

The Battery Revolution

Benchmark World Tour 2018

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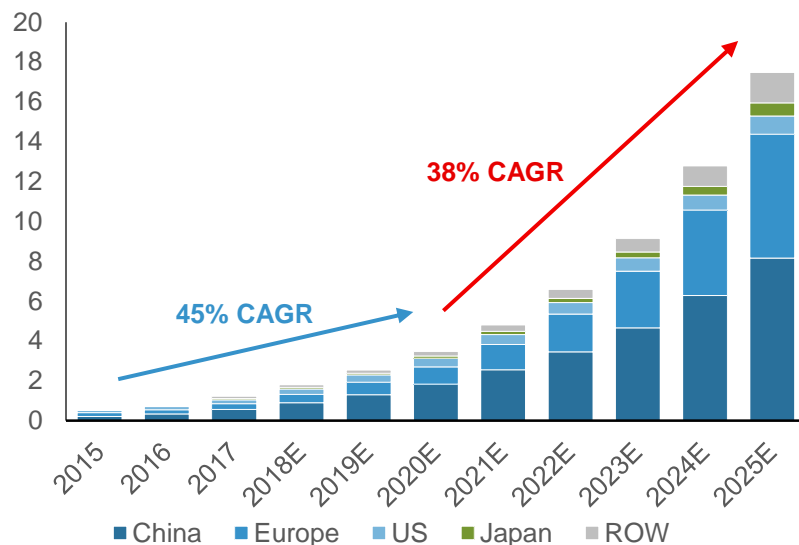
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Section 1

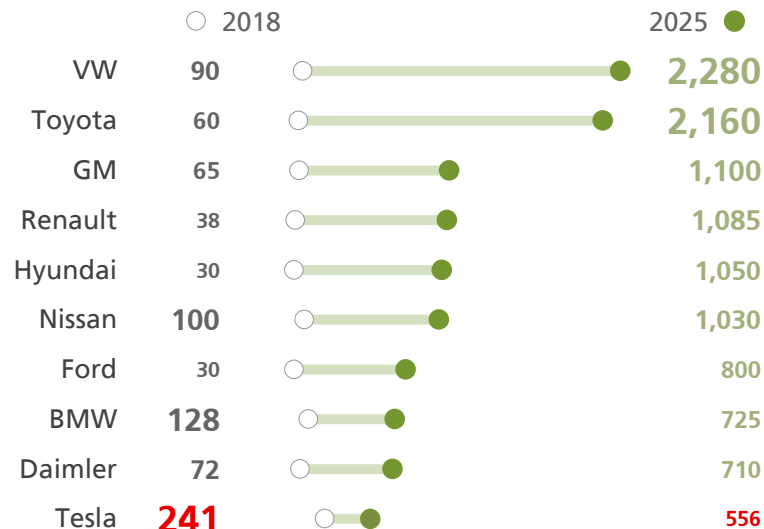
Electric Vehicle & Battery Revolution

How does the teardown change our view on **EV sales**?

UBS global EV sales model by region (m units)



EV sales forecast by OEM (thousand units)



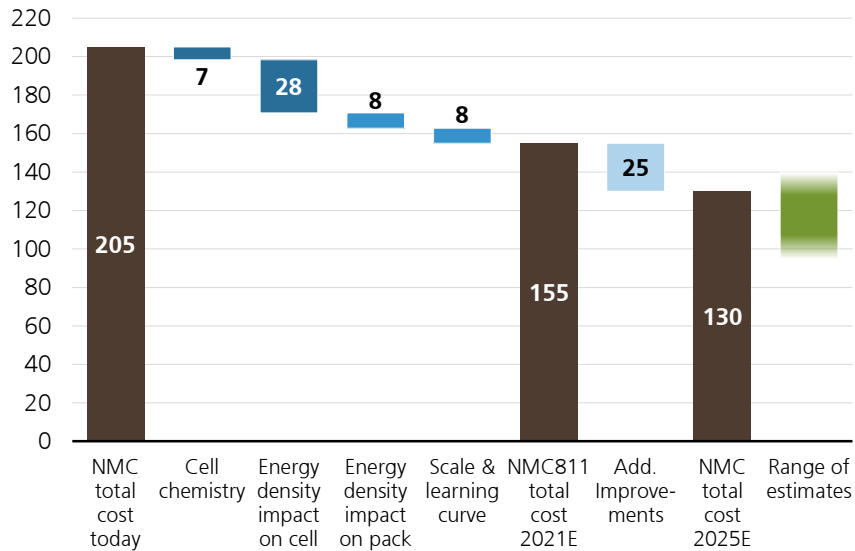
We raise our EV penetration forecast slightly to **17.5m units in 2025** (17% vs. 16% previously)...

...and expect **VW to be the #1 in EV sales** whereas Tesla is likely to remain a niche player

Source: UBS estimates

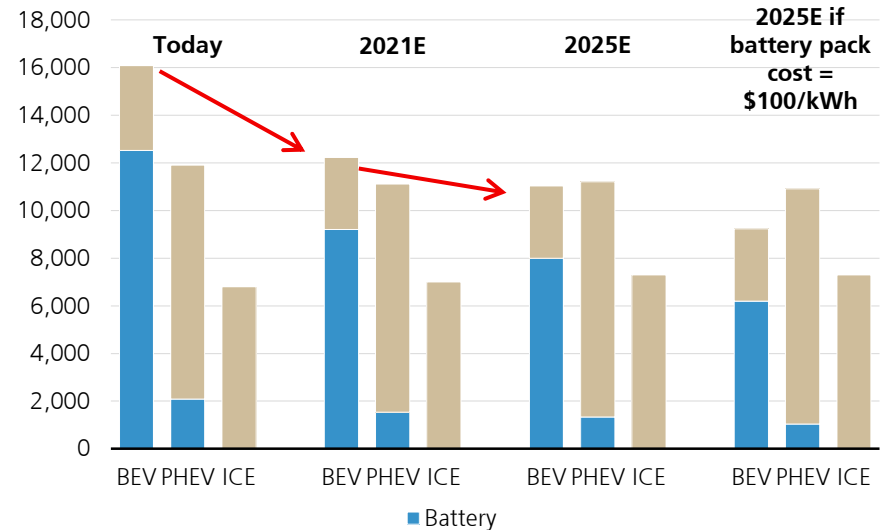
Falling powertrain costs to drive Electric Vehicle demand

