



ANGeLiC

ALD-protected Next Generation Lithium-Sulphur Battery Cell

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Project overview

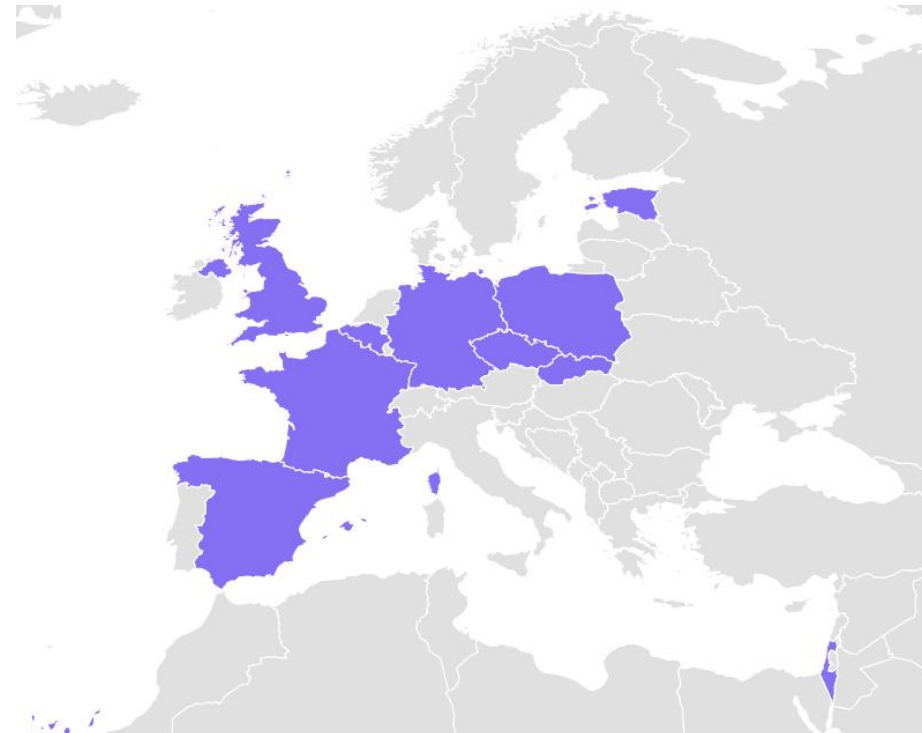
- **Full Title:** ALD-protected Next Generation Lithium-Sulphur Battery Cell
- **Acronym:** ANGeLiC
- **Grant Agreement No:** 101202842
- **Call:** HORIZON-CL5-2024-D2-02
- **Topic:** Post-Li-ion technologies and relevant manufacturing techniques for mobility applications (Generation 5) - Batt4EU Partnership
- **Duration:** 42 months (June 2025 - November 2028)
- **Total Budget:** 4 992 189, 13€
- **Coordinator:** MTU Civitta Foundation (Estonia)

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ANGeLiC project aims to develop cutting-edge lithium-sulfur batteries that unite high energy density, enhanced safety, affordable manufacturing, and functional excellence, advancing beyond current Li-ion capabilities.

11 partners, 10 countries

Partner	Country	Type
MTU Civitta Foundation (CIV)	Estonia	Non-profit Foundation, Coordinator
Centre for Advanced Materials Application (CEMEA)	Slovakia	RTO
Warsaw University of Technology (WUT)	Poland	HES
Fraunhofer IKTS	Germany	RTO
Imperial College London (ICL)	United Kingdom	HES
J. Heyrovsky Institute (HIPC)	Czech Republic	RTO
University College London (UCL)	United Kingdom	HES
CNRS (+2 affiliated entities: USMB, GINP)	France	RTO
POLYMAT	Spain	RTO
Technion	Israel	HES
Avesta Battery Engineering (AVESTA)	Belgium	Industry



Batt4EU Members: CEMEA, IKTS, WUT, CNRS
Battery2030+ Members: AVESTA, CNRS, IKTS, WUT

Project objectives

Five strategic objectives:

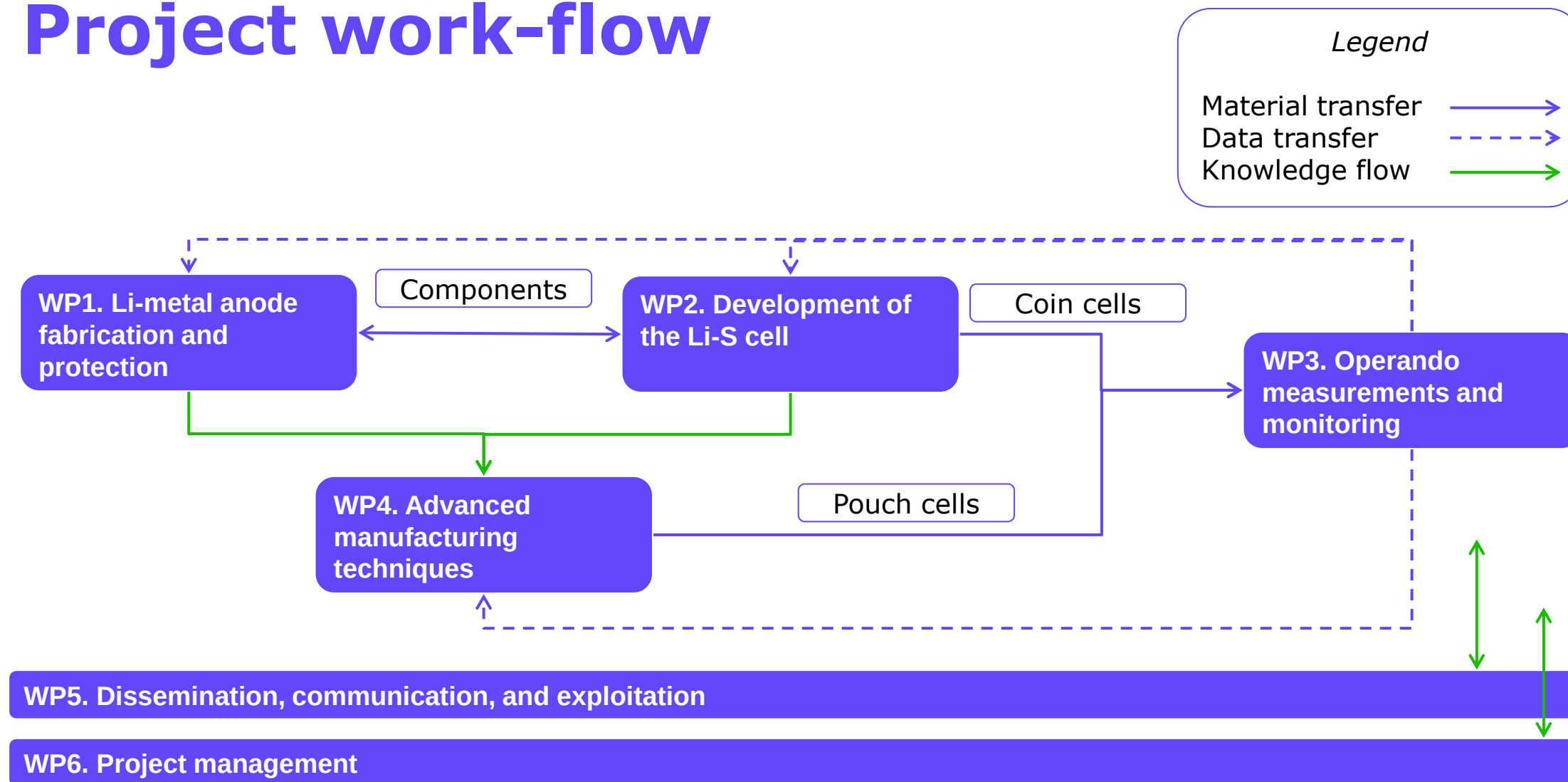
- **O1:** Develop Generation 5 Li-S battery cells with ALD/MLD protection techniques for anodes and cathodes (TRL 2→4)
- **O2:** Design high-capacity Li-S cells integrating innovative materials (sulphur-carbon cathodes, polymer electrolytes) (TRL 2→4)
- **O3:** Implement advanced operando measurement techniques for real-time monitoring (TRL 3→5)
- **O4:** Scale up and integrate advanced manufacturing processes (roll-to-roll Li anode deposition, ALD/MLD coatings) into pouch cell production compatible with existing Li-ion production lines (TRL 3→6)
- **O5:** Perform comprehensive techno-economic assessment and implement dissemination/exploitation strategy

Implementation

List of work packages

Nr	WP title	Leading partner	Duration (month)
1	Li-metal anode fabrication and protection Li electrodeposition, ALD/MLD coatings, polymer electrolyte coating, electrolyte additives	Centre for Advanced Materials Application (CEMEA)	1 – 41
2	Development of the Li-S cell New binders, ALD powder/cell protection, cell with liquid/polymer electrolytes	J. Heyrovsky Institute (HIPC)	1 - 36
3	Operando measurements and monitoring XRD, Raman, FTIR, EIS, multiparametric sensor	University College London (UCL)	6 – 41
4	Advanced manufacturing techniques Pouch cell – demonstrator, roll-to-roll Li electrodeposition	CNRS (+2 affiliated entities: USMB, GINP)	12 - 41
5	Dissemination, communication and exploitation	MTU Civitta Foundation (CIV)	1 - 42
6	Project management	MTU Civitta Foundation (CIV)	1 - 42

