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Advancing lithium projects & expansions

27 September 2012

Room for two or twelve new players by 2020?

By Gerry Clarke*

*An updated version of the article below will appear in **IM** in January 2013. This article was originally submitted for publication mid-August 2012. The January article will replace the substantially edited version, “An Americas tale – lithium’s future”, published in Industrial Minerals’ September 2012 Critical Materials for Green Energy supplement which omitted significant coverage and inadvertently introduced errors throughout. The January article will also be updated to include changes that have occurred since mid-August.*



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Salar de Atacama. This is SQM's final evaporation pond before the yellow-green brine containing 6% LiCl is pumped to tankers for transfer to the brine processing plant on the coast near Antofagasta

Increasing prices in 2011 and 2012 reflect increasing tightness between lithium supply and demand. Rockwood announced 20% price increases in mid-2011 and further increases of up to \$1,000 a tonne in mid-2012, as has FMC, which represents about a 22% hike. SQM reports prices 16% higher in Q1 2012 compared with Q1 2011 average prices and expects improvement throughout 2012. Talison also posted two 2012 increases amounting to 25% for chemical grade concentrates effective H2 2012 and technical grade is up 10%. And in August 2012 Galaxy highlighted increased spot prices in China to almost \$7,000 a tonne for battery grade and \$6,250 a tonne for technical grade Li_2CO_3 .

Developing projects have begun to emerge and more are planned by end 2014 whilst several more are holding back and watching for more substantial market improvement. Comparing aggregated demand forecasts of 9-10% (CAAG) to 2020 with producer capacity expansions combined with mid-2012 initiated, emergent, or post DFS stage advanced project starts and ramp up periods, the scenario is less promising as the accompanying demand supply balance table shows.

Estimated supply demand balance

<i>LCE tpa</i>	2015	2020
Forecast Demand High	265,000	500,000
Average	191,472	279,945
Forecast Demand Low	138,500	174,800
<i>Compared with producer capacity only:</i>		
Producer Capacity (4)	231,000	251,000
Excess over FD High	(34,000)	(249,000)
Excess over Average	39,528	(28,945)
Excess over FD Low	92,500	76,200
<i>Compared with producer & advanced projects:</i>		
Advanced Projects (6)	58,200	95,900
Producer 4 +Advanced 6	289,200	346,900
Excess over FD High	24,200	(153,100)
Excess over Average	97,728	66,955
Excess over FD Low	150,700	172,100

Four producers: SQM, Rockwood, FMC, Talison
Six advanced projects initiating, emerging, or post DFS
stage mid-2012 are ADY, CLC, GAL, LAC, ORO, SIMBOL.
NB: Ignores supply from resources in China.

There appears room (28,945 tpa LCE) for one, or possibly two projects, based on the 2020 average forecast, although the high forecasts would allow several projects to enter to fill a theoretical supply shortfall of up to 249,000 tpa by 2020. But nobody has yet forecast when the required demand inflection might happen nor which of the many advancing projects will prevail, or not, for the longer term.

Might it be that the present prices surge heralds a period of sustained market improvement, perhaps growth inflection to a new pace, or merely short term supply tightness ahead of 2012-2014 expansions and new capacity beginning to bite?

The demand supply scenario shown is illustrative today but, along with demand, the advanced project supply mix will undoubtedly change tomorrow. Also there are three continental brines-based companies in China with as yet unfulfilled promise for significant Li₂CO₃ output, and several minerals-based companies, but reliance for high quality material remains on imports. Several Chinese enterprises have also invested in foreign developing projects.

And Bolivia's COMIBOL is hopeful about overcoming significant technical challenges at Salar de Uyuni, with help from South Korea, to reach full 30,000 tpa Li_2CO_3 capacity from 2015. But, even some Bolivians are sceptical about that.

Whilst not totally, much depends on the automotive battery sector for the market inflection so desired. Potential consumer adopters are increasingly being seduced by driving experience advertising messages as opposed to being harangued by save the planet messages. And the market for lead replacement in batteries for e-bikes is substantial in China and wider Asian markets.

This review looks at progress of the leading projects in the context of producer expansions now being realised.

Continental brines-hosted projects

Although there are continental brines projects elsewhere, Argentina is host to five that are the most advanced with combined design capacity approaching 78,000 tpa lithium carbonate equivalent (LCE) units planned to start in or before 2015. With FMC's 30% expansion to 23,000 tpa LCE in Salar de Hombre Muerto, effective Q4 2012, theoretical Argentine supply capability exceeds 100,000 tpa LCE from 2015. However, further project slippage combined with demand shortfall may well stretch out project and/or capacity realisation or perhaps lead to indefinite project shelving. Significantly, FMC reports no change in brine pumping rates or quality over 15 years' operation and, although FMC has disclosed a salar life of at least 50 years, it confirms actively considering all opportunities for additional resources.

