



EERC

EERC Technology... Putting Research into Practice

Algae – A Future Component of the U.S. Energy Solution

**Carbon Recycling Forum
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Grand Forks

What Does the EERC Do?



- The EERC is recognized as one of the world's leading developers of:
 - Cleaner, more efficient and innovative energy technologies to guarantee clean, reliable energy supplies for the United States and the world.
 - Environmental technologies to protect and clean our air, water, and soil.
- The EERC is a research, development, demonstration, and commercialization (RDD&C) center.
- The EERC vigorously maintains a nonadvocacy position.
- The EERC enhances any guarantee.
- The EERC is NOT an academic enterprise.

EERC RDD&C

EERC ES31650.CDR



Over 245,000 square feet of state-of-the-art facilities.

“... the road to energy independence runs right through Grand Forks and up to the front doors of the EERC.”

–U.S. Senator Byron Dorgan



Strategic Solutions to Real-World Problems

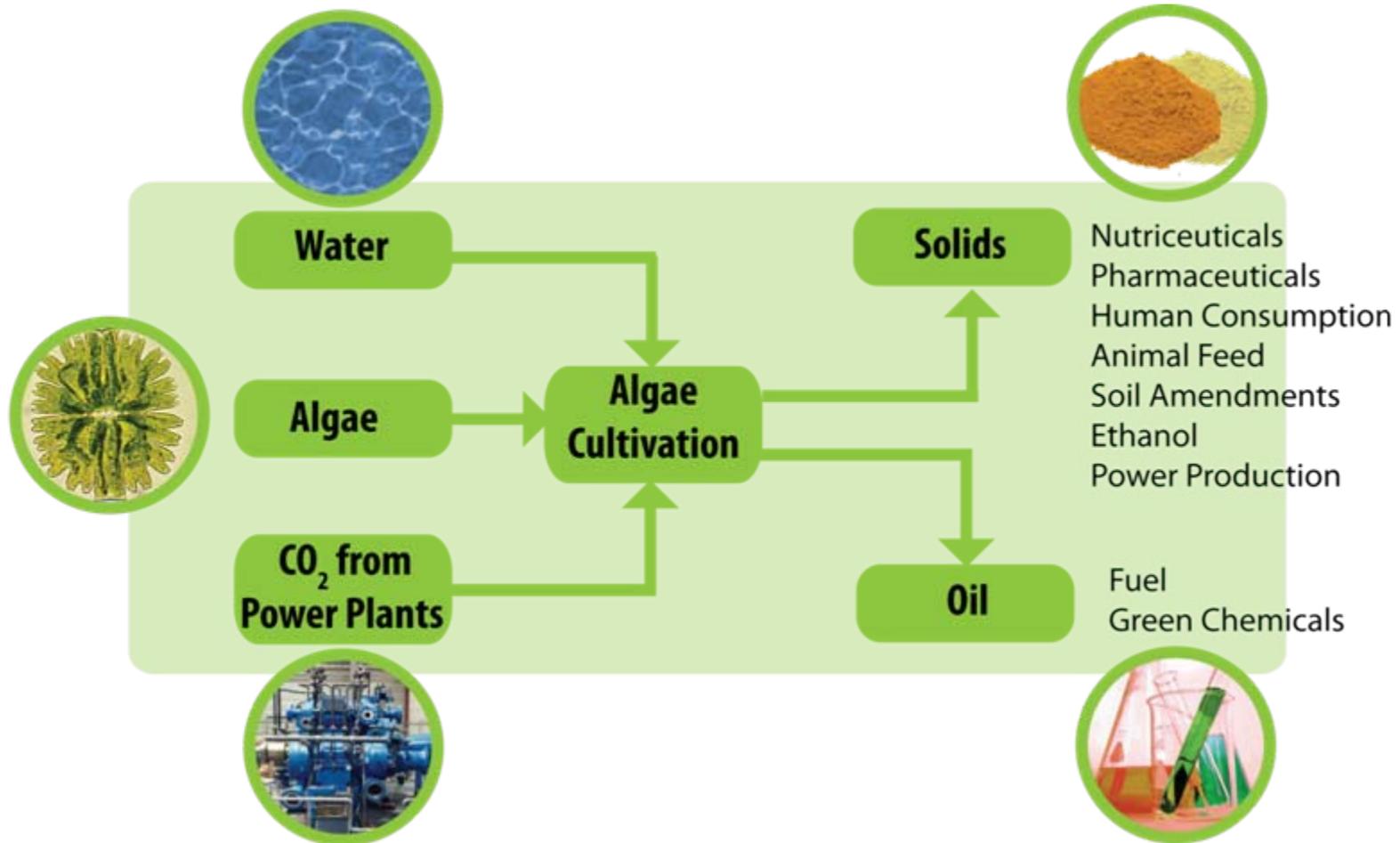
The EERC provides practical, cost-effective solutions to today's most critical energy and environmental issues and challenges. Our research portfolio includes:

- **Clean coal technologies**
- Coalbed methane
- Underground coal gasification
- Emission control
 - SO_x , NO_x , air toxics, fine particulate, and CO_2
- Mercury measurement and control
- **CO_2 capture and sequestration**
- Global climate change
- **Energy and water sustainability**
- Energy-efficient technologies
- Distributed power generation – various fuels
- Hydrogen technologies
- **Alternative fuels**
 - Ethanol, biodiesel, biojet, Fischer–Tropsch (FT) fuels, and strategic fuels for the military
- Biomass
- Wind energy
- Water management
- Flood prevention
- Waste utilization
- Contaminant cleanup
- Advanced analytical technologies/extraction technologies
- Pesticides and neurological diseases

EERC Quick Facts

- Total value of current EERC contract portfolio is \$227 million.
- The EERC had 434 active contracts in FY08.
- In FY08, 87% of contracts were with private sector partners.
- Total employment of over 330 highly skilled scientists, engineers, and support personnel, with about 20 new open positions.

