Biofuels/Biomass

Dr. Jennifer Curtis, Interim Director

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Current Status – Renewable Energy

- Renewable Fuel Standard - 36 billion gallons by 2022
- Volume of renewable fuel required to be blended into transportation fuel 21 billion from advanced biofuels
- From 2000 to 2010, ethanol production in US from the fermentation of corn increased from 1.6 to 13.2 billion gallons/year
- About 9 percent of all energy consumed in the United States in 2012 was from renewable sources
- Renewable sources account for about 12 percent of the nation's total electricity production
- Slightly over half of these renewable sources are from biomass

- Florida has more biomass resources than any other state, ~10% of the US total, ~ 7% wood (51% tree coverage)
- Florida has more waste to energy facilities than any other State, leads US in wood and biomass waste consumption

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Waste to Energy

Florida Crystals Corporation, Palm Beach County, FL - one of America's largest sugar companies, owns and operates the largest biomass power plant in North America. The 140 MW facility uses bagasse and urban wood waste as fuel to generate enough energy to power its large milling and refining operations as well as supply enough renewable electricity for nearly 60,000 homes.

American Renewables 100-MW wood-fired biomass electric generating project outside of Gainesville, FL on a site approximately eight miles northwest of downtown Gainesville. The Gainesville Renewable Energy Center site is adjacent to an existing coal power generation facility.

Covanta Energy - 5 locations in Florida and over 40 worldwide

Burn waste to recover electricity and steam in specially designed boilers to ensure complete combustion.

Sigarca (Gainesville, FL)

Biodegradable waste to energy via digester

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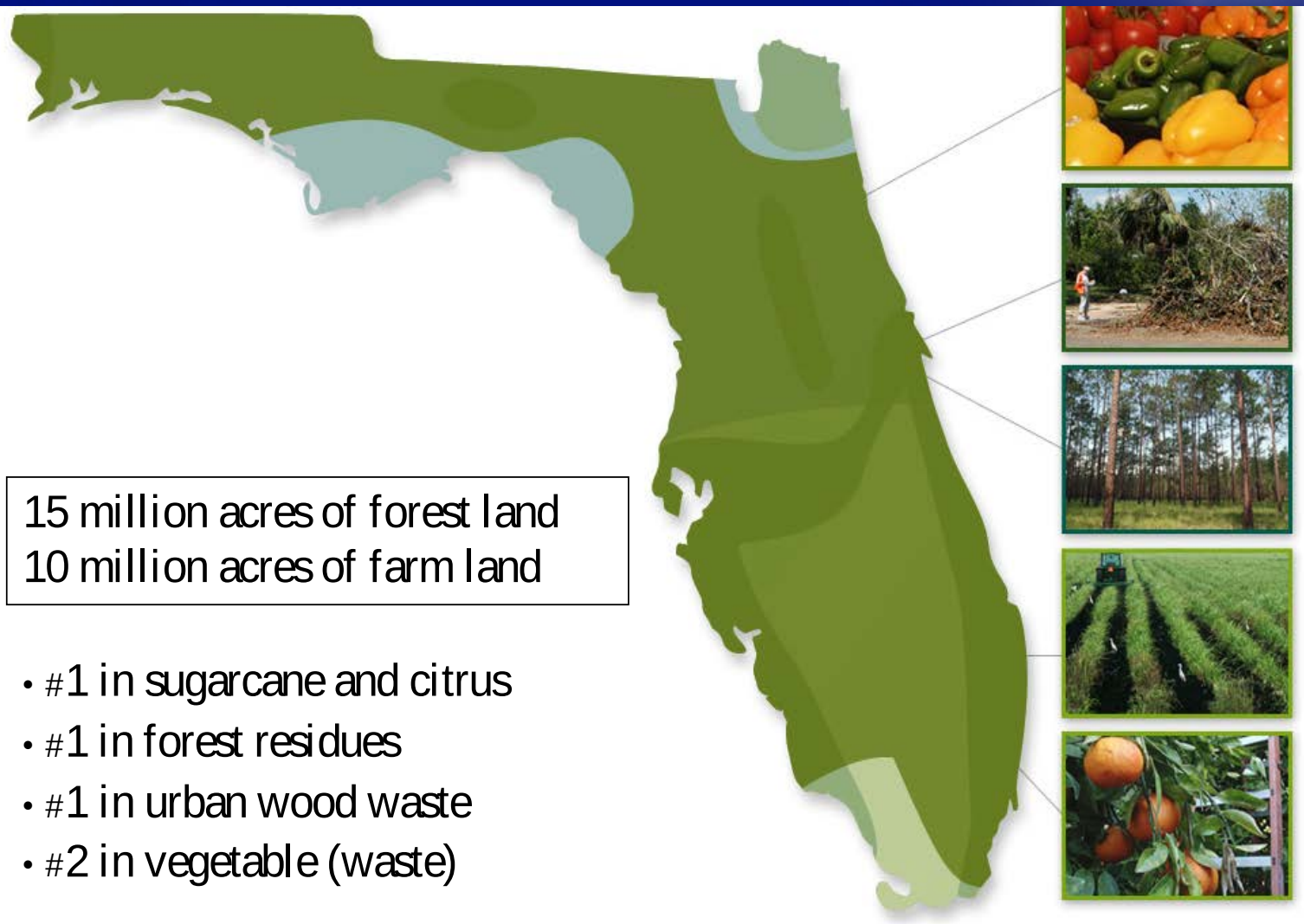
Florida's Inedible Biomass Feedstocks



