

# evs | 27

The 27th INTERNATIONAL  
ELECTRIC VEHICLE  
SYMPOSIUM & EXHIBITION.

Barcelona, Spain  
17th-20th November 2013

## GREENLION

Advanced Manufacturing Processes for  
Low Cost GREENer Li-ION Batteries

*Dr. Oscar Miguel Crespo*

*Coordinator*

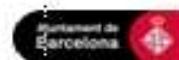
*Energy Division Manager*  
IK4-CIDETEC

IK4 CIDETEC  
Research Alliance

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**GC.NMP.2011-1**

Project financially supported by 7th Framework Program of the European Commission under Grant Agreement no. 285268

A large green background image of a stadium at night. In the foreground, there is a globe and the text "eVS|27" in green and blue. Below that, the text "Advanced Manufacturing Processes for Low Cost Greener Li-ion Batteries" is displayed in white. The background has a green and white geometric pattern.

## 27th Electric Vehicle Symposium (EVS27)

Barcelona, Spain, November 17-20, 2013



Call: FP7-2011-GC-ELECTROCHEMICAL-STORAGE

**Topic: Advanced eco-design and manufacturing processes for  
batteries and electrical components**

Grant Agreement #285268

Total budget: 8.6 M€

EC contribution: 5.6 M€

Starting date: 1/11/11

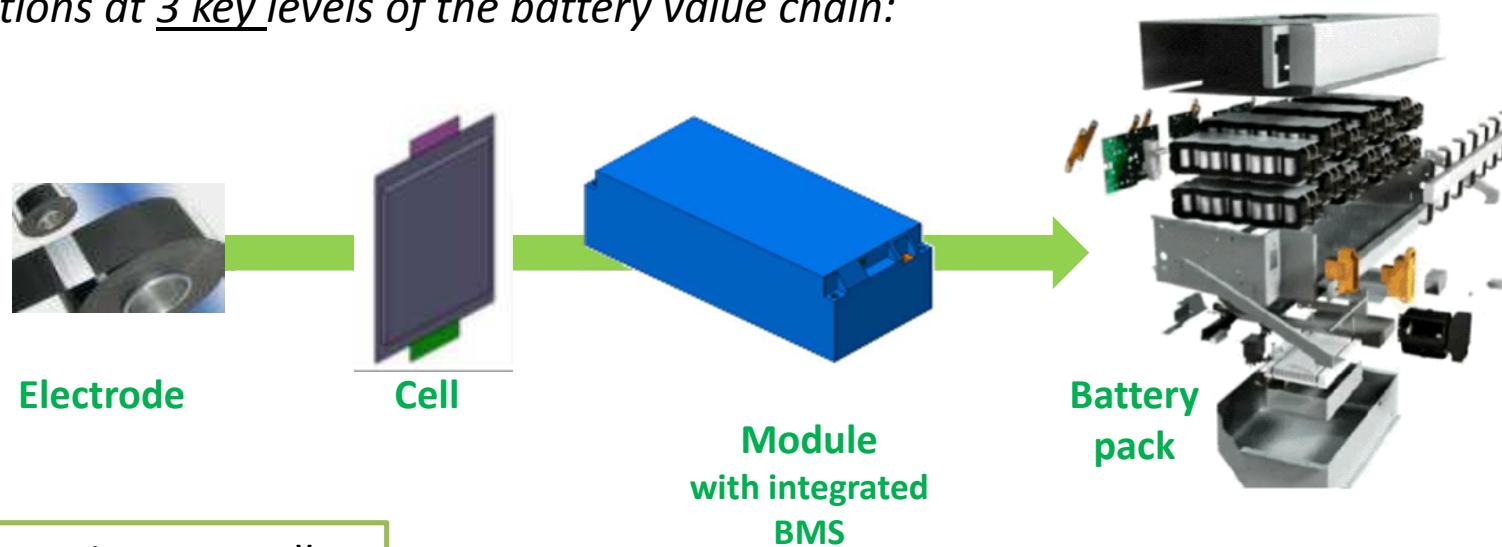
Duration: 4 years



# GREENLION CONCEPT

From green materials to greener batteries

*Actions at 3 key levels of the battery value chain:*



i) more environmentally friendly production of the battery components

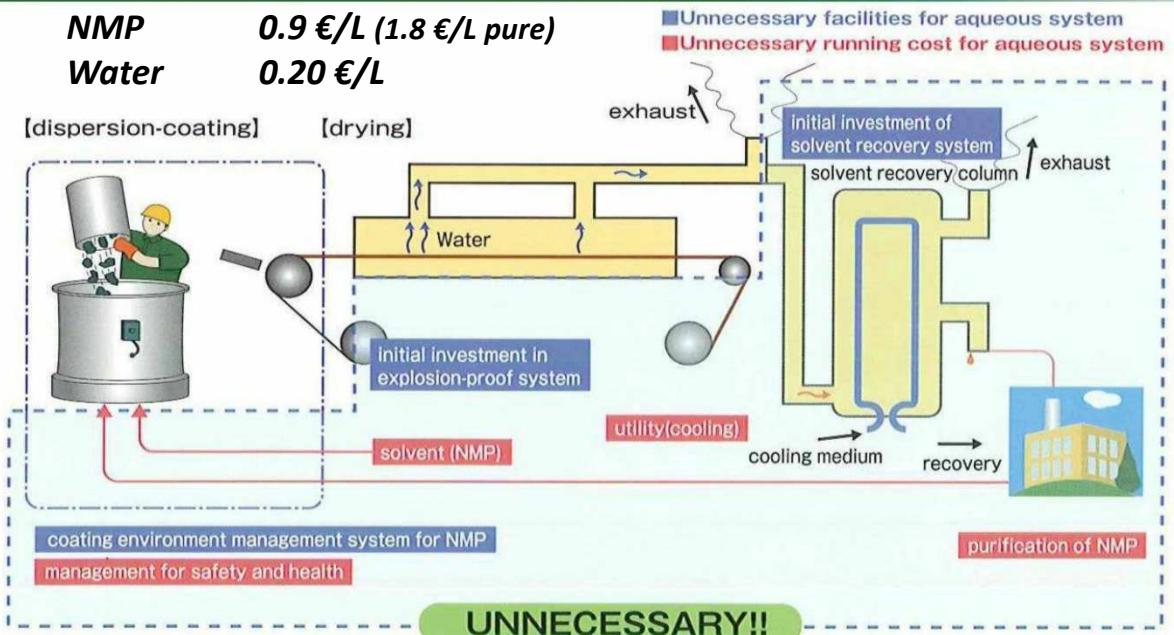
ii) substantial shortening of the battery assembly procedure

iii) easier and more effective disassembly and end-of-life recycling

# Aqueous Electrode Processing Advantages



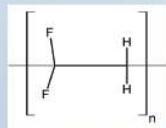
**NMP** **0.9 €/L (1.8 €/L pure)**  
**Water** **0.20 €/L**