Challenges in bringing these remote high altitude projects to fruition are hard to overstate whether it's brine conversion chemistry, hydrology characteristics, raw materials and product logistics, skilled workforce availability, and permitting and product quality achievement. Each project is entirely different but a common feature to them all is the high and unpredictable cost of the principal chemical reagent, soda ash, that needs to be imported and, in Argentina, taken to high altitude.

The accompanying tables provide details of the advancing projects including theoretical operating cost estimates which some industry insiders believe are significantly understated. Indeed, one industry insider describes advancing project disclosures as "mere window dressing" and worries about potential market degradation in the absence of substantial market improvement.

Chile's producers expanding.....

SQM and Sociedad Chilena de Litio Ltda (SCL), a subsidiary of US incorporated Rockwood Holdings Inc, are Chile's two lithium chemicals producers based on Salar de Atacama resources. SQM is primarily a potash company with minor co-product lithium whereas SCL is dedicated to lithium.

SQM currently has 48,000 tpa Li_2CO_3 capacity near Antofagasta port where up to 6,000 tpa of LiOH is also manufactured. The company is now undertaking engineering work for a 42% expansion to 68,000 tpa Li_2CO_3 .

Rockwood Lithium is also expanding, with new facilities in the US at Silver Peak and Kings Mountain and La Negra near Antofagasta. A \$75m expansion will upgrade and double Silver Peak's Li_2CO_3 capacity and a new 5,000 tpa high purity LiOH plant at Kings Mountain opened in July 2012. A new \$140m Li_2CO_3 plant in La Negra will be completed in 2013 enabling Rockwood to increase output by 20,000 tpa. By 2013 Rockwood will have total Li_2CO_3 production capacity of 50,000 tpa.

and Chile's government courting a long list

And now the long anticipated opening up of Chile's lithium resources is underway presented as the re-launching of the Chilean lithium industry by unlocking, rather than changing, the country's restrictive mining legislation.

Under Chilean law, modified in 1979, lithium is not exploitable via regular mining concessions. The Chilean Mining Code reserves lithium to the State and expressly provides that its exploitation may only be performed directly by the State or its companies, or by means of administrative concessions, or special operation contracts.

An auction for a lithium production quota and license known as a Special Lithium Operations Contract (CEOL), that requires no change to existing mining law, is to be held with a 12 September 2012 tender submission deadline. The CEOL is for 100,000 tonnes lithium production over 20 years, equivalent to an average 26,615 tpa LCE. An initial sum and 7% sales royalty is payable to the State which forecasts total income of \$350m over the 20 years. A minimum \$5m tender submission has been set.

The process echoes the AMAX/Molymet partnership that successfully answered CORFO's invitation to bid 26 years ago in 1984. An initial 15,000 tpa LCE operation was eventually brought to fruition by SQM in 1997.

Some 66 companies had bought the tender terms and conditions document by end-July and a Chilean delegation had visited Australia, Japan, South Korea, Canada and the USA to stimulate interest. In Chile, however, the process stimulated opposition to what some see as privatisation of a designated strategic asset that ought to be exclusively exploited by the state such as by Chile's Corporación Nacional del Cobre de Chile (CODELCO).

Companies with significant exploration projects in Chile that have risked not securing mining rights include Chile's *Errazuriz Group*, backed by KORES (18%) and Samsung C&T Corp (12%) investing \$190m in the NX Uno project; *Salares Lithium Inc*, recently merged enterprise between Talison Lithium and its Chilean partners pursuing its Salares 7 project; and two Canadian juniors; *Pan American Lithium Corp*, backed by 19.9% equity participation from POSCO, advancing its flagship Laguna Verde project and *Lomiko Metals Inc*. with several claims at Salar de Aguas Calientes.

And there are five more enterprises with claims areas and exploration projects at Salar de Maricunga where historical and recent work shows favourable resource characteristics. With two majors, *CODELCO* and *SQM*, and three juniors, *Li3 Energy*, *Simbalik Group*, and *Cia Lithium Investments Ltda*; Maricunga appears fragmented and consolidation would seem logical.

Peru's Li3 Energy Inc, with POSCO's \$10m funding commitment, is furthest ahead amongst the Chilean exploration projects with an April 2012 measured resources estimate of 574,064 tonnes LCE and 1,482,638 tonnes potash for its northeast section of Maricunga. Li3 is now working on a PEA. CODELCO owns two pre-1979 lithium claims areas with the most likely for development in Maricunga. Unsurprisingly, CODELCO has been openly courted and, unlikely as it seems, the copper giant has confirmed its interest to enter the small lithium industry. Its involvement, most logically in some form of post hoc partnership, could therefore emerge.

It is not confirmed whether or not there may be further tender opportunities for CEOLs in 2013 so, for most, the permit risk will continue beyond 24 September when the Ministry of Mining is expected to announce the result. But Simbalik Group's project is firm as its legal basis is different. The Santiago-based company navigated its way through Chile's legislation and obtained a production permit in August 2011 for concessions registered before the 1979 mining modification law bestowed strategic status onto lithium and made it non-concessional from that time. Simbalik's permit is for up to 50,000 tonnes lithium over 15 years at Maricunga and renewable once the production quota is reached as is the case for SCL and SQM. Simbalik has technical and exploration input from the Chinese Academy of Sciences Qinghai Institute of Salt Lakes with target capacities of 35,000 tpa Li₂CO₃ and 80,000 tpa potash.

