Colts

A research initiative by Canaccord Genuity

Collerina Cobalt (ASX:CLL)

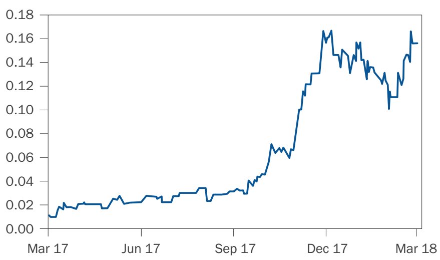
Developing the key ingredients for an electric future

Key Facts	
Company Code	ASX:CLL
Closing Price (14/3/18)	$0.14
Date of Report	15/3/18
Company Website	collerinacobalt.com.au
Analyst	Larry Hill

Company Statistics	
12 Month Range (A$)	$0.01 - $0.17
Market Cap (A$Mil)	71.1
Issued Shares (Mil)	508.3
Issued Options (Mil)	38.0
Cash (A$Mil)	A$1.8m

Major Shareholders	%
PT Archi Indonesia	22.7%
Permgold Pty Ltd	10.7%
Budworth Capital Ltd	7.2%
BT Portfolio Service Limited	6.6%

Share Price Performance



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If you have received this indirectly, please click **here** to receive future research on CLL and other Colt companies.

Collerina Cobalt (ASX:CLL) have progressed several development activities at the Homeville project located in New South Wales that we view as providing further price catalysts over the short term. Through continuous testwork currently underway, CLL are aiming to recover Nickel & Cobalt (Ni-Co), potentially as a NMC (lithium ion battery) pre-cursor as well High Purity Alumina (HPA). HPA is the pre-cursor material to synthetic sapphire glass, a key ingredient in LED lights and Li-ion battery separators and as such we view this product has a strong associated demand outlook (CGe CAGR to 2025 of 15%). Favourable geology at Homeville has potential to place CLL at a distinct advantage to other HPA developers in terms of overall project economics. These are to be validated in the release of a Pre-Feasibility Study (PFS) over JunQ'18.

Key Points

Unique orebody and inventive processing could give CLL the edge. The Homeville resource (16.3 Mt at 0.93% Ni + 0.06% Co) is contained within the Lachlan Fold belt in New South Wales. What makes it distinct however is iron grades around half (~19% Fe) of other regional laterite projects. This presents as an enormous advantage through the elimination of high pressure acid leaching (HPAL) to control iron precipitation. With the average capital cost > US$50,000/t for a standard HPA process flowsheet, CLL proposed use of conventional processing (atmospheric leach/solvent extraction) provides a potential cost advantage over other HPA and Ni-Co laterite developers. Recent testwork has returned a 4N (99.99%) purity of HPA, demonstrating that producing a readily saleable product is achievable.

Strong interest from commercial partners likely. Current HPA supply is dominated by large diversified chemical companies with ~60% of production originating from the top five producers. Major HPA producers reportedly manufacture HPA through the re-processing of aluminium metal and sulphates with removing impurities contributing to the current pricing of 4N material around US$20-35/kg depending on offtake terms. With the substitution in high end applications such as LED parts and separator within lithium-ion batteries low, we expect that interest in any lower cost product that CLL can supply would be welcome by market participants.

What is HPA and why is it important? The main use for HPA are significant with market research indicating demand is expected to grow from gross revenue of ~US$1.3B in 2016 to US$3.6B by 2021. Within this the 4N segment is expected to grow the most in absolute terms from US$0.9B in 2016 to US$1.8B by 2021 implying a CAGR of ~16%. Due to the lack of ready substitutes price demand is expected to remain relatively inelastic, supportive for stable price forecasts over the medium term. For comparison we estimate that gross revenue from the lithium carbonate industry was ~US$2B in 2016 moving to US$4.8B by 2021. Across this demand from the lithium-ion battery segment is expected to grow at 20% with gross sales revenue increasing from US$1.0B to US$3.5B by 2021. A key market for HPA is also in LED lighting, a sector that industry research predict forecast demand of +20% CAGR over the next five years. We highlight the opportunity HPA has in improving energy efficiency.

Key Catalysts

- Completion of Mini Rig Test work: Over 250 litres of leach liquor will be treated to generate ~1kg of 4N HPA. Successful completion of this work is due over May'18.
- Progression of product offtake: CLL will provide representative 4N HPA product to commence offtake and funding discussions with potential project partners. Product qualification and advancement is expected over JunQ'18.
- Pre-feasibility study release – Final documentation and delivery expected in June 2018.

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Company Overview

Collerina Cobalt (CLL:ASX) is an Australian based exploration and development company (known as Augur Resources until 2017) who have advanced the Homeville project since acquisition in 2006. The Homeville project was first drilled out by CLL (formally Augur Minerals) in 2006 with a maiden resource (12.2Mt at 0.91% Ni and 0.06% Co) declared over 2008. Since this time a scoping study was prepared in September 2013 outlining a 10 year operation producing 5.2ktpa of nickel cathode and byproducts of cobalt sulphate for a total capital of $105m at a cash cost of US$6.04/lb Nieq. The low economic return of this project did not support development and as such CLL have explored alternative strategies to exploit the favourable mineralogy (ie low Fe) contained within the ore deposit.

2017 however represented as a transformative year for the project as CLL were able to verify a proprietary process for the production of High Purity Alumina (HPA). The process has been developed through a long standing collaboration with a metallurgy consultancy over the last number of years. The process is comparatively low cost and does not use novel techniques or reagents. In our view the ability to replicate very encouraging initial test work on a larger continuous scale should provide the foundations for a pre-feasibility study due out over JunQ'18.

CLL also have the ability to earn in up to 85% on the Becker Gold Project located in the Region VII of Chile through subsidy company Carlin Resources. The Becker Gold project covers two main zones of intermediate to low sulphidation epithermal gold-silver veining across a 2,000 hectare property. Early stage geophysical and geological work has been undertaken. CLL also have a 45% interest in the Wonogiri copper-gold project located in central Java in Indonesia. The project has a JORC 2012 compliant resource of 81.56Mt at 0.44g/t AuEq with a scoping study completed om a 21Mt at 0.85g/t gold + 0.16% copper project. CLL however are currently focussing its efforts on the development of the Homeville resource.

Corporate and Finance

CLL reported cash as at 1 March 2018 of $1.8m with the addition of $1m from Tranche 2 from the most recent capital raising that occurred in November 2017 to raise A$3.5m through the issue of 64m shares at $0.055/share.

Board and Management

Norman Seckold – Chairman
Mr Seckold has spent more than 26 years in the full time management of natural resource companies, both in Australia and overseas. Mr Seckold has been the Chairman of a number of publicly listed companies across a number of differrent commodities including gold and coal where he was Chariman of Cockatoo Coal Liminted. Mr Seckold is currently Chairman of Planet Gas Limited, an energy explorer with interest in conventional and unconventional oil and gas resources operating in Australia and Santana Minerals Ltd., a precious metals exploration company with projects in Mexico. He is also a director of the unlisted public companies Mekong Minerals Ltd and Nickel Mines Limited

Justin Werner – Managing Director
Mr Werner was appointed Managing Director of CLL in August 2014. Prior to his appointment he worked in management consulting specialising in the natural resource sector. He was a founding partner of PT Gemala Borneo Utama, a private Indonesian exploration and mining company, which developed a heap leach gold mine in West Kalimantan and which is also exploring the highly prospective Romang Island with ASX listed Robust Resources Limited. Mr Werner is also a director of unlisted public company Nickel Mines Limited.

