Li-S Energy Ltd

An emerging giant, ready to charge

Share Price: $1.545

ASX: LIS

Sector: Industrials

9 December 2021

Li-S Energy recently did its ASX IPO to fund further development of what can potentially be the world's first viable lithium-sulphur battery. It aims to capture the market opportunity created in the rechargeable battery space by addressing the challenges faced by users of Li-Ion batteries as well as the shortcomings of standard Li-Sulphur batteries. The company has established test results for its battery technology and plans to produce it at a pilot scale and engage product original equipment manufacturers (OEMs) and battery manufactures to establish the relevance of improved performance of its batteries. The objective is to attain commercialization through licensing of its intellectual property (IP), material supply and production of its batteries.

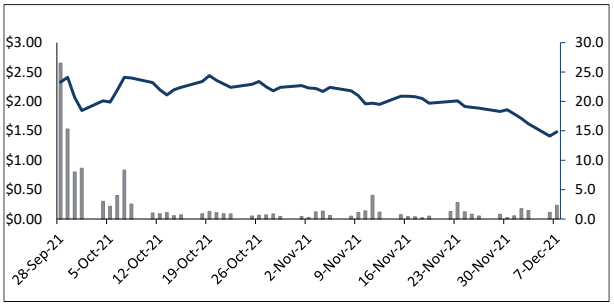
Market Cap. (A$ m)	950.7
# shares outstanding (m)	640.2
Free Float	39.1%
12-months high/low (A$)	3.05/ 1.41
Avg. 12M daily volume (m)	2.4
Website	www.lis.energy

Source: Capital IQ

The rechargeable battery market is forecast to grow at an exponential rate and the company is set to capture an important part of the market

The company is operating in a space which has an ongoing requirement of battery technologies with improved performance. Li-S Energy has proven its performance through research results and is all set to produce its batteries at a pilot scale and establish their commercial viability. The company has secured its capital requirements through the A$34 million raised in an IPO this September, in addition to A$20 million raised in a fundraising activity in April 2021. Additionally, the company has its supply and distribution agreements defined at least for the next five years and has a three-year roadmap to progress from development to production.

Share price (A$) and daily volume (m, r.h.s.)



Source: CommSec, Pitt Street Research

However, currently it is at a nascent stage of development and needs to cross various hurdles before it realizes monetization

Li-S Energy will generate limited revenue in the near future through the provision of its trial batteries from its pilot production facility. The company has identified various avenues for cash inflow over the time such as battery manufacturing, licensing, and distribution of Boron Nitride Nano Tubes (BNNT), a nanomaterial core to the company's technology. However, the market in which the company operates is highly competitive and has various established and upcoming players and is constantly looking for new and alternative technologies. Thus, the need for Li-S Energy to establish its technological superiority and guarantee its market acceptance is paramount.

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Analyst: Stuart Roberts

Tel: +61 (0)447 247 909

Stuart.roberts@pittstreetresearch.com

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Introducing Li-S Energy, ASX Code LIS

Application requirements in the fields of EV, aviation and drones are the major drivers of foreseeable growth in the requirement and adoption of rechargeable batteries

The rechargeable battery market is witnessing growth at exponential levels as it finds scope of application across various domains such as EVs, consumer electronics, aviation, and defence. The increase in adoption of EVs owing to global climate change targets, coupled with increased electrification of two-wheeled vehicles are drivers of demand for mobile batteries, which need to be light, safe, and energy-dense. Advances in technologies such as IoT have led to widespread usage of portable personal devices and remote asset monitoring sensors, which require improved batteries with ultra-long life. Similarly, drones and electric aircraft are driven by product innovations and demand batteries with high flying capacity to enable scale up of commercial applications.

The market has various solutions to fulfil the demand of rechargeable batteries for both consumer and industrial markets. One such prevalent technology is Li-Ion, but it has its limitations of life cycle and has reached the plateau of energy storage. Hence, manufacturers are resorting to alternative advanced battery technologies such as Li-Sulphur batteries which are lighter, cheaper, faster to charge and more socially responsible in comparison to Li-Ion batteries. However, difficulty in optimizing battery components and dendrite formation on the surface of anodes have to date prevented the adoption and mass production of Li-Sulphur batteries.

Li-Sulphur batteries have the potential to provide greater storage capacity than Li-Ion batteries but tend to fail after relatively fewer charging cycles, thus inhibiting their mass adoption

Li-S Energy, a newly listed player in Australia, is striving to overcome the current challenges of Li-Sulphur batteries by utilizing BNNTs, a nano material, previously not produced at a large scale owing to its high cost of production, to stabilize the battery components; and Li-Nanomesh, a proprietary material, which prevents dendrite formation. The company is capitalising on over 10 years of Li-sulphur R&D at Deakin University and is working, in collaboration with Deakin University, on development of an improved Li-Sulphur battery by addition of these materials which result in an Li-S battery that can considerably outperform standard Li-Ion batteries in terms of capacity, performance, stability and cycle life.

