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Polygenerating Solar Collector's Alliance (PolyGen Alliance)

Summary

Polygenerating solar collectors, capable of simultaneously producing multiple energy vectors, represent a promising pathway toward highly integrated and efficient renewable energy systems. However, their progress is limited by fragmented research, limited standardisation, and a lack of coordinated dialogue among researchers, industry, policymakers, and stakeholders.

The Polygenerating Solar Collector's Alliance (PolyGen Alliance) is a collaborative initiative, part of the EU-funded SPECTRUM project, that brings together innovation stakeholders to address these challenges. PolyGen Alliance provides a structured yet flexible platform for knowledge exchange, identification of research gaps, and alignment of methodologies, with the aim of accelerating technology readiness and supporting scalable deployment.

Keywords: Polygeneration, solar collectors, hybrid solar technologies, system integration

Field of application for the findings: Renewable energy systems, solar thermal and hybrid technologies, solar fuels, industrial energy applications

Addressed audience: Researchers, technology developers, system integrators, industry stakeholders, policy and standardisation bodies

1. Introduction

The transition toward climate-neutral energy systems requires technologies capable of delivering multiple energy services efficiently and sustainably. Polygenerating solar collectors, which enable the simultaneous production of heat, electricity, and solar-derived fuels or other chemical commodities within a single device, are emerging as a promising solution to increase solar energy harvesting efficiency, optimize land use and reduce system complexity.

Despite significant advancements in individual technologies, including photovoltaic (PV) modules, thermal collectors, and solar-driven chemical processes, including applications such as solar-to-hydrogen and solar-assisted wastewater treatment, the development of fully integrated polygenerating collectors remains limited. Current research efforts are often fragmented across disciplines, focusing on isolated components or specific applications. This fragmentation creates challenges in achieving optimal integration, performance evaluation, and scalability.

In addition, the lack of harmonised methodologies for modelling, testing, performance measurement and socio-economic and environmental impact assessment further limits comparability and technology validation. The lack of coordinated dialogue among research, industry, and standardisation bodies also slows the transition from laboratory-scale innovation to industrial deployment.

To address these challenges, there is a need for structured collaboration that connects component-level innovation with collector level integration and cross-cutting considerations. This work presents the Polygenerating Solar Collector's Alliance (PolyGen Alliance) as a response to this need.

2. Concept and Scope of the PolyGen Alliance

The PolyGen Alliance is conceived as a collaborative framework designed to support the development and deployment of polygenerating solar collectors as integrated devices. It aims to bring together stakeholders from

research, industry, and innovation ecosystems to facilitate knowledge exchange and align research efforts.

The scope of the PolyGen Alliance focuses on polygenerating solar collectors as single devices. Within this scope, both component-level and integration aspects at collector-level are considered. Key technological components include catalysts, solar reactors, photovoltaic elements, thermal receivers, optical devices, such as solar concentrators and spectral splitters, and insulation materials.

These components must operate in a coordinated manner within a single collector architecture, requiring careful design and optimisation to balance thermal, electrical, and chemical outputs. Therefore, the PolyGen Alliance emphasises not only component performance but also the interactions between components and their impact on overall device efficiency and stability.

Beyond technological aspects, the PolyGen Alliance also addresses horizontal challenges that are critical for advancing the field. These include modelling and simulation approaches to predict multi-physics behaviour, experimental methodologies for testing and validation, and the development of performance metrics and key performance indicators.

Additional focus areas include environmental and social life cycle assessment (LCA) and life cycle cost (LCC) analysis, which are essential for evaluating environmental and socio-economic performance, as well as legislative and regulatory considerations that influence technology deployment. By integrating these dimensions, the PolyGen Alliance fosters the adoption of a holistic approach to advancing polygenerating solar collectors.

3. Methodological Approach and Activities

The PolyGen Alliance adopts a flexible and collaborative approach, structured around knowledge exchange, identification of research gaps, and alignment of methodologies. Rather than acting as a formal organisation with rigid governance, it operates as a facilitative platform that evolves in response to its members' needs and contributions.

Core activities of the PolyGen Alliance include thematic discussions on technological and non-technological challenges, exchange of best practices, and the identification of common barriers in the development and deployment of polygenerating collectors. These activities enable cross-fertilisation between different disciplines.

The PolyGen Alliance also supports aligning modelling approaches and experimental protocols, which are often developed independently across projects. By encouraging dialogue on methodologies, it improves the comparability of results and enhances the robustness of performance evaluation.

Furthermore, the initiative promotes collaboration across projects and networks, including research and educational initiatives. While respecting intellectual property constraints, the PolyGen Alliance facilitates the sharing of experiences, relevant results, and lessons learned.

Through these activities, the PolyGen Alliance aims to lay the foundation for future standardisation efforts and coordinated research agendas in direct solar polygeneration.

4. Expected Impact and Outlook

The PolyGen Alliance is expected to advance the field of polygenerating solar collectors by strengthening collaboration and addressing key barriers to innovation and deployment. Connecting stakeholders across disciplines and sectors enables a more integrated approach to technology development.

In the short term, the Alliance will support the identification of priority research areas and the alignment of methodologies. In the medium term, it can contribute to the development of shared frameworks for performance assessment, modelling, and validation. In the longer term, it has the potential to inform standardisation processes and support the integration of polygenerating solar collectors into energy systems and markets. This includes applications extending beyond energy generation, such as solar-driven environmental processes, including wastewater treatment.

The initiative will also provide a platform for building partnerships and fostering new research and innovation activities. By positioning polygenerating solar collectors as integrated, multi-functional devices, the PolyGen Alliance contributes to the broader transition toward efficient, flexible, and sustainable energy solutions.