



BUSINESS PLAN

FUELLING THE FUTURE



/IGEMMACQUARIE



@IGEM_MACQUARIE

[HTTP://2017.IGEM.ORG/TEAM:MACQUARIE_AUSTRALIA](http://2017.igem.org/team:macquarie_australia)

Table of Contents

OVERVIEW	2
H ₂ YDROGEM'S MISSION:.....	2
MARKET AND COMPETITOR ANALYSIS	3
OVERVIEW OF THE CURRENT VEHICLE MARKET IN AUSTRALIA	3
HYDROGEN VEHICLE MARKET	3
COMPETITION	6
CUSTOMER RESEARCH (SURVEYS, INTERVIEWS)	9
COLLABORATION WITH INDUSTRY (CSIRO).....	13
MARKET STRATEGY	15
PRODUCT	15
PRICE	17
PROMOTION.....	19
DISTRIBUTION	21
FUTURE DIRECTIONS AND SOURCES OF FUTURE FUNDING	23

OVERVIEW

We are living in a world of extremes. Temperatures are soaring. Sea levels are rising. Population growth is exploding. Non-renewable resources are dwindling. Our planet is facing the biggest environmental crisis in known history and what's worse, ***we are running out of time to turn it around.***

“Climate change is intrinsically linked to public health, food and water security, migration, peace, and security. It is a moral issue. It is an issue of social justice, human rights and fundamental ethics. We have a profound responsibility to the fragile web of life on this Earth, and to this generation and those that will follow.” – United Nations Secretary-General Ban Ki-moon

The transport industry is one of the biggest contributors to greenhouse gas emissions, responsible for a whopping 27% of emissions in 2015 in the US. Attempts to convert to renewable fuel sources have shown promise with solar and electric vehicles entering the market. However, levels of customer adoption have remained disappointingly low due to the high cost, poor efficiency and inconvenience of most alternative fuels. Governments have taken little action to build the supporting infrastructure necessary, leaving consumers with little choice but to resort to traditional fuel. Some that claim to be 'green' are not actually green at all, either – most methods of hydrogen production, for example, require fossil fuels!

WHAT'S THE SOLUTION?

A zero-emission energy source, produced with zero fossil fuels. No, this isn't some pipe dream or wishful thinking. It's H₂GEM.

H₂hydrogem's revolutionary at-home refuelling station uses no harmful chemicals or pollutants, just modified e-coli and glucose. **That's it.** No fossil fuels, fancy or expensive technology required. Pure hydrogen fuel produced on demand in your own garage, 24/7. As Australians make the switch to hydrogen-powered vehicles over the next two decades, H₂GEM will be there to meet the demand for convenient, sustainable hydrogen fuel. **We are putting the power to change the world back into the consumers' hands, literally.**

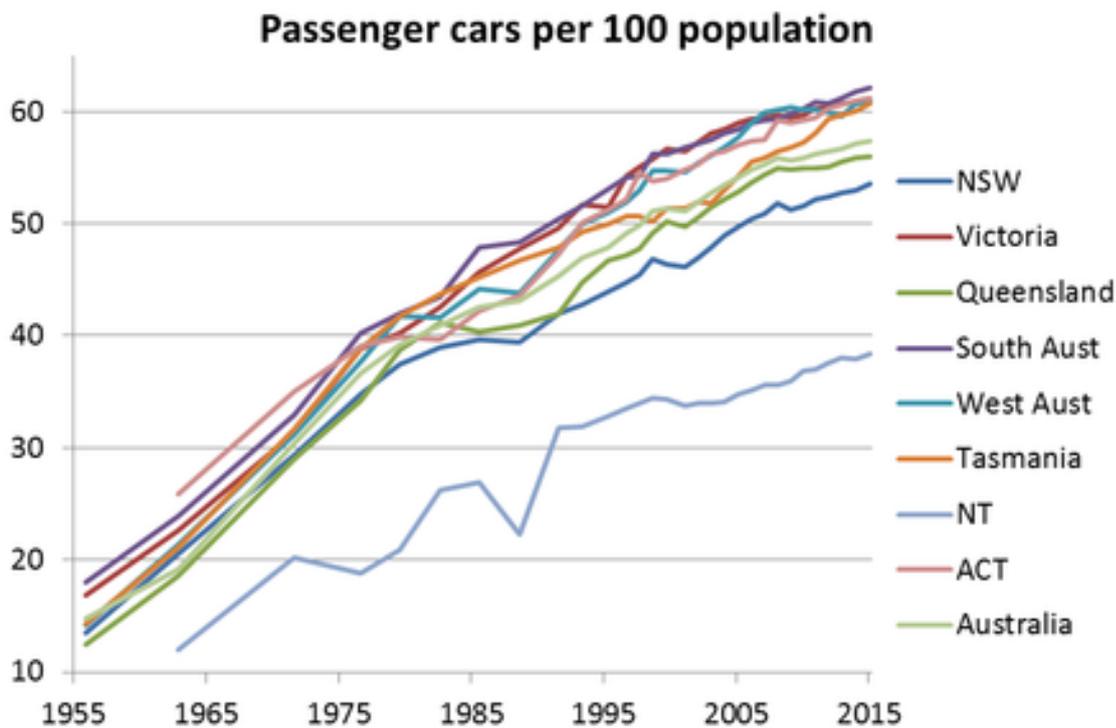
H₂YDROGEM'S MISSION:

1. To empower everyday Australians to sustainably and affordably power their own hydrogen vehicles.
2. Change the world (OK, maybe this one's a little lofty...but as the saying goes, a journey of a thousand miles begins with a single step, right?)