Peter Nightingale – Director and Chief Financial Officer
Mr Nightingale holds a Bachelor of Economics and has worked as a chartered accountant in both Australia and the USA. Mr Nightingale is currently a director of Planet Gas Limited and unlisted public companies Nickel Mines Limited and Prospech Limited.

Rimas Kairaitis – Technical Director
Mr Kairaitis has 20+ years experience in minerals exploration and resource development in gold, base metals and industrial minerals including the discovery of the Tomingley and McPhillamy gold deposits in NSW and steering the Hera gold-lead-zinc Project from discovery to production. He was previously founding Managing Director and CEO of ASX listed Aurelia Metals and is currently a Director of ASX listed General Western Exploration Ltd.

Tony Sgro – Non-Executive Director
Mr Sgro has 40+ years' experience as a Chemical Engineer with a background in Minerals Chlorination used in the extractive metallurgy of various minerals including titanium, nickel, chromium and tungsten ores. He was previously co-founder and General Manager of Kelair.

Project Overview – Homeville (100% owned by CLL)

The project area is located ~200km west of Dubbo in central New South Wales, Australia. The project is contained in the Lachlan Fold Orogen and is ~80km east of Aurelia Metals (ASX:AMI) Nymagee project and is within 150km to the north of other lateritic Ni-Co hosted deposits including CleanTeq's Sunrise (ASX:CLQ), Australian Mines' Flemington (ASX:AUZ) and Platina Resources (ASX:PGM) Owendale project.

The project area is held within two exploration licenses (EL 6336 and ELA 5506) and covers ~ 224km². The project is situated in close proximity from rail (<50km), road and grid power infrastructure.

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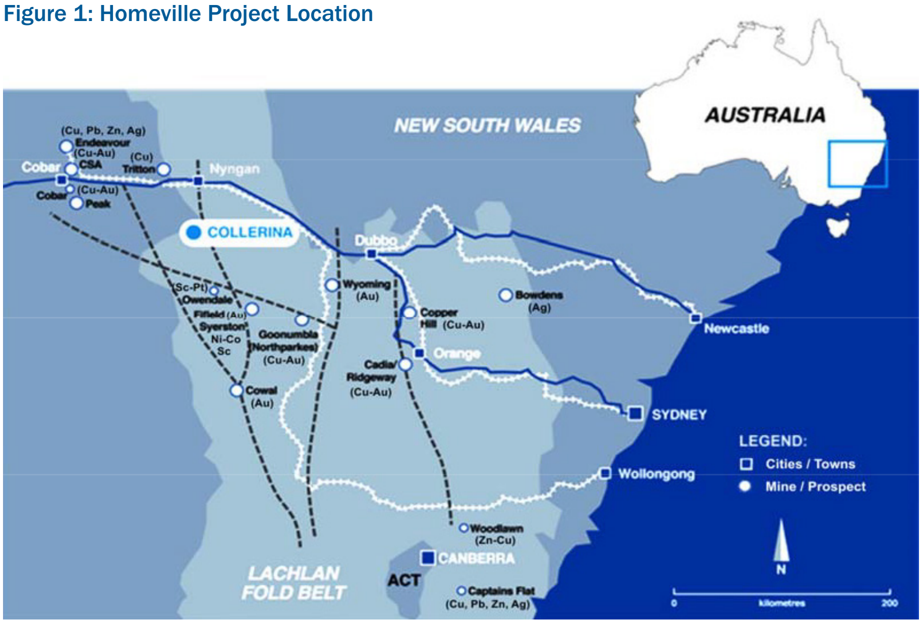
Figure 1: Homeville Project Location



Source: Company Reports

Background

- **June 2011:** Augur announced an updated indicated and inferred resources of 16.3 million mt grading 0.93% Ni and 0.05% Co (cutoff 0.7% Ni) at the Homeville deposit. The mineralization was at surface in some areas and had an average depth of only 10 m below surface.
- **September 2013:** A scoping study at Homeville outlined a 470ktpa open pit operation producing 5.1ktpa NiEq over a 10-year mine life. Initial capital costs were estimated at $105.1m and life of mine cash costs were estimated at $6.04/lb NiEq.
- **December 2014:** A Starved Acid Leach Technology ('SALT') process was proposed as an alternative method of nickel and cobalt extraction to cost prohibitive high pressure acid leaching (HPAL) processing. While this provided selective extraction of nickel and cobalt in preference to iron and magnesium further work was required to understand geometallurgy and ore variability on leaching performance.
- **July 2015:** Counter current atmospheric leaching (CCAL) testwork completed on a saprolite composite sample. This resulted in overall extractions of 90% for nickel and 96% for cobalt and 710kg/tonne of sulphuric acid consumption. This work led to initiating a scoping study for between 3-5ktpa of NiEq production of a mixed cobalt-nickel sulphide precipitate (containing ~60% Ni).
- **2016:** Scoping study work at Homeville was reduced over 2016 as CLL focussed on development work at its Wonogiri Copper/Gold project in Indonesia. Some minor drilling occurred at Homeville to delineate additional mineralisation.

- **March 2017:** CLL raises up to $1.2m at $0.01/share to advance the Homeville project. The funds were aimed at optimising the final stage of the flowsheet at Homeville to consider producing nickel and cobalt as a high value end product. This included high purity cobalt carbonate, nickel sulphate and potentially a high purity alumina (HPA) product.
- **August 2017:** Confirmatory CCAL testwork commences with results yielding 90%, 94% and 65% recoveries for nickel, cobalt and aluminium respectively within pregnant leach solution (PLS). This replicated results from testwork completed over July 2015 across various ore grades and lithologies.
- **September 2017:** PLS was treated through a proprietary solvent extraction (SX) process to generate high purity HPA (99.99%) samples. Recoveries averaged 73.3% across multiple tests with the aim to test this process on a more continuous basis using a pilot scale mini-rig.
- **November 2017:** Further batch SX tests were performed to extract nickel, cobalt and manganese as a potential battery precursor from treated PLS. This work suggested four CCAL stages would be required to achieve greater than 99% Ni and Co recoveries and up to 80% Mn recovery. In addition CLL placed ~64m new shares at $0.055/share to raise up ~$3.5m.
- **December 2017:** A 368kg representative composite sample was processed as part of a continuous SX process (5 days) to generate ~1kg of 4N HPA from 160 litres of PLS that is generated. It is expected that this sample will be submitted to potential offtake and funding partners for product qualification. In additional key process data from the testwork will generate a PFS providing process plant capital and operating cost estimates (+/- 30%).
- **February 2018:** Confirmatory CCAL testwork was completed that incorporated the reuse of stage 2 acidic solutions to feed stage 1 of leaching. This resulted in 762kg/t ore acid consumption and achieved overall nickel, cobalt and aluminium recoveries of 85%, 94% and 61% respectively. 260kg of PLS was generated for use in the continuous min rig SX program.

