Strategic Energy Technology Plan

Implementation Working Group on
Solar photovoltaics (PV)

Thematic Vision on Solar photovoltaics

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Executive summary

The IWG PV Thematic Vision outlines how photovoltaics can support Europe's energy transition while strengthening industrial resilience, system stability and economic competitiveness while providing energy security and sovereignty to Europe. The Vision establishes common ambitions and milestones for 2030, 2040 and 2050.

By 2030, photovoltaics is expected to consolidate its role as the most competitive source of electricity generation in Europe, supported by the large-scale integration of flexibility resources. Digital tools and artificial intelligence are already reshaping PV manufacturing and operation, improving quality control, enabling predictive maintenance and facilitating deeper integration into electricity markets and grids. These developments underpin higher levels of PV in the energy system while maintaining security of supply and system operability. Looking towards 2040, the Vision places strong emphasis on the consolidation of a competitive and resilient European PV industry which makes use of a new level playing field created by new materials like perovskites. This includes scaling up European manufacturing capacity, accelerating the industrial deployment of current and next-generation cell and module technologies, and embedding digitalisation, automation and quality assurance throughout production processes.

Sustainability becomes a defining feature of PV development, encompassing not only circularity aspects such as eco-design, durability, reuse and high-quality recycling but also broader environmental, social, and system-level considerations across the entire value chain. This approach reduces material dependencies and reinforces public acceptance while also differentiating EU-produced PV from other global markets. Meanwhile, innovation remains central during this phase, ensuring that Europe stays at the forefront of technological progress as PV technologies and market conditions continue to evolve.

By mid-century, solar photovoltaics are expected to provide around half of Europe's energy needs, deeply embedded across highly electrified built environment, transport systems, agriculture and industrial ecosystems. Integrated PV applications such as agri-PV, building-integrated PV, floating PV and solar mobility enable widespread deployment while addressing land-use constraints and strengthening citizen engagement. In parallel, high-voltage direct current solutions, electrified industrial processes and Power-to-X applications allow solar electricity to underpin the decarbonisation of industry and the production of renewable fuels, contributing to long-term economic resilience.

Throughout the Vision, cross-cutting priorities are treated as integral components rather than standalone themes. Access to market is addressed through application-driven deployment, system integration and stakeholder participation. Digitalisation underpins competitiveness, interoperability and energy security across the PV lifecycle. Circularity supports sustainable growth, raw material autonomy, and the efficient use of resources. Together, these dimensions frame photovoltaics as a mature, system-forming technology capable of responding to Europe's energy, climate, security and competitiveness objectives.

Developed within the framework of the Strategic Energy Technology (SET) Plan, this Thematic Vision provides a strategic reference for coordinated action by Member States, industry, and research actors. It lays out the foundation for the forthcoming Common Implementation and Investment Plan for photovoltaics and supports alignment between national initiatives and EU-level objectives. In doing so, the IWG PV Thematic Vision outlines a credible pathway for solar photovoltaics to remain at the core of Europe's energy system while delivering long-term value for society, the economy and the environment.

1. Introduction

1.1. General introduction to the IWG

The Implementation Working Group on Photovoltaics (IWG PV) operates within the framework of the European Strategic Energy Technology (SET) Plan as the country-led forum dedicated to guiding the coordinated development, deployment and integration of solar photovoltaic technologies across Europe. Bringing together national authorities and key stakeholders, the IWG PV addresses the full PV value chain, from research and innovation through manufacturing, system integration and market uptake. In a context marked by accelerated decarbonisation objectives, heightened energy security concerns and increasing global competition in strategic clean-tech sectors, the IWG PV plays a central role in aligning national efforts with EU-wide priorities to ensure that solar PV can fully deliver on its potential as a cornerstone of Europe's climate-neutral, secure, resilient and competitive energy system.

