Eat Prosperity Campaign: Techno-Economic Forecasting of a Food Waste Collection Scheme for Growing Economically Sustainable Algae on Landfills

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ABSTRACT

Global mean surface temperatures and global methane emissions have steadily risen over the past 40 years. Residential food waste disposal has increased by as much as 30% since the beginning of the COVID-19 pandemic, and landfills are reaching capacity more quickly as up to 40% of food is thrown into the trash (USDA, 2010). A residential food disposal collection campaign to recycle food waste and carbon emissions could be implemented to grow economically sustainable algae on landfills. NASA Surface-Adhering BioReactor (SABR) technology optimizes growth performance of algae, reduces the capital expenditure by 69% compared to clear polyvinyl chloride (PVC) photobioreactors, and the landfill infrastructure reduces the operational costs for growing algae by 42%. The novel Eat Prosperity Campaign food waste collection and landfill biodiesel model may outcompete standard drilling methods, yielding revenue greater than $140 million in biofuel, diverting more than 200,000 tons of municipal solid waste, recycling 13,000 tons^2 of methane from food waste, and upcycling as much as 8.31 million metric tons^2 of CO2 from landfills, converting the sequestered carbon into $498.6 million in carbon tax credit 45Q. The Eat Prosperity Campaign model for food waste collection provides a significant abatement of global greenhouse gas emissions potential within a communal behavioral change. By allowing residents within communities the opportunity to recycle at the source of disposal and actively participate, business-as-usual estimations of global greenhouse gas emissions could be offset by as much as 47 $GtCO_2$ in 20 years compared to current 2030 projected estimates.

INTRODUCTION

Due to the rise in atmospheric temperatures of our planet, storms are becoming more severe, ocean and atmospheric temperatures have continually increased, and climate scientists fear that we need to begin diverting carbon emissions immediately and upscale our efforts. The world needs an economically sustainable solution to reverse the acceleration of carbon emissions that will meet the energy demands of our planet and provide for the common welfare of people. By implementing a county-wide food waste collection campaign and transforming our landfills into energy factories, the Eat Prosperity Campaign will provide substantial ecological relief by recycling food waste and methane into algae feedstock for the production of biodiesel.

Landfills and other methane capture sources represent an untapped energy opportunity. Humans throw out up to 46% of all food waste into the trash, which ends up deposited in our landfills, emitting nearly 5 $GtCO_2$ each year, or 9% of total greenhouse gas (FAO, 2011). By separating our food waste at the commercial, or even residential level, we will be able to recycle food waste and convert it into a potent nitrate source for plant growth, specifically a feedstock for algae growth inside bioreactors. Instead of purchasing CO_2, the methane captured at the landfill can be combusted for its electricity, and waste CO_2 emissions can be utilized as a carbon feedstock for algae growth. The combination of recycling waste CO_2 and ammonia emissions vastly improves the growth rate of algae and substantially reduces its operational costs. The fate of our communities will rely on how well we decide to recycle properly.

SOCIAL AND ENVIRONMENTAL ANALYSIS

A.) Global Temperatures

There are many obstacles that need to be overcome if we plan on living in a sustainable society. Global temperatures and global carbon emissions increases have been correlated since the industrial revolution. Figure 1 below shows a linear increase in both global temperatures and global methane emission with no indication of these metrics leveling out or declining. North Carolina governor, Roy Cooper, proposed Executive Order 80 to set electricity sector targets and reduce carbon pollution by 70% below 2005 levels by 2030 and attain carbon neutrality by 2050.

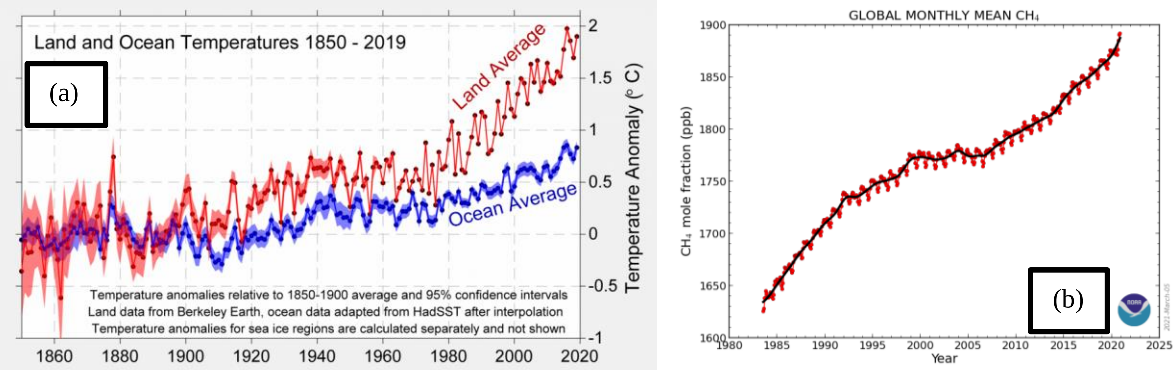

Figure 1. (a) Global mean land and oceanic temperature trend (Berkeley, 2020) and (b) Global methane emissions measured by the NOAA (NOAA, 2021).

