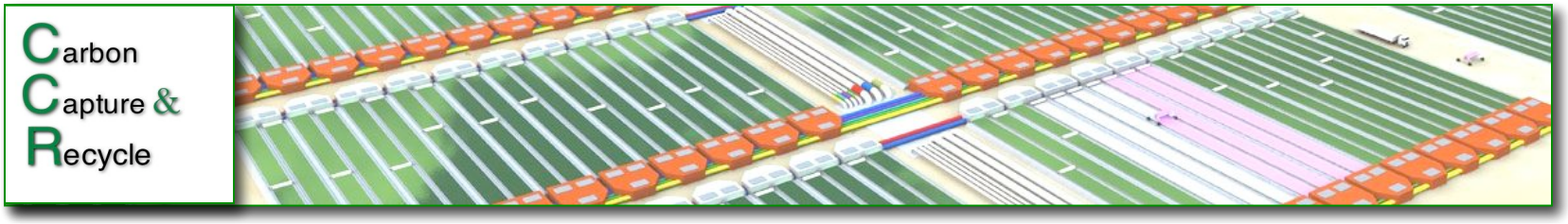

A2BE Carbon Capture LLC

www.algaeatwork.com

Strategic Road to Commercialization
- Food and Fuel from Algae -

AFOSR Algae Oil for Jet Fuel Production

Workshop, 2/19/2008

Jim Sears

Chief Technology Officer

Carbon Capture & Recycle

Theme & Organization

- **Current State of the Algae Biofuels Industry**
- **System Engineering Considerations**
- **A2BE's Technical and Economic Approach**
- **Near Term Recommendations for Industry Acceleration**

Carbon Capture & Recycle

Diminishing Returns

"Stop sending me research papers." "Its doable"
- Doug Kirkpatrick, DARPA

"We have no object example that persuades investment capital, (Wall Street), to fund an industry. In order to 'Cross the Chasm' sizeable facilities need to be built with an acknowledgment up front that most of those efforts will underperform or fail. There will be some setbacks, but even out of the failures we can aggregate a solution."
- Mark Allen, A2BE Carbon Capture

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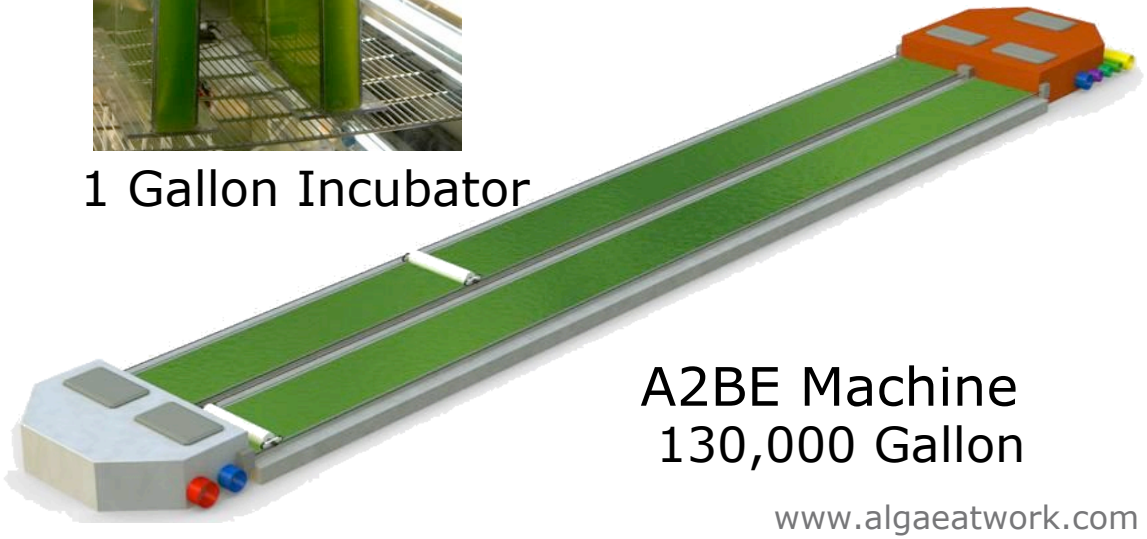
What is an Object Example?

1 Gallon Incubator

100 Gallon Incubator



A2BE Machine
130,000 Gallon

www.algaeatwork.com

5000 Gallon Experiment

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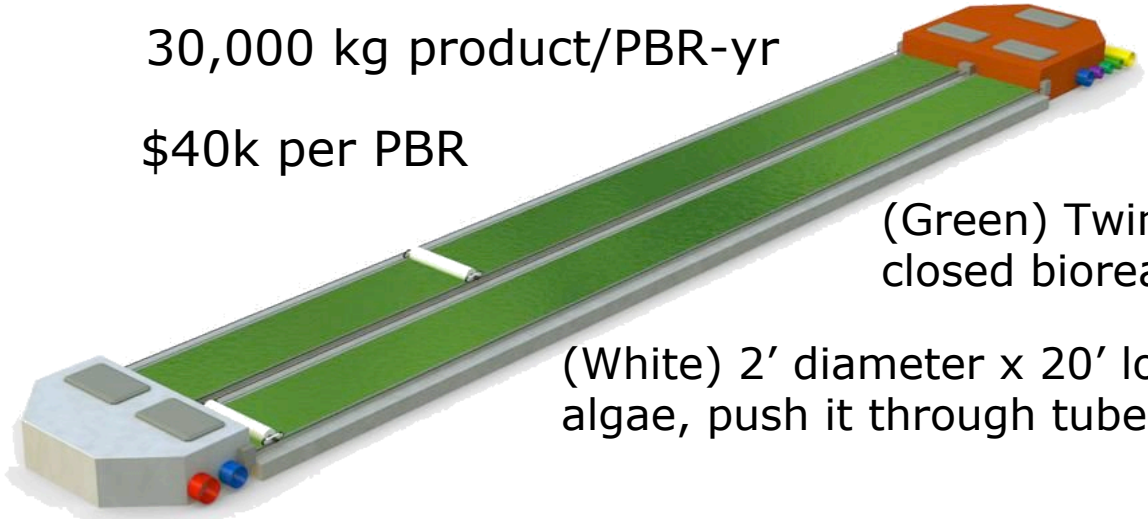
A2BE Machine Characteristics

Maximizes CO2 to Biomass conversion

30,000 kg product/PBR-yr

$40k per PBR



(Red) Bio-harvester I & Gas, Liquid, and Product piping

(Green) Twin 400’ x 20’ x 10” clear plastic closed bioreactor algae growing tubes

