Monthly EV Battery Chemistry Assessment March 2021

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Contents

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Report methodology and glossary can be found on the final page

EV Battery Chemistry developments this month

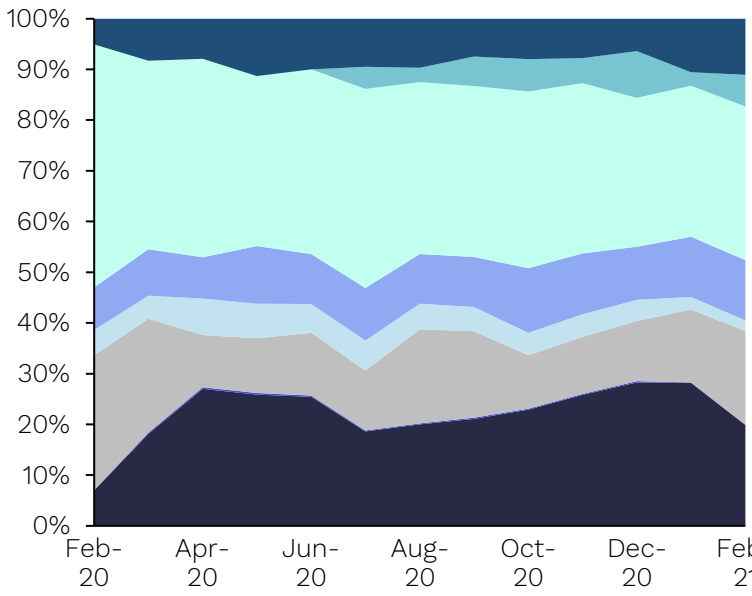
- LG Energy Solutions announced it will invest more than USD 4.5 billion in its US battery production business over the next four years. The investment will provide an additional 70GWh of US battery production capacity through the construction of at least two new plants, locations of which are unconfirmed. LG, through its joint venture with GM, is also in advanced talks to build a second facility in Tennessee, as the JV's first in Ohio nears completion, both of a similar production capacity of 35GWh.

- Staying with GM, more details were announced on the companies next-generation Ultium battery, as well as an agreement with SolidEnergy Systems (SES) to co-develop improved lithium-metal batteries. Li-metal batteries have been identified by GM for possible use in future Ultium-based vehicles. The first Ultium-based products are due to go on sale later this year.

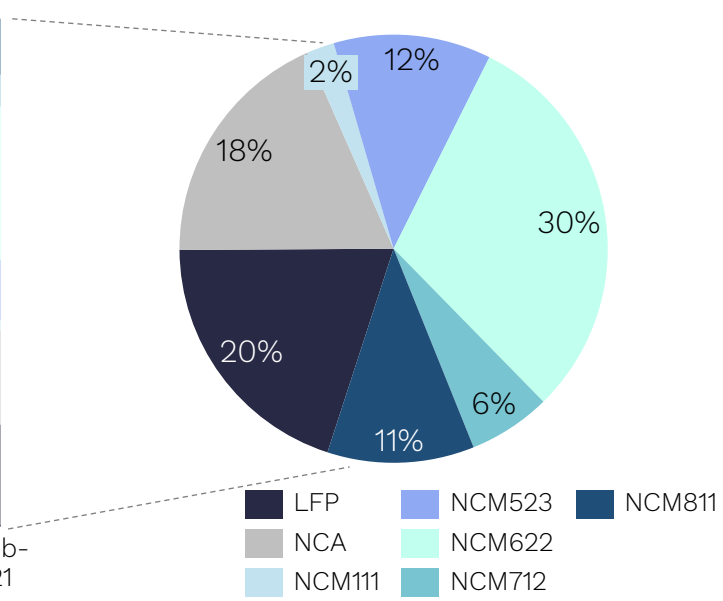
- GM's initial lithium metal prototype battery, with a protected anode, has successfully completed 150,000 simulated test miles, demonstrating its real-world potential. As part of the collaboration, GM and SES plan to build a manufacturing line in Massachusetts, for a high capacity, pre-production battery by 2023.

