Cadena de valor de las tecnologías de baterías disponibles y futuribles por la movilidad eléctrica y el estacionario

LEITAT Technological Center member of TECNIO

ACCIÓ Generalitat de Catalunya

Pla Auto

Value chain and battery technologies

Christophe Aucher
Area Manger Energy Storage

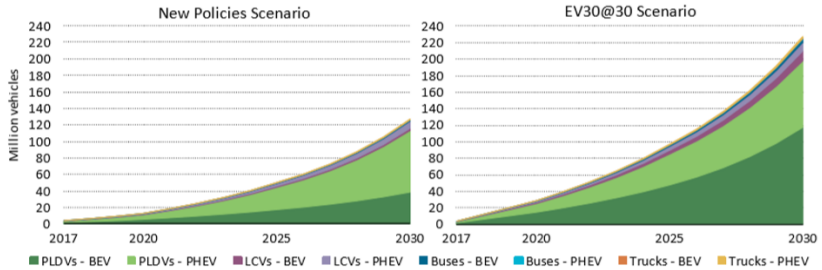
Outline

- Context: Regulation and electrification transition
- Actor of the values chains
- Battery manufacturer as key players on the value chain
- Public founding support action and technology roadmaping
- Raw material and the importance of the revers logistic value chain
- Diversification: Power **OR** Energy technologies
- LEITAT coordinating EU projects on Li-S since 2015
- Market opportunities
- Take away

Electrification, and electrification of transport is a reality

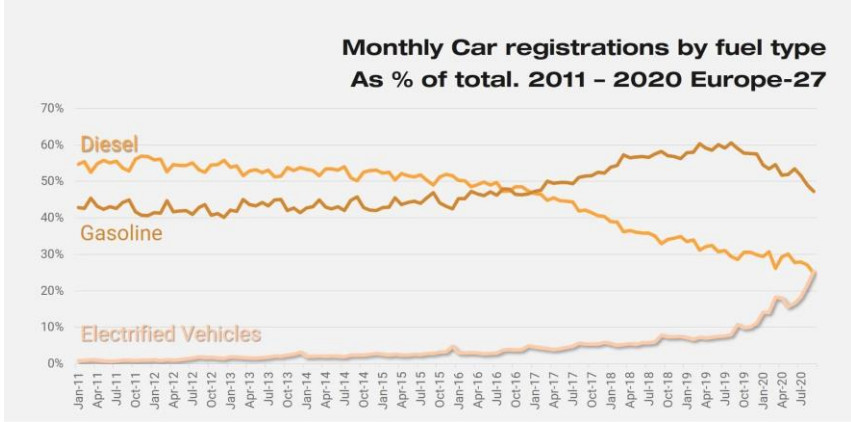
The past *The futur*

- EMIRI Roadmap: Total rechargeable battery market (dominated by Li-ion) is forecasted to reach $274 billion euros, or **€250 billion**, per year by **2025**, (80% for mobility)
- LiPLANET: By 2030, **600 GWh/yr** battery demand is expected for mobility, stationary, consumer electronics and machinery
- Council of the EU adopted Europe's first-ever CO_2 emission standards for trucks and other heavy-duty vehicles. Under the new rules, manufacturers will be required to cut carbon dioxide emissions from new trucks on average by 15% from 2025 and by 30% from 2030, compared with 2019 levels (June 2029)
- Strict regulation for car (Euro 6) and moto (Euro 5, January 2020) emissions
- Manufacturer responsibility and alignment with CAFE's bonus/penalization (€95 for each g/km above 95g/km)
- The battery cost ↓ 10 times less from 10 years ago
- Agenda 2030
- ....



Notes: PLDVs = passenger light duty vehicles; LCVs = light commercial vehicles; BEVs = battery electric vehicles; PHEV = plug-in hybrid electric vehicles.

Source: IEA analysis developed with the IEA Mobility Model (IEA, 2018b).



JATO

LG reportedly threaten to cut VW's battery cell supply for EVs over gigafactory plans

"We must not make ourselves dependent on a few Asian manufacturers in the long term," VW CEO Herbert Diess

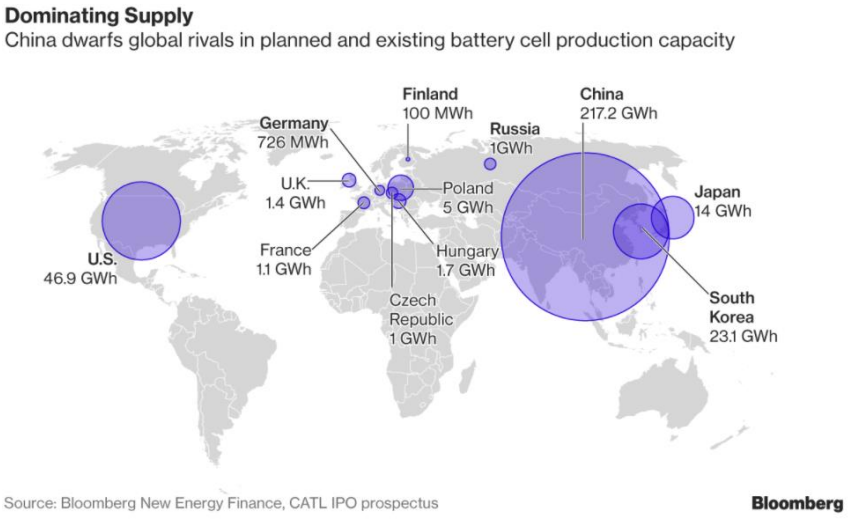
Source: Volkswagen Group's annual general meeting in Berlin, Germany, May 3, 2018. REUTERS/Axel Schmidt