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The shallow mineralization at Homeville (see figure below) is conducive for simple open pit mining with no blasting likely due to the weathered nature of the material.

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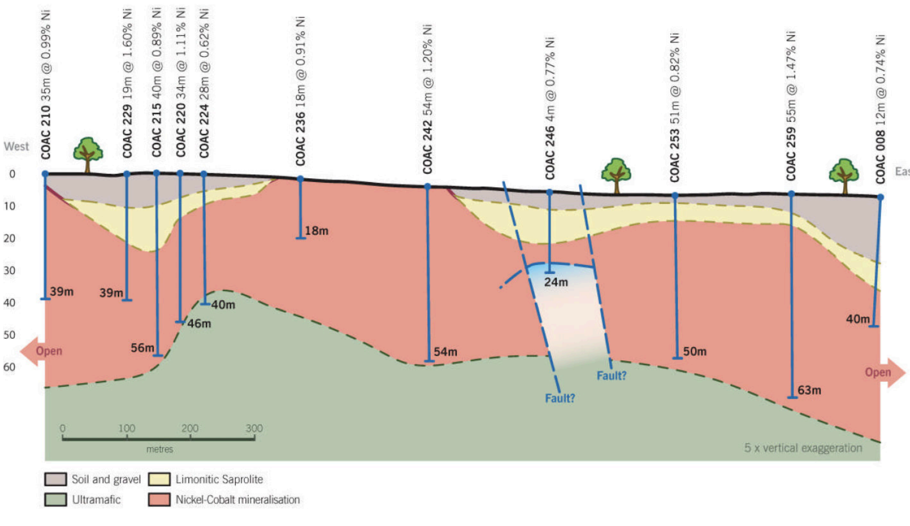
Geology

The Homeville Deposit is hosted over the Yathella Serpenitite stratigraphic trend. The process of 'serpentinisation' involves a pre-cursor ultramafic (eg a dunite) undergoing hydrothermal alteration and the addition of water. During serpentinisation, nickel (and sometimes cobalt) are generally upgraded and iron is depleted. This has been observed in tropical laterites such as the Koniambo Mine in New Caledonia. In general terms, the hydrated silicates hold weaker bonds than the precursor silicates, and so less chemical energy is required to liberate the metals. This has a direct impact on associated operating conditions (pressure, temperature and acid consumption) within the process plant.

There appears to be a strong correlation between cobalt and iron at Homeville. Hence although the cobalt in the global resource is relatively low, it does appear to be grouped in higher grade pods, which will be assessed within the mine plan along with the grade of other elements (key being iron, nickel and aluminium).

Figure 2: Long Section of the Homeville deposit from the initial resource drill out - Aug 2008



Source: Company Reports

Resources and Mining

A maiden resource estimate for Homeville was declared in August 2008 for 12.2Mt at 0.91% Ni and 0.06% Co at a 0.7% nickel cut off. Since this time the resource has been upgraded to 16.3Mt at 0.93% Ni an 0.05% Co based on a 0.7% nickel grade as indicated in Figure 3. There is likely potential for increased tonnage with only 1300m of over 4000m of strike length being included in the resource estimate. Mineralisation is interpreted to remain open to the east and west.

Over 2017 a 45 hole reverse circulation (RC) drill program was initiated at Homeville at an average depth of 60 metres. Data from this campaign will be used to update the current resource from a 2002 to 2012 JORC code classification with increased confidence towards measured resources likely.

Key outcomes of this drilling program were the occurrence of discrete shallow zones of higher grade cobalt (46m at 0.11% Co, 38m at 0.12% Co) which will assist with optimising the preliminary open pit mine design for the current mine life (~20 years).

The shallow mineralization at Homeville (see Figure 2 above) is conducive for simple open pit mining with no blasting likely due to the weathered nature of the material. Pre-strip of a very minor depth (<10m) of overburden is expected before initial mineralisation occurs within the limonitic/saprolite ore body. Importantly magnesium grade is expected to be moderate <5% which will assist with reducing acid consumption.

Figure 3: Current Mineral Resource at Homeville

	Cut off grade Ni %	Mt	Ni %	Co%	Fe%	Al%
Indicated	0.50	6.40	0.87	0.06	21	3.7
	0.70	4.40	0.99	0.06	20	3.4
	1.00	1.80	1.21	0.05	19	3.0
Inferred	0.50	20.70	0.78	0.05	18	3.0
	0.70	11.90	0.91	0.05	18	3.0
	1.00	3.10	1.16	0.05	17	2.7
Total	0.50	27.20	0.80	0.05	19	3.2
	0.70	16.30	0.93	0.05	19	3.1
	1.00	4.90	1.18	0.05	18	2.8

Source: Company Reports

> "Importantly the organic reagent used was identified as highly selective for aluminium which has significant downstream implications when ultimately looking to achieve the requisite purity of a 4N HPA product."

Metallurgy

Previous work undertaken in the September 2013 PFS on Homeville confirmed that sufficient recoveries of metals (90% for Ni, 94% for Co) could be achieved at atmospheric conditions albeit at high levels of reagent consumption vs High Pressure Acid Leaching (HPAL) of 762 vs <300 kg of H_2SO_4/t ore treated. Through the continued involvement of a highly experienced metallurgical consultant, CLL commenced testwork to produce High Purity Alumina (HPA) in September 2017. The key objectives of this work were;

- To utilise pregnant leach solution (PLS) that has been generated from bench scale counter current atmospheric leaching for assessing the recovery of metals through conventional solvent extraction (SX).
- Selectively extract aluminium from the PLS.
- Strip and clean the loaded organic to produce a commercially acceptable 4N HPA product.

Through testwork that is currently underway, CLL are finalising the process flow sheet that will be used at Homeville. It is expected that this will incorporate;

- Stage 1 Counter current Atmospheric Leaching (CCAL): Ore is leached at a lower free acid concentration (~178kg/t) to produce a pregnant leach solution (PLS) with relatively low free acid (~14 g/l). Upon thickening this product is filtered with the resultant solids repulped for stage 2 leaching.
- Stage 2 CCAL: Highly concentrated sulphuric acid (~653kg/t) will be used to liberate contained metals along with the resultant leaching of iron that was supress during stage 1. Importantly the resultant leach solution, once filtered, is recycled back to stage 1 to make use of the high residual free acid (~59g/l).

- Importantly this process is expected to be conducted at modest grind size and moderate temperature (<90°C) which will assist with reducing site energy requirements. As the largest operating cost component, CLL are considering installing a sulphuric acid plant with investigations part of the current DFS.

Recent test results presented in Figure 4 indicate overall nickel, cobalt and aluminium recoveries of 85%, 94% and 61% respectively over a 150kg sample. Importantly a precipitation step on the generated PLS was effectively neutralised to remove iron while keeping aluminium (and other valuable metals) in solution for treatment in the solvent extraction stage.

