17th June 2019

Sector: Mining

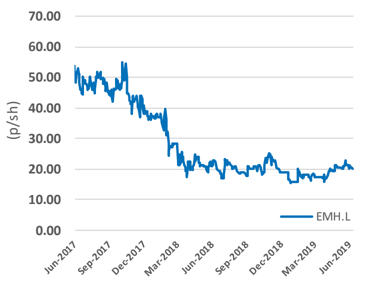
Commodities:

Lithium, tin, tungsten in the Czech Republic

Lithium hydroxide and Lithium carbonate

Market data

Ticker	EMH
Price (p/sh)	20.50p
12m High (p/sh)	27p
12m Low (p/sh)	15p
Shares (m)	146.6m
Mkt Cap (£m)	30.0m
Markets	AIM & ASX



Source: LSE

Description

European Metals Holdings Limited is a mineral exploration and development company listed on AIM and the ASX. The company's main focus is on advancing the Cinovec lithium-tin project located in the Czech Republic. EMH has completed a PFS (updated June 2019) and Cinovec will produce either lithium carbonate or lithium hydroxide.
www.europeanmet.com

Board & key management

Chairman	Dave Reeves
MD	Keith Coughlan
Exec Director	Richard Pavlik
Non-Exec	Kiran Morzaria

European Metals

Lithium hydroxide boosts PFS economics

European Metals has reported an updated PFS for the company's 100% owned Cinovec lithium project in the Czech Republic. The update incorporates results for the production of battery-focused lithium hydroxide, a premium lithium product. This has improved the economics of the project considerably, producing a post-tax NPV$^{8\%}$ of $1,108m (+105%) and a post-tax IRR of 28.8% (+38%). Lithium hydroxide is a higher value product increasingly preferred by a variety of battery manufacturers.

- **PFS updated.** The update incorporates testwork undertaken to investigate production of lithium hydroxide at Cinovec. The most robust process route is the production of battery-grade lithium carbonate followed by conversion to battery-grade lithium hydroxide. As well as reducing risk, this gives more freedom during discussions with potential funding/strategic partners and the ability to adapt to prevailing market conditions. The majority of the April 2017 PFS parameters remain unchanged except those specifically related to the production of hydroxide. Prices assumptions are unchanged at $10,000/t carbonate and $12,000/t hydroxide. The current market price for hydroxide is $15,000-16,000/t

- **New PFS Hydroxide scenario.** Post-tax NPV$^{8\%}$ of $1,108m, IRR of 28.8% - NPV up 105% over April 2017 ($540m) and 55% over the updated carbonate scenario ($716m). 38% increase in post-tax IRR. Capex $482.6m a moderate increase over the $400m for carbonate, reflecting higher cost of the hydroxide plant but capital intensity remains below sector average. Total opex net of by-products $3,435/t $LiOH.H_2O$. Production 25,267tpa hydroxide. Although opex and capex are marginally higher on an absolute dollar basis, the hydroxide flowsheet produces more tonnes of product, so metrics are largely unchanged on a unit basis.

- **Carbonate option tweaked.** EMH retains an alternative carbonate production strategy with parameters largely the same as the 2017 PFS but reflecting increased recoveries and the use of more cost-effective reagents. This has resulted in a considerable boost to carbonate project economics. NPV$^{8\%}$ $716m (+33%), IRR 21.4% (+2.4%) and a higher production rate of 22,500tpa carbonate (+8.2%). Capex is largely unchanged to $400m from $393m but opex has reduced significantly to $2,914/t post-by-products from $3,483/t.

- **EU priority.** Lithium-ion batteries remain of strategic importance for Europe and the EU is stepping up initiatives and investment aimed at building a sustainable battery ecosystem covering the entire battery chain. Europe is highly dependent on raw material imports and the EU's share of cell manufacturing is a mere 3%. This presents a significant disconnect between Europe's supply and manufacturing capabilities versus projected EV growth.

- **Hydroxide gaining ground.** Both carbonate and hydroxide can be used in lithium-ion batteries, but hydroxide is increasingly becoming the product of choice for a wide variety of battery manufacturers. This is driven by changes in battery chemistry and the quest for higher energy density, thermal stability and ultimately the aim to increase the range of EVs.

- **Sector activity is increasing.** Despite recent weakness in lithium pricing, 2019 has seen a considerable increase in activity in the sector with a raft of off-take and supply deals, strategic alliances and direct project investments, many of these related to lithium hydroxide. There remain limited opportunities for European-based hydroxide production at the mine site and we see Cinovec as a key cog in Europe's supply chain.

The PFS update confirms the potential to produce lithium hydroxide and demonstrates superior economics using prices below current market levels. With the ability to first produce carbonate and then convert to hydroxide, EMH retains significant flexibility in a rapidly evolving sector. Cinovec is shaping up to be one of the only long-life hydroxide producers with scale that may be able to supply directly into the growing European lithium market. Next step: feasibility/funding.

Metrics are similar to our previous hydroxide assumptions. Our updated hydroxide SotP (post-funding) is 76p/sh (prev 80p/sh), the immaterial reduction due to marginally higher capex and the fact that we have pushed back production by one year for a more conservative timeline. Our carbonate SotP (post-funding) is 55p/sh (prev 40p/sh) reflecting higher recoveries and more cost-effective reagents, tempered by our timeline pushback. Our modelling assumptions remain conservative and we see considerable upside to our numbers.

Analyst

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PFS update

Event:

- **Hydroxide scenario introduced.** European Metals has announced the results from the successful update of the Cinovec process flowsheet and testwork to produce battery-grade lithium hydroxide, a higher value lithium product suitable for use in EV batteries. EMH has updated relevant portions of the April 2017 PFS to reflect the production of hydroxide with the result of significantly enhancing the economics of Cinovec.

- **Carbonate economics updated.** In addition, the economics to produce lithium carbonate have also been updated to reflect increased recoveries and the use of more cost-effective reagents. Previously the main scenario, the production of carbonate is now classed as an alternative production scenario.

Figure 1 - Financial summary - 2019 PFS update and previous PFS iteration

Key metrics	Unit	April 2017	June 2019	June 2019
		PFS Lithium carbonate	PFS update Lithium carbonate	PFS update Lithium hydroxide
NPV @ 8% Discount	US$ m	540	716	1,108
IRR (post-tax)	%	20.9	21.4	28.8
Price	$/tonne	10,000 LCE	10,000 LCE	12,000 LiOH
Capital Expenditure	US$ m	393	400.6	482.6
Average production rate	tpa	20,800	22,500	25,267
Product	-	carbonate	carbonate	Hydroxide LiOH
Avg Production Cost (with Credits)	US$ /t LCE	3,483	2,914	3,435/t LiOH

Source: European Metals

Key Points:

- **Boost to economics.** EMH has updated the project economics to reflect a lithium hydroxide production route. This has resulted in a post-tax $NPV^{8\%}$ of $1,108m and IRR of 28.8%. This is a significant increase over the both the previous 2017 PFS ($NPV^{8\%}$ $540m, IRR 20.9%) and the updated carbonate scenario ($NPV^{8\%}$ $716m, IRR 21.4%).

- **Prices.** The lithium carbonate price has been kept the same at $10,000/t and the hydroxide study assumes $12,000/t hydroxide. We view these as reasonably conservative prices.

- **Capex.** The capex estimate has increased marginally, increasing from $393m to $400m for the carbonate scenario. The new hydroxide scenario capex comes in at $483m but note that hydroxide is a higher value add product and the despite the capex increase, the NPV and IRR are considerably higher and the capital intensity remains low (more tonnage of hydroxide product).

- **Optionality.** As previously reported (8th April), the most robust flowsheet was selected, involving the production of battery grade lithium carbonate followed by conversion to battery grade lithium hydroxide. This gives EMH significant optionality in terms of supplying either battery grade lithium carbonate or lithium hydroxide, depending on prevailing market conditions, or the preference of potential funding partners.