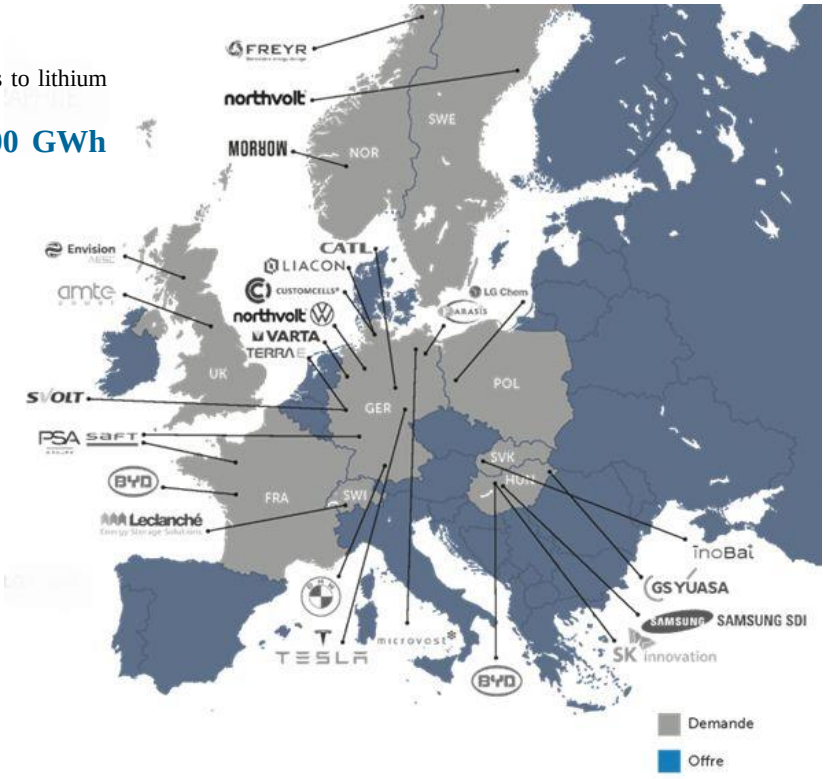
LG Chem, Samsung SDI, CATL and SK Innovation were all named as cell suppliers last year for the Volkswagen Group, which is on course to become the largest cell customer in Europe. In March VW Group said it was planning to launch 50 full-electric vehicles globally by 2025 and increase its range to nearly 70 battery-powered vehicles by 2028. VW will invest 30 billion euros in electromobility by 2023 and will require battery capacity of 150 GWh per year by 2025.

Global Li-ion battery manufacturing

❑ Asia and USA are leading Li-ion mass production market

- ❑ In Europe, lithium-ion cell manufacturer and capacity are lacking in the value chain
- ❑ Impacting on industrial sector (OEM, TIER1...)
- ❑ New economic opportunities for EU industry and Spain to supply secondary battery raw materials to lithium ion manufacturers.
- ❑ The LIB manufacturing capacity in **Europe** is witnessing a significant growth from **9 to 300 GWh from today to 2025**