(White) 2’ diameter x 20’ long rollers re-suspend algae, push it through tubes and clean inner surfaces

(Gray) Bio-harvester II, CO2/Flue gas input, and Pure Oxygen output

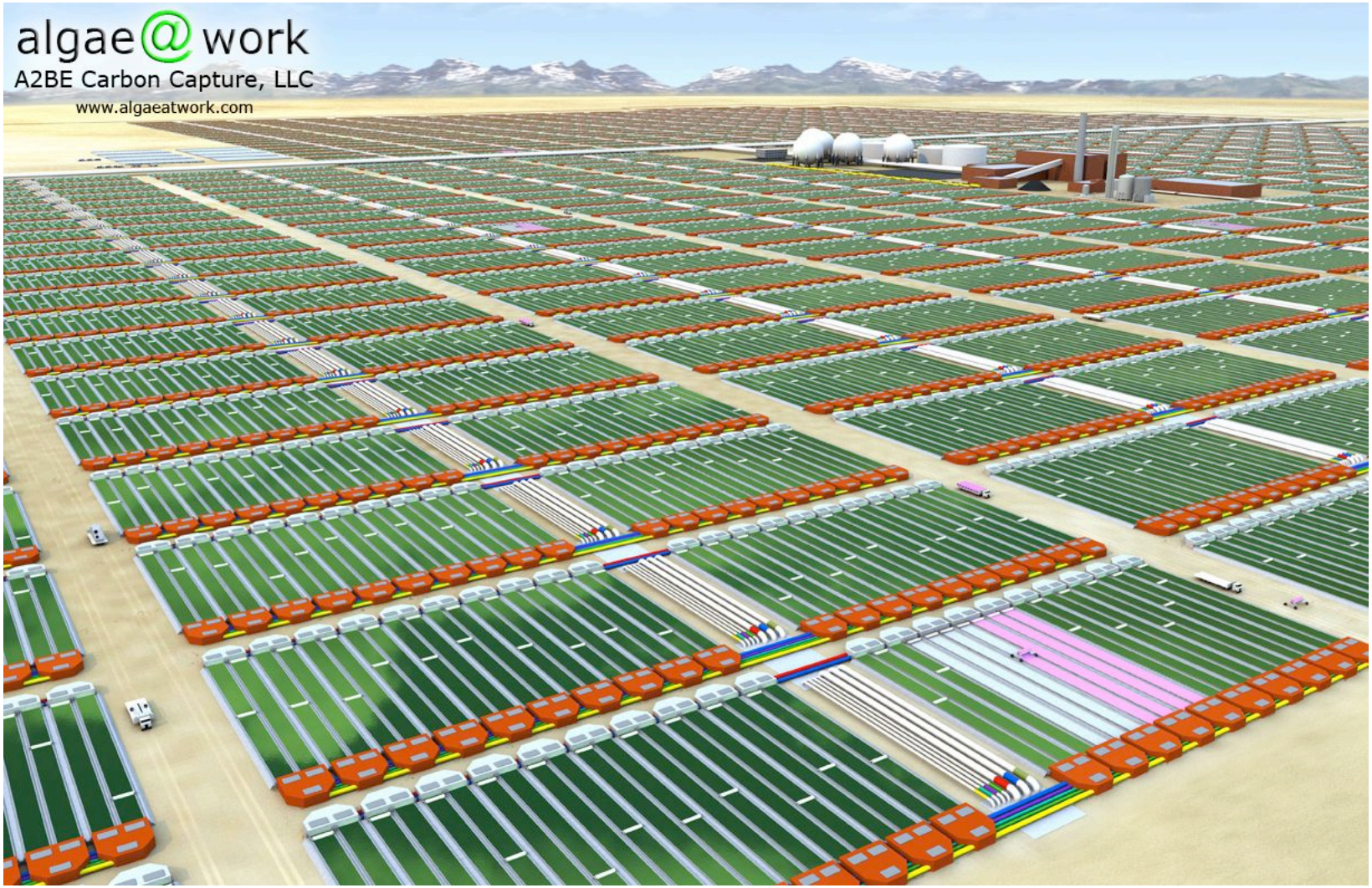
- Assembled modules, formed in-place concrete, barrier over graded earth
- ½ acre footprint with 75% = 1500 m2 photosynthetic capture area
- Passive temperature stabilization via conduction + long-wave radiation switch
- Photo-modulation via internal helical currents + refractive surface structure
- All biological surfaces are recyclable, inexpensive, and never need sterilization

Core Claims: Productivity = 55 gms/m2/day yearly average (2012). Infrastructure cost = $27/m2 photosynthetic

Carbon
Capture &
Recycle

Photosynthetic Industrialization

Harnessing the Power of Human Nature



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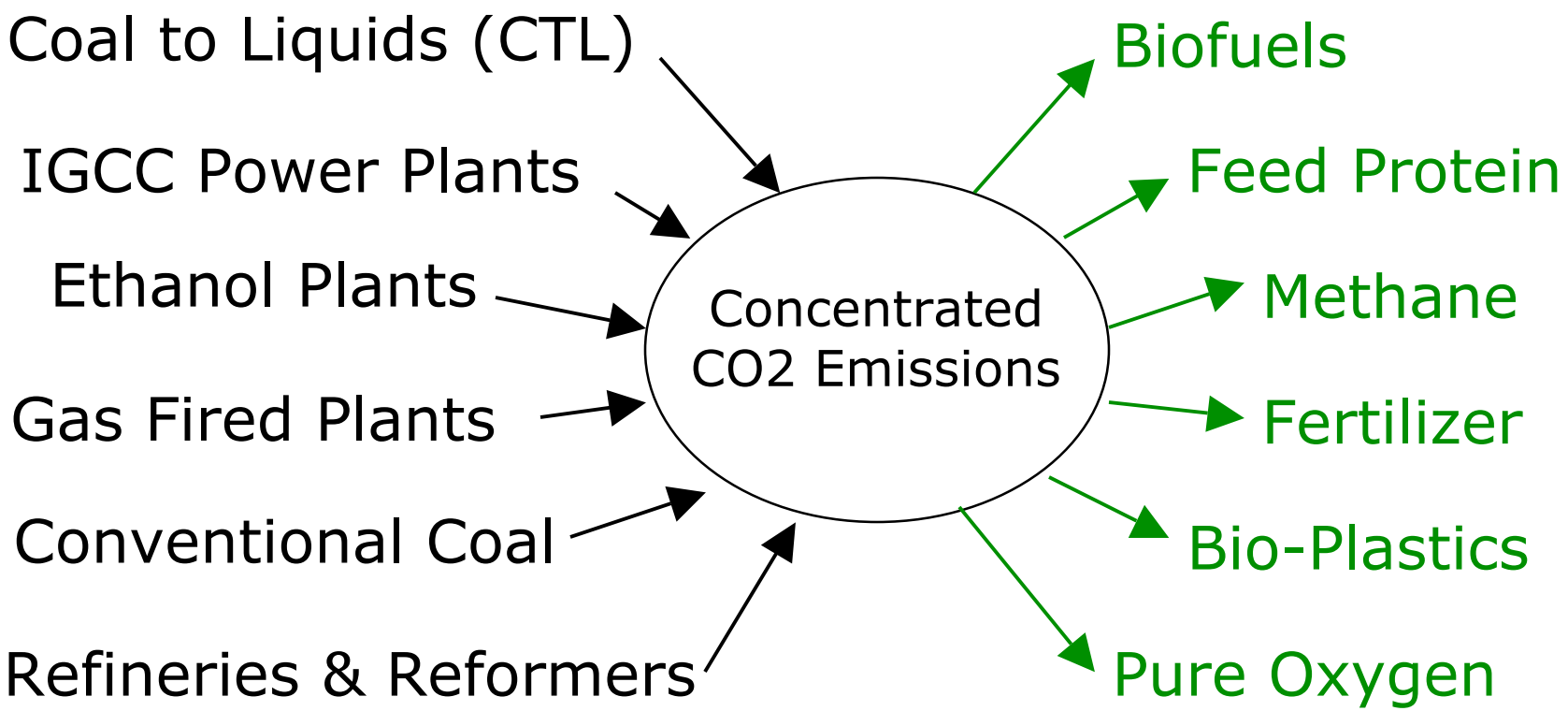
Industrial Intensity CO2 Recycle



