ETIP PV

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The European Technology and Innovation Platform for Photovoltaics

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Assistant Professor at Utrecht University in Solar integration system

- PhD from Utrecht University in 2021,
  focusing on the evaluation of offshore photovoltaic (PV) systems in the North Sea.
- Experienced in both industrial and academic settings.

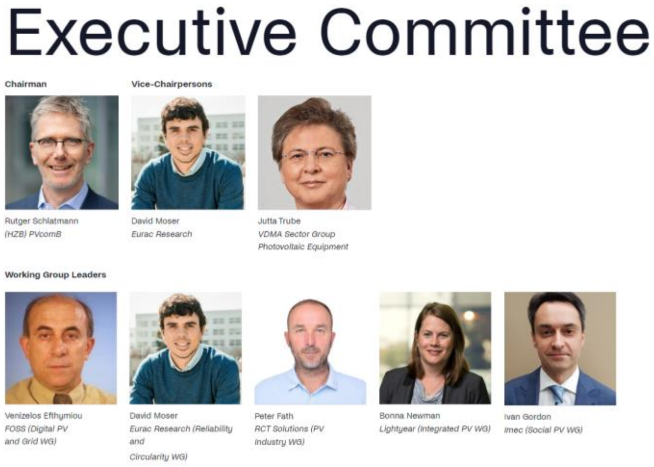
- Member of the steering committee of the European Technology and Innovation Platform for Photovoltaics (ETIP PV), helping to shape the future of solar energy technology in Europe.
- An active member of the International Energy Agency (IEA) Task 13, which focuses on performance and reliability of PV systems.

Contents

- What is ETIP PV?
- Strategic Research and Innovation Agenda Update 2024
- SRIA Challenge 3: R&I Priorities
- New publications

Our vision

Solar PV is transforming Europe’s and the World’s energy system and energy industry and ETIP PV is committed to actively support this to the benefit of climate and economy, as a contribution to the future of mankind and responding to the Sustainable Development Goals.



Executive Committee

Chairman

Rutger Schlatmann
(HZB) PVcomB

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Eurac Research

Jutta Trube
VDMA Sector Group Photovoltaic Equipment

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FOSS (Digital PV and Grid WG)

David Moser
Eurac Research (Reliability and Circularity WG)

Peter Fath
RCT Solutions (PV Industry WG)

Bonna Newman
Lightyear (Integrated PV WG)

Ivan Gordon
Imec (Social PV WG)

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ETIP PV EU Technology & Innovation Platform for PV

Committee of experts from the field of Solar PV representing industry, academia, and institutes focused on innovation and research.

Aim: Actively support achieving the EU's green energy policy through activation of all stakeholders sharing a long-term European vision for PV

Working Groups – Looking for experts

- LCOE & Competitiveness
- Integrated PV
- Digital PV Systems & Grid
- Social PV
- PV Industry
- Reliability and Circularity

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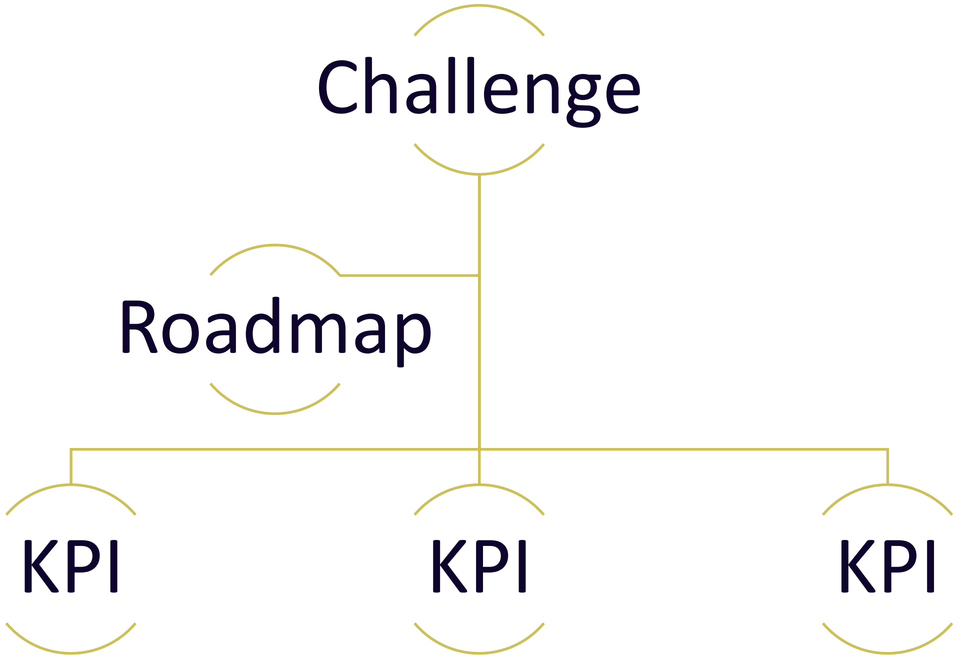
SRIA Strategic Research & Innovation Agenda

Document published every 2 years by the ETIP-PV to provide an overview of trends priorities and pathways in coming years.



