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ENVIRONMENTAL AND ECONOMIC ASSESSMENT OF THE PV-MOREDE DEVICE

(Photovoltaic Panels Mobile Recycling Device)

Terrassa, 29/09/2016
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1. INTRODUCTION

LEITAT has been involved in the following tasks within the PV-MOREDE project:

Environmental assessment:

- Evaluation of environmental impacts and benefits arising from the PV-MOREDE device.
- Comparison between current recycling technology of PV panels and PV-MOREDE technology.

Economic assessment:

Economical evaluation of the LCC (Life Cycle Costing) including environmental information. (direct & indirect costs, tangible costs, ...)

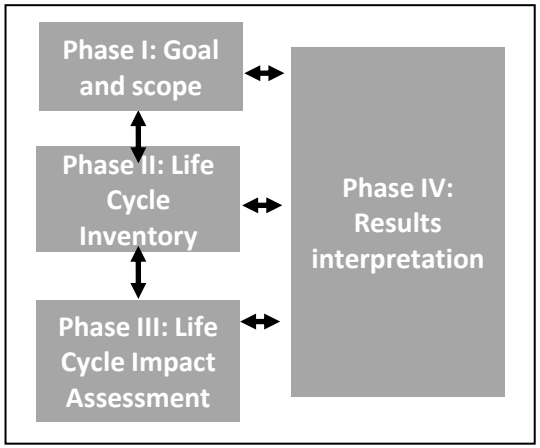
2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.1 . ENVIRONMENTAL ASSESSMENT (LCA) -INTRODUCTION

The methodology to assess the environmental performance of PV-MOREDE technology is the **Life Cycle Assessment methodology (LCA).**

*"The **Life Cycle Assessment** is a tool to analyze the environmental aspects of a product, process or activity throughout its life cycle, considering all inputs and outputs related to every stage analyzed"*

- LCA methodology is based on:
  - Standard ISO 14.040: 2006
  - Standard ISO 14.044: 2006
  - The International Reference Life Cycle Data System (ILCD)
  - Four interrelated stages are followed to apply LCA methodology



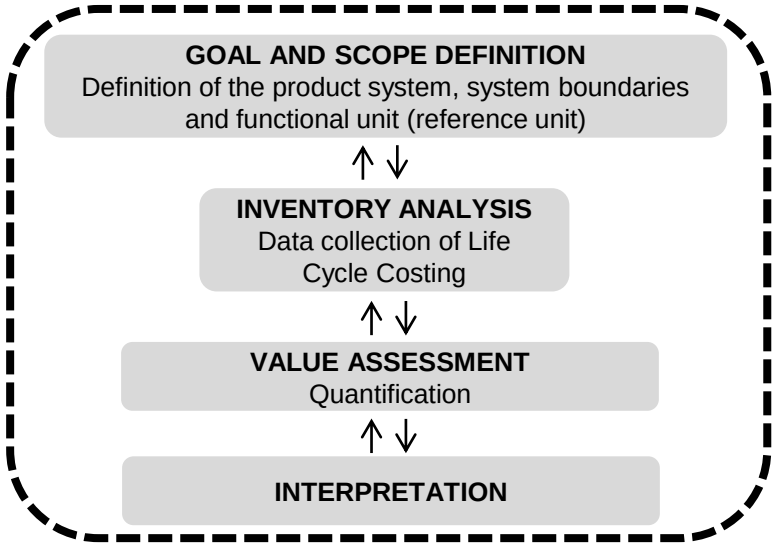
2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.2 . ECONOMIC ASSESSMENT (LCC) -INTRODUCTION

The methodology to assess the economic performance of PV-MOREDE technology is the **Life Cycle Costing methodology (LCC).**

*"The **LCC** is an assessment of all costs associated with the life cycle of a product that are directly covered by any one or more the actors in the product life cycle (supplier, producer, user/consumer, end of life actor)."*

The **LCC** is not a standardization method and follows the same approach of the LCA analysing all the product:



2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.3 . PHASE I: GOAL of the LCA and LCC

Goal of the LCA:

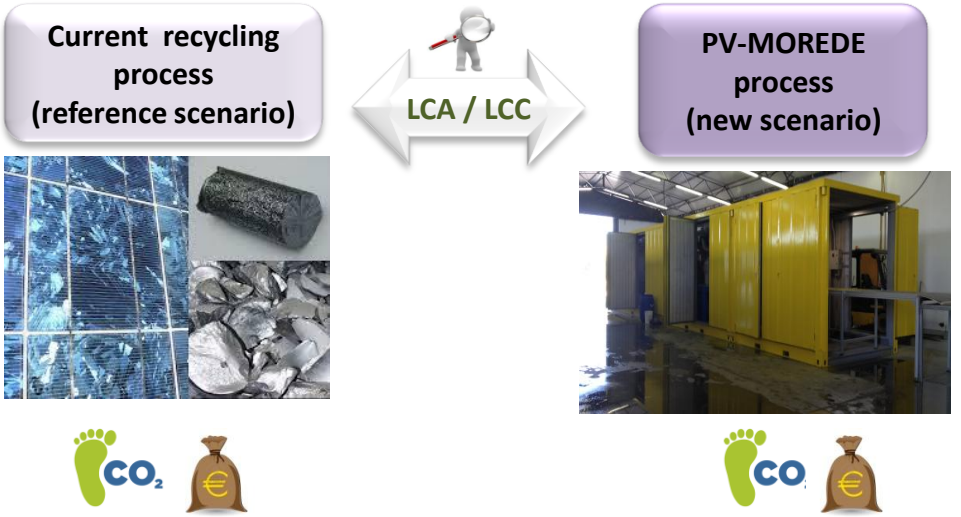
➢To quantify the potential environmental impacts of the PV-MOREDE technology, in order to identify the hotspots of the technology.

➢ The environmental assessment allows to quantify the environmental benefits of PV-MOREDE technology in comparison to current technology.

Goal of the LCC:

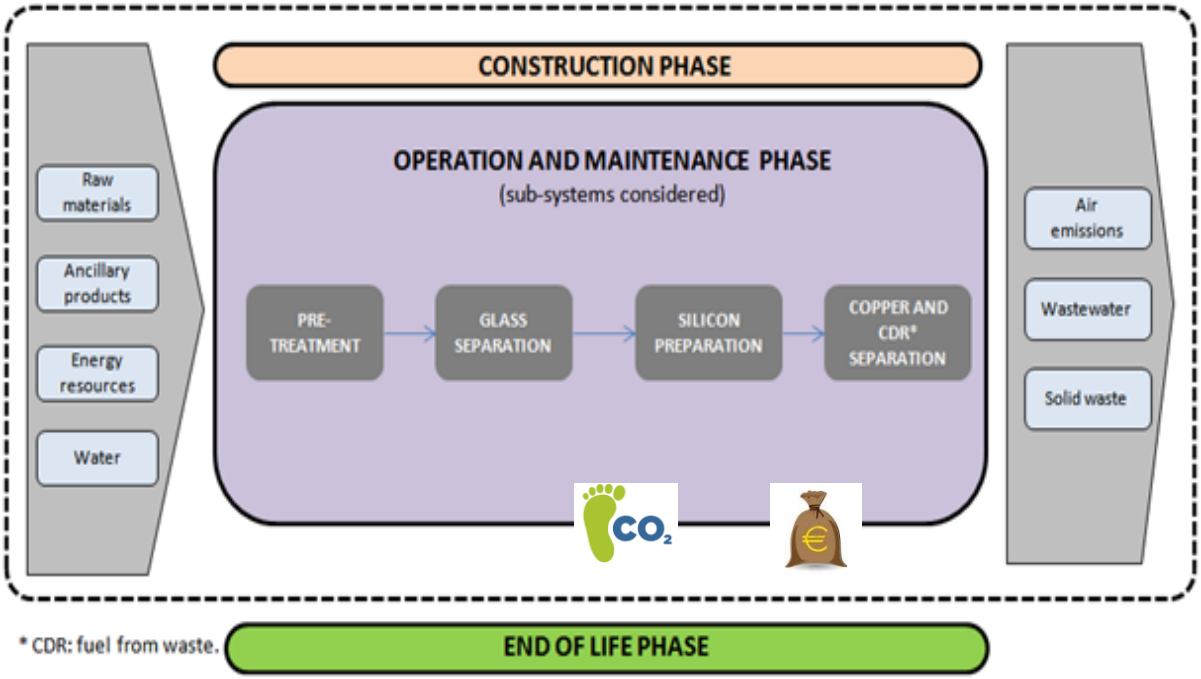
➢To determine and analyze the costs of PV-MOREDE technology along its life cycle. The costs considered are related to the construction phase, operational phase and maintenance phase (of the device).

