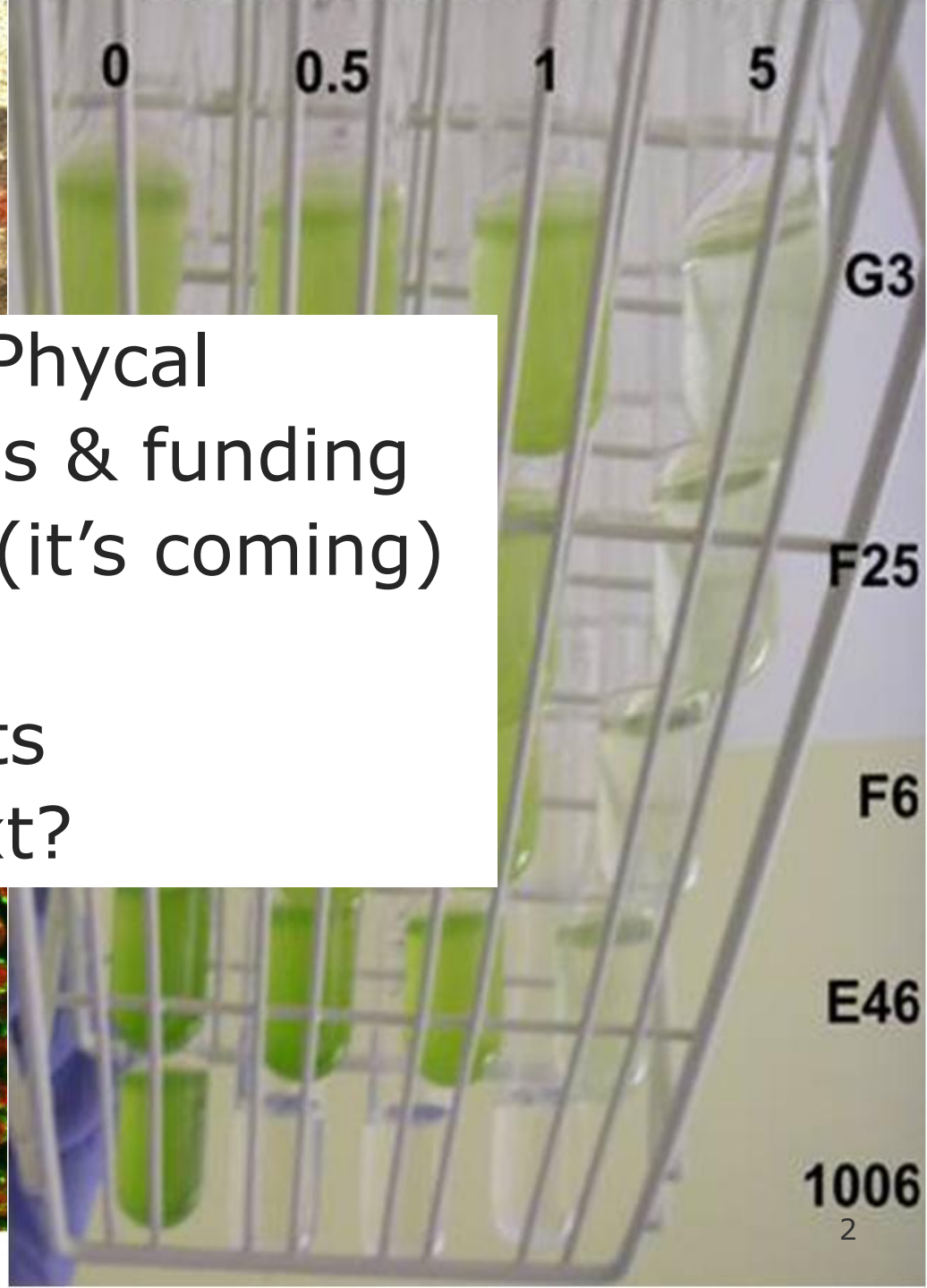
Phycal

Defatted Algal Co-products

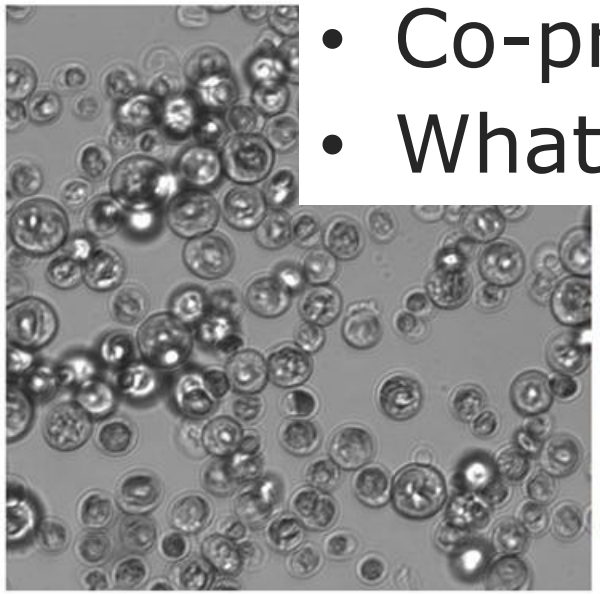
Biofuels Co-products Workshop
Hosted by the Aquatic Feeds & Nutrition Dept.
Oceanic Institute

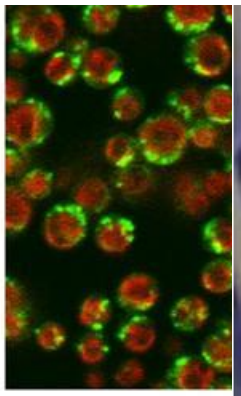
1 December 2011

F. C. Thomas Allnutt
Research & Development



- Introduce Phycal
- Our process & funding
- Pilot Plant (it's coming)
- Products
- Co-products
- What's next?