1.2. Objective of the thematic vision

For the solar PV sector, it is crucial to always keep a balance between short term technology trends and long-term perspectives and objectives. Solar PV is a field that moves very fast in every aspect: technology changes rapidly, with technology cycles as short as 5 years. Meanwhile, PV has been following an exponential growth trajectory over the past decade, despite short-term fluctuations. The objective of this Thematic Vision is to provide a coherent perspective on the contribution of solar PV to Europe's energy transition, while supporting concrete short- and medium-term decision-making under the SET Plan. Given the short technological cycles and exponential deployment trajectory of solar PV, the Vision seeks to reconcile near-term R&I priorities with the structural transformations required to reach climate neutrality by 2050. It establishes shared ambitions and milestones for 2030, 2040 and 2050, identifies key drivers and barriers, and highlights priority areas for research, innovation and systemic integration. In doing so, the Thematic Vision provides a strategic reference for national authorities, informs the development of SET Plan implementation pathways, and supports coordinated action to maximise the economic, environmental and societal value of solar PV for Europe.

1.3. Key developments

Over the coming decades, the European energy system will achieve an energy transition process that was kicked off in 2009 with the adoption of the Renewable Energy Directive, which enshrined into the European Union's law the objective to shift the block's economy and energy system away from fossil fuels and towards renewable energy sources. At that time, solar PV merely represented 16 GW of cumulative installed capacity in the EU, which amounted to 70% of the world total . In 2024, the EU has reached a cumulative installed capacity of 338 GWdc with ambitions to more than double this figure to 750 GWdc by 2030, in line with the targets set out in the European Solar Energy Strategy.

The current decade is marked by dramatic geopolitical developments that have exposed the vulnerability created by Europe's persistent fossil fuel dependencies. This highlighted the needs of European countries for decentralised, resilient energy systems, with solar PV as the backbone alongside other renewables and storage. These developments underpin higher levels of PV in the energy system while maintaining security of supply and system operability.

In response, the EU has reinforced its strategic focus on energy sovereignty, resilience and domestic value creation. Building on REPowerEU and the European Solar Energy Strategy, solar photovoltaics

has been firmly identified as a strategic industry capable of delivering secure, affordable and locally produced energy at scale. The EU has consequently set targets to strengthen strategic autonomy across the PV value chain, including the objective to establish a European industrial PV value chain based on the establishment of gigafactories with 30 GW of integrated capacity by 2030. These ambitions are further supported through industrial and regulatory measures under NZIA, IAA and the Green Industrial Deal, reflecting a clear shift from short-term crisis response toward long-term structural transformation of Europe's energy system, with solar PV at its core.

1.4. Focus areas

The IWG PV Vision focuses on defining the contribution of different technology areas for solar photovoltaics to become the backbone of the European energy system. These include the continued improvement of PV performance, reliability and sustainability through advanced cell and module technologies. It also covers the large-scale industrialisation and competitiveness of the European PV value chain, driven by digitalisation, automation and quality assurance. Another key area is the development of more circular and resource-efficient PV modules, strengthening strategic autonomy and reducing material dependencies and the deep integration of PV into the energy system through flexibility solutions such as batteries, sector coupling and grid-forming power electronics. Particular emphasis is placed on the role of digital tools and artificial intelligence across the PV lifecycle to enhance R&I and manufacturing quality, optimise operation, enable predictive maintenance and unlock new system services. Circularity and eco-design are identified as strategic priorities to address raw material constraints, reduce environmental impact and reinforce PV's social licence to operate.

Finally, the IWG PV highlights the importance of integrated and application-driven PV solutions, including PV's contribution to the electrification of the economy, PV in the built environment, agriPV, floating PV and solar mobility. PV also acts as an enabler of widespread deployment, citizen engagement and efficient land use, ensuring that innovation, system integration and societal value creation progress in parallel, notably to address social concerns around potential impacts of PV deployments.

1.5. Task forces recommendation reflection

The IWG PV Thematic Vision is developed in full alignment with the SET Plan guiding principles and integrates the recommendations of the cross-cutting Task Forces, in particular those on Access to Market, Circularity and Digitalisation. The Vision takes a holistic perspective that reflects the evolving role of solar PV as a backbone of the European energy system. It directly addresses market uptake and deployment, thereby echoing the trends and pathways outlined by the transversal Task Forces recommendations.