15 million acres of forest land
10 million acres of farm land

- #1 in sugarcane and citrus
- #1 in forest residues
- #1 in urban wood waste
- #2 in vegetable (waste)

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Florida's Inedible Biomass Feedstocks

- Forest residues (North Florida)
- Citrus pulp (Central Florida)
- Bagasse and sugarcane waste (South Florida)
- Municipal waste, green waste
- Invasive trees and plants
- Animal waste
- Agricultural residues

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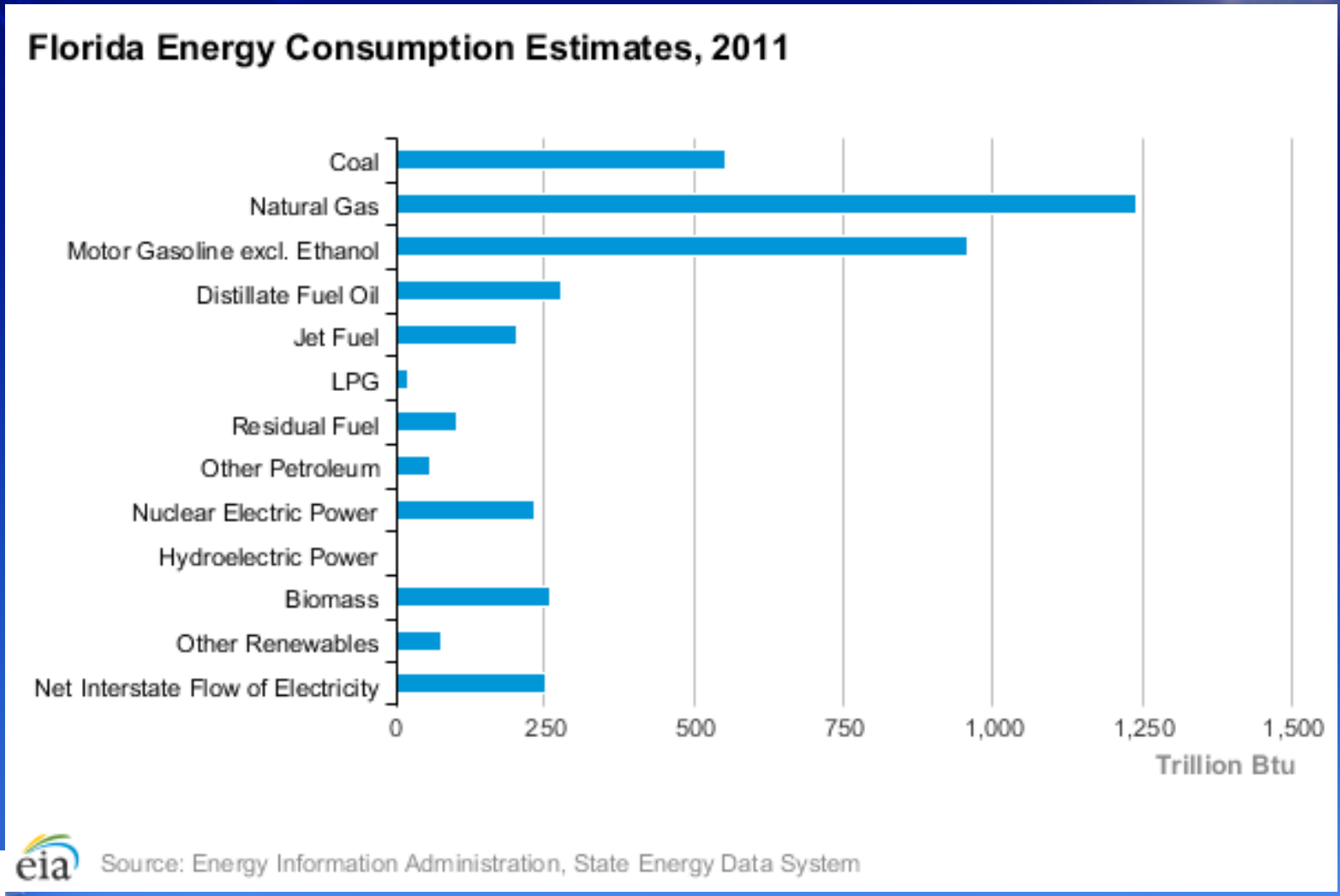
Florida Energy Consumption