Carbon Capture & Recycle

Algae Industry Launch Strategy

Global Need: **Internet of Food and Fuel**

Going for it: **Attracting Creative Vitality**

Systematic: **Convergent Process Energy**

Who does it: **Primary Industry Participants**

Schedule: **Algae Industry Timing**

Carbon Capture & Recycle

Internet of Food and Fuel

Scaleable carbon-negative growth industry

- Low market elasticity for inputs and outputs
- Growth of industry good for society
- Profit growth unlikely to saturate

Water and food network security

- Conservation and remediation of water
- Spatially distributed robust food generation

Energy and transportation network security

- Allows coal-electric and CTL to be acceptable
- Spatially distributed robust fuel generation
- Synergistic with CO2 sequestration network

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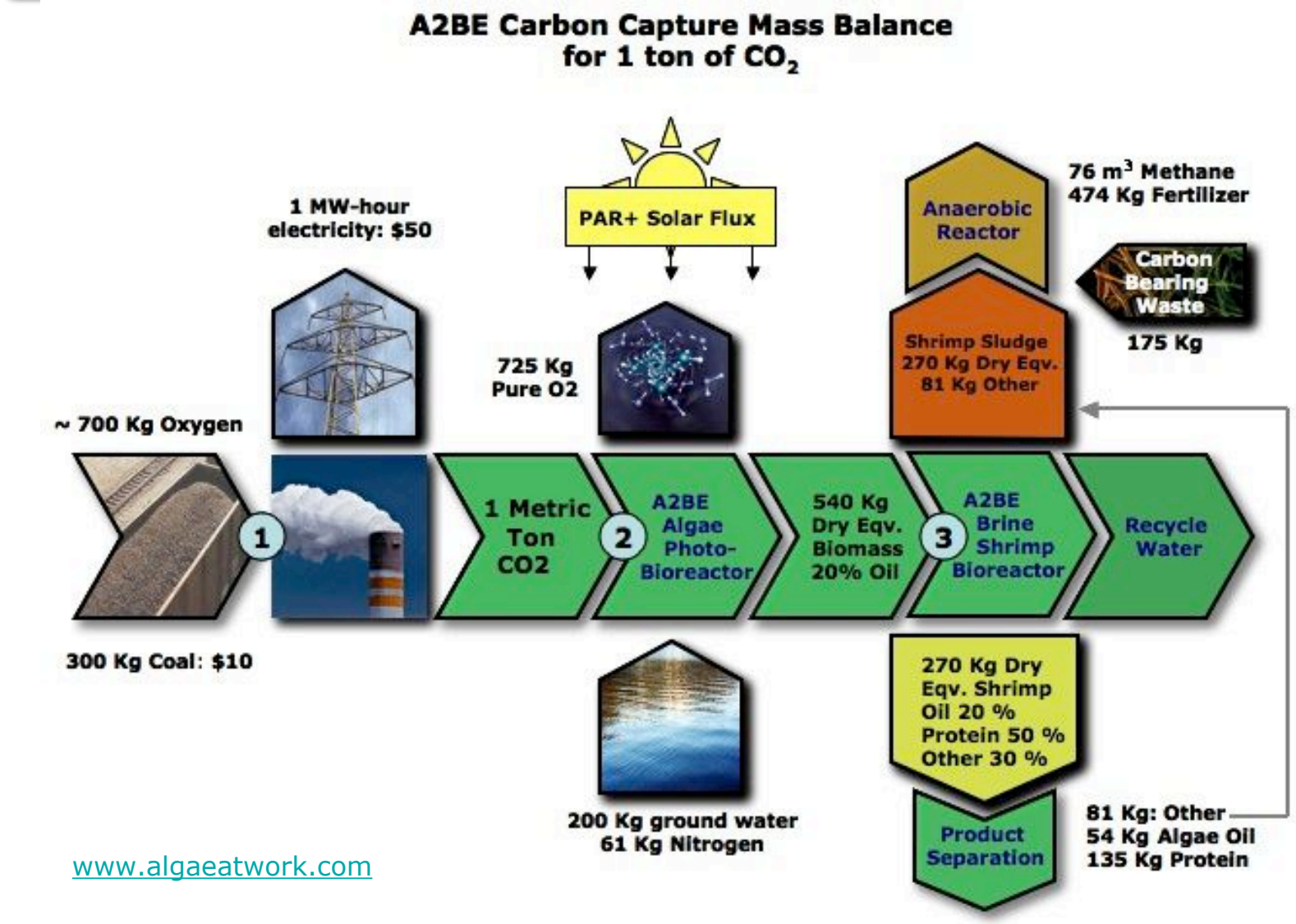
Carbon to Product Mass Balance



