

# GREENLION

## Advanced Manufacturing Processes for Low Cost GREENER Li-ION Batteries

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# GREENLION

## Advanced Manufacturing Processes for Low Cost GREENer Li-ION Batteries

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 November 2011

Duration: 4 years

# GREENLION CONCEPT

## From green materials to greener batteries

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



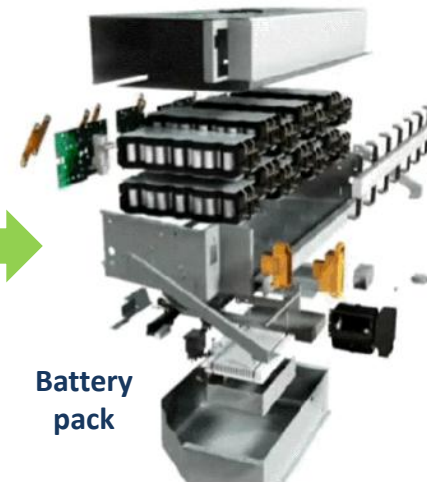
**Electrode**



**Cell**



**Module**  
with integrated  
BMS

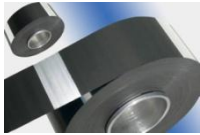


**Battery pack**

more environmentally friendly production of the battery components

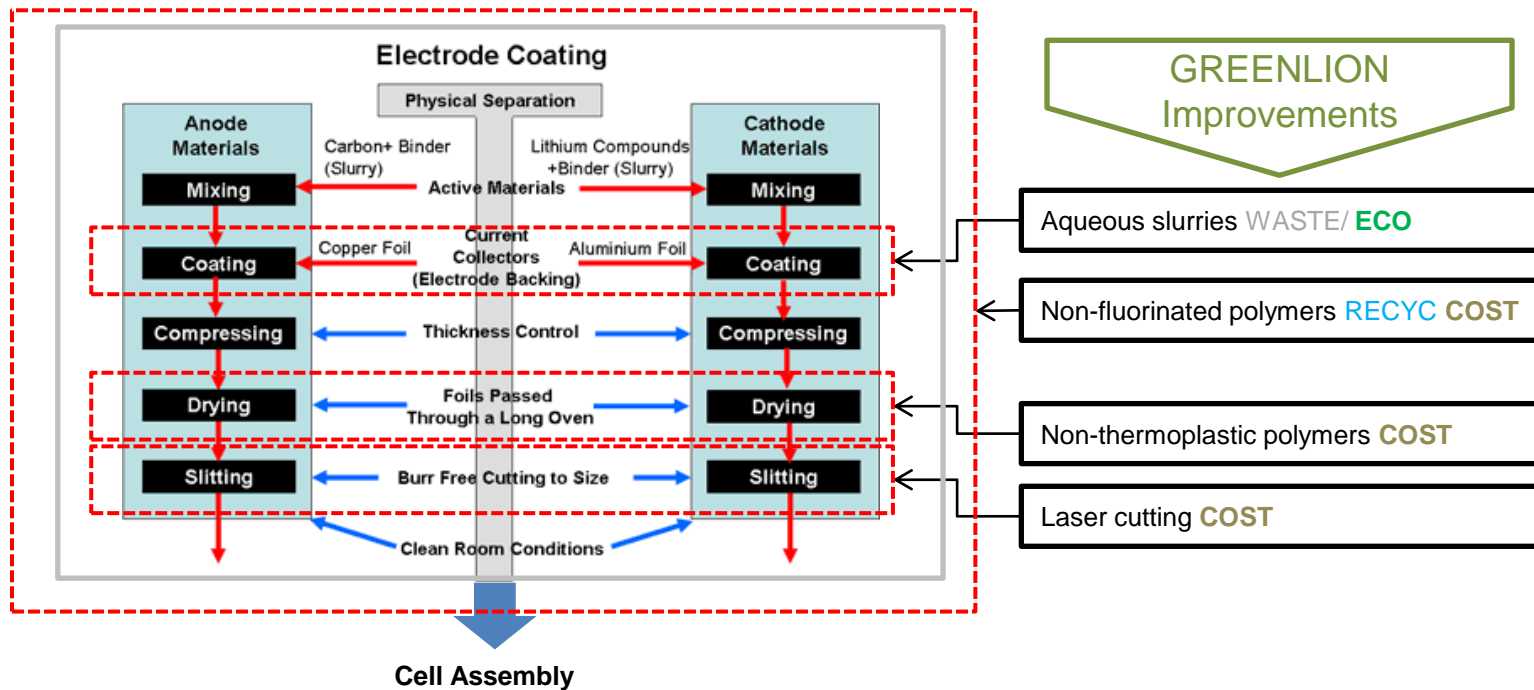
substantial shortening of the battery assembly procedure