- VW Power Day saw three key announcements related to its battery chemistry, the entry segment will use LFP, volume production will use NM, and vehicles requiring 'specific solutions', e.g. luxury models, will continue to use NCM. Note: All subscribers will have received a copy of Rho Motion's VW Power Day analysis and forecast 'think piece', this can be accessed via the Membership page.

Monthly weighted average EV battery cathode chemistry all vehicle classes



Monthly weighted average EV battery cathode chemistry all vehicle classes

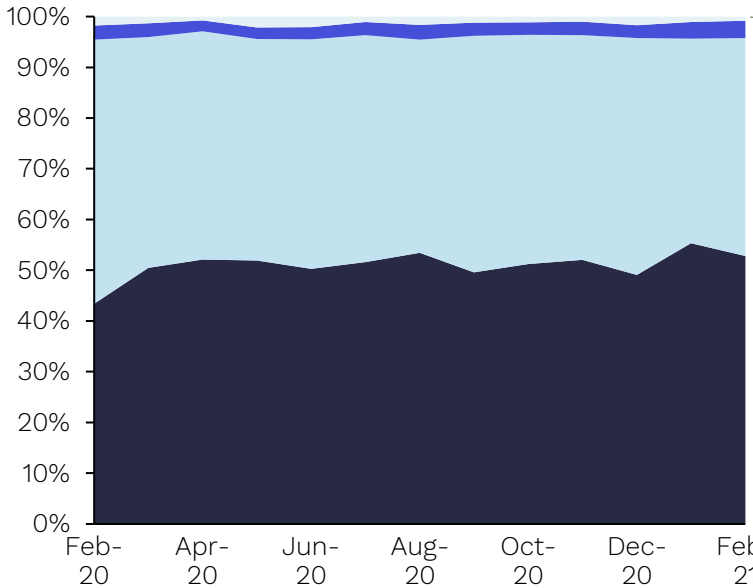


- Two major Indian OEMs, Ashok Leyland and Maruti Suzuki, are to test Phinergy's aluminium-air battery in electric vehicles. Israeli company Phinergy develops metal-air technology to generate electricity from aluminium and zinc with oxygen from ambient air. Through Phinergy's JV with Indian Oil Company it has signed letters of intent with the OEMs, for collaboration to assess the commercial use of aluminium-air batteries. This will include the development of prototypes, field trials and the adaption of the battery to the mass Indian market, with Ashok Leyland and Maruti Suzuki testing the battery in electric buses and electric passenger vehicles, respectively. Phinergy recently completely its collaboration with Mahindra Electric for a prototype electric rickshaw with an aluminium-air battery.

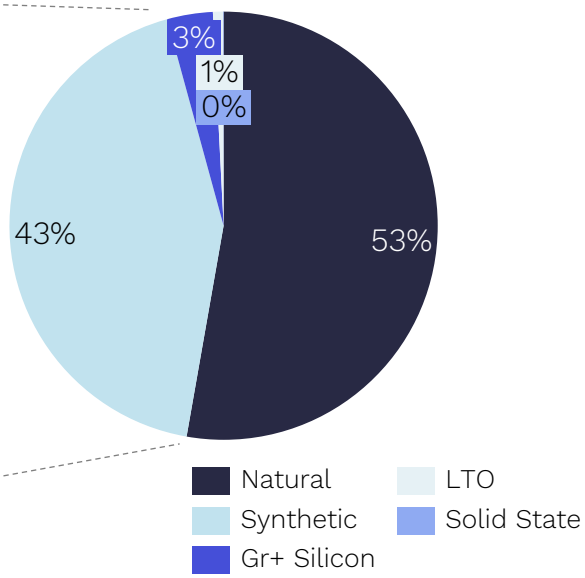
- Several announcements were made in March relating to Tesla's vehicle and cell production. The first relates to GigaBerlin, with production now due to start in July 2021, with initial production capacity of 100,000 vehicles. The second saw Tesla submit an application for 4680 cell production at GigaBerlin targeted for 2022. The third saw talks between Tesla and LG Energy Solutions to produce 4680 cells at a new LG Energy Solutions factory in the US or Europe, with Spain identified as a potential location. Tesla previously indicated it would produce its 4680 cells in its own factories, as well as continuing to purchase from suppliers, with these announcements supporting this. Panasonic has also been in discussion with Tesla to build its 4680 cell, however at present Panasonic and LG are yet to secure orders for the Tesla 4680 cell which is still under development.

