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VERMONT PHOSPHORUS INNOVATION CHALLENGE
STAGE 2 REPORT
STAGE 3 IMPLEMENTATION
09/31/2019

Introduction:
The Principal Investigator, Green State Biochar Team, and our Strategic Partner on the VPIC Project have not changed since the initial proposal was submitted.

Contact Information for Principal Investigator Stage 2 and Stage 3:
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Green State Biochar Team:
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Strategic Partner:
Hugh McLauglin, Ph.D., P.E.- hsmclaughlin@verizon.net

We are a Vermont company that utilizes local renewable organic waste materials that are processed in an innovative machine that we developed in Vermont as a prototype pyrolysis machine that produces a sequestered carbon product called biochar. We are passionate about cleaning the waters of the State of Vermont and our Phosphorus Capture System utilizes biochar to act as a filter that efficiently captures the majority of the phosphorus, while producing valuable soil amendment/ fertilizer products for local reuse.

Our team brings to the table over 100 years of combined biochar industry experience, digester projects with pyrolysis/gasification systems including the scale up of new technologies and a solid working knowledge of agriculture and excavation. We are inventors, business managers, business owners, mechanics, and welders. We are stewards of the environment with a keen interest in keeping our waterways clean and addressing water quality issues.

Donna Pion is a founding partner and General Manager of Green State Biochar. Donna has over 24 years of diverse business experience as Business Manager, Registrar and Controller for several Vermont and Indiana Industrial Companies and Institutional Facilities.

Roger Pion is a founding partner and Owner/Operator of Green State Biochar and has more than 34 years of diverse business experience in Manufacturing and Construction (in Indiana) as a Consultant/Manager/Operator and in Trucking (in Vermont) as an Owner /Operator of a truck fleet. Roger helped to build and currently operates the pyrolysis system and the related filtration systems.

Luke Persons is a founding partner and Biochar Filtration Specialist of Green State Biochar and has over 40 years of experience as a truck driver, mechanic, welder and inventor. Luke designed, built and currently operates the pyrolysis system and the related filtration systems.

John Forcier, P.E., is President of Forcier Consulting Engineers and has over 46 years of experience in Construction and Engineering, including over 40 anaerobic digester projects and several biochar related projects with pyrolysis/gasification systems. He is a member of the International Biochar Initiative and of Lee Enterprises Consulting (which has several biochar and pyrolysis experts).

Hugh McLaughlin, Ph.D., P.E., is CTO of NextChar and has over 42 years of experience in Industry, Engineering and Research & Development and scale-up of new technologies in the U.S. and Canada. Dr. McLaughlin is a recognized expert in pyrolysis/gasification, biochar, and activated charcoal and has designed and commercialized patented technologies and has written several publications and authored three chapters in the book, “The Biochar Revolution”.

The Concern –

The runoff of fertilizers from lawns, greens, agricultural fields, manure pits, human and animal waste, the overflow from taxed municipal and private sewer/septic systems, especially after heavy rains, and storm water runoff from roadways in need of upgrades are all contributing to the high phosphorus levels being found in our waterways and soils. We are seeing our lakes turned into pools of algae; we are witnessing excessive aquatic plant growth, beaches closing

due to health risks, tourism and real estate values declining around our once pristine lakes. There is no single solution that works for all these causes.

We have a solution for the runoff created from our beloved farms. Our biochar filters are installed on two NEK farms, one producing a high butterfat content yogurt, the other organic milk. Over the course of the past couple of months we have been successful at capturing phosphorus from the runoff of their cleaning waters and barnyard runoff in these filters. The liquid samples are yielding 90-98% captured P after the biochar filter. This pilot program will take us more time as the biochar is still actively absorbing the phosphorus. It may be six months or more before it is fully saturated. Even though our preliminary testing of the biochar in the filter has not yielded the results that we originally estimated (for the duration that the filters would last), the indication from the lab results of the liquid samples tells us that the phosphorus in accumulating and we are continuing to test it to measure the amount captured. The lab results from the liquid samples, pre-filter also reveals that on these two farms, the amount of phosphorus that was originally thought to be released is not as concentrated as estimated. Therefore, these two farms were already doing a pretty good job of reducing phosphorus runoff and we reduced that phosphorus runoff to extremely low levels.