MARKET AND COMPETITOR ANALYSIS

OVERVIEW OF THE CURRENT VEHICLE MARKET IN AUSTRALIA

As a country of wide open spaces, car ownership is considered a basic necessity for most Australians. Car ownership has steadily increased over the past 60 years, increasing from 0.15 to 0.55 cars per person as of 2015. This increase has largely been the result of cars becoming more affordable over that same time period, aided by increased competition and improvements in technology.



Car ownership in Australia per 100 people, 1955-2015. Sourced from: Charting Transport. (2016). *Trends in car ownership*. [online] Available at: <https://chartingtransport.com/2011/08/07/trends-in-car-ownership/> [Accessed 17 Sep. 2017].

In 2015, a staggering 1,155,408 new cars were sold in Australia – the most annual sales on record – with thousands more used vehicles being sold as well. The five top-selling car models on the market as of 2015 were the Toyota Corolla, Mazda 3, Toyota HiLux, Hyundai i30 and Ford Ranger, evidently cementing these manufacturers as trusted car brands by Australians.

HYDROGEN VEHICLE MARKET

Globally, the market for hydrogen vehicles is growing exponentially as the race continues to find a more sustainable, cost-efficient way to transport passengers from A to B. Toyota's Mirai model currently dominates 80% of that market, with Hyundai and Honda placing in second and third. Mercedes Benz is also set to release a hydrogen vehicle model later in 2017. Around 2500

hydrogen vehicles were sold or leased last year representing a 300% increase on 2015, although it is estimated that by 2032, over 22.2 million hydrogen fuel cell vehicles will be leased or sold globally. Adoption has been strongest in California, Europe and Japan as those are the locations with the greatest infrastructure availability (such as hydrogen refuelling stations).

While cars are widely adopted by most Australians, there is not currently an existing market for hydrogen vehicles. There are currently four demonstration hydrogen vehicles in Australia:

- 3 x Toyota Mirai – holds 5kg of compressed hydrogen which lasts about 550km. Takes 3 minutes to refuel. Cost of each vehicle is approximately \$57,000 USD.
- 1 x Hyundai ix35 – Takes 3-5 minutes to refuel and each tank lasts approximately 600km.



Toyota Mirai. Sourced from: DeGasperi, D. (2017). *Toyota Mirai first drive review*. [online] Drive. Available at: <http://www.drive.com.au/new-car-reviews/toyota-mirai-first-drive-review-20161127-gsyses.html> [Accessed 1 Oct. 2017].



Hyundai ix35. Sourced from: CarAdvice.com. (2017). *Hyundai ix35 News, Safety Ratings & Price | CarAdvice*. [online] Available at: <http://www.caradvice.com.au/hyundai/ix35/> [Accessed 5 Oct. 2017].

Interest has also gone beyond just cars. Melbourne's Moreland City Council recently announced plans to convert some of its diesel trucks into hydrogen-powered trucks and invest in a commercial refuelling station. Similarly, the South Australian government has injected \$8.2 million into the trial of a hydrogen bus fleet and refuelling station.

The future of mainstream hydrogen vehicles in Australia is very promising. Michael Dolan, principal research scientist at CSIRO, said "there's potentially a very big market for the technology, given these cars are starting to get onto the road in pretty big numbers in Asia and Europe". In August 2017 it was announced that more than 20 hydrogen-powered Hyundai SUVs (claimed to run up to 800km on a single fuel tank) will reach Australian shores in 2018, becoming the nation's first commercially available fuel cell vehicle. The timeframe within which this dream becomes a reality will depend heavily on the Australian Government's willingness to invest in the necessary testing, refuelling infrastructure and consumer incentives. It costs approximately \$2.3 million to build a public hydrogen refuelling station which is clearly a huge financial investment. For this reason, it is likely that hydrogen vehicle use will (at least initially) be limited to densely populated cities where this investment is likely to receive the most use.

Sources:

Chesterton, A. (2016). *Hyundai Australia confirms 2018 on-sale date for hydrogen fuel cell cars*. [online] CarsGuide. Available at: <https://www.carsguide.com.au/car-news/hyundai-australia-confirms-2018-on-sale-date-for-hydrogen-fuel-cell-cars-45522> [Accessed 27 Sep. 2017].

McCowen, D. (2017). *Exclusive: Australia set for world-first hydrogen vehicle trial*. [online] Drive. Available at: <http://www.drive.com.au/motor-news/exclusive--australia-set-for-world-first-hydrogen-vehicle-trial-64955.html> [Accessed 28 Sep. 2017].

Research Markets (2017). *Global Market for Hydrogen Fuel Cell Vehicles Report 2017: 2015-2020, 2021-2026, and 2027-2032*. [online] GlobeNewswire News Room. Available at: <https://globenewswire.com/news-release/2017/07/12/1043076/0/en/Global-Market-for-Hydrogen-Fuel-Cell-Vehicles-Report-2017-2015-2020-2021-2026-and-2027-2032.html> [Accessed 1 Oct. 2017].

Turner, R. (2017). *CSIRO breakthrough could turn renewable hydrogen into export boom*. [online] ABC News. Available at: <http://www.abc.net.au/news/2017-05-11/hydrogen-breakthrough-could-fuel-renewable-energy-export-boom/8518916> [Accessed 26 Sep. 2017].

Turner, R. (2017). *Why all the fuss about hydrogen cars?*. [online] ABC News. Available at: <http://www.abc.net.au/news/2017-09-14/hydrogen-car-explainer-what-are-they-and-when-will-we-drive-them/8946184> [Accessed 24 Sep. 2017].

COMPETITION

As far as our team is aware, an at-home hydrogen refuelling product does not currently exist in the Australian market which is a huge bonus for our competitive prospects. In this sense we have the rare potential to hold a monopoly over the market, at least in the short term. It is likely that if our product is successful, direct competitors will attempt to imitate our technology and compete against us. Our business has pre-emptively prepared for this likelihood by establishing a five-year research and development strategy dictating the avenues for product improvement that we intend to focus on. We believe that this will help us retain a competitive edge over any newcomers in the industry and ensure that H₂GEM remains the most innovative, trusted one on the market. Details regarding our five-year R&D plan can be found in 'Future Directions and Sources of Future Funding'.

