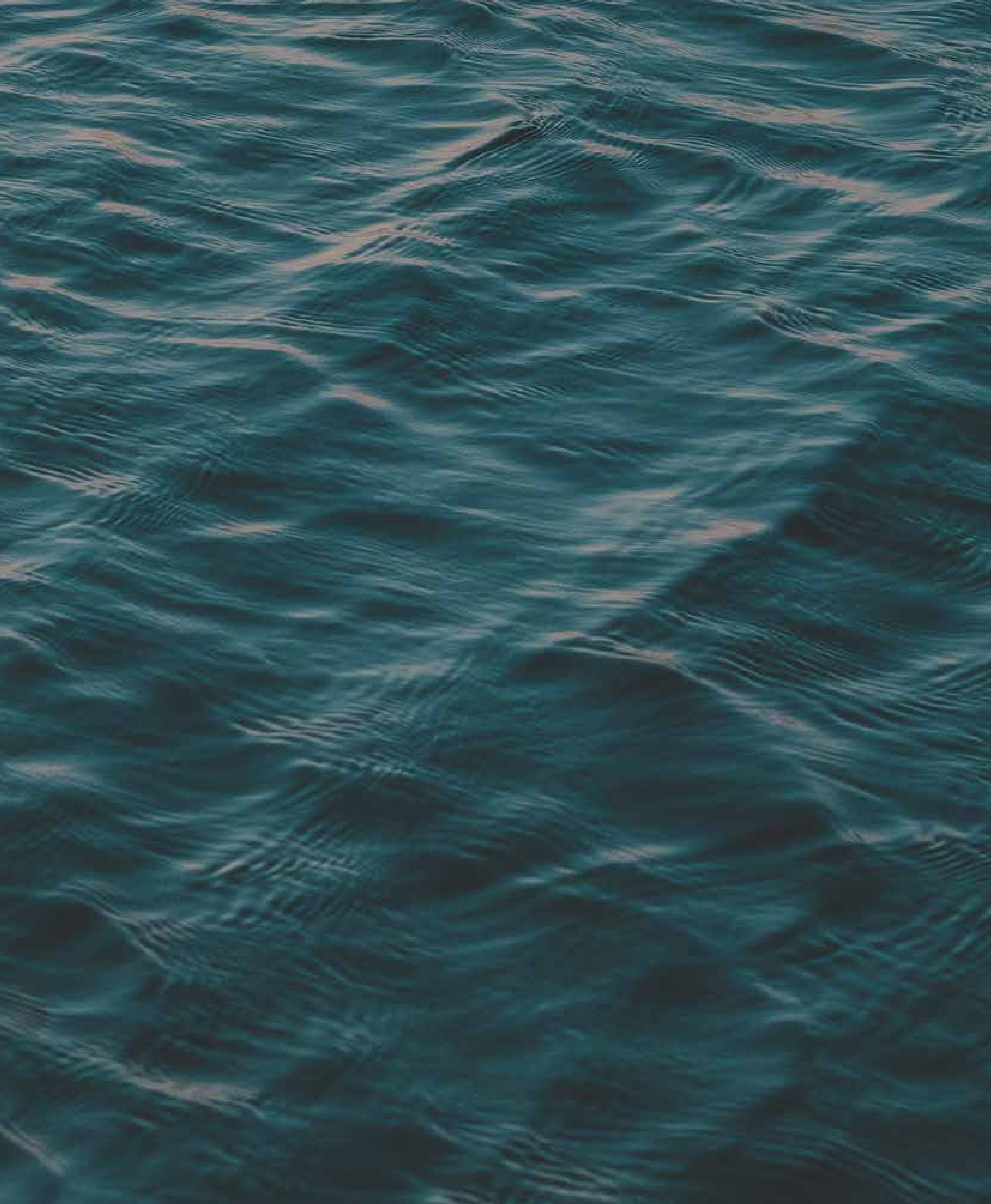

Aqualithium

Business Plan

A pathway to a new sustainable source of lithium contents.

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Aqualithium

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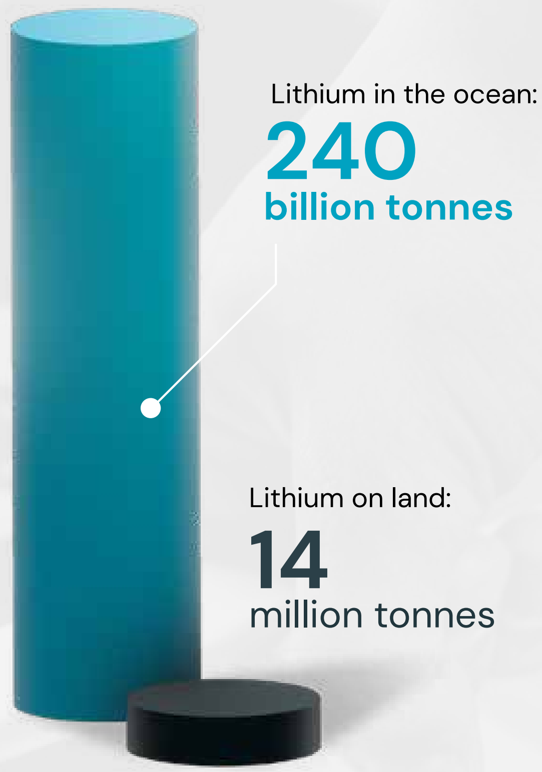
The demand for lithium is set to rise exponentially as the world transitions from fossil fuel powered vehicles to battery powered ones.

