Business Plan

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AmberCycle Industries

Introduction

The following business plan describes AmberCycle Industries' proposed manufacturing model for the production and sales of terephthalic acid via novel synthetic biology based recycling approaches to the common plastic polymer Poly (ethylene) Terephthalate (PET). AmberCycle's unique process (*Biocycling*) can be described by three phases. First, engineered microbes, grown in a controlled bioreactor environment, degrade poly(ethylene) terephthalate into its chemical substituents. Second, a high-value product, purified terephthalic acid (PTA) is separated from other byproducts. Finally, a solvent recovery process recycles reusable reactants. Once fully implemented, we aim to produce terephthalic acid for the intent of utilization in the production chain of sustainable and environmentally friendly materials for years to come.

AmberCycle Industries fits directly into existing lifecycle models for plastic recycling and utilizes commercially available equipment and infrastructure. The key innovations lie in the use of engineered biological systems and in the creation of an entirely new paradigm for the recycling of plastics - degrading them to their core chemical components and reincorporating these into existing plastic synthesis pipelines. Our initial product, terephthalic acid, experiences 4 to 6 percent growth annually, and is slated to experience continued growth in the foreseeable future. As of October 2012, purified terephthalic acid sells for $0.67 per pound, with analyst reports indicating an estimated potential for 7 to 11 percent expansion over the next 10 years. Consequently, we project that PTA will be essential to AmberCycle Industries as a primary product for production and sale for the next 5 to 10 years, during which additional feed stock and product processes will be developed.

This report details the biocycling process, required infrastructure, cost estimates, a sensitivity analysis, supply requirements, and profitability analysis for this project.

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1.0 Abstract

While working at the University of California at Davis, AmberCycle scientists used a synthetic biology approach to engineer strains of *Escherichia coli* that secrete a hydrolytic enzyme capable of breaking down the plastic PET into two chemical byproducts, ethylene glycol and terephthalic acid. The organism utilize the ethylene glycol for fuel, minimizing energy input, while a mechanical and chemical separation process isolates the high-value purified terephthalic acid for resale. The process was analyzed for technological and economic feasibility, while also considering other potential issues, such as start-up and safety. Designs for the plant include projections to produce thousands of pounds of purified terephthalic acid, and under assumed current economic conditions, this process is projected to present high net value once fully functional, with an attractive investment rate of return of 11 percent. These conditions would make biological degradation of PET to terephthalic acid a marketable product, not only in terms of process and profitability, but more so through the utilization of a large source of pollution as a feedstock, which in turn makes AmberCycle Industries an environmentally viable option presently and for the future.

In the waste management and cyclical consumer goods industry, terephthalic acid is primarily used as a raw material for the synthesis of polyester PET, a resin polymer used in the construction of a variety of household items such as bottles, containers, and fibers. Currently, terephthalic acid is primarily derived from the oxidation of paraxylene in the presence of corrosive catalysts. While these catalysts produce highly pure PTA they do not produce exceptionally high yields, are corrosive, and require high energy and material investment.

2.0 Executive Summary

AmberCycle Industries focuses on reducing the costs of recycling plastic pollutants by engineering microorganisms to convert plastic waste into biomass and high-value chemicals, promoting the future of more sustainable plastics industry. We call our approach "biocycling" and expect this process to generate revenue from (a) recycling services provided directly to customers with plastic-rich waste input streams and (b) reselling valuable degradation byproducts of the process.

While plastics recycling has become universally viewed as environmentally friendly, current recycling technologies are epitomize inefficiency, with under 6 percent of total plastic waste actually being recycled, and processes utilizing as much as 4,000,000 kilojoules of energy to degrade half a ton of Poly(ethylene) Terephthalate (PET), the most abundant consumer plastic. Substantial percentages of this energy come from burning natural gas and electricity. This energy cost makes recycled PET roughly 4-6 times more expensive than virgin material. Of course, technologies research and development that can enhance the efficiency of plastic recycling not only make economic sense, but also make environmental sense by reducing the amount of plastic in our landfills and in the environment.

