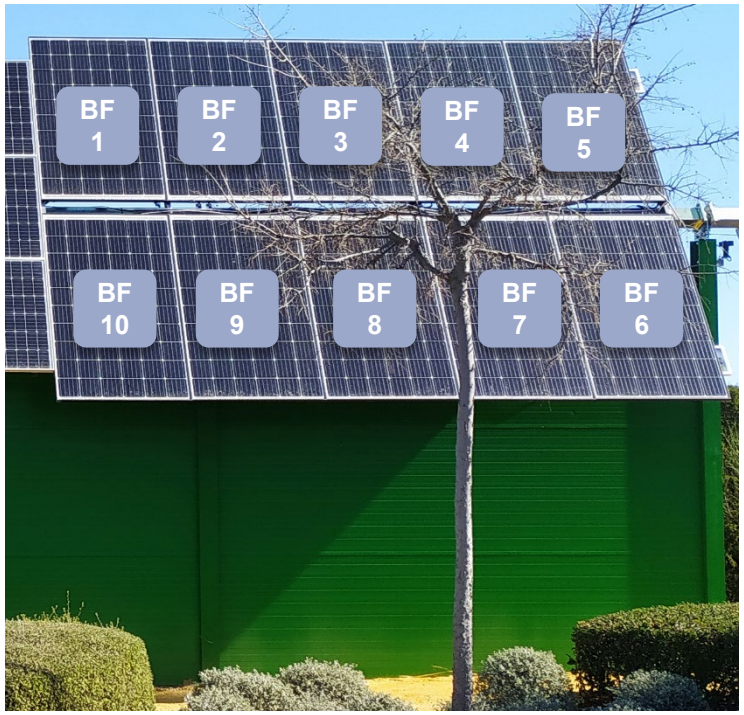
Bifacial PV Characterisation

Bifacial vs Monofacial

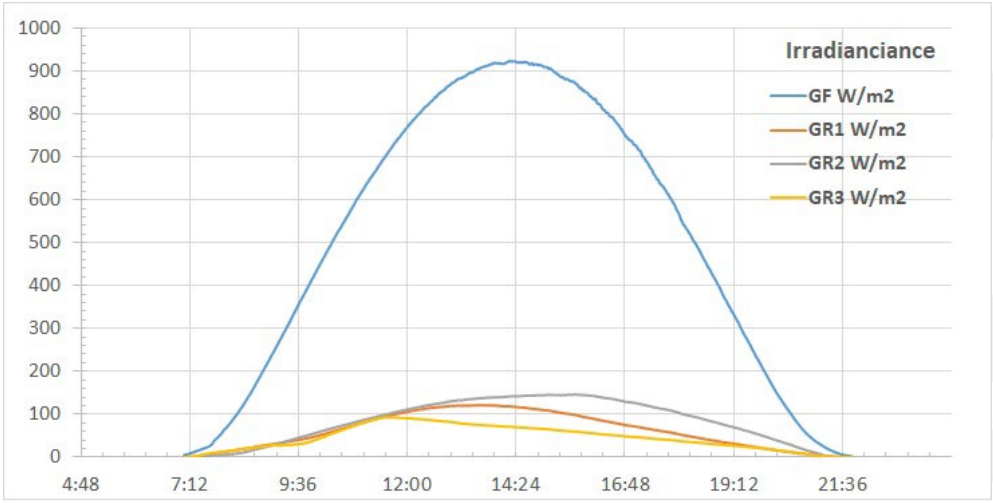


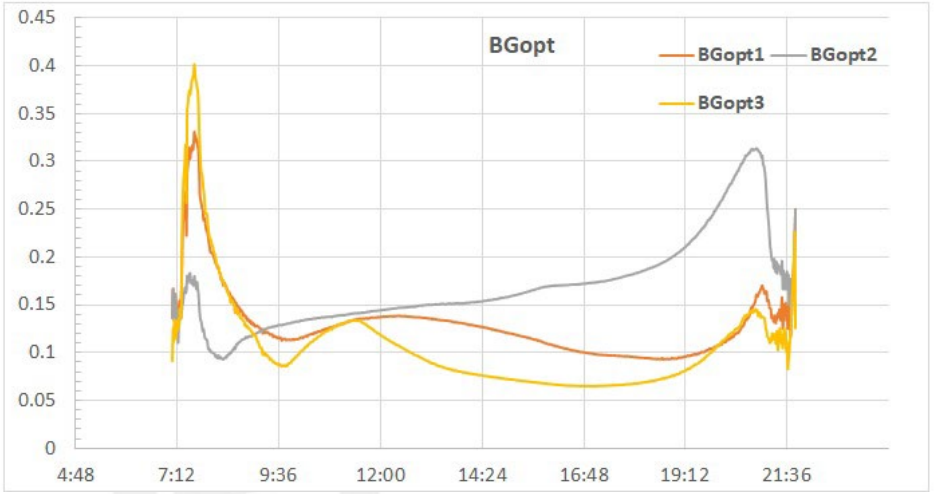
R&D Results

Bifacial PV Characterisation



Grear
vs
Gfront





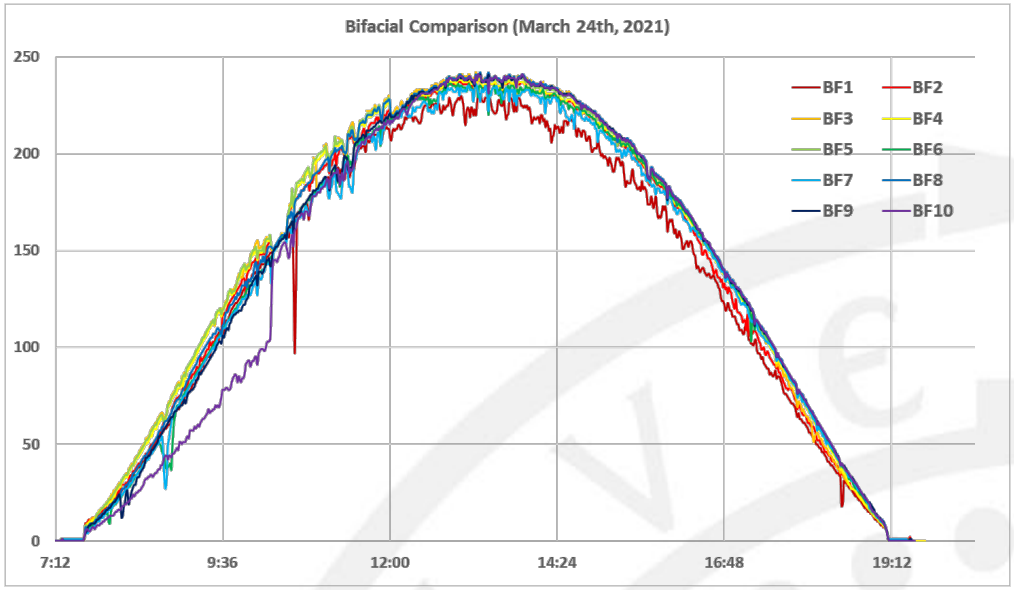
R&D Results

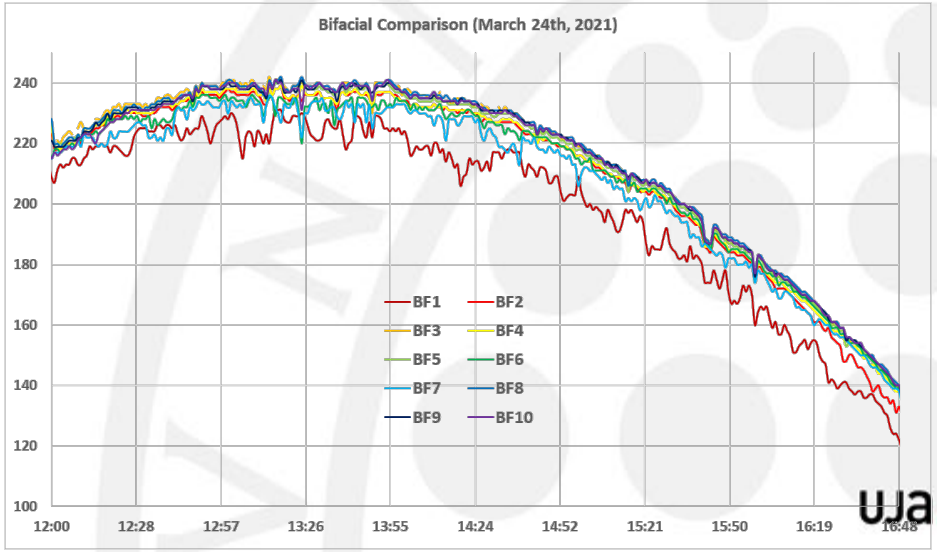
Bifacial PV Characterisation

BF Mismatch

@14h → +6.3% (BF1-BF8)