Advancing brines-hosted lithium projects in Argentina

COMPANY	Location	Capacities ¹		Life	Cap Ex ²		Cost/tonne	
		Li ₂ CO ₃	Potash		US\$m.	US\$/t	Ex credit	In credit
FMC	Hombre Muerto	23,000					3,200e	
Producer	Salta	FMC's 30% expansion to 23ktpa expected to be effective during Q4 20						
ADY RES ³	Rincon, Salta	1,500			75*			
Initiated	(43,500)	First commercial sales early 2012. *To mid-2011						
GALAXY ⁴	Sal de Vida, Salta	25,000	107,000	40	356	356	1,537	(?500)
PEA 03/11	(38,500)	Expect DFS Q1 2013						
LI AMERICAS	Cauchari-Olaroz	20,000	40,000	40	269	336	1,876	1,332
DFS 06/12	Jujuy (83,104)	Stage One project. Awaiting EIS approval expected Q3 2012						
OROCOBRE	Olaroz, Jujuy	16,400	10,000	40	207	316	1,512	1,230
DFS 06/11	(63,000)	Secured EIS approval. Concluding financing to start construction 2012						
RODINIA	Diablillos, Salta	15,000	60,000	20	144	480	1,519	(703)
PEA 11/11	(5,786)	Advancing to FS late 2012. Also has second option for 25,000 tpa Li ₂ CO ₃						

¹Capacities are tpa. ²Estimated Capital Expenditure (US\$m) also shown as US\$ per tonne Li₂CO₃ over project life. ³No data available for ADY Resources' industrial scale plans.

⁴Formerly Lithium One Inc.

Ha: Hectares. Start year is for initial production with full capacity attainable in future years, subject to technical and market success, and mostly not expected before third year.

ADY Resources in incremental mode

The Salar del Rincon project, the longest running of the present wave of development projects, dates back to 2002. A 17,000 tpa LCE plant starting mid-2008 was envisaged by Admiralty Resources. But that vision was curtailed in 2008 when Admiralty sold the project to survive the

global financial crisis. Venture capitalist, The Sentient Group, picked up six years project development work for \$22.17m.

Just two years later Sentient was first to initiate Li_2CO_3 production outside China since 1997, albeit small scale at 1,500 tpa, for \$75m capital expenditure so far. Today, as a result of internal reorganisation, the project is run by ADY Resources, a part of newly created (February 2012) Enirgi Group owned by Sentient Group of Global Resource Funds.

Since acquisition, the company has completed an extensive drilling programme and is confident it has sufficient resource and quality to deliver high grade Li_2CO_3 for over 20 years. However, ADY has not made public any details regarding its recent resource estimate or what capacity it foresees for an industrial scale operation. The company does assert, however, that it has proven the technology in progressing from pilot plant to small scale commercial plant and that its proprietary technology has led to improvements in costs and product quality.

ADY has been running the plant to optimise the extraction process and, beginning early 2012, to produce initial commercial parcels for customers. ADY intends to increase capacity on an incremental basis as demand requires whilst gaining operational experience before committing to what it describes as a sustainable grand scale production facility.

Orocobre secures Olaroz mining leases

Following receipt of EIS Project Approval under Jujuy Strategic Mineral Law, mining leases were granted to Orocobre in July 2012. First to release a DFS for its 16,400 tpa Li_2CO_3 Olaroz project in May 2011, Orocobre is now expecting to commence in 2014 with co-product 10,000 tpa potash production two years later for 40 years mine life. Earlier this year Orocobre entered into a binding agreement with Jujuy Energia y Minería Sociedad del Estado (JEMSE), the recently formed mining investment company owned by the Provincial Government of Jujuy, whereby JEMSE will hold 8.5% equity interest in the project, through Orocobre subsidiary, Sales de Jujuy.

ADY Resources (Rincon Lithium) 1,200 tpa plant is now sending small volumes to market



The project will extract just 14% of the identified resource over 40 years. But, as the resource tonnage is estimated to only 200 metres depth in a basin that plumbs 500 metres, the company believes there is scope for significant project life extension. Orocobre has been producing high purity battery grade Li_2CO_3 in its on-site pilot plant since early 2011. Engineering work on the ponds, borefields, and related infrastructure to support construction is complete.

The company is now completing financing with Mizuho Bank, associated loan guarantees with Japan oil, Gas and Metals National Corporation (JOGMEC), and definitive agreements with project partner, Toyota Tsusho Corporation. When these are completed, expected in September, the company will immediately start construction.