“Despite the fact that CH_4 is emitted into the atmosphere in smaller quantities than CO_2, its global warming potential (i.e., the ability of the gas to trap heat in the atmosphere) is 25 times greater” (Cui et al, 2015). The majority of the global commercial energy consumption is primarily due to oil, followed by coal and then natural gas, shown in Figure 2. Landfills, natural gas, and petroleum systems make up 45% of methane emissions. Food waste deposition accounts for 11% of global greenhouse gas emissions (World Wildlife Fund, 2021). Converting to a carbon neutral, 100% renewable energy sources will likely take decades, as only 9% of all energy consumption is renewable. Crude oil is in finite supply, and the environmental impacts of oil drilling has been seen in both air quality and oil spills that threaten to pollute our waters and large aquatic ecosystems. The state of North Carolina has fought numerous legal battles against Dominion Energy and Duke Energy to cancel the Atlantic Coast Pipeline (ACP), and on July 5th, 2020, the ACP was cancelled. In 2020, President Trump signed an executive order that omitted new leases from drilling offshore the coasts of North Carolina until 2032. The two environmental legislation boosts for the state of North Carolina could have economic impacts, as commercial energy consumption is expected to rise, along with oil, gas, and electrical prices over time.

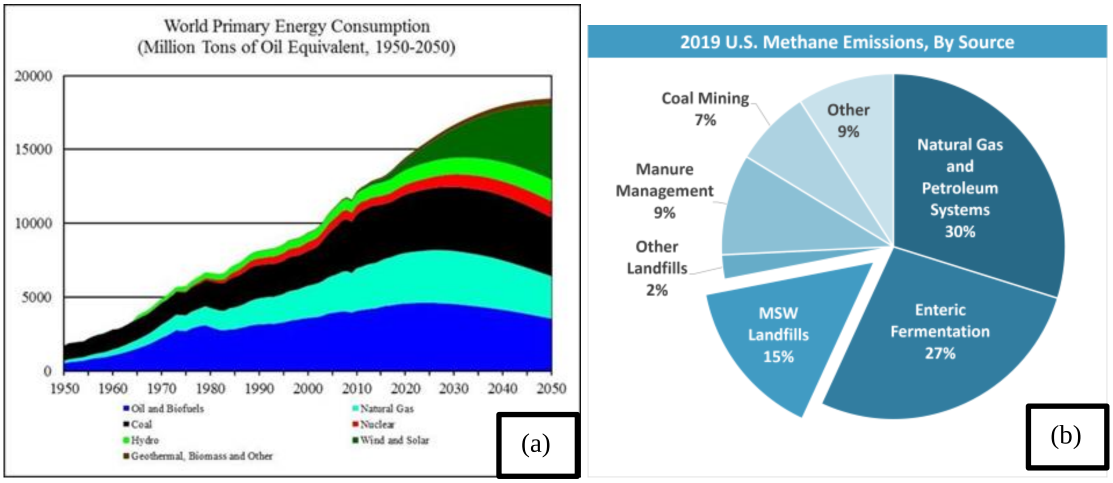

Figure 2. (a) Global primary energy consumption and projections – million tons of oil equivalent (Jiang et al, 2018) and (b) 2018 U.S. methane emissions by sector (EPA, 2020).

B.) Landfill Crisis

There is a notable landfill crisis in the United States, as China's "National Sword" policy banned the import of most plastics and other materials due to "dirty" recycling in January of 2018. China has been collecting the majority of recyclable waste from around the world for over 25 years. Many communities are being forced to throw away their recyclables, resulting in landfills approaching their peak capacity at an accelerated rate, or having to burn their trash, which releases even more carbon emissions. The active Wake County landfill is projected to reach peak capacity by 2040, with "no plan B," and "since the COVID-19 pandemic, residential food waste increased by 30%," says John Roberson, Solid Waste Director of the South Wake County landfill.