Median Value→ +9.8%

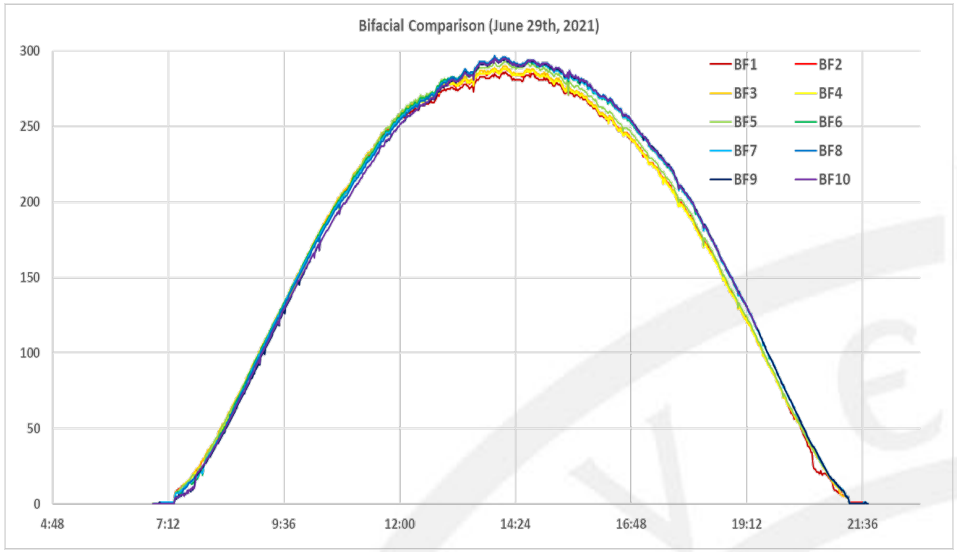


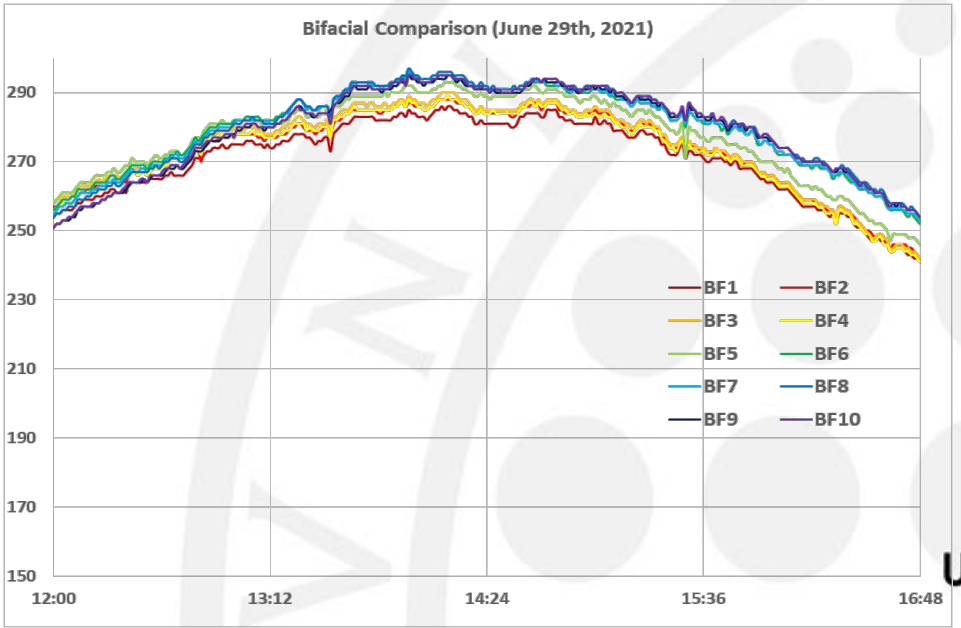


R&D Results

Bifacial PV Characterisation

BF Mismatch





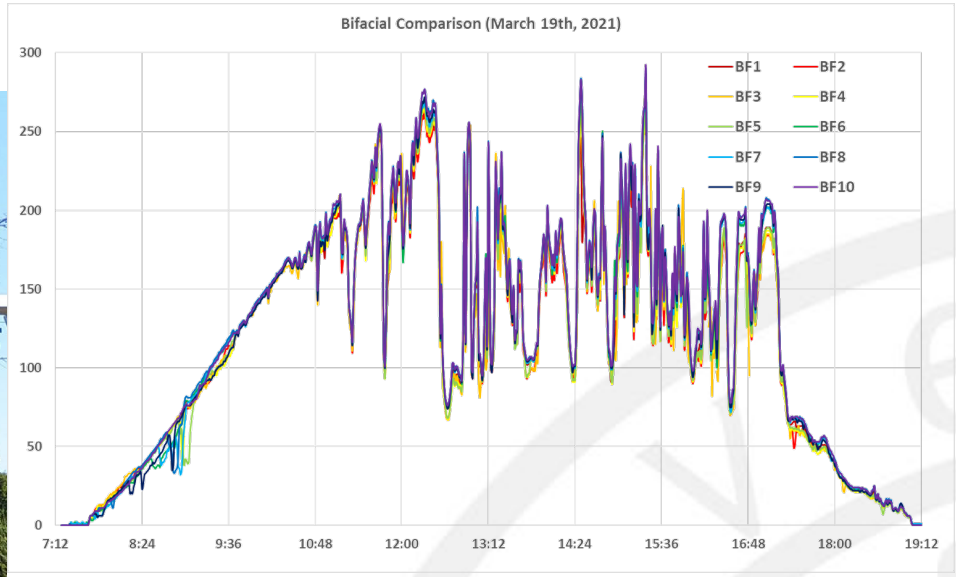
@14h → +3.9% (BF1-BF8)