## FLUORINE BINDERS (State of the art)

## Polyvinylidenefluoride (PVdF)

**15-18 €/kg**

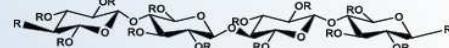


## NON-AQUEOUS processing solvent

- Special caution during electrode processing
- Difficulties to recycle components

## **FLUORINE-FREE BINDERS (Future)**

## Carboxymethylcellulose (CMC)



1-2 €/kg

### **AQUEOUS processing solvent**

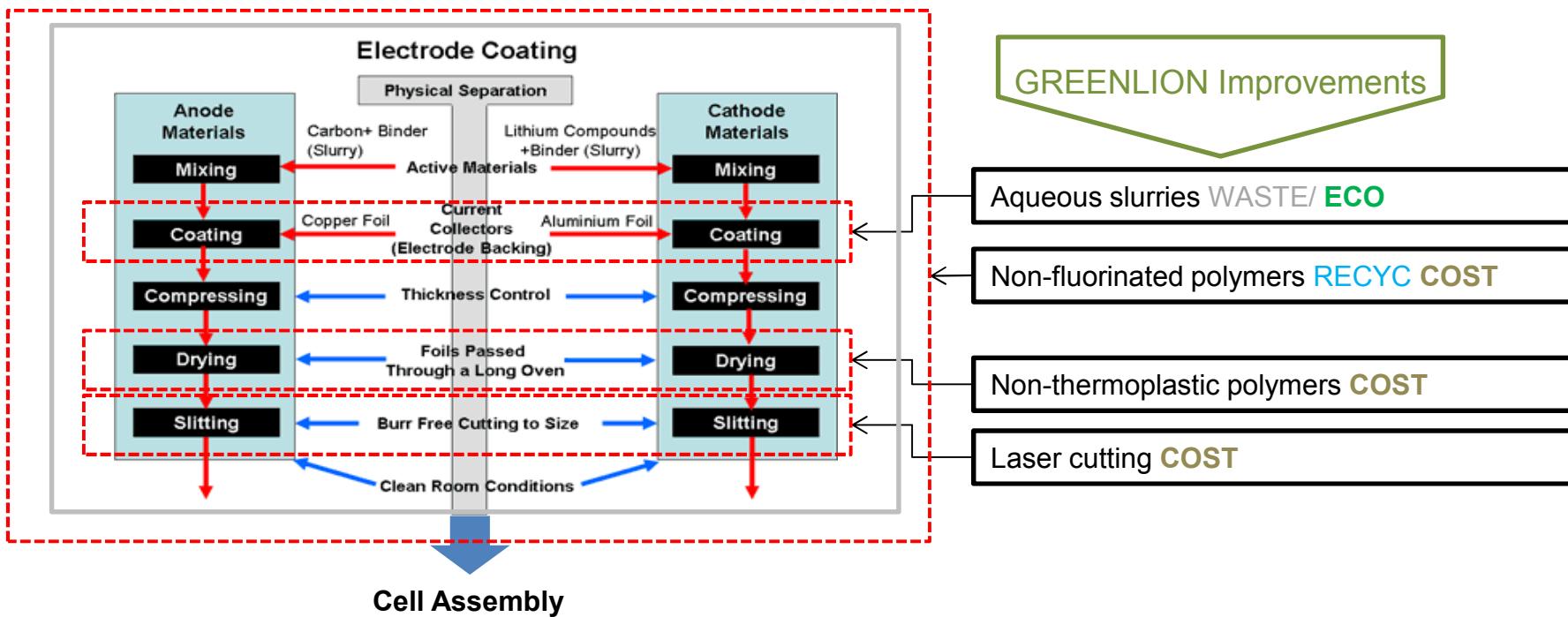
- Water is not polluting
- Possibility of recycling: Easy separation of electrode components by dissolving the binder



## i. Electrode Processing

### - Aqueous Processing of Natural Binders

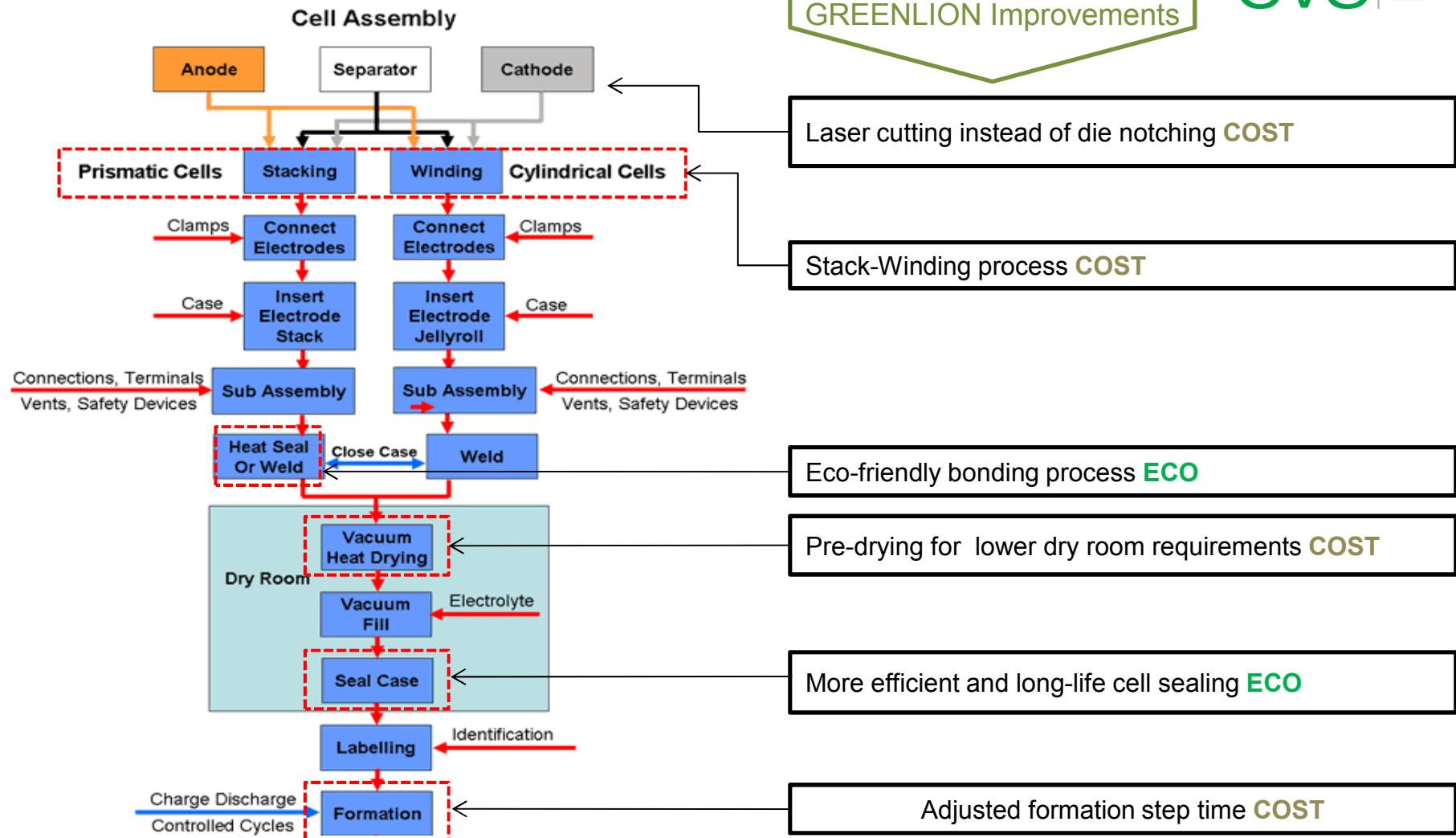
(independent of active materials chemistry – starting selection: C/LFP)

