CABRISS

CABRISS – EU H2020

IMPLEMENTATION OF A **C**IRCUL**A**R ECONOMY BASED ON **R**ECYCLED, REUSED AND RECOVERED **I**NDIUM, **S**ILICON AND **S**ILVER MATERIALS FOR PHOTOVOLTAIC AND OTHER APPLICATIONS

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Main project features

- **CABRISS**: IMPLEMENTATION OF A **C**IRCUL**A**R ECONOMY BASED ON **R**ECYCLED, REUSED AND RECOVERED **I**NDIUM, **S**ILICON AND **S**ILVER MATERIALS FOR PHOTOVOLTAIC AND OTHER APPLICATIONS

- **HORIZON 2020 CALL**
  - ✓ Waste: A Resource to Recycle, Reuse and Recover Raw Materials
  - ✓ WASTE-1-2014: Moving towards a circular economy through industrial symbiosis

- **INSTRUMENT**: Innovation actions

- **Project key features**
  - ✓ Grants #641972
  - ✓ Start date: 01/06/2015 – End date: 31/05/2018 (36 months)
  - ✓ Maximum EU grant amount: 7,844,564.54€

- **Coordinator**: CEA (French Alternative Energies and Atomic Energy Commission)

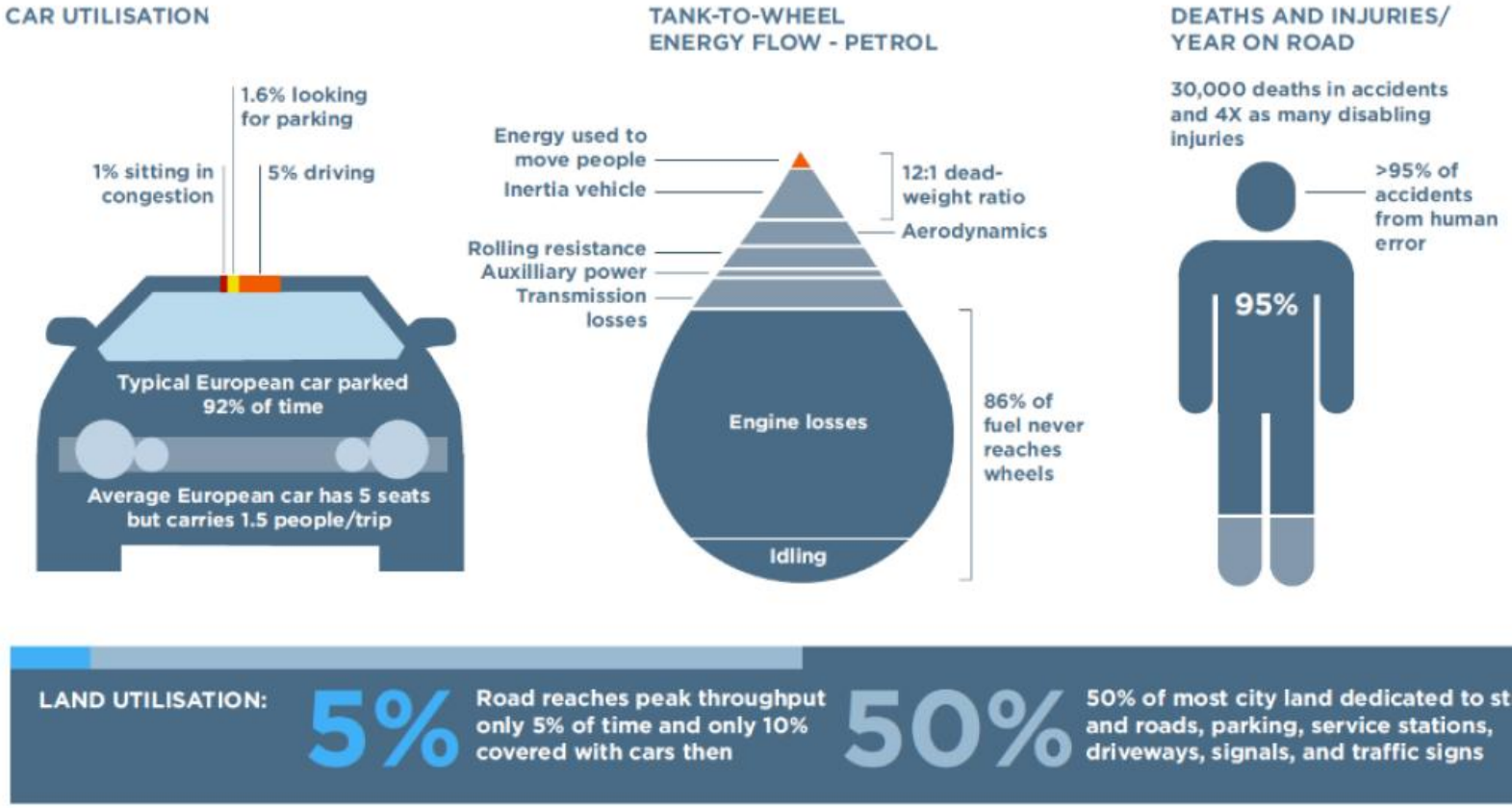
Main project features

- **CONSORTIUM**
  - ✓ 16 partners from 9 countries
  - ✓ 6 SMEs and 5 Industries
  - ✓ 5 RTO

- **TIMELINE**
  - ✓ Official starting date: June 1st, 2015
  - ✓ Kickoff meeting July 7th-8th, July 2015
  - ✓ Now at M14

Some words about the circular economy…

Exemple of a car (mobility):