However, we do face significant indirect competition in the form of substitute products. The mainstream vehicle market is currently saturated with several non-hydrogen-powered vehicle types that all have different pros and cons. We have compiled a table comparing the different fuel types currently used by Australian drivers to help us analyse where our product may fit and what our competitive advantages would be over the current market.

Vehicle and fuel type	Benefits	Limitations
Oil-based petroleum	- Widely available	- Finite resource (will run out eventually) - Significant greenhouse gas emissions - Significant contributor to air pollution
LPG	- Fewer greenhouse gas emissions than petroleum or diesel - More abundant than petroleum or diesel	- Poor fuel efficiency - Limited vehicle availability - Less readily available
Diesel	- Greater fuel efficiency than petroleum -	- Finite resource (will run out eventually) - Significant greenhouse gas emissions - Significant contributor to air pollution - More expensive than petroleum
Electric (battery)	- Power source is readily available (electricity grid) - Fewer greenhouse gas emissions than	- Lower efficiency than hydrogen cars - Longer fuel recharge time

	<p>most petroleum cars</p> <ul style="list-style-type: none"> - No water required - Currently cheaper than hydrogen vehicles 	
Hydrogen produced using e-coli	<ul style="list-style-type: none"> - Zero greenhouse gas emissions - High efficiency (distance travelled per kWh) - No water required - Fast refuelling time 	<ul style="list-style-type: none"> - Limited existing infrastructure for refuelling - More expensive than electric vehicles

The presence of these substitute products in the market does increase the possibility that demand for our refuelling station will be somewhat elastic – that is, it will be influenced by changes in demand for all other types of vehicles. Likewise, demand for our product will most likely vary proportionately with demand for hydrogen vehicles as the two products are complementary. Our team needed to consider these factors when developing our pricing strategy.

Another type of substitute product that we will need to compete against is public hydrogen refuelling stations, which enable customers to fill up their hydrogen-powered vehicle just as you would a normal car at a gas station. As the hydrogen vehicle market grows in Australia, hydrogen-refuelling stations will inevitably emerge to meet demand for fuel for these cars. An example of a potential competitor is HyGen Industries, a Californian company producing and distributing hydrogen fuel in partnership with pre-existing gas station owners. They produce hydrogen refuelling stations for hydrogen fuel cell electric vehicles (FCEVs). It is possible that HyGen and other similar companies will decide to enter the Australian market once demand for hydrogen vehicles grows.

We believe that our product holds several unique competitive advantages over refuelling stations, including:

- Convenience of being able to refuel at home
- Protects the customer from volatile hydrogen fuel price changes
- Guaranteed no-emission fuel production, making it more sustainable than many regular hydrogen energy production methods

These are the competitive advantages that we intend to emphasise in our promotional materials.

Sources:

Allianz Australia. (2017). *Cars and their fuels*. [online] Available at: <https://www.allianz.com.au/car-insurance/news/cars-and-their-fuels> [Accessed 17 Sep. 2017].

Irfan, U. (2016). *Lack of Cheap, Clean Hydrogen Slows Fuel-Cell Cars*. [online] Scientific American. Available at: <https://www.scientificamerican.com/article/lack-of-cheap-clean-hydrogen-slows-fuel-cell-cars/> [Accessed 7 Sep. 2017].

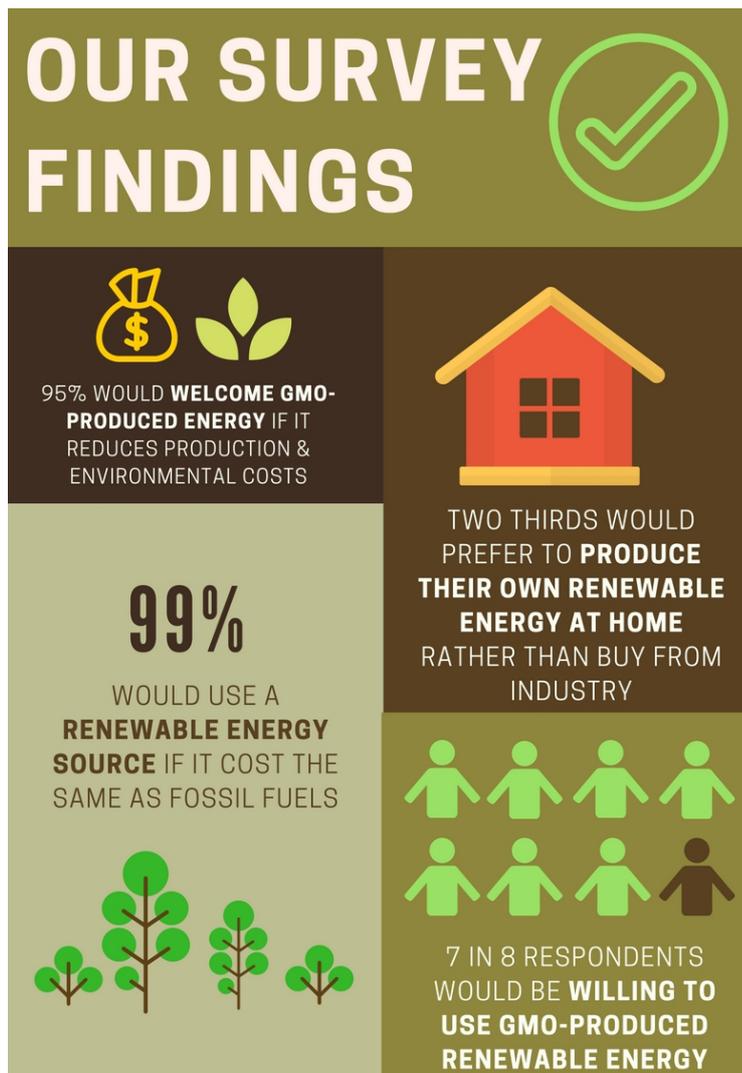
Muoio, D. (2016). *Hydrogen-powered cars are better than electric cars — but there's a catch*. [online] Business Insider. Available at: <http://www.businessinsider.com/why-hydrogen-powered-cars-are-better-2016-1/?r=AU&IR=T> [Accessed 16 Sep. 2017].

