Department of Chemical and Biomolecular Engineering

Senior Design Day 2008

Overview

- Non-traditional projects
- Energy-related projects
- Biotech-related projects

Use of Magnetohydrodynamic Fluids

in Manufacturing

Kendra Moreau

Jake Vestal

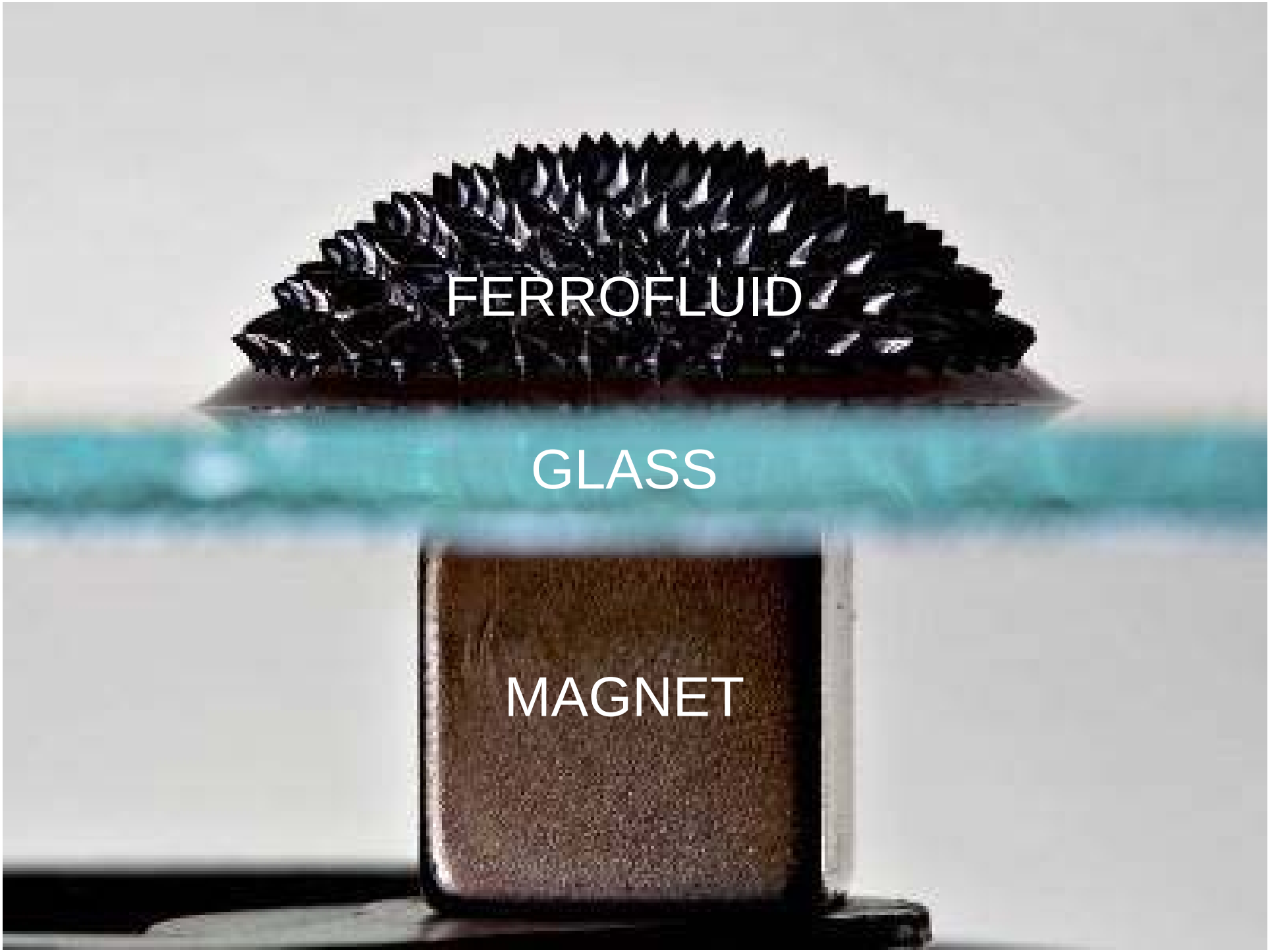
Christine Watson

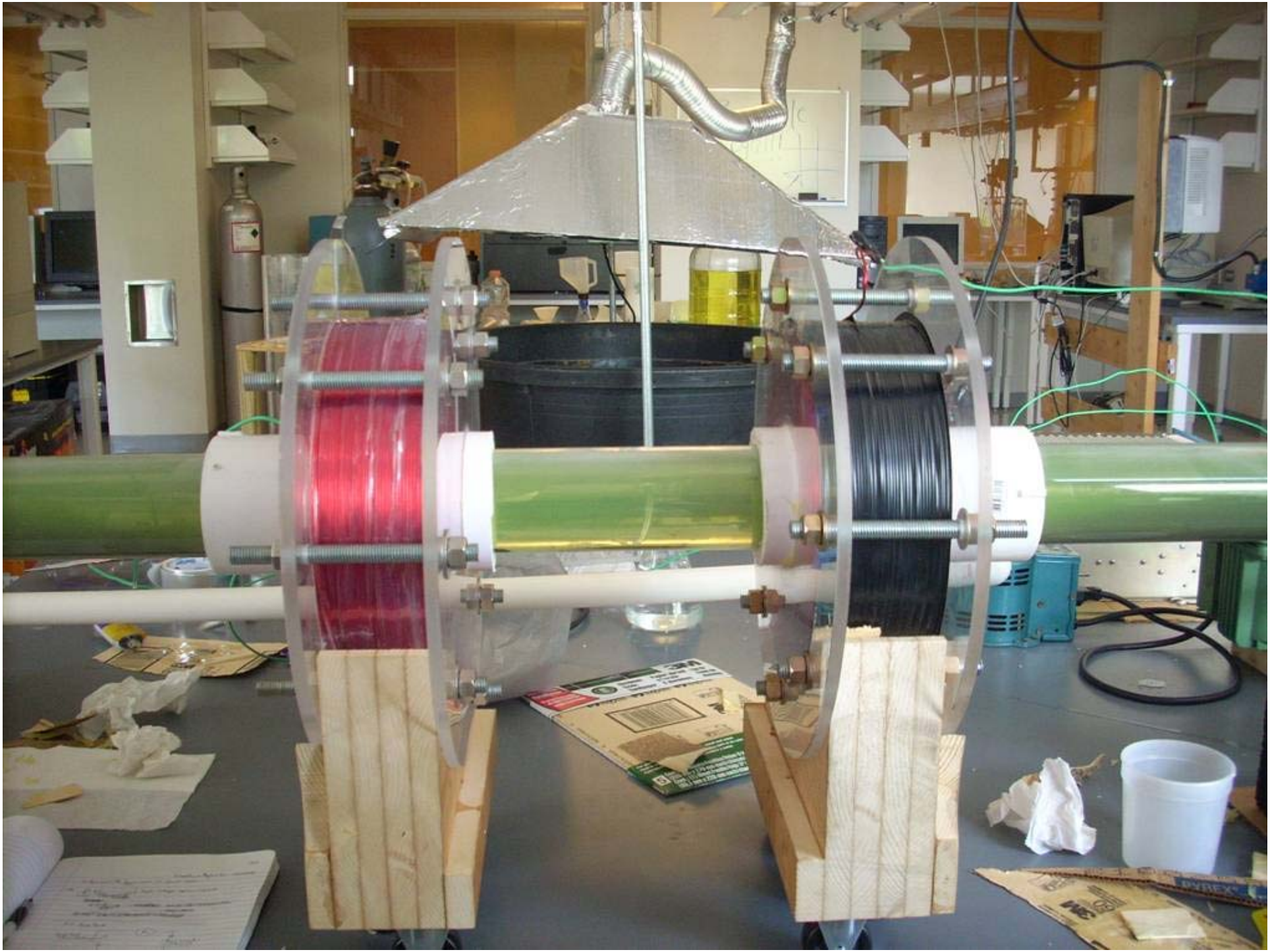
Microgravity University

Proposal includes:

- Design of device
  - Functions in microgravity
- Outreach component
  - Magellan Charter School
- Test flight aboard C-9
  - Simulates microgravity

McDonnell-Douglas C-9


FERROFLUID
GLASS
MAGNET



ZEROG

MHD

EXTRACTING OXYGEN FROM LUNAR SOIL

Team MoonROx

Willie Barton, Laura Blackwell, Jonathon Harding, Daniel Harpham, Eric Hodgden, Patrick McNeely

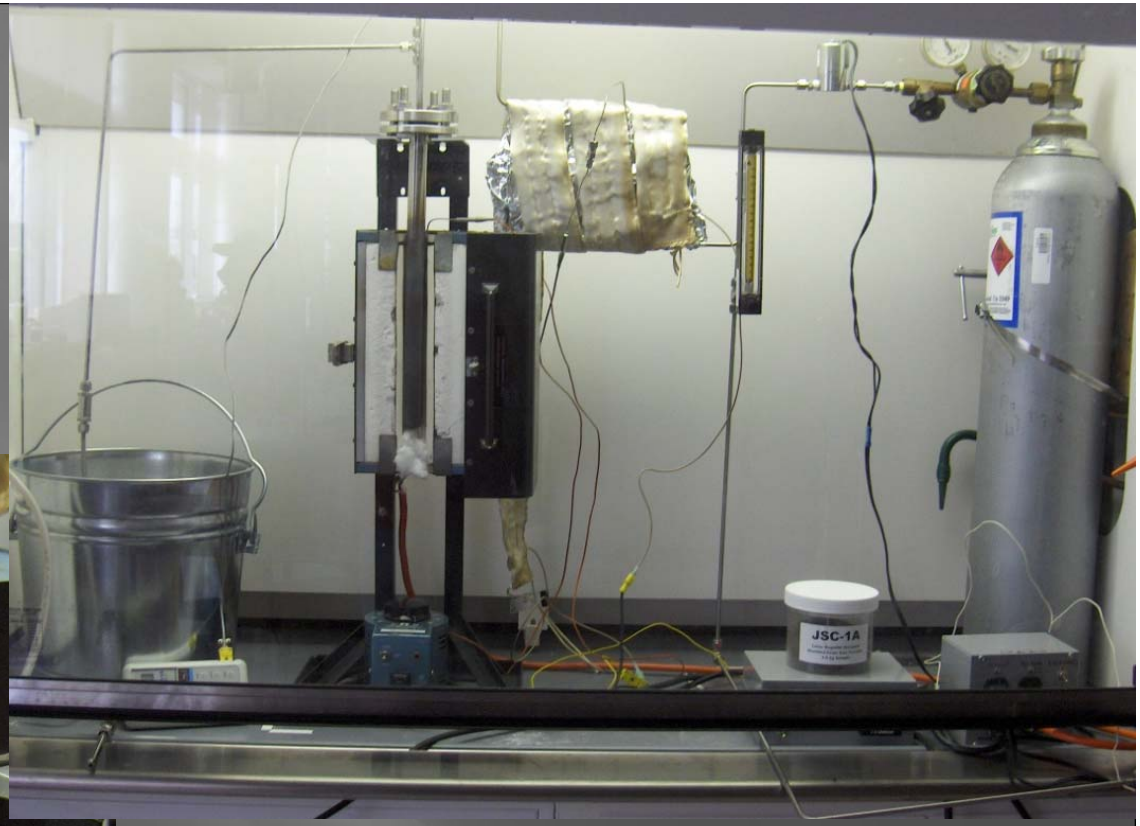
Motivations and Objectives

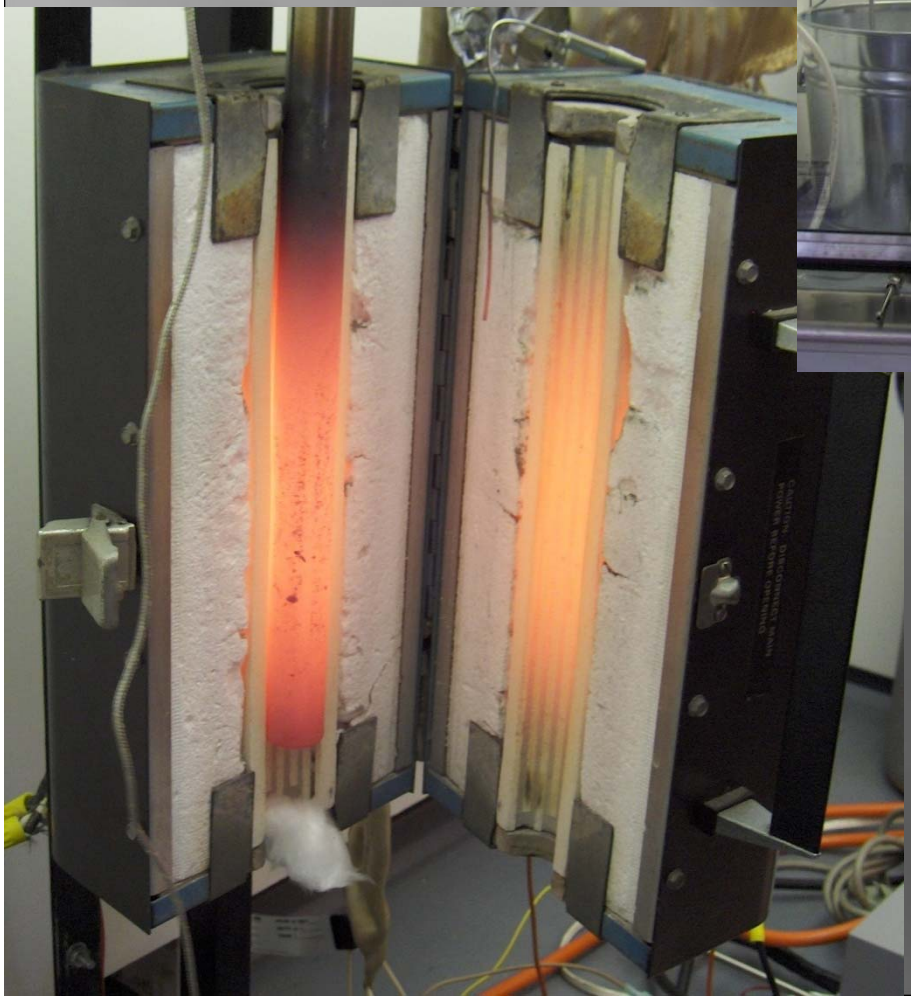
- Oxygen for lunar base
- Oxygen fuel for space exploration
- 1 million dollars

How do we do it?

Components in moon rock	Percent by weight
Silicon dioxide	46-49
Aluminum oxide	14.5 - 15.5
Calcium oxide	10 – 11
Magnesium oxide	8.5 - 9.5
Iron (II) oxide	7 - 7.5
Iron (III) oxide	3 – 4
Sodium oxide	2.5 – 3
Titanium dioxide	1 – 2
Other Components	1.5 - 1.8

Experimental Setup





Hydrogen + Lunar Soil → Water + Metal

Come See Our Poster!

CHEMICAL & BIOMOLECULAR ENGINEERING

NC STATE UNIVERSITY

NCSU MoonROx Senior Design Team

Willie Barton, Laura Blackwell, Jonathon Harding, Daniel Harpham, Eric Hodgden, Patrick McNeely

Motivations

- Back to the Moon Initiative
- Establishment of a lunar colony
- Outpost for further space exploration
- Contest to develop technology

Introduction

- NASA issued Centennial Challenges
- MoonROx Challenge is to extract oxygen from lunar soil
- Thirteen reactions have been discovered
- More work required to advance technology

Objectives

- Produce oxygen from lunar soil
- Focus on three reactions
- Establish the viability of chosen reactions
- Simulate a feasible reaction scheme

MoonROx Competition Rules

- Produce 2.5 kg of breathable oxygen
- Complete reaction within 4 hours
- Use no more than 10 kW at any time
- Complete apparatus may not exceed 50 kg
- Consume up to 100 kg of lunar soil

Component	Percent by Weight
Silicon dioxide	46-49
Aluminum oxide	14.5-15.5
Calcium oxide	10-11
Magnesium oxide	8.5-9.5
Iron (II) oxide	7-7.5
Iron (III) oxide	3-4
Sodium oxide	2.5-3
Titanium dioxide	1-2
Other Components	1.5-1.8

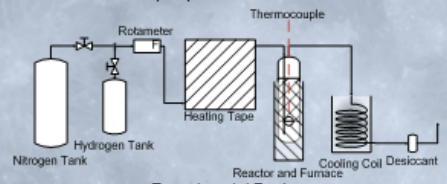
Lunar Simulant Composition

Experimental Design

- Hydrogen Reduction of Ilmenite
  - Pass hydrogen gas over lunar soil at 900°C to produce water from ilmenite in lunar soil
  - Ilmenite is titanium dioxide and iron (II) oxide
- Caustic Electrolysis
  - Dissolve and electrolyze lunar soil in molten sodium hydroxide at 400°C
- Ion Separation
  - Vaporize lunar soil at 7-10,000°C using a laser

Experimental Design

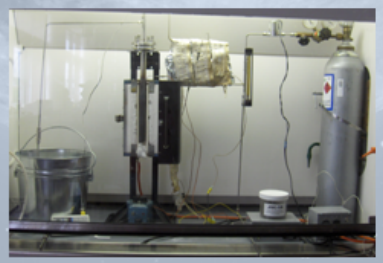
- Hydrogen reduction was investigated further
- Other reactions were not realistic with available resources
- Reactor designed to carry out hydrogen reduction
- Varied reaction temperature and time
- Collected water vapor product with desiccant



Experimental Design

Experimental Design

- Converted 55% of ilmenite to water
- Reaction time approximately 15 minutes
- Reaction yield suitable at 850°C

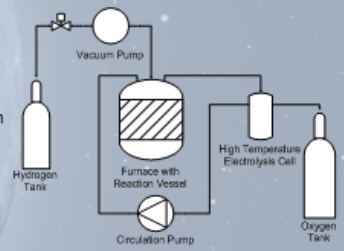


Experimental Apparatus

Simulation

- Scale-up hydrogen reduction to work on the moon
- Reactor will be 42 cm in diameter and height
- Titanium is ideal material for reactor
- High-temperature electrolysis converts water to oxygen

Simulation Flowchart



Conclusions

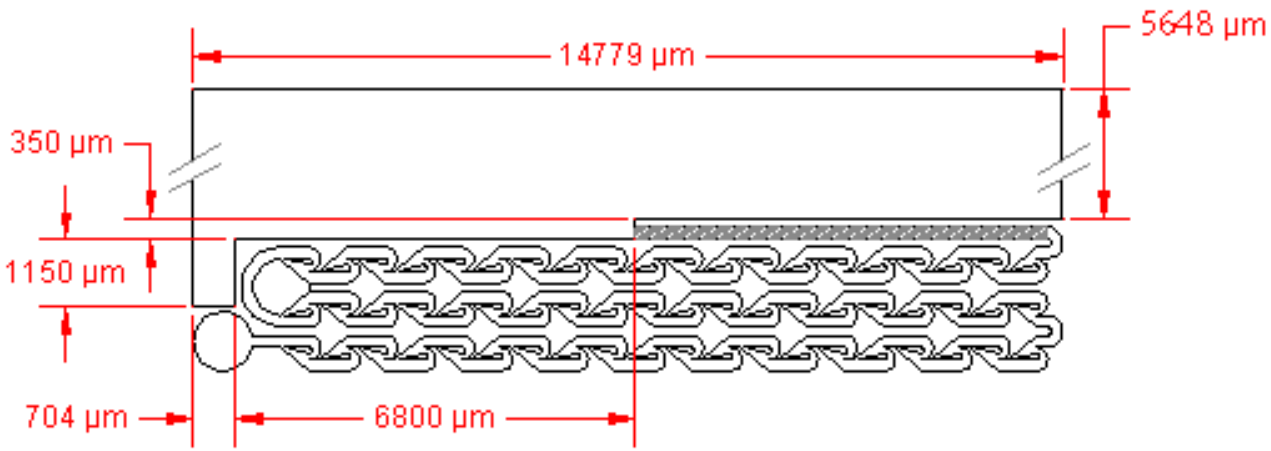
- Experimental
  - Reaction produced water
  - Better construction and materials
  - Better water collection method
- Simulation
  - Verified successful prototype is possible
  - More work needed for final construction

Acknowledgements

The NCSU MoonROx senior design team would like to recognize the faculty of the NCSU Department of Chemical and Biomolecular Engineering, Orbitec Inc., Bobby Cook and Tim Winter of Diosynth Biotechnology Inc., Jim Bierwirth of STI Inc., Harold Morton, Kit Yeung, and Jason Kelly.