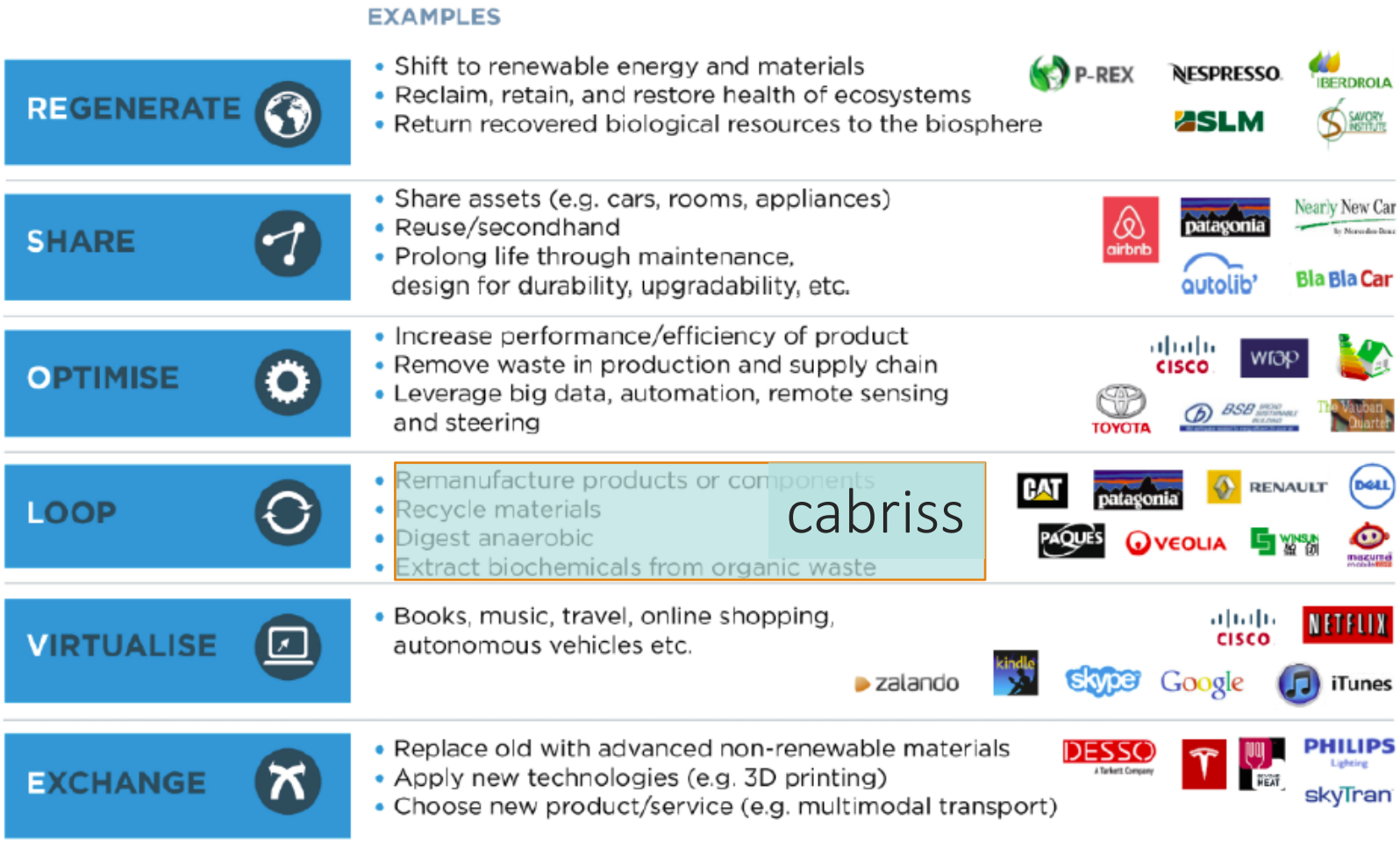
Circular economy

- Massive improvements are needed for all 4 human needs:

1. Mobility
2. Food
3. Build environment
4. Leasure and sport

« Resolve » in Circular economy

And this is the reason why companies started to move



Ackn: systemIQ

Origin of CABRISS

- Already an important amount of photovoltaic waste

✓ Long term challenge: the total PV products disseminated throughout Europe represent **now** roughly 8 million tons of future PV waste.

Annual tonnage of EU PV waste (end of life modules only) until 2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Europe	710	690	891	1353	1363	2079	5564	12849	13525	19706

Sources: IEA Photovoltaic Power Systems Programme, EPIA, EurObserver and national sources.

✓ Short term challenge: deal with the waste coming from installation breakage and production scrap.

- in 2012, the 17.7 GW installed capacity in Europe has generated around **27000 tons of waste** from installation

Origin of CABRISS

- **Rarefaction of strategic materials like In, Ag, Ge, …**
- **Si is also becoming a strategic material**
- **The European legislation is pushing towards the development of green solution that tackle the issue of PV waste.**

PV within the WEEE Directive 2012/19/EU provides a legislative framework for extended producer responsibility of PV modules at European scale.

- **Annual tonnage of EU PV waste increases and will become significant in 2020 i.e. at the time where the CABRISS project's outcomes will be available.**

