Fueling Africa

OLDS COLLEGE

Biodiesel Production and Research

Abimbola Abiola, Ph.D, P.Ag.

Outline

- What we do at Olds College Centre for Innovation
- Future of Africa
  - Limitations to Africa's Growth
- Example of how we could meet the Energy needs of the continent through the use of biofuels

OCSI: Applied Research

- Accelerate innovation
- Industry problem solving
- OCSI/ SME collaboration
- Move innovations to marketplace
- Encourage transfer, adaptation and adoption of new technologies

School of Innovation

- Applied research in agricult
- Industry problem solving
- Technology/ process/ product development and testing
- Facilities
- Areas of focus:
  - New Products from Crops and Bioprocessing
  - Bioenergy and Waste Management
  - Waste Management
  - Water
  - Agronomy

Basic Human Needs

- Food
- Clothing
- Shelter

Economic Development

- Food Security
  - Availability
  - Nutrition
- Safety
- Welfare – Health and Education
- Energy Security

Africa's Turn

- May be hampered
  - Human resources
  - Food
  - Energy

Recent Revolutions

- Dot com
- IT
- Biotech
  - Bioactive compounds
  - Food that heals
  - Growing our fuels, clothing, medicines and parts


powered by
BioDiesel
nature friendly, nature safe
4x4

Petrodiesel Issues

- Toxic Pollutant
  [air contamination; health issues; climate change]
- Finite / Depleting Fuel Source
  [formed over millions of years – 1/3 to 1/2 used during last 100 years]

World faces not only end of 'cheap oil' but the 'end of oil'

Liquid BioFuels

- **Ethanol**
  [gasoline additive; starch/cellulosic feedstock; partly existing infrastructure compatible]
- **Biodiesel and Renewable Diesel**
  [petrodiesel replacement; fatty/oily feedstock; fully existing infrastructure compatible]

BioFuel Technology Centre

powered by

BioDiesel

nature friendly, nature safe

What is Biodiesel?

What is Biodiesel?

- A clean burning alternative fuel, produced from domestic, renewable resources.
- Produced by chemically reacting an alcohol (methanol) with vegetable oils or animal fats and a catalyst.
- Conversion process results in 90% biodiesel and 10% glycerin.

Biodiesel Review

- Less Pollution *(~50% global average)*
- Carbon Neutral Renewable Resource
- Longer Engine Life *(~50%)*
- Positive Lifecycle Energy Return *(~3:1)*
- Multi-feedstock Supply
- Lower Insurance Risk *(utilizes damaged crops)*
- Existing Infrastructure Compatible
- Minimal Safety Issues
- Immediate Transitional Solution

Global Biodiesel Production

Estimated (Litres/Year)

Location	2005/2006	2011/2012
Africa	0	???? (*)
Canada	80,000,000	500,000,000 (**)
Asia	200,000,000	4,500,000,000 (*)
S. America	550,000,000	2,500,000,000 (*)
U.S.A.	950,000,000	8,000,000,000 (*)
Europe	4,500,000,000	10,000,000,000 (*)

(*) anticipated volume

(**) minimum forecast

Government Support

- Provincial: Infrastructure, Commercialization and Market Development support, Producer Credit Program, $239 million over 5 years
- Federal: Biofuels Opportunities for Producers Initiative , Renewable Fuels Standard- proposal to have an average of 5% renewable fuels in 100% of transportation fuels by 2012 (10% by 2015)