The Vision also addresses the key priorities linked to raw material use and circularity out of the task forces. Circularity indeed is a pillar of long-term sustainability, competitiveness and resilience. For the PV sector, a strong emphasis on eco-design, extended product lifetimes, reuse, high-quality recycling and the recovery of critical raw materials allows to pursue this strategic priority in a technology pathway. Meanwhile, the topic of digitalisation is a clear condition for the successful implementation of the IWG PV Vision, whether it touches upon system integration and reaching deployment pathways, or competitiveness, system operability and energy security. By integrating these cross-cutting priorities throughout its short-, medium- and long-term ambitions, the IWG PV Thematic Vision contributes to a coherent implementation of the SET Plan.

2. Vision and targets

The Thematic Vision developed by the IWG PV is consistent with the nine SET Plan Guiding Principles and integrates the findings and recommendations of the SET Plan cross-sectoral Task Forces. It adopts a systemic approach that reflects the increasing role of solar PV as a core pillar of the European energy system, addressing cost competitiveness, system integration, security of supply, and European added value through coordinated R&I and deployment efforts. The Vision places particular emphasis on digitalisation, circularity and skills development, reflecting Task Force recommendations on digital transformation, sustainable value chains, and workforce preparedness. It also acknowledges the importance of access to market, scale-up and societal acceptance, ensuring that technological progress goes hand in hand with citizens' engagement, fair participation and market uptake. By embedding these cross-cutting priorities throughout its long-, medium- and short-term ambitions, the IWG PV Vision contributes to a coherent, resilient and competitive European solar PV ecosystem, consistent with the objectives of the SET Plan.

2.1. Vision of the future for the IWG PV

The IWG PV envisions that Solar PV could represent upwards to half of the European energy needs in 2050[1], driven by its tremendous growth potential. Continuous falling costs, improved performance and evolving services are unlocking new opportunities to generate electricity from sunlight. Over the past decades, PV has consistently exceeded policy targets and policy modelling, with the consistent cost decrease and diversity of PV systems – which can be deployed at GW scale in utility system or plugged in one module at a time on people's balconies – trumping constraints of most top- down economic analysis. In coming decades, PV has a clear pathway to deliver around one in two kWh used across Europe, and the bulk of installed electricity capacity amounting to 12- 15kW per capita across the EU (amounting roughly to 20-40 PV modules per capita).

The coupling of solar PV with other generation technologies, combined with the widespread availability of flexibility resources in an electricity system structured around this technology mix, ensures a balanced and resilient energy supply, capable of meeting varying demand patterns across different weather conditions. From the 2030's, it is also expected that total system costs of such hybrid energy solutions are lower than those prevailing in the wholesale market, creating incentives for the development of off-grids systems at various scales. Storage solutions, both short-term and long-term, are the glue that brings this energy system together, while grid infrastructure plays a crucial role in allowing this decentralised system to function, allowing interoperability of systems, aggregation of demand and generation, and the provision of safeguards for system stability such as synthetic inertia.

The widespread deployment of PV and relevant storage/hybridisation solutions leads to significant economic impacts, through their contribution to stabilising and reducing electricity prices, particularly for industry and small businesses. The wider integration of low-cost solar electricity into the grid helps lower wholesale electricity prices and mitigates the price volatility that define fossil fuels along with

[1] This vision is notably based on the modelling exercise undertaken by Breyer & al. which postulate a 54-56% share of final energy demand to be covered by solar PV. While corresponding to more ambitious development scenarios than other models, these figures are not inconsistent in terms of order of magnitudes with other modelling efforts, and the underlying assumption of the model and scenarios correspond to paradigm shift described in the following vision. Breyer C, Bogdanov D, Ram M, et al. Reflecting the energy transition from a European perspective and in the global context—Relevance of solar photovoltaics benchmarking two ambitious scenarios. Prog Photovolt Res Appl. 2023;31(12):1369-1395. doi:10.1002/pip.3659

energy security challenges. This is particularly crucial in energy- intensive sectors, where structurally lower, predictable and stable electricity prices with high share of PV and relevant flexibility resources help to drive sustained improvement in competitiveness. The expansion of solar PV, paired with the implementation of load-based grid tariffs and dynamic pricing, further enables businesses and consumers to optimise their consumption and reduce costs. In this context, large-scale PV deployment can quickly translate into effective electrification.

