ASABE Bioprocess Startup Competition

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Name of the company: Howdy Greener Inc.

1. **Company Overview:**

Howdy Greener Inc is a biorefinery based in Texas dedicated to the processing of waste agricultural residues into valuable products such as ethanol (as a precursor for Jet fuel), single-cell protein (subproduct of the fermentation), high content lignin pulp for an ecologic paper towel (subproduct of the fermentation solid waste). The fourth sub-product, carbon dioxide, of the process is geologically sequestered into old oil wells giving us participation in the carbon market.

2. **Novelty and Innovation**

We repurpose waste into valuable products using top technologies already on deployment. A genetically engineered yeast able to ferment C5 and C6 sugars for ethanol production, then later is converted to Jet fuel and potentially in other building blocks for a biobased economy.
We integrate processes and valorized processes that our competitors have not seen as an opportunity. We take advantage of our geographic competitive advantage to decrease the cost of transportation of raw materials, products, and gas.

3. **Engineering design**

The flow diagram process is shown in Figure 1. The process starts with agreements with surrounding farmers for the sale of stubbles. Mechanized densification of the residues will happen in situ using balling machines, these machines can replace the labor of five people speeding up the cleaning process for the next crop. The densification process increases the volumetric weight of bales to optimize transportation. The use of bale machines also decreases significatively the size of particles of biomass facilitating the acid pretreatment. Biomass will be pretreated in a continuous reactor with phosphoric acid diluted (Concentrations lower than 1.%). The purpose of the acid pretreatment is to breakdown the vegetable wall mainly by solubilizing partially lignin and hemicellulose. The slurry pretreated will be mixed with black exhausted liquor and final pH

adjusted to pH= 5.0 and will undergo enzymatic hydrolysis reaction with a mixture of Cellulase and hemicellulose at 50 C for 6 h. Then, the temperature of the reactor is cold down to 30 C. Saccharification and simultaneous fermentation will be performed with commercial yeast (Cellerity1) able to ferment C5 and C6 sugars. During the fermentation process, the CO2 will be captured and compressed for further geological sequestration in the near old oil well. The liquid phase and solid phase are separated after the end of the fermentation. The liquid phase is distillation for ethanol purification, vinasses from the distillation are anaerobically co-digested with the residual water for biogas production. Solid residue, containing residual fiber and protein as single-cell protein from the microbial biomass is used for the separation of raw protein for livestock feed and the high lignin residue is used to manufacture unbleached paper towels.

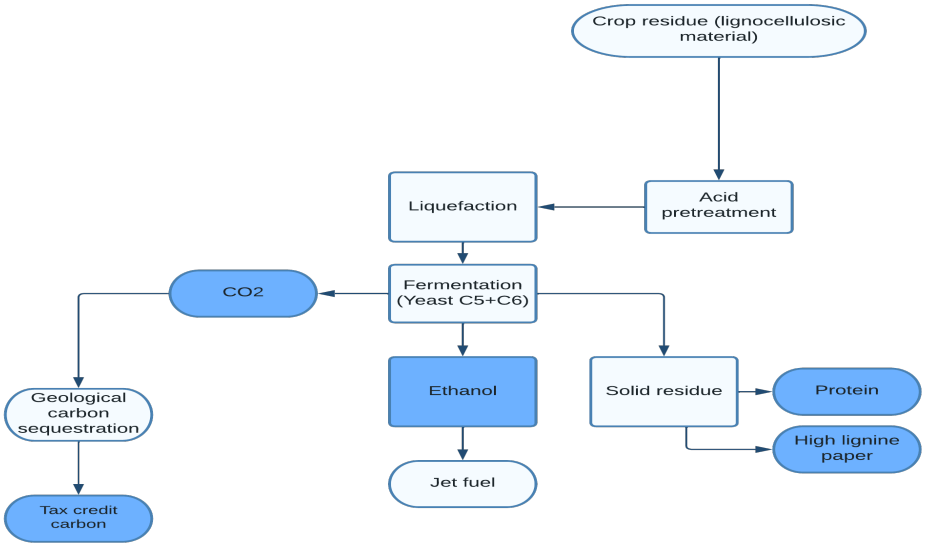

Figure1: Flow diagram process of Howdy Greener Inc.

4. Bussines strategy

Geographic competitive advantage

The installation of a biorefinery for the conversion of crop residues in Texas represents a geographic competitive advantage for several reasons. Our biorefinery will convert crop residues and softwood liquor paper into ethanol. Texas the cost of biomass transportation, our biorefinery is located close to extensive crop areas, old petroleum wells and maritime port easier for transportation of our products.

Building blocks for more valuable products

Our partner Lanzatech will synthesize Jet Fuel through a catalytic conversion process. LanzaTech has the only process available in a commercial scale to produce Renewable JetFuel with a growing market. On the other hand, Lanztech has a business model compatible with our initiative with a decentralized production, that rather than scaling up is about numbering up, which means they are in starting facilities all around the country with lower production volume per facility.

