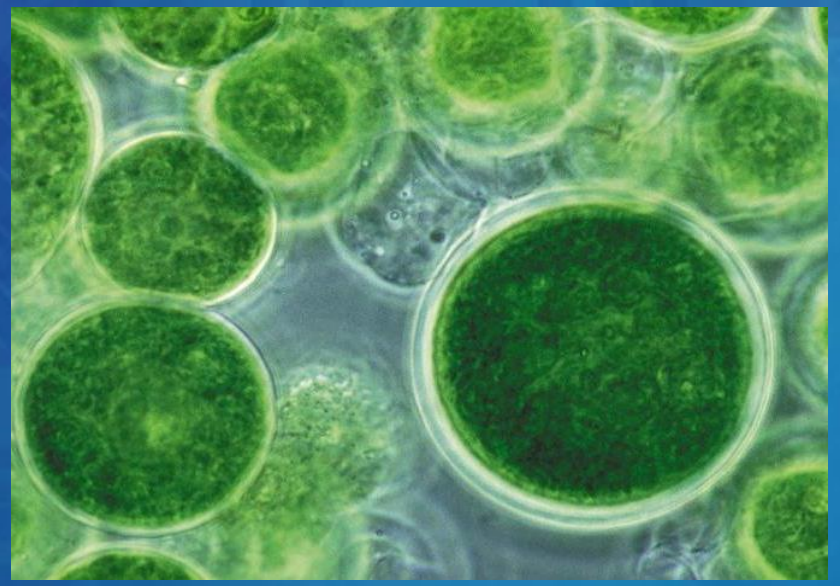


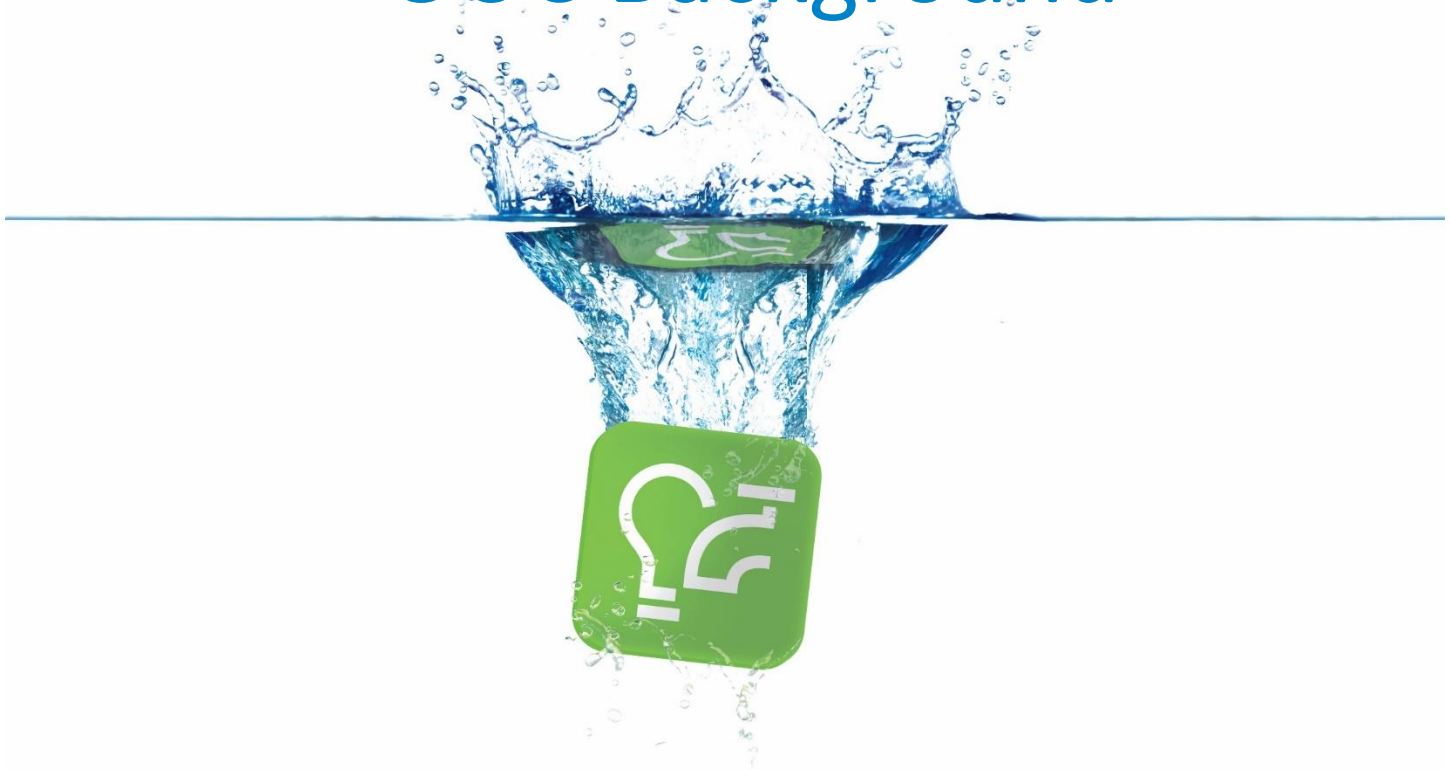
Florida's Bio-economy: Potential of Recycling Nutrients and Carbon to Monetize your Community's Sustainability Goals

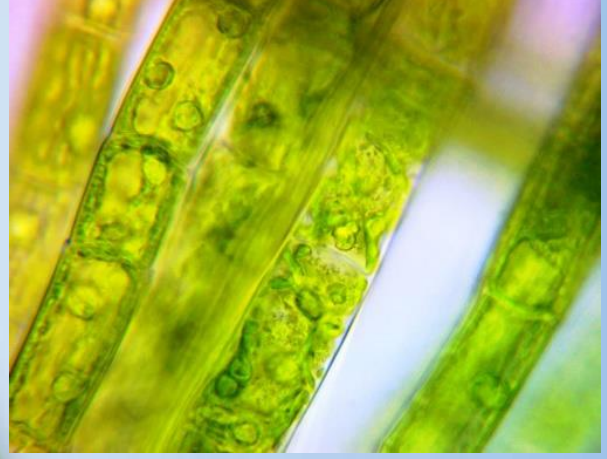
FloridaWCA Workshop December 20, 2018

Rob Teegarden, P.E. Water Policy and Research Officer
Orlando Utilities Commission

OUC The Reliable One

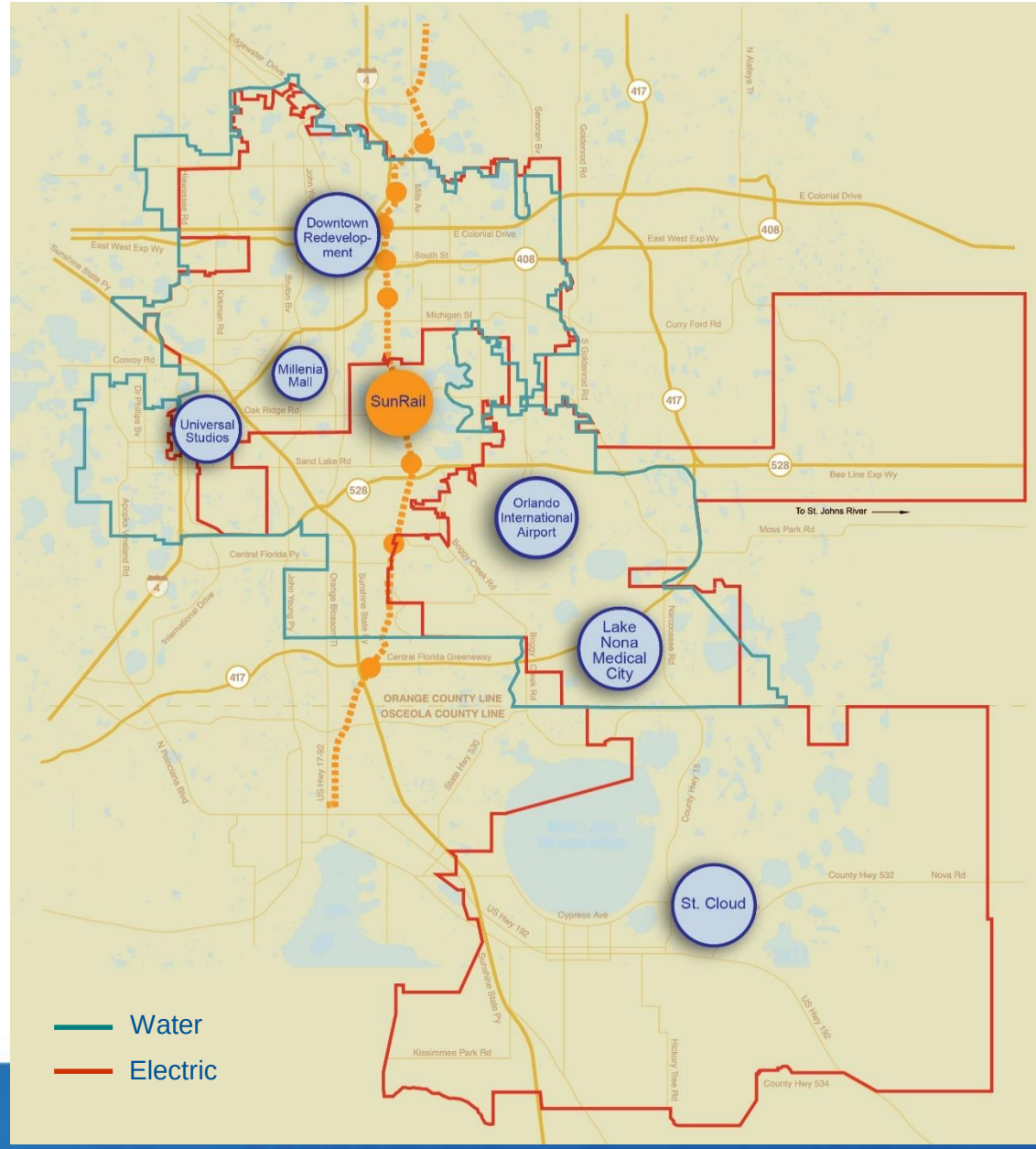
OUC Background





OUC Service Territory & Stanton Energy Center (SEC)

OUC Electric & Water Service Territory



Electric

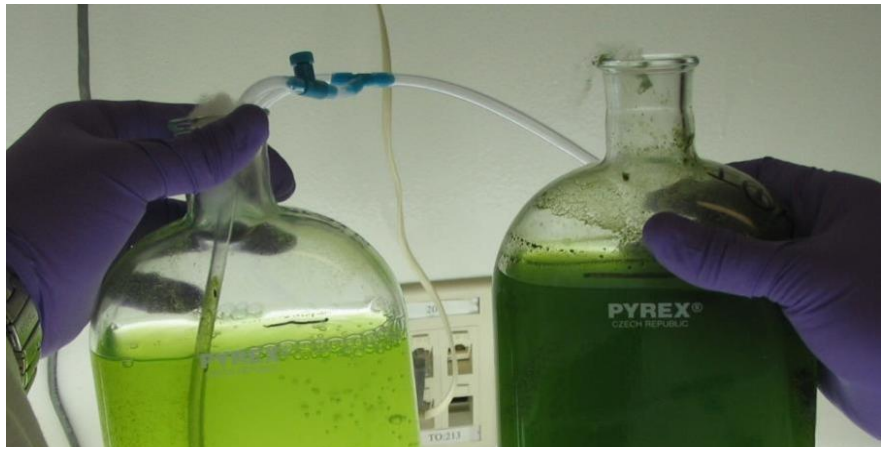
- Service area
  - Orlando: 244 sq mi
  - St. Cloud: 150 sq mi
- Number of meters
  - Orlando: 180,000
  - St. Cloud: 30,000