Lab on a Chip:

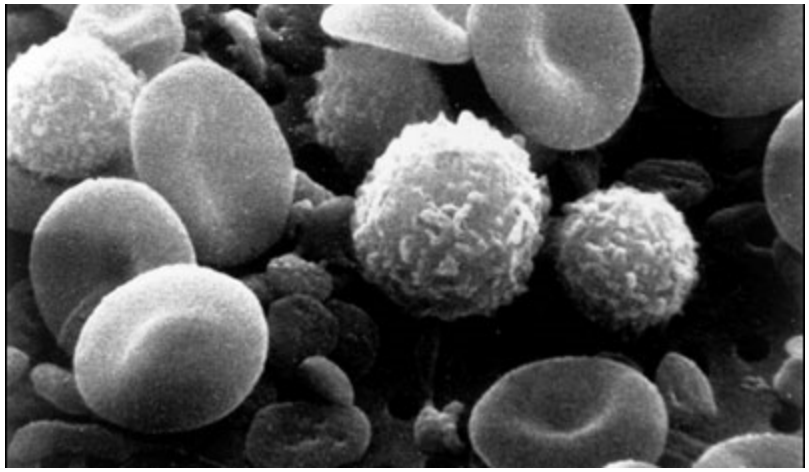
A Microfluidic White Blood Cell Counting Device



Bessie Bryant, Khalid Kopanski, Justin Smith, Schuyler Wilson
Advisors: Dr. Efimenko, Dr. Velev, Dr. Genzer

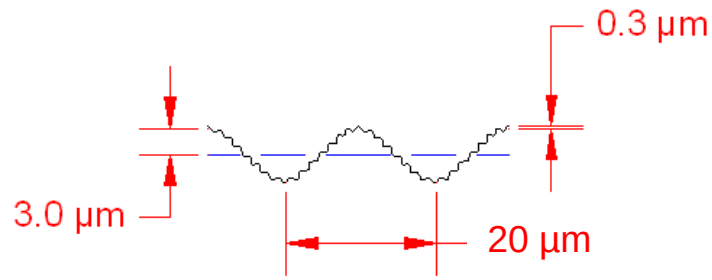
Motivations

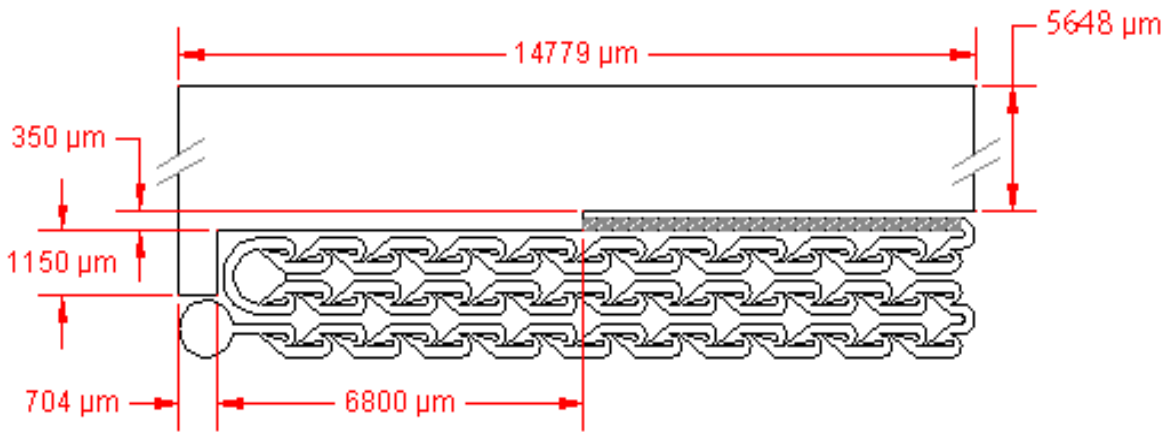
- HIV, leukemia, neutropenia, lupus
- Fast, accurate test results – no lab needed
- Easy to use – clinics, doctors' offices
- Relatively inexpensive



Processing a Sample

- Mixing
  - Passive mixing structures
- Separation
  - Electric fields
  - Cells captured in buckles
- Detection
  - Conductivity measurements





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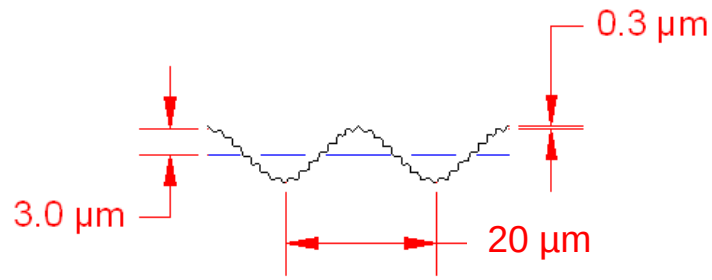

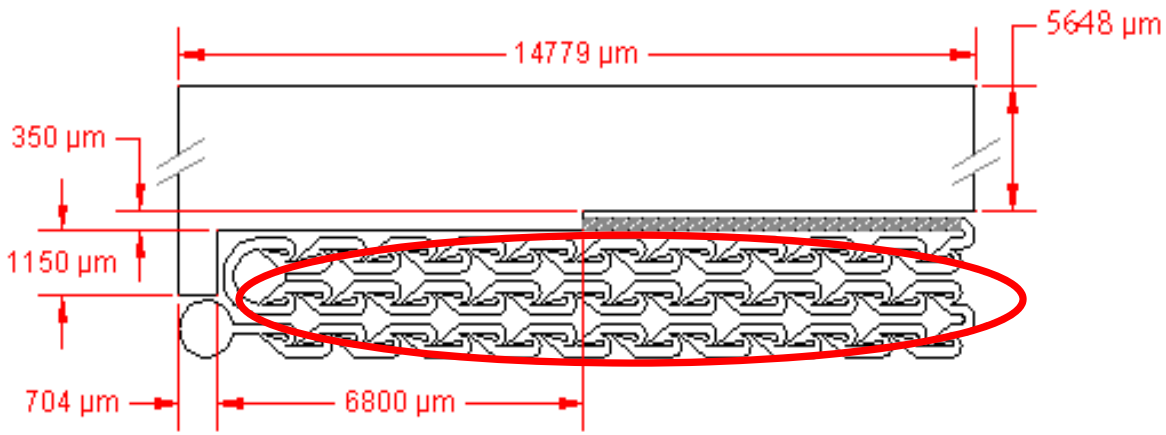

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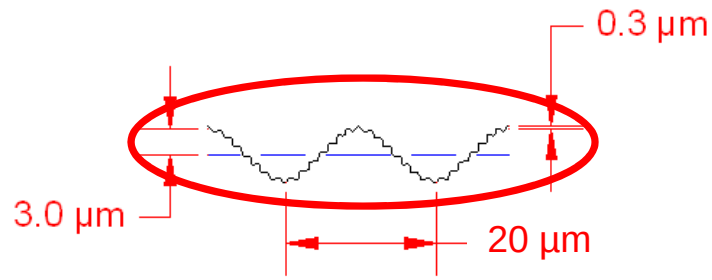

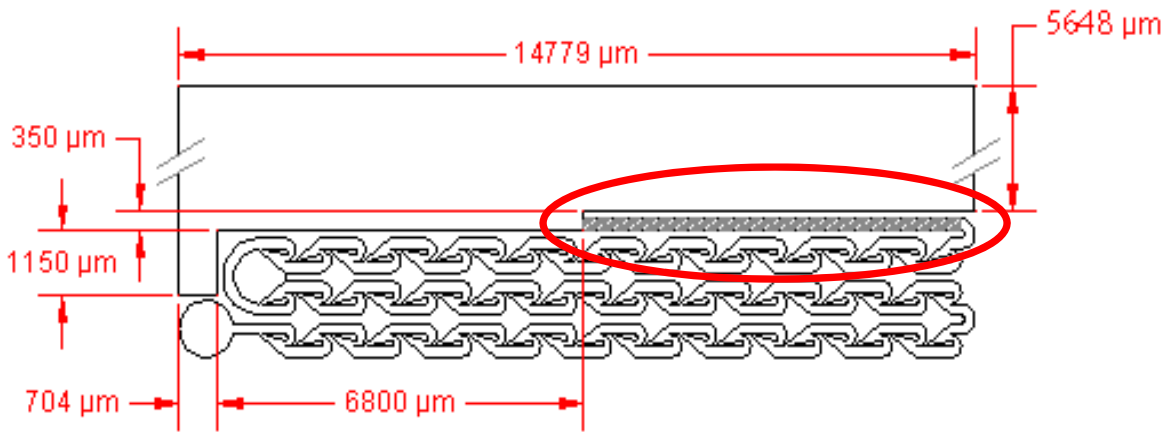

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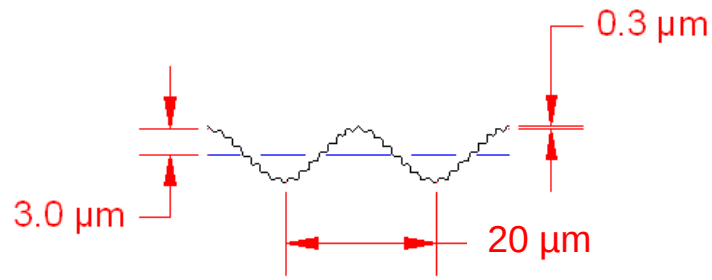
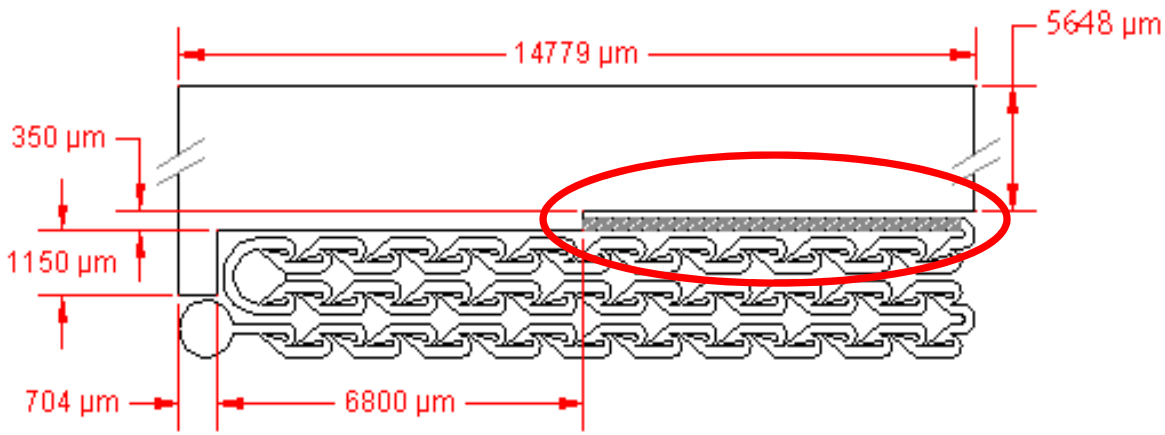




Come See Our Poster

Lab on a Chip: White Blood Cell Counting Device

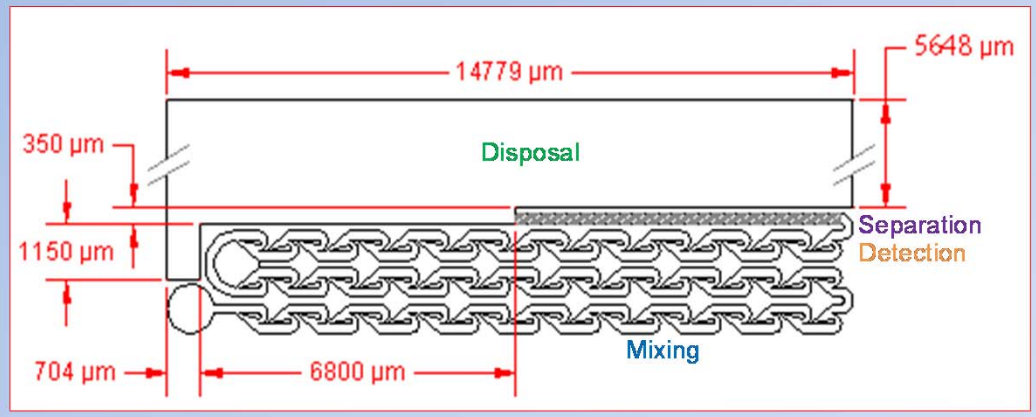
Bessie Bryant, Khalid Kopanski, Justin Smith, and Schuyler Wilson

Background

Microfluidics is a growing technology allowing synthesis and analysis of fluids on a micro scale. A device similar to a glucose meter was designed to count the white blood cells in a sample of blood. This device would be useful worldwide for patients with diseases that affect white blood cell levels and require close monitoring.

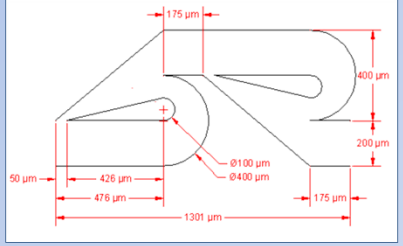
Process Description

- Sample Introduction
- Mixing: Telsa Structures
- Separation
  - Buckled Substrate
  - Dielectrophoresis
- Detection: Cell Lysis Impedance Spectroscopy
- Disposal



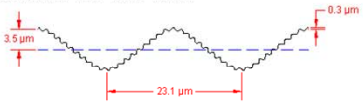
Mixing

- Mixing not effective in laminar flow
- Tesla structure
  - Use of Coanda effect
  - Form of passive mixing
- Approximately 30 structures needed
- Achieve near perfect mixing



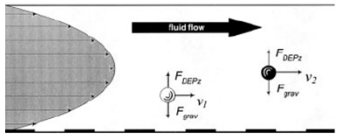
Buckled Substrate

- Hierarchical buckling
- Angled to facilitate flow and mass transfer
- Used to immobilize the white blood cells
- Sized to fit the dimensions of a white blood cell



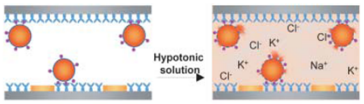
Dielectrophoresis

- Primary separation method
- Separates according to dielectric properties
- Attracts white blood cells; repels red blood cells
- AC frequencies induce dipoles on cells



Cell Lysate Impedance Spectroscopy

- Detection method - accurate to 20 cells per microliter
- Releases intracellular ions via lysis
- Correlates ionic conductivity to cellular concentration
- Easily implemented in microfluidic device



Disposal method

- Waste chamber incorporated into device
- Designed to accept more than 10 microliters of fluid
- Entire device can be incinerated to dispose of biohazardous waste

Acknowledgements: Dr. Efimenko, Dr. Velev, Dr. Genzer, Dr. Bullard, and Dr. Peretti

NC STATE UNIVERSITY

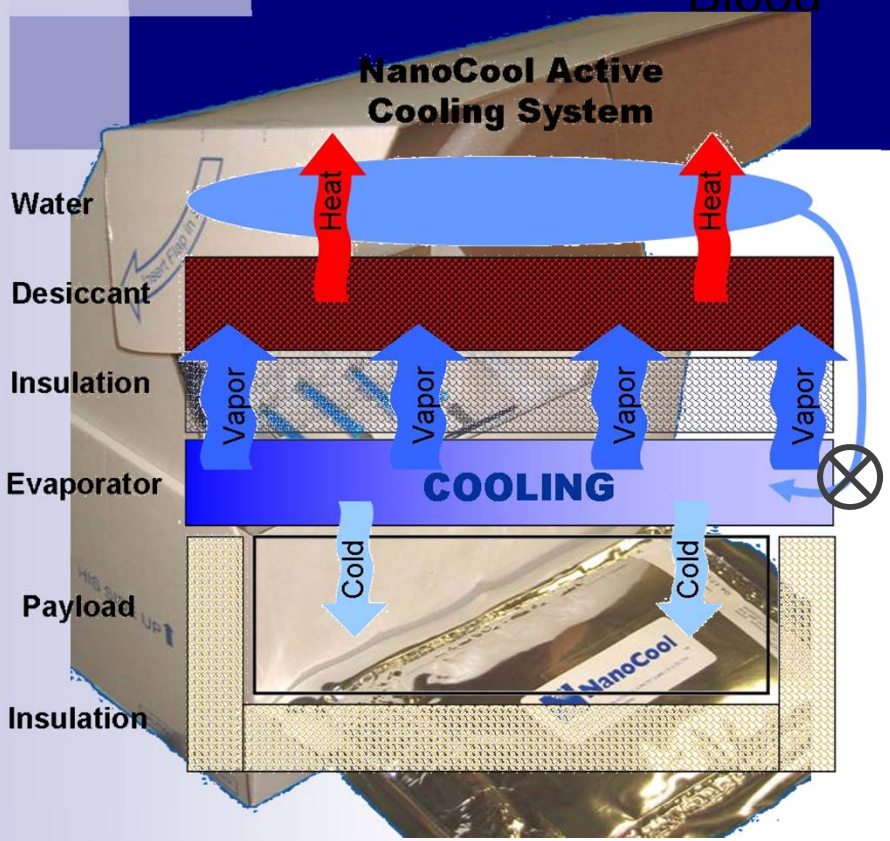
What is NanoCool?