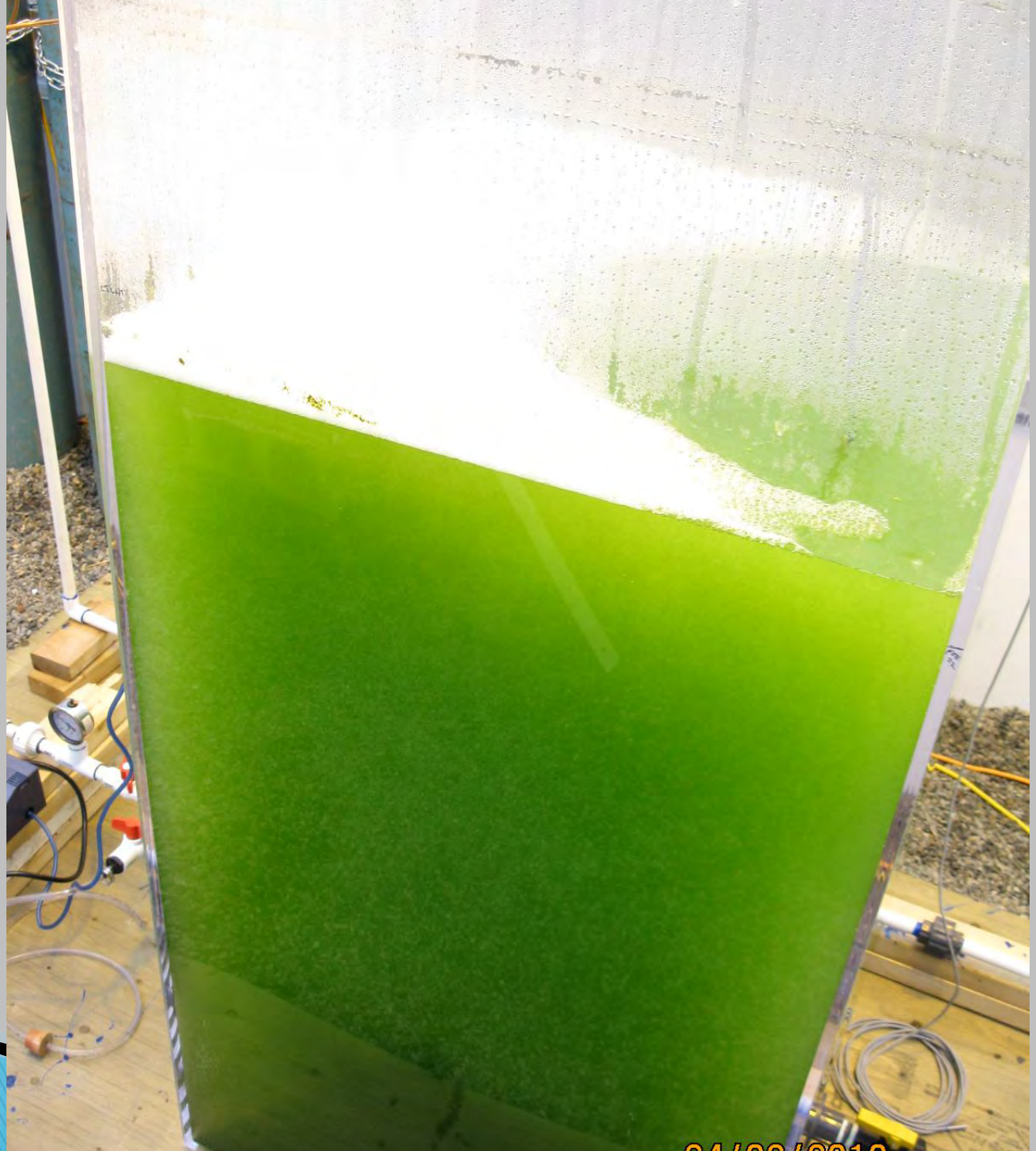
Feedstock

Feedstock

- Canola (#1, heated, green)
- Camelina, jatropha
- Coffee grounds
- Waste oil, tallow


Hemp Oil
Pennycress Oil
Camelina Meal
Camelina Meal


NSERC
CRSNG




09/19/08
(09/08/08)
08
07/22/08
(09/08/08)

Feedstock	Biodiesel (L/ha)
Canola/Rapeseed	1000
Soybeans	375
Jatropha	1590
Mustard seed	1300
Palm oil	5800
Algae	95,000

Source: US Department of Energy

Process

Biodiesel Production and Demonstration

A. Abiola, T. McDonald, C. Vandenberg, S. Gil, and B. Zenert
Olds College School of Innovation, Olds, Alberta, Canada

INTRODUCTION

Biodiesel is a biodegradable, clean burning fuel that is similar to petroleum based diesel, but produced from renewable resources including plant oils and animal fats. In order for vegetable oil to be used, it must be processed using a reaction called transesterification, to make it more acceptable to modern diesel engines. Olds College is seeking to implement a biodiesel production facility at Olds College for the purposes of research, technology demonstration and product use. The proposed facility will have the capability of producing up to 2,000L biodiesel per day and will serve as a demonstration site for agricultural producers with an interest in environmental sustainability and self-reliance as well as a learning tool to enhance the educational experience of students.