The ETIP PV SRIA

- Collective and cooperative work to assess R&I priorities for PV until 2035 coordinated by the ETIP PV with the support of the EERA Joint Programme on Photovoltaics
- Comprehensive overview of R&I Challenges across the different segments of the PV value chains, different PV applications and at all levels of technology readiness
- Innovation of the SRIA PV 2024:
  - Greater emphasis on socio-economic R&I challenges for PV compared to previous versions of the ETIP PV SRIA
  - Document serves as the basis for the EUPI-PV shortlist of priority R&I topics for PV

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Update

Strategic Research and Innovation Agenda on Photovoltaics

ETIP Photovoltaics

The European Technology and Innovation Platform for Photovoltaics

EERA
European Energy Research Alliance
Photovoltaic Solar Power

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SRIA Challenges

Challenge 1: Performance Enhancement and Cost Reduction through Advanced PV Technologies and Manufacturing

Challenge 3: New Applications through Integration of Photovoltaics

Challenge 2: Lifetime, Reliability and Sustainability Enhancements

Challenge 4: Smart Energy System Integration of Photovoltaics

Challenge 5: Socio-Economic Aspects of the Transition to high PV Contribution

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Challenge 1: Performance Enhancement and Cost Reduction through Advanced PV Technologies and Manufacturing

Key objectives of the challenge

- PV modules with higher efficiencies AND longer lifetimes AND lower costs:
  - Bringing next generations of silicon PV to market
  - Enabling the market uptake of strategic technologies such as tandems or perovskites
  - Continued efforts in emerging or promising areas of R&I (e.g. traditional and emerging thin films technologies)
  - Embedding circularity in the value chain emerging as a medium term priority
- System design for lower LCOE through innovation in BOS components: inverters’ changing services is at the heart of unlocking new business models for PV systems

Challenge 1:

- Objective 1: PV modules with higher efficiencies, long lifetime, and lower costs
  - Roadmap 1: Silicon PV Modules
  - Roadmap 2: Perovskite PV modules
  - Roadmap 3: Thin-film (non-perovskite) PV modules
  - Roadmap 4: Tandem PV modules
  - Roadmap 5: Other Tandem Technologies
- Objective 2: System design for lower LCoE of various applications
  - Roadmap 6: Balance of System (BoS) and energy yield improvement
- Objective 3: Digitalisation of Photovoltaics
  - Roadmap 7: Digitalisation of PV manufacturing

Challenge 2: Lifetime, Reliability and Sustainability Enhancements

Key objectives of the challenge:

- Sustainable and circular PV: addressing R&I priorities along the ‘R ladder’ to align the PV sector with the transition towards a circular economy and solve specific challenges, including related to material use, or to setting up second use/material recovery processes
- Reliable and bankable solar PV: ensuring that PV systems operate as rated, minimising failures and optimising financial investments, electricity generation and resource use

Challenge 2:

- Objective 1: Sustainable and Circular solar PV
  - Roadmap 1: Refuse and Rethink, Reduce (Low environmental impact materials,products, and processes)
  - Roadmap 2: Reuse, Repair and Refurbish (Designs, Systems and O&M for reuse)
  - Roadmap 3: Recycle and Recover
  - Roadmap 4: Technologies for sustainable manufacturing
  - Roadmap 5: Eco-labelling and energy-labelling
- Objective 2: Reliable and Bankable Solar PV
  - Roadmap 6: Quality assurance to increase lifetime and reliability
  - Roadmap 7: Increased field performance and reliability
  - Roadmap 8: Bankability, warranty and contractual terms

Challenge 3: New Applications through Integration of Photovoltaics

Key objectives of the challenge:

- Physical integration of PV into the built environment, vehicles, landscape and infrastructure: unlocking new areas for PV electricity generation and optimising the built environmental
- Standardisation emerges as a key challenge for integration of PV across applications, and a structuring priority for the coming years. Part of the standardisation work relies on a better understanding of the behaviour of integrated PV technologies at market scale (performance, degradation, non-energy services…)

Challenge 3:

- Objective 1: Physical integration of PV into the built environment, vehicles, landscapes and infrastructures
  - Roadmap 1: PV in Buildings
  - Roadmap 2: Vehicle Integrated PV
  - Roadmap 3: Agrivoltaics and landscape integration
  - Roadmap 4: Floating PV
  - Roadmap 5: Infrastructure Integrated PV
  - Roadmap 6: „low-power“ energy harvesting PV

Challenge 4: Smart Energy System Integration of Photovoltaics

Key objectives of the challenge:

- Increased shares of PV means challenges for the electricity infrastructure, the electricity market and the profitability of PV systems. R&I can deliver answers to ensure PV can reach high penetration rates while solving these challenges
- Digitalisation is an increasingly important component of PV systems, from enabling flexible operation to guaranteeing the safe and reliable operation of systems. A key objective of this challenge is to enable further energy services from PV plants through digitalisation.