Lithium reserves are finite and current extraction methods are environmentally questionable. Land based reserves are estimated to be 14 million tonnes with annual global demand set to approach 1 million tonnes by 2026.

There are alternative sources of lithium: the world's seas contain an estimated 240 billion tonnes and even higher concentrations exist in brines and wastewater streams from geothermal sources, desalination plants and oil & gas industry installations. The science of extracting lithium is constantly evolving.



Lithium in the ocean compared to land based lithium

Aqualithium is a partnership embracing the worlds of science and commerce. Business professionals, scientists and investors, united by a common objective: to resolve the imminent shortage of lithium in an environmentally friendly and sustainable manner. The Aqualithium team are at the forefront of the research and development into a commercially viable method of harvesting lithium from seawater.

(U.S. Geological Survey - 2021)
(Science org - 2021)

Challenge

The world needs lithium. It is contained in our smartphones and laptops and will play a vital role in the global shift towards electric cars. By 2026, global demand for lithium compounds is expected to approach 1 million tonnes by 2026 (Roskill, 2021).

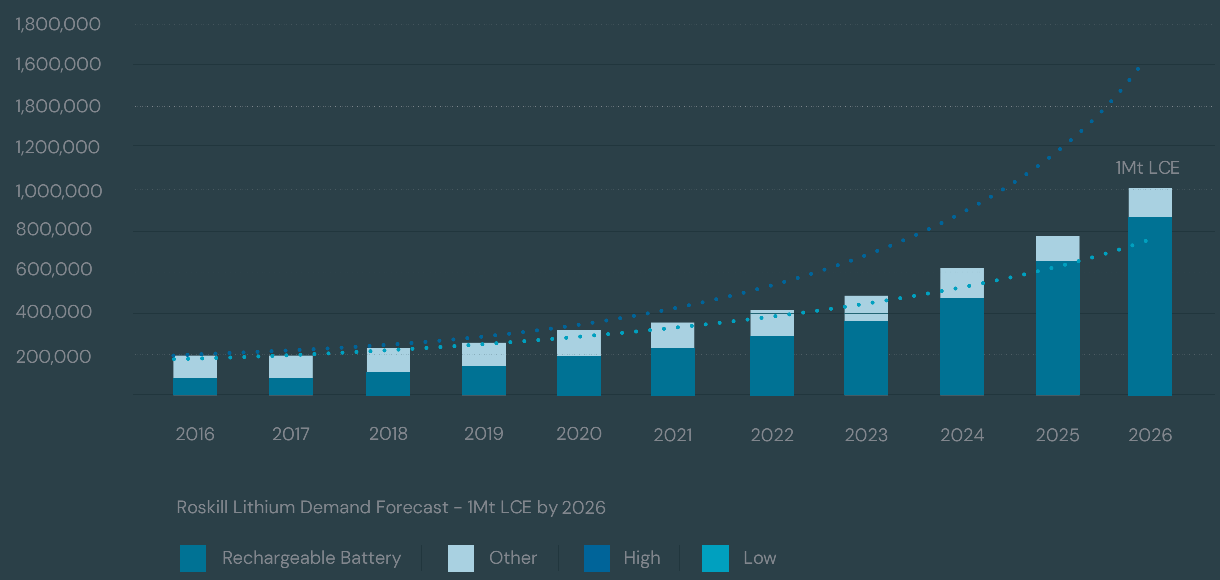
Lithium carbonate is the key raw material in lithium-ion battery manufacturing. Over recent years, these have become the principal rechargeable batteries for use in electric vehicles, mobile phones and for the storage of power generated by wind turbines.

There is an ongoing global research effort to find replacements for lithium, which could take many forms, but these will take a very long time to come to market if proven. Billions have been invested in building battery factories and infrastructure around lithium-ion batteries. Additives and enhancers will have a role to play but lithium as the principal battery metal is here to stay.

Tesla delivered 936,000 vehicles in 2021 (Tesla, 2021). With an average capacity of 70 kilowatt-hours per vehicle requiring to estimated 63kg of lithium carbonate equivalent (LCE) per Tesla model's battery pack (Electrek, 2018). This represents 60,000 metric tonnes of LCE in total.

Land based supplies are estimated to be at 14 million tonnes. Current consumption is around 500,000 tonnes (SPglobal, 2021) LCE per year, which is set to increase to around 1,000,000 tonnes by 2026. (Roskill, 2021).

Forecast demand for lithium by use to 2026 (t LCE)



This graph shows high and low forecast demand for lithium carbonate equivalent by use to 2026 measured in metric tonnes. The graph is corroborated by a McKinsey paper 'Lithium and Cobalt – a tale of two commodities' published June 2018 in Metals and Mining. Based on impact of the electric vehicle revolution, their analysis predicts robust demand growth for lithium to a range between 669,000 tonnes for the base case, to a higher case of 893,000 tonnes in 2025. They estimate battery applications will constitute 76% of the demand.
(Mckinsey, 2018)

Currently lithium is obtained from hard rock mining in China and Australia and more predominantly from brine deposits in the 'Lithium Triangle' spread across Argentina, Chile and Bolivia. Lithium bearing brines sit in underground aquifers, deep beneath the earth's surface, the brines are pumped up into the desert where they sit in vast pools while the sun evaporates the water, leaving mineral rich salts. This process takes about two years and is followed by a secondary process which entails the use of 500,000 gallons of fresh water to produce 1 tonne of lithium carbonate or lithium hydroxide. This water should be supplying local villages and agriculture. Additionally, when lithium is extracted from hard rock ore, mine "tailings" scar the countryside. The secondary process of treating the ore with hydrochloric acid to produce lithium chloride is hugely damaging to the environment. Waste discharged into Chinese rivers has left them full of dead fish and the riverbanks strewn with the bodies of yaks.
(EuroNews, 2022) (BBC, 2021).