Battery pack cost bridge 2017-2025E (\$/kWh)



The battery pack, the largest cost item in an electric car, is likely to **decline 25% by 2021...**

Electric powertrain cost trend (\$)



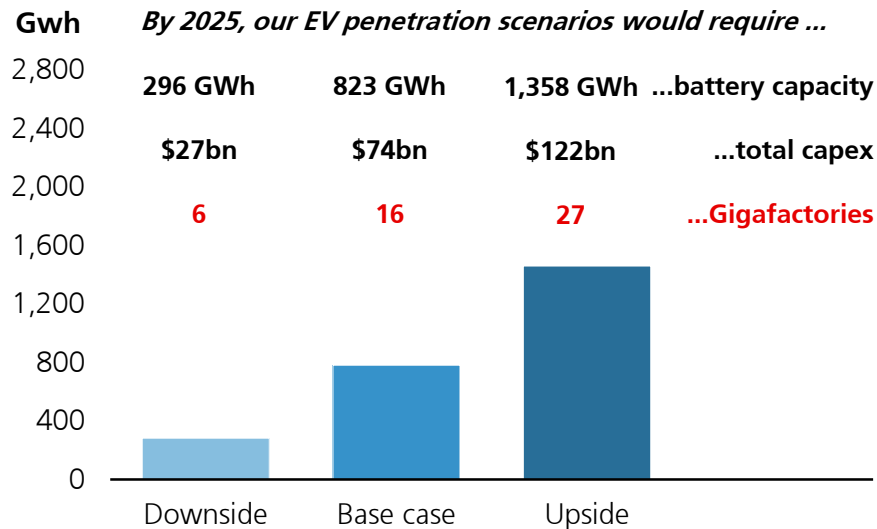
...bringing the total BEV powertrain cost close to **parity with a PHEV** by 2021 and below by 2025

Technology costs are declining even faster than anticipated in the EV teardown Q-Series last year

Source: UBS estimates

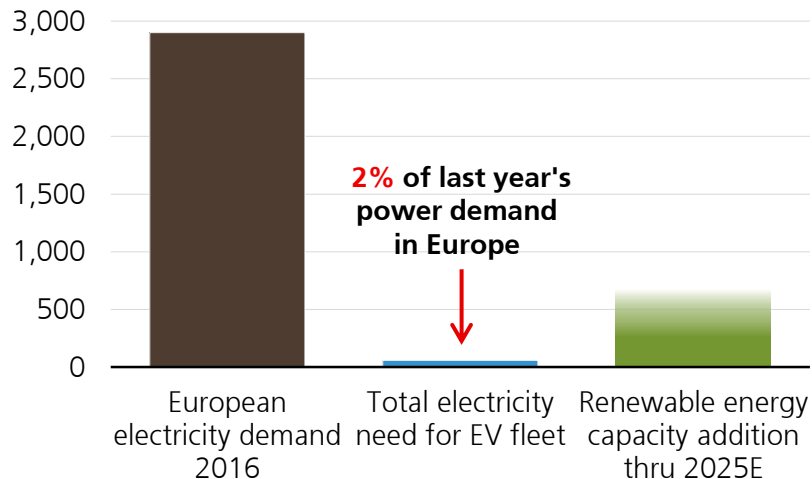
Stress-testing our forecasts – power demand and capex

16 Gigafactories to meet 2025E battery cell demand



Our EV sales forecasts would require the equivalent of **16 Gigafactories...**

EV impact on power demand (2025)



...and no incremental power generation capacity

Our EV sales forecast appears aggressive at first glance, but our stress-test suggests they are not unrealistic

Source: UBS estimates

China EV Market: **Big 2018 subsidy changes**

- China's EV subsidy regime has changed dramatically in 2018, & when coupled with addition of the big 3 Korean battery makers to the "white list", suggest government wants much faster quality improvement

China EV subsidy regime evolution

RMB	2015	2016	2017	2018
Vehicle range (kms)				
>80kms	31500	0	0	0
100-150kms	31500	25000	20000	0
150-200kms	45000	45000	36000	15000
200-250kms	45000	45000	36000	24000
250-300kms	54000	54000	44000	34000
300-350kms	54000	54000	44000	45000
400kms +	54000	54000	44000	50000

