



From waste to power New solutions for battery production

Reviving of End-of-Life Photovoltaic Silicon for High-Capacity Lithium-Ion Batteries

RESiLEX Project Webinar series
January 29, 2026, 11 AM CET



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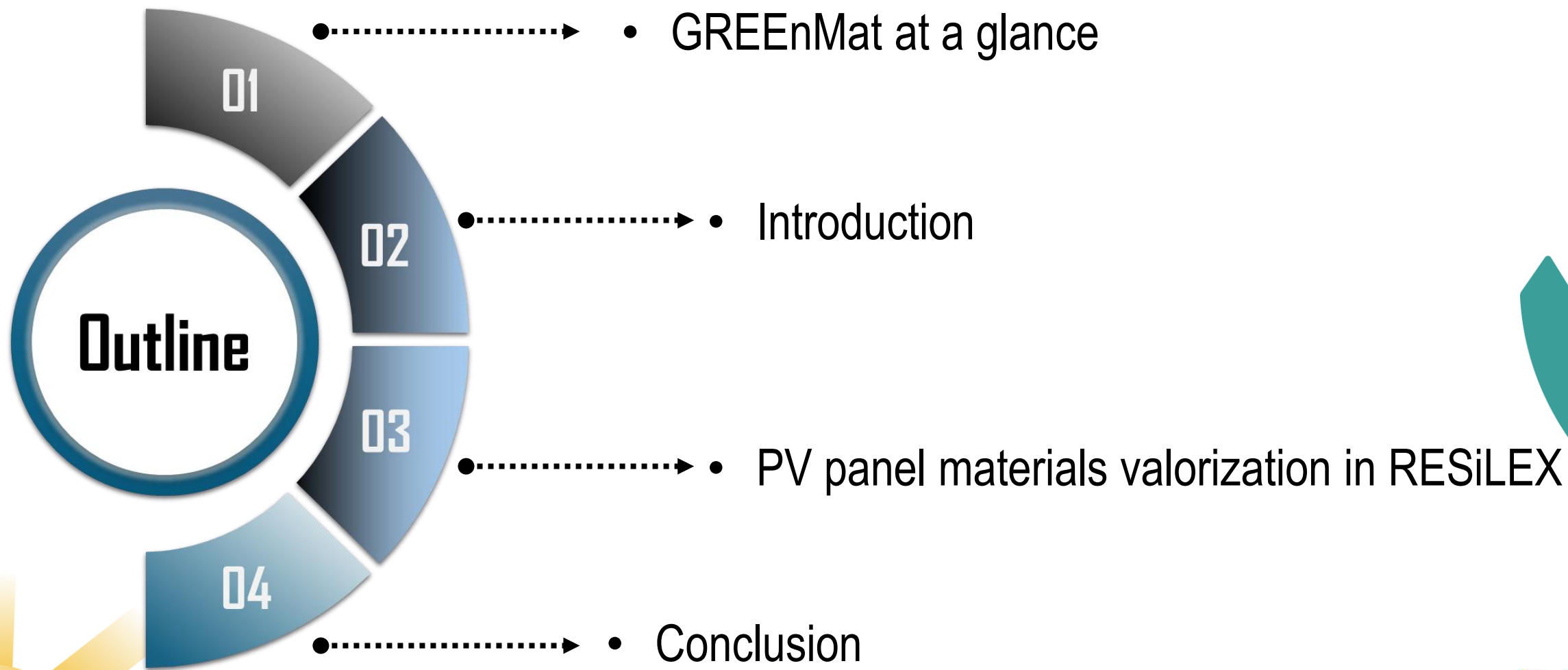


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Outline



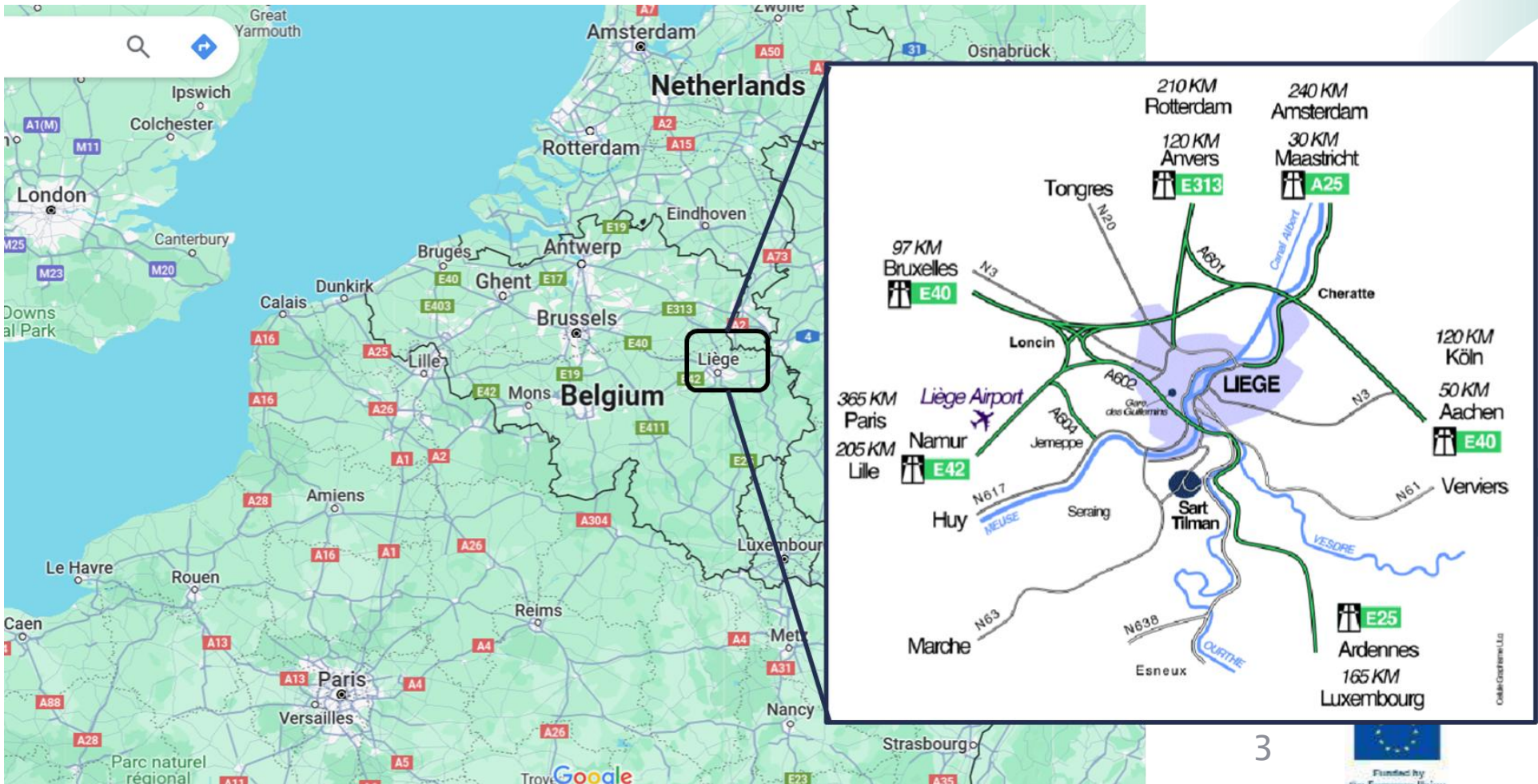
GREENmat at a glance

Group of Research in Energy and Environment from Materials



GREENmat

Allée du 6 Août, 13 - (Sart-Tilman)
4000 LIEGE (BELGIUM)

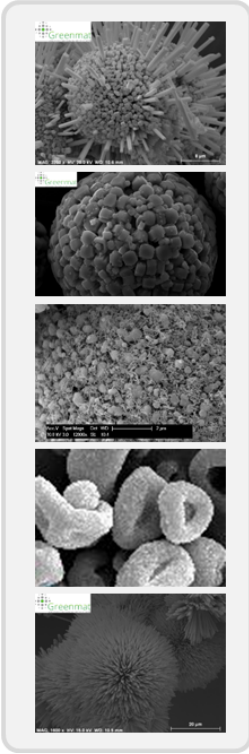


ULiège - GREENmat - Proprietary & Confidential

GREENMat at a glance

GREENMat: Research Activities

Inorganic Materials with controlled microstructure



Scientific and technology research key

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GREENMat at a glance



GREENMat at a glance

Batteries & Recycling @ GREENMat

01

Materials Synthesis & shaping

Synthesis

- 2 Co-precipitation Reactors
 - Laminar continuous Taylor (LCTR)
 - Continuous stirring (CSR)
- 2 Spray Dryers (5L/h)
 - Aqueous & non-aqueous
 - ATEX-certified
- 1 Hydro- & Solvo-Thermal
 - 5.5L reactor