➢To compare the cost of PV panels treated by PV-MOREDE with other existing solution.



2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.4 . PHASE I: FUNCTION, SCOPE OF THE SUDY and FUNCTIONAL UNIT



THE FUNCTION:
is to treat first generation PV Panels (c-Si) /obtain different types of recoverable waste products: glass, plastics, copper, silicon.

FUNTIONAL UNIT :
"to treat 20 kg of a PV waste panel"

Construction phase:

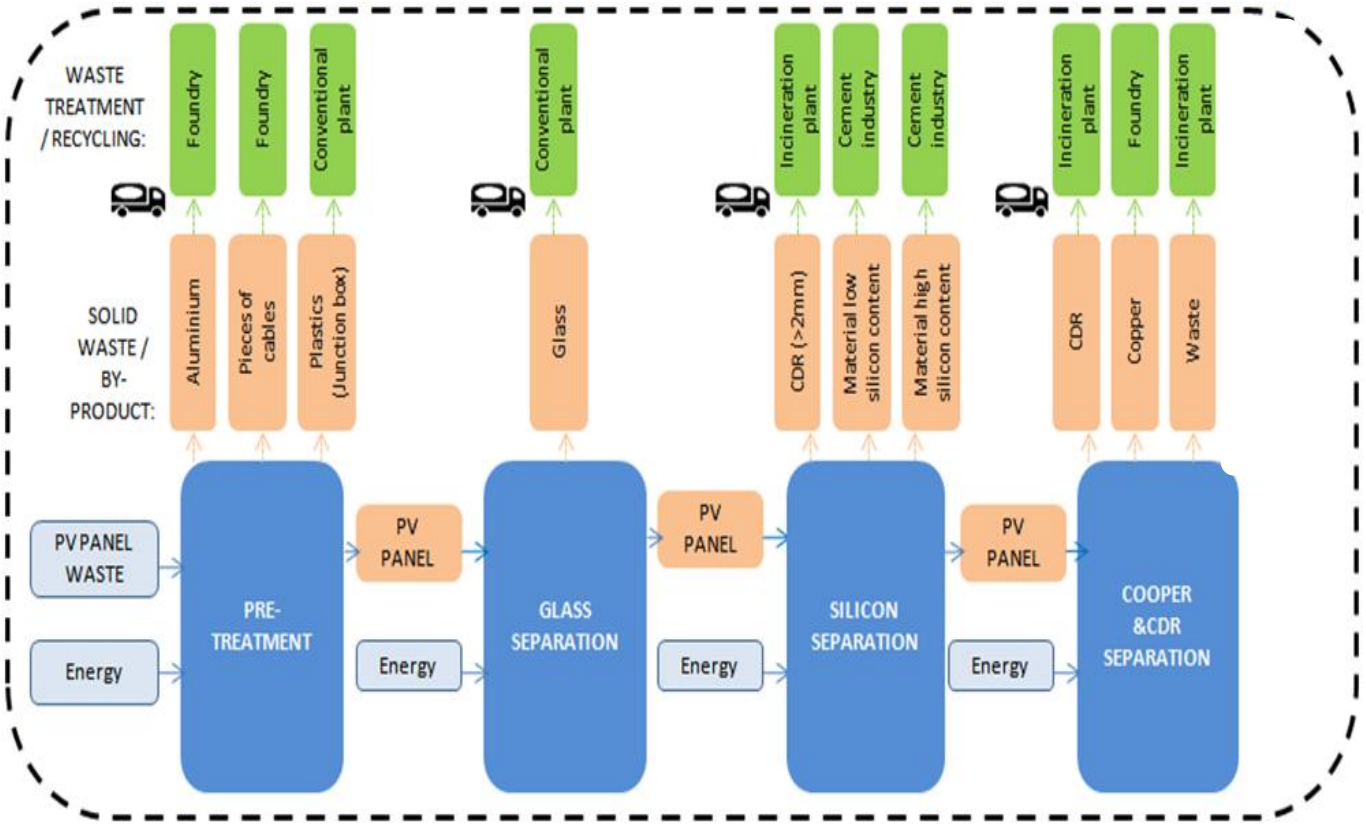
- machines and equipments
- external transport (equipments from suppliers to LME)

Maintenance phase (tasks as cleaning, oil change and mechanical supervisions):

Maintenance of equipments / machinery (ancillary products, energy and water consumption required).