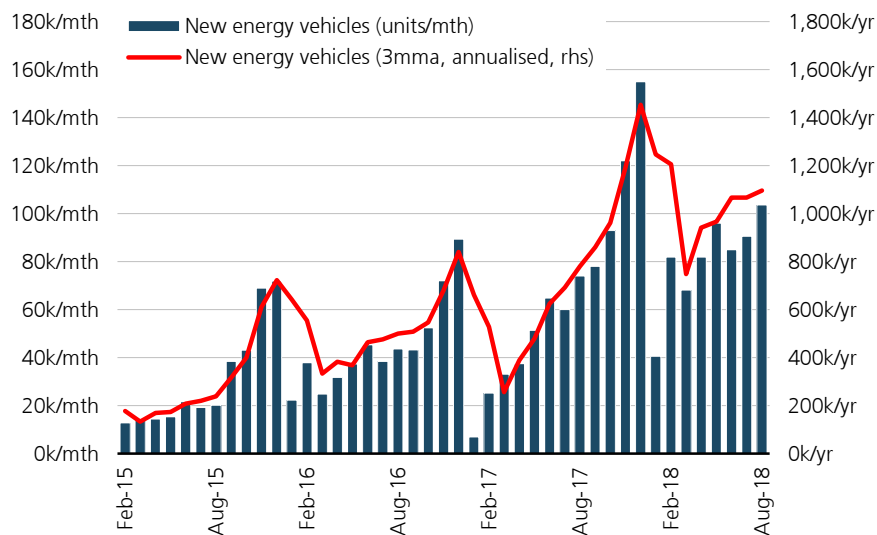
Multiplier	2015	2016	2017	2018
Battery Specific Energy				
90-105 wh/kg	1.0	1.0	1.0	0.0
105-120 wh/kg	1.0	1.0	1.0	0.6
120-140 wh/kg	1.0	1.0	1.1	1.0
140-160 wh/kg	1.0	1.0	1.1	1.1
160 wh/kg +	1.0	1.0	1.1	1.2

Best battery chemistry	LFP	LFP	NCM111	NCM523
	NCM111	NCM111	NCM523	NCM622
		NCM523	NCM622	NCM811
				NCA

China EV subsidies => Bigger & higher density batteries

- The effect of the subsidies is to encourage
 - 1) bigger LFP batteries (30%-50% increase in kWh size according to corporates), and
 - 2) a shift toward Ni containing batteries

China NEV output – mth & annualised



2018

RMB subsidy Vehicle range (kms)	Battery specific energy				
	90-105 wh/kg	105-120 wh/kg	120-140 wh/kg	140-160 wh/kg	160 wh/kg +
>80kms	0	0	0	0	0
100-150kms	0	0	0	0	0
150-200kms	0	9000	15000	16500	18000
200-250kms	0	14400	24000	26400	28800
250-300kms	0	20400	34000	37400	40800
300-350kms	0	27000	45000	49500	54000
400kms +	0	30000	50000	55000	60000

2017

RMB subsidy Vehicle range (kms)	Battery specific energy				
	90-105 wh/kg	105-120 wh/kg	120-140 wh/kg	140-160 wh/kg	160 wh/kg +
>80kms	0	0	0	0	0
100-150kms	20000	20000	22000	22000	22000
150-200kms	36000	36000	39600	39600	39600
200-250kms	36000	36000	39600	39600	39600
250-300kms	44000	44000	48400	48400	48400
300-350kms	44000	44000	48400	48400	48400
400kms +	44000	44000	48400	48400	48400

2018 change relative to 2017

RMB subsidy Vehicle range (kms)	Battery specific energy				
	90-105 wh/kg	105-120 wh/kg	120-140 wh/kg	140-160 wh/kg	160 wh/kg +
>80kms					
100-150kms	-20000	-20000	-22000	-22000	-22000
150-200kms	-36000	-27000	-24600	-23100	-21600
200-250kms	-36000	-21600	-15600	-13200	-10800
250-300kms	-44000	-23600	-14400	-11000	-7600
300-350kms	-44000	-17000	-3400	1100	5600
400kms +	-44000	-14000	1600	6600	11600

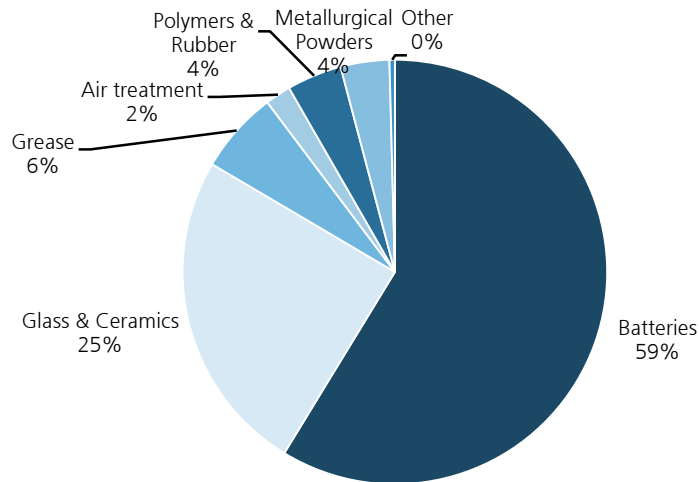
Section 2

Battery Raw Materials

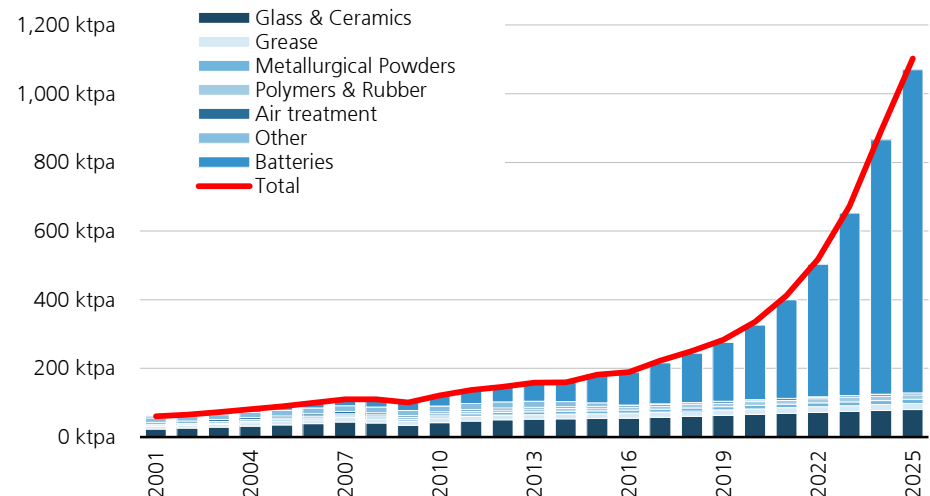
Lithium Demand: All about **Li-ion batteries**