NanoCool

Senior Design Project

Temperature controlled packaging

- Pharmaceuticals
- Biotech
- Clinical Trials
- Blood



Uses "Active" heating/cooling

- Reduces package size and shipping costs

Emily Ho

Wran Metzler

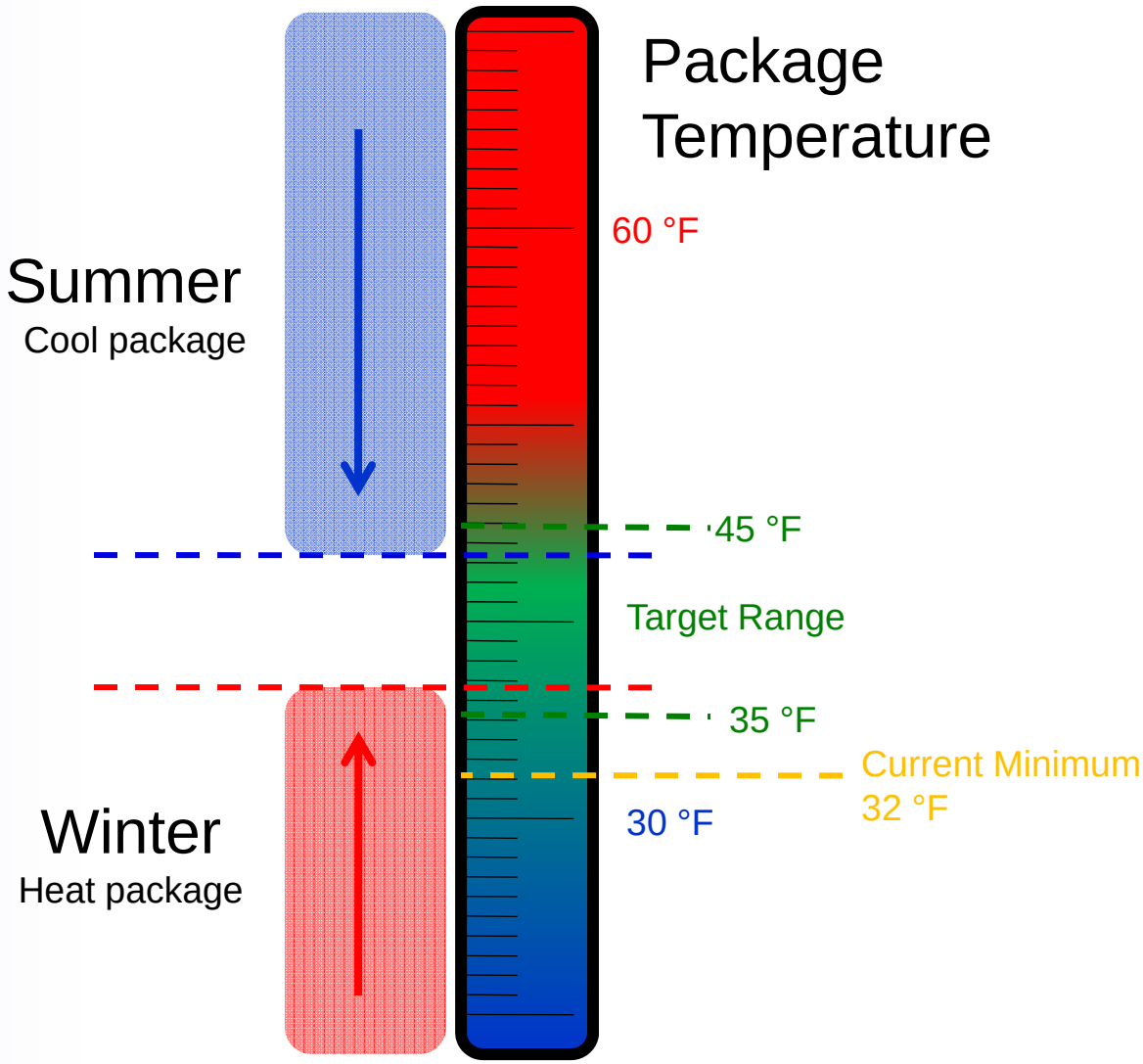
Sarah Trexler

Clifford Tse

Clay Wright

- Improvements
  - Incorporate temperature control system

Why Valves?


Package
Temperature
60 °F
Summer
Cool package
45 °F
Target Range
35 °F
Current Minimum
32 °F
30 °F
Winter
Heat package

Brought to you by:

NCStateUniversity

Department of Chemical and Biomolecular Engineering

Dr. OrlinVelev

Dr. Lisa Bullard

Dr. Steven Peretti

MeadWestvaco

Mr. Steven Metzler

Stop by our table for more information!

NanoCool™

A Cool Revolution...

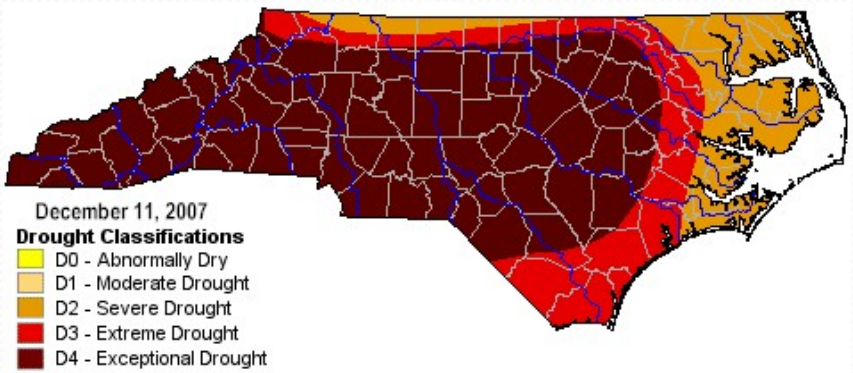
Biodiesel Waste Water Management

Advisors:
Dr. Alex Hobbs and Dr. Steven Peretti

Group Members:
Vanessa Blaylock
Gabrielle Raymond
Cindy Wang

Motivations

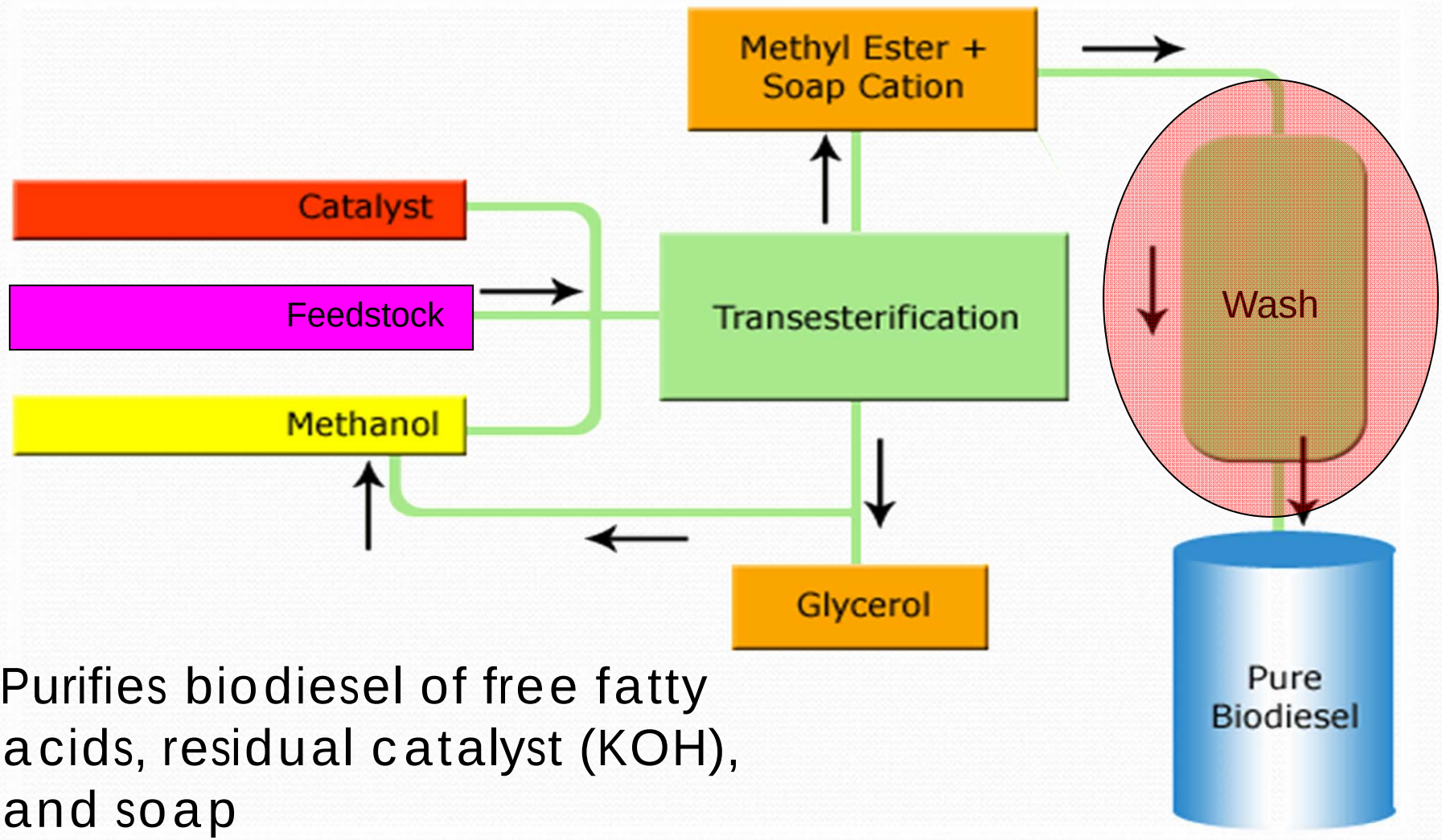
- Drought



- Importance of renewable energy

- Conservation/Environmental

The Biodiesel Process



Purifies biodiesel of free fatty acids, residual catalyst (KOH), and soap

Objective

- To reduce and treat the water used in the biodiesel water washing process by:
  - Designing an efficient washing system that recycles water
  - Testing possible water treatments for biodiesel waste water

Conclusions

- Counter current washing dramatically reduced water use

- Coagulation Flocculation using aluminum salts proved to be effective in removing contaminants

How Much Water Did We Save?

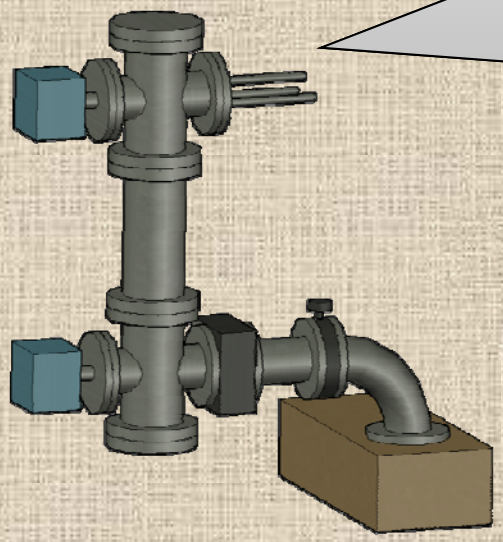
Stop by our poster and find out!

Design, Control, and Scale-up of an Atomic Layer Deposition Reactor:

Deposition on Textiles

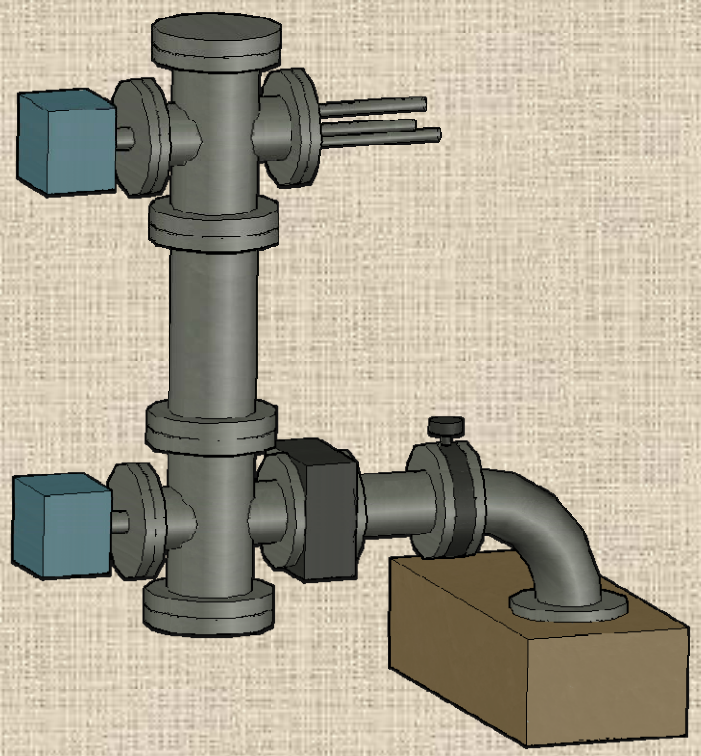
Ryan VanGundy

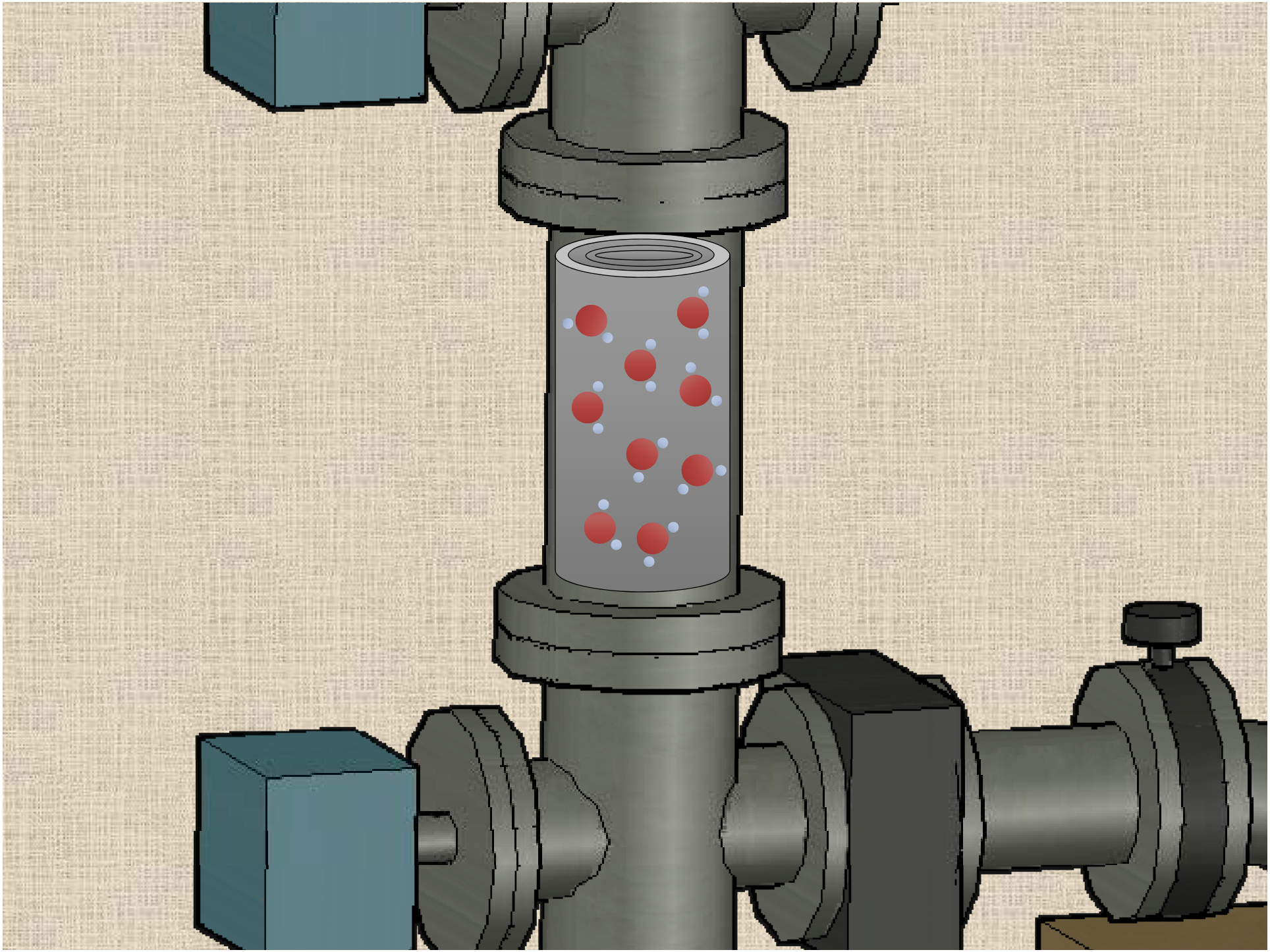
Advisors:
Dr. Gregory Parsons
Dr. Lisa Bullard
Dr. G. Kevin Hyde

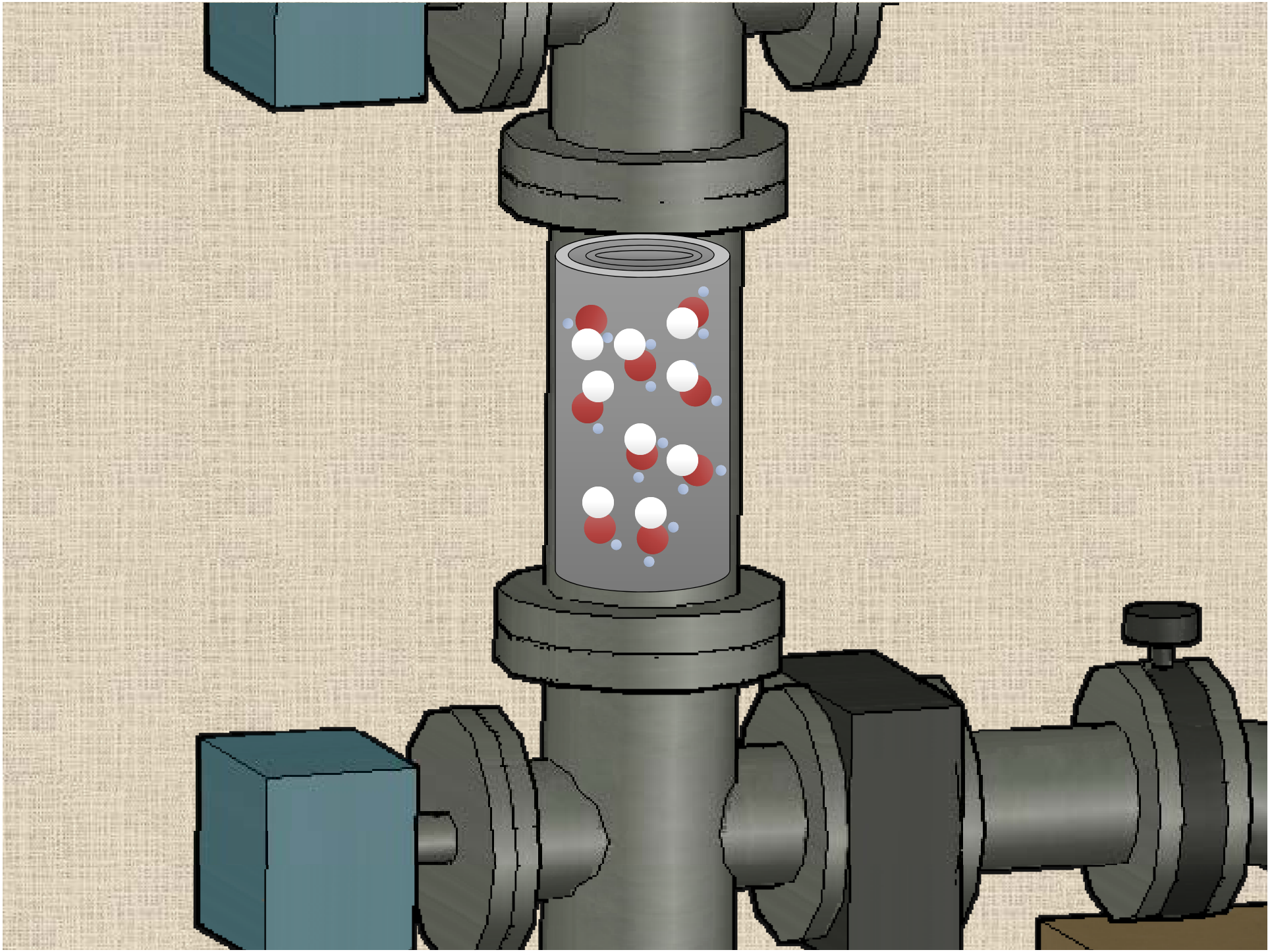


Alditri

The next generation of textile technology...







