NEWCASTLE: RENEWED

Image Source: Getty

Business proposal for
FMG | 2019

Prepared for:

Fortescue Metals Group

Board of Directors

Proposal Issued

10/10/2019

CONTENTS

PREFACE

वतेर् / **Nera = Water**

NERA/Team 4 acknowledges the traditional custodians of the land and waters linked to this project, the Awabakal and Worimi people. We pay respect to knowledge holders and community members of the land and acknowledge and pay respect to Elders past, present and future.

> **Water is the driving force of all nature.**
>
> **- Leonardo da Vinci**

01 EXECUTIVE SUMMARY

We are NERA, the Newcastle Energy Research Agency. Founded in 2019 by participants of the Hunternet Future Leaders development program and now backed by Newcastle City Council, the Hunter Development Corporation, Newcastle University and a commercial partnership with Siemens to use their world leading hydrogen production equipment. We are a passionate group that is critically aware of the current climate crisis that our planet faces. In this document we believe we have a viable solution and a framework for an industry innovation in Newcastle.

Newcastle has been viewed for decades as a coal centric, rural city that is sitting in the past. NERA's outlined plan is going to drag Newcastle out of the past into a new green future; working collaboratively with the current plans for Newcastle's and its surrounds. Our goal is to enable alternative energy sources and technology to be developed in the Newcastle region. We believe this will create economic stability and resilience as well as a world class lifestyle for Novocastrians.

We plan on accomplishing this by transforming the old BHP site at Mayfield into a future energy innovation district with a focus on hydrogen. The jewel of the district will be the Cocoon Innovation Centre, a new building providing a flexible space for large and small companies to collaborate. Initially, there will be the relocation of an ASX200 company to the site, followed by other companies who are investing in hydrogen technology.

To create a tangible short term benefit for investment, there will be a hydrogen production facility constructed at the now vacant aluminium plant at Kurri Kurri. This will be powered by solar panels and fed water from a reverse osmosis plant. Initially, this hydrogen will be used to enrich natural gas which will be transported to Orica on Kooragang island. The required investment will be sourced collectively from federal and local government, private investment and public partnerships. The proposed investment is $375m with a ROI of 3 years.

After this successful transition, the hydrogen production facility will be able to expand and begin to take advantage of the technology and knowledge produced in the Innovation District. Hydrogen produced in Newcastle will be used to power the city, be a key component of the state energy mix, and be exported around the world.

NERA is empowered with the resources of vacant land and funding, enabling a large scale disruption of an industry as huge as the energy industry. The future is NERA.

02

INTRODUCTION

The time is now; Newcastle has long relied on carbon based fuel exports and industry as the backbone of its economy. There are both environmental and economic pressures on carbon based fuel that will see them being phased out over the next half century. Dealing with the climate emergency is the challenge of our modern society, and the decisions made now will resonate through generations. The transition away from carbon fuels seems daunting but cities and companies that approach this in an intelligent way will ensure their financial success during the complete disruption of the energy market.

There is a way to not only ensure employment for workers from traditional industries but to grow Newcastle as a leading second city. This has led to the creation of NERA, Newcastle Energy Research Agency. NERA's goal is to promote and enable alternative energy sources and technology to be developed in Newcastle region.

By leveraging our industrial and cultural heritage, NERA will reinvigorate the Newcastle region by creating a hydrogen economy as a catalyst to shift the traditional focus from carbon extraction and use to a green economy. This will create a dynamic economy and a world class lifestyle for Novocastrians that repositions the Newcastle region as the focal point for renewable energy technology in our region, attracting technology, commercial and institutional partners to the innovation district NERA is creating.

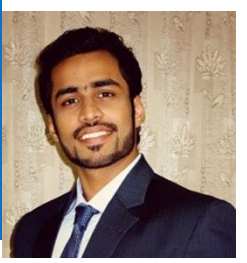
NERA have secured key land in the Newcastle area to help make this vision a reality.

03 ORGANISATIONAL STRUCTURE

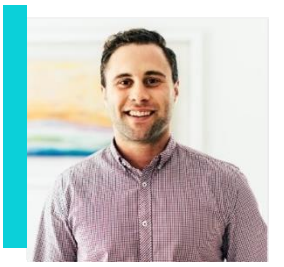
NERA BOARD OF DIRECTORS

BAHAR CHAICHI
CHIEF EXECUTIVE OFFICER

TIMOTHY HIGGINS
CHIEF OPERATING OFFICER

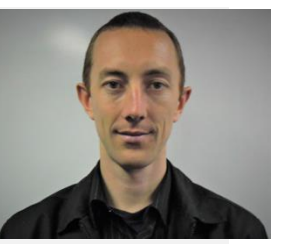


NIRAN VARMA
CHIEF TECHNOLOGY OFFICER



REECE MARINI
CHIEF FINANCIAL OFFICER

BRIDGET ANDERSEN
CHIEF MARKETING OFFICER



ASHLEY MCKELLAR
CHIEF INNOVATION OFFICER

PART 1 NEWCASTLE: THE BRAND

NERA sees the Newcastle region as a vibrant collection of communities, centred around a city which embodies the same innovative and sustainable values as NERA. In order to allow the Newcastle region to fulfil its potential, build a sustainable future and become a “second city”, NERA has defined objectives which align with its mission and vision.

04

MISSION AND VISION

Mission

The Newcastle region will be South East Asia's first renewable energy capital and a leader in innovation.

VISION

Newcastle has a need for a resilient economy that moves from carbon based fuels to renewables in line with the current social dialogue. This needs to take place without negative repercussions on the regional economy. Hydrogen production and its supporting programs can create a diversified economy for Newcastle and help it to reduce its reliance on existing coal revenue.

As well as economic advantages, introducing a renewable energy initiative will also change the region's perception.

NERA plans to facilitate the creation of a Hydrogen Economy in Newcastle that grows to be a global trade of hydrogen energy. This will support Newcastle's economy into the future, helping create initiatives which enhance the liveability and economic prosperity of the region.

In time Newcastle itself will transition into a carbon neutral second city, with not only our local transport (light rail, buses, cars and planes) being run on hydrogen energy, but our entire power source. Even the largest port on the east coast will not only exporting these renewables, but completely running on hydrogen moving forward.

05 OBJECTIVES

INVEST

Through the introduction of an anchor company, Fortescue Metals Group, an example will be provided for other organisations to follow. NERA will give the opportunity for Fortescue Metals Group to headquarter their renewable energy division in Newcastle and develop a hydrogen energy facility which will provide economic diversification for the area and in turn fund the strategies that will enhance the region as a whole.