- Lithium demand today is reasonably diverse across batteries (~59%), ceramics & glassware (~25%), greases & lubricants (6%) and other
- Extraordinary growth is in the pipeline thanks to the li-ion battery revolution driving disruption through automotive and power
 - Battery demand to almost double to be ~84% of overall Lithium demand by 2025e

Lithium demand by use – 2018e



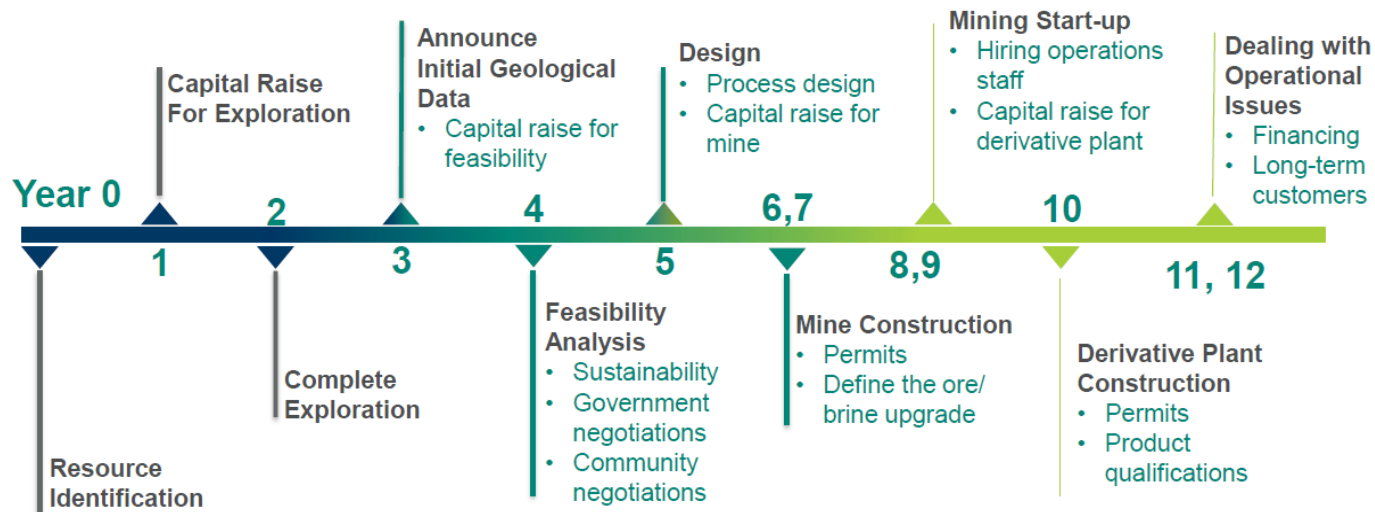
Lithium demand forecasts to 2025e



Lithium Supply: **Rising quality hurdles** the challenge

- Lithium is not geologically scarce, nor are there a shortage of new projects/expansions
- But an emerging & relentless pursuit of lower impurity battery feedstocks presents a critical challenge for industry
 - Low grade lithium feed will find it increasingly difficult

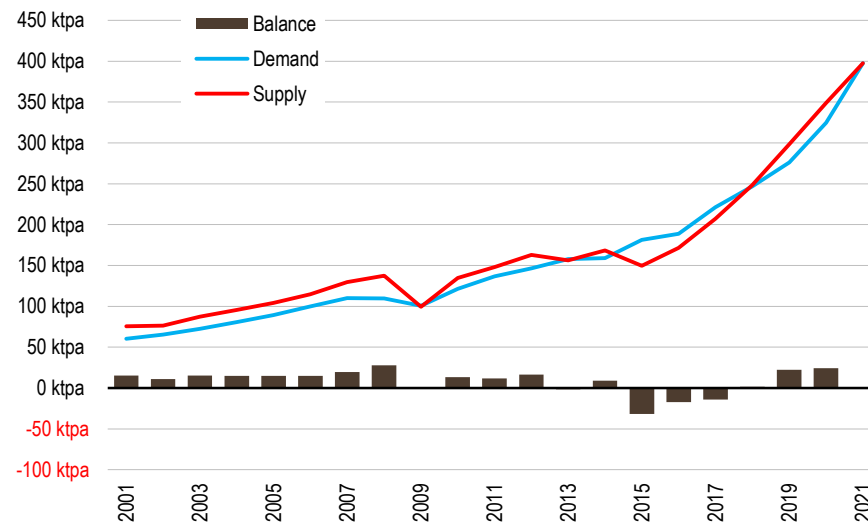
Multi-year Lithium project lead times...if all goes to plan...



Lithium Market: **Near term "air pocket"...**

- China's subsidy upheaval is rippling through the chain; markets appear weak near term
- But supply of battery grade carbonate & hydroxide, of an increasingly low impurity, will remain tight in our view
- Into early/mid next decade, a large step up in supply will be needed to meet projected demand growth