Challenge 4:

- Roadmap 1: More intelligence in distributed Control
- Roadmap 2: Improved efficiencies by integration of PV-systems in DC-networks
- Roadmap 3: Hybrid systems including demand flexibility (PV+ Wind + Hydro with embedded storage + batteries + green hydrogen/fuel cells or gas turbines etc.)
- Roadmap 4: Aggregated energy and VPPs
- Roadmap 5: Interoperability in communication and operation of RES smart grids
- Roadmap 6: Digitalisation of PV Systems

Challenge 5: Socio-Economic Aspects of the Transition to high PV Contribution

Key objectives of the challenge:

- A priority of the challenge is to identify pathways to facilitate stakeholders engagement around the PV sector, a key parameter in addressing negative forces that may hamper deployment rates.
- The rapid growth of the PV sector creates a challenge relates to the skills of the PV workforce and the need for more qualified workers.
- As the energy transition progresses, clean energy technologies are increasingly scrutinised regarding their environmental impact, and it is key to understand the environmental and social impacts and increase acceptance of PV to further improve as the sector continues to grow.

Challenge 5:

- Objective 1: Social Acceptance and Public Engagement
  - Roadmap 1: Acceptance of European PV deployment
  - Roadmap 2: Acceptance of novel true-cost pricing grid tariff schemes
  - Roadmap 3: Citizen’s participation in PV Deployment
  - Roadmap 4: Socio-economic dimensions impacting decisions to implement and use PV Technology
- Objective 2: Skills and workforce
  - Roadmap 5: Re-skilling and Up-skilling in the PV sector
  - Roadmap 6: Gender Equality
- Objective 3: Environmental and Social Sustainability
  - Roadmap 7: Social Impact Assessment and S-LCA
  - Roadmap 8: Environmental, Social and Governance (ESG) Framework

More details of challenge 3:
New Applications through Integration of Photovoltaics for Diversified

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More details of challenge 3:
New Applications through Integration of Photovoltaics for Diversified and

More details of challenge 3:

New Applications through Integration of Photovoltaics for Diversified and Dual Use Deployment and

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More details of challenge 3:

New Applications through Integration of Photovoltaics for Diversified and Dual Use Deployment and

More details of challenge 3:
New Applications through Integration of Photovoltaics for Diversified and Dual Use Deployment and Enhanced Value

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Challenge 3: IPV

New Applications through Integration of Photovoltaics (for Diversified and Dual-Use Deployment and Enhanced Value)