Provide innovation, infrastructure and opportunity through the development of a Techno Park with the resources to enable individuals to create businesses in Newcastle. By allowing large and small companies with a similar vision to exist in the same zone, the collaboration and healthy competition will advance energy technology research at a greater rate.

Leverage existing infrastructure such as the port of Newcastle, CSIRO's energy research centre, Hunter Valley and Lake Macquarie power stations, and power and gas feed of the Kurri Kurri aluminium plant.

LIVE

Through a Hydrogen Economy, approximately 250 direct and 1,000 indirect jobs will be created in the first year which will in turn create a demand for more mixed density housing regions which are currently being developed in line with the Greater Newcastle Metropolitan Plan. Overtime in Phase 2 & 3 (covering the following 2-5 years), the growth in employment from subsequent investment will create 10,000 direct and 50,000 indirect jobs.

VISIT

The Cocoon is the centre piece of the bold future NERA will deliver. It will be a beacon that attracts the world's best and brightest; an iconic landmark that positions Newcastle region internationally - the next Opera House of Australia. Newcastle will be known as a global leader in hydrogen energy and will be the research and innovation capital of renewable energy which will host renewable energy summits and conferences out of the Cocoon.

CREATIVE SOLUTION 06

Branding represents more than a logo. The brand of a place characterises the identity, values, future and people of that place. It connects and reflects different aspects of the region and creates recognition and pride of place. To create a new visual identity for the Newcastle region, NERA commissioned the design of a new landmark, The Cocoon, which will act as the heartbeat of renewable energy movement in Newcastle. A logo and visual identity for NERA was also developed to complement the vision for the region.

As part of the research and development of a new creative solution, we reflected on previous iterations and identities of the region and Newcastle City in order to develop and distinguish a new creative identity which integrates the mission and vision NERA has for the Newcastle region.

City of Newcastle

Figure A: City of Newcastle Logo

The current City of Newcastle Council logo (Figure A) was created in 2018, 25 years since the previous logo was designed in 1993. The 'N' ripple effect represents the water as a connection to the coastal landscape.

"The 'N' logo bears six colours in a simple yet effective design that encapsulates Newcastle as an emerging global city. The ripple effect represents water, as a strong symbol and shared connection across our coastal city" - Kathleen Hyland, Manager of Major Events and Corporate Communications, Newcastle City Council.

Community consultation undertaken for the Newcastle 2030 Strategic Plan revealed that the ocean, beaches and coastline were among the most important features of Newcastle to the community, therefore the logo represented this. The vibrant palette captures the beauty of Newcastle's natural environment and represents the city's bright outlook. The various colours also represent the different aspects of Newcastle; the natural environment, industry, arts and culture. We felt that this logo accurately represents the Newcastle region and should be implemented across the different local governments to connect and unite them with a single vision. The design for both The Cocoon and the NERA logo have taken the Newcastle branding elements into consideration.

THE COCOON

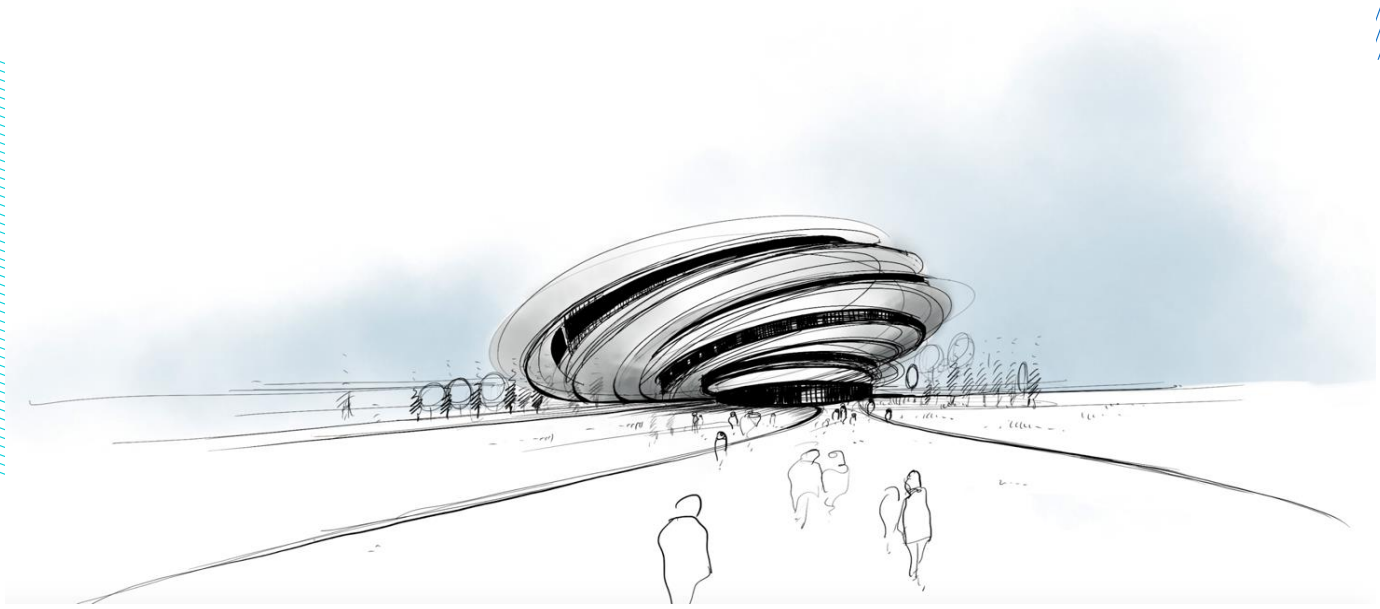


Figure B: The Cocoon artist's sketch

Its architectural structure is state-of-the-art. Commissioned by NERA and designed by Neda Roohnia, an Iranian-born Canadian architect and landscape architecture designer who has a passion for creativity and authentic design solutions for sustainable communities.

The Cocoon portrays the artisan character of Novocastrians, as Newcastle has the largest number of artists per capita in Australia. A Landmark that engraves Newcastle region's name in everyone's memory, Neda's vision for The Cocoon is a metaphoric design, a dynamic envelope wrapped around a fragile, yet strong existence to bloom, to rejuvenate. It has its mysterious manifestation from the outside it is not totally exposed, it is introspective, mysterious to read, to keep a secret to be shared with the world, soon. It is not completely separated from the outside. There are transparent ribbons within and around the form to make people on the outside curious, wanting to know what's inside, and to be drawn to it. These architectural concepts are in line with what will actually happen inside The Cocoon. Unknown solutions will be identified, developed, grown, expanded and exported globally.