Orocobre is also actively exploring to the south of Olaroz at neighbouring Cauchari and 70 kms to the south-east at Salinas Grandes, through 85% owned South American Salars (SAS). At Salinas Grandes, an inferred resource has been identified to just 13 metres depth and brine chemistry is particularly attractive. Pumping test results are expected Q4 2012. At Cauchari, adjacent to LAC's claims area, Orocobre has a 30,000 hectares exploration project where a resource estimate is expected Q3 2012.

Resource characteristics at advancing projects in Argentina

COMPANY	Salar	kt LCE			kt	mg/l				Ratios	
		Meas	Ind	Inf	Potash	Li	K	B	Li c/o	Mg:Li	SO ₄ :Li
ADY: 07/07 ¹	Rincon			7,346	50,800	330	6,560	400	n.a.	9.18	30.76

GAL: 03/12	De Vida	3,005	1,048	3,180	16,071	782	8,653		500	2.2	11.5
LAC: 06/12 ²	C. Olaroz	3,039	8,713		35,274	585	4,856	1,040	354	2.34	29.71
ORO: 06/11	Olaroz	1,437	5,004		19,300	690	5,730	1,050	n.a.	2.4	25
ROD: 03/11 ³	Diablillos			2,817	11,270	556	6,206	646	230	3.7	14.48

LCE: Lithium Carbonate Equivalent, kt: thousands of tonnes; Li c/o: lithium cut-off grade

¹*Rincon brine chemistry is generic for the Salar and not ADY Resources project specific*

²*Lithium Americas also has proven and probable reserves of 2,714 kt LCE at average 666mg/l Li*

³*Rodinia Lithium resources are qualified as recoverable inferred resources*

Lithium Americas' EIS recommended for approval

Following mid-August 2012 recommended approval of LAC's December 2011 EIS by the Provincial Environmental Agency of Jujuy Province, the first stage of its Cauchari-Olaroz project is now being reviewed by the Provincial Committee of Experts for submission to the Governor of Jujuy for final construction approval. Once approved, expected near term, project finance negotiations with strategic partners, Magna International and Mitsubishi, will conclude and engineering progress made towards construction start 2013.

LAC's pilot plant, product testing in Canada since November 2011, is now operating on-site. Definitive mining title and long term land use agreements with five aboriginal communities are secured. LAC released its DFS for the first of the two-stage project June 2012 and now expects to commence revenue generating operations in 2015 ramping up from 10,000 tpa Li₂CO₃ to 20,000 tpa capacity in 2017 for 40-years' mine life.

Of the advanced projects in Argentina, LAC's is largest in terms of claim area, M+I resources, and production capability, and, on a theoretical cost per tonne basis, the first stage is the higher of two post-DFS advancing projects. LAC's second stage is equivalent in production size and, subject to DFS, expansion is expected to start in 2018 with full Li₂CO₃ capability of 40,000 tpa in 2022. At each stage co-product potash is planned two years following start-up with first stage 40,000 tpa in 2017 and 80,000 tpa in 2020.

LAC's other exploration prospects in the region are at Incahuasi, Pocitos and Arizaro salt lakes which, combined, are almost the same size (82,200 hectares) as the Cauchari-Olaroz claims.

Galaxy fast tracking Sal de Vida post merger

In July 2012 Galaxy Resources, through agreed merger with Lithium One, completed acquisition of two projects, one each in Argentina and Canada, to add to its emergent operations in Australia and China.

The Argentine project at Sal de Vida, now owned 70% by Galaxy and 30% by a Korean consortium (Korea Resources Corp, LG International and GS Caltex), is now the company's flagship development project being fast tracked to completion of DFS expected Q1 2013. Separated by a mountainous rock formation Sal de Vida is adjacent to Salar de Hombre Muerto where FMC has harvested lithium for 15 years.

A 30% resource expansion compared with Lithium One's October 2011 PEA was announced March 2012. The PEA estimated a theoretical cost per tonne of Li₂CO₃ without co-product credits of US\$1,537

but with full potash credits the Li_2CO_3 cost plummets into negative territory by more than US\$500. Whilst the 2013 DFS will provide more appropriate comparison Galaxy's PEA cost per tonne, without co-product credits, is very close to that of Orocobre's DFS cost estimate.

Rodinia and International Lithium in the next wave

These are companies with multiple lithium exploration projects and backing from Chinese lithium chemicals companies each with a flagship project in Argentina's Salta Province.

Of the two, Rodinia's Salar de Diablillos project is further advanced and distinguishes itself by being the smallest of all advancing projects in just 5,786 hectares. One of China's largest lithium-ion battery materials manufacturers, Ningbo Shanshan Co Ltd, acquired 7.6% equity in November 2010. The following March inferred resources estimates were published. A November 2011 PEA revealed project scenarios of 15,000 tpa and 25,000 tpa Li_2CO_3 for 20 years mine life. Potash is expected to be recovered through the lithium harvesting process and initial work indicates 4:1 potash to Li_2CO_3 production ratio. Rodinia has now completed a prototype production well and drilling programme.