Thus, our company as a provider of renewable ethanol can have part of that potential market.

Process integration and subproducts valorization

During the ethanol process, high purity CO_2 is released as a result of the fermentation process. In Howdy Greener we do our process more sustainable, diverse studies determined the feasibility of performing geological carbon sequestration into old/exhausted petroleum wells which represent an additional source of income in our process in a way of carbon bonuses. During the previous decade's endeavors to make lignocellulosic ethanol failed to be competitive when compared to the oil fuels price. In our case, the integration of process and valorization of subproducts as Single-cell protein for animal feed will help to decrease the intensive use of land to grow crops for animal feed. The additional advantage of feeding cattle with additional protein in particular when the forage has a low content of crude protein and during the warm season when grasses might lack nitrogen or with frosted pasture during winter. It's been demonstrated that poor forage or a diet below protein needs can have a negative impact in growth rates of the rumen

Promising markets for our products

The microbial cell protein for livestock feed is an unexplored promising market within the Texas context due to the representative portion of the state economy in cattle. For instance, a large cost of cattle operations is on animal food Currently, protein supplementation is not widely practiced regardless of the proven benefits in health, development, productivity, and growth of beef cattle. Supplementation of protein is expensive.

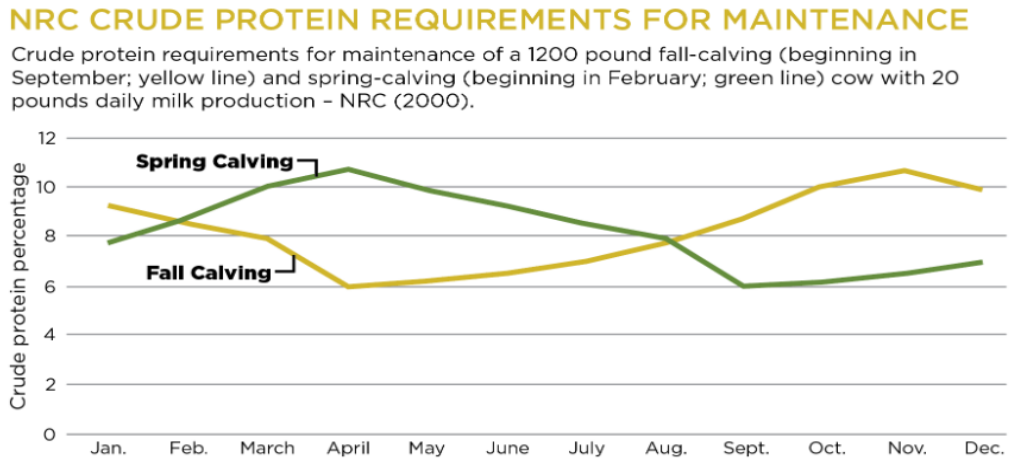

Figure 2: Protein requirement for maintenance of cattle.

Taxes and environmental benefits

Our process will benefit from carbon assets and tax benefits for the avoidance of emission, carbon, and sequestration in our processes. Our participation in geological carbon sequestration services open as well participation in the Carbon Markets

5. Social and Environmental Impacts:

Howdy Greener repurpose black exhausted liquors from surrounding pulp mill the use of agricultural residues that would be removed or burned out from crops in the state of Texas as cotton, sorghum, winter wheat, rice fruit, and tree nuts. For instance, stubble burning consists of a cheap practice to clear residues after the mechanized harvesting. Composting those leaves behind is in some cases advisable, but it might take half a month to decompose which sometimes interferes with the tight timeline for switching crops.

Which also avoids the greenhouse emissions of gases and deterioration of the air quality. Burning crops is now illegal in several counties in Texas, such as Brazoria, Fort Bend, Galveston, Harris, Liberty. Regardless the legal restrictions to burn crop residues, the law presents exceptions when there is no other maintenance practices available. Opening a local market for those residues will disincentivize the agricultural practice of stubble burning, studies demonstrate that farmers choose it due to the short time between the rotation of crops. For instance, two to three weeks between rice harvesting and wheat crop. Table 1 shows the percentage of area of some crop that is for instance removed or burned down.

Table 1: Measured in Area Planted on Cotton, Sorghum, Wheat, Fruit, and Tree Nuts - Texas: 2019. % area of Crop according to maintenance practices (Texas Annual Statistical Bulletin).

			Practice (%area)		
Crop	**Planted (acres)**	**Harvested (acres)**	Crop residues removed or burned down	Field edges, ditches, or fence lines were chopped, spread, mowed, plowed, or burned	Flaming weed
Cotton	7,062,000	5,260,000	10	50	-
Sorghum	1,550,000	1,400,000	8	52	1
Winter Wheat	4,600,000	2,100,000	5	26	-
Fruits and peanuts	165,000	160,000	71	--97	-

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