



U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

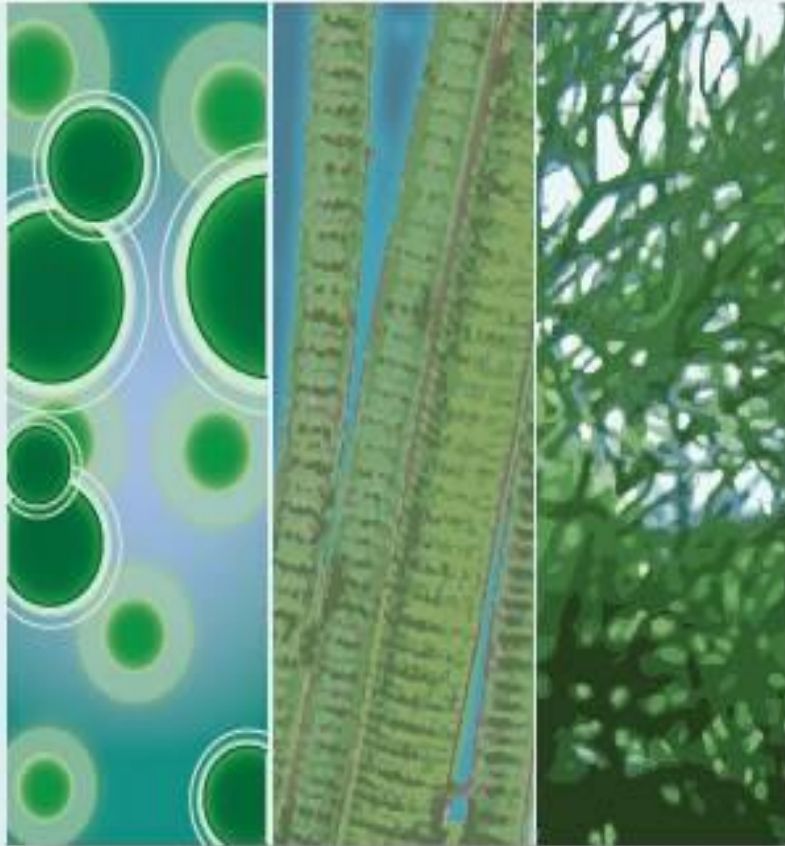
# 2015 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY  
BIOENERGY TECHNOLOGIES OFFICE

## Algal Feedstocks R&D

Alison Goss Eng  
Algae Program Manager  
(Acting)

# Algae Program Overview



- **The Team**
- **Goals & Objectives**
- **Focus Areas**
- **Strategic Approach**
- **Funding History**
- **Key Accomplishments**
- **Partnerships**
- **Upcoming Activities**

# Introductions – Algae Program Staff



Alison Goss Eng,  
Algae Program Manager (Acting)



Daniel Fishman,  
Technology Manager



Roxanne Dempsey,  
Technology Manager



Christy Sterner,  
Technology Manager



Will Schrode,  
Project Monitor, CNJV



Evan Mueller,  
Project Monitor, CNJV



Jessica Phillips,  
Project Monitor, CNJV



Colleen Ruddick,  
Asst. Manager, BCS, Inc.



Alexis Martin,  
Knauss Sea Grant Fellow

# Benefits of Algal Biofuels

## Benefits

- ✓ High productivity relative to terrestrial feedstocks.
- ✓ Adds value to unproductive or marginal lands.
- ✓ Able to use waste and salt water.
- ✓ Able to recycle carbon dioxide.
- ✓ Able to provide valuable co-products, such as protein to meet animal feed needs.
- ✓ Produces a range of biofuels including gasoline, diesel, jet fuel, and ethanol.



Photos Courtesy of Sapphire Energy

# Algae Program Goals and Objectives

- **Develop and demonstrate** technologies to make **sustainable** algal biofuel intermediate **feedstocks** that perform reliably in conversion processes to yield renewable diesel, jet, and gasoline in support of the BETO's **\$3/gge biofuel goal in 2022**.
- Meet **aggressive productivity** targets (2,500 gallons of biofuel intermediate per acre annual average by 2018; and 5,000 gallons by 2022).