International Lithium Corp. has a portfolio of nine exploration projects in Argentina, Canada, Ireland and USA embracing lithium brines and hard rock. ILC's first resource estimate for its 16,000 hectare Salar de Mariana flagship project is expected Q4 2012. Drill analyses revealed Mariana to be the richest in potassium of all the salars so far discovered. The company, in which TNR Gold retains 25.5% equity, recently reinforced its relationship with Chinese partner, **Jiangxi Ganfeng Lithium Co Ltd** (GFL) through increased equity to 14.7%. GFL is to loan ILC \$2m to advance the Mariana project and has also entered into a LOI option to earn 75% of ILC's southern Ireland Blackstairs pegmatite project.

Novel resources projects

The US is host to three novel lithium resources projects two of which are based on two entirely different brine resource types and the other on rare hectorite.

Albemarle taking lithium from oilfield bromine tailings

With \$5.2bn market capitalisation (27 July 2012) Albemarle Corporation is in a league of its own amongst aspiring new entrants to lithium chemicals supply. The company, with a pedigree stretching further back than the birth of the lithium industry to 1887, revealed its lithium plan in April 2011.

Albemarle is the world's dominant producer of bromine chemicals at its Magnolia plant in Arkansas. Brine held in the highly porous and permeable deep-lying oolitic sedimentary rocks of the Smackover Formation is pumped to the surface to feed estimated 148,000 tpa bromine capacity. These oilfield brines are a huge lithium resource. In 1976 Collins estimated a possible 750,000 tonnes of lithium was held in just one tenth of the area underlain by the Smackover Formation that extends through five western states.

In April 2011 Albemarle announced new technology to extract lithium from its bromine brine tailings proven on a laboratory scale and the existence of a pilot plant. With 200-300 ppm lithium in the bromine tailings feedstock, an average 15 times lithium's 17 ppm crustal abundance and at the lower end of exploitable continental brines deposits, Albemarle has set its

sights on constructing a 20,000 tpa Li_2CO_3 plant with initial 3,000 tpa in 2013 ramping up to full capacity by 2015.

In the first instance Albemarle expects to meet battery grade Li_2CO_3 specifications but other lithium chemicals are in view. Albemarle is quiet regarding further details but its process is expected to be operating cost competitive compared with existing sources.

Simbol Materials partnered with EnergySource

Simbol Materials Corp is different. Venture capital backed and boosted by Japan's Itochu Corp taking 20% equity in July 2010, Simbol has developed new technology to extract lithium from geothermal brines derived from active plate tectonics deep beneath California's Imperial Valley in what is known as the Salton Sea Known Geothermal Resource Area (KGRA).

Here the brine also contains 200-300 ppm lithium. The commercial potential of the geothermal resource is enormous as indicated by one existing 228 MW well with 200 ppm lithium concentration that pumps 84,000 tpa LCE each year (R K Evans in Press).



Featherstone geothermal energy plant, Salton Sea, California — the site where Simbol Materials is operating

Whilst brine heat at around 315°C is the primary resource, the cooled brine is Simbol's feedstock plus associated steam, carbon dioxide and water. All Simbol is doing is applying patented technology to extract dissolved solids; recover, separate and refine lithium, manganese and zinc compounds; and return mass-balanced spent brine to the energy generator for reinjection. The process technology is clean, with a small footprint as there is no mining and little waste product other than very fine silica which needs to be removed prior to lithium extraction, fast at just 90 minutes to harvest the lithium, and the lithium carbonate product is exceptionally pure well above today's market requirement of 99.5% Li_2CO_3 . Simbol also plans to manufacture high purity LiOH and lithium speciality materials in due course.

Simbol's vision is to establish several industrial scale 16,000 tpa Li_2CO_3 production facilities each hosted by separate geothermal power plants. Commercial progress has been facilitated by partnering with EnergySource, a new and independent renewable energy company headquartered in El Centro, CA. EnergySource opened its first \$400m power plant in March 2012 now named the John L. Featherstone Plant, at Hudson Ranch in Imperial County. Featherstone, a three stage flash geothermal power facility and the first to be built on the KGRA in over 20 years, will host Simbol's inaugural lithium extraction plant.

Simbol has now relocated its demonstration plant to the Featherstone site to allow production of samples from the actual brine source that will assist in fast tracking product qualification efforts. Simbol's first in-line 16,000 LCE tpa capacity facility at Featherstone is planned for 2014 start up subject to EIS approvals. An EIS report is expected by year-end. Simbol is also debottlenecking its 500 tpa high purity Li_2CO_3 plant to achieve 1,500 tpa LCE by late 2013.

EnergySource is drilling additional wells for a second nearby facility, Hudson Ranch II, for construction start in 2013 and power production in 2015 and from which Simbol also plans to

extract lithium. Hudson Ranch II and the Featherstone plant each have, comparatively small, 49.9 MW design capacities with each supplying sufficient brine to produce 16,000 tpa LCE.

