# Algae Biofuels in California

Matthew Hutton

Research Engineer

**Algae Technologies Group**

**California Polytechnic State University**

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***Joint California Agriculture Biofuel Forum***

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**Cal Poly Algae Technologies Group:**
6 faculty investigators; 6 graduate students; 15 undergrads; 17 research ponds; full-scale ponds

**Professor Tryg Lundquist**

**Civil & Environmental Engineering Department**

**20 years in algae research and engineering practice**

# Algae are highly productive

Rapid production of biomass

- Up to 70 t/acre-yr
- 1,000 – 5,000 gal/acre-yr oil

Several biofuel options

- Rapidly commercializable biogas, gasification
- Longer term oil

Co-products to lower fuel cost

- Water treatment - fixation of 5,400 lbs/acre-yr nitrogen
- High value nutritional oils, feeds – omega-3 fatty acids, 13 t/acre-yr crude protein

Avoids food vs fuel

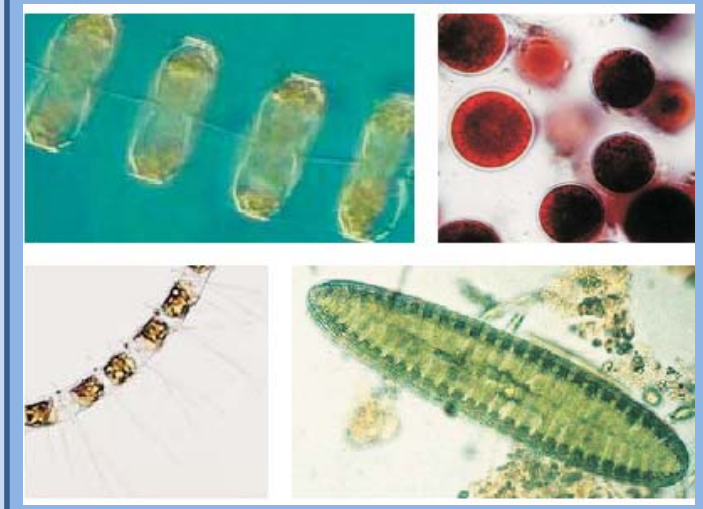
- Non-arable land, low quality water, waste nutrients