Compiled by IPV Working Group with help from EERA

Six Roadmaps


@Zigzag


@Lightyear

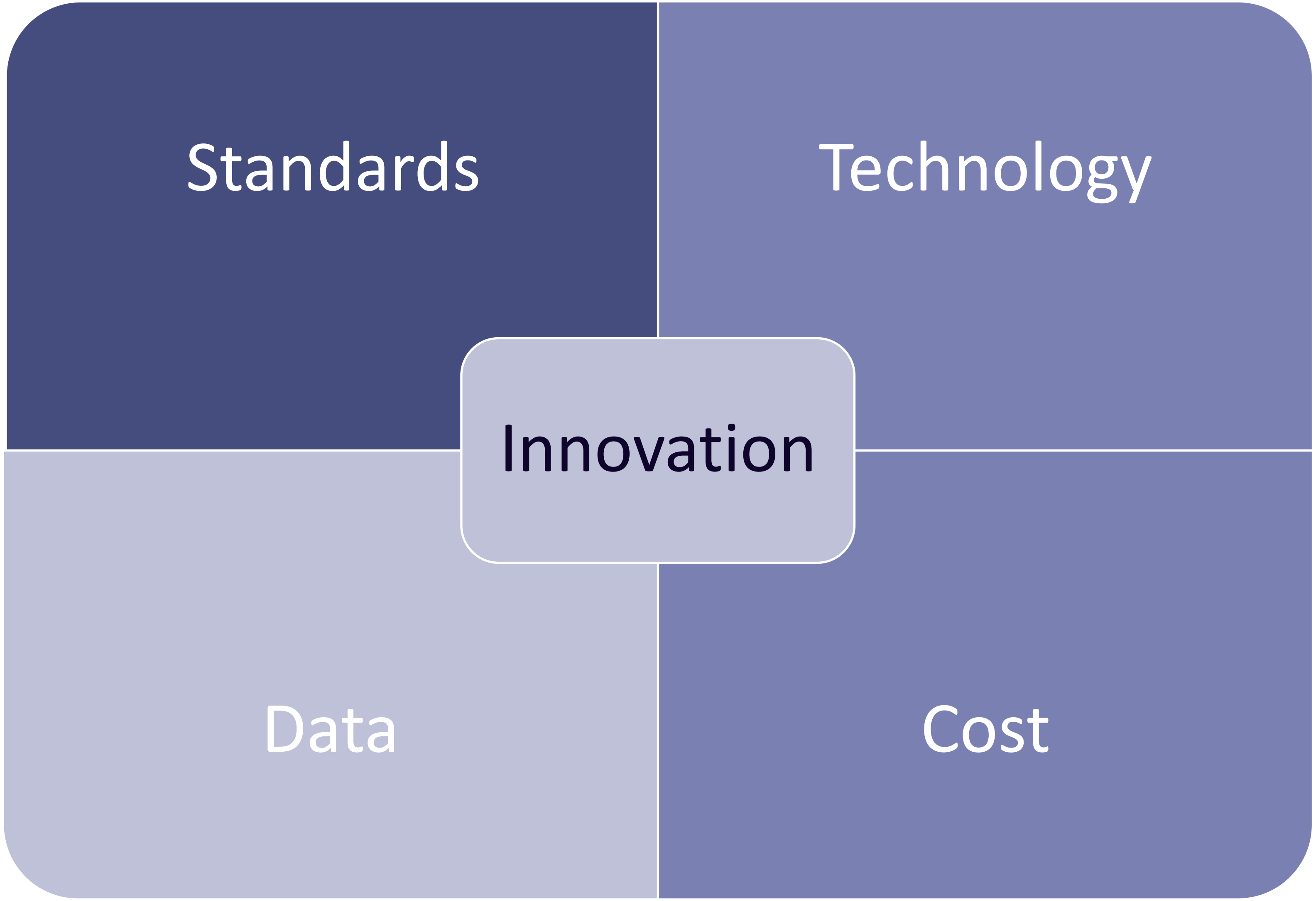

@Oceans of Energy


@Fraunhofer ISE


@Omega


@AIT and PV-SUD project (concept)

Integrated PV R&I Challenges



Standards

Technology

Innovation

Data

Cost

Technology

Aesthetics

Improved options with more options, stability, and efficiency for colored PV

Weight and Flexibility

Reduced weight and improve flexibility with wind loading capacity

Solar Windows

Semitransparent options of solar windows

Performance

Shadow resilience for wide range of applications

Circularity

Improvements including: assembly/disassembly, LCA driven design, operating lifetimes >35 years

Cost

Manufacturing

Increase manufacturing flexibility and mass customization approaches.

Systems

Development of BIPV solutiosn supported by advanced economic and business models for investors with payback times < 10 years

BIPV system net present value > 0 including installations (assuming 10-15 year lifetimes)

Standardization

Fire & Safety:
Defined standards including validation for characterization and testing

Building Codes:
Hamronization of EU and National BIPV component approvals
Harmonization of characterization methods for BIPV modules and systems
Help in navigation of existing standard

Building Codes:
Building and district Energy Matching Indicators
Overall Building design indicators:

- 50% of annual building electricity demand;
- self-sufficiency > 30%;
- self consumption > 80%