Large-scale production, commercially viable...

2000

100-cm^2
Fabric disks

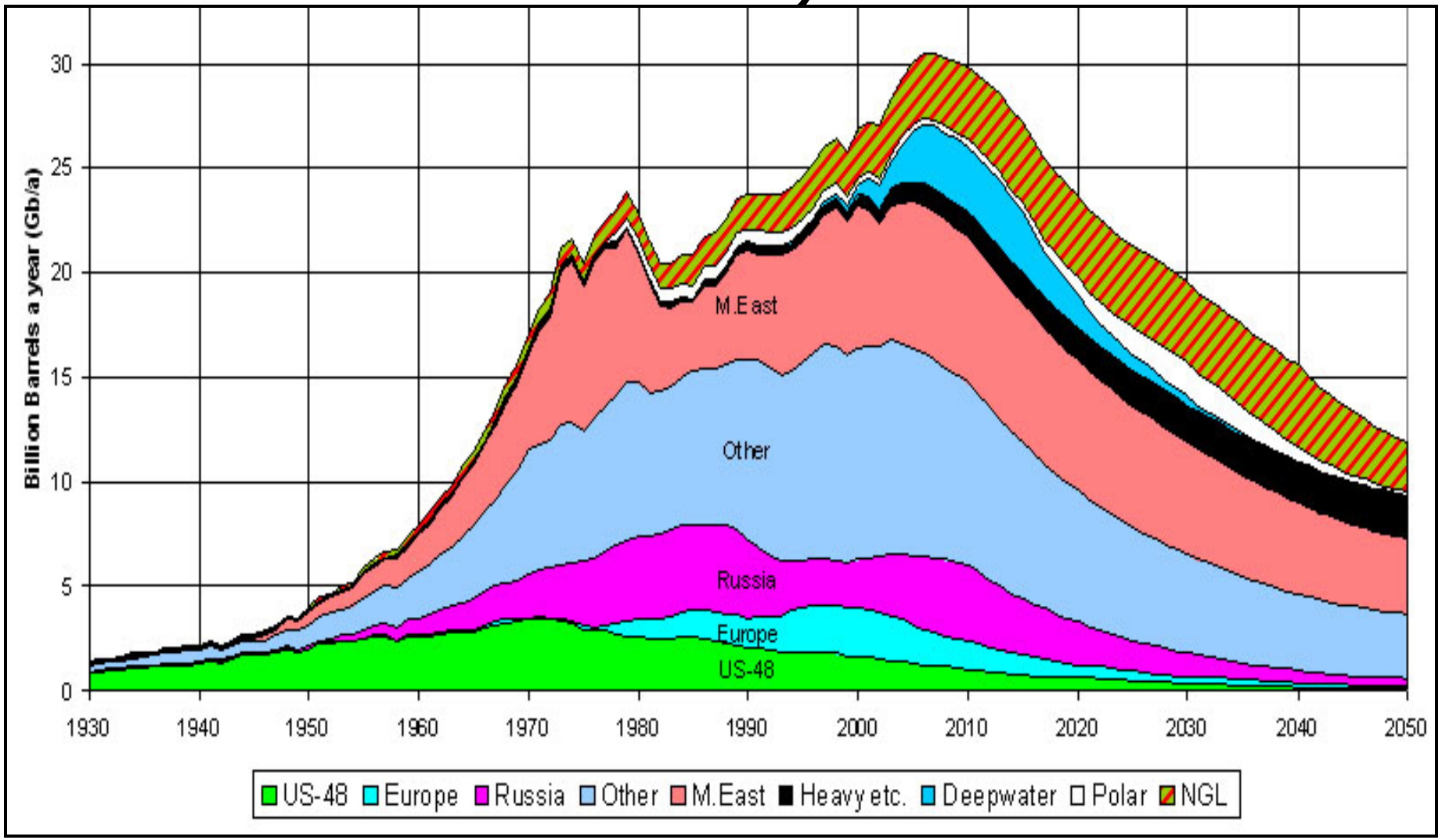
or

… Per Day!

Thank You!

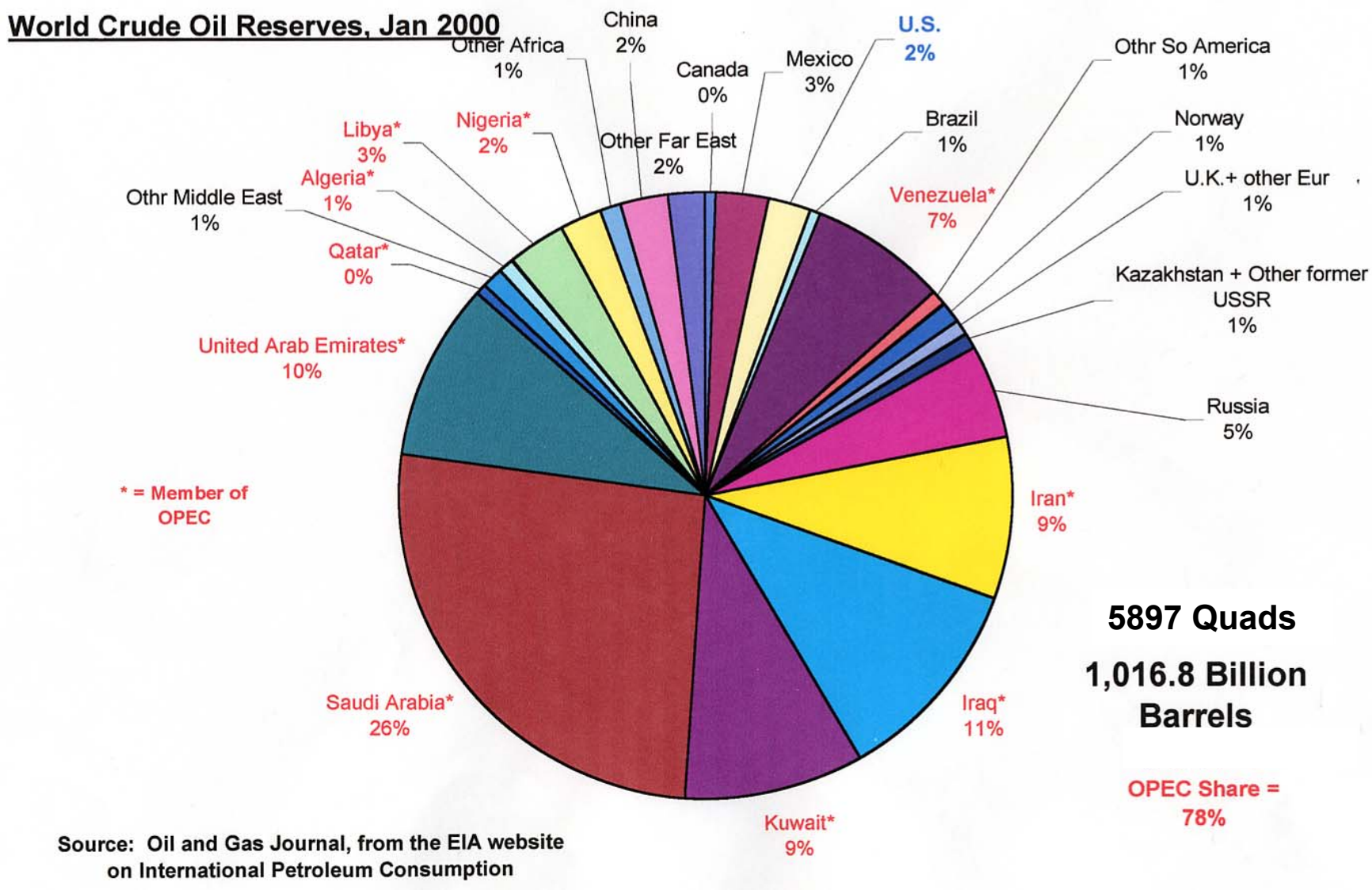
Energy-Related Projects

Projected oil peak worldwide in next 10+ years

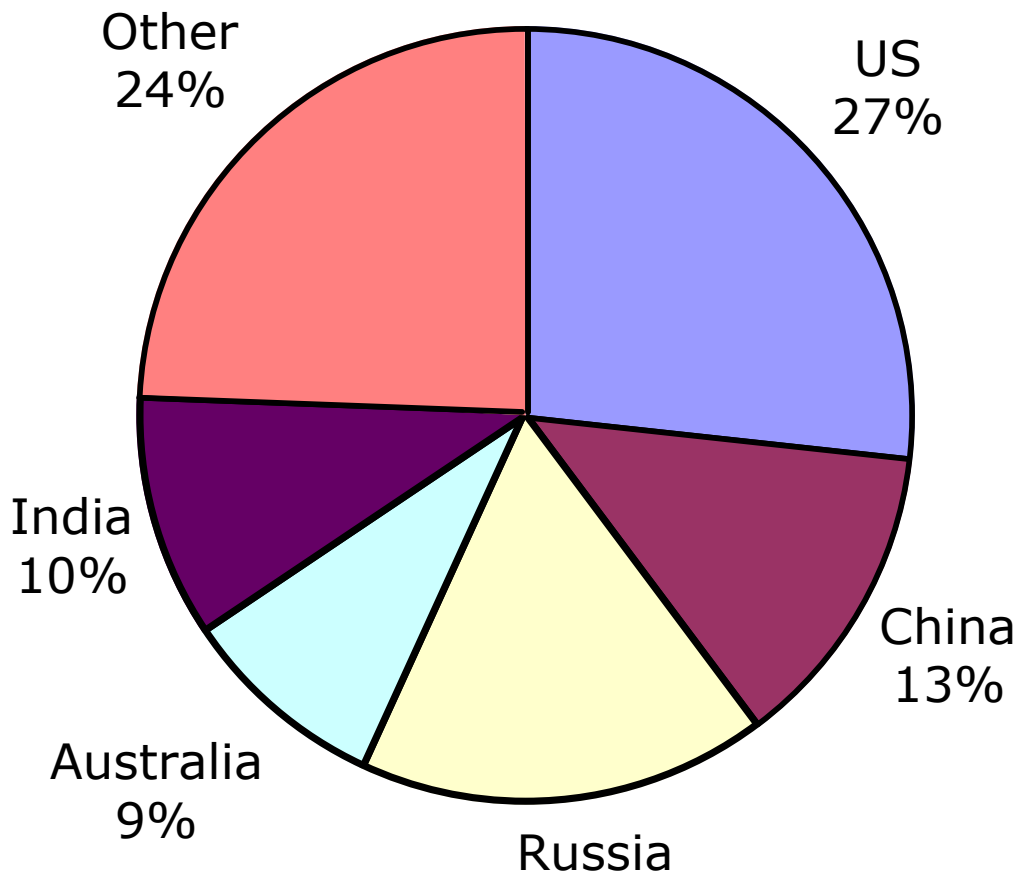


"Forecasting Global Oil Supply: 2000 - 2050", Colin Campbell, Oil Depletion Analysis Centre, London

World crude reserves



World Coal Reserves - 2005

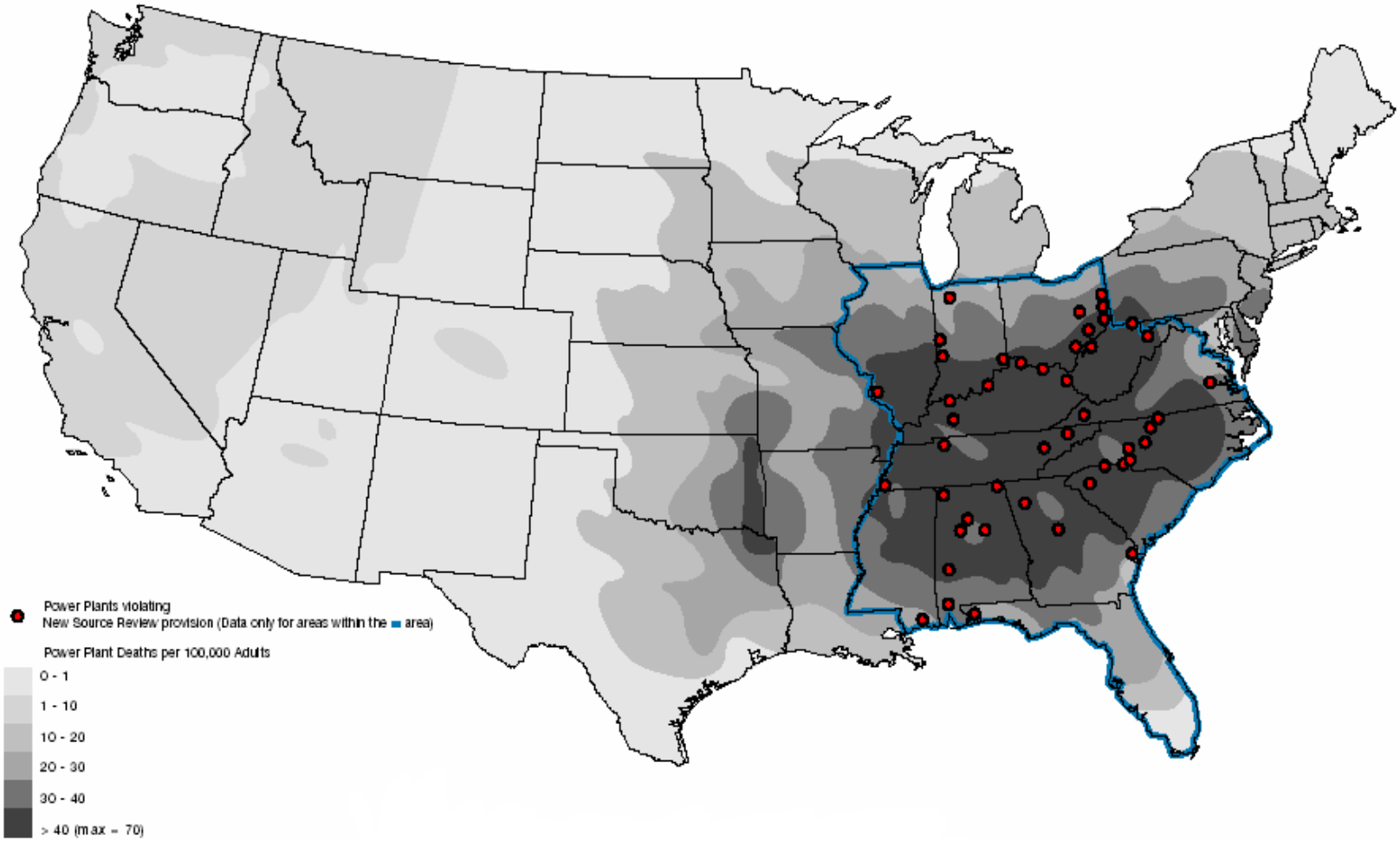


World Total: 1000 Billion Short Tons
19000 Quads

Source: www.eia.doe.gov/pub/international/iea2003/table82.xls

Southeast has relatively cheap power

Risk of dying from coal fired power plant caused particulates



The new industrial biorefinery

Biomass Feedstock

- Trees
- Grasses
- Agricultural Crops
- Agricultural Residues
- Animal Wastes
- Municipal Solid Waste

Conversion Processes

- Enzymatic Fermentation
- Gas/liquid Fermentation
- Acid Hydrolysis/Fermentation
- Gasification
- Combustion
- Co-firing

USES

Fuels:
- Ethanol
- Renewable Diesel

Power:
- Electricity
- Heat

Chemicals
- Plastics
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Furfural
- Fatty acids
- Acetic Acid
- Carbon black
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Etc.