Algae – Part of the Answer for U.S. Energy Security



Why Use Algae for Biofuels?

- Greenhouse gas reduction
 - Renewable feedstock
- Does not compete with food
- Does not compete with high-value agricultural land
- Higher-energy-density oil with more potential fuel products
- Potential to stimulates rural economies
- Provides energy security



Unwanted algae in bay off of Qingdao, on an east China coast

Projected Oil Production Yields

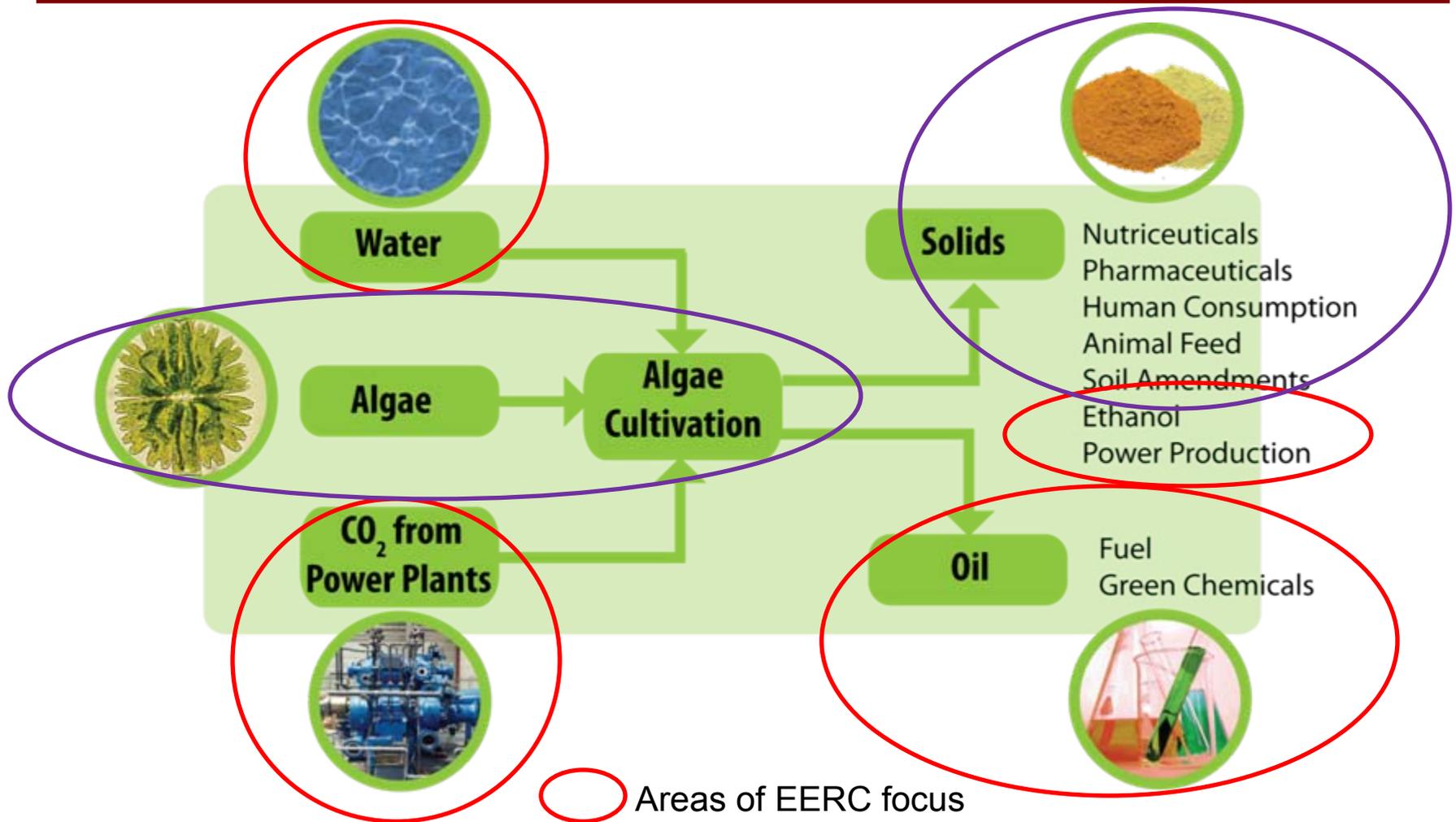
Feedstock	Gallons of Oil per Acre per Year
Soybean	48
Sunflower	102
Rapeseed	127
Castor Bean	151
Jatropha	200
Kukui	237
Coconut	287
Palm Oil	635
Microalgae	5000–15,000