The Cocoon will act as a global tourist destination, including a science museum with one of the most mesmerising views to Newcastle Beach and the city. A circular form is also a metaphoric representation of bringing people around a table to initiate a conversation, to brainstorm, create, cooperation and collaboration.

NERA LOGO

Figure C: NERA logo

The design thinking behind this identity was to emphasise the new, transformational and innovative region Newcastle is and communicate mission of NERA in a visual way. The colour palette uses shades of blue to reflect multi-coloured elements of both the Visit Newcastle and Newcastle City Council logos whilst simplifying the palette. The shape of the N represents the flow of water which is at the heart of hydrogen energy production. The gradient of blues represent the city- the sky reflecting off the University of Newcastle City campus, the blue-grey of steel which harks back to the “steel city” moniker of Newcastle, as well as the oceans and coast.

The curved line is reflective of both the curve of a wave, that again draws into the coastal references, but also represents the curved shape of The Cocoon innovation building which is the landmark that embodies Newcastle’s renewable energy precinct, innovative thinking and ‘smart’ culture, but still respects the industry and heritage of Newcastle that enables renewable energy to flourish.

PART 2: THE BUSINESS CASE

Talent wins games, but teamwork and intelligence win championships.

NERA plans to facilitate the creation of a Hydrogen Economy in Newcastle that grows to be a global trade of hydrogen energy. This will support Newcastle's economy into the future, helping create initiatives which enhance the liveability and economic prosperity of the region.

07 INTRODUCTION TO HYDROGEN

As the world seeks to find alternatives to its dependence on carbon fuels, renewable energy sources are becoming more prevalent as an alternative. Both the extraction and the burning of carbon fuels leads to degradation of the land, sea and sky as the release their carbon into the environment. There are many low- or zero-carbon energy sources currently available such as Hydroelectric, Nuclear, Wind, Solar, Tidal, Geothermal, and Bioalgae. While they each have varying strengths and weaknesses, none of these energy sources enable sufficient energy storage to be considered as a viable alternative to key features of fossil fuels. Hydrogen, however, does.

The “hydrogen economy” refers to a hypothetical future system of delivering energy through the use of hydrogen. The term was first coined by John Bockris at a 1970 talk at the General Motors Technical Centre. Advocates of this proposed system promote hydrogen as a potential fuel source.

Hydrogen is a chemical element with the symbol H and atomic number 1 (the first on the periodic table). With just one proton and one electron it is the simplest and also the lightest element. It is also the most abundant element in the universe, accounting for 75% of all mass. Hydrogen is a gas at normal pressure and temperature. While hydrogen fills stars and gas planets, here on Earth, it is rarely in a naturally free state. Rather, it’s bonded to other elements. Hydrogen is considered an energy carrier – it stores energy which has been created elsewhere. To do this, hydrogen needs to be created by separating other compounds.

Hydrogen as a fuel is not a new phenomenon. In the mid-1800’s, a hydrogen mix was used to power gas streetlights in cities and the first fuel cell was invented around the same time. Prototype Hydrogen powered cars have existed since the 1960’s (Bellis, 2019).

Hydrogen is an excellent fuel for many reasons. It is light, odourless, non-toxic and safe to produce. When it is burned, heat and water are produced. The recent resurgence in Hydrogen fuel is due to the fact that it is carbon free and therefore has no emission of carbon dioxide when consumed.

$$2\,H_2 + O_2 \rightarrow 2H_2O + \text{Energy}$$

08 FORTESCUE METALS GROUP

Fortescue Metals Group (FMG) has identified the need to diversify to ensure continued investment and a sustainable future (FMG Annual Report, 2018). FMG has also formed $20million Hydrogen Research Partnership with CSIRO and has begun to position themselves as energy traders, rather than mineral traders, to ensure they have a prosperous and profitable future long after fossil fuels have become a minor part of the energy mix.

FMG chairman Andrew Forrest has developed an energy strategy that considers renewable energy sources for their operations and factors the price of carbon when assessing new projects. In the long term they have set a voluntary goal to achieve net-zero operational greenhouse gas emissions in the second half of the century. FMG has joined Hydrogen Mobility Australia with the aim of creating a hydrogen society within Australia which will be built on clean renewable energy technology. FMG already invests in Hydrogen research and have partnered with CSIRO for the development of metal membrane technology, which enables ammonia to be used as a carrier for hydrogen storage and transport.

NERA's mission aligns with FMG's vision for a sustainable future in the energy sector. NERA has therefore identified FMG as a perfect anchor organisation to spearhead the Hydrogen Economy in Newcastle.

BENEFITS FOR FMG

Newcastle has a myriad of advantages to offer FMG as its renewable energy headquarters that are unparalleled by other cities. The Newcastle Region also has significant unused land area as well as existing infrastructure such as gas pipelines, which is one of the proposed approaches for hydrogen distribution and storage.

Newcastle owns a leading coal export port and largest bulk shipping port on Australia's east coast, with a deep water shipping channel operating at 50% of its capacity, significant port land available and enviable access to national rail and road infrastructure. Port Newcastle is a major Australian trade gateway handling 4,600 ship movements and 166 million tonnes of cargo each year. This means that Newcastle can be a major offsite

supplier to Sydney and other cities, with a proximity to Asia enabling access to the Asian market.

The presence of CSIRO Energy in Newcastle provides expertise in hydrogen safety regulations and application. This knowledge can be exported and shared with the rest of the world and will benefit the economy of Newcastle.

All of these advantages position Newcastle to be a significant player in the Hydrogen energy export market.

09 TECHNICAL CONSIDERATIONS

HYDROGEN CREATION

Hydrogen is created using two methods; steam reforming of natural gas, and electrolysis. Steam reforming uses natural gas along with steam to create hydrogen. Most of the world's hydrogen is produced this way however the process is inherently tied to fossil fuels and not considered to be a future-proof solution.

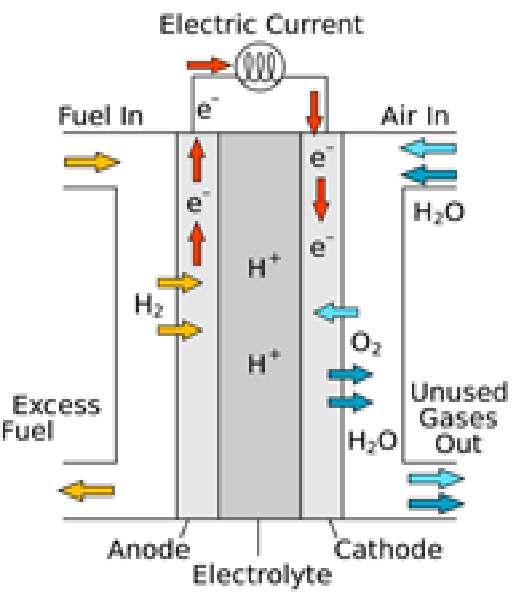
Electrolysis is the process of splitting water molecules by passing a current through the water. One electrode produces oxygen and another electrode produces hydrogen. The process is energy intensive but both the quality of hydrogen and the byproducts are better. Powered by renewable energy this is known as "green hydrogen" (LePan, 2019).