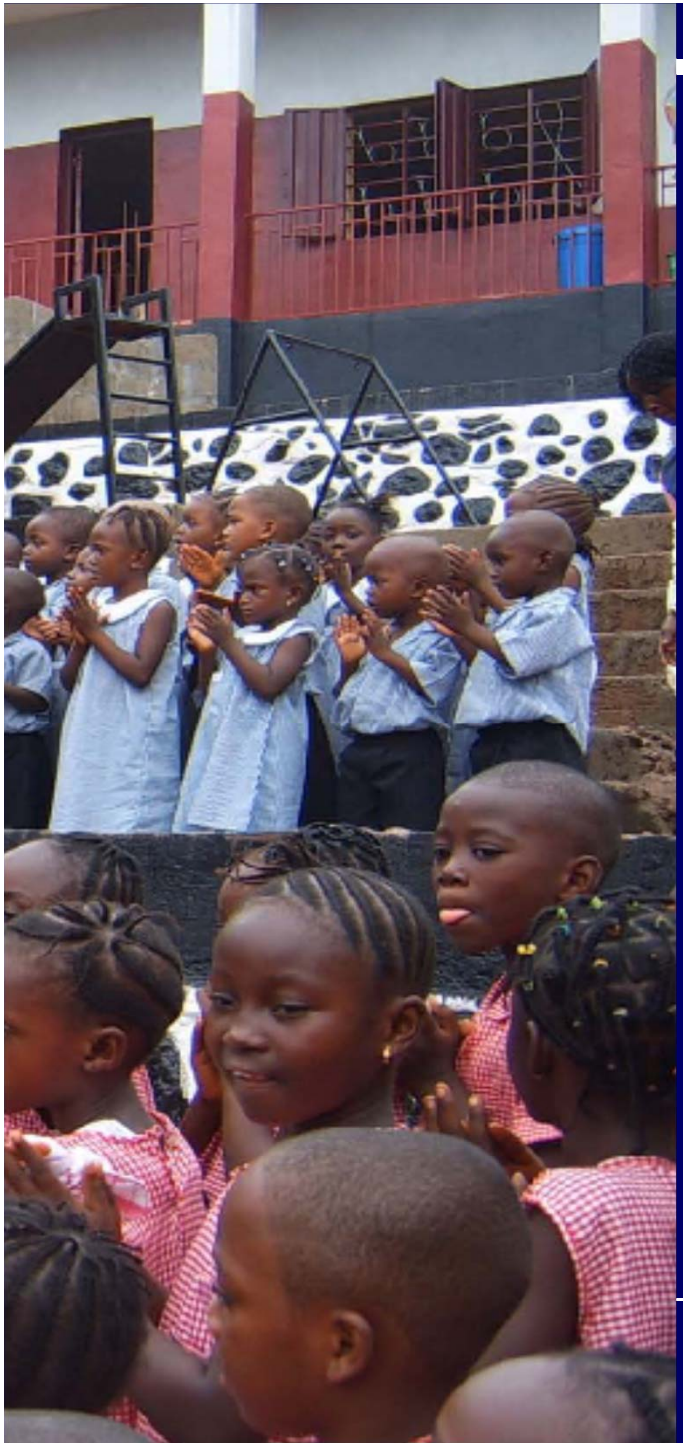
Food and Feed

From Doug Kaempf - DOE

Sustainable Energy in Africa

Lauren Crumpler
Renee Mitchell
Akin Ọmófóyè
Christie Reynolds
Una Stone
Sid Subramanian
Chadwick Thompson

Advisor: Dr. Steven Peretti



Scope

Design sustainable energy system:

- Three story building
- 500 students, all year long

Plan

Evaluate:

- Solar-wind hybrid system
- Hydroelectric system
- Stand alone solar system
- Various forms of energy storage

Challenges along the way

- Applying the engineering model to an unfamiliar topic
- Designing a system for an unfamiliar region
- Wind-solar hybrid?

Come find out how you can help provide sustainable energy to schools in Africa!

Coal Gasification

EASTMAN

An original design of a coal to methanol plant with novel options for carbon dioxide removal

Advisors

Dr. Lisa Bullard

Mike Lowder

Dr. Steven Peretti

Design Team

Josh Beatty

Kendall Liner

Brandon Locklear

Dmitri Moundous

Samuel Mootoo

Elizabeth Vara

Brennon Youngblood

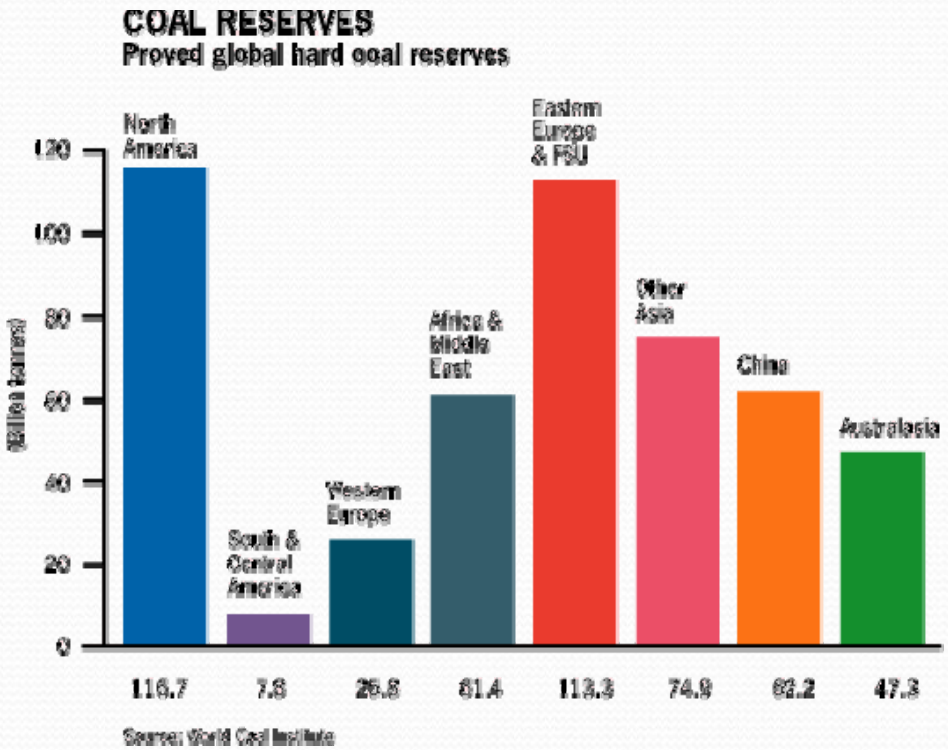
Motivations and Goals

Motivations

- Rising oil prices
- Availability of US coal reserves

Goals

- Design a coal to methanol plant
- Determine the business impact of the Carnol process
- Evaluate process economics



http://www.rudrumholdings.co.uk/second_level_pages/ff2.htm

Process Description

Coal to Methanol Plant

Gasification → Acid Gas Removal → Water-Gas Shift → Methanol Synthesis → Methanol Refining → METHANOL

Acid Gas Removal → CO_2 → Methanol Synthesis

Carnol Plant

Methane Decomposition → Methanol Synthesis → METHANOL

Results

Coal to Methanol Plant

- 5900 MT/day methanol
- 320 kgal/day ethanol
- Profitable investment

Total Capital Investment	**$1.3 billion**
Raw Materials Cost	**$500 million/yr**
Operating Cost	**$83 million/yr**
Revenue	**$940 million/yr**
Internal Rate of Return	**12.4%**

Carnol Addition

- 8000 MT/day methanol
- Reduces 85% of CO_2
- Non-profitable investment

Total Capital Investment	**$179 million**
Raw Materials Cost	**$1.6 billion/yr**
Operating Cost	**$450 million/yr**
Revenue	**$1.0 billion/yr**

Come See Our Poster!

Thank You!

SUPERCRITICAL CO_2

By

O = C = O

Henry Lan

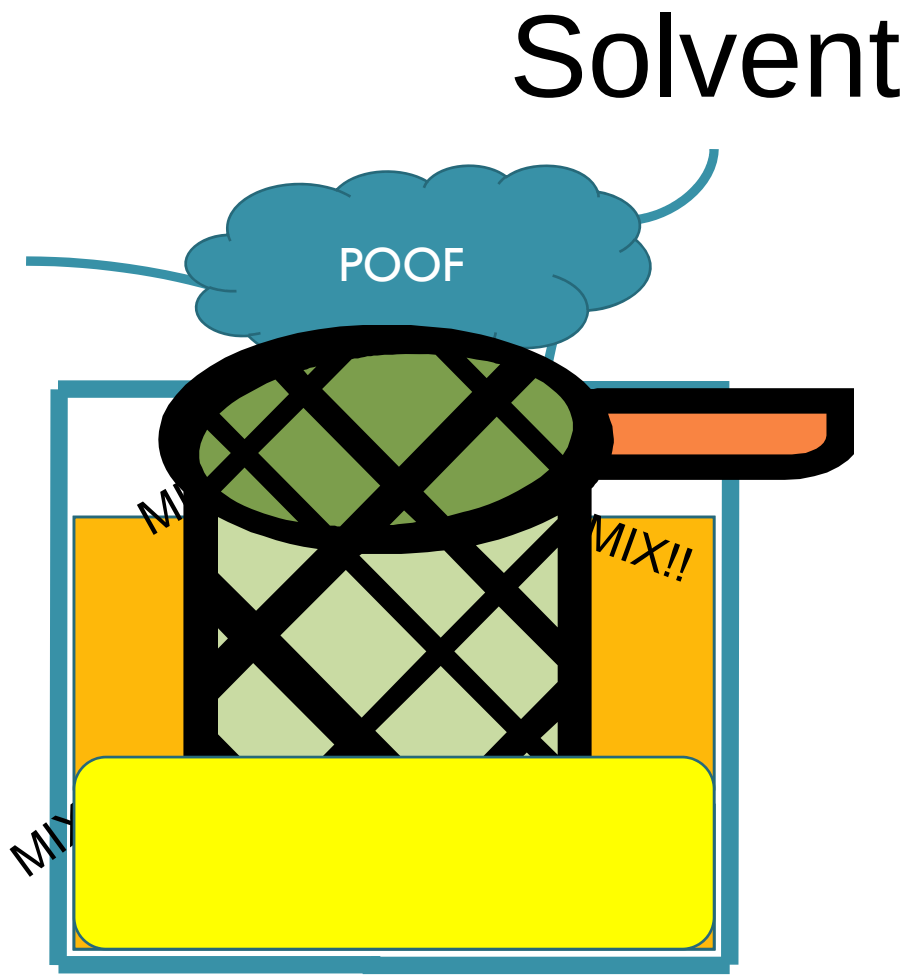
Diana Tysinger

Derek Hernandez

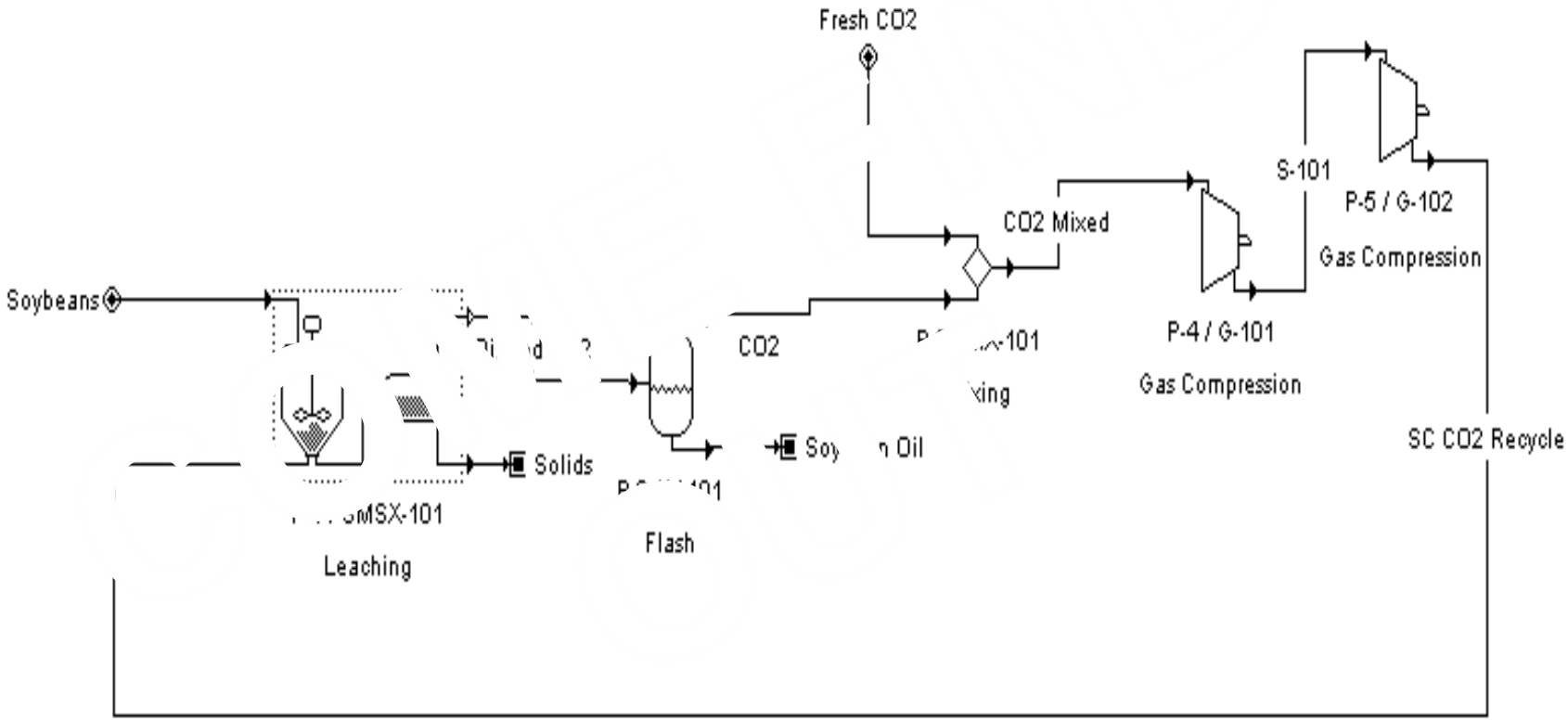
Process Goal

$ScCO_2$ vs. Hexane

Extraction Basics



Does CO_2 Compare to Hexane?



Bull City Biodiesel: Production for Shimar Recycling

Advisor: Dr. Steven Peretti

Members: Ahmed Abdel-Rahman

Matthew Markland

Erika White

Bryan Wright

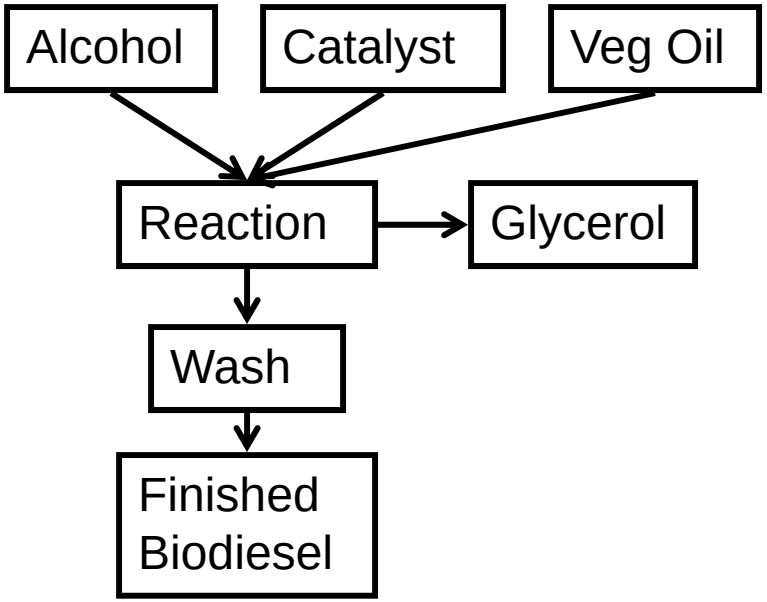
Objective

- Produce a 1,500 gallon per month design for Shimar Recycling in Durham, NC
- Attempt to make cheaper than current biodiesel supplier
- Make process as hands off as possible
- Leave flexibility for future expansion and other chemical options

ShimarRecycling

Accomplishments

- Process size of 500 gallons per batch
- Minimized operator input needed per batch
- 1 week batch process time
  - 3 batches/month
- Capital investment ~$6,000
- Cost of raw materials ~$1.50/gallon



Come see our poster!