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Carbon Capture & Recycle

Economic Value Engine

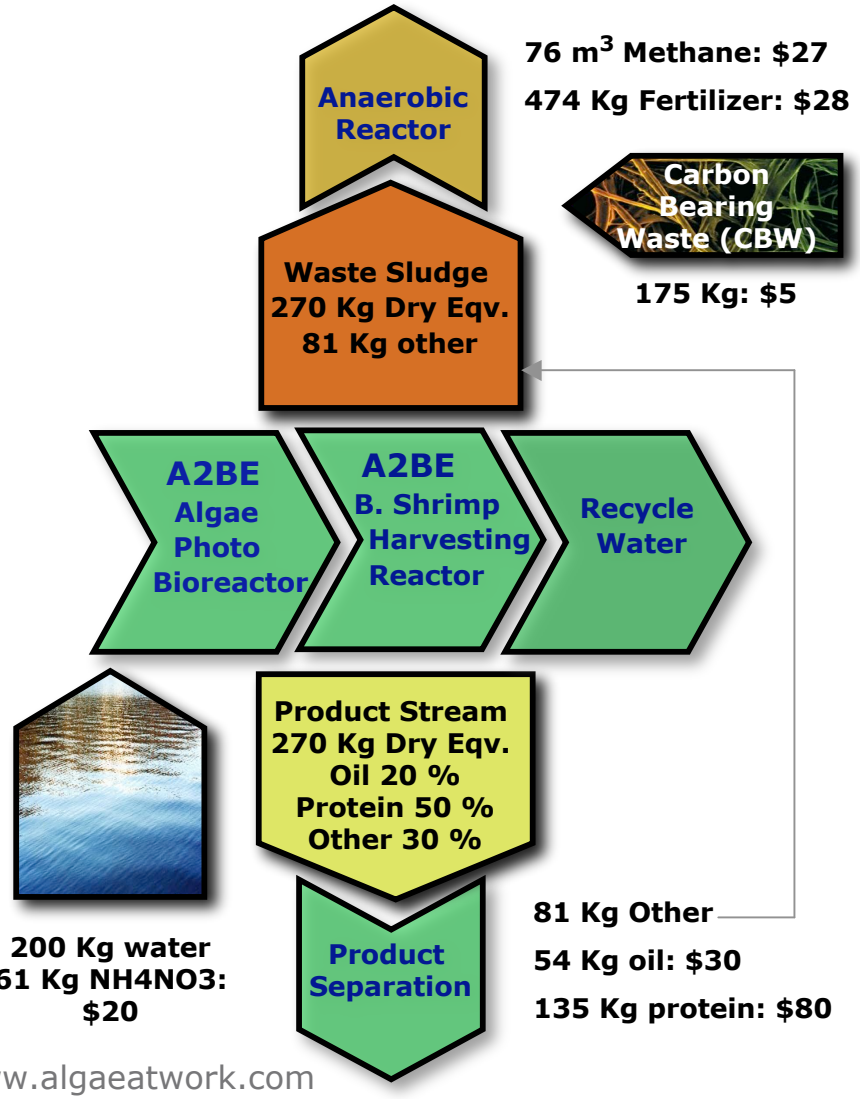
Value Summary

(based on 1 Metric Ton CO2)

Revenue:	
Oil	$30
Protein	$80
Methane	$27
Fertilizer	$28
CO2 Credit	$25

Cost:	
Nutrients	$20
CBW	$5

Net Revenue: $165



Carbon
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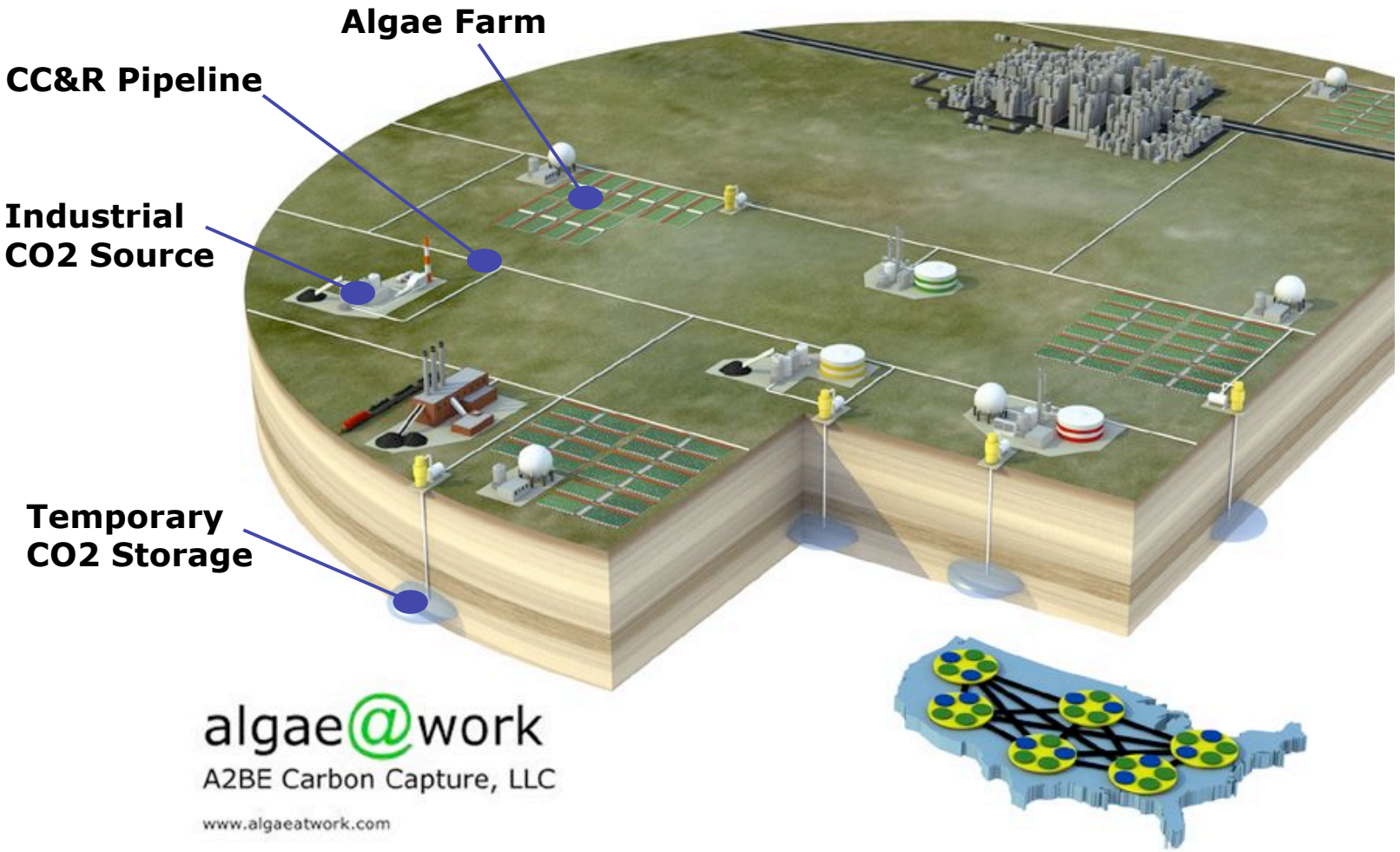
Carbon Capture & Recycle (CC&R) National Pipeline Grid