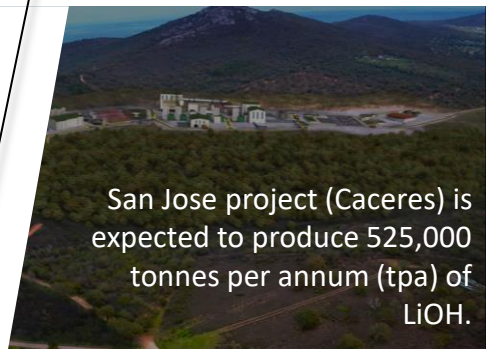


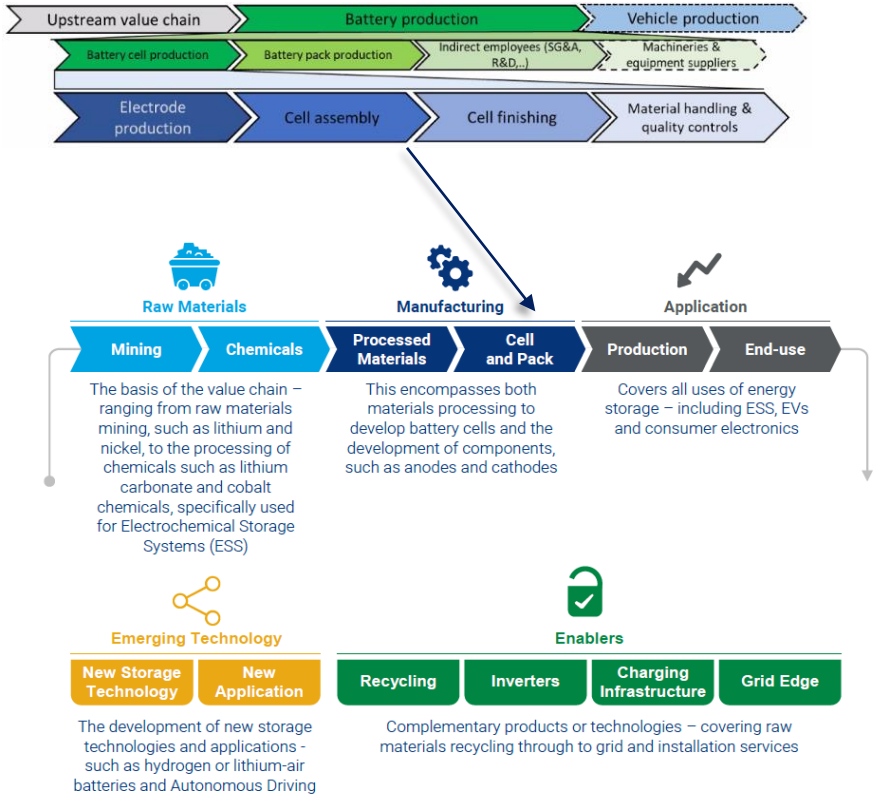


Actors of the battery values chains

- The future might be a mix of sources including fossil fuel, hydrogen and batteries following adapted parameters of use (cost, weight, volume, power, cycles, temperature...)
- (Technology) **Battery cell manufacturing is central** for the transition from fossil fuel to greener energy
- Europe is strong in all fields, except Li-ion battery cell manufacturing
- **Spain** is leading **non-lithium technology**
- Spain show opportunities for Lithium sources
- **Catalunya** has the unique **car brand 100% made in Spain**
- Catalunya show higher competitiveness on the value chain for integration (TIER, OEM, DSO)

cecasa EXIDE BATTERIES SEAT

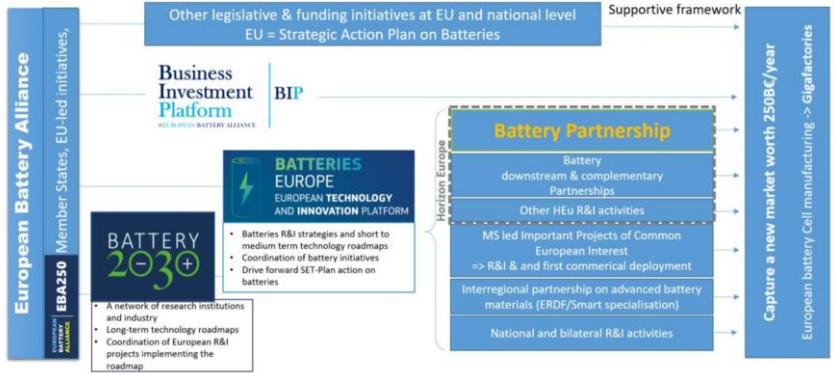




European battery roadmap

PPPs (2009-2013) European Economic Recovery Plan 26th November 2008	cPPPs (2017)	Horizon2020 Indicative budget Million €	cPPPs (2020)
Factories of the Future	Factories of the Future	1150	Factories of the Future
Energy-efficient Buildings	Energy-efficient Buildings	600	Energy-efficient Buildings
Green Cars	Sustainable Process Industry	900	European Green Vehicles Initiative
	European Green Vehicles Initiative	750	Sustainable Process Industry
	5G networks for the Future Internet	700	Photonics
	High Performance Computing	700	Robotics
	Robotics	700	High Performance Computing
	Photonics	700	Advanced 5G networks for the Future Internet
	Total	6200	Cybersecurity
			Big Data Value

Proposition of a Battery European Partnership



- **Onion like scheme**: EU Found -> National Funding (CDTI) -> Regional (ACCÍO)
- Case by case, Spanish reality is not German one
- European decision has been taken on the next technology to be developed principally dedicated to EV integration based on so called Generation 3 and 4, respectively for liquid and solid state electrolyte.
- Gen3 to be developed during 2020-2025 period, deal with Silicon doped Graphite as anode and NMC as cathode (Nickel, Manganese, Cobalt)
- 400M€ from 2019 to 2025 - Previous ETIP Battery Europe and European Battery Alliance led to 200M€ funding in LC-BAT framework topics call between 2019-2020. Next work program will be supported by the creation of new and specific PPP (Public Private Paternship) on battery called Battery European Partnership (BEP) with approximative similar budget for the next 4 years. BEP might be approved in January 2021.

Generation	1	2		3		4			5
		2a	2b	3a	3b	4a	4b	4c	
Type	Current	Current	State-of-the-Art	Advanced Li-ion HC	Advanced Li-ion HV	Solid State			Beyond Li-ion
Expected Commercialisation	Commercialised	Commercialised		2020	2025	>2025			
Cathode	•NMC/NCA •LFP •LMO	•NMC111	•NMC424 •NMC523	•NMC622 •NMC811 •NMC910	•HE NMC •Li-rich NMC •HVS	•NMC	•NMC	•HE NMC	•O_2 •S
Anode	•Modified Graphite •$Li_4Ti_5O_{12}$	Modified Graphite	Modified Graphite	Carbon (Graphite)+Si (5-10%)	Silicon/Carbon (C/Si)	Silicon/Carbon (C/Si)	Li metal		Li metal
Electrolyte	•Organic •$LiPF_6$ salts				•Organic+ Additives	•Solid electrolyte – Polymer (+Additives) – Inorganic – Hybrid			
Separator	Porous Polymer Membranes								

Advanced Materials for Clean and Sustainable Energy and Mobility EMIRI key R&I priorities

Lithium-ion battery raw material

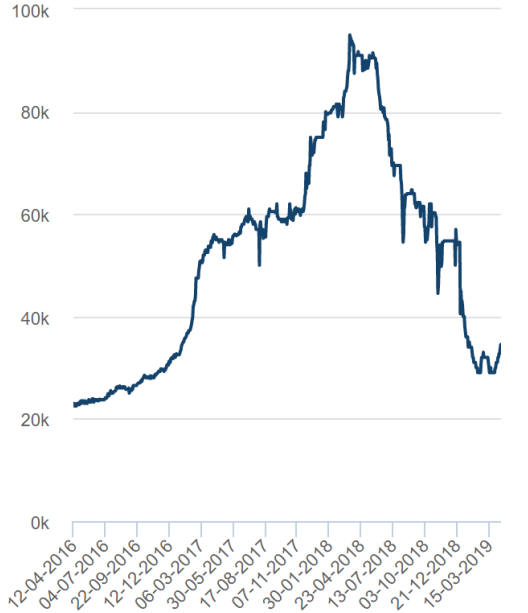
Sourcing of raw materials from Asia and the rest of the world; Li (78%) sourced in Latin America and Asia (~25%), Co from the Democratic Republic of Congo (68%), Silicon (53%) and Graphite (47%) from China. Cobalt, Silicon and Graphite are EU critical raw material. Lithium is in the list of critical raw material since 2020. Nickel might be critical raw material in < 5 years.