TRANSPORTATION AND STORAGE

Due to its weight and size, hydrogen is not easy to store. It can be compressed but the process is energy intensive and requires pressurised containment. Liquefaction is possible using a combination of pressure and reduced temperatures, which then requires cryogenic storage. Due to these factors, most of the hydrogen created commercially worldwide is produced within close proximity of where it is used.

When viewing hydrogen as an energy storage method rather than strictly as a fuel source, a more creative approach can be taken. Hydrogen can be pumped

Figure D: A fuel cell



underground for storage at low pressures and it can be used to spin turbines which store kinetic energy. Fuel cells are a viable way of converting hydrogen into electricity. The electrochemical cell converts the chemical energy of the hydrogen and the oxidising agent into electricity using an anode and cathode reaction. Fuel cells will continue to produce electricity as long as the hydrogen and oxygen are supplied. The fuel cell reaction is approximately 50% efficient, which is double that of combustion engines.

ELECTROLYSIS

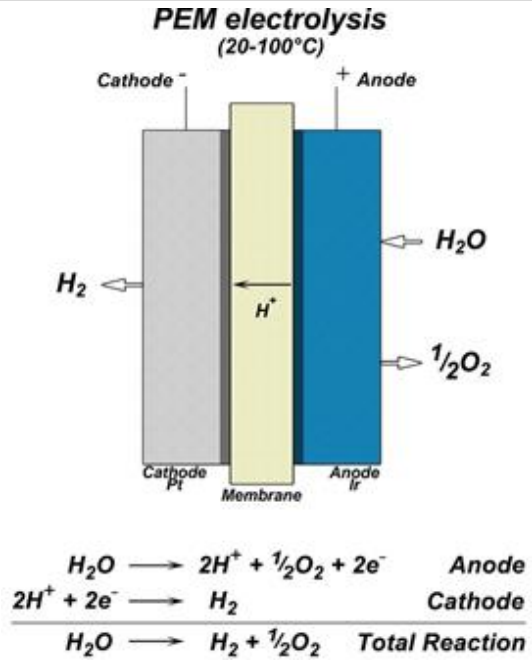
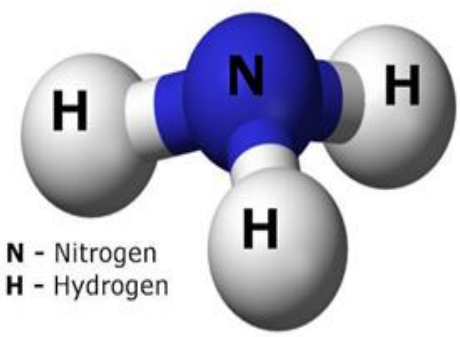


Figure E: PEM Electrolysis method

The future of Hydrogen production will be via Proton Exchange Membrane Electrolysis (PEM). This method uses a solid polymer membrane rather than alkaline solution for the water separating. The PEM electrolyzer is seen as an improvement over the alkaline system because it allows for increased purity of the Hydrogen produced due to the solid membrane, the system is simpler to maintain, and the method can receive greater range of input currents which allows spikes from wind and solar energy to be used in full.

AMMONIA

Figure F: Ammonia structure



Another use for Hydrogen is in the creation of Ammonia. Ammonia actually contains more hydrogen per molecule than raw hydrogen and therefore has an increased fuel density. Some see Ammonia as a good way to store and transport hydrogen, but there is a resurgent movement who believe Ammonia will be the combustible fuel of the future. The Australian Renewable Energy Agency (ARENA) are currently funding $3million dollars worth of CSIRO research into Ammonia as an energy source (ARENA, 2019).