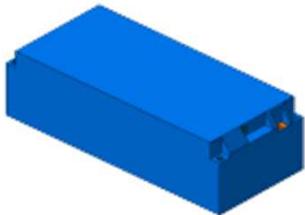


- Slot-die coating process adjustment on pilot line

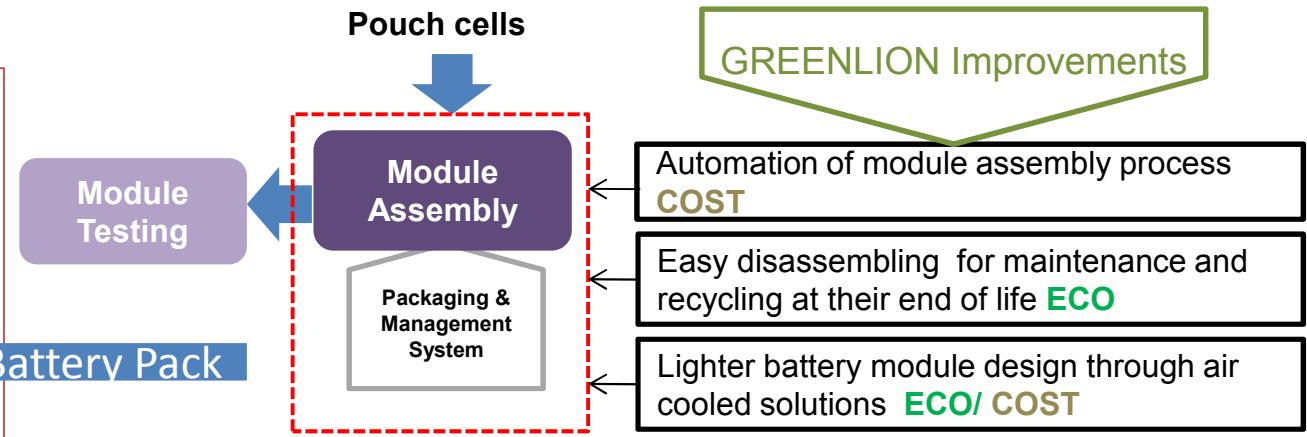
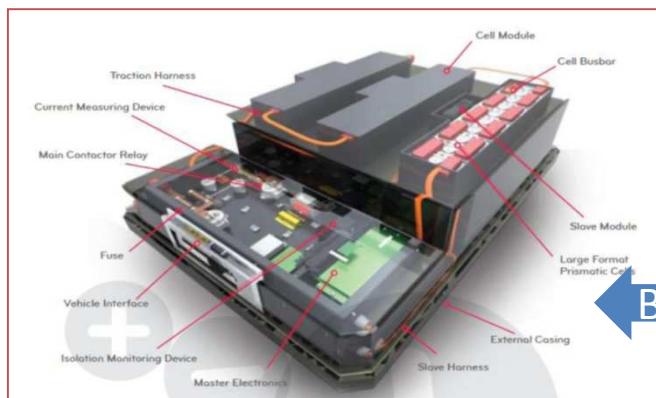


## ii. Cell Assembly





### iii. Module Design & Assembly



#### - Lighter module design through air cooled solutions:

Electrical and thermal simulation of GREENLION cells to develop a module including BMS (SOC, SOH algorithms, equalization) and Thermal Management System.

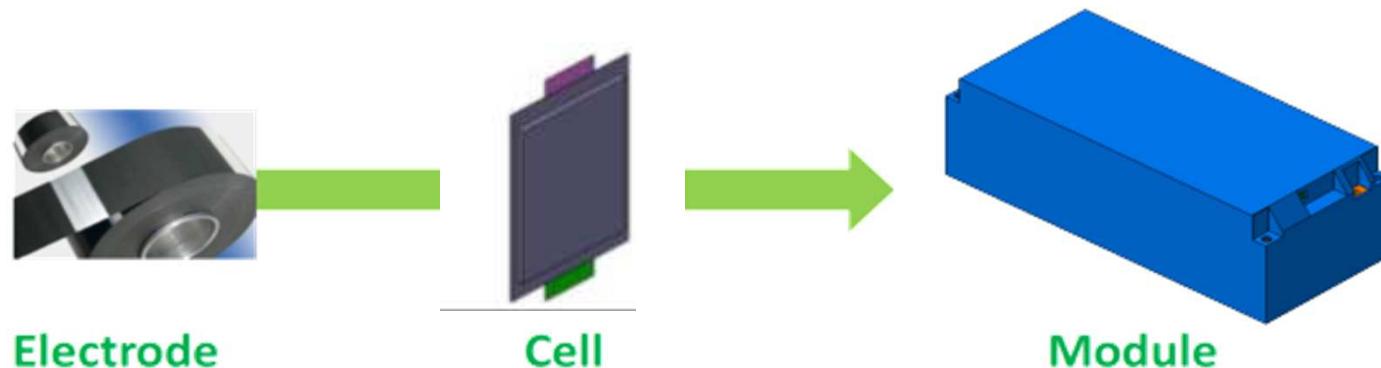
#### - Eco-designed bonding techniques to improve sealing and disassembly:

Degreasing and activation/primering of surfaces for structural bonding. Adhesives/glues with additives to activate easier disassembly for maintenance/reuse/recycling.