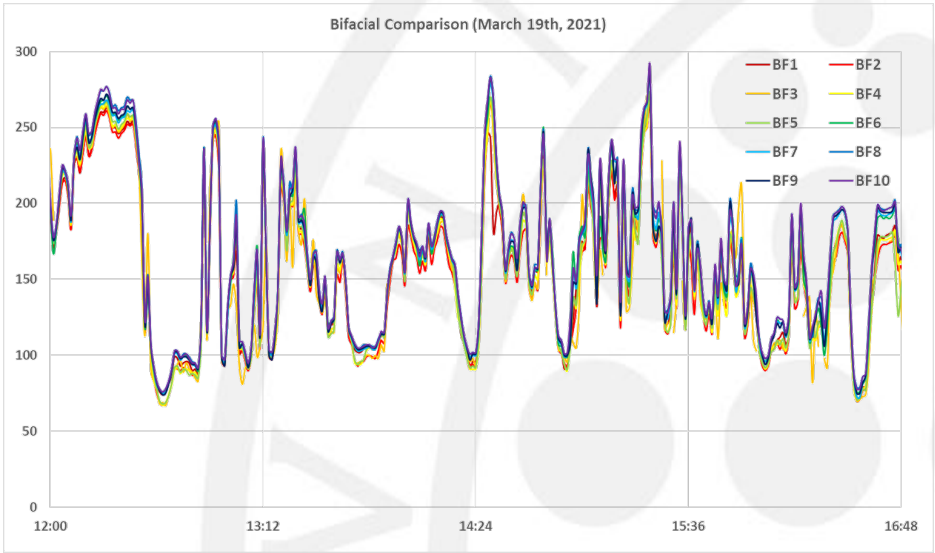
Median Value→ +5.2%

R&D Results

Bifacial PV Characterisation

BF Mismatch

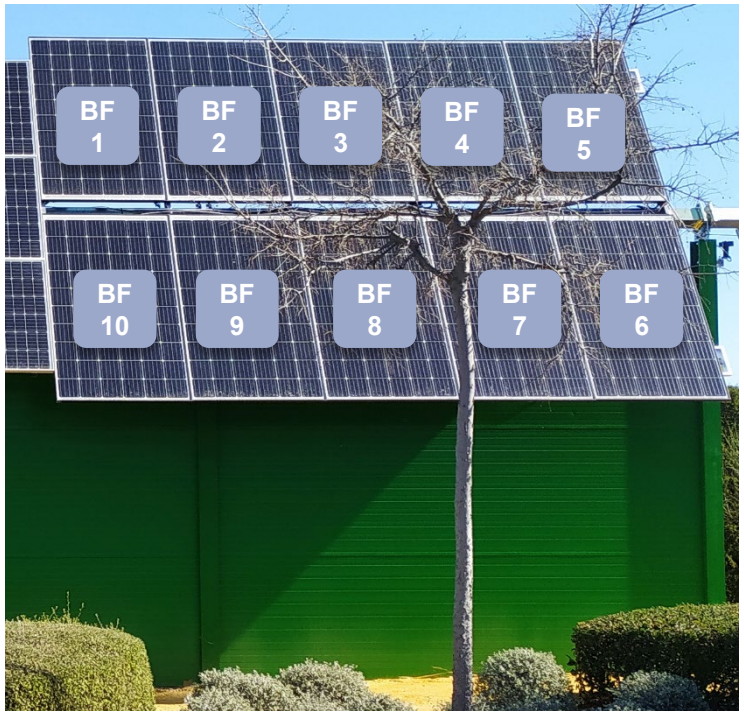




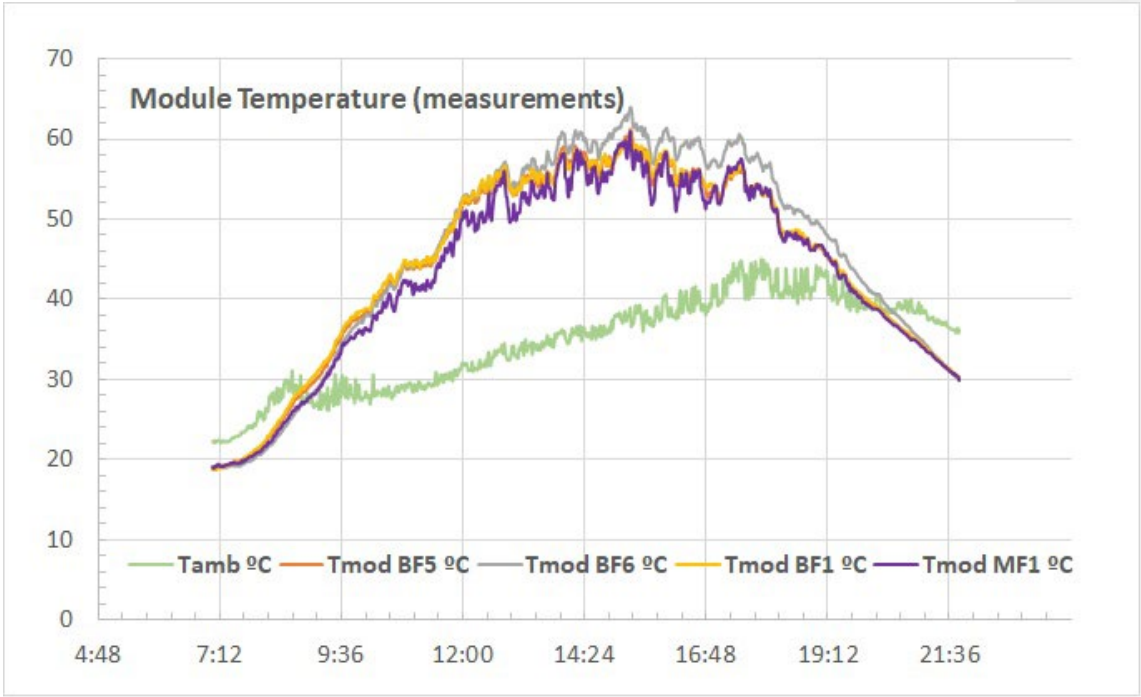
Median Value→ +11.5%

R&D Results

Bifacial PV Characterisation



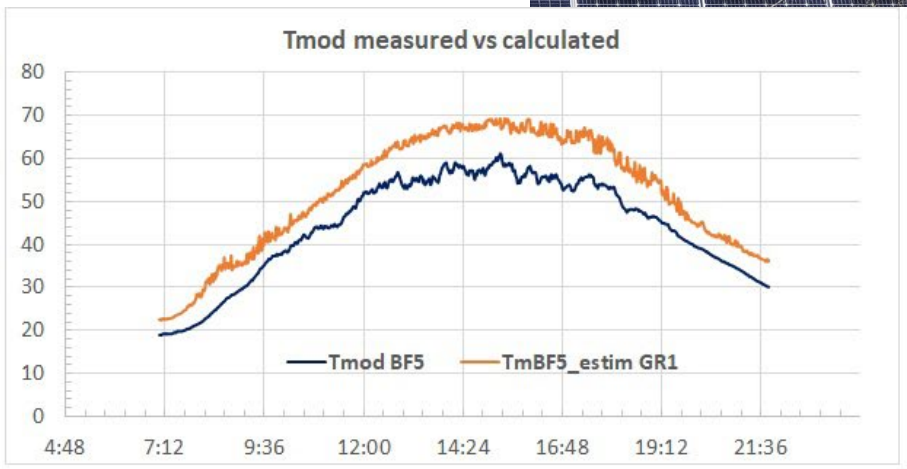
Temperature Analysis

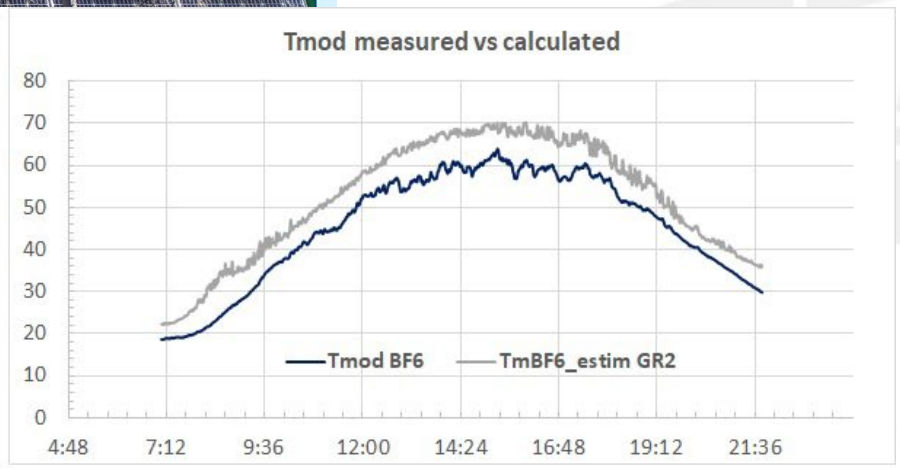


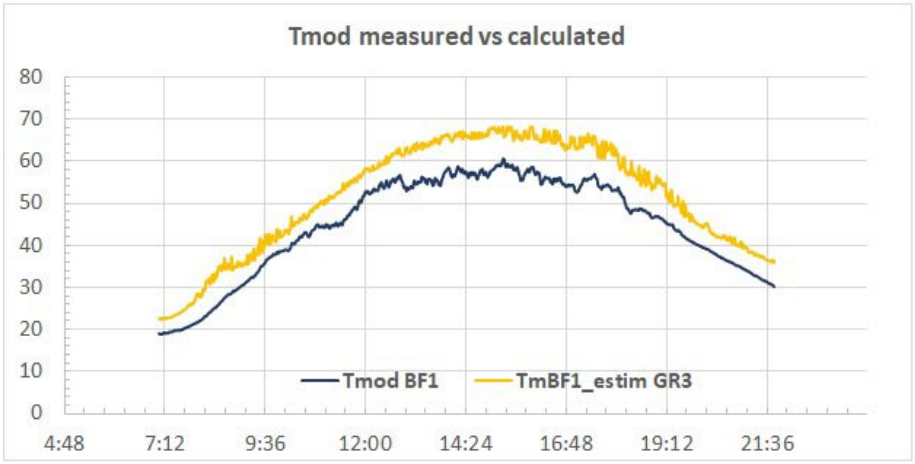
R&D Results

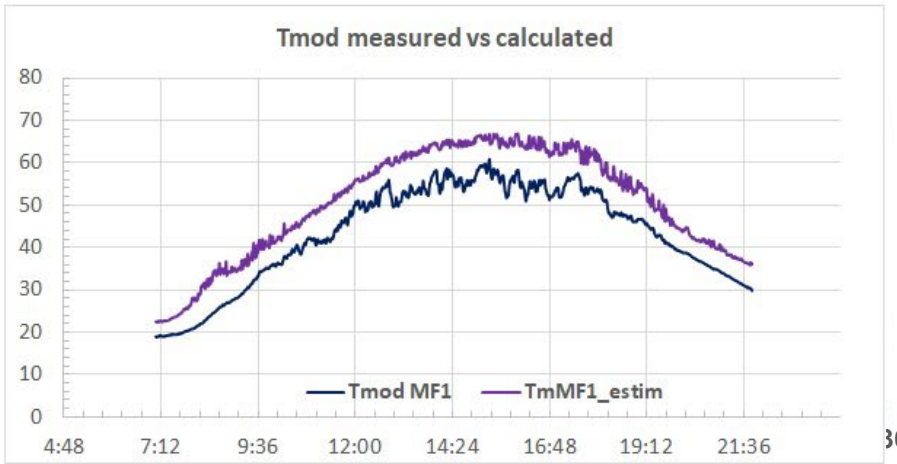
Bifacial PV Characterisation

Temperature Analysis



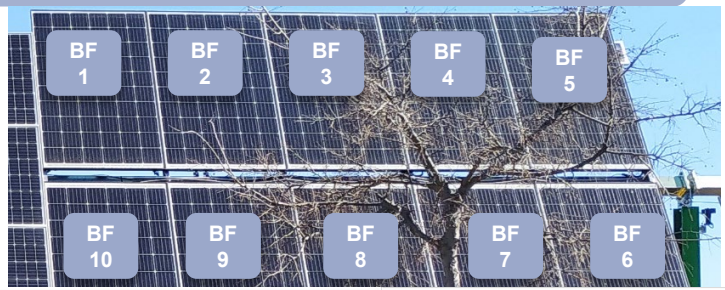




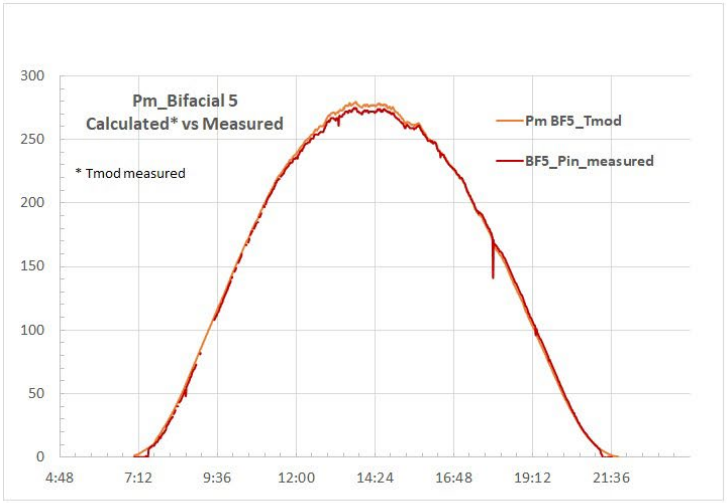


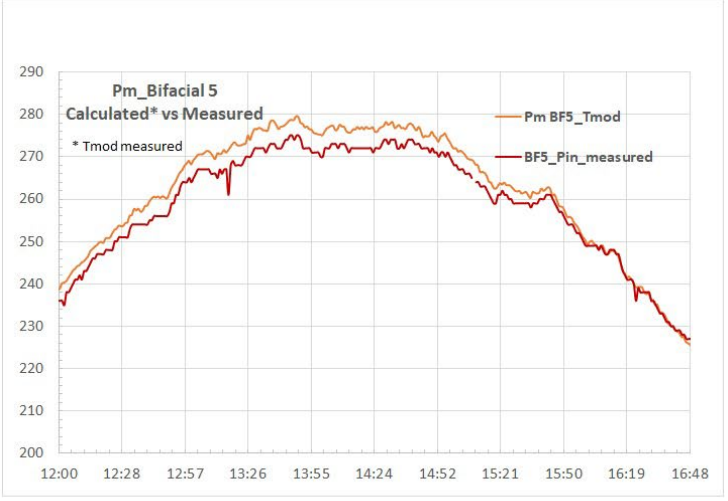
R&D Results

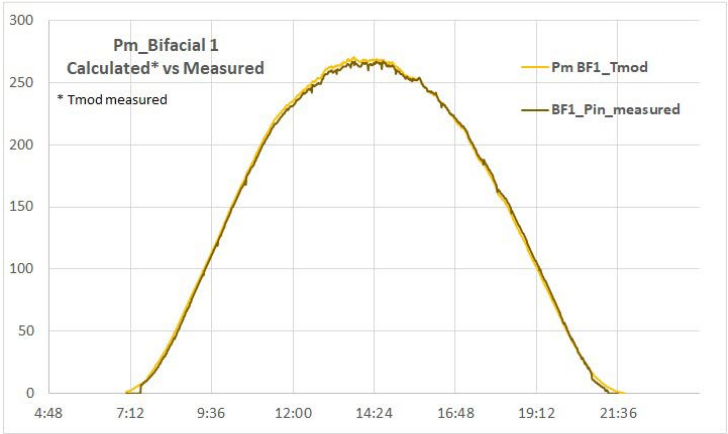
Bifacial PV Characterisation

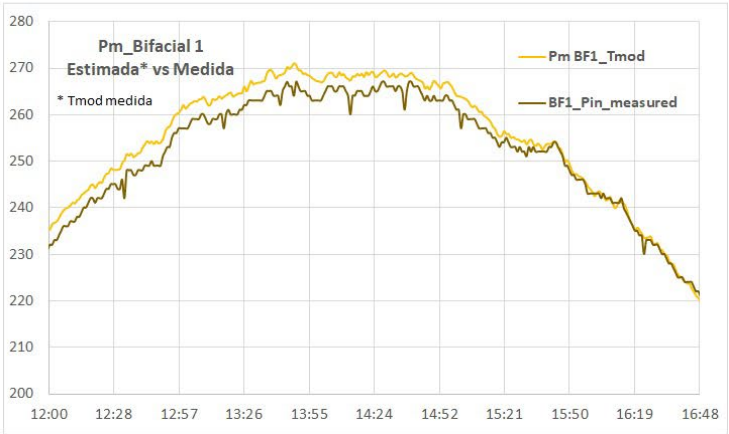


Power calculations









Universidad de Jaén

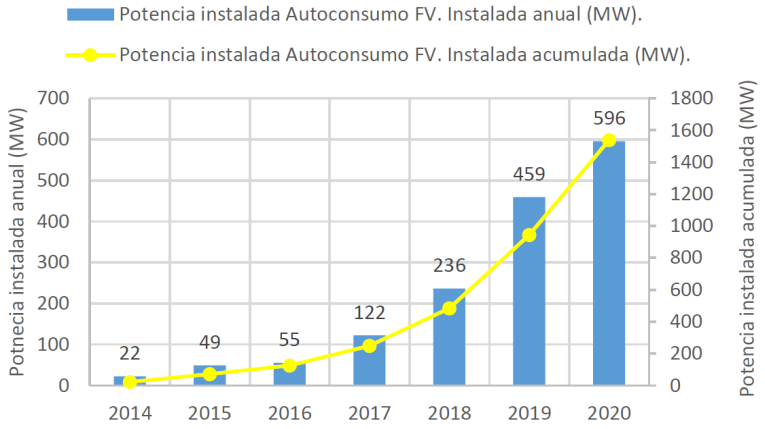
