

**Macquarie
iGEM 2014**

Green Machine - Business Plan



**First Steps to
our Greener Future
via Synthetic
Chlorophyll Powered
Bacteria**



Business Plan - *Green Machine*

Executive Summary

The purpose of this report is to provide an analysis of the development and commercial viability of the *Green Machine*. *Green Machine* is the product of the Macquarie international Genetically Engineered Machine (iGEM) team's ongoing research and development into a synthetic chlorophyll biosynthesis pathway. This report was convened by the 2014 Macquarie University iGEM team where work has originated from one year prior and conducted at Macquarie University.

The development of a sustainable future is fast becoming a requirement to ensure we are able to meet future energy needs. The United Kingdom, Italy and France each have less than one year's supply of fossil fuels left for consumption and are now heavily reliant on surrounding countries (Vincent, 2014). Current sources of renewable energy, such as wind turbine farms, despite being around for almost 150 years, are yet to become cost effective for strong growth. There are also very few active companies in the industry, hardly enticing enough for significant investment (Economist, 2014)

We believe that we are opening new gateways towards a new source of renewable energy as we develop a way to synthetically manufacture the chlorophyll molecule from *Chlamydomonas reinhardtii* in a high output medium - bacteria. Significant progress has been made over the last year and further research will unveil great insight into the mechanisms of photosynthesis and chlorophyll's role within it as a sun absorbing pigment. If the photosynthesis system is recreated synthetically, it will create a viable, cheap method of hydrogen and chemical energy production or also a new biofuel.

Our Pitch

Renewable energy makes a better investment than the stock market.
The last time we checked, you still need electricity in a recession¹.

¹ (Williams, 2010)

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2.0 Market Analysis

Key Points:

- Renewable energy will contribute 25% of the global power mix in 2018, up from 16.7% in 2010, twice exceeding the power generation of nuclear and exceeding natural gas
- Emerging markets are driving investment and development, with China and non-OECD leading the global increase in renewable energy use
- Renewables have become cost-competitive and are now able to better compete against fossil fuel based companies

2.1 Market Growth

The renewable energy industry is experiencing rapid growth. In 2011, half of the estimated new electricity capacity that was added globally is accountable for by renewable energy sources. Outside of environmental concerns there are also economic, political and technological influences that are strengthening this market and driving its growth. This includes a significant growth in investment into new renewable energy technologies (up 37% between 2009 and 2011) and 29 new countries have put renewable energy target policies in place (up to 118 in 2011) (Committee, 2012).

Additionally, large global organisations and nations are increasingly setting their renewable energy targets at 100% in the coming decades (Smead, 2014).

Global energy consumption is expected to rapidly grow and will soon outpace global production and will be approximately 50% higher in 2050. This is being driven by the industry sector which contributes to half of global energy consumption (see Figure 1.) and has been cited for its unnecessary waste of energy (EIA, 2014). Consumers and small-scale enterprises are better able to implement renewable energy strategies and it is likely that their overall percentage of consumption will decline. Emerging economies typically use manufacturing as their main driver for growth and employ less energy efficient technology. This is the most attractive sector of the industry and should be targeted due to its future potential for high growth and current lack of renewable energy alternatives.

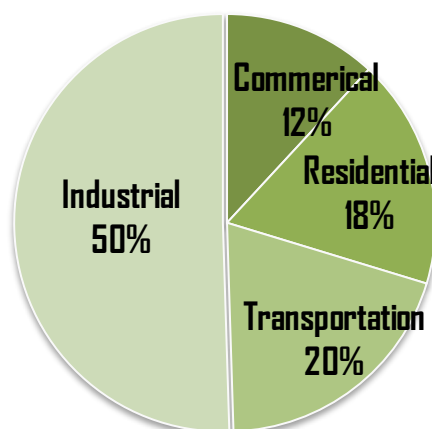


Figure 1. Breakdown of 2011 global energy use. Industry is the main user.

2.2 Industry and Rivalry

The attractiveness of any industry is dependent on factors outside of market growth. A fair assessment of an industry will also reveal a business's level of profitability it will likely have. Porter's 5 Force Analysis is a framework model that assesses the pure competition that is present in an industry and how this threat is likely to be maintained in the future. It is therefore a useful tool in developing long term strategic planning and assessing if the current core competencies of the organisation will hold against its competitors.

