

23-25 September 2024

Luxembourg

WORKSHOP Smartness and artificial intelligence for sustainability

23-25 September 2024

Luxembourg

INSTITUTE OF SCIENCE AND TECHNOLOGY RAN

Advanced manufacturing of new-generation renewable plants



www.sustainableplaces.eu

Advanced manufacturing of new-generation renewable plants

- 16:00 16:10 | Opening Remarks | Regis Decorme, R2M Solution
- 16:10 16:20 | SuperTandem | Martina Chopart, AMIRES
- 16:20 16:30 | Engine | Anssi Laukkanen, VTT
- 16:30 16:40 | Flex2Energy | Rodica SUTEU, Build & Connect
- 16:40 16:50 | Seamless-PV | Philippe Thony, CEA
- 16:50 17:00 | Platform-ZERO | Victor Izquierdo, IREC
- 17:00 17:20 | Q&A / Networking
- 17:20 17:30 | Closing Remarks



Advanced Manufacturing of New Generation Renewable Plants





MIRES

Project at a glance

Sustainable materials and manufacturing processes for the development of <u>highly</u> <u>efficient (>30%) all-perovskite tandem photovoltaic modules on flexible substrates</u> with low CO_2 footprint



Objectives

Efficient Single-Junction Cells Using Earth-abundant Materials

NBG (1.20-1.30 eV) perovskites → 25% efficiency

WBG (1.75-1.85 eV) perovskites 20% efficiency

Scalable Manufacturing Processes

Safe, scalable, low-cost, low-CO2-footprint processing technologies → large-area all-perovskite tandem modules

Coating, patterning, and interconnection process

High-Efficiency Tander Cells

Combine WBG and NBG absorbers and RL in 2T tandem cells with efficiency >32%.

Low-indium or indium-free TCOs to reduce material costs.

Sustainable Packaging for Flexible Modules

Packaging methods for flexible modules that protect against outdoor exposure.

Ensure compatibility with R2R manufacturing, low-CO2 footprint, and sustainable end-of-life (EoL) scenarios.

Demonstrate Flexible Tandem Modules

>30% efficiency in 2T flexible tandem modules, 10×10 cm²

Proof-of-concept for largearea manufacturability equipment.

Objectives

Reduce Industrial Production Costs

Flexible, packaged 10×10 cm² modules with efficiency >30% and a production cost <20 €/m² at industrial scale.

Develop Recycling Routes for Circularity

Define & test recycling processes for flexible all-perovskite tandem PV devices

Ensure circularity and minimize waste

Long-Term Stability

Achieve stability of allperovskite tandem modules comparable to c-Si modules.

Reduced Environmental Impact

All-perovskite tandem PV devices **by a factor of >5** in terms of **gCO2/kWh** compared to c-Si and c-Si/perovskite

Blueprint for Future Production Lines

Design a future allperovskite tandem module production line, incorporating endof-life recycling scenarios.

www.amires.eu

Project at a glance

Stability & Performance
Focus on up-scaling labmade cells (currently 10x10cm WBG) → 80%
PCE after 1000h outdoor testing









TU/e technische universiteit eindhaven

Fraunhofer







Efficiency 26% all-perovskite (rigid glass) 25.4% all-perovskite on flexible PEN substrate





VWISES

∧MIRES

Manufacturing technologies What is next?

- Blueprint of R2R in-line production facility for allperovskite tandem module PV technology
- R2R-Laser-Scribing-Tools for flexible all-perovskite solar cells (3DM) 2026
- Spatial ALD (atomic layer deposition) equipment optimized for new thin films 2026
- 2-junction perovskite pilot scale manufacturing plant for BIPV (roofing, mobility, aerospace) & Indoor light harvesting, (incl. low-cost printing & recycling) 2027
- Slot-die coating machines optimised for in-line production of tandem perovskite PV cells (FOM) 2028





MIRES

www.amires.eu

Thank you!

