Algal Biofuels
Presentation to State Legislature

Vimal Chaitanya
Vice President for Research
New Mexico State University

NM STATE

U.S. Consumption/Imports

Potential Size of US Bio-crude Market

Imports of Crude Oil (average from 2000-2008 in barrels)		3,544,660,889
Average Price of Crude Oil (real US$/bbl)		48.93
Total Gross Value of Market (real US$)	$	173,443,582,734

**From http://www.eia.doe.gov data*

Potential Size of US Bio-gasoline Market

Total US Supplies of Finished Motor Gasoline		3,273,027,556
Average Retail Price of Gasoline (real US$/gallon)		2.24
Total Gross Value of Retail Gasoline Market (real US$)	$	7,326,373,926

**From http://www.eia.doe.gov data*

Potential Size of US Bio-diesel Market

Total US supplies of Diesel		1,451,224,000
Average Retail Price (exlcuding taxes) of Diesel (real US$/gallon)		2.34
Total Gross Value of Retail Diesel Market (real US$)	$	3,390,283,082

**From http://www.eia.doe.gov data*

Biofuels

- Biofuels from renewable biomass feedstock has gained significant interest in the past two decades
- Examples: Methane from crop and animal wastes; bioethanol from sugar crops; biodiesel from plant/animal oils, waste cooking oil; and biohydrogen from wastewaters
- Of these, biofuel has the greatest potential for use in transportation and aviation fields, because it requires little/or no modification to existing infrastructure
- Only small amounts of plant-based biodiesel can be produced without negative impacts on food production

Oil Yield and Land Requirement

Crop	Oil Yield [L/ha]	Land Required [M ha]	% of U.S. Cropland
Corn	172	1540	846%
Soybean	446	594	326%
Canola	1,190	223	122%
Jatropa	1,892	140	77%
Coconut	2,689	99	54%
Oil Palm	5,950	45	24%
Microalgae[a]	58,700	4.5	2.5%
Microalgae[b]	136,900	2	1.1%

a: 30% oil by wt

B: 70% oil by wt [Chisti, 2007]

Why Algal Biofuels

- Algae are estimated to be >40 times more efficient at lipid production than soybeans, with algal lipid production estimates ranging from 4,000 to 20,000 gallons/year/acre
- Land requirement is low
- Microalgae is a non-food source
- Generates valuable by-products
- Can be cultivated in brackish or impaired waters with minimal nutrition and energy input
- Can be cultivated in continuous mode rather than in a crop mode

Why New Mexico

- High-light intensities
- Abundant underground saltwater resources for large-scale algal cultures
- LANL and NMSU, as well as SNL, UNM, NM Tech, and NM businesses are involved in algal-biofuel research and development
- Natural synergy between the dairy industry, cattle production, and algae production
  - nutrient streams from the animals can be used under some scenarios for algae growth
  - dairy industry (cheese manufacturing) generates large quantities of nutrient-rich discharge water that must be treated and disposed