Seba, T. (2016). *Toyota vs Tesla: Can hydrogen fuel-cell cars compete with EVs?*. [online] RenewEconomy. Available at: <http://reneweconomy.com.au/toyota-vs-tesla-can-hydrogen-fuel-cell-cars-compete-with-evs-11540/> [Accessed 16 Sep. 2017].

CUSTOMER RESEARCH (SURVEYS, INTERVIEWS)

It's an undeniable, yet oft overlooked truth that no business venture can be successful without customers. As such, our team conducted extensive market research when designing our prototype to discover exactly who our target customers are and what they want, tailoring our offering to meet their needs.

Our first step in this process involved conducting an online survey that was completed by over 150 respondents across multiple age brackets and geographic locations within Australia. This survey was designed to give us insight into our potential consumers' perceptions around renewable energy and what sort of product might appeal to the Australian market. A statistical analysis of the results was performed and yielded some extremely useful information:



Based on these results we realised that there was unmet demand for a product that empowered individual consumers to produce their own renewable energy at home. In response to this, and after reviewing the huge potential for hydrogen vehicles over the next two decades in Australia, H₂ydrogem decided that an at-home hydrogen refuelling station would be the best product to create as our prototype.

The second stage of our market research involved conducting face-to-face interviews with a sample of 40 different individuals chosen deliberately as a representative cross section cross-section of our target market. The questions asked were specifically constructed to guide our design of the refuelling station (what features to include/exclude) as well as our pricing, promotion and distribution strategies. Some of the common themes that arose in the respondents' answers are summarised below.

What are your main concerns about the future of Australia in terms of sustainability, energy security and climate change?

- You need only turn on the news to see the plethora of natural disasters occurring all over the planet. Weather patterns across Australia are increasingly unpredictable, with this past September being Sydney's driest since 1882. Our consumers see "governments and science at odds over climate change and unfortunately may reach a critical point and be too late to reverse in the short term". Australia's population growth signifies that there will be even greater demand for energy in the near future, so it is necessary that we invest in renewable energy to meet that demand long-term. Carbon neutral energy, clean fuel and reduced reliance on fossil fuels (for the sake of their children) are all priorities.
- Frustration with the Australian government's failure to take the issue seriously or take real action, not high on their agenda. Desire to take matters into the people's hands. Most respondents were optimistic about our potential to turn the situation around, but fear that if left to the 'head honchos', we will quite likely run out of time.
- Desire for independent energy production so that we're not reliant on unstable economies' fuel
- Growing technology insecurity worldwide is a huge concern – the rise of security system hacking, extremist groups and uprisings is frightening and poses a great deal of insecurity. Our consumers want to know that they are able to produce their own energy so that they are not reliant on unstable economies which are constantly under threat. This provides them with peace of mind and a crucial sense of security in what is becoming an increasingly uncertain world.

Conclusion: Our customers are very concerned about the long-term impacts of climate change and reliance on fossil fuels. They want the empowerment to be a part of the solution by taking their own actions.

What do you already know about hydrogen-powered cars? What would you like to know more about them?

- There was a definite sense of awareness and excitement around hydrogen as an energy source, but very little was known as to how exactly it works and what it can be used to power.
- Most respondents weren't familiar with how hydrogen cars work which isn't surprising given that they are not commercially available here yet

- There was a great interest in learning more about hydrogen cars, including about the safety and cost of the vehicles, how many models there are available to choose from, do they emit many fumes, how far can they travel?
- Refuelling was a major concern. Many expressed a desire to know where the hydrogen came from and whether producing it themselves would be a viable option

Conclusion: There is currently little known about hydrogen vehicles in Australia but our customers are very interested in learning more about them.

What would convince you to consider purchasing a hydrogen-powered car in the near future?

- Consumers concerned with environmental sustainability all expressed serious interest in buying a hydrogen car, particularly if it was on par with other vehicles financially and operations-wise.
- Most customers compared hydrogen vehicles as direct alternatives to electric vehicles, so they would want to see proof that hydrogen cars are the more efficient, sustainable and affordable alternative
- Among young adults who are considering buying their first car, the main criteria identified were durability of the vehicle (can this last me for ten or more years?), safety, cost and performance. They overwhelmingly said that if these criteria were exceeded when compared to regular cars, they would seriously consider buying a hydrogen-powered car in the near future.
- The ability to easily refuel the vehicle at home was considered highly desirable, particularly for those who do not live near big cities (and would therefore not have access to refuelling stations once they are built).
- Other bonus (but not necessary) desired benefits mentioned included reduced insurance premiums and government financial incentives

Conclusion: Our customers are motivated by sustainability, durability, affordability, safety and convenience. These need to be our major selling points.

If you were to buy a hydrogen-powered car in the future, would you be more likely to purchase a home hydrogen fuel cell/generator as a combination with the car (i.e. the car and cell both sold to you as a package by the car manufacturer) or from a third-party seller after buying the car?