In the United States, food is wasted at an estimated 30-40 percent of the food supply (USDA, 2010). This estimate, based on estimates from the USDA's Economic Research Service of 31 percent food loss at the retail and consumer levels, corresponded to approximately 133 billion pounds and $161 billion worth of food in 2010. "This amount of waste has far-reaching impacts on society, including wholesome food that could have helped feed families in need is sent to landfills, and other implications including land, water, labor, energy, and other inputs used in producing, processing, transporting, preparing, storing, and disposing of discarded food." Food compost is being primarily used a regenerative soil feed, but there needs to be a more economical initiative that will incentivize recycling at the industrial and residential level, as well as optimizing efficiency at recycling facilities.

Residential wasted food generation is estimated by establishing a nationwide per capita estimate that is based on curbside sampling studies, and the commercial and institutional wasted food generation estimates are based on industry-specific studies from across the nation (U.S. Food Waste EPA, 2018). The U.S. Environmental Protection Agency (EPA) estimated that 63.1 million tons of food waste was generated in the commercial, institutional, and residential sectors in 2018. Landfills accumulated an estimated 35.3 million tons of wasted food, or 56% that went to landfills in 2018, representing 24.1 percent of all MSW landfilled. As depicted in Figure 3, residential food waste made up the largest portion of food waste generation at 37.5 percent in 2018. In October 2014, California Governor Jerry Brown signed AB 1826 Chesbro (Chapter 727, Statutes of 2014), requiring businesses to recycle their organic waste, including multifamily residential homes and apartments.

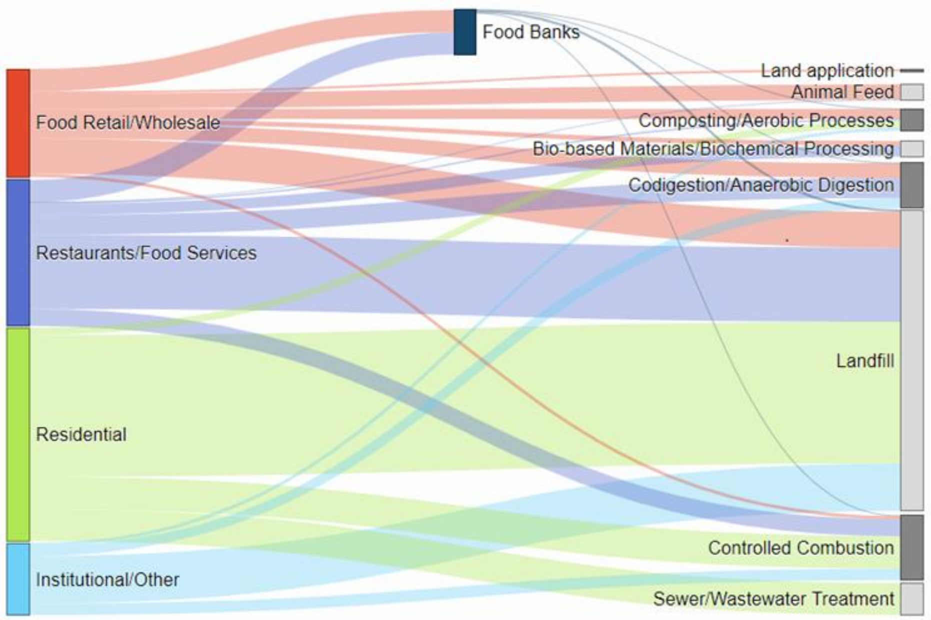

Figure 3: Food waste generated and management pathways, 2018 (U.S. Food Waste EPA, 2018)

C.) Business Opportunity

Eat Prosperity Campaign is a unique business opportunity that can be conveniently integrated into law as garbage trucks are already scheduled to collect waste and deliver it to landfills. The average landfill in the U.S. is roughly 600-acres with more than half of the landfill being unused. Once all of the waste cells of the landfill in a given district are filled to capacity and reach the maximum height, they are typically covered with topsoil, vegetation, and left to settle for what could be decades. The perimeter of the landfill also has available land, and capturing the carbon emissions onsite could reduce foul smells for the surrounding community.

Grocery stores and farms are the predominant compost generators, but there is a convenient solution that will allow the residential community to participate in recycling. The primary way Californian's collect food waste is in a large, labeled trash can, but this method often smells and makes indoor food waste disposal difficult. To encourage residential participation in the Eat Prosperity Campaign, the large trash bin could be reinvented into a downsized, one-way valve tin trashcan that would be conveniently stored under the kitchen sink, preventing both leaks and odors. Through curb-side collection, full tin trashcans will be collected and swapped with empty, refurbished, clean tin trashcans.