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



# Electrode Processing

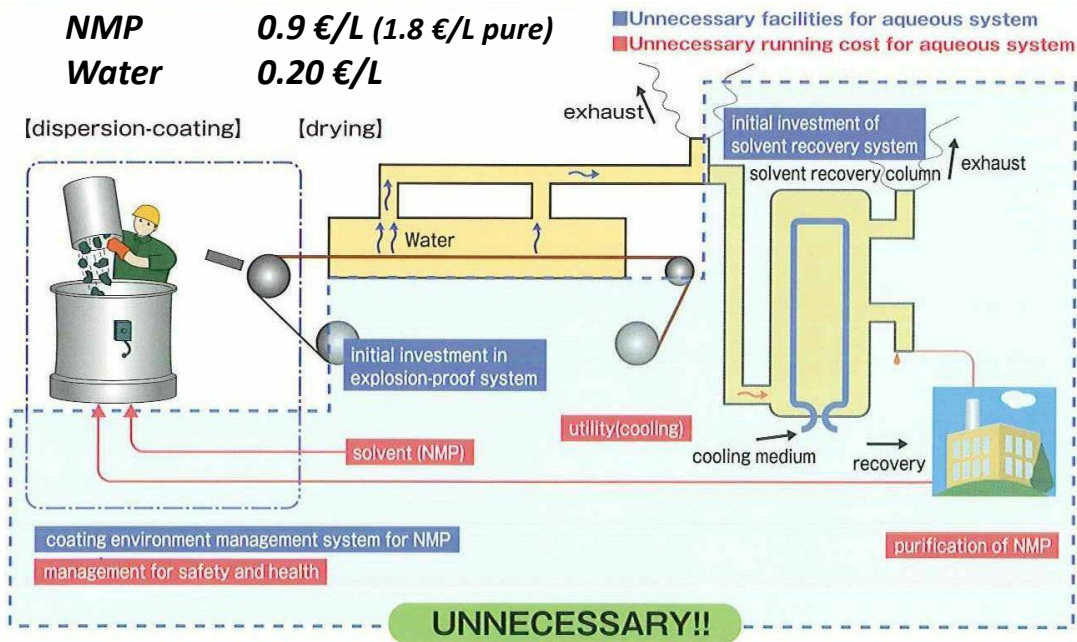
- **Aqueous Processing of Natural Binders**  
(independent of active materials chemistry – starting selection: C/LFP)



- **Slot-die coating process adjustment on pilot line**

# Aqueous Electrode Processing Advantages

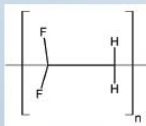
**NMP** 0.9 €/L (1.8 €/L pure)  
**Water** 0.20 €/L



**FLUORINE BINDERS**  
 (State of the art)

**Polyvinylidene fluoride (PVdF)**

15-18 €/kg

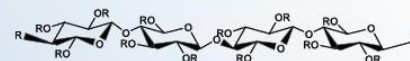


**NON-AQUEOUS processing solvent**

- Special caution during electrode processing
- Difficulties to recycle components