The majority of respondents favoured purchasing the fuel generator with the vehicle as a bundle for several reasons:

- There would be a single point of contact should something go wrong with either the vehicle or the generator and better after-sales support
- It is more convenient to simply buy both at once
- The warranty for both items would have matching time frames

- Buying as a bundle is often cheaper than buying two things separately, so it would be more likely to be cost efficient
- More confidence that the fuel cell was compatible with the car
- They would feel more comfortable buying a fuel cell that is affiliated with a trustworthy vehicle brand like Toyota or Hyundai

Conclusion: Selling the refuelling station as a bundle with the car would be the best distribution model for us to use.

What would be your primary concerns that would stop you from purchasing a home hydrogen fuel cell (if you owned a hydrogen-powered car)?

- Safety - they want to know whether it has been certified as safe by government authorities (strict regulations), that it won't explode in the garage, that it won't leak, that it's childproof and fireproof.
- Brand image and trustworthiness– they would only buy from a brand that has an established reputation
- Cost – many respondents would only buy an at-home fuel cell if it were cheaper than regular gas or using public hydrogen refuelling stations in the long run. They also wanted to know what the ongoing running costs would be.
- Space – some respondents didn't think they would have room in their garage to store it.
- The aesthetics of the refuel station – they favoured a streamlined, sleek design that doesn't draw attention

Conclusion: Our promotion strategy should focus on reducing cognitive dissonance, reassuring customers that our refuelling station is safe, trustworthy, time-efficient and sleek.

These findings were extremely useful and were used to guide our entire product strategy.

As an aside, one of our witty interviewees pointed out a novel side effect of our prototype: "Sugar into fuel rather than cakes and soft drinks sounds great...might reduce obesity."

COLLABORATION WITH INDUSTRY (CSIRO)

CSIRO is one of the globe's pioneers in scientific research. In recent years, CSIRO has dedicated a significant amount of time and resources towards improving the viability of hydrogen gas as an alternative renewable energy source. It was announced in May 2017 that the organisation has created a membrane reactor which converts ammonia into high-purity hydrogen to be used in fuel cell vehicles. This aims to solve the dilemma of transporting liquid hydrogen for use as energy, which has historically been very expensive and difficult given its high volatility. The membrane only allows hydrogen gas to pass through while blocking any others. Brett Cooper, Chair of Renewable Hydrogen, believes that this technology could position Australia to be "the number one renewable fuel provider in the world's fastest growing region" with an export industry equal in scale to the LNG industry. Several motor vehicle companies such as Toyota and Hyundai are very interested in utilising the membranes in their hydrogen-powered fuel cell vehicles once development is finalised.

Given their longstanding experience in producing hydrogen, three members of H₂hydrogem met with Dr Howard Lovatt, Team Leader of Electrical Machines at CSIRO, to gain feedback on our project and discuss a potential future collaboration between our team and CSIRO.

In terms of our proposed refuelling station prototype, Dr Lovatt believed that it held strong long-term potential given the high likelihood that hydrogen vehicles will become more popular in Australia over the next two decades or so. However he was concerned that there was not enough demand for it currently in the Australian market given that hydrogen vehicles are only just reaching our shores now. He also raised a few important safety considerations that we have not (as of yet) addressed including how we will purify the hydrogen to >99.99999995%, which is necessary to ensure that the fuel cell nor the vehicle will be damaged. This is typically an expensive, time consuming process and our team needs to find a way to make that process more efficient and cost-effective before our product can be sold. As such, his recommendation was that we need to also develop a plan for how we can acquire income in the short term in order to fund the R&D necessary for our product to be ready to launch in roughly ten years time. He pointed out that our project is sufficiently far enough along the fuel path to be a viable business venture on its own as there are lots of commercial customers out there who would want green hydrogen even if they needed to pay a premium. It's a sellable idea as there are very few producers of green hydrogen. Dr Lovatt recommended that in the short term we try to form a partnership with energy companies to use hydrogen energy to power 'the grid' in small rural communities. This concept is already being embraced in the city of Adelaide and has great potential for expansion. Based on this recommendation, as of October our team is currently investigating forming short-term partnerships with AGL Energy to fund our long-term refuelling station prototype. See 'Future Directions and Sources of Funding' for more information.

Dr Lovatt thought that selling the refuelling station as a bundle with hydrogen vehicles was a good idea as it made the entire purchasing process for the customer far simpler and more streamlined. He suggested that the most likely company to entertain the possibility of such a partnership is Toyota, as they have a very vertically integrated view of car manufacturing so

would want to be heavily involved in the production process of the refuelling stations. This is promising because it would hopefully mean that they would be willing to work alongside us to figure out how to produce the stations on a large scale and give us access to their mass production facilities.

Dr Lovatt also gave H₂ydrogem some very promising directions to explore regarding a future partnership with CSIRO. One avenue he suggested was contacting the Energy Centre at CSIRO Newcastle who are heavily involved in researching sustainable energy production. Another was CSIRO Victoria, who are currently investigating how to use of algae to produce emission-free fuel. Our team intends to contact both of these CSIRO branches to meet with their executives and discuss the possibility of a joint research venture within the next five years. Dr Lovatt also recommended that we contact Katie Green, coordinator of CSIRO's 'ON Accelerate' program. This 12 week program, beginning early next year, connects small start up companies with industry experts who can help you refine your product idea, perfect your business pitch to potential investors and guide you on how to make your product sellable. H₂ydrogem is looking into applying for this program to help us take the next step with our project.

