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**One little cell,
a world of
possibilities.**

ATP3



Algae Testbed
Public-Private Partnership

www.atp3.org



- Introduction to AzCATI
- Objectives for ATP³
- Open Collaborative Testbed
- High Impact Data from Long Term Cultivation Trials
- Summary

Arizona Center for Algae Technology and Innovation

The Arizona Center for Algae Technology and Innovation (AzCATI): formed in 2010 through stimulus funds designated by the Science Foundation of Arizona to serve as a hub for research, testing, and commercialization of algae-based products.



- **Connect**
- **Advance**
- **Collaborate**
- **Educate**
- **Launch**

AzCATI capability

AzCATI
 Arizona Center
 for
 Algae Technology and Innovation

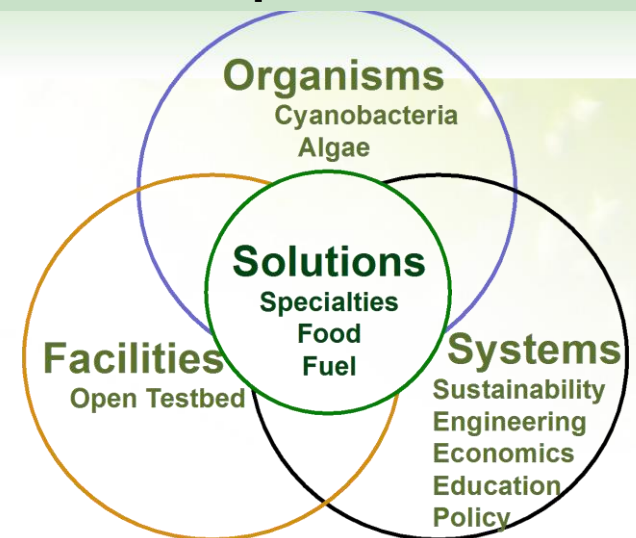
Systems



Fully integrated program teams

- Comprehensive and integrated solutions

ASU Microorganisms Core Capabilities



AzCATI Portfolio



AzCATI – \$4M. CO₂ mitigation from flue gas into algae based fuels; Reactor development; Strain selection and development; Processes for products; Wastewater; Downstream processing and nutrient/media recycling; Test bed expansion



USDA – \$1M. Development of best management practices for algal crop protection



ARPA-e – \$7M. Cyano-bacterial based photosynthetic factories - secrete fatty acids for fuel production



SABC – \$ 6M. Biochemical conversion of algae to fuels; QA/QC protocols & characterization; Enzymatic pretreatment for fuels

**Bioenergy
Technologies
Office**

ATP³ – \$15M. National algae test bed network

DOE – \$0.5m. Managing microbial ecology in cultivation systems

Steady and encouraging progress for the Algae Industry

Challenge Space:

1. High cost of production
2. Demonstrating scalability and
3. Availability of nutrient/CO₂/water resources

Opportunity Space:

Technical

- Increase productivity
- Increase lipid content
- Increase robustness and resiliency to resist predators
- Improve early detection of contaminants
- Develop new strains to handle high salinity
- Improve energy efficiency of downstream processing

Policy

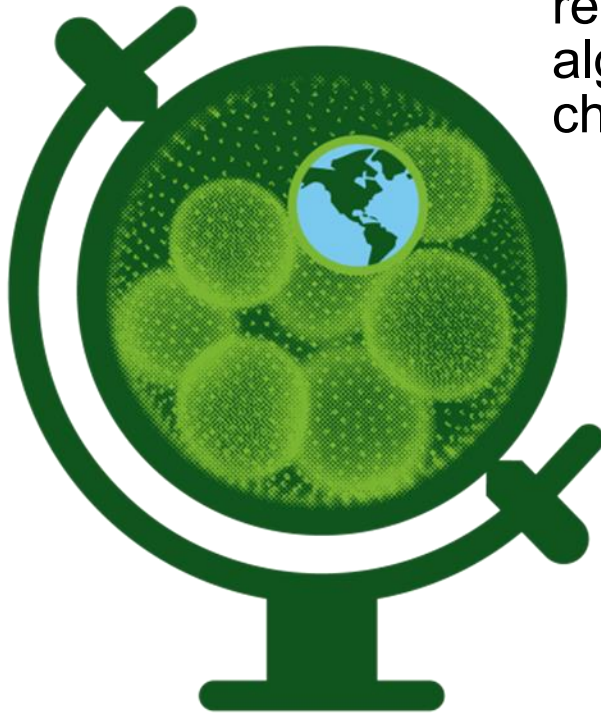
- Support from USDA for algae as precision agriculture
- EPA and USDA collaboration critical on CO₂ and GMO policies, crop designation, agricultural practices and policies and tax incentives/rebates.
- Carbon reuse and EPA rule-making: recycle waste rather than bury waste