Grinding

- Planetary mill
- Pilot-scale DYNOMILL Agitator

Heat treatment

- Ovens and furnaces (up to 3000 °C, Ar, N₂, H₂)
- 3-zone horizontal tubular furnace (T_{max} 1200 °C)

02

Electrode Material Characterization

Elemental Analysis

- ICP
- EDS
- TGA/DSC
- Carbon/sulfur analyzer

Morphology

- SEM, TEM, AFM
- BET
- Laser diffraction particle sizer
- Tap Density Tester

Structure

- XRD
- ⁵⁷Mössbauer spectroscopy
- Raman spectroscopy

03

Electrodes Formulation & Evaluation

Formulation & Shaping

- Slurries development
- Rheology of slurries
- Electrodes & electrolyte:
 - Coin cells
 - Monolayer pouch cells

Electrochemical

- Galvanostatic cycling
- Cyclic voltammetry
- Impedance spectroscopy

Operando & *in situ* methods

- XRD
- Impedance spectroscopy
- Raman spectroscopy

04

Spent LIBs Recycling

Direct Recycling of spent LIBs

- Electrochemical discharging
- Cells dismantling

Electrodes Separation

- Electrode delamination:
 - Heat treatment
 - Using green solvent

Regeneration

- Solid state
- Hydro- solvo-thermal
- Spray drying
- Molten salt

GREENMat at a glance

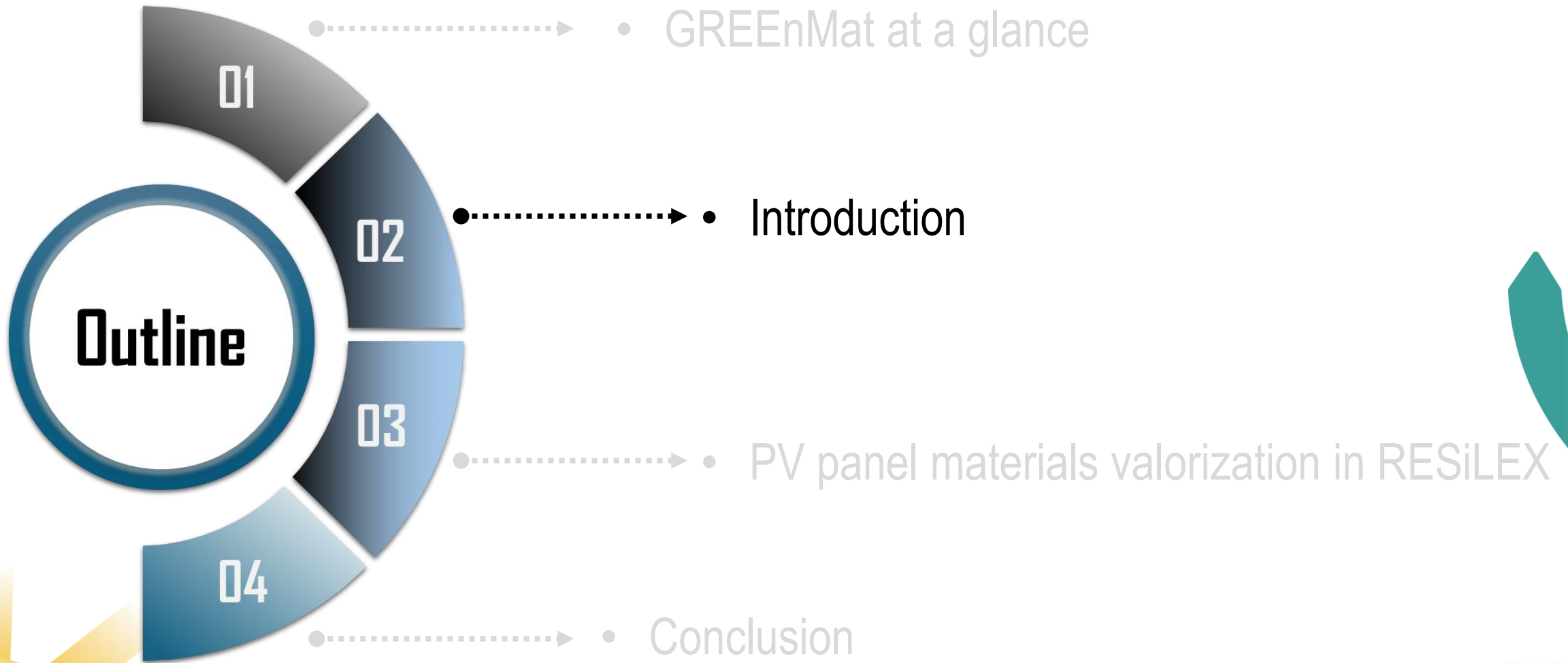


Project	Funding	Coordinator
MoSiLIB	FFG Promoting Innovation.	AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
RESTINA	M-ERA.NET	
RESILEX	Horizon Europe	IGMC IBERIAN SUSTAINABLE MINING CLUSTER
STREAMS		AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
PURSILICON	Wallonie service public SPW	LIÈGE université GREENMat
ECuME		LIÈGE université GeMMe
SOLIDBATTERY		LIÈGE université GREENMat
Battery Factory		UNIVERSITÉ DE NAMUR
CISTEMEEC	PLAN DE RELANCE DE LA WALLONIE	groupe comet



Horizon Europe calls 2026-2027

Outline



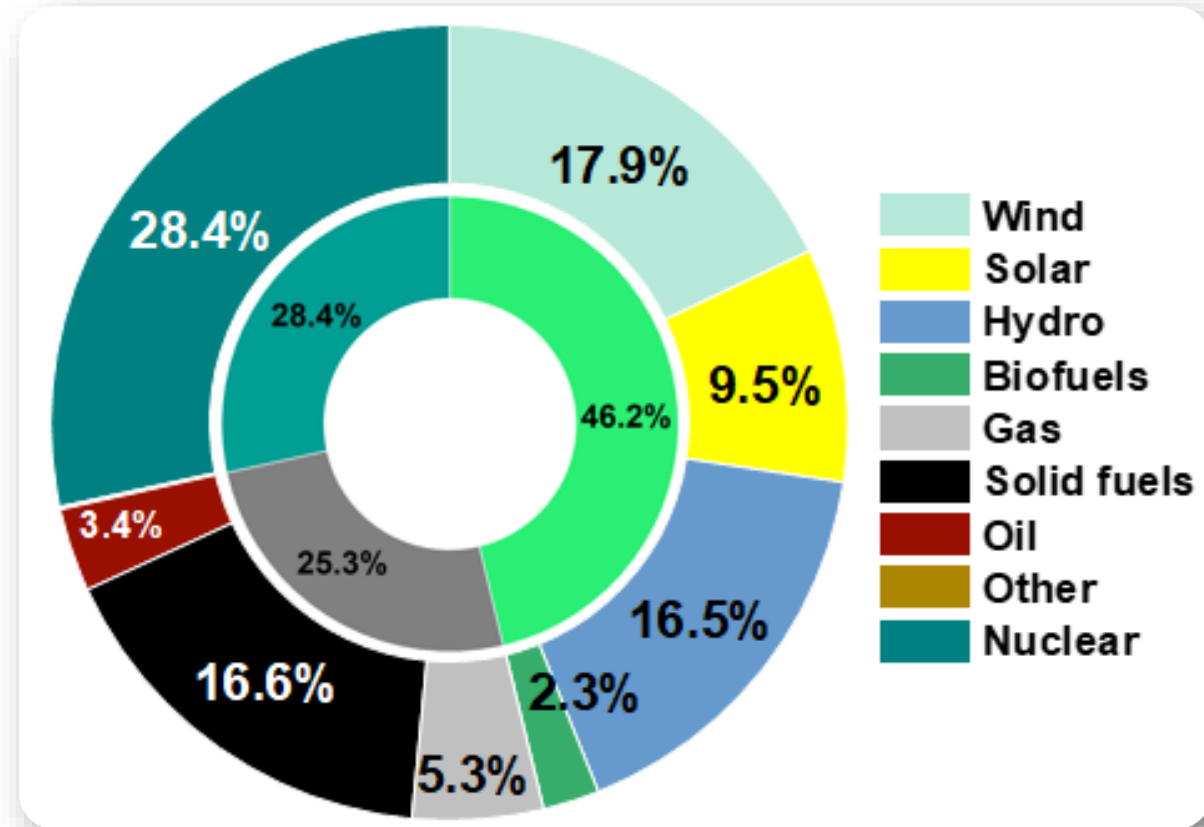
PV Power Generation plays a key role in the Energy Transition