Consider the "propane tank model": empty propane tanks are swapped out for refurbished, filled ones. Same concept, except once the tin trashcan is full, it is left at the curb. Modified trucks containing fresh, empty tin trashcans will swap out the fresh cans for the filled trashcan. Curbside pickup could be streamlined by utilizing inexpensive LiDAR (Floyd et al, 2016) radio-frequency identification microchips invented at N.C. State, for automated, precision accuracy of roadside pickup and drop off of tin trashcans. Within the modified trucks would be automated organization to maximize storage space and efficiency during collection. RFID chips could signal when they need to be picked up from the street and assist in data collection for calculating how much food waste each consumer recycles.

Collectors will pick up residential tin trashcans on the same scheduled route, adding simplicity for both consumer and collectors. Separating the waste at the disposal source allows reuse of nutrients by preventing it from being contaminated by toxic chemicals at the landfill. Collectors will then unload the food waste to be screened and grinded at the landfill. The West Salem Organic Processing System converts green waste, food waste, and mixed organics into high quality feedstock for compost within a streamlined feeding, screening, cleaning, sorting, and grinding system.

Once food waste is grinded, it could be stored separately in anaerobic digestors called leachate tanks. Algae fixes carbon at a higher rate for NH^{+4}-grown cells (ammonia) compared to growth with NO^{-3} (nitrates) under anaerobic conditions (Lachmann et al, 2019). The use of hyper-ammonia producing bacteria would yield higher ammonia fixation compared to other bacterial species to produce a greater concentration of ammonia. Landfill gas must be continously extracted by drilling perforated tubes into the landfill cells, and using a blower, the gas is sucked from the landfill. Methane is captured and subjected to high pressure from refurbished diesel engines to produce electricity in the landfill gas-to-energy facility, and waste CO_2 emissions is made as a byproduct. Methane collection must reach a continuous threshold to be utilized for combustion in gas-to-energy.

The majority of methane captured at a landfill does not get used as energy, but rather, is flared and combusted into CO_2 as a “not as bad solution.” Recycled methane generally produces 7.5 MW of electricity a year. This amount of electricity supplies nearly 15,000 homes in Wake County, which is more than an adequate electrical supply to power a 400-acre algae farm onsite. The abundant CO_2 would be recycled as a feedstock for accelerated and cost effective algae growth. Landfills have clean water onsite that is routinely tested for contamination. What is traditionally used for dampening to suppress debris, dirt, and dust from moving everywhere, could be used as an adequate water supply to further reduce operational costs.