Project work-flow



Target KPIs (2030 Pathway)

Indicative KPIs to guide the R&I efforts:

Parameter	Target value	Pathway to achievement
Safety	EUCAR Level 4 (liquid) / Level 2 (polymer)	Multi-layer anode protection + polymer electrolytes + real-time sensor monitoring
Specific energy	500 Wh/kg (cell level)	Ultra-thin Li deposition (10-30 μm) + high-capacity sulphur cathode + optimized cell design
Volumetric energy density	600 Wh/l (cell level)	Compact cell architecture + efficient space utilization
C-rate	4C (liquid) / 2C (polymer)	Enhanced ionic conductivity through optimized electrolyte formulations
Cycle life	800+ cycles at 50% DoD	Prevented shuttle effect + stable SEI formation + protected cathode
Cost	< 75 EUR/kWh	Abundant materials (sulphur) + scalable R2R manufacturing + reduced material usage

Addressing key Li-S battery limitations

Challenge 1: Anode degradation (HSAL/dendrites)

ANGeLiC solution: Multiple complementary protection layers

- ALD/MLD ultra-thin coatings (precision nanoscale control)
- Polymer electrolyte application (mechanical stability)
- Electrolyte additives (engineered SEI formation)

Challenge 2: Cathode shuttle effect (polysulfide dissolution)

ANGeLiC solution: Multi-mechanism stabilization

- Macro-porous carbon matrices (physical trapping)
- Protective ALD coatings (barrier layers)
- High-entropy electrocatalysts (accelerated conversion)
- Advanced binders (chemical coordination)
- Optimized electrolyte compositions (fluorine-free salts and additives to reduce polysulfide solubility)

Challenge 3: Electrolyte limitations

ANGeLiC solution: Dual-track development

- Liquid: Fluorine-free salts + ALD-modified separators
- Polymer: Hybrid formulations with ionic liquids

ANGeLiC technologies

Technology	Innovation	TRL path	Key benefit
1. ALD/MLD Anode Protection	Ultra-thin protective layers eliminate dendrite formation	2→4	Safe lithium metal use with extended life
2. Protected S/C Cathode	Macro-porous carbon + ALD coatings + electrocatalysts prevent shuttle effect	2→4	Stable capacity over 800+ cycles
3. Anode protection with Polymer Electrolyte	Tape-cast thin layers provide mechanical stability	2→4	Enhanced safety through solid-state benefits
4. Liquid Electrolytes	Fluorine-free salts + novel additives minimize shuttling	2→4	Fast charging with reduced environmental impact
5. Polymeric Electrolytes	Ionic liquids overcome traditional polymer limitations	2→4	Solid-state safety with liquid-like performance
6. Li Electrodeposition Manufacturing	Roll-to-roll deposition (10-30 μm layers)	3→6	70% material reduction, scalable production
7. Embedded Mesh Sensors	Real-time monitoring without performance impact	3→5	Predictive safety and failure prevention
8. Advanced Binders	Water-based binders coordinate with polysulfides, provide mechanical stability	2→4	Enhanced recyclability and sustainable processing
9. Electrolyte Additives	Engineer protective SEI formation creating polymer/2D structures on Li-metal	2→4	Scalable, cost-effective dendrite protection

Expected impact

Measurable contributions to EU strategic goals:

Expected impact	Key deliverables and contributions
EI1: Scientific excellence & competitiveness	• 15+ open-access publications advancing Li-S state-of-art • Patent applications for novel protection and manufacturing techniques • 7+ core technologies progressed to demonstration readiness (TRL 4-6) • Long-term cooperation framework for 11 partners across 10 countries
EI2: Strategic independence & circularity	• Sulphur-based chemistry eliminates dependency on cobalt/nickel (critical raw materials) • Fluorine-free salts improve recyclability (facilitate metal recovery by preventing HF formation) • Modular, separable cell design enables easy disassembly • Water-soluble binders simplify end-of-life processing
EI3: Breakthrough innovation	• First demonstration of multi-layer ALD/MLD protection on Li-metal in Li-S cells • Integration of real-time sensor monitoring in pouch cell format • Roll-to-roll ultra-thin Li deposition (70% material reduction)
EI4: Climate neutrality	• Target application: Heavy-duty vehicles (28% of EU transport CO₂ emissions) • Enhanced safety enables wider EV adoption in commercial fleets • LCA-validated environmental benefits
EI5: Strategic collaboration	• Active reporting to Batt4EU Partnership KPIs • Contribution to Battery2030+ research roadmap • Industrial Advisory Board representing end-user requirements

Keep in touch!

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