- **Shard view: The economics of the hydroxide scenario are vastly superior for only a modest increase in capex**. Given the lack of European hydroxide production capability, we see this as the most attractive development scenario given the forecast increase in demand for battery-grade lithium hydroxide which is becoming a favoured product for some battery manufacturers.

What's been updated?

What's been updated? The sections of the PFS pertaining to mining, crushing, beneficiation, Sn and W recovery and utilities have not been reviewed or updated. Only the sections of the PFS relevant to the production of lithium hydroxide have been altered. These include:

- The design for the roasting and leaching circuits has been upgraded.
- The fluoride and calcium removal circuit designs have been upgraded as a result of recent testwork results when battery grade lithium hydroxide was produced (as reported 8 April 2019).
- Lithium hydroxide precipitation and product handling facilities

Testwork

- **Testwork** was conducted over several months primarily at Dorfner Anzaplan, Germany on lithium hydroxide production process development as well as earlier roasting confirmation testwork. This testwork was reported by EMH on 28 March 2018, 11 July 2018, 4 September 2018 and 8 April 2019.
- **Higher recovery.** Results from the early roasting testwork yielded up to 95% lithium extraction and was ultimately replicated in three separate laboratories.
- **Lower cost reagents.** As well as producing higher recoveries, a changed reagent mix substituted higher cost hydrated lime and purchased sodium sulphate with more cost-effective waste gypsum from European power stations along with the addition of limestone and the recirculation of excess sodium sulphate.
- **Adapted for hydroxide.** The flowsheet has been updated to adapt EMH's lithium carbonate producing flowsheet to one that converts battery grade lithium carbonate into lithium hydroxide.
- **Flexible process route selected.** Two process routes were tested, firstly the direct production of lithium hydroxide from leach liquors and subsequently testing a more traditional route of converting lithium carbonate through to lithium hydroxide. Both process routes were successful in producing battery grade lithium hydroxide, but analysis of the process risk risks indicated that the more robust flowsheet involved the production of battery grade lithium carbonate followed by conversion to battery grade lithium hydroxide. This also gives EMH more flexibility to switch to a carbonate only operation if needed.
- **High purity product.** The lithium hydroxide product produced from Cinovec ore is very low in impurities and compares well with typical industry specification as detailed in the table below. EMH has also completed testwork for the successful removal of fluoride.

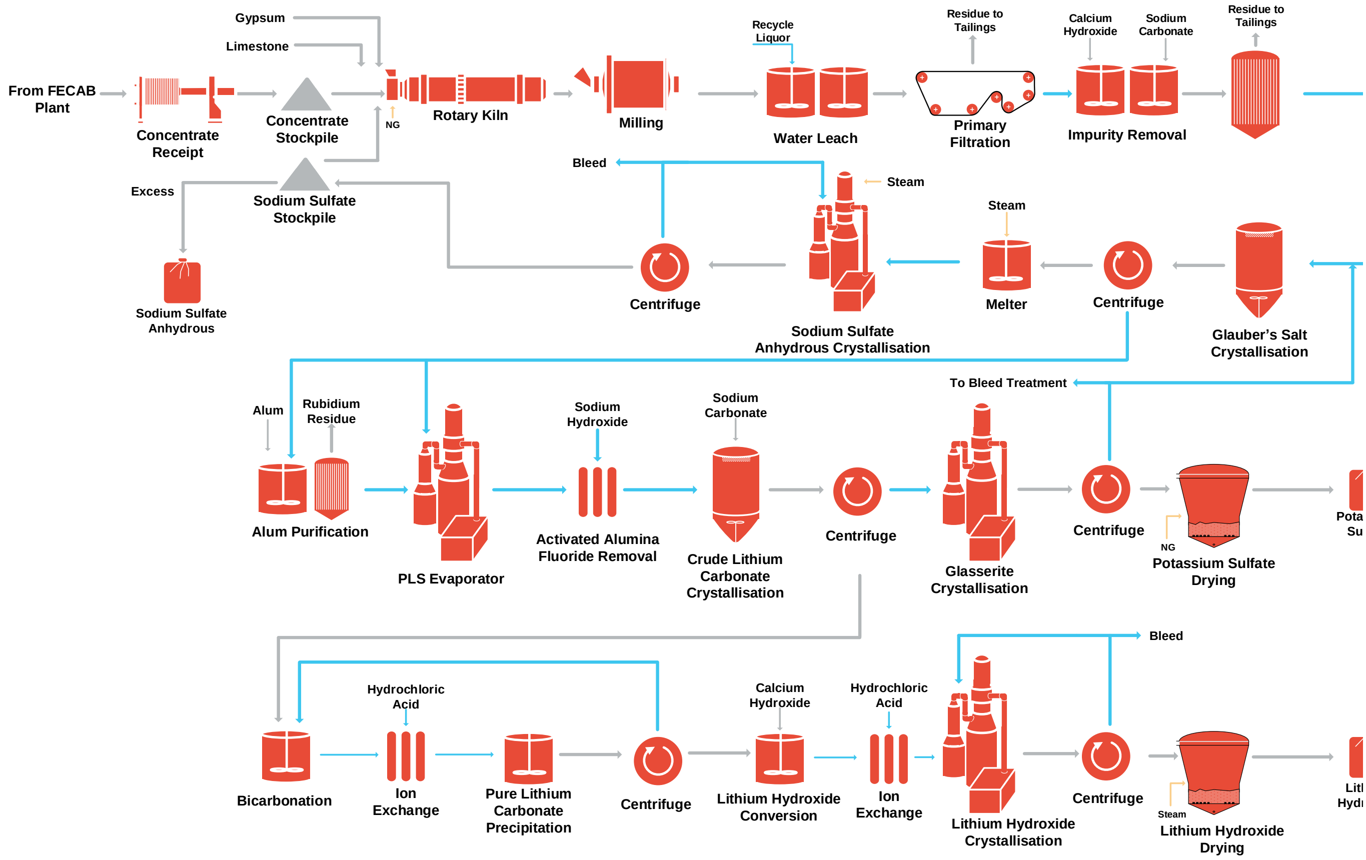
Figure 2 - Cinovec lithium hydroxide vs typical industry specification

Species	Typical Specification (ppm)	EMH Cinovec (ppm)
Na	50	<1
K	50	<1
Cl	30	<15
SO_4	100	~51
Fe	7	<1

Source: European Metals

- **The flowsheet** produces battery-grade lithium carbonate by roasting and leaching which is then put through further processing steps to produce battery grade lithium hydroxide. Lithium hydroxide solution is formed initially through conversion with hydrated lime slurry followed by a final purification step involving ion exchange, then lithium hydroxide crystallisation, solids recovery, drying and packaging for sale.

Figure 3 - Cinovec Lithium Hydroxide Conversion Process Schematic



Source: European Metals

Hydroxide financial summary

EMH has re-estimated Cinovec's economics derived from the production of lithium hydroxide as opposed to carbonate.

- Post-tax NPV at 8% discount rate US$1,108m and a post-tax IRR of 28.8%.
- Increase of 105% over the April 2017 PFS (NPV$^{8\%}$ $540m) and 55% over the updated carbonate production scenario (NPV$^{8\%}$ $716m).

Figure 4 - 2019 PFS hydroxide update - Financial summary

Key metrics	Unit	Metric
NPV @8% Discount	US$ m	1,108
IRR (Post tax)	%	28.8
Capital Expenditure	US$ m	482.6
Avg Production Cost (without credits)	per tonne LiOH	4,876
Avg Production Cost (with credits)	per tonne LiOH	3,435
Life of Mine	years	21
Total Mined Ore	Mt	34.4
Peak Mill Feed	Mtpa	1.80
Avg Mill Rate (yr. 3-20)	Mtpa	1.68
Average LiOH Production rate	tpa	25,267
Price assumptions		
Lithium hydroxide	US$/t	12,000
Lithium carbonate	US$/t	10,000
Tin	US$/t	22,500
Tungsten	US$/mtu	330
Potassium sulphate	US$/t	520

Source: European Metals

Capital cost estimate

- The new capital cost estimate is $482m for an average production rate of 25,267 t/a lithium hydroxide. The only section containing new cost estimates is that for the lithium processing facility (LPF).

