



**UNIVERSITÀ  
DI PADOVA**

## **Symbol - Solar-driven hYBrid Methane production via BioelectrOchemical CO2 utilization**

The SYMBOL Doctoral Network pioneers a new generation of solar-biohybrid technologies for decentralized biomethane production. SYMBOL introduces a Dual Pathway Conversion (DPC) architecture that merges two synergistic CO<sub>2</sub>-to-CH<sub>4</sub> routes: (i) a biophotoelectrochemical (BPEC) process in which Cu<sub>2</sub>O-based plasmon-enhanced photocathodes generate H<sub>2</sub> in situ for biological methanation, and (ii) a direct interspecies electron transfer (DIET) process enabling direct photo-electron uptake by methanogenic archaea without molecular hydrogen. The integrated system achieves hydrogen-free, low-temperature, solar-driven biomethanation from biogenic CO<sub>2</sub>, fully consistent with the EU Green Deal, REPowerEU and Fit-for-55 objectives. Ten doctoral projects combine frontier research in materials chemistry, electrochemistry, microbiology, photovoltaics, modelling and system engineering, culminating in a validated TRL 3 prototype. Key innovations include self-healing plasmonic Cu<sub>2</sub>O photocathodes, low-overpotential transition-metal chalcogenide anodes, semi-transparent patterned perovskite solar cells for light-sharing, and advanced membranes enabling stable hybrid operation. Together they target  $\geq 5$  % solar-to-methane efficiency and  $\geq 95$  % selectivity under continuous illumination. Beyond scientific excellence, SYMBOL establishes a pan-European doctoral training ecosystem integrating academia and industry (Prodeval, Antares, EBA) through intersectoral secondments, transferable-skills courses, open-science practices, and career mentoring. The programme will train ten highly employable researchers capable of advancing CO<sub>2</sub> valorisation and renewable-gas innovation. By coupling cutting-edge technology with structured training, SYMBOL strengthens Europe's capacity for climate-neutral energy, sustainable process engineering and the circular-carbon economy.

**Coordinator:** Politecnico di Torino

**Beneficiary:** Università degli Studi di Padova

**UNIPD Supervisor:** Silvia Gross

**Department:** Department of Chemical sciences

**Total Contribution:** € 2 997 712,08

**Project Duration in months:** 48 months

**Find out more:** [SYMBOL](#)