**FLUORINE-FREE BINDERS**  
 (Future)

**Carboxymethylcellulose (CMC)**



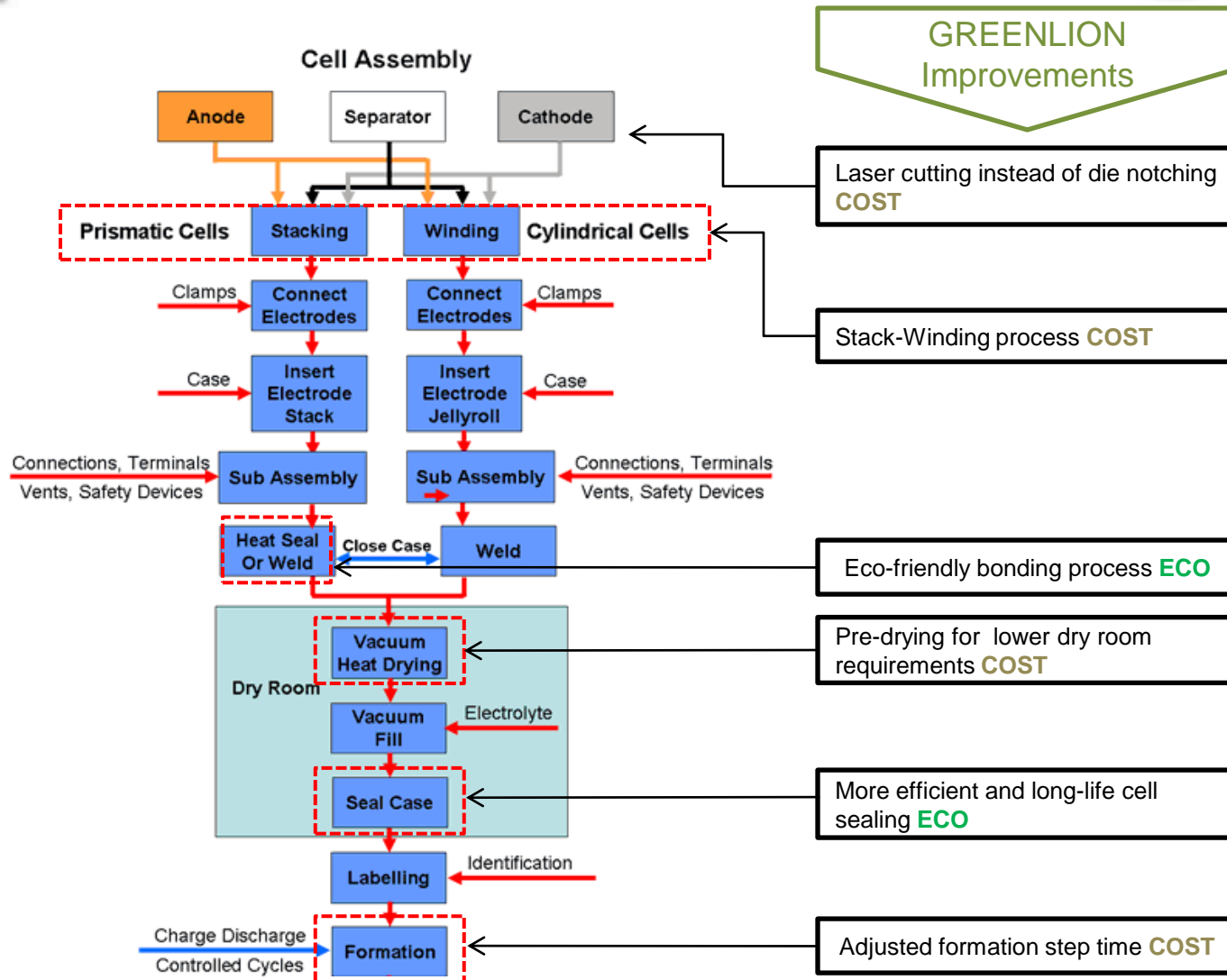
1-2 €/kg

**AQUEOUS processing solvent**

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



# Cell Assembly



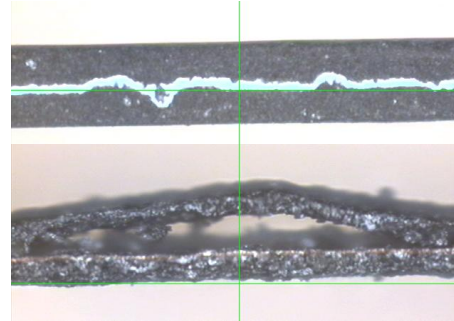
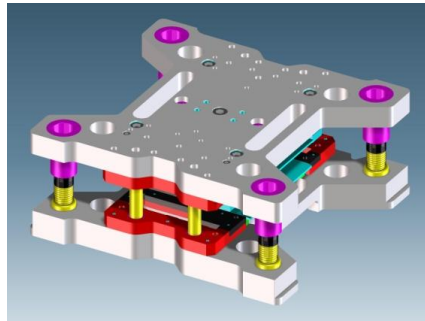