Figure 5 - Lithium hydroxide capital cost estimate

Section	TOTAL US$ M
Underground Mining Development	
Mining Directs	67.3
Mining Indirect Costs	3
Total Mining Cost	70.3
Front End Comminution & Beneficiation Plant (FECAB)	
Comminution - Direct	25.2
Beneficiation - Direct	40.5
Infrastructure - Direct	20.8
FECAB Indirect Costs	18.4
Total FECAB	104.9
Lithium Production Facility	
Production Plant Directs	213.8
Production Plant Indirect Costs	50.5
Total Lithium Production Plant	**263.5**
Overall Project Contingency @ 10%	43.9
TOTAL CAPITAL COST	482.6

Source: European Metals

Operating cost update

- **Not updated.** Operating costs have not been updated in the areas of mining, FECAB plant operation, tin and tungsten recovery or corporate office costs and other overheads.
- **Updated.** The operating costs that have been re-estimated are those specifically for the production of lithium hydroxide from the flowsheet. The costs are based on an average production rate of 25,267tpa lithium hydroxide ($LiOH.H_2O$) which is equivalent to 22,259 t/a of lithium carbonate.
- **Opex.** The average operating cost for the Cinovec Project is $3,435/t of lithium hydroxide after by- product credits.
- **Variance.** The main difference between the new hydroxide route and previous 2017 carbonate route opex is that the LiOH plant opex is higher at $62m pa or $37/t ROM versus the previous opex of $47m pa or $28.2/t ROM. However, because the hydroxide flowsheet produces more tonnes of product, the opex on per tonne of product basis is very similar – net $3,435/t hydroxide vs net $3,488/t carbonate (2017 PFS), net $2,914/t (2019 PFS update).

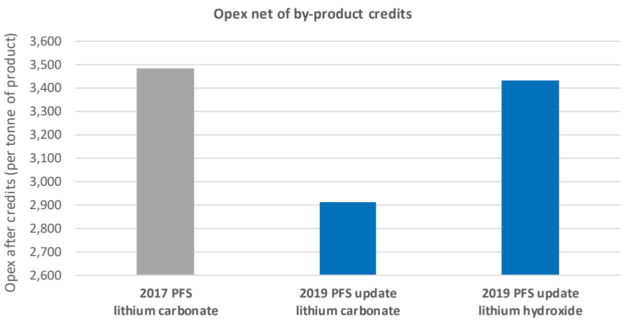
Figure 6 - Average project operating cost - lithium hydroxide

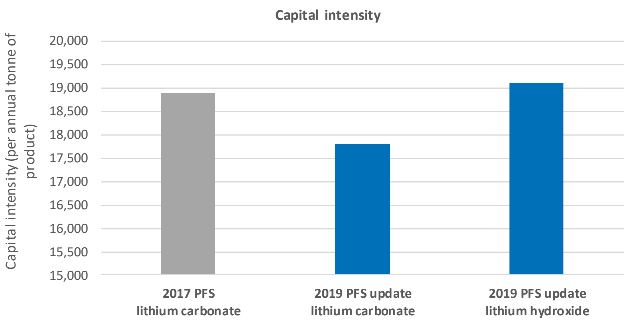
Average Operating Cost (yr. 3-20)	$m pa	$t / ROM	$t / LiOH	% Op Cost
Mining	40.7	24.3	1,614	33%
FECAB	19.4	11.6	770	16%
LiOH plant	62.1	37	2,458	50%
Overall Project Admin	0.9	0.5	34	1%
Total Operating Cost	**123.1**	**73.4**	**4,876**	

By-product Revenue Credits	$m pa	$t / ROM	$t / LiOH
SN/W (yr 3-20)	29.2	17.4	1,156
Potash	7.8	4.6	285
Excluding Sn/W Royalties & Transportation Cost			
Total Opex (Net of By-product credits)	**86.1**	**51.4**	**3,435**

Source: European Metals

Figure 7 - PFS opex and capital intensity comparison





Source: Shard Capital

Valuation update

Our base case valuation was previously predicated on the production of lithium carbonate with the production of lithium hydroxide was an upside scenario. The updated PFS makes it clear that hydroxide is the preferred route. However, as EMH retains an alternative lithium carbonate production strategy we also retain both as valuation scenarios.

- **Lithium Carbonate SotP: 55p/sh.** Our indicative valuation for European Metals is 55p/sh fully-diluted. This is based on a sum-of-the-parts NAV valuation driven by our $NPV^{10\%}$ of US$388m (£299m) for the Cinovec project risked at 0.5x NAV, appropriate adjustments and post financing. This is an increase over our previous model of $NPV^{10\%}$ $289m (£222m) and SotP of 45p/sh. The variance is due to the updated PFS metrics announced by EMH (17th June 2019) demonstrating increased lithium recovery and lower costs reflecting the use of more cost-effective reagents. The uplift to our carbonate valuation is slightly tempered as we push back first production to 2023 from 2022. This is an increase over our previous 45p/sh SotP, largely due to updated recovery and operating cost assumptions.

  Sensitivity snap-shot: Removing our 25% capex escalation assumption and commencing the discounting of cashflows from the point of construction, the Cinovec $NPV^{10\%}$ increases to $510m (SotP 70p/sh) and $NPV^{8\%}$ increases to $670m (SotP 86p/sh).

- **Lithium Hydroxide SotP: 76p/sh.** Our indicative hydroxide valuation for EMH is 76p/sh fully-diluted. This is based on a sum-of-the-parts NAV valuation driven by our $NPV^{10\%}$ of US$684m (£526m) for the Cinovec project risked at 0.5x NAV, assuming the production of hydroxide, appropriate adjustments and post-financing. The uplift in our hydroxide valuation has been tempered by an increase in our capex assumption and changes to our model to push back first production to 2023 from 2022. Although our original modelling estimate of $564m capex for the hydroxide option is more than EMH's updated PFS estimate of $482m, we continue to add 25% escalation to reflect a PFS level of study. Consequently, for conservatism we now model using $603m capex equating to $482 plus 25%. Our previous hydroxide assumptions were more or less on par with what EMH has released, but as we push back production to 2023, this reduces our NPV resulting in a marginal and immaterial reduction in our SotP to 76p/sh from 80p/sh previously.

  Sensitivity snap-shot: Removing our 25% capex escalation assumption and commencing the discounting of cashflows from the point of construction, the Cinovec $NPV^{10\%}$ increases to $865m (SotP 99p/sh) and $NPV^{8\%}$ increases to $1114m (SotP 121p/sh).

- **Discount to NAV.** Our risked SotP valuation implies that EMH is trading (based on current share price 20.5p) at an unchallenging 0.37x P/NAV discount on our carbonate scenario and 0.27x P/NAV for our hydroxide scenario. The substantial discount to NAV reflects that the fact that there are several milestones ahead including a resolution to permitting and project funding. Further development progress or strategic/financing discussions could drive a considerable re-rating in the company's share price, in our view.

