OPUS 12 – RENEWABLE CHEMICAL AND FUEL PRODUCTION THROUGH THE ELECTROCHEMICAL REDUCTION OF CO2

APPLICANTS & AFFILIATIONS

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PARTNERS - Shell, GameChanger, Proton OnSite

INTELLECTUAL PROPERTY STATUS, PATENT OR TECH TRANSFER NUMBER(S)
Currently filing patents - all IP is owned by company;

TIME TO MARKET - Within the next 12 months

C2M OBJECTIVES

We are developing a platform technology that can meet a number of different customer needs. We would like help in going deep on a few of the areas that we have identified as high-margin first applications, e.g., modular onsite gas production. Moreover, a huge driver of profits for us is identifying areas with high CO2 emissions and low-cost electricity. We could use help in developing a go-to-market strategy that takes these factors into account.

TECHNOLOGY

What if the emissions of the world’s largest industries never reached the air? What if those emissions were instead transformed into valuable assets for the global economy? At Opus 12, we are developing a bolt-on electrochemical device that recycles CO2 back into fuels and chemicals.

Using only water and electricity as inputs, we have demonstrated the electrochemical reduction of carbon dioxide (ECO2R) to 16 different products, including ethylene, ethanol, and syngas, which can be upgraded to carbon-neutral diesel, jet fuel, or gasoline.

Originally founded at Stanford in 2015, we are now operating out of LBNL through the Cyclotron Road program. We have developed a breakthrough reactor design for ECO2R, and have built and tested a high-performance prototype that is ready for scale-up. We have exceeded the best-known published performance for CO2 reduction by a factor of 4X.

The main contributor to Opus 12’s record results is our novel integration into a proton exchange membrane (PEM) reactor architecture, which has been used commercially for water electrolysis for decades. We have overcome the
key technical barriers to successful PEM integration that have hindered past ECO2R efforts.

In addition to recognition from Shell GameChanger and Cyclotron Road, we are also the 2015 winners of the DOE Transformational Idea Award and the Fortune Cool Companies competition. We were accepted into the StartX startup accelerator and completed the I-Corps program. Kendra (CTO) is one of the Levo 100 Millennial Innovators for 2015, and Nicholas (CEO) was among Forbes 30 Under 30 for Energy in 2016.

CUSTOMERS

We are developing a bolt-on reactor for the onsite conversion of industrial CO2 emissions into valuable fuels and chemicals. Our product would not only reduce the emitter’s carbon footprint, but would also create a new profit stream from what is currently discarded as waste. The top nine products we can produce from CO2 have a combined global market of over $300 billion.

Our initial target market is existing fuel producers, i.e. oil refineries, corn ethanol manufacturers, and natural gas fields, as they have highly concentrated CO2 emissions and existing supply chains for the products we can make.

Shell has expressed a strategic interest in our ability to make carbon-neutral syngas from CO2, and has provided grant funding for an initial feasibility study. They have described our achievements as “groundbreaking”.

We have conducted over 150 customer interviews across the oil & gas, chemicals, gas delivery, utilities, ethanol and basic materials sectors. We have identified small-scale modular CO production as an early entry point that could be monetized at the 5kW pilot scale.

SCALING

A key advantage of electrochemical technology is that it scales linearly, which means that we can produce modular units that can be interconnected to achieve the desired output. At commercial scale, we will use the same size modules as existing PEM water electrolyzers: 250kW, about the size of a checked luggage. A 1MW system would include four modules, and would process about 5 tons of CO2 per day.

There are 2-3 interim steps before we reach the 250kW scale. Our current prototype is about 10W, with a 5cm2 active area. Our next step is to scale up to a 200W, 100cm2 cell. Once we achieve this 100cm2 scale, our manufacturing partner, Proton Onsite, has indicated that they can produce a full electrolyzer stack. Our pilot device, which we are building with Proton, would be a 5kW unit. The next milestone would be to increase the capacity of this stack to 250kW.
ADVANTAGES

Converting CO2 to a hydrocarbon fuel is an endothermic process, and all CO2 conversion technologies, be they biological, thermochemical, or electrochemical, must overcome the same thermodynamic barrier. Each CO2 conversion approach has advantages and disadvantages with respect to overcoming this barrier and yielding a useful output.

• Biological approaches tend to have low-cost inputs but they face high capital costs, major scaling challenges, and complex separations.

• Thermochemical processes can take advantage of waste heat to reduce input costs, but they often require massive scale and offer a limited range of potential products unless high-energy chemicals are added, e.g., sodium hydroxide or epoxides.

• Electrochemical processes (ECO2R) offer integration with renewable electricity and the greatest potential for modularity, but until now, these approaches have also faced high capital costs, scale-up challenges, and a limited range of end products.

Opus 12’s technology overcomes these conventional limitations to electrochemical processes thanks to two core innovations:

1) First, a breakthrough reactor design that enables integration into existing PEM electrolyzers. This significantly reduces system capital cost and scale-up risk.

2) Second, a suite of catalysts that have demonstrated ECO2R production of 16 different products. This creates a value proposition for a broad range of potential customers and eliminates secondary processing steps.

BARRIERS

Since we are producing products that are already widely available, there is relatively lower market risk, as long as we can offer competitive economics; the fact that our products have a much lower CO2 footprint is an added incentive. Hence, the main risk is technical: can we achieve a conversion efficiency that will allow us to generate cost-competitive products? We are addressing this risk in two ways: first, by gathering the best team in the world for electrochemical CO2 reduction, and second, by pursuing high-margin niche applications that we have identified through over 200 customer interviews, which will allow us to get to market faster.

The second core barrier to commercialization was alluded to in a previous answer: identifying enough markets with attractive electricity prices. We will mitigate this risk by doing a region-by-region analysis of both electricity prices and the barriers to accessing the lowest rates.
Feedback

In general, we have received significant interest from existing oil and gas players, e.g., Shell, Exxon, Chevron, Total, and Valero. Players like Shell and Total have begun to make significant investments in renewable electricity assets, so the concept of turning electrons into chemicals that they already produce from fossil feedstocks is attractive. Early in 2015, we saw significant interest around our ethylene product, but given recent price collapses, this interest has decreased. The most attention has been paid to our renewable syngas product - whether as an input to Fischer Tropsch (this is what Shell is funding us to do), as an input to a polymerization process (Covestro, formerly Bayer Chemical, is very interested), or as salable CO (Air Liquide and Praxair are interested in modular CO production).

Overall, the consensus is that we will not receive a "green premium", but if two products are priced equally, almost everyone would take the green product as a way to increase market share.

Academic/Job Title(s) - Co-Founder & CEO, Opus 12

Status

Company or LLC formed, Other DOE funding, NSF funding, I-Corps participant, Cyclotron Road participant, FLOW, CTO or other business plan competition(s), Bench scale prototype(s), Significant lab performance data, Founder(s) plus 1-2 full-time equivalent employees

Time to Market Background

We are beginning commercial partnerships for pilot development with Proton Onsite over the next couple of months, and Shell is beginning the feasibility study with us during that time period as well.

Over the next 12 months, we aim to develop our first pilot (5kW) reactor, which is actually the right size for onsite CO production in some of the niche applications we have identified.