The PYSOLO Project: Biomass Pyrolysis by Concentrated Solar Power

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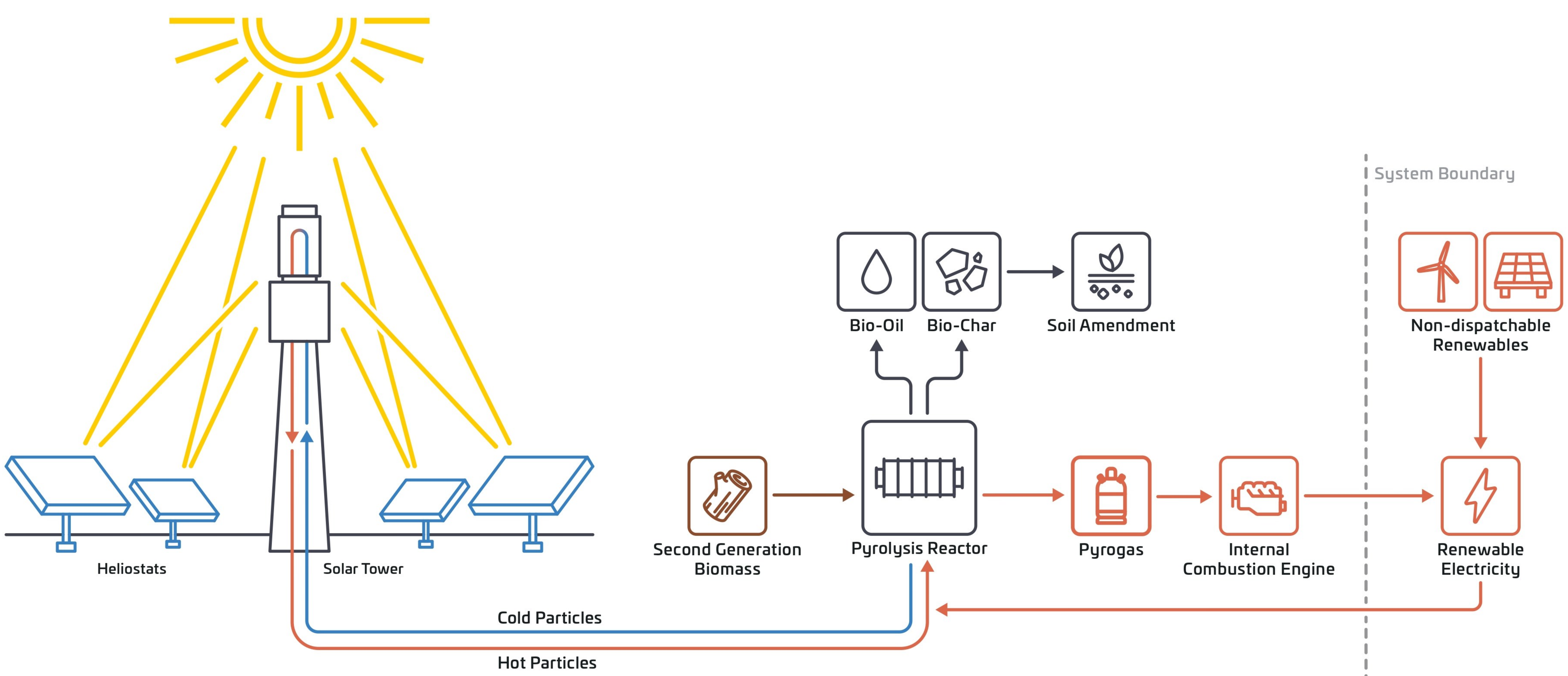
PYSOLO

Introduction

Decarbonisation through electrification is not sufficient to reduce CO_2 emissions in the chemical industry, as fossil feedstocks remain a major emissions source. Defossilisation by switching to renewable carbon sources such as second-generation biomass should thus be pursued. Conventional biomass pyrolysis, converting wood residues into high-value products such as bio-oil, biochar and pyrolysis gas, is typically sustained by burning char and pyrogas, an economically and ecologically inefficient step which also results in additional CO_2 emissions. The PYSOLO project aims at developing an **indirectly heated solar-driven biomass pyrolysis system** which, thanks to the use of solar heat in the pyrolysis process, **maximizes** the products **yield** and achieves **negative emissions** associated to biochar production.



System Description

The **particles** heated in the solar receiver are directly used as **heat carrier** (PHC) in the pyrolyzer to sustain the endothermic pyrolysis process, thus avoiding the need of heat transfer surface in the reactor facilitating the system scale-up. Downstream, a particle separator allows the separation between the PHC and the biochar produced.

Compared to directly irradiated biomass reactors, the decoupling between solar receiver and pyrolizer enhances **flexibility** and allows **continuous operation** with thermal energy storage integration or with hybrid operation.