Content

Photovoltaic Engineering Applications: Alternatives to standard designs

- Context (UJA PV Team and PV news)
- Infraestructure PV Integration
- Self-Consumption PV Design Tool

Context

Spanish PV Sector: Priorities



FUENTE: Ministerio para la Transición Ecológica y el Reto Demográfico a partir de datos de la Unión Española fotovoltaica (UNEF).

	2030	
Tipo de consumidor (GW)	**Escenario OBJETIVO**	**Escenario ALTA PENETRACIÓN**
Comercial	5,8	7,7
Residencial plurifamiliar	1,9	3,8
Residencial unifamiliar	0,1	0,9
Industrial	1,1	1,6
TOTAL NACIONAL[15]	**9**	**14**

FUENTE: Ministerio para la Transición Ecológica y el Reto Demográfico a partir del informe de potencial IDAE.

Context

Self-Consumption Designs

“Standardised” Designs

Conventional Modules

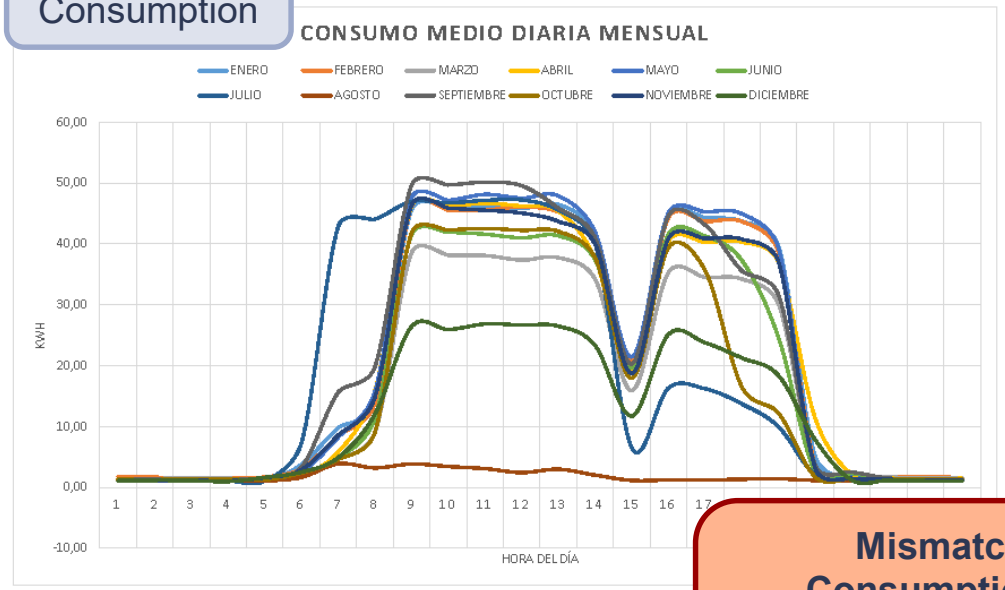
South Orientations (if possible)