Objectives and novelty of CABRISS

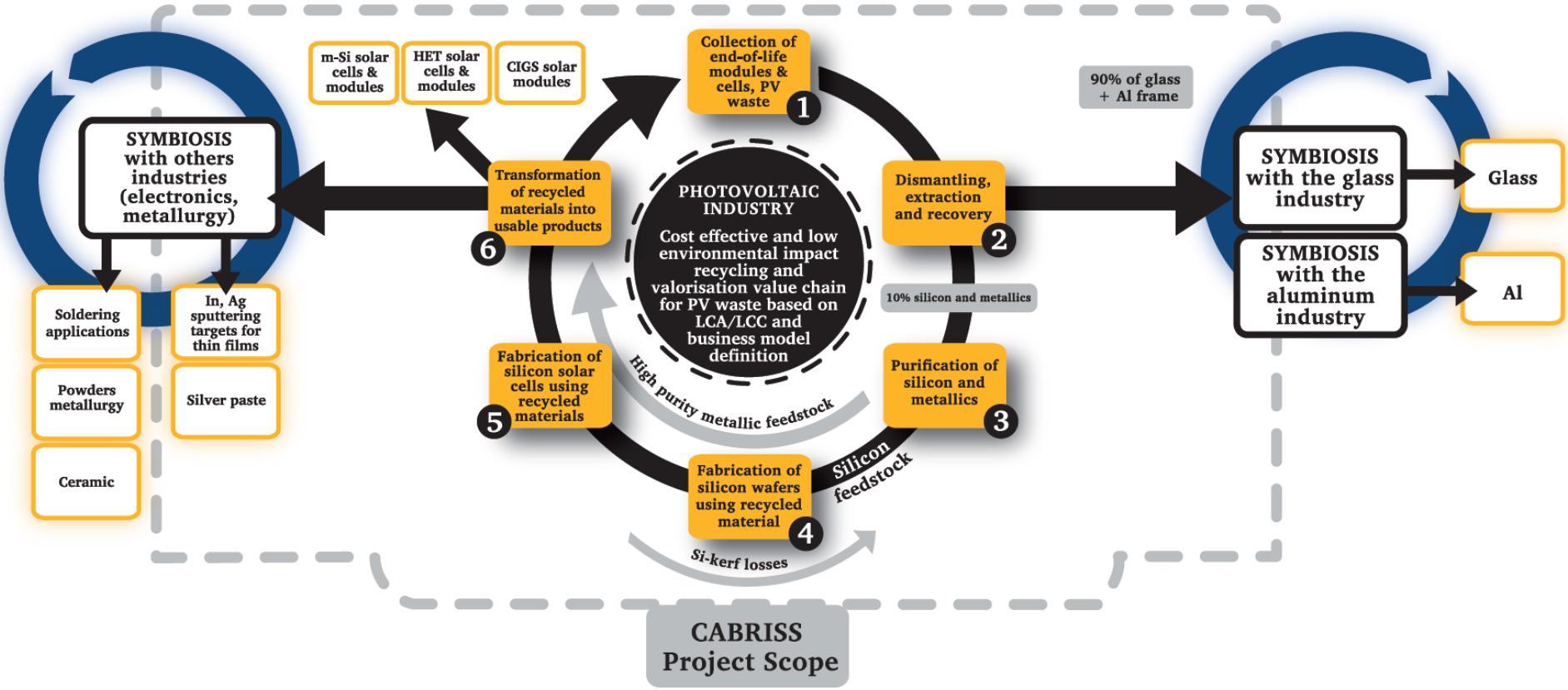
Four objectives of CABRISS:

- Collecting up to 90% of the PV waste throughout Europe compared to the 40% rate in 2013 and 80% rate since August 2015.
- Retrieving up to 90% of the high value raw materials from the PV cells and panels: Silicon, Indium and Silver.
- Developing industrial symbiosis by providing raw materials such as glass, silver paste as feedstock for other industries (e.g. glass, electronics or metallurgy).
- Manufacturing PV cells and panels from the recycled raw materials achieving lower cost (25% less) and at least same performances (i.e. cells efficiency yield) as the conventional processes