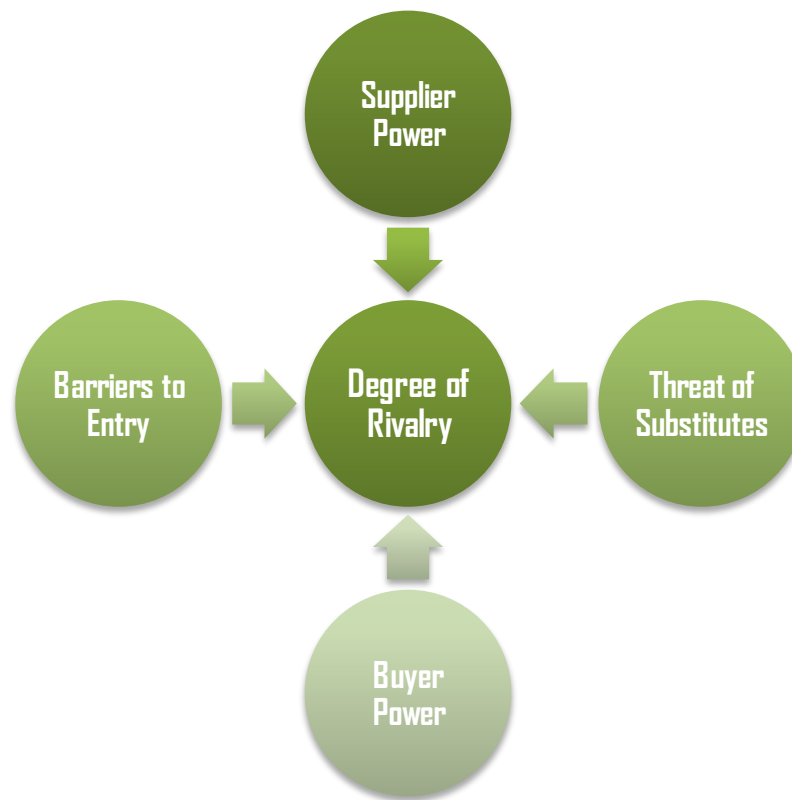


Figure 2. Porter's 5 Force Analysis to determine the attractiveness of an industry.

The most unattractive factor of this industry, and therefore increaser of rivalry, is the threat of substitute products. Figure 3 shows the contribution that each source of renewable energy had towards overall growth between 2010 and 2011. Unsurprisingly wind farming, solar power and hydro-generation continue to be the leading sources of renewable energy; with only 5% produced from other sources which include the production of biofuels and biomass. As will be noted in the product analysis section, the potential for our project lies within both biofuels and hydrogen gas generation, neither of which are currently dominate in the renewables family. These dominate technologies are getting more cost effective by the day as better technologies are developed and will therefore continue to push down the current price that is payed for energy from renewable sources, decreasing profitability in the industry.

Supplier power is negated due to a number of factors, increasing the attractiveness of this industry and is also a significant core competency. The power that will be held by Green Bacteria will be similar to that of a company that has undergone complete reverse integration. The products

required for the production of Green Bacteria are standardised and there would be little cost involved in switching suppliers. The power of buyers is difficult to assess in these initial stages. Whilst there is a large amount of potential buyers it is unknown how manoeuvrable Green Bacteria will be across different markets and what infrastructure might be required which would limit its flexibility.

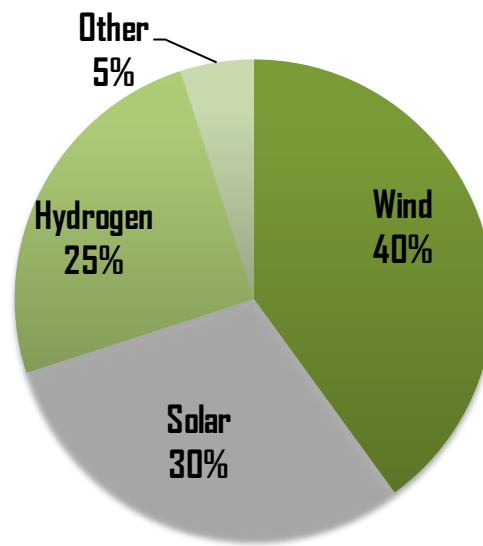


Figure 3. Contribution to growth of different renewables between 2010 and 2011.

The renewables market requires high investment due to the large scale processes that are built to generate economies of scale (Painuly, 2001). This high start up price serves as a significant barrier to entry that would deter new competitors to enter the market. More often, government's subsidise individual industries or companies, striking up long term deals to secure their future energy needs. It is also likely, as our knowledge into renewables becomes more specialised, that patents and proprietary knowledge will become more common place in the industry. Currently the technology and processes in place are not specialised and are easily immedicable by other companies. As such, it would be increasingly difficult for new companies to quickly enter a market and gain profitability. This is an attractive feature of the market as, if Green Bacteria was to be quickly established, new competitors would find it difficult to reduce our market share.