The company has signed distribution and supply agreements with BNNTTL for its BNNT. The production facility for BNNT was successfully commissioned in 2020 and utilizes Deakin University's patented BNNT manufacturing technology and has worldwide exclusive rights to use Deakin University's IP for 20 years.

Li-S Energy, in conjunction with Deakin University, has developed a novel battery technology using BNNTs as a nano-insulator in Li-Sulphur batteries

The company is currently in the development phase where it has proven the results of its research on the better performance of its Li-Sulphur batteries after incorporation of BNNT. The company is working towards setting up a pilot production plant for its batteries and aims to prove the commercial viability of its product and drive its mass adoption, the steps for which include collaboration with product OEMs to prove technological capabilities and commercial benefits of its batteries, engagement with battery manufacturers with a view to licence IP for use in battery production and adjustment of large-scale manufacturing plants with existing Li-Ion battery production lines to adapt to production of the company's batteries. Additionally, the company has applied for relevant patents to protect its know-how which are core for the company's successful operations.

Reasons which make Li-S Energy attractive

Application market is poised to grow due to surge in ongoing demand

The requirement for rechargeable batteries is growing exponentially and will continue in the foreseeable future, driven by various applications led by rapid growth in EV, evolving applications of drones and emerging consumer electronic products. The demand from EV is predicted to grow more than five times by 2025 and more than fifty times by 2040. Drone technology is advancing with development of new commercial applications leading to requirements to fly farther and carry heavier payloads. Consumer electronics, such as wearable devices, accounted for 36% of total Li-Ion demand in 2020 at 70 GWh/year and is forecast to grow to 137 GWh/year by 2030.

The rechargeable battery market is highly receptive to new and alternative technologies offering better performance

C. 90% of current energy requirements of the batteries market is fulfilled by Li-Ion batteries, but they have limitations related to energy capacity, charging rate, cost per Wh, weight and safety. With the surge in need and demand for batteries customized as per need, the market is upbeat for advanced battery technologies which offer higher energy density, rapid charging, safety, cost competitiveness and are easy to recycle. For example, at 2,567 Wh/kg, the theoretical energy capacity of a Li-Sulphur, battery is over five times that of a standard Li-Ion battery. However, conventional Li-Sulphur batteries face the challenge of instability of their components during the charge and discharge cycles, thus making them prone to failure and prohibiting their commercial usage. Li-S Energy offers advanced Li-Sulphur batteries which address the challenges of Li-Ion batteries and overcome the shortcomings of conventional Li-Sulphur batteries.

A successful IPO has provided the company with a much-necessitated source of funds

Li-S Energy raised A$20 million in a fund-raising activity in April 2021 followed by a successful IPO which raised A$34 million in September 2021. The results of the IPO reflect the market's confidence in the company's objective, direction and capabilities and provide the company with the security of meeting capital requirements for its various R&D initiatives.

Offers a potential battery which helps overcome the challenges faced during the use of traditional and conventional batteries

Li-Sulphur batteries have established significance in terms of their superiority over Li-Ion batteries but to date have failed in mass adoption and commercial production due to issues such as fewer charge cycles, short circuits and failure, loss of capacity and overheating causing barriers to charging speed. The company has established the improved performance of its advanced Li-Sulphur batteries augmented by usage of the nanomaterial BNNT and plans for its production as well as tie-up with established producers by means of licensing. The company claims that its advanced battery provides 15% more capacity retention during long-term cycling and prolongs the number of cycles (until capacity falls below 60%) to more than 900 cycles (compared to 30 cycles for an identical cell without BNNT), anddelivers a specific capacity that is three times that of Li-Ion batteries.

Clear focus with a defined roadmap for the near term

The company has established plans for three years with activities revolving around its objective to optimize the battery technology in the first year such that capacity and cycle life is further improved, followed by progression to the third year where the company would focus on engaging product OEMs and battery manufacturers and attain licensing agreements. Additionally, the company has commenced construction of a pilot production plant and has leased a facility in the Deakin ManuFutures building, with an aim to establish relevance of its batteries in collaboration with product OEMs.

Aims to be cost-competitive and has secured supply and distribution agreements for its core requirement of nanomaterial

The success of the company's operations is subject to secure supply of BNNT, a nanomaterial, which it uses in the Li-sulphur cells to enhance performance and cycle life. Additionally, the company plans to distribute BNNT to battery manufacturers to aid the production of an advanced battery. BNNT has not been secured or manufactured at commercial scales to date due to the costs involved, however, BNNTTL has demonstrated capability of being the largest and lowest-cost producer based on its annual potential capacity of 50 kg per manufacturing module per shift, at more than 95% purity. BNNTTL is currently scaling its manufacturing with additional manufacturing modules. Li-S Energy has signed agreements effective from July 2021 for the supply and distribution of BNNT for five years followed by an automatic renewal for two years. The distribution agreement is one way exclusive such that Li-S Energy can purchase BNNT from any supplier but BNNTTL can only supply its product to Li-S Energy, thus mitigating any potential risks arising from dependency on one supplier.

