Final performance Report for NRCS CIG
Production of synthetic diesel from animal manure and food waste

Background:

Although the major objective of this project was the production of a liquid fuel (synthetic diesel) from waste products, a secondary objective was to assist in the development of an inexpensive biogas cleaning system using a zeolite product (sodium aluminosilicate).

In collaboration with Brigham Young University (BYU), Provo, Utah and Anaerobic Digestion Technology (A D Tech) also of Provo, Utah a full sized zeolite biogas cleaning system was incorporated into the Andigen Induced Bed Reactor system (IBR digester) that was located on the Blaine Wade dairy near Ogden, Utah. The biogas cleaning system was able to remove hydrogen sulfide to non-detectable levels. It also removed water and some carbon dioxide. A D Tech in cooperation with BYU is now commercializing this biogas cleaning technology. The biogas produced and cleaned was then pressurized to 2000 plus P.S.I. and transported in two 40 gallon tanks to Ceramatec in Salt Lake City, Utah

Hansen Energy and Environmental (HEE), the recipient of this grant, had been collaborating for three years with Ceramatec, a research and development company located in Salt Lake City, Utah, in order to develop a small scale economically feasible Fischer -Tropsch (FT) process to convert natural gas to a synthetic diesel. Ceramatec had developed a proprietary reformer to use in their system and they had also experimented with a proprietary catalyst in the process.

Before this grant was awarded, small amounts of biogas (biomethane) had been delivered to Ceramatec to aid in research and development. When this grant was awarded, Ceramatec built a larger FT system to accommodate the larger quantities of biogas that we would be delivering. During the last three months of this project, deliveries of cleaned biogas were made to Ceramatec about twice weekly. Ceramatec then used its Fischer-Tropsch process to create synthetic diesel. The conversion rate and quantities of liquid fuel that can be produced from the biogas are shown in the economic analysis.

Results:

Deliverables for this project included: 1. The production of a liquid fuel (synthetic diesel) from biogas and 2. An economic analysis comparing economics of using the biogas to generate electricity with using the biogas to produce synthetic diesel.

Production of synthetic diesel:

Synthetic diesel was produced from biogas using a proprietary Fischer-Tropsch system. Samples of the Synthetic diesel produced were sent to Bently Tribology Labs in Minden, Nevada for testing. Testing and analysis was also done at Utah State University. The results of that testing and analysis have shown that the synthetic diesel had a higher energy density (46.5 KJ/gm) when compared with typical petroleum diesel (46 KJ/gm). B100 fuel is usually only 40 KJ/gm. Tests also showed that the synthetic diesel contained no sulfur. In fact the synthetic diesel produced from the biogas was similar to high hydrogen, zero sulfur and zero aromatic petroleum diesel. The cetane rating for this synthetic diesel was 60.2. Typical cetane numbers (CN) for diesel fuel fall between 40 and 55. Some European countries require a minimum CN of 51. Premium diesel fuels often need additives to improve the CN.

Economic Analysis: Electrical Generation verses Synthetic Diesel:

Table 1. Comparisons from a typical 1000 Cow Dairy[a]

Item	**IBR/Electrical**	**IBR/ F-T fuel**
Total capital investment	$750,000	$830,000
Energy available from methane, Btu/d	27,530,202	27,530,202
Net energy available in product, Btu/d	21,535,431	21,535,431
Electrical output generated, 80 kW/hr	1920 kW hr/day	
Volume F-T product, gal/d		126 gal /day
Annual gross income ($0.06/kWh, $3.50/gal)	$42,048	$160,965
6.5 Annual operating &maintenance	$15,000	$34,000
Net income per year	$27,048	$126,965
Simple payback (years)	**28 yrs[b]**	**6.5 (4.4)yrs[b,c]**

a. Preliminary design/costing study, Joe Hartvigsen, Ceramatec, Inc., Salt Lake City, UT and Conly Hansen, Utah State University. The calculations for the F-T system is for production models after optimization but are based on realistic estimates at today's prices.
b. The payback can be much less than this because generally anaerobic compost (fiber) and carbon credits can also be sold. This applies to both scenarios. Also co-digestion with off farm substrates can decrease pay back for both scenarios.
c. Number in parenthesis is payback time if available tax credits were applied.

Conclusions:

Although the net loss in BTUs is about 26% when converting the biogas to liquid fuels, the synthetic diesel is so much more valuable than the methane that the extra step to make the conversion shows economic feasibility. However, to scale up the FT system to accommodate all of the biogas produced by the IBR system on the Blaine Wade dairy or another similar dairy, additional proof of concept money would need to be raised. The first installation is always much more expensive than production models.

The value of the synthetic diesel produced might be enhanced if blended with other diesel fuels. In fact, because of its higher energy density and high cetane rating, using it as an additive or as a blend with other fuels might be the best end use for this product. Additional research would be needed to answer these questions.