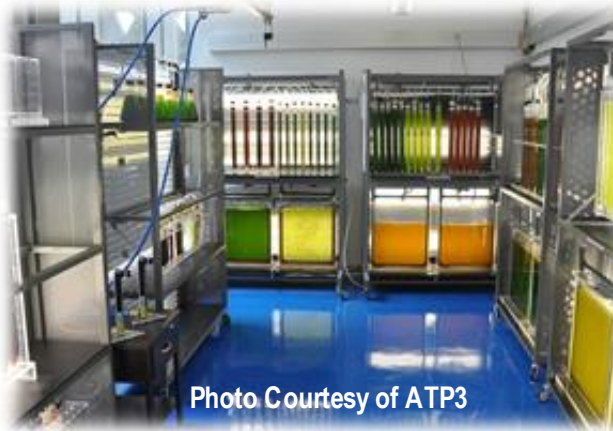


Photo Courtesy of ATP3



Photo Courtesy of Texas A&M



Courtesy Sapphire Energy, LLC

Getting lab scale work outdoors at increasing scales

# Algae Focus Areas

There are two overarching focus areas:



**Reducing costs of production**

- Strategies focus on improving biomass **productivity** and **yield**, and increasing the value of the biomass with **co-products**.



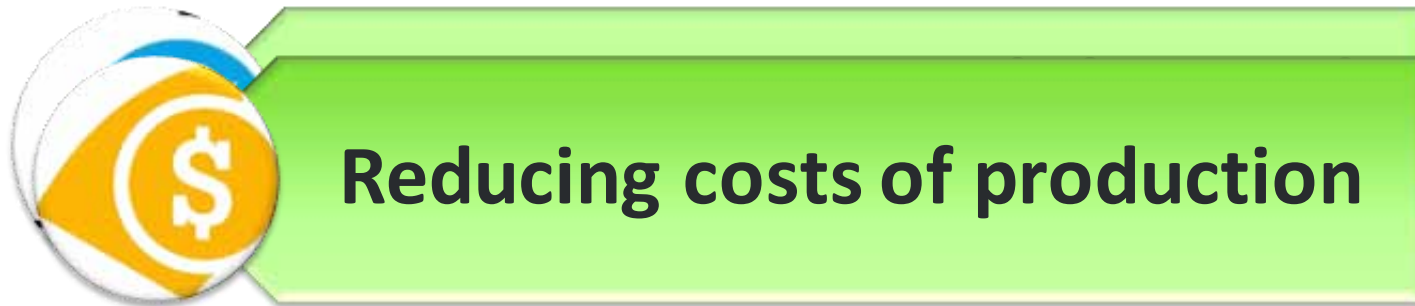
**Ensuring sustainability and availability of resources**

*projects focused on improvements in yield*



# Algae Focus Areas

There are two overarching focus areas:



- Strategies focus on: **water** and **nutrient** recycle, improving **energy** efficiencies, improving **CO<sub>2</sub>** utilization, and conducting resource assessment analyses



*projects focused on water  
& nutrient recycle*



# Approach: Work Breakdown Structure

Algal Feedstocks R&D

Analysis & Sustainability

Feedstock Production

Feedstock Logistics

Conversion Interface

Integration & Scale-up

**Algae harvesting, processing, and stabilization and production and bench-scale bio-transport of algae lipid extraction and hydrothermal liqu...**

**Outdoor test environments that: resource assessments, and produce high yields, life cycle assessments, and...**

**Developing stable, algal biorefineries - Demonstration Program (Will be reviewed in the DMT room, Tues from 9:45-1:45p)**