Our currently technology is focused on degrading PET into Terephthalic Acid (PTA), a valuable precursor for de novo plastic synthesis. PTA currently sells for around $1400 per ton, with millions of pounds currently produced annually, and increasing demand projections in the tens of millions in the coming decades. Additionally, by reintroducing our biocycled PTA back into plastic production, we enrich the percentage of recycled material and reduce the need for petroleum-based synthesis of materials, resulting in established economical, political, and environmental security and sustainability.

To producers of mixed synthetic materials waste, such as the carpet industry (the number one producer of such waste by weight) and municipal recycling centers, we offer the value proposition of reduced waste disposal costs.

AmberCycle Industries will immediately foster corporate level investment and industrial establishment as progressive environmental trends incentivizes companies towards "going green" in attempts to beneficially distinguish themselves as more progressive and environmentally sustainable institutions. Furthermore, the race for more biodegradable material infrastructure propels significant demand for products that will allow AmberCycle Industries to thrive. With the World Wildlife Fund initiative, dubbed the Plant PET Technology Collaborative, Fortune 500 companies such as Coca-Cola, Nike, and Ford will be more than willing to dedicate investment into the bioplastic industry for environmental innovation in widely used packaging processes. PTA, independently valuable to the chemical and material industries, can be sold to companies creating biodegradable plastics. PTA can secondly be converted into PHA, which is in high demand in the materials realm due to its pure biodegradable nature. The PHA industry itself is growing around the world allowing in turn a market for PTA producers to grow. Since our PTA will be grown biologically we can market a new synthetic form of PTA for other PET producers.

Coupling the business model of synthesizing chemical compounds utilized in sustainable materials with the necessary consumer utility and international demand for environmentally sustainable infrastructure and materials, the potential place for AmberCycle Industries as a corporate leader and industry standard in an upcoming multi-million dollar enterprise is evidently clear. With high demand and an under populated market, AmberCycle Industries fits well with needs on a consumer and corporate level, and has the potential to develop into a world class recycling and chemical synthesis endeavor.

3.0 Business Description

3.1 History of the Company

The initial intent to form AmberCycle is rooted in the International Genetically Engineered Machines Competition (iGEM) collegiate team at the University of California, Davis. For the 2012 competition, the UC Davis team aimed to engineer pathways for the degradation of Polyethylene terephthalate (PET). The similar propagation of the iGEM Entrepreneurial track, new in 2012, aimed to propel teams to take their laboratory constructs, and develop them in the public realm. Thus, AmberCycle Industries was developed to take the concept of degrading PET and develop it to marketable standards.

3.2 Proposed Company Charter

Name:

AmberCycle Industries

Project Leaders:

Akshay Sethi, Mattan Hamou

Project Goals:

- Outline and design infrastructure to produce and process PTA utilizing our developed microbial degradation pathways.
- To assess the technoeconomic feasibility of terephthalic acid production through PET breakdown.

Proposed Scope:

Short Term

- Maintain production of PTA for sale into the biodegradable plastics industry in the United States.

Long Term

- Develop an effective means to expand possible recyclable product pool
- Promotion of synthetic biology platform for the future socioeconomic endeavors.

Deliverables:

- Economic analysis of our process and product, compared to current methodologies.
- Feasibility study of the startup of AmberCycle as a business.

3.3 Management

The business administration of AmberCycle Industries will be run through the UC Davis iGEM Entrepreneurship team.

- Chief Executive Officer: Akshay Sethi; B.S. Biochemistry and Molecular Biology 2015 Candidate

  B.A. Economics 2015 Candidate

- Chief Financial Officer: Mattan Hamou; B.S. Cell Biology 2015 Candidate
- Chief Operations Officer: Nick Csicsery; B.S. Systems Biology Engineering 2013 Candidate
- Chief Technology Officer: Deborah Park; B.S. Biology 2013 Candidate

  Andrew Yao; B.S. Biomedical Engineering. Research Associate

- Managing Partner: Marc T. Facciotti; Ph. D. Professor at UC Davis
- Corporate Consultant: Peter Y. Matlock; M.S. Material Sciences Engineering. Biotechnology Consultant

3.4 Current Status and Goals of AmberCycle

Currently, AmberCycle Industries is in technological development stages. We hope to improve our technology such that our process will not only become viable, but clearly desirable over current methods to disposing of PET as well as synthesis of PTA.