Figure 8 - Shard indicative SotP valuations

Lithium CARBONATE scenario				
NPV	**Disc Rate**	**US$m**	**£m**	**£/sh**
Cinovec - Lithium carbonate operation	10%	388	299	0.69
Subtotal		388	299	0.69
Risked NPV	**NAV multiple**			
Cinovec	0.50x	194	149	0.35
Exploration	-	0	0	0.00
Sub-total		194	149	0.35
Cash from B/S		0.9	0.7	0.00
Cash from option exercise		0.0	0.0	0.00
Equity funding		125.2	96.3	0.22
Forward Corporate G&A / Other		(14.3)	(11.0)	(0.03)
Base-case NAV VALUATION		**306**	**235**	**£0.55**
Current NAV Multiple (Implied)				0.38
Shares on issue (basic)		146.6m		
Shares on issue (Fully-diluted, post equity financing)		431.8m		

Lithium HYDROXIDE scenario				
NPV	**Disc Rate**	**US$m**	**£m**	**£/sh**
Cinovec - Lithium Hydroxide	10%	684	526	1.08
Subtotal		684	526	1.08
Risked NPV	**NAV multiple**			
Cinovec	0.50x	342	263	0.54
Exploration	-	0	0	0.00
Sub-total		342	263	0.54
Cash from B/S		0.9	0.7	0.00
Cash from option exercise		0.0	0.0	0.00
Equity funding		150.8	116.0	0.24
Forward Corporate G&A / Other		(14.3)	(11.0)	(0.02)
Hydroxide scenario NAV VALUATION		**479**	**369**	**£0.76**
Current NAV Multiple (Implied)				0.27
Shares on issue (basic)		146.6m		
Shares on issue (Fully-diluted, post equity financing)		488.1m		

Source: Shard Capital estimates

Assumptions

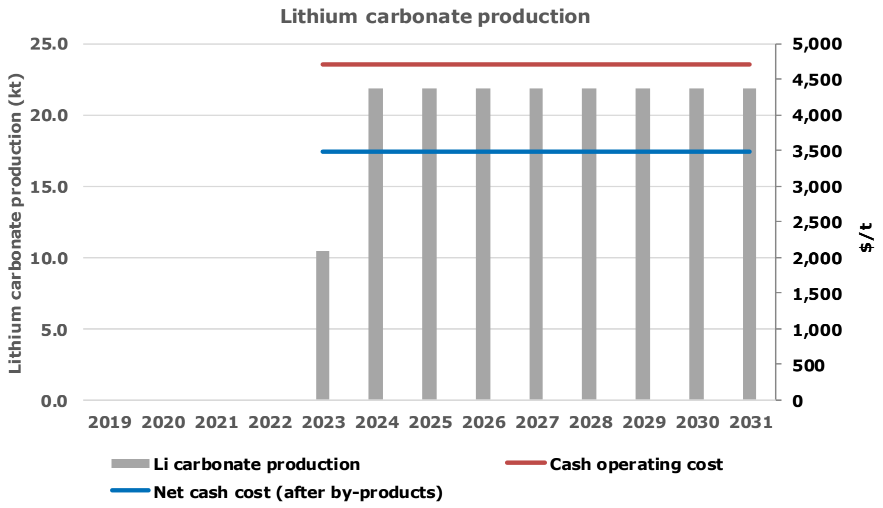
- **Basis.** Our carbonate scenario reflects updated PFS metrics from EMH's "alternative carbonate production scenario" released on 17th June. We have also sharpened up assumptions in our hydroxide scenario based on the reported metrics.
- **Capex.** As mentioned, we also incorporate a more punitive assumption on capital expenditure by adding a 25% to the company's estimate. This reflects the PFS level of capex accuracy of +/- 25%. We therefore assume $500m capex for carbonate (EMH $401m) and $603m capex for hydroxide (EMH $483m).
- **Production.** We model annual LOM average lithium hydroxide production of 24.6ktpa and 25.2ktpa at steady-state. In our carbonate scenario we model LOM average of 21.3ktpa and steady-state at 21.8ktpa. We model 90% recovery in the carbonate plant despite test-work indicating potential recoveries up to 95%.
- **Tax.** Tax is calculated at 19% with a 10-year tax-free window as provided by Czech investment legislation.
- **Timeline.** We assume a nominal construction start date of 2021 (pushed back from our previous assumption of 2020) with a 24-month construction period leading to commissioning in 2023. We assume full production from 2024. We discount cashflows from present day.
- **NAV multiple.** Our valuation standpoint remains cautious. We retain a 0.5x multiple to reflect remaining permitting risk in the Czech Republic in addition to typical risks surrounding timelines, funding and execution and the development stage of the project.

- **Adjustments.** We further adjust for future corporate costs (DCF basis), net debt (in this case cash on balance sheet as EMH is debt free) and funding assumptions. It is too early to speculate about potential funding mechanisms, but we simplistically assume a 75% debt, 35% equity funding scenario based on our escalated capex and assume mine-build equity funding at 35p/sh. Whilst this is in excess of the current share price, it is conservative when compared to EMH's share price prior to the purported cancellation of the MOU with the government. It also reflects the fact that equity funding will be post-DFS with considerable time for the company's share price to recover, in our view.
- **Cinovec's advantage.** Cinovec remains a potentially low capital intensity, low operating cost project due to the following key advantages:
  - Infrastructure. Situated on the border of the Czech Republic and Germany, Cinovec has access to first-world quality infrastructure and grid power, a stark contrast to many of the other remote lithium development projects.
  - **By-products.** The deposit has significant by-product credits from the recovery of tin, tungsten, potash and sodium sulphate. Based on PFS price assumptions, these reduce opex by $1,441/t LiOH, or 30%.
  - **Geology and processing.** Cinovec is a hard rock deposit, but the ore is hosted by lithium mica (zinnwaldite) and not spodumene. The ore is amenable to single-stage crushing and single-stage coarse SAG milling, reducing capital and operating costs and complexity. Zinnwaldite is also paramagnetic which allows the use of low cost wet magnetic processing to produce a lithium concentrate for further processing at relatively high recoveries. Relatively low temperature roasting can be utilized using conventional technologies, reagent recycling and the use of waste gypsum.

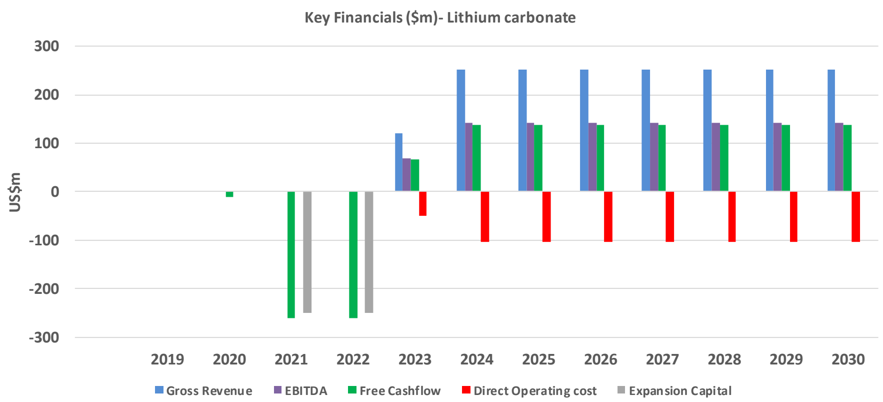
Updated carbonate scenario outcomes

- We have updated our carbonate scenario model to reflect updated recoveries and operating costs as reported by EMH as part of the recent PFS update.

