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ASSOCIATION OF EUROPEAN AUTOMOTIVE AND INDUSTRIAL BATTERY MANUFACTURERS

Welcome

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Presentation Battery Innovation Roadmap 2030

Christian Rosenkranz, EUROBAT Technical Cluster Leader and Vice President Industry & Government Relations EMEA, Clarios

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Battery Innovation Roadmap 2030

Purpose

- Highlights the **strong innovation potential** of all battery technologies, looking forward to 2030.
- Shows how different technologies **contribute to EU decarbonisation** and **« Green Recovery »** net-zero pollution targets.
- Makes **recommendations to EU policy-makers** on the **Batteries Regulation**, based on the **EUROBAT Election Manifesto**, aiming to:
  - ✓ Secure future **EU investment**
  - ✓ Enhance **growth, skills and jobs in the EU**
  - ✓ Create a **level playing field for all technologies**

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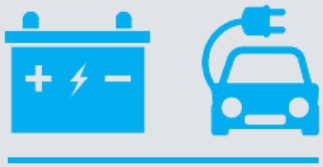
Battery Innovation Roadmap 2030

Scope: 4 Areas – 12 Battery Applications

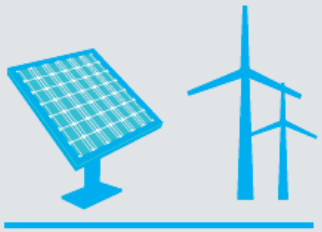
AUTOMOTIVE

Batteries contribute to the decarbonisation of the European transport sector - reducing CO_2 emissions via start/stop batteries and innovative solutions in xEVs



STATIONARY ENERGY

Batteries are indispensable for storing renewable stationary energy coming from solar and wind farms in on grid and off grid solutions.They also contribute to a more stable and reliable grid.



MOTIVE POWER

MATERIAL HANDLING

Batteries are a perfect fit for powering industrial vehicles such as forklifts and cranes, while also reducing noise and emissions.

MOTIVE POWER

OFF-ROAD TRANSPORTATION

Batteries are widely used in rail, marine and air transportation. The concepts of smart charging of road vehicles to support the energy system is also relevant for off-road because their wide deployment and large energy capacities

- **No one-size-fits-all battery technology**
- **Battery Innovation is an ongoing process**, driven by the **requirements of applications**
- **Europe's battery sector has for decades had a market-driven innovation approach** to meet new demands

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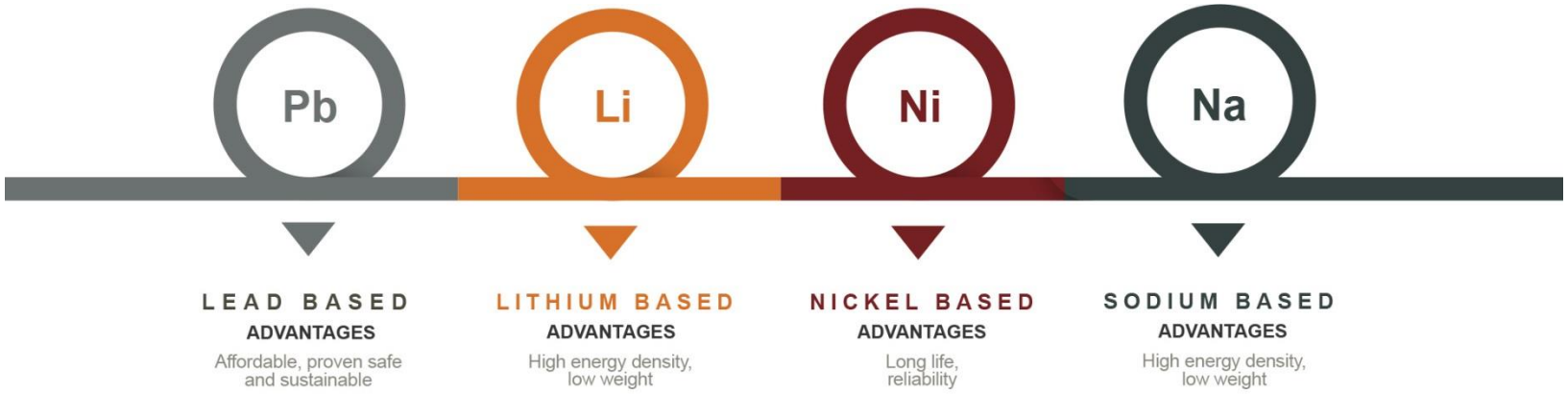
Battery Innovation Roadmap 2030