At the macroeconomic level, PV helps Europe to erase its dependency on imported fossil fuels, improving its trade balance (considering that fossil fuels represent nearly 90% of the EU Trade deficit in 2025). When accounting for the major social and economic risks linked to the instability of global fossil fuel supply chains, the sift of the European energy system towards PV also deliver benefits through shielding the economy from geopolitical and market disruptions. The decline in fossil fuel imports strengthens Europe's energy independence, enhances economic stability, and redirects capital towards domestic innovation and infrastructure.

The growth of the European PV sector also brings about significant employment and industrial benefits. Scaling up domestic manufacturing and deployment creates thousands of skilled direct jobs across the Europe. Deployment rates in 2025 correspond to nearly 1 million solar workers. On the long-term automation, improved efficiencies and digitalisation may lead to a reduced job intensity of the sector. However, it is expected that even considering these trends, employment in the PV sector will grow significantly towards the 2050 scenario defined in this vision.

The expansion of the value chain for the end of life of PV systems represents a specific opportunity in the coming decades as it is a wholly new segment of the PV sector with well-defined growth trajectories. High-quality recycling of PV modules also contributes to the European economy through recovering valuable secondary raw materials, adding to resource security and creating additional economic value within the EU value chain.

Through the development of relevant re-skilling and upskilling programmes, the PV industry as a whole represents an outlet for workers from industries declining due to the decarbonisation and digitalisation of the European economy, while providing a wide array of career opportunities for millions of European workers. Beyond jobs linked to production, installation and end of life, the PV sector also provides an array of employment opportunities based in local communities notably linked to quality insurance, maintenance, and system integration.

The positive impacts of PV extend well beyond emissions reduction. When deployed thoughtfully, PV can stimulate local economies, improve regional cohesion, reduce energy poverty, and foster innovation in business models and community energy schemes. These benefits, if made accessible and equitable, strengthen public support for the energy transition.

2.2. Short-term (2030)

2.2.1. Interaction with storage and other flexibility resources to maximise PV generation

The large-scale hybridisation of PV and flexibility resources allows to optimise the use of energy produced from solar and other renewable energy sources. It also acts as a factor of energy security and system stability for which additional measures are needed in terms of system design and market reforms. Chief among these solutions are flexibility resources such as batteries, thanks to their versatility and competitiveness at various deployment scales. The combination of solar PV and batteries has become a winning team not only in remote areas but also in integrated energy markets although there may be accessibility challenges for lower income groups.

Through integration with flexibility resources, such as storage and demand-side management, PV curtailment remains low but continues to be an option for balancing the system, with around 4.5% of PV generation curtailed on average (Breyer & al.). Managing this curtailment is crucial for maintaining grid stability and providing ancillary services like frequency regulation and voltage support. The evolving role of PV in the grid is made possible by advancements in inverter technology, communication technologies and different forms of artificial intelligence. Grid- forming solutions that allow for system control operation are expected to become mainstream solutions before 2030, notably for utility scale PV systems. Inverters play a key role in ensuring PV is an active contributor to energy system stability and reliability. They are also the key element that allows hybridisation of PV with other flexibility solutions, including batteries storage, solar mobility, power to heat and so on, at various scales.

Already in 2025, PV coupled with batteries is competitive against all forms of thermal generation according to Fraunhofer ISE. As both technologies continue to progress, in efficiency and cost reductions, the competitiveness of PV and battery storage is expected to continue increasing all the way to 2050. Looking beyond LCOE, integrating PV with flexibility solutions such as batteries improves the value capture value for generated PV electricity.

Anticipatory grid planning and enforceable grid access rights are essential to align PV deployment trajectories with network development, enabling efficient integration of PV and hybrid systems. The deployment of PV-storage hybrid systems requires long-term revenue visibility reflecting the full value of flexibility, adequacy and ancillary services, to support bankable investment decisions.