- Solid state battery manufacturer, Prologium has signed a MoU with Vinfast, Vietnam's first national car brand, to accelerate the commercialisation of solid-state batteries in EVs in Vietnam. The two companies plan to set up a JV to produce automotive solid-state battery pack's for Vinfast's EVs. Prologium will produce semi-finished cells composed of cathode, solid state electrolyte and an anode layer for the JV at one of its Asian Manufacturing centres, with the finished solid state pack produced in Vietnam. Mass production for Vinfast EV's is scheduled for 2023-2024. Taiwan based Prologium previously partnered with NIO for its solid state battery in 2019, the new JV will have priority purchase of Prologium's technology.

Monthly weighted average EV battery anode chemistry all vehicle classes



Monthly weighted average EV battery anode chemistry all vehicle classes



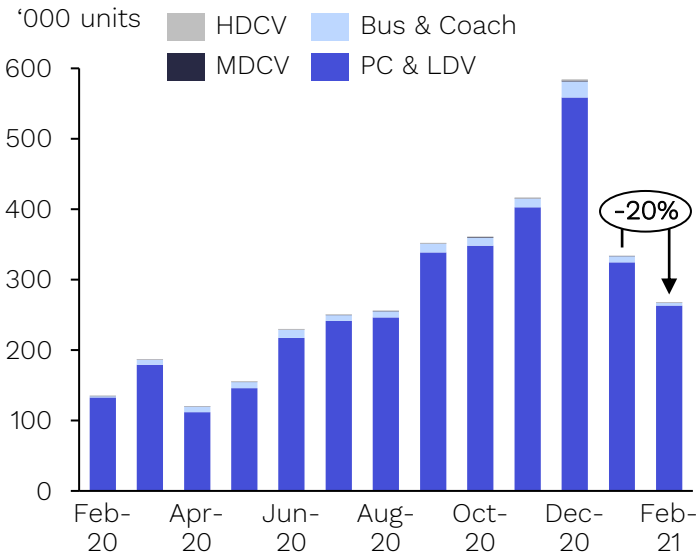
Electric vehicle market developments

- Overall BEV & PHEV sales decreased by 20% m-o-m in February 2021. However, Y-o-Y sales increased by 98% across all vehicle classes. PC & LDV sales in China were 105,000 in February 2021. In the EU & EFTA & UK region sales reached 109,000, of which 55% were PHEVs. The Y-o-Y growth is mainly the result of the Covid impact in China in early 2020, which saw EV sales fall to less than 20,000 in February 2020.

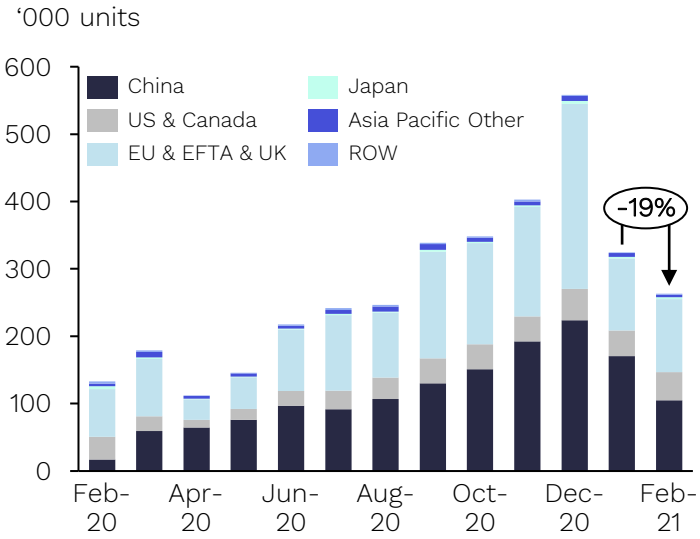
- Several new models were released in China in February 2021, including VW-FAW's ID.4 Crozz BEV, BYD's Qin Pro DM PHEV, and Honda's EA6 BEV. There will be two versions of the ID.4 in China. Firstly, the ID.4 Crozz released by VW-FAW in February. Secondly, the ID.4 X which is due to be released by the VW-SAIC joint venture.