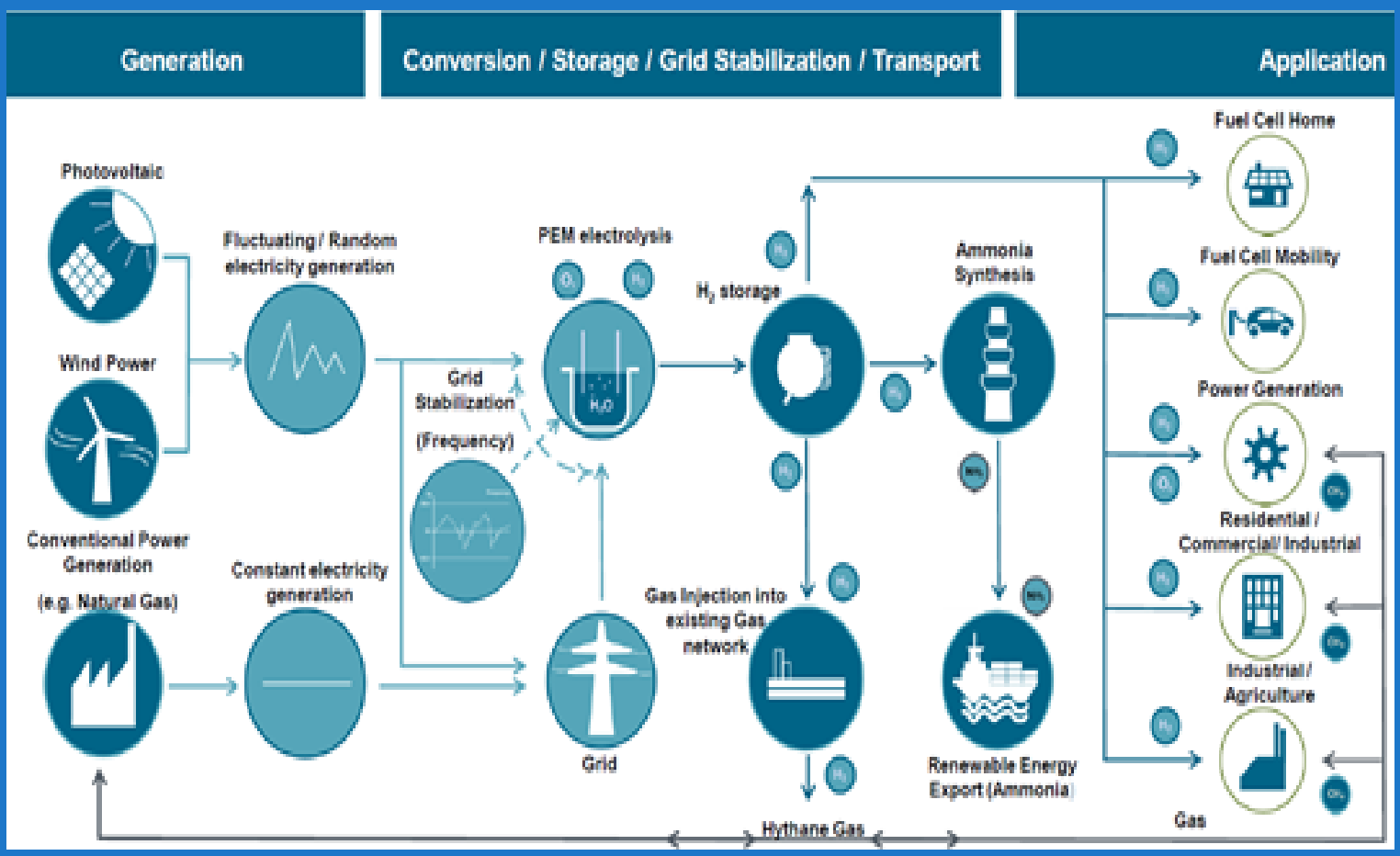


Figure G: the hydrogen cycle

10 THE BUSINESS CASE

Hydrogen production and its supporting programs can create a diversified economy for Newcastle as a second city and help it to reduce its reliance on existing coal revenue. NERA proposes Fortescue Metals Group support the creation of a hydrogen production facility and innovation hub which will provide economic prosperity not only to the Newcastle region, but significant profitability for FMG.

HYDROGEN PRODUCTION FACILITY

Key to the proposal is the creation of a hydrogen production facility located on the previously used aluminium smelting plant at Kurri Kurri. The site is located 35km west from Newcastle in Cessnock LGA. The smelter ran from 1969 to 2012 when it was decommissioned by the current owners, Hydro, who have drawn up a plan for the redevelopment of the 2000 hectare site that includes industry, a small section of residential and a significant designation of conservation land.

This site would be ideal for a Hydrogen facility as aluminium smelting requires considerable amount of electricity and so the site has existing provision for 330MW power feed from the grid which can be utilised by the facility. Plus, the NSW East Coast natural gas pipeline runs through the site due to the need for natural gas to convert bauxite ore into alumina before it can be smelted into aluminium. This could also be utilised to easily transport the hydrogen energy offsite.

PHASE ONE

For the initial phase of this facility, we would recommend the use of green power produced by solar. To reduce capital outlay and planning complexity it is proposed to source this power using a Power Purchasing Agreement (PPA). The legal arrangement see grid power used for the hydrogen plant whilst allowing a solar investment group to receive funding for the construction of their solar farm due to the agreed use of their production. In addition to this we propose that the plant be run at 70% duty cycle to allow energy to be purchased at cheaper rates. This agreement provides grid stability but can only be performed by energy users who have no restrictions on their operating hours (Solar PPA, 2016).

The hydrogen produced by the facility should initially be used to enrich the natural gas pipeline, which can be enriched by up to 30% as seen in the UK (Fuscaldo & Young, 2019), which renders it a more calorific high fuel. An immediate use, and financial return, for this enriched gas would be Orica's fertilizer plant at Kooragang Island. Conveniently located on the natural gas pipeline, the Orica plant is a large user of natural gas which is extracts hydrogen for the production of Ammonia. This process is key to the production of fertilizer. Orica's gas supply contract will come up for renewal soon and a supplier who can offer hydrogen enriched gas would be viewed very favourably.

PHASE TWO

After this phase of initial production and return on investment, a greater plan will be put in place. Currently, hydrogen and ammonia are able to be used as a power source in the transportation sector or for residential and industrial power sources. This wide range of possibilities will allow Newcastle to become the leader in Hydrogen use.

Additional to domestic use is the desire to export both hydrogen and ammonia. Both South Korea and Japan are in the process of changing their energy mix to include these fuels and Australia has been earmarked as a major supplier. When produced by Solar, this exporting of these fuels has been dubbed as exporting "Liquid Sunshine". Newcastle port is ideally positioned to become a Hydrogen export terminal. It has deep water shipping channels and operates at only 50% capacity. There is significant vacant port front land and the area has access to national rail and road infrastructure (Port of Newcastle, 2017).

A by-product of splitting water for the creation of hydrogen is the production of oxygen. Due to the rigorous water treatment pre conversion this oxygen is 99.9% pure and a saleable commodity to hospitals and laboratories. This would require an expansion of the Kurri Kurri Hydrogen facility.

The NSW energy mix currently contains approximately 15% renewables. There is uncertainty of the grids ability to operate effectively with increased renewables in the mix. Some believe that there is already more solar in Australia than the grid can handle (Latimer, 2018). As more renewables enter the grid, energy storage methods will be needed to improve grid stability. The sobering statistic that the Australian energy sector produces three times more energy than is consumed illustrates why it is so important that the energy mix is balanced in the grid (Australian Energy Update, 2018). More

Hydrogen in the energy mix overcomes the baseload power shortfalls that wind and solar cannot overcome without a secondary storage method.

Fluctuating power generation including renewables such as Solar & Wind power requires lots of energy storage and Lithium-ion batteries seems like the obvious choice. As the demand for lithium battery technology continues to grow, recycling schemes are needed to avoid huge amounts of waste ending up in landfills as a new report by Australia's CSIRO outlines.

As electric vehicles become increasingly common, this problem is likely to compound itself. Combustion engines rely on lead acid batteries, and 98% of these are currently recycled in Australia as there are established schemes in place. Such schemes will be required to avoid huge amounts of lithium battery waste going to landfills, but could also provide an estimated $813m to $3bn worth of resources.

The best alternative is water electrolysis technology, which is the most flexible and tenable solution to store renewable energy on a large, long-term scale. Using excess renewable electricity the Proton Exchange Membrane (PEM) electrolyzer splits water into its constituent parts, hydrogen and oxygen, that can be stored in common tanks. Our challenge is to scale-up hydrogen generators to meet the demand of the growing renewable power industry.