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Current Status – Florida Energy Consumption

- Consumes over 8 billion gallons per year of gasoline (US consumption 134 billion gal/yr)
- Consumption is growing by 300 million gal/yr
- Depends almost exclusively on other states and nations for supplies of oil and gasoline

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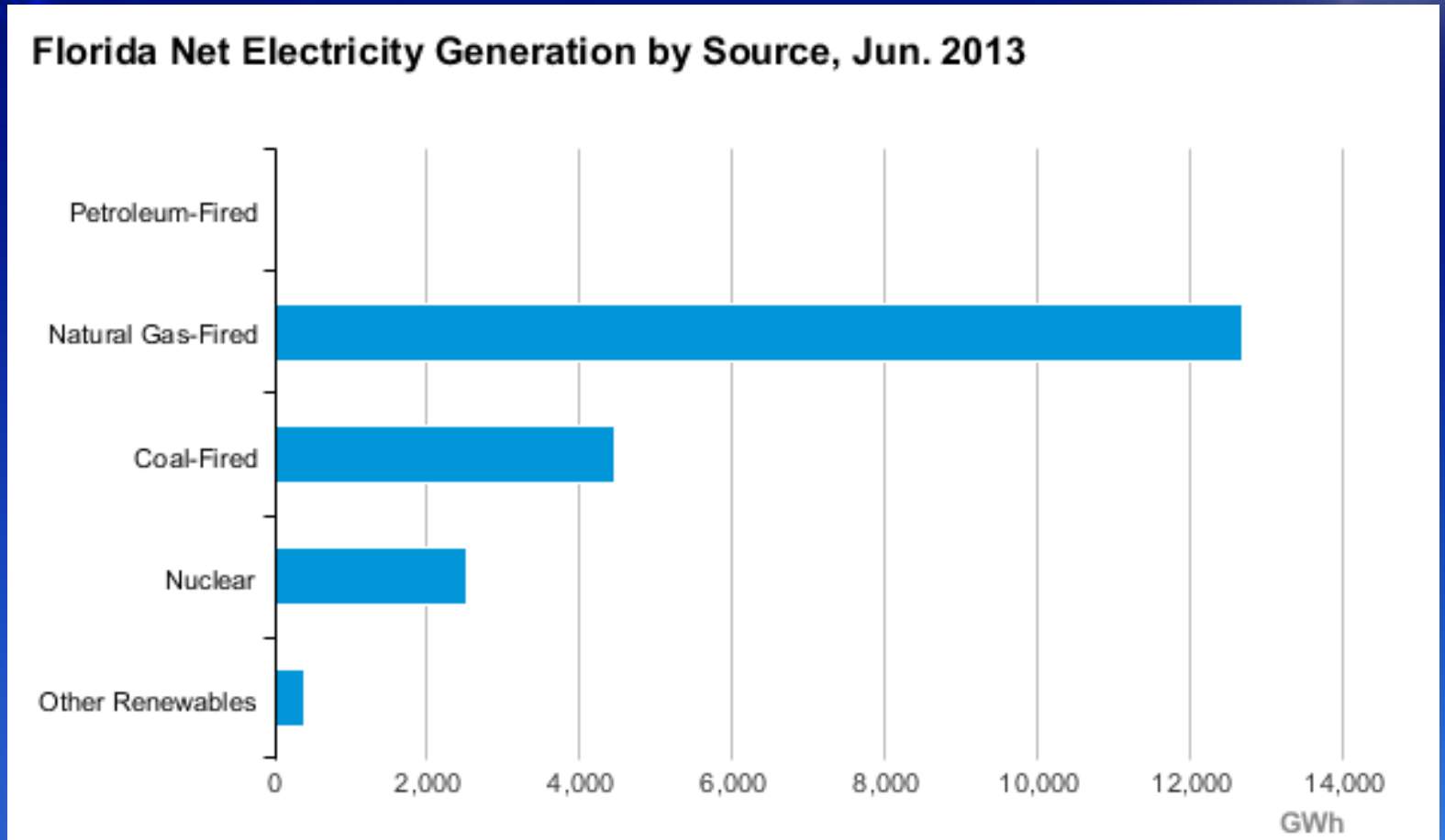
Florida Electricity Generation by Source