ENGINEERING ANALYSIS

A) NASA SABR Technology

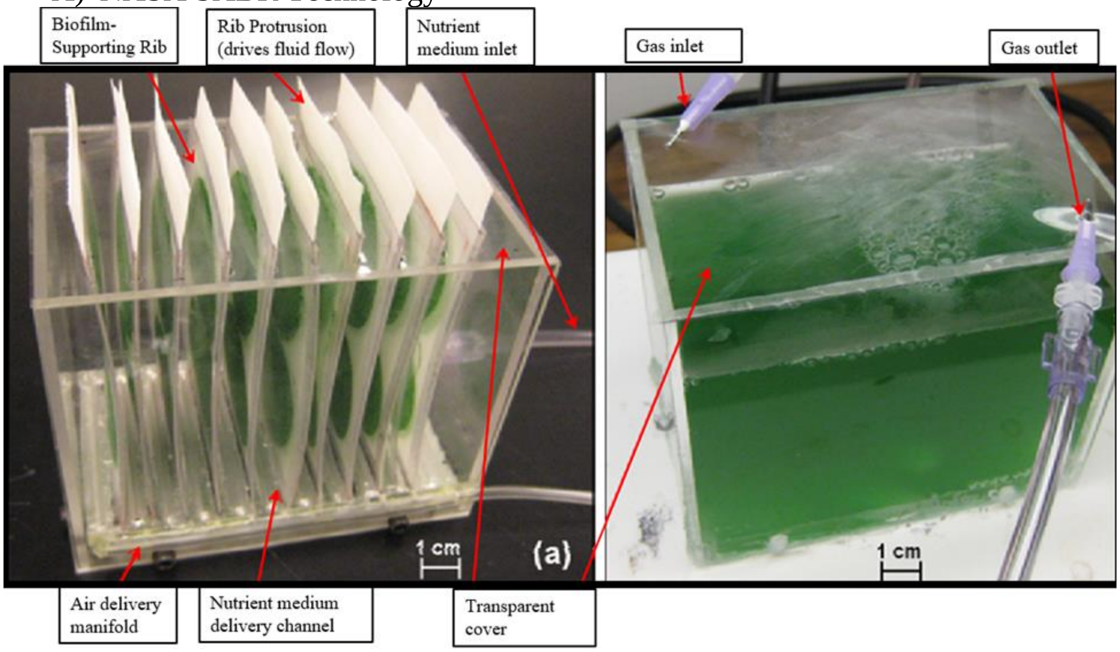

Figure 5. Prototypes of (a) Surface-Adhering Bioreactor (SABR) and (b) conventional planar photobioreactor (CPP) (Murphey et al, 2012).

NASA's Surface-Adhering BioReactor (SABR), shown in Figure 5, is a novel microbial cell cultivation platform made of thin-film polyethylene that "mimics the way vascular plants use transpiration to passively deliver water and nutrients to their cells" (NASA Tech Transfer, 2018). Nutrients are transported using evaporation and the cohesive property of water, pulling through the device with a high degree of control, on an as needed basis. This water delivery method "eliminates the hydrodynamic shear stress on the cells and eliminates the need for a pump, effectively decreasing the working volume of water needed for cultivation by a factor of 25 compared to planktonic (PVC) bioreactors." Growing densely packed microalgae biofilms in three dimensions rather than in suspension improves yields by as much as 100-fold more product and decreases energy requirements compared to similar algal growth systems.

B) Sustainable Agriculture

Algae grown in bioreactors is the definition of sustainable agriculture, as its growth has no impact on stripping soil of nutrients unlike other crops grown for biodiesel, ethanol, or livestock feed. Bioreactors play a vital role in the landfill model as it prevents environmental contamination and better controlled growth yields. Algae is a single cellular organism that grows very quickly and expands uniformly under optimal nutritional and temperature conditions. This trait allows 90% of the yield to be harvested and utilized for biodiesel production, and the remaining 10% is used to continually expand and grow.

Optimal temperature conditions apply when grown in the SABR, as transpiration enables a passive cooling system for the cells. Mitigating heat, either externally or internally due to cellular activity, prevents overheating that could lead to decreased productivity or even cell death (Murphey et al, 2012). Some microorganisms may even eat biomass and decrease yields, which make critically necessary to integrate a microbial detection monitoring system. Bioreactors and nutrient storage sources, such as the food waste collection trashcans and anaerobic digestors, should be equipped with microbiome gas-detection sensors and a bioinformatics service to provide next generation sequencing. Continuous microbiome monitoring coupled with the Internet of Things blockchain would create a cloud-based, decentralized augmented intelligence network for optimizing growth potential and maintaining a healthy food ecosystem.

C) Strain Selection

Strain selection and evaluation is one of the most critical steps in designing high efficiency algal systems. There are thousands of strains of algae that are being considered as biofuel feedstocks, where the "overall, the technical viability of an algal production system hinges on the intrinsic properties of the selected algae strain, indicating a need for greater species screening, as well as research on culture conditions and production systems." (Ali et al, 2014). For example, the red macroalgae *Asparagopsis taxiformis* is a potent natural antimethanogenic that reduces methane production during in vitro fermentation with rumen fluid by up to 99% in livestock (Kinley et al, 2016). Enteric fermentation accounts for 28% of U.S. methane production, as shown in Figure 2. Algae consists of an abundant amount of fats and proteins with no sugar, which could aid in raising heavier, healthier cattle, faster. Strains such as *Schizochytrium limancinum* when introduced to a cattle herd, yield similar omega-3 to omega-6 fatty acid ratios from their meat as from fish (Till et al, 2019), and boosting productivity by as high as 7%.

Picochlorum oklahomensis is a viable strain for biofuel manufacturing because of its high oil and protein content, as well as its biomass productivity (Zhu and Dunford, 2018). There is also heavy interest in genetically modifying algae to improve biomass growth rates and fatty acid production. Algae has been shown to have the highest photosynthetic efficiency at 6.7% compared to other plants, such as moss at 4.4% or high plants 5.3% (Schmidt, 2020). Photosynthetic efficiency improves carbon fixation characteristics, which increases biomass yields, oxygen production, and atmospheric carbon reduction.