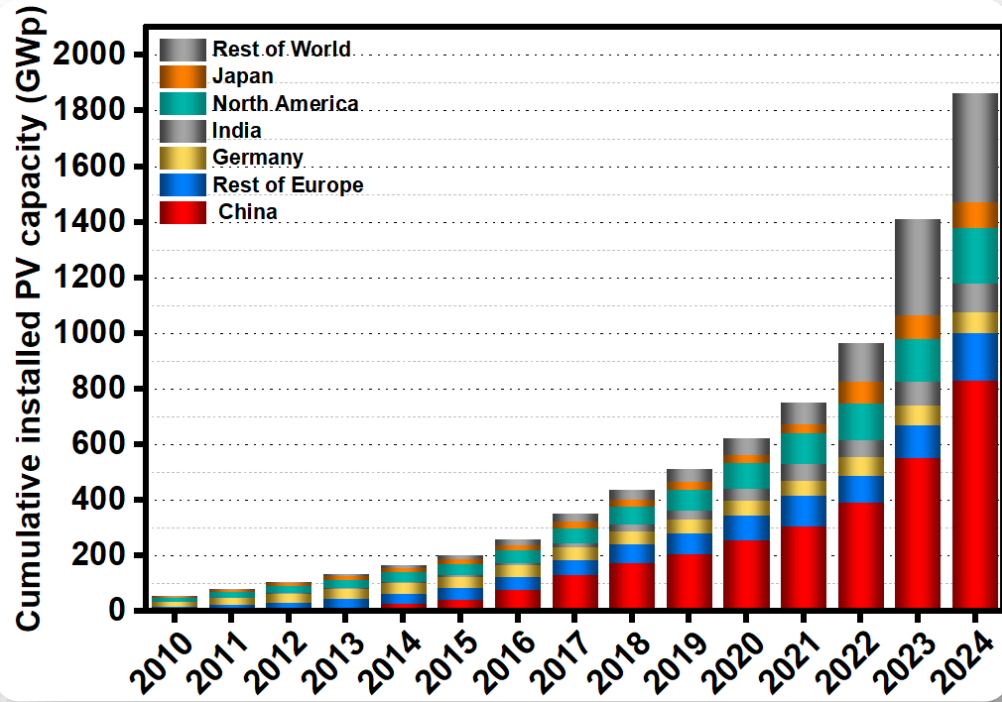
consilium.europa.eu/en/infographics/how-is-eu-electricity-produced-and-sold/#0 energy.ec.europa.eu/topics/renewable-energy/solar-energy_en;
<https://www.pv-magazine.com/2024/06/06/worlds-largest-solar-plant-goes-online-in-china-2/>

2023

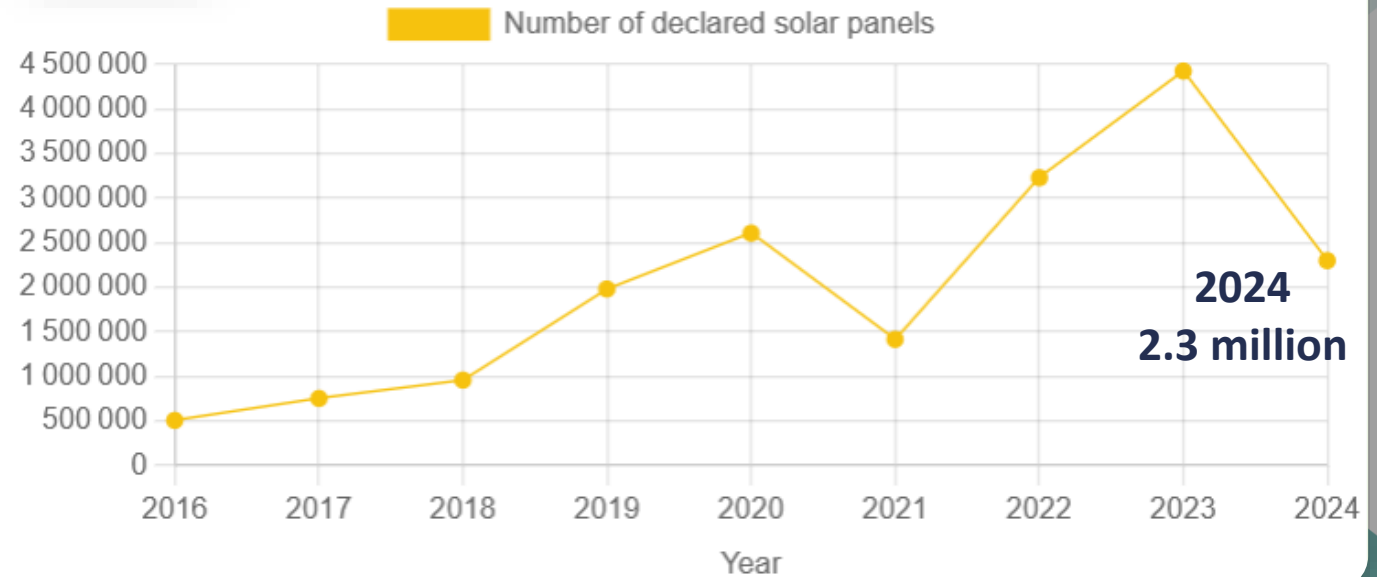
- **EU Electricity production:**
2 637 TWh
- **Renewable Energy: 46.2%**
- **Solar: 9.5%**



Introduction



Evolution of declared solar panels



2.3 million new photovoltaic panels were declared to PV CYCLE Belgium in 2024

EPJ Photovoltaics 15, 21 (2024)

Adapted from: ©Fraunhofer ISE: Photovoltaics Report

<https://pvcycle.be/en/annual-reports/2024-annual-report>

- PV panel Lifespan: 25 – 30 years
- First Installations: Late 80s early 90s
- Soaring growth: 2000 – present



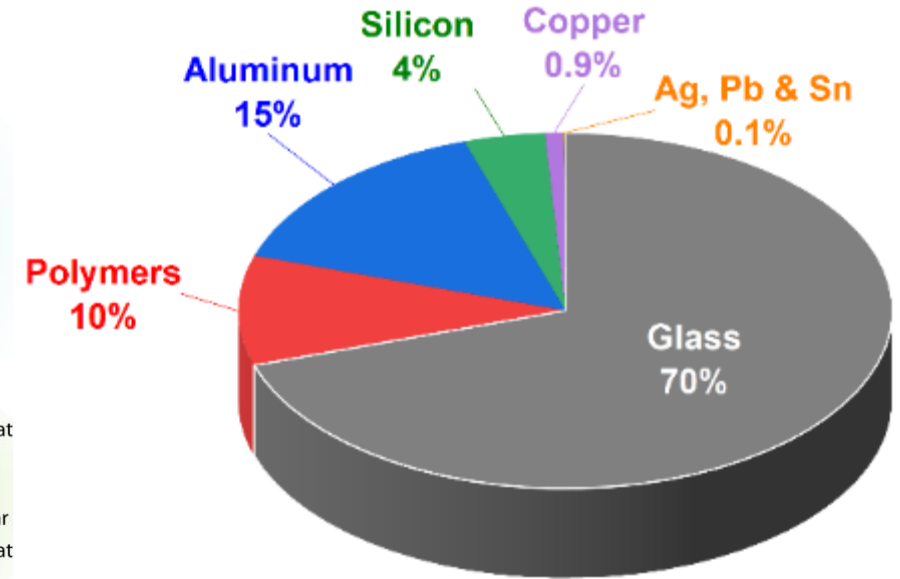
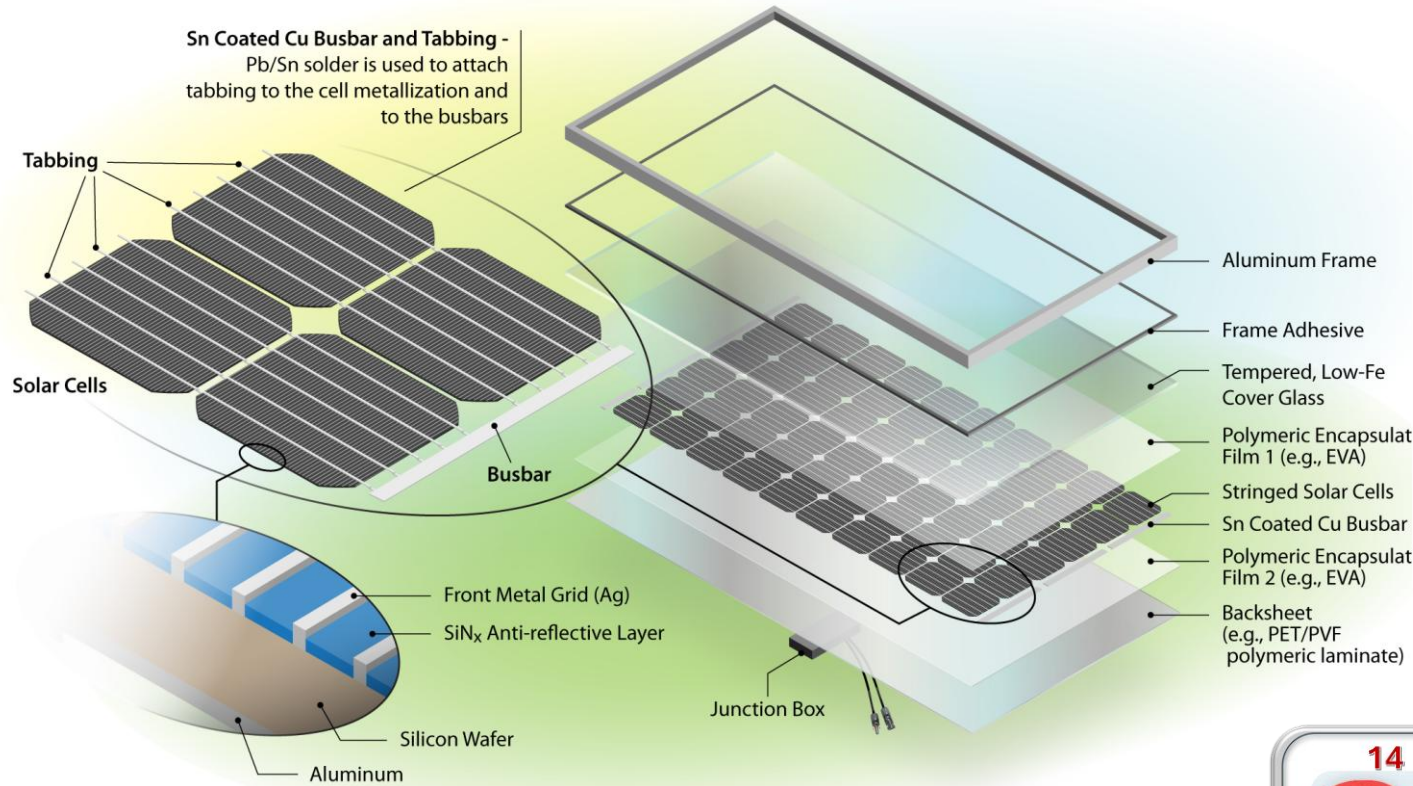
Large volumes of PV panels are now reaching EoL