Lithium S-D balance – UBS base case

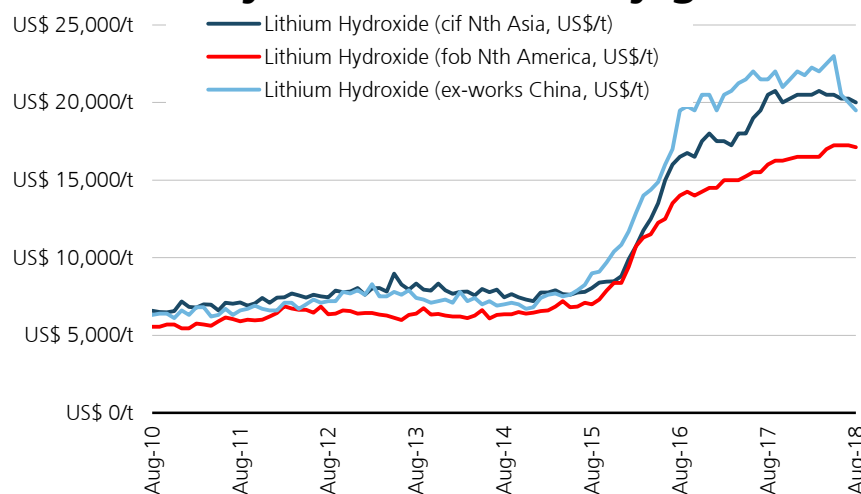


Lithium Prices: China EV subsidy "air pocket"

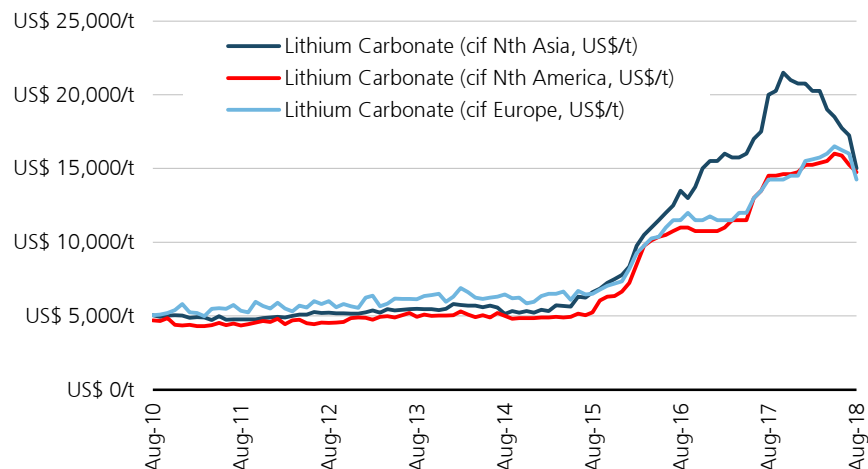
Lithium price history and forecasts

	Li2CO3 Battery grade 2000-16	LiOH Battery grade 2007-16	Min Conc 6% Li2O 2000-16
Historical Real	\$5,073	\$10,503	\$285
2017-25	\$12,718	\$13,909	\$690
UBS LT real - Downside	\$6,500	\$8,500	\$420
UBS LT real - Base Case	\$9,000	\$12,000	\$550
UBS LT real - Upside	\$12,000	\$15,500	\$700