2020 Critical Raw Materials (new as compared to 2017 in bold)		
Antimony	Hafnium	Phosphorus
Baryte	Heavy Rare Earth Elements	Scandium
Beryllium	Light Rare Earth Elements	Silicon metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural Graphite	Vanadium
Coking Coal	Natural Rubber	**Bauxite**
Fluorspar	Niobium	**Lithium**
Gallium	Platinum Group Metals	**Titanium**
Germanium	Phosphate rock	**Strontium**

Figure 1: biggest supplier countries of CRMs to the EU

Source: European Commission report on the 2020 criticality assessment

Cobalt prices Apr. 2016 – Apr. 2019



Black Mass from EV battery pack

50 Ktons/years for recycling by 2030

Lithium	Manganèse
3	25
Li	**Mn**
6.9395	54,938044
Cobalt	**Nickel**
27	28
Co	**Ni**
58,933194	58,6934 (4)

Si from PV Panels

4.500 Ktons/years for recycling by 2030

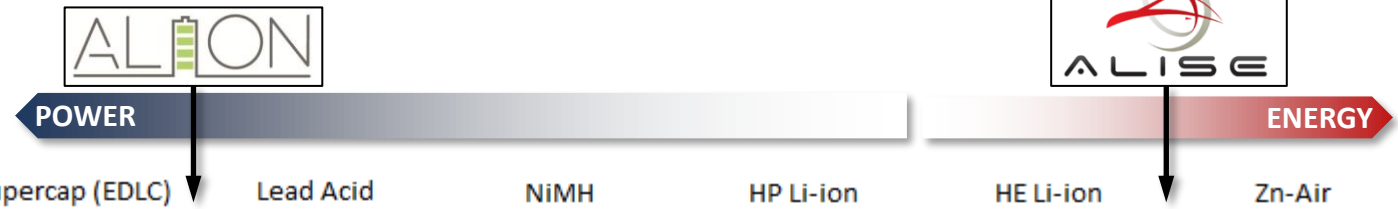
Silicium
14
Si
28,085 (1)