- In terms of battery chemistry in the PC & LDV market, the global share of LFP reached 14% in February 2021. This is almost entirely driven by the Chinese market, where around one-third of kWh's deployed was LFP in the PC & LDV market. Around 80% of this LFP demand is from three vehicles, the SAIC-GM-Wuling Mini, BYD Han, and the Tesla Model 3. The majority of Model 3 sales in China are now expected to have an LFP battery, based on our research of insurance filings, as opposed to the initial LG Energy Solutions NCM811 battery.

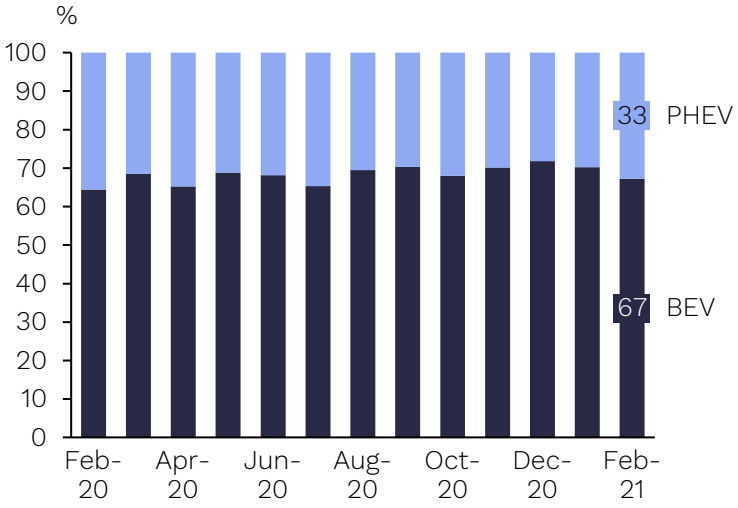
Global Monthly EV sales by vehicle class