Figure 9 - Production (tpa) and operating costs ($/t) – Shard estimates



Key financials - Shard Capital estimates



Source: Shard Capital estimates

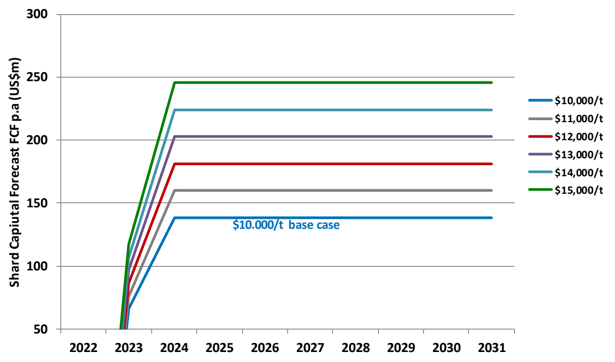
Figure 10 - Key project-level financials - Shard Capital estimates – carbonate scenario

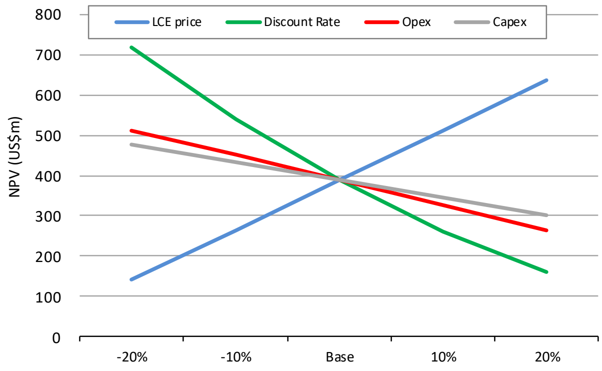
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Ore Mined	kt	0	0	0	800	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Li Concentrate produced	kt	0	0	0	171	360	360	360	360	360	360	360	360	360
Total ore processed	kt	0	0	0	800	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
LCE produced	kt	0.0	0.0	0.0	9.8	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7
Tin produced	t	0.0	0.0	0.0	396.0	831.6	831.6	831.6	831.6	831.6	831.6	831.6	831.6	831.6
W produced	mtu	0	0	0	12,000	25,200	25,200	25,200	25,200	25,200	25,200	25,200	25,200	25,200
Potash produced	kt	0.0	0.0	0.0	6.2	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Total revenue	$m	0	0	0	114	239	239	239	239	239	239	239	239	239
Direct Operating cost	$'m	0	0	0	-52	-109	-109	-109	-109	-109	-109	-109	-109	-109
Total opex	$'m	0	0	0	-54	-113	-113	-113	-113	-113	-113	-113	-113	-113
EBITDA	$'m	0	0	0	60	125	125	125	125	125	125	125	125	125
Free Cashflow		0	-10	-260	-260	66	139	139	139	139	139	139	139	139
Expansion Capital	$'m	0	0	-250	-250	0	0	0	0	0	0	0	0	0
Sustaining Capital	$'m	0	0	0	0	-2	-4	-4	-4	-4	-4	-4	-4	-4
Proj eval / working cap	$'m	0	-10	-10	-10	0	0	0	0	0	0	0	0	0

Source: Shard Capital estimates

Updated carbonate scenario - Sensitivity analysis

Figure 11 - LHS- Base-case forecast FCF at higher lithium price assumptions
RHS - Sensitivity Analysis – unrisked project NPV at 10% discount rate





Source: Shard Capital

Figure 12 - Sensitivity Analysis – carbonate case

Carbonate case NPV Sensitivity **(USD $m)**

LCE price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	482	247	141	62
9,000	693	398	265	165
10,000	903	550	**388**	267
11,000	1113	701	512	370
12,000	1323	853	636	473
13,000	1533	1004	760	576
14,000	1744	1156	884	678
15,000	1954	1307	1008	781

Carbonate case Risked SotP Sensitivity
to equty raise price assumption **(GBP £/sh)**
At 0.5x NAV multiple

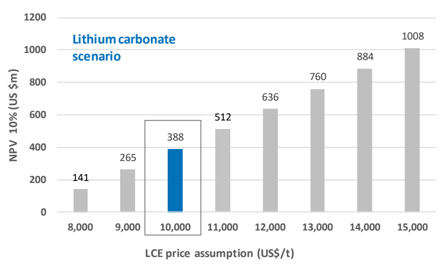
Equity fundraise price (p/sh)	Discount rate (%) 5%	8%	10%	12%
0.20	0.68	0.47	0.37	0.30
0.25	0.80	0.55	0.43	0.35
0.30	0.91	0.62	0.49	0.40
0.35	1.00	0.69	**0.55**	0.44
0.40	1.09	0.75	0.59	0.48
0.45	1.17	0.80	0.64	0.51
0.50	1.24	0.85	0.67	0.54
0.55	1.31	0.90	0.71	0.57

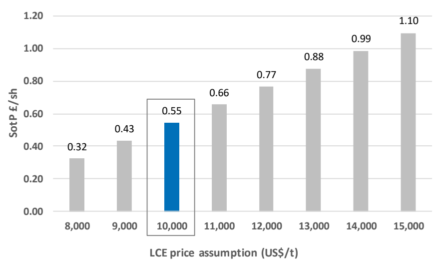
Carbonate case Risked SotP Sensitivity **(GBP £/sh)**
At 0.5x multiple

LCE price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	0.63	0.42	0.32	0.25
9,000	0.82	0.55	0.43	0.35
10,000	1.00	0.69	**0.55**	0.44
11,000	1.19	0.82	0.66	0.53
12,000	1.38	0.96	0.77	0.62
13,000	1.57	1.09	0.88	0.71
14,000	1.75	1.23	0.99	0.80
15,000	1.94	1.36	1.10	0.89

Carbonate case Risked NAV/sh Sensitivity **(GBP £/sh)**
At 1.0x NPV multiple

LCE price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	0.76	0.44	0.30	0.20
9,000	1.08	0.67	0.49	0.35
10,000	1.41	0.91	**0.68**	0.51
11,000	1.73	1.14	0.87	0.67
12,000	2.06	1.38	1.06	0.83
13,000	2.38	1.61	1.26	0.99
14,000	2.71	1.84	1.45	1.15
15,000	3.03	2.08	1.64	1.30



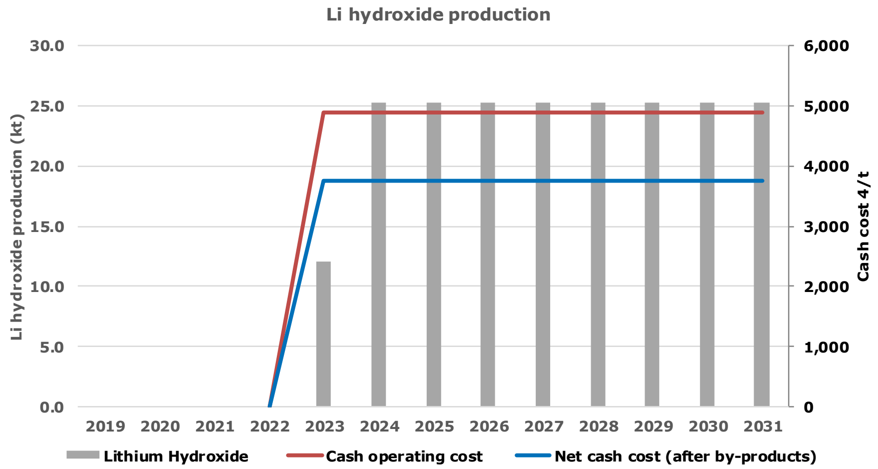


Source: Shard Capital estimates

Updated hydroxide scenario outcomes

- ► We have updated our hydroxide scenario model to reflect the updated PFS.

