Life Cycle Assessment applied to new and advanced material solutions in Concentrated Solar Thermal technology

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1. INTRODUCTION

The benefits of high efficiency Concentrated Solar Power (CSP) and photovoltaic (PV) are numerous: environmental protection, zero-carbon process, energy security and economic growth.

The CSP thermoelectric plants concentrate sun heating power through different mirror configurations and sun orientation into a receptor. The receptor is designed to optimize the heat transfer to a Heat Transfer Fluid (HTF) that circulates inside tubes allowing the heat transport to the power storage block, while minimizing thermal losses. This heat is used to power the conventional thermal cycle and produce electricity.

CSP has advantages in front of PV: possible 24h continuous electricity production, electricity and heat generation, heat for distributed in cogeneration plants. Nonetheless, the energy efficiency and the energy production cost of this promising technology have to be improved.

2. AIM OF THE PROJECT

The aim of IN-POWER is to develop high efficiency solar harvesting Concentrated Solar Power (CSP) architectures based on holistic materials and innovative manufacturing processes while reducing the environmental impact associated to CSP architectures and the energy production cost. To achieve this objective

IN-POWER develops a set of advanced solutions:

1. Polymeric Smart light mirrors with high optical and mechanical performance.
2. An optimized and lighter mirror support structure.
3. High-operational-temperature absorber coating in new vacuum-free-designed receiver.
4. A novel modular solar field architecture and design reducing the land use requirements by 4 times.
5. High-operating-temperature thermal storage materials for TES increasing up to 3 times the thermal capacity.