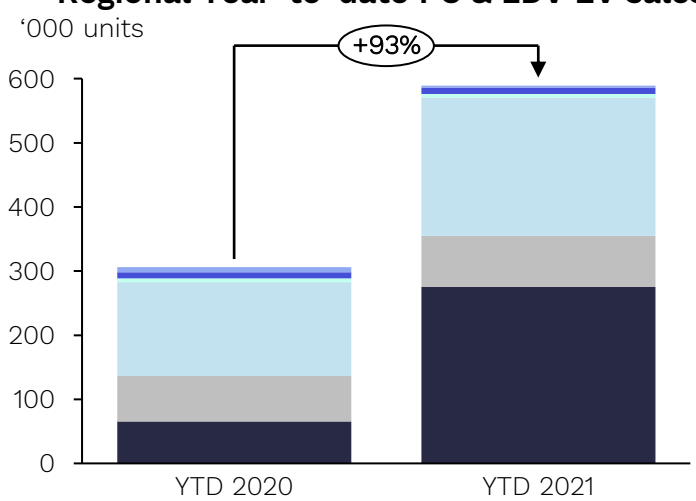
Regional Monthly PC & LDV EV sales



Global PC & LDV BEV/PHEV market share



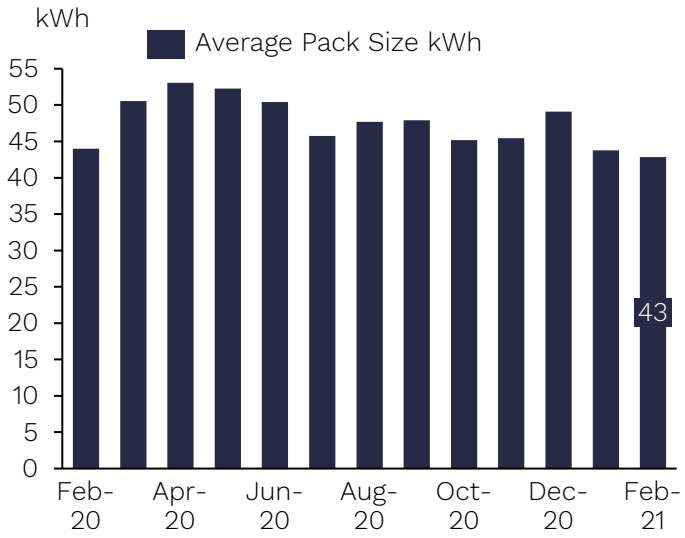
Regional Year-to-date PC & LDV EV sales



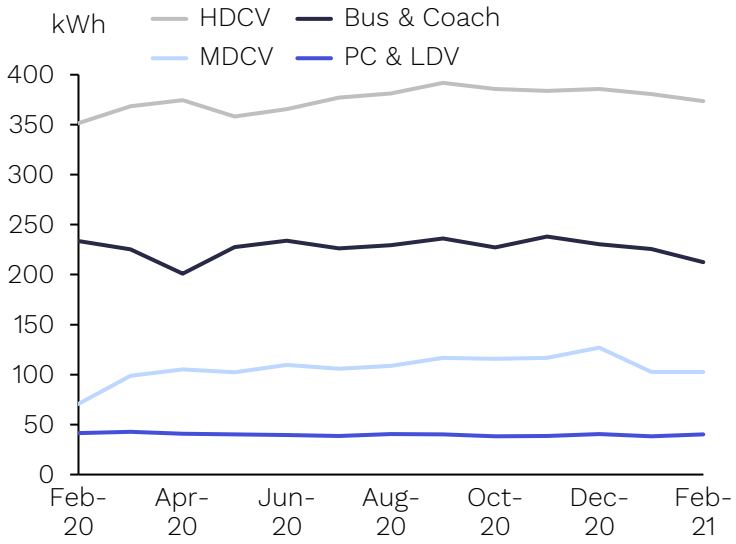
Electric vehicle battery market developments

- Global battery demand for all vehicle classes decreased by 22% m-o-m in February 2021, to 11,451MWh. This is due to a reduction in global EV bus sales by more than half, combined with a reduction in global EV PC & LDV's by 19% m-o-m.
- 2021 YTD battery deployment still remains above 2020 levels, by 81% in February 2021. This is due to a rise in total EV sales by 91% over the same period. The average pack size has reduced slightly Y-o-Y from 44kWh in February 2020 to 43kWh in February 2021, due to the fall in EV bus sales.

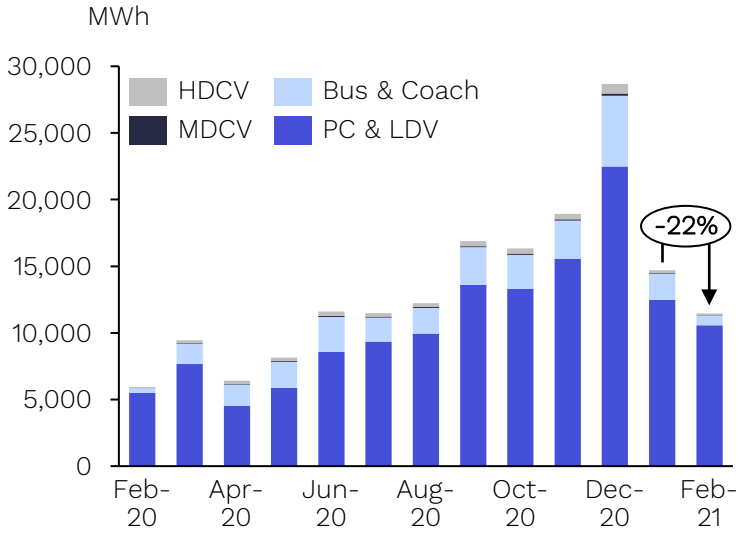
Monthly Sales weighted average EV battery pack sizes all vehicle classes



