Bioenergy Research
Hawaii Natural Energy Institute

Briefing for
Rear Admiral Matthew Klunder
Chief of Naval Research

Hawaii Natural Energy Institute
University of Hawaii
September 7, 2012
Pathways for Bioenergy Systems

Crops

Sugarcane
Sweet Sorghum
Cassava
Corn
Guinea Grass
Banagrass
Eucalyptus
Leucaena
Jatropha
Kukui
MicroAlgae
Soybean
Peanut
Sunflower
Oil Palm

Intermediate Products

Sugars
Starch
Fiber
Oil

Conversion Technologies

Hydrolysis
Fermentation
Gasification
Pyrolysis
Combustion
Transesterification

Bioenergy Products

Ethanol
Synthetic Diesel, and Other Fuels, Chemicals, & Biomaterials
Electricity & Heat
Biodiesel

Waste Cooking Oil

Blue – Commercial in Hawaii
Green – Commercial elsewhere
Pink – Grown commercially in Hawaii
Orange – Under Development
Research and the Bioenergy Industry Value Chain

Feedstock Production

Feedstock Logistics

Conversion

Distribution

End Use

Agriculture ---- Industry ---- Investors ---- Government ---- Community

Feedstock Production - CTAHR
Gasification & Contaminant Removal - HNEI

Fuel Fit for Purpose

Technology Assessment

Resource Assessment
GIS Tools Development

Technology Development


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Resource Assessment/Planning

- Hawaii Bioenergy Master Plan
  - Assessment of land, water, labor, infrastructure, technology, permitting, financial incentives, policy requirements, economic and environmental impacts

- GIS-based analysis of bioenergy production potential
  - Products: electricity from fiber, algae, ethanol, etc.
  - Analysis criteria: soil type, water access, rainfall, slope, insolation, land use zoning, community


Algae Production Siting

Areas Meeting Slope, Rain, Solar, and Zoning Criteria

- Slope ≤ 5%
- Rain < 40 inches/year
- Solar insolation ≥ 400 cal/sq cm/day
- Zoned Agricultural, Conservation, or Industrial Area ≥ 50 acres

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Biofuel evaluation (fit for purpose)

• Target: Fuel qualities that are beyond established specifications

• Objective: Evaluate biofuel and biofuel blends relative to petroleum fuel standard
  – Microbial activity – develop rapid detection assay using bioinformatics
  – Corrosion – controlled exposure of fuel tank materials to biofuel fuel seawater mixtures
  – Storage stability
Mass spectrometry based method for bacterial identification

1. Extract proteins
2. Spot target plate
3. MALDI
4. Matrix Assisted Laser Desorption Ionization
5. Protein barcode
6. Barcode alignment with database to ID
7. Mass spectrum
8. Database of standard protein barcodes
Technology Development

- Thermochemical – gasification and pyrolysis using local feedstocks; product yield, contaminant removal/control for gas quality improvement, $\text{H}_2$ production
- Biochemical – syngas fermentation for the production of biofuels, bioplastics and high value products
- Purification and separation of lipids and proteins using ionic liquids; single reactor separation and transesterification
- Biocarbon production (improved quality and yield) for waste disposal and solid fuel production
HNEI Biocarbon RD&D

- Scale-up, commercialization, & licensing of UH patented Flash Carbonization process
- Emissions remediation
- Biocarbon fuel cell
- Biocarbon yield improvement for Si production
- Biocarbon soil amendment to enhance plant growth
Research objective: a simple processing technology for effective conversion of syngas into bio-oil and liquid fuel

Cellulosic Biomass $\rightarrow$ Syngas (CO$_2$, CO, H$_2$)

Autotrophic microbes
30 °C, dark conditions

$\Delta H_{o,c,\text{PHB}} = -24.1$ MJ/kg

$\Delta H_{o,c,\text{glucose}} = -15.6$ MJ/kg

PHB contains 54% more energy than starch!

PHB chemical structure: $\text{CH}_3\text{O} - [\text{OCHCH}_2\text{C}]_n\text{OH}$ (n=500-10,000)
Bio-oil composition compared with biodiesel standards over a GC column
Gasification Facility

Objectives

- Develop analytical methods to measure contaminants in product gas
- Characterize fuels (tropical biomass feedstocks, solid waste, etc.) for gas production, quality, and contaminant levels
- Evaluate contaminant removal and control strategies
- Investigate biomass derived syngas conversion to liquid fuels or other high value products

Sampling ports:
- Port 1: trace element sample pt
- Port 2: outlet of sorbent bed
- Port 3: outlet of catalytic tar reformer
- Port 4: outlet of water gas shift

The goal of this project is to produce **multi-component solvents** that possess unique chemical (e.g., charge or hydrophobic/hydrophilic) and physical (e.g. structure) distribution patterns at micro-scale that result in advantageous extraction and separation features at macroscale.
We believe a new class of IL based co-solvents can be designed that can extract and guide the separation of multiple compounds of disparate size, polarity, and hydrophobicity will provide **broad impact** to the separations industry, including technology areas such as specialty chemicals, pharmaceuticals, and biofuels.

Model prediction of lipid aggregation after extraction into [EMIN] [MeSO₄]-methanol mixture.
Program on Water, Energy, and Soil Sustainability (WESS)

http://www.hnei.hawaii.edu