Figure 13 - Production (tpa) and operating costs ($/t) – Shard estimates



Key financials - Shard Capital estimates

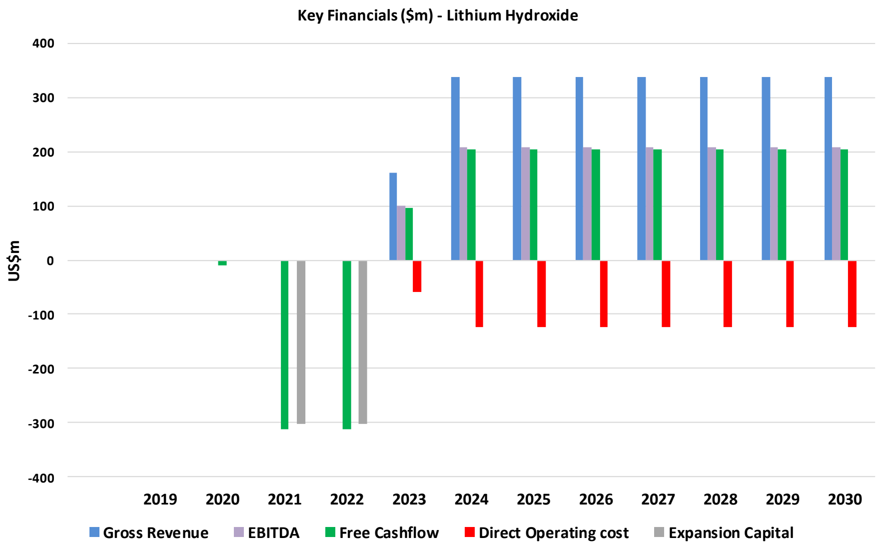


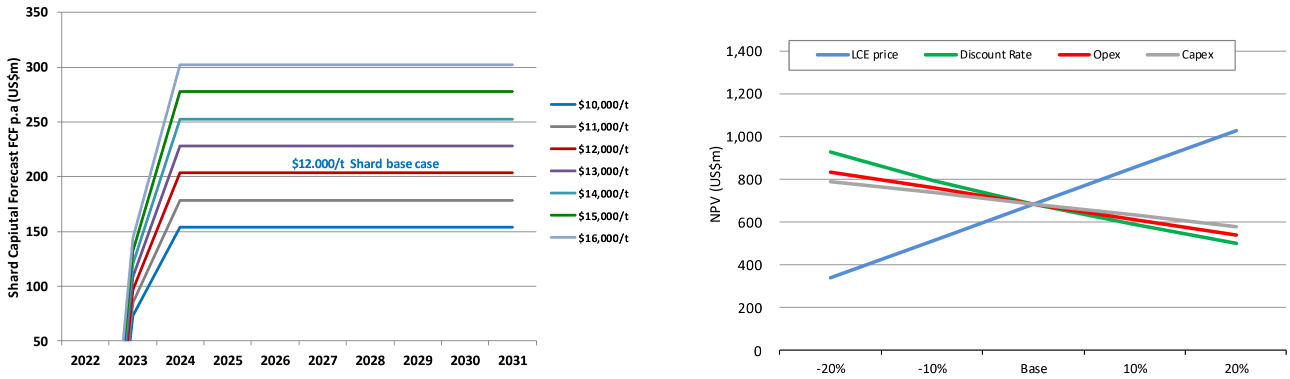
Figure 14 - Key project-level financials - Shard Capital estimates - hydroxide scenario

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Ore Mined	kt	0	0	0	0	800	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Li Concentrate produced	kt	0	0	0	0	171	360	360	360	360	360	360	360	360
Total ore processed	kt	0	0	0	0	800	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Lithium Hydroxide	kt	0.0	0.0	0.0	0.0	12.0	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
Total revenue	$m	0	0	0	0	161	338	338	338	338	338	338	338	338
Cash operating cost	$/t Lithium hydroxide	0	0	0	0	4,880	4,880	4,880	4,880	4,880	4,880	4,880	4,880	4,880
Net cash cost (after by-products)	$/t Lithium hydroxide	0	0	0	0	3,757	3,757	3,757	3,757	3,757	3,757	3,757	3,757	3,757
Total opex	$'m	0	0	0	0	62	130	130	130	130	130	130	130	130
Expansion Capital	$'000	0	0	-302	-302	0	0	0	0	0	0	0	0	0
Sustaining Capital	$'000	0	0	0	0	-2	-5	-5	-5	-5	-5	-5	-5	-5
EBITDA	$'m	0	0	0	0	99	208	208	208	208	208	208	208	208
Free Cashflow	$'000	0	-10	-312	-312	97	203	203	203	203	203	203	203	203

Source: Shard Capital

Updated hydroxide scenario - Sensitivity analysis

Figure 15 - LHS- Forecast FCF at higher lithium hydroxide price assumptions
RHS - Sensitivity Analysis – unrisked hydroxide project NPV at 10% discount rate



Source: Shard Capital

Figure 16 - Sensitivity Analysis – hydroxide scenario – Shard estimates

Hydroxide scenario Sensitivity **(USD $m)**

Hydroxide price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	479	225	111	27
9,000	722	400	254	146
10,000	965	575	397	264
11,000	1207	750	540	383
12,000	1450	925	**684**	502
13,000	1693	1100	827	620
14,000	1936	1275	970	739
15,000	2179	1450	1113	857

Hydroxide case Risked SotP Sensitivity
to equty raise price assumption **(GBP £/sh)**
At 0.5x NAV multiple

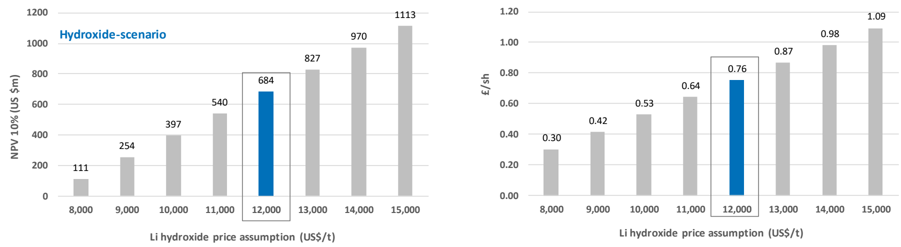
Equity fundraise price (p/sh)	Discount rate (%) 5%	8%	10%	12%
0.20	0.90	0.63	0.50	0.41
0.25	1.07	0.74	0.59	0.48
0.30	1.22	0.85	0.68	0.55
0.35	1.36	0.95	**0.76**	0.61
0.40	1.49	1.03	0.83	0.67
0.45	1.60	1.11	0.89	0.72
0.50	1.71	1.19	0.95	0.77
0.55	1.80	1.26	1.00	0.81

Hydroxide Risked NAV/sh Sensitivity **(GBP £/sh)**
At 0.5x multiple

hydroxide price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	0.59	0.39	0.30	0.24
9,000	0.79	0.53	0.42	0.33
10,000	0.98	0.67	0.53	0.42
11,000	1.17	0.81	0.64	0.52
12,000	1.36	0.95	**0.76**	0.61
13,000	1.55	1.08	0.87	0.71
14,000	1.74	1.22	0.98	0.80
15,000	1.93	1.36	1.09	0.89

Hydroxide Risked NAV/sh Sensitivity **(GBP £/sh)**
At 1.0x NPV multiple

Hydroxide price ($/t)	Discount rate (%) 5%	8%	10%	12%
8,000	1.16	0.73	0.53	0.39
9,000	1.51	0.98	0.74	0.56
10,000	1.86	1.24	0.95	0.74
11,000	2.22	1.49	1.16	0.91
12,000	2.57	1.75	**1.37**	1.08
13,000	2.92	2.00	1.58	1.25
14,000	3.28	2.26	1.79	1.43
15,000	3.63	2.51	1.99	1.60