Business

- Take advantage of high value markets to facilitate learning
- Continue to focus on multiple technology pathways and strategies
- Foster business innovation

Collaboration, convening and leverage

Collaboration, convening and leveraging represents the largest set of opportunities the algae industry can seize in order to confront its challenges



Collaborate Convene Leverage

- Share knowledge, accelerate learning
- Reduce risk
- Accelerate R&D (commercial) outcomes
- Maximize return on investments
- Increase probability of success
- Reduce business failures

ATP³: National open test bed

The formation of the Algae Testbed Public-Private Partnership **leveraged** the existing resources at AzCATI and partner sites. The network represents a **collaboration** of industry, laboratory, and educational facilities across nation. ATP³ aims to **convene** all algae stakeholders to facilitate opportunities and progress more rapidly to commercialization..



ATP³ primary objectives

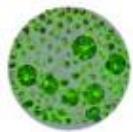
Collaborative Open Testbeds

- Establish **network** of facilities for the algal research community and **increase stakeholder access** to real-world conditions for algal biomass production.
- **Accelerate** applied algae research, development, investment, and commercial applications for biofuel and bioproduct feedstock production.

High Impact Data from Long Term Algal Cultivation Trials

- Design and implement a unified experimental program across different **regional, seasonal, environmental and operational conditions** comparing promising production strains at meaningful scales.
- **Data made widely available** to the TEA/LCA and overall research community allowing for a robust analysis of the state of technology.

ATP³ partners

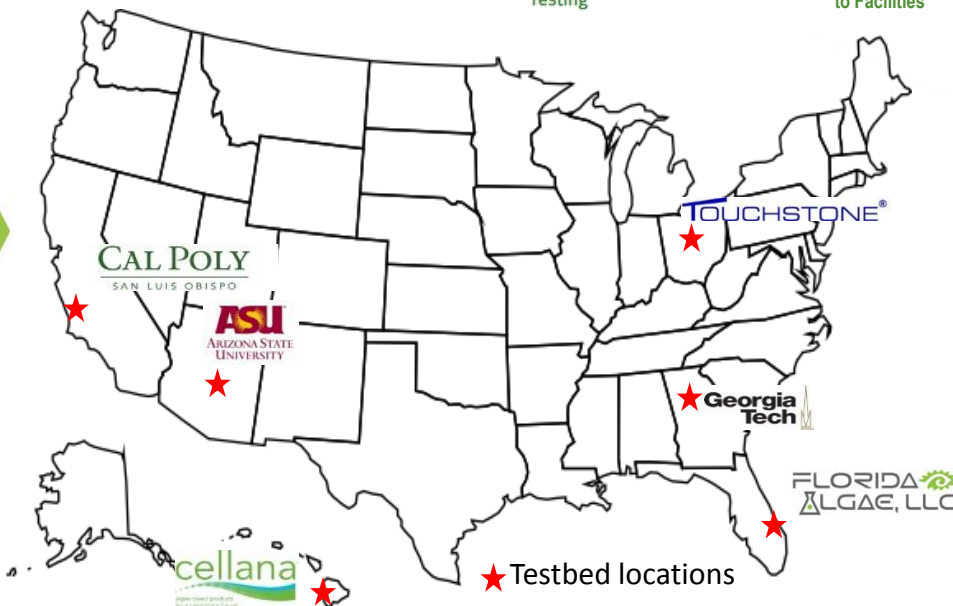
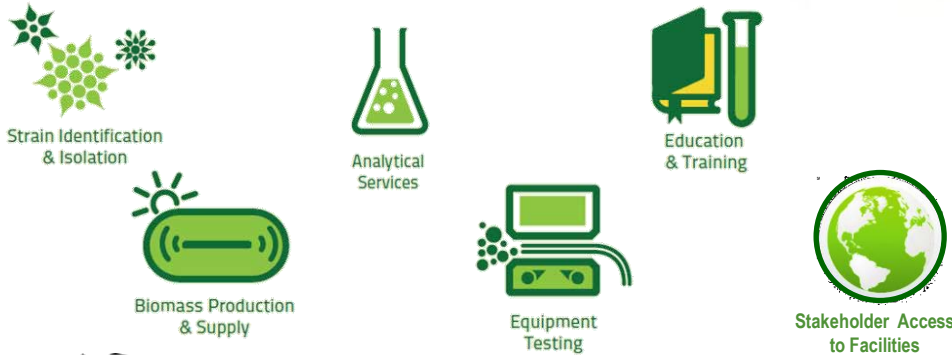


