Fuel, Feed and Water: Algae because a pig won't eat a lump of coal

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# Global Energy Consumption



## Today: Production Cost of Electricity

(in the U.S. in 2002)



# **Oil and the Future**

### As Demand Increases Diversification of Feedstocks will Occur





# Trends in U.S. Water Withdrawals 1950-2000 (Hutson, et.al., 2004)

**Recent Trends Flat ... Approaching Full Supply Allocation** 



Major Biofuel Production Scale-Up Will Need to Include Exploitation of Non-Fresh Water Sources





# Water Challenges are Nationwide





# **Algae Biofuels**

# Because a pig will not eat a lump of Coal



## GOOGLE : Interest down for ethanol, biodiesel and jatropha but up for algae biofuels in 2009

#### ethanol



Of course, Google is not reality, even though many seem to

# The Promise of Algae-Based Biofuels

Algae has potential advantages over corn, cellulosic materials, and other crops as an alternative to petroleum-based fuels



- High biomass productivity potential
- Oil feedstock for higher energy-content fuels
- 50% residual high protein feed for animals avoid competiwith agricultural lands and water for food & feed production
- Can use non-fresh water, resulting in reduced pressure on limited fresh water resources
- Captures CO<sub>2</sub> and recycles carbon for fuels and co-products

Land Needed for Biofuel to Replace 50% of Current Petroleum Diesel using oil from: Corn Soybean Algae



Algae Triglyceride Production Cost Estimates *(From Benemann)* From US DOE National Algal Biofuels Technology Roadmap (Draft Aug 2009) Note: studies are of different scales, methodologies, objectives, assumptions, locations,

technologies, etc.; few have any supporting data. Not comparable!



# Policy Driver: Advanced Biofuels in 2007 EISA Renewable Fuel Standard 36 billion gallons of renewable fuels by 2022



Source: EISA 2007, Sec. 202, p. 121 Stat 1522-1523



# Algae oil can only make a difference at large scale. Fuel is a very low value commodity Brazilian ethanol empirical learning curve applies to algae (Goldemberg, 2004).



...first 10<sup>7</sup> **Bbl** will cost \$5-10B; as in other new technology there is a need for policy....e.g. **PARITY** 

USA corn ethanol subsidy is >5B/year!

# 40-60% of algae biomass is high protein for animal feed

# **Biomass Yields: Goals and Reality**



Cellulosic Goal Miscanthus 10 tons acre<sup>-1</sup> yr<sup>-1</sup> Reality Earthrise Spirulina 50 tons acre<sup>-1</sup> yr<sup>-1</sup>

## **Positive Disruptive Consequences** Use Sea Water for Imperial Valley Algal Aquaculture 500,000 acres 2.5M acre feet/year of Colorado River Water



- Salton Sea remediation: cost \$5-10B based on LAO report
- S. California water needs will cost State ~ \$5B (~50% of Cal. Need)
- Imperial Valley fresh water value: \$1 2
  B/yr on free water market
  Savings on Salton Sea, Water, and revenue for water, fuel and proteins create a new algal industry at scale
- Profitable for oil in 10 years
  Solve S. California water issues
- ~0.5B/year property tax revenuc to state due to increated values on sea shore
- Meet California AB 118 mandate for biofuel use by 2020
- •Produce as much protein for animal feed as 4M acres of soy bean production

http://www.lao.ca.gov/2008/rsrc/salton\_sea/salton\_sea\_01-24-08.pdf http://www.energy.ca.gov/2009publications/CEC-600-2009-008/CEC-600-2009-008-CTF.PDF

## **Obvious: The Earth is warming!**



## Policy makers will not want to be NAKED in the halls of Congress!