# Laser Cutting and Stack-Winding for improved pouch cell assembly



## - Laser cutting instead of mechanical notching:

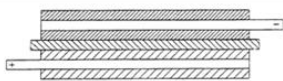
Adjust laser parameters to ensure efficient material removal and minimize heat-affected zone to avoid coating degradation



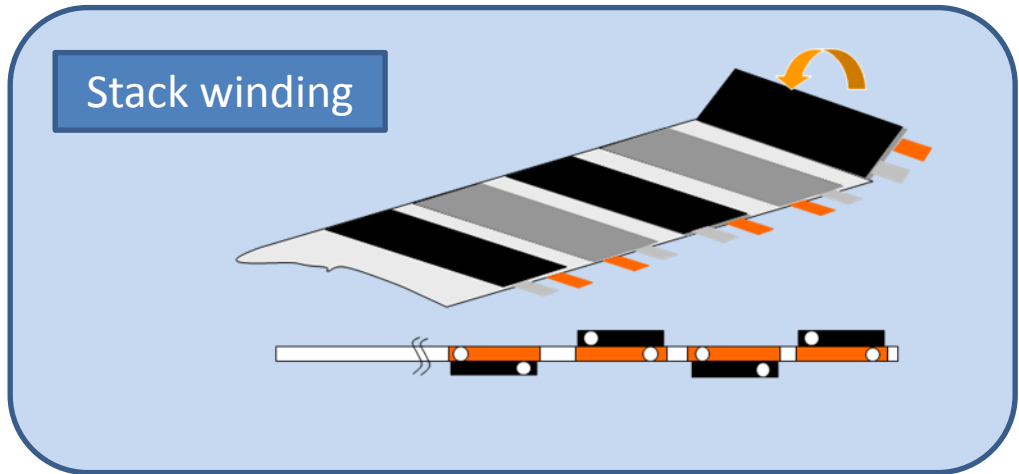
Burrs and delamination with mechanical notching

## - Stack-Winding: combine continuous process of Winding with volumetric efficiency and energy density of Stacking

### Stacking

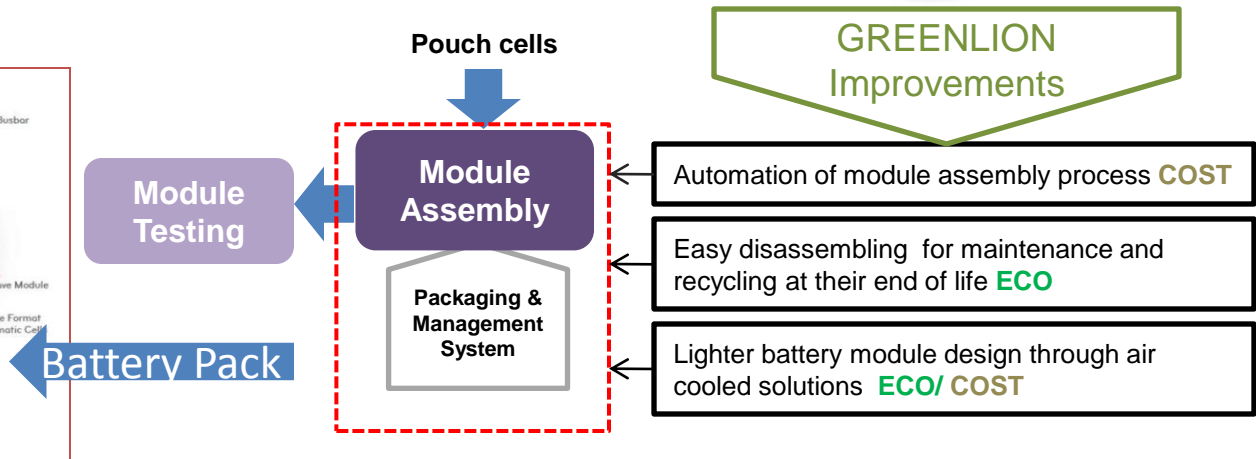
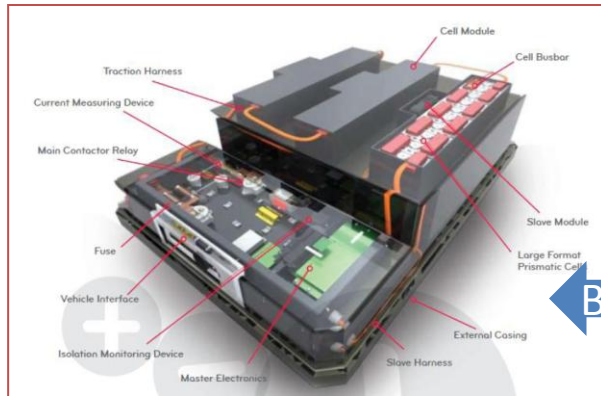


Process	Each layer (anode, separator, cathode) pick and placed
	Multi-layer precision placement difficulties
	Long cycle time





# 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. Module validation including Hardware-In-the-Loop (HIL) methodology.