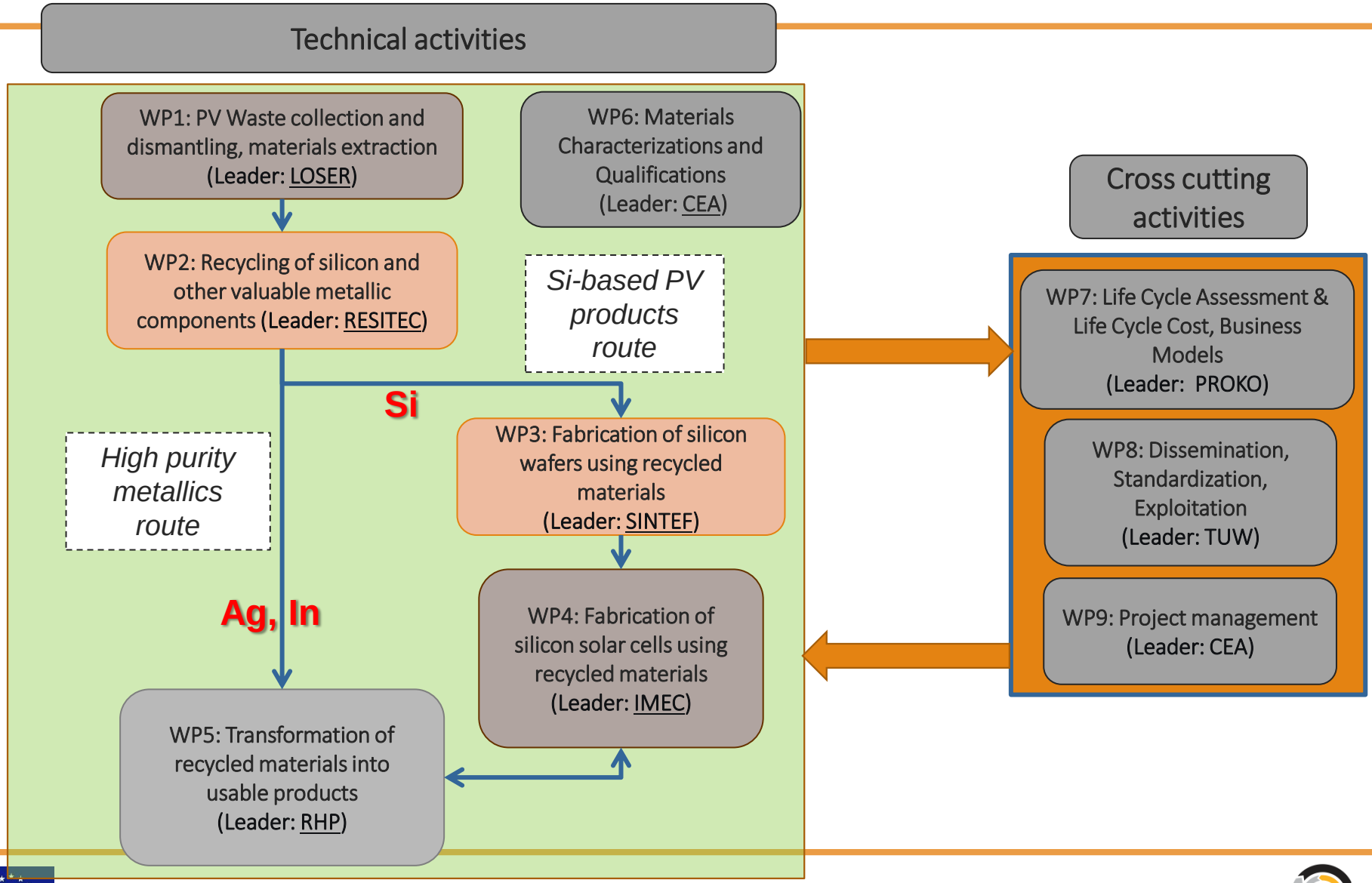
Novelties of CABRISS:

- CABRISS considers ONLY critical raw materials such as silver, indium and silicon.
- CABRISS will promote the development of a circular economy around PV wastes:
  - by re-using recovered materials as new feedstocks for PV.
  - by developing industrial symbiosis with other industries.
- CABRISS will develop **business models** for sustainable PV recycling based on circular economy.

Symbiosis within CABRISS project



CABRISS – PERT Diagram



CABRISS wastes sources

EOL modules

Dismantling

Production wastes

Broken wafers (as cut)

Broken doped wafers (emitter w/wh ARC)