#### - 3D design of automatic battery module/pack assembly line:

Pilot line in 3D (validation of a prototype for Key-Processes) as a turn-key production line for Li-ion module manufacturing (Cycle time: 3 sec/cell → production capacity 880MWh/year)

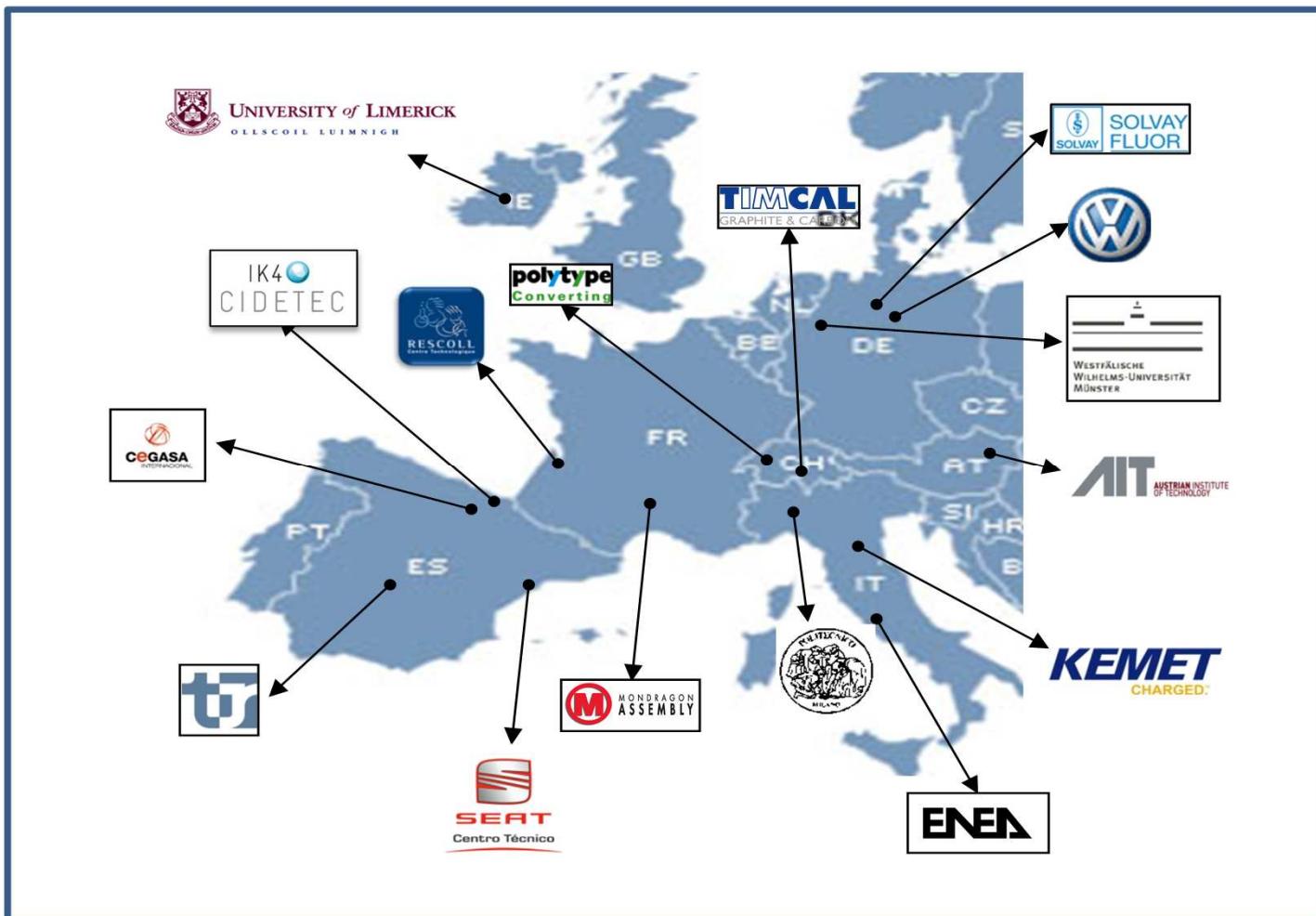
... through an step by step approach:



GEN1	GEN2	GEN3
Electrodes (0.5 m <sup>2</sup> , s.s.) Laboratory coater	Electrodes (m <sup>2</sup> , d.s) Industrial pilot plant coater	
Cells (ca. 5 Ah)	Cells (ca. 20 Ah)	
	Modules (5-10 kWh)	

# GREENLION Consortium

16 partners from 7 member states:



- 10 Industries  
(8 Large, 2 SME)
- 3 Research Institutes
- 3 Universities

# GREENLION Partnership and Roles



## CIDETEC

Management  
Li-ion module development  
(+BMS,+TMS)  
Testing of cells  
(incl. thermal)



## WWU

Electrode formulation  
Optimization of cell assembly  
Testing of cells  
Recycling



## AIT

Procedure development  
Testing (incl. Abuse)  
Equalization development  
HIL Validation



## UL

Silicon  
Nanowire/  
CMC and  
recyclable  
anodes



## POLIMI

Natural binder choice  
Characterization of components  
Ionic liquid electrolytes  
Ionic liquid electrolytes



## ENEA

Characterization of electrodes & components  
Ionic liquid electrolytes  
Testing of cells and modules



## RESCOLL

Bonding and sealing for cells and modules  
Regulatory issues & LCA assessment



## CEGASA

Manufacturing of Li-ion cells and module  
Battery module demonstrator



## SOLVAY

Cathode material developer for aqueous electrode processing



## TIMCAL

Development of a negative electrode material and conductive additives



## MASS

Automated assembly line for the battery modules



## PCF

Develop and optimize coating methods  
Electrode Coatings in pilot lane



## KEMET

Cell assembly  
Laser notching of electrodes  
Manufacture of cells  
Recovery of materials  
Waste treatment



## TECNICAS REUNIDAS

Reuse/ recycling of cells or battery components  
Recovery of materials  
Validation of battery module