OBJECTIVES

Lakeland College and Olds College initiated a research demonstration project to:

- **Conduct a technical feasibility study to determine the quality of biodiesel produced from varied feedstocks using the technology selected,**
- **Assess the effectiveness of magnesol filtration as a dry wash process for biodiesel,**
- **Explore end-use alternatives and assess the market potential for raw (unrefined) oilseed cake and glycerin,**
- **Explore the fuel performance and impacts of biodiesel use in pilot trials as well as in dynamometer tests,**
- **Conduct an economic feasibility assessment to determine the cost of small scale biodiesel production in Alberta using locally grown feedstocks and this technology, and**
- **Disseminate project information through workshops, tours, reports, and publications.**

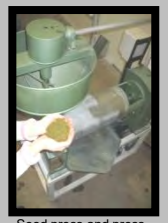
To meet these research goals, Olds College is constructing a biodiesel refinery with capability to produce enough biodiesel to meet the demand of the project partners while serving as a demonstration facility for new technology or process evaluation, a training site for students or operators and a controlled environment for conducting feasibility assessments.

PARTNERS

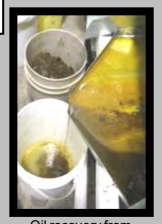
This initiative has received interest and financial support of numerous government, community, and industry partners. Funding for research personnel has been provided by the Alberta Association of Colleges and Technical Institutes (AACTI). Biofuel Canada Ltd., based out of Calgary, AB, partnered as the technology supplier for this facility. Mountain View County, Town of Olds, and the Chinook's Edge School Division are contributing to the project and are committed to using biodiesel in fleet vehicles and school buses. Both General Motors Canada and John Deere have also shown their support. Funding from the Agriculture and Food Council under the Biofuels Opportunities for Producers Initiative (BOPI) had been received with support form local agricultural producers and industry partners including Agricore United and Alberta Feeds and Consulting Ltd. Local agriculture producers supporting the project will have the opportunity to utilize biodiesel on a trial basis, access canola press cake for use in livestock feeding and receive an economic assessment for biodiesel production on their farm operation. Funding for the storage and dispensing system was received from Alberta Energy under the Biofuel Commercialization and Market Development Program (BCMDP).

PROCESS FLOW

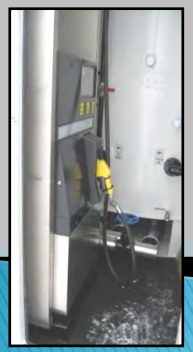
Field of canola.



Seed press and press cake.



Oil recovery from seed press.

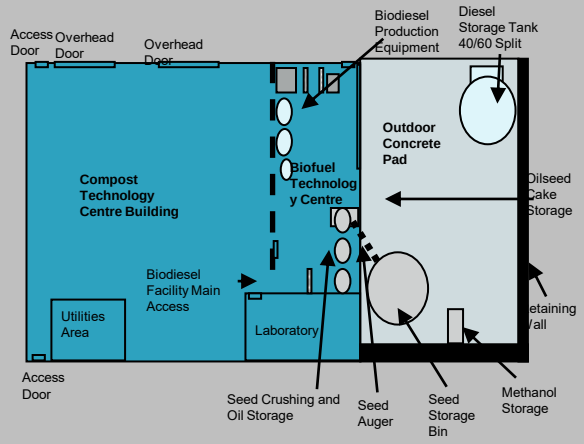


Biodiesel blender and pump dispenser unit.

Outdoor storage area containing heated tank, seed bin, and press cake storage.

EQUIPMENT

The equipment includes a 5t seed press, oil filter, oil preheater, 400L stainless steel batch reactor, 400L stainless steel settling tank, 2,000L poly biodiesel storage tank and magnosol filtration. BFC's dry wash process produces clean biodiesel exceeding the ASTM standard, without the traditional use of water which reduces shelf life and produces a contaminated effluent. The equipment is compact and modular which produces a small footprint and allows for production expansion. The indoor processing area is 740ft² and the outdoor storage is 2,300ft². Additional equipment required for the facility includes a seed heating unit, gravity filtration tank for pressed oil, air drier devices for the compressor, all required pumps and flow meters as well as appropriate storage for feedstock, methanol, catalyst and glycerin.