S from waste industry

7.000 Ktons/years from crude oil refining by 2019

Soufre
16
S
32,0675

Power or Energy Status

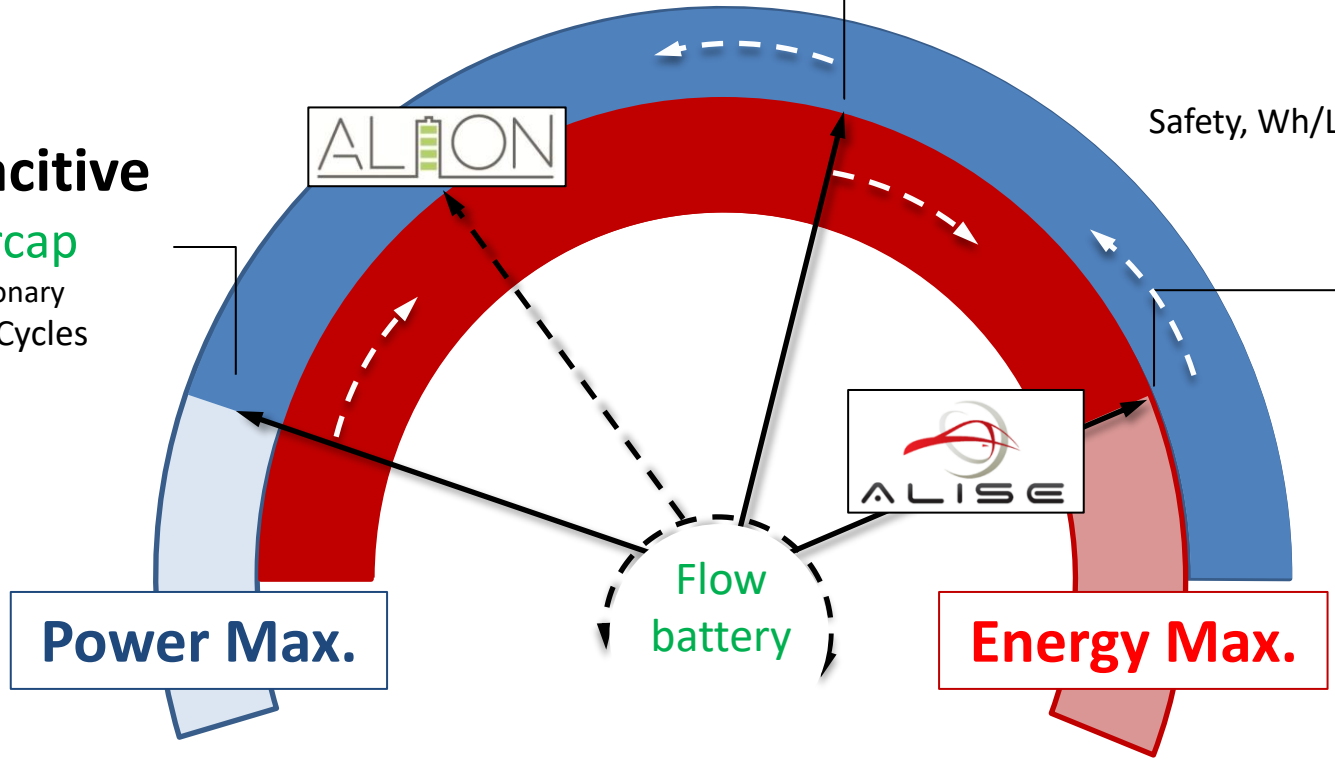


	Supercap (EDLC)		Lead Acid		NiMH		HP Li-ion		HE Li-ion		Zn-Air	
KPI	Min	Max	Min2	Max3	Min4	Max5	Min6	Max7	Min8	Max9	Min1	Max1
Specific Energy (Wh/L)	7	14	50	97	73	420	85	350	700	750	1.612	1.674
Nominal current (A)	770	2.960	4	30	0,21	43	0,8	350	1,5	10	0,001	0,06
Peak current (A)	770	2.960	12	75	0,21	43	50	700	10	20	0,001	0,06
Capacity (Ah)	0,6	2,7	0,8	5,5	0,07	6	3,2	5,2	3,2	5,2	0,035	0,9
Nominal Voltage (V)	2,3	3	2	2	1,2	1,2	3,2	3,3	3,5	3,85	0,8	1,4
Temperature (ºC)	-40	70	-20	70	-20	70	-40 (0)	60	-30	60	-10	50
Cycles	100.000	100.000	200	500	300	1.000	2.000	15.000	300	1.000	1	1

Type	Other	Secondary	Secondary	Secondary	Secondary	Primary
Chemistries	C	PbO2, Pb	Ni	LTO, LFP, G	LCO, NMC, LMO, NCA, C	Zn, O2
DoD (%)	100	40	80	80	80	100
Typical format	Prismatic	> 6V pack	Cylindrical	Cylindrical 18650	Cylindrical 18650	Button cell
Typical application	Grid stabilization	ICE starter	Hybrid ICE	Renewable Stationary	E-mobility	Hearing aid

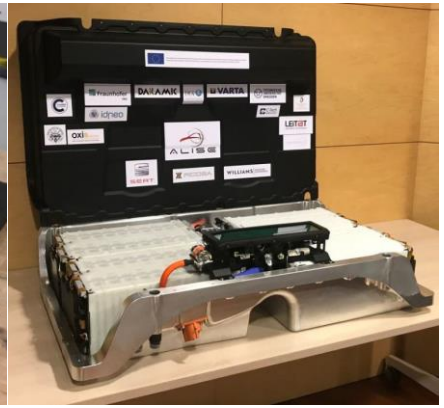
http://www.batteriesdatabase.com **(Shmuel De-Leon Energy, Ltd.)**

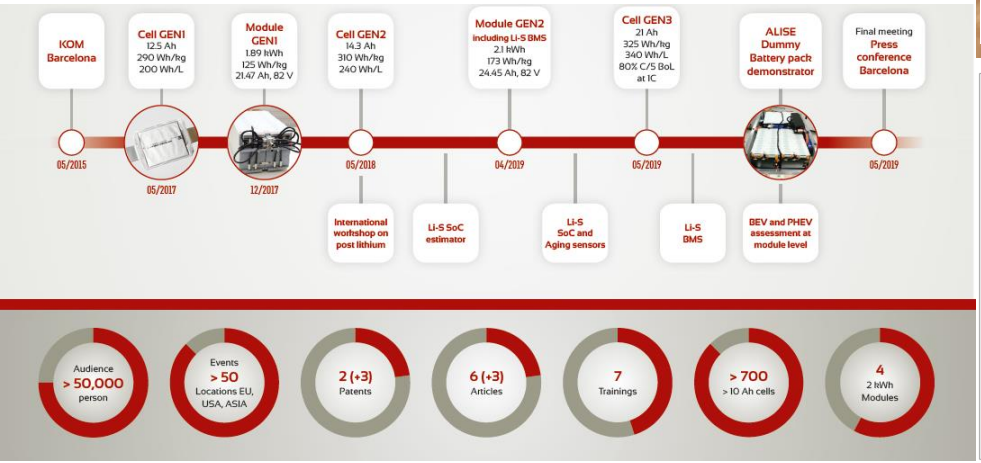
Power or Energy and associated Challenges