Tilt Angles: 25-35º Roof Slope

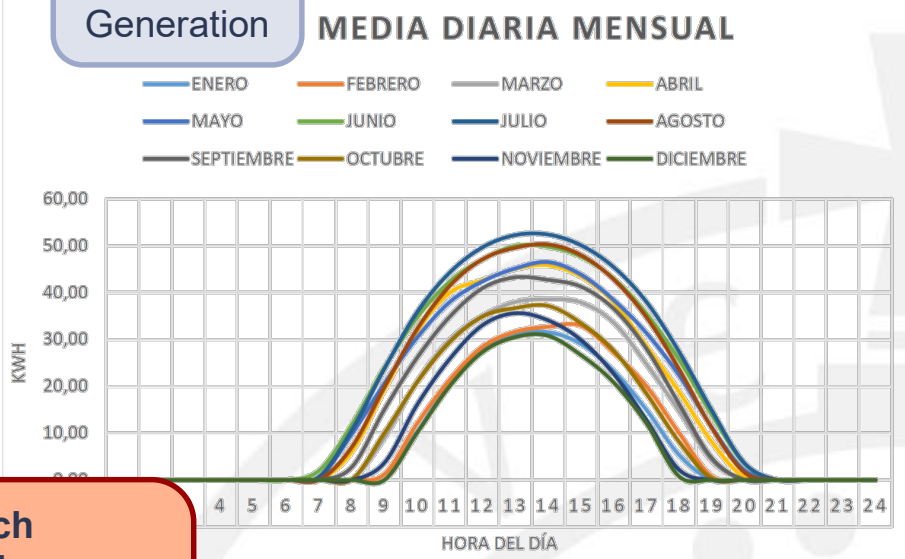
Context

PV Generation vs Consumption Profiles

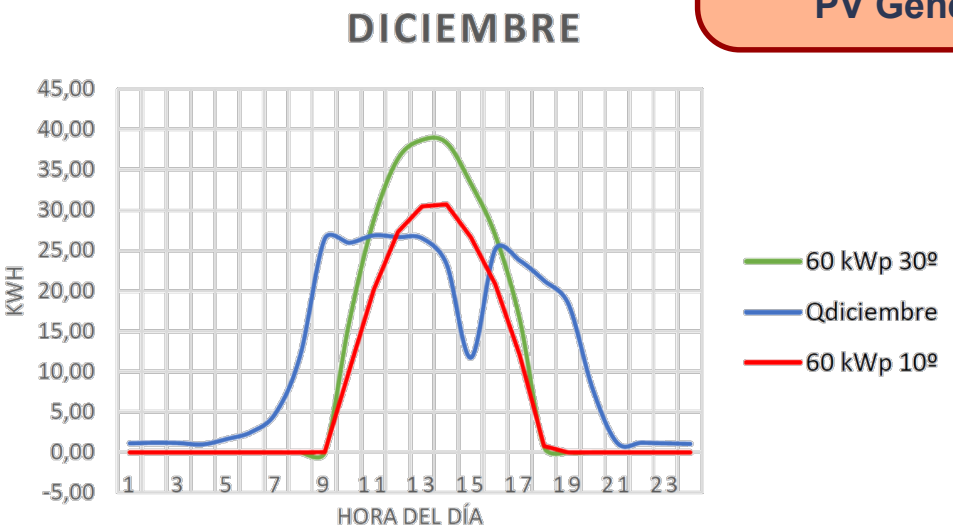
Consumption

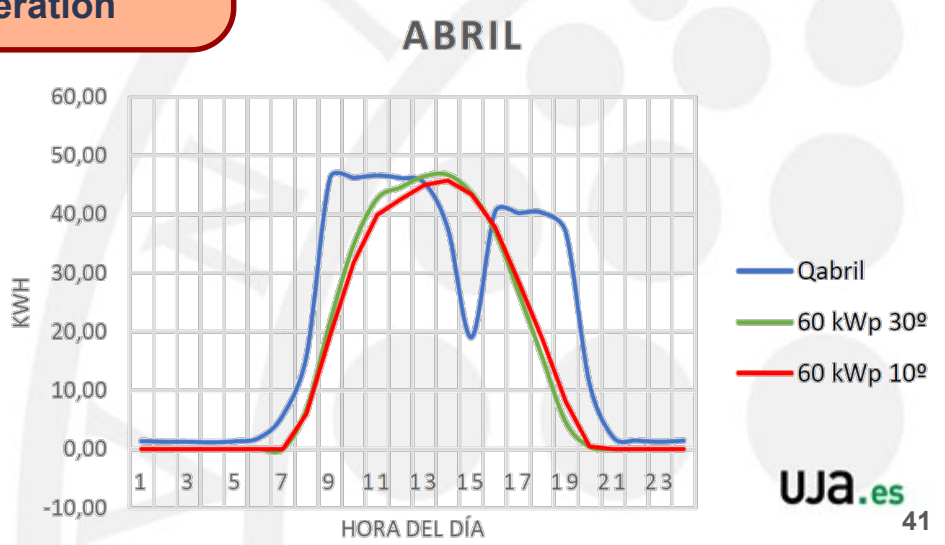


PV Generation



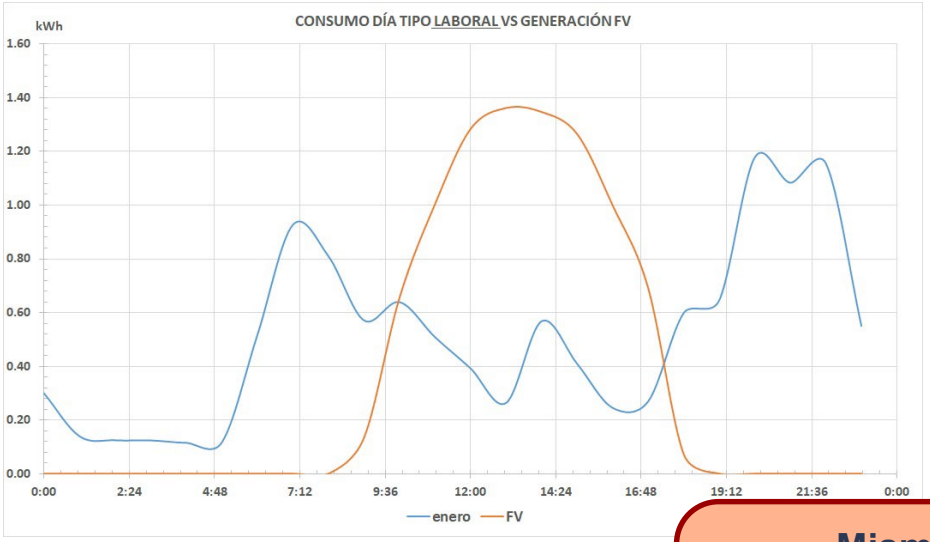
Mismatch Consumption – PV Generation

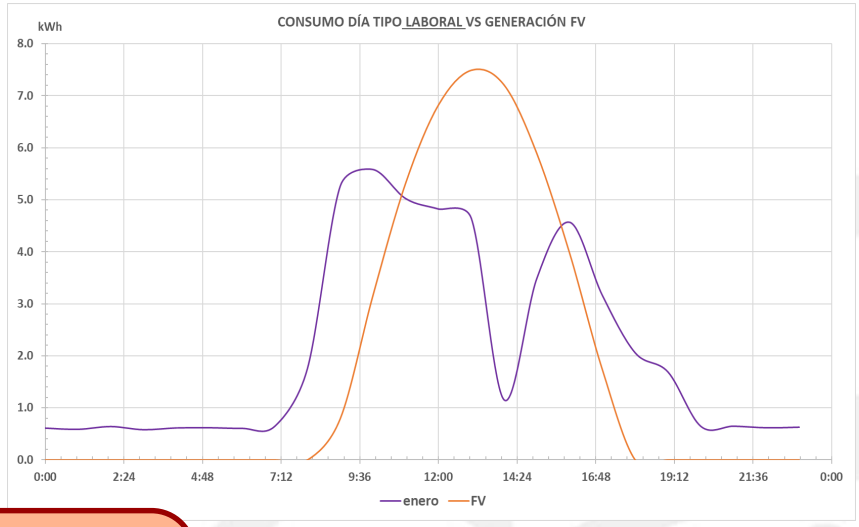




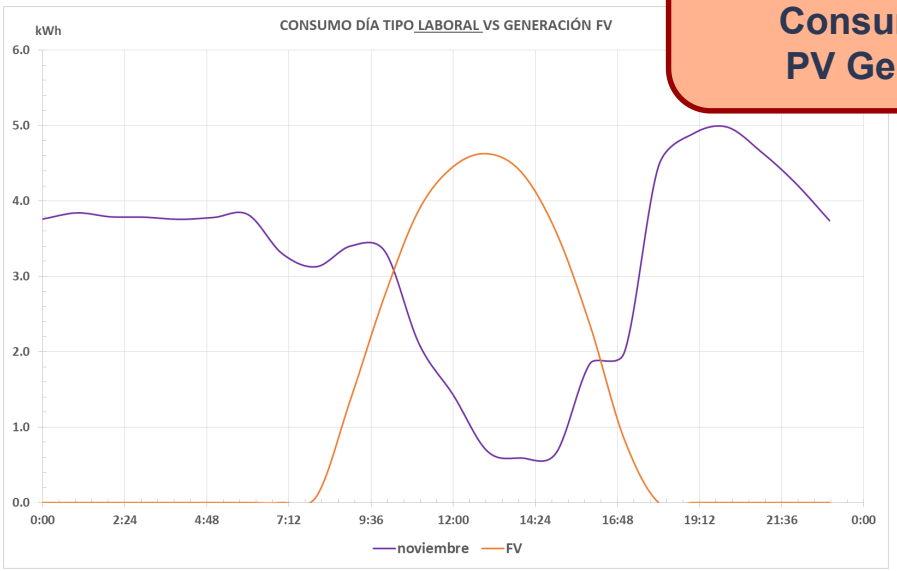
Context

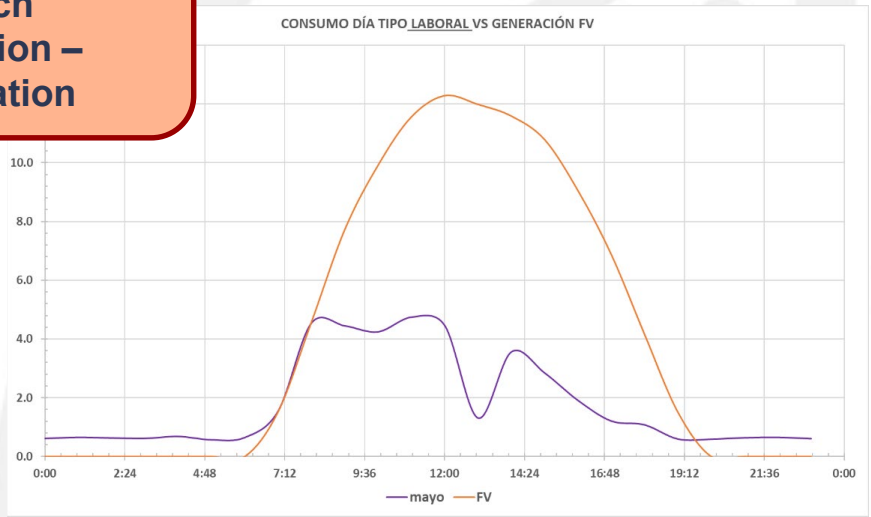
PV Generation vs Consumption Profiles





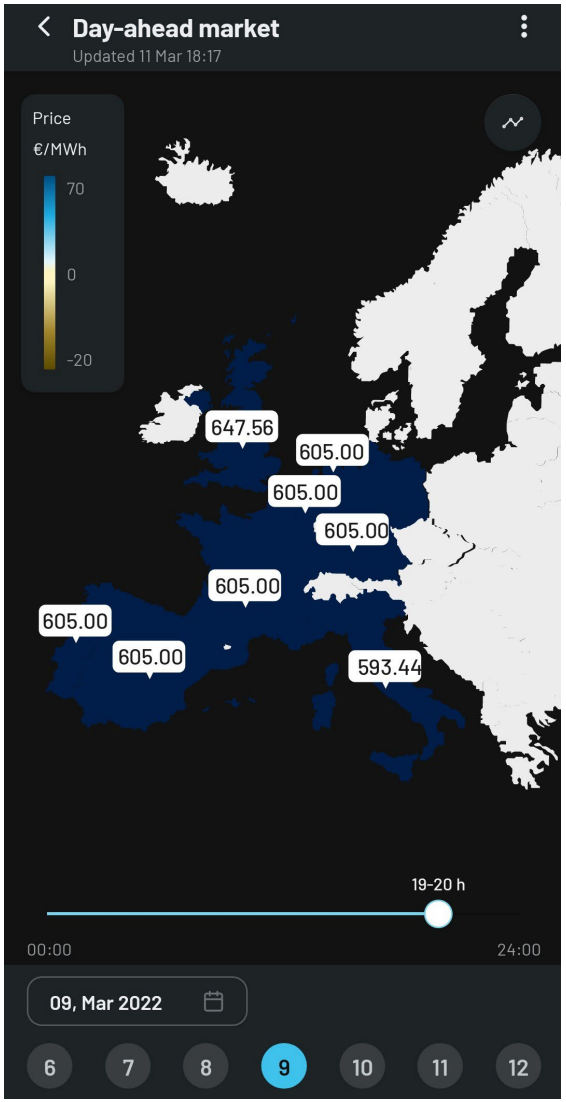
Mismatch Consumption – PV Generation

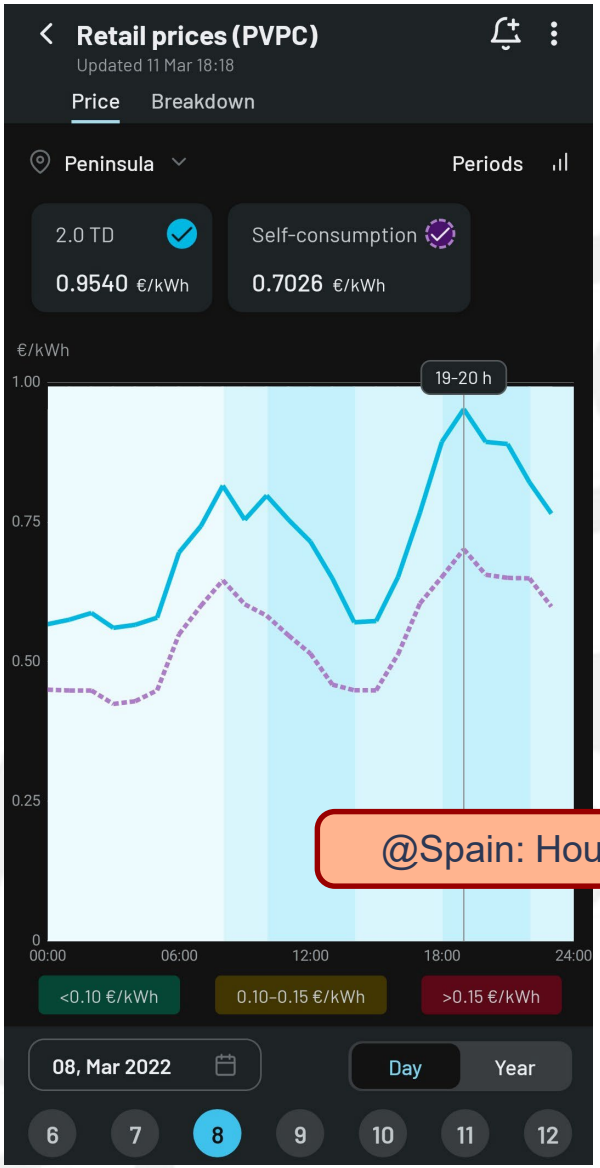




Context

High Electricity Prices