Projects underway to further enhance the IP in addition to the established form of technology

The company plans to build on the existing research of Deakin University in the fields of 3D printed batteries, flexible-form batteries and solid-state batteries and further aims to construct battery cells which demonstrate the capabilities. Additionally, it plans to leverage the successful R&D results to engage battery manufacturers and product OEMs.

Backing of PPK Group provides potential of technology application across a range of segments

PPK Group has a shareholding of c. 45% through its subsidiary PPK Aust. and could create huge upside for Li-S Energy by leveraging BNNT technology across a range of applications, such as 3D printing, better polymers, and ceramics. Additionally, other technology partners Deakin University and BNNTTL have stakes of 13% and 4.7%, respectively.

The company offers a potentially better performing battery for various domains of application

The rechargeable battery industry is currently dominated by Li-Ion batteries; however, they are reaching their theoretical energy capacity limits and emerging industries are driving the need for better batteries. Hence, the rechargeable battery market is highly receptive to alternative technologies and innovations to existing methodologies driven by the trend of surge in emerging demands of battery applications, especially for the manufacture of EV, drones and consumer electronics.

Some of the key requirements for new battery technologies essential for driving their broad adoption and mass production include the following:

- Development of higher-energy-density batteries without increasing their size and weight
- Speedy charging capability is essential; however, Li-Ion battery chemistry is inherently slow charging and if it is configured for faster charging, energy capacity is sacrificed, and it requires charging more often
- Li-Ion batteries are flammable and tend to overheat, which can lead to thermal runaway and combusting; hence batteries must be safe to avoid any catastrophic events
- Lower cost of batteries is crucial for their commercial-level production and mass adoption. Additionally, removal of barriers related to cost per KWh can enable innovations in applications related to higher energy capacity
- Li-Ion batteries have various heavy metals within the battery components which are expensive to procure, subject to geo-political supply chain risk, and are difficult to recycle. New battery technologies need to have an improved environmental footprint and should be more socially responsible

Li-Sulphur batteries are emerging as a potential solution which can address the complex interlinkages of the requirements for mass adoption. A conventional Li-Sulphur battery offers various advantages over a Li-Ion battery such as greater energy capacity, lighter weight, lower cost per Wh, faster charging, enhanced safety, and environment-friendliness.

However, conventional Li-Sulphur batteries have a relatively low number of recharge cycles, making them useless for commercial applications. Li-S Energy is trying to overcome these challenges by utilizing BNNT and its own proprietary nanotechnology composite.

Li-S Energy is researching on and developing the use of Li-Nanomesh as a protective layer for lithium metal anodes, and BNNT to protect cathodes and to improve battery safety

Registered on July 12, 2019, a joint venture between PPK Group Limited, BNNTTL and Deakin University resulted in formation of Li-S Energy, with an objective to research and develop a more advanced battery technology based on the Li-Sulphur chemistry but augmented by utilizing BNNTTL and Deakin University's existing technology and incorporating a nanomaterial BNNT into the battery components. The improved Li-Sulphur battery is aimed at overcoming the challenge of limitation of energy capacity of existing Li-Ion batteries while providing an improved cycle life in comparison with conventional Li-Sulphur batteries.

Li-S Energy has collaborated with Deakin University for its existing technology and developed an advanced battery technology using BNNT, a nano material provided by BNNTTL, to act as a nano-insulator such that problems related to traditional Li-Sulphur batteries are solved.

In addition the company proprietary Li-Nanomesh nano-composite has been proven to prevent dendrite formation on Lithium anodes – the company is now testing Li-nanomesh to improve the cycle life of Li-Metal batteries, which offers the prospect of a substantial additional product line and revenue stream for the company.

The company identifies the following benefits it offers in its advanced battery over the conventional technology:

Issue	Problem with standard Li-Sulphur battery	Solution provided by BNNT-enhanced Li-Sulphur battery
Loss of energy capacity	Soluable polysulfides result in permanent loss of active sulphur from the cathode, causing the battery capacity to deteriorate over relatively fewer charge cycles	BNNT interlayer assists sulphur retention as active material in the cathode, helping to maintain battery capacity during charge and discharge
Failure of battery	Lithium spikes or dendrites form on the anode surface during battery cycling, which can damage the insulating separator, causing short circuits and failure	The company's technology is based on the usage of its proprietary Li-Nanomesh composite on the anode, which impedes dendrite formation and reduces risk of battery failure
Loss of structural integrity	Movement of lithium ions during the battery's operation causes sulphur cathode to expand and contract, resulting in the loss of capacity and failure	BNNT helps to mitigate the effect of cathode expansion and contraction, thus reducing the mechanical stress
Limitation on speed of safe charging	Concentrated heat spots during charge and discharge can cause increased mechanical and chemical stress, leading to excessive localized heating	BNNT is a more efficient conductor of heat in comparison to copper, which can result in better dissipation of heat across the battery cell

The company has discovered, through its research & development, that integrating BNNT into Li-Sulphur battery architecture effectively stabilizes the battery components during charge and discharge, resulting in a cycle life at par with consumer-grade Li-Ion batteries, thus offering the potential of commercialization and mass production of its Li-Sulphur battery.