UTEX The Culture Collection of Algae
at The University of Texas at Austin



Collaborative Open Testbeds

ATP³ offers access to a wide array of services, capabilities and facilities:



ATP ³ Partner Site	Cultivation Capacity Total (Liters) (unit scale range)		Annual Production Capacity (AFDW)
	Open Pond	Closed PBR	
ASU (AzCATI)	235K (200 - 125K)	21K (150 - 1.5K)	1.5 - 2.0 MT
Cal Poly (CP)	100,000 (1K - 10K)	1.2K (200-1K)	1.0- 1.5 MT
Cellana (KDF)	750,000 (200 - 120K)	300K (200 - 24K)	12 - 15 MT
Florida Algae (FA)	30,000 (500-1K)	200 (indoor only)	<0.5 MT
Touchstone (TRL)	525,000 (500 - 125K)	9000 (75 - 750)	3 - 4 MT
Georgia Tech. (GT)	6000 (1K-1.5K)	200 (indoor only)	< 0.1 MT
Total	1,600,000 L	330,000L	17 - 25 MT

Regional testbed facilities for the partnership are physically located in **Arizona, Hawaii, California, Ohio, Georgia, and Florida.**

ATP³: Open for business

- Providing biomass, equipment testing, analytical, culture maintenance and consultation services to academia, industry and national labs
- Includes fee-for service activities, sponsored research, and subsidized projects through ATP³ Support Program
- The ATP³ model is positioned to drive technology research and development- a place to de-risk and validate technology innovations



ATP³ Offers Support Program

The Goal – encourage and enable small businesses, entrepreneurs and underfunded academic researchers to pursue new approaches to solving technical issues associated with commercialization of algae biofuels, processes, and co-products.

What is it ? – For a limited number of applicants that need access to laboratory and outdoor facilities as well as resource support for novel projects, ATP³ will provide subsidized access to testbed facilities, technical expertise, materials, and supplies. Preference for support will be given for short-term projects ranging from 1-3 months and the willingness to share data and results widely through publication.

Easy to start the process: Visit ATP3.org and fill out an expression of interest form

Initial cohort of support projects

includes:

- Novel cultivars for flue gas capture (University of Delaware)
- Carbon management and delivery (LBNL)
- AD with LEA (Cal Poly)

Initial cohort of support projects

includes:

- Accepting applications for next cohort selection

Support may include:

- Biomass (whole, extracted, oil)
- Access to cultivation & downstream equipment (eq. transport, install/removal)
- Access to R&D, production & analytical expertise
- Access to laboratory and office space
- Travel stipends to testbed (currently limited to academic clients)

Education & training



Education
& Training



- Quarterly educational workshops hosted at ATP³ sites
- Well attended by broad mix of academic and industrial participants

TESTIMONIALS

"ATP³ workshops provide access to large-scale algae facilities and a great forum to chat with experts in an informal setting."

Berat Haznederoğlu, Assistant Professor

Water Resources Engineering, University of Buffalo

"ATP³'s workshop really helped me learn how algae is produced from beginning to end."

Scott Forsberg, Director of Product Development

Health Enhancement Products, Inc.

High Impact Data: Long Term Algal Cultivation Trials

ATP³ sets standards and conducts harmonized, rigorous, and objective long term cultivation trials to provide a realistic assessment of the state of technology for algal based biofuels and bioproducts.

