Digitalisation and Digital Twins in Photovoltaic Systems
光伏系统中的数字化与数字孪生

IEA PVPS has published a new report under Task 13 – Reliability and Performance of Photovoltaic Systems, examining how digitalisation and digital twins can be used to enhance the performance, reliability and lifecycle management of PV systems.
近日，IEA PVPS Task 13 最新发布了光伏系统可靠性与性能课题下的一份最新报告，探讨了数字化与数字孪生技术如何用于提升光伏系统的发电性能、可靠性及全生命周期管理水平。

Titled "Digitalisation and Digital Twins in Photovoltaic Systems", the report provides a technical overview of how digital technologies are being applied across the PV value chain, from manufacturing to operation and maintenance. It highlights the role of digital twins – virtual representations of PV systems updated with real-world data – in supporting performance analysis, predictive maintenance and informed decision-making throughout a system's lifecycle.
该报告从技术层面综述了数字技术在光伏全产业链（从制造到运维环节）的应用落地情况。报告重点阐述了数字孪生 —— 基于实际运行数据实时更新的光伏系统虚拟映射体 —— 在系统全生命周期内，支撑性能分析、预测性维护与科学决策制定方面的核心作用。

The report emphasises the importance of robust, standardised data models and interoperable data structures as a foundation for effective digitalisation, alongside the growing use of artificial intelligence (AI) and Internet of Things (IoT) technologies. It also stresses that cybersecurity must be addressed at all levels as PV systems become increasingly data-driven and interconnected.
报告强调，构建完善、标准化的数据模型与可互操作的数据架构，是实现高效数字化转型的基础；与此同时，人工智能（AI）与物联网（IoT）技术在光伏领域的应用正日趋广泛。报告还指出，随着光伏系统愈发趋向数据驱动化与互联互通，网络安全问题需在全层级予以重视。

Key Findings 核心结论：

Digitalisation significantly contributes to risk analysis in PV projects, allowing stakeholders to quantify and mitigate risks associated with component failures, design flaws, and environmental factors.

数字化技术可显著助力光伏项目的风险分析，帮助相关方量化并缓解由部件故障、设计缺陷及环境因素引发的各类风险。

The emphasis on the digital twin as a core concept signals its potential to revolutionise how PV systems are designed, operated, and maintained, ultimately contributing to the sector's growth and sustainability in the energy transition.
数字孪生作为核心技术理念被重点关注，彰显出其革新光伏系统设计、运行与维护模式的潜力，最终将助力光伏产业在能源转型中实现增长与可持续发展。

Two approaches to digital twinning are discussed: physics-based digital twins, which use physical models to simulate behaviour, and data-driven digital twins, which rely on real-world data to model system performance.
报告探讨了两类数字孪生构建路径：一类是基于物理模型的数字孪生，通过物理模型模拟系统运行特性；另一类是数据驱动型数字孪生，依托实际运行数据构建系统性能模型。

The integration of artificial intelligence (AI) and the Internet of Things (IoT) are key components in optimising operations and maintenance (O&M) processes for PV systems.
人工智能（AI）与物联网（IoT）的融合应用，是优化光伏系统运维（O&M）流程的核心要素。

Supporting Reliable and High-Performance PV Systems
支撑光伏系统实现可靠高效运行

By providing harmonised definitions, technical frameworks and examples of digital applications, the report supports stakeholders involved in the design, operation and maintenance of PV systems. It contributes to a deeper understanding of how digitalisation and digital twins can strengthen the reliability and performance of PV systems and support the long-term development of the PV sector.
本报告通过提供统一的术语界定、技术框架与数字化应用案例，为光伏系统设计、运行及维护环节的相关从业者提供支撑，有助于业内更深入地理解数字化与数字孪生技术如何强化光伏系统的可靠性和发电性能，助力光伏产业长期发展。

关于 IEA PVPS

IEA PVPS是在国际能源署内设立的合作研发协定机构之一，自1993年成立以来，PVPS参与方一直在开展各种应用光伏技术将太阳能转化为电能的联合项目。

截至 2024 年底，PVPS 的 27 个正式成员为：澳大利亚、奥地利、比利时、加拿大、中国、丹麦、芬兰、法国、欧洲联盟委员会、德国、印度、以色列、意大利、日本、韩国、马来西亚、摩洛哥、荷兰、挪威、葡萄牙、南非、西班牙、瑞典、瑞士、泰国、土耳其、美国。

关于 IEA PVPS Task 13

Task13 工作组旨在改善光伏组件和电站的运行，可靠性和发电质量。汇总不同气候带区域的光伏系统的运行数据并进行分析研究，给出材料、器件、系统的可靠性和发电性能评估结论；研究光伏组件和系统的耐久性及使用寿命特性。另一方面，Task13 工作组收集及分享来自各成员国家光伏发电性能和可靠性的各类技术问题及最新信息、不同国家在光伏测试技术领域的关键技术、各类型光伏组件和系统设计的经验。根据不同国家/地区光伏系统、组件的运行及测试数据，研究现场测试和实验室测试方法及数据比对，进行光伏系统性能衰减、可持续运行趋势、运维技术及发电量测算技术研究，通过技术报告出版、研讨会、网络等形式公开发布研究成果。