BNNTs have been costly to produce – 1KG costs $900k

BNNT, comprising boron and nitrogen, acts as a nano-insulator due to its properties related to thermal conductivity and thermal resistance, in addition to flexibility and low weight. Manufacturing high-purity BNNT at a commercial scale had been a challenge until recently due to issues related to cost and supply, however, BNNTTL has demonstrated potential capacity to manufacture 50kg of BNNT per year, per manufacturing module, per shift at >95% purity and claims to be the largest and lowest-cost producer in the world. BNNTTL is expanding its number of manufacturing modules to further increase supply and reduce costs. The company has signed a supply agreement with BNNTTL for commercial quantities of BNNT and an exclusive distribution agreement to distribute BNNT to the global battery industry for usage in Li-Sulphur batteries, both effective from July 2021 for a term of 5 years and automatic renewal for 2 years.

The company has a functional lab-based battery facility, established in Australia, for development and testing of a prototype of its Li-Sulphur batteries. It states that test results prove a better cycling stability compared to conventional Li-Sulphur batteries. The company is currently desigining its pilot scale production facility.

The company has a clear view of its goal and has its strategies in place to achieve the objective

Li-S Energy has put in place a development programme designed to provide a path to deliver its batteries, materials, and IP to market for mass adoption and has four primary goals:

- Further optimize the technology and achieve higher cell performances and more aggressive use scenarios
- Produce batteries in various formats, such as pouch, cylinder, and flexible cells, with an objective to maximise total addressable market and improve speed of adoption
- Build a pilot-scale battery production facility, manufacture batteries and collaborate with product OEMs to build on the early-stage results and prove commercial application of batteries
- Develop IP in relation to adaption of Li-ion cell manufacturing facilities to produce advanced Li-Sulphur batteries based on the company's know-how.

Li-S Energy intends to scale up its development and production team, install a pilot production line and collaborate with OEMs to demonstrate product application and prove performance advantages

The company does not generate any revenue and does not anticipate any cash inflows soon. However, to attain its goal of commercialization, the following are the strategies the company intends to adopt:

- Engage product manufacturers to prove technological and commercial benefits of the company's batteries in real-world applications and establish superior performance benefits in comparison to Li-Ion batteries
- Engage flexible-form product manufacturers once the validation is established for flexible-form battery
- Once the tests with product OEMs generate decisive results, the company plans to collaborate with product OEMs and approach battery manufacturers to generate and capture licensing opportunities for its IP
- Adjust large-scale battery manufacturing plants to produce the company's Li-Sulphur batteries in existing Li-Ion battery production facilities
- Distribute BNNT and Li-Nanomesh Materials to the manufacturers making Li-Sulphur batteries
- Test its proprietary Li-Nanomesh nano-composite in other battery chemistries that experience dendrite growth, in particular Li-Metal batteries – as this offers a substantial additional product revenue stream fo the company
- Evaluate and complete complementary acquisitions

The company has a three-year plan to realize its targets

The company has identified a three-year roadmap where each year will build on the outcomes of prior year.

Year 1 - The focus would be to demonstrate the practical benefits of the company's batteries over conventional Li-Ion batteries

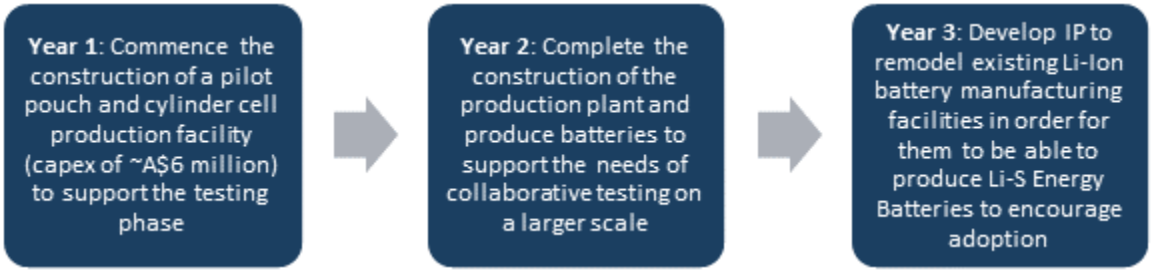
Year 2 – Continue to build on the outcomes of Year 1

Year 3 - Continue to conduct R&D and further develop IP based on the outcomes of Year 1 and Year 2 projects and feedback from collaboration partners.