- Our Unified Field Studies (UFS) at the 6 testbed sites along with our Advanced Field Studies (AFS) enable comparison of promising production strains at meaningful scale across variable conditions
- Our Scientific Data Management System and validated, harmonized SOP's for analytical and production processes ensures data integrity across all sites
- Our data from the UFS and AFS will be made publicly available and provide a critical resource to TEA and LCA analysis yielding **high impact, validated data**



Field Studies for High Impact Data

- Unified = All six testbed sites performing the same experiment in the same systems with the same protocols and strains simultaneously
- Advanced = Sites with various capabilities will test additional production methods and variables to provide data to further enrich the model inputs



Cellana UFS ponds



Cellana Large Scale Ponds

Standardization of processes and systems is key to executing meaningful multi-site cultivation trials



Standard Experimental Conditions and Sampling

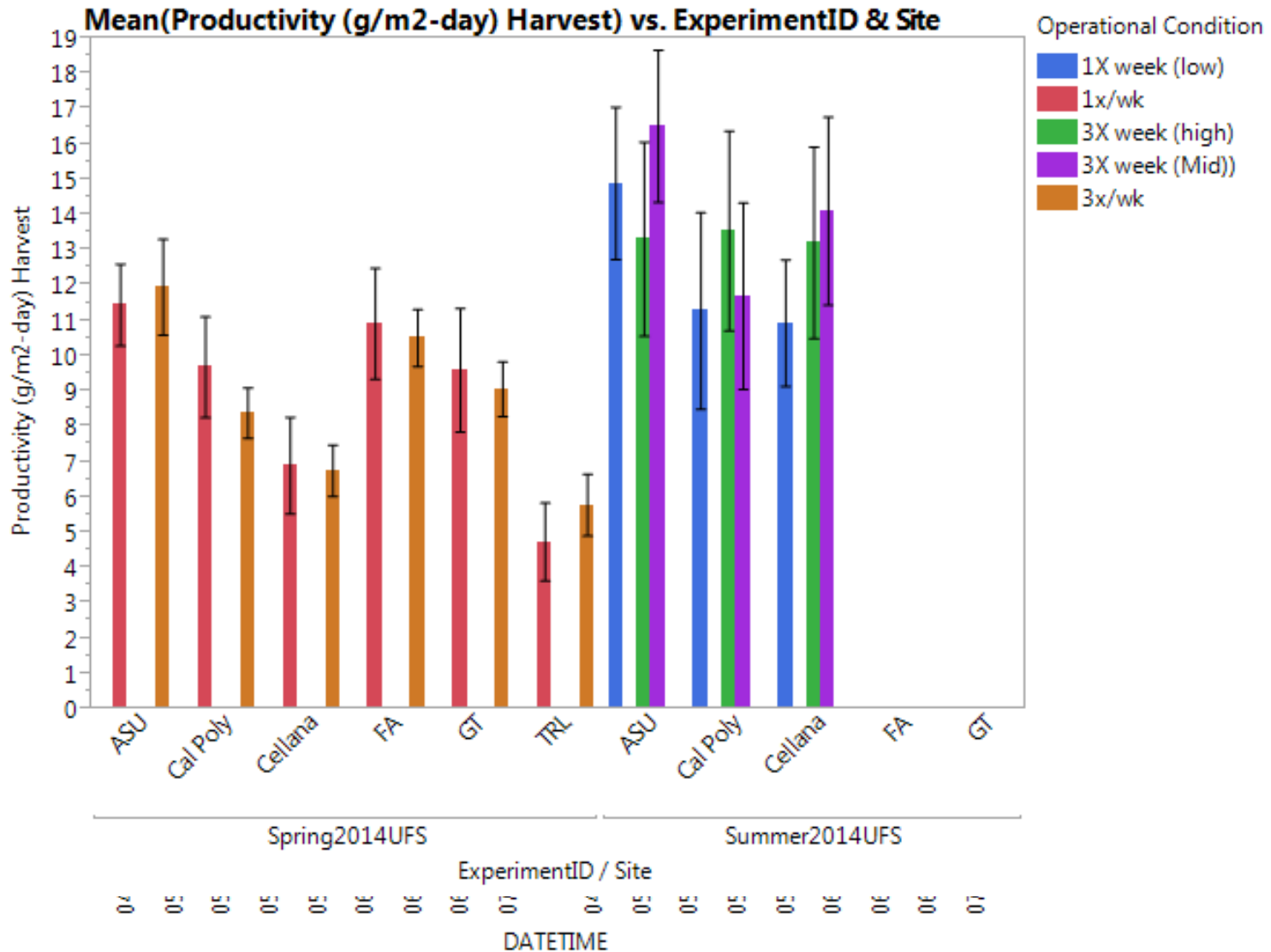
Factors	Set Point
Aqueous N (μM)	2200 (136.4 mg/l)
pH (Nanno)	7.9
pH (Chlorella)	7.9
Depth (cm)	25
PW speed (Hz)	20
Inoculum (g L^{-1})	0.05