Current PTA production methods utilize p-xylene (PX) as a feedstock, for which at high temperatures and pressures, PX reacts with oxygen in the presence of an appropriate solvent, promoter complex, and catalyst system to form PTA. Around 74 percent of PTA produced utilizes acetic acid as the solvent, cobalt and manganese salts as catalysts, and a form of bromine, such as HBr, as the promoter complex. In this process, 91.6 percent of the feedstock PX is converted to PTA. Several side reactions unfortunately take place in the process, generating undesired compounds such as p-toluic acid, 4-carboxybenzaldehyde (4-CBA), and other heavy molecular weight impurities. Without further purification, the main product is referred to as "crude PTA". To achieve polymer-grade PTA that is pure enough to utilize in PET production, additional purification steps are required to remove unwanted by-products.

The largest downside to producing PTA via chemical synthesis arises in the use of a bromide promoter that is highly corrosive, and requires equipment to be lined with expensive metalloid alloys and to be replaced often; this inextricably generates high capital infrastructure costs to the producer. Find out other problems/costs.

3.5 Product Description

Our International Genetically Engineered Machines team at UC Davis is currently engineering a microbial construct that produces a novel catalyst capable of degrading Polyethylene Terephthalate into two principal by-products, Ethylene Glycol and Terephthalic Acid. Both by-products can then be usefully manipulated, as our organic process permits simplified ease in extraction for further isolation, purification, and identification. Terephthalic Acid can be mechanically separated, and through our process, would exist in a polymer form, therefore it would not require further purification to meet standards for plastic production. Furthermore, Ethylene Glycol, when utilized in additional enzymatic constructs, can be captured and re-utilized by the organism as a food source in its metabolic pathways. Therefore, the degradation pathway can immediately be visualized as sustainable and innovative in scientific approach and application.

4.0 Products and Services

The section below contains the products and services offered by AmberCycle Industries

4.1 Product and Service Description

Terephthalic Acid, as a commodity, is internationally ranked as twenty-fifth in cumulative tonnage of all synthetically manufactured chemicals. Ninety percent of all terephthalic acid produced goes into Polyethylene terephthalate production. PET is a co-polymer plastic, and is the main constituent in a large array of industrial and consumer goods, ranging from manufacturing containers to upholstery and fabrics to packaging materials. As the most prevalent chemical used in bottling and packaging processes, PET had significantly risen in demand due to its high tensile strength and toxin-free nature. Chemicals such as Bisphenol-A, known to have harmful effects on biological organ systems, are nonexistent in PET, which validates it as a preferential choice for bottling agencies pursuing production of more sustainable products. Demand has similarly spiked due to advocacy in the SODIS initiative, a solar disinfectant method for treating drinking water in developing countries, and specifically that this method solely requires PET bottles and sunlight.

4.2 Competitive Comparison

This section will go over our physical product of PTA, and how it compares to current PTA. In terms of our finishing product PTA, it has the same qualities and characteristics as its chemically synthesized and purified counterpart. The table below illustrates our cost comparison to other main corporations who produce PTA. The prices provided are given for current technologies. With AmberCycle in specific, we are making scale-up assumptions about increasing the size of our endeavor without taking into calculation possible effects the increased quantity will have on our degradation rates.