Technological Description –

We have constructed the initial working prototype pyrolysis system. We constructed, adapted, delivered, and installed, a custom nutrient capture system that captures nutrients from manure pits and cleaning waters on two farms. (Per Drawings No. 1 & 2).

Our intention was to use part of the Grant funds as a down payment to develop a larger version of our working prototype pyrolysis machine. This was removed from our Phase 2 funding. We will pursue this in Phase 3 as part of matching funds. We are confident we can secure the match needed to build the new kilns. It is our belief that demand for biochar is on the rise and that it should be produced locally, within Vermont, and utilizing local waste wood. It should not need to be transported long distances and across state or country borders.

Results –

Each farm is unique in its size, product, production schedules, lay of the land, and the calculated number of gallons going through the filter. Their wastewaters are different. All of this information is gained through extensive conversations with the farmers and being on site through several production cycles over multiple days. Siting and preparing the best location for the filters is crucial to them operating efficiently and for ease of maintenance and removal of spent biochar when fully saturated. Determining the tightness of each filter, whether a pre-filter

is necessary, and the amount of biochar to compensate for the number of gallons going through it, is all part of the learning curve. The placement of the pipes, plastic liners and filtering fabric between layers is part of the equation as each filter will be unique, initially, until patterns can be determined and there is recognition that similar designs will work for other farms. All farmers do not want waste water in their manure pits. They already have enough natural water in them from rain or melt off.

Still unknown is how long the biochar will continue to absorb phosphorus and how much of it there will be once at capacity. When the liquid samples indicate that the biochar can no longer capture it, then it will be removed. This spent material will be thoroughly and completely mixed together, before a sample is pulled and tested to determine the amount of phosphorus captured. This test will be more accurate than the previous ones where we have just pulled small amounts of biochar from a few places of the tote filter at Butterworks, not long in the ground, and sent to the lab.

In Stage Two, our first filter went in at Butterworks, Westfield, VT, not in layers, but in 8 totes, bumper to bumper, with room around each to compensate (over in this case) for the amount of fats going through it. There was no sand below in this first filter. We began taking the water samples within two weeks at Butterworks and were not pleased with the % we were capturing. The Churchill filter went in ground after the 1st one at Butterworks. We did not use the tote bag system but put the filter materials in layers, sand below, filter fabric above. Our water tests from this filter were and continue to be over 91% capture of P and as much as 98% capture.

In late July, we pulled all the totes out of the Butterworks filter and put in a new one, same as Churchills, only larger and with a prefilter. The phosphorus load at Butterworks is far greater than that of Churchill. The filter has to be larger and a prefilter is necessary. Until such time that the water tests indicate that the biochar is no longer able to capture P, which could be six months or more, the filter should remain in place. When it is time to freshen the filter material, at that time a sample will be sent to the lab to determine the amount of P being held by the biochar. Any sample sent before the biochar reaches saturation would not be a clear indicator of the amount of P the filter is able to capture.

When we changed over the filter at Butterworks we also included 1000 pounds of Black Mineral, to our 7500 pounds of biochar, from Tom Vanacore, Rock Dust Local, which he donated. The water test results yielded a 91% capture rate of P, within the same range at Churchills.

Anticipated changes to our biochar filtration systems include the addition of minerals from Rock Dust Local (for commercial sites like Butterworks Farm) and precast concrete and biochar forms.

Bigger farms will need prefilter systems and two, maybe three, rather than one biochar filter in ground depending on the gallons of water going through each. A system will also need to be engineered to capture any runoff of clean water from the final filter; an irrigation/dragline system has been suggested by Rob Achilles when the clean water output exceeds ANR guidelines. The installation of additional filters on those farms, limiting the output to less than 350 gallons per, would eliminate the need for this expense. It would create more cost upfront, with the addition of additional filters but with the benefit of a saleable, useable product at the end rather than just a collection pond or leech field.

The award money received for Phase 2 of VPIC was $30,000. Our expenses/costs for this project exceeded this amount, since we chose to replace the first filter at Butterworks.

