ABSTRACT:

Carbon Engineering (CE) serves the primary purpose of removing CO2 from the atmosphere and converting it into something useful (i.e. clean and affordable transportation fuels). This executive summary discusses a general overview of our cutting-edge technology, addresses the five main fields of engineering present in our production process (mechanical, electrical, chemical, computer science, and materials), and offers room for company improvement based on needed development. Though ahead of our time in environmental sustainability with our net zero emission process, the need for economic support will be obvious throughout this paper.

OVERVIEW OF TECHNOLOGY:

The Direct Air Capture system has four main parts. Initially, an air contactor collects carbon dioxide from the air. A strong potassium hydroxide solution is able to react with carbon dioxide from the air and water. This forms a carbonate solution that can then be transferred to a pellet reactor. The pellet reactor reacts the carbonate with calcium to form calcium carbonate pellets. These pellets can be decomposed in a calciner to produce dense volumes of CO_2. The remaining calcium oxide after the decomposition is rehydrated and moved back to the pellet reactor.

The CO2 captured using DAC can be permanently stored underground to create negative emissions in a process called sequestration. Carbon sequestration permanently stores carbon through biological, chemical or physical processes. Carbon captured from the air is stored in carbon sinks such as saline aquifers, deep soil, reservoirs, ocean water or oil fields. Soils hold four times the amount of carbon stored in the atmosphere. Roughly half of this is estimated to be found deep within soils and 90% of this deep soil is stabilized by mineral-organic associations. Carbon can be stored in saline aquifers, reservoirs and sea water through processes to encourage increased dissolution or biological methods such as seaweed farming. Carbon can also be sequestered in oil reservoirs and can even be used to facilitate enhanced oil recovery. Once the oil reservoir runs dry or is closed, the carbon is then permanently stored deep within the earth's crust, partially or completely counteracting the carbon emissions from the oil.

CE's DAC technology can be used to create large-scale "negative emissions," and ultimately, to produce clean transportation fuels. Various advantages of the DAC technology include scalability, flexibility and efficiency of use, sustainability, and cost-efficiency. The DAC plants can be built at large industrial scales with known supply chains and reliable equipment costs, as it integrates known equipment and processes from other large industries into the new system. They are also location-independent, which doesn't compete for arable land and can be placed in locations where there's abundant, low-cost local energy to power the facility. On a large scale, the DAC technology captures CO2 from the air in a closed "chemical loop" that uses the same capture chemicals and produces minimal waste products. Also, the DAC plants do not create additional CO2 emissions as the CO2 from any natural gas used in powering the system is also captured along with the atmospheric CO2, and both streams are then used or buried permanently underground. These plants can capture CO2 from the air for approximately 100 USD per ton of CO2, which also makes them cost-efficient. DAC's cutting-edge technology combined with conventional, approved equipment makes up for the inefficiency and unsustainability that other industries use to capture CO2, which allows CE to be highly competitive in the field.

Currently, CE is in the process of integrating the balance of equipment required for the process of full "air to fuels", which will use this captured carbon dioxide, as well as water and renewable electricity, to directly synthesize liquid fuels such as gasoline, diesel, or jet. A hydrogen production and fuel synthesis platform will be integrated into the DAC prototype pilot, which will form an “air to fuels” prototype system. Once CE has completed the engineering design for the subsequent full-scale commercial facilities, it can start deploying first projects in leading markets as such British Columbia and California where existing Low Carbon Fuel Standards favor permanent sequestration of atmospheric CO2 and clean fuels such as CE’s.

AREA SUMMARIES:

Chemical:

Chemical Engineering is needed to oversee the chemical processes that dictate Direct Air Capture (DAC) technology. The first step in this process is carbon dioxide capture through wet air scrubbing. A strong potassium hydroxide solution is used which reacts with the CO_2 and water to create a carbonate solution. A pellet reactor purifies the carbonate solution into solid pellets of calcium carbonate so it can be reacted more easily in the following steps. In a calciner the pellets are heated to cause a decomposition reaction, in which the pellets become carbon dioxide gas and calcium oxide solid. Finally the calcium oxide is rehydrated and moved back to step two to create more pellets. This closes the chemical loop.