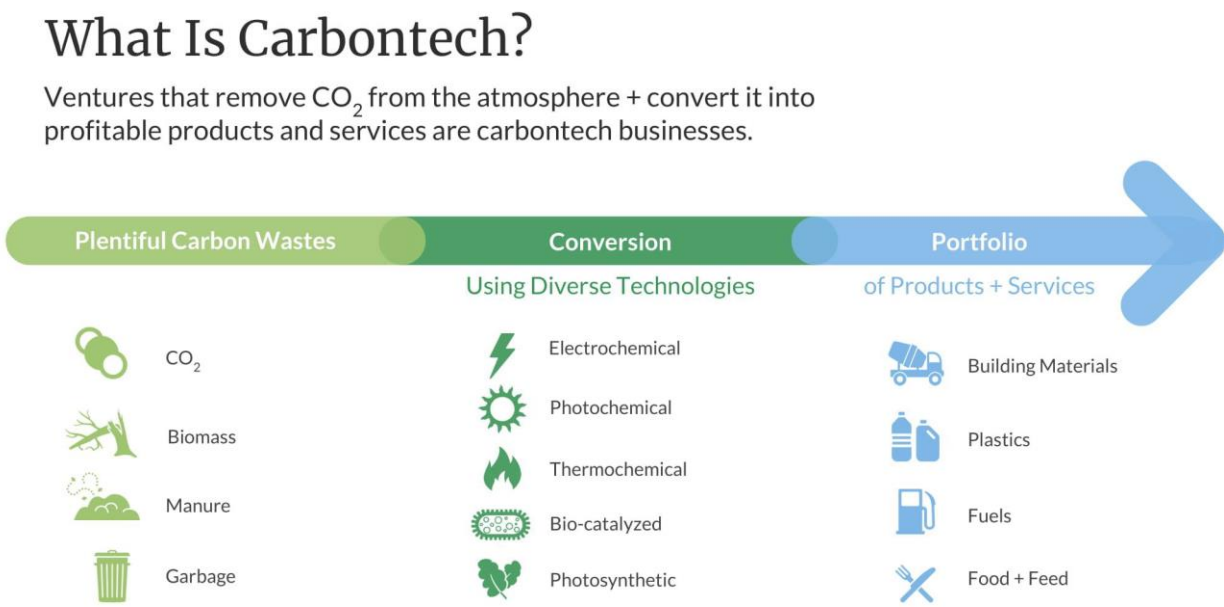
Water

- Service area
  - 200 sq mi
- Number meters
  - 135,000

Florida's Bio economy –Integrating the Agriculture, Energy, and Water Sectors for Future New Markets

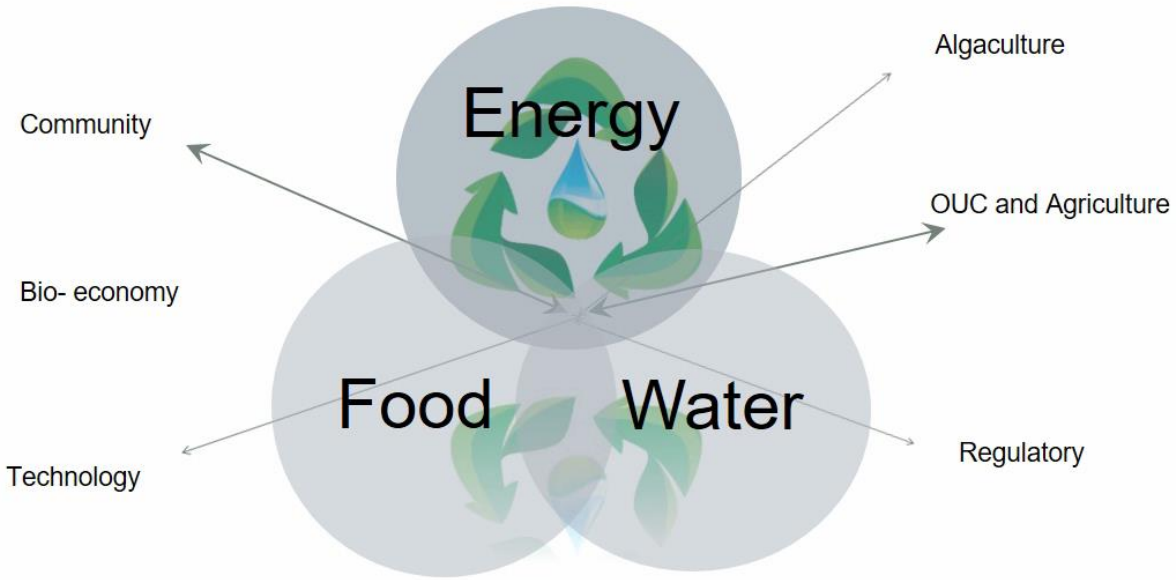
- Algae 101
  - Florida Utilities Perspective Across Sectors
  - Approach Replacing petroleum products by the Whole Barrel
- Carbon Utilization & Management
  - Complexity/ Risk and the problem it solves – community sustainability goals
  - Collaborations with University and National lab researchers – value proposition
  - Impact potential
- DOE NETL #1849 research
  - Schedule, Design, and SEC site work
  - Partners – MBE, UCF, and Global Thermostat
  - Support the Financial Case and Spur Investment in Novel Con Infrastructure - Integrated Bio refinery
- Florida Markets
  - Environmental Services
  - Animal Feeds
  - Organic Fertilizer



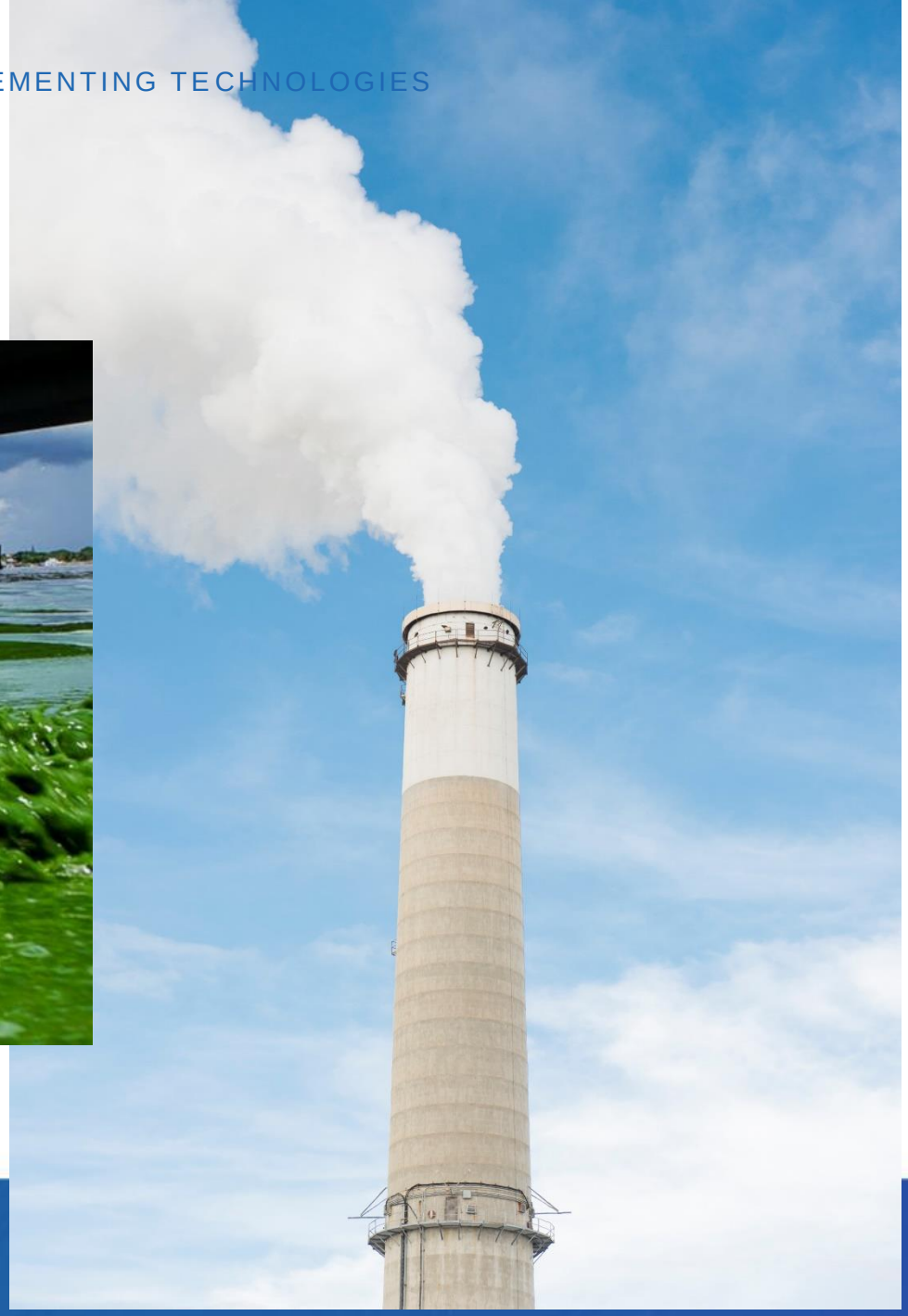


What Problems Are We Solving? How do We Select the Markets and the Technologies for the Greatest Potential Impacts