## SEAT

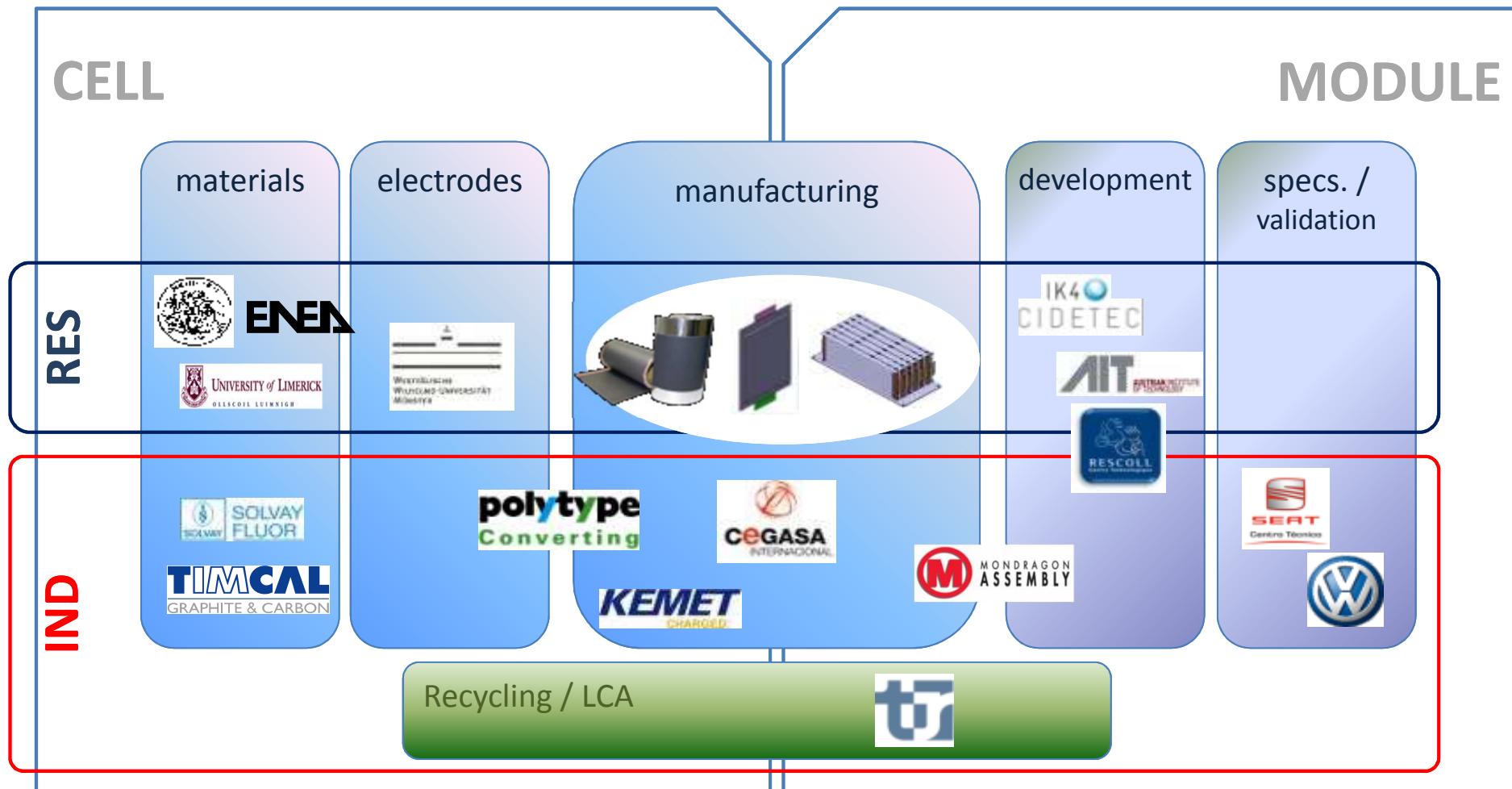
EV specifications for module development  
Validation of battery module



## VOLKSWAGEN

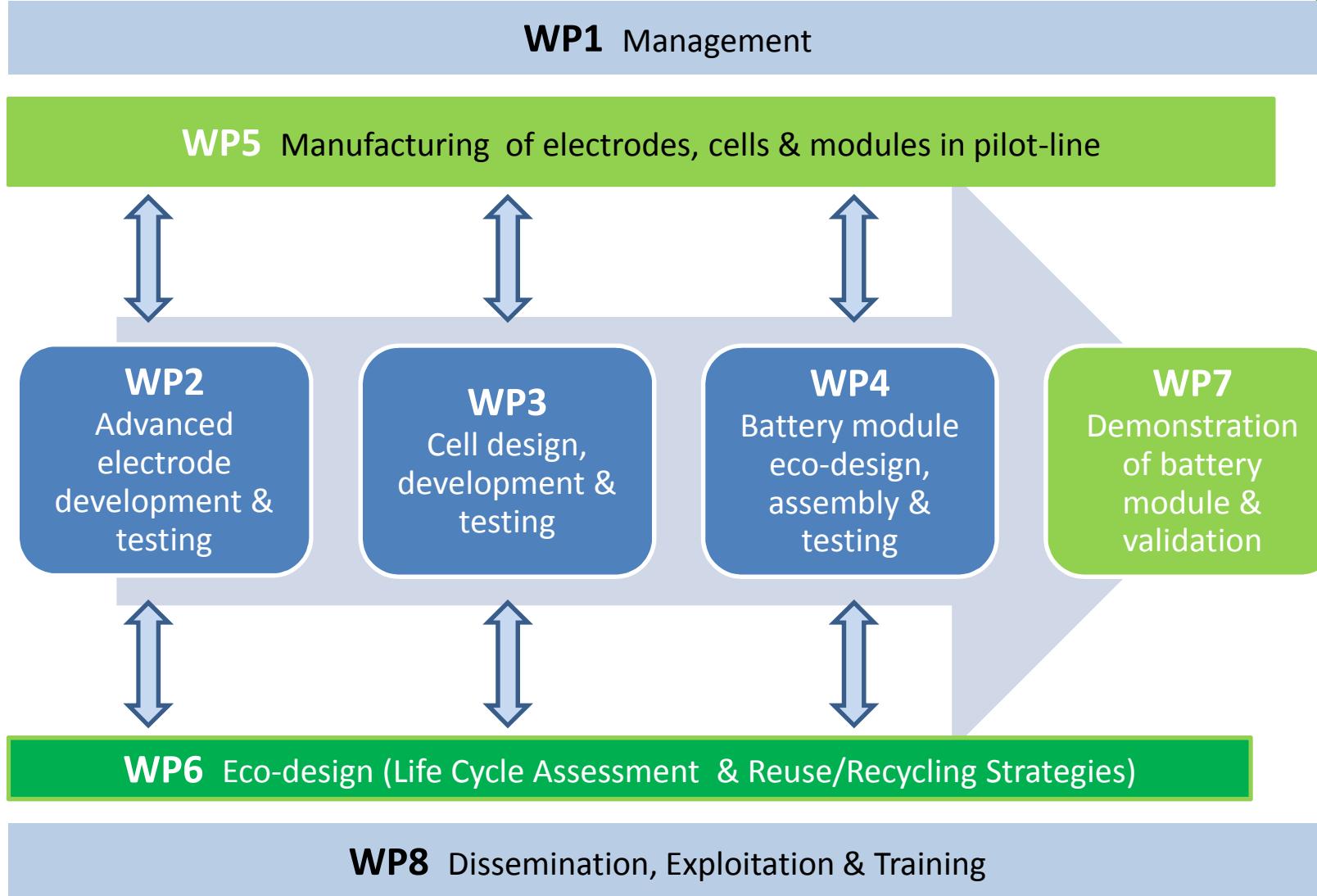
Design of cell, module and system.  
Efficiency and geometry issues.  
Evaluation of materials