To ensure quality storage of biodiesel, a 10,500L split-tank storage system (60% petro-diesel and 40% biodiesel) designed to meet environmental safety considerations and to maintain the stored fuels at a temperature amenable to utilization and blending year round, regardless of outside temperature has been purchased. A blending and dispensing system designed by Keller Equipment Supply Ltd. will

replication many times [illegible] enabling expanded biodiesel use and enhancing [illegible]

Olds College Biodiesel Facility

- Need for increased awareness, research and demonstration
- Production target: 250,000L per year (small producer focus)
- BioFuel Canada Ltd. (www.biofuelcanada.c


SCREW PRESS
VEGETABLE OIL
CONTROL PANEL
TARPON
DANGER
FLAMMABLE LIQUID
CORROSIVE


M.S.D.S.
STATION
NO
SMOKING

Products

How to combat cold-flow?

- Same as with diesel fuel
- Blend with #1 petrodiesel and kerosene
- Inject cold flow enhancement additives
- Fuel and vehicles in heated environment
- In B20 blends or lower, cold weather performance is typically dictated by the diesel fuel portion

Storage and Blending Facility

- Designed and installed by Tanksafe
- 1st of its kind in North America
- Dual-walled, heated biodiesel storage
- Glycol heated
- 60/40 split
- 3 blend dispenser

The blender dispensing system is able to mix three different blends of biodiesel, (B5,B20 and B100) on site.

Quality Compliance

- ASTM D-6751
  [North American standard developed by the 'American Society for Testing and Materials' related to biodiesel production for commercial sale]
- BQ-9000
  [North American standard developed by the U.S. 'National Biodiesel Board' to manage storage, handling, distribution & marketing of commercially available biodiesel products]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Engine Performance and Wear Testing Using Biodiesel Blends

D. Daley, C. Vandenberg, B. Zenert, T. McDonald, and S. Gil
School of Innovation and School of Trades and Career Studies

OLDS COLLEGE
School of Trades and Careers

OLDS COLLEG
School of Innovatio

OBJECTIVES

To test the effect of neat (100% biodiesel) versus petroleum blends of biodiesel on engine wear and performance, Dan Daley, instructor within the Olds College Engine Mechanics Laboratory, performed engine testing on two displacement engines: a 8.1L and a 12.5L. Oil samples were collected to determine engine wear and oil contamination in the fuel.

METHODS

Neat biodiesel (B100) and petroleum blends of biodiesel, including B5, B20, and B50 were supplied in 45 gallon drums by the BioFuel Technology Centre located on the Olds College campus. Biodiesel was produced on site using canola oil as a feedstock. Quality assurance (ASTM) testing for biodiesel was completed at the Saskatchewan Research Council in Regina, SK.

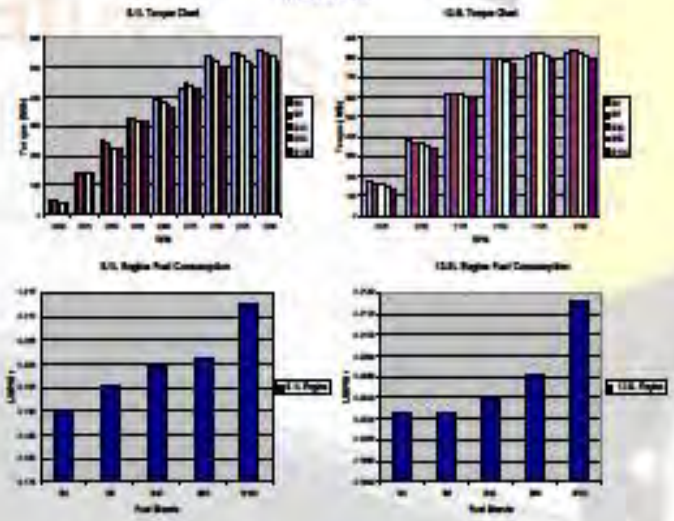
ENGINE SPECIFICATIONS AND TESTING PROCEDURE

All engine testing was completed in an open air dynamometer test facility located at the Olds College Engine Mechanics Laboratory.