3.0 Risk Analysis

Key Points:

- The initial stages of product research and development are turbulent and hold a lot of risk.
- These risks that must be evaluated and acted on appropriately, or risk termination of the research project
- As part of our project we are running outreach programs that educate the global community on the issues that are discussed

3.1 Technical

Controls must be put in place that regularly assess if the quality and criteria put in place for *Green Machine* are being met. This project is currently very specific and will therefore offset many of the risks associated with taking on too much that is too wide in scope. This will aid in ensuring project quality and keeping to deadlines that we set ourselves. Our core-team to begin with however is small, inexperienced and lacks internal expertise. We have sourced external academic and student advisors that are able to help us with the practical components of the project.

3.2 Financial

Financial risks include failing to meet and manage cost restraints and cost changes. It is a likely event that budgets will change at short notice. Regular financial monitoring and reviews will be put in place and overseen by an appropriate member of the group. Contingency sources of funding should also be established, possibly from Macquarie University.

3.3 Safety and Social

As this is a synthetic biology project there safety and social risks that must be addressed. Current debates include the open access to the products and benefits of the project, environmental contamination, and possible misuse of the standardised parts for malicious use as knowledge into this field grows. It is fair to claim that the benefits that *Green Machine* and synthetic biology brings should be fully realised and accessible by everyone. As is the requirement of the iGEM competition, any new parts (genes) that are designed must be uploaded to the competition's registry. From here they can be accessed and used by anyone. In regards to environmental contamination by *Green Machine*, once designed, the product will have automatic 'kill-switches' that will stop it from surviving outside of a growth medium that we can select. As the project progresses we will also be able to put external controls as knowledge of the properties of *Green Machine* grows.

Whilst other synthetic biology projects will be focused on creating cheaper biofuels, industrial machines and more effective medicines, there are fears that there will be more malicious uses including pathogens for terrorism. As this is a relatively new field of research, there is a perceived lack of oversight mechanisms and regulations. Currently there is great freedom in scientific research which has allowed for global competitions such as iGEM. A balance needs to be made between the positives and drawbacks and this is best achieved through discussion with the scientific community.

4.0 Product Analysis and Deployment

Key Points:

- Whilst technological excellence and product uniqueness are defining factors in an emerging market, articulated commercial strategy and deployment is crucial to the product's success.
- Average time period of investment by venture capitalists ranges from 3-6 years and from an increasing amount of multinational enterprises (Botha, 2007).
- Joint venture or corporate venture funding is most appropriate for emerging technologies
- Due to the early stages of the project, financial analysis is limited. Unit sale cost and cost of unit production is likely to be at high volume and low cost respectively, increasing the profitability of a potential venture.

4.1 Product Analysis

A “SWOT” analysis can evaluate the strengths, weaknesses, opportunities and threats of a research project, product or business venture. It is useful in helping to consider the internal characteristics and external influences that are involved with *Green Machine*. These can be used to proactively plan an effective strategy that will focus our strengths on our opportunities, while catering for weaknesses and possible threats.