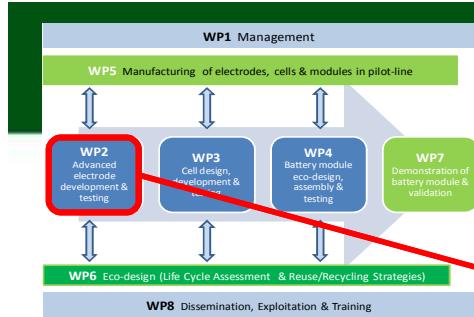
# GREENLION Partnership and Roles



*NOTE: attribution of roles to partners not exhaustive*

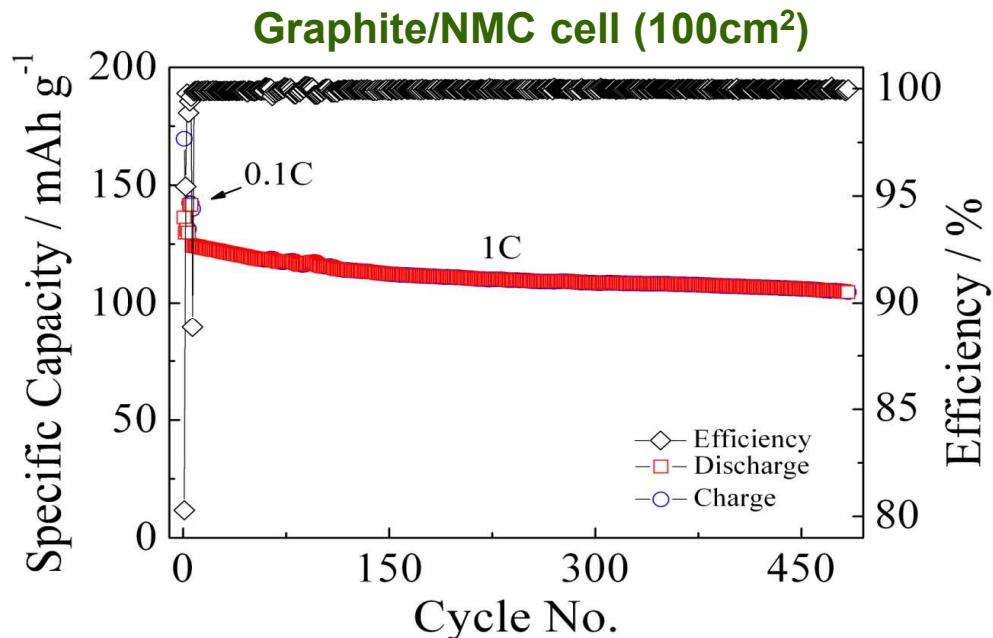
# WorkPackage structure





## WP2 Advanced electrode development & testing

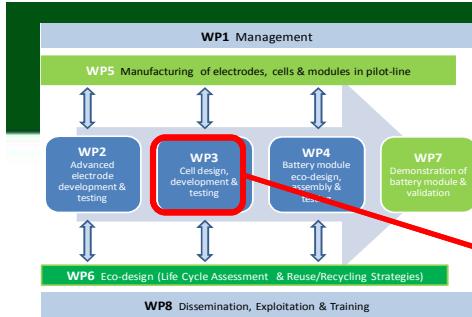
- Optimized formulation for aqueous coating using CMC as binder:
  - ✓ Anode: Graphite (SLP30)
  - ✓ Cathode: NMC
- Transfer to pilot line (electrodes for GEN2 cells)



**Selection of components for GEN1 cells ( $\approx 5\text{Ah}$ ):**  
Graphite / NMC  
CMC binder

**0.5 m<sup>2</sup> negative and positive electrodes for GEN1 cell:**  
DELIVERED

**Optimized formulation of positive and negative electrodes with CMC**  
Pre-pilot



## WP3 Cell design, development & testing



- GEN1 manufactured cell: testing and evaluation:



- GEN2 cell preliminary design:

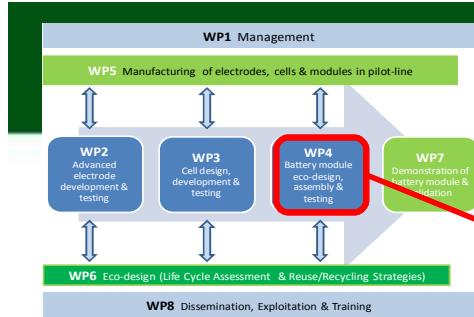


- Cell thickness: 8.5-9mm

MAIN  
ACHIEVEMENTS  
SO FAR

Manufacture of GEN1 cells from  
fluorine-free binders, small area  
electrodes  
DELIVERED