**Algal Testbed**

**able for cultivation - Sapphire Energy cellana**

**ing operations**

**RAFT** Regional Algal Feedstock Testbed

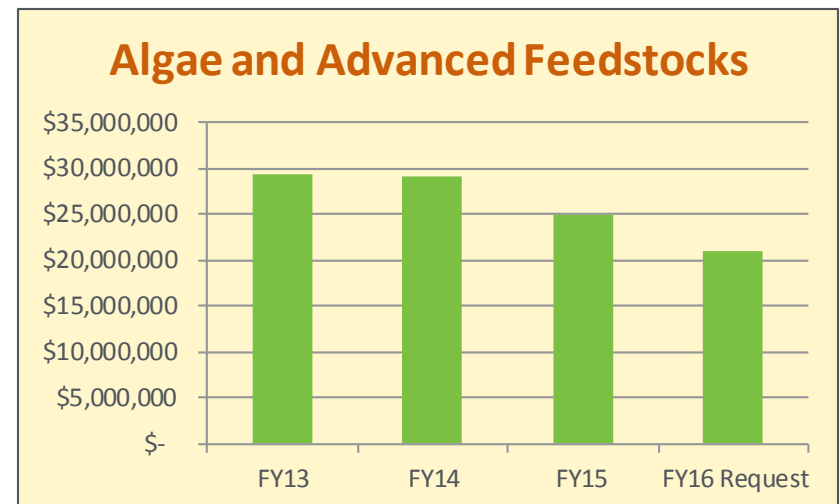
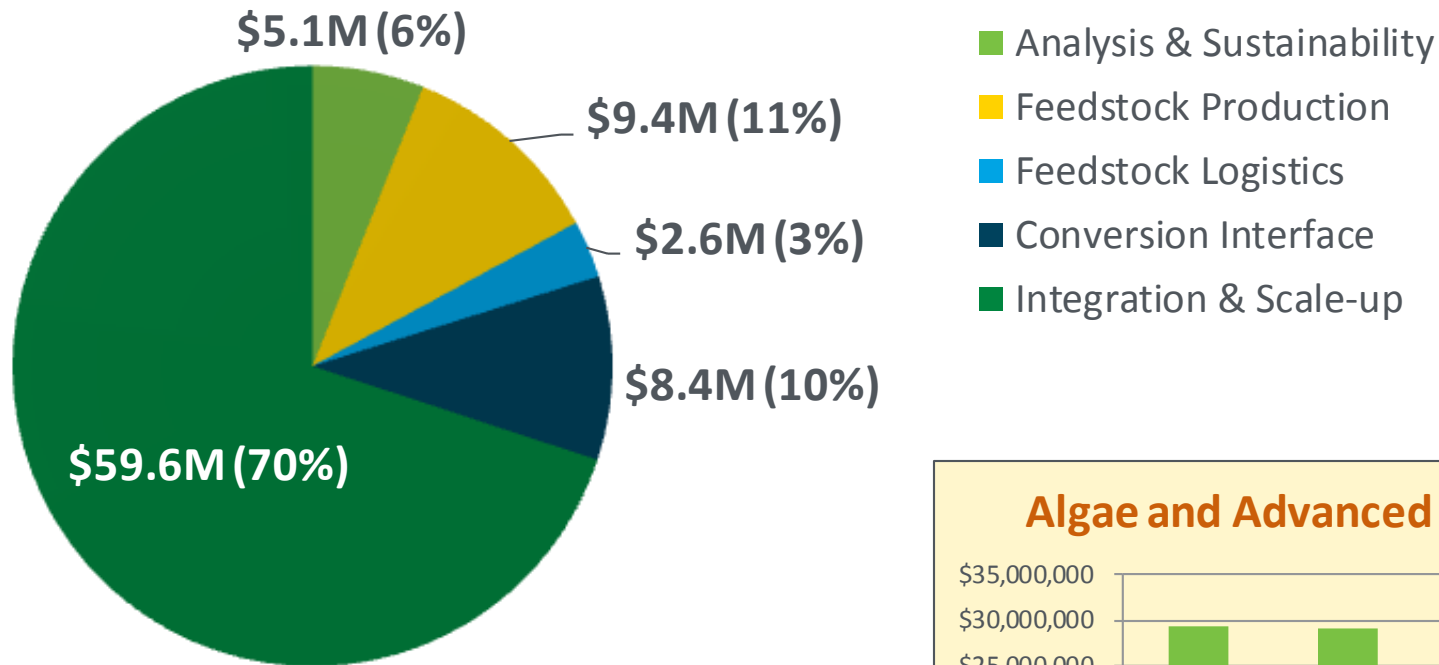
**HAWAII BioEnergy**