Data

Digitalization

Reduction in project costs due to BIM/digitalization

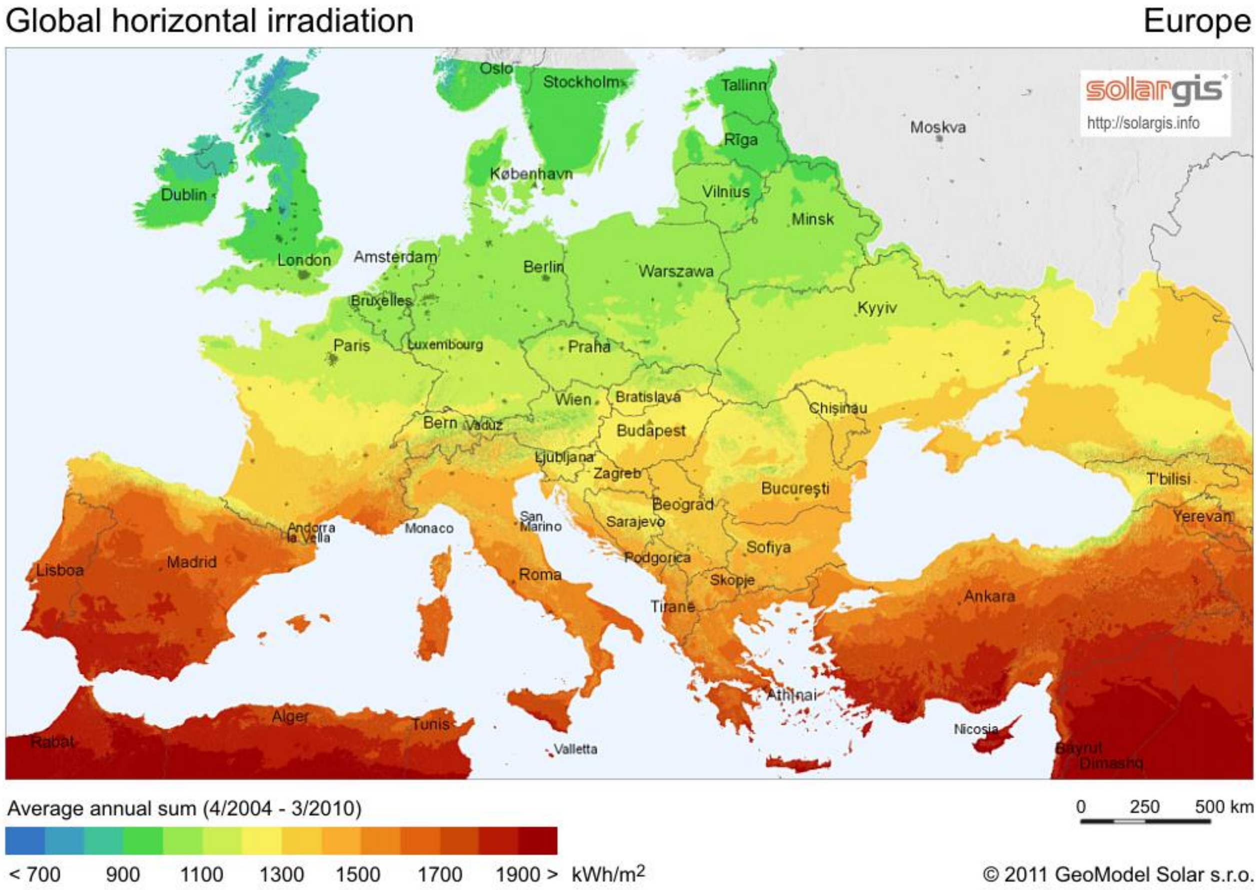
Improved value chain

Design for Manufacturing

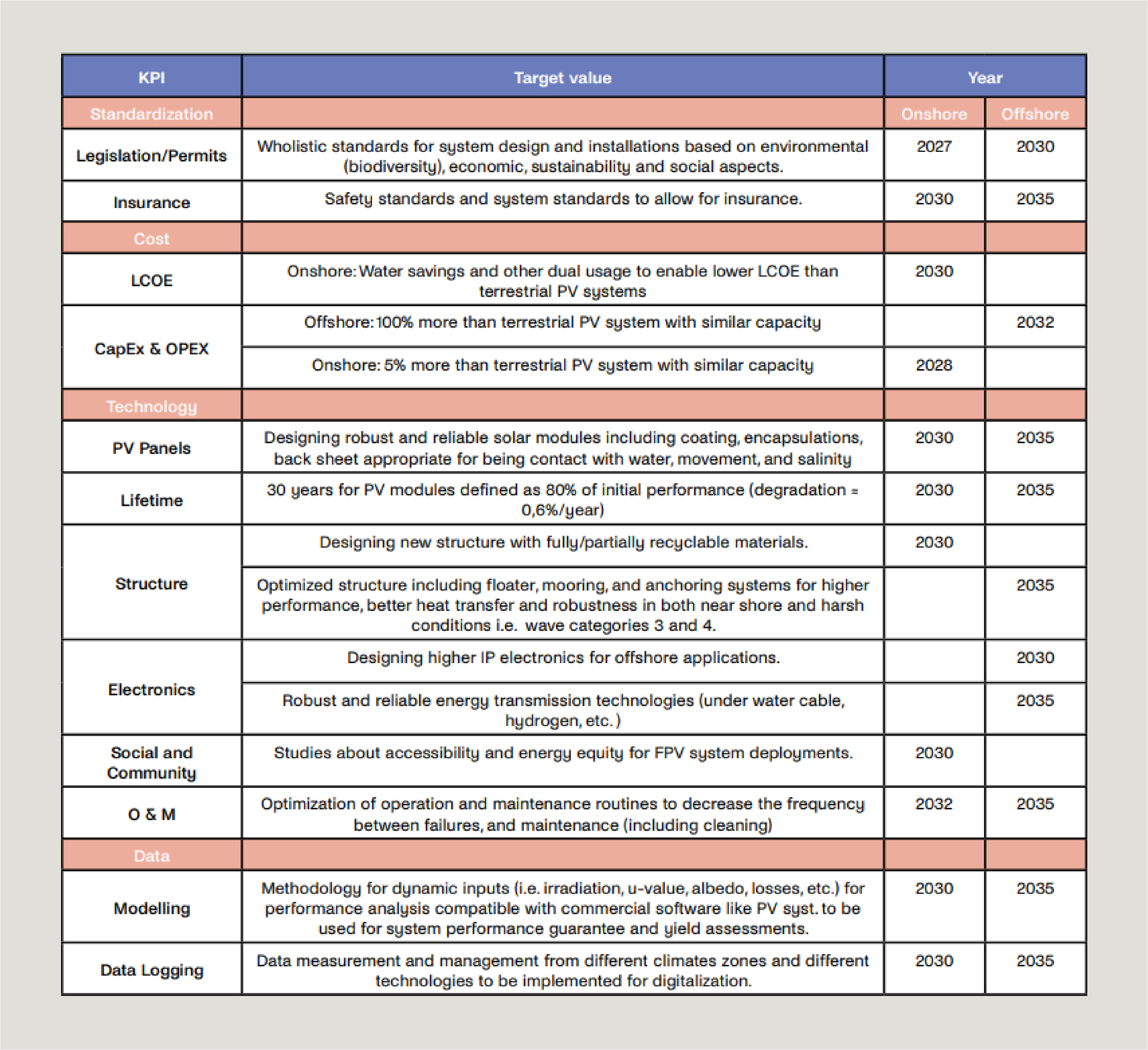
Design for Installation

BIPV: An opportunity for Europe

- Local markets
- Unique Products
- Local production
- On-site assembly
- System integration
- Component/materials integration
- ESG aspects