Renewable energy accounted for 2.2 percent of Florida's total net electricity generation

eia Source

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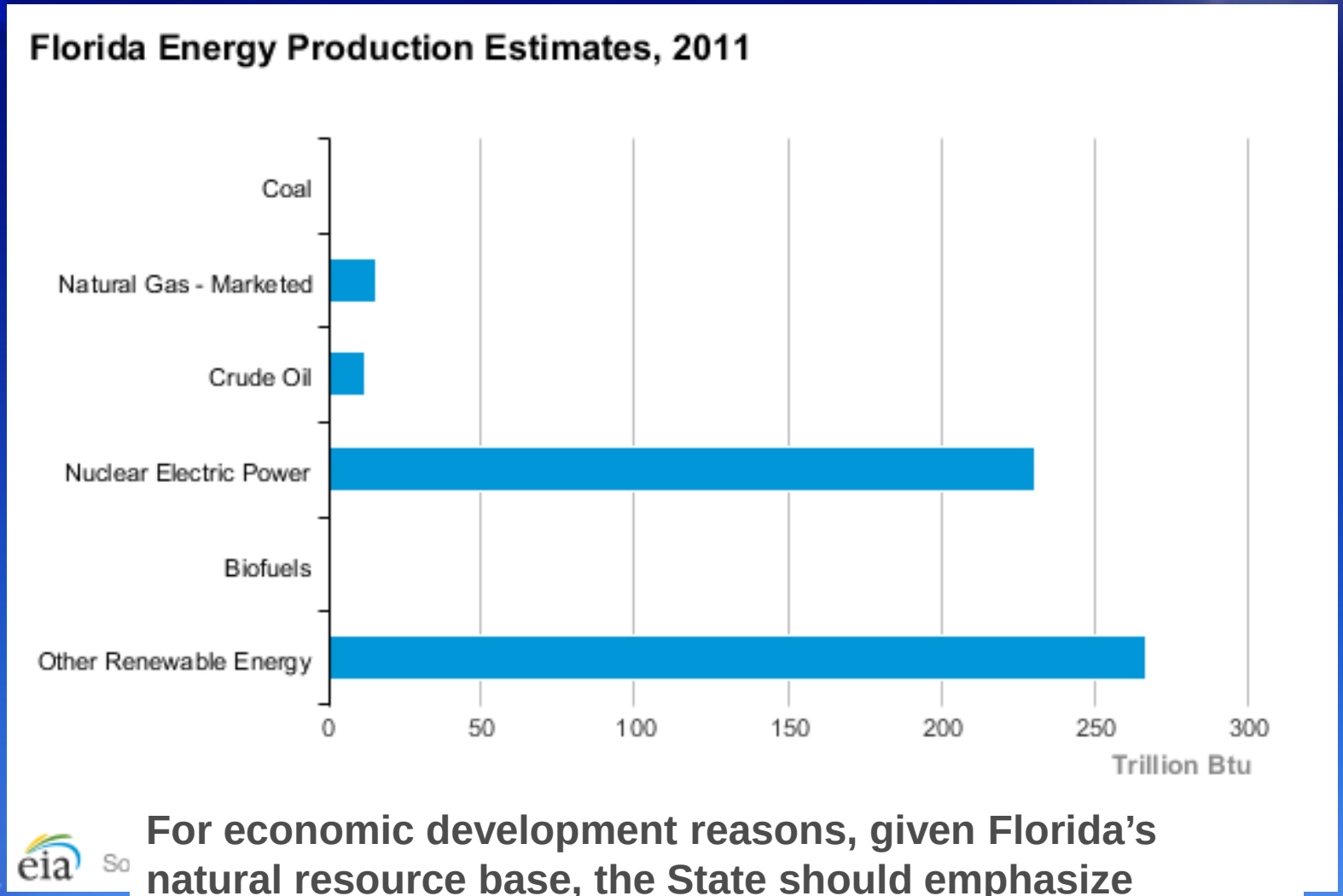
Florida Energy Production



eia So

For economic development reasons, given Florida's natural resource base, the State should emphasize renewable fuels research and development