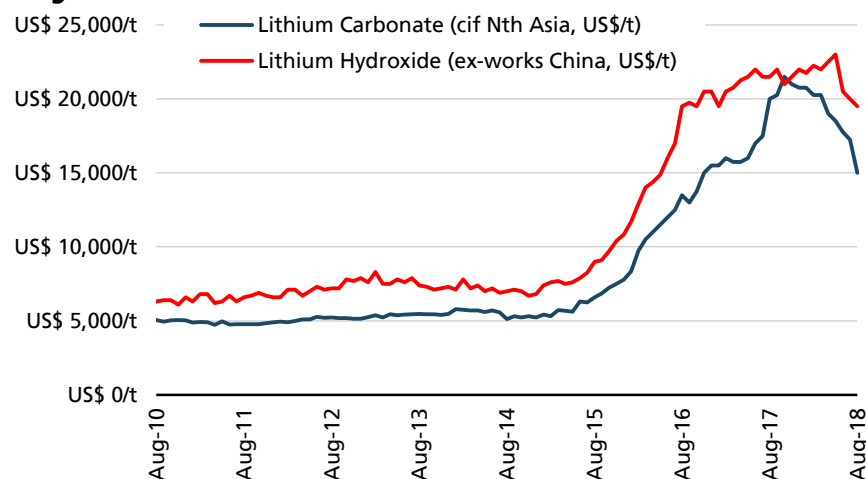
Lithium hydroxide – battery grade



Lithium carbonate – battery grade

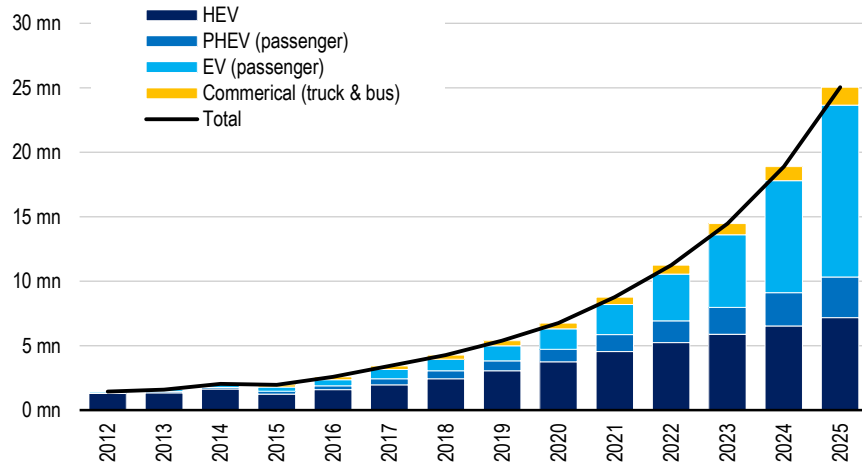


Hydroxide vs Carbonate

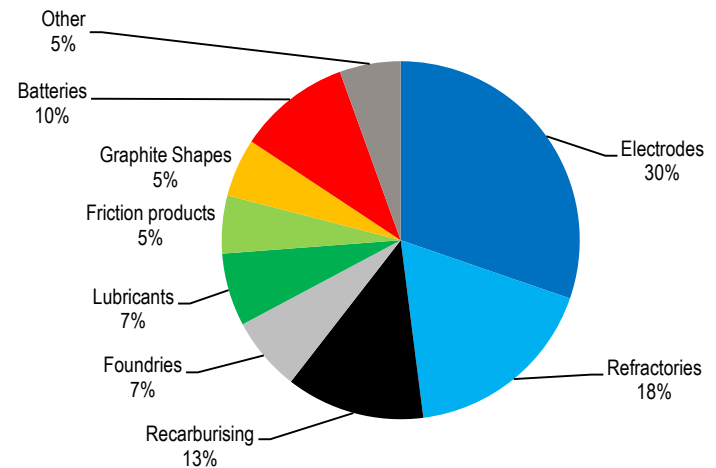


Graphite: Can Mozambique meet demand growth?

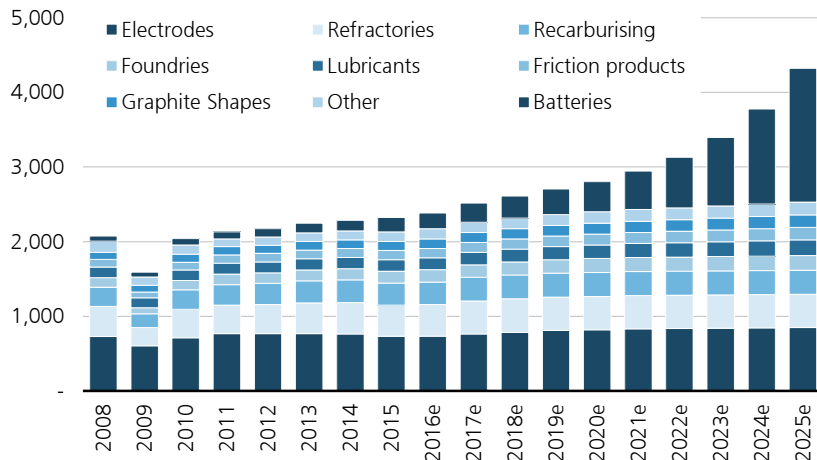
Growth in Electric Vehicles is robust...



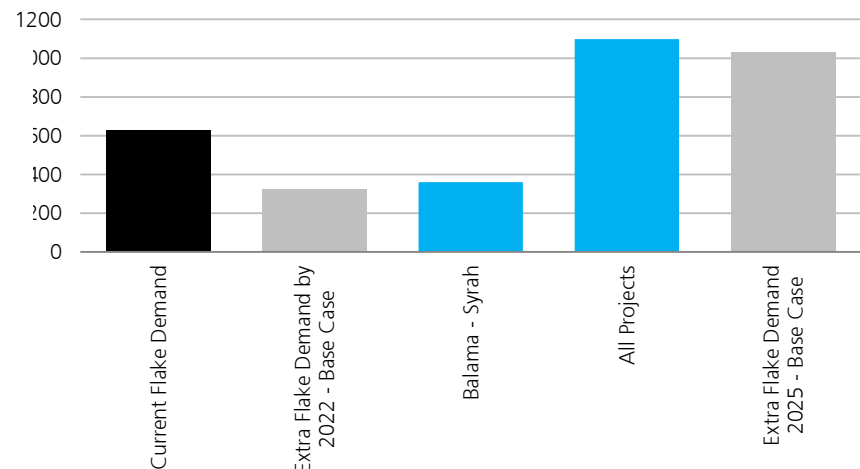
But Batteries are a small portion of graphite demand



...so that a step change in demand will take a few years yet (ktpa)



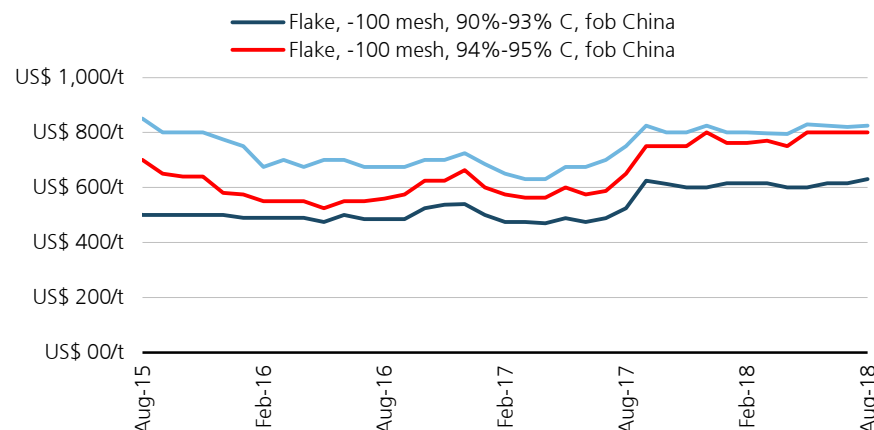
...planned mine expansions are large (ktpa)



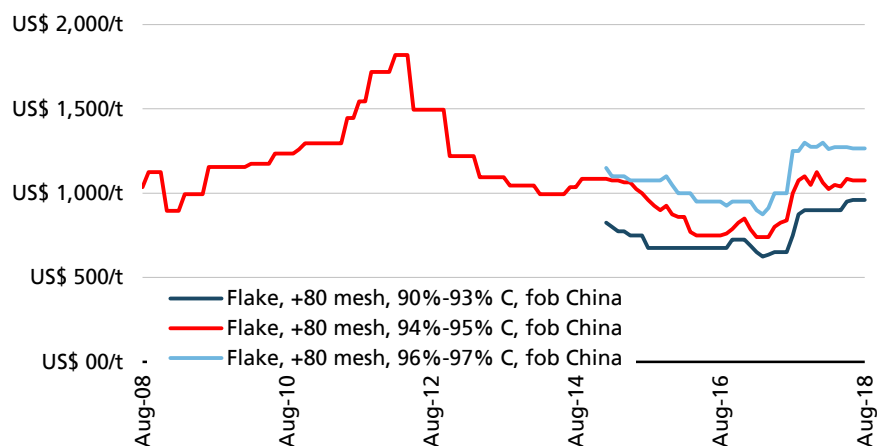
Graphite Prices: Stronger on China supply closures