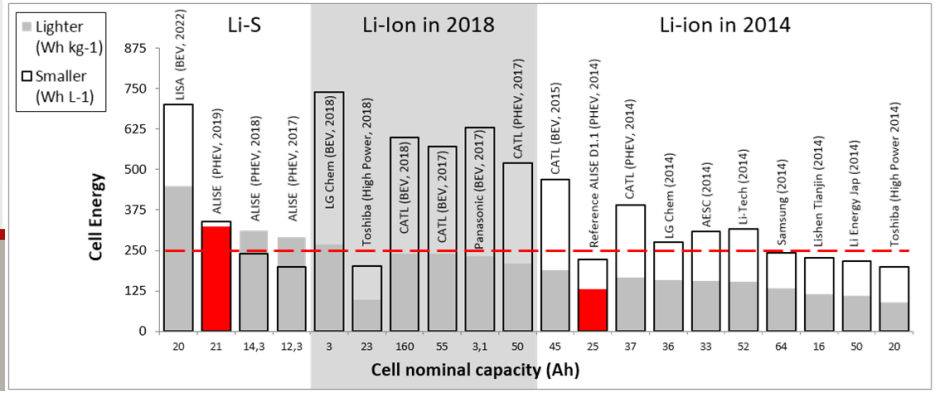


LEITAT is coordinating EU projects on Li-S for EV since 2015

- https://egvi.eu/project-highlight/alise-project/
- Lithium Sulphur achievements in 2019 is 440 and 360 Wh kg^{-1} respectively at C/10 (10 hours discharge) and at C/5 (5 hours)
- ALISE demonstrators reached 325 Wh kg-1 (x2.5 our reference), 340 Wh L^{-1} at C/5 (5 hours), 21 Ah, 80% of the C/5 BoL at 1C
- Li-S behaves similar respect Li ion with slight **increase in electrical range** +2% and +10% respectively for BEV and PHEV, -15% **decrease in weight**, within the **same volume** and optimistic scenarios, i.e. evaluated in optimal and limited temperature and current rate







ALISE

- Powder to Car: Materials, Cell components, cell manufacturing, sensor, SoH estimator, BMS, module, battery pack
- 50% partners dedicated to materials TRL <5
- 50% partners dedicated to integration
- Technology validation: Performances, cost, safety

LISA

- **Powder to Power to Powder**: Materials, Cell components, cell manufacturing, SoH estimator, recycling.
- **Upscaling**: material and process for cell components
- 50% budget **dedicated to lithium anode and solid-state electrolyte**: material research and manufacturability
- **Technology validation**: Reliability (20Ah, 450Wh/kg, 700Wh/L, 700 W/kg, 1.000 cycles), cost (70€/kWh), safety, sustainability (50%wt)

Market opportunities from ICE to EV transition

Safety

- Device integration (battery cell, electronics, sensors, IA...)
- Postmortem (accident, fire...)
- Processes manufacturing, integration, second use recycling...

Transition in business

- Balancing the loose of volume activities related to ICE to reach new development specific to EV
- Domino impact ⇒ OEM ⇒ TIER1,2 and 3 ⇒ Component, material provider ⇒ chemical industry ...

Niche market opportunities

- Not enough lithium-ion battery cell for all + specific use case with specific parameter not compatible with Lithium ion
- Second life to less demanding application (stationary)
- Non-car application: large heavy pack (truck, bus), light pack (space, aeronautic), high temperature...

Formation

Skill gaps identified which can create serious bottlenecks

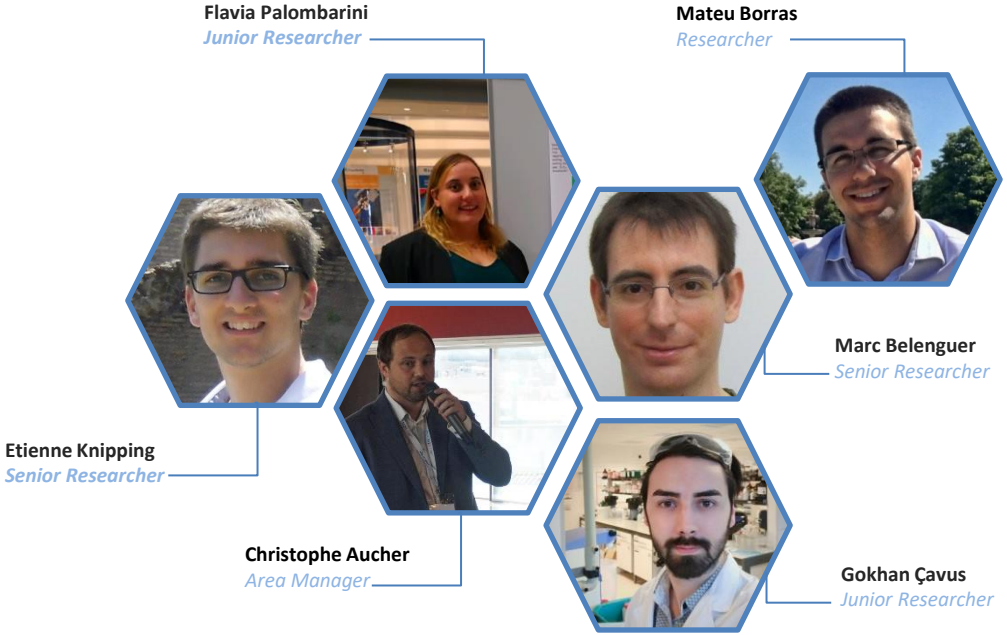
- Material design
- Electrode and Cell design and manufacturing
- Product integration
- Battery management
- Process design for large-scale manufacturing

Take away

Christophe Aucher
Area Manager LEITAT Energy Storage

- Existing guidelines and working groups driving material, technology and integration development
- Material, technologies, advantages and barriers are already well identified
- Application is driving technology, and technology is driving material selection
- Application is limited by available technologies limitations
- Manufacturing concepts must consider existing production, and TRL value chain
- New opportunities from a real EU (public/private) motivation to be competitive
- New business opportunities link to the electrification

Thanks for your attention



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ABOUT LEITAT

Established in 1906, Leitat is a private non-profit organization expert in offering disruptive solutions to the technological needs of companies and entities, with a clear orientation towards generating competitive value and a sustainable future.

MISSION

We manage technologies to create and transfer social, environmental, economic and industrial sustainable value for companies and entities through research and technology processes.

VISION

Be a referent at global level in managing innovative technologies and reinforcing people creativity and talent.