D) Silver Nanoparticles Extraction

The addition of silver nanoparticles in the extraction matrix should considerably improve the lipid extraction efficiency. Silver nanoparticles attach themselves to the surface of cell wall, and from a combination of electrostatic forces and molecular interactions, rupture and perforate the cell membrane, releasing the fatty acid contents. This technology may be licensed from Louisiana State University as a cost-efficient, environmentally friendly approach to extract lipids from algae. Centrifuges are currently widely used, but the cost of harvesting is about $1500-3000/ton of dry algae, which alone contributes to 15-25% of production cost of algal biomass (Bai et al, 2013). Silver nanoparticles increases efficiency of lipid extraction by 30% - 50% by eliminating the drying step required by conventional techniques because it can be used on wet algal paste. Silver nanoparticles can also improve lipid extraction efficiency without the need for large amounts of solvents, high temperatures, agitation, and pressure, and is particularly useful for single cellular organisms with thick cell walls.

ECONOMIC ANALYSIS

A) Capital Expenditure Analysis – Bioreactors

The traditional algae farm model utilizes clear PVC pipes, which are unable to compete with oil drilling prices as they are too capital intensive and reduces the return on investment. Algae grown in a pond is less capital intensive, but the operational costs are much higher and do not compare to achieving the same yield as bioreactor farms. Pond systems are exposed to the elements, including the toxins and fly ash contamination, thus should not be considered in this model. The capital expenditure to renovate land should be considered negligible for operating on public land. In a technological-economic analysis of installing a clear PVC photobioreactor system, the capital cost of a 1000-acre facility was calculated at $104.2 million (Davis et al, 2011). Comparing materials, the cost of thin polyethylene film compared to clear PVC is just 3.4% the costs for the material alone. The capital expenditure to install a thin film photobioreactor system was estimated at $8 per meter^2 (Davis et al, 2011). The total capital investment necessary to install a 400-acre SABR system costs $13 million, a 69% capital cost reduction compared to installing clear PVC bioreactors.

B) Operational Cost Analysis – Bioreactors

Based on a 1,000-acre algae cultivation bioreactor farm, the total operating expenditure percentages for ammonia and carbon nutrients, electricity, water, and land shown in Figure 6, surmounted to 42.3% of the total operating costs. The total operating cost for each 400-acre landfill algae farm equates to $5.24 million annually, a cost savings of nearly $4 million.

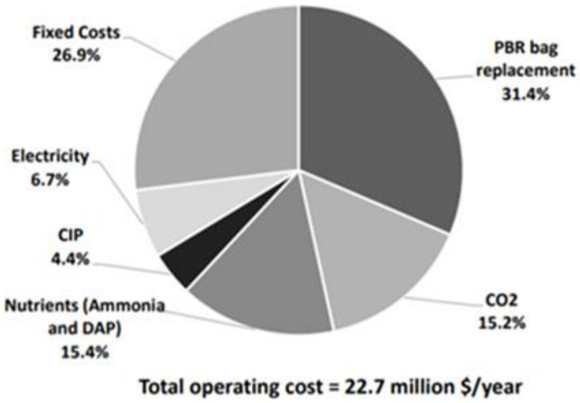

Figure 6: (left) Operational expenditure by sector in 1000-acre study of thin-film photobioreactor (Zhu et al, 2018).

C) Capital Expenditure and Operations/Maintenance Analysis – Collection

Waste collection is the most expensive component of any landfill operation. The following assumptions were made to estimate calculations for a collection scheduled once a week per home for 450,000 residential homes in a county.

Based on a five-day collection schedule, 90,000 collections would be scheduled per day during an employee 8-hour workday. The route collection is expected to be about 60 pickups per hour, with collection/swap times of 45 seconds, and moving from house to house at 15 seconds for a total of 60 seconds. The food waste collection schedule is as follows: trucks leave the garage and begin pick-up on their route within 30 minutes. Each driver spends 3 hours on their route collecting the food waste trashcans, and spend 10 minutes returning to the transfer station to unload. Unloading the full trashcans and loading empty, furbished trashcans requires another 10 minutes, followed by 5 minutes to refill gas. The workers will have a 30-minute lunch break, and will begin pickup on their route from the transfer station within 10 minutes. The drivers will collect on route for 3 additional hours with a 15-minute restroom break, followed by returning to the transfer station, unloading full trashcans, loading refurbished trashcans, and filling gas for 25 minutes. The driver will return to the garage from the transfer station within 15 minutes. The time spent collecting at residential homes is 6 hours, allowing for 360 pick-ups per day, per truck. 250 trucks will be required for pickups on weekday on route, along with 250 drivers.