PTA Production Process	Required Process Materials	Companies that Use the Process	Cost to Produce 1 pound of PTA
BioCycling	Bioindustrial Enzyme	AmberCycle Industries	$0.55
DuPont Catalyst Process	Ionic Catalyst, Metal Solute	DAK Americas, DuPont Chemical	$0.42
Henkel Process	Potassium Salt, Benzene Derivative	GTC Technology, InVista, DOW Chemial	$0.74

Amoco Process	Halogen Promoter	BP	$0.375

4.3 Organism Efficiency

Below is briefly stated our in lab achievements that are moving us toward the technological capabilities and biological efficiency we wish our company to ultimately have. First, in terms of progress made toward increased degradation of PET products, our scientists have succeeded in the production and secretion outside the cell of the LC-Cutinase gene in the E. Coli strain named DH5alpha. Another set of scientists have generated improved mutants that have shown increased enzymatic activity over the original unmodified LC-Cutinase gene. The graph below signifies that our modified construct has higher enzymatic activity compared to the wild type organism and its base degradation rates.

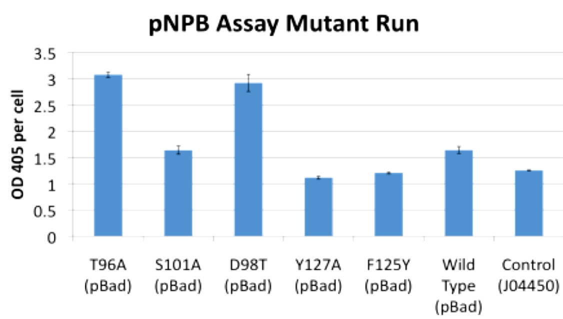

Figure 1: Enzymatic Degradation Comparison

Goals in the utilization of ethylene glycol have also been achieved. Another part of our science team has been able to use directed evolution to enhance the ability of the original E-15 EG3 strain to utilize ethylene glycol as a carbon source. They have also been able to replicate the ability to utilize ethyl glycol through the creation of a genetic construct and the construct has been both tested and confirmed to work as predicted.

Our goals in the utilization of ethylene glycol as a metabolic food source have also been achieved. Another part of our science team has been able to use directed evolution to enhance the ability of the original E-15 EG3 strain to utilize residual ethylene glycol as a carbon source. They have also been able to replicate the ability to utilize ethyl glycol through the creation of a genetic construct and the construct has been both tested and confirmed to work as predicted. The graph below demonstrates the increased survivability of our engineered strains over the wild type strain, which directly indicates our optimization of the strain.

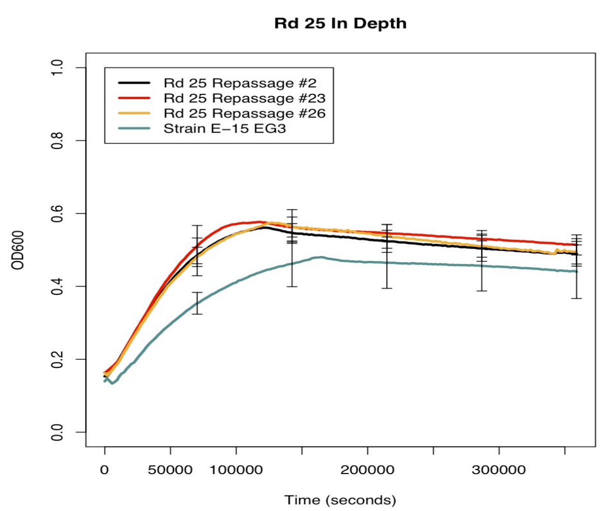

Figure 2: Survivability off of Ethylene Glycol

4.4 Sourcing and Optimization

Organisms were constructed, custom-made for Biobrick standards as well as optimized and mutated to be more efficient.

4.5 Future Products and Services

Once we can efficiently produce PTA and sell it, AmberCycle would like to develop involvement in synthetic biology solutions to petrochemical products. We would like to expand to have the capability to degrade more plastics, and hopefully more discarded materials.