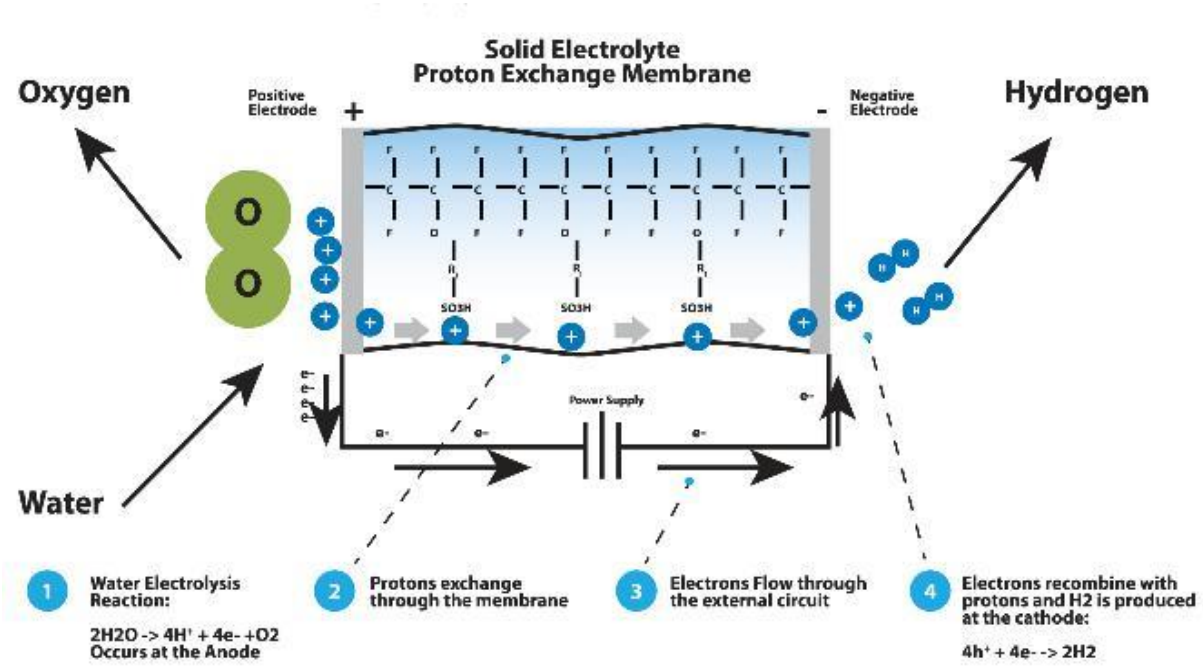


Figure H: PEM Electrolysis

Hydrogen production requires a large supply of high purity water. The only way to produce this is through reverse osmosis filtration. Our plan is to take water from the Tomago Sand Beds, which are currently under a contamination crisis stemming from the Williamtown Airforce Base, through a Pumping Station and Pipeline to our facility at Kurri Kurri. We will run this water through our reverse osmosis plant [Gilghi Unit] to convert 500KL of contaminated water into 250KL of potable water per day.

This Potable water will be fed to our Hydrogen Electrolyzer [Silyzer 300] which can output up to 48T of Hydrogen per day. The Hydrogen produced by the facility will initially be used to enrich the natural gas pipeline which renders it a higher calorific value. An immediate use and financial return for this enriched gas would be Orica's fertiliser plant at Kooragang Island. Conveniently located on the natural gas pipeline, the Orica Plant is a large user of natural gas to extract hydrogen for the production of ammonia. This process is key to the production of fertilizers. As Orica's gas supply contract is coming up for renewal, a local supplier who can offer hydrogen enriched gas at a very competitive rate, such as FMG, would be viewed very favourably.

Orica currently consumes 41 tonnes of hydrogen per day which would be provided by the hydrogen facility via pipeline. The surplus 7 tonnes of hydrogen can be exported overseas to buyers like Japan and South Korea by using the Newcastle Port.

THE TECHNO PARK

Figure I: Visual representation of the Techno Park land use

NERA has acquired the former BHP site at Mayfield. This 152 Hectares has been vacant since 1999 and clean up works were completed by Daracon in 2018. Initially split up and designated to the Port of Newcastle and Newcastle Development Corporation, the creation of NERA in 2019 has seen a change of direction.

NERA will use this site to create a Techno Park with an emphasis of Hydrogen technology. We are able to offer a considerable portion of land for the building of offices and light industrial areas, perfect for Fortescue Metals Group to utilise this as a head office location. The designated land has significant advantages in its relation to Greater Newcastle as the land is only 5km from the city centre and is bordered by a deep water harbor.

THE COCOON

As well as housing campuses for CSIRO and The University of Newcastle, the cornerstone of the Techno Park will be the Cocoon innovation hub. “Cocoon” is a hub to “gather” to create, and celebrate community’s progression and sustainable development.

It can offer significant opportunities for Newcastle to develop its innovation in the hydrogen space and also share these findings with the rest of the world. It is a centre of experimentation, research and development for manufacturing sectors investigating new technologies for Hydrogen production, storage and transportation. Cocoon is a place for nurturing and growing start-ups, where they can benefit from facilities for experimenting to commercialising their products. It is a premium venue for exhibiting latest technology, conferences and seminars.

It is envisaged that in three years the advantages of the innovation zone would have attracted various combinations of research divisions from large national and international companies, start-ups with niche product focus and companies who produce components used in hydrogen technology. By creating a broad spectrum of spaces accessible to these groups the Cocoon building and the wider Innovation zone in general will be able to house large companies in discrete office suite but also have the flexibility to offer co-working spaces to start-ups and individuals.

RETURN ON INVESTMENT

The Hydrogen Facility will be sitting on 3.5 acres of Land at Kurri Kurri with the required capital investment of $375million AUD. This $375m is bifurcated into $250M for the Reverse Osmosis Plant and $125M for the Hydrogen Electrolyser. This Facility shall offer employment to around 1250 personnel and will have an annual operational cost of $150M.

The capital return on investment is calculated for a period within 3 years with a sales price of $16 per kilogram of Hydrogen compared to $19 per kilogram of current market sales rate. In the first 3 years the cost of hydrogen production is estimated to be $15.70. We will generate close to $16m profit by selling 52,560T of Hydrogen in the first 3 years. After the initial three years the cost of producing hydrogen will be reduced to $8.56 per kg. This will enable us to sell the hydrogen at an even more competitive price of $12 per kilogram. With this business model we forecast generation of $136m in the first 5 years of operation.

With the profit generated we propose to invest $122m into establishing a 100MW solar farm at Kurri Kurri NSW to make our Hydrogen facility self-sustaining and completely green. This investment will also reduce the operational cost of the hydrogen facility by $27m.