PV panel waste management and recycling is a crucial need



Directive 2012/19/EU:
at least 80% or more of the retrieved panel waste must be recycled

Introduction

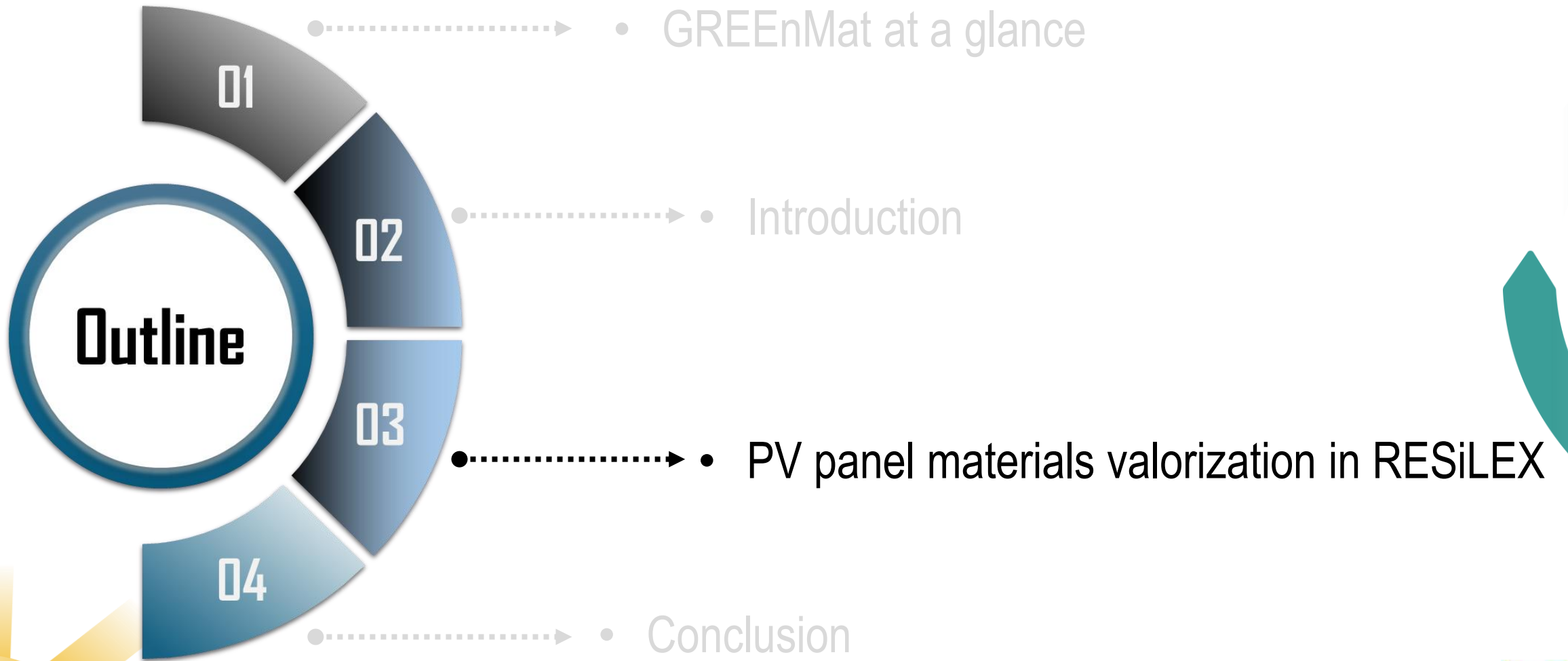


- Half of the total module cost & the embodied energy
- > 90 % of the PV market is covered by solar grade c-Si (0.6-1.0 kg/module)

Heath *et al.* Nature Energy 2020, 5 (7), 502–510.

Rahman *et al.* Adv. Energy Sustainability Res. 2021, 2, 2100081

<https://www.epa.gov/hw/solar-panel-recycling>



PV panel materials valorization

RESiLEX Project



www.resilex-project.eu/



Grant N° 101058583

RESiLEX: Resilient Enhancement for the Silicon Industry Leveraging the European matrix

Ambition: Demonstration of 7 industry-driven technological and business innovative solutions covering the whole **SILICON** value chain



Call: HORIZON-CL4-2021-RESILIENCE-01



Duration: 48 months (Start: June 2022)