Path to Algae Utilization



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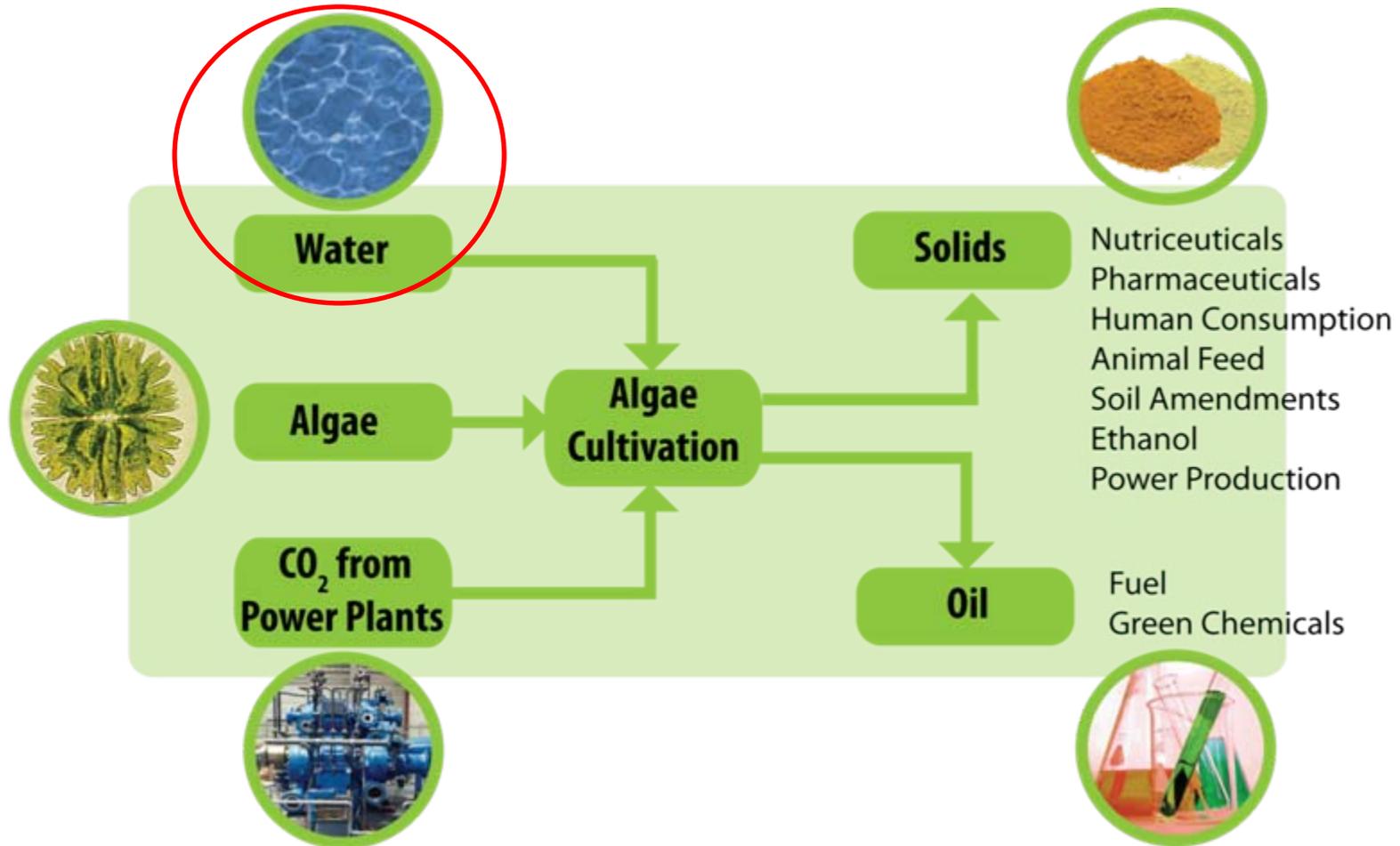
Algae – Part of the Answer for U.S. Energy Security



○ Areas of EERC focus

○ Areas of EERC partner focus

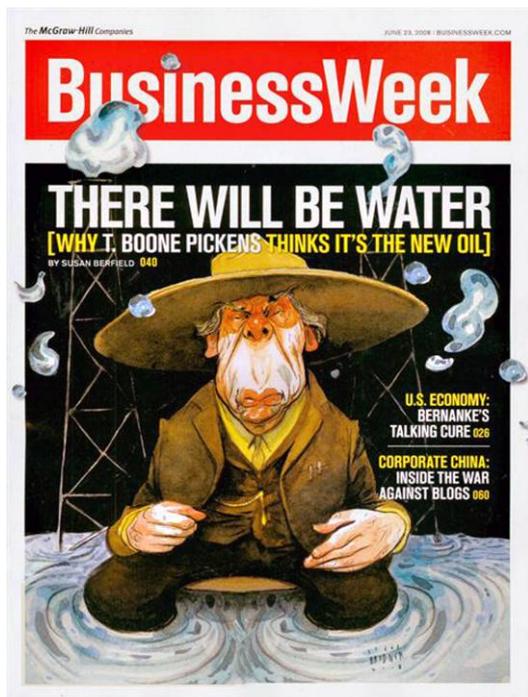
Algae – Part of the Answer for U.S. Energy Security



Water

“Whiskey is for drinking, water is for fighting.”

– Mark Twain



Water Consumption for Algae Growth

- Water consumption varies significantly with each system type.
 - Closed-loop(less) vs. open-loop design (more)
 - Pond (more) vs. reactor design (less)
- Able to utilize brackish water.
- Use gray water from power production, CO₂ cleanup, coalbed methane production, ...



EERC Water Activities

The EERC works with industry and technology developers to evaluate and commercialize water solutions.

EERC projects focused on water issues related to energy:

- Great Plains Water Consortium – Stakeholder-based program focused on methodologies and technologies for water minimization
- CO₂ Water Consortium – Dealing with water issues tied to CO₂ capture and sequestration and water reuse
- Power plant water capture and minimization



Water Content of Flue Gas

A 700-MW coal plant flue gas may contain approximately 1000–2400 equivalent liquid gpm of water.