5.0 Manufacturing Plan

In this section, a visual process flow diagram of the proposed project is presented along with brief descriptions of the overall process, followed by in-depth discussions of each of the sections. The process has been divided into four sections

Section 1: Enzyme Incubation

Single Reactor

Section 2: Bioreactor with Initial Reactants

Reactor Network

Section 3: Recovery Tank for PTA Isolation

Section 4: Solvent Recovery and Recycling

Distillation Columns

5.1 Facility Size and Location

The pilot plant will be constructed in Sacramento area, which allows for access to a variety of trade and export routes and widespread availability of the utilities needed to operate the plant. The capital of California would additionally suit AmberCycle Industries well, as hard and yield location factors, such as market transparency, entrance barriers, competition, and other enterprise-referred factors favorably influence the establishment of such an institution in this region. Appendix 1

5.2 Manufacturing Operations

Section 1: Enzyme Incubation

Our process begins with the growth of our organism. Our organism has engineered characteristics such as an alternative metabolic pathway for Ethylene Glycol and the over expression of LC-Cutinase, our novel catalyst. At an operational temperature of 55 °C, an organism culture is allowed to exponentially grow in the bioreactor supplied with mineral media solutions that will allow the organism to grow and reproduce as well as recovered Ethylene Glycol from section 4. The majority of the catalyst is produced in this stage, and in order to achieve the highest efficiency, the reactor is monitored at specific pressures, pH, as well as other conditions. Bioindustrial enzyme purification leads to a mass of the enzyme that can be transported to Section 2 for application to the substituent material. Eventually, cellular optimization will lead to catalyst production and purification being the only process the organism engages in. At this point, a conveyer system will transport the enzyme to section 2.

Section 2: Bioreactor with Initial Reactants

As the biomass enters section 2, substituent material degradation is initiated here. This section consists of _____ continuously stirred tank reactors in parallel. For each reactor, room temperature PET is delivered to the tank in the form of 4cm^2 squares. With temperature and pH still maintained at the same rates, our catalyst would achieve PET degradation at rates up to 20 grams per kilogram of PET per hour, degrading PET into its two constituents, PTA and Ethylene Glycol. Furthermore, the reactor outlet is a slurry stream consisting mainly of product PTA, enzymatic biomass, and Ethylene Glycol. This slurry stream is sent to Section 3 for separation and solvent recycle through a conveyer system.

Section 3: Recovery Tank for PTA Isolation

Once the PET is broken down, the slurry mixture of products and used enzyme is moved to a recovery tank for separation. A unique characteristic of purified terephthalic acid is its extreme hydrophobicity. Therefore, placing the slurry in a tank of de-ionized water would serve as an effective means by which density could propel PTA separation. Current chemical synthesis methods yield crude terephthalic acid, and in this step, expensive purification systems must be employed to separate dry TPA from a chemical composition of many ionic liquids. Using water provides another avenue for cost reduction overall. At normal atmospheric conditions, PTA sublimes at 402°C, therefore it assumes a solid state until that temperature. The dry PTA will then be moved using belt conveyors to be stored in bins, and shipped from the plant in tank cars.

Section 4: Solvent Recovery and Recycling

At the point that PTA has been extracted, a waste stream is transported to a final tank for distillation. The streams from section 3 are pumped into the first distillation column. The first distillation column removes water from the slurry to be distilled and recycled into section 3 for more use. Because of chemical properties, ethylene glycol adheres to water, and evaporation can be used to separate it from the water as well in the distillation column. This should yield the used enzyme, and tests will be run to determine future efficiency in recycling the catalyst. The catalyst, ethylene glycol, and water will all be re-introduced into the Biocycling process, making the process cyclical with extremely low waste sources.

5.3 Key Assumptions

AmberCycle Industries operates in the field of synthetic biology, a relatively new genre of biotechnology that is projected to play a large role in the development of biological application in the future. That being said, there are some assumptions AmberCycle has considered in the development of our technology and proposed industrial expansion. The most crucial of which pertains to our catalyst, and its enzymatic rate. The mechanism constructed by the UC Davis iGEM is currently unable to achieve such a degradation rate, and by no means is AmberCycle Industries proposing the current maintenance of such an enzyme. Comparing our current degradation rate with the rate required to make this endeavor profitable, significant improvement must still be made to the catalyst.