Existing infrastructure

- Full scale algae ponds operational in California since the late 60s

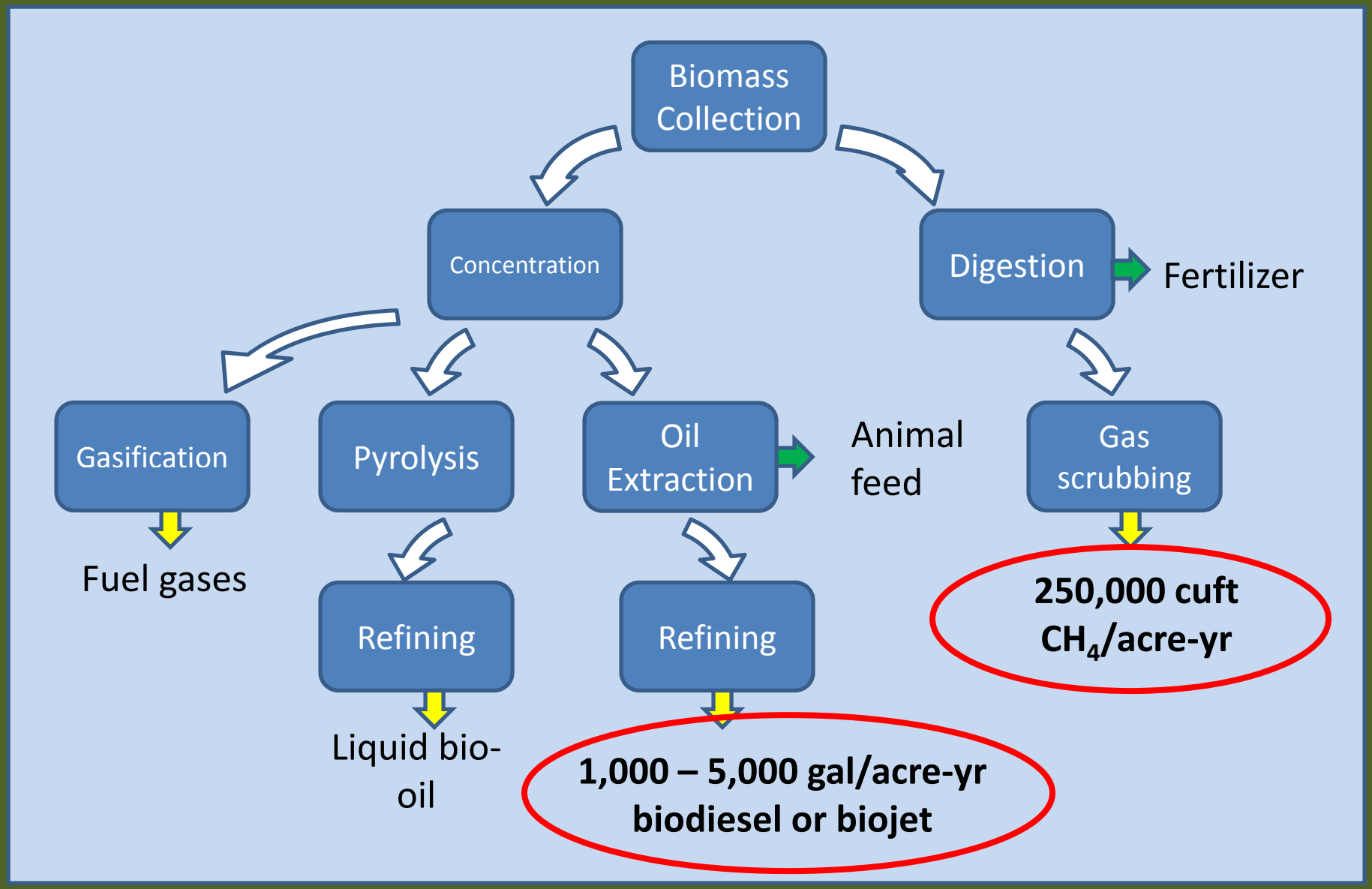
Oil productivity

| Plant | Gal/acre-yr |
|---|---|
| Soy | 50 current yield |
| Palm Oil | 1,600 maximum yield |
| Algae | 1000 - 2000 currently (~6,000 future limit) |



# Ponds for algae production and wastewater treatment

# Algae biomass to fuel



# Land needs for algal fuel in US

- Total US petroleum use 300 B gal/yr, US has ~100 MM acres non-competitive land (PNNL)
  - 3,000 gal/acre-yr needed
- Aviation uses12,600 MM gallons
  - 4.2 MM acres needed for aviation
  - 0.4 MM acres salinized land in San Joaquin Valley, Salton Sea region

2,900 acres of evaporation ponds in Tulare Lake Drainage District

# Technical challenges

| Challenges | Solutions in Progress |
|---|---|
| ■ Growing more oil per acre | ■ Better pest control<br>■ Genetic modification |
| ■ Harvesting algae with less energy and chemical use | ■ Bioflocculation and settling<br>■ Filtration |
| ■ Dewatering and drying algae with less energy use | ■ New screw press technology<br>■ Solar drying |
| ■ Oil extraction with less energy and chemical use | ■ Super critical $CO_2$ extraction<br>■ Hot oil extraction |

# Business and market challenges

- **Economies of scale**
  - 1,000 acres is the minimum facility size – 10x larger than biggest existing.
  - Small scale extraction technology needed
- **Co-location of resources**
  - Flat land
  - Flue gas $CO_2$ to accelerate growth
  - Saline or wastewater
- **Cost of barrel of oil** (Lundquist et al. 2010)
  - **$300** with no co-products, using **near term** technology
  - $225 with no co-products, using plausible **future** technologies
  - $30 with wastewater treatment or animal feed revenue, using **near term** technology

# California algae industry examples

## Solazyme, South San Francisco

- Fermentation, not photosynthesis
- Biofuel, high-value oils for cosmetics, nutrition industry

## Sapphire Energy, San Diego

- Long-term biofuels focus
- Demonstration facility planned

## Aurora Algae, Hayward

- Pharmaceuticals, nutritional supplements, feeds for short term
- Demonstration facility in Karratha, Western Australia

## Cal Poly (with MicroBio Engineering, CEC)

- Algae production with treatment of wastewater (sewage, ag drainage, manure)
- Near commercialization
- Full-scale systems exist but need retrofitting

# Cal Poly research capabilities

## Pilot plant

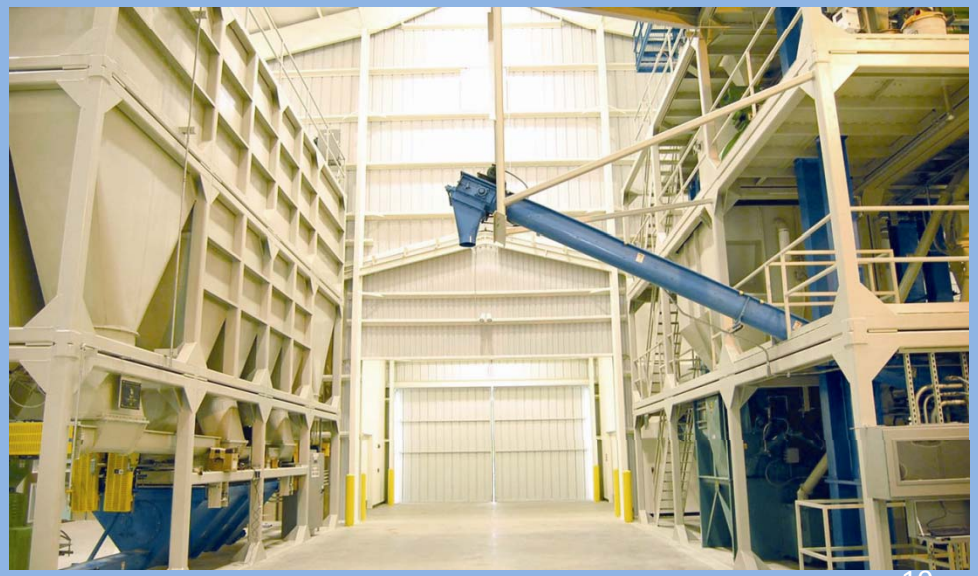
- Nine 35 $m^2$ ponds
- Eight small ponds
- Tube settlers

## Laboratory

- Water chemistry, algae, lipid analysis, biogas analysis

## Feeding trials

- Research feed mill
- Several algae feeding studies completed



# Cal Poly research capabilities, continued

Biofuel research

- Lipid studies
- Digestion/biogas

Wastewater research

- Nutrient removal
- Settling

# Questions?

mhutton@calpoly.edu

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