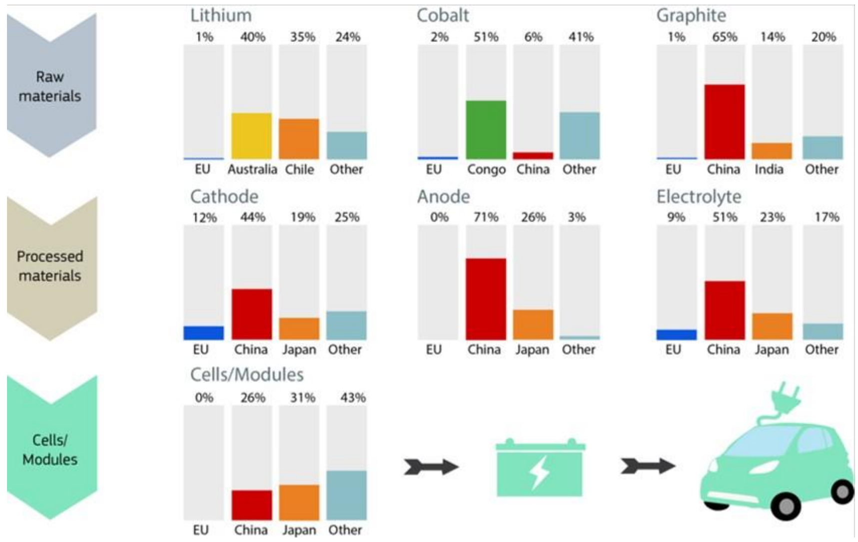


Source: Shard Capital estimates

European battery update

- **An EU priority.** The EU Commission has identified batteries as a "strategic value chain" stating that *"the EU must step up investment and innovation in the context of a strengthened industrial policy strategy aimed at building a globally integrated, sustainable and competitive industrial base".* Electrification is seen as one of the key pathways for a carbon-neutral economy by 2050*.*
- **But there's a problem.** This requires huge investment as the European share of global cell manufacturing is just 3% compared to Asia's 85% share. The EU is thus concerned about becoming dependent on imports of battery cells and the raw materials used in the battery chain.
- **The EU's aim.** The EU commission's aim is to build a competitive and sustainable battery ecosystem in Europe, covering the entire value chain. To this end, the EU launched the European Battery Alliance in October 2017. This has a clear focus on battery cells but also starts with the supply of raw materials. Europe not only has a high dependency on battery cell production but also access to the five essential battery raw materials (lithium, nickel, cobalt, manganese and graphite). This is where we see opportunities for EMH and Cinovec to be of strategic importance, providing a long-term supply of European-based lithium.
- **China** dominates the lithium-ion battery chain with the highest concentration of battery-grade refinancing and processing facilities. Whilst processing capacity exists in Europe for cobalt and nickel, there is none for battery-grade lithium compounds.
- **Deficit.** According to the EU, *Global market forecasts project demand for lithium-ion batteries to grow significantly to up to 660 GWh by 2023, 1,100 GWh by 2028 and could reach up to 4,000 GWh by 2040, compared to only 78 GWh today. As the global market size increases, Europe is forecast to develop a capacity of 207 GWh by 2023, while European demand for electric vehicle batteries alone would be around 400 GWh by 2028.*
- **The EU lags at every stage of the value chain**:

Figure 17 - Supply dependency of materials in the EV battery value chain



Source: European Commission, Joint Research Centre

Future battery chemistry could favour lithium hydroxide

- **Hydroxide is becoming favoured.** Both lithium carbonate and lithium hydroxide can be used as the starting lithium material in the production of batteries. The recent trend is that Tesla and other EV-leading companies such as Panasonic are increasingly becoming aligned with the hydroxide route.
- **Why the shift to hydroxide?** The answer is related to the one of the perennial issues raised by potential buyers of electric vehicles – the question of range. Consumer concerns about the driving range of EVs has always been a barrier to more widespread adoption and switch from petrol/diesel to EV.
- **EV Range.** One of inputs into EV range is the battery component, in particular energy density. This has resulted in a situation where batteries with higher energy density are being incentivised. In most cases this means a switch in cathode chemistry primarily to NCM or NCA batteries[1]. In particular, the potential adoption of the NCM 811 battery is gaining pace as the 811 is said to produce a higher energy density. 811 refers to 8-parts nickel, 1-part cobalt and 1-part manganese which implies significantly more nickel and less cobalt than other NCM types e.g. 111 and 523 on the same Ni-Co-Mn ratio basis.
- **Stability.** 811 chemistry minimises cobalt which has cost (expensive) and supply (reliance on DRC) implications. The flipside is that cobalt plays a major part in the thermal stability of a battery. According to Argus, as the nickel content approaches 60%, the high temperature required to synthesis cathode material with lithium carbonate can damage the crystal structure of the electrode and change the oxidation state of the nickel metal. One solution to stability issues is to use lithium hydroxide which allows rapid and complete synthesis at lower temperatures increasing the performance and life span of the battery.
- **What next?** Solid-state batteries and graphene related technology could represent the next phase of long-term battery evolution. Solid-state batteries substitute the liquid electrolyte with a solid electrolyte. The impact of solid-state technology is difficult to gauge but it will likely result in less (or no) cobalt but still require a lithium-ion solid electrode.
- **Positive for Lithium.** Irrespective of batter chemistry, all types use a significant proportion of lithium, unlike cobalt which is being engineered out of some of the new battery chemistries. See table below:

Figure 18 - Critical material intensity of key battery chemistries

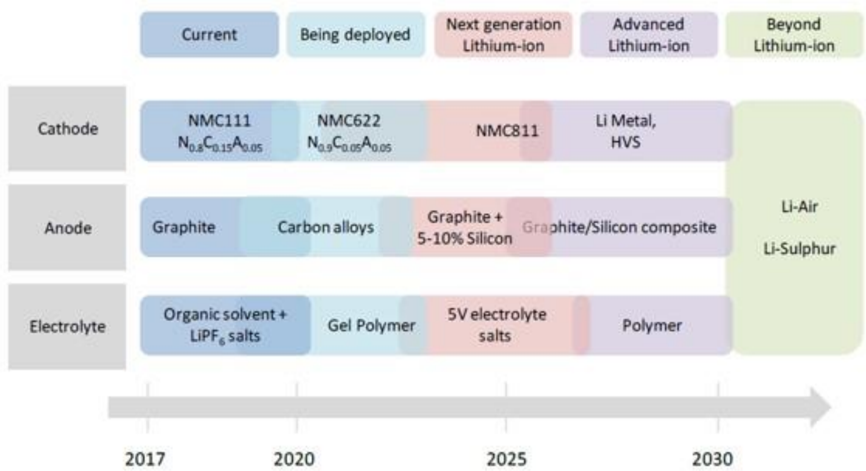
Battery Chemistry	kg/kWh (atomic share of each metal) Lithium	Nickel	Cobalt	Manganese
NCA	0.10	0.67	0.13	0.00
NMC 111	0.15	0.40	0.40	0.37
NMC 433	0.14	0.47	0.35	0.35
NMC 532	0.14	0.59	0.23	0.35
NMC 622	0.13	0.61	0.19	0.20
NMC 811	**0.11**	**0.75**	**0.09**	**0.09**
LFP	0.10			

Source: ANL BatPaC, OCED/IEA 2018

[1] NCM = lithium plus Nickel-Manganese-Cobalt, NCA = lithium plus nickel-cobalt-aluminium oxide

- **Carbonate is a larger market, but hydroxide gaining importance.** Lithium hydroxide (LiOH) or a product called lithium hydroxide monohydrate ($LiOH.H_2O$) is a form of lithium compound which along with lithium carbonate is suitable for direct use in the battery market, unlike spodumene concentrate which is an intermediate product. Lithium hydroxide currently represents approximately 25% of the global lithium product market, compared to 50% for lithium carbonate. Lithium carbonate remains the dominant choice for cathode manufacturers in China. Any further move towards hydroxide will favour hard-rock producers, either those producing a spodumene concentrate for downstream processors, those producing or planning to produce hydroxide on site, or companies like EMH with a non-spodumene resource but ability to build conversion capacity at the mine site.
- **Pricing premium for hydroxide.** Based on atomic weights, lithium hydroxide contains 16.54% Li whereas lithium carbonate contains 18.8%. However, the hydroxide has a higher energy mass and the advantage is the production of more "product" for the same lithium tonnage. Over the last couple of years this has resulted in lithium hydroxide trading at a premium to lithium carbonate. Currently, the lithium carbonate[2] price is \$11,500-13,000/t, with lithium hydroxide[3] trading at \$15,000-\$16,000/t, a 26% premium, although this has been much higher in the past (2017 c.40% premium).
- **Limited hydroxide opportunities at the mine site for other producers.** There are limited opportunities for the production of LiOH at mine sites currently. Hard rock lithium producers (pegmatites etc.) tend to have a smaller resource base and generally produce a spodumene 6% Li_2O concentrate. This concentrate requires further processing to produce lithium carbonate or hydroxide. As hard rock resources tend to be smaller (Cinovec being the noticeable exception) it is harder to justify or fund the capital outlay and indeed many projects cannot support the resulting capital intensity. Consequently, most spodumene producers have historically not been vertically integrated, requiring concentrates to be shipped to a conversion plant. Typically, this incurs significant transport and logistics costs as there is limited lithium carbonate/hydroxide conversion capacity outside of China.