Figure 4: Leach test work results

Leach Stage	Stage Acid Addition (kg/t)	Residual Free Acid (g/L)	Extractions (%)				
			Ni	Co	Al	Fe	Mg
Stage 1	178	17.4	28	54	14	0	32
Stage 2	653	58.6	80	87	55	74	57
Overall	762	17.4	85	94	61	73	71

Source: Company Reports

> “
> High selectivity has enabled the recovery of >98% nickel, 97% cobalt and 80% manganese within the loaded organic across ~ four counter current stages.
> ”

Solvent Extraction

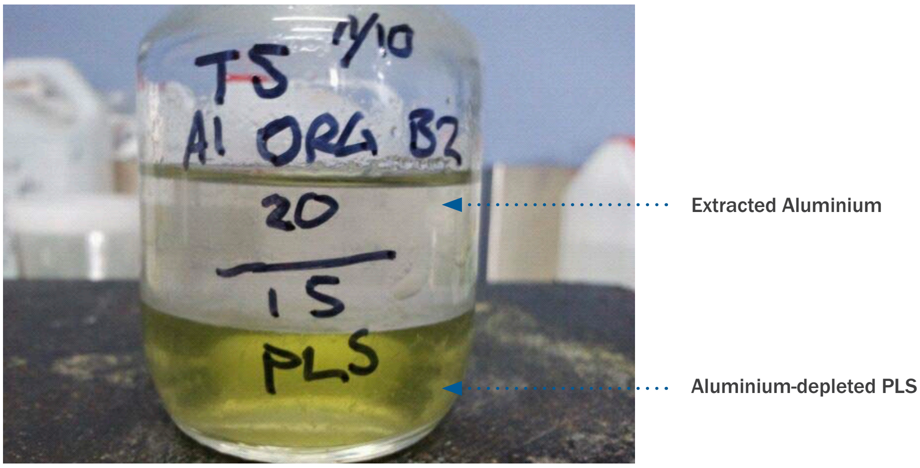
- Initial batch test work resulted in a recovery of 73.3% of aluminium within solvent extraction. More importantly the organic reagent used was identified as highly selective for aluminium which has significant downstream implications when ultimately looking to achieve the requisite purity of a 4N HPA product.
- Secondly, high selectivity has enabled the recovery of >98% nickel, 97% cobalt and 80% manganese within the loaded organic across ~ four counter current stages. It is currently under investigation if these elements can be refined to a NMC composite which would be of high interest to manufacturers of cathode precursor materials.
- Over late 2017 CLL also tested the viability of extracting scandium from the generated PLS. This work demonstrated that 100% of scandium that was leached stayed in solution after neutralisation to remove free acid and iron. This bodes well for considering separate scandium downstream extraction however given the small size of the overall demand (~50tpa) will be dictated market conditions and overall final product specification.

Figure 5: Solvent Extraction test work results

	Metals			
	Ni	Co	Al	Mn
Extraction %	98	97	73.3	80
Product Purity %	99.80	TBC	99.99	TBC

Source: Company Reports

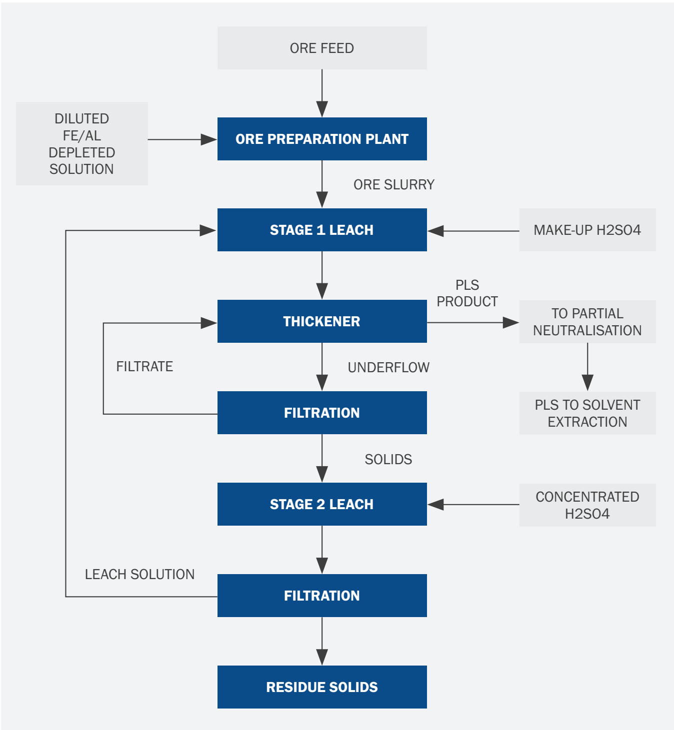
Figure 6: Photo of Extracted HPA from bench scale solvent extraction work



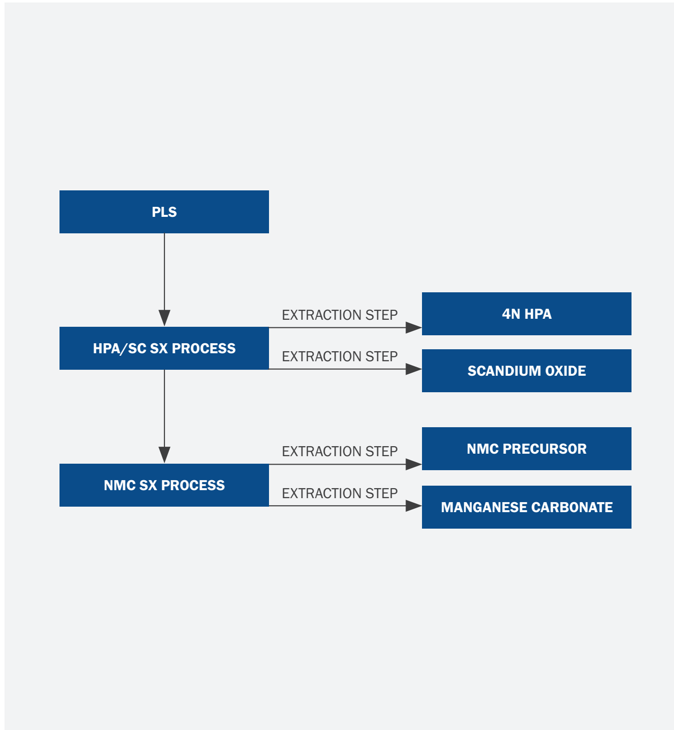
Source: Company Reports

- This bench scale testwork is currently subject to scale up within a continuous SX mini rig test. It is envisaged that all steps of the process will be ran over a five day duration in order to produce a one kilogram 4N HPA sample for product qualification. Process parameters (such as leach stability, ore variability, rheology/filtration along with solvent extraction stages etc) will provide key design data to incorporate into the PFS production and cost estimates. Testwork to this stage has lead to a rather conventional leaching and solvent extraction flowsheet being proposed. This is presented in Figure 7 and 8 that will be confirmed as a part of the current PFS.