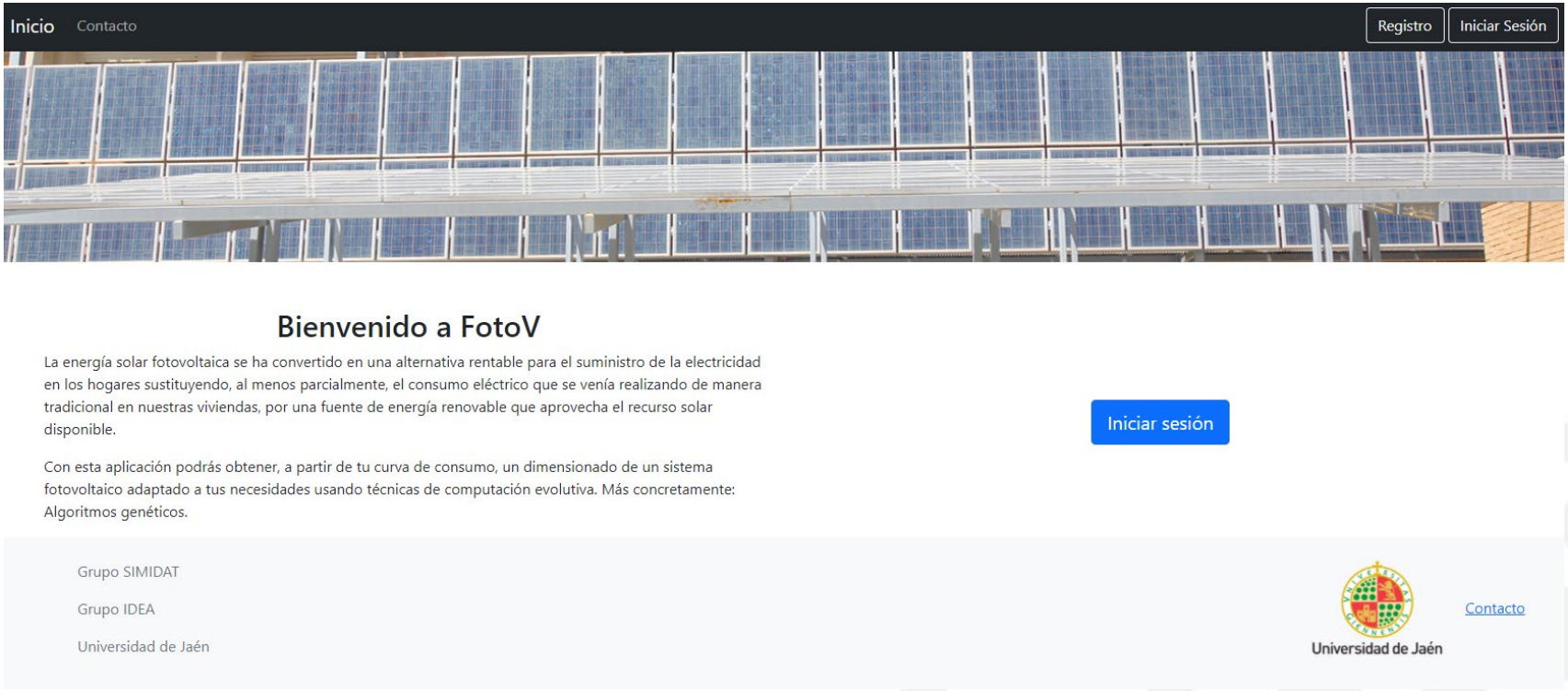




@Spain: Hourly basis

Design optimisation tool

Joint Venture



IDEA Photovoltaic Engineering Research Team

+

Intelligent Systems and Data Mining Research Team

Design optimisation tool

Customised design solution

Experimentos realizados

Experimento ID: 48

Información básica

Fecha	March 8, 2022, 3:25 a.m.
Latitud	37.77342006532819
Longitud	-3.7868928909301762
Curva de consumo	cristobalmerged.csv
Total de energía consumida	9997.9 kwh
Coste sin placas	3465.04 €

Resumen | 5 modulos - 2.5 kw | 6 modulos - 3.0 kw | 7 modulos - 3.5 kw | 8 modulos - 4.0 kw | 9 modulos - 4.5 kw