Value Added Enzymatic Processing of Waste Glycerol and Low Value Oils

Team Members

Kevin M. Porch, Jose Tan II

James Wright, Ding Shan Yuan

Advisor

Dr. Steven Peretti

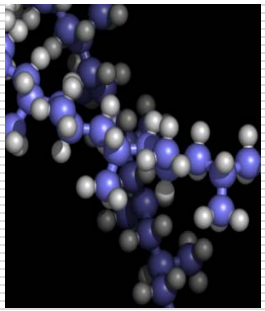
MOTIVATIONS

- Increased Biodiesel production = surplus waste glycerol



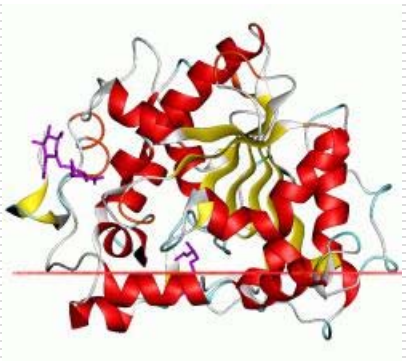
- Refined waste glycerol = $
- Glycerol Carbonate = $1.40/gram
- Applications





PROJECT GOALS

- Determine lipase activity for processing
- Design downstream process for glycerol carbonate production
- Analysis (engineering, economic)
- Recommendations

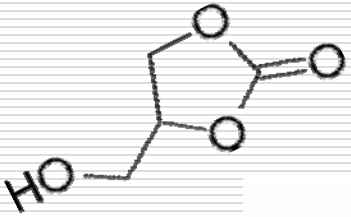


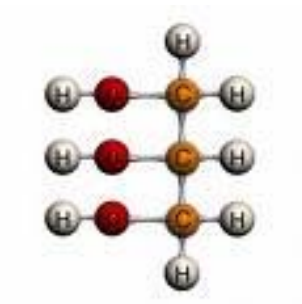
PROCESS DESIGN

Biodiesel Process

Enzymatic Reaction

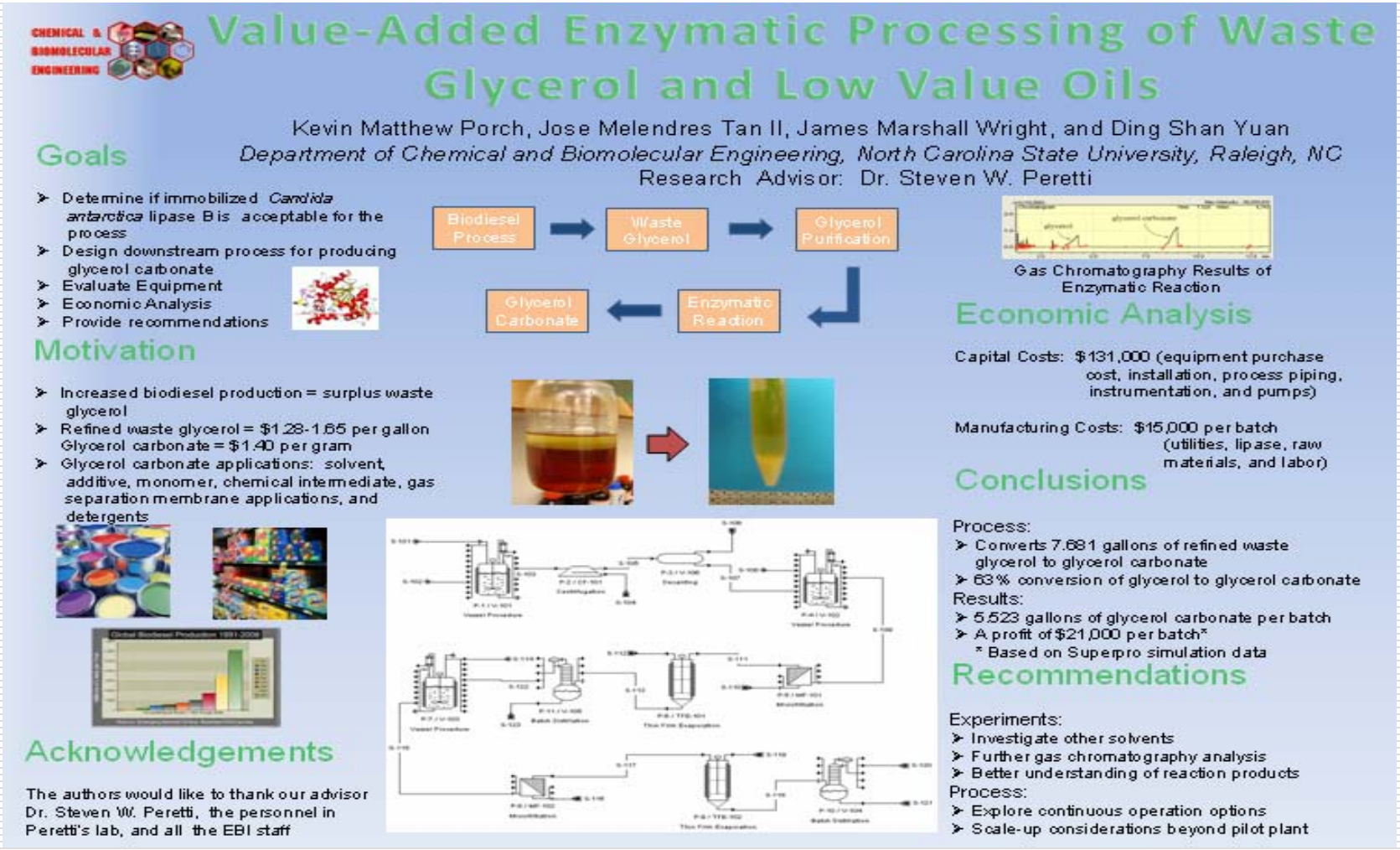
Glycerol Carbonate





Thank you for your time!

Come see our poster!



CHEMICAL & BIOMOLECULAR ENGINEERING

Value-Added Enzymatic Processing of Waste Glycerol and Low Value Oils

Kevin Matthew Porch, Jose Melendres Tan II, James Marshall Wright, and Ding Shan Yuan
Department of Chemical and Biomolecular Engineering, North Carolina State University, Raleigh, NC
Research Advisor: Dr. Steven W. Peretti

Goals

- Determine if immobilized *Candida antarctica* lipase B is acceptable for the process
- Design downstream process for producing glycerol carbonate
- Evaluate Equipment
- Economic Analysis
- Provide recommendations

Motivation

- Increased biodiesel production = surplus waste glycerol
- Refined waste glycerol = $1.28-1.65 per gallon
  Glycerol carbonate = $1.40 per gram
- Glycerol carbonate applications: solvent, additive, monomer, chemical intermediate, gas separation membrane applications, and detergents

Acknowledgements

The authors would like to thank our advisor Dr. Steven W. Peretti, the personnel in Peretti's lab, and all the EBI staff

Biodiesel Process → Waste Glycerol → Glycerol Purification → Enzymatic Reaction → Glycerol Carbonate

Gas Chromatography Results of Enzymatic Reaction

Economic Analysis

Capital Costs: $131,000 (equipment purchase cost, installation, process piping, instrumentation, and pumps)

Manufacturing Costs: $15,000 per batch (utilities, lipase, raw materials, and labor)

Conclusions

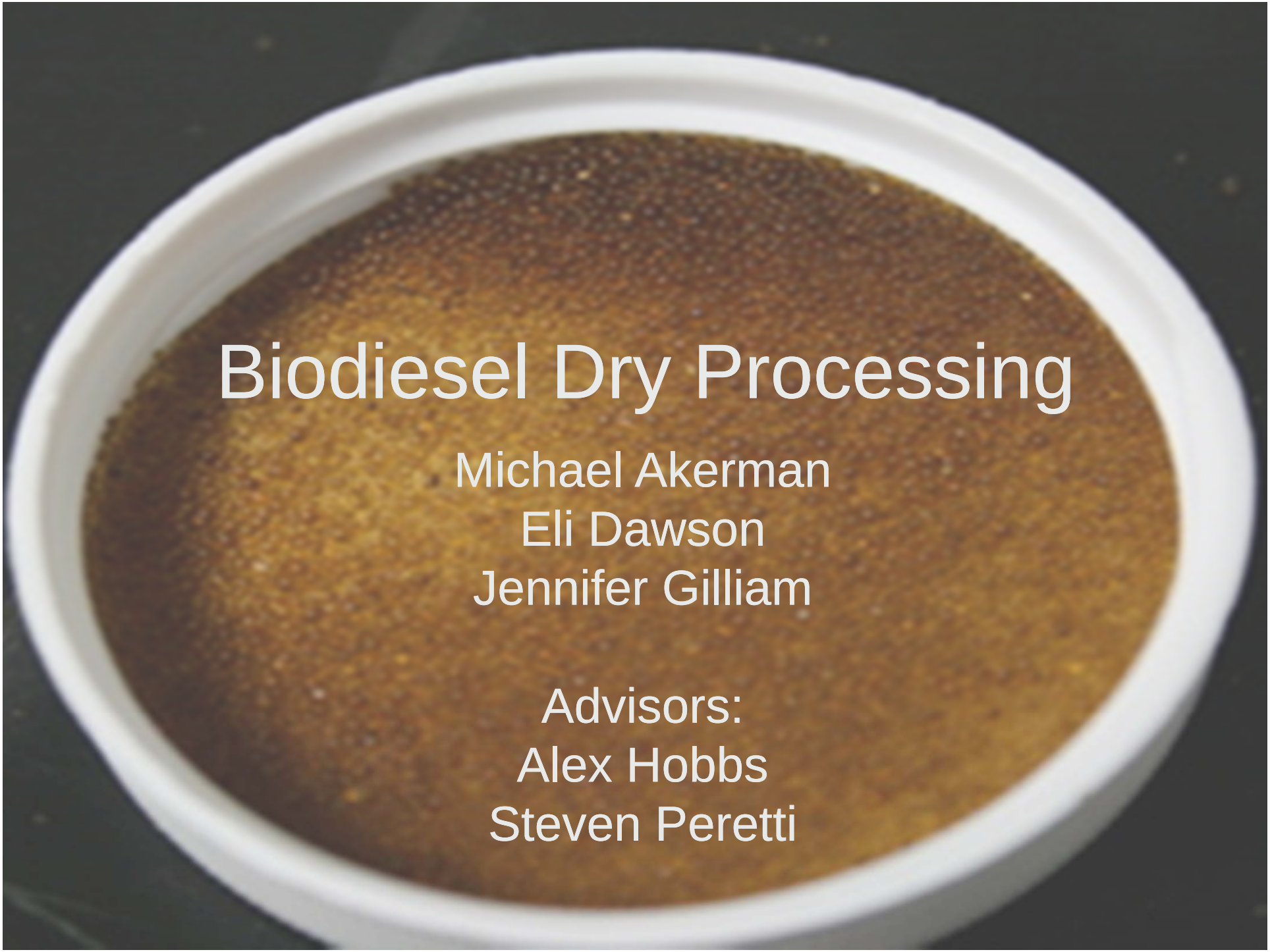
Process:
- Converts 7.681 gallons of refined waste glycerol to glycerol carbonate
- 63% conversion of glycerol to glycerol carbonate

Results:
- 5.523 gallons of glycerol carbonate per batch
- A profit of $21,000 per batch*
  * Based on Superpro simulation data

Recommendations

Experiments:
- Investigate other solvents
- Further gas chromatography analysis
- Better understanding of reaction products

Process:
- Explore continuous operation options
- Scale-up considerations beyond pilot plant



Biodiesel Dry Processing

Michael Akerman
Eli Dawson
Jennifer Gilliam

Advisors:
Alex Hobbs
Steven Peretti

What is it?

- Purifies biodiesel without using water
- Less environmental impact!
- Reduces production cost

How do you wash it ?

What is it ?

Unwashed Washed

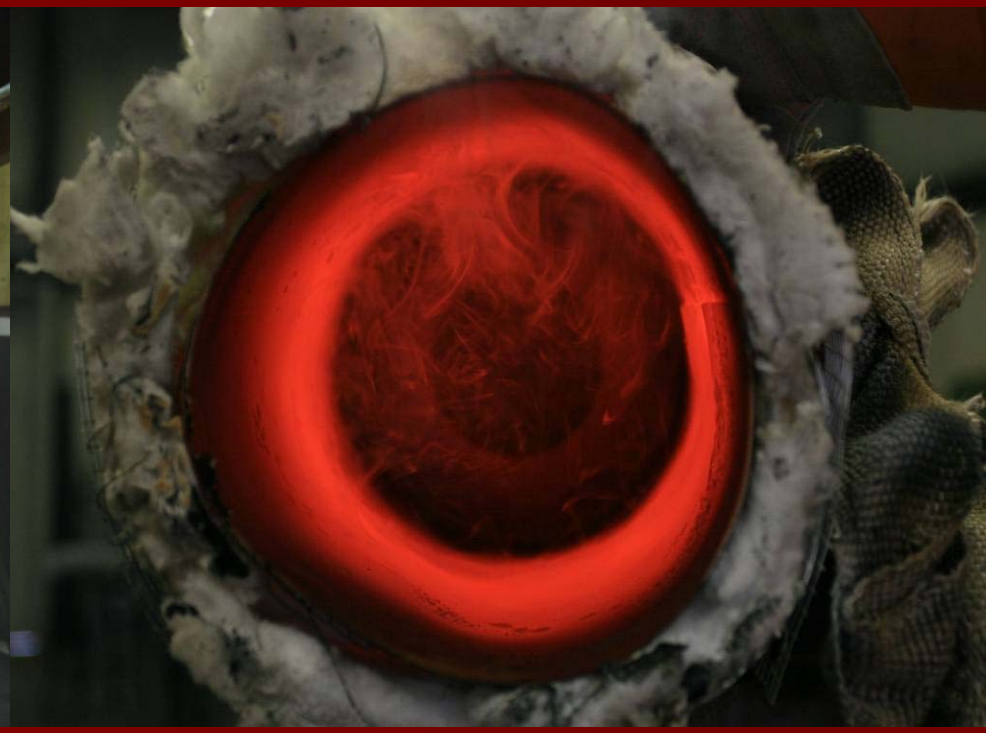
3 adsorbents

4 designs

Only one survived…..

Come see which design succeeded!

Glycerol Burner



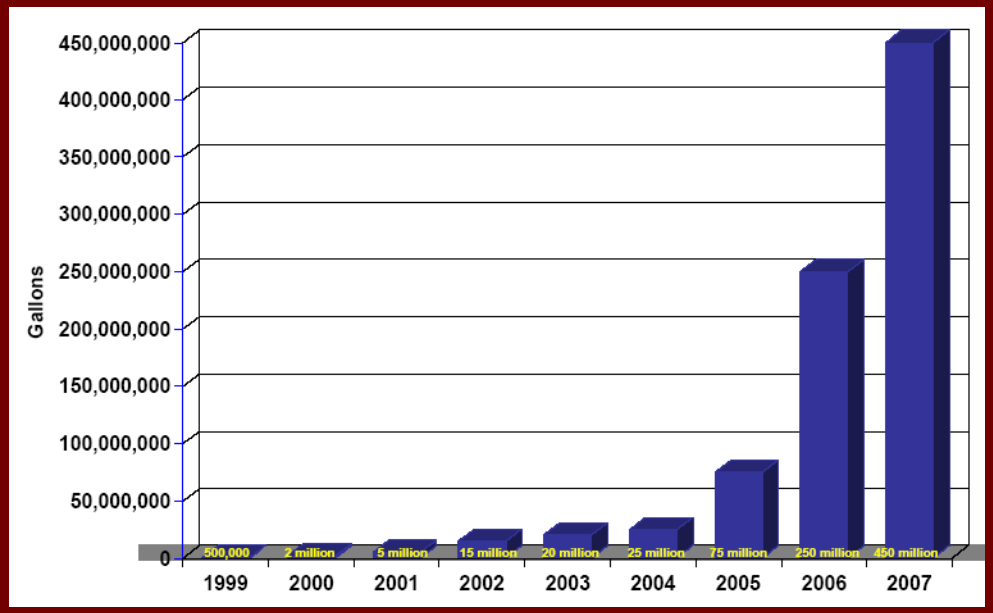
Members:
Marc Leyrer
Henryk Orlik
Patrick Johnson

Advisors:
Dr. Steven Peretti
Dr. Alex Hobbs

Photos courtesy of Brian Metzger

Motivations

- Biodiesel production has tripled
  - 2010: 245 US biodiesel plants expected
- 400 million pounds of glycerol produced per year
  - Price of glycerol: $0.06-$0.10 per pound (2007)



Goals

- Construction of burner capable of combusting glycerol
- Glycerol purification through filtration and acidification
- Utilization of heat from combustion

Glycerol Combustion Challenges

- Highly viscous, similar to molasses
- High auto-ignition temperature: 370 ºC
- Produces less heat than most other fuels
- Large amount of solids and contaminants

Will it work?

Come see our poster!

NC STATE UNIVERSITY

Wood to Ethanol: Craven County Facility

Group members

Devin Cribb, Jesse Daystar,
Rebekah Howes, & Johnson Scarboro

Advisor

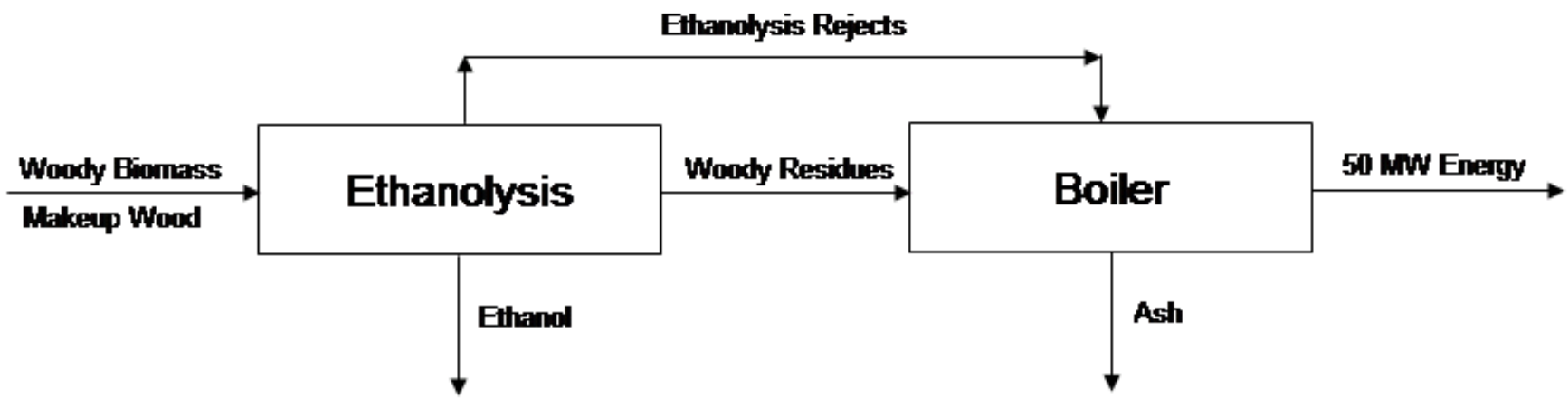
Dr. Med Byrd

Current Facility

- Craven County wood energy facility
  - New Bern, NC
  - 50 MW biomass plant
  - Uses 100% wood and wood waste
  - Burns 530,000 green tons / year

Objectives

- Determine if the addition of an ethanol producing facility to the Craven County wood energy plant will increase profitability
- Process optimization



Design Challenge

How big can we build and still be profitable?

- Determine the ethanol production with the highest incremental rate of return (IRR)
- Must balance:
  - Ethanol production
  - Electricity production
  - Costs
- Constraint: boiler cannot produce any additional steam

Come see our poster!

Wood to Ethanol: Craven County Facility

Devin Cribb, Jesse Daystar, Rebekah Howes, & Johnson Scarboro

Advisor: Dr. Med Byrd

Department of Chemical and Biomolecular Engineering

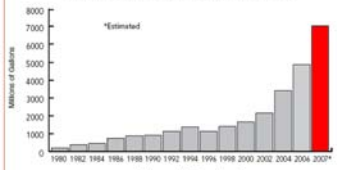
North Carolina State University

Objective

- To determine if the addition of an ethanol producing facility to the Craven County wood energy facility will be economically feasible and desirable
- Process optimization of the ethanol process
- Economic analysis

Motivation

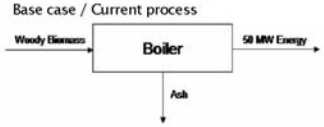
Craven County wood energy facility



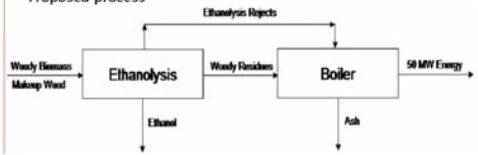
Ethanol Production

Process Background

Base case / Current process

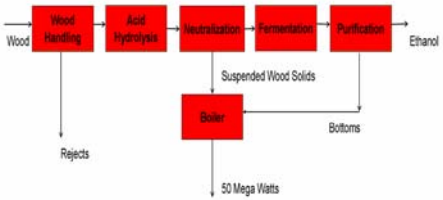


Proposed process



Simulation: Proposed Process Model

Cellulosic ethanol production:



Optimization

- High risk project
- Discount rate = 28%
- Optimal production = 9.35 million gallons of ethanol per year

Ethanol Production (MM gal / year)	Thousand green tons / year	Incremental IRR	Incremental NPV
9.063	583	-5.3%	-$19,714,142
9.350	602	21.4%	-$4,029,155
11.509	741	8.7%	-$16,667,192
14.386	926	-6.7%	-$24,876,854

Process Flow Rates: Base vs. Proposed Case

- Base case
  - Wood: 530,000 green tons / year
  - Water: 2,000,000 gallons / year
  - Ash: 6,075 tons / year
- Proposed case
  - Wood: 602,000 green tons / year
  - Water: 3,000,000 gallons / year
  - Ash 5,464 tons / year
  - Other inputs include ammonium, sulfuric acid, corn steep liquor and lime
  - Other outputs include ethanol, sludge, and gypsum

Assumptions

	Assumption
Plant start-up	December 2009
Ethanol sales revenue	$2.50/gallon in 2009 Increases 3% per year
Power sales	$60 / MWh (held constant throughout the project)
Subsidy	$1.25/gallon for 2009-2012
Depreciation schedule	IRS 940
Taxes	38%

Sensitivity Analysis

- Performed to separately evaluate the impact of wood price, ethanol selling price and capital cost.