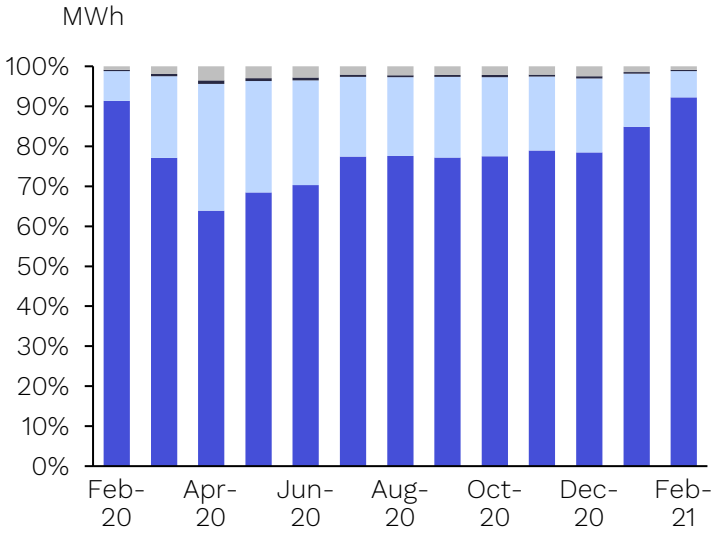
Monthly Sales weighted average EV battery pack sizes by vehicle class



Global Monthly EV battery demand by vehicle class



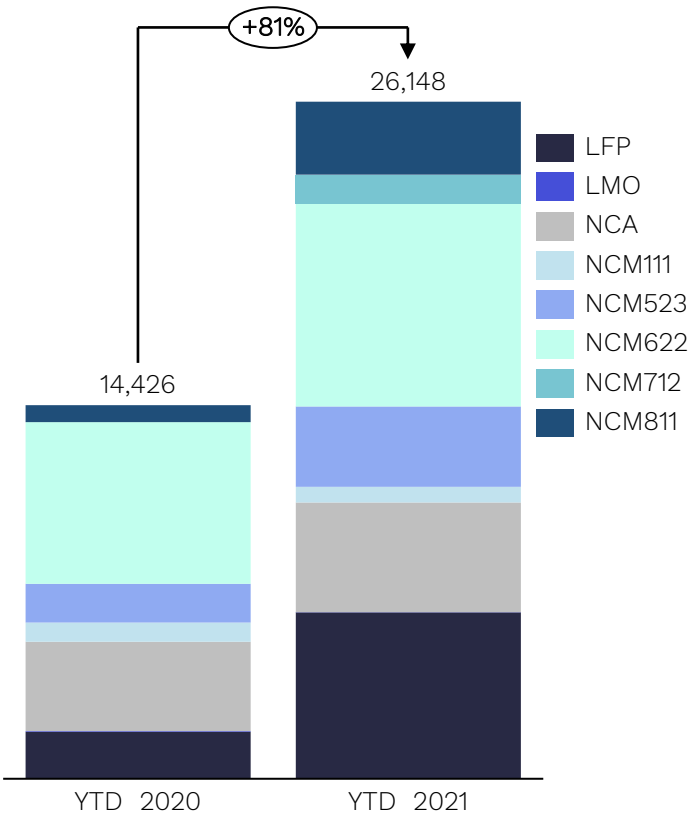
Monthly sales weighting by vehicle class, % of MWh deployed



Monthly market share by cathode chemistry

Battery Chemistry	Estimated monthly MWh EV battery demand	Estimated monthly battery chemistry market share
LFP	2,278	20%
LMO	2	<1%
NCA	2,117	18%
NCM111	239	2%
NCM523	1,363	12%
NCM622	3,467	30%
NCM712	714	6%
NCM811	1,270	11%
Total	**11,451**	**100%**