Ejecución	Coste sin compensación	Coste con compensación	Energía generada	Amortización
5 modulos - 2.5 kw	3288.37 €	2983.33 €	4746.11 kWh	7.781652861680263 periodos
6 modulos - 3.0 kw	3271.63 €	2885.6 €	5720.61 kWh	7.763012563854756 periodos
7 modulos - 3.5 kw	3257.7 €	2799.73 €	6653.49 kWh	7.887901880326466 periodos
8 modulos - 4.0 kw	3245.2 €	2721.79 €	7695.46 kWh	8.069424823410698 periodos
9 modulos - 4.5 kw	3241.05 €	2638.97 €	8421.09 kWh	8.167951868485721 periodos

User's Consumption Profile + **PV Generation Simulation** + **Electricity tariffs**

Hourly basis

Design optimisation tool

Customised design solution

Coste sin placas	3465.04 €

Resumen | 5 modulos - 2.5 kw | 6 modulos - 3.0 kw | 7 modulos - 3.5 kw | 8 modulos - 4.0 kw | 9 modulos - 4.5 kw

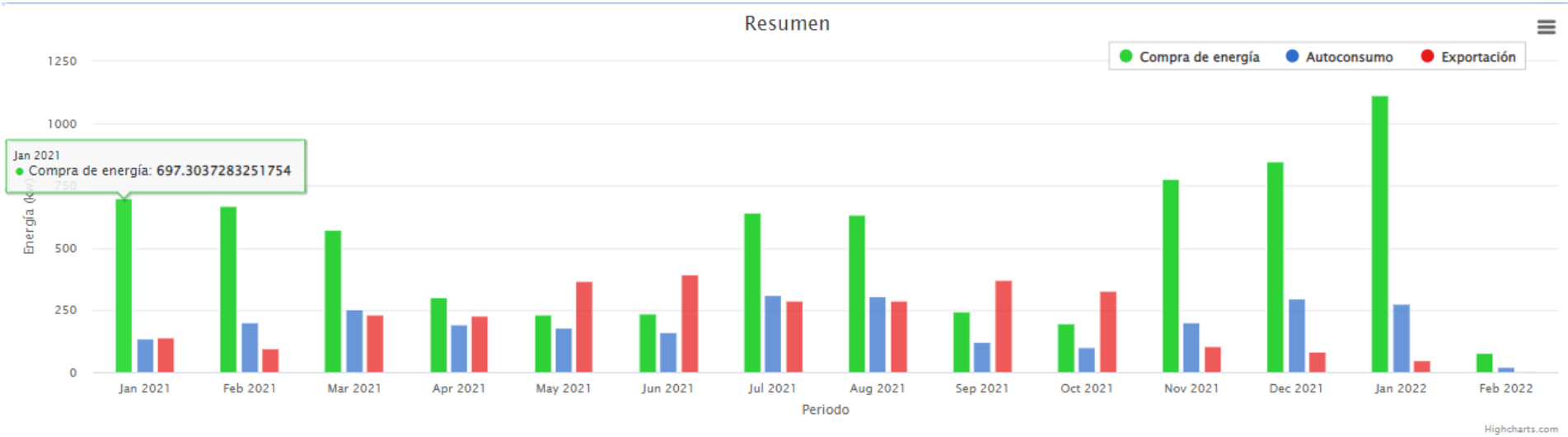
Resultados del algoritmo

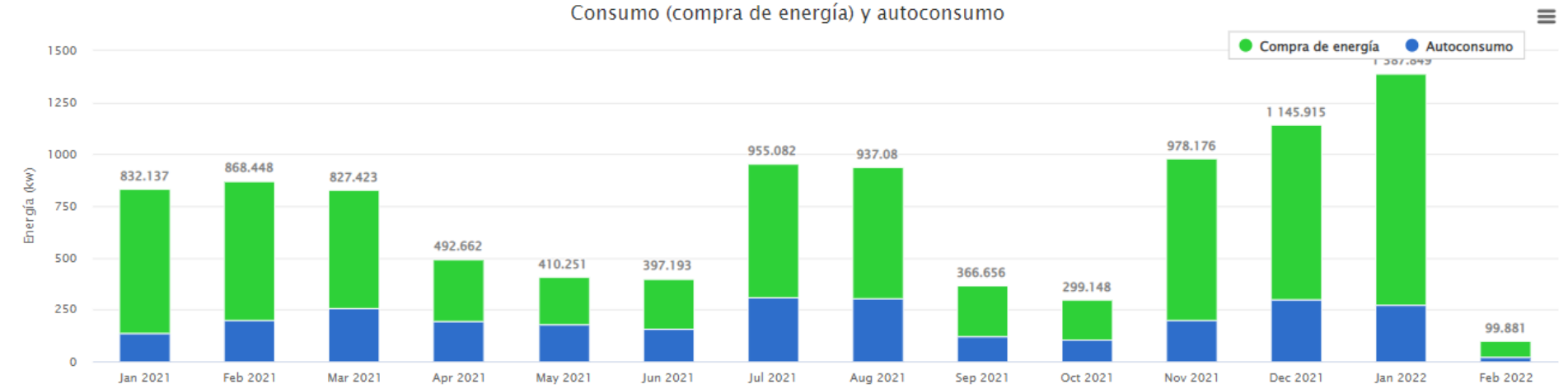
Tiempo de ejecución	0:16:07.830000 s
Coste instalación	4498.2 €
Coste total con placas (sin compensación)	3271.63 €
Coste total con placas (con compensación)	2885.6 €
Energía producida	5720.61 kWh
Energía comprada	7241.78 kWh
Energía autoconsumida	2756.12 kWh
Amortización (en periodos dados por la curva de consumo, sin compensación)	23.257322699022803 periodos
Amortización (en periodos dados por la curva de consumo, con compensación)	7.763012563854756 periodos

Nº Modulo	Nombre	Descripción	Potencia (kw)	Inclinación (º)	Acimut y orientación real (º, siendo 0º el Sur)
1	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
2	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
3	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
4	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
5	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
6	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)