Scope: **Mainstream Battery Technologies**



- **Market-driven R&D** has resulted in a variety of **lead-, nickel-, lithium- and sodium-**based battery products on the market today.
- **All battery chemistries have further innovation potential** towards 2030 and contribute to the EU's decarbonisation goals.
- In consultation with **CBI** (Consortium for Battery Innovation) and **RECHARGE**

CONSORTIUM FOR BATTERY INNOVATION

RECHARGE

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Battery technologies: Performance targets 2020 - 2030

Overview of Key Performance Indicators per technology:

		Lead based Technology		Alkaline Technology		Lithium-Ion	
		Pb 2020	Pb 2030	NiX 2020	NiX 2030	Lithium Ion 2020	Lithium-Ion 2030
Electrochemical -System	Cathode	PbO_2	PbO_2	β–NiOOH	β–NiOOH	NCM 111 (Gen.2a); NCM 523-622 (Gen.2b), LFP, LMO, LCO,NCA	NCM 622 –NCM811 (Gen.3a); NCM811, HE-NCM, HVS (Gen.3b); Solid State
	Anode	Pb, Pb+C	Pb, Pb+C	Cd, MH	Cd	LTO, C (Gen.2a, 2b)	C+ Si (5-10%) (Gen.3a); Si/C (Gen3b)
Energy Density [Wh/kg]	Cell	24 - 48	30 - 60	28 – 50	30 - 55	60 - 250	300 -450
	System	23 - 45	35 - 55	24 -43	38 - 50	20 - 140	80 - 400
Energy Density [Wh/l]	Cell	60 - 105	80 - 150	55 – 80	60 - 90	140 - 580	650 - 1100
	System	36 - 100	50 - 110	47 – 70	50 - 75	20 - 250	100 - 1000
Power Density [W/kg]	Cell	34 - 448	80 - 505	80 – 225	100 - 240	210 - 1800	450 - 1100
	System	41 - 400	65 - 450	68 – 180	80 - 210	170 - 520	250 - 700
Power Density [W/l]	Cell	91 - 880	120 - 920	112 – 400	120 - 460	470 - 2200	800 - 2500
	System	76 - 840	72 -900	95 – 350	100 - 380	180 - 650	600 -1200
Lifetime	FCE (Full Cycle equivalent)	200 - 2500	1000 – 4800	3000	4000	> 3500	>10.000
	Calendaric Lifetime [a]	10 - 25	10 - 25	20	20	10	15 - 25
Operation Temperature range [°]		- 25 - +50	- 25 - +50	- 50 - +60	- 50 - +60	0 … +45 °C charge -20 … +60 °C dischage -30 … +55 (LTO)	-30 … +60
Energy efficiency [%]		67 - 85	> 90	70 – 85	> 85	> 90	95
Recycling	Efficiency (% of average weight)	90	90	79	80 - 85	50	80 - 85

Key takeaways

- 3 major chemistries show **different strengths and innovation potential** in next 10 years, underlining complementarity, driven by **application**.

- EUROBAT **Innovation Roadmap** uses the following dimensions:
  - Specific & volumetric power and energy
  - Calendaric and cycle life time
  - Energy efficiency of charge & discharge
  - Environmental operating conditions
  - Recycling efficiency
  - Raw material mix and development potential