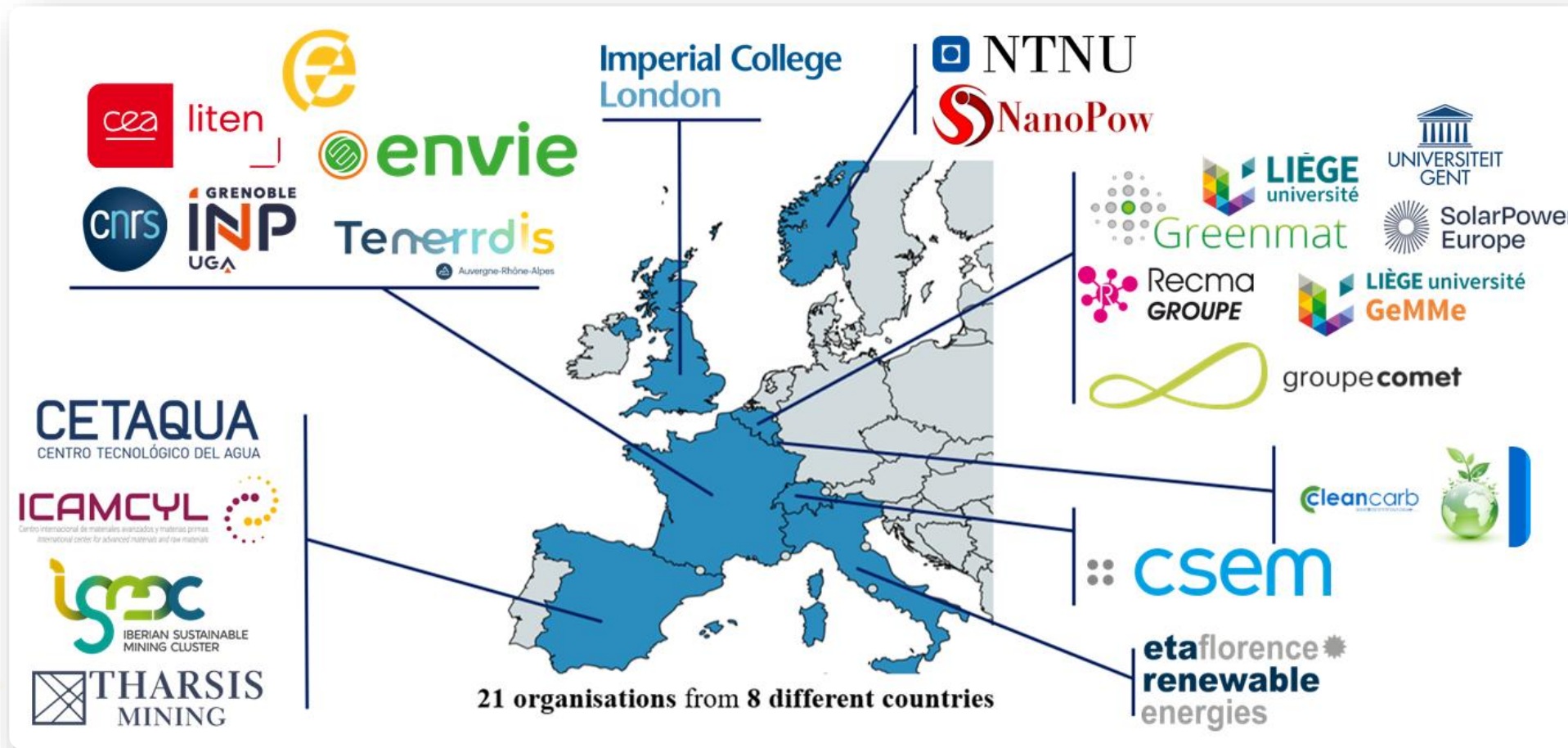


Budget: 12 M €



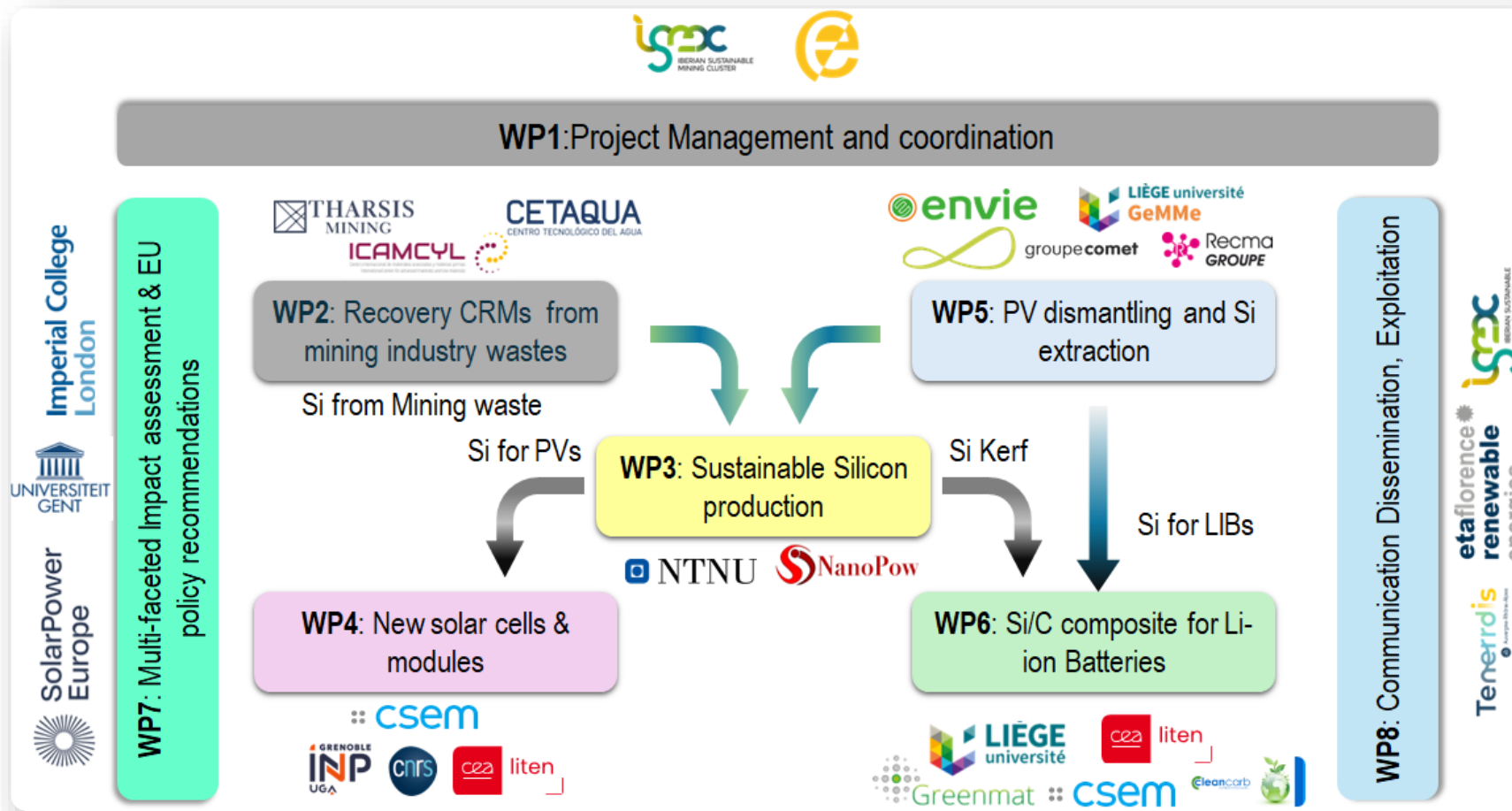
PV panel materials valorization

RESiLEX Consortium



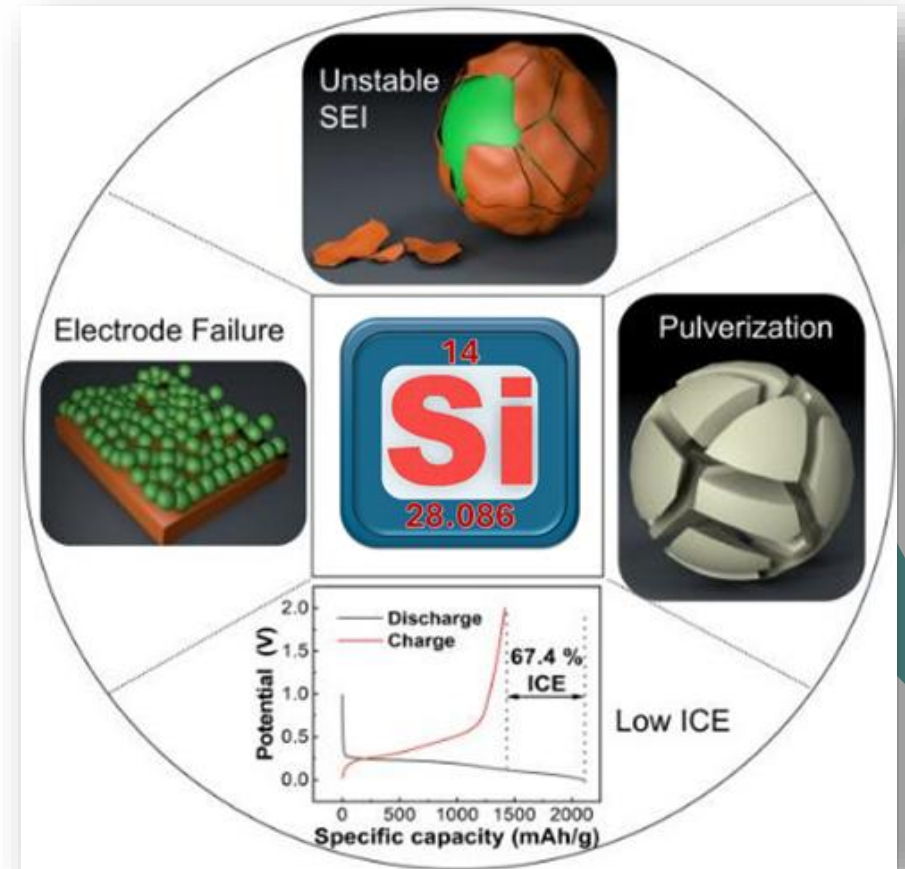
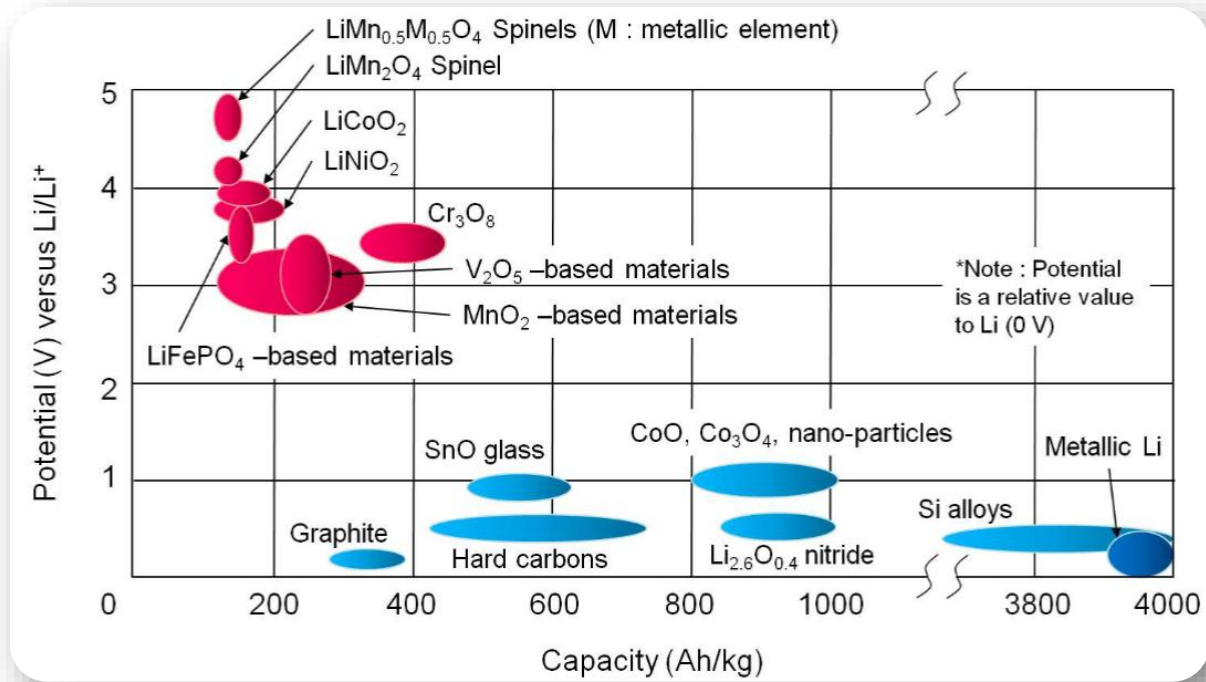
PV panel materials valorization