An 8.1L John Deere engine equipped with a Bosch electronic governor, port and helix fuel injection pump, and a larger 12.5 L John Deere engine equipped with a full electronically controlled and mechanically activated fuel injection system were used to compare the performance of different petroleum blends of biodiesel. The 8.1L and the 12.5L engine were connected to the flywheel of a Go Power D2000 water break dynamometer.

Each engine was allowed to warm up for 10 minutes prior to the initial fuel test being performed. Each blend was then run through the engine for a four hour period in sequential order of B0 (petro-diesel alone), B5, B20, B50, and finally B100. Before the start of the test sequence, the fuel system was flushed of any residual fuel for a period of 10 minutes to ensure an accurate fuel sample blend was tested.

RESULTS



RESULTS

In both the 8.1L engine and the 12.5 L engine, there w
increase in wear metals which indicates that, regardle
the concentration of biodiesel in the blend, the lubricit
the operations of the engine were normal. In both en
fuel dilution and soot contamination in the oil samples
found to be the same regardless of the concentrati
biodiesel in the blend. This indicates if engine tempera
are maintained and operated within normal param
complete combustion is possible. Complete combusti
neat biodiesel may be due to the fact that modern
engines have higher injection pressures which aid wit
atomization of fuel as it enters the combustion chamber.

The results of the engine wear analysis demonstrate
there are no adverse affects of using biodiesel or bio
blends in a diesel engine as an alternative to petroleum
as long as the engine is operated within manufact
recommended operating parameters.

Though biodiesel blends will slightly reduce the e
torque and increase fuel consumption at higher blends
environmental benefits (reduced air emissions)
increased lubricity (smoother performance, longer li
engines, and decreased maintenance costs) of biodies
significant advantages.

DAN DALEY
Instructor
Trades and Career Studies

Dan Daley, principle investigator on the project, is a graduate from Olds College's Agricultural Mechanics program.

Dan performed the biofuel testing on two engines at the Olds College Engine Mechanics Laboratory.

Dan is heavily involved in developing teaching modules for Alberta's apprenticeship programs and currently sits on the OCSI Advisory Board.

ACKNOWLEDGEMENTS

The authors would like to thank Agriculture and Agri-Food Council for supporting this research through the Biofuels Opportunities for Producers' Initiative (BOPI) Program.

Agriculture & Food Council
The Catalyst

Agriculture & Food Coun

Uses


PetroVend
Automated Fueling System
INSERT KEY
PetroVend
DANGER
FLAMMABLE
NO SMOKING
NO OPEN FLAME OR SPARK
TURN OFF CELL PHONES

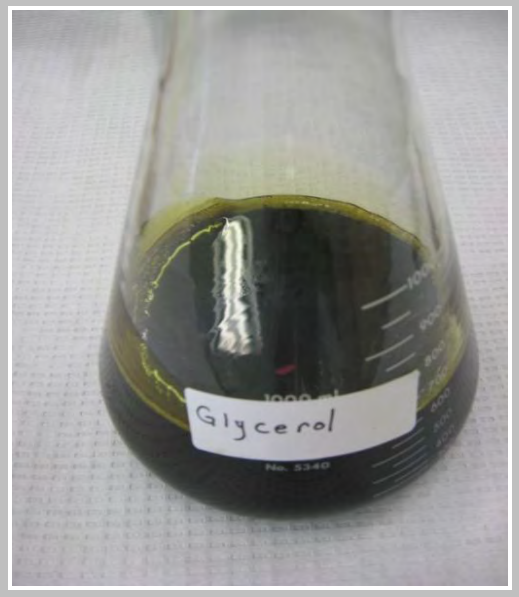

PUSH
TO
START
PUSH
TO
START
PUSH
TO
START


ATCO
EnergySense
www.atcoenergysense.com
310-SAVE
Call Toll-Free for Expert Energy Advice!
Energy Education Mobile
ATCO
TARE 9810
GVW 11793