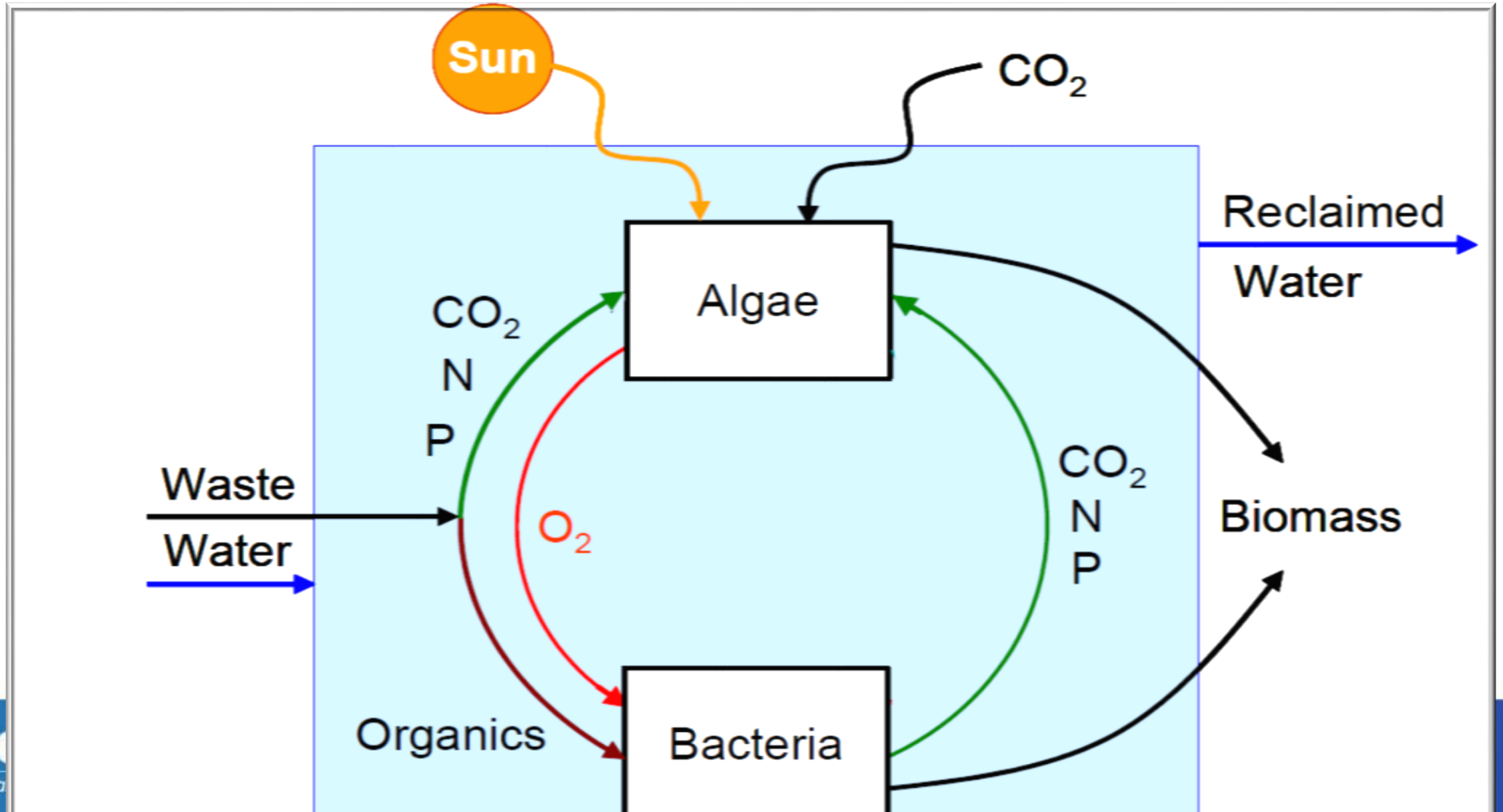
The Right Energy for the Right Use…

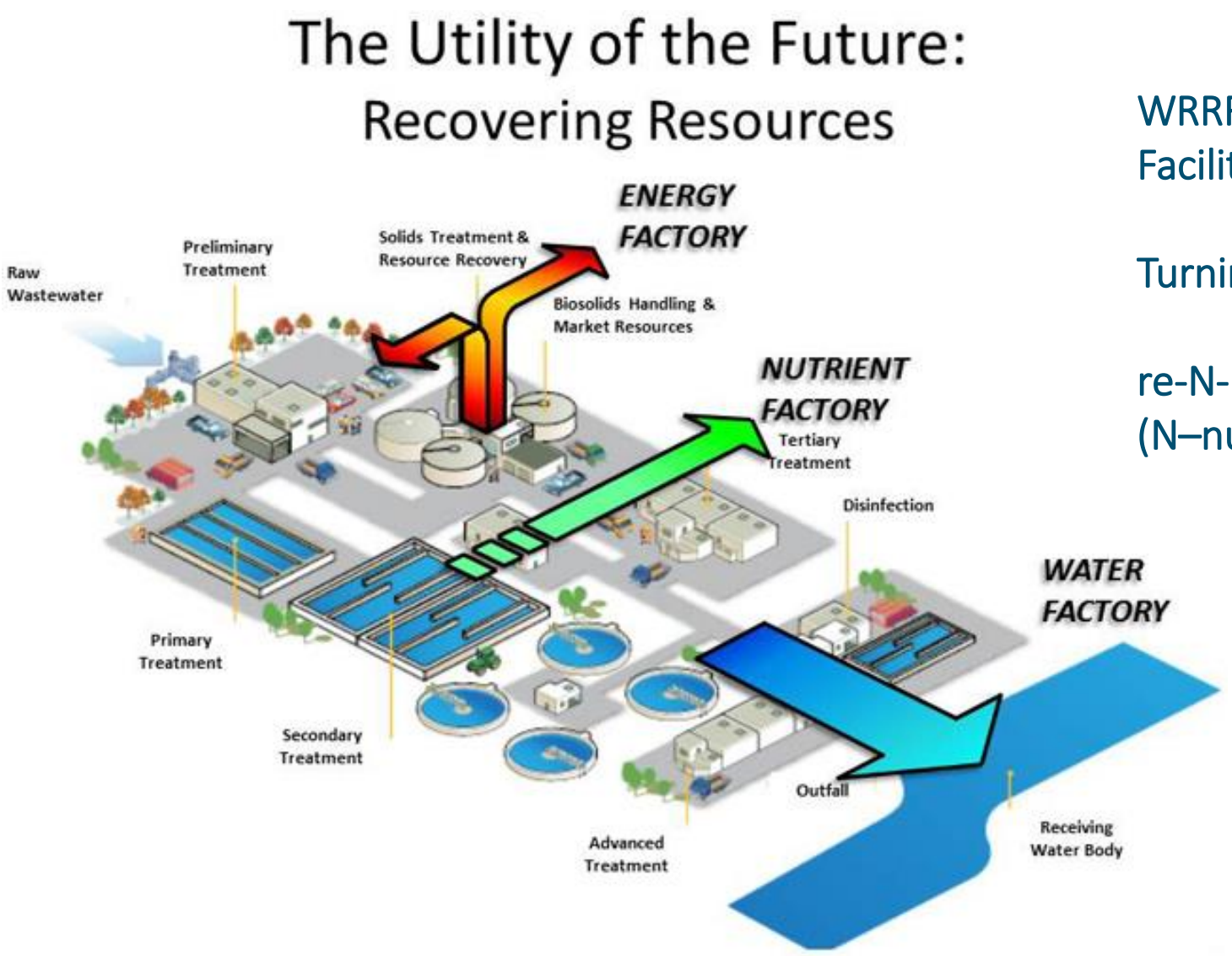


Monetize this?



Why algae 101 works?





WRRF – Water Resource Recovery Facility (bio refinery)

Turning Waste Streams to Value Streams

re-N-E-W-able resource extraction (N–nutrients, E–energy, W–water)

Community Sustainability Requires the “Whole Barrel Approach”

- Sustainable production of biomass feedstocks and capture of usable wastes
- Development of innovative and efficient technologies that transform renewable carbon into intermediates and products
- Construction of more biorefineries and manufacturing facilities
- Expansion of the market for biofuels, biochemicals, biopower, and other biomass-derived products

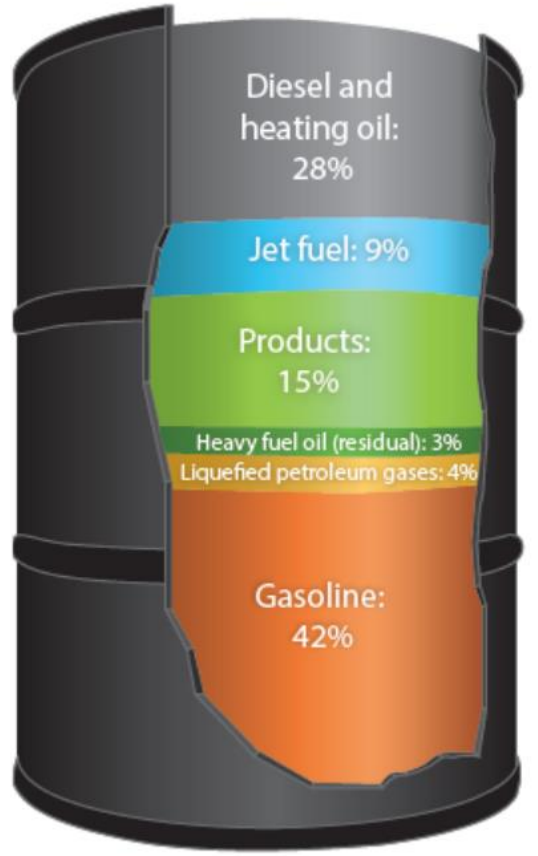
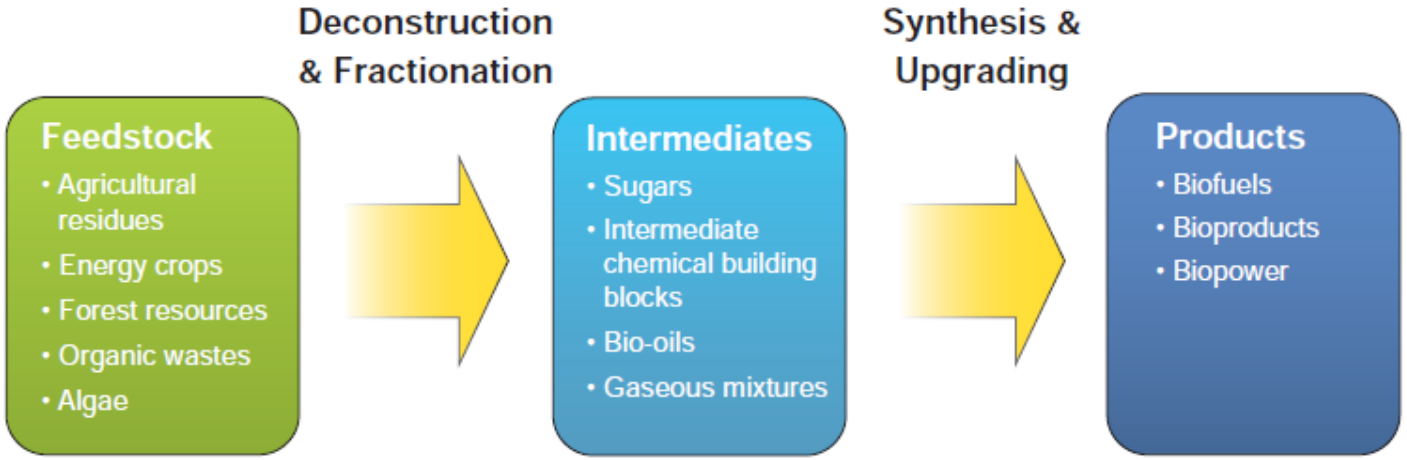


Figure 1. Products from a barrel of crude oil

ABS ‘18 Highlights - Food & Feeds Markets

OUC The Reliable One

Technology Push and Market Pull Drives the Conversion to a Bio Economy in Florida