Design optimisation tool

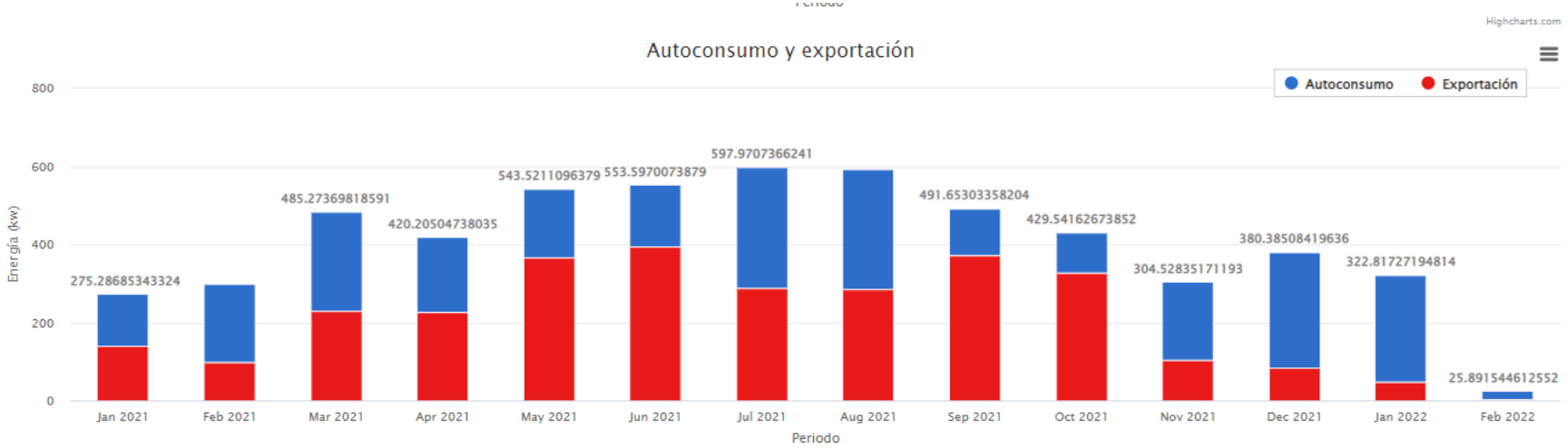
Customised design solution





Design optimisation tool

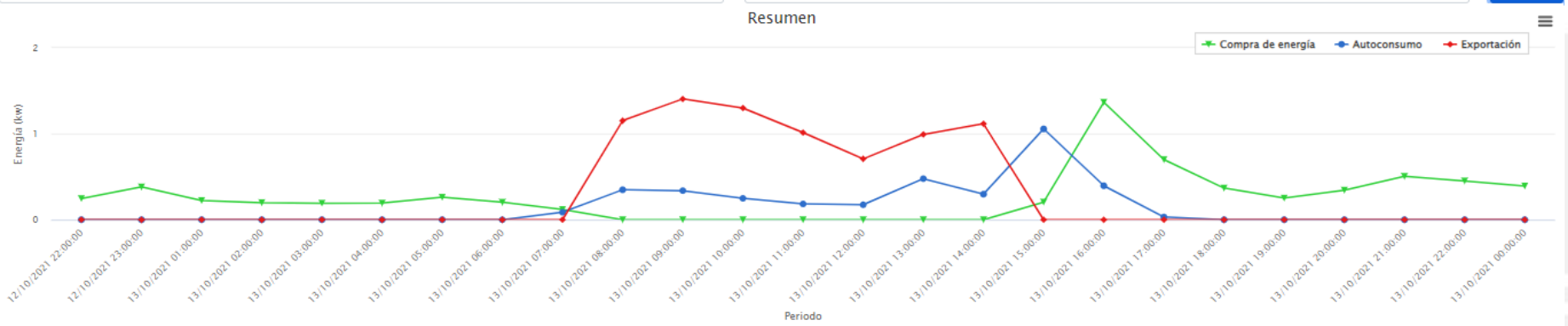
Customised design solution

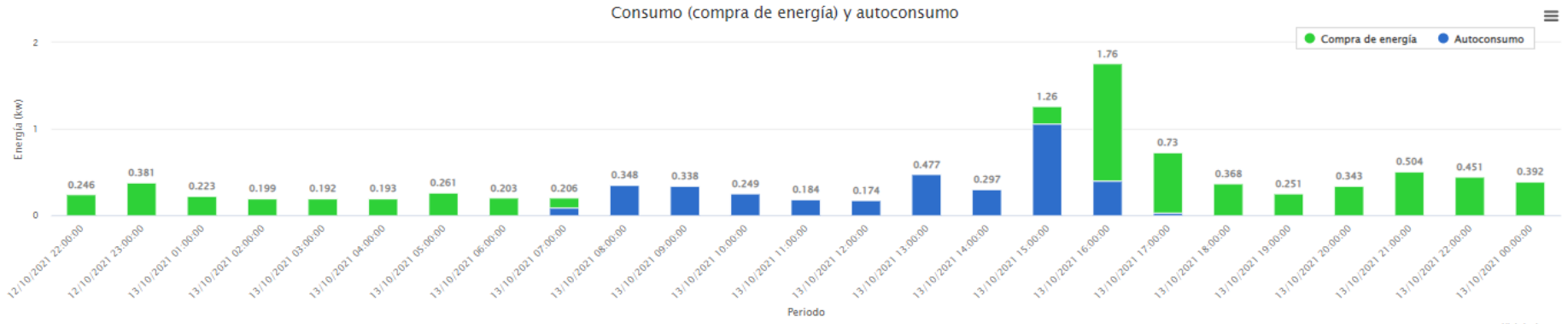


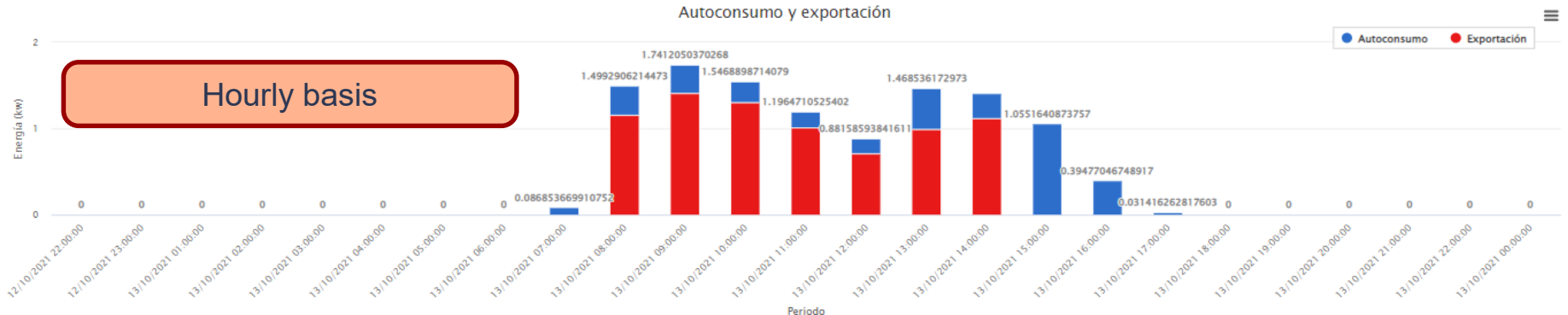
Design optimisation tool

Customised design solution

13/10/2021 | 14/10/2021 | Realizar consulta







Hourly basis

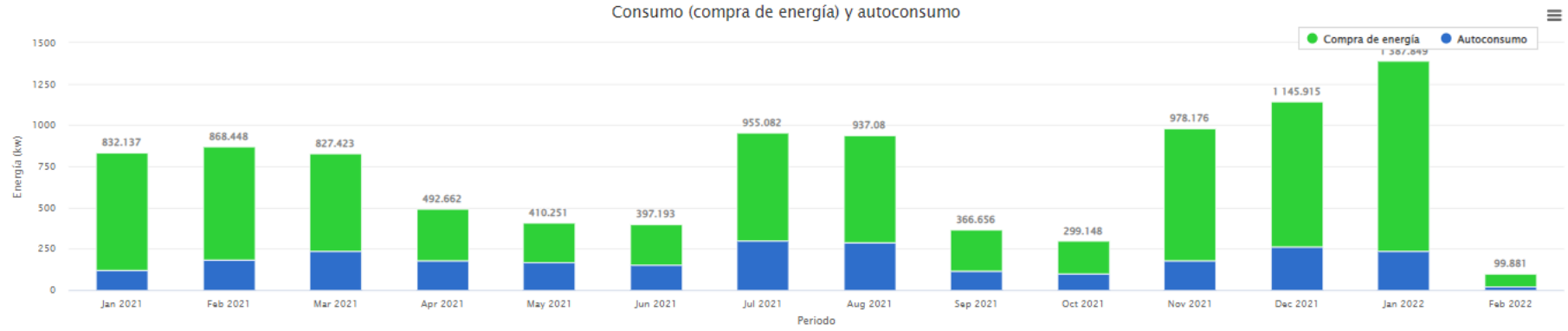
Design optimisation tool

Customised design solution

Nº Modulo	Nombre	Descripción	Potencia (kw)	Inclinación (º)	Acimut y orientación real (º, siendo 0º el Sur)
1	Sin nombre	Sin descripción	0.4998	35.0	165.0º, NNW (Nornoroeste)
2	Sin nombre	Sin descripción	0.4998	30.0	155.0º, NNW (Nornoroeste)
3	Sin nombre	Sin descripción	0.4998	40.0	140.0º, NW (Noroeste)
4	Sin nombre	Sin descripción	0.4998	40.0	150.0º, NNW (Nornoroeste)
5	Sin nombre	Sin descripción	0.4998	45.0	145.0º, NW (Noroeste)

Adapted Tilt Angles - Orientations

Presentar datos por mes



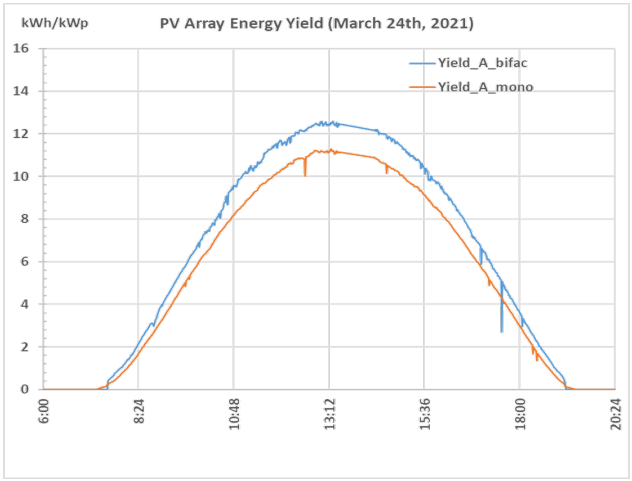
Summary

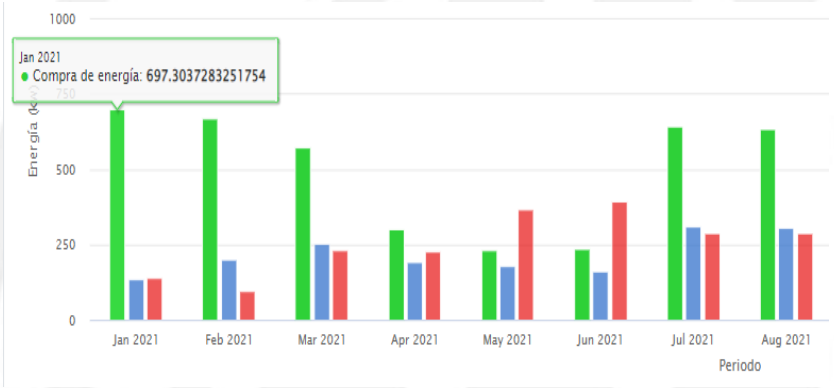
Context

Infraestructure PV Integration

Self-Consumption PV Design

Photovoltaic Engineering Applications: Alternatives to standard designs





Next Steps

Universidad de Jaén

CEACTEMA
CENTRO DE ESTUDIOS AVANZADOS EN CIENCIAS DE LA TIERRA, ENERGÍA Y MEDIO AMBIENTE

Grupo IDEA

PEARL PV

Photovoltaic Engineering Applications: Alternatives to standard designs

COST Action PEARL PV's Conference
Enabling the PV Terawatt Transition

Emilio Muñoz Cerón
emunoz@ujaen.es
IDEA PV Research Team - University of Jaén

Session 1: PV in Grids

March 14th, 2022