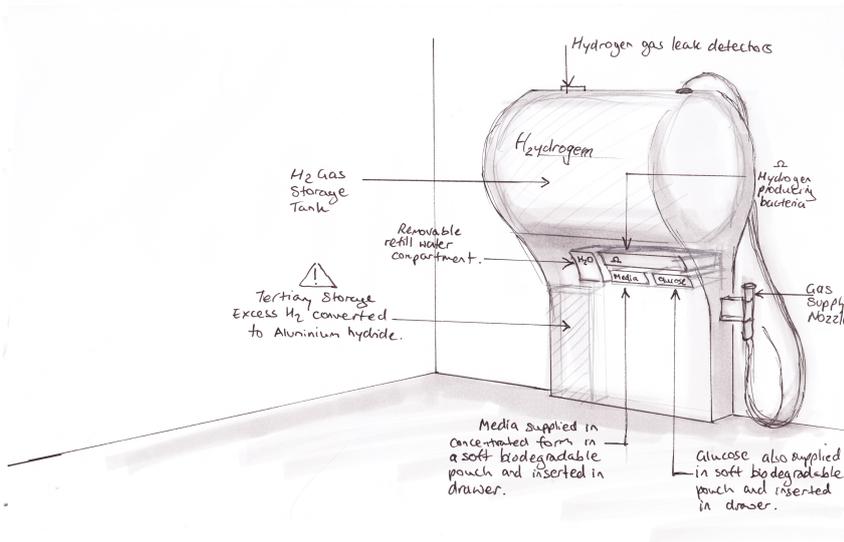
MARKET STRATEGY

PRODUCT

Our product prototype, the H₂GEM, is an at-home refuelling station for hydrogen powered vehicles. We have chosen this as our prototype for several reasons, dictated by our market analysis, survey results, interview results and research on the current hydrogen energy landscape in Australia:

- There is strong consumer interest in sustainability, climate change, renewable energy sources and the desire to take the power to make a difference out of the government's hands and into the consumers'
- A significant majority of household owners express a desire to generate their own renewable energy, rather than purchase it pre-made from a company
- While currently small, the demand for hydrogen-powered vehicles in Australia is expected to grow steadily over the next decade as infrastructure improves and costs are reduced
- There are already several companies that sell hydrogen for various energy purposes (transportation, stationary power, etc) but no competitors currently exist for at-home refuelling stations, making this a novelty product
- Our team lacks the necessary capital and distribution channels to produce hydrogen gas and sell it directly to consumers, nor would we be able to compete with the existing companies scale-wise

The H₂GEM has been designed so that it is compact enough to fit within a standard Australian household garage. The unit itself is shaped as a compact, sleek lightbulb-shaped design. Its dimensions are 1 metre tall, 60 centimetres wide and 30 centimetres deep. It will be constructed using two rectangular pieces of sheet metal welded together at the top of the unit, with two lightbulb-shaped metal pieces at either end. A small input tray is located near the base so that feed stock can be inserted by the user with ease. A petrol bowser is connected to the base and coils around a holder at the side of the unit to allow for easy, compact storage. As stated in our overriding objective, sustainability is our team's top priority. As such, the H₂GEM's exterior will be made from recycled stainless steel sourced from scrap yards which would have otherwise been destined for landfill.



The H₂GEM's interior has been designed so that hydrogen gas can be produced directly within the unit to then feed into any hydrogen-powered vehicle. The internal compartments were designed such that the e-coli vat would sit at the bottom. Nutrients such as the media and glucose would be delivered through biodegradable pouches which are inserted the machine, as shown in the sketch above. The gases produced then pass through a hydrogen-selective membrane and are stored in the round compartment sitting atop the vat, which will help equalise pressure. The hydrogen gas then passes through a column to convert it into a more safely-stored aluminium hydride. When the gas is needed, it can be reverted back and used for consumption.

PRICE

To determine an appropriate price for the fuelling station, it was important for our team to consider our motivations in creating the H₂GEM. Our key objective, as stated in our mission statement, is to empower everyday Australians to sustainably and affordably power their own hydrogen vehicles. This guiding principle has two implications for our pricing strategy. Firstly, the H₂GEM would need to be priced such that in the long term, purchasing the H₂GEM and refuelling their own hydrogen-powered vehicle at home is cost-effective and affordable when compared to refuelling at commercial hydrogen fuel stations. Secondly, we endeavour to use any profits made from sales of the H₂GEM to fund future research into how we can further reduce the impact of our product life cycle on the environment (i.e. improve its sustainability).

We have sought to achieve a balance between these two objectives – choosing the lowest/most affordable price possible that will still cover our production and fixed costs and provide some small additional profits that can be injected into R&D. As we do not intend to gain most of our R&D funding from product sales (see 'Future Directions'), we do not deem it necessary to strive for more than this very modest profit.

The cost of production per unit has been estimated below. Note that the hydrogen vehicle market is still in its infancy in Australia and our plan for implementation will not be executed until roughly 2027 (see Distribution strategy), so these will need to be adjusted for inflation when our product goes to market in ten years' time. Additional costs that will need to be factored in closer to the time are manufacturing costs, salaries, business insurance and promotion.

Ingredient/costs	Required amount	Approximate cost (AUD)
500mL LB Media: *		
- Tryptone	4g	$(\$79.10/500g) / 500 \times 4 = \0.63
- Yeast extract	2g	$(\$64.50/500g) / 500 \times 2 = \0.26
- NaCl	4g	$(\$103.35/500g) / 500 \times 4 = \0.83
2 M D-glucose *	20ul	$(\$41/1kg) / 10000000 \times 20 = < \0.01
1 M IPTG (control factor) *	2ul	$(\$98/1g) / 10000 \times 2 = \0.02
DH5 alpha e-coli cells (OD 0.2-0.3) *		\$10
Polymeric membrane		\$50
Recycled stainless steel	2 square metres, 2mm thick	\$140
Bolts, screws		\$3
Drawers	3	\$15
Fuel hose with car nozzle	1.5m	\$70
Total		\$289.75

**Note: These are the ingredients of the feedstock, which will need to be replaced by the customer every 35 hours. Only the first loading has been accounted for in this costing analysis, all replacements will be covered by the subscription service cost – see below.*

Based on these costs and allowing some extra leeway for our additional costs, we will be selling the hydrogen fuelling station at a price of around \$799 AUD. This price may have to be negotiated either up or down depending on whether our proposed partnerships with hydrogen vehicle manufacturers such as Hyundai and Toyota go ahead, as this would involve selling the H₂GEM along with the cars as a bundle pack (see 'Distribution').