Figure 7: Proposed flowsheet of Counter Current Atmospheric Leaching circuit (LHS)
Figure 8: Proposed flowsheet of Solvent Extraction circuit (RHS)



Source: Company Reports, Canaccord Genuity Estimates

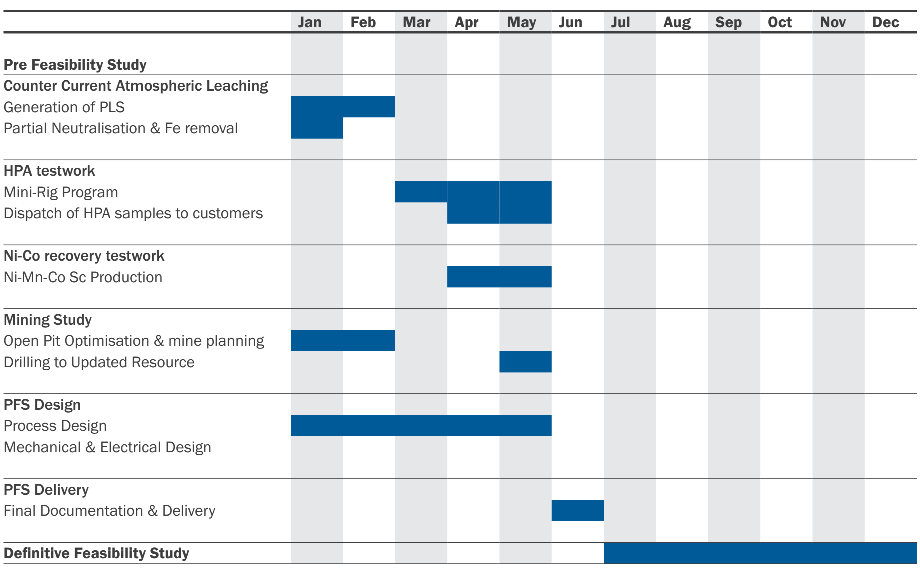


Source: Company Reports, Canaccord Genuity Estimates

Project Development Timeline

CLL have several work prgrammes concurrently underway which will all provide critical information towards the PFS due in Jun'18. We expect that CLL are adequately funded to achieve this work program with only a moderate level of infill drilling required to upgrade the resource confidence (towards measured) and classification (from 2002 to 2012 JORC compliant).

Figure 9: Homeville Project Development Timeline CY18



Source: Company Presentation

Project Permitting and commercial activities

The Project is at Exploration Licence (EL) stage at present. The PFS outcomes will provide outputs to commence early stage permitting. It is expected the final project permitting will consist of:

- Approval under Part 3A of the EP&A Act (NSW Department of Planning)
- Mining Lease Grant (Department of Resources & Energy)
- Environmental Protection License (EPA)

CLL will seek to run permitting processes in parallel with the overall DFS schedule to align the timing project approvals with project financing activities before a final investment decision (FID) is reached.

High Purity Alumina Market - Demand

"We understand that the size of the HPA market is ~US$1.3B in 2016 which is a comparable size to the lithium carbonate market (~US$2.0B in product sales over 2016)."

High Purity Alumina (HPA) is a high value product that is part of the non-metallurgical alumina market and serves as a base material for the manufacture of synthetic sapphire products. While the majority of current demand (~55%) is for semiconductors in light-emitting-diodes (LED) lighting products and phosphors coatings (16%), the application of HPA as a separator within a lithium-ion battery is gaining increased importance.

The HPA market is divided on the basis of purity, density and particle size distribution. Of these factors, the largest influence of product price is purity which is determined by the concentration of trace elements such as iron, magnesium and sodium. Purity is the main influence on performance qualities such as scratch resistance, thermal stability, chemical resistance and yield strength. Pricing for the various grades is like most industrial chemicals by way of negotiation however market research indicates the pricing is broadly in the ranges given in Figure 10 below.

Figure 10: HPA pricing matrix

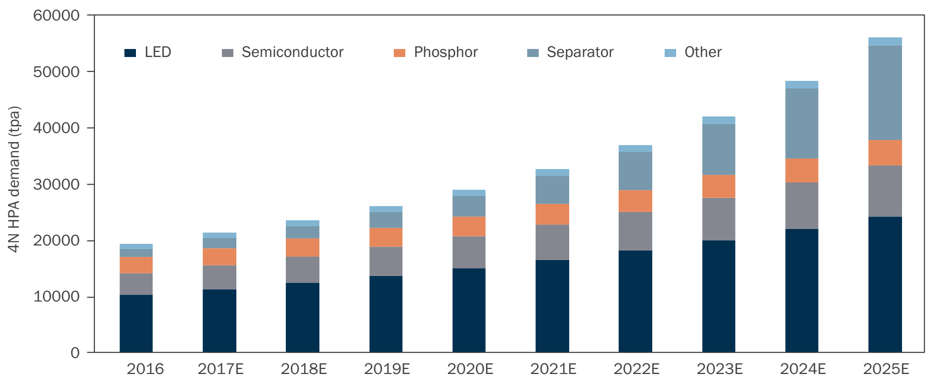
Product Name	Grade (% Al2O3)	Price (US$/t)
Smelter Grade	99.5	400
3N HPA	99.9	6000
4N HPA	99.99	25000
5N HPA	99.999	50000
6N HPA	99.9999	by negotiation

Source: Company Presentation

HPA - Demand

We understand that the size of the HPA market is ~US$1.3B in 2016 which is a comparable size to the lithium carbonate market (~US$2.0B in product sales over 2016). Approximately 55% of the sales revenue was derived from 4N HPA product which accounted for ~74% of overall production of ~26ktpa as indicated in Figure 11 below.

Figure 11: CGe 4N HPA Demand forecast



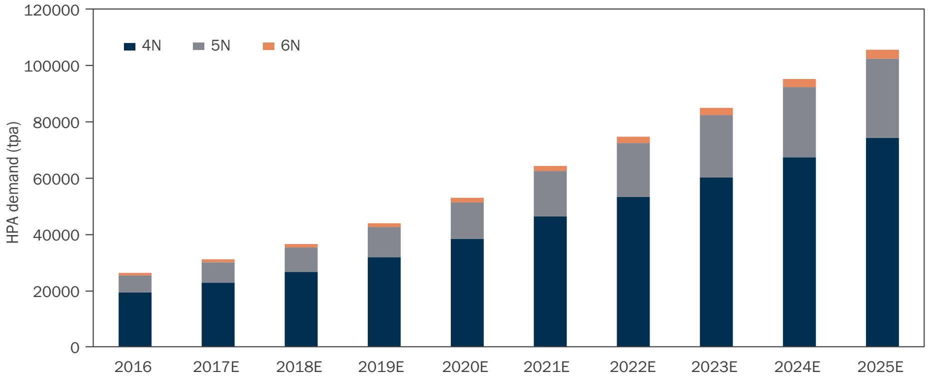
Source: Canaccord Genuity Estimates

We have incorporated recent consultant outlooks along with our own internal estimates of demand from the Lithium Ion battery market to provide a forecast of potential demand for HPA as presented in Figure 12 below.

Overall we expect demand for HPA products to grow by a CAGR of 16.7% to 2025 and within the 4N segment at 16.1%. Within our forecasts we have assumed that the light emitting dioide (LED) will remain the largest segment of demand (33% by 2025) within 4N products with demand from lithium ion batteries to grow by 32% CAGR out to 2025 to represent ~30% of the total 4N HPA market.