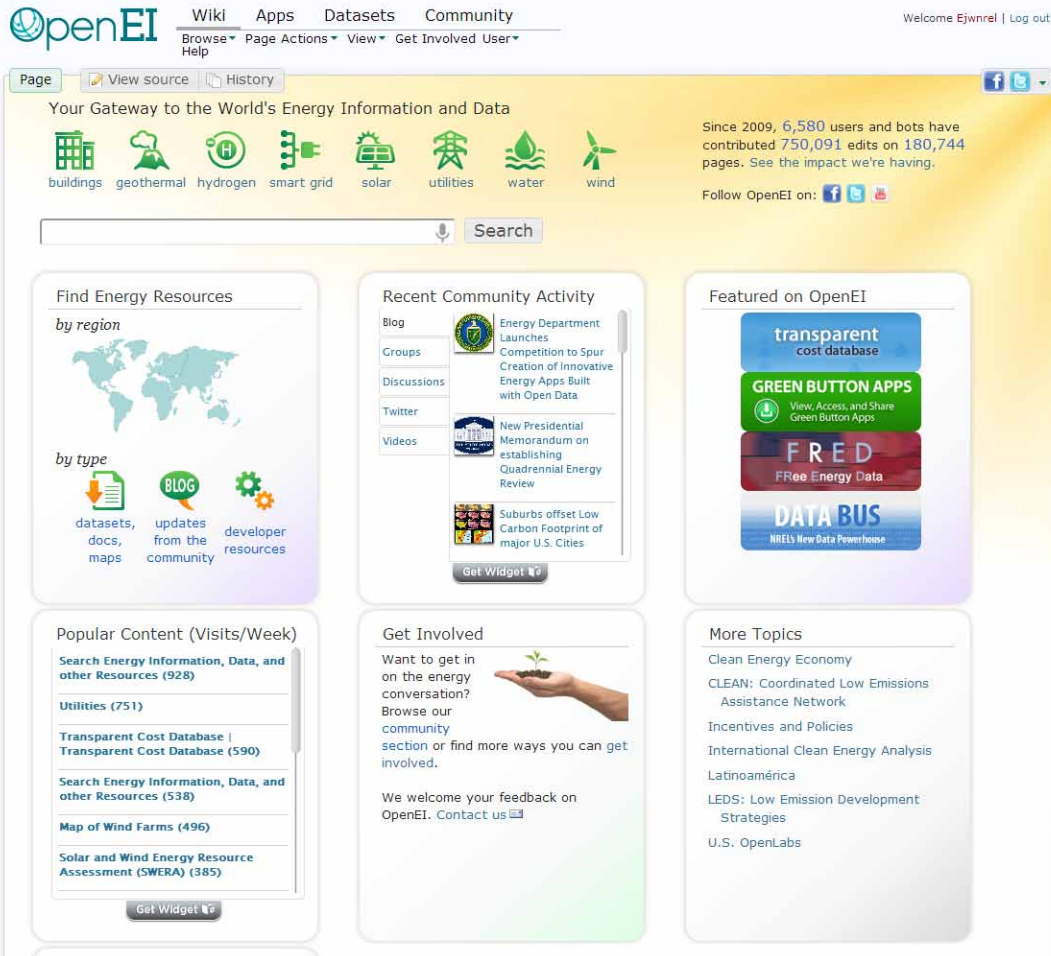
Samples	Schedule
OD@ 750nm	Dawn +60 min, M – F
DW	Dawn +60 min M, W, F, T0, TF
AFDW	dawn +60 min M, W, F, T0, TF
Mass balance (lipid/FAME, carbs, starch, protein). Parameter must have an AFDW associated with all samples	T0 (inoculation or directly post-dilution), TF (prior to a harvest or dilution occurring) – samples MUST be taken within 1 hour of AFDW/OD or a new AFDW sample is required
Nutrients	Dawn +60 min M, W, F, TF
Weather data	Real time (hourly)
In-situ sensors	Real time (15 minute intervals)
Microscopic exam	dawn +60 min M, W, F
Genetic Analysis, qPCR	Weekly, upon pond health decrease,
Manual checks (pH, temp, salinity, depth)	Daily; AM and PM
% Shading	Monthly; AM, Mid, PM
Water chemistry	Monthly ICPMS testing