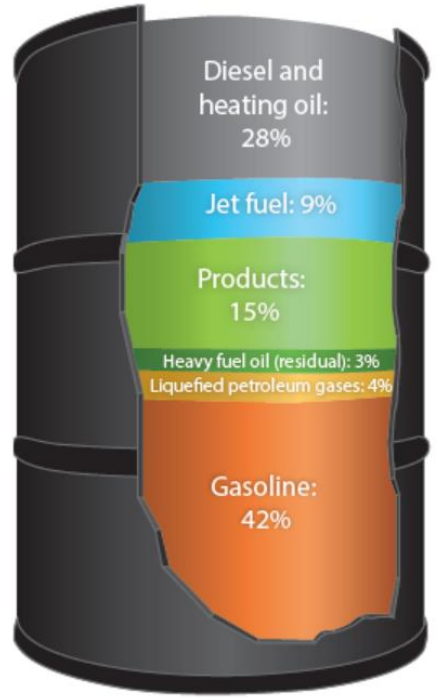


Figure 1. Products from a barrel of crude oil

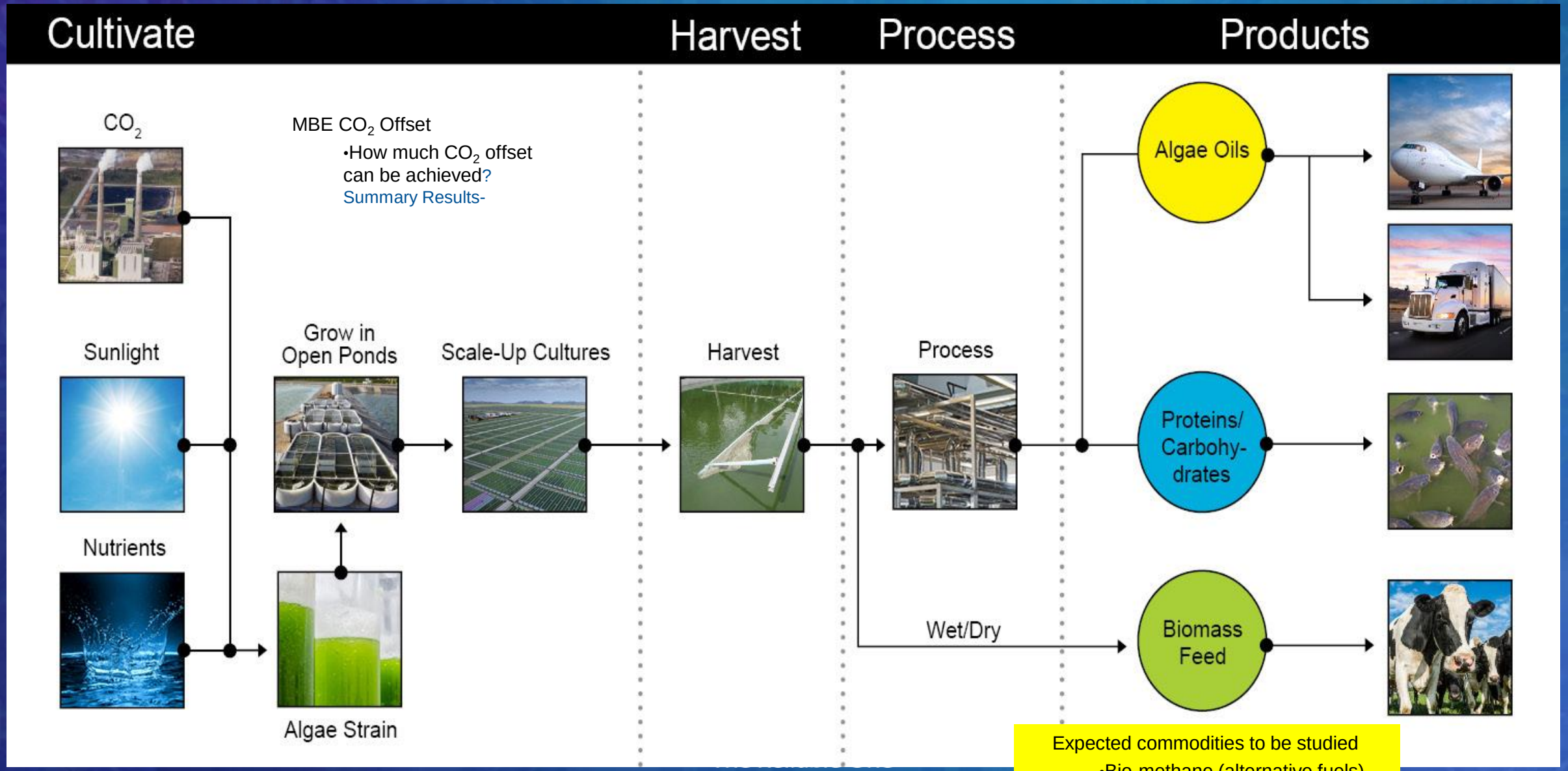
Profitable Conversion of Carbon Waste Is a $1T Opportunity

Carbontech market includes major products + high-value consumer goods.

$480B	**Transportation Fuels**	*Gasoline, Diesel, Jet*
$313B	**Agriculture**	*Fertilizer, Feed*
$99B	**Built Environment (Non-Wood)**	*Cement, Concrete, Asphalt, Aggregate*
$37B	**Plastics**	*Polyethylene, Polypropylene*
$27B	**Consumer products**	*Diamonds, Spirits, Guitars, Furniture*
$7B	**Engineered Wood Products**	
$1B	**Industrial Gas**	

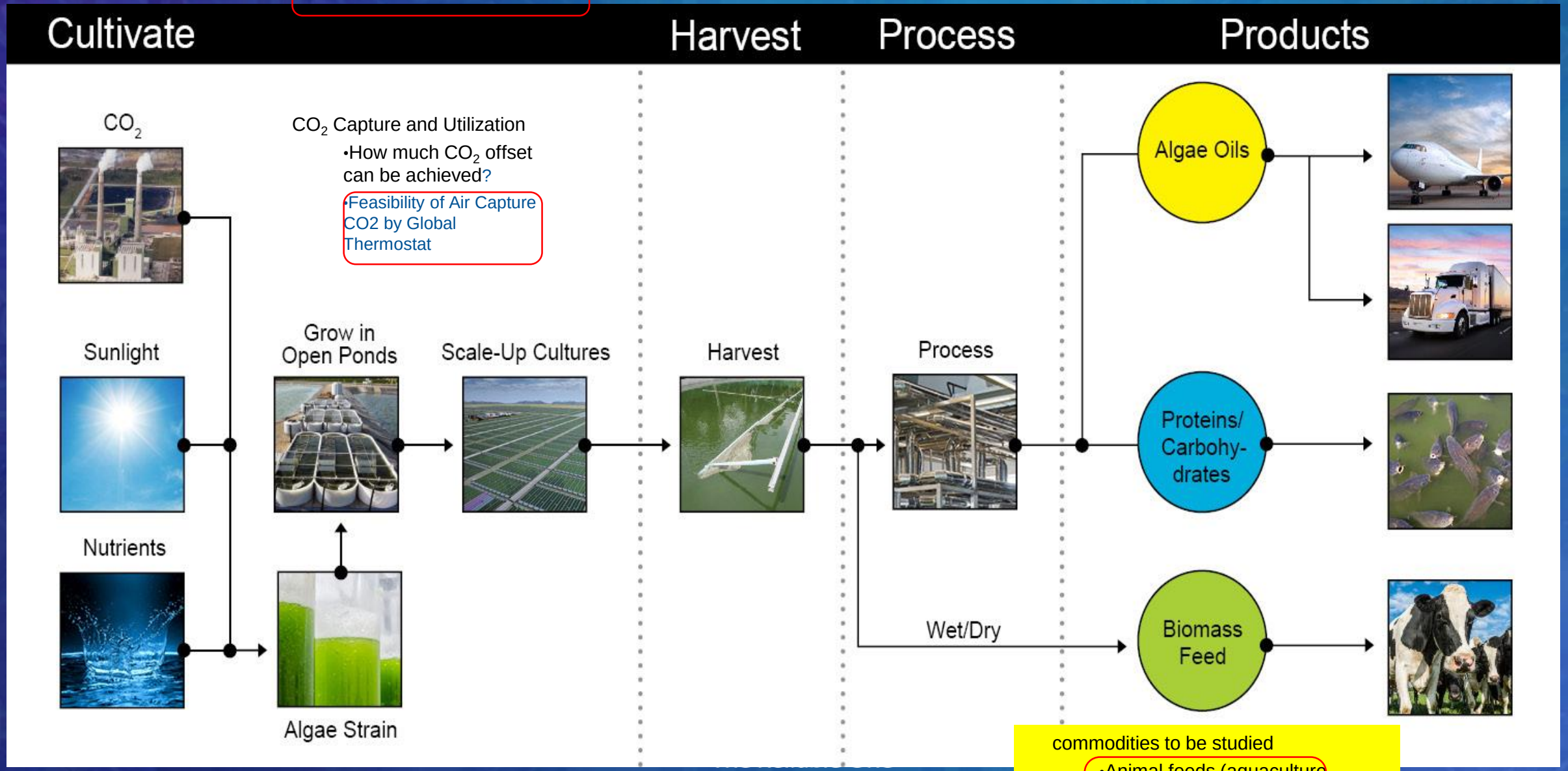
Goals of the Dept of Energy NETL 2015 Research

Can Flue Gas + Algae = Future Commodities



Goals of the Dept of Energy NETL Research

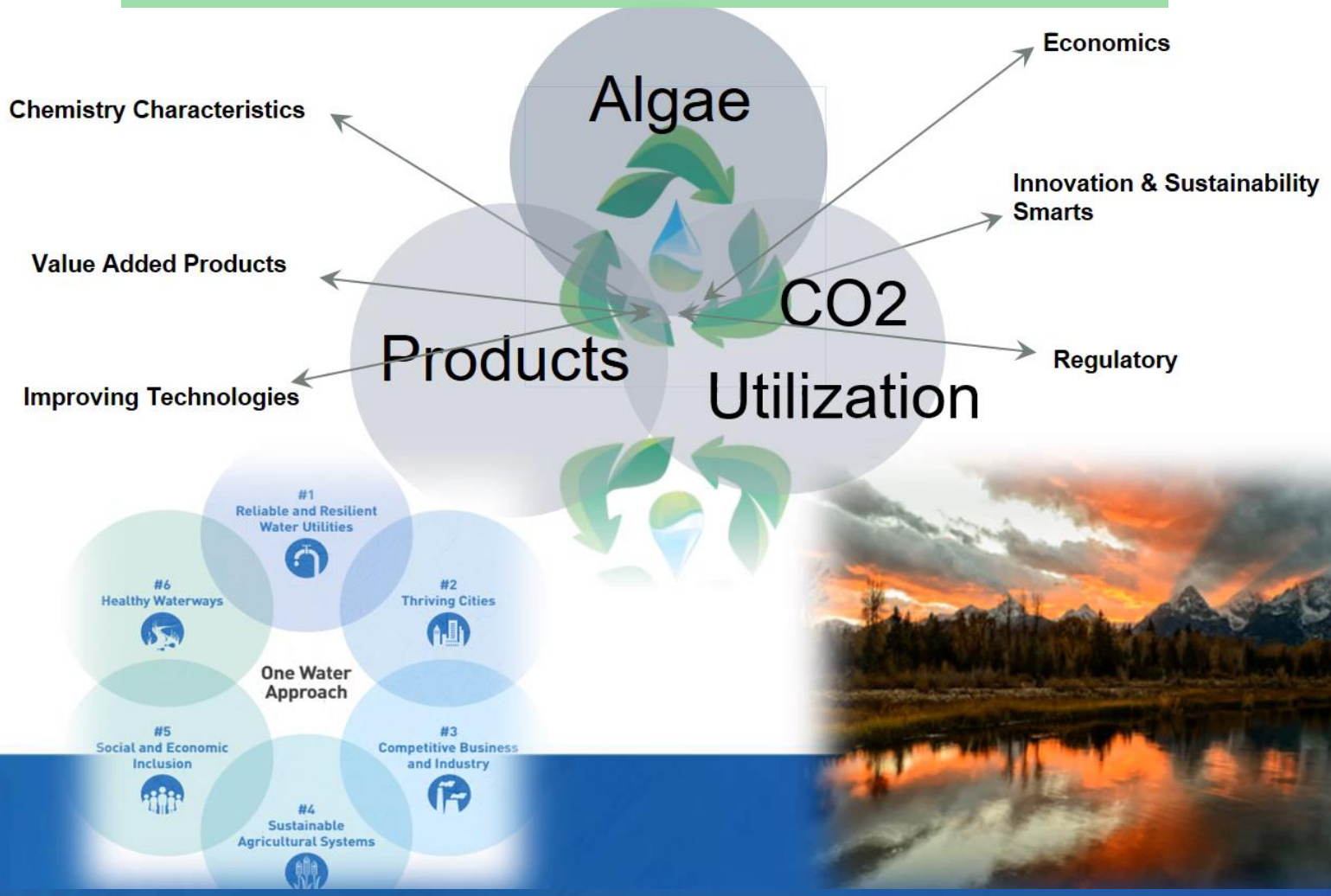
Can Flue Gas + Recycled Nutrients + Algae = Future Commodities