Western Lithium now bidding time

In December 2011 Western Lithium (USA) Corp completed pre-feasibility work for the southernmost stage one lens at its Kings Valley, Nevada hectorite project: A two-stage plan with 13,000 tpa LCE for the first three years doubling to 26,000 tpa in year four for 20 years mine life commencing, a year later than first envisaged, in 2015. Comparatively high operating costs are dramatically reduced if co-product credits from the sale of potassium sulphate and sodium sulphate are applied.

Argonne National Laboratory, US Department of Energy, tests on hectorite-derived Li_2CO_3 indicate that WLC is able to produce the high purity required. But, whilst remaining committed to the Li_2CO_3 project and timetable, WLC is presently watching for improvements in financial markets and end user support for new supply before progressing to the next phases of DFS, permitting, and demonstration plant construction and operation.

Meanwhile, the company is working on developing clay additive products for the oilfield business where the pursuit of shale gas resources in the US, and now the rest of the world, is creating increased demand. WLC's entry would target the bulk oilfield industry first and, later, potentially into more specialised high value products for cosmetics, coatings etc.

Spodumene-based lithium projects

In December 2010 Talison's monopoly of large scale lithium minerals production from the unique Greenbushes, WA deposit ended when Galaxy brought Mt Cattlin's 137,000 tpa concentrates plant to production. In the same month Talison increased spodumene concentrates capacity by 21% to 315,000 tpa and, in August 2012, celebrated completion of expansion to 740,000 tpa concentrates, equivalent to 110,000 tpa LCE. It is against this backdrop that Galaxy continues to emerge as a global player and four more projects are developing with announced start up dates to 2014.

Together four post-PEA spodumene projects theoretically add 793,000 tpa concentrates capacity to Talison's and Galaxy's combined 877,000 tpa on stream 2012. To this may be added Galaxy's James Bay Cyr project in early 2013 when its FS report is expected. The probability that this planned volume realisation is unlikely to occur in the timelines indicated is already unfolding.

China shortage driving demand growth

The driver for all these projects is China's insatiable appetite for high quality spodumene concentrates for conversion to lithium chemicals. Supplies remain short in China and are expected to remain so for some time. Hitherto, Talison has been the only major supplier. In 2011 China's spodumene concentrates production and imports were about 9,500 tonnes LCE and 38,000 tonnes LCE respectively whilst lithium chemicals production was approximately 51,000 tonnes LCE. Lithium chemicals imports were 15,000 tonnes LCE of which 30% was brine. Consumption in 2011 is estimated at about 54,000 tonnes LCE comprising 51,000 tonnes

production, 15,000 tonnes imports, 5,000 tonnes mineral usage, and 17,000 tonnes exports including lithium metal (Tan, 2012).

China's three western brines-hosted producers one in Zhabuye, Tibet and two in Qinghai are still not a major factor in the market with, combined, perhaps around 3,000 tonnes Li_2CO_3 so far this year. However, technical breakthrough continues to be expected in Qinghai perhaps during 2012 and Zhabuye has yet to start its expansion project at Baiyin. Having received the mining permit for the Cuola part of the Jiajika deposit in April, Sichuan Tianqi Lithium plans to start mining and producing chemical grade spodumene concentrates in 2013 or early 2014. Meanwhile, Tianqi Lithium continues to rely on imports from Australia to underpin its approximate 50% expansion to 20,000 tpa all lithium compounds by end 2012.

Advancing minerals-hosted lithium projects

COMPANY	Location	Capacity tpa		Life yrs	Capex US\$ ¹		Cost/tonne US\$		Sta	
		concs	Li_2CO_3		\$millions	\$/tonne	Excredit	incl credit		ye
TALISON	Greenbushes	740,000	20,000*					n.a.	198	
Producer	W Australia	*Decision on Kwinana Li_2CO_3 plant expected Q4 2012						Ta concs		
GALAXY	Mt Cattlin	137,000	17,000*	18	141	461	n.d.	Ta concs	201	
Emergent	Jiangsu	*Zhangjiangang Li_2CO_3 plant began Q1/12 now ramping up						Na_2SO_4		201
CANADA LI	Val d'Or	165,000	20,000	15	232	773	3,164	n.a.	201	
Construction	Quebec	Plus 2,000 tpa LiOH. Li metal under FS assessment						Na_2SO_4		
NEMASKA LI	Whabouchi	202,000		15					201	
PEA 12/11	Quebec	New PEA for revised plan expected 09/12 & FS 12/12 to include LiOH/ Li_2CO_3								
REED	Mt Marion	200,000	Project development fully funded by Mineral Resources Ltd							N.A
Site cleared	W Australia	Project on hold pending market improvement. Also 60ktpa mica study.								
WESTERN LI	Kings Valley	2,000tpd	13,000*	20	248	516	3,472	968	201	
PFS 12/11	Nevada	Project on hold. *Increase to 26,000 tpa year 4 (+\$161m)						$\text{Na}_2/\text{K}_2\text{SO}_4$		
CRITICAL EL	Rose	226,000	31,000	17	305	579	67.65	Ta concs	201	
PEA 11/11	Quebec	Cost per tonne for milled ore only								

¹Capex is for mine and Li_2CO_3 plant unless otherwise stated

Galaxy ramping up Jiangsu....