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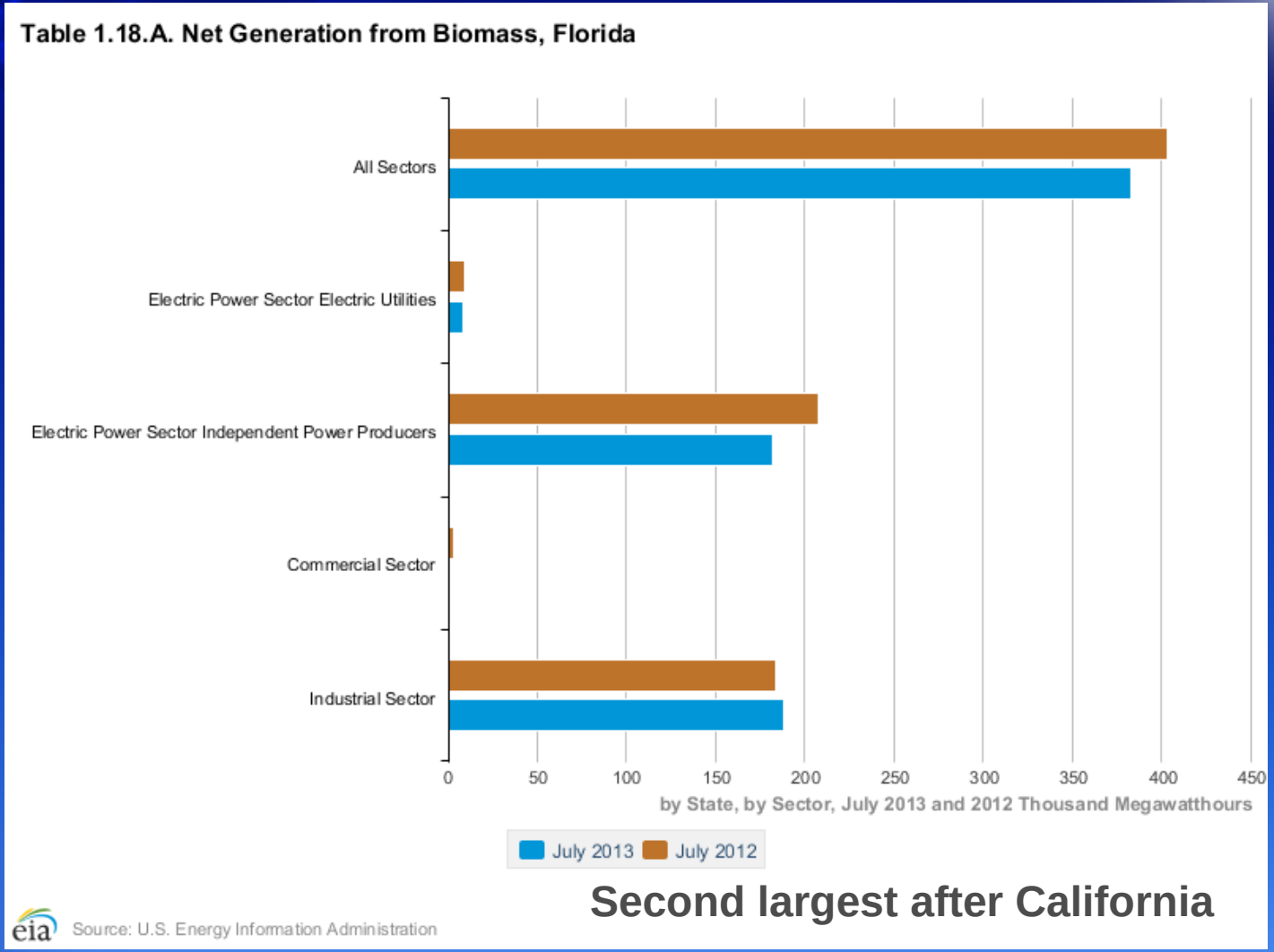
Net Generation from Biomass



Second largest after California

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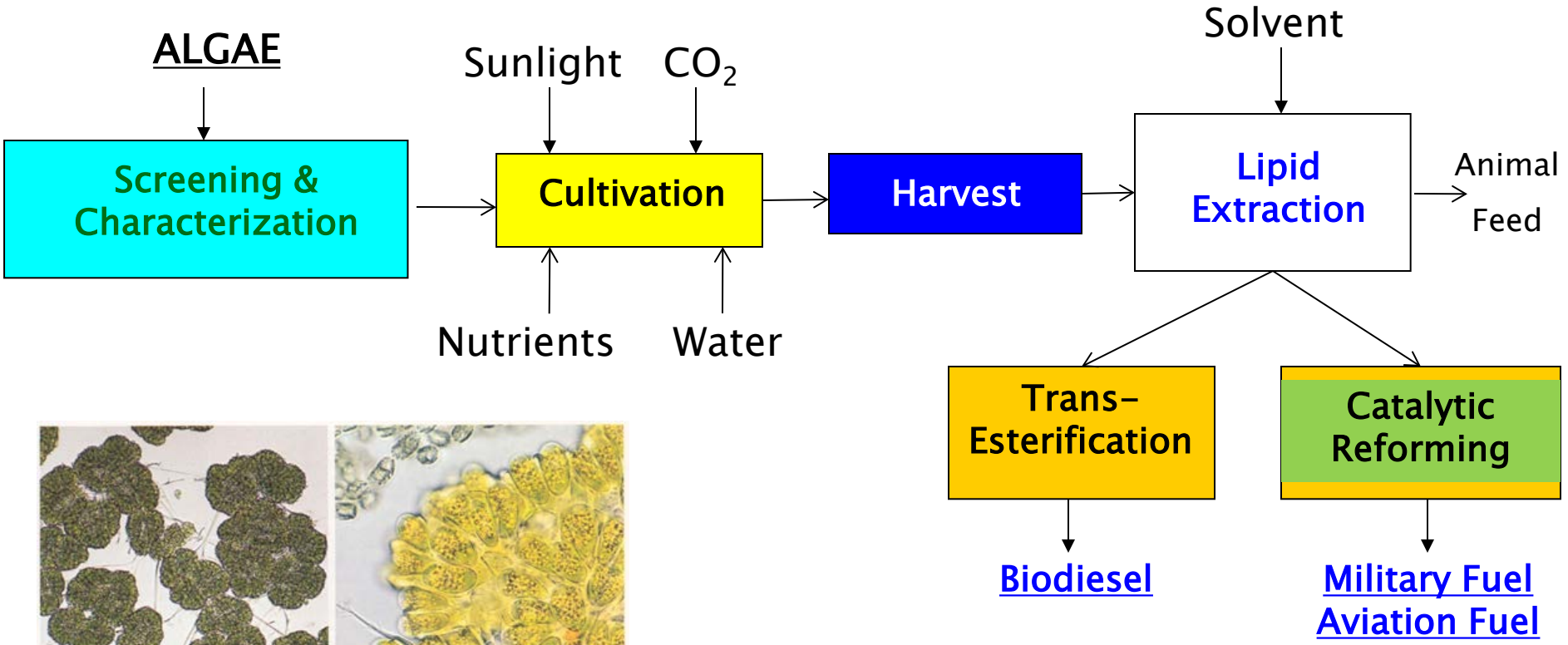
Advanced Biofuels Technologies