2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.5 . PHASE I: SYSTEM BOUNDARIES– PV-MOREDE operation phase



INPUTS:

- PV waste panel
- Energy consumption (electricity)
- Transport of the PV-MOREDE device to the PV waste panel point generation

OUTPUTS:

- Transport of the waste / by-product to the waste treatment or recycling point
- Recovered materials (waste)
- Types of waste treatments / recycling

2. FRAMEWORK OF ENVIRONMENTAL AND ECONOMIC ANALYSIS

2.6. PHASE II: LCI – Life Cycle Inventory

For each life cycle stage **quantitative data (<u>inputs</u> and <u>outputs</u>** of the process) is collected. (They are considered in relation to the functional unit)

LME provides the **information for the Life Cycle Inventory** (LCI) of each life cycle stage considered in the LCA & LCC of the ***PV-MOREDE technology***

FRELP project provides the **environmental data for the LCI** of each life cycle stage considered in the LCA of ***the current process (reference scenario)***

Primary data sources	Data provided by LME
Secondary data sources	LCI databases (ECOINVENT 3) & literature

PRE-TREATMENT	Photovoltaic Module Remediation Sector					
Process description	The photovoltaic panel to be subjected to recycling treatment is preliminarily weighed. After this we proceed with the extraction of the aluminum frame and the removal of the connection cable and the junction box (these components, if broken, would strongly contaminate the byproducts derived from it). Then the module is placed in mobile plant Pv_Mo.Re.De. to start the treatment of recycling that consists in the succession of the phases of volumetric reduction, detachment of the scrap glass, detachment of the					
INPUTS						
REFERENCE BASE: PHOTOVOLTAIC PANEL: 20 kg	Name /source	Amount	Units	Origin (geographical, synthesis process)	Observations / Other information (supplier, % recycled content....)	Cost (€)
Raw Materials (additives, solvents, others...)	Aluminum / Photovoltaic panel	2,00	kg	Mechanical process	10% / Retrieving in foundry	
	Pieces of cables / Photovoltaic panel	0,20	Kg	Mechanical process	1%	
	Plastics (junction boxes) / Photovoltaic panel	0,20	Kg	Mechanical process	1% / Retrieving in conventional plant	
Other materials/substances used within the process (ancillary materials) including auxiliary processes			g			
			g			
Packaging	No	.....	g			
Energy consumption (electricity)		0,79	kWh		Taggia quadrotti machine	
Energy consumption (heat)			MJ			
Water consumption	No	.....	l			

LCA of an innovative recycling process for crystalline silicon photovoltaic panels. Italy. 2016. Cynthia E.L.Latunussa. http://www.sciencedirect.com/science/article/pii/S0927024816001227

3. LIFE CYCLE ASSESSMENT (LCA)

3.1. PHASE III: ENVIRONMENTAL IMPACT ASSESSMENT (LCIA)

The potential environmental impacts have been expressed by the following impact categories:

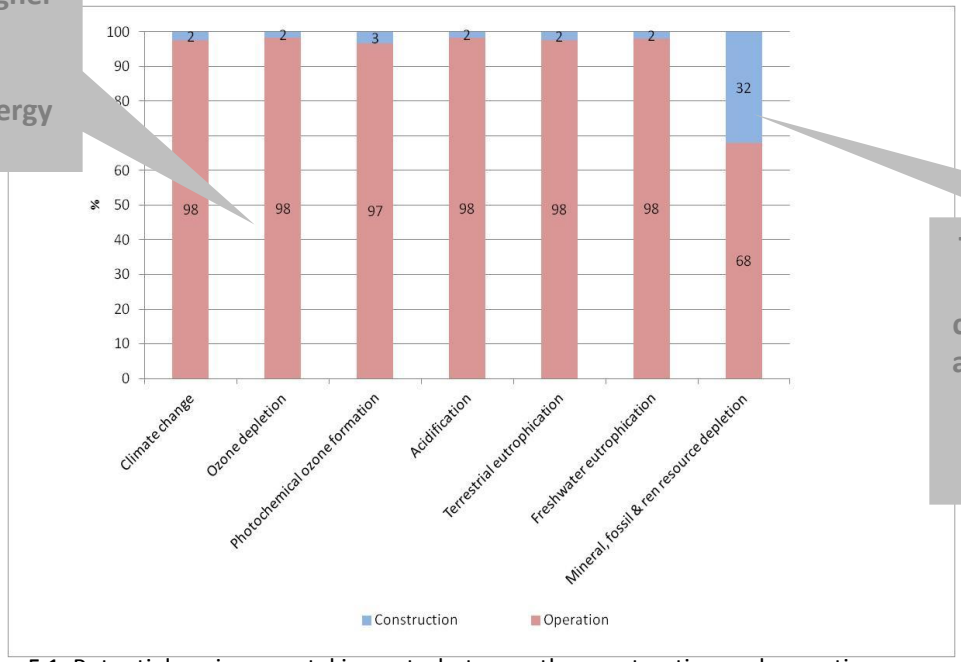
Impact categories selected	Units
Global Warming potential (GWP)	kg CO_2 eq
Ozone depletion	kg CFC-11 eq
Photochemical oxidant formation	kg NMVOC eq
Acidification	molc H+ eq
Terrestrial Eutrophication	molc N eq
Freshwater Eutrophication	kg P eq
Mineral, fossil & renewable resource depletion	kg Sb eq