> "Overall we expect demand for HPA products to grow by a CAGR of 16.7% to 2025 and within the 4N segment at 16.1%."

Figure 12: CGe HPA Demand forecast

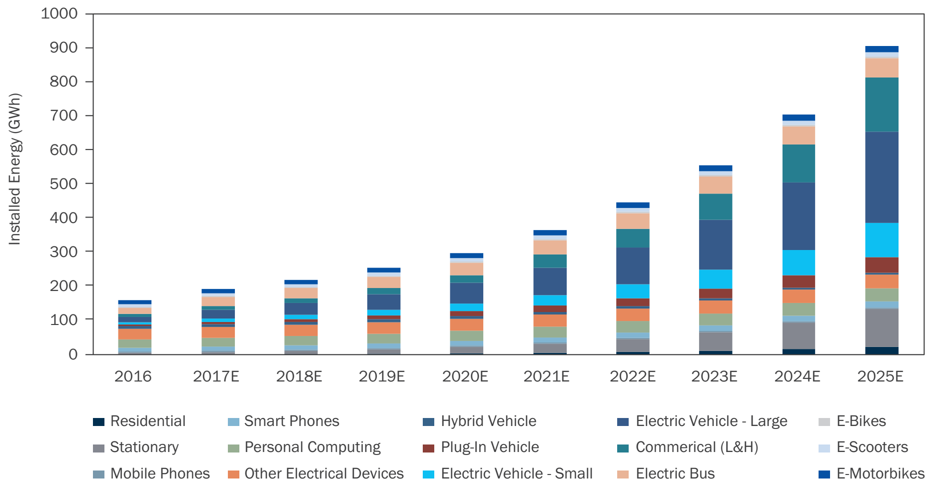


Source: Canaccord Genuity Estimates

Key product markets for 4N HPA: Lithium Ion Battery separators

We currently forecast the li-ion battery market to increase 6x from ~150 GWh of annual production capacity in 2017 to ~900GWh in 2025 as indicated in Figure 13 below.

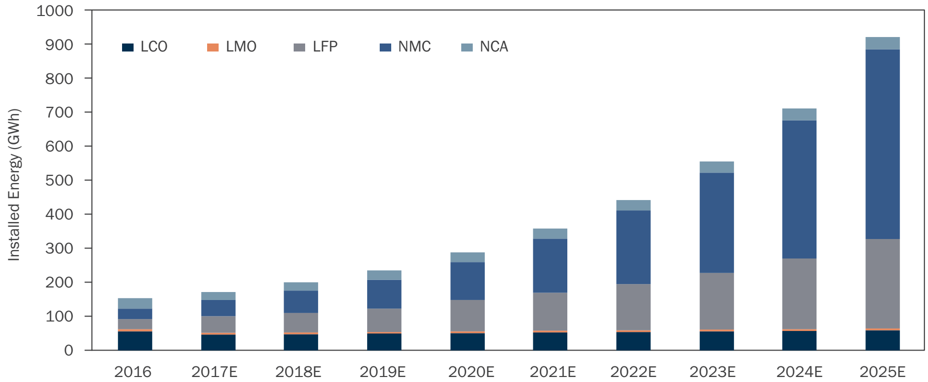
Figure 13: CGe Installed Lithium Ion Battery Capacity by application



Source: Canaccord Genuity Estimates

The strongest demand segment within the li-ion battery market are those within electric vehicle and grid storage applications. High performance requirements (specific energy, stability and range) are likely to preference ternary cathode chemistry using a combination of Nickel:Manganese:Cobalt. We expect growth in this cathode segment to increase ~20x from 31GWh of consumed output in 2016 to ~530GWh of consumed output in 2025 as indicated in Figure 14.

Figure 14: CGe Installed Lithium Ion Battery Capacity by battery type

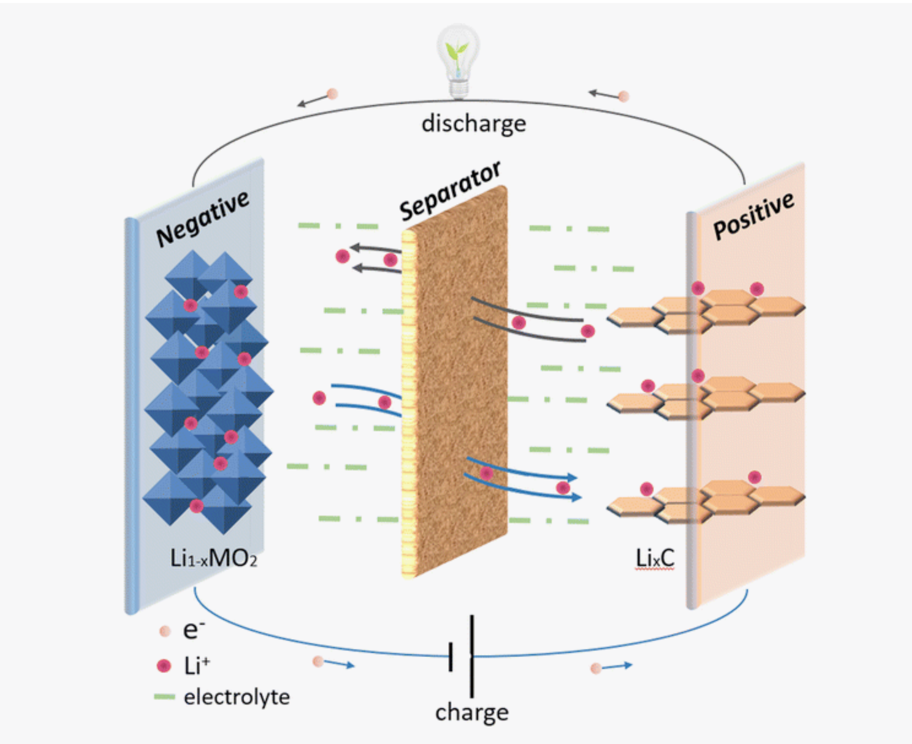


Source: Canaccord Genuity Estimates

> "The move to more nickel rich ternary cathodes is likely to place greater importance on stabilising components such as the separator to produce the desired specific energy (Wh/kg) without compromising safety requirements."

As the use of high performance batteries becomes more widespread, the requirements of a battery's safety and reliability characteristics are highly scrutinised. One of the key components to ensure cell safety is the separator. This thin porous membrane prevents contact between a battery anode and cathode while facilitating ion transport within the cell (see Figure 15 below).

Figure 15: Separators play a critical role in managing performance aspects within a lithium ion battery



Source: RSC Publishing

The most common, solid state separators are made of nylon, polypropylene (PE) and polyethylene (PP). Separators are typically manufactured through an extrusion process (wet or dry) followed by a mechanical stretching to enhance porosity (see Figure 16). Separators are typically multi-layered where layers with different phase transition temperatures are layered to assist in managing overheating risks. As a result, when the temperature of a cell increases, the lower melting component melts and fills the pores of the other solid layer and stops ion transport and current flow in the cell.