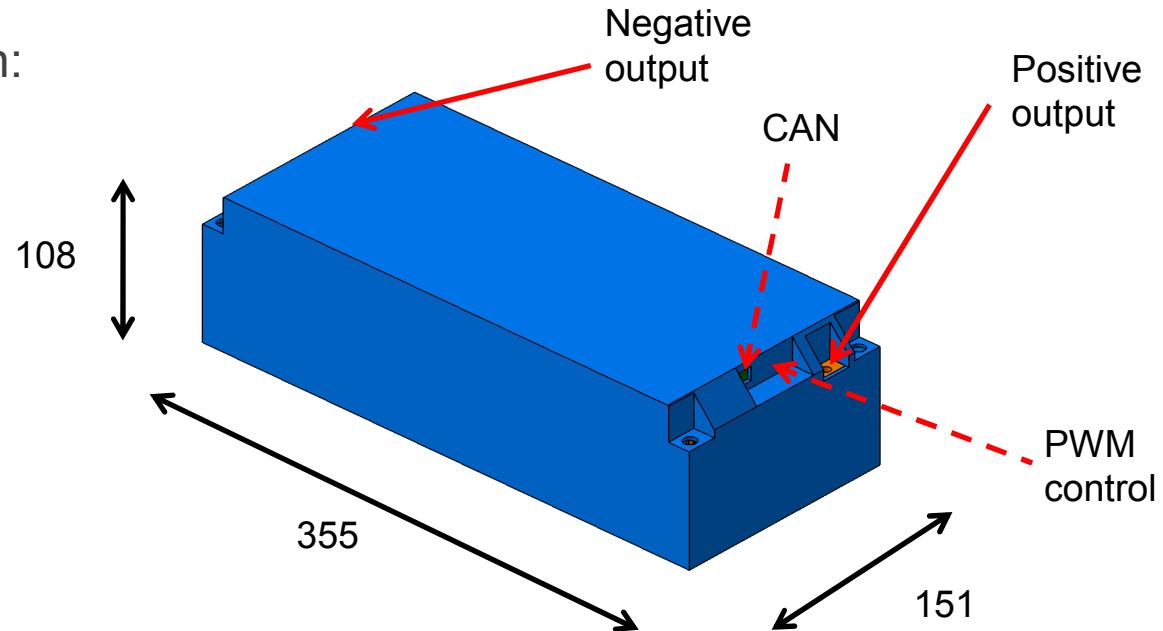
Design of the initial  
GREENLION cell (≈ 20Ah)  
GEN2



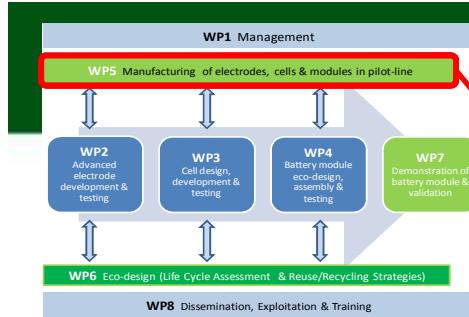
## WP4 Battery module eco-design, assembly & testing



- Mod1 design:



**Design of the GREENLION battery modules**  
UNDER DISCUSSION  
→ COUPLED WITH CELL DESIGN & ECODESIGN



## WP5 Manufacturing of electrodes, cells & modules in pilot-line



- Electrode manufacturing options:

- ✓ Gen2 coated with 2 passes (4a)
- ✓ Gen3 goal: 1 coating pass (4b)

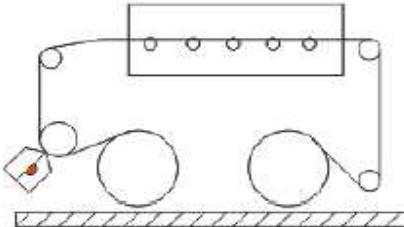


Figure 4a: One-sided coating and drying of the metal foil.

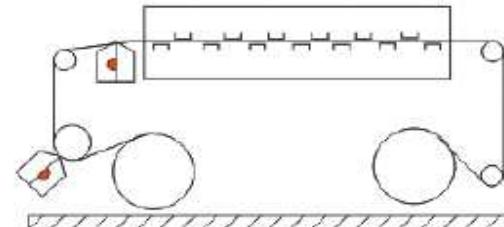


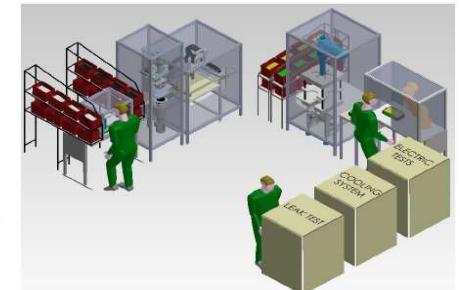
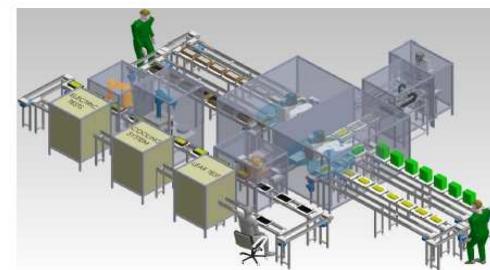
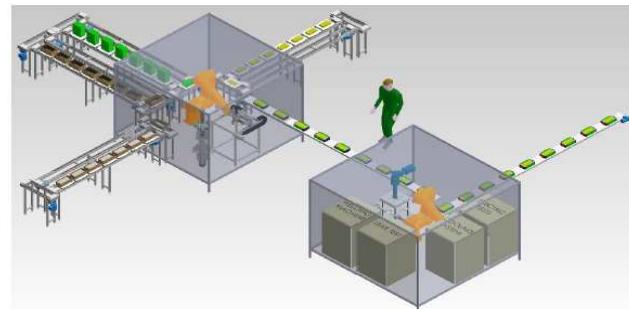
Figure 4b: Simultaneous double-sided coating with subsequent drying of the metal foil.



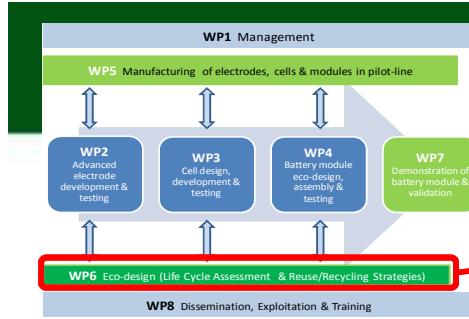
MAIN  
ACHIEVEMENTS  
SO FAR

Electrode manufacturing:  
transference from lab-coater to  
industrial pilot line  
ABOUT TO MANUFACTURE