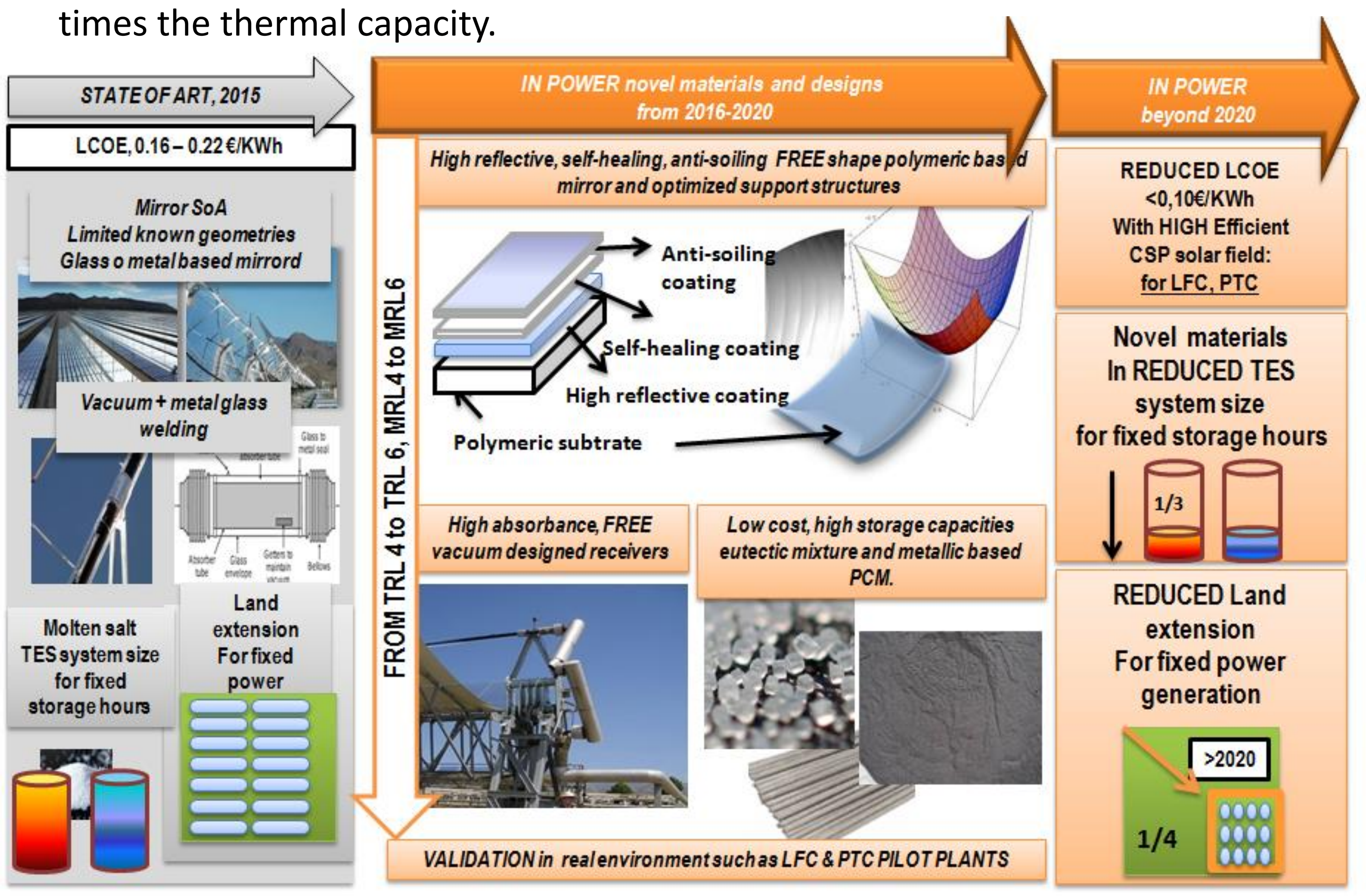


Figure 1: IN-POWER materials & components for reduced LCOE (Levelized Cost of Energy) beyond 2020

3. ENVIRONMENTAL ASSESSMENT

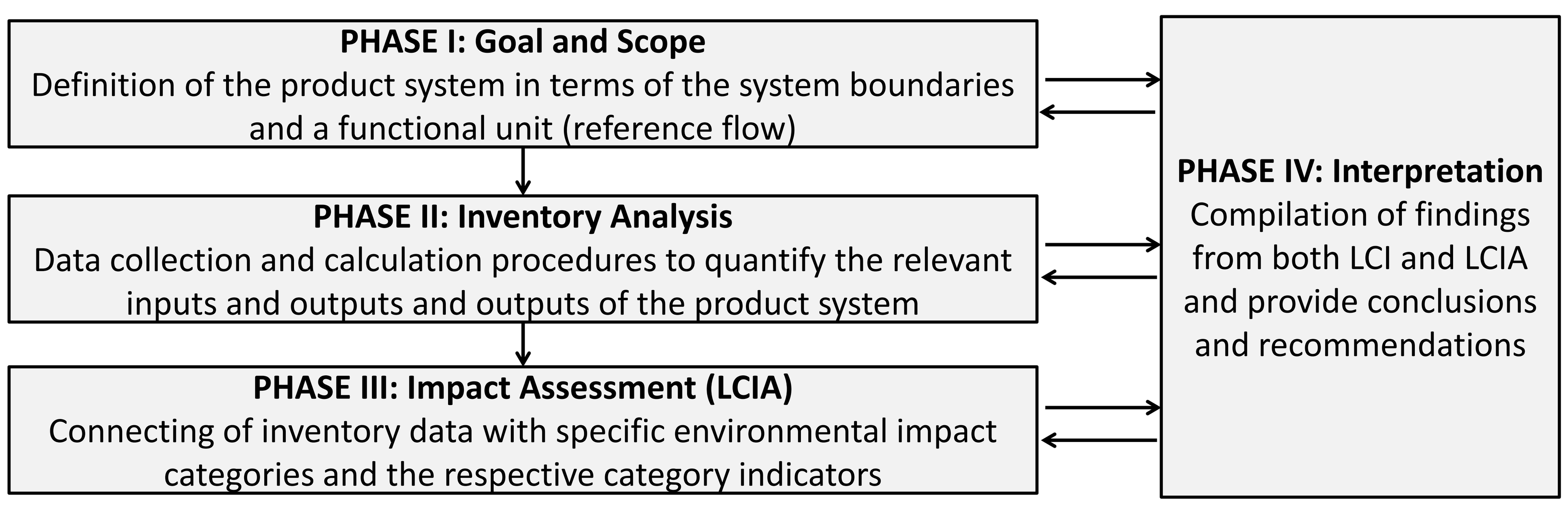
All these advanced solutions are being assessed through a comprehensive environmental Life Cycle Assessment (LCA), considering the entire life cycle of materials and components, from raw material extraction until the end-of-life. The results of the environmental assessment will be very valuable for the decision making process, where not only technical and quality aspects are taken into account, but also the sustainability approach will be added considering environmental and economic issues.