HPA due to its superior heat resistant properties can be utilised within a separator in a number of ways. Within a commercial PE separator, the polymer membrane layers are "coated" with a thin film of HPA around the exterior of the membrane. A more advanced method is a "composite separator" in which HPA is embedded within the multiple layers of polymer membranes as micro-thin "sheeting" layers.

This method is likely to have improved ionic conductivity however detailed research and development work is ongoing in this area.

While it is difficult to ascertain how much HPA is within a battery cell, technical literature suggests that typical separators are designed to a thickness of ~20µm for a standard 18650 NCA Li-ion cylindrical battery. HPA content will also be influenced by alternative cell designs (ie pouch, prismatic) and interior/exterior coatings.

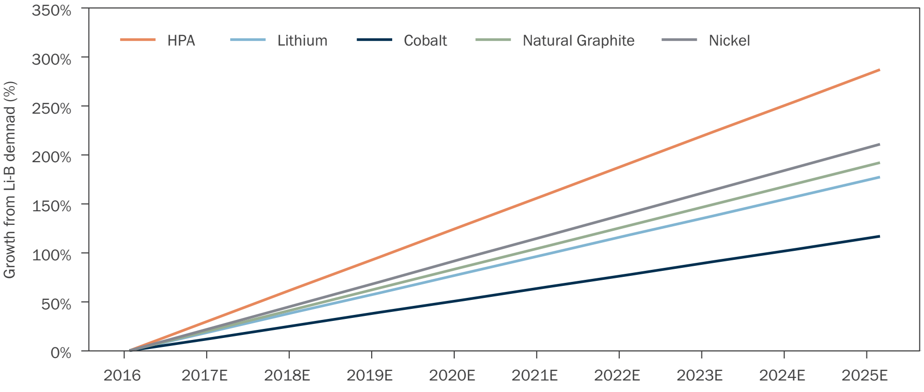
Figure 16: HPA membrane used in Lithium ion battery separators

Source Trade Today

We have calculated from first principles an assumption of 30 g/kWh of 4N HPA within a standard NCA/NMC battery cell. We have applied this usage to along with our Li-B demand profile in Figure 13 to present separator demand from the Li-ion battery segment in Figure 11. We expect this to grow from less than 2,000t in 2017 to ~17,000t in 2025. This implies a growth rate (CAGR) of 32% out to 2025 which Figure 17 suggests offers the highest CAGR of raw materials consumed in the manufacture of lithium ion batteries.

> “We expect demand from the Li-ion battery segment to grow from less than 2,000t in 2017 to ~17,000t in 2025. This implies a growth rate (CAGR) of 32% out to 2025, which we estimate is the highest CAGR of raw materials consumed in the manufacture of lithium ion batteries.”

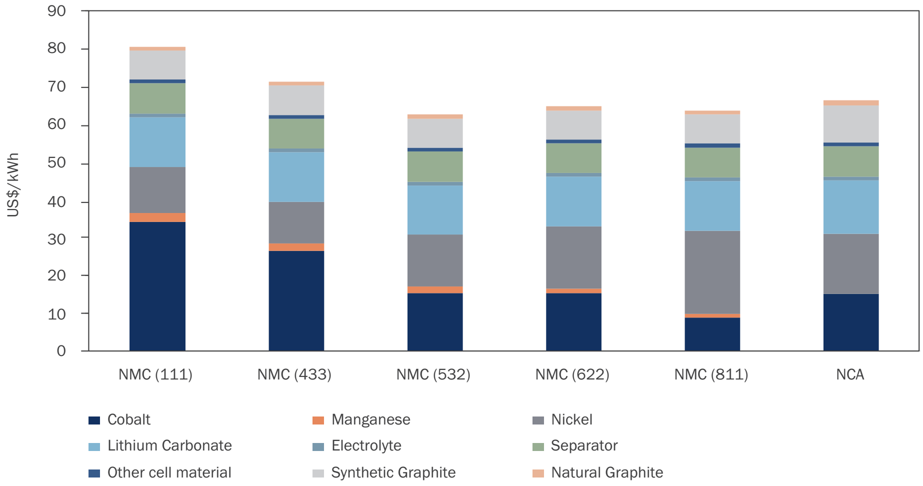
Figure 17: Projected growth rates of various lithium ion battery constituents



Source: Canaccord Genuity Estimates

We also present in Figure 18 that the separator itself accounts for ~16% of the overall raw material cost dependant on the cathode chemistry used. In the ongoing pursuit to reduce unit cost (US$/kWh) battery manufacturers will look to lower variable costs through experience curve (ie scale) where as the fixed costs associated is likely to fall through raw material substitution (ie natural for synthetic graphite, nickel for cobalt). The move to more nickel rich ternary cathodes (ie NMC 811) is likely to place greater importance on stabilising components such as the separator to ensure that selected cathode chemistry produces the desired specific energy (Wh/kg) without compromising safety requirements. Based on this we expect that our demand for HPA within the separator segment can be considered ‘base case’ with moves to deploy lithium ion batteries in higher performance applications providing potential uplift to our forecasts.

Figure 18: Cost structure of components within various lithium ion battery



Source: Canaccord Genuity Estimates

"The explosive growth in the LED market is well documented with expectations for double digit growth over the next decade."

Light emitting diodes (LED)

High purity alumina (HPA) is used to manufacture synthetic single crystal sapphire providing a substrate in the manufacturing of light emitting diodes (LEDs). LEDs are used in traffic lights, LED-backlit LCDs, backlight in electronics, and general lighting products. The main factors determining the chosen HPA specifications are crystallinity, chemical and physical properties. There is some substitution of HPA in the form of gallium nitride and silicon carbide however HPA has been observed to retain superior overall performance.

The explosive growth in the LED market is well documented with expectations for double digit growth over the next decade. We have assumed 10% CAGR within our demand forecasts out to 2025. Aside from the cost benefits, LED lighting has been demonstrated to offer meaningful reductions in electricity consumption and in turn carbon emissions. A demonstration of the comparative advantages of LED lighting over incandescent lights is provided in Figure 19 below. Given that according to the US Energy Information Administration (EIA) around 7% of total electricity consumption is on lighting, we expect the phasing in of LED lighting to continue over the foreseeable future.