To model the environmental impacts- LCA Software called SIMAPRO v8 and the selected method is ILCD (International reference Life Cycle Data System) 2011 (recommended by the European Commission)

3. LIFE CYCLE ASSESSMENT (LCA)

3.1. PHASE III: ENVIRONMENTAL IMPACT ASSESSMENT (LCIA, preliminary results)

The operation phase of the PV-MOREDE technology has a higher environmental impact contribution than the construction phase **due to energy consumption**.

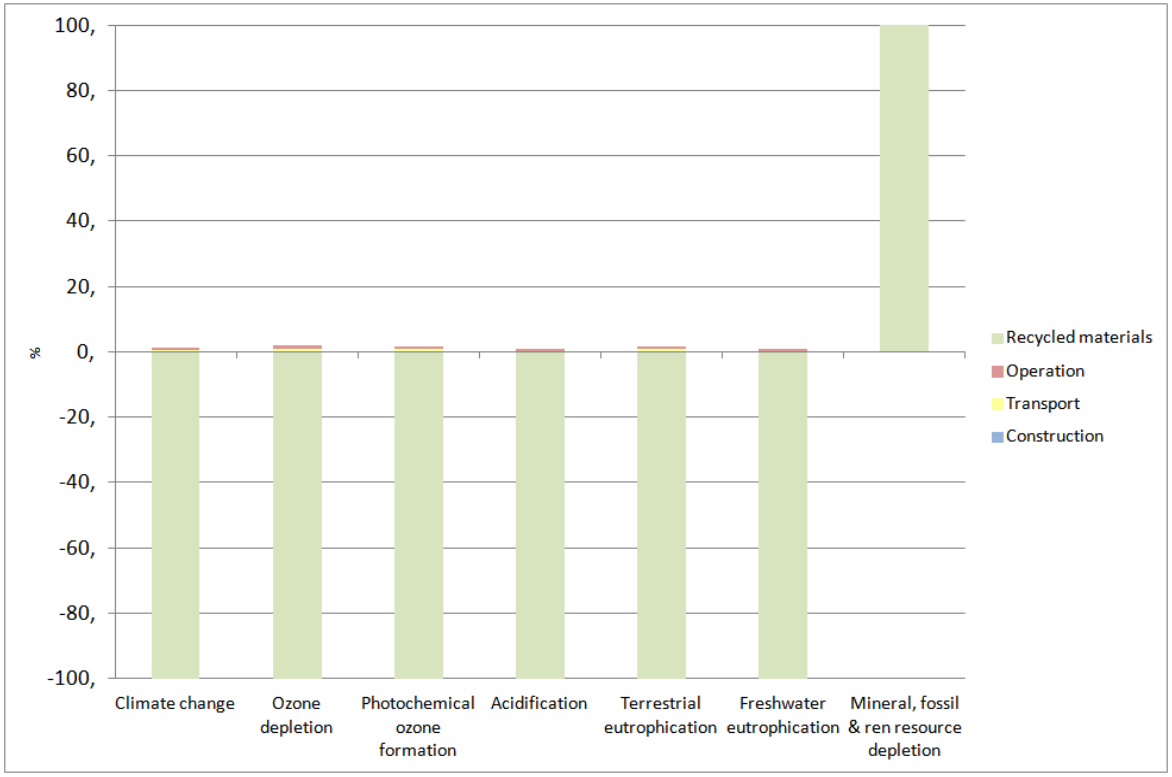


F.1. Potential environmental impacts between the construction and operation phase of the PV-MOREDE process

The construction phase has 32% of environmental impact contribution in the Mineral , fossil and renewable resources category due to the large amount of metals required to build the PV-MOREDE device.