Objectives of the LCA study

1. To conduct an environmental assessment of the High Efficiency Solar Harvesting CSP architectures developed within the IN-POWER project and to detect the main environmental hot spots.
2. To keep an environmental assessment during the execution of the project as a decision maker looking for high performance materials and component but environmental friendly.
3. To compare the environmental profile of IN-POWER High Efficiency Solar Harvesting CSP architectures with the environmental profile of reference materials, components, architectures and solar field structures for CSP.

LCA methodology

- Four interrelated phases are applied:

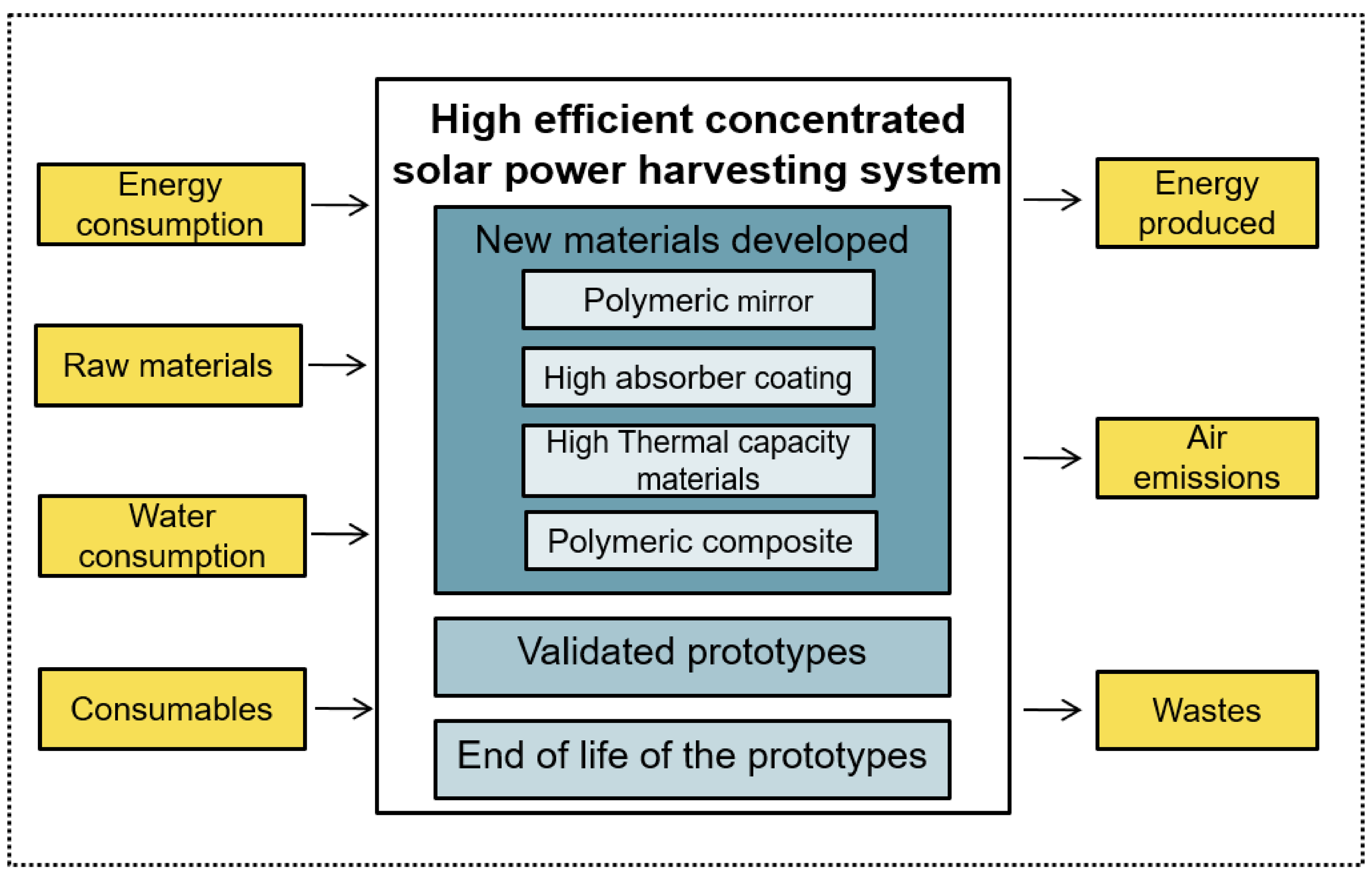


- LCA performed based on the standard ISO-framework for LCA:
  - ✓ International ISO norms ISO 14040 and 14044
  - ✓ Recommendations of International Reference Life Cycle Data System (ILCD) Handbook and the Product Environmental Footprint (PEF) Guideline
- Software used for the LCA: GaBi version 8.1.0.29
- Database used: GaBi 8.6 database and Ecoinvent 3.1 database

Goal and scope

Functional Unit: 1MWh of electricity generated by a CSP system.

System boundaries:



Expected results of the project

IN-POWER development	Due to	CO_2 Footprint	Land requirement	Other
Mirror, materials & design	+ 35% reduction in weight	35% reduction due to the transport process.	In new solar collector design, 75% less of land extension due to a new configuration and better optics parameters of the mirrors.	Reusable H_2O footprint: Some indicators remark that 74-148 litres/MWh is an average water consumption rate for cleaning mirrors. At least 10% reduction is expected especially due to dedicated anti-soiling coating for each type of dust zone and weather geosite. Lighter structure and foundations due a lighter mirrors.
	+ Polymeric substrate vs. glass	Unbreakable mirror reduce the amount of manufactured pieces along all lifecycle of CSP plant.		