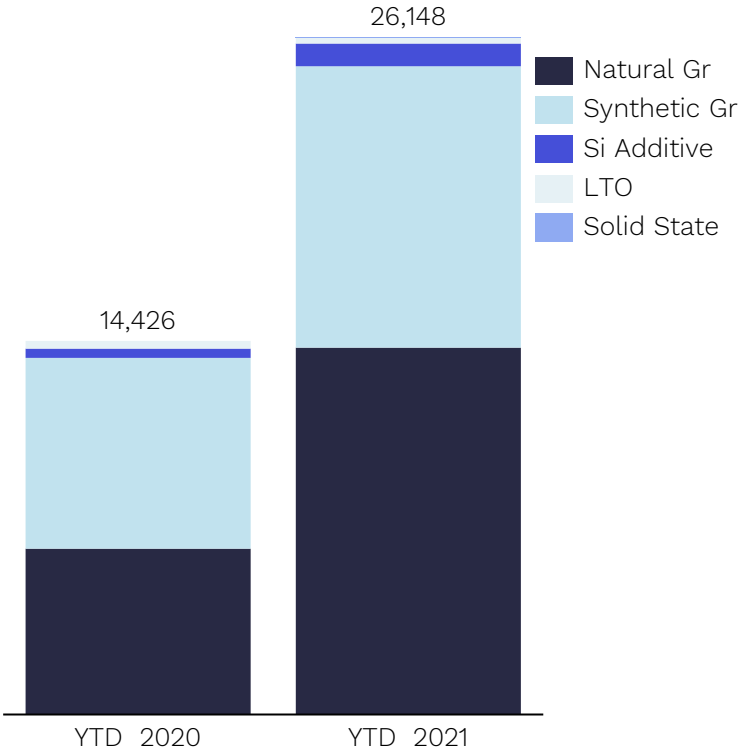
EV battery deployment by cathode chemistry (all vehicle classes), MWh



Monthly market share by anode chemistry

Battery Chemistry	Estimated monthly MWh EV battery demand	Estimated monthly battery chemistry market share
Natural Graphite	6,042	53%
Synthetic Graphite	4,922	43%
Silicon Additive	395	3%
LTO	86	1%
Solid State	5	<0%
Total	**11,451**	**100%**

EV battery deployment by anode chemistry (all vehicle classes), MWh



Assessment Methodology

- This assessment provides a weighted average EV battery chemistry by cathode and anode across passenger car and light duty vehicle, bus and coach, and medium and heavy duty vehicle sectors. EV sales data is collected on a model-by-model basis from automotive associations, OEMs and data providers at country level for both BEV and PHEV vehicles for major markets.
- This analysis covers a minimum of 95% of total global market sales, and provides a balanced representation of markets with different vehicle characteristics, suppliers and seasonality. Where EV specific model data is not explicitly stated estimates are used based on industry and company reports and primary research. These are then corroborated or adjusted when official data becomes available.
- For each vehicle model we collect data relating to battery pack size, battery chemistry and cell supplier in addition to a number of other vehicle metrics. This data is collected from a number of both public and private sources, and includes estimates where reliable data is not available.
- The chemistry classifications used in this report are designed to provide representative coverage of the total market, while still being broad enough to facilitate a useful comparative analysis between categories. It should be noted that within categories there is significant variation in the actual chemistry and material mix.
- In addition, different chemistry cathodes are often blended in order to achieve certain performance or cost parameters for a given vehicle.
- On the anode side, the share of natural and synthetic graphite is determined by material intensity covering 100% synthetic, 100% natural and blended synthetic/natural anodes. The classifications used in this report are below, along with subcategories included in each broader grouping. These groupings are open to review as new chemistries become more dominant.

Cathode

- LFP
- LMO
- NCA
- NCM111
- NCM523
- NCM622 (includes NCM613)
- NCM712
- NCM811 (includes NCMA)
- Other (includes LMNO, Lithium Sulphur and other early stage technologies).

Anode

- Graphite, of which:
  - Natural
  - Synthetic
- Silicon additive
- Silicon Dominant
- LTO
- Solid State

Assessment Glossary

Vehicle: EV – Electric Vehicle, BEV – Battery Electric Vehicle, PHEV – Plug-in Hybrid Electric Vehicle, PC-passenger car, LDV – Light Duty Vehicle, MD – Medium Duty, HD – Heavy Duty, CV – Commercial Vehicle.

Battery: LTO - Lithium–titanate, LFP - Lithium iron phosphate, LMNO – Lithium Manganese Nickel Oxide, LMO - Lithium Manganese Oxide , NMC - Lithium Nickel Manganese Cobalt Oxide, NCA - Lithium Nickel Cobalt Aluminium Oxide, LCO - Lithium Cobalt Oxide, NCMA - Nickel Cobalt Manganese Alumina