Over the next decade production will start to lag behind the demand created by electric cars and consumer electronics. Brian Menell, CEO of TechMet, a company focussed on securing the critical metals required by the technology industry commented “The prospect of something replacing it gets more difficult every month”.

Land based lithium production
(Statica,2022)

Australia I 52%

Chile I 24%

China I 14%

Argentina I 6%

The worldwide production of lithium carbonate and lithium hydroxide is controlled by a handful of companies with four of the major players accounting for more than 90% of the output. The graphic above reflects this monopoly. Of equal concern is that the countries who control this production are not the most politically or economically stable.

The lithium-ion battery market is expected to worth from an estimated value of US$ 37.4 billion in 2019 to more than US$ 129.3 billion by 2027, which represents a CAGR (compound annual growth rate. 2020 - 2027) of 18%.

the solution.

The quest for a new source of lithium will not be solved by science alone. It will be necessary to have a working partnership between research scientists and the world of business; a partnership capable of talking to those in government and those in a position to raise funding and attract investment to collaborate in the search for a solution.

Aqualithium's purpose is twofold. Firstly, they will bring together a group of scientific researchers with specialist knowledge of the extraction of minerals from aqueous media. Their remit will be to devise and develop a viable process to extract lithium in an environmentally friendly and sustainable manner. Secondly, they will develop, improve and revise the Aqualithium Harvester, their platform in which they will deploy their filtration extraction system once perfected.

With respect to filtration, energy density calculations show that current filtration technologies are outside the economic range for processing seawater. However entropic minimum energy calculations confirm that the lower bound on the energy costs is negligible. This confirms there can be, in principle, a technology that enables feasible extraction of lithium from seawater. Lithium brine concentration is 750 to 7,000 times greater, which clearly puts these sources within economic range too.

The innovative extraction process pioneered by the University is a result of combining the use of Nanofiltration (NF) membranes and adsorption separation. Membranes will selectively remove divalent ions, specifically magnesium. NF offers an environmentally friendly alternative to chemical precipitation, reducing chemical usage with low energy consumption while achieving high selectivity. Lithium from the nanofiltration permeate is then selectively adsorbed in an ion-exchange adsorption column. Adsorption is a widely used process with a high selectivity for lithium and low capital cost. The successful experiments conducted for Aqualithium in late 2021 which extracted lithium from seawater at Bath's Department of Chemical Engineering reached an efficiency level of 96%.

UNIVERSITY OF BATH

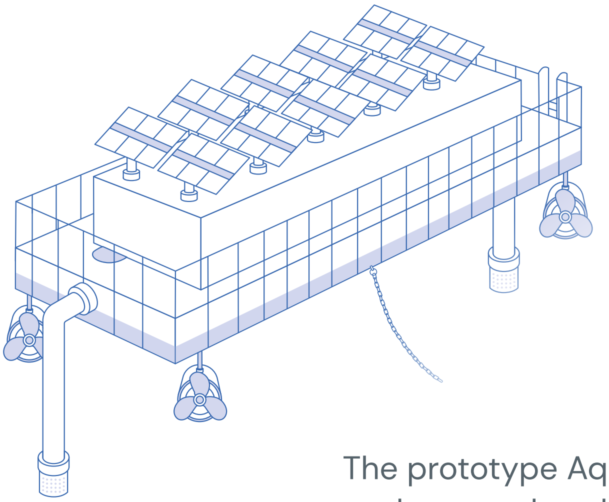
Professor Semali Perera
Univ. Bath - Leading expert in nano-filtration

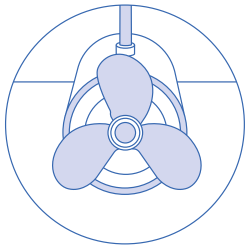
The Aqualithium Harvester
(patent applied for number 2002260.4)

The Aqualithium Harvester will be a world first; a floating solar powered lithium extraction system, efficiently collecting lithium from an endless supply in a sustainable, ecologically and environmentally sound way that produces no seaborne waste product and uses no fossil fuel power. It is the only truly green way of obtaining lithium, utilising extraction methods that will improve as time goes on.

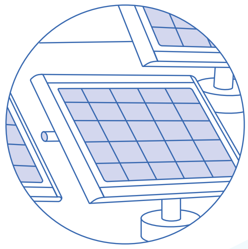
The Aqualithium Harvester is a floating platform that uses solar panels to power on-board pumps. Seawater is pumped from 10 meters below the surface (to avoid surface-borne debris) up and through the filter collection system, returning the wastewater back into the ocean. The unit is designed to inform the base operation when the extraction repository is full so the operator can collect the lithium bearing filters and replace them with new ones. The unit then returns to round the clock operation. On board rechargeable lithium batteries ensure that the pumps can operate at night and at times when the sunlight levels are low. The Harvester can also be powered by onboard wind turbines if the location so requires. The GRP construction of the platform will incorporate internal bulkheads in order that the platform will not sink if partially holed by a collision with another object.

The remaining obstacle has been that existing filtration systems have been unable to capture significant enough amounts of lithium to make the prospect of filtration commercially practical. Scientists worldwide have been working to solve this issue. Now Aqualithium's team of experts are making significant progress towards reaching a solution.