As the H₂GEM also requires regular feedstock to be purchased and added by the user, we have endeavoured to make this as easy and convenient for the consumer as possible by selling the feedstock via a mail subscription service. When a buyer purchases the fuel station/vehicle bundle, they will have the option to sign up for a monthly delivery of 30 biodegradable bags of media and glucose sent to their house by registered courier for a fee of \$60 per month plus delivery costs. This means that our consumers do not even have to think about when or where to buy their feedstock, which was noted to be a potential purchasing barrier by several of our interview respondents. They can also opt to receive a monthly shipment of DH5 alpha e-coli cells to replace their existing cells (which will minimise the risk of the cells dying unexpectedly) for \$15. Our target customers (young working millennials and parents) have extremely busy schedules and it was essential to our team that our product fit seamlessly into their lives rather than add yet another item to their to-do lists.

PROMOTION

The primary market research that we conducted revealed that our consumers' purchasing decisions are motivated primarily by sustainability, longevity and price. As such, these are some of the key 'selling points' of the H₂GEM that we will emphasise in our promotion campaigns:

- Fossil fuels are a finite energy source that will run out! Hydrogen is a renewable source of fuel for transport that, when produced using our unique e-coli technology, emits no greenhouse gases and is a sustainable, innovative alternative to petrol.
- The financial security offered by producing your own hydrogen energy at home – once purchased, the H₂GEM requires minimal running costs and means that the user is not at the mercy of the volatile petrol/gas market prices
- The H₂GEM gives the power back to the consumer, equipping them with all the tools they need to easily produce their own hydrogen energy

The Elaboration Likelihood Model of persuasion (a marketing theoretical model developed by Richard E. Petty and John Cacioppo in 1986 attributing consumer attitude change to exposure to stimuli) states that there are two types of consumers – high involvement and low involvement. Changing the attitudes of **highly involved** consumers is most effectively achieved through communicating information about the product while changing the attitude of **low-involvement** customers should be done through emphasising peripheral product details. We hypothesise that most of the customers within our target market fall into the former category as purchasing a car (and subsequently, the H₂GEM) is an expensive, risky endeavour which typically involves a significant amount of prior research and comparing of options. As such, we will focus our promotional material around the beneficial features of our product in order to persuade potential buyers.

Within our target market of Australian households, it has been identified that there are 2 major customer segments that exist who we will aim to primarily target:



Environmentally conscious, future-minded, innovative **Gen Yers** who are **purchasing their first car** and want the empowerment to produce their own sustainable fuel



Parents with young children who want to protect the environment for their children's generation

As will be mentioned in 'Distribution', our intention is to create a partnership with hydrogen-powered vehicle manufacturers to utilise their distribution channels and sell the H₂GEM as a bundle with the cars. This will mean that our promotion strategy will be closely aligned with the car manufacturers' strategies. We will hopefully be able to advertise the H₂GEM alongside the cars via the mediums that are currently favoured by these companies, including:

- Television advertisements: able to reach a very large audience, particularly effective for communicating the key details of the H₂GEM in a short time frame, has the advantage of combining visual, written and auditory information
- Billboards: simple, eye-catching, puts our product in the line of sight of drivers i.e. our target customers
- Informative brochures: can communicate more in-depth information about the H₂GEM to highly-involved customers

As dictated by our interview findings, our promotional material will aim to allay any concerns that may prevent potential customers from purchasing the H₂GEM. Some of the ways in which we intend to do this are as follows:

- "It's too expensive" – our campaigns will highlight the Emissions Reduction Fund, a voluntary government scheme that provides financial incentives (in the form of Australian carbon credit units or ACCUs, which can be sold to generate income) for Australians to adopt emission-reducing practices
- "It's not safe" – our campaigns will emphasise the rigorous government-approved testing that has been conducted on the H₂GEM to ensure that it is perfectly safe to keep in a household garage
- "It's too hard to use" – we will demonstrate how the product works using online, easy-to-follow video tutorials that will be mass marketed to our target audience via social media advertising, such as on Facebook and Twitter

Sources:

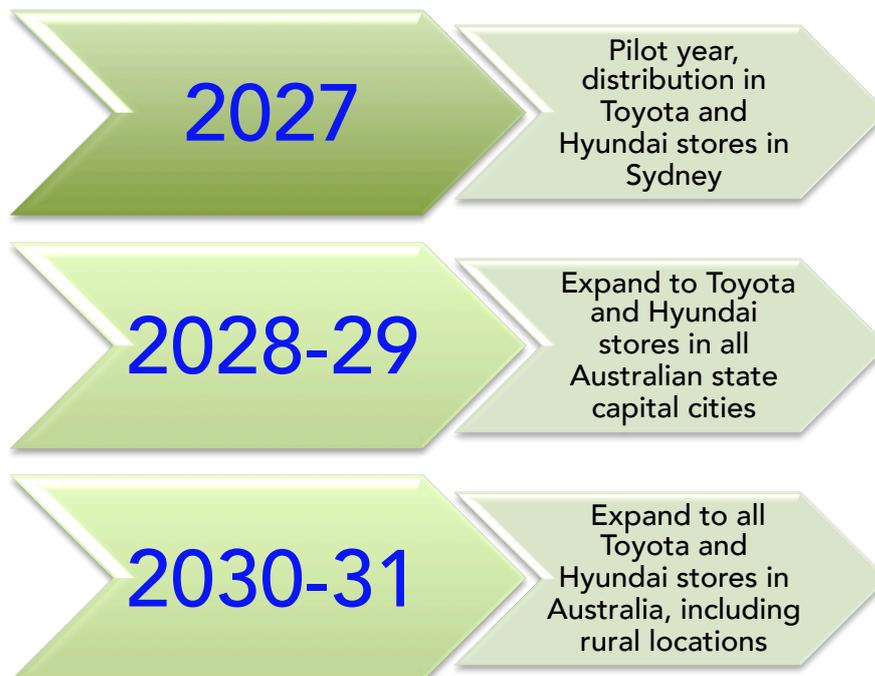
Australian Government Clean Energy Regulator. (2017). *About the Emissions Reduction Fund*. [online] Available at: <http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund> [Accessed 5 Sep. 2017].