Varies with coal moisture.

Varies with treatment.

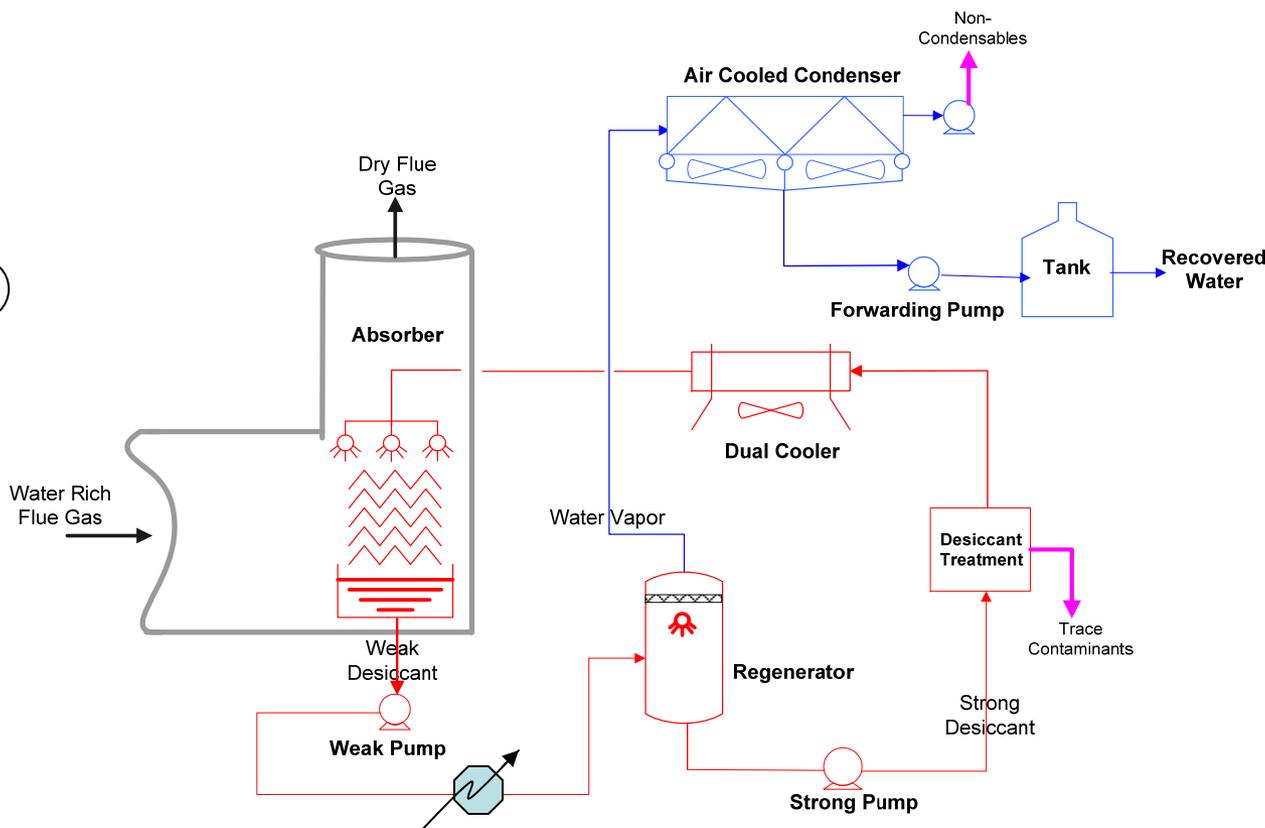
Water Extraction Technology - In Partnership with Siemens Power Generation

WETEX™ involves the installation of a desiccant based water absorption system to extract the combustion product water from the flue gases.

Recovery Rate

30% - 40% Water recovery is readily achievable. Higher rates possible, but drives system costs.