Project Objectives and Advantages

The PYSOLO process aims at developing at **TRL4** the two key unit operations of this novel solar pyrolysis system: the **solar particle receiver** and the **pyrolysis reactor** with the associated particle-char separator. The PYSOLO system can operate in different modes, offering several advantages:

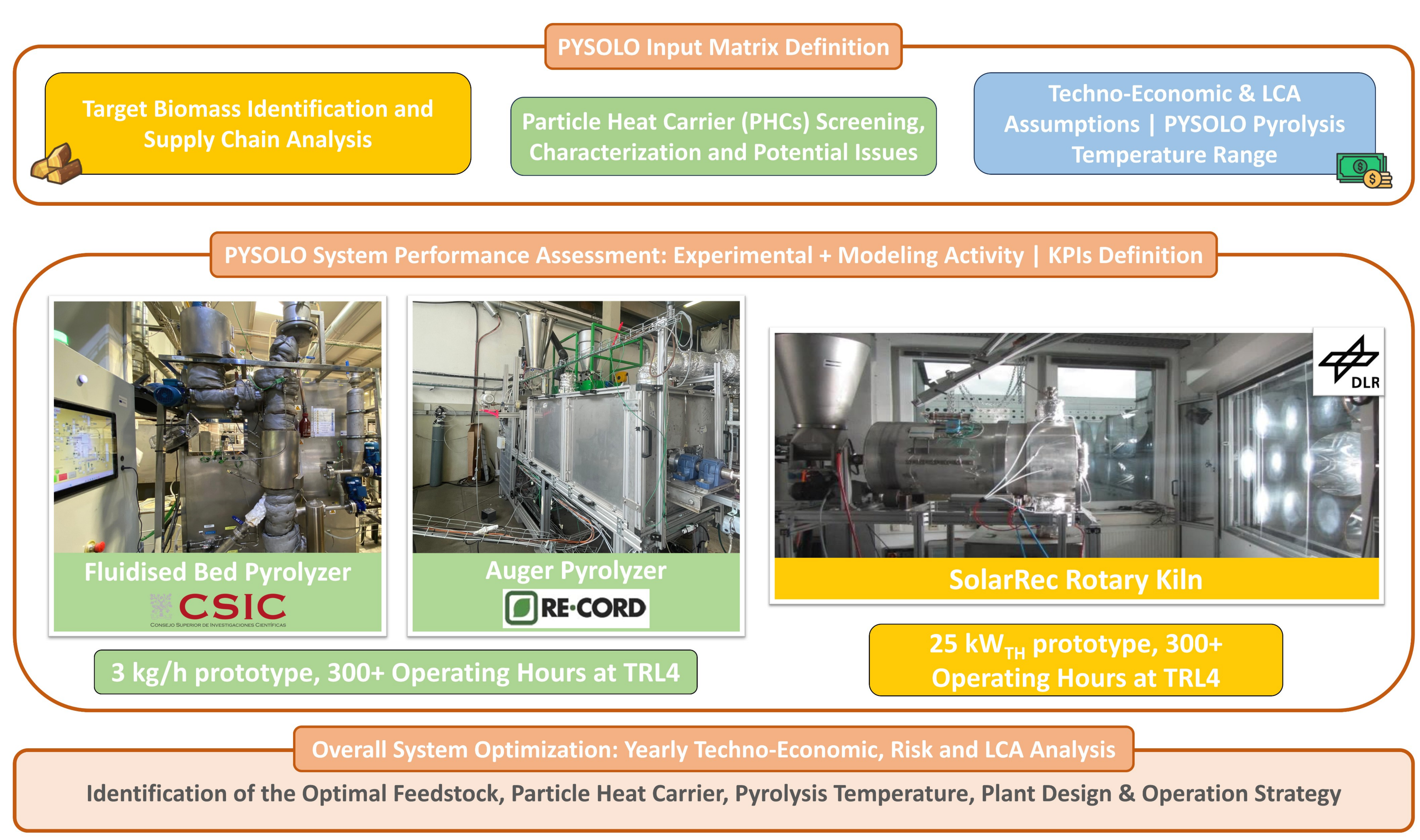
i) **Solar mode**: Produces bio-oil, pyrogas, and biochar using solar heat or stored high-temperature solids;
ii) **Self-sustained mode**: Operates without solar input by using electric heating or combusting pyrogas/biochar when storage is depleted;
iii) **Grid balancing services**: provides grid ancillary services by generating power from excess pyrogas or converting surplus PV/wind electricity to heat via induction heating.

Methodology and Project Status

The PYSOLO project has started in July 2023. The particle receiver, based on a **rotary kiln** design, will be developed and tested by **DLR**. For the pyrolysis section, **CSIC** will design and test a **fluidized bed reactor**, while **RE-CORD**, supported by POLITO, will develop an **Auger reactor**. The project will also test particle/air and particle/char separators, along with a particle induction heating system.

Various particle heat carriers (PHCs) will be assessed to identify the most effective option based on integrated system performance. **POLIMI** will carry out **modelling** at both component (receiver and pyrolyzer) and **system** levels to define the most **cost-effective plant layout**. **NOVA** and **INERIS** will evaluate the PYSOLO system through life cycle assessment (**LCA**) and **risk analysis**, respectively.

CTFC will guide **biomass selection** for the experimental campaigns and identify the most suitable feedstocks for southern European applications. Finally, the **biochar** produced will be tested by **CSIC** for its potential as a **fertilizer**.



Expected Results

PYSOLO is expected to successfully **operate the TRL4 solar particle receiver** in experimental campaigns at temperatures and with PHC relevant for solar pyrolysis for about 300h reaching **peak thermal efficiencies in the 80-85% range**. The **TRL4 pyrolysis** units will also be tested for about 300h with the selected PHC with **expected limited variation (<10%) in the product composition** for a selected set of operating conditions. The system's techno-economic analysis is expected to demonstrate **over 80% carbon efficiency** and **at least a 20% reduction in bio-oil production costs** compared to conventional pyrolysis, with LCA indicating **significant negative emissions** of approximately **−0.3 kg CO_2 per kg of biomass** fed to the system.

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