		50%	25%	0%	-25%	-50%
Wood Price	Price	$30.33	$25.28	$20.22	$15.17	$10.11
	NPV (million)	-$11.4	-$6.5	-$4.0	$3.3	$8.2
	IRR	15%	21%	24%	31%	35%
Ethanol Selling Price	Price	$3.75	$3.13	$2.50	$1.88	$1.25
	NPV (million)	$14.6	$6.5	-$4.0	-$9.7	-$17.8
	IRR	39%	33%	24%	17%	-4%
Capital Cost	Cost (million)	$70.5	$58.8	$47	$36	$23.5
	NPV (million)	-$11.1	-$6.3	-$4.0	$4.1	$10.0
	IRR	20%	23%	24%	33%	43%

Recommendations

With the demand for renewable energy, ethanol has a promising future. Therefore, with a 24% rate of return for the optimized process, this investment option should be considered in further detail. We recommend proceeding with the next level of design process analysis.

NC STATE UNIVERSITY

RP1

Feasibility of a Greenfield Wood-Ethanol Plant Pender County – North Carolina

Philip Crawford
Truong Dong
Dionne Kimani
Liam Royce

North Carolina State University
May 5, 2008

RP1 Generally I think you have done a very logical treatment of the subject, and the results seem reasonable, with a few points I have inserted in the specific file pages.

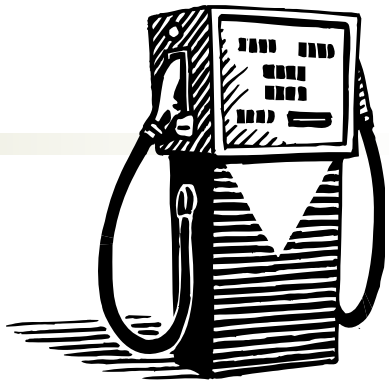
Two things that seems to be missing:

1. Explicit identification of the Base price of ethanol distinguished from the subsized price. This would allow the reader to distnguish the price paid for corn ethanol vs cellulosic ethanol. One enjoys a $0.51 per gallon subsidy and the other $1.28.

2. I believe there was a requirement to demonstrate the impact of the accelerated depreciation schedule allowed by IRS 946.

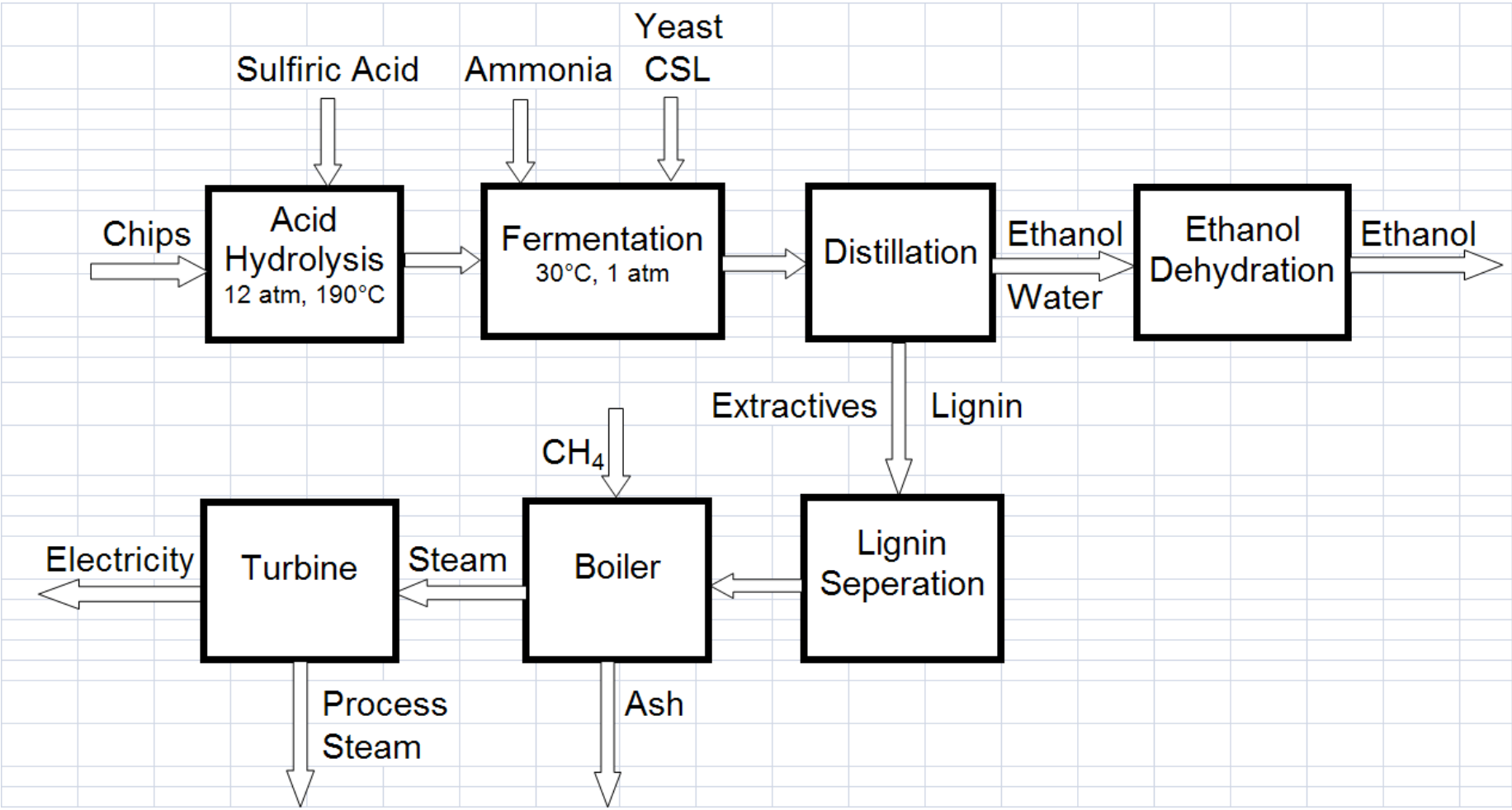
Richard Phillips, 4/19/2008

Why did we do it?



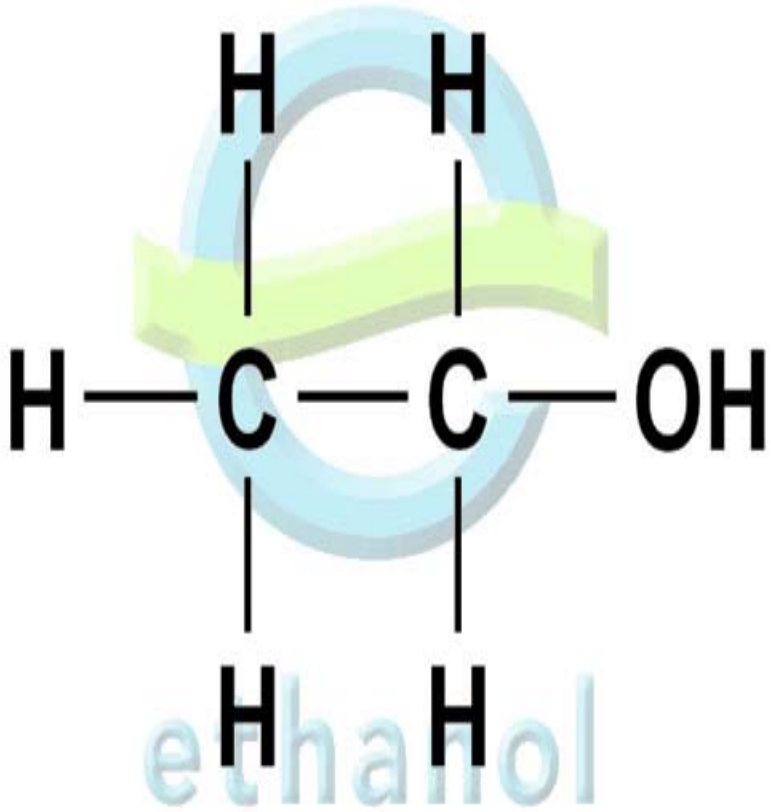
- “Food vs. Fuel”
- Abundant Renewable Resource
- Profitable

Process Flow Diagram



What we Did!

- Win Gems
- Raw Materials Model
- Financial Model
- Optimization
- Sensitivity Analysis



http://www.ericsons.co.uk/uploaded_images/ethanol-705128.jpg

Will it work?

- Please visit our poster!

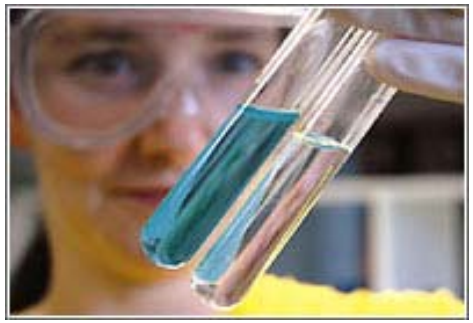
Biotech-Related Projects

Fun facts about Biotech in NC

- **North Carolina is home to the third largest biotechnology industry in the United States**
- In the RTP region there are **258 life sciences company sites** with a total of 24,989 life sciences jobs.
- **Over $1 billion in industrial life science R&D funding annually** in the Research Triangle region

Biotech Goals for NC

- 48,000 biotechnology-related jobs by 2013
- BTEC - The Golden LEAF Biomanufacturing Training and Education Center



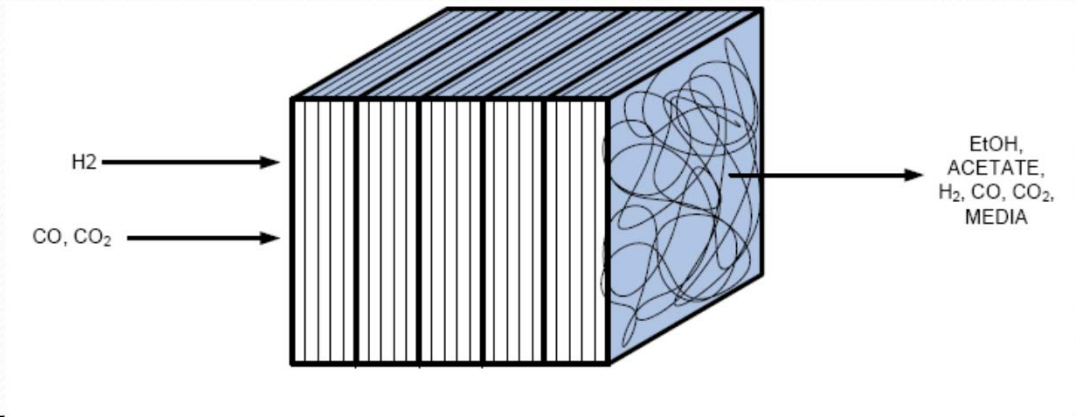
Carbon Dioxide Conversion to Ethanol via Bacterial Composite Coating

Co-advisors:
Dr. Michael Flickinger
Dr. Kirill Efimenko

Team members:
Lulu Alborno
Robert Crews
Jessica Lisane
Erin Redmond
Heather Ruby

Objectives – Think Air Filters!

- Create a design to implement immobilized bacteria for conversion of carbon dioxide to ethanol
- Scale-up design for cement manufacturers
- Analyze and justify economical feasibility of design and scale-up

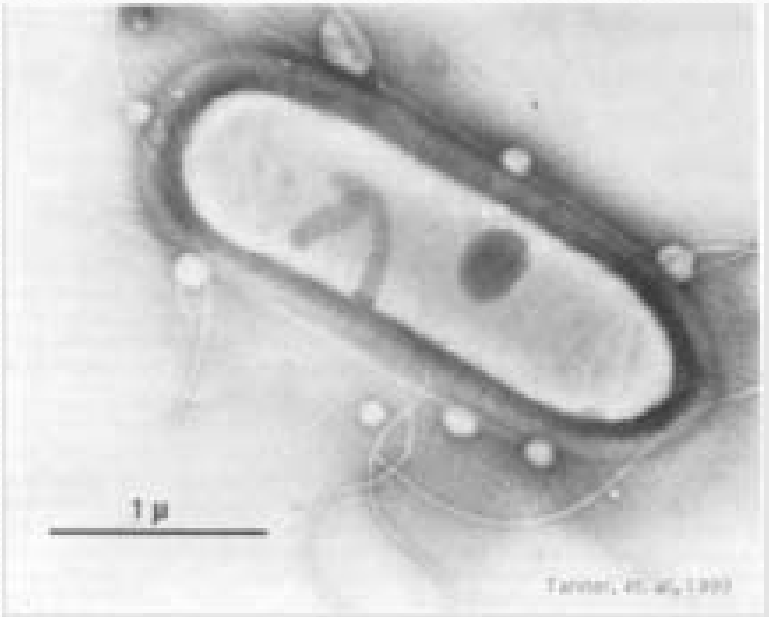


Motivations

- Increasing worldwide demand for ethanol
- Steady increase of CO_2 in the atmosphere
- Cement plants emit over ½ pound of CO_2 for every pound of cement produced

Clostridium ljungdahlii

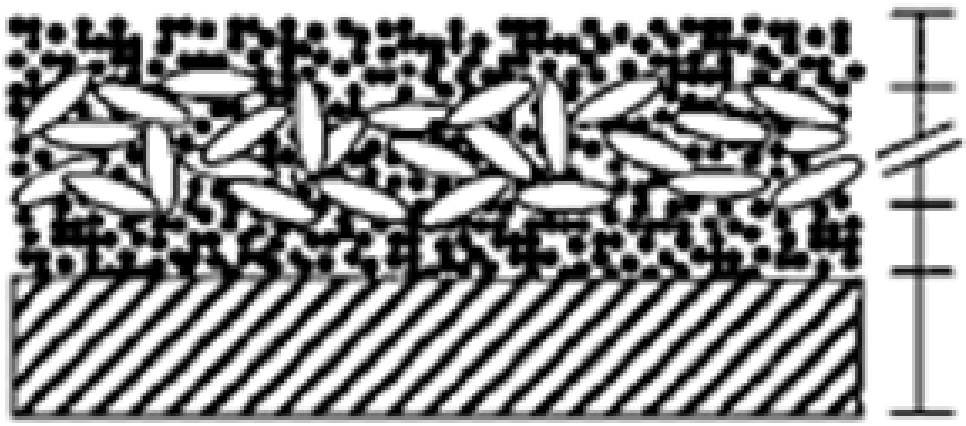
- Can absorb both CO and CO_2
- A gram of cells can absorb 0.28 g of CO_2 in one hour
- Produces Acetate and ethanol in a 7:1 ratio



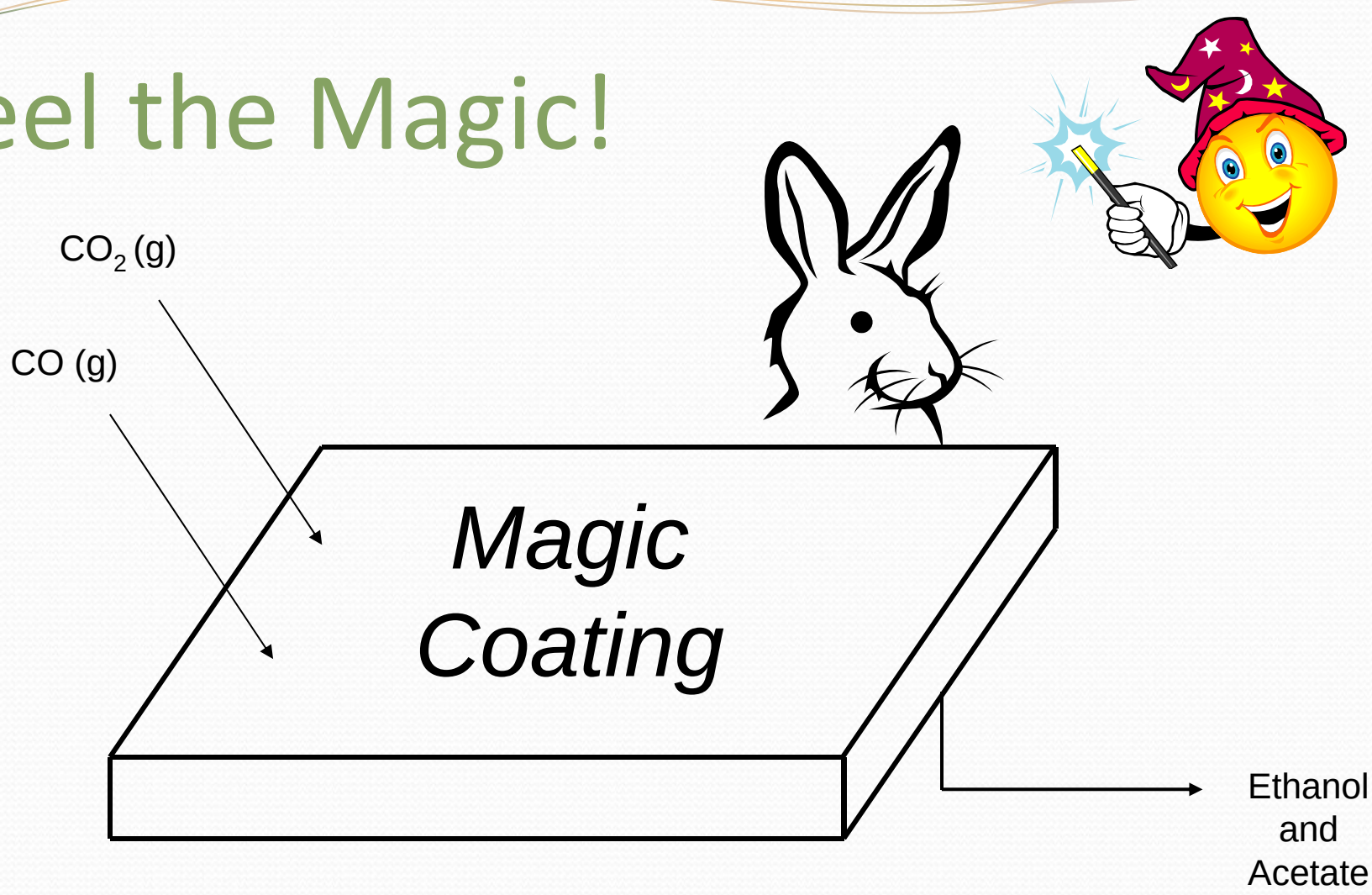
Synthetic Bio-film Coating

Think Paint!