Carbon Capture & Recycle

Attracting Creative Vitality

On-the-ground Pilot Plants

- Point example of existence and opportunity
- Test bed for new ideas and new markets

Financial Domain Trust and Investment

- Demonstrated government commitment
- Demonstrated econometric focus

Expectation of Learning Curve Mistakes

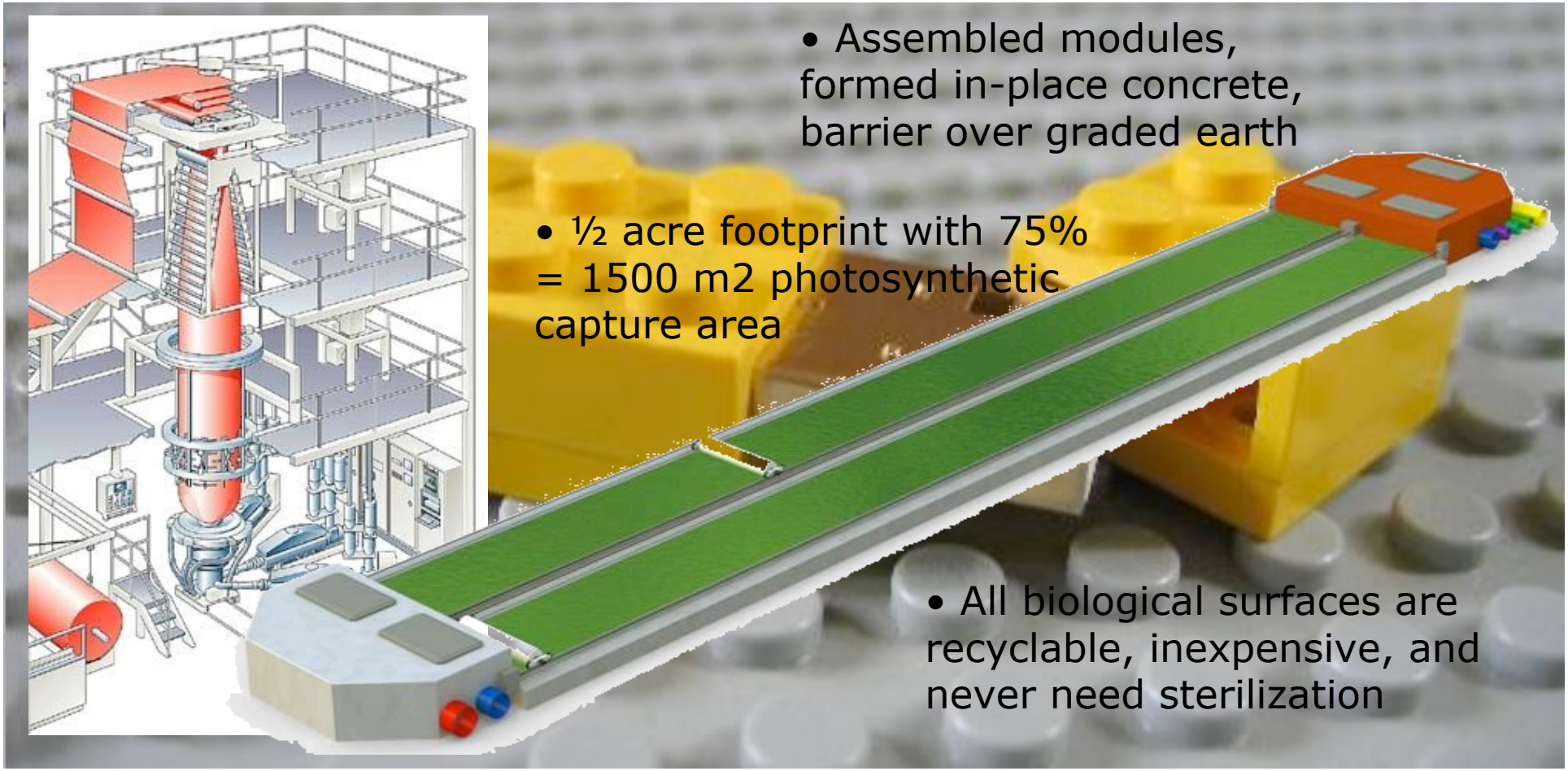
- Even failures add learning value to program
- Systematic integration of empirical learning

Regional, National, Corporate, Individual Competition

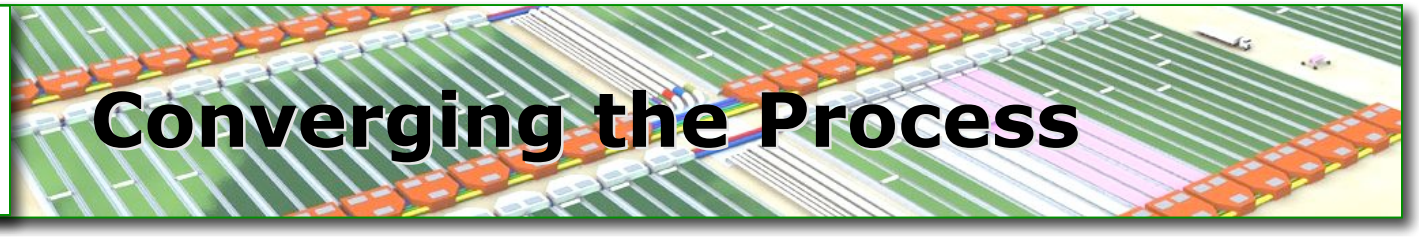
- Uniquely American industrial challenge
- Restore American prestige, purse, and popularity

Carbon Capture & Recycle

Drive the Industry to Really Smart Legos



Carbon Capture & Recycle



Converging the Process

National System Engineering Plan

- DARPA algae fuel initiative
- AFOSR conference to build master plan
- Aerospace and defense contractor involvement