Thomas
CHINOOK'S EDGE SCHOOL DIV. No. 73
6-193
OVERFLOW

By-products

- Economics hinge on value
- Press cake- high in protein (30%), fat (8-12%)
- Research required to meet needs of biofuel and livestock producers
- Glycerin- quality depends on process, high energy potential
  - A platform chemical



Animal Feed

- Oilseed cake is high in protein (30%), fat (12%)
- Glycerin- sweet, high energy, low cost feed amendment
- Applications in dairy, feedlot, hog operat

Biogas production

- Increased biogas (methane and carbon dioxide) production with the addition of press cake or glycerin as a co-substrate

Biogas Production and Demonstration

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OLDS COLLEGE School of Innovation

Anaerobic digestion involves the input of organic waste mixed with water in an anaerobic (oxygen-free) environment.
An anaerobic digester, or biogas plant, is a sealed, heated tank which provides a suitable environment for naturally occurring anaerobic bacteria.
Anaerobic bacteria transform manure into biogas and a liquefied effluent.
Biogas can be burned to produce heat, electricity or both.

Introduction

Increased environmental awareness, rising waste management and energy costs, and the need for environmentally sustainable waste management solutions provide the impetus for the adoption of biogas recovery from waste in Canada. The majority of Canadian digester projects have been conducted on a single industry and a single waste stream (i.e. sewage sludge or manure).

Co-digestion of mixed waste is relatively new to Canada but has been employed successfully in Europe where mixtures of biosolids and organic solid wastes originating from households, agriculture and industry are handled at centralized digestion facilities.

Comprehensive baseline information regarding the type and amount of feedstock available as well as its relative vicinity is critical in the planning of a biogas plant. These factors must be quantified in order to determine a suitable digester design, establish practical feedstock blends and predict the economic success of a centralized biogas plant.

Municipal solid waste containing grass clippings and food waste.

Obje

The goals of this research were to:

- assess the biogas and electricity generation potential of available feedstocks, and
- determine the impacts of co-digestion on biogas quantity and quality.

These goals were achieved using a detailed waste stream inventory, waste analysis and the determination of biogas potential using in vitro tests.

Project Plan

PHASE I: Waste Stream Inventory

The objective of the organic waste stream inventory and survey was to quantify the number of waste generators, the type of waste and the volume generated in and around the Town of Olds. With escalating transportation costs, proximity to a central facility is important and a 20km radius around the Town of Olds was set as the boundary of inclusion. Some exceptions were made for businesses outside this radius with large volumes of organic waste or high disposal costs. Agricultural, industrial and municipal waste generators within this area were identified, contacted by phone and surveyed to determine the volume of waste produced each year.

Project Plan

PHASE II a: Waste Stream Characterization

Different feedstocks vary in their physical, chemical and biological characteristics, biogas potential, degradability, concentration of contaminants, toxic materials, and recalcitrant compounds. Site visits were made to local waste generators and representative 4L waste samples were collected and subjected to complete analysis. Eleven waste streams were sampled: feedlot, dairy, hog and poultry manure, food waste, grass clippings, biosolids, seed hulls, tannery fat, used cooking oil (UCO), and offal collected from a hog processing plant. Waste analysis was conducted at Olds College and Bodycote Labs in Lethbridge and Edmonton, AB.

PHASE II b: Determination of Biogas Potential

Once the chemical, physical and biological attributes of locally available feedstocks were determined, the next step was to determine the viability of biogas production using these wastes. *In vitro* fermentation tests were designed according ... tential (BMP) assay to ... uality during digestion ...

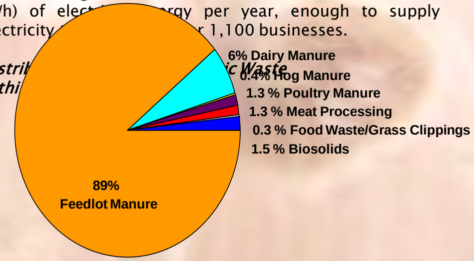
Testing was conducted on a larger scale using modified 30 litre pressure cookers which store biogas during anaerobic digestion.