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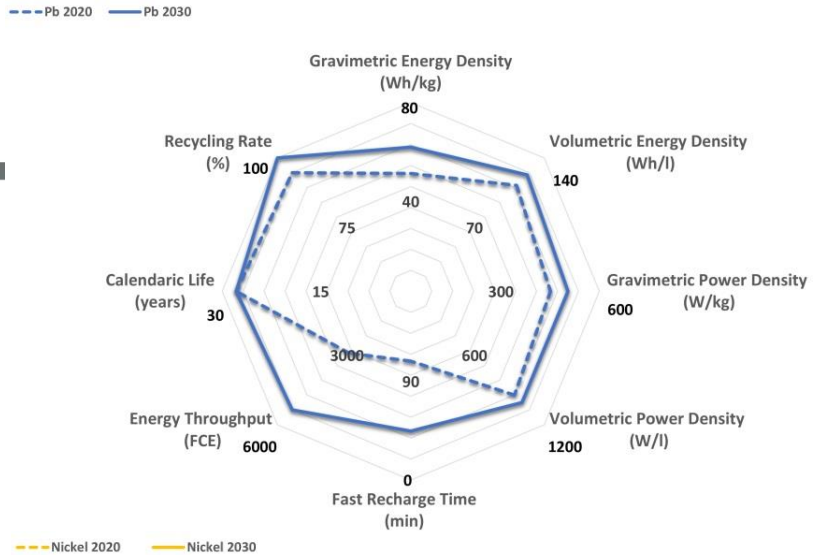
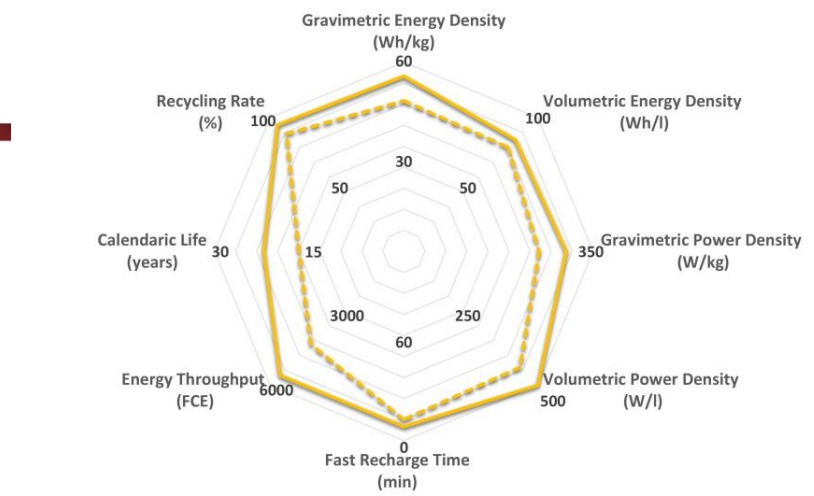
Battery technologies: performance targets 2020 - 2030
Lead- and Nickel based





Lead-based batteries

Strengths:

+ Recycling efficiency
+ Calendaric life (stationary)
+ Functional safety

Development potential :

- Rechargeability (automotive)
- Cycle life time (stationary)

Nickel-based batteries

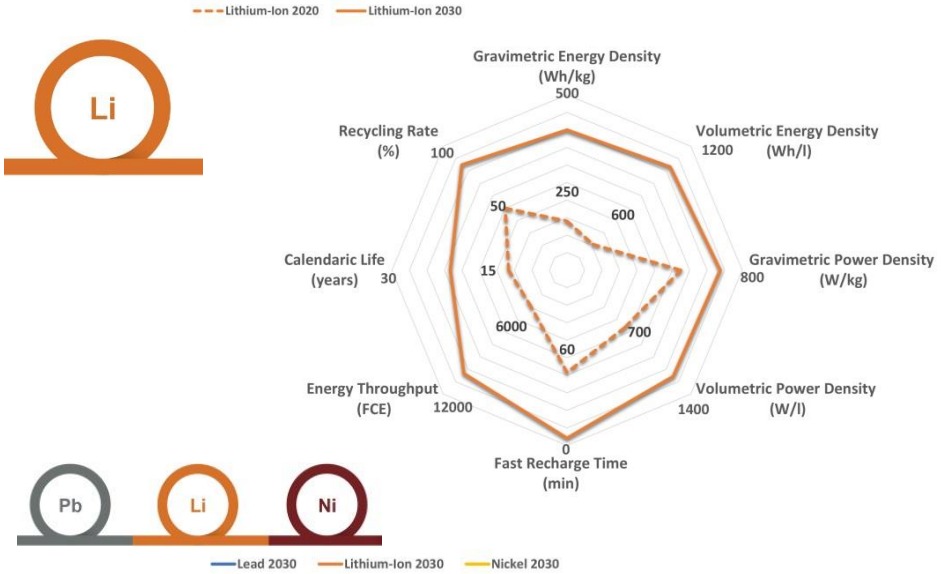
Strengths:

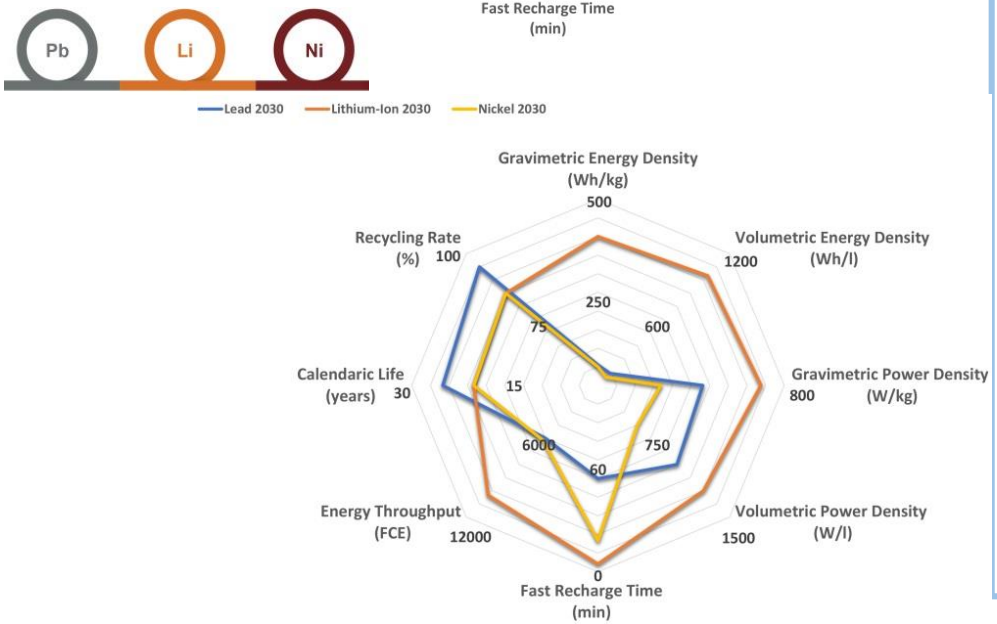
+ Cold temperature performance (NiCd)
+ Fast recharge time

Development potential:

- Cycle life
- Calendaric life

Battery technologies: performance targets 2020 - 2030
Lithium and Summary





Lithium-based batteries:

Strengths:

+ Specific energy density
+ Specific power density
+ High cycle life

Development potential:

- Recycling efficiency (& material sourcing)
- Calendaric life

Comparing the 2030 outlook:

- ❑ Li-ion: newest chemistry with highest development potential for coming 10 years
- ❑ The established chemistries prove their right of existence due to:
  - Affordability
  - Proven and reliable functionality
  - Circular economy aspects

Battery Innovation Roadmap 2030
Area 1: Automotive Mobility

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- **Micro-and Mild Hybrid Vehicles** use 12V Start-Light-Ignition batteries and 12V Start-Stop batteries (> 80% new vehicles in 2019). **99% of new cars utilise Pb-batteries**.
- **Key areas of development**: capture **regenerative braking energy,** improve **dynamic charge acceptance**, **better temperature robustness**
- Dominant technology by 2030: Pb-based, Lithium to penetrate with few percentages

- **PHEV and EV traction batteries**: mainly Li-on, LFP or NMC
- **Key areas of development**: **volumetric energy density** and **preventing thermal runaway**
- Solid state will help to increase the energy content and the security aspects in case of an accident or other high physical stress
- Dominant technology by 2030: Lithium-based

- **12V Auxiliary Batteries are used in ICEs and x-EVs to support the 12V on-board net**, majority lead-based as an affordable and reliable energy source.
- **Key areas of development**: increase **cycling life, energy efficiencies**
- Dominant technology by 2030: Pb-based, lithium to penetrate with small percentage

- **Heavy Duty Commercial Vehicles**: Total cost of ownership is KPI for fleet operators
- **Key areas of development:** support **hotelling functions** through better energy supply and deep-discharge capability.
- Dominant technology by 2030: Pb-based

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Bernhard Riegel, EUROBAT TF Innovation Leader and Director R&D Hoppecke Batteries

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Battery Innovation Roadmap 2030
Area 2: Motive Power – Material Handling & logistics