RESiLEX Structure



PV panel materials valorization

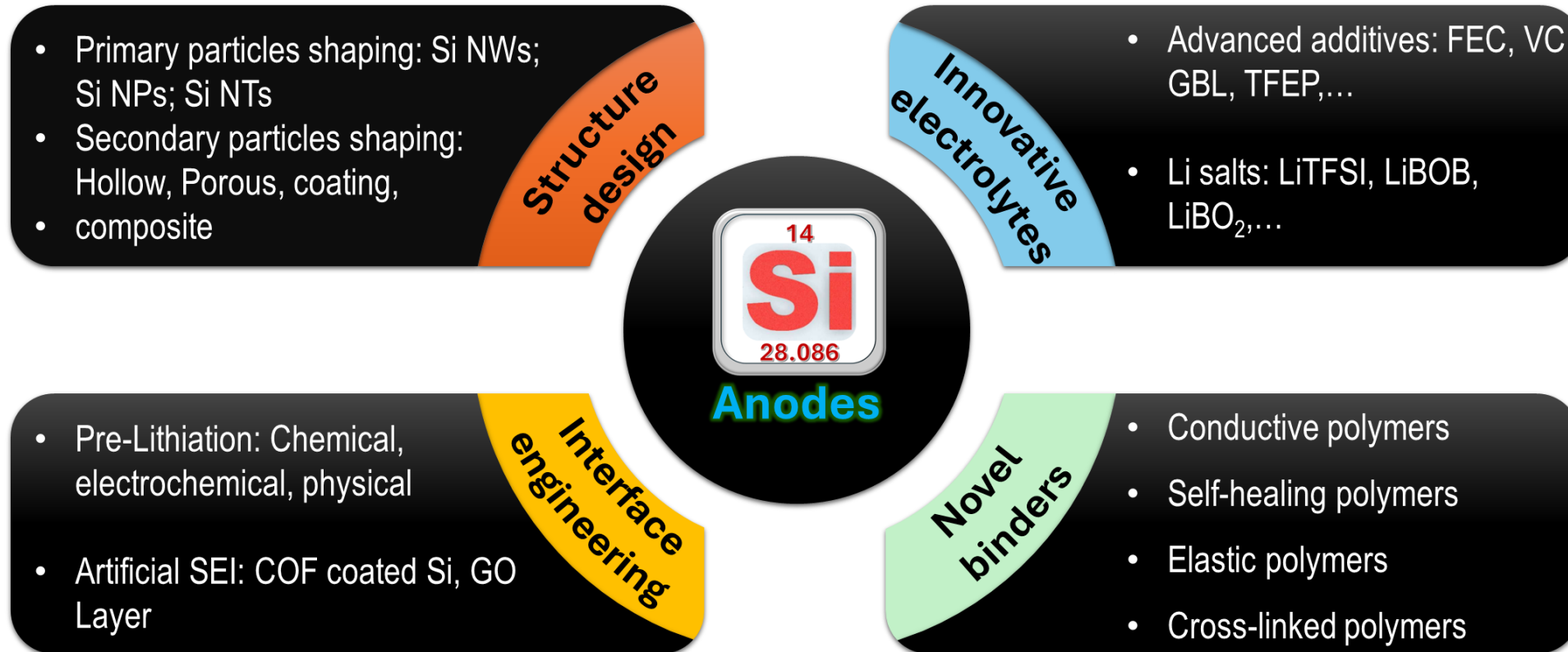
Silicon anodes: Great Energy Density, but...



Adv. Energy Mater. **2023**, 13, 2300367; Green Energy Environ. **2023**, 8, 1325-1340; Ind. Chem. Mater., **2024**, 2, 226-269