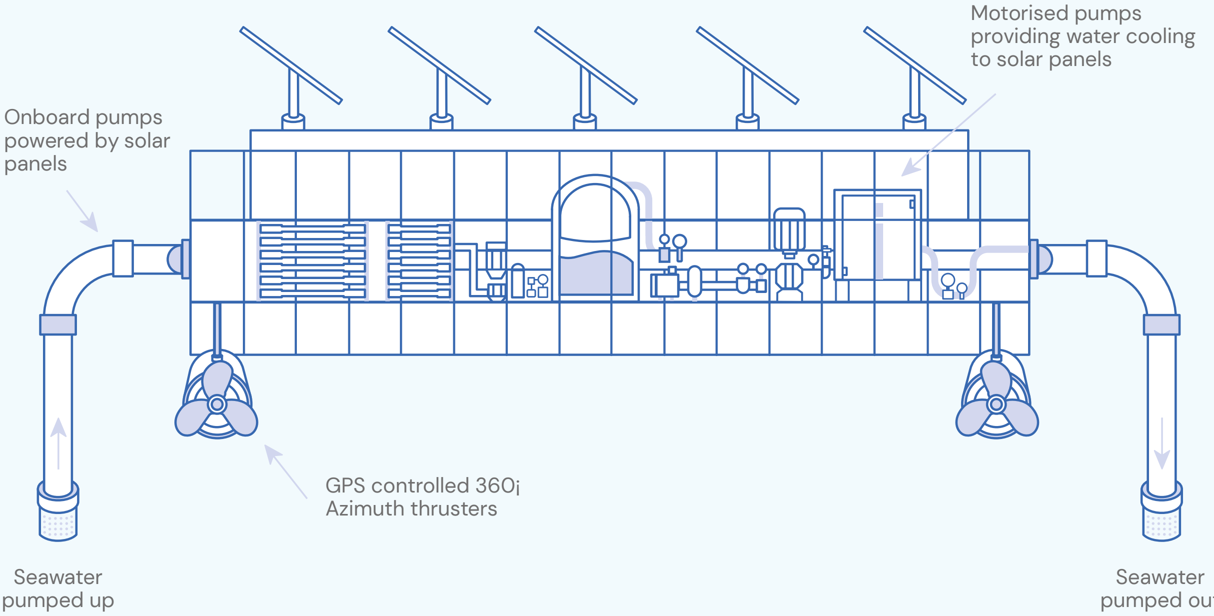
360-degree azimuth thrusters



Solar panels power on board pumps

The prototype Aqualithium Harvester is being designed in such a way that the filtration system will be interchangeable enabling the use of whichever method is technologically more advanced and therefore most efficient at extracting the highest percentage of lithium.

The platform is modular so there will be no restriction to its size. The platform can be tethered to an onshore mooring. The motorised rudders can also be connected to a tracker that keeps the solar panels pointing directly at the sun to optimise the solar energy collected. The panels can also track vertically via built in motors. Solar panels operate 16% more efficiently when water cooled so the panels will feature small pumps that will pump seawater through the back of the panels to keep them operating at the optimum efficiency.



strategy / outline plan.

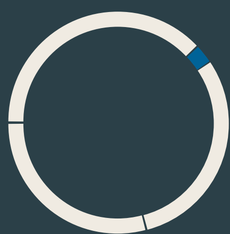
The commercial goal is to find a new pathway to a sustainable source of lithium production. This is an attractive proposition for technology funders. The Aqualithium team, a consortium of scientists, engineers and business leaders, are ideally placed to tender strong applications for innovation grants. The objective is for Aqualithium to secure its place as the ‘go to’ technology group for those wanting to seek long term, sustainable lithium production.

Research and development activity will be commissioned and overseen by Directors with the aim of identifying and developing optimum filtration technologies. Technological advances will be verified by proof of concept, achieved with engineered prototypes. A separate objective will be to ascertain the most advantageous commercial opportunities for the new technologies.

Aqualithium Harvester development

28%
Staffing and overheads

65%
Research



7%
Other

First round of funding allocation:

Aqualithium Harvester Development

- Research and development of Aqualithium Harvester.
- Creation of AutoCAD model of Aqualithium Harvester.
- Creation of 3D printed working desktop model.
- DWG engineering drawings of full scale Aqualithium Harvester.
- Manufacture of scale model of Aqualithium Harvester.
- Patent filing.

28% – Overheads

- Office costs.
- Staff wages.
- Director's remuneration.
- Business operating costs.
- International patent publication.
- Insurance.

65% – Research

- Research and development of filtration methods by University of Bath.
- Proof of concept study on extraction methods.
- Extract lithium carbonate from sea water in laboratory environment.
- Absorbent materials regeneration and membrane fouling study.
- Membrane and nano filtration manufacture.
- Patent filing.

7% – Other

- Travel costs.
- Other expenses incurred.

investment.

The funding round will be for the sum of £500,000 in return for 5% equity in the company. This will come from private investment in stages as required. The first stage of the funding, £500,000 will sustain 18 months of overhead together with research and development at The University of Bath - their remit being to further advance lithium filtration methods with specific proof of concept targets. The Aqualithium team will oversee the development of the Aqualithium Harvester simultaneously. Please see Gantt chart for detailed initial 18 month work plan.

E.I.S

Investment in Aqualithium Ltd qualifies for the Government's Enterprise Investment Scheme for U.K. based investors, who benefit from 30% tax relief on investments in growing British companies.

The business will progress by increasing the amount of research undertaken by academics. The growth of the company will come by virtue of increasing its ownership of Intellectual Property, the longer-term growth will come as a result of identifying businesses with an interest in acquiring a stake in our intellectual property. Furthermore, Aqualithium will continue to develop our Aqualithium Harvester to the point of manufacture, production and sales.