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

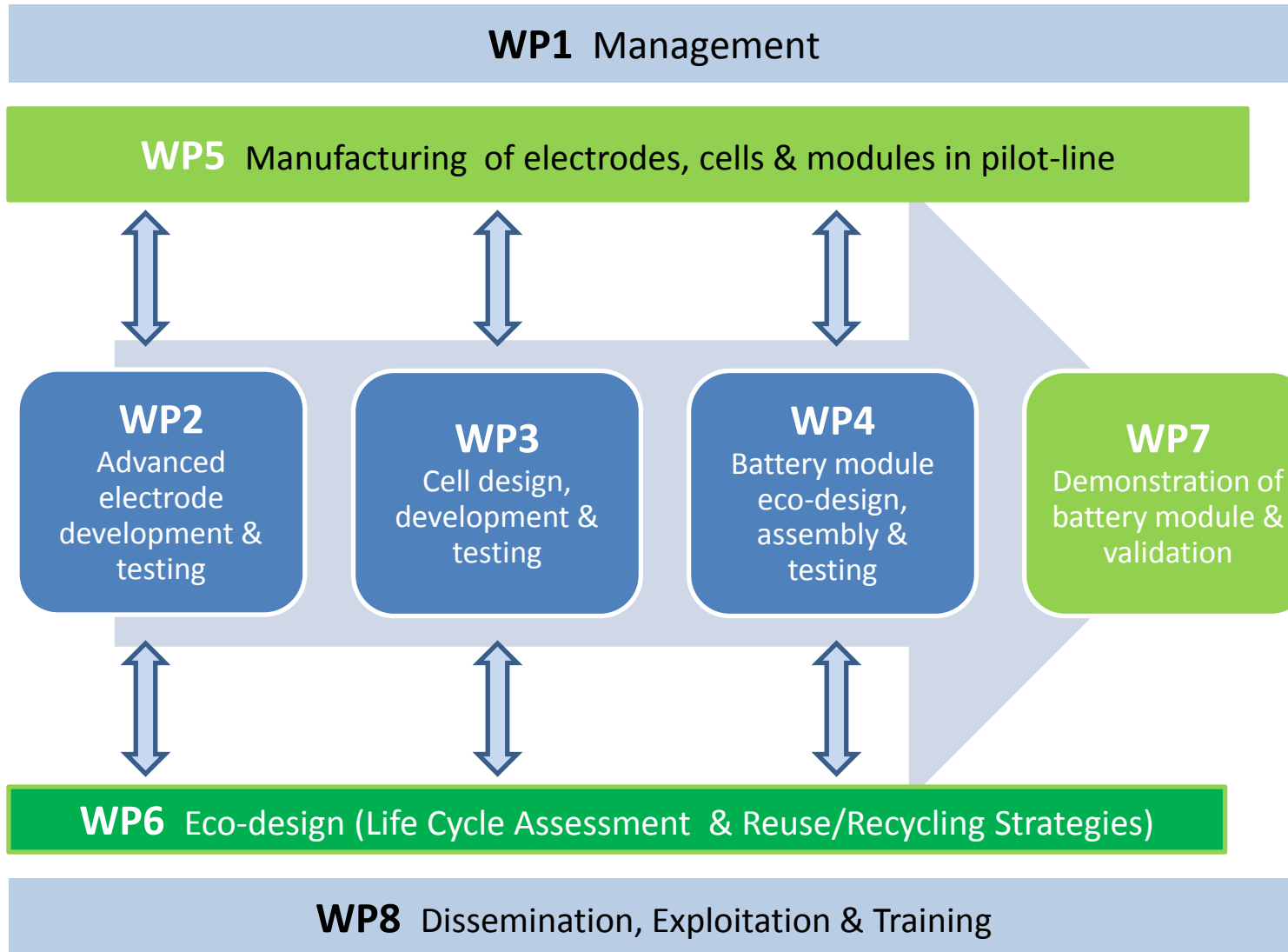
Degreasing and activation/primering of surfaces for structural bonding. Adhesives/glues with additives to activate easier disassembly for maintenance/reuse/recycling.