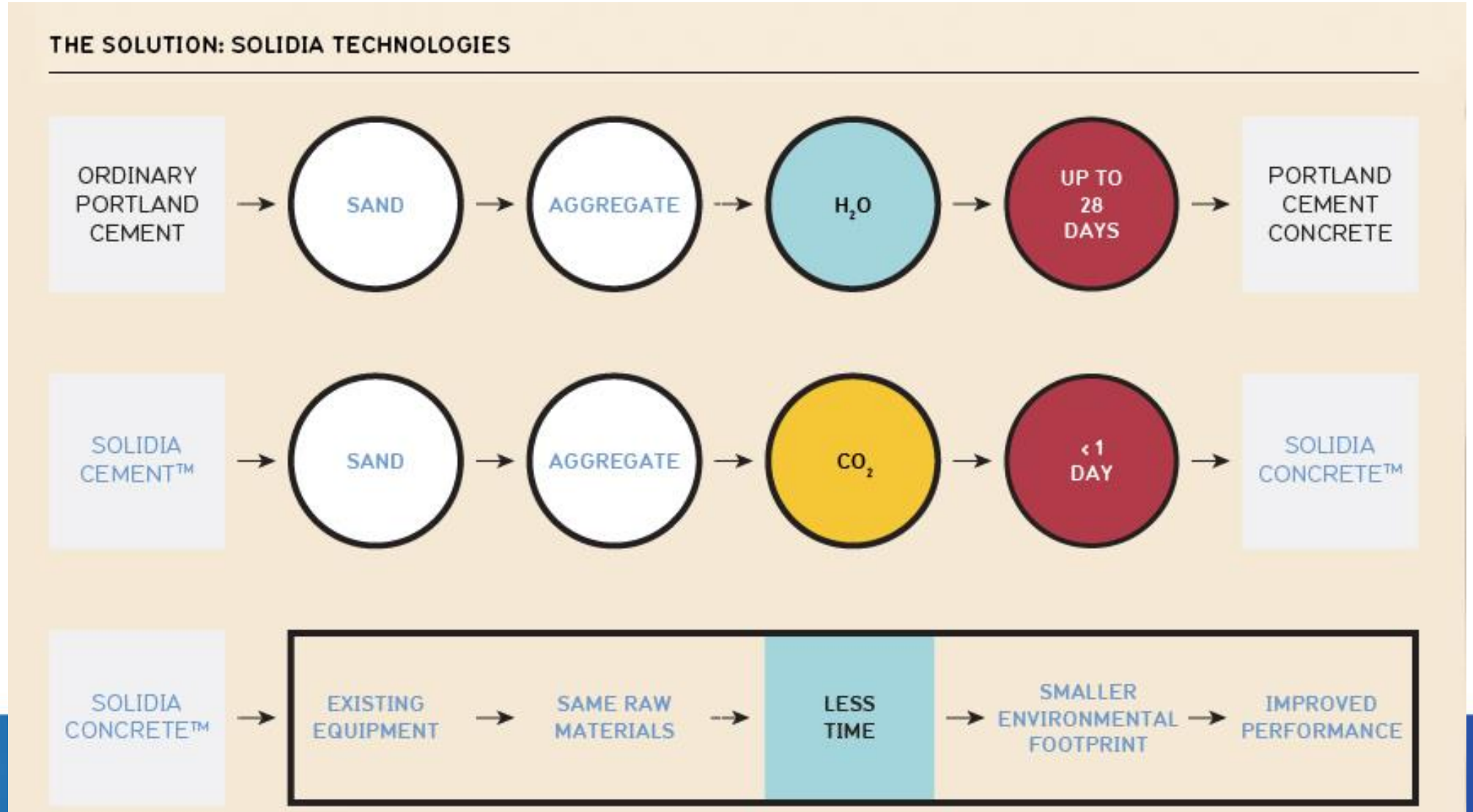
Crosscutting, Innovative, & Increasing Scale

DOE references >>> 1) https://www.energy.gov/eere/bioenergy
2) https://www.energy.gov/sites/prod/files/2017/09/f36/beto_strategic_plan_december_2016.pdf

Questions > ?


Algae
Products
CO2
Utilization
Chemistry Characteristics
Economics
Innovation & Sustainability
Smarts
Value Added Products
Regulatory
Improving Technologies
#1
Reliable and Resilient
Water Utilities
#2
Thriving Cities
#3
Competitive Business
and Industry
#4
Sustainable
Agricultural Systems
#5
Social and Economic
Inclusion
#6
Healthy Waterways
One Water
Approach

Solidia Concrete Technology



Hybrid Power - Reduction of Carbon to the new Renewable Carbon Economy by integrating the Chemical, Bioenergy, and Refineries Industries

CO2 Capture Technology

- Packed bed absorption tower with 3rd generation solvents
- Membranes
- Air

CO2 Sources and Cleanup

- Organic or Inorganic
- Costs and efficiency
- Purity from power plants vs biochemical source
- Chemical bonds potentially increase the security and storage for grid management

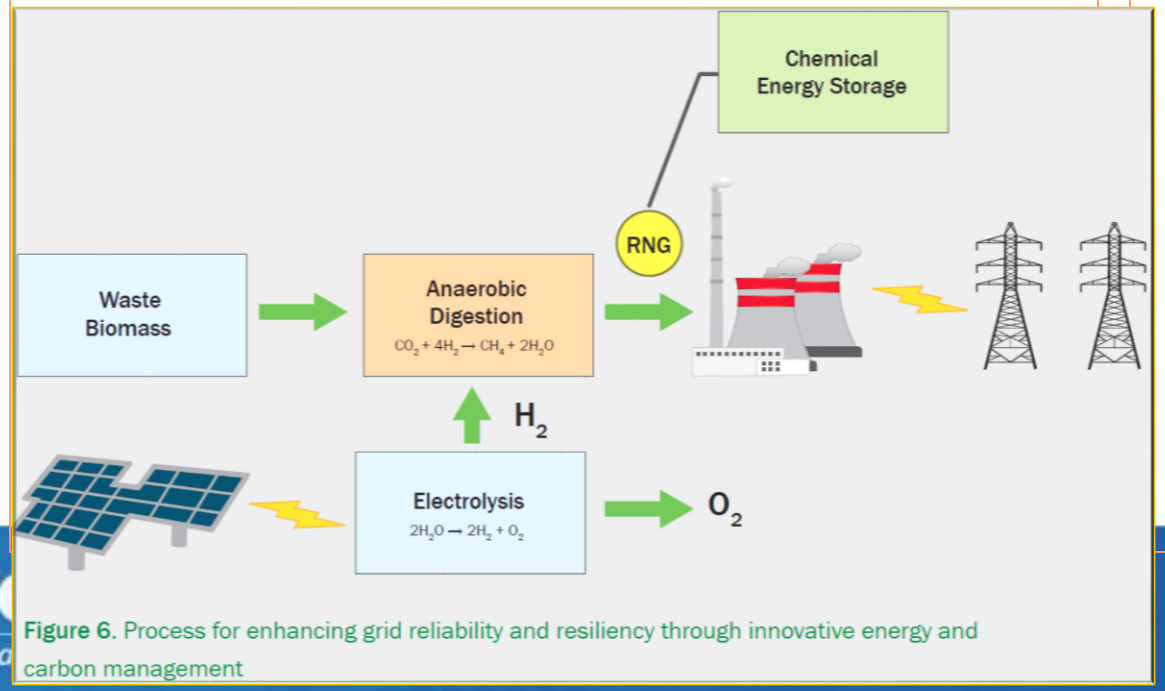
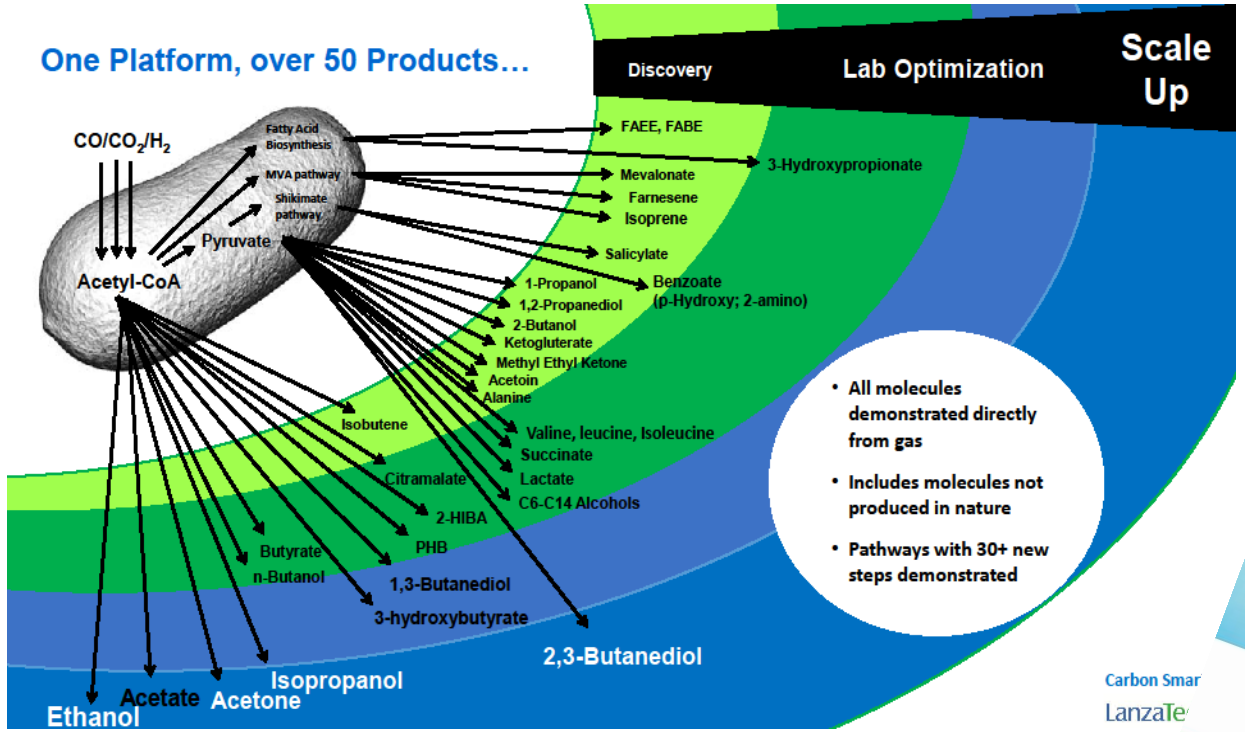


Figure 6. Process for enhancing grid reliability and resiliency through innovative energy and carbon management

Lanza Tech


One Platform, over 50 Products…
Discovery
Lab Optimization
Scale Up
CO/CO2/H2
Fatty Acid Biosynthesis
MVA pathway
Shikimate pathway
Pyruvate
Acetyl-CoA
FAEE, FABE
3-Hydroxypropionate
Mevalonate
Farnesene
Isoprene
Salicylate
Benzoate (p-Hydroxy; 2-amino)
1-Propanol
1,2-Propanediol
2-Butanol
Ketogluterate
Methyl Ethyl Ketone
Acetoin
Alanine
Isobutene
Valine, leucine, Isoleucine
Succinate
Lactate
Citramalate
C6-C14 Alcohols
2-HIBA
PHB
Butyrate
n-Butanol
1,3-Butanediol
3-hydroxybutyrate
2,3-Butanediol
Isopropanol
Ethanol
Acetate
Acetone
All molecules demonstrated directly from gas
Includes molecules not produced in nature
Pathways with 30+ new steps demonstrated


STRATEGIC PLAN
FOR A THRIVING AND SUSTAINABLE BIOECONOMY
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
BIOENERGY TECHNOLOGIES OFFICE

Separation and Utilization of CO_2 from Flue Gas as a Sustainable Carbon Source for Large Scale Algae Growth

Sponsor: Orlando Utilities Commission

Coach: Dr. Sindia Rivera-Jiménez, Assistant Director IPPD, 352-846-1974, NEB 176

Description

Design an industrial CO_2 separation system using software recommended by US Department of Energy and build a bench-scale system to demonstrate the process and tune the analytical model.