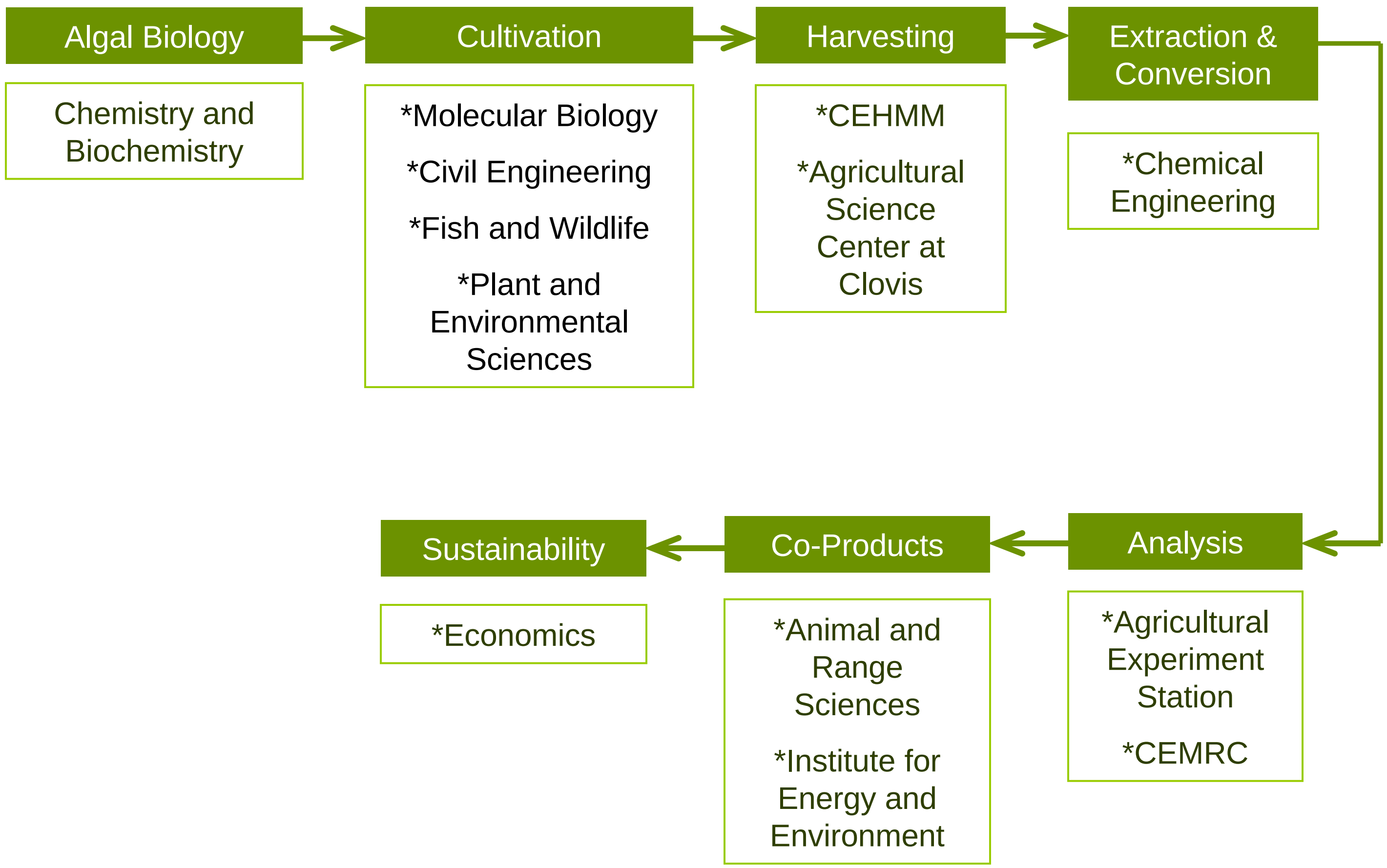
Economic Benefits to New Mexico

- Utilization of rural area acreages in areas where substantial infrastructure and technical knowhow in farming and oil and gas production are prevalent
- Creation of domestic jobs in renewable energy to help displace declining employment in oil and gas production
- Generation of tax revenues for state and local governments in which production occurs to displace declining revenues from oil and gas
- Source of carbon credits for sale in a market exchange
- Potential use of municipal waste streams
- Utilization of produced water from the oil and gas industry which will reduce production costs of oil and natural gas
- Utilization of waste streams from coal fired power plants and natural-gas processing--large sources of carbon dioxide

NMSU Capabilities

- NMSU has extensive research and development capabilities in algal biofuels
- Capability spans four colleges—Arts and Sciences, Agriculture, Business, and Engineering
- Areas of expertise include
  - Algal biology
  - Cultivation
  - Harvesting
  - Analysis
  - Extraction and Conversion
  - Co-Products
  - Sustainability

Algal Biofuel Production



Cultivation

- Determining growth conditions and developing reactor designs that maximize algal growth and lipid accumulation (Van Voorhies and Khandan)
- Integrated cultivation protocol and effects of water chemistry on algal cultivation (Unc)
- Environmental factors determining lipid content in *Nannochloropsis* (Boeing)
- Algal pond ecology and limiting undesired organisms (Boeing)

Extraction and Conversion

- Chemical characterization of the distribution of glycerides, phospholipids, carotenoids, and the complex array of lower level chemical composition for algal lipid extracts and resultant fuel (Schaub and Conca)
- Extraction and conversion of algal biomass under supercritical carbon dioxide or subcritical/supercritical water condition (Deng)
- Evaluation of efficient conversion technologies for refining algal oils at supercritical methanol condition (Deng)

Co-Products and Sustainability

- Evaluation of algal co-products--lipid extracted algae (LEA) and glycerin—for suitability in ruminant and horse diets (Ivey)
- Evaluation of co-products such as methane, oxygen, carbon dioxide, hydrogen, synthesis gas, etc. (Mimbela)
- Economic analysis, both micro and macro (Starbuck, Peach, Erickson)
- Supply chain and distribution analysis (Starbuck, Peach, Erickson)
- Environmental assessment (Starbuck, Peach, Erickson)
- Water quality and quantity assessment and data integration (Wood)