**PV module manufacturing and indoor & outdoor characterization**
**TECNALIA Workshop 2025**

## Objectives

The objective of this two-day workshop is to provide participants with a comprehensive and hands-on understanding of advanced photovoltaic (PV) technologies, with a particular focus on characterisation, reliability, and integration. Hosted across TECNALIA's facilities in Derio, Azpeitia, and Donostia, the programme is designed to showcase the full value chain of solar module development—from outdoor performance monitoring to indoor testing and manufacturing processes. The sessions aim to bridge theoretical knowledge with practical experience, fostering technical exchange among researchers involved in the CACTUS project.

The first day centres on outdoor testing and infrastructure, including a detailed visit to TECNALIA's solar laboratory in Derio. Participants will engage in practical demonstrations involving IV curve tracing, sensor calibration, and fault tracking in PV modules, with a specific focus on CACTUS-related samples. Complementary visits to the electrical systems lab and the KUBIK building testing platform will highlight integration challenges and energy efficiency strategies. The day concludes with an indoor session on lock-in electroluminescence (EL) characterisation, combining lecture, demonstration, and hands-on practice.

The second day expands the scope to fire safety and manufacturing. Starting with a visit to the fire laboratory in Azpeitia, attendees will explore testing protocols and standards relevant to PV modules and batteries. The afternoon session in Donostia offers a deep dive into the fabrication and quality control of PV modules, including flash testing, interconnection, encapsulation, and module-level IV and EL analysis. The workshop concludes with a wrap-up session in Derio, summarising key insights and reinforcing collaboration across the consortium.

Funded by the European Union

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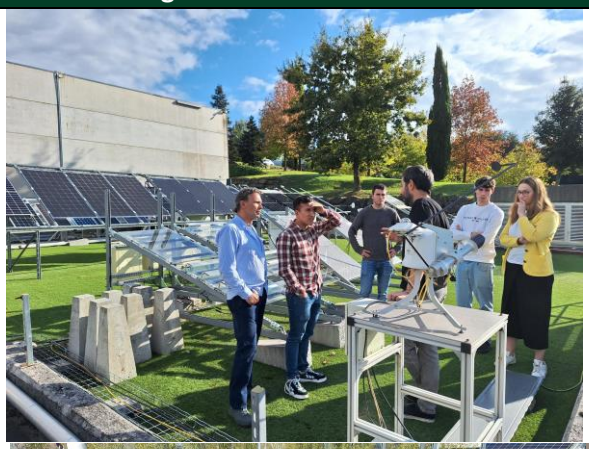




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## Results

The CACTUS training workshop, held on 29–30 September 2025 at TECNALIA's facilities in Derio, Azpeitia, and Donostia (Spain), provided participants with a comprehensive overview of photovoltaic (PV) technologies, testing methodologies and integration strategies. The first day began with an institutional introduction to TECNALIA and its Solar Group, followed by a hands-on session at the outdoor solar laboratory. Attendees explored real-time monitoring systems, IV curve tracing, and sensor calibration, with a particular focus on the CACTUS project's modules and degradation analysis. The day continued with visits to the electrical systems lab and the KUBIK building testing infrastructure, concluding with an indoor session on electroluminescence (EL) characterisation techniques and a group dinner for informal networking.

The second day expanded the technical scope with a visit to TECNALIA's fire laboratory in Azpeitia, where participants learned about fire behaviour testing for PV modules and battery systems, including relevant standards and ongoing research. The group then travelled to Donostia for a deep dive into PV manufacturing, indoor characterisation and quality control. This included both theoretical overviews and practical sessions on flash testing, cell interconnection, encapsulation, and EL/IV testing at the module level. Emphasis was placed on quality assurance procedures and reliability metrics across the PV value chain.

The workshop concluded with a wrap-up session back in Derio, where key insights from both days were summarised, and participants provided feedback. The event successfully combined theoretical knowledge with practical demonstrations, fostering collaboration and knowledge exchange among researchers and professionals involved in the CACTUS project. It also highlighted TECNALIA's multidisciplinary capabilities in solar energy research, testing infrastructure, and system integration.

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| **Training Activity** | PV module manufacturing and indoor & outdoor characterization<br>TECNALIA Workshop 2025 |
| **Date** | 29-30th September 2025 |
| **Number of attendees** | 5 attendees |
| **Place and country** | Derio/Azpeitia/SanSebastian, Spain |
| **Consortium Partners involved** | Tecnalia |
| **Additional Notes** | Thanks for your assistance |



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