Martina Chopart, AMIRES (chopart@amires.eu)



Development of advanced manufacturing equipment and processes aimed at the seamless integration of multifunctional PV solutions, enabling the deployment of IPV sectors



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Objectives and consortium

- Pilot lines
 - advanced flexible automated PV manufacturing equipment
 - high efficiency c-Si PV technologies.
- New manufacturing processes
 - key advantages (lightness, integrability)
 - cost reductions
 - seamless integration into final applications
- IPV products
 - High efficiency
 - cost-competitiveness
 - compliance with market requirements and standards.

tecno

TECHNOLOGY ALLIANCE



Started 01/01/2023 – 4 years



Activities towards industrial flexibility

- 6 pilot lines: for the industry and R&D labs Flexible and automated manufacturing tools Specific designs towards market and industrial needs, at various TRL
- Compatibility with upcoming cell formats and interconnection technologies
- Software tool developement for high flexibility

Work flow with low code platforms Optimisation capability base on IA

Cost analysis

Effective and high-efficiency integrated PV solutions







Target demonstrations

11 demonstrations

In various sectors:

- Buildings with various typologies (residential, collective, C&I)
- Highway infrastructure (noise barrier)
- Agricultural (open field, greenhouse)
- Vehicle, various sizes and usage
- Showcase the flexibility of pilot lines
- Strategic plan for market uptake





Market access and training

- Analysis of value chains of use cases
- Relevant standards from various sectors
 - European level
 - Country local level
 - Risks analysis
- Training and workshops







The platform EU Solar Buildings



The mission of European Solar Buildings is to advance and promote the integration of solar photovoltaics into the built environment (BIPV), fostering innovation, collaboration, and education. Our platform aims to support the EU's RepowerEU and Renovation Wave initiatives by connecting the solar and building sectors, ensuring a "Made in EU" BIPV industry, and coordinating strategic actions and events

6



The IPV conference, our flagship event!

www.ipv-conference.com

1st edition: 28th November 2024, Florence (Italy)

Integrating PV technologies in the Built Environment

Meet the experts and the innovations

The conference will be a unique chance to exchange and distribute knowledge for everything concerning the integration of PV. Emphasis will be on demonstrating integrated approaches of the many solutions in technology, engineering, design, and finance.



Discover More

Check our Website and Linkedin for recurrent updates











Cakucenergy

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renewablescorgies



podenepier



3S Solar Solutions

CSem









Advanced manufacturing of new-generation renewable plants

Platform-ZERO

ACHIEVING ZERO DEFECT MANUFACTURING

FOR THE PHOTOVOLTAIC INDUSTRY

Victor Izquierdo Roca – IREC





Meet the Consortium

12 European Partners :

























12M meeting Hagenberg, Austria (11-12th January 2024)



- **1.** Four research centers and one university with knowledge in the development of spectroscopic methodologies (IREC, HZB), imaging (AIT), device optoelectronic assessment (UPO), AI analysis (AIT, IREC, RISC) and data management (RISC).
- 2. Two research centers with know-how in advanced PV technologies and with industrial pilot lines to validate concepts (two demo-sites) based on CIGS devices (ZSW) and nano-based surface processes and coatings (Lurederra).
- **3. Metrology SMEs with strong know-how** in the implementation of industrial process monitoring applications (LENZ) and by two third-generation PV manufacturing SMEs (SUNPLUGGED and SAULE), both providing their production lines for demonstrating the Platform-ZERO technology (two demo-sites). Additionally, two other partners, R2M Solution France and R2M Solution SRL Italy, for dissemination, exploitation and communication actions.



THE CONSORTIUM

Context

- Solar photovoltaic (PV) provides an important contribution to the European energy mix, equal to 3.1% of EU-28 gross electricity generation in 2020 (source: Eurostat).
- Furthermore, solar energy has the potential to meet 20% of the EU electricity demand in 2040 (source: BloombergNEF).
- The latest generation of PV technologies combine high performance with a strong flexibility for integration in buildings, vehicles, agrivoltaics and internet-of-things devices.