Key Objectives

Data analytics: investigate separation methods, optimal algae growth conditions, and potential transportation methods

Modeling: Using CCSI toolset, propose an operational process solution for CO_2 separation, transportation, and utilization.

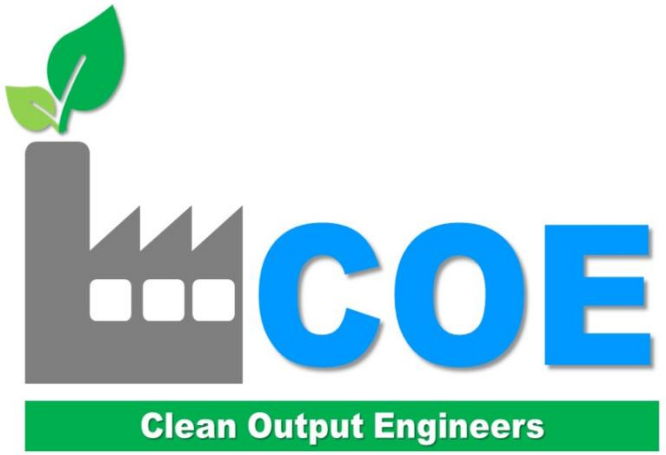
Design: Based upon cost and scalability, select one or more technologies to recommend for implementation in a bench-scale prototype.

Business: cost/benefit/shared-analysis

Our team!

3 CHE (design/development/modeling)
ABE (design/development/shared-analysis)
ENV(design/development/shared-analysis)

The University of Florida's Integrated Process and Product Design (IPPD) Program – Carbon Capture & Utilization Research Grows our Florida Algae Bench



The University of Florida's IPPD – Carbon Capture & Utilization Research Topics

Carbon Capture Simulation Modeling

-TO-ACTION
Orlando Utilities Commission
IPPD Class '17-'18

Absorption Tower Pilot

2nd Generation Solvents

COE
Clean Output Engineers

Explaining the Bio economy and Implementing Technologies

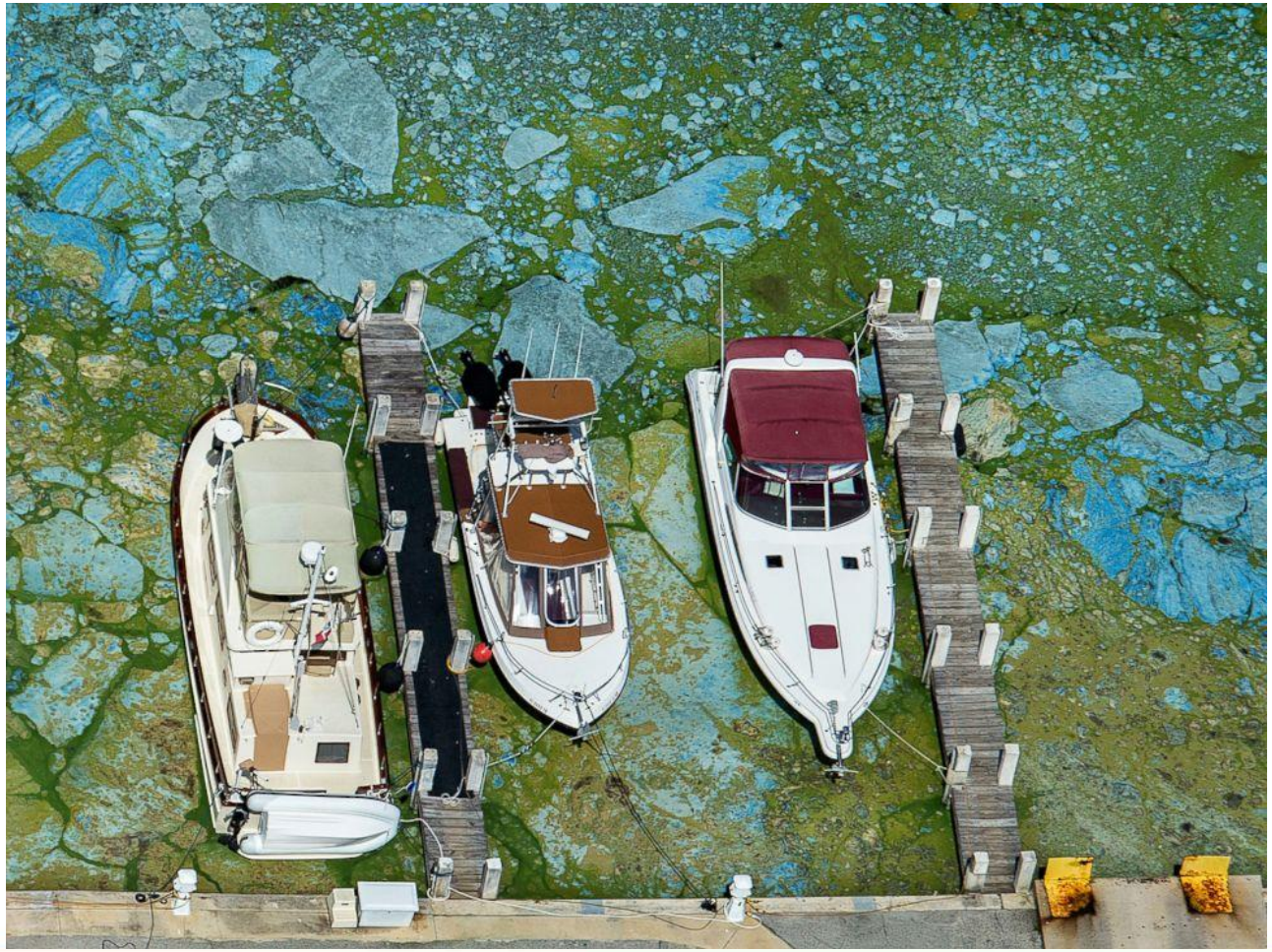
- Plan for Multiple Futures
  - BMPs across sectors
  - Blended infrastructure – storm water
  - Scale, Scale & Scale
- High Tech Rendering and Energy Conversion
  - Renewable energy specific to a location
- Harmonize Cross Sector Models
  - Carbon Capture
  - Biomass
  - Technology and Climate Science
  - Carbon Markets and LCA
  - Water Quality Credit Trading
  - Electricity distribution

Implementing Technology

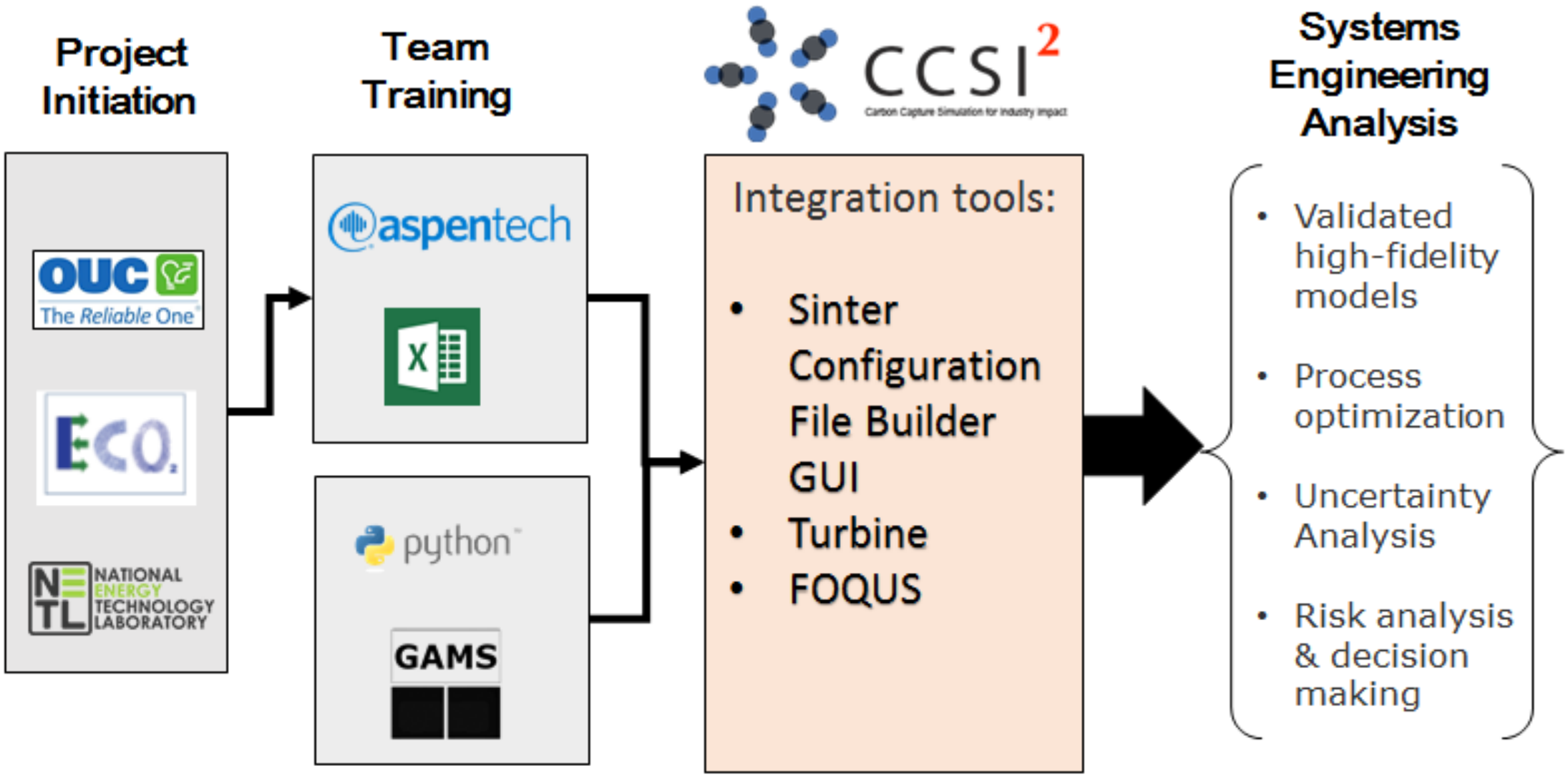
- CO2 Capture, store, transport and utilize
- Integrated water process management with water treatment residuals, wastewater biosolids and coal combustion materials