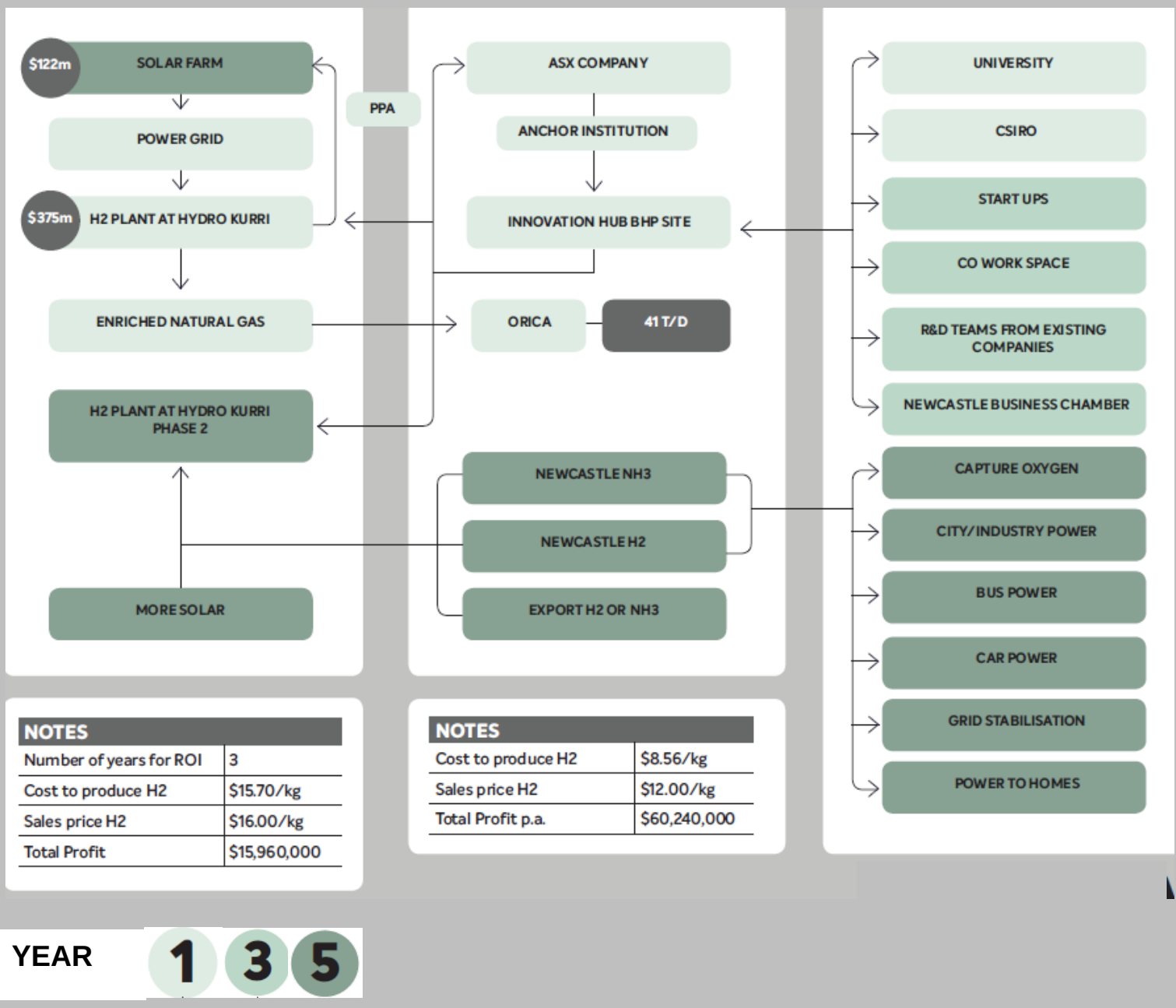


Figure J: Timeline of the business plan

11 APPLICATION OF HYDROGEN

CURRENT AND FUTURE

Hydrogen is a particularly versatile fuel. Existing applications can be split into three groups. The first is hydrogen that is to be burnt, the second is hydrogen for fuel cells and the third is hydrogen that is used in industrial process.

Hydrogen as a combustible fuel has a wide range of uses. Most important is its ability to replace natural gas as a fuel source. It is already possible to enrich natural gas with Hydrogen and in the future, cooking, water heating and a range of industrial uses for natural gas will be replaced by Hydrogen. Each kilogram of hydrogen contains 2.4 times as much energy as natural gas.

Hydrogen fuel cells are primarily used to make the energy source transportable and therefore are generally seen in vehicles. The major car manufacturers have all developed fuel cell cars but a lack of early adoption and infrastructure has led most fuel cell vehicles to be those that return to a centralised fueling station. Hundreds of fuel cell busses currently run in cities around the world. The ability to refuel at depot and the environmental appeal have made this attractive to LGA's. Forklifts are another popular use for fuel cells. As many operate inside warehouses fumes from carbon based fuels are a concern electric of fuel cells powered units are preferred. The USA alone has over 4000 fuel cell forklifts in operation. Airplanes, boats, motorcycles and submarines that use fuel cells have also been developed but not in commercial quantities.

Hydrogen is currently used in the production of ammonia for agricultural fertiliser, the production of methanol for rocket fuel, plastics and pharmaceutical manufacture, to remove sulfur from crude during oil-refining and in the process of making glass sheets and silicon chips. At the moment the vast majority of the annual global production of hydrogen is for these purposes.

Finkel report of 2016 was an independent review of the future security of the national energy market. This influential report listed hydrogen as an important part of Australia's energy future.

The current global production of hydrogen is 55 million tons per annum. Countries who have shown commitment to the reduction of carbon emissions and who have limited ability to produce renewable energy themselves will be looking to Australia and other for clean fuel sources.

Japan currently imports 94% of its energy and South Korea imports 81%. Both have committed to the Paris accord. Currently Australia exports half of its produced LNG to Japan which covers 50% of Japan's required supply, valued at $23 billion in 2017.

All levels of Government in Australia will be attracted to the Newcastle Hydrogen vision due to the financial benefits.

12 CONCLUSION

The plan outlined above has been developed with Newcastle's future planning in mind, ensuring alignment to strategy but refraining from recreating existing initiatives. We believe that Innovation district created on the BHP site will come to be a defining part of Newcastle's brand and identity. It simultaneously upgrades the harbor front while providing a symbolic landmark, in the Cocoon building, for the city to use in global promotion. As a key piece of infrastructure it will draw the CBD westward and allow new business grow. We also see the innovation district as improving the cultural diversity of the region by attracting skilled migrants. Global energy summits could be held in the region if we had a district like this as a drawcard.