However, the high **complexity of the latest generation of PV technologies** makes them **prone to the appearance of critical defects**, leading to significant production waste



Platform-ZERO addresses this challenge aiming at reaching zero defect manufacturing for the photovoltaic industry

In-line process monitoring, control and artificial intelligence strategies are key technologies:

- to **allow early detection**, correction and/or prevention of pre-critical production faults
- to substantially reduce production costs and improve quality for industry in the photovoltaic sector

These strategies will be tested in four different PV industrial pilot plants throughout Europe

ABOUT THE PROJECT



OVERALL OBJECTIVES



Sensor Stations

To develop advanced sensor stations compatible with customizable sensor arrays for morphological, physicochemical and optoelectronic in-line inspection of PV materials and devices

🊓 Al System

To develop an innovative Al-based prediction and decision-making system along with methodologies compatible with heterogeneous data, realtime monitoring, and process control

🔆 Data Management

🛛 Overall goal

To develop a modular in-

line process monitoring

and control solution for

the third-generation PV

industry

To develop a big data infrastructure, control unit and GUI software for managing the large amount of data generated by the platform

Generation Monitoring Platform

To implement and install a process monitoring platform in 4 PV manufacturing lines across Europe

🕮 Photovoltaic Devices

To optimize PV manufacturing by validating the process monitoring and control platform developed to minimize production defects

PROCESS MONITORING PLATFORM

Platform-ZERO develops a new customizable in-line process monitoring platform, supported by Artificial Intelligence, for achieving zero-defect manufacturing of the PV Industry with:





Process monitoring platform configuration



TECHNICHAL MAPPING & METHODOLGY

4M approach

•Mapping (year 1)

•Manufacturing (year 2)

•Making (year 3)

Monitoring (year 4)



Demonstrators

Platform-ZERO innovations will be tested in 4 PV industrial pilot plants throughout Europe: Spain, Germany, Poland and Austria



Pilot Line	Lurederra		suplugged	
Pilot line objective	Technology Demonstration / optimization	Technology Demonstration/ optimization	Production	Production
Products	Oxide based smart coating	High eff CIGSe PV	Customizable CIGSe PV	Customizable Perovskite PV
Product Image				
Production process	Discontinued (batch)	Sheet-to-Sheet (StS)	Roll-To-Roll (RtR)	Front end of Line (FEOL)
	Research Pilot-line (Laboratory to Industry)		Industrial Pilot-line	

Different type of industries in terms of: PV products, Production methods, materials fabrication, and samples transference



Demonstration of suitability of Platform-Zero process monitoring platform



TIMELINE 2023-2024



TIMELINE 2024-2025



- 1. Increase of sustainable PV production through improved control systems and non-destructive inspection methods
- 2. Tools to prevent the generation of defects at different production stages and propagation of the prevention to the final product level
- 3. Diagnostic methodologies for in-line monitoring of industrial PV production
- 4. Increase of efficient use of materials and reduced PV modules production costs

Expected impacts:

- 10% increase in productivity of the EU's PV industry
- 10% decreased requirement of high-value raw materials required for the production of PV devices

PROJECT OUTCOMES

PROJECT OUTPUT AND KPIS



1) Develop of dedicated high sensitivity inspection sensors

2) Develop strategies for real StS and RtR in-line Monitoring

3) Implementation of AI-based algorithms library

4) Implementation of data management and control algorithms library

5) Implementation of costumizables GUI software for monitoring, data visualization and decision-making advising

6) Implementation of fully operational platform demonstrators compatible with a real-time industrial process monitoring

7) Detection of process deviations

PROTENTIAL SYNERGIES

SEAMLESS-PV: Development of advanced

manufacturing equipment and processes aimed at the seamless integration of multifunctional PV solutions, enabling the deployment of IPV sectors



→ Test inspection tools for fabrication monitoring and quality control of the product.