Results

***PHASE I:* Waste Stream Inventory**

The waste inventory, designed to determine the local availability of feedstock for a centralized co-digestion facility revealed that 291,000 wet tonnes of organic waste was generated each year. This volume of waste has the potential to generate as much as 40 GWh (1 GWh = 10^6 kWh) of elect... ergy per year, enough to supply electricity ... r 1,100 businesses.

Distrib... ic Waste withi...



Results

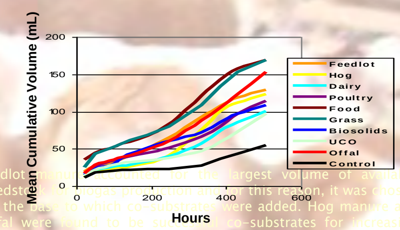
PHASE II a: Waste Stream Characterization

Laboratory analysis revealed that there is an opportunity for blended wastes to adjust the solids content, nutrient balance and pH level for optimal digestion. Coupled with the inventory results, the waste analysis was useful for identifying wastes that were unsuitable for biogas production, such as tannery fat or seed hulls, and those that should be used with consideration of their biodegradability, heavy metal or ammonium content, such as poultry manure or biosolids.

PHASE II b: *Determination of Biogas Potential*

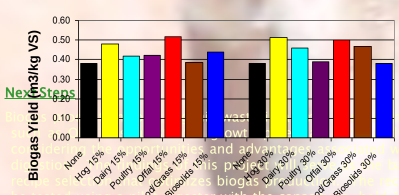
Biogas yield was higher when digesting food (0.656 m^3/kg volatile solids (VS)) and grass (0.676 m^3/kg VS) and lower when digesting dairy manure (0.269 m^3/kg VS), poultry manure (0.330 m^3/kg VS) and biosolids (0.320 m^3/kg VS), compared to feedlot manure (0.438m^3/kg VS) ($P<0.05$).

Biogas Potential of Available Feedstocks



Feedlot manure accounted for the largest volume of available feedstock for biogas production and for this reason, it was chosen as the base to which co-substrates were added. Hog manure and offal were found to be successful co-substrates for increasing biogas yield and quality. Specific biogas yield increased from 0.382m^3/kg VS for feedlot manure alone to 0.513, 0.517 and 0.500m^3/kg VS with co-digestion of 30% hog manure, 15% offal and 30% offal, respectively (see graph below). Methane content of biogas increased from 75.8% in feedlot manure digestion to 78.8, 79.5 and 80.9% with co-digestion of 30% hog manure, 15% offal and 30% offal, respectively.

Biogas Yield from Co-substrates with Feedlot Manure



Next Steps

Biog... wast... mmunity such as O... owt... y when considering the opportunities and advantages associated with co-digestion. The findings of this project will serve as the basis for recipe selection that optimizes biogas production. The recipe will be tested using a pilot digester with the capacity to hold 15m^3 of waste material. The results will be used to assess the technical and economic viability of a centralized co-digestion facility in the Town of Olds.

Acknowledgements

The authors would like to thank the Federation of Canadian Municipalities, through the Green Municipal Enabling Fund, Olds College School of Innovation, The Town of Olds, Mountain View County, and Alberta Environment for providing financial support for this research. The efforts of all those directly or indirectly involved in conducting this research are gratefully acknowledged.

Composting

- Glycerin supplies moisture as well as energy to bacteria


Pharmaceuticals

Biopesticide

- Glucosinolates- sulfur bearing compounds with bitter flavor, may cause thyroid dysfunction
- Use of mustard cake to inhibit growth of weeds and fungi
  - Dandelion, Redroot pigweed, wild oat, Fusarium
- Applications in turfgrass industry or organic vegetable production