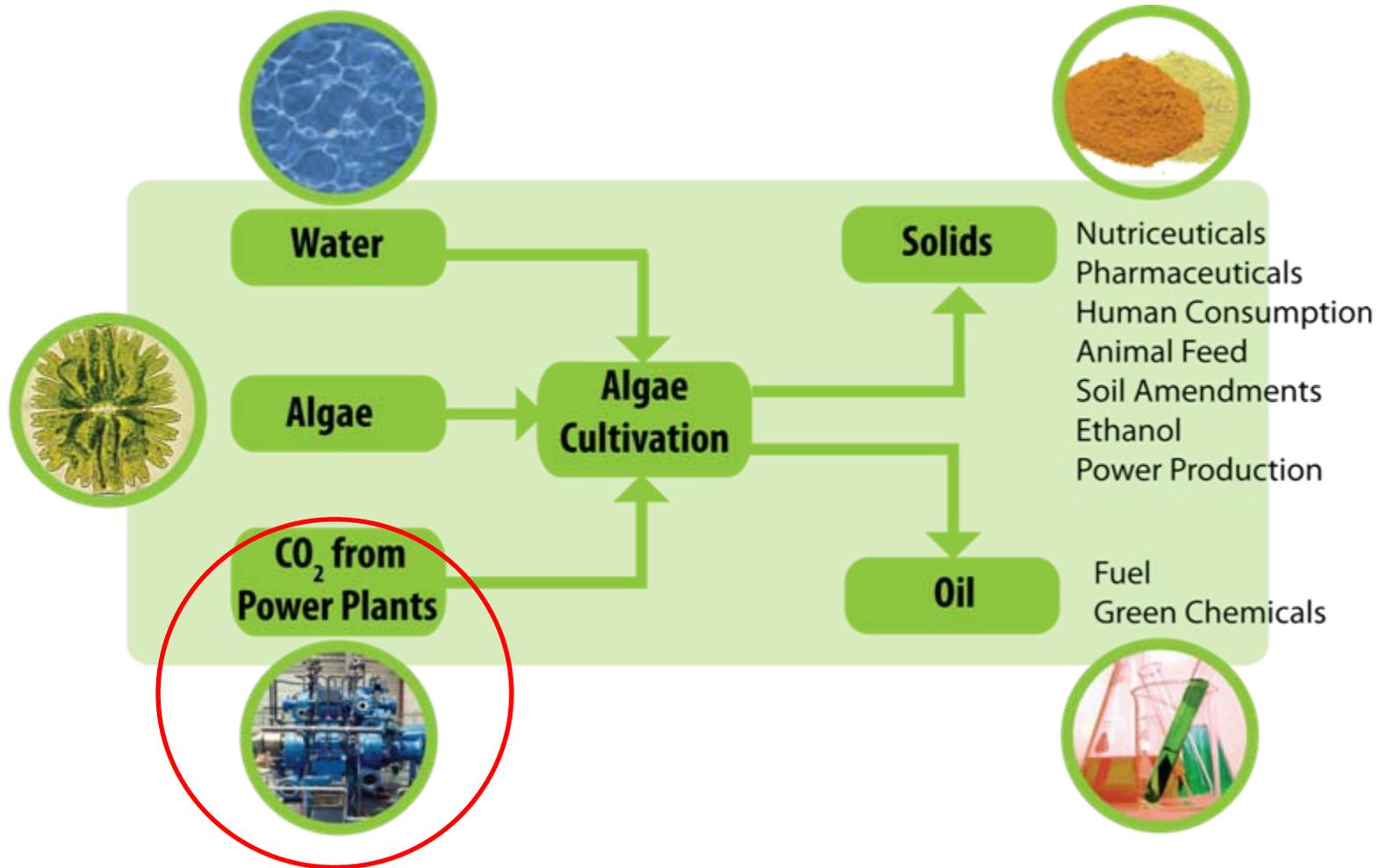
The water is then extracted from the absorption system and is made available for use within the plant.



•Pilot Facility Tested – 1MW system



Algae – Part of the Answer for U.S. Energy Security



Power Plant CO₂ for Algae Cultivation

Few companies currently using power plant CO₂.

Variations in coal and operational performance can alter algae performance (significantly?).

Key – How to produce a consistent, high-quality CO₂ feedstock.

Seambiotic



 **GREENFUEL**
TECHNOLOGIES CORPORATION



Algae becomes a flue gas-scrubbing system (removing CO₂ and NO_x).

Center for Climate Change and CO₂ Sequestration



- The EERC is one of the leading organizations selected by the U.S. Department of Energy (DOE) to determine the best ways to manage our country's CO₂ emissions.
- The EERC's Plains CO₂ Reduction (PCOR) Partnership is the largest of seven lead organizations around the nation heading up an effort to meet the President's Global Climate Change Initiative.
- The EERC PCOR Partnership was awarded \$67 million to advance commercialization of climate change technologies to capture and permanently store greenhouse gases. This award is the EERC's largest single award to date.

PCOR Partnership Region

Nine states and four
provinces

1,362,089 square miles

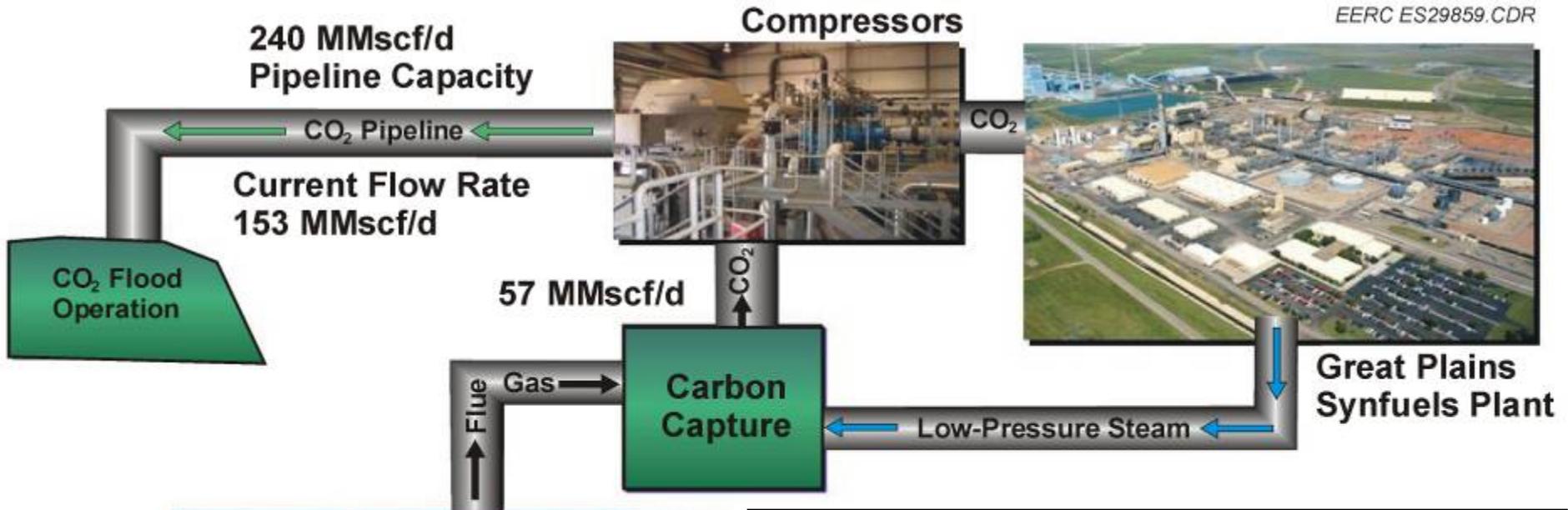


The PCOR Partnership has brought together the key stakeholders to make geologic CO₂ sequestration a viable option for carbon management in our region.