## - 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)



# WorkPackage structure



# Work Plan

WP	WP/Task name	Start	End	Year 1				Year 2				Year 3				Year 4			
				I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	<b>Management</b>	1	48																
	1.1 Project administrative coordination	1	48																
2	<b>Advanced electrode development and testing</b>	1	36																
	2.1 Battery materials for aqueous coating	1	36																
	2.2 Formulations and processes for aqueous coatings	1	30																
	2.3 Characterization and testing of electrodes	13	36																
3	<b>Cell design, development and testing</b>	1	42																
	3.1 Cell specifications and design	1	12																
	3.2 Cell assembly process optimization	3	36																
	3.3 Cell testing procedure	7	18																
	3.4 Testing and evaluation of Cells	13	42																
	3.5 Cell simulation/modelling	15	42																
4	<b>Battery module eco design, assembly and testing</b>	1	48																
	4.1 Battery module design	1	36																
	4.2 Battery module assembly processes development	19	42																
	4.3 Battery module testing procedure	25	30																
	4.4 Battery module testing	31	48																
5	<b>Manufacturing of electrodes, cells and modules in pilot line</b>	7	42																
	5.1 Electrode manufacturing process on pilot line	7	42																
	5.2 Cell manufacturing process on pilot line	13	42																
	5.3 Definition & design of battery module assembling processes	13	42																
6	<b>Eco Design (LCA, reuse and recycling strategies)</b>	1	48																
	6.1 Regulatory assessment REACH-CLP (GHS) aspects	1	34																
	6.2 Eco design	1	24																
	6.3 Life Cycle Analysis (LCA)	7	48																
	6.4 Recycling/Reuse Study	1	48																
7	<b>Demonstration of battery module and validation</b>	37	48																
	7.1 Specification of demonstrator and validation test plan	37	42																
	7.2 Battery pack production process validation	37	42																
	7.3 Testing and validation of the battery module	43	48																
8	<b>Dissemination, exploitation and training</b>	1	48																
	8.1 Training activities	1	48																
	8.2 Dissemination of project results	1	48																
	8.3 Exploitation of project results	1	48																