The approximate dimensions of the automated food waste collection truck should be compared to a smaller semi-trailer, at a length of 42 feet long, 8.5 feet wide, and 12 feet in height with multiple rows. The tin trashcans would be 12-inches in diameter and 2 feet high, allowing for an automated trailer threshold capacity of 179 tin trashcans. With an 10% operational maintenance budget, 275 trucks should be available. The net present value of each truck per year is the capital expense ($220,000 per truck) times 3% compounded present interest (14.25%) plus the operational and maintenance expense ($50,000), minus decommissioning value times interest ($75,000 per truck times 11.25%), for a sum total of $72,912. The net present value operational costs for 275 trucks are just over $20 million annually.

Labor costs should be inferred by assuming 1 truck per 1 employee, with 250 daily route trucks needed requiring 250 employees to collect. Based on an 8-hour workday of 250 employees per truck is 2,000 labor hours. Multiply labor hours by 5 days per week at $20 per hour for a labor expense of $200,000 per week, or $10.5 million for annual labor. Gas prices will continue to rise, but fuel efficiency may be improved. Assume current fuel efficiency of 3 miles per gallon per truck, garage to route is 15 miles, two route trips around 10 miles, route to transfer station of 17.5 miles for three trips, and 10 miles from transfer station to garage for a total of 52.5 miles driven per day. With diesel prices at approximately $3 per gallon times 52.5 miles, times 250 trucks per day for 5 days a week will cost $3.4 million annually for gas.

The total annual operational costs for labor ($10.4 million), net present value of trucks ($20.5 million), gas ($3.41 million), 400-acres of SABR ($5.24 million), and a next generation sequencing monitoring network ($500,000) with 20% overhead sums to be $48 million per year. The total annual cost per household in a community of 450,000 houses is $106.67. On average, people waste up to 1 pound of food waste per day (USDA, 2010), and of a population of 1.112 million, 406 million pounds of waste can be diverted from landfills each year, or 202,940 tons annually. The average cost per ton of compost can be reduced from a commercial price of $4,000 per ton to just $236.5 per ton, a 94% reduction in operational expenses. Food waste produces 65 kilograms of methane every year (FAO, 2011). The amount of methane reduced is equivalent to 13,191 tons^2 per year from 202,940 tons of food waste encapsulated and diverted. Landfill carbon emissions produce as much as 16,327,448 tons^2 of carbon emissions annually, and a portion of this could be recycled.

Each household should have their own food waste tin trashcan. The equivalent cost of a 20-pound propane tank is $20. The minimum number of tin trashcans needed is about 2 per household, as one will need to be replaced when one is picked up, for a total of 900,000 per county. The cost of residential food waste collection cans is $18 million, with RFID chips cost of $0.01 per can. The capital expenditure is calculated to be $500,000 for the compost grinder and screener, a $250,000 anaerobic digestor, $200,000 for 400-acres of gas-sensors, $137,000 cost of LiDAR devices on trucks for automated pickup, and a 400-acre SABR installed landfill for $13 million. The capital expenditure and annual operational expenses total $32.5 million and $40.05 million, respectively.

D) Biodiesel Revenue Projections

Biodiesel has not made headway due to economic inefficiencies of capital and operational expenses. To make algae-based biofuels economically viable, the cost of production has to be brought down to $250/ton from the current cost of $5000/ton (Das et al, 2012). Capital investment and operational expenditures are too steep, inevitably preventing a competitive price for biodiesel to be sold. “An acre of corn produces approximately 400 gallons of ethanol per year; an acre of algae produces up to 100,000 gallons of biofuels per year” (Edwards, 2011).

The expected yield of a 400-acre algae farm produces 100,000 gallons of biodiesel per acre. The expected revenue when sold at the national average of diesel at $3.225 per gallon yields $129 million per year, per landfill. The SABR technology was intended to be utilized in space, however, the proposed Mission to M.A.R.S. (Mobilize All Resources for Sustainability) emphasizes the necessity to commercialize NASA technologies and provide for the common welfare by improving our socio-economic involvements. The revenue estimate is more than likely substantially lower compared to its potential revenue. The current estimate has not evaluated the SABR and silver nanoparticles in large-scale algae farm operations.

Imagine no more drilling for oil or oil spills in our oceans, less waste and extended life of landfills, an unlimited supply of fuel, outcompeting oil drilling prices resulting in stable gas prices, and best of all, profit from recycling carbon emissions and trash. The revenue generated from biodiesel production would offset the initial capital and operational expenses within its first year. Biodiesel should be sold to airlines and vessels, for biofuels are more efficient and release lower levels of greenhouse gas emissions compared to fossil fuels (Ramos et al, 2016).