- Pre-coat functions as an adhesive surface
- Cells are metabolically active but not growing
- Top-coat prevents cells from leaching out of coating



Feel the Magic!



Bioreactor Design Presentation

Team Members:

Kevin Brown

Abby Lithgo

Michael Perkins

Tracy Sapp

Advisors:

Marcelo Anderson

Dr. Steven Peretti

Andy Stober

btec Biomanufacturing Training and Education Center

design team biogen idec

Motivation

Biopharmaceutical industry growing rapidly

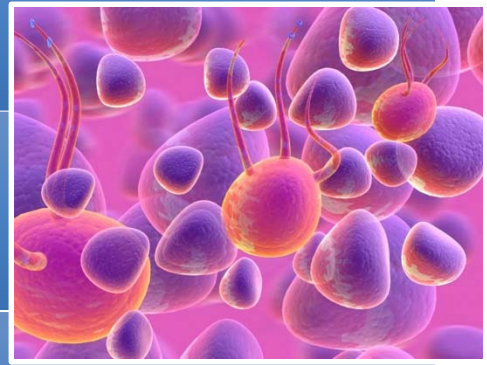
Trying to optimize manufacturing performance and flexibility

Need innovative bioreactor technologies to generate their products

design team biogen idec

Project Goals

Support Biogen Idec's current processes and offer flexibility



Minimize cell death and foaming

Maximize product yield and mass transfer

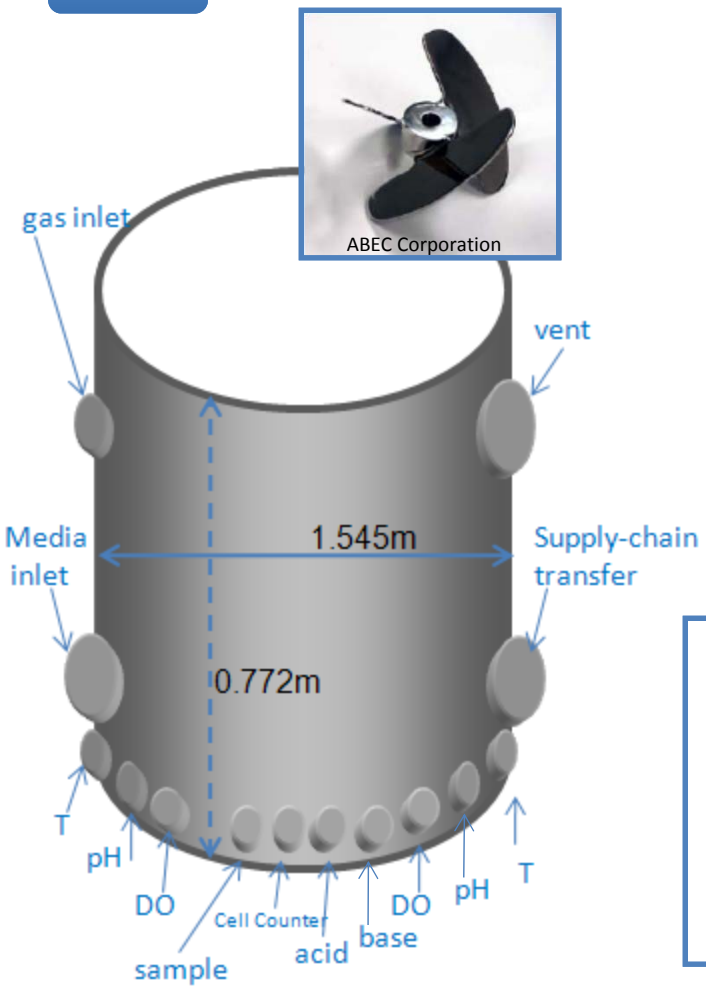
Create two 2000L bioreactor designs: *Conventional* and *Innovative*

- Stirred Tank Reactor
- Disposable Airlift Reactor
- Antifoaming Net

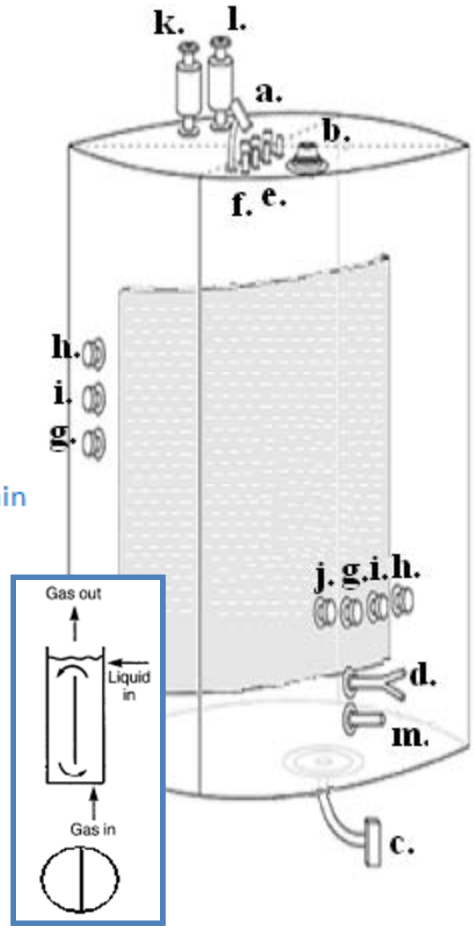
design team | biogen idec

Results & Decisions

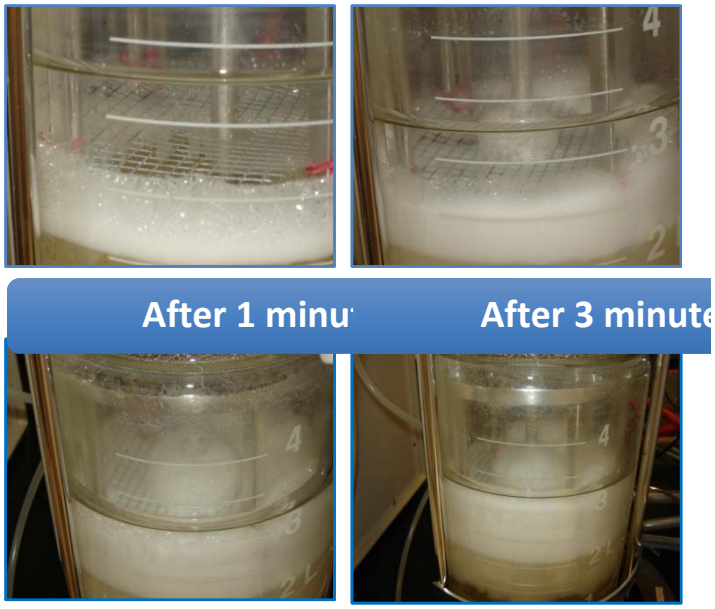
STR



Disposable Airlift



Antifoaming Net

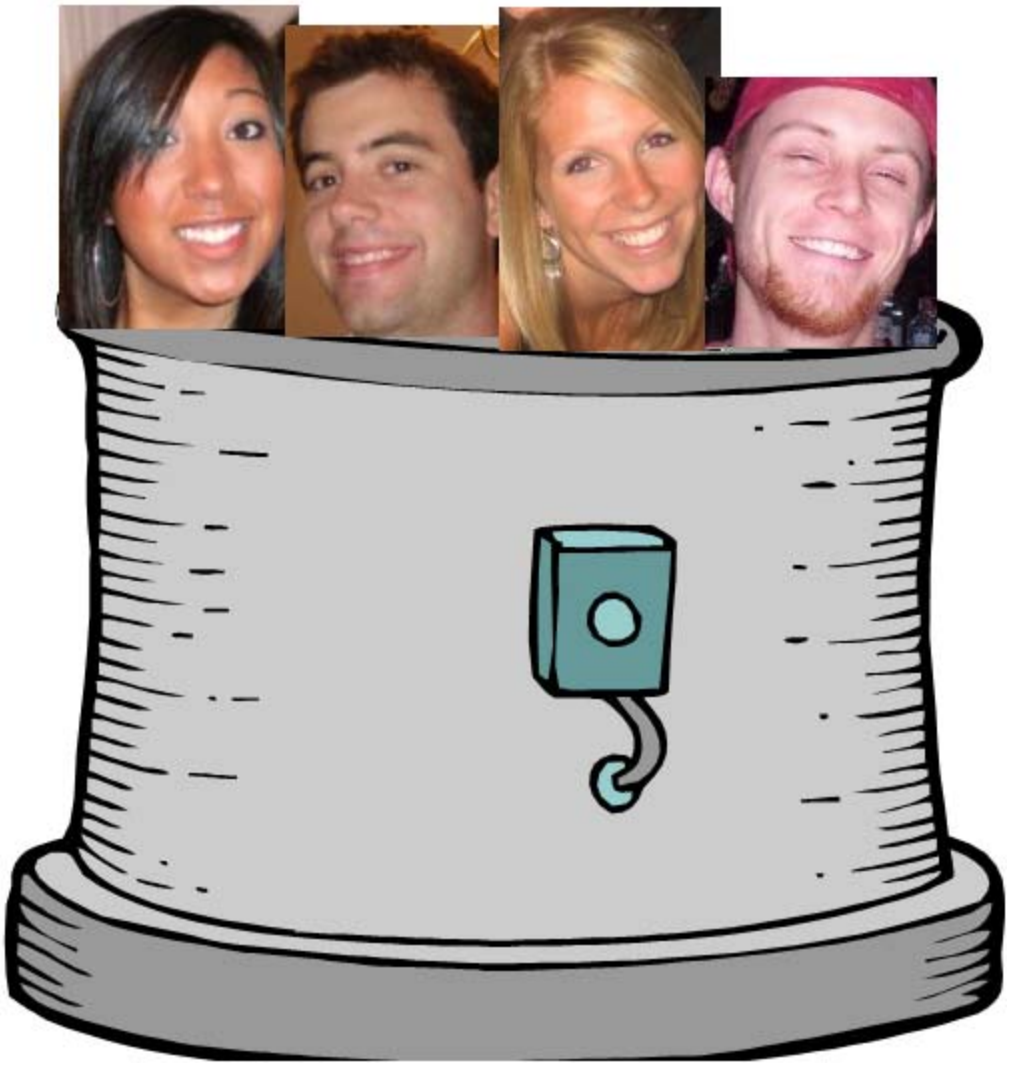


After 1 minu | After 3 minute

After 4 minut | After 5 minute

design team | biogen idec

Thank you!



Come see us and our bioreactors!

design team

biogen idec

Design of Protein Production Facility for Novozymes

Design Team:

Emily Blackwell
Malonda Bumba
Taylor Loftis
Yorke Reynolds
Lindsey Robinson
Alison Thomas
Danielle Zimmerman

Advisors:

Dr. Steven Peretti – NCSU
Mike Hess- Novozymes
Marcelo Anderson – BTEC
Dr. Gary Gilleskie - BTEC

January 31, 2017

Design Project Motivation

- Expanding biotechnology market

Bagsvaerd, Denmark

Kalundborg, Denmark

Franklinton, NC, USA

Beijing, China

Mihama-ku, Japan

Tianjin, China

Manufactured Products

- **Food Grade Enzymes:** Environmentally friendly and energy efficient
- **Active Pharmaceutical Intermediates:** Safe and effective vaccines

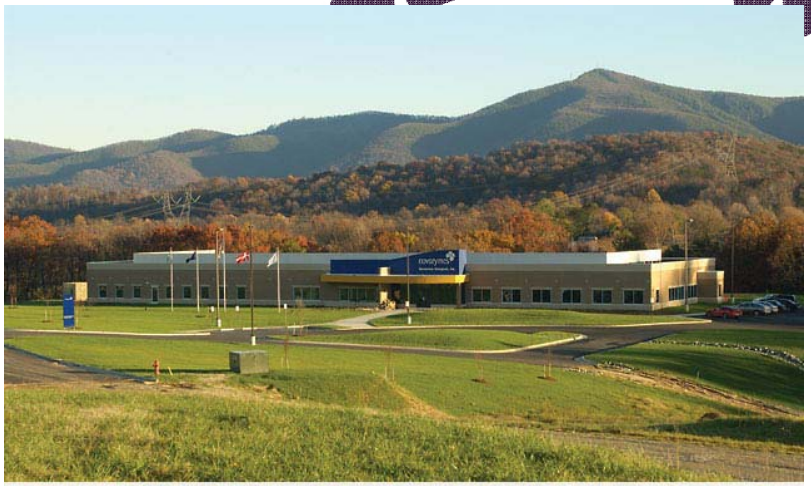
http://www.vestaldesign.com/blog/2005/06/tide-coldwater-detergent.html

http://www.sptimes.com/2007/05/04/images/Cheese_KraftSingles.jpg

http://www.time.com/time/health/article/0,8599,1543319,00.html

Project Goals

- Design a **process to produce a total of 500,000 gallons** per week of
  - Active Pharmaceutical Intermediates (API)
  - Food Grade Enzymes
- Design the **site layout** of the production facility
- **20% ROI** – Food Grade Enzymes
- **50% ROI** – Active Pharmaceutical Intermediates



http://www.varney.biz/images/novozymes.jpg

novozymes
Rethink Tomorrow

To learn more about
our exciting design,
come and visit us!

Disposable Bioreactors for Seed Expansion Fermentation in Biotechnology Manufacturing

Team Members

Graham Gibson
Stephanie Goss
Taylor Kirkland
Derrick Laton
Christopher Smith

Advisors

Dr. Steven Peretti, NCSU
Rick Lawless, BTEC
Terry Burns, Wyeth

Motivation

Money!

Time!

Quality!

Goals

btec
Biomanufacturing Training and Education Center

Wyeth

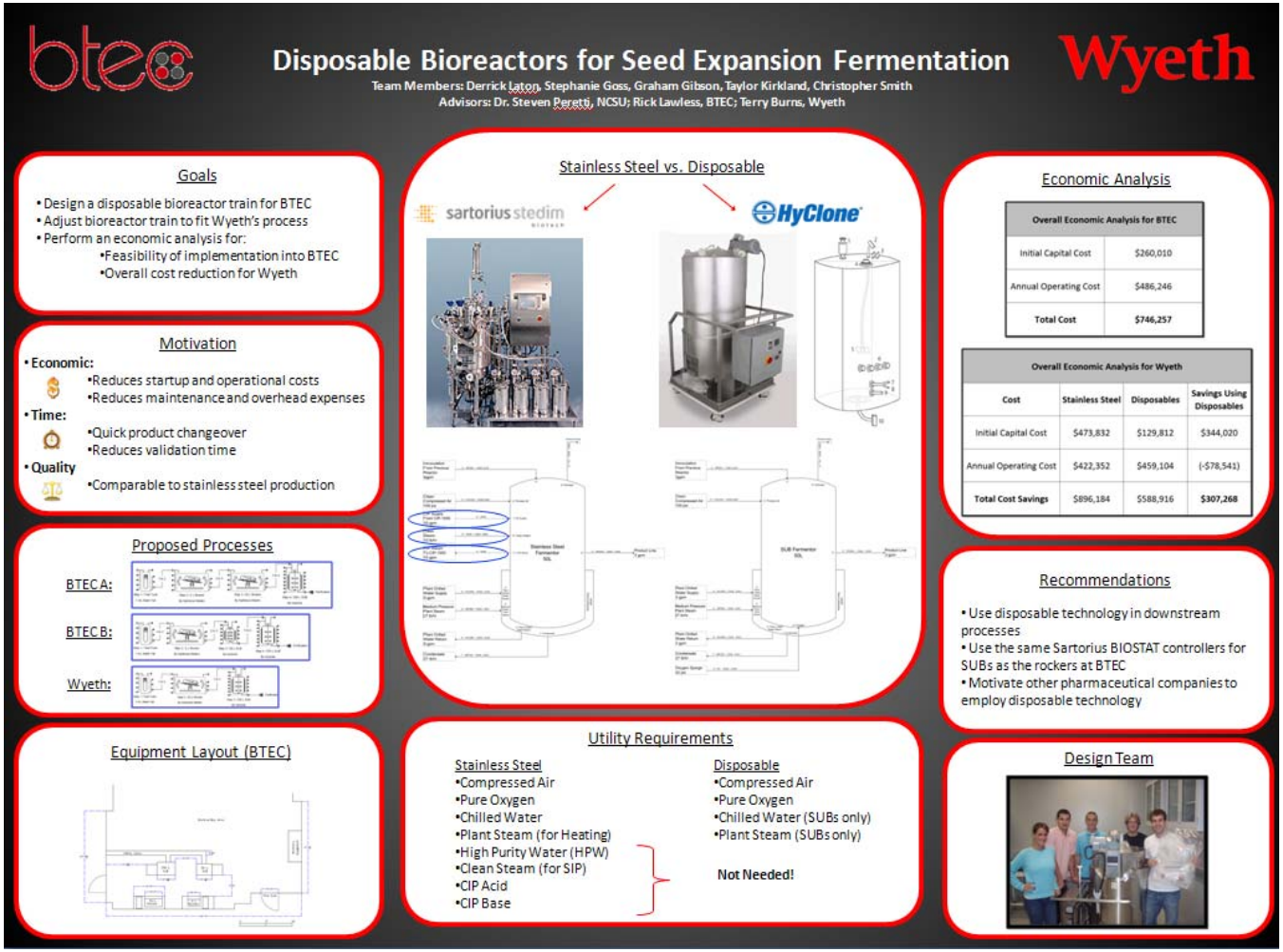
- Equipment Selection
- Process and Lab Design
- Batch Scheduling

- Utility Savings
- Environmental Analysis
- Economic Analysis

- Recommend Fermentation Train
- Time Savings

Is the Disposable Process Practical?

Come see our poster and find out!



Enjoy the posters in the Atrium of Engineering Building I!

Come back at 11:30 for some special presentations!