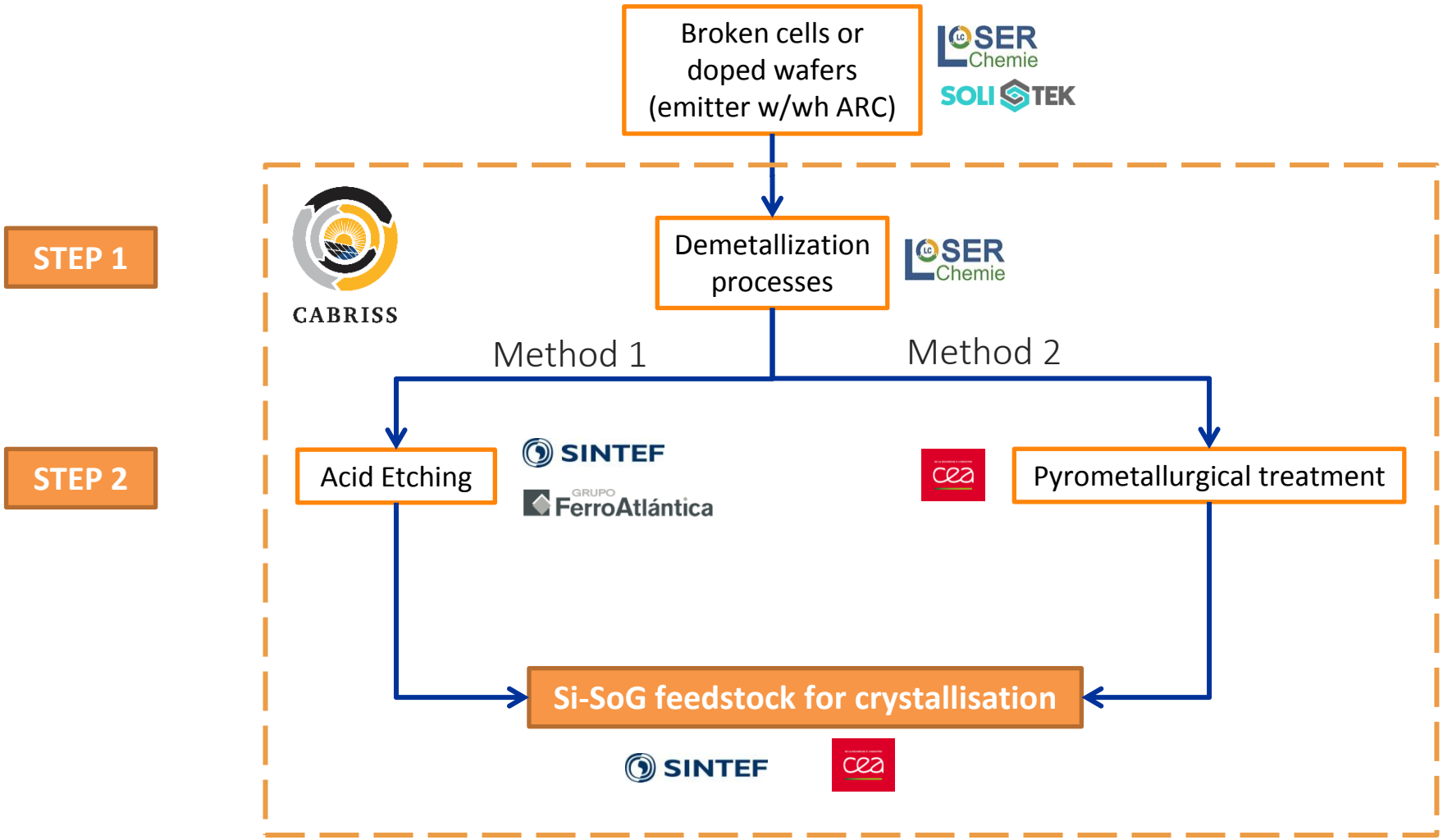
Broken cells

Si-kerf from slurry (bricks sawing, wafering)

Si, …

In, Ag, … recovery

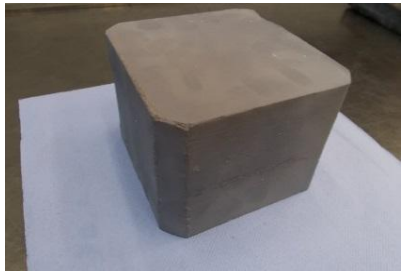
Si-shards purification methodology



CABRISS re-use of material

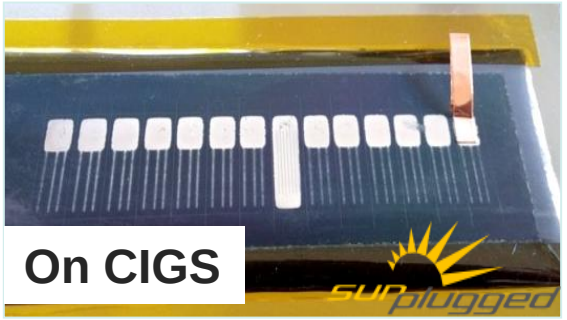
Reuse of Si: fabrication of Solar cells :