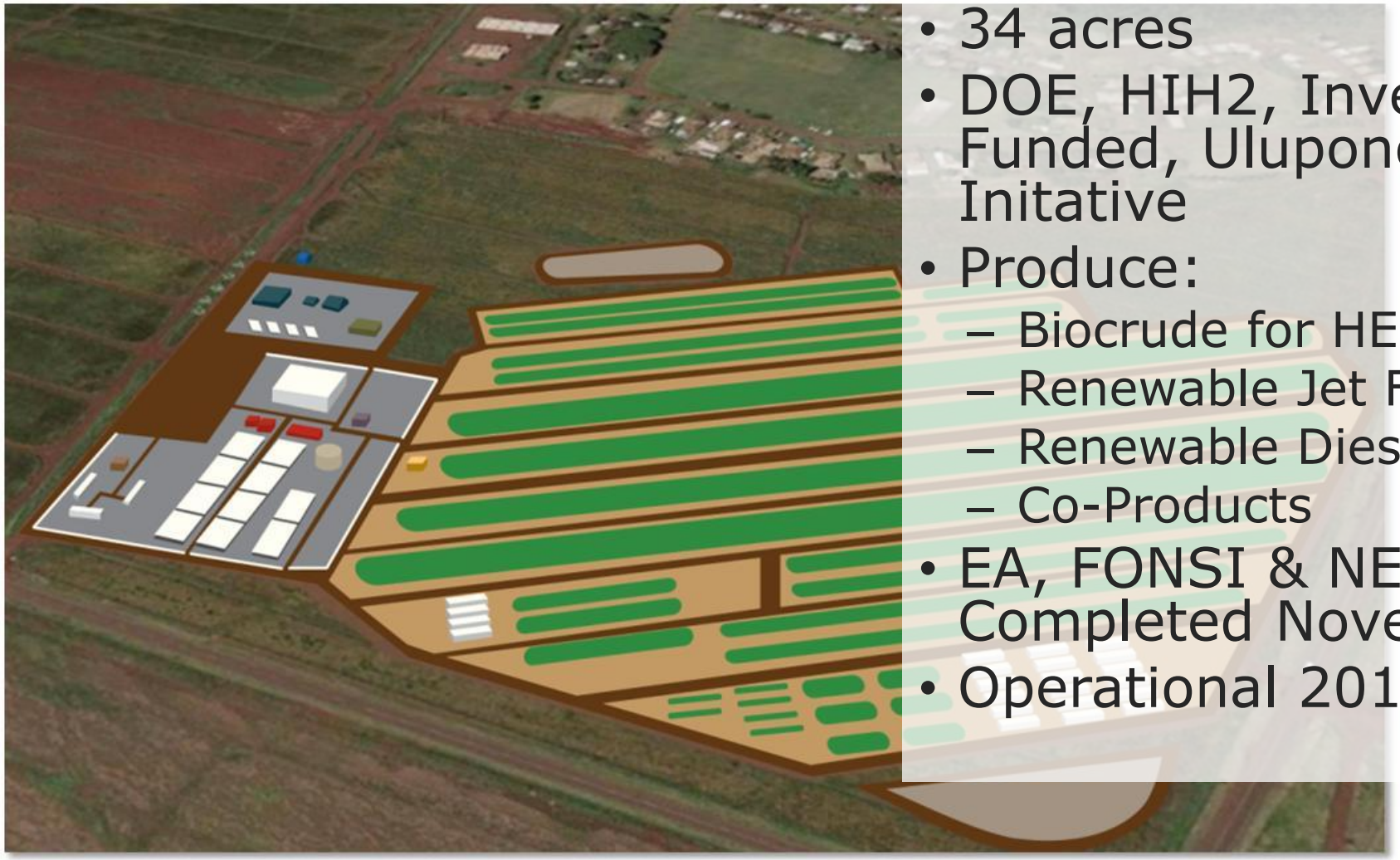




About Phycal

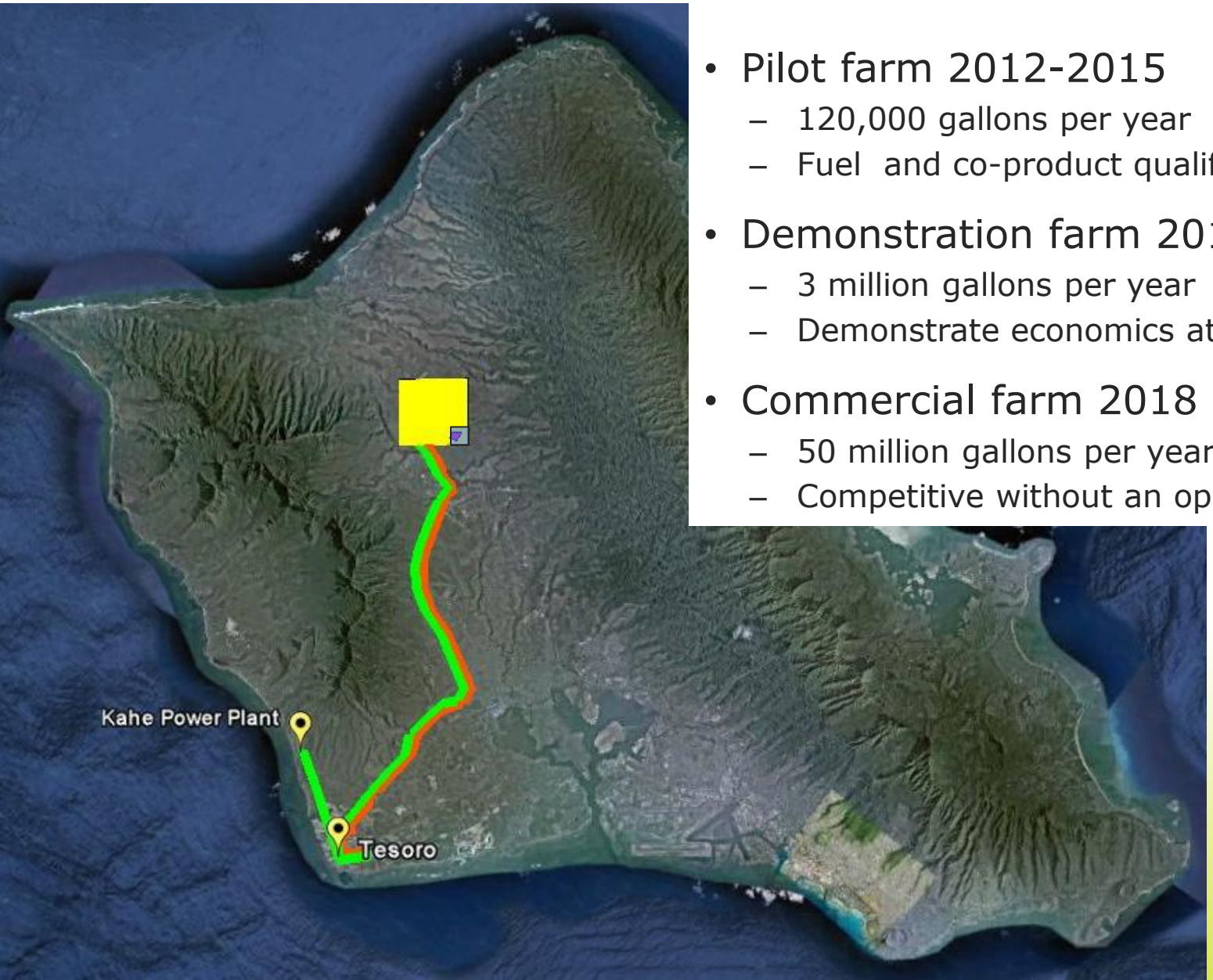
- Founded 2006
- Subpilot Facility and R&D in Ohio
- Algal Biotechnology Lab in Missouri
- Projects and support from :
  - DOE (National Energy Technology Lab - NETL)
  - NSF (SBIR/STTR)
  - DOD (Air Force Research Lab -AFRL)
- Recently selected for $51.5 million in funding from DOE for our pilot algae farm in central Oahu, Hawai'i
- Pilot farm operational in Hawai'i in 2012-2015.