Cios.org. (2017). *Elaboration Likelihood Model*. [online] Available at: http://www.cios.org/encyclopedia/persuasion/Helaboration_2routes.htm [Accessed 5 Oct. 2017].

DISTRIBUTION

H₂hydrogem's intention is to sell the H₂GEM refuelling station as a package bundle with hydrogen-fuelled cars from major car manufacturers. We have taken the advice of Dr Lovatt from the CSIRO and have chosen Toyota and Hyundai as the primary car producers that our team will aim to form distribution partnerships with. These two companies are both widely trusted throughout Australia and are known for producing highly reputable, durable cars. Selling the H₂GEM as part of a package with a Toyota or Hyundai hydrogen-fuelled car will project these same desirable qualities onto our product and increase its perceived value.

Our plan for entering the Australian market is to start with a pilot year in Sydney in approximately ten years' time (around 2027), selling the H₂GEM as a bundle with hydrogen-powered vehicles at Toyota and Hyundai stores across Sydney. This pilot year will be a good 'testing ground' for us and give us the opportunity to iron out any kinks in our distribution system before expanding to the rest of the nation. Assuming that the pilot year is successful, we then intend to expand to Toyota and Hyundai sellers in all major Australian state capitals. From there, we will expand into rural locations as well over the following two years. This will mean that five years after entering the Australian market, the H₂GEM will be readily available across the country. At this stage, H₂hydrogem does not have any plans to enter the global market. Our team's collaboration on the iGEM GMO legislation document (collated by several iGEM teams) highlighted to us the sheer complexity and inconsistency of GMO legislation across the world. This would invariably make navigating international exportation extremely difficult and potentially require us to hire staff in multiple countries to ensure that we are fully complying with all legal requirements in the countries of export. As such, we have decided to limit our distribution to the Australian marketplace for at least the first five years of operation.



Manufacturing of H₂GEM will initially take place in small manufacturing plants located in Sydney and will be exported to other selling locations across the country after our pilot year. The feedstock will be distributed to customers via a subscription service, as mentioned in our Pricing Strategy. It will be delivered to customers' homes once a month at a desirable time by registered postal courier in an isothermic cooler bag. Customers must sign for the feedstock upon delivery and immediately remove the feedstock from the bag to put into their own refrigerator (for the media) or freezer (for the e-coli), so that the bag can be brought back to H₂drogem Headquarters by the postal courier for reuse. Should the customer wish to suspend their subscription (e.g. if they are going on holidays), they need only contact H₂drogem and we will suspend delivery and payment for the desired timeframe.

FUTURE DIRECTIONS AND SOURCES OF FUTURE FUNDING

The landscape of synthetic biology is ever-changing and evolving, shifting rapidly as new discoveries are made. As such, it is highly likely that the H₂GEM in its current state will be adjusted and improved several times before it reaches the market in approximately 10 years time. This process will involve ongoing collaboration with researchers in the field of hydrogen energy and the makers of hydrogen powered vehicles, to ensure that our product is a complementary, seamless fit with the vehicles themselves once they reach the mass market. As mentioned earlier, some of the necessary research that needs to be conducted before the H₂GEM can be sold include:

- Developing affordable, scalable purification systems that are small enough to be embedded into the H₂GEM
- Rigorous safety testing to ensure that the H₂GEM meets the strict standards set by the Australian Competition and Consumer Commission
- Partnered research with Toyota and Hyundai to ensure maximum compatibility of the fuel we produce with their hydrogen powered vehicles
- Exciting potential to use waste materials (such as cellulose from sugar cane husks, after the sugar has been extracted) as the feedstock for the H₂GEM, thus making our product even more environmentally-friendly

While it is impossible to predict exactly which directions the field of synthetic biology will take in the next decade, team H₂ydrogem plans to be a leading frontier in this exciting research. This will require a long-term funding and deployment strategy to ensure that sufficient capital is secured to fund future R&D. Thus far, the majority of our funding has come from generous sponsors and organisations who strongly believe in the potential of our product to revolutionise the renewable energy landscape in Australia. However, this strategy is not sustainable in the long run. We will be applying for several federal government grants to provide longer term R&D capital, including:

- The Clean Energy Finance Corp, who invest in industry sectors with the greatest potential to reduce carbon emissions in Australia - investments include project and equity finance, corporate loans and aggregation funding
- The Australian Renewable Energy Agency (ARENA) fund multi-million dollar projects that develop renewable energy technologies that will improve investor confidence in renewable energy

As mentioned earlier, we are also investigating the potential for an ongoing partnership to be established with CSIRO Newcastle's Energy Centre so that we can access their financial and physical resources for our own R&D in return for a stake in our future profits. Other options for funding that we are currently investigating include crowdsourcing, corporate venture capital, short-term partnerships with energy companies such as AGL (to power small rural communities with our hydrogen) and foreign investment.

Sources:

Australian Renewable Energy Agency. (2017). *About ARENA*. [online] Available at: <https://arena.gov.au/about/> [Accessed 4 Oct. 2017].

Clean Energy Finance Corporation (CEFC). (2017). *Where we invest*. [online] Available at: <https://www.cefc.com.au/where-we-invest.aspx> [Accessed 4 Oct. 2017].