Figure 19: Daily reduction in CO² emissions (tonnes) through using LED lights over incandescent lights

Product Name	Units	Incandescent	LED
Power consumption	W	50	6
Electricity/hour	kWh	0.05	0.006
operating time	hr/day	10	10
CO2 emissions *	tpa/lamp	0.151	0.018
Reduction in CO2	t/lamp		0.133
Household CO2 emissions**	tpa/house	6.816	0.818
Reduction in CO2	t		6

* 830g of CO2 eq released per 1kWh of electricity **Assumes the average household contains 45 lights for replacement

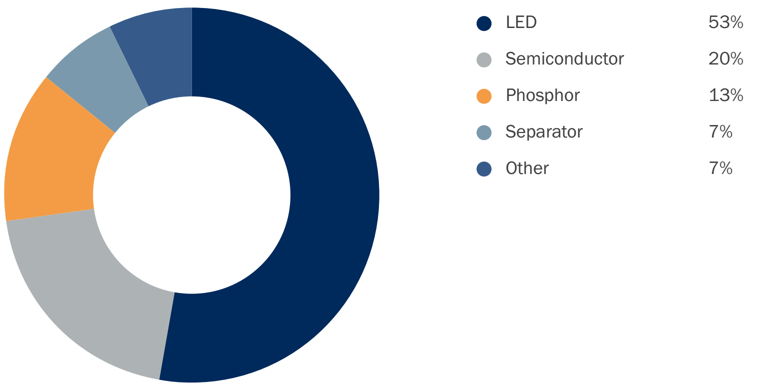
Source: APO News

Semiconductors: HPA is used within these electrical components to provide thermal resistivity and competes with Silicon crystals as the most common semiconductor material. The use of HPA as a semi-conductor insulating material is well established as such we have 10% CAGR in this market.

Phosphors: These materials are used within screens to promote luminescence and project visual information such as plasma displays. A vast array of highly refined chemicals are used dependant on colour, definition and light intensity. We have applied a 5% CAGR in this market.

Other: HPA in the form of sapphire glass is used in smart phone applications such as protective glass screens and sensors on automotive control systems. We have applied a 5% CAGR in this market.

Figure 20: Overall demand for 4N HPA products

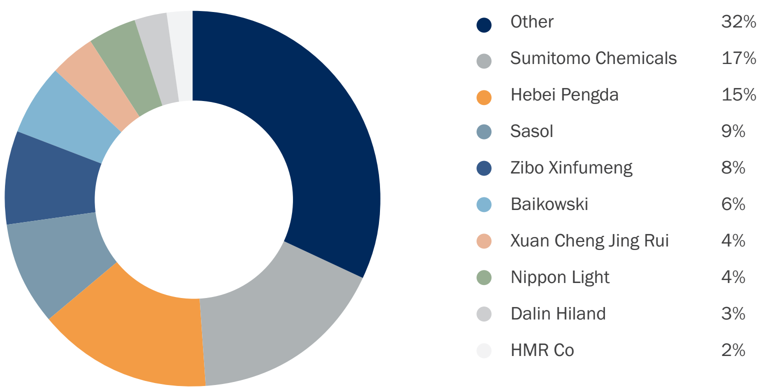


Source: Persistence Market Research, 2015

High Purity Alumina Market - Supply

Current HPA supply is dominated by large diversified chemical companies with ~60% of production originating from the top five producers who are mostly large diversified industrial chemical producers. China has the majority of smaller producers in the HPA market and are likely to form the mainstay of new capacity build out in our view due to existing integration with feed stock supply and operational capabilities.

Figure 21: Current Market Supply



Source: Company Presentation

Within the conventional production process HPA is a refined product that uses refined aluminium metal as a feedstock to a dedicated HPA plant. While there are several common sequences involved in a HPA plant most involve the hydrolysis of aluminium alkoxide that was developed by Japanese corporation Sumitomo.In this process, high purity aluminum alkoxide is synthesised from aluminum metal and alcohol, and hydrated alumina is produced by hydrolysis of the alkoxide. High purity alumina is obtained by calcination with impurities being removed in a distillation stage or with nano porous membrane filters.

Figure 22: Conventional Production processes

Source: Persistence Market Research, 2015

HPA Developers

Given the strong demand outlook for the sector, several developers have recently emerged with intentions to manufacturer HPA product directly from a kaolin (aluminious clay) or lateritic (iron bearing) deposit. These are presented in Figure 23 below. Due to the early stage of both FYI Resources and Hill End Gold studies it is difficult to provide a direct comparison to Collerina's proposed project.

One of the critical influences on both operating and capital cost is reagent consumption and energy requirements. From a broad perspective CLL's proposed flow sheet described in the Metallurgy section above is well served by dual stage atmospheric leaching (as opposed to multi-stage pressure leaching at elevated temperatures) and a highly selective solvent extraction process (as opposed to multi-stage calcination). This has the potential to lead to comparatively lower operating and capital cost assumptions in the upcoming studies.

"

CLL's proposed flow sheet is well served by a dual stage atmospheric leaching and a highly selective solvent extraction process. This has the potential to lead to comparatively lower operating and capital costs.

"

Figure 23: Comparative Analysis of currently listed HPA Developers

Name	Collerina Cobalt	FYI Resources	Hill End Gold	Altech Chemicals
ASX Ticker	CLL	FYI	HEG	ATC
Market Capitalisation (A$m)	81	18	20	68
Project Name	Homeville	Cadoux	Yendon	Meckering
Project Location	NSW	Western Australia	Victoria	Western Australia
Resource size (Mt)	16.3 (JORC 2002)	16.1	Non JORC 2012	12.7
Grade (Al%)	3.1%	11.8%	Non JORC 2012	7.81%
Resource type	Laterite	Kaolin	Kaolin	Kaolin
Status	PFS Q2'18	PFS Q2'18	PFS Q1'18	FID/Debt Approved
Metallurgical Process	H2SO4 leach, SX, precipitation,calcine	HCl leach (high temp/pressure), precipitation, calcine	HCl leach (high temp/pressure), proprietary	HCl leach (high temp/pressure), precipitation, calcine
4N HPA produced in testwork	Yes	Yes	Yes	Yes
Location of HPA facility	TBC	TBC	TBC	Malaysia
Targeted Production (tpa)	~10000	5000-10000	TBC	4500
Offtake Stauts	pending samples	TBC	TBC	10 years with Mitsubishi
Capex (US$m)	TBC	TBC	TBC	298

Source Company Reports, Canaccord Genuity Estimates

Altech Chemicals (ASX:ATC) are an advanced developer who have secured US$190m in project debt for its US$298m, 4,5000tpa HPA plant to be located in Johor, Malaysia. The main steps within the production cost estimate of US$9,900/t are:

- Calcining: Beneficiated kaolin feed (<300um) is calcined in a rotary kiln at around 700ºC to liberate the aluminous clay for leaching.
- Leaching: Calcined product is treated with standard concentration HCl acid (~33% w/w) where a highly concentrate PLS of AlCl3 is produced for filtration with the silica residue neutralised with lime.
- Stage 1 crystallisation: The PLS is processed through a pressurised crystalliser where AlC3.6H20 or ACH is precipitated. This is achieved in highly reactive conditions with the use of concentrated HCl and anhydrous (dry) HCl bubbling within the liquor.
- Subsequent crystallisation The resultant ACH solids are dissolved in demineralised water which releases any contained impurities from the first crystallisation step. The ACH acid concentrate then increased by bubbling in HCl gas with the ACH product centrifuged.
- Roasting/Calcining/Grinding of Final product: The purified ACH crystals are then decomposed releasing any entrained HCl/moisture to produce a very highly purified alumina (Al2O3) product. This is subsequently dried, sized and bagged for final product qualification.

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Additional information is available on request.

Sydney
Level 26, 9 Castlereagh Street, Sydney 2000
Ph: +61 2 9263 2700

Melbourne
Level 4, 60 Collins Street, Melbourne 3000
Ph: +61 3 8688 9100