3. LIFE CYCLE ASSESSMENT (LCA)

3.1. PHASE III: ENVIRONMENTAL IMPACT ASSESSMENT (LCIA, preliminary results)

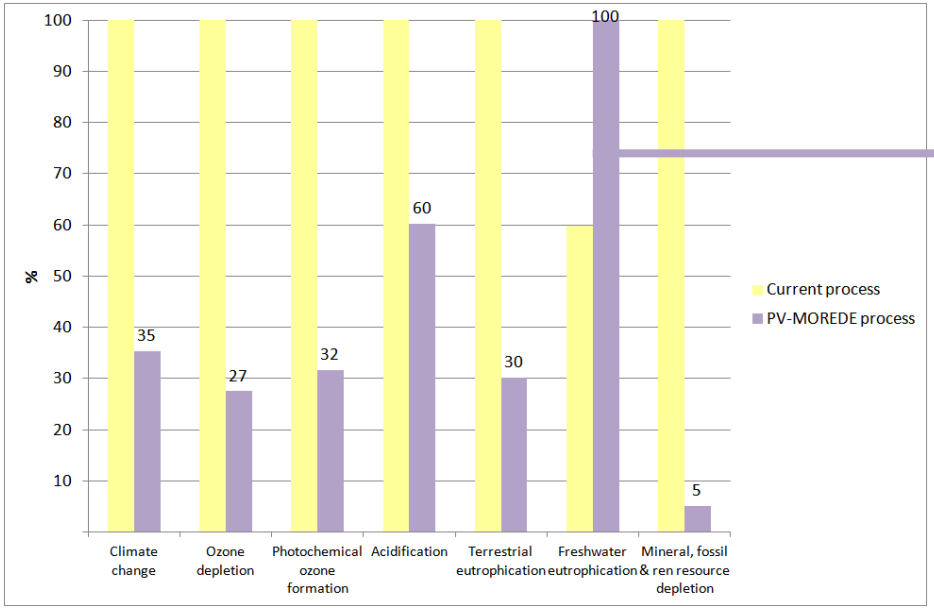


F2.Contribution of each phase to overall impacts of the recycling 20 kg of PV waste panel

The negative values refer to the avoided impacts related to the recycling of the recovered materials (e.g. in comparison to the impacts of the production the primary raw materials used in the PV panel).

3. LIFE CYCLE ASSESSMENT (LCA)

3.1. PHASE III: LCIA- COMPARATIVE ASSESSMENT BETWEEN CURRENT PROCESS & PV-MOREDE PROCESS (LCIA, preliminary results)



F3.Comparative assessment between current process and PV-MOREDE process

The current process has a higher environmental impact than PV-MOREDE technology in almost all impact categories.

For the *freshwater eutrophication*, the PV-MOREDE technology shows a higher impact than a current process, which is due to energy consumption.

3. LIFE CYCLE ASSESSMENT (LCA)

3.1. PHASE III: LCIA- COMPARATIVE ASSESSMENT BETWEEN CURRENT PROCESS & PV-MOREDE PROCESS. CARBON FOOTPRINT.

WHAT IS THE CARBON FOOTPRINT?
The total amount of greenhouse gases produced by human activities

Impact category	Current process	PV-MOREDE process	Unit
Climate change	3,94	1,39	kg CO2 eq
Ozone depletion	3,01E-07	8,27E-08	kg CFC-11 eq
Photochemical ozone formation	0,01	4,00E-03	kg NMVOC eq
Acidification	0,02	1,03E-02	molc H+ eq
Terrestrial eutrophication	0,05	1,38E-02	molc N eq
Freshwater eutrophication	3,91E-04	6,53E-04	kg P eq
Mineral, fossil & ren resource depletion	7,52E-05	3,87E-06	kg Sb eq

The carbon footprint is being reduced 2,55 kg of CO_2 eq. (65%) per FU by PV-MOREDE technology