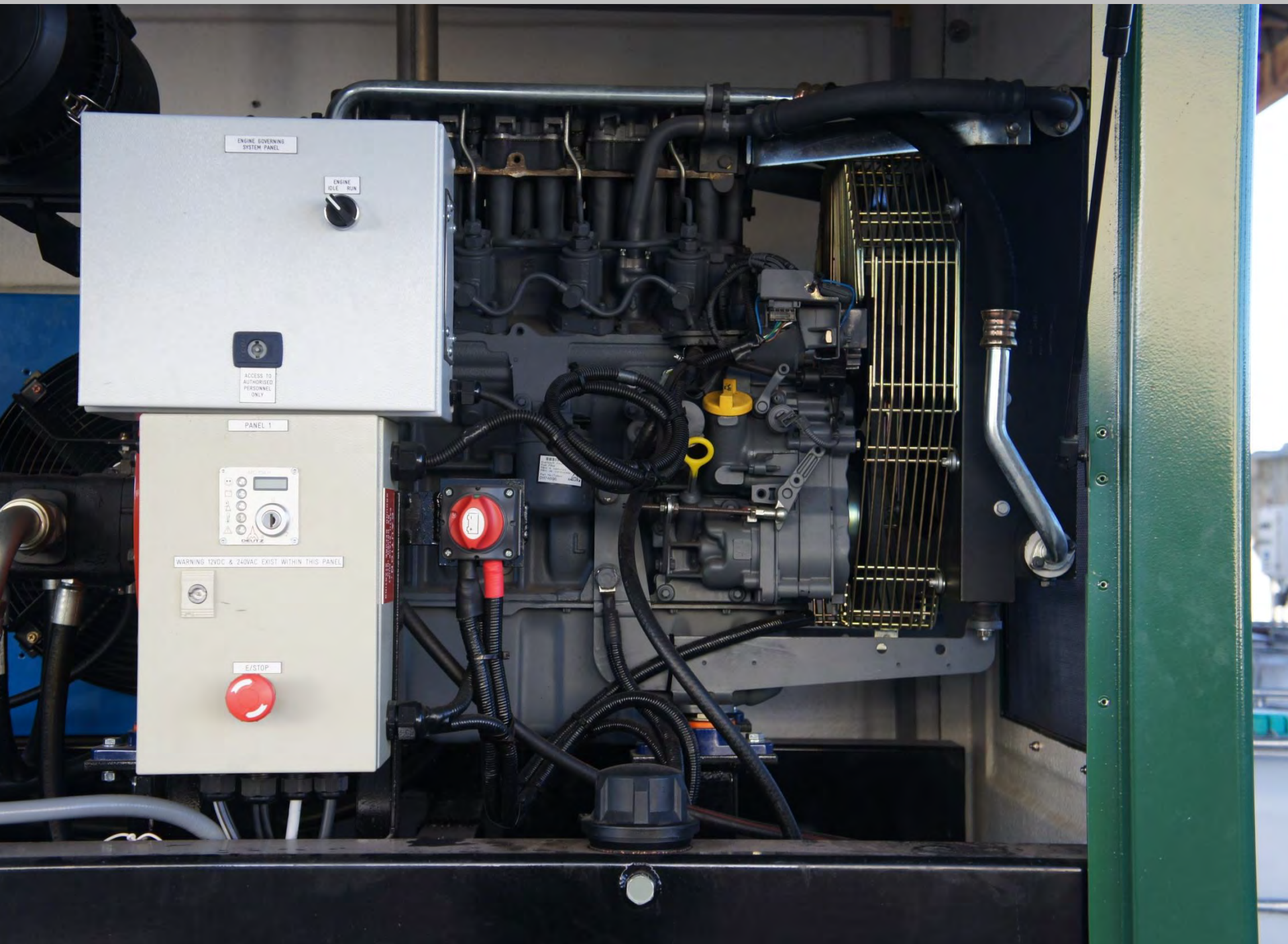
Important Considerations for Economic Sustainability

- Easily accessible, low cost feedstock
- Market for products
- Muti-pathways with multi-products

Portable Biodiesel Production


BioCube™


BioCube™
CANOLA OIL


ENGINE GOVERNING SYSTEM PANEL
ENGINE IDLE RUN
ACCESS TO AUTHORISED PERSONNEL ONLY
PANEL 1
DEUTZ
WARNING 12VDC & 240VAC EXIST WITHIN THIS PANEL
E/STOP


OIL TANK

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SUNFUEL
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TANKSAFE®

BioFuel Canada Ltd.™

Mountain View COUNTY

KELLER EQUIPMENT SUPPLY LTD

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CHINOOK'S EDGE SCHOOL DIVISION

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ALBERTA FEED & CONSULTING LTD.

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