UFS Strains

- *Nannochloropsis oceanica*, supplied by Cellana
 - Distributed to all sites fall, 2013
- *Chlorella vulgaris*, LRB-AZ-1201 supplied by ASU
 - Distributed to sites June, 2014
- Representative cultivars for fuel and high value (feed, omega-3's) production
- Additional strains may be used for AFS

2014 UFS cultivation trials: Progress to date





The screenshot shows the OpenEI website interface. At the top, there are navigation links for Wiki, Apps, Datasets, and Community. Below this is a search bar and a 'Search' button. The main content area is divided into several sections:

- Your Gateway to the World's Energy Information and Data:** A row of icons representing different energy sectors: buildings, geothermal, hydrogen, smart grid, solar, utilities, water, and wind.
- Find Energy Resources:** A section with a world map and icons for datasets, docs, maps, updates from the community, and developer resources.
- Recent Community Activity:** A list of recent blog posts, groups, discussions, and videos.
- Featured on OpenEI:** A vertical stack of featured content boxes: 'transparent cost database', 'GREEN BUTTON APPS', 'FRED FRee Energy Data', and 'DATA BUS'.
- Popular Content (Visits/Week):** A list of popular content items, including 'Search Energy Information, Data, and other Resources (928)', 'Utilities (751)', 'Transparent Cost Database | Transparent Cost Database (590)', 'Search Energy Information, Data, and other Resources (538)', and 'Map of Wind Farms (496)'.
- Get Involved:** A section with a hand holding a small plant, encouraging users to get involved in the energy conversation.
- More Topics:** A list of topics including Clean Energy Economy, CLEAN: Coordinated Low Emissions Assistance Network, Incentives and Policies, International Clean Energy Analysis, Latinoamérica, LEDS: Low Emission Development Strategies, and U.S. OpenLabs.

OpenEI International Sponsors and Partners

Overview

OpenEI partners with a variety of international organizations to enhance its content, services and data offerings. Additionally, some directionally with OpenEI. Below is a list of OpenEI sponsor organizations, partnerships and notable data consumers.