Flex2Energy: Automated Manufacturing Production Line for Integrated Printed Organic Photovoltaics

→ Extension to Organic PV technologies

SuPerTandem: Sustainable materials and manufacturing processes for the development of high efficiency, flexible, all-Perovskite Tandem photovoltaic modules with low CO2 footprint

→ Extension to tandems configurations



THANK YOU, GET IN TOUCH



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SUSTAINABLE PLACES 2024







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CONFIDENTIAL – Flex2Energy project 101096803



Overview of the Flex2Energy Project

Automated R2R Manufacturing Line for 1.000.000 m² / year

- **Type:** Innovation Action (IA)
- Work programme: HORIZON-CL5 2022-D3-01-03
- **Project Number:** 101096803
- Duration: 48 Months (01/01/2023 31/12/2026)
- Total Budget: 21,116,625 Euros
- EC Contribution: 15,702,550 Euros







Overview of the Flex2Energy Project

Consortium Partners, Country and Nature

Part no.	Participant Organisation Name	Short name	Country	Nature
1 (Cor)	Organic Electronic Technologies P.C.	OET	GR	SME
2	Nanotechnology Lab LTFN/AUTh	AUTh	GR	HE
3	Coatema Coating Machinery GmbH	COA	DE	IND
4	Mondragon Assembly	MOND	ES, FR, DE	IND
5	Semilab Semiconductors Physics Laboratory Co. Ltd.	SEML	HU	SME
6	Workshop Of Photonics	WOP	LT	SME
7	Centro Riserche Fiat	CRF	IT	RES
8	Alumil Aluminium Industry S.A.	ALU	GR	IND
9	Hellenic Organic & Printed Electronics Association	HOPE-A	GR	ASSO
10	Pole Fibres-Energivie	PFE	FR	ASSO
11	In-Core Systèmes	INC	FR	SME
12	Centre Technique Industriel de la Plasturgie et des	IPC	FR	RES
13	Kiriakidis S.A.	KIR	GR	SME
14	Municipality of Alba Iulia	ALBA	RO	PUBLIC
15	DEPIA Automations	DEPIA	GR	SME







Overview of the Flex2Energy Project

Flex2Energy Workplan







Flex2Energy Automated Manufacturing Production Line

Location







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Flex2Energy Automated Manufacturing Production Line

- Coating Stations
- Drying Steps
- Laser processing
- Automated Assembly
- Robotic Handling
- Real Time Integrated Quality Control
- High Accuracy monitoring
- Artificial Intelligence Platform
- Digital Processing







Flex2Energy Automated Manufacturing Production Line



Final IPV Products





Flexible

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> 3 Types of Demonstrators





VIPVs Car Port - 20m²





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the European Union

- BIPVs Building Integrated Photovoltaics
 - 1st BIPV Demos: 50 m² on the Façade of Alumil's Industrial Building (Greece) ٠



Sutor Glass Para

ternal place pane with IPV

Installation Facade







Head offices in Industrial area of Kilkis







> BIPVs – Building Integrated Photovoltaics



• 2nd BIPV Demo: 100m² on the Glass Façade of Alba Iulia Municipality Building (Romania)







Alba Iulia Municipality Building



Installation of BIPVs in LTFN offices



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Agri-PVs – Photovoltaics Integrated on Mediterranean Greenhouse

- Agri-PVs will be installed on the rooftop of OET's 200 m² Mediterranean Greenhouse working as a shade curtain
- ✓ **Dimensions:** W12*D17*H5
- ✓ 100m² of "Green" OPVs integrated on the half of the MGH
- ✓ **OPV Transparency:** >40%
- Penetration of PAR: 400-700nm
- Storage capacity: 24 Batteries 2V
 Nominal capacity: 900Ah, C10h = 900Ah, C120h=1220Ah
- Cultivation: Tomato



the European Union

Funded by











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- VIPVs Vehicle Integrated Photovoltaics
 (2 Demonstrators, Italy & Greece)
 - 9 m² of VIPVs will be installed on FIAT Ducato Electric Vehicle
 - 20m² of IPV Products on a Carport Providing EV Charging Spots













Dissemination & Communication Activities

Flex2Energy Social Media











Thank you for your attention!







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