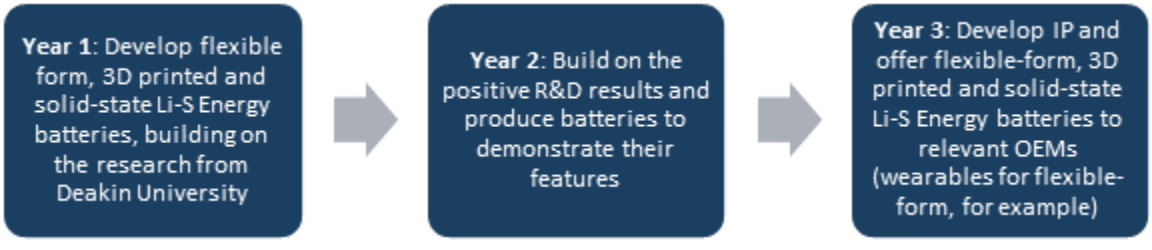
The strategic roadmap of the company is planned to revolve around the following four themes:

Partnerships and collaborations

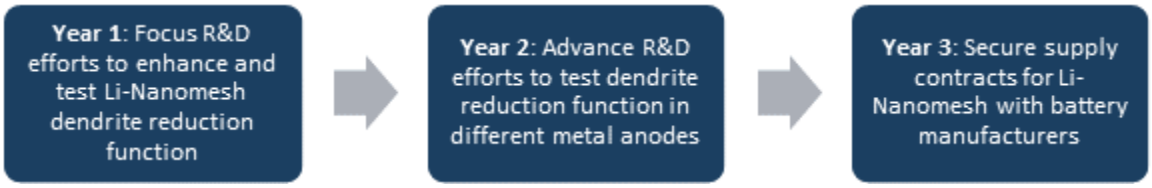
Battery production plant



Other development projects



Li-Nanomesh technology



Source: Company Website

Competitive Environment

Global sales of Li-Ion batteries amounted to $46 billion in 2020

The rechargeable batteries market is expected to grow rapidly to keep pace with the growing end-user markets. EV for example, are an important end-user market, with batteries representing an important cost for EV owners (~30% of vehicle cost). EV are expected to make up 10% of all passenger vehicle sales by 2025, a figure which is expected to increase to 58% by 2040. Other important end-user markets, such as mobile phones and wearables, are likely to see an increase in Li-Ion battery requirements from 70GWh/year in 2020 to 137GWh/year by 2025. With the markets for end-products forecast to peak in the next couple of decades, the knock-on effect of the momentum is expected to be visible in the rechargeable batteries space which is likely to flourish concurrently.

Demand for Li-Ion batteries (from different end-user industries) is expected to grow 10-fold by 2030

Traditionally, the rechargeable battery space has been dominated by Li-Ion batteries (makes up 90% of the market). However, with increasing demand, some previously overlooked disadvantages of Li-Ion batteries (such as high cost, tendency to overheat, heaviness, energy capacity) have led to the exploration of alternative battery solutions.

Consequently, novel technologies developed by battery avant-gardes are perceived as welcome changes in the highly competitive battery space. One such technology is Li-Sulphur batteries which have long been claimed as a replacement for Li-Ion batteries. However there are other alternatives under development, such as:

- **Supercapacitors**. Whereas batteries store energy in stores energy in chemicals, capacitors store energy in an electric field. Supercapacitors are similar to conventional capacitors, with the usual plates and separators, but altered for superior energy storage. Supercapacitors are often touted as the future of energy storage but they currently have limits[1].
- **Aluminium-air batteries**. These batteries use oxygen from the air to fill their cathodes, are far lighter than liquid-filled Li-Ion batteries to give EV a far greater range, Provided you are prepared to dispose of the battery pack and replace it after every trip.
- **Zinc-ion batteries**. This battery approach, being worked on by Salient Energy and Eos Energy, is much safer and less expensive than Li-Ion batteries, but such batteries are very heavy so better suited to stationary grid storage.

[1] Which is to say, they have good power density (ie can charge and discharge quickly) but are yet to reach satisfactory levels of energy density (ie they can store only a small fraction of the energy of a convential lithium ion battery per unit weight)

- **Hydrogen fuel cells**. There is also ongoing research to engineer hydrogen fuel cells for the automotive industry as when hydrogen is burnt, water is its only by-product. Hydrogen fuel cells are an established technology, but the cost of producing hydrogen, and the explosive nature of the gas are limiting factors.
- **Aluminium-graphite batteries**. If developed successfully, they will be exceptionally more efficient and environment-friendly than lithium batteries. Research on aluminium graphite batteries has shown them to be safe and lightweight, with fast charging speed, but to date energy density has lagged.
- **Sodium-ion batteries**. The main advantage of Sodium ion batteries is that sodium is more abundant than lithium. The energy densities achieved to date are 75-150 Wh/Kg – significantly lower than the best Li-ion batteries. They are not considered faster than Li-ion batteries, and as they are heavier they are better suited to Grid storage or home storage, where lower cost matters and weight is less important. Recently CATL, one of the world's biggest suppliers of EV batteries, has recently announced that it will started to work with Na-Ion alternatives by the end of 2023.
- **Solid-state batteries**. a solid-state battery uses solid electrolyte, not liquid. Samsung SDI is working with internal R&D departments to develop such a battery, which it believes can increase energy density per unit area which will be perfect to make an EV battery system with higher capacity.