Change the Algae Future - Via Implementing Technology

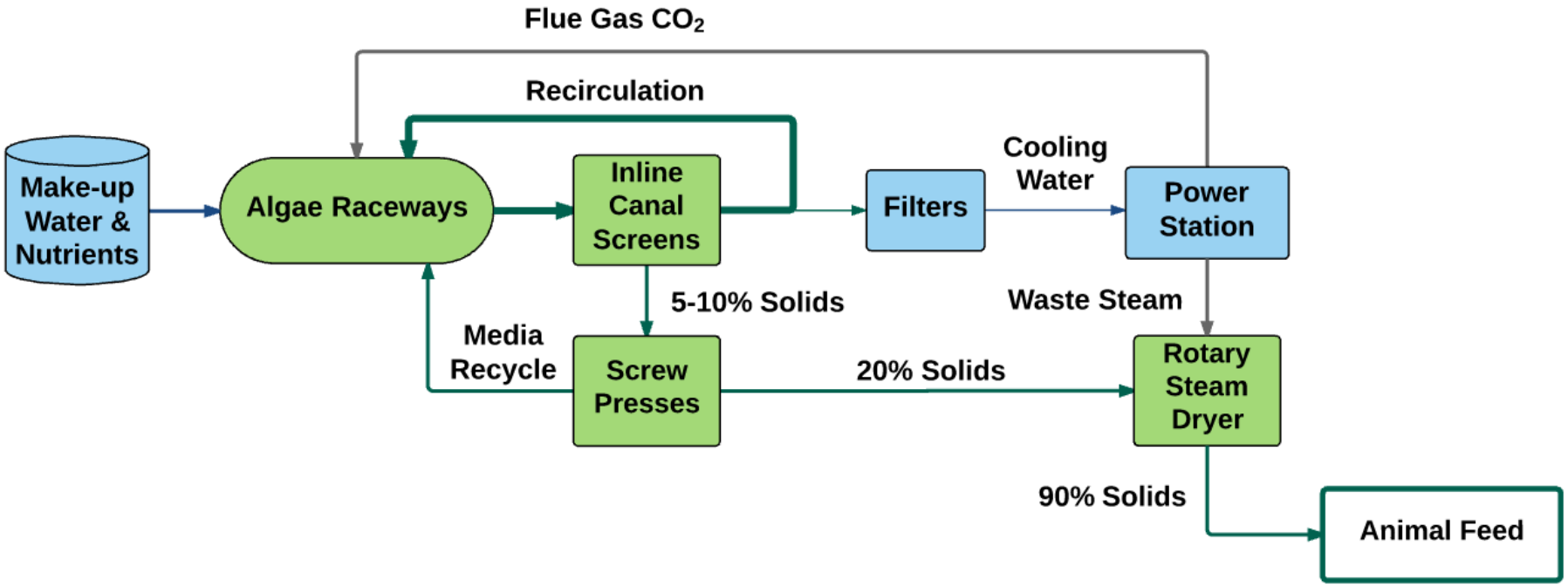
- Several plausible scenarios exist for incorporation into Sustainability Plans; continuously change and adapt for multiple futures
- Create blended infrastructure
- New agricultural commodities from algae biomass
- Water resources benefits – “one water” thinking and collaborate on community sustainability goals



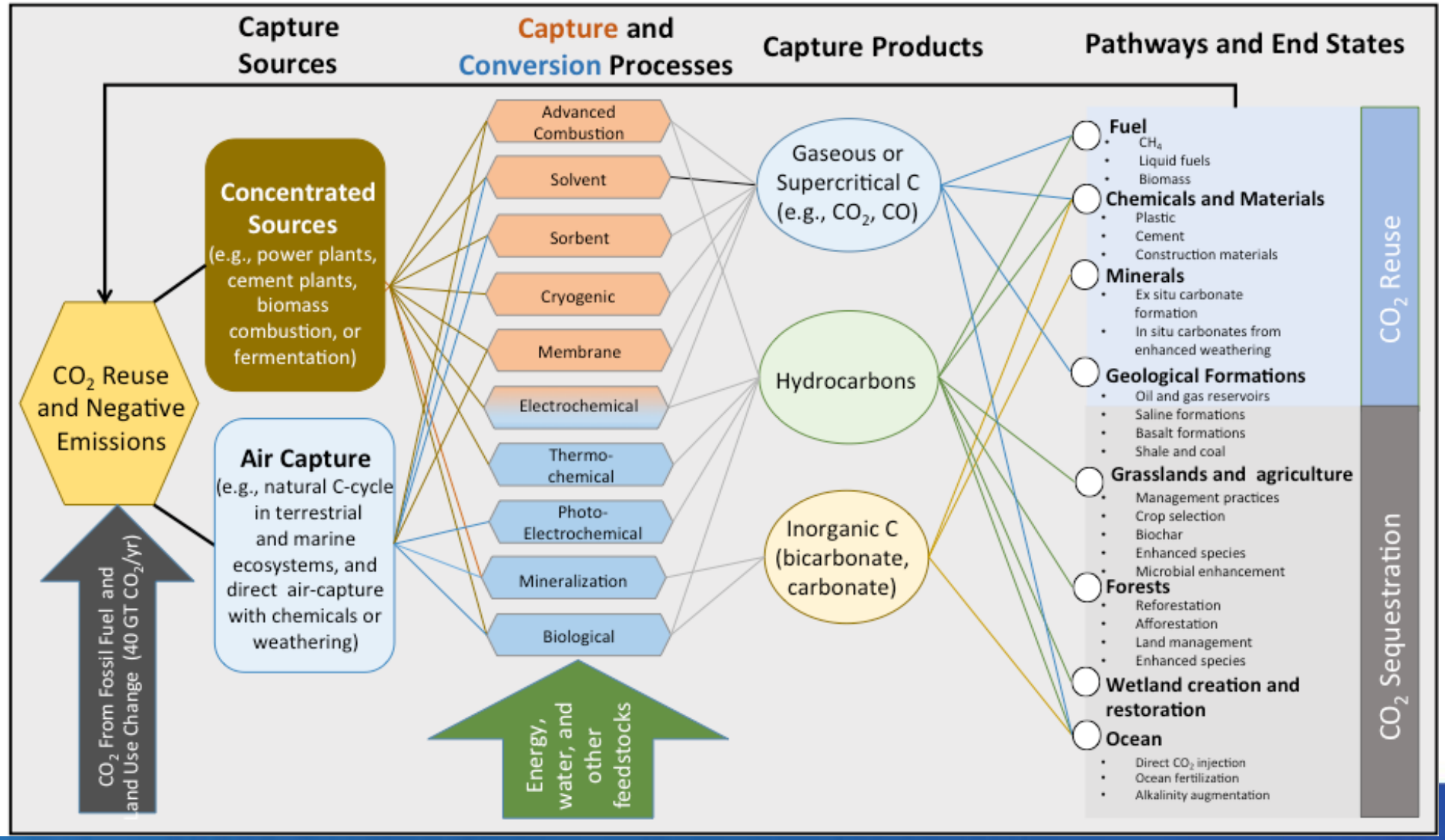
Methodology for Systems Engineering Analysis



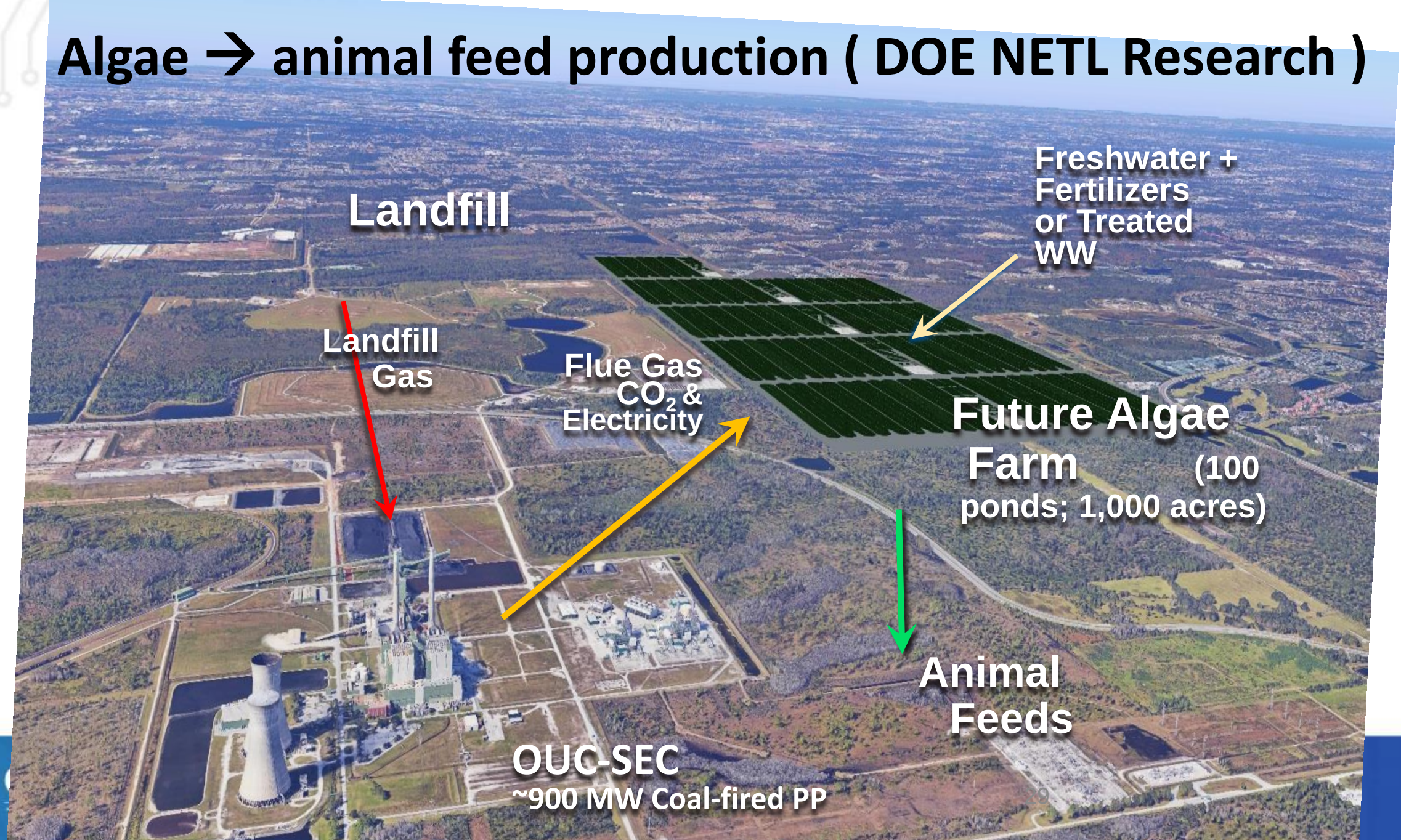
Animal feed case: uses clean water and agricultural fertilizer.