Phase III: Williston Basin Project Overview

EERC ES29859.CDR



Antelope Valley Station

- Capture at least 500,000 tons/yr of CO₂ at existing coal-fired power plant in central North Dakota.
- Transport via pipeline to Williston Basin oil field.
- Meet or exceed all of the DOE Phase III objectives.
- Conduct activities to document the efficacy of carbon capture and storage.
- Ultimately monetize credits.

The Partnership for CO₂ Capture



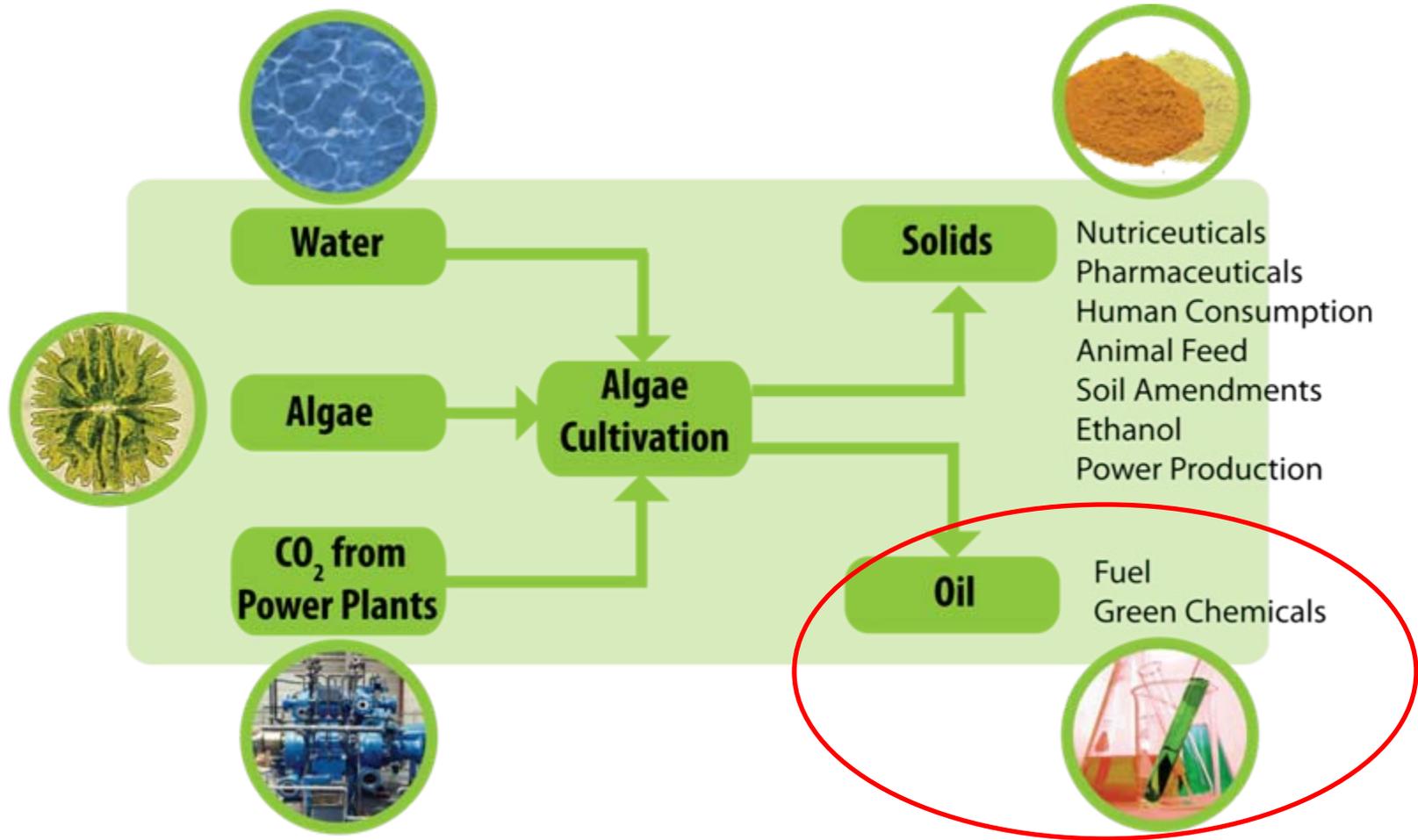
\$3.4 million program

**\$1 million sister program for water issues
In CO₂ capture**

Sponsors Include:

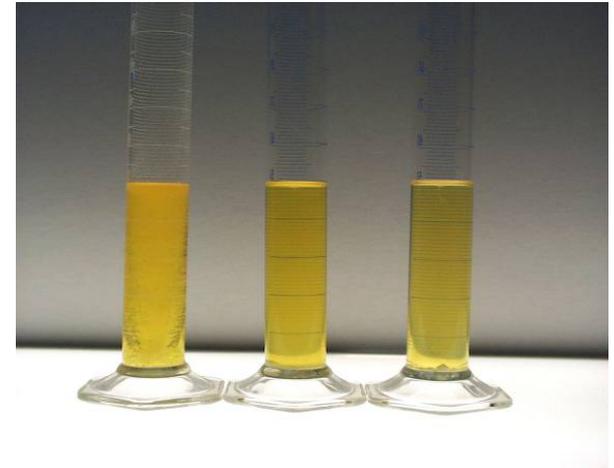
- MN Power
- C-Quest
- Black & Veatch
- Midwest Generation
- Huntsman
- SaskPower
- PPL
- Transalta
- ATCO Power
- Basin Electric
- Constellation Energy
- ICCI
- DOE
- NDIC

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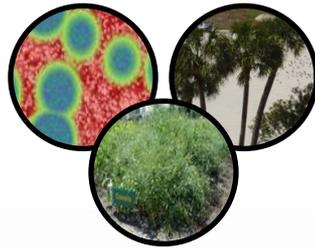
Producing Fuel from Algae Oil

- The EERC has produced 100% renewable JP-8 (jet fuel) from multiple crop oils – no expected differences with algae oil.
- Currently partnered with two DARPA (Defense Advanced Research Projects Agency) awardees to convert algae oil to JP-8.
- In discussions with multiple algae producers to conduct fuel production tests.

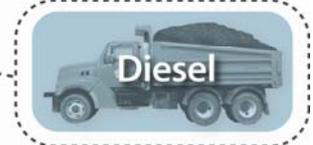


EERC Process Produces Spec-Compliant Fuel from Renewables

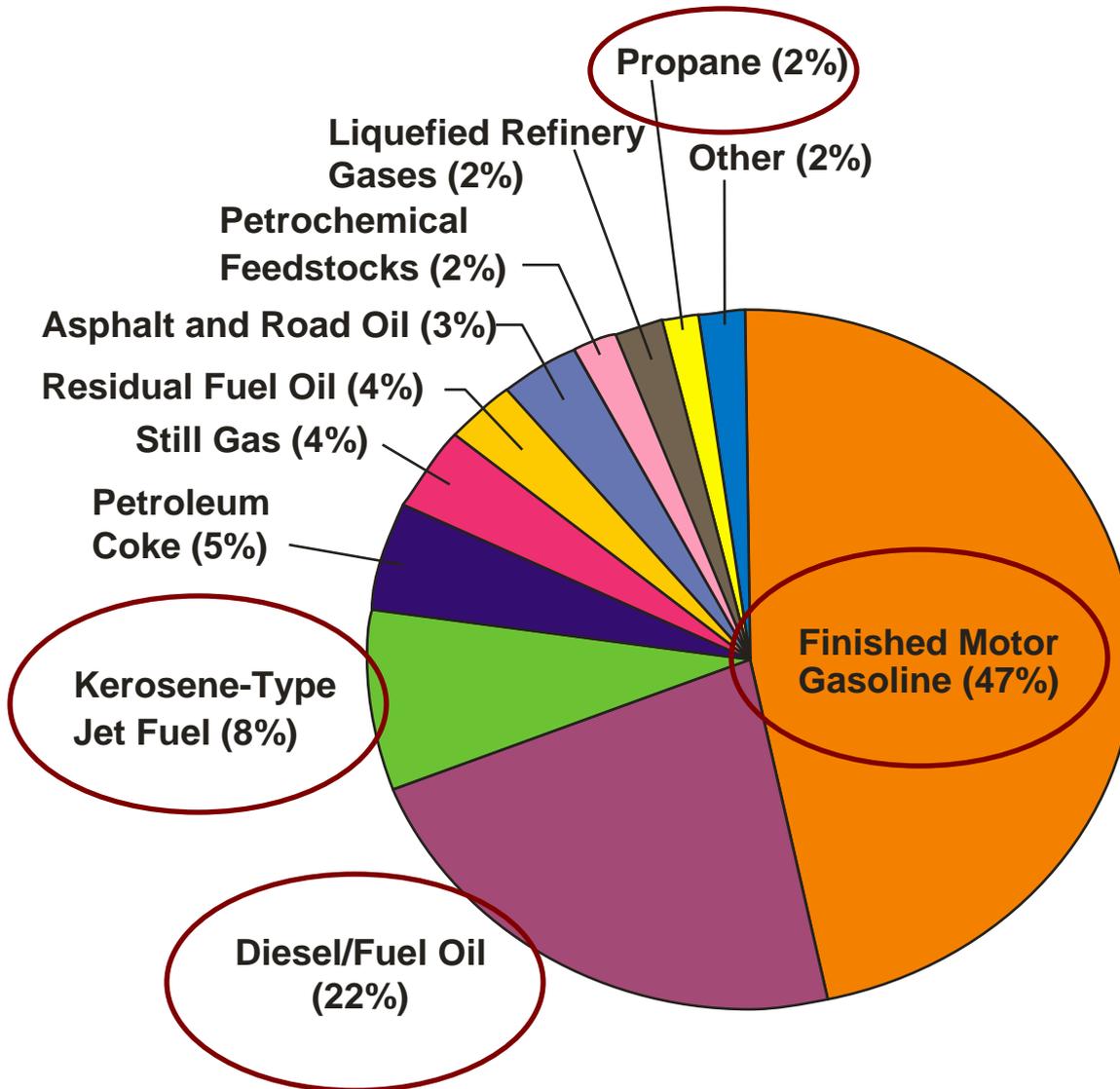
Crop Oils
Algae Oils



Suite of Fuels



Crude Oil Disposition



The EERC process will produce at least 80% of the suite of products from crude oil.