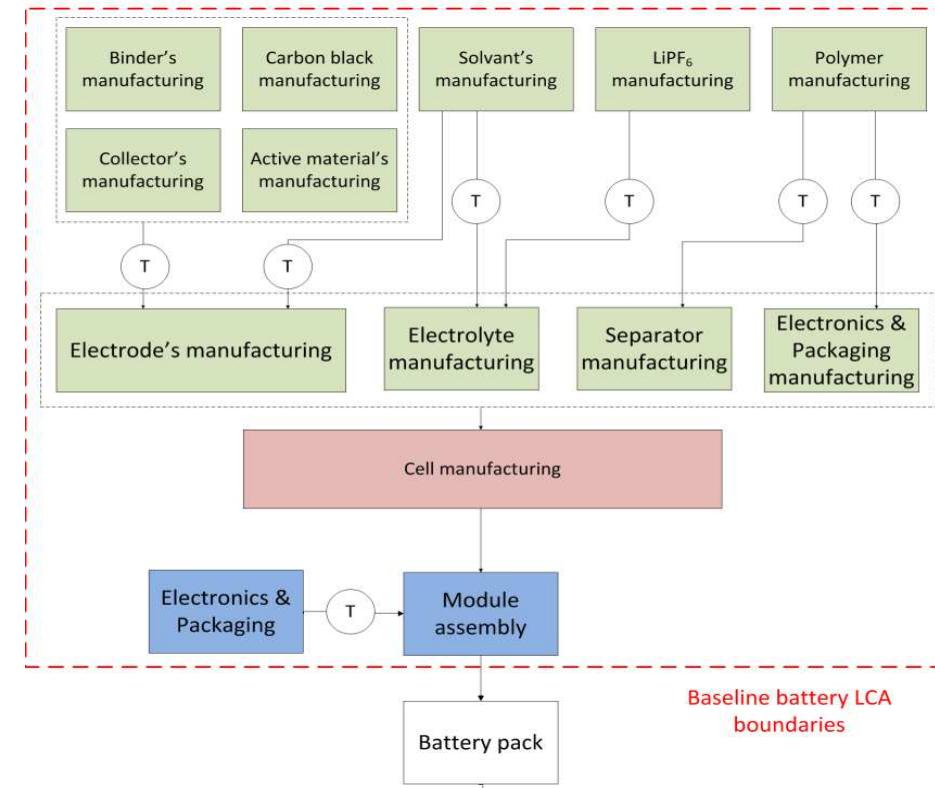
- Plant layout options



Production process defined  
PRELIMINARY



## WP6 Eco-design (LCA & Reuse/ Recycling Strategies)

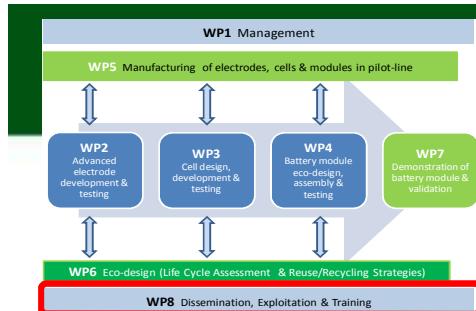


- Baseline battery LCA boundaries:

MAIN  
ACHIEVEMENTS  
SO FAR

Benchmarking on recycling  
processes done:  
ALREADY STARTED

LCA& ecodesign ;  
gathering of inputs from partners  
• reference cell & module  
• Greenlion cells & modules



## WP8 Dissemination, Exploitation & Training



MAIN  
ACHIEVEMENTS  
SO FAR

Greenlion website:  
LAUNCHED

Project brochure & semestral  
newsletters:  
ONGOING

# *Thank you !!*



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#### **GreenLion Project Coordination:**

##### **IK4 Cidetec**

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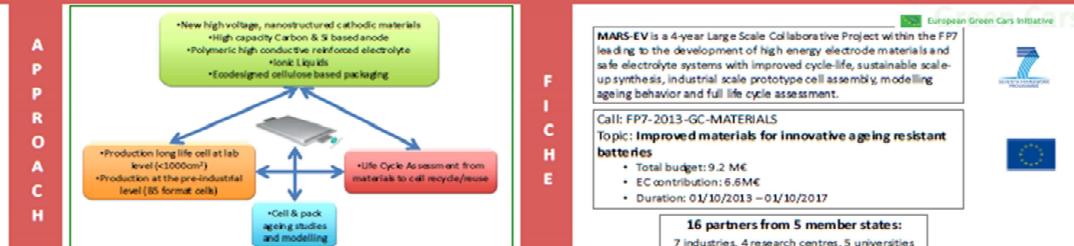
[omiguel@cidetec.es](mailto:omiguel@cidetec.es)

**IK4** CIDETEC  
Research Alliance

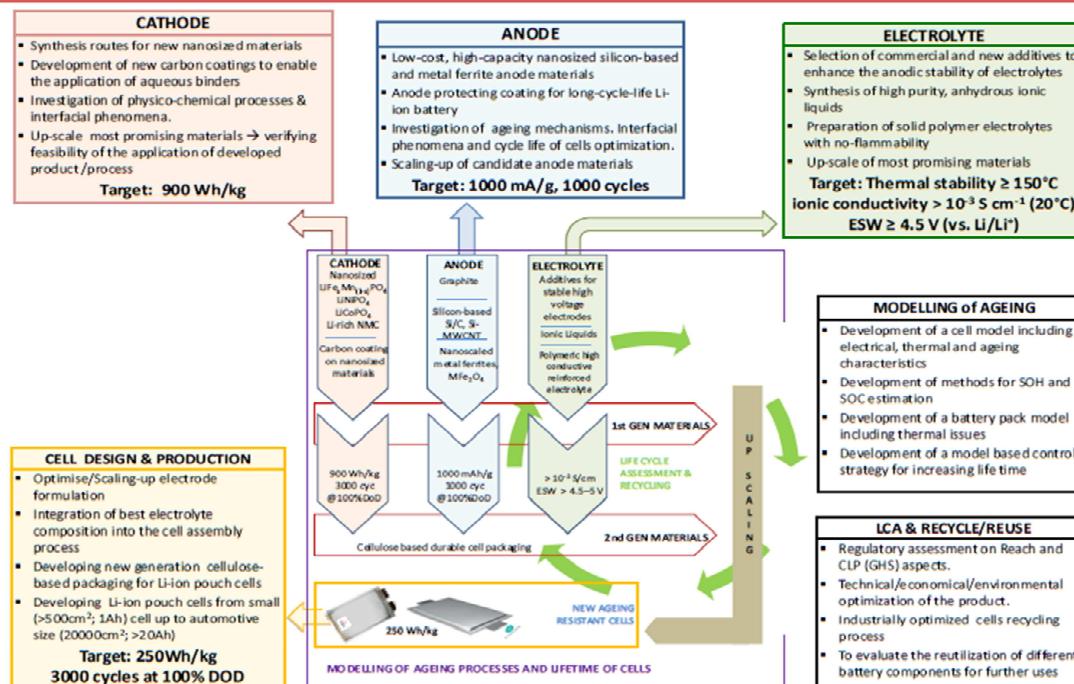
# Materials for Ageing Resistant lithium ion energy Storage for the Electric Vehicle



## “Overcoming the ageing phenomenon in Li-ion batteries”



## PROJECT OUTLINE



Coordinator: Dr. Oscar Miguel - [omiguel@cidetec.es](mailto:omiguel@cidetec.es)

IK4-CI DETEC - Parque Científico y Tecnológico de Gipuzkoa, Paseo de Miramón 196 - 20009 Donostia - San Sebastián, Spain



The 27th International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium  
Barcelona, Spain, November 17-20, 2013

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