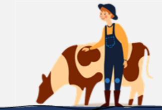


KPI
Floating PV



KPI	Target value	Year	
Standardization		Onshore	Offshore
Legislation/Permits	Wholistic standards for system design and installations based on environmental (biodiversity), economic, sustainability and social aspects.	2027	2030
Insurance	Safety standards and system standards to allow for insurance.	2030	2035
Cost			
LCOE	Onshore: Water savings and other dual usage to enable lower LCOE than terrestrial PV systems	2030	
CapEx & OPEX	Offshore: 100% more than terrestrial PV system with similar capacity		2032
	Onshore: 5% more than terrestrial PV system with similar capacity	2028	
Technology			
PV Panels	Designing robust and reliable solar modules including coating, encapsulations, back sheet appropriate for being contact with water, movement, and salinity	2030	2035
Lifetime	30 years for PV modules defined as 80% of initial performance (degradation ≈ 0,6%/year)	2030	2035
Structure	Designing new structure with fully/partially recyclable materials.	2030	
	Optimized structure including floater, mooring, and anchoring systems for higher performance, better heat transfer and robustness in both near shore and harsh conditions i.e. wave categories 3 and 4.		2035
Electronics	Designing higher IP electronics for offshore applications.		2030
	Robust and reliable energy transmission technologies (under water cable, hydrogen, etc.)		2035
Social and Community	Studies about accessibility and energy equity for FPV system deployments.	2030	
O & M	Optimization of operation and maintenance routines to decrease the frequency between failures, and maintenance (including cleaning)	2032	2035
Data			
Modelling	Methodology for dynamic inputs (i.e. irradiation, u-value, albedo, losses, etc.) for performance analysis compatible with commercial software like PV syst. to be used for system performance guarantee and yield assessments.	2030	2035
Data Logging	Data measurement and management from different climates zones and different technologies to be implemented for digitalization.	2030	2035

ETIP Photovoltaics



EU PVSEC 2024

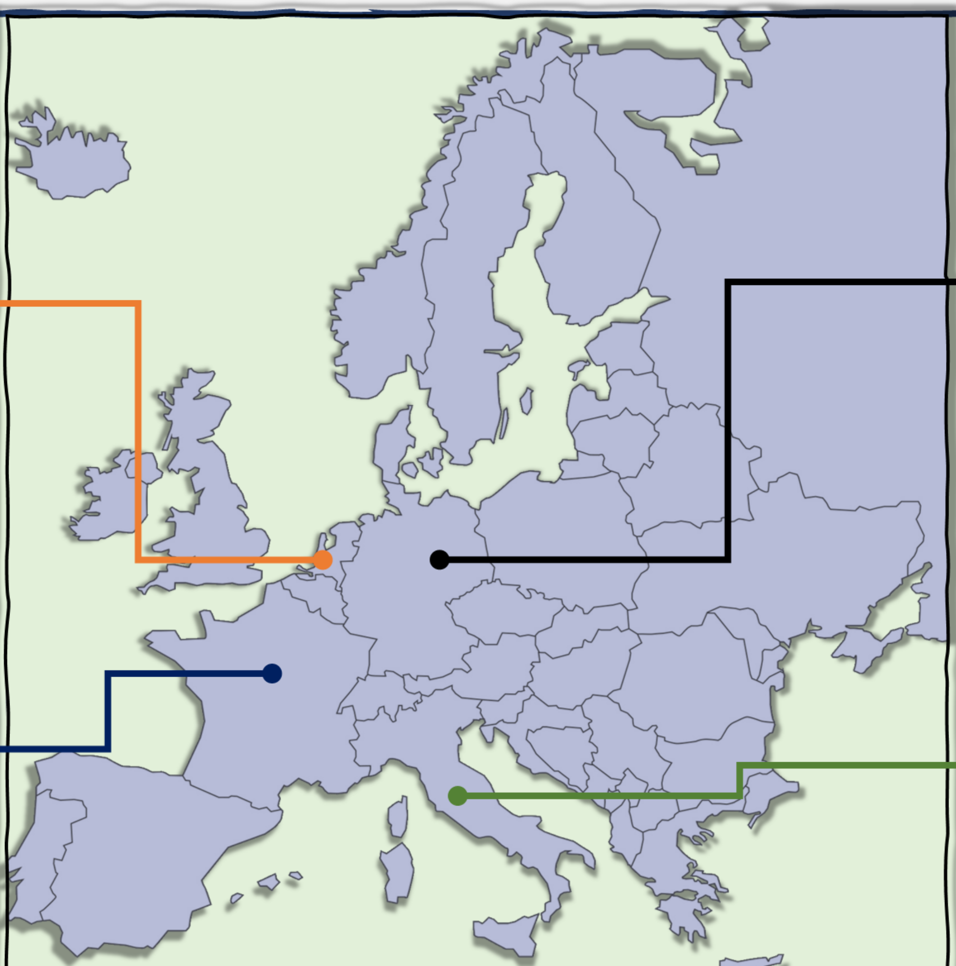
Agrivoltaics in European Countries and Happy Farmers