	+ Antisoiling coating, reduce 10% fouling factor	Reduction due to less maintenance, for dry or wet cleaning process → water savings.		
Receiver, materials & design	+ Non vacuum system for LFC	Lower because non vacuum system is required.	Lower land requirement, in case of LFC, because higher proportion of the reflected radiation by the primary reflector will be transformed in thermal energy.	Safer condition of operations. Less worker's accidents.
	+ Improved geometry	Lower because the number of receivers will be lower than in a conventional LFC plant.		
Solar field, materials & designs	+ Reduction of weight 30% due to GFRP (Glass Fiber Reinforced Plastic) instead of steel	35% reduction of environmental impact contributions in Climate Change impact category.	51% of reduction, due to a new configuration/design.	94% reduction of environmental impact contributions in Mineral, fossil & renewable resource depletion impact category. 88% reduction of H_2O footprint: water resources depletion impact category
TES materials, materials & designs	+ Three times current heat capacity	It has been shown that 24h of renewable availability is possible with TES system, reduction of the tank size, foundations and auxiliary systems.	Reduction in land is correlate with TES system size reduction, reduction of the area dedicated to the thermal storage in at least 50%.	Three times less volume for TES system.

The IN-POWER consortium consists of 10 partners from 6 different European Countries: LEITAT, Acondicionamiento Tarrasense (Spain), VOTTELER (Germany), OHL Industrial (Spain), KOLZER (Italy), NEMATIA (Spain), GEOCAD (Spain), IK4-TEKNIKER (Spain), CEA – LITEN (France), FERTIBERIA (Spain), Italian National Agency for New Technologies, Energy and Sustainable Economic Development (Italy). *This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 720749 . This publication reflects only the author's views and the European Union is not liable for any use that may be made of the information contained therein.*