2.2.2. Continued innovation delivers sustained competitiveness and cost improvements for PV

A key priority is the advancement and commercialisation of innovative PV technologies that will remain competitive on the medium to long term, notably for cells and modules. These include high-efficiency cell architectures, including technologies such as TOPCon (Tunnel Oxide Passivated Contact), HJT/HBC (Heterojunction), and especially tandem and perovskite-silicon cells. By allowing PV module efficiencies beyond 30%, these technologies allow to reduce the LCOE of PV and improving land-use efficiency. Along with accelerating the emergence of new technologies and the continued improvement of state-of-the-art architectures and technologies, innovation's focus in PV delivers continued improvement into the reliability and quality of PV systems, ensuring equipment performs reliably at scale. European research institutions and companies must collaborate through coordinated R&D programmes, pilot lines, demonstration facilities, shared testing infrastructures, and industrial partnerships and business models to translate laboratory breakthroughs into scalable industrial products. with a shorter time to market than before.

2.2.3. Embedding AI technologies in the PV value chain to deliver new services and maximise PV's potential

As Europe's energy system becomes more digitalised and market rules change to highlight the importance of PV in maintaining system stability, technical solutions like inverters, system interoperability, and improved communication have become crucial for ensuring reliable grid stability. This layer of digital infrastructure for interoperability and secure operation (e.g. standardised data collection formats, cybersecurity standards) added to the physical grid allows PV systems to be fully interoperable and controllable remotely, while providing security against disruption, whether linked to a physical disruption (e.g. climate events), malicious (e.g. cyberattacks) or geopolitical actors looking to leverage the energy weapon.

AI-driven solutions also transform the entire lifecycle of PV projects delivering higher efficiency, reliability, and sustainability. It also allows new system services, for instance as a flexibility provider on the electricity grid. PV systems generate enormous volumes of high-frequency data, the interpretation of which AI technologies can be leveraged for. In manufacturing, automation and digitalisation of processes are core features of competitiveness, with AI-powered visual inspection systems that can detect micro-defects in solar cells and modules with speed and precision beyond human capability. In R&I, AI-assisted new material discoveries and new cell architectures enables higher efficiency and more stable PV cells and panels.

Operationally, digitalisation, and the inclusion of AI tools to exploit the data from PV systems, enable predictive maintenance by analysing data from sensors and monitoring equipment to foresee potential failures before they occur. This proactive approach minimizes downtime and extends the lifespan of PV systems. Furthermore, AI improves energy forecasting by integrating weather data and historical performance, allowing for better grid integration and energy management. In the realm of quality assurance, AI facilitates real-time monitoring and diagnostics, swiftly identifying anomalies and ensuring optimal performance.

2.3. Medium-term (2040)

2.3.1. A PV industry that contributes to European resilience through digitalisation, circularity and innovation

The IWG PV Thematic vision assumes that, by the middle of the century, Europe could cover at least 40% of its PV demand across the entire value chain with domestic production. This represents an aspirational benchmark inspired by the Net Zero Industry Act requiring significant capacity build up between now and 2040. In specific areas, such as inverters, where Europe is already producing at levels nearly matching demand, innovation supports improved competitiveness for European production to remain robust.

While large-scale sites and capacity building for European PV manufacturing rely on the best available commercial technologies heading into 2030, innovation remains at the core of the sector's evolution through 2050. The 2030s period is crucial in that it requires the large scale availability of the next generation of production technologies and equipment at scale for PV technologies that are at low-mid TRL today (PK/PK tandems, fully circular PV modules, kerfless wafers, CRM free modules, Lead free PK, and flexible modules). This is essential for adapting to the short technology cycle of PV and driving the development of next-generation solutions. This includes advancements in material design, new manufacturing processes, and innovative cell and module structures. By focusing on improving the performance of PV devices in terms of efficiency, lifetime, cost, and integration, Europe can lead the way in cutting-edge solar PV technology.

2.3.2. New applications unlocking PV’s energy production potential:

Throughout the first half of the 21st Century, PV applications diversify with solar electricity generation happening everywhere, on fields, in cities, on water and even in motion.

Agri-PV exemplifies how Europe can generate greater value from its landscapes without compromising energy security or food quality. By pairing solar PV panels with active farmland, this dual-use model enhances land-use efficiency, supports rural economies, strengthens food- energy synergies and improves resilience against drought and heat. Agri-PV provides a solution to accelerate the energy transition while preserving the productivity and sustainability of the agricultural sector.