Pilot Farm on Oahu, HI



- 120,000 gpy
- 34 acres
- DOE, HIH2, Investor Funded, Ulupono Initative
- Produce:
  - Biocrude for HECO
  - Renewable Jet Fuel
  - Renewable Diesel
  - Co-Products
- EA, FONSI & NEPA Completed November
- Operational 2012

Commercialization Path



- Pilot farm 2012-2015
  - 120,000 gallons per year
  - Fuel and co-product qualification
- Demonstration farm 2015-2018
  - 3 million gallons per year
  - Demonstrate economics at scale
- Commercial farm 2018 onwards
  - 50 million gallons per year
  - Competitive without an operating subsidy

Products


Phycal
LEA
Phycal
PHY·OIL PLUS
Phycal
PHY·OIL
Phycal
CASSAVA SYRUP
Phycal
MIXED BIOMASS FEED
Phycal
EXTRACTED ALGAL PROTEIN
Phycal
CAL·OIL
Phycal
CAL·OIL PLUS
Phycal
LEA

Co-products

Phycal is a Renewable Energy Commodity Producer

- Energy will be the product, not the co-product
- Optimize production system for oil; then take available co-products

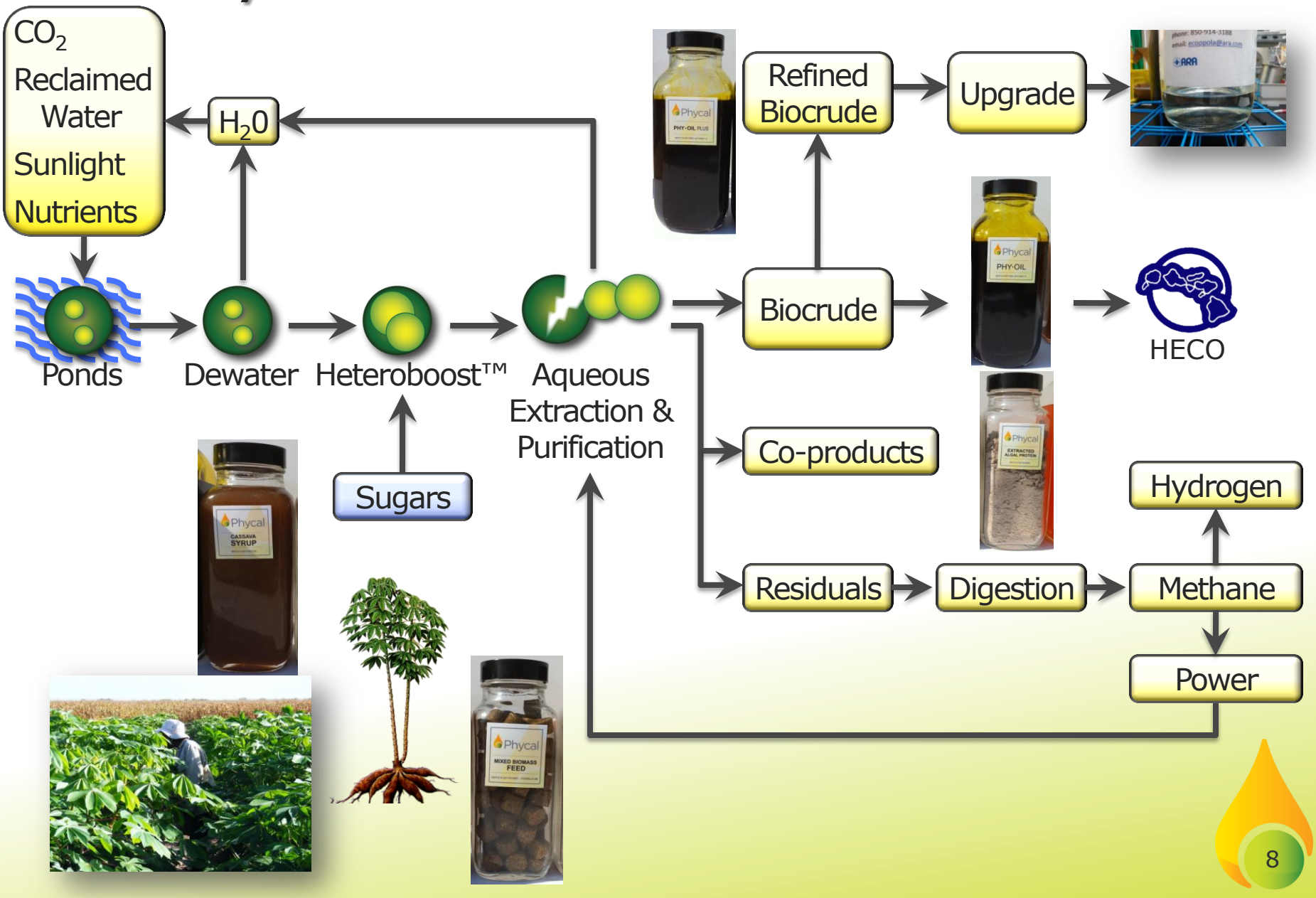
Co-product Markets and Prices

- Target large commodity markets (e.g. animal feed, high oleic acid product), not niche markets
- Co-product pricing is complex, effort currently being supported by scaled production, protein digestibility index (PDCAAS) results, and feed industry consultants.
- PDCAAS - Protein Digestibility Corrected Amino Acid Score is a method of evaluating the protein quality based on both the amino acids requirements of humans and their ability to digest it

Current Status

- Currently completing analyses of material our lipids, biomass
- Decisions about co-products made in the context of our production cost model (e.g., more co-product volume could reduce co-gen)
- In-progress now; we include only what we have done so far

Phycal 1st Generation Process



Co-Products (Work In Process)