4. LIFE CYCLE COSTING (LCC)

ECONOMIC IMPACT ASSESSMENT

Construction costs

CONCEPT
Equipments
Personnel
Transport

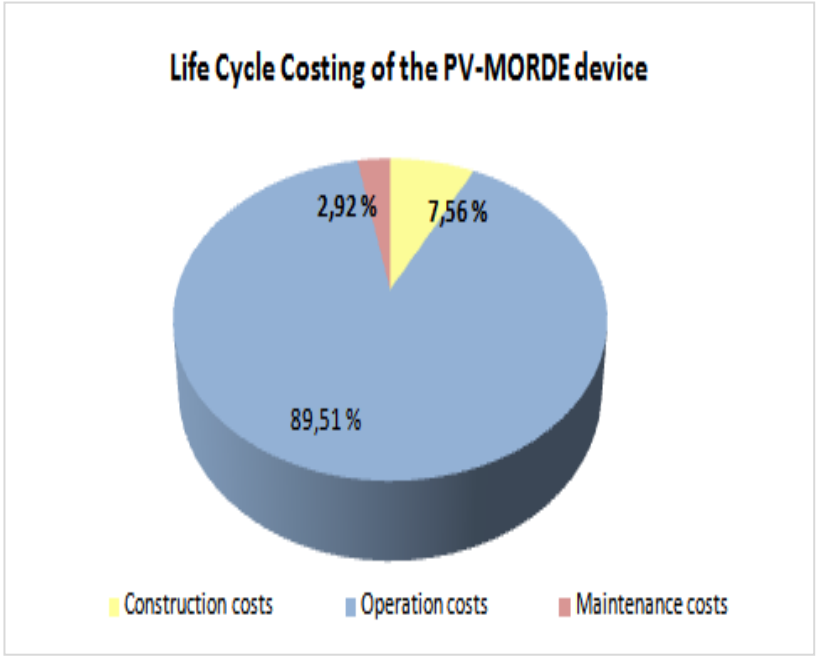
Maintenance costs

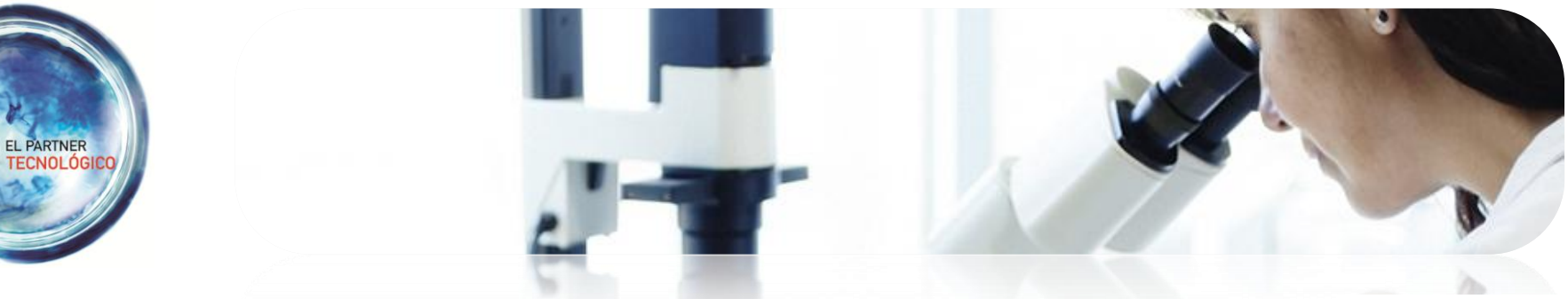
CONCEPT
Consumables
Personnel

Operational costs

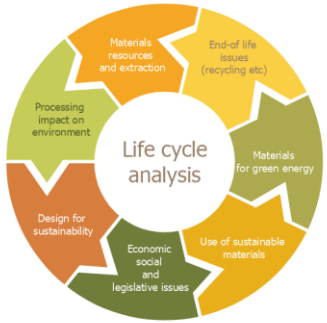
CONCEPT
Electricity consumption
Personnel
Recycling and recovery
Waste disposal

The net cost benefit balance of the PV-MOREDE technology **is POSITIVE** thanks to the recovered materials





5. PRELIMINARY CONCLUSIONS OF THE LCA & LCC ANALYSIS



➢**The preliminary results of the LCA show that PV-MOREDE technology has been developed as an innovative an eco-friendly recycling process.** The highest contribution of the environmental impacts comes from the operation stage but the global balance is positive due to the savings for the recovered materials.

➢**The cost-benefit balance indicates the positive economic benefits of the PV-MOREDE technology.**

THANKS FOR YOUR ATTENTION!!!

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