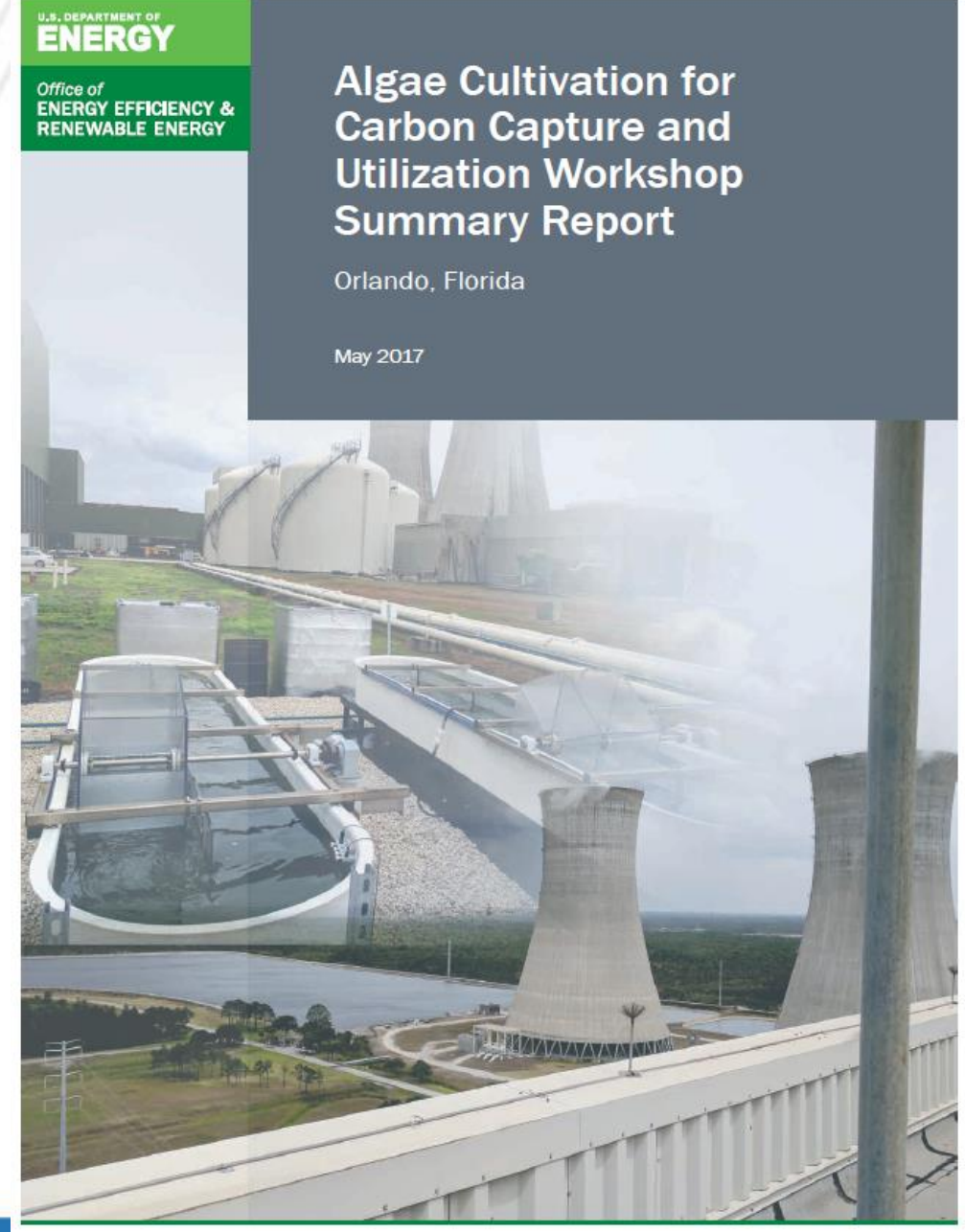


CO2 Utilization Landscape



Algae → animal feed production (DOE NETL Research)

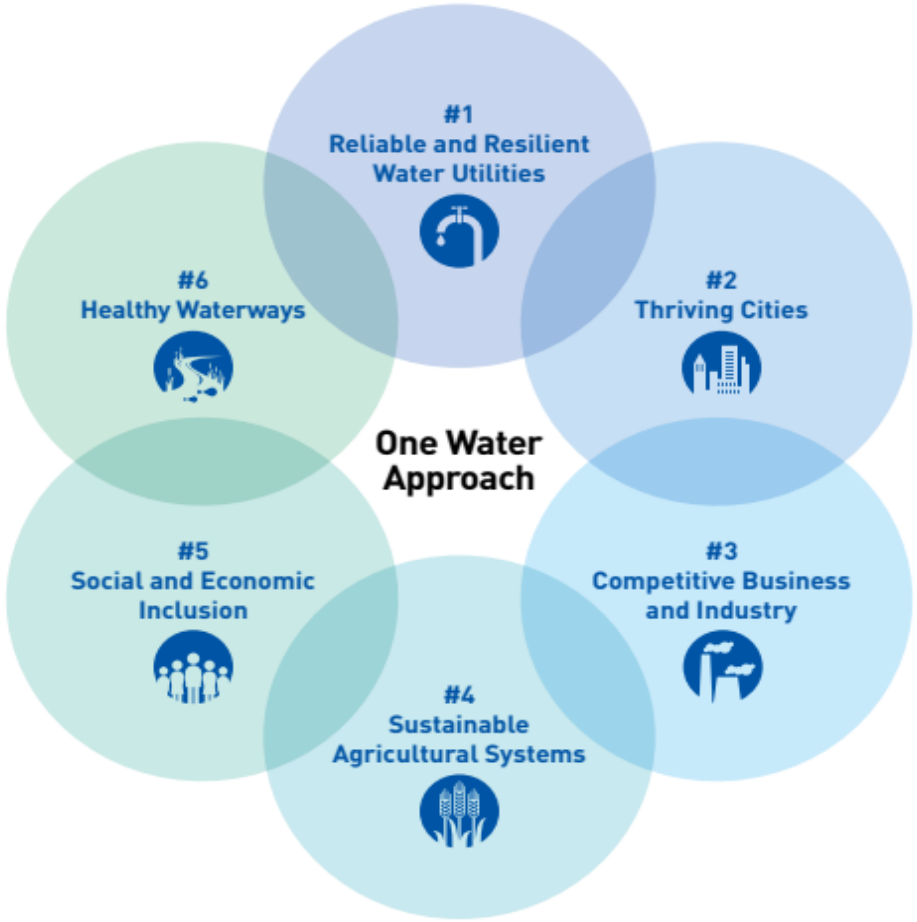



U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
Algae Cultivation for Carbon Capture and Utilization Workshop Summary Report
Orlando, Florida
May 2017

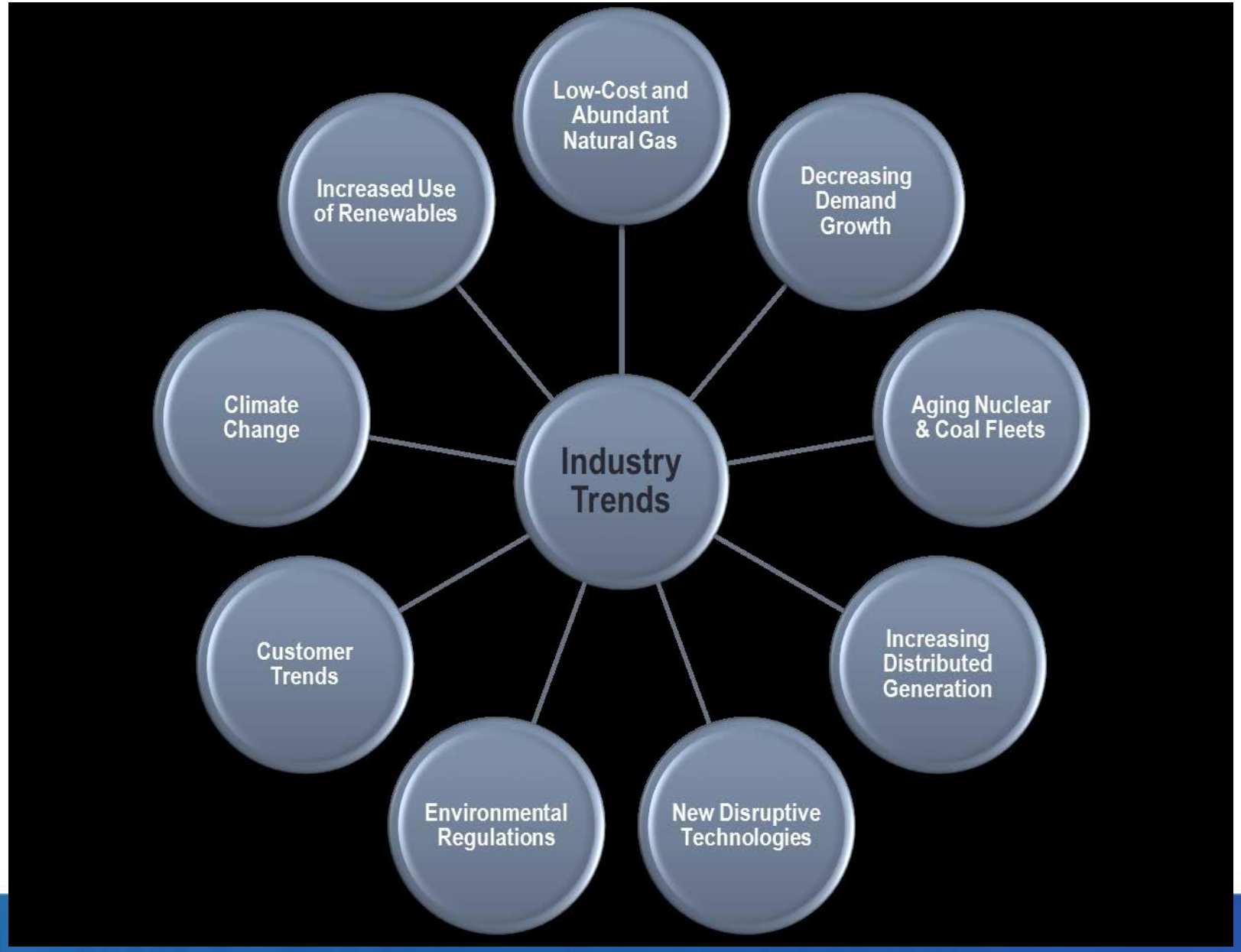

Process Design and Econ
for the Production of Alga
Biomass:
Algal Biomass Production in O
Systems and Processing Throu
Dewatering for Downstream Co
Ryan Davis, Jennifer Markham,
Christopher Kinchin, Nicholas Grundl
Eric C.D. Tan
National Renewable Energy Laboratory
David Humbird
DWH Process Consulting
national laboratory of the U.S. Department
Energy Efficiency & Renewable Energy
by the Alliance for Sustainable Energy, LLC
available at no cost from the National Renew
REL) at www.nrel.gov/publications.
ort
54772
AC36-08GO28308
2016 BILLION-TON REPORT
Advancing Domestic Resources for a Thriving Bioeconomy
Volume 2: Environmental Sustainability Effects of Select Scenarios from Volume 1
January 2017
U.S. DEPARTMENT OF ENERGY

Connect wastewater, stormwater, drinking water, reuse along with other water resources

- **New Efforts:** Cross cutting across sectors via multi disciplines of stakeholders
- **Research Needs** "One Water Roadmap"



SOLUTION – EXPLAINING THE ALGAE BIOMASS PROPOSITION WITHIN THE UTILITIES SECTORS



Converting to the Bioeconomy

- Implementing Technology
  - Florida environmental remediation at springs, estuaries, lakes, and natural systems
  - Green infrastructure is just infrastructure
  - Water quality credits trading - TBD
  - Carbon policy -TBD
- Recycle Carbon
- Accelerated R&D
  - Consumer performance of co products
  - Increase the co products to industrial scale
  - Grow our algae knowledge/solutions within Florida
- Recycle Nutrients
  - Enhance Ag earnings
  - Enhance community Infrastructure - Stormwater BMPs
  - Wastewaters : Domestic, Industrial, Septage & Leachate