	Mesh Size, Flake, 94-95% C, FOB China			Spherical	
	-100	+80	+50	Uncoated	Coated
2018E	800	1,091	1,755	3,763	7,000
2019E	900	1,125	1,688	4,500	6,000
2020E	838	1,038	1,556	4,125	5,000
2021E	788	1,050	1,575	3,525	4,500
2022E	788	1,050	1,575	2,925	4,500
LT price (nom. 2023)	828	1,085	1,627	2,398	3,997
LT price (real 2018)	725	950	1425	2100	3500

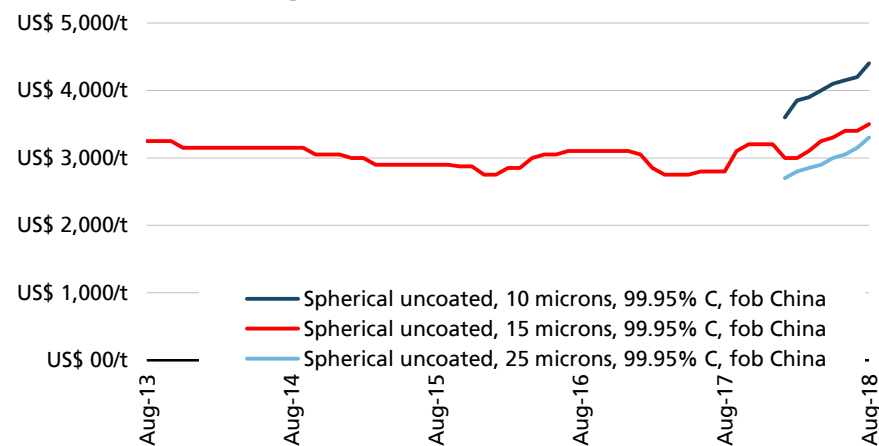
Flake, -100, various grades, fob China



Flake, +80 mesh, various grades, fob China

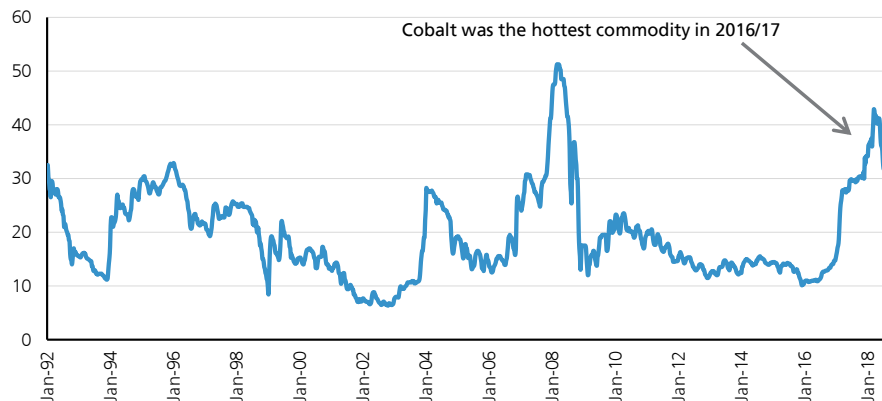


Spherical uncoated prices, 99.95% C, various sizes, fob China

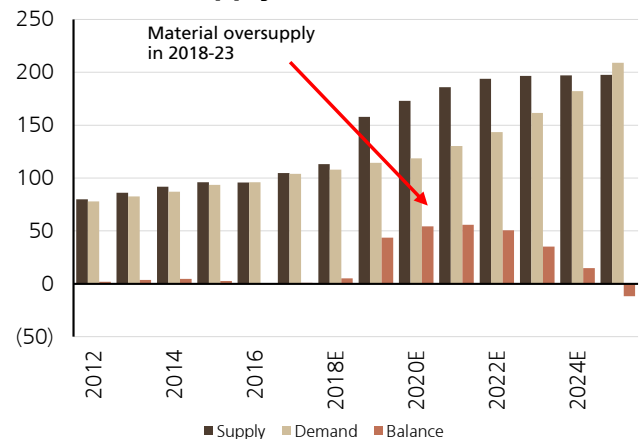


Cobalt: **Is there enough** for the battery revolution?