 Electrodes

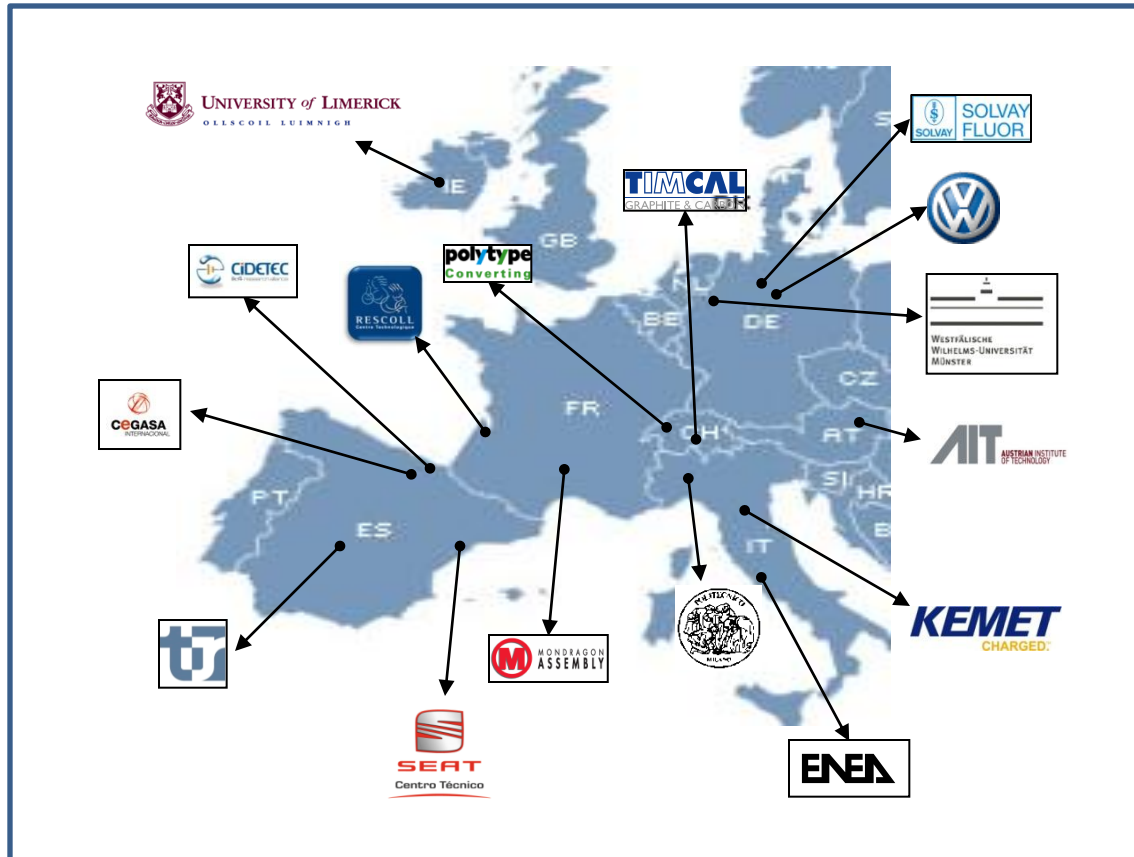
 Cells

 Modules

# GREENLION Consortium



















16 partners from 7 member states:



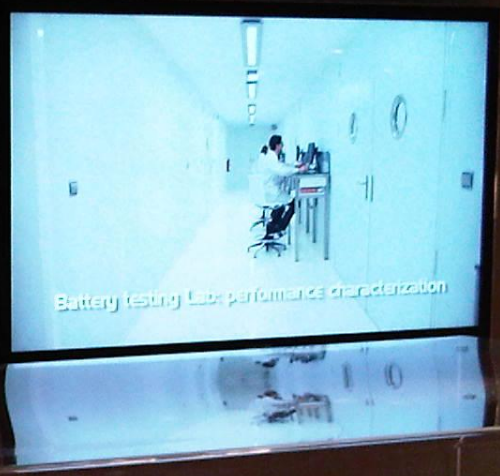
- 10 Industries (8 Large, 2 SME)
- 3 Research Institutes
- 3 Universities

# GREENLION Partnership and Roles



 <p><b>CIDETEC</b></p> <p>Management Li-ion module development (+BMS,+TMS) Testing of cells (incl. thermal)</p>	 <p><b>WWU</b></p> <p>Electrode formulation Optimization of cell assembly Testing of cells Recycling</p>	 <p><b>AIT</b></p> <p>Procedure development Testing (incl. Abuse) Equalization development HIL Validation</p>	 <p><b>UL</b></p> <p>Silicon Nanowire/ CMC and recyclable anodes</p>	 <p><b>POLIMI</b></p> <p>Natural binder choice Characterization of components Ionic liquid electrolytes</p>	 <p><b>ENEA</b></p> <p>Characterization of electrodes &amp; components Ionic liquid electrolytes Testing of cells and modules</p>	 <p><b>RESCOLL</b></p> <p>Bonding and sealing for cells and modules Regulatory issues &amp; LCA assessment</p>	 <p><b>CEGASA</b></p> <p>Manufacturing of Li-ion cells and module Battery module demonstrator</p>
 <p><b>SOLVAY</b></p> <p>Cathode material developer for aqueous electrode processing</p>	 <p><b>TIMCAL</b></p> <p>Development of a negative electrode material and conductive additives</p>	 <p><b>MASS</b></p> <p>Automated assembly line for the battery modules</p>	 <p><b>PCF</b></p> <p>Develop and optimize coating methods Electrode Coatings in pilot lane</p>	 <p><b>KEMET</b></p> <p>Cell assembly Laser notching of electrodes Manufacture of cells</p>	 <p><b>TECNICAS REUNIDAS</b></p> <p>Reuse/ recycling of cells or battery components Recovery of materials Waste treatment</p>	 <p><b>SEAT</b></p> <p>EV specifications for module development Validation of battery module</p>	 <p><b>VOLKSWAGEN</b></p> <p>Design of cell, module and system. Efficiency and geometry issues. Evaluation of materials</p>





*Thank you for your attention !!*