Exit

The exit strategy is clear and straightforward; the sale or licensing of the company, the protected results of its research and the patented Aqualithium Harvester to a producer of EV batteries such as Ganfeng, Panasonic, Livent or CATL or an EV manufacturer such as Tesla, Nio, General Motors, BAIC or Renault-Nissan.

Two well supported startups: Simbol Materials, who turned down an offer of $325 million from Elon Musk (fortune, 2016) of Tesla and Lilac Solutions who have recently received $20 million in backing from Jeff Bezos, Bill Gates and Michael Bloomberg are based on the extraction of lithium from geothermal waste water (EconomicTimes, 2020). Simbol, who wanted $1.6 Billion – subsequently and understandably collapsed.

It is obvious why a more basic technology designed to extract lithium from the higher concentrations in geothermal wastewater commercially represents “lower hanging fruit”. It fails however to address the fact that these sources are finite, limited and the technology is neither scalable nor appropriate for extracting lithium from the infinite sustainable seawater resource. The technological development surrounding commercial extraction from seawater requires superior scientific research and thorough development but potentially offers much greater rewards.

The value lies in the Unique Selling Point : A permanent long term sustainable solution to an increasing world problem. If Tesla viewed a solution that provided a short term, unscalable, finite solution to be worth $325 Million seven years ago then the directors of Aqualithium have every confidence of a valuation that would eclipse this figure many times over once their deliverables have been achieved.

£500k

Investment Target

+120x

Forecast return on profit for investors

4/6 years

Planned exit via trade sale

EIS tax relief

road map

road map.

- Fully identify the issue. Research the history, nature and possible future direction of the challenge and potential paths to finding a solution - August 2019
- Gather information, gain insight into current thinking, current methods of extracting lithium, alternatives to lithium, production problems and produce a document with reading list detailing this information - September 2019
- Produce 3-month plan with a clear path of what the company aims to achieve - September 2019
- Create a company profile (Aqualithium Ltd) including logo, branding, marketing and website. Engage with a media firm to handle PR and Media (Our Agency) - October 2019
- Assemble a team of scientists, business leaders and engineers - October 2019
- Identify partnership requirements- make contact with universities and advisors - October 2019
- Locate premises. Hold first meeting with potential board members - November 2019
- Visit University of Bath and introduce Aqualithium with the object of creating a partnership with the Department of Chemical Engineering - November 2019
- Instigate patent application process to protect the initial Lithium Harvester concept - November 2019
- Formalise University of Bath partnership, engage with Abbas Daruwala of Imperial College, London - December 2019

- ✓ Present our filtration development proposal to Bath University as a contender for the Final Year Student Project (decision date January 17th) – December 2019
- ✓ Procure a cloud based document repository application with user's permission controls for technical IP and forthcoming business plan – December 2019
- ✓ Complete business plan – January 2020
- ✓ Formalise agreement with board, chairman, non-executive directors & academic partners – January 2020
- ✓ Set out initial research programme with academic partners – February 2020
- ✓ Complete and launch our website & social media presence – February 2020
- ✓ Widen our contact with academics within the field of lithium filtration – February 2020
- ✓ Submit initial grant applications – March 2020
- ✓ Commence first round of seed investment and equity participation – March 2020
- ✓ Final Year Student Projects commence at University of Bath – April 2020
- ✓ Funded research begins on extraction methods – May 2020
- ✓ Receive final year students results – June 2020
- ✓ Continue development on prototype Aqualithium Harvester, complete patent filing, initiate scale drawings – August 2020
- ✓ Test and compare current extraction methods within a small-scale model – November 2020
- ✓ Gather test results and produce data based on each method – February 2021
- ✓ Identify and engage with potential energy partners – March 2021
- ✓ Extracted lithium from sea water in a laboratory environment – November 2021

The UK ranks as the sixth strongest start-up environment in the world due to the abundance of government grants on offer for new science advances and technology start-ups. Aqualithium is working with a number of UK grant consultants to prepare and submit grant applications.

Innovate is the UK's innovation agency. Their goal is to partner and fund organisations who are driving the science and technology that will grow the UK economy. According to their spokesperson "Innovate UK is part of UK Research and Innovation, a non-departmental public body funded by a grant-in-aid from the UK government. We drive productivity and economic growth by supporting businesses to develop and realise the potential of new ideas, including those from the UK's world-class research base. Innovate connects businesses to the partners, customers and investors to help them turn ideas into commercially successful products and services. Our support is available to start-ups across all economic sectors, value chains and UK regions. We have invested around £2.5 billion to help businesses across the country to innovate, with match funding from industry taking the total value of projects above £4.3 billion".

The Faraday Battery Challenge is part of the Industrial Strategy Challenge Fund, designed to ensure research and innovation takes centre stage in the UK government's Industrial Strategy. Through an investment of £246 million, the challenge addresses the productivity gap in a growing market worth an estimated £5 billion in the UK and £50 billion across Europe by 2025. The challenge is addressing 8 key targets of automotive battery technology which will allow the UK to realise its commitment to move to full electrification and zero emissions vehicles.

The Knowledge Transfer Partnership (KTP), a branch of Innovate, is a scheme to help businesses in the UK to innovate and grow. It does this by linking them with an academic or research organisation and a graduate. This enables a business to bring in new skills and the latest academic thinking to deliver a specific, strategic innovation project through a knowledge-based partnership. The scheme can last between 12 and 36 months, depending on what the project is and the needs of the business. A KTP is part-funded by a grant. Applicants will need to contribute to the salary of the Associate who will work with their business, plus the cost of a supervisor who will oversee the scheme. The amount that applicants will need to contribute depends on the scale and length of the project. It will also depend on the size of the company.