1. **Cellulosic Biomass** —(*Enzymes* / *Chemicals*)→ **Sugars** —(*Fermentation* / *Reforming*)→ **Alcohols** / **Hydrocarbons**
2. **Cellulosic Biomass** —(*Gasification* / *Pyrolysis*)→ **Syngas** / **Oil** —(*Catalysis*)→ **Alcohols** / **Hydrocarbons**
3. **Cellulosic Biomass** —(*Gasification*)→ **Syngas** —(*Fermentation*)→ **Alcohols**
4. **Algae** —(*Cultivation*)→ **Lipids** —(*Esterification* / *Reforming*)→ **Aviation fuel** / **Diesel**

Professor George Philippidis, USF

Algae Technology



Professor George Philippidis, USF

Algae Technology – Pilot Scale

Algenol Biofuels, Inc., Fort Myers, FL

- Over 120 employees
- Cyanobacteria used in flexible plastic film photobioreactors to produce ethanol
- Immediate Goal of over 100,000 gallons of ethanol per year
- Commercial scale next year
- Long term goal 20 billion gallons of ethanol per year within 20 years with over 4000 employees

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Algae – Smaller Scale

- AgOil International, LLC – St. Petersburg, FL
- Algae to Omega, Oakland Park, FL
- AlgaStar Inc., Gulf Breeze, FL
- Culture Fuels, Lakeland, FL
- Culturing Solutions, Inc., Port Richey, FL
- Parabel, Melbourne, FL

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Algae Technology

- Differ in type of algae – algae cultivation systems
- Growth rate and lipid content
- Yields and culture density
- Footprint
- Closed photobioreactor versus open pond
- Contamination barriers
- Water and energy usage
- Lipid extraction

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Algae – Pros and Cons

PROs

Absorbs carbon dioxide as it grows

Both waste CO_2 and wastewater can be used as nutrients

Higher energy per-acre than other bio-fuels

Can be grown on land unsuitable for other types of agriculture

PNNL Study found that 17 percent of U.S. oil imports could be met with algae

For Florida – year-round warm weather, sunlight, long shoreline, underutilized land (e.g. decommissioned phosphate mines), industrial flue gases CO_2 and wastewater

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Algae – Pros and Cons

CONs

Need to be grown under controlled temperature conditions

Requires a considerable amount of land and water

Cold flow and degrading issues with algal biofuel

Some researchers using genetic engineering to develop optimal algae strains

Requires phosphorus as a fertilizer which is becoming scarce

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Cellulosic Biomass

Chemical

- Pretreatment to break down the plant cell wall
- Hydrolysis of cellulose to sugars (most challenging step)
- Fermentation process by microorganisms
- Distillation

  - Feedstock and transportation costs
  - Technical challenges associated with large-scale, continuous production
  - Process scale is factor of 1/50 compared to petroleum refinery

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Cellulosic Biomass

Thermochemical

- Gasification, syngas converted using Fischer-Tropsch reaction or methanol synthesis followed by methanol to gasoline
- Pyrolysis followed by upgrading to fuels

  - Prediction - less efficient but lower capital and operating costs
  - Compatible with existing infrastructure
  - Storage of CO_2, pollutants, toxicants, particulates (particularly if mixed with coal)

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Cellulosic Ethanol at Commercial Scale

Indian River BioEnergy Center, Vero Beach, FL

Joint venture between
New Planet Energy Florida LLC and Ineos Bio

Goal of 8 million gallons per year and
generating 6 megawatts of electrical power