**Photo courtesy of PNNL**

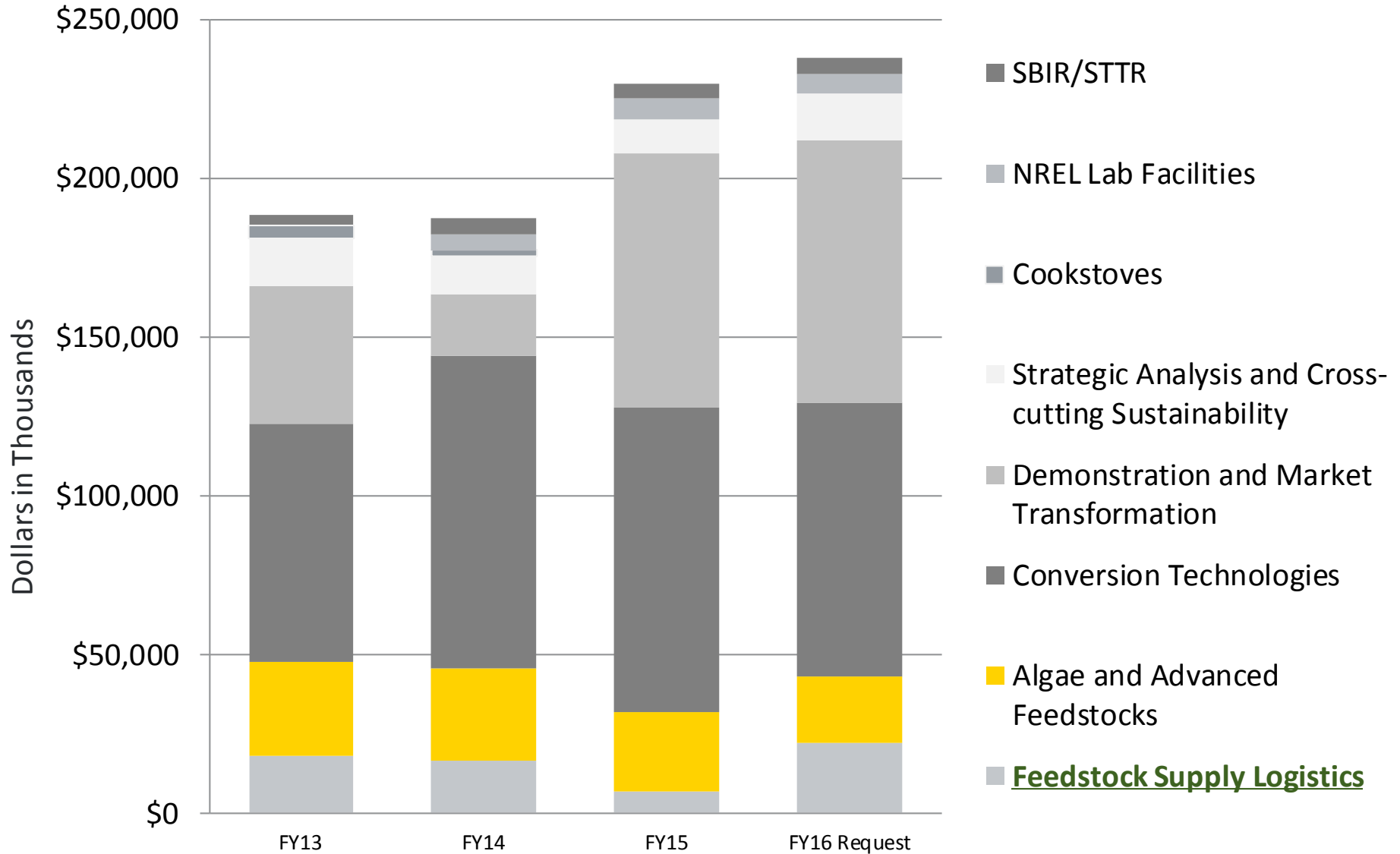


# Peer Reviewed Project Funding by WBS

## Algae Program FY13-15 Funding for the 29 Projects to be Reviewed this Week



# BETO Funding History



\*\$45 million was transferred in FY14 to DPA

# Algae Program FOA History

2009

2012

2013

2014

2015

2016

2018

R&D Consortia (\$76M)

