

PV System Technology Considerations for PV-Powered Passenger Vehicles

太阳能乘用车的光伏系统技术要点

IEA PVPS Task 17 has released a comprehensive new report, PV System Technology Considerations for PV-Powered Passenger Vehicles. This publication provides an in-depth review of the unique technological aspects, challenges, and opportunities of integrating PV systems directly into vehicles.

近日，国际能源署 IEA PVPS Task 17 发布最新综合性报告——《太阳能乘用车的光伏系统技术要点》。该报告深入剖析了将光伏系统直接集成于车辆所独具的技术特征、挑战与发展机遇。

VIPV technology is emerging as a promising pathway to enhance the sustainability and autonomy of electric mobility. By generating clean electricity directly on-board, VIPV can reduce dependence on external charging infrastructure and contribute to lowering the carbon footprint of the transport sector. However, its integration into vehicles presents distinct technical challenges that require careful consideration in design, manufacturing, testing, and deployment.

车载集成光伏（VIPV）技术正成为提升电动交通可持续性与续航自主性的重要发展方向。通过车载直接发电，VIPV 可降低车辆对外部充电基础设施的依赖，并助力减少交通领域碳排放。然而，光伏系统与车辆的集成面临显著技术难题，需在设计、制造、测试与部署全流程进行审慎考量。

The report explores the main technological aspects influencing the successful integration of photovoltaic systems into vehicles. It examines the challenges of installing PV modules on curved vehicle surfaces, addressing manufacturing techniques, the limits of cell bending, and the effects of curvature on performance. Aesthetics are highlighted as a decisive factor for consumer acceptance, with detailed insights into colouring methods, colour reproducibility, and compatibility with automotive design trends.

报告系统分析了影响光伏系统成功车载集成的核心技术要素，重点探讨了光伏组件在车辆曲面安装的难点，涉及制造工艺、电池片弯曲极限及曲面形态对发电性能的影响。外观美学被视为影响消费者接受度的关键因素，报告详细阐述了着色方法、色彩重现性及其与汽车设计趋势的兼容性。

The weight of the PV system is shown to affect vehicle efficiency, and the report introduces a methodology to balance additional weight against energy yield, demonstrating that parking-phase generation can offset weight-related losses. It also addresses the current absence of dedicated VIPV standards, recommending a tailored safety qualification programme that merges PV and automotive testing protocols. Special testing requirements for curved PV modules are discussed, drawing on results from international round-robin projects. Finally, the report notes the need to manage potential toxic materials, ensure recyclability, and improve vibration resistance to maintain long-term system reliability.

研究表明，光伏系统自重会影响整车能效，报告提出一种系统增重与发电量收益平衡方法，并证实驻车发电可有效抵消自重带来的能效损耗。报告同时指出，当前尚无专门针对 VIPV 的标准体系，建议构建融合光伏与汽车测试规程的定制化安全认证体系。依托国际联合比对试验成果，报告讨论了曲面光伏组件的特殊测试要求。最后，报告强调需管控潜在有毒材料、保障可回收性并提升抗振性能，以维持系统长期可靠性。

Key takeaways

要点

VIPV technology faces unique design challenges – including curvature, aesthetics, and weight – that must be addressed to enable effective and reliable integration into vehicles.

VIPV 技术面临曲面适配、外观美学、系统自重等独特设计挑战，需妥善解决方可实现高效可靠的车载集成。

Standardisation is critical – work is underway to create dedicated testing and safety qualification programmes tailored to VIPV applications.

标准化至关重要：面向 VIPV 应用的专用测试与安全认证体系正在构建中。

Energy balance depends on multiple factors – such as PV technology choice, vehicle type, and driving/parking patterns.

能量平衡受多重因素影响，包括光伏技术选型、车型以及行驶 / 驻车模式。

Aesthetics matter for market acceptance – colour, surface finish, and seamless integration into vehicle design are essential for consumer uptake.

美学设计决定市场接受度:色彩、表面质感及与车身设计的无缝融合是获得市场认可的关键。

Special testing methods are required – curved PV modules need tailored approaches to ensure accurate performance assessment and long-term reliability.

需采用专用测试方法:曲面光伏组件需定制化评估方案,以确保性能精准评价与长期可靠性。

The report concludes that VIPV offers significant potential for the automotive industry, but further research, standardisation, and technology development are essential. Improved testing methodologies, optimised electrical designs for curved modules, and PV technologies tailored for vehicle integration will be key to unlocking VIPV' s full potential.

报告总结认为, VIPV 在汽车行业具备巨大应用潜力,但仍需持续研究、标准完善与技术迭代。优化测试方法、曲面组件电路设计及适配车载场景的光伏技术,将是充分释放 VIPV 应用价值的关键。