Figure 19 - Expected battery technology commercialisation timeline



Source: OCED/IEA Global EV Outlook 2018

[2] Battery grade lithium carbonate 99.5% Li_2CO_3 CIF China
[3] Lithium Hydroxide monohydrate min 56.5% LiOH.H2) battery grade spot Europe.

Sector activity update

► **Sector activity is increasing, projects are finding funding.** The majority of long-range forecasts remain positive for lithium. Lithium carbonate, hydroxide and spodumene prices have moderated over the last 12 months and this has had a knock-on effect to lithium-related equities. Despite current price levels we see sentiment improving. 2019 has seen a considerable increase in activity in the sector with a raft of off-take and supply deals, strategic alliances and direct project investments. In March 2019 to May 2019 alone, we track 9 major announcements. See table below. This bolsters our confidence that projects are getting funded and financing is available for the best opportunities.

Figure 20 - Recent lithium sector activity

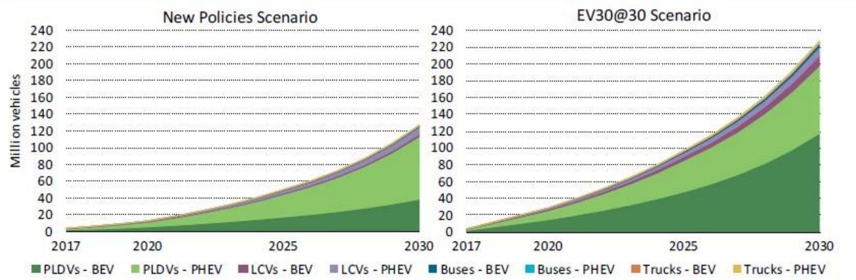
Date	Groups involved	Relevant lithium product	Event
May 2019	Sinomine	Lithium hydroxide	Sinomine Resource group commences construction of lithium hydroxide plant in Jiangxi Province
May 2019	Bacanora, Ganfeng	Lithium carbonate	Proposed cornerstone strategic investment by Ganfeng Lithium - 29.99% of Bacanora, plus a 22.5% interest (option to increase to 50%) in Sonora Lithium, the holder of the Sonoro project. Gangfeng rights to 50% of off-take. Sonoro feasibility indicates 17.5kt Li_2CO_3 Stage 1, 35kt Li_2CO_3
April 2019	Sigma Lithium, Mitsui	Spodumene, Lithium hydroxide	HoA for strategic alliance between Sigma Lithium and Mitsui. Mitsui to provide $30m prepayment towards funding of Grota do Cirilo in Brazil in return for 55ktpa of spodumene concentrate over 6 years, plus off-take over a further 25ktpa. Ganfeng to ship the concentrate to China to convert to lithium hydroxide
April 2019	VW, Gangfeng	Lithium, not disclosed	VW signs MOU with Ganfeng for 10-year lithium supply deal. Agreement to cooperate on future endeavours such as battery recycling and solid-state batteries.
April 2019	Lithium Americas, Ganfeng	Lithium carbonate	$160m investment by Ganfeng in Cauchari-Olaroz, 50:50 JV. 25ktpa Li_2CO_3 Phase 1, 40ktpa Li2CO3 Phase 2
April 2019	Alliance, Jiangxi	Lithium hydroxide	Alliance Mineral Assets and Jiangxi Special Electric Motor - JV to produce and sell battery-grade lithium hydroxide.
April 2019	Desert Lion, BASF	Lithium hydroxide	Desert Lion Energy off-take with BASF for lithium hydroxide from planned facility in Namibia
April 2019	Orocobre, Toyota	Lithium hydroxide	Orocobre and Toyota push button on 10ktpa $77m Naraha lithium hydroxide plant in Japan
March 2019	Johnson Matthey, Nemaska	Lithium hydroxide	Johnson Matthey long-term 10-year supply agreement with Nemaska lithium for Lithium hydroxide
December 2018	Kidman, LG Chem	Lithium hydroxide	Kidman Resources - MOU to supply 12kpa lithium hydroxide to LG Chem (50% of production)
November 2018	Kidman, Mitsui	Lithium hydroxide	Kidman Resources 2-4 year to supply Mitsui & Co for approximately 15% of company's 22.6ktpa production.
November 2018	Altura, Ganfeng	Lithium hydroxide	Altura Mining signs 100% off-take deal with Ganfeng for downstream carbonate and hydroxide production.
September 2018	Tesla, Ganfeng	Lithium hydroxide	Chinese firm, Ganfeng Lithium signed an agreement with Tesla for the delivery of lithium hydroxide from 2018 to 2020 with an option to extend for three years.
September 2018	LG Chem, Ganfeng	Lithium hydroxide	LG Chem, the South Korean battery manufacturer signed an agreement with Ganfeng Lithium to supply 48,000t of lithium hydroxide until 2022.
August 2018	Nemaska, Northvolt AB	Lithium hydroxide	5-year supply agreement signed to supply up to 5kpta of lithium hydroxide to Northvolt from Nemaska'sShawinigan plant
August 2018	Galaxy Resources, POSCO	Lithium hydroxide	South Korean POSCO buys lithium rights in Argentina from Galaxy Resources for $280m.
July 2018	LG Chem, Namaska	Lithium hydroxide	LG Chem signed an agreement with Nemaska Lithium for 7,000tpa lithium hydroxide.
May 2018	Kidman, Tesla	Lithium hydroxide	May 2018. Kidman Resources signs 3-year lithium hydroxide off-take with Tesla
May 2018	Nemaska, Hanwa	Spodumene	Nemaska to supply unspecified quantity of spodumene concentrate to Hanwa
April 2018	Nemaska, SoftBank	-	SoftBank takes 9.9% stake in Nemaska for C$99m

Source: Shard Capital, Company reports

EV outlook

- **Uptake driven by policies.** The uptake of EVs is largely driven by policy environment with the ten leading countries in terms of EV adoption all having a range of policies in place.
- **120-228m new EVs.** The New Policies Scenario (NPC) is based on already announced transport and EV policies. The EV30@30 scenario is based on the aspirational goal of all EVI members for 30% market share for electric vehicles by 2030 which reflects a wider adoption of EVs. The NPC scenario sees c.120m new EVs by 2030 and the EV30@30 Scenario sees 228 million EVs by 2030.
- **Cost driven.** Whichever EV buildout scenario ends up being accurate, the common theme is that auto manufacturers will need not only more battery capacity, but also cheaper batteries. This will only by driven by economies of scale in addition to reducing the cost of cell production. Currently, cells represent 70% of total battery pack costs[4]. In turn, the battery pack (multiple battery modules and battery management system) accounts for around 35% of the total battery-electric vehicle cost. Reducing the cost of cell production will primarily be driven by increasing the energy density (including chemistry) and by reducing manufacturing costs.
- **IEA View:** Lithium-ion is expected to remain the technology of choice for the next decade, when it is expected to take advantages of a number of improvements to enhance battery performance. Other battery technology options are expected to become available after 2030.

Figure 21 - Global EV stock in the NPC and EV30@30 scenarios – OECD/IEA 2018



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

Source: European Commission, Joint Research Centre

[4] BCG 2018, Kupper et al Sep 2018.

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