Smart - Proof of Concept Grant is to assist small and medium sized businesses to engage in Research & Development projects in the strategically important areas of science, engineering and technology, from which successful new products, processes and services can emerge. Through the Proof of Concept Grant businesses can apply for funding of up to £100,000 to explore the technical feasibility and commercial potential of a new technology, product or process, including: initial feasibility studies; basic prototyping; specialist testing and demonstration to provide basic proof of technical feasibility; intellectual property protection; and investigation of production and assembly options.

Smart - Development of Prototype Grant, formerly known as Grant for Research and Development, is to assist small and medium sized businesses, including start- ups, to engage in Research & Development projects in the strategically important areas of science, engineering and technology, from which successful new products, processes and services can emerge. Through the Development of Prototype grant, grants of up to £250,000 are available to develop a technologically innovative product, service or industrial process, and can include projects such as: small demonstrators; intellectual property protection; trials and testing, including clinical and market testing.

board of directors & scientific advisors

Sir Rodney Walker
Chairman
Seasoned Campaigner

Sir Rodney Walker is a respected and distinguished advocate for many organisations where he lends his considerable expertise to promote sports businesses and charitable enterprises for which he has raised over £40 million.
He holds many honorary titles including Chairman of the London Marathon Trust, The Chair of the British Basketball League, Vice Chair of Wembley Stadium and the life Vice President of the Rugby Football League.

He has chaired four companies listed on the London Stock Exchange and a number of public bodies including the NHS Trust Federation, Sport England and U.K. Sport. He is the past Chairman of Leicester City Football Club.

A chartered engineer, Sir Rodney is a fellow of the Institute of Directors and member of the Imperial Society of Knights Batchelor. He's also found time to support the NSPCC, being Vice Chair of the Full Stop Appeal as well as being Chair of the Sports Steering Group raising £25 million and elected honorary member in 2008.

Recognised by the education sector, he's received honorary doctorates from the Universities of Bradford and Huddersfield and has recently accepted the position of Chair of the Yorkshire Society.

David Oddie
CEO
Experienced CEO

David's career has been predominantly spent in engineering related enterprises however he has had a great deal of experience in the printing industry. He has worked internationally overseeing some very large projects and has a broad knowledge of a number of diverse industries.

As an investor he is shareholder in a number of successful companies including Aromaworks, the award winning natural lifestyle brand. David's rich and varied experience will help him galvanise the efforts of the Aqualithium team and extend its opportunity network.

Tom Black
Founder Director
Filtration expert

Having won the prestigious Doosan Babcock sponsored award for excellence in design and technology, Tom elected to make an early entrance into the commercial world of filtration where he has built up a broad knowledge of systems and media. Most recently Tom has completed The MBA Essentials Qualification at the London School of Economics.

Tom has been instrumental in both conceiving and developing this project and his passionate enthusiasm has been a major driver behind the speed and efficacy that has helped it progress from its embryonic stage to its launch as a venture with huge potential.

John Jeffrey
Director
Troubleshooting
Business mentor

John brings both engineering and research skills. CEO and founder of Critical Activities, a research consultancy that uses customer insights to steer effective boardroom strategy, John's services are employed by leadership teams and private equity houses.

As a Non-Executive Director and shareholder at Pyeroy, John worked with the group board to deliver year on year profit growth. Profits quadrupled over this period and as the company readied for flotation it was acquired pre-float by WOOD PLC.

John is the former Managing Director of the CAN Group, a pioneer in the market for industrial roped access with an innovative cost-effective approach for civil and petrochemical industries.

His early career included working as a project engineer and subsequently as an offshore construction Chartered Engineer with a specialism in high-speed rotating equipment and gas compression.

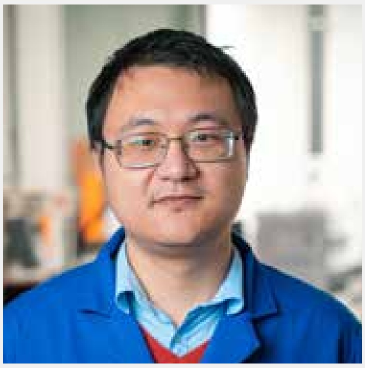
the team.

Professor Semali Perera
Univ. Bath
Leading expert in
nano-filtration

Professor Semali Perera has a BSC(Eng) in Chemical Engineering and a PhD from Brunel University, Uxbridge. She is a Chartered Engineer and a Fellow of the IChemE. In 2007 she won the prestigious Royal Society Brian Mercer award for Innovation in pollution control technology. From 2007 to 2010 she was Research Director for the University spinout company Nanoporous Solutions Ltd. In 2007 she was the winner of the Academic Award in the UK's biggest program championing women in technology, FDM Everywoman in Technology awards.

She specializes in adsorption membranes and low pressure drop adsorbent structures for advanced separation micro -pollutant removal, nanomaterials and microencapsulation of drug molecules. She is currently the Director of the Centre for Advanced Separations Engineering, Department of Chemical Engineering at the University of Bath. Her research is funded by a range of industrial organizations and government bodies.

Professor Perera leads a team of scientists at the University of Bath whose diverse areas of specialization are invaluable to the research of Aqualithium.