Mechanical:

Mechanical Engineering is key to the functionality of the DAC technology. The process begins with a turbine pulling atmospheric air through an air contactor and mechanical engineering is used to refine the turbine and contactor design in order to achieve maximum carbon capture. Mechanical engineering is also essential to the following processes including thermodynamics and pressure regulation in the pellet reactor, slaker and calciner. Furthermore, mechanical engineering is essential to the carbon sequestration processes for permanently storing carbon within the earth.

Materials:

The method that CE employs to capture carbon is DAC, which uses aqueous basic solution as a sorbent and gas turbines that exhaust stream to strip CO2. Another popular method to capture carbon is using a good solid sorbent. However, Adsorption-based technologies require the manufacture of hardware—specifically the cost-effective and efficient adsorbers like MOFs. Inventing the adsorbent as well as scaling up its manufacturing process can be difficult and costly processes. Here, even though the construction of such an industrial facility needs commodity equipment and methods, CE manages to have a good estimation of the costs. Here, DAC chooses aqueous basic solutions over solid sorbents as the capture media so that the medium works the best with the industrial facility. Although the solid sorbents require low energy input and operating cost and can be scaled up easily, they demand of high sorbent performance and have to operate with a large facility that can be periodically sealed from the ambient air during the regeneration step, so the temperature, pressure, and humidity can be cycled at a low cost. With aqueous basic solutions, the contactor can now operate simultaneously with the aqueous basic solutions without interrupting the process. Additionally, the contactor would have longer contactor lifetimes and can be built using cheap hardware.

Computer Science:

Elements of computer science were used to optimize the efficiency of our product and increase profitability. A simulation was programmed to compute plant performance by finding how different parameter values affect the energy and material balance. The goal of this software was to improve plant profitability by optimizing plant design and increasing productivity and the rate of production.

Electrical:

The fundamentals of electrical engineering are prevalent throughout the entire production process. Specifically the CO2 Absorber (0.4 MW), Air Contactor (9.2 MW), Pellet Reactor (3.4 MW), AUX (2.6 MW), Quicklime Mix Tank (0.2 MW), Steam Slaker (3.6 MW), CO2 Compressor (22.0 MW), Calciner (0.8 MW), and ASU Oxygen Preheat (13.3 MW) are all technologies that take electricity in, while the HRSG Gas Turbine (46.0 MW) and Steam Turbine (9.8 MW) produce electricity. The main aspects of electrical engineering are simply seen in the integration and collaboration of the many production vehicles mentioned above.

INTEGRATION:

Since there is no price on carbon, simply capturing carbon while good for the environment is not profitable. Our company is in the process of developing an air to fuels technology that distinguishes us from competitors by using the CO2 obtained from our direct air capture technology to produce synthetic crude. This synthetic crude can then be processed into clean transportation fuels such as gasoline, diesel, and jet fuel. The transition to liquid hydrocarbon fuels is easily achievable, as this fuel works in the engines of existing vehicles without any modification. Also these fuels are competitive with existing fuel industries, as liquid hydrocarbon fuels burn cleaner than fossil fuels and require 100 times less land than biofuels. Moreover, the production and use of our fuels releases no additional CO2 into the environment. This is because our technology creates a circular system of emission by continually reusing atmospheric CO2.

Our company is currently running the world's first plant that uses air to fuels technology. This plant is still in the experimental phase, focusing on testing and refining the fuel synthesis process. Our mechanical and chemical engineering teams have been working to scale our air to fuel technology up to an industrial size. As of now the pilot plant produces roughly one barrel of fuel a day. The computer science team has coded a simulation to further optimize the plant, and we expect that the plant's fuel production will grow in the future.

SUMMARY:

Due to sublime integration of engineering fields, Carbon Engineering (CE) has been able to establish a totally unique, working process of converting atmospheric carbon dioxide (a global pollutant) into clean transportation fuels like diesel, gasoline, and jet fuel. Our company's absolute advantage in producing these fuels to a net zero emission standard must be the major focus of future development for our company (rather than simply capturing the carbon). Should the necessary funding be obtained, it will go toward expanding our air to fuel service, and constructing more plants that have the capacity to complete this process. Since a carbon tax has yet to be enacted, profit will only be attainable with large quantities of these transportation fuels being produced. Therefore, this must be the main focus. Should the day arrive when an international carbon tax is implemented, thus subsidizing companies who extract carbon from the atmosphere, not only will our company be making profit purely from our synthesized fuels, but from our extraction process as well. To put it bluntly, at this point, money will no longer be an issue.