Likewise, we are assuming allocative efficiency in that all mechanical processes work well with no drop in efficiency.

5.4 Suppliers

With our proposed process, the only input that will incur a cost is the quantity of discarded PET. There is a plethora of suppliers of the plastic material, on a local, national, and international level. For startup, AmberCycle Industries will purchase processed PET from Carpet Collectors, a carpet recycling service based in the western United States. Carpet Collectors currently provides a carpet removal service to consumer and corporate customers, and processes the carpet for nylon fibers, which are recycled. Carpet consists of 40-55 percent PET by weight, and Carpet Collectors currently sells the processed flakes to cement kilns as an energy source. A partnership with corporations such as Carpet Collectors will ensure supply security as well as provide members to an initial customer base, which is crucial to the growth of any startup company.

5.5 Facility and Equipment Conditions

As outlined, our process involves 4 principal parts, all of which require specific infrastructure and process requirements to sustain.

Infrastructure: For our factory operations, 6 2600 Gallon Fermenters will be purchased, and housed to carry our the processes in section 2. Assuming a degradation rate of 20 grams per kilogram of PET per hour, each fermenter would be able to degrade 417.32 kilograms of PET per ton of PET per operational day. Each tank is capable of holding 11.39 tons of material each day.

6.0 Market Analysis Summary

PTA production, once a booming industry almost singularly comprised of United States corporations, has since decreased due to increased textile production in Asian and middle eastern markets around the 1990's. Up until the global economic downturn in 2008, demand for terephthalic acid had consistently rose 6-8% each year. Current methods of producing PTA mainly involve the compound p-xylene, whose price has been on the rise, currently at $0.75 per pound. International prices for PTA average at around $0.67 per pound, however prices in the United States trend higher due to rising material costs, but fixed contracts, which is preventing increases in profitability.

When looking at the financial landscape for such a chemical, certain groundwork and assertions must be understood relating to the process and key factors. PET is mainly comprised of Monoethylene Glycol (MEG) and Terephthalic acid. MEG is produced at very cheap rates, and current means of producing terephthalic acid rely on its main constituent, paraxylene. Paraxylene is a pertroleum based product, so the transparent connection between crude oil prices and PET leads to high costs in terms of feedstock volatility. Globally, PET production grew by 5.6m tones in 2010, and is expected to increase another 4m tonnes (7%) to 60m tones in 2012, according to Philip Gibbs, chairman of PCI Xylenes & Polyesters. Over the next 5 years, global PET production is expected to increase to near 80m tonnes.

The availability of feedstocks of PTA complicates the outlook. Although companies are progressively pursuing developments in PTA infrastructure, limited supply of paraxylene (PX) will constrain production and drive up prices of PET producers globally. Rajen Udeshi, president of the polyester chain at Reliance Industries, estimates that "fiber consumption demand in the north American region is growing around 1.5 times faster than the rate of aggregate growth of polymer producing corporations." If this 6 percent difference is maintained, the Americas will need about 1.3m tonnes of additional fiber every year. With cotton production unlikely to increase beyond 23m-24m tonnes/year, the incremental requirement will have to come from polyester. The world will therefore require an additional 3.5m tonnes of PTA each year.

6.1 Target Market Segmentation Strategy

There is a clear need for PTA, as demand is expected to increase worldwide to provide for an increasing population and uses for recycled plastics. An India Case Study has indicated that by 2022, the deficit between PTA production and PTA use will exceed 45%.

7.0 Competitive Edge

Coupling our unique process with the generation of high value products, the advantage we provide compared to other companies is clear.

7.1 Milestones

There are certain markers that indicate stability and projected growth of AmberCycles propagation, which we have listed out below. It is with the intent to map out future plans that we have developed milestones to give those interested in products and processes of AmberCycle an idea of the direction we aim to take in the development and utilization of Bioindustrial practices.

Goal 1: Continue the development of Bioindustrial enzyme; strive to reach 10-20 grams/kg hr.