Contributors: ETIP PV Integrated WG
Sara Golroodbari (Utrecht University), Nabih Cherradi (Desert Technologies), Kay Cesar (TNO), Bas Van Aken (TNO), Tim Kaasjager (TNO, TU Delt), Paolo Picchi (ETA-Florence Renewable Energies), Bonna Newman (LightYear)

Country-Specific Developments

- The Netherlands is aligning Agri-PV projects with its common agricultural policy (CAP) strategic plan to ensure PV installations complement agriculture.
- Smit et al. (2020) emphasize the need to consider regional differences in the Netherlands' CAP national strategic plan, balancing agricultural and environmental concerns for Agri-PV integration.
- Farmers in the Netherlands join Agri-environmental collectives for both economic and environmental reasons, enhancing cooperation and communication.

- France is a first-mover in European Agri-PV, driven by innovation tenders for rapid market expansion.
- In 2021, ADEME established a clear definition of Agri-PV, setting criteria for systems to be recognized, including their impact on agricultural production and farmers' revenues.
- National standards and regional criteria have been established to support Agri-PV installations under the 2023 Law on the acceleration of renewable energy production.



- Germany led in Agri-PV development with initial standards and solar tenders in 2022 but faces legal challenges due to the systems not being fully integrated into the legal framework.
- Trommsdorff et al. (2021) evaluated the technical feasibility and design of Agri-PV systems in Germany, highlighting their ability to increase land productivity, especially during drought conditions.
- Germany's policy measures, including the FIT (feed-in tariff), have been effective in enhancing solar energy growth and incorporating Agri-PV systems both domestically and globally.

- In 2021, ENEA and ETA-Florence launched the Italian Network Sustainable Agrivoltaics to share research questions and best practices for sustainable Agri-PV systems.
- The concept of Sustainable Agrivoltaics influenced policy-making, leading to the inclusion of "advanced Agri-PV systems" in Environmental Ministry guidelines.
- Italy's Environmental Ministry Decree of February 14th, 2024, allocated nearly €1.1 billion in public funds for Agri-PV development, aiming to create 1.04 GW capacity with specific provisions for small-scale and large-scale projects.

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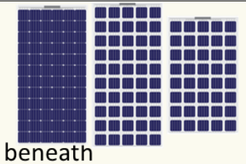
2023 Law on the acceleration of renewable energy production.

2024, allocated nearly €1.1 billion in public funds for Agri-PV development, aiming to create 1.04 GW capacity with specific provisions for small-scale and large-scale projects.

Technology

Solar Modules

Standard Photovoltaic Modules

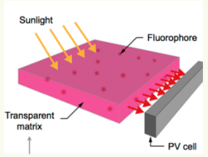


- A popular choice
- Can be mounted on elevated structures
- Can provide shade for crops or livestock beneath
- Customized design is required

Luminescent Solar Concentrators (LSCs)

Luminescent Solar Concentrator (LSC) PV integration for greenhouse

- Refocus on eco-friendly materials like carbon dots and quantum dots



Bifacial Photovoltaic Modules

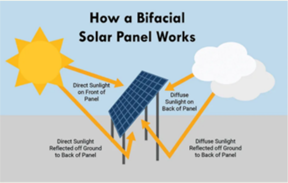
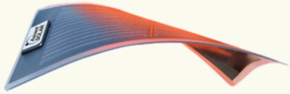


Image courtesy of Paradise Energy Solutions

- A cutting-edge approach
- Utilize reflected light from surrounding surfaces
- The bifaciality factor ranges from 60% to 90%
- Energy yield improvement from 5% to 30% (depending on albedo and installation environment)
- For vertical non-bifacial modules are really not smart

Thin-Film panels



- Flexible
- Lightweight
- Easy integration into various environments
- Semitransparent panels and partial shading for crops
- Panels can be installed in a higher elevation due to light weight
- Longer machinery is possible

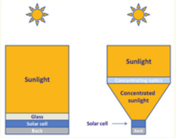
Uchanski, Mark, et al. "Characterization of agrivoltaic crop environment conditions using opaque and thin-film semi-transparent modules." Energies 16.7 (2023)

Integration of thin film solar panel for Agri-PV by TubeSolar AG

Concentrating PV panels

The Photovoltaic modules developed by Insolight, based at EPFL's Innovation Park

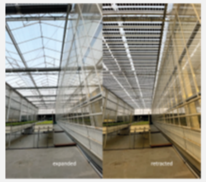
- Very high efficient (40%)
- Very expensive