ABATEMENT POTENTIAL

Worldwide, landfill emissions account for approximately 1.4 gigatons of carbon dioxide equivalents per year ($GtCO_2$-eq/year) of global anthropogenic greenhouse gas emissions relative to total emissions from all sectors of 57.4 $GtCO_2$-eq/year (Bogner et al, 2008). Of the 4.4 $GtCO_2$-eq/year food waste emissions, North America is the most wasteful at 860 $kgCO_2$-eq/year, followed by Asia at 810 $kgCO_2$-eq/year and Europe at 680 $kgCO_2$-eq/year (FAO, 2011). The Eat Prosperity landfill model has abatement potential for offsetting or providing restorative (negative) emissions in multiple sectors including cropland nutrient management, waste recycling, biofuels, reduced pastureland and intensive agricultural conversion, and retrofitting coal and gas plants (McKinsey&Company, 2013). One acre of algae can recycle up to 18,000 tons[2] of CO2 annually per acre, or 7.2 million metric tons for each county landfill [Singh et al], plus 203,000 tons[2] of food waste emissions of 1.11 million tons[2], totaling 8.31 million tons[2] of CO2 sequestered from both landfill and food waste. The abatement potential can be converted into a communities potential earnings of $498.6 million dollars using carbon tax credit 45Q, which provides $60/ton[2] of CO2 sequestered.

The most significant abatement opportunity of the Eat Prosperity model is within a behavioral change of point source waste disposal. By allowing residents within communities the opportunity to actively participate in recycling at the source of disposal, business-as-usual estimations of global greenhouse gas emissions could be offset by as much as 47 $GtCO_2$ in 20 years compared to 2030 projected estimates, as shown in “Major categories of abatement opportunities model” (McKinsey&Company, 2013). With the potential to create sustainable agricultural farms, recycle carbon emissions, replace fossil fuels directly, reduce livestock emissions, and reduce the cost of healthcare, there will be substantial and measurable ecological, economical, and societal impacts.

CRITICAL ASSESSMENT, CHALLENGES, AND OPPORTUNITIES

Technical feasibility of the current state of technologies is needed to analyze pursuing a full-scale launch of the Eat Prosperity Campaign. The NASA SABR thin film bioreactor bags are not in commercial production as of yet, and have only been tested in laboratories for space shuttles. The SABR prototypes would need to be scaled and reproducible to develop for commercial use. The industrial one-way valve tin trashcan has yet to be developed, and N.C. State’s inexpensive LiDAR chips have not begun commercialization production. Modified garbage trucks with an automated arm and sorting chamber will need to be designed, developed, launched, and upscaled. Multiple screening, sorting, and grinding systems are available for separating a clean source of food waste. As mentioned, the landfill infrastructure is ideal for providing land, electrical energy, solar rays, water, nutrients, and carbon dioxide feedstock.

With gas prices estimated to increase in the coming year, the production of cost efficient and regenerative biofuels could not only reduce the need for fossil fuels, but outcompete production if the biofuel yields and revenue provide economic feasibility to compensate for the capital and operational expenses. The silver nanoparticles may be too costly if unable to recover the silver after use, but Louisiana State University's research team is working on developing an inexpensive fiber nanoparticle with the same capabilities.

Next generation sequencing of entire genomes for improving biological monitoring systems are becoming less expensive, faster, and more accurate than ever before. Gas sensing has yet to be incorporated into algal bioreactors for microbiome optimization, however, low-energy gas sensors with ultrasound are being developed at N.C. State University. A bioinformatics service could provide a cross-species analysis to compare how algae impacts livestock intestinal health, and how the livestock that consumed algae impacts human health, closing the food ecosystem monitoring loop.

CONCLUSION

The Eat Prosperity Campaign landfill model will provide an enduring benefit to society as the operational costs to supply nutrients to algae farms drastically reduces as the community becomes more involved. Incorporating novel technologies to reduce capital costs and improve growth efficiencies will create a competitive landscape that may outcompete standard drilling methods. The Eat Prosperity Campaign is meant to be a community-based restoration project to redevelop landfills into energy factories. Although it is a lucrative business model, the intended purpose is for this model to be written into law, similar to the Green New Deal, to jump start the economy as the Eat Prosperity Campaign, offsetting carbon emissions, and curbing the impacts carbon and methane emissions have on our climate. By providing for the common welfare, low-income and underserved populations, the campaign will serve to provide access to essential care and resources, reduce taxes, offset the costs of municipal solid waste collection and recycling, and deliver climate justice.

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