From first resource estimate in December 2007 it took just three years for Galaxy to attain producer status when Mt Cattlin started and first concentrates were shipped to China Q1 2011. In March 2012 Galaxy opened the world's first continuous spodumene conversion plant at Zhangjiangang, Jiangsu near Shanghai. Result of a six-month feasibility expansion study to increase Jiangsu capacity to 22,000 tpa LCE is now due. The extra 5,000 tpa capacity is for battery grade LiOH and, if approved, is expected on stream within two years.



Mt Cattlin's 137,000 tpa concentrates plant in Western Australia

In mid-July 2012 Galaxy halted operations at Mt Cattlin. Accrued inventory levels of concentrates at Jiangsu, just three months into its scheduled 12-month ramp-up phase, approximate to 12 months' feedstock. Two to three months feedstock is the objective for Cattlin resumption. Coincident with news of the temporary shutdown Galaxy also stated that, in line with integration of Mt Cattlin and Jiangsu operations, it will no longer sell spodumene concentrates to third party competitors. Also in July, Galaxy announced that Jiangsu had achieved battery grade quality above the minimum 99.5% Li_2CO_3 specification and within tolerances for the range of specified trace impurities.

Post merger Galaxy is focussing more on building out its resource base and so is contemplating joint venturing or divesting its Jiangsu battery project. Discussions with a number of potential JV partners have started. The lithium-ion battery plant, with a design capacity to produce 620,000 e-bike battery packs a year, already has environmental and safety regulatory approvals.

and advancing Cyr in Canada

Galaxy, with November 2010 indicated and inferred resources estimates for its Cyr Property in Quebec's James Bay area, is working towards a FS report expected in early 2013.

Resource characteristics for advancing mineral-based projects

In-situ Resources		Measured/Grade	Indicated/Grade	M+I	Inferred/Grade	Cutoff
COMPANY	Location	'000tonnes/% Li_2O	'000tonnes/% Li_2O		'000tonnes/% Li_2O	% Li_2O
Report Date		Tonnes LCE	Tonnes LCE	kt LCE ¹	Tonnes LCE	
TALISON ²	Greenbushes	200/3.9	70,200/2.6	70,400	2,000/2.2	1.00
03/11	W Australia	19,290	4,513,720	4,533	108,812	
GALAXY ³	Mt Cattlin	3,139/1.17	10,613/1.06	13,752	4,382/1.08	0.40
03/11	W Australia	90,824	278,207	369	117,036	
CANADA LI ⁴	Val D'Or	6,914/1.18	26,325/1.19	33,239	13,757/1.21	0.80
12/11	Quebec	201,760	774,711	976	411,655	
GALAXY	Cyr, James Bay	n.d.	11,750/1.30	11,750	10,470/1.28	0.75
11/10	Quebec		377,750	378	331,422	
NEMASKA	Whabouchi	11,294/1.58	13,785/1.50	25,079	4,401/1.50	0.40
06/11	Quebec	441,295	511,355	953	163,255	
REED ⁵	Mt Marion	2,015/1.45	4,770/1.39	6,785	8,082/1.30	0.30
07/11	W Australia	72,476	163,661	236	259,744	
WESTERN LI ⁶	Kings Valley	(Pv) 14,937/0.400	(Pb) 12,198/0.388	27,135		0.32
12/11	Nevada	147,757	117,043	265		
CRITICAL	Rose	n.d.	26,500/0.98	26,500	10,700/0.86	n.a.

EL					
07/11	Quebec		642,238	642	227,565

¹LCE: Lithium Carbonate Equivalent. ² March 2011: Talison proven and probable reserves stood at 31,400,000 tonnes @3.1% Li₂O (2,407,218 tonnes LCE) of which probable reserves are included within measured resources and proven reserves (0.03% total P&P) were run of mine and fine ore stocks. Talison lithium mineral resources are within lithium domains drawn at a 1% Li₂O grade boundary and above 1,000 reduced level. ³March 2010: Galaxy proven and probable reserves stood at 11,367,000 tonnes @ 1.05% Li₂O (295,161 tonnes LCE). ⁴Canada Lithium has proven and probable reserves of 17,064,000 tonnes @ 0.94% Li₂O (396,673 tonnes LCE). ⁵Reed resources spread through six proximal deposits. ⁶Western Lithium resources are proven (Pv) and probable (Pb) reserves for Stage I Lens only with a 95% mine recovery applied.

Reed Resources on hold

Reed improved Associated Minerals' 1996 Mt Marion, WA resources estimate in August 2010 and provided an update in July 2011 that's close to its targeted 7-8m tonnes of spodumene ore grading about 1.5% Li₂O. Reeds 30% JV partner, Mineral Resources Ltd, was expected to bring the mine and plant on stream in December 2011.