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- **Material handling & logistics market:** mainly Pb batteries in forklifts (+/ 90% market share).
  - ✓ **Noise and emissions legislation**: battery forklifts replace ICE (73GWh by 2030).
  - ✓ **Lead** to remain dominant (2030: 80% market share vs 15-30% for Li).
  - ✓ **Key advantages for Pb**: counterweight and standardisation
- **Key areas of development**:
  - ✓ Cycle life, charge efficiency, fast charge in a wide temp range and PSOC cyclability.
- **Dominant technology in 2030**: Pb

- **Automated Guided Vehicles and Carts (AGV/AGCs):** transport systems operating without direct human interaction and powered by lead, NiCd and lithium batteries.
- **Key areas of development:** high volumetric energy and power density, broad operation temp range and cyclability.
- **Dominant technology in 2030:** Li

Battery Innovation Roadmap 2030
Area 3: Motive Power – Off-Road Transportation

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- **Railway batteries and railway standby:** used in various applications today; mainstream technologies: NiCd, lead and lithium.
- **New applications for battery systems**: hybridization and electrification of rail power traction. High energy, power density and cyclability suit **lithium systems** best and fastest growing battery segment for railway applications.
- **Key areas of development:** volumetric energy density, lifetime and operation temp range.
- **Dominant technology in 2030 traction:** Li **auxiliary:** Ni, Pb

- **Marine sector** strong contributor to CO2 emissions and pollution. Lithium used for hybrid/pure electric propulsion, lead for on-board auxiliary services.
- **Key areas of development**: gravimetric/volumetric energy density and cyclability
- **Dominant technology in 2030 traction:** Li **auxiliary:** Pb

Battery Innovation Roadmap 2030
Area 4: Stationary Energy Storage Batteries Telecom/UPS

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Global Telecom and industry (UPS): biggest segments in "stationary" market with highest volume and growth in EU. UPS: data centres and commercial/industrial/health facilities; security, emergency lighting.

- **Uninterrupted power supply** (**UPS**): lead is the dominant technology providing instant power if the main power source fails. Existing market with new requirements where **Lithium** will have 7-18% market share by 2030.
- **Key areas of development:** power density, charge acceptance, high temperature float life and fast rechargeability
- **Dominant technology in 2030**

Pb

- **Telecom**: largest income stream for lead batteries. Technical enhancement of 4G, 5G, and better telecom infrastructure key drivers for lead. Telecom batteries are cells or blocks supplying power to ICT or telecom sites if the main power source is unavailable/insufficient.
- **Key areas of development**: energy and power density, energy throughput, charge acceptance and high temp operation.
- **Dominant technology in 2030**

Pb

Battery Innovation Roadmap 2030
Area 4: Stationary Energy Storage Batteries RES behind the meter/ESS batteries

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- **Renewable Energy Storage batteries behind the meter:** supply load when electricity costs are high or renewable power output low.
  Main drivers: increased self-consumption and need for power continuity.
  Both **lead and lithium** compete in this market, each with their own features.
- **Key areas of development:** design life and cyclability
- **Dominant technology in 2030**

- Utility grid-scale energy storage (**ESS batteries):** batteries provide grid stability in multiple ways - store energy quickly or feed in for grid compensation and supply energy to an island power. Depending on requirements and grid-functionalities, **all battery technologies** to be used.
- **Key areas of development:** cycle life, PSOC operation, power density, high power discharge capability, and round-trip efficiency.
- **Dominant technology in 2030**

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Battery Innovation Roadmap 2030
Concluding remarks

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Battery Innovation Roadmap 2030 demonstrates that:

- ✓ **All battery technologies are complementary**: each have specific features and **significant development potential**
- ✓ Different **battery chemistries powering numerous applications** will continue to evolve according to specific requirements developing
- ✓ **Developing all battery** chemistries will maximise the contribution of our Industry to meet the zero-pollution targets **of Europe's Green Deal by 2050**
- ✓ If the EU battery industry is to meet future demand – anticipated at 3x today's volume by 2030 – **all 4 chemistries have to be able to play their role**
- ✓ Having different manufacturing chemistries in our portfolio also **provides strategic advantages** with regard to **Europe's competitiveness** and **self-sufficient sourcing and manufacturing**

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Many thanks for joining our webinar
See you next time !

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