We expect the next decade or so will see numerous startups focused on all these modalities. Some companies will start with one technology and then move to another. A good example of this is an American company called Sion Power2. The company initially sought to develop a Li-Sulphur battery before shifting its focus when it could not make a Li-Sulphur battery work for a reasonable cycle life. Today its potential payoff technology is 'Licerion', a lithium metal approach designed to deliver the highest combination of energy density and specific energy available. The company is planning to enter the EV and Aerospace applications market segments.

Certain risks could impede the growth of the company

The following could pose challenges in the smooth functioning of the company's operations:

The company is at the early stages of research and needs to cross various barriers over a significant period before it generates revenue and realizes cash inflows

Reliance on BNNTTL, the sole supplier of low-cost, high-purity BNNTs

A secure supply of BNNTs at required volumes and a commercially viable price point is crucial for the company's operations. The company has supply agreements and distribution agreements in place. However, BNNTTL's ability to manufacture BNNTs at a commercial scale is based on a relatively new technology.

Nascent stage of commercialisation

The company has benefited from over 10 years of R&D at Deakin University, however is currently working to scale its battery cells. It is poised to face various challenges, such as design and construction of its pilot production facilities within the specified budgets before it can to scale up to commercial production.

[2] Tucson, Az., sionpower.com.

Uncertainty of market acceptance

The Li-Sulphur battery technology needs to meet industry standards for power and battery storage in terms of an efficient and safe design. The company's battery needs to be competitive with other existing batteries in the market. Additionally, there remains continued risk of obsolescence because of the development of other advanced, alternative technologies.

The rechargeable battery space has numerous players at various stages of development to production[3]

The replacement battery market is cramped with globally established names with vast resources and new, emerging players with potentially market-disruptive technologies vying for a share in the market

The rechargeable battery space is a highly competitive market with a mix of established players and new, emerging companies with potentially disruptive technologies. Traditionally, the market has been dominated by companies offering Li-Ion batteries. However, newer alternatives such as Li-Sulphur, Na-Ion, Zinc-Ion are also on the rise. Each chemistry has different performance and physical characteristics which make them suitable for different applications

Following are some of the prominent competitors for Li-S Energy:

LG Energy Solution: It is one of the leading manufacturers of advanced Li-Ion batteries for the EV market with 24.6% market share in 2020 4. It has presence in various industries such as drones, aerospace, marine, ESS and consumer electronics market segments. The company is working towards developing a new Li-Sulphur battery technology which is expected to offer 1.5 times higher density with lower weight and higher safety in comparison with its current Li-Ion batteries targeted at the remotely controlled crafts, drones and EV segments. The plan is to commercialize its Li-Sulphur batteries by 2023 and achieve mass production by 2026.

Lyten: An advanced materials company which offers energy storage batteries, composites & sensors, developed through its patented 3D Graphene. In the battery space, it has laid the foundation for its Li-Sulphur platform called LytCell EV which is optimized for the EV market to offer c. three times the gravimetric energy density as compared to conventional Li-Ion batteries. Lyten is yet to start its pilot production line in San Jose in the Silicon Valley and is currently in discussions with several OEMs about their production timelines with an objective to introduce their Li-Sulphur batteries in EV space by 2025/265.. It aims to enter other segments such as VTOL, aeronautics, aerospace, transportation, and government/military.

Polyplus: Founded in 1991 and based in the U.S., the company is working to develop and commercialize its proprietary glass-protected li-metal battery and is carrying out an initial testing phase in collaboration with SK Innovation. It has previously worked with a tier 1 battery manufacturing firm to produce Li-Sulphur batteries, protected lithium anodes, lithium-air and aqueous-lithium batteries based on its patented Protected Lithium Electrode (PLE) technology. The company aims to use its proprietary technology to address the shortcomings of conventional small and light batteries to cater to various industries such as consumer electronics, EV, drones, robotics, and medical devices.

[3] Source: Company Website
[4] Source: SNE Research
[5] Source: https://www.electrive.com/2021/09/28/lyten-to-launch-li-s-battery-for-2025-26/

Ion Storage System: Based in the U.S., the company has merged technologies developed at the University of Maryland and the Maryland Energy Innovation Institute to produce its breakthrough Li-Ion batteries which are less costly, more versatile and ensure faster charging than standard solid-state batteries. It is in the phase of development and has teamed up with United States Advanced Battery Consortium (USABC) 6 to demonstrate the benefits of its batteries for use in several automotive applications. It considers defence and aerospace, consumer electronics, EV and grid storage as its target end-markets.

Enevate Corporation: Backed by some well-known investors (Mitsubishi, LG Chemicals, Samsung, Fidelity Investments), the company has developed a proprietary XFC-Energy Technology (more than 400 patents7) which utilizes a pure silicon anode at the core of its multi-layer design for Li-Ion batteries and offers 5 to 10 times the range of conventional batteries. Its battery technology has already been tested by more than top 20 battery and automotive manufacturers. It operates by licensing its technology to OEMs and battery manufacturers in the EV market. It signed a licensing agreement with EnerTech International in June 2021 with the aim to commercialize its technology in 2022. The company has secured $81 million in a Series E funding from Fidelity Investments8.