But, having cleared the mine site, the project is on hold. Talison's near doubled expansion at Greenbushes and the perceived potential response to that from the South American producers gave cause. An update on the preferred production profile and timing for the commencement of operations was expected in the June quarter 2012 but as yet there is no firm date for commencement. Meanwhile, mica is being evaluated as a commercial by-product of the spodumene recovery plant.

Canada Lithium cruising through construction

Canada Lithium produced a fourth resources update in December 2011 for its Quebec Lithium project near La Corne Township and remains on schedule. The mining licence from Quebec's Ministry of Natural Resources and Wildlife was received June 2012 and other essential permits are either signed off or well advanced. Mine and plant construction is advancing and commissioning is expected before end 2012 with battery grade Li₂CO₃ production expected to start first quarter 2013, building up to 20,000 tpa design capacity by end 2013. Additional 20,000 tpa spodumene concentrates will also be available for sale and 2,000 tpa LiOH will be produced from lithium carbonate. Feasibility work for lithium metal production is scheduled for 2013/2014.

As part of its focus on Asian lithium battery manufacturers Canada Lithium is opening its Shanghai marketing office in September.

Nemaska Lithium new direction

Mid-2012 Nemaska Lithium tore up its January 2011 PEA and abandoned a June 2012 DFS for its Whabouchi, James Bay 202,000 tpa concentrates project in Quebec. Market studies and patented electrolytic process technology for producing LiOH direct from spodumene persuaded Nemaska to change direction. A new PEA is under way for a chemical plant and for which Nemaska recently purchased 12.2 hectares of land in Salaberry-de-Valleyfield, southwest of Montreal.

The PEA, expected in September 2012, will be followed by a DFS before end 2012. The change of plan is not expected to hinder commissioning at Whabouchi in mid-2014 for which environmental, social and economic impact reports are to be filed in Q4 2012. Simpler permitting in the Montreal area is expected to allow commissioning six months following Whabouchi so allowing initial LiOH production in late 2014.

The chemical plant design is for 15,000 tpa LiOH and 5,000 tpa Li_2CO_3 capacities requiring about 150,000 tonnes of spodumene feedstock. A particular advantage is that the electrolytic hydroxide production process does not require soda ash so eliminating a major and unpredictable variable cost. Electricity is used instead which, in Quebec, is a predictable cost allowing long term LiOH supply contracts to be entered into more easily.

A significant endorsement for Nemaska's project came in March 2011 when China's leading battery grade lithium chemicals manufacturing company, Chengdu Tianqi Industry Group, acquired a 10% interest recently strengthened to 19.9%.

Critical Elements Corp racing to catch up

Critical Elements' lead project, another well known James Bay deposit, the Rose Li-Ta deposit, was acquired August 2009. The company moved quickly through initial exploration and, focussing on Rose West, a resource estimate in July 2011 and a PEA in November 2011 for 226,000 tpa concentrates at 5.87% Li_2O for a mine life of 17 years to feed a 31,000 tpa battery grade Li_2CO_3 plant. By the end of 2012 CEC expects to have completed a feasibility study and environmental impact statement, signed offtake agreements with customers, and initiated permitting procedures and project financing when a decision to go ahead will be taken for a 2014 start.

The lithium resources industry is ready to serve

Whether two or twelve, or any number of lithium resource projects, join the ranks of the expanding established producers in the course of the decade to 2020 will depend on the pace of growth in demand. As so much is dependent upon revolutionary technology change at a time of global economic and financial turmoil future demand volumes are hard to pin down as demonstrated by the wide difference between high and low forecasts. It seems clear, however, that despite apparent present day supply tightness and price rises, an increase in the pace of demand growth will be required by 2015 to call more than just a few advancing projects to production before 2020. Nevertheless there is a long project pipeline looking to serve advanced technology markets the most exciting of which are cleaner energy related in their infancy: two and four wheel automotive electrification, electricity grid storage, and solar and nuclear energy.

Unless and until nascent and emergent technology demand is overtaken by more attractive alternative applications solutions, demand for lithium resources of all types will grow as the decades unfold. All technologically feasible projects will be called upon at some stage as demonstrated by Ford Motor Company and University of Michigan in an unprecedented study which identified demand over the period to 2100 for 20m tonnes of elemental lithium that, owing to resource conversion losses, will require 40m tonnes of in situ resource (**IM** Lithium Asia, Shanghai, 2011).

And that matches the latest global lithium resources estimate (38.89m tonnes) published by industry veteran, Keith Evans, at **IM**'s Lithium Supply and Markets conference in Buenos Aires, January 2012 and that of Gerry Clarke in Proceedings of the Advanced Automotive Battery Conference, Long Beach, CA, US, June 2009 (39m tonnes). As exploration continues these resource estimates will very likely be overtaken.

But for many projects, particularly those less advanced in the pipeline, it will be a long time before return on project development investment will be realised. Project slippage is already evident.

**Gerry Clarke was first a mine geologist, ore mineralogist and university lecturer; second a former Editor of Industrial Minerals and Executive Director of Metal Bulletin plc; and third an independent commentator and consultant on the wide range of industrial minerals resources and markets.*