Spent to date as follows:

Furnish biochar and install Phosphorus Capture Systems which includes all transport of equipment, materials, and labor:	$39,432
Testing/Lab supplies and Engineering to date:	$ 4,920
Total to date:	$44,352

We will continue to test both filters until such time that the biochar has reached capacity. At that time we will remove the spent biochar. We will do this at our expense unless the farm is interested in keeping the material. We have a market for the spent biochar (as a valuable soil enhancement with time-release fertilizer) so it is possible that the farm may be interested in being part of this transaction as well. It is our intent to replace the biochar, so the process of capturing P can begin again.

Attached are the lab test results and summary sheet with field notes to date.

STAGE THREE

Full Implementation

Business Description

The installation of biochar filters on local area farms is a low cost and effective way to control phosphorus from reaching our rivers, lakes, and streams and creating a byproduct that is available to the farmer to resell or reuse. Green State Biochar intends to install and service these filters in northeastern VT and parts of NH.

This technology will be scaled up to include pre-cast concrete and biochar forms. The addition of biochar reduces the weight of the form. These forms make the removal of spent biochar and the addition of new materials easier and will eliminate the need for plastic liners which are not environmentally friendly and also create slippery and potentially dangerous surfaces.

Full implementation of this technology requires Green State Biochar to build additional kilns. The production of biochar, the elimination of waste wood into a valuable commodity, carbon sequestration, and the capture of phosphorus are all hand in hand in this process while providing the farmer with a product that they can resell, either to Green State Biochar or others, or utilize themselves.

One of the markets Green State Biochar is targeting for the spent biochar with phosphorus is that of farms seeking to add it to digesters. This addition will increase efficiency, capture the "nasties" and hydrogen sulfide, absorbs CO2, provide greater energy output, reduce wear and tear of the digester, provide longer periods between oil changes, and increase the time needed to replace parts and for complete engine rebuilds.

Markets for our biochar as produced, without the addition of enhancers, can be sold directly to local area outlets (Gardeners, Aubuchon, Willeys, Allen Lumber, E.M. Brown) and available for pick up or delivery within proximity of 50 miles and dependent on the size of the order. We are looking into biodegradable packaging and will offer biochar for sale online in 2020 and securing retail stores to carry our product. We have received the USDA Bio-Preferred Seal for our product as approved and tested from the University of GA. Included as an attachment is the label we put on our 5 gallon pails. Biochar is not yet available on the shelves of the above named retail outlets.

Several companies offer biochar for sale online with prices ranging from $4-$8 per pound, not enhanced. There are also designer varieties of enhanced biochar available with these products targeting the growth of certain crops including cannabis. Prices for these types of biochar are upwards of $20 per pound. They include P. In the budget attached we have included the salary for a biologist, a graduate from one of the universities that has offered programs which study biochar, and have over the past decade, that will work on creating these formulations.

Our entry into online sales will focus on "straight" biochar and we will let the consumer determine what additives, fertilizers, and types of compost are desired. Once the market has been established for designer biochars, we will look to expand our line. We will offer our biochar for sale between $4 and $6 per pound. Our future cost (with 2 new kilns, adding 1500# per day) to produce biochar is $.30/pound and is 94% hard carbon. We can buy it in Canada 6 hours north of the Derby, VT border, and transport it by tractor trailer for a cost of $.80/pound. This biochar ranges between 60-74% hard carbon which means it does not have the same holding/absorption

capacities and will break down sooner than ours. It is still good biochar. Green State Biochar wants to reduce our carbon footprint, eliminate local wood waste, and create jobs in Vermont by producing our own material.

Green State Biochar is not in direct competition currently for the installation of biochar filters to capture phosphorus and create an end user product. There is a growing demand for biochar and enhanced biochar online, offered by a handful of suppliers, and we feel this is the time to enter the market. Farmers that are interested in selling the enriched biochar that is removed from their filters and will be encouraged to do so. They can also sell it back to us, at which point it will be processed into a soil conditioner having gone through a quality control process, and sold to retail outlets and consumers with the Green State Biochar label. In the budget attached, we have included the salaries for a marketer and a sales lead, preferably graduates from one of the universities that has offered programs which study biochar. We are looking for those individuals, as passionate and interested in biochar, as we are, and foresee it as an industry with positive and long lasting benefits.

Sale of spent biochar that is removed from filters, either repackaged and offered for sale by the farmer to consumers, or to Green State Biochar in bulk, is money in the farmers till. Runoff captured from the farmers cleaning waters and manure pits aids in the prevention of the degradation of Vermont's waterways. This in turn keeps property values around otherwise pristine lakes where they should be and encourages tourism, both of which contribute to Vermont's till, and reduces the need for taxpayers to provide all of the funds needed for clean water initiatives.