Advancements in Sustainable Algae

Production (ASAP) (\$22M)

Nutrient & Water  
Recycle

Regional Test  
Partnerships

Advancements in Algal  
Biomass Yield

Integrated production  
and logistics R&D at a  
production relevant  
scale

Targeted Algal Biofuels and  
Bioproducts – TABB (\$18M)

Multi-disciplinary  
research across  
the supply chain

CAB-Comm



NAA

National Alliance For Advanced Biofuels and Bio-products



Cornell University



CAL POLY SAN LUIS OBISPO



Energy Efficiency & Renewable Energy

# NEW: FY14/15 Targeted Algal Biofuels and Bioproducts

- **GOAL**: Reduce the cost of algal biofuels from **\$7 per gallon (current projection for 2019)** down to **\$5 per gallon algal biofuel by 2019**.
- **TOPICS**:
  1. Multi-disciplinary consortia to produce **valuable bioproduct precursors**, alongside fuel components
  2. Single investigator/small teams focused on developing **crop protection** and **CO<sub>2</sub> utilization** technologies
- **STATUS**:
  - Closed December 19
  - **Selections anticipated April 2015**, and awards in June



*Photo credits FSU and NREL*

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# KEY ACCOMPLISHMENTS

# Key Accomplishments – Tech to Market

## Technology-to-Market (Tech-to-Market or T2M) Mission

To identify and develop strategies to overcome key barriers to the development and success of commercial enterprises built around the Office of Energy Efficiency and Renewable Energy's (EERE's) technologies and initiatives.

- BETO-funded Algae projects successful in Tech-To-Market Transformation.
- Tools available through Life Technologies
  - Research through the Consortium for Algal Biofuel Commercialization (CAB-COMM) developed a number of genetic tools for green algae, cyanobacteria, and diatoms that are now available for purchase online.



# Key Accomplishments – Academic impact

- **NAABB** started a new peer reviewed journal, *Algal Research* (by Elsevier) and initiated a new conference series: *International Conference on Algal Biomass, Biofuels, and Bioproducts*
  - Filed 37 Intellectual Property disclosures and released >100 peer-reviewed publications.
- **ATP3** holds formal and informal education and training in the use of algae as a feedstock for biofuels and bioproducts through hands-on learning opportunities, workshops, and seminars.



"ATP<sup>3</sup> 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

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# Key Accomplishments – Workforce Impact

The ALGAE SECTOR,  
provides San Diego with:  
**505 direct jobs**  
**\$103 million in direct economic activity**  
**\$175 million in total economic activity annually**

**CAB-COMM** directly provided opportunities for:

- 30 Postdoctoral Fellows
- 29 PhD students
- 6 Masters students
- 71 Undergraduate students
- 4 High School students

**NAABB** directly provided >80 job opportunities for a wide range of expertise.



# Key Accomplishments - Technical

Cornell Consortia demonstrated economic feasibility of delivering a fuel price of \$2.76 to \$8.96 per gallon gasoline equivalent (gge)

**Cornell Consortia achieved DOE MYPP target of 1,500 gal intermediate/acre/yr (2014)**



Sustainable Algal Biofuel Consortium (SABC) Project and several NREL AOP projects

- Results\* demonstrated that there is significant potential for overall cultivation productivity improvement and associated cost savings by **shifting the focus of biomass production away from solely high-lipid production conditions towards capturing value from all biomass components (carbohydrates, proteins, and lipid)**

\*Results published in Laurens et al. "Acid-catalyzed algal biomass pretreatment for integrated lipid and carbohydrate-based biofuels production." Green Chemistry August 2014.

# Coordinating with Key Partners

- The Algae Program held public stakeholder workshops to discuss what research and development is needed to achieve affordable, scalable, and sustainable algae-based biofuels.
- These discussions and further focus group meetings will help inform an upcoming technical update to the National Algal Biofuels Roadmap.