LEITAT managing technologies

FACILITIES

Leitat has several work centers around Spain, with cutting-edge facilities which respond to specific technology areas:

9 MULTIDISCIPLINARY AREAS:

- Health & Biomedicine
- Applied Chemistry & Materials
- Artificial Intelligence & IOT
- Advanced Manufacturing & 3DP
- Circular Economy
- Food
- Energy & Engineering
- Robotics
- Advanced Technological Solutions

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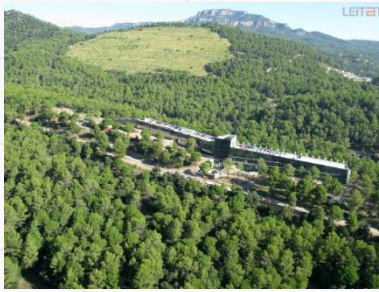
Valencia
Biopolo La Fe

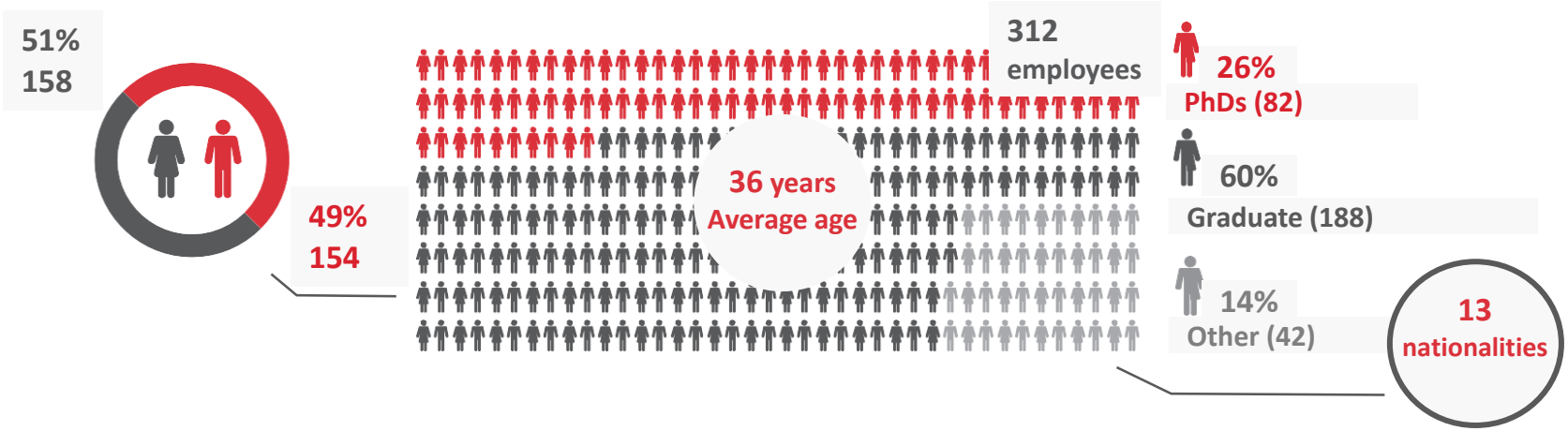


LEITAT Terrassa

LEITAT Barcelona

TEAM

Our team is formed of high-skilled professionals with know-how and experience in several knowledge areas, being specialized in technology transfer.



VALUES

We work with enthusiasm and a self-improvement attitude to solve our clients' technological challenges, we act with respect to create cooperative and reliable professional relationships, and we carry out our activities protecting the environment.

LEITAT Energy Storage lab overview

Si and Li anodes

- Si-doped graphite aqueous formulation and coating
- Li anode for either LiO_2 or Li-S
- 3D microstructured Li
- Lithium functionalization (patent)

Dielectric

- Aqueous, organic, RTILs, gel, SPE, ceramic
- RTILs and mixture for LiO_2 and Li-S
- SPE and Ionogel for Lithium-ion
- Separator functionalization (patent)
- Nanocellulose binder and separators
- Chemical fuse / self healing concept

Cathode

- Electrospun Si-LFP GDL, and others
- Nanomaterials LFP, S/C and others
- Surface functionalization (patent)
- Catalysts

Testing

Electrical-Thermal-Electrochemical

- Cyclic voltammetry
- Chronoamperometery
- Chronopotentiometry
- Rotating disk voltammetry
- Linear sweep voltammetry
- Electrochemical impedance spectroscopy
- Charge/discharge profiles
- Cycle life
- Pression / Temperature
- UN38.3 (T1, T2, T5, T6, T7 and T8)

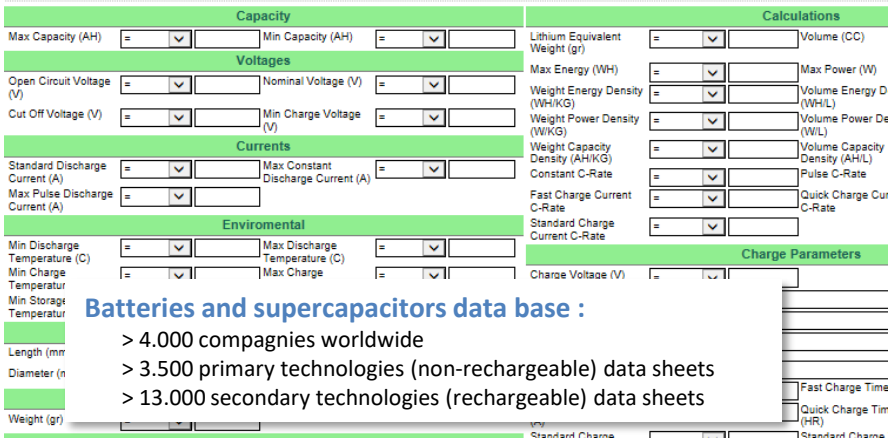
Optical-Physical-Chemical

- DSC (thermal working window)
- TGA
- Elemental analysis
- Water content
- Conductivity
- Rugosity
- Inks: Grindometer, Rheometer, adhesion
- Contact angle and Surface tension of different membranes in contact with electrolyte
- ...