Sponsors



Partners

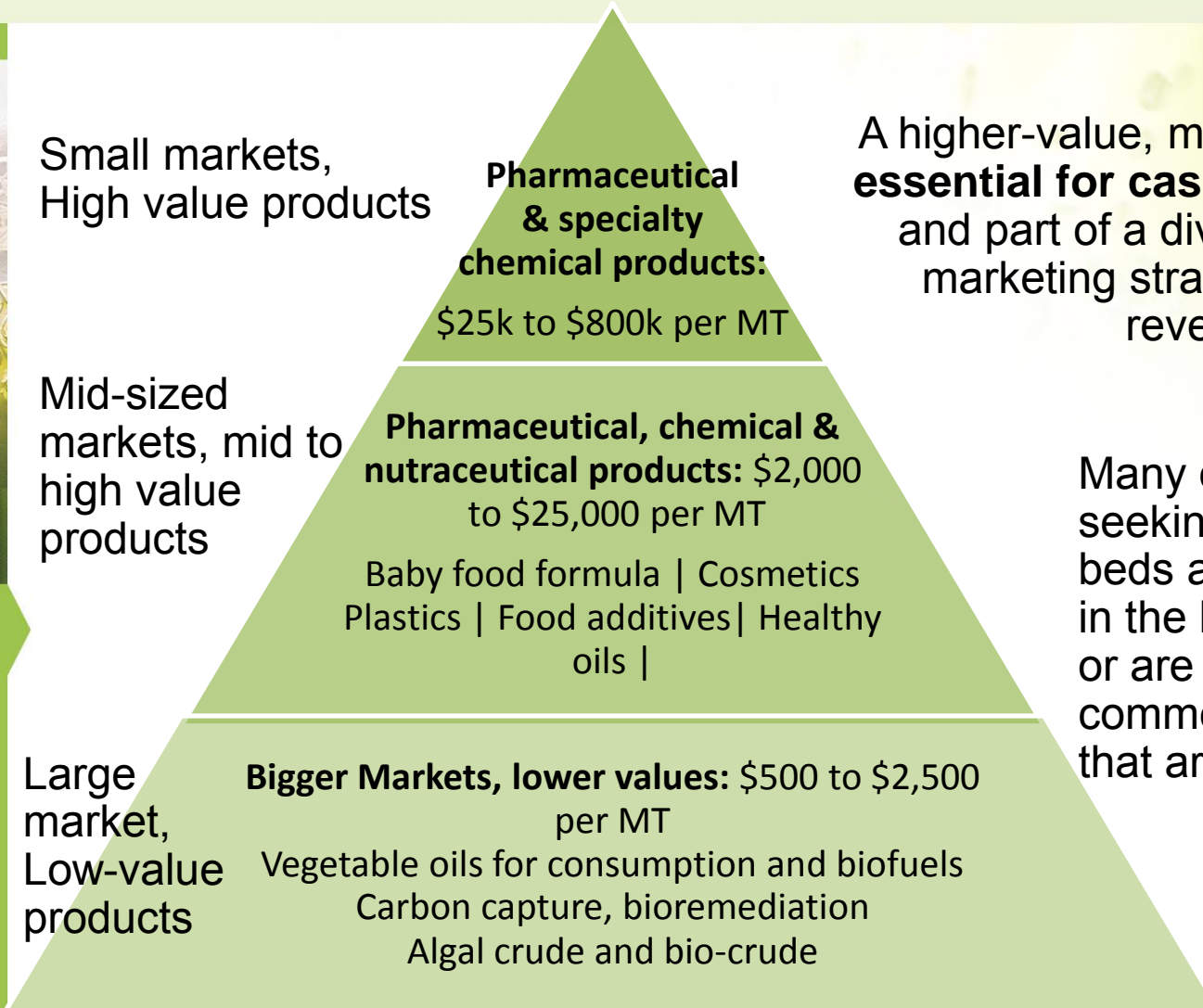


Notable data consumers



Using the existing infrastructure and expertise of OpenEI.org will provide a rapid, robust, and low-cost solution for making the ATP³ datasets public. Target for first data release: September, 2014.

Example business opportunity: Near term markets facilitate long term learning



A higher-value, multi-product focus is **essential for cash flow** for start-ups, and part of a diversified, targeted marketing strategy to generate revenues.

Many of the stakeholders seeking access to the test beds and ATP³ services are in the higher-value market or are developing and commercializing innovations that are market agnostic.

Summary

- The algae industry has the potential to displace sizeable quantities of petroleum consumption as a co-product.
- Through open access programs like ATP³ stakeholders can **convene**, **collaborate** and **leverage** in accelerating the pace of innovations.
- To succeed, algae R&D needs sustained support through grant funding and policy enablers
 - ✓ CO₂ re-use is critical to algae production; policy should be geared to making it low cost and deriving valuable when possible.
 - ✓ Crop protection needs research to improve capacity, utilization, and volumes.
 - ✓ GMO policies, crop designation, agricultural practices and policies, and tax incentives/rebates are needed.



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Commercial Algae Management

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Georgia Tech
Yongsheng Chen
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Thomas Igou
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Cellana

Valerie Harmon
Egan Rowe
Emily Knurek
Kate Evans
Peter Prentiss
Reyna Javar
Kari Wolff
Keao Bishop-Yuan
Lynn Griswold
Christina Boyko
Charlie O'Kelley

ASU Undergrads

Wyatt Western
Mariah Patton
Maria Bautista
Carlos Luna
Delaney De Hertogh
Shaylin Mcghee
Caden Offield

G.Tech Undergrads

Fariha Hassan
Jerry Duncan
Frazier Woodruff
Shusuke Doi
Hao Fu
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Allison Dunbar

Florida Algae

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Mary Riddle
Nancy Pham Ho (FIT)

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Xueyan Liu
Phil Lane
Doug Amie
Brian Gordon

Allison Carr
Sichoon Park
Priya Pradeep
Terry Snell
Catherine Achukwu
Christine Yi

Cal Poly Undergrads

Aydee Melgar
Gulce Ozturk
Kaitlyn Jones
Michael Antoine
Trung K Tran
Jake Bender
Heather Freed
Daniel McBroom
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Gerard Nguyen
Deven Diliberto
Jack Sunderland
Dan Averbuj
Ann Marie Sequeira
Lauren Miller
Michele Hendrickson
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Jack Sunderland
Ann Marie Sequeira
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Lauren Miller
Samantha Lui
Michele Hendrickson
Gabiella Campos
Will Briles
Letty Thottathil



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