# Coordinating with Key Partners



Energy Efficiency & Renewable Energy

# Upcoming Activities

- Upcoming design case will focus on refining the projected cost of algal feedstock production (NREL)
- Algae will be incorporated into the 2016 Billion Ton Update
- The program is beginning the process of a technical update to the 2010 National Algal Biofuels Technology Roadmap
- June 23 & 24, Bioenergy 2015 Breakout Session on Algae Scale-up & Integration



U.S. BILLION TON UPDATE

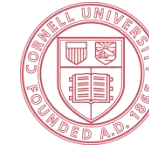


# Introductions – Peer Reviewers

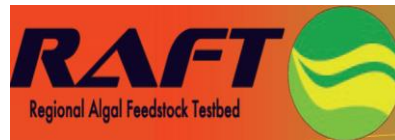
- **Emilie Slaby (Lead Reviewer), Independent Consultant**
- **David Babson, Union of Concerned Scientists**
- **F. Glenn Gallagher, DuPont**
- **Joanne Morello, Northrop Grumman**
- **Roger C. Prince, ExxonMobil**
- **Jennifer Stewart, University of Delaware**

**THANK YOU!**

# Algae Program R&D Partners



Cornell University



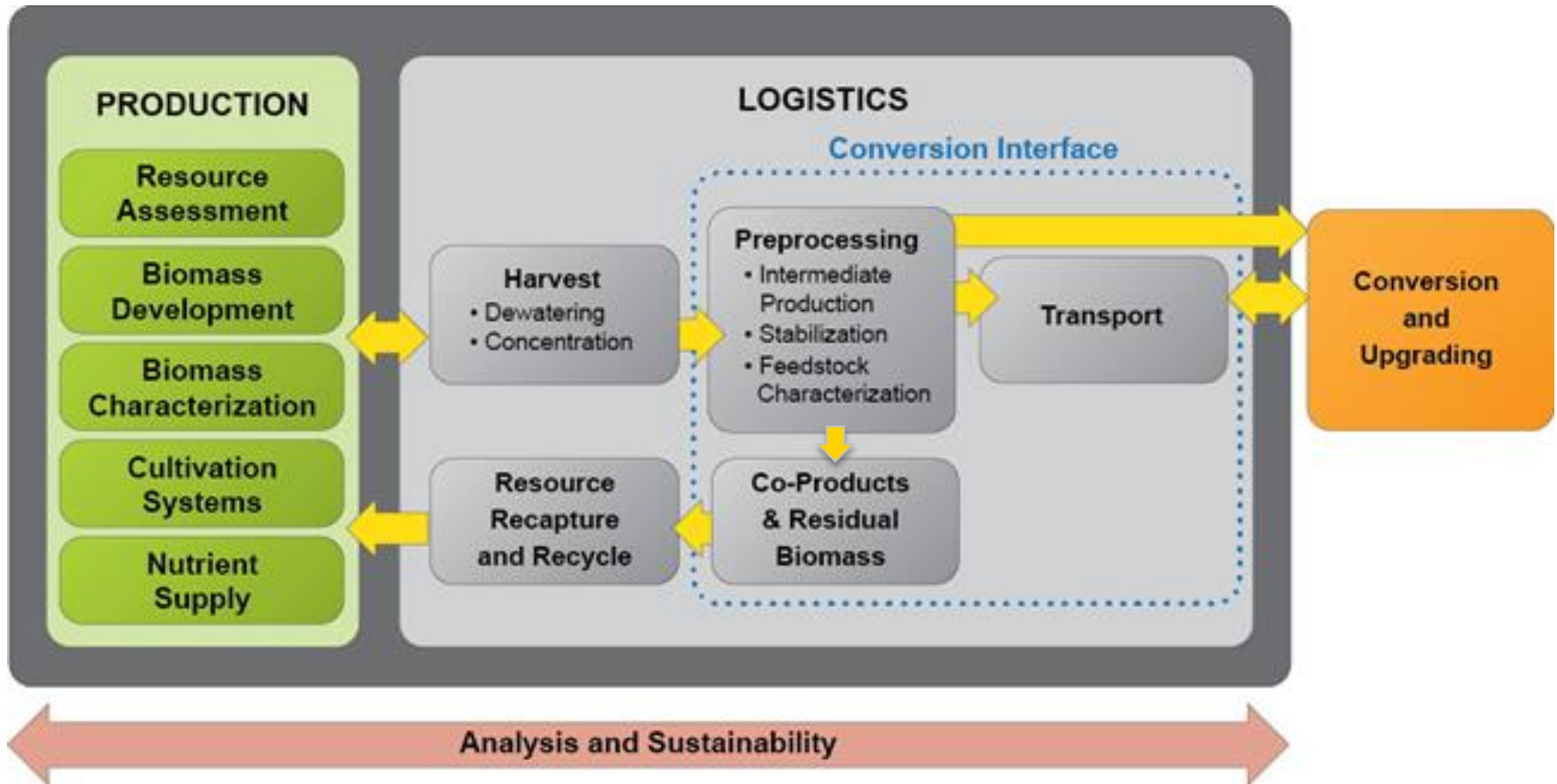
# BACK-UP SLIDES

# Algae Funding Table

	FY2012	FY2013	FY2014	FY2015