- PV conventional route
  - Different cells technologies: Al-BSF, PERT, PERC
  - To test recycled material in standard production line
- Innovative route (no kerf route)
  - Production of wafers by sintering, hot pressing
  - Production of low cost supporting substrates



Reuse of other materials:

- Ag paste for Screen printing
- In target for ITO
- Others ....



CABRISS impact

Economic/Social

1. 210 000 tons of **end-of life PV waste** will be collected by 2030 in Europe

Total addressable market of :

- 12 to 90 M€ for recycled Si depending purity (2-15€/kg)
- 10 M€ for recycled Ag (514€/kg)
- 1 M€ for recycled In (550€/kg)

2. Estimated EU PV market (production of Cells in Europe): about **20G€ in 2030**.

Environmental

-Important Gains expected on "Green" recycling technology

-the following metrics will be used in CABRISS project:

1. The average emission of greenhouse gases per 1kWh of electricity produced (gCO_{2eq}/kW) and in total (tCO_{2eq}).
2. The primary energy required to produce 1Wp of solar panel (GJ/W_p).
3. The energy pay-back time (EBPT) in years.

CABRISS and the IPR

- IPR/ Licencing- patents: Set up of a continuous patent watch on <u>expected foreground, initial IP diagnostic on the different technology routes.</u>

Work Package	WP1: PV waste collection and dismantling, materials extraction		WP2: Recycling of silicon and other valuable metallic		WP3: Fabrication of silicon wafers using recycled materials		WP4: Fabrication of silicon solar cells using recycled materials		WP5: Transformation of recycled materials into usable products		
Technological Pillars	#1 PV modules dismantling	#2: Metallics extraction from PV waste	#3: Purification of silicon	#4: Purification of metallic elements	#5: Sintering (or Hot Pressing) & Spraying from Si powders	Conventional methods	#6: Cells based on recycled silicon		#7: Ag pastes, ITO targets based on recycled raw materials		Modules process
							mc-Si and Cz-Si	HET cells on sintered and sprayed wafers	Serigraphy paste	ITO targets; Targets based on In, Ag	#8: Easy recycling PV module architecture
IP protection	No enforceable patent & medium know-how	1 really enforceable patent & medium know-how	At least 5 really enforceable patents and several strong know-how	no patents & medium know-how	1 potential patent & strong know-how	1 enforceable patent & strong know-how	No patents & Several medium know-how	no patents & medium know-how	no patents & strong know-how	no patents & weak know-how	1 enforceable patent & strong know-how

⇒ ensure the Freedom to Operate and the application of patents/IP

Somes technical achievement

1. Recycling Silicon waste from demetallized broken cells pieces:

Collection / dismantling

Loser Chemie

CEA tech

High level of impurities (Al, Ag, P)

Purification by hydrometallurgy

GRUPO FerroAtlántica

Low level of impurities – under specifications !

Some achievements

2. Growing Si ingots using Si waste

collection of Si kerf

ReSiTec

Direct growth of an ingot

SINTEF

Need to introduce process steps to remove/segregate particles/inclusions

collection of end of life cells

Loser Chemie

Extraction of Ag and Al. Removal of SiNx based layers by chemical treatment

Loser Chemie

ceatech

SINTEF

Direct growth of an ingot

First wafers are under investigatio

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EUROPEAN COMMISSION

SPIRE
Sustainable Process Industry through Resource and Energy Efficiency

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THANK YOU FOR YOUR ATTENTION!