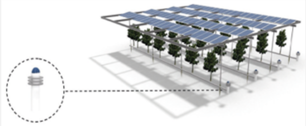


Mounting systems

- IoT sensors can enhance shade control by optimizing panel positions based on real-time data on plant type, soil moisture, sun radiation, and microclimate.
- A startup is replacing passive greenhouse shades with photovoltaic screens, delivering 40%-70% shading and harnessing blocked sunlight.
- High-efficiency solar cells in lightweight materials allow photovoltaic screens to replace passive shades, providing flexible light management.
- Rainwater collection systems, such as gutters and storage tanks can be a part of mounting system

The Photovoltaic screens can be retracted and expanded





Shade optimization implementing IoT sensors

Tilted PV with clearance

Vertical system with clearance

Overhead with vertical clearance

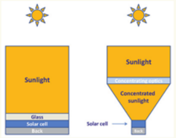
Results and Discussions

Simulated photon sharing between photovoltaics and photosynthesis for seven Agri-PV systems in the Netherlands, Germany, and Austria

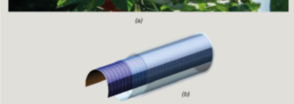
Country	Farm Description	Main Benefits	Challenges	Farmer Feedback
	In Monticelli d'Ongina, Emilia Romagna, this farm grows	Increased income 4% boost in corn production. Enhances farming	The main challenge is the loss of	The final balance is positive and

The Photovoltaic modules developed by Insolight, based at EPFL's Innovation Park

- Very expensive



agrivoltaic crop environment conditions using opaque and thin-film semi-transparent modules." Energies 16.7 (2023)



Integration of thin film solar panel for Agri-PV by TubeSolar AG

Tilted PV with clearance

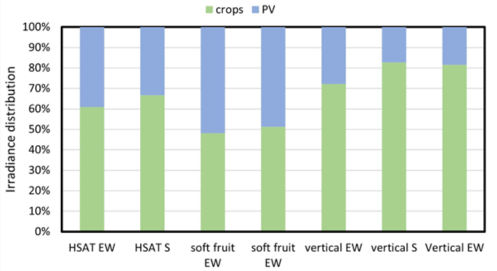
Vertical system with clearance

Overhead with vertical clearance

Results and Discussions

Simulated photon sharing between photovoltaics and photosynthesis for seven Agri-PV systems in the Netherlands, Germany, and Austria.

- The soft fruit Agri-PV systems show a 50-50 division of the irradiance. The distribution of irradiance on ground level for these systems is very homogeneous.
- The tracker and vertical system show more variation in relative irradiance on soil level. The area directly below the PV panels and mounting structure has the lowest irradiance. The area between the trackers shows a high level of irradiance with some variations.
- For vertical systems that have a gap between ground level and the bottom of the system, the irradiance will be lowest in a zone next to the solar fences. The region in between will have a high irradiance that is also rather homogeneous.



Soil irradiance for the Agri-PV systems of the respondents in DE, AU and NL.

Country	Farm Description	Main Benefits	Challenges	Farmer Feedback
Italy	In Monticelli d'Ongina, Emilia Romagna, this farm grows winter and summer cereals under 4-meter-high structures.	Increased income 4% boost in corn production. Enhances farming sustainability system, particularly beneficial for clay soil.	The main challenge is the loss of 20% of arable land.	The final balance is positive and the farmer would recommend it to other farmers.
Italy	Located in Gioia del Colle, Apulia, uses a 2.5-hectare Agri-PV system with 2.9-meter-high fixed panels for cultivating cereals and vineyards in dry conditions.	Allows for delayed grape harvesting by 4-6 weeks and enables the production of sparkling wine. Improves the hydroclimatic balance, reduces pest risks, and shields crops from extreme weather, collecting rainwater.	Uncertainties in harvest revenue, rising production costs. System's innovative, handcrafted nature, like uncertainty in long-term vineyard growth without extensive observational data.	The final balance is positive and the farmer would recommend it to other farmers.
Netherlands	Soft fruit under raised PV systems.	Improved labor conditions, less water via drip irrigation (30-40%), less fungicide Need for netting reduced, saving labor and costs.	Visual integration in the (agricultural) landscape are not so good.	Very positive, no significant change in working methods.
Netherlands	Soft fruit under raised PV systems (Traditional methods)	Improved labor conditions, less water via drip irrigation (30-40%), less fungicide.	Not specified.	Very positive, no significant change in working methods.
Austria	Hay/silage with vertical PV system.	Not specified.	Long and tiresome permitting and grid connection procedures.	Satisfied, but administrative burden noted.
Germany	Grains and clover with horizontal single-axis trackers & bifacial/monofacial modules.	Additional protection against hail/heavy rain, less shading before harvest.	Slow GPS machinery, additional labor hour per hectare/year.	Satisfied, but points out lack of knowledge among peers and marginal agricultural yield impact.

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