E-One Moli Energy: Part of Taiwan Cement Corporation (TCC) Group and headquartered in Canada, the company is a manufacturer of high-energy-density Li-Ion cells and battery packs. It has over 40 years of experience in the industry and has been one of the pioneers of Li-Ion batteries in the 1980s. It has entered strategic collaborations with Uber to develop batteries for Evtol and with William Advanced Engineering9 to demonstrate the benefits of its technology. The company is setting up a $350 million Gigafactory in Taiwan with a capacity of producing batteries for 24,000 EV in a year. Additionally, it supplies to segments such as home appliances, ESS, VTOL, power and garden tools, and aerospace markets.

Sionic Energy: Formerly known as NOHM, the company is based in the U.S. and offers low-cost non-inflammable Li-Ion batteries. The company uses the combination of electrolyte products and silicon anode technology to develop high-functioning Li-Ion batteries. It plans to operate on a licensing model and is on track to have its battery design ready for production and commercialization by the end of 2022. The target industries for deployment of its batteries include automotive EV, stationery storage and grid applications, light aviation (drones) and consumer electronics markets.

Note: Other prominent players include companies such as Panasonic, SK Innovation and Samsung SDI. Further details are provided in the appendix

[6] Source: http://www.uscar.org/guest/news/1020/News-Release-USABC-AWARDS-487-310-BEYOND-LITHIUM-ION-TECHNOLOGY-ASSESSMENT-PROGRAM-CONTRACT-TO-ION-STORAGE-SYSTEMS
[7] Source: https://www.electrive.com/2021/09/28/lyten-to-launch-li-s-battery-for-2025-26/
[8] Source: https://www.enevate.com/fidelity-leads-81m-investment-in-enevate-to-accelerate-commercialization-of-fast-charging-electric-vehicle-battery-technology/
[9] Source: http://www.molicel.com/corporate/williams-advanced-engineering-molicel-strategic-collaboration/

The management comprises rich talent in the related industry fields

The company is backed by a strong and experienced leadership team to guide through its journey from development to production and commercialization

DR. LEE FINNIEAR

Chief Executive Officer

During his 25 years of work experience in the field of technology, Dr. Lee has held many senior positions and has also been CEO and Managing Director of Metal Storm Ltd, (a NASDAQ- and ASX-listed technology company). He has been a founder and director of an IoT products company which served business and consumer markets

MR. KEN HOSTLAND

Chief Financial Officer and Joint Company Secretary

Mr. Hostland serves as the Chief Financial Officer of PPK Group Ltd, and its related mining companies, BNNTTL, White Graphene Ltd, BNNT Precious Metals Ltd, Strategic Alloys Pty Ltd, 3 D Dental Technology Pty Ltd and Ballistic Glass Pty Ltd. He has more than 30 years of experience as a senior finance executive with public and private companies

DR. STEVE ROWLAND

Chief Technology Officer

He has served as the deputy CTO of OXIS Energy which is also an innovator of Li-Sulphur battery technology. Dr. Stephen has accumulated valuable knowledge on nanomaterials and their effects on the detailed mechanisms of Li-Sulphur technology over the course of his career

MR. GLENN MOLLOY

Chief Strategic Advisor

Mr. Molloy founded and served as the director of PPK Ltd. He has substantial years of experience on public company boards and has valuable experience in managing commercial aspects such as mergers, acquisitions, or divestment activities

MR. ANDREW COOKE

Joint Company Secretary

Having gained a considerable amount of experience by serving as a director/company secretary of several ASX-listed companies, he is responsible for ensuring corporate administration and regulatory compliances at Li-S Energy

Appendix I – Glossary

BNNT: It refers to boron nitride nanotubes, an advanced material, which is produced in 11 countries all over the world

Dendrite formation: It refers to metallic microstructures which forms on batteries and speeds up battery failure process

Energy density: It refers to the amount of energy a battery can keep in relation to its weight

ESS: It refers to Energy Storage Systems, which are devices which can store various types of energy for use later

EV: It refers to 'Electric Vehicle'

GWh/year: It refers to gigawatt-hours per year. Gigawatt-hours is used as a measure of electric energy. GWh/year measures the electric energy produced in a year

IoT: It refers to 'Internet of Things'

KWh: It refers to kilowatt-hours per year. Kilowatt- hours is used as a measure of electric energy.

Li-Ion: It refers to Lithium-Ion

Li-Metal: It refers to Lithium Metal

Na-Ion: It refers to Sodium-Ion

OEMs: It refers to 'Official Equipment Manufacturers'.