Dr. Ming Xie
Univ. Bath
Leading expert in
membranes

Ming's specialization is in the field of membranes. His work has been widely disseminated and he has authored, co-authored and edited a number of scientific publications. His PhD (with distinction) came from the School of Civil, Mining and Environmental Engineering at the University of Wollongong, New South Wales, Australia. Since then he has been a visiting graduate at Yale University in America and a research fellow at Victoria University in Australia and Kobe University in Japan. Ming has lectured at Bath since 2018, supervising graduate students and postdoctoral fellows.

Dr. Yannis Wenk
Univ. Bath
Leading expert in extraction from liquids

Dr Jannis Wenk studied Environmental Engineering at the Technical University Berlin including a one year stay at POSTECH (Korea). He conducted his PhD studies at Eawag and ETH Zurich from where he graduated in 2012. Subsequently, he worked as a postdoctoral fellow at UC Berkeley in California.

Jannis joined the Department of Chemical Engineering at the University of Bath as a Lecturer and Assistant Professor in January 2015. His research has been in the areas of aquatic oxidation processes, transformation pathways of trace organic water contaminants, chemistry of humic substances and environmental photochemistry. More recently Jannis became interested in the fate of pathogens during water treatment and nature-oriented low-energy water treatment systems.

At the University of Bath and the recently formed Water Innovation and Research Centre (WIRC) Dr.Wenk would like to utilise his knowledge in aquatic oxidation chemistry and build up his initial research programme on oxidation and advanced oxidation processes for water treatment. Key aspects will be the combination of oxidative processes with other treatment processes, integration of oxidative processes into existing water treatment schemes and process design for oxidative waste water treatment applications for both chemical contaminant and pathogen removal.

Geoff Turral
NED
Former CEO Porsche

Formerly CEO and Marketing Director at Porsche Cars Great Britain, Geoff brings extensive experience in leading companies to reshape their product offer and marketing strategy to address new and fast-changing markets.

In recent years he has focused in taking tech businesses from start-up through to revenue and market maturity.

In addition to his current primary focus in taking a transport app through to revenue, he is a Non-Executive Director on the Board of a NHS Mental Health & Care Trust.

Geoff has a Manufacturing Engineering Degree from Loughborough University

cpi ROYAL SOCIETY OF CHEMISTRY

Cornish Lithium Ltd
www.cornishlithium.com
Cornish Lithium in the UK have raised considerable funding from Government grants and crowdfunding to explore their theory that the mineral rich geology of Cornwall may provide a source of Lithium brines deep beneath the surface.

MGX Minerals Inc
www.mgxminerals.com
MGX Minerals Inc. is a diversified Canadian mining company engaged in the development of large-scale industrial mineral portfolios in western Canada and the United States. The Company operates lithium, magnesium and silicon projects throughout British Columbia and Alberta as well as petrolithium exploration in Utah.

Japan & South Korea Research
Japan and South Korea are currently at the forefront with regard to extracting lithium from saltwater, but disagreements exist over the most effective technology. There are a number of companies in the region working on different projects.

Samco
www.samcotech.com
Since its 1998 founding, SAMCO Technologies has provided custom water, wastewater, process separation, and filtration solutions to a diverse range of industries.
Based in Buffalo, NY.

International Battery Metals
www.ibatterymetals.com

IBAT is an advanced disruptive technology company focused on lithium brine extraction. The company is in the process of creating and applying intellectual property related to lithium extraction from brines. IBAT claim that their unique extraction process is environmentally friendly, low cost, and has the potential to produce high-quality, commercial grade lithium at a much faster rate than the current industry standards. The principal of this company was previously the CEO of Simbol Materials Inc., a company created to operate the Lithium plant, sitting on the edge of the Salton Sea, which was designed to extract lithium from the wastewater of several geothermal power plants sited around the lake.

Simbol Materials

Simbol planned to use ground-breaking technology to co-produce critical materials, all sourced from the most prolific mineral-rich brine source in the world. Tesla visited the site with talks of a giga-factory being built alongside the plant. Tesla offered $325 Million for the company but the company declined the offer and decided to fund the project themselves. Unable to complete the raising of the finance due to differences between the owners, the company ran out of funds and filed for bankruptcy.

Saltworks Technologies
www.saltworkstech.com

Standard Lithium has commissioned Saltworks Technologies of British Columbia, Canada to design and build their novel, selective crystallization pilot plant. The plant is intended to make battery-grade lithium carbonate in a continuous process using lithium brine extraction. The modular containerized plant will enable rapid, mobile testing on lithium- rich brines. Saltworks are based in BC, Canada.

Battery Metals

Every chemical battery is made up of the same basic parts (https://curiosity.com/topics/why-extreme- temperatures-mess-with-your-batteries-curiosity) including two electrodes and some sort of electrolyte. Rechargeable batteries take in energy via a chemical reaction that makes charged particles (or ions) in the positive electrode (or cathode) travel through the electrolyte and into the negative electrode (or anode), where they stay. When the battery is discharging energy into a device, the ions travel back from the anode into the cathode to produce that energy.

In a Lithium-ion Battery (www.explainthatstuff.com/how-lithium-ion-batteries-work) the cathode is made of a compound containing lithium (typically lithium cobalt oxide or lithium iron phosphate), the negative electron is made of carbon graphite. The electrolyte varies depending on the battery type. Lithium-ion batteries work well because they are dense can charge and recharge many times during their life. They have a high energy density.

Are there alternatives to lithium?

- **Sodium** is plentiful in seawater - requiring little in the way of mining or extraction. The challenge is that you exchange lithium battery components for sodium. Sodium is a larger ion than lithium, so it won't fit between the carbon layers of the battery's graphite-based anode. Sodium also has a lower energy density than lithium.