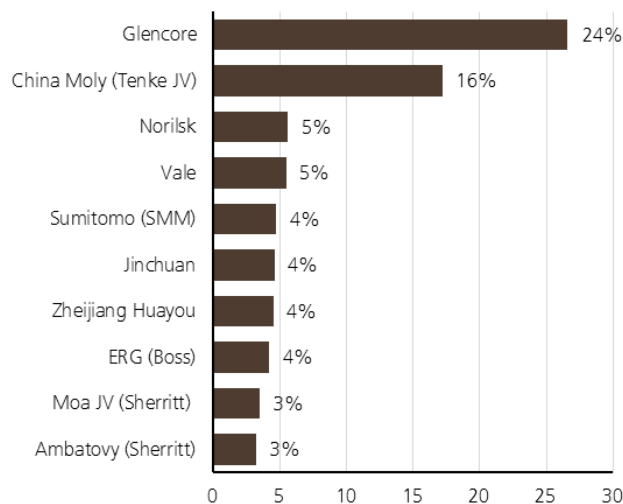
Cobalt prices, US\$/lb



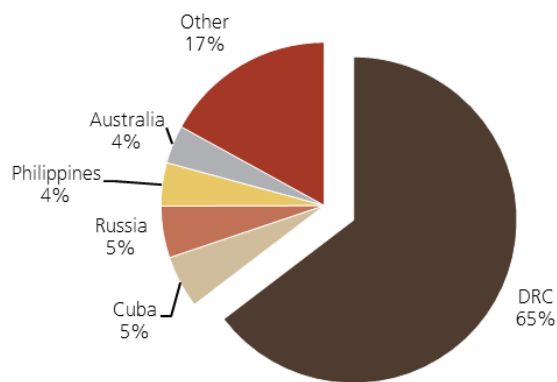
Cobalt supply demand outlook, kt



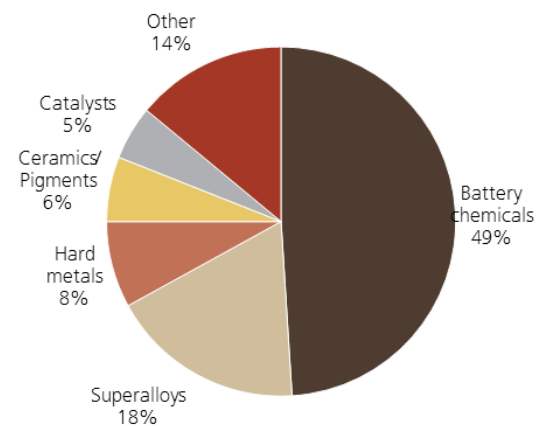
Cobalt top producers, kt, 2017



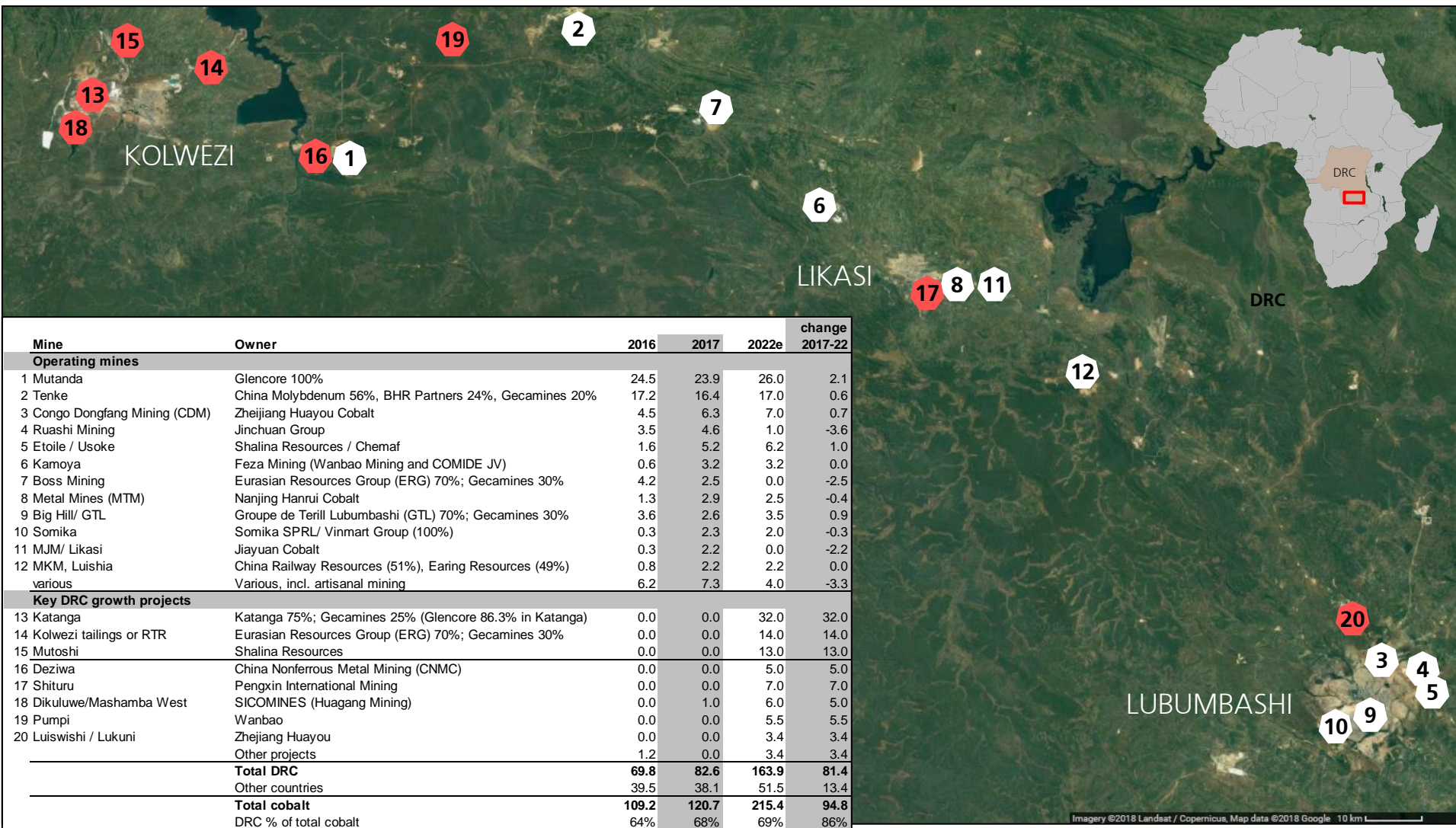
Cobalt supply by country



Cobalt demand by sub-sector



Cobalt: **DRC mine supply** concentrated in Katanga



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Neutral	FSR is between -6% and 6% of the MRA.	37%	21%
Sell	FSR is > 6% below the MRA.	15%	13%
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Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

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