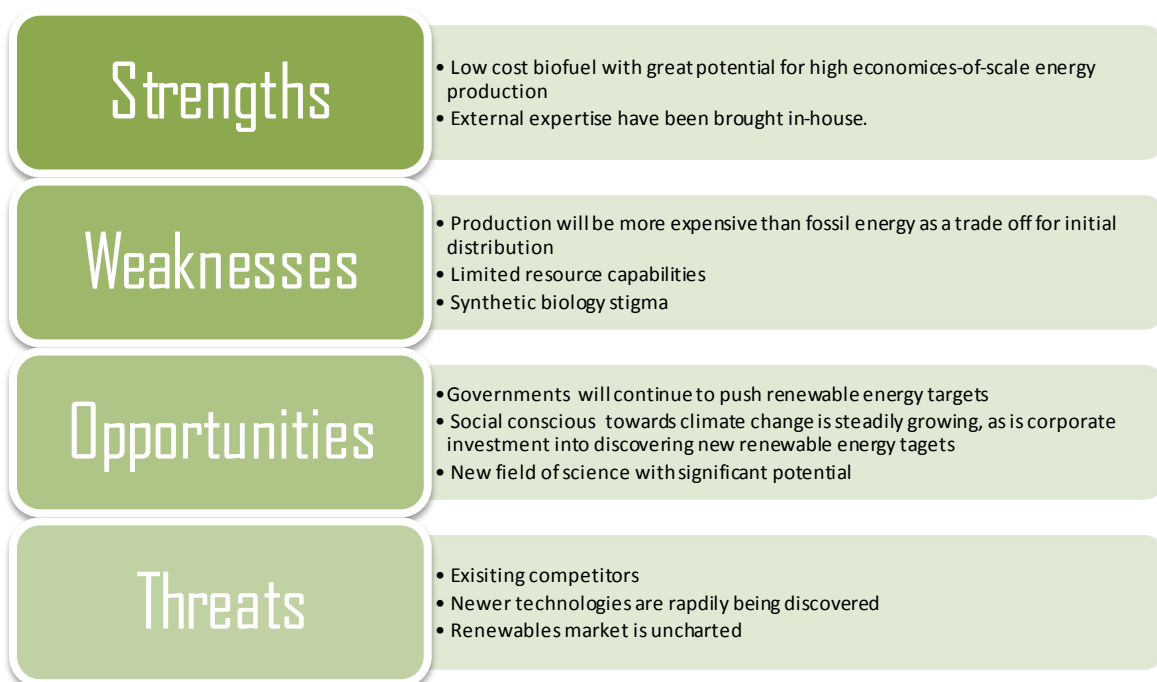


Figure 4. SWOT Product Analysis of the *Green Machine* project

Internal factors of the project are typically in direct control. Strengths assess the positive attributes of the project including the advantages of the project's product itself, capabilities of the project, and expertise of the team. Our project has fantastic potential for use as a low cost biofuel. There is significant interest in our project from stakeholders including biotechnology businesses, Academics and the community. We also have a highly dedicated team, small team with a common goal and

have sourced local expertise in academic staff and advisors who have invested their interest in the project.

Weaknesses therefore consider limitations and areas of improvement. Initial research and production will incur a high cost if to become a commercial venture will likely struggle to compete against established energy sources including. As discussed in social risks, there is a fear in the community that synthetic biology could be used for malicious actions. The lack of education about synthetic biology has also led to its confusion with genetic engineering. These fears will likely become a barrier attempting to market the benefits that *Green Machine* will provide. Furthermore there are currently limited product and people resource capabilities until more funding can be sourced for the project.

External factors may influence the project but are outside of our direct control and include opportunities and threats. As has been shown by the substantial growth of the renewable energy industry, there are a number of opportunities that should be harnessed. Firstly, government policy will continue to push for industry to reach greater renewable energy targets. The general community consensus is that global warming is from our carbon emissions. This is pushing companies, often as part of their corporate social responsibility program, to invest in research for new or improved renewable energy technology. Synthetic biology is also a new field of science that is experiencing strong growth. Knowledge in this field is continually improving and as we begin to understand more about it there will be further potential for benefits that can be harnessed.

New technologies are constantly being developed and there is the threat that our project may become obsolete. If a new technology was developed that was to show greater potential than *Green Machine* it will likely gain greater funding and reduce the attractiveness of investment in our project. Therefore, despite the attractiveness of the renewable energy industry, entering it involves a lot of risk until the technology matures in the industry. These threats must be monitored with a strategy developed that minimises the adverse affects they may have on the project.

4.2 Funding and Deployment Strategy

Whilst gaining funding from companies out of goodwill and genuine interest in the project has so far been successful, this is not a long term sustainable form of income for the project. Other possible sources of funding include government grants and Corporate Venture Capital (CVC). Measures have been put in place in an attempt to gain substantial annual funding (\$20K AUD) from the state government; the outcome of this is yet to be decided with meetings with government representatives scheduled for 21st October 2014. CVC is a practice where large businesses invest in an innovative project or firm and aid in its start-up. The business gains a small stake in the start-up business and provides, on top of funding, management and marketing expertise. To secure the long-term development we believe that CVC is the best route for *Green Machine* to be funded under.

CVC investment peaked at \$6.2B in 2000. However, this has steadily decreased as businesses have lost sight on the potential value that external start-up companies have (Chesbrough, 2002). The renewable energy industry however is in need innovation if we are to start meeting renewable energy targets. One disadvantage of sourcing funding from private enterprise is that it will go against the open source information ideal set by iGEM.

5.0 Current milestones and Future Goals

This *Green Machine* project has already had significant success in its research, fundraising and outreach activities. High regard and subsequent donations have been made by Australian scientific companies including Biomolecular Frontiers Research Centre and Bioplatforms Australia.

Contributions have also been made from Labcyte and Beckman Coulter. The progress of the 2014 Macquarie iGEM team has seen relationships made with five other companies that will likely lead onto greater research funding for the 2015 team.

As a result, greater resources and capabilities will be channelled into *Green Machine*. This project has significant potential for positive environmental impact whilst also fostering the undergraduate and private industry relationship. Within the next five years *Green Machine* will grow from an undergraduate research project into a partially funded corporate joint venture.

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