Phys. Chem. Chem. Phys., **2015**, 17, 4799-4844

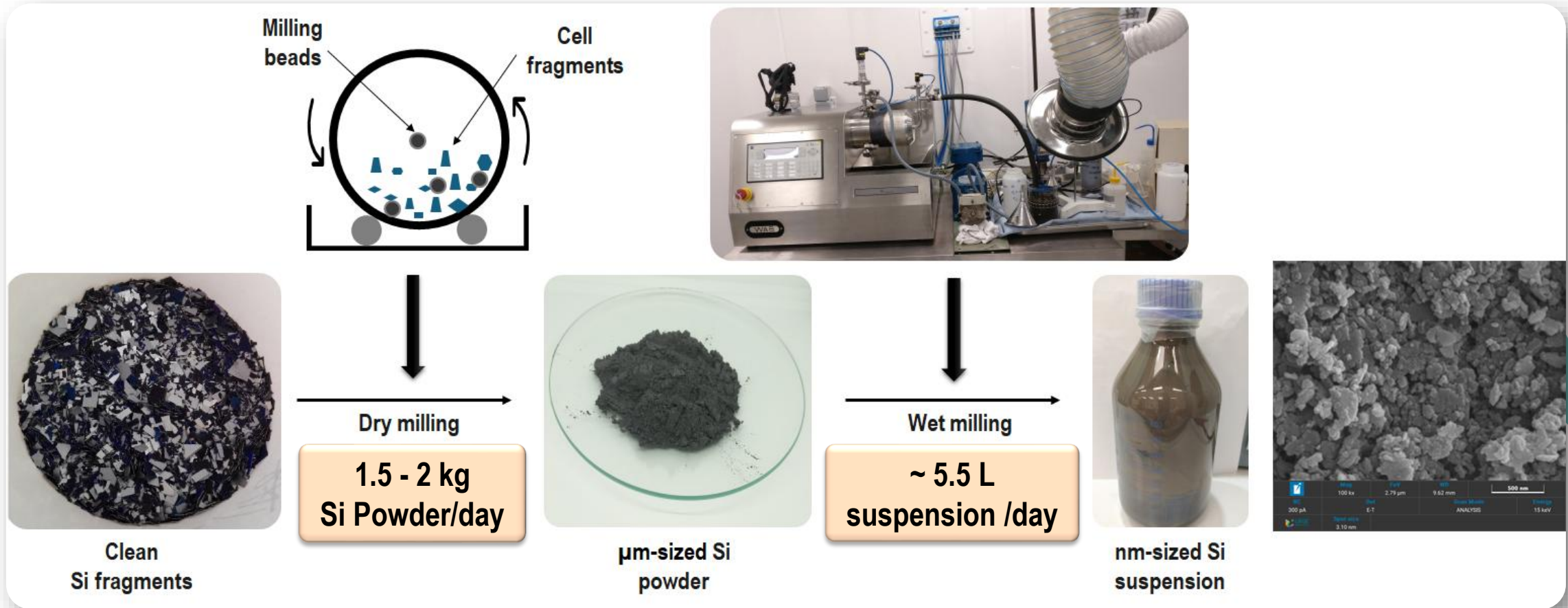
PV panel materials valorization



**Synergy of 2 technologies:
Nano-structuring and Si/C composite formation**

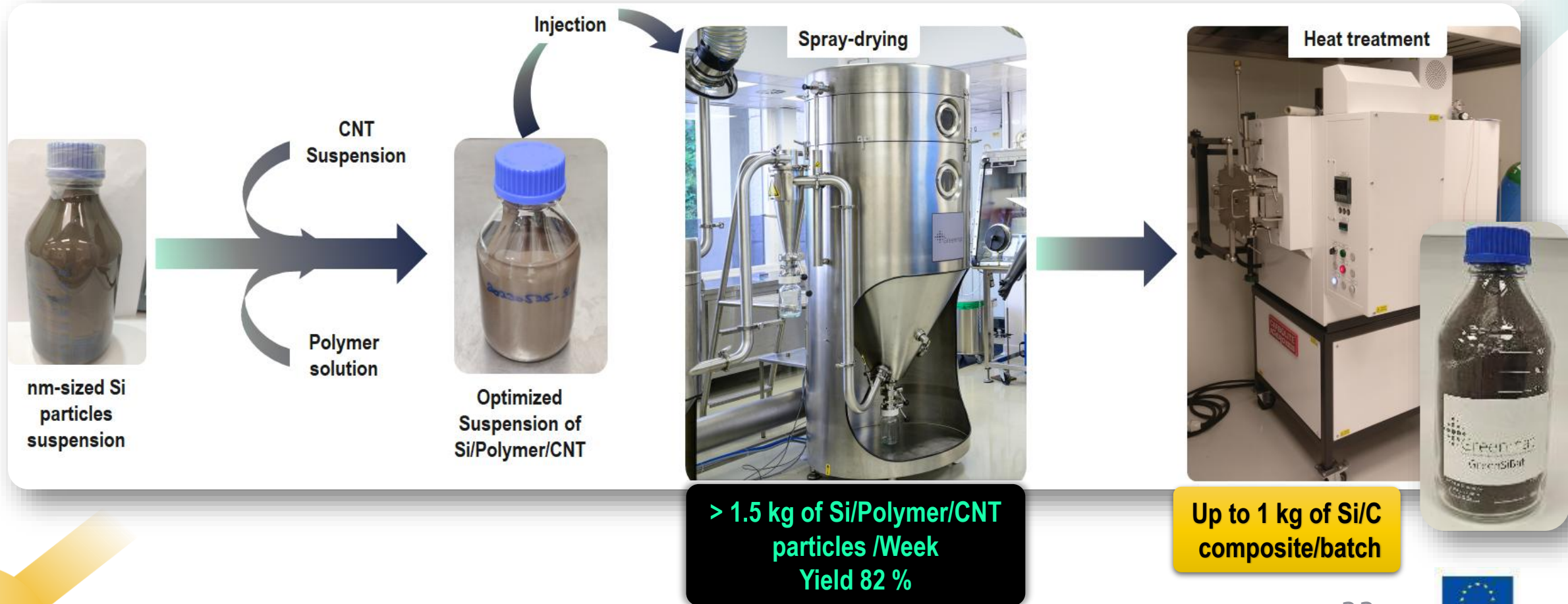
PV panel materials valorization

GREENMat Solutions for EoL Si valorization



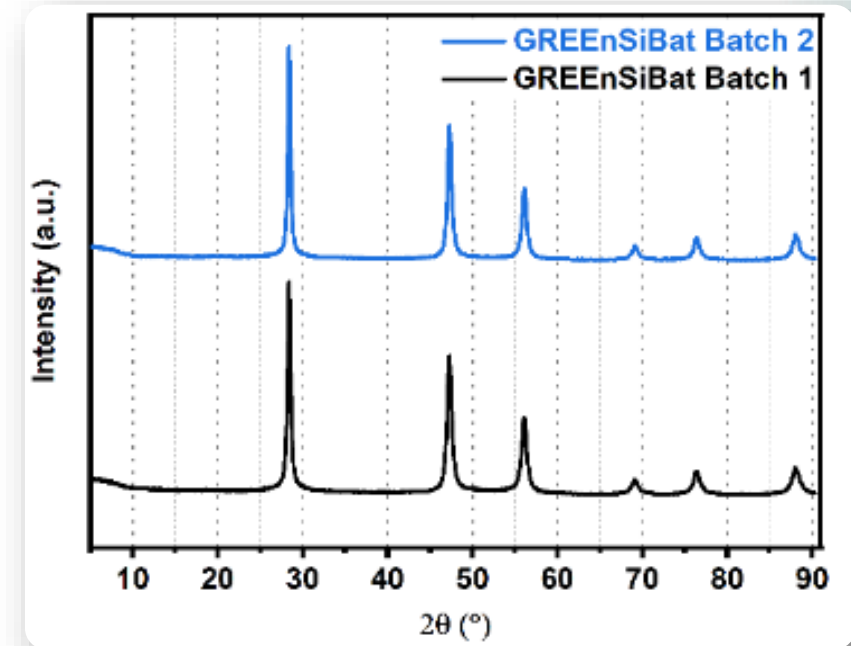
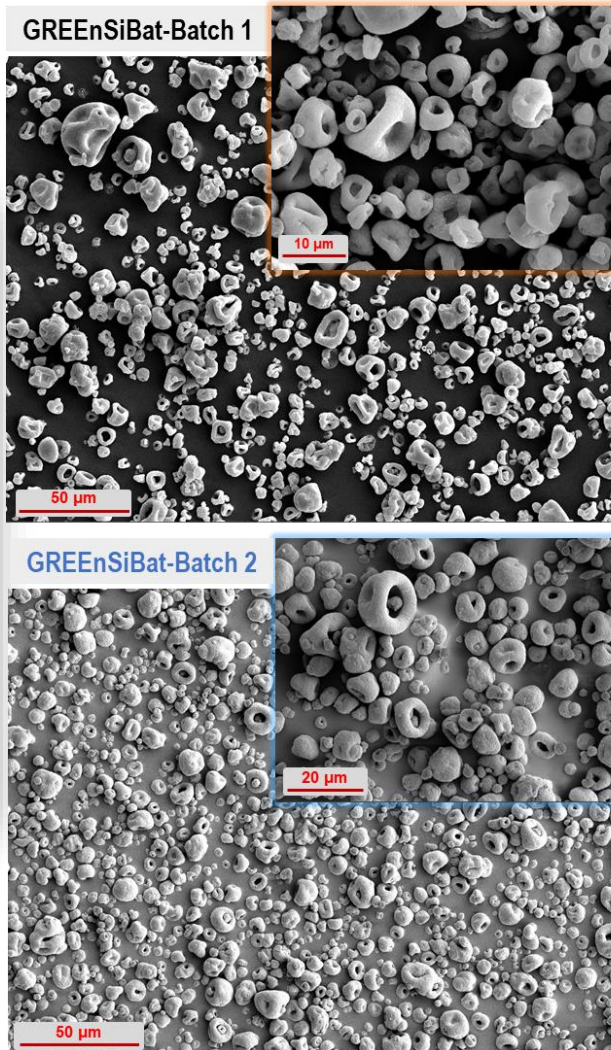
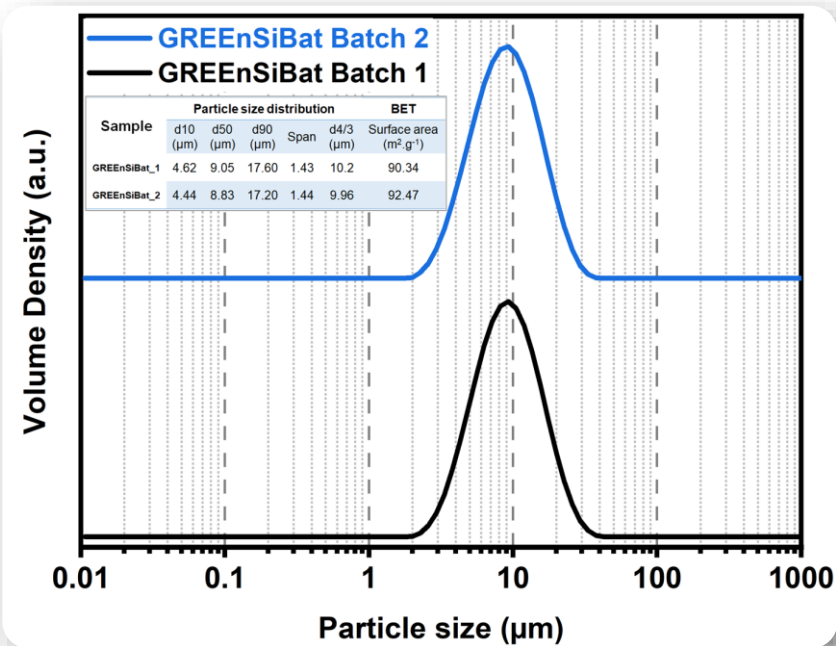
PV panel materials valorization