- **Fluoride** batteries have the theoretical potential to last eight times longer than lithium batteries. The high energy density is because fluoride is an anion, or a negatively charged ion. However, for this reason fluoride is reactive and hard to stabilize.

- **Magnesium** is more common than lithium, but is more susceptible to the imperfections (known as dendrites) that can lead to battery fires. Magnesium batteries cannot compete with lithium for power or storage capacity. The chloride in a commonly used electrolyte was to blame for the poor battery performance. When swapped for a chloride-free version and combined that with a specially formulated cathode and a magnesium-based anode, significant improvements in energy, power, and stability are possible. However, it is still not good enough to compete with the most recent generation of lithium batteries.

- **Ammonia** powered batteries are not available, but ammonia is an alternative to lithium. It can power fuel cells in vehicles and other equipment. If scientists can develop a way to produce ammonia without creating greenhouse gas emissions, it can be converted into hydrogen to power fuel cells. If achieved, the energy density by volume is almost twice as much as that of the liquid hydrogen that's usually used to power fuel cells.

- **Aluminium** has potential as a battery metal. However, there remains much work to do with the electrolyte, and with developing better charging mechanisms. Aluminium is in principle a significantly better charge carrier than lithium, since it is multivalent – which means every ion 'compensates' for several electrons. For now, this is only a proof of concept and more work needs to be done before cars could function on aluminium batteries.

- **Potassium** like sodium has similarities to lithium but is less stable and interest has waned because of safety risks.

- **Grafite (Graphite)**, Graphene, Sulphur and silicon batteries are sometimes mentioned. These elements are enhancers, added to Lithium-ion batteries to form the cathode or anode. They are not a replacement for the Lithium content. Silver-zinc batteries have a safe application in hearing aids but are too expensive to scale up.

Battery manufacturers will continue to invest in research relating to alternatives to lithium-ion batteries as well as ways of enhancing and improving the technology behind them. Every single car battery manufacturer is heavily committed to Lithium-ion batteries as their preferred choice.

Lithium metal extraction from seawater.
Sixie Yang, Fan Zhang, Huaiping Ding, Ping He and Haoshen Zhou.
Joule 2, 1648-1651 Copyright 2018 Elsevier Inc.
www.sciencedirect.com/science/article/pii/S2542435118302927
This article by some of the leading scientists in the field estimates that all land-based Lithium reserves will be exhausted by 2080. This article further suggests the possible use of solar energy as a power source although not in the way Aqualithium foresee it nor with the same extraction method.

Quest to mine lithium from seawater advances.
Richard Martin
MIT Technology review. 2015.
www.technologyreview.com/s/538036/quest-to-mine-seawater-for-lithium-advances/
This article discusses the advances made by Tsuyoshi Hoshino and his research into extracting lithium from seawater by dialysis.

Innovative lithium recovery technique from seawater by using world-first dialysis with a lithium iron superconductor.
Tsuyoshi Hoshino.
ScienceDirect/Joule Copyright Elsevier B.V. 2019.
https://core.ac.uk/download/pdf/82317531.pdf
This paper deals with Dr. Hoshino's research in detail.

Membranes will slash energy and harvest lithium say researchers.
Copyright Faversham House Group 2018. www.desalination.biz/news/0/MOF-membranes-will-slash- energy-use-harvest-lithium-say-researchers/8942/
This article references the work of Australian and American scientists and their work on Metal Organic Frameworks via Monash University.

Mining critical metals and elements from seawater: opportunities and challenges.
Dr. Mamadou S. Diallo, Madhusudhana Rao Kotte and Manki Cho.
Environmental Chemical Society. Copyright American Chemical Society. 2015.
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This article highlights the work of Dr. Diallo of the California Institute of Technology.

Extraction of lithium with functionalised lithium ion-sieves.
Copyright Elsevier B.V. www.researchgate.net/publication/308339816_ Extraction_of_lithium_with_ functionalized_lithium_ion-sieves
This paper related to the extraction of lithium from seawater by the use of ion-sieves.

New desalination process could extract vital battery material: lithium.
Matt Weiser.
Water Deeply. 2018.
www.newsdeeply.com/water/community/2018/06/27/new-desalination-process-could-extract-vital-battery- material-lithium
This article is in part an interview with Benny Freeman, Professor of chemical engineering at the University of Texas, discussing the use of MOF's in the extraction of lithium from seawater and the progress that is being made.

Extracting lithium from water using synthetic membranes.
Amanda Doyle. The Chemical Engineer.
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www.thechemicalengineer.com/27841
This article is about further MOF research and development.

Lithium and cobalt - a tale of two commodities.
Marcelo Azevedo, Nicolò Campagnol, Toralf Hagenbruch, Ken Hoffman, Ajay Lala, Oliver Ramsbottom. Metals and Mining: June 2018 https://www. mckinsey.com/industries/metals-and-mining/our-insights/ lithium-and-cobalt-a-tale-of-two-commodities

The washington post - tossed aside in the 'white gold' rush – indigenous people are left poor as tech world takes lithium from under their feet.
www.washingtonpost.com/graphics/business/batteries/tossed-aside-in-the-lithium-rush/?

Intellectual Property

withers & rogers
Patent and Trade Mark Attorneys

The Aqualithium Harvester is the subject of a patent application filed by Withers & Rogers LLP. Derwent House, 150 Arundel Gate, Sheffield City Centre, Sheffield S1 2FN.

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Samir Ferdowsi

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