Advancements in Sustainable Algae Production (ASAP)	6.3			
ASAP Testbeds	15.0	8.0		
Advancements in Algal Biomass Yields		16.5	3.5	
Targeted Biofuels and Bioproducts			11.0	6.7
Other FOAs (CHASE & Incubator)			3.5	4.0
Core R&D (National Labs)	5.0	5.0	7.5	11.0
<b>Algae Total Directed Funding</b> <i>(Excluding Taxes and Programmatic Funding)</i>	<b>23.3</b>	<b>29.5</b>	<b>25.5</b>	<b>21.7</b>



# Approach: Integrated R&D



- To achieve program goals, the Algae Program funds research and development across technology readiness levels (TRL 2-6) within a broad portfolio of disciplines across the production and logistics chain.

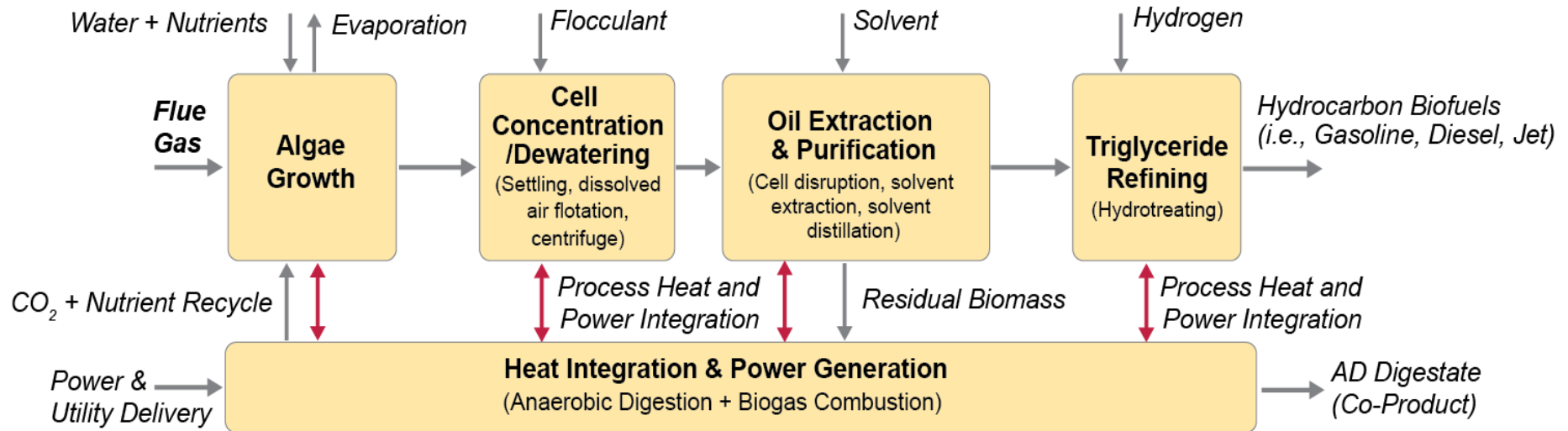
# Approach: Priority Pathways

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The Office selected two initial priority technology pathways as the most promising approaches to achieving the Algal Feedstocks R&D 2022 targets:

1. Algal lipid extraction and upgrading
2. Whole algae hydrothermal liquefaction and upgrading.

# Algal Lipid Upgrading



# Algal Hydrothermal Liquefaction