- *Algal Delipidated Biomass* - >10% protein, residual lipids and remainder carbohydrate (predominately glucomannans)
- *Algal Protein Concentrate* – On protein digestibility index (PDCASS) similar to pea protein
- *Crude Oleic Acid* – High oleic acid cut
- *Pigments* – Under development, primarily lutein

<u>Other synergistic co-products (Phycal Sugar & Phycal Fuel)</u>

- *Leaf meal* ~27% protein with digestibility index of 0.76
- *Fiber Meal*
- *Cassava Protein Concentrate* ~75% protein with digestibility index of 0.37

Phycal Oil Composition

Lot No. 0511-2832

Fatty Acid	C# : Dbl. Bonds	Relative Basis %	Sample Basis %
Myristic	14:0	0.66	0.62
Palmitic	16:0	9.58	9.10
Palmitoleic	16:1	0.36	0.34
Heptadecanoic	17:0	0.14	0.14
Heptadecenoic	17:1	0.05	0.05
Stearic	18:0	3.71	3.52
Oleic	18:1ω9	68.64	65.19
Linoleic	18:2ω6	14.91	14.16
Linolenic	18:3ω3	1.05	1.00
Arachidic	20:0	0.38	0.36
Eicosanoic	20:1ω11	0.11	0.10
Eicosanoic	20:1ω9	0.19	0.18
Behenic	22:0	0.11	0.10
Other	n/a	0.12	0.11
		100.00	94.98
	Total % ω3	1.05	1.00
	Total % ω6	14.91	14.16

- Not making long-chain, poly-unsaturated fatty acids (PUFAs)

LEA Amino Acid Profile

Amino Acid	mg aa/ g protein	PDCASS
Histidine	22	n/d
Isoleucine	46	1.65
Leucine	96	1.46
Lysine	58	1.00
Met + Cys	24	0.95
Phe + Tyr	73	1.15
Threonine	55	1.63
Tryptophan	18	1.68
Valine	71	2.04
Total →	442	0.82

PDCASS = digestibility score vs. requirement for preschoolers.
Chickpea is 0.78 and Soybean 0.91

Looking Ahead

- Break ground in 2012 (Q1)
- Prepare to be surprised
- Continue development programs in technologies, co-products & crops
- Open Innovation – we want to work with anyone who can help us develop these co-products for their industry

Phycal

Thank You!

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