Goal 2: Develop infrastructure for the up-scaling of degradation to an industrial level. In order to be competitive, AmberCycle must produce 100 lb PTA/day.

Goal 3: Expand customer base to improve product marketability, contract with waste management NGO or municipal organizations for the expansion of environmentally friendly waste management techniques.

Goal 4: Further improve process design and efficiency. Collection of PET, mechanical separation, and biomass effectiveness exemplify variables that can be improved with investment into research and development.

Goal 5: Expand product and technology base, possibly to develop means to recycle and remove other classes of plastic polymers through organic approaches to degradation and reutilization of component chemicals.

8.0 Financial Plans

A thorough economic analysis was conducted regarding the development of AmberCycle Incorporated as a fully functional industrial institution. Detailed input summary cost summary, cash flows and profitability measures are presented in the next few pages.

Fixed Capital Investment is summarized in the previous section, which is estimated to be $5 million.

Fixed Cost of the plant is divided mainly into operations, maintenance, operating overhead, property taxes, depreciation and insurance, and royalty costs. Fixed Costs is estimated to be $2 million a year. According to the framework described in Product and Process Design Principles, 3rd Edition by Seider et al. (Seider, Seader, Lewin, & Windagdo, 2009), we have estimated that 2 operators are required per shift for our continuous-flow plant. The plant can be divided into one organic matter processing section, one solids-fluids processing section, and two fluids processing sections. Established moderate sized plants containing these sections require 5 operators per shift, however for startup we will begin with 2 operators to reduce initial capital investment.

Variable Cost of the plant is calculated based on the amount of PTA produced. Raw materials cost $0.184/lb of PET and utility costs $/lb of PTA, which sums up to be $0.366/lb of PTA produced. This is around 54 percent of the selling price of crude PTA. General expenses related to the business operations of AmberCycle Industries are estimated to be 16 percent of the total variable cost. (Signifies cost of best way to currently produce PTA)

Currently, the market average price of PTA falls around $0.67/lb, according to data from the Chicago Mercantile Exchange as of September 2012. Utilizing these factors, along with ICIS Chemical Market Intelligence for growth projections over the next five years, the economic analysis yields a return on investment of 11 percent, for capital investment and collaboration. (Side Note: PET prices move seasonally, with a Sept 2012 price of $385/metric ton, according to CalRecycling. Need to incorporate.

8.1 Important Assumptions

One of the most important factors to consider in terms of developing a business is the price stability of goods and services. In specific, the price of PET fluctuates monthly. For the sake of calculation, our financial calculations were conducted using a price of $367/ton CFR(Cost and Freight) of PET for the month of October 2012, provided by CalRecycle. Likewise, the price of PTA maintains an average price of around $1400/ton CFR, with fluctuations moving price up to $1600/ton CFR and down to $1200/ton CFR. A method to eliminate this supply-side risk is through the employment of long-term contracts with partners and corporations. BP, the world's largest and leading producer of PTA, can offer a stable price of $0.67/lb of PTA CFR due to 5 and 10 year contracts it has established with conglomerates such as 3M, which is attractive to customers and consumes of BP PTA.