Budget

Two complete detailed budgets describing the proposed implementation for VPIC Stage Three are provided. Both outline the uses of grant and loan funds and projected sales revenue and expense for the years ending 12/31/20 and 12/31/2021.

Version 1 asks $120,000 from VPIC with a $125,000 match from Green State Biochar from secured loans. This version looks to build two kilns (adding 1,500#/day) and the structure to house them with grant and loan funds. They would be located on the current site of our working prototype kiln which was a working nursery in Greensboro Bend. Revenues from the installation of 10 filters in 2020 and 20 in 2021, and the sale of biochar would be used for the salaries for three new employees, a Marketing and Social Media position, a Sales Lead, and a Researcher. Current staff includes Roger Pion and Luke Persons, biochar production and installation of filters and Donna Pion, Business Manager and support. In 2022, and as demand for biochar increases, we anticipate creating positions for two additional biochar production/packaging/installation employees. This version is dependent on our biochar filters acceptance into BMP. We have the

farms lined up who would apply to the program. The successful implementation of this budget creates 6 full time positions by 2021 with the intention of 3 of them coming from universities, out of state, and making their residency in Vermont. An estimate of the ROI, to Vermont, for three new employees from out of state and three residents is approximately 65% of their annual salaries or $102,700 in 2020 and $134,550 in 2021. I do not have a method to calculate the ROI from the reduction of P runoff into our waterways and the addition of a value added product to our farmers.

Version 2 asks $120,000 from VPIC with a $125,000 match from Green State Biochar from secured loans. This version looks to build one kiln (adding 750#/day) and the structure to house it and funds for the installation of 5 biochar filters on farms to capture runoff from cleaning waters and overflow from manure pits. In the year ending 2021, retail sales of biochar will need to be the focus if the filtration units are not accepted as BMP systems. Market opportunities for biochar will be expanded to include the mandatory composting laws, ACT 148 and with emphasis on the addition of biochar to increase the efficiency and energy output of anaerobic digesters. It will also be packaged and sold to consumers to add to their household food scraps to decrease odor and keep animals from being attracted to the compost bin. Green State Biochar will ensure that this market is educated about all of the uses and benefits of adding biochar to food waste, including the capture of methane gas that contributes to climate change and the creation of rich soil and a renewable energy product. Other market opportunities exist for the addition of biochar in urban and agricultural settings including botanical gardens, tree farms, orchards, and nursery stock.

An estimate of the ROI, to Vermont, for two new part time employees, one new full time employee, from out of state, and three current part time residents is approximately 65% of their annual salaries or $63,700 in 2020 and $78,650 in 2021. The ROI from the installation of 5 biochar filters installed to capture P from entering our waterways is not yet in the form of an equation.

Timeline for Launch

We would begin the permit process for the site to erect the Calhoun structure and at the same time work with the engineer for the construction of the new kiln(s), also needing to go through a permit process. The kiln(s) would be assembled in a 4000 sq. foot heated garage in Barton until being moved to the new facility, where they will be operational. This would begin as soon as our budget, Version 1 or 2, was accepted into Phase 3 VPIC. We would continue the production of biochar on our smaller working prototype housed at the nursery in Greensboro Bend to keep inventory on hand. Biochar filters cannot be put in frozen ground. Installation would occur in early/late spring 2020. Concrete/Biochar forms would also start at the same time. The search

for new employees to join our team would be initiated immediately with the plan they could start early/late spring 2020.

Hurdles, Obstacles

If Version 1 of the budget is approved, we will be up against the farms submitting their BMP applications for approval with installation to begin in the Spring/Summer 2020. Coordinating the receipt of funds from the state and loans from other organizations can also present a challenge as everyone will have to be working off the same script and people have busy schedules.

Green State Biochar- VPIC Photos With Captions
Prepared by: Forcier Consulting Engineers
9/30/19

Butterworks Farm- Holding Pond

GSB- Biochar- 5 gallon pail

Butterworks Farm- Filter Installation

Churchhill- Filter Installation

Churchhill Filter- Testing Tub & Outlet (rotated 90 degrees)

Churchhill Holding Pond