The primary focus has been on producing 100% renewable jet fuel (JP-8) for the U.S. military (DARPA).

DARPA Project Overview

- Fuel sample submitted to U.S. Air Force
 - Qualified as JP-8 based on seven key fuel property screening tests
 - Ahead of our development schedule
 - Ahead of our DARPA competition
- Economic modeling
 - Feedstock scenarios
 - Process scenarios
 - Evaluating field-to-fuel options based on feedstock production and processing economics
- Commercialization
 - Identifying partners and scenarios, partnership discussions ongoing
 - Assessing early market entry options



EERC Renewable JP-8 vs. Petroleum JP-8

**EERC
renewable
JP-8 meets key
specifications –
testing
conducted by “a
government
research
laboratory”.**

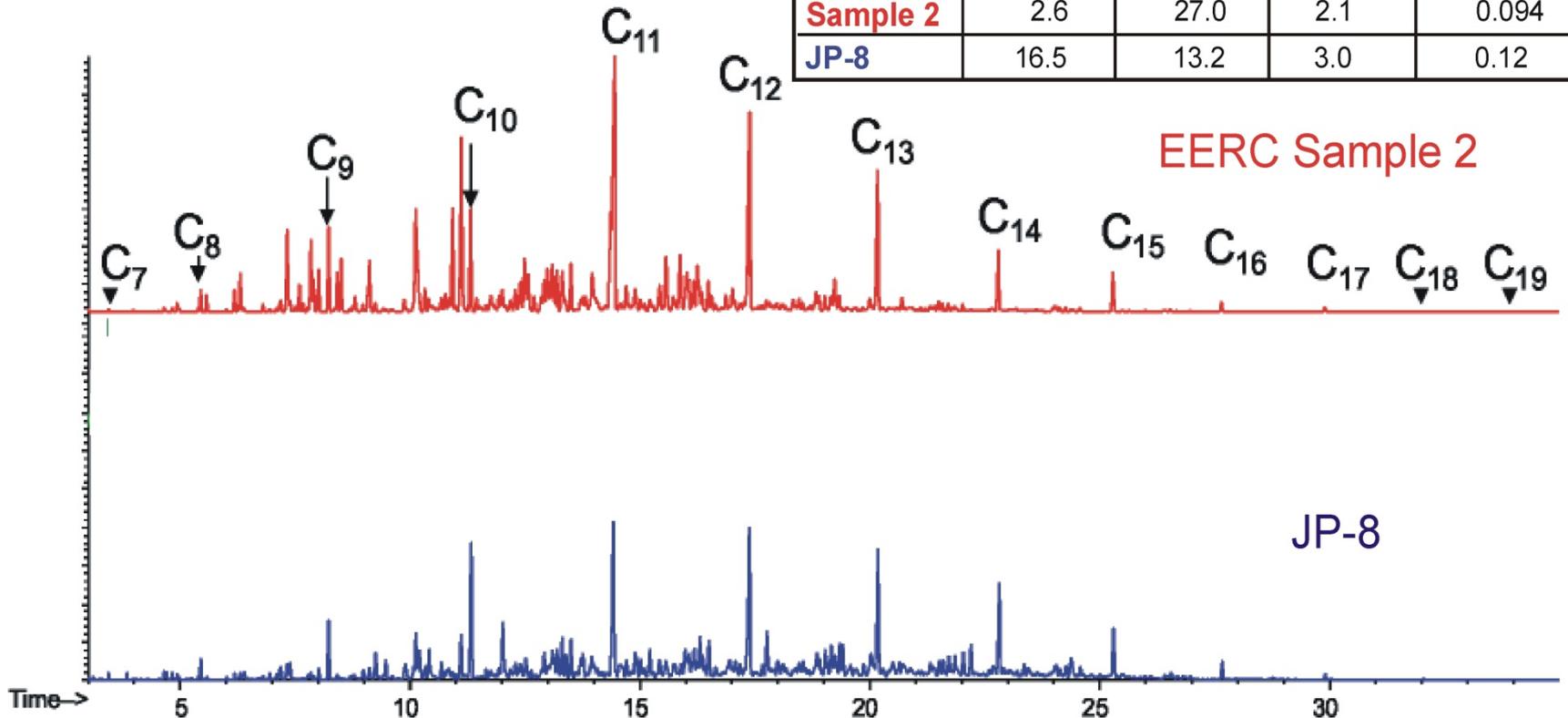
Specification Test	EERC JP-8	JP-8 Avg	JP-8 Spec.
Aromatics, vol%	19.8	17.9	≤25.0
Olefins, vol%	1.9	0.8	≤5.0?
Specific Gravity	0.805	0.803	0.775–0.840
Flash Point, °C	49	49	≥38
Freeze Point, °C	-52	-51.5	≤-47
Heat of Combustion, MJ/kg	42.9	43.2	≥42.8

Composition Comparison – EERC JP-8 vs. Petroleum JP-8

Looks like petroleum JP8 – just a new, renewable source.

EERC TA31442.CDR

Weight % n-Paraffins				
	C ₇ -C ₉	C ₁₀ -C ₁₃	C ₁₄ -C ₁₆	C ₁₇ -C ₁₉
Sample 2	2.6	27.0	2.