Building Integrated PV and Infrastructure Integrated PV also play a key role in maximising the solar potential of the European built environment, providing diversified answers to the evolving expectations Europeans have of their buildings and infrastructure: they now also need to be energy positive insofar as possible. This supports local energy generation, as well as the contribution of the PV sector to the European architectural landscape which plays a crucial role in Europe's cultural identity and global image, thanks to the technical and aesthetic flexibility provided by integrated PV technologies. By enabling photovoltaic integration on non traditional surfaces such as façades, skylights and other building elements, BIPV can expand the usable solar surface in cities by up to 50% compared to rooftop only solutions.

With Hydrogen (H_2) and Synthetic Fuels (Power-to-X) production, solar PV solves specific challenges of industrial energy use decarbonisation (supply of high temperature heat, use of for feedstocks…). At system level, e-fuels production can support the provision of seasonal flexibility, provided the market incentives are relevant. Electrolysers convert PV electricity into hydrogen, which can be stored seasonally or used as e-fuels. Power-to-X provides a flexible and scalable solution for long-term energy storage and enables the use of renewable energy in various industrial applications against competitive prices if advantages of scale are achieved

2.4. Long-term (2050)

2.4.1. Expanding PV integration across land use, mobility, and industrial systems

In many contexts where land use is constrained by environmental, landscape, or cultural heritage considerations, the deployment of photovoltaics requires particular attention to how systems are integrated into their surroundings. Rather than focusing solely on widespread deployment, greater emphasis should be placed on the design and integration of PV solutions. This entails developing technologies that not only optimise efficiency and cost, but also address architectural and spatial integration within the built environment. Key aspects include improved aesthetics and the development of standardised, easy-to-implement solutions for the construction sector and for architects and designers. This approach is consistent with Challenge 3 of the ETIP-PV SRIA, which focuses on new applications through the integration of photovoltaics for diversified and dual- purpose deployment and enhanced value.

PV also becomes an increasingly standard feature of vehicles and charging infrastructure, supporting the seamlessness of the electrified European transport sector. Vehicle integrated PV (in cars, trucks, public transports) delivers significant impact. It is part of the wider trend towards solar mobility which notably includes smart charging and bi-directional energy flows that optimise solar power production.

Floating PV, supported by the implementation of electrical infrastructure toward remote or water-related assets, is installed on reservoirs, lakes, dams and even offshore, delivering greater PV potential by enlarging exploitable surfaces. Offshore floating PV meanwhile can support efficient energy infrastructure use, complementing offshore wind in hybrid energy parks, helping to smooth supply variability and support grid stability. They also offer broader options to deliver the energy transition in regions with limited land availability or competing land-use priorities.

The electrification of industry is a crucial challenge to achieve carbon neutrality by 2050. The delivery of high voltage DC power allows to run machinery with high power needs, which are typically used when electrifying energy intensive industrial processes such as arc furnaces for steel making. High voltage DC power is also relevant for sites with high power needs, and it can bring significant efficiency benefits (as DC use of electricity represent a 30% efficiency improvement compared to the AC alternative by 2030 for applications ranging from local grids to behind the meter). In addition to technical benefits, such systems can be relevant to developers in cutting costs and lead times when

developing PV systems aimed at supplying industrial sites since they can be “off grid” and as such circumvent bottlenecks linked to planning and permitting of grid infrastructure, while allowing industrial consumers to avoid costs related to the grid infrastructure itself.

2.4.2. Circularity solving raw materials challenge, competitiveness and cementing PV’s social license to operate

Circularity becomes central to cell and module development, with Europe taking a lead in eco- design principles, emphasising recyclability, non-toxic material selection, and circular manufacturing. This is further enabled by the development of digital traceability tools, such as digital product passports for PV modules, allowing full lifecycle tracking of components, materials, and performance history. Modules designed for a balance of long-term reliability and circularity and reuse contribute to a more resilient and responsible solar industry, aligned with the European Green Deal. In parallel, certified reuse schemes are established to ensure quality, safety, and performance standards for second-life modules across the EU market.