UAV: It refers to Unmanned Aerial Vehicle

VTOL: It refers to vertical take-off and landing. It is an aircraft system that can hover, take-off and land vertically, having forward speeds comparable to those of conventional aircraft

Wh/kg: It refers to watt-hours per kilogram. It is used to measure the density of energy

Wh/year: It refers to watt-hours per year. Watt-hours is used as a measure of electric energy. Wh/year measures the electric energy produced in a year

XFC: It refers to 'eXtreme Fast Charging'. It is used to refer to new technologies in the battery space which allow faster charging (usually for EV)

Appendix II – Major Shareholders

Holder Name	Ownership (%)
PPK Aust	45.43%
Deakin University	13.02%

Source: Company

Appendix III – Other Comparable Companies

Company	Differentiating Factor (Scale of Operations/Alternate Technologies)	Description
Panasonic	Established player (market leader)	Panasonic's Energy division manufactures zinc carbon batteries, Li-Ion, Nickel-Metal Hydride, alkaline batteries, torches, and rechargeable batteries under the Eneloop brand. Panasonic held 19.5% share in the EV Li-Ion market in 2020
Contemporary Amperex Technology (CATL)	Established player, switching from Li-Ion batteries to Na-Ions batteries in 2023	CATL offers energy storage solutions, energy storage batteries, lithium-ion rechargeable batteries for EV and battery recycling services. It held 23.7% of market share in the Li-Ion market in 2020
Samsung SDI	Established player	It manufactures lithium-ion rechargeable batteries for mobile phones, middle-sized automobile and large-sized batteries used for energy storage systems (ESS). It held 6.2% of the market share in the EV Li-Ion market in 2020
Build Your Dreams (BYD)	Established player	It offers EV, Consumer Electronics, Li-Ion batteries (thus, acting as a battery manufacturer and OEM) and develops rail transit.
Automotive Energy Supply Corporation (AESC)	Established player	It is a leading battery technology company which offers Li-Ion batteries. It is working on incorporating IoT technology in its batteries to optimize battery life cycle management.
SK Innovation	Established player	It operates in the fields of energy, petrochemical, e-mobility battery, information electronic materials, EV battery and E&P. It develops Li-Ion batteries and has supplier agreements with world's leading automotive companies in Hyundai/Kia Motor, Daimler, Volkswagen, and Ford. It held 4.4% share in the EV Li-Ion battery market in 2020
Natron Energy	Develops Na-Ions batteries	It uses its patented Blue Prussian Na-Ions technology and combines it with Li-Ion manufacturing techniques to cater to the needs of EV fast-charging market, data centres and forklifts
Faradion	Develops Na-Ions batteries	It has developed Na-Ions batteries based on its technology which has been licensed to partners to cater to the EV and ESS market segments
Imprint Energy	Develops zinc-based battery technology	It has developed its own proprietary ZincPoly technology which it licences to OEMs and battery manufacturers in the IoT devices and wearables market

ZAF Energy Systems	Develops nickel-zinc and zinc-air batteries	It has combined decades of research in zinc batteries with its own proprietary technology to develop Nickel-Zinc and Zinc-Air batteries to cater to the Marine, Data Centres, Medical, Telecom/5G, Trucking and Aerospace/Defence segments
ZPower	Develops silver-zinc micro batteries	It develops and manufactures silver-zinc micro batteries which offer significant benefits as compared to Li-Ion batteries. It caters to the needs of the Hearing Aids, Medical Devices, Consumer Electronics and Defence market segments
Enerpoly	Develops zinc-ion batteries	It develops zinc-manganese dioxide batteries based on zinc-ion technology and licenses it to battery manufacturers for use in Energy Power Systems, UPS and EV charging stations
Nawa Technologies	Develops carbon-based batteries	It built on its research on nanomaterials and its electrode technology to develop a range of ultra-fast carbon battery that can be used in the Power Tools, Manufacturing, Automotive, IOT and Consumer Electronic devices segments

Source: CapitalIQ, Company Website, SNI Research

Appendix IV – Analyst's qualifications

Stuart Roberts, lead analyst on this report, has been covering the Life Sciences sector since 2002.

- Stuart obtained a Master of Applied Finance and Investment from the Securities Institute of Australia in 2002. Previously, from the Securities Institute of Australia, he obtained a Certificate of Financial Markets (1994) and a Graduate Diploma in Finance and Investment (1999).
- Stuart joined Southern Cross Equities as an equities analyst in April 2001. From February 2002 to July 2013, his research specialty at Southern Cross Equities and its acquirer, Bell Potter Securities, was Healthcare and Biotechnology. During this time, he covered a variety of established healthcare companies such as CSL, Cochlear and Resmed, as well as numerous emerging companies. Stuart was a Healthcare and Biotechnology analyst at Baillieu Holst from October 2013 to January 2015.
- After 15 months in 2015 and 2016 doing Investor Relations for two ASX listed cancer drug developers, Stuart founded NDF Research in May 2016 to provide issuer-sponsored equity research on ASX-listed Life Science companies.
- In July 2016, with Marc Kennis, Stuart co-founded Pitt Street Research Pty Ltd, which provides issuer-sponsored research on ASX-listed companies across the entire market, including Life Science companies.

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