The plant at Kurri Kurri will be the first step in securing the regions long term future as a carbon free fuel supplier. The longer term benefits explained in the second phase of the plan will have effects that align with Newcastle's planning strategies. Initiatives like Hydrogen charging stations and carbon free energy for city and inhabitants will improve the lifestyle of the region.

13 APPENDIX

REFERENCES

Department of the Environment and Energy (2019). Australian Energy Update. Retrieved 3 October 2019, from https://www.energy.gov.au/sites/default/files/australian_energy_update_2018.pdf

Bellis, M. (2019). Hydrogen Fuel Cells Innovation for the 21st Century. Retrieved from https://www.thoughtco.com/hydrogen-fuel-cells-1991799

Fuscaldo, D., & Young, C. (2019). UK Could Replace 30% of Its Natural Gas With Hydrogen in Effort to Curb Climate Change. Retrieved 3 from https://interestingengineering.com/uk-could-replace-30-of-its-natural-gas-with-hydrogen-in-effort-to-curb-climate-change

Hydrogen to Ammonia - Australian Renewable Energy Agency (ARENA). (2018).

Latimer, C. (2018). Australia heading for a 'battle royale' on solar power. Retrieved from https://www.smh.com.au/business/the-economy/australia-heading-for-a-battle-royale-on-solar-power-20181012-p5099v.html

LePan, N. (2019). The Evolution of Hydrogen: From the Big Bang to Fuel Cells. Retrieved from https://www.visualcapitalist.com/evolution-of-hydrogen-fuel-cells/

Solar PPA (Power Purchase Agreement) and Commercial Leasing. (2019). Retrieved from https://www.energymatters.com.au/commercial-solar/solar-ppa-leasing/

DETAILED COST ANALYSIS

Requirements & Cost Analysis			Daily		Yearly		Notes
Orica							
Ammonia produced current			986	T/d	360000	T/pa	Info from Tim Wylie
Nitric acid produced current			904	T/d	330000	T/pa	Info from Tim Wylie
Ammonium nitrate produced current			1096	T/d	400000	T/pa	Calculated by Bahar
Above NH4NO3 requires ammonia			233	T/d	85000	T/pa	Calculated by Bahar
H2 needed for the above			**41**	T/d	**15000**	T/pa	Calculated by Bahar
energy to produce ammonia 1T			12	MW/h			Calculated by Bahar
Calculations			**Daily**		**Yearly**		**Notes**
Electrolysis							
Electrolyser	**Silyzer 300**						
Capacity	**100**	**MW**					
Hydrogen Production	2000	Kg/hr	**48**	**T/d**	17520	T/pa	
Nominal Electrolysis Plant Footprint	14280	sq. mtr	**3.5**	**Acre**			Based on 70MW Plant
Pottable Water (16.689L/1kg of H2)	33378	L/hr	**801.072**	**KL/d**	292391.28	KL/pa	
Demineralised Water (10.013L/1kg of H2)	20026	L/hr	480.624	KL/d	175427.76	KL/pa	
Electrolyser Plant Cost for 100MW	**$125**	**Million**					Based on Plant Cost 17.5MW is $25 Million
Reverse Osmosis							
Reverse Osmosis - Sea Water Intake - Gilghi Unit	2333.33	L/hr	56	KL/d			
Pottable Water Output	1166.67	L/hr	28	KL/d			
Max Scaled Up Pottable Water Output	10416.67	L/hr	250	KL/d			
Nominal Footprint of Reverse Osmosis Plant	6.1x2.4	sq. mtr	**0.0035**	**Acre**			
No of Reverse Osmosis Plant Required for desired O	3						
Total Cost of Reverse Osmosis Plant	**$250**	**Million**					$ 150 Mil per Plant
Total Footprint of Reverse Osmosis Plant			0.011	Acre			
Solar Power Plant							
Power Requirement /1kg of H2	53	KWh					
Power Requirement 2T/H of H2	106	MWh					
Solar Plant Cost for 100MW	**$122**	**Million**					
Nominal Solar Power Plant Footprint	600x300	sq. mtr	**450**	**Acre**			
Return on Investment							
Capital Investment (Infrastructure)	**$375**	**Million**					$122 Million Solar Plant not included in the first Stage
Land Size Acquried	**3.5**	**Acre**					Solar Plant not included
New Jobs Creation	1250	People					Estimation for a project of this scale
Payrole & Operational Cost (Recurring Cost)	**$150**	**Million/Yr.**					
Number of Yrs for ROI	**3**						
Total Cost of ROI Years of Operation	**$825**	**Million**					
Total H2 production in ROI Yrs	**$52,560**	**T**					
Cost to produce H2/Kg (in ROI years)	$15.70						
Sales Price og H2/Kg	$16.00						Current Rate AUD $19.00 per Kg
Total Revenue Generated in ROI Yrs	$840,960,000.00						
Total Profit Generated in ROI Years	**$15,960,000.00**						ROI Achieved
Cost to Produce H2 after ROI (3rd Year Onwards) per	$8.56						
Sales Price og H2/Kg (3rd Year onwards)	$12.00						
Total Profit Generated per Year	**$60,240,000.00**						5 years to have enough profit to build Solar Plant to further reduce Operational Cost by 27 Million /Year (Rate $0.03per KWH)

INTERVIEW REFERENCE LIST

Name	Title	Organisation	Date	Items Discussed
Tim Wylie	Chief Technology Officer	Ampcontrol	22/08/2019	Hydrogen history & application
Warner Priest	Business Development Manager- Emerging Technologies	Siemens	05/09/2019	Hydrogen technology
Michael McKensey	Renewables Division Director	Macquarie Bank	8/09/2019	Hydrogen capitalization
Neda Roohnia	Architecture Designer	Neda Roohnia landscape design	12/09/2019	The Cocoon design
Adele Bradshaw	Senior Graphic Designer	nib Health Funds	12/09/2019	NERA logo design
Will Rifkin Kate Robinson	Director and Centre chair Principal	Hunter Research Foundation Kate Robinson Consulting	17/09/2019	
Juandre Coetzer	Maintenance Superintendent	AGL Macquarie Liddell	24/09/2019	Hydrogen concepts as future energy source and the technology behind it
Kathleen Hyland	Manager Major Events and Corporate Affairs	Newcastle City Council	02/10/2019	Branding of place, NCC's brand transformation process

Every once in a while, a new technology, an old problem, and a big idea turn into an innovation.

-Dean Kamen

NEWCASTLE: RENEWED

Business proposal for FMG | 2019