Durability and reliability remain core considerations. Innovations in encapsulation materials, backsheet technologies, and degradation-resistant designs are essential to extend module lifetimes to 35-40+ years. High-performance modules must withstand extreme environmental conditions while maintaining output with minimal degradation. These technological advancements also support the emergence of circular business models, including leasing, take- back systems, and service-based approaches that incentivise longer lifetimes and reuse.

The development of reuse and refurbishment strategies, standardised recycling protocols, and supportive policy frameworks must go hand-in-hand with the continued scaling of PV deployment. In this context, the European PV ecosystem should progressively move beyond conventional recycling approaches towards fully regenerative and closed-loop manufacturing systems, minimising reliance on virgin critical raw materials. By 2050, re-use PV operations are integrated in the EU O&M value chain and at least 50% of end-of-life PV is repaired or re-used and can function for at least 10 more years, reaching cumulative lifetimes of more than 40 years for Si and more than 25 years for Pk and tandem Pk-Si.

As such, the PV industry demonstrates end-of-life recycling rates of above 95% for Silicon, Silver, Indium, Copper and Gallium, 100% glass recovery with antimony traceability, for a total material recovery after deframing and deboxing of above 98%. The recovery of polymers will also be central to circularity strategies, reaching above 70% for EVA, 90% for PET and 99% recovery rates for PVF and PVDF. Finally, reuse of recovered (unbroken) glass will be crucial in the continued reducing CO2 emissions of PV panel production.

3. Conclusions and next steps

The IWG PV Thematic Vision confirms the strategic role of solar photovoltaics as a cornerstone of Europe's climate-neutral, competitive, secure and resilient energy system. Building on the SET Plan guiding principles, the Vision provides a coherent long-term perspective on how PV can contribute to energy security, industrial competitiveness and system stability, while delivering affordable, locally produced electricity at scale. By articulating shared ambitions for 2030, 2040 and 2050, and by embedding cross-cutting priorities such as access to market, digitalisation and circularity, the Vision establishes a common reference framework for coordinated action by Member States, industry and research stakeholders under the SET Plan.

In line with the renewed SET Plan governance, the Thematic Vision constitutes the strategic basis for the development of the IWG PV SRIA and a Common Implementation and Investment Plan (CIIP) for photovoltaics, translating this long-term vision into concrete targets, milestones, research and innovation priorities and investment commitments. As a next step, the IWG PV will initiate and steer the drafting of the PV CIIP, in close cooperation with national authorities and relevant stakeholder organisations, notably ETIP PV, EERA and European industrial and research actors. This process will identify priority actions along the PV value chain, align national funding programmes and investment priorities, and ensure coherence with EU-level instruments supporting industrial scale-up, system integration and deployment.

The implementation of the Vision and the forthcoming CIIP will require strong coordination and synergies with other SET Plan Implementation Working Groups. A joint vision on renewable, digital, decentralised, secure energy systems will solidify the case in light of other less renewable or less robust energy options and system designs.

In particular, close interaction will be pursued with the Energy Systems IWG and the Direct Current Technologies Working Group on grid integration, flexibility, power electronics and system operability; with the Batteries and Hydrogen Working Groups on hybridisation, storage and sector coupling; with the Energy Efficiency in Buildings, Positive Energy Districts and Industry IWGs on integrated PV applications, electrification and demand-side solutions; and with cross-cutting activities related to circularity, digitalisation and skills development. By actively engaging with these working groups, the IWG PV aims to maximise complementarities, avoid duplication and contribute to a coherent, system-oriented implementation of the SET Plan.

Finally, the IWG PV will continue to monitor progress against the objectives set out in this Vision through regular reporting under the SET Plan framework, while updating priorities as technology, markets and the geopolitical context evolve. Progress should be monitored not only in terms of installed capacity, but also through system-level indicators such as electrification rates, PV-linked flexibility deployment, grid hosting capacity and circularity performance.

Through sustained collaboration, shared commitment and coordinated investment, the IWG PV seeks to ensure that solar photovoltaics fully delivers its potential as a strategic European technology supporting decarbonisation, energy sovereignty and long-term economic resilience

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