8.2 Projected Profit and Loss

Once functional, this process will yield

17000 tons of Terephthalic Acid per year

21250 tons of pollutant PET removed from the environment

Total Permanent Investment

Cost of Site Preparation: 7 percent of total start-up cost

Cost of Service Facilities: 5 percent of total start-up cost

Allocated Cost for Related Facilities: 4 percent of total start-up cost

Cost of Contingencies and Contractor Fees: 3 percent of total start-up cost

Cost of Land: $75,000

Licensing Fee: $50,000

Cost of Plant Start-Up: $2,000,000

8.3 Projected Cash Flow

Operations		
Direct Wages and Benefits:	$35 /operator hour (5 operators per day)	$318,500
Direct Salaries and Bene-fits:	15% of Direct Wages and Benefits	$47,775
Operating Supplies and Services:	6% of Direct Wages and Benefits	$19,110
Technical Assistance to Manufacturing	$60,000.00 per year, for each Operator per Shift	$300,000
Control Laboratory:	$65,000.00 per year, for each Operator per Shift	$325,000
Operations Subtotal		**$1,010,385**
Maintenance		
Wages and Benefits:	4.50% of Total Depreciable Capital	$90,000
Salaries and Benefits:	25% of Maintenance Wages and Benefits	$79,625
Materials and Services:	100% of Maintenance Wages and Benefits	$318,500
Maintenance Overhead:	5% of Maintenance Wages and Benefits	$15,925
Maintenance Subtotal		**$504,050**
Operating Overhead		
General Plant Overhead:	7.10% of Maintenance and Operations Wages and Benefits	$58,401.05
Mechanical Department Services:	2.40% of Maintenance and Operations Wages and Benefits	$19,741.20
Employee Relations Department:	5.90% of Maintenance and Operations Wages and Benefits	$48,530.45
Business Services:	7.40% of Maintenance and Operations Wages and Benefits	$60,868.70

Operations Subtotal	___	**$126,672.70**
Property Tax and Insurance		
Property Taxes and Insurance:	2% of Total Depreciable Capital	$40,000.00
Taxes and Insurance Subtotal	___	**$40,000.00**
Straight Line Depreciation		
Direct Plant:	8.00% of Total Depreciable Capital, less 1.18 times the Allocated Costs for Utility Plants and Related Facilities	$116,190.43
Straight Line Subtotal	___	**$116,190.43**
Total Fixed Cost		
Total Depreciable Capital	___	**$2,000,000.00**
Allocated Cost	___	**$1,641,107.70**

9.0 Other Considerations

9.1 Process Startup

The cost of startup will range around $2,000,000 dollars, per previous company startup costs and intelligence reports for biotechnology. Plants of this proposed size will generate around 150-350 direct and indirect jobs once fully initiated.

9.2 Environment and Safety

Originally, we wanted to optimize our engineered bacteria to live in landfills. Our goal was to break down PET at the source of the problem itself. As a team, we took a trip to Yolo County Landfill and learned that a diverse group of bacteria already lives amongst the debris. However, we also learned that our engineered bacteria would have next to no chance of survival amid the competitive microbes already present. Since our E. coli could not survive in the landfill, we shifted our focus to thinking about how the bacteria would work on an industrial level, with the controlled atmosphere of bioreactors to help the E. coli survive. If our project were implemented in industry, this would have the added bonus for safety of containment, which would prevent any concerns associated with releasing the bacteria into the environment.

Our team made sure to perform a thorough analysis of safety for all parts of our project, since safety for researchers, the public, and the environment are all important. We work within a Level 2 Biosafety Lab, as defined by the Laboratory Biosafety Manual. This facility is well equipped to work with all the strains of E. coli we used. We used MG1655, DH5α, and K12, all of which are Risk Level 1, meaning these strains pose no pathogenic risk to humans, and were completely contained within the lab.

We always made use of protective gear, such as wearing gloves at all times, face masks when using UV lamps, and lab coats when appropriate. All of our waste was autoclaved on site as well, and all tools and glassware thoroughly cleaned after each use. We worked with ethylene glycol during our experiments, which is toxic to the kidney, liver and central nervous system, as well as a skin and eye irritant. Obviously, we wanted to be very safe when using this chemical, so we made sure to consult with our advisers on how best to handle it. When using ethylene glycol, we always worked under a fume hood and wore lab coats. We had a separate waste bottle for all of the byproducts with ethylene glycol, so that the waste could be treated and properly disposed of.

9.3 iGEM Entrepreneurship

Over the past few years, we have seen the iGEM competition go from a small venture to the premier synthetic biology competition for undergraduates at universities internationally. With just under 200 teams competing in this years competition, many new technologies and solutions to important problems are being tackled in creative and intuitive ways. But after the competition, what happens to the work on these novel solutions? The iGEM competition has done great work initiating the Entrepreneurial division of the competition, where teams can look at the economic implications of their project, and begin to think about factors pertaining to the proliferation of these ideas in the public market domain.