Targeting waste streams – yard and agricultural waste, numerous feedstocks

Biomass is gasified to produce syn gas, heat recovered from the cooling gas used to generate power

Cleaned, cooled syngas goes to a patented anaerobic bacterial fermentation process producing ethanol

In the continuous process, feedstock enters into the gasifier and exits as ethanol less than 10 minutes later

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Biofuels – Pilot Scale

- LS9, Okeechobee, FL
  - Uses biocatalysts to convert renewable feedstocks in a single-step fermentation process
  - Tailor the chain length, functionality, etc. of each product
  - Product scale demonstration facility (135kl) and potential larger scale fermentation capability (4 vessels @ 750kl each) which they estimate could produce approximately 10 million gallons per year of product

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Biofuels – Small Scale

- Applied Research Associates, Inc., Panama City, FL
  - Partnership with Chevron Lummus Global Catalytic Hydrothermolysis process and CLG's market-leading hydroprocessing technology.
  - CAPEX of $1 per annual production gallon and OPEX similar to petroleum refining costs
  - Converts oils from plants or algae into jet and diesel fuels

- Genuine Biofuel, Inc., Indiantown, FL
- Ag-Oil, LLC, Boca Raton, FL
- Agri-Source Fuels, LLC, Dade City, FL
- Smart Fuels Florida, LLC, Fruitland Park, FL
- Greenwave Biodiesel, Inc., Ft. Lauderdale FL
- Florida Biofuels, LLC, Fort Myers, FL
  - These companies use virgin/used cooking oil, vegetable oil, recycled restaurant grease, and/or animal by-products, etc. to create biodiesel

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Demonstration/Test Facilities

- Thermochemical Conversion

  Clean Energy Research Center at USF – new catalyst

- Cellulosic Ethanol

Stan Mayfield Biorefinery Pilot Plant in Perry, FL

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Research and Development Opportunities

Develop and optimize biofuel feedstocks

- Energy rich
- Cultivars with improved biosafety
- Growing systems for Florida annual and perennial grasses
- Reduced pesticide and fertilizer
- Less water usage
- Conversion to sugars easier
- Reduce variability around feedstock quality – sugar content, moisture, and ash

Ongoing research at Florida universities

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Research and Development Opportunities

- Utilizing spent feedstocks to produce additional bioenergy and products such as fertilizers
- Maximizing solids loading, associated solids handling issues
- More efficient pretreatments to free up cellulose to enable more efficient downstream conversion
- Better enzymes/organisms to improve efficiency of conversion process
- Utilization of waste streams
- Chemical pathways for converting biomass to fuels that are more compatible with current infrastructure
- Determining full life-cycle greenhouse gas emissions of various biofuel crops
- Economic modeling

Ongoing research at Florida universities

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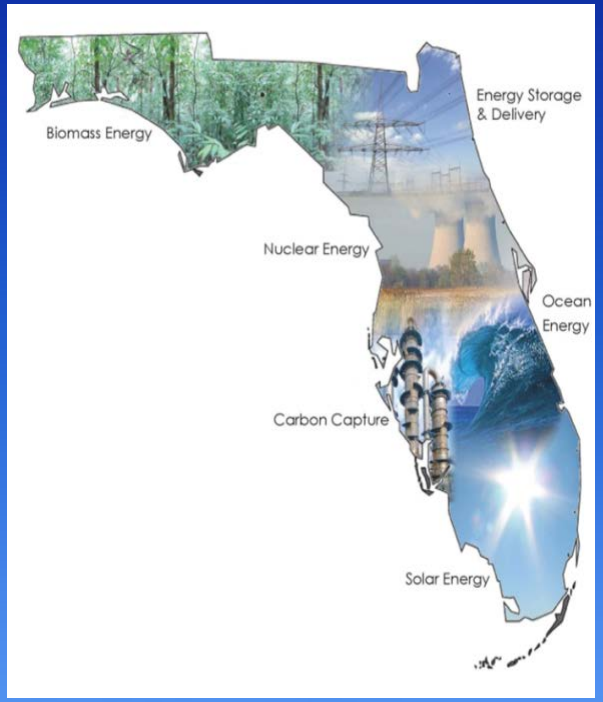
Created by Statute in 2008

Unites energy experts among Florida's 11 Universities so that the State is a leader in research and development of innovative energy systems

Unique in US, no other state has a statewide energy consortium among all of its universities

FESC network involves more than

- **300 State University System Faculty**
- **30 Centers and Institutes**
- **200 Companies within Florida**