LEITAT Energy Storage Technology benchmarking

Our >10 years core expertise related to chemistry and electrochemistry from supercap, flow battery, lithium ion, and post-lithium technologies (i.e. Al-ion, Al-air, Li-S, Li-O_2), among others, which is allowing us:

- To assess the best technology for our customer from data sheet
- To assess in test bench for simulating real use case condition
- To ensure reliable communication between technologies enabler and our customers
- To save the time of our customers (i.e. technologies and providers)



- 16 kW, 130 Vcc, 192 Acc
- 350 L (650x720x750mm3),
- Temperature -40 < ºC < 180,
- Heat rate 3.5K/min, Cooling rate 4K/min,
- Humidity 10 < % < 98

LEITAT Energy Storage collaborative projects

Since 2011, LEITAT Energy Storage team has been participated to > 15 industrial private projects, > 20 founded projects and 4 coordinated projects

1. **O2FREE** [H2020 CleanSky, SYS-01-22], Metal-air battery integration for cargo compartment fire suppression, 2020 – 2022, **LEITAT co-ordination**.
2. **ASTRABAT** [H2020-SC-LC-BAT-01, nº875029], All Solid-sTate Reliable BATtery for 2025, 2019-2023
3. **CoFBAT** [H2020-SC-LC-BAT-02, nº875126], Advanced material solutions for safer and long-lasting high capacity Cobalt Free Batteries for stationary storage applications, 2019-2023
4. **TRREX [CIEN],** Robótica de rango extendido para la fábrica flexible, 2017 - 2020 https://projects.leitat.org/trrex/
5. **eMIM [ESA Tender],** Electrosprayed Metal-nanoparticle-Metal (eMIM) capacitor for energy storage, 2018-2019.
6. **LIBERATE [H2020-CE-SPIRE-02-2018],** Lignin Biorefinery Approach using Electrochemical Flow, http://www.liberate-project.eu/, 2019-2022, **LEITAT co-ordination**.
7. **LISA [**H2020-LC-NMBP, GA nº814471-2**]** Lithium sulphur for SAfe road electrification, https://www.lisaproject.eu/, 2019 – 2022, **LEITAT co-ordination**.
8. **GREENSENSE** [H2020-PILOT-NMBP, GA nº761000-2] Sustainable Nanocellulose-based Quantitative DoA Biosensing Platform, https://www.greensense-project.eu/, 2017-2021, **LEITAT co-ordination**.
9. **PRESTIGE** [H2020-NMBP, GA nº761112-2] Design-driven integration of innovative PRinted functional matErialS into inTeractive hIgh-end and fashion consumer Goods addressing tomorrow's societal challenges, 2017-2020
10. **AURORA 4.0** [H2020-SMEINST-1, GA nº782927] Production line of battery packs for telecommunications application, 2017.
11. **HDBAT** [H2020-SMEINST-1, GA nº790643] High Density Batteries for e-Mobility and Industrial Automated Guided Vehicles, 2017-2018.
12. **ENERGYKEEPER** [H2020-LCE, GA nº731239] Keep the energy at the right place (aqueous polymeric flow battery integrated in electrical grid), http://www.energykeeper.eu/, 2017-2020.
13. **POROUS4APP** [H2020-NMBP-PILOT, GA nº686163] , http://www.porous-4app.eu/, Pilot plant production of controlled doped nanoporous carbonaceous materials for energy and catalysis application (carbon for lithium ion, LiO_2 and LiS, and other applications), 2016-2020, **LEITAT co-ordination**.
14. **ALISE** [H2020-NMBP, GA nº666157] Advanced lithium sulphur battery for xEV, https://egvi.eu/project-highlight/alise-project/, 2015-2019, , **LEITAT co-ordination**.
15. **ALION** [H2020-NMBP, GA nº 646286-2] High specific energy aluminium-ion rechargeable decentralized electricity generation sources, http://alionproject.eu/, 2015-2019, **LEITAT co-ordination**.
16. **BASMATI** [H2020-NMBP-PILOT, GA nº 646159] Bringing innovAtion by Scaling up nanoMATerials and Inks for printing. (Industrial-scale production of nanomaterials for printing applications, lithium ion), http://basmati-project.com/, 2015-2017.
17. **NanoCaTe** [FP7-NMP, GA nº604647] Nano-carbons for versatile power supply modules (TEG, lithium ion, supercap), http://nanocate.eu/, 2012-2017.
18. **ARGOS** [Horizonte PYME, GA nº697192] Aluminium-air primary Cells for growing Energy storage markets, 2015.
19. **STABLE** [FP7-GV-NMP, GA nº314508] STable high-capacity lithium-Air Batteries with Long cycle life for Electric cars, http://www.fp7-stable.com/, 2012-2015.
20. **PRINT4PACK** [OLAE] Low cost integrated autonomous RF temperature sensors for food packaging, 2012-2014.
21. **LIQUION** [CENIT], Investigación en Tecnologías de Líquidos Iónicos para Aplicaciones Industriales (ionic liquid for aluminium electroplating), 2010-2013.