GREENMat Solutions for EoL Si valorization



PV panel materials valorization

GREENmat Solutions for EoL Si valorization



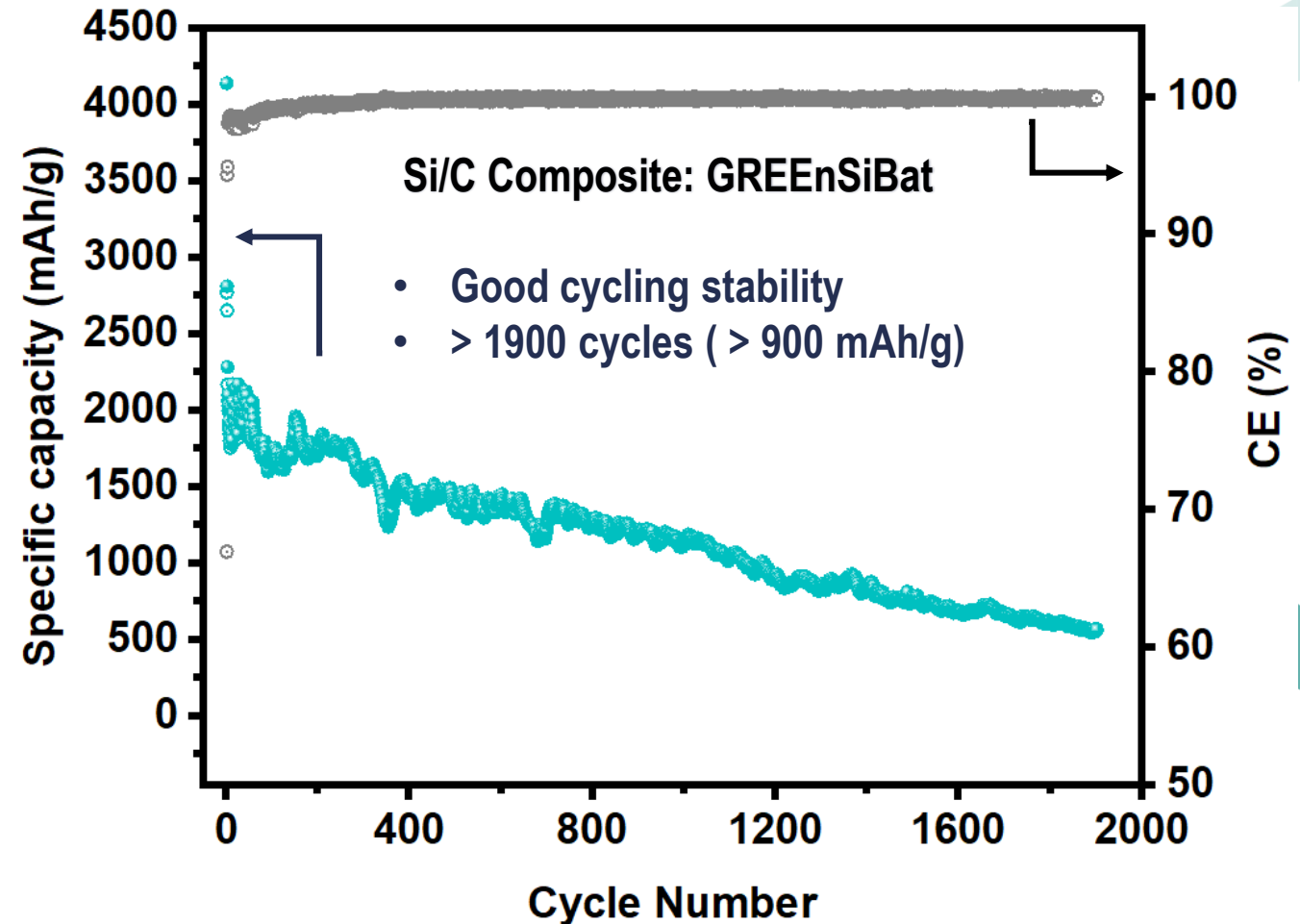
GREENMat Solutions for EoL Si valorization

Electrochemical tests at coin cell configuration: Half-cell electrochemical tests

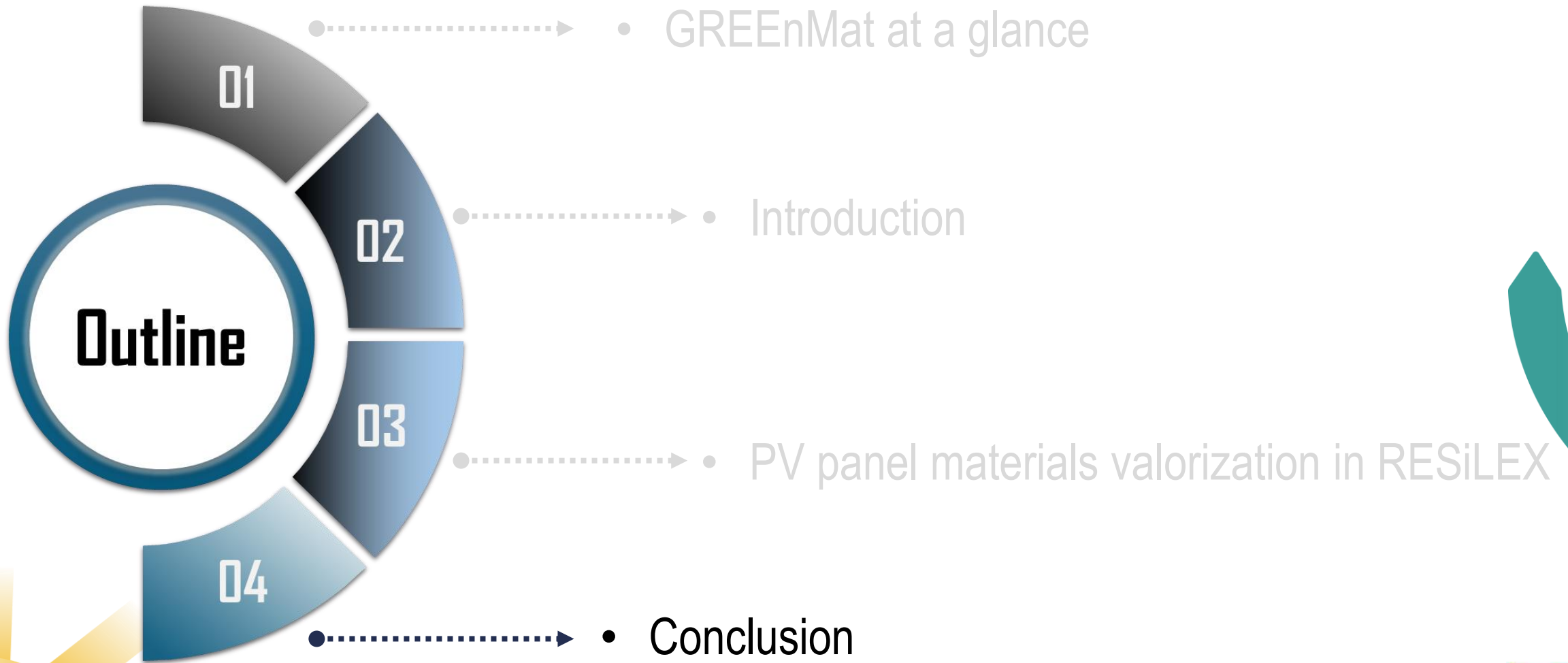


Half-cell configuration: Galvanostatic discharge/charge

Electrolyte	Separator	Counter electrode	Cycling condition
1 M LiPF ₆ in 1:1 EC/DEC + 10 wt.% FEC & 2 wt.% VC	Celgard 2500	Li metal	r.t. Voltage: 0.05 - 1.2 V vs Li ⁺ /Li ⁰ C/40 & C/10



Outline



Conclusion

GREENMat Solutions for EoL Si valorization

Manufacturing at Pilot-scale of Si/C composite for LIBs (TRL-6-7)



Suspension Optimization



Spray-drying



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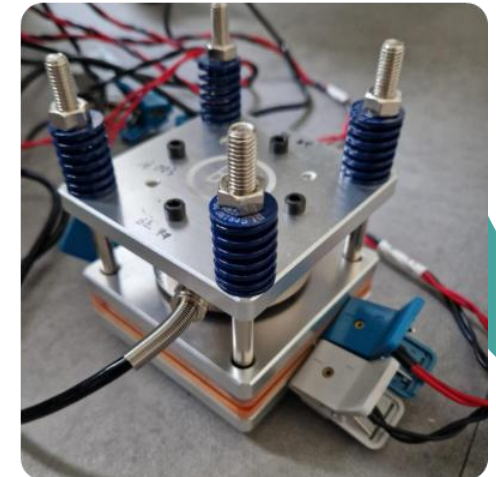


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Conclusion



CEA Grenoble



Neuchâtel,
Switzerland