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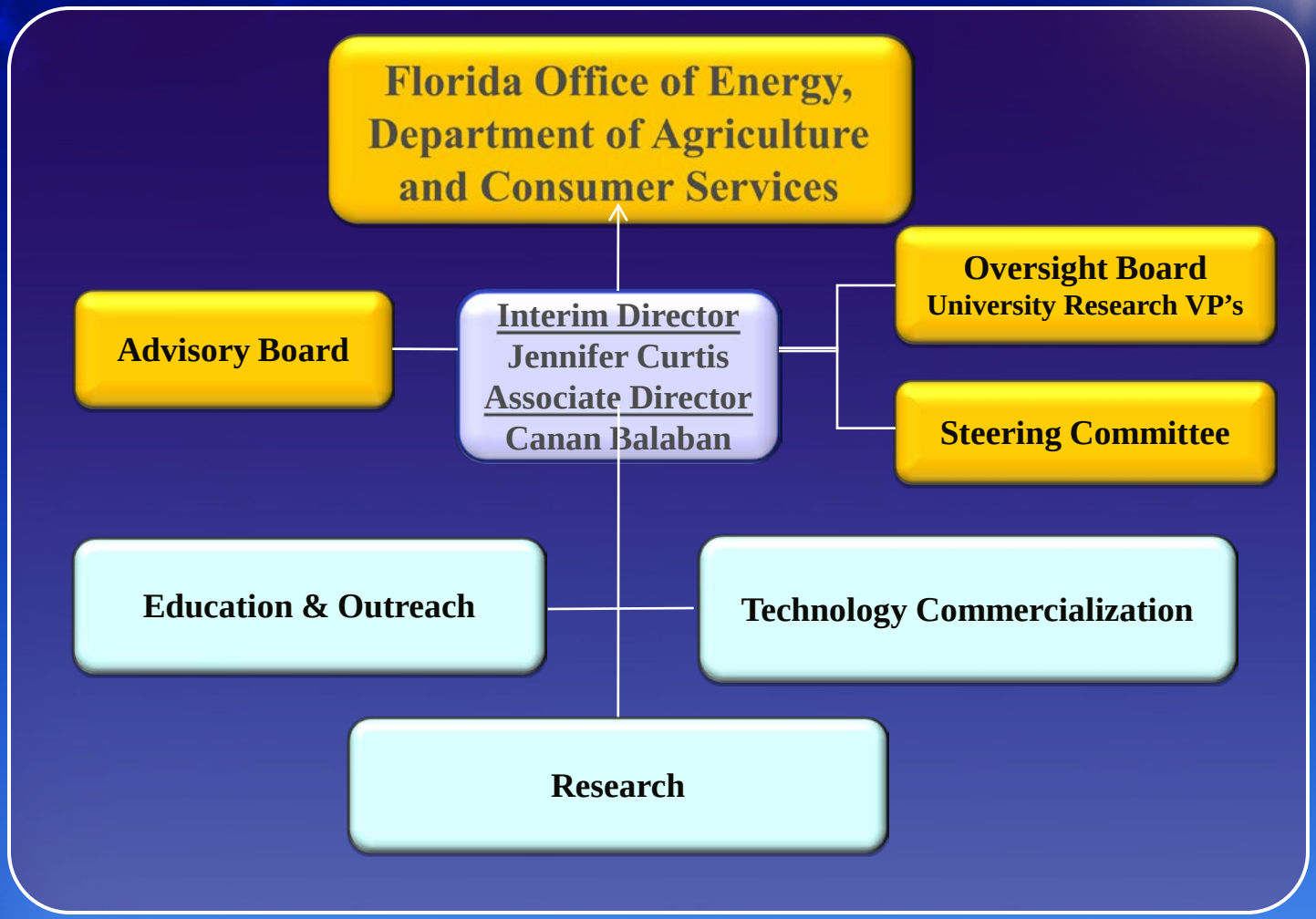
FESC Leadership Structure



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Summary of FESC Successes

- Leveraging of the initial $38 million state appropriation in 2008 to obtain ***an additional*** $265 million in energy research funding from third parties to entities in the state of Florida
- Translation of this energy research funding into 169 invention disclosures and 64 energy technologies licensed to industry
- Creation of 24 start-up companies in the energy sector
- Conducted 69 energy workshops for Florida industry education and training
- Workforce development – support offering of an Alternative Energy Technologies Associates Degree (which has been implemented at 5 community colleges)

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FLATE
FLORIDA ADVANCED TECHNOLOGICAL EDUCATION CENTER
A National Science Foundation Regional Center For Advanced Technological Education

Summary of FESC Successes

- Delivery of 30 continuing education classes for Florida licensed building contractors and architects
- Dissemination of more than 50 Fact Sheets and two books informing the Florida public of both how to modify their energy use and avenues for funding energy efficiency improvements
- Educating, through their direct involvement in energy-related research and technology projects, over 300 undergraduate and post-graduate students at Florida universities
- National dissemination of FESC research results - over 700 publications and over 700 presentations - that have promoted Florida's energy capabilities and technical leadership

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