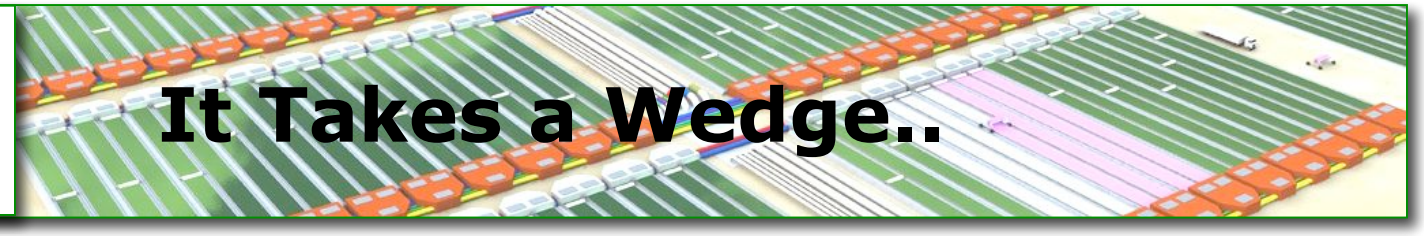
Intellectual Property Pooling & Cooperation

- DARPA *cooperate-or-else*.. mandate
- Wilson, Sonsini, Goodrich, & Rosati global brand
- RFID, Cable industry, USB, WiFi, Hybrid cars

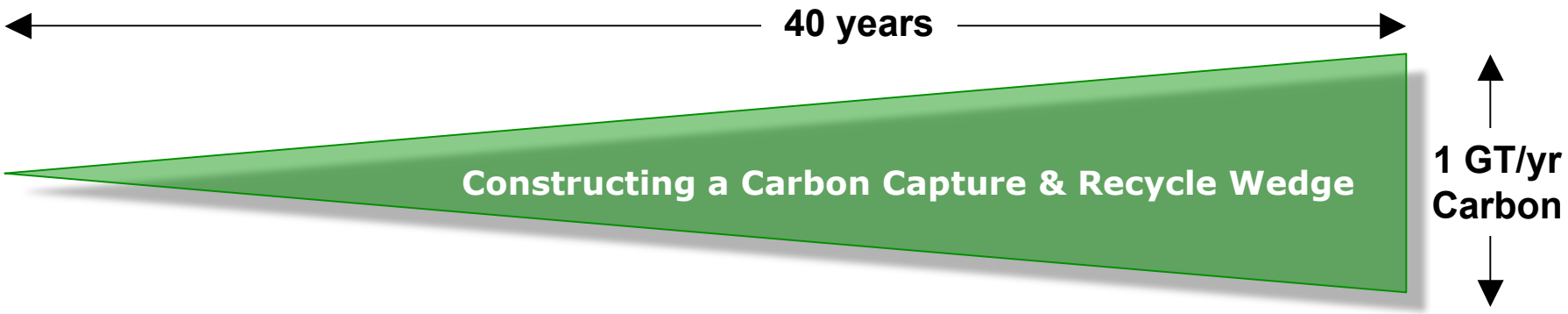
Environmentalism, Patriotism, Education, Jobs

- Harnessing the power of popular movements
- Merging with the personal ethos of individuals
- Creating an attractive future career path

Carbon Capture & Recycle



It Takes a Wedge..



Annual Global Business Growth using 1 Wedge

- 800,000 Acres (0.002% global land)
- $66 Billion infrastructure investment (0.1% global GDP)
- 240,000 New jobs (25% on farm, 75% in ancillary economy)
- $15 Billion CO2 derived product revenue

1 GT Carbon = Carbon in 3.66 Billion tons of CO2

Carbon Capture & Recycle

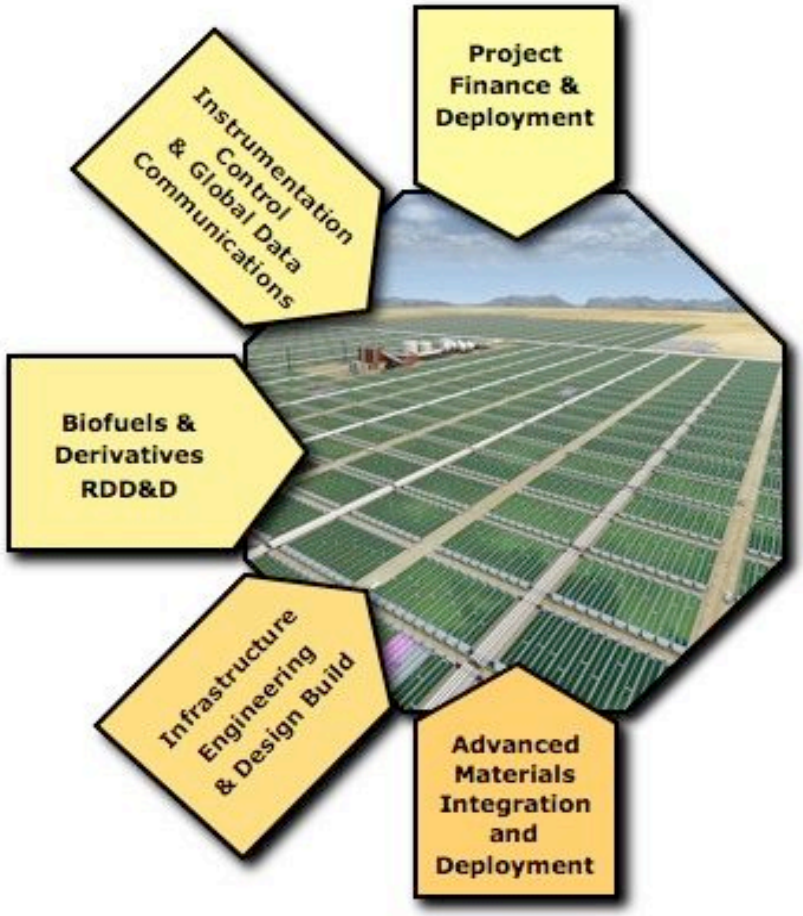
Carbon Negative via Offsets

Coal Based Carbon Negative Power Generation via CO2 Offsets

	Process	CO2 Produced	CO2 Consumed	Products Produced	Fossil CO2 Off -Set
1	Electricity generated from 300 kg of coal	1000 kg (1 MT)	-0-	1 MW -hour of electricity	-0-
2	A2BE Carbon Capture Machine	-0-	1 000 kg (1 MT)	540 kg dry weight equivalent Algae biomass	-0-
				725 kg pure O2	530 kg
3	A2BE Bioharvesting	-0-	-0-	54 kg Algae oil	130 kg
				135 kg protein	135 kg
				474 kg fertilizer	300 kg
				76 m^3 methane	150 kg
	Total CO2 Produced	1 MT			
	Total CO2 Consumed		1 MT		
	Total CO2 Offset				**1,24 5 kg**

Carbon Capture & Recycle

It Takes an Industry….

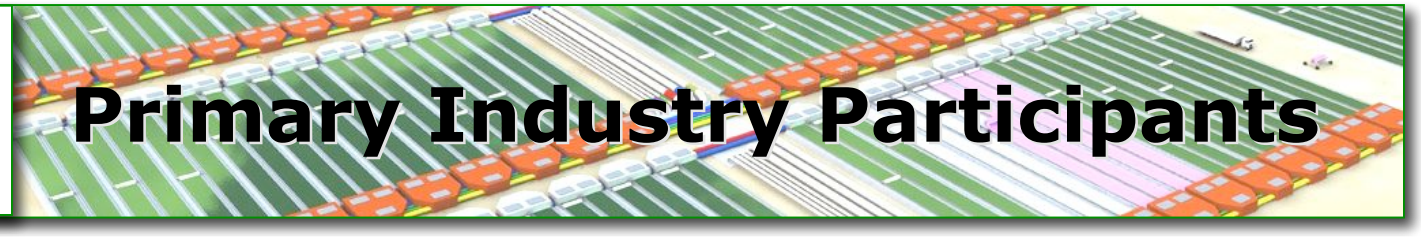


Consortium Team Approach

Objective

- Capture Essential IP
- Integrate Processes & Technologies
- Deploy Projects & License Technology
- Work Continuous Improvement
- Reap Long Term ROI

Carbon Capture & Recycle



Primary Industry Participants

DARPA, Air Force, NAVY

- Require operations fuel. *No fuel - No force*
- Gov. will comply with CO2 & Biofuels legislation

Coal, gas, electric power, oil industry

- Schedule driven solely by legislative regulation

Universities and National Labs

- Seek prominence and funding via national participation

Secondary and trade schools

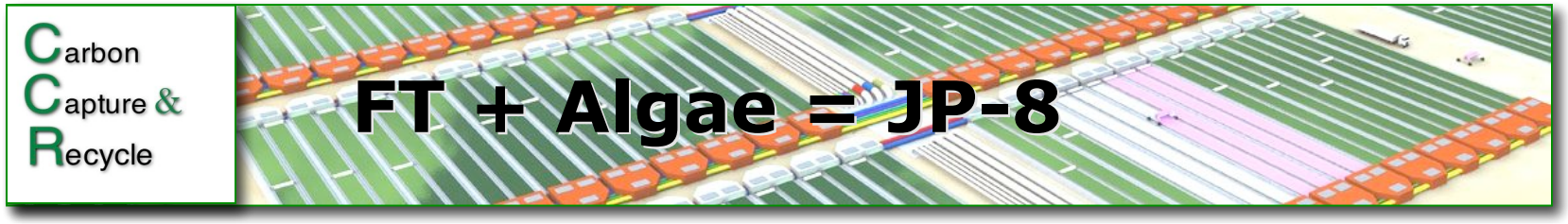
- Workforce development, STEM engagement, Grants

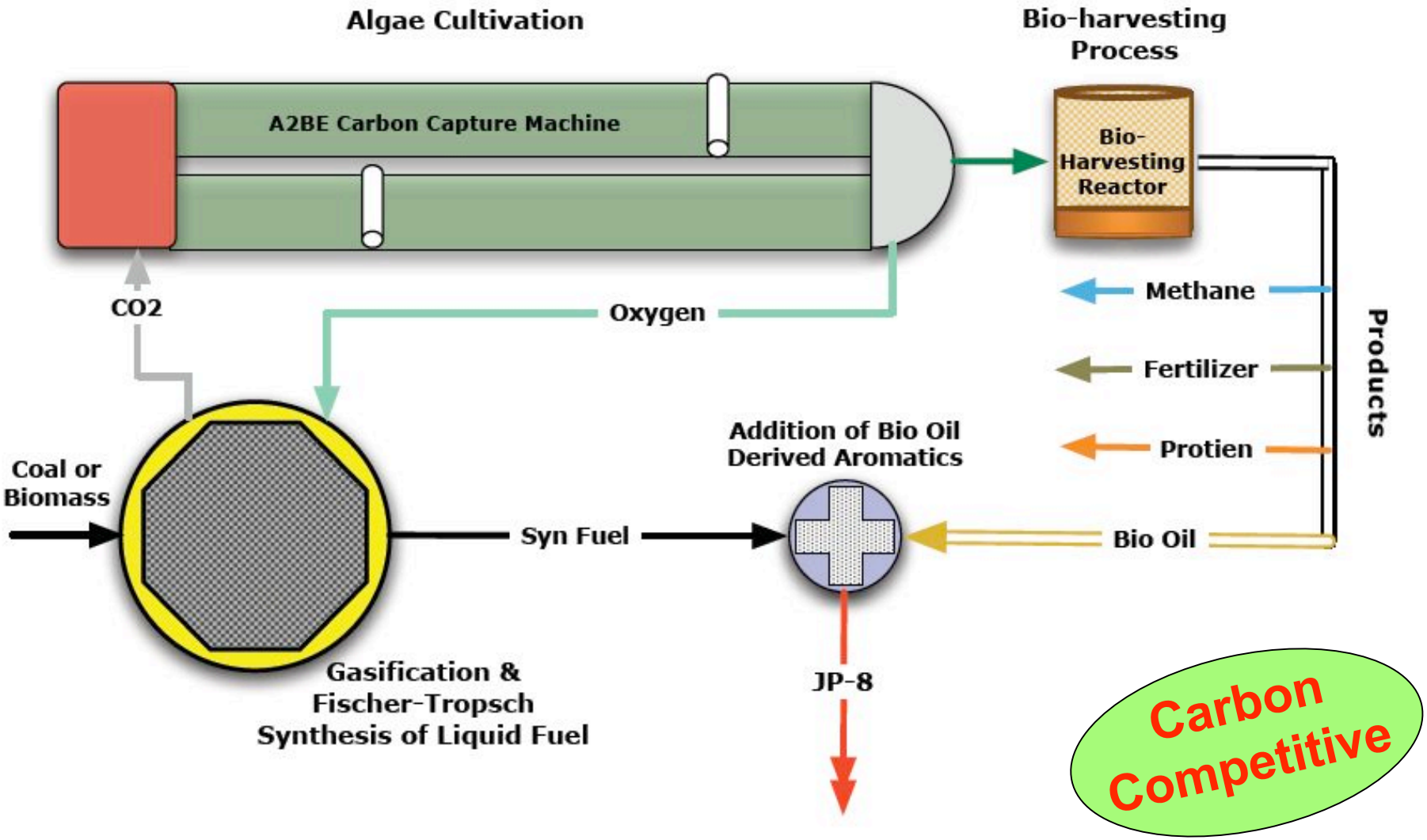
Entrepreneurs and investors

- Jump at market opportunity benefiting first movers

Carbon Capture & Recycle

FT + Algae = JP-8





Carbon Competitive

Carbon Capture & Recycle

Algae Industry Timing

Now is the time for a National Strategy

- Science report on biofuels has *dazed* industry
- Election provides receptivity for new direction

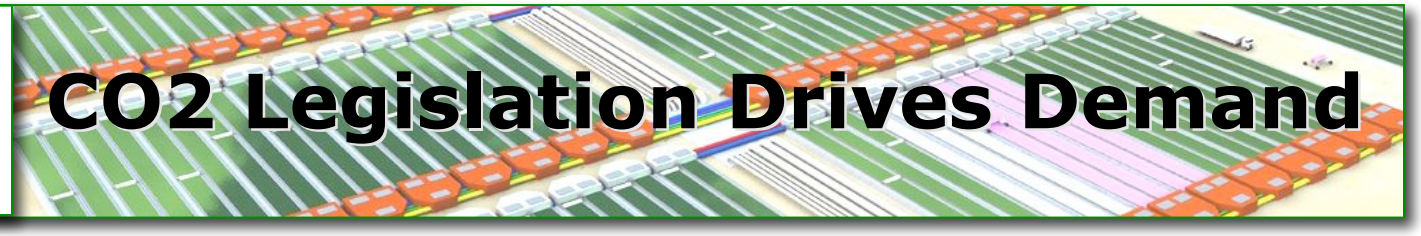
Projects initiated on ground this year

- Investors need to see and trust gov. intention
- Legislators need object example to study

A2BE Carbon Capture has these timing goals

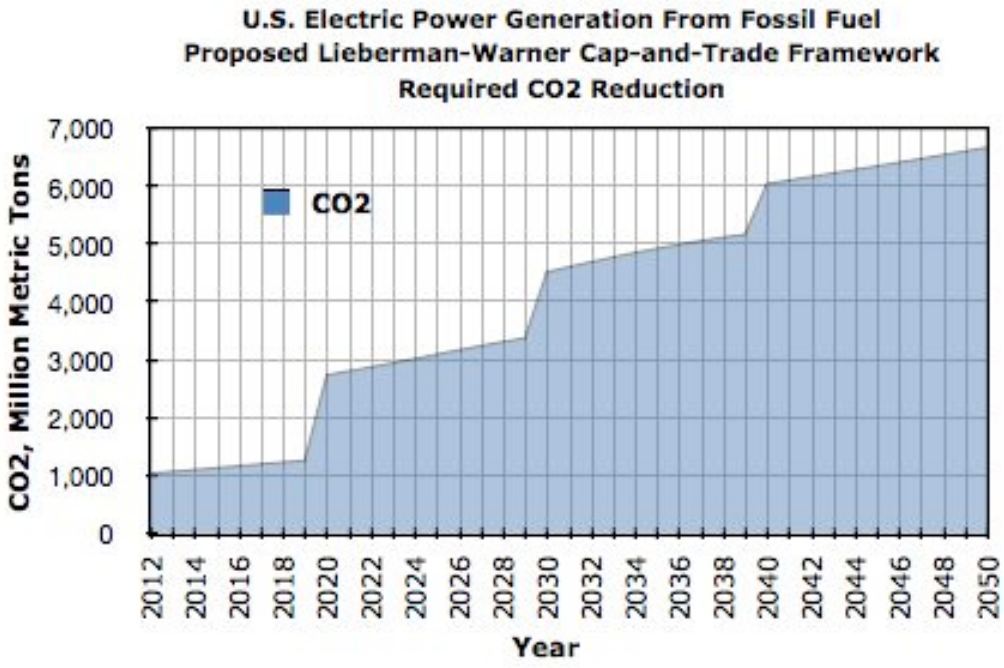
- Operating pilot with full-scale elements: 3 years
- Commercial design ready for build-out: 5 years

Carbon Capture & Recycle



CO2 Legislation Drives Demand

Looming 2012 Date will Require Validated Technology

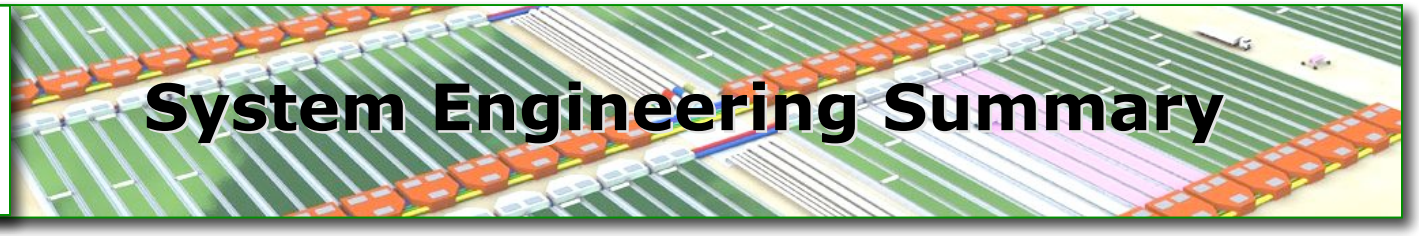


Legislative Framework

1. 2012 cap will be set at the aggregate CO2 emissions level of 2005
2. 2020 cap 10% below 2005
3. 2030 cap 30% below 2005
4. 2040 cap 50% below 2005
5. 2050 cap 70% below 2005

Senate Bill 2144, and others, are addressing national CO2 pipeline grid

Carbon Capture & Recycle



System Engineering Summary

- Low mixing energy with engineered light distribution
- Thermal switching with near zero energy cost
- Positive energy balance, does not rely on continuous fossil input
- Highly scaleable, modular mass production
- Bio-security, resiliency, infections do not spread, sterile restart
- National CO2 grid, operate off CO2 grid anywhere in US/Mexico
- Very low water impact in all climates
- Consistent food and fuel quality with lower-than-nature mercury
- Engineered environment adapts to all climate changes
- Highest present and future land use efficiency
- Environmental imprint: zero waste discharge
- Ecological security, operates with indigenous watershed species

Carbon Capture & Recycle

Action Summary

Choices need to be made:

- Pick 4 – 6 systems
- Fund them
- Define the timeline
- Incentive for people to work together

Demand Results:

- DARPA demanded fuel at a specific price
- Research directed at commercial relevant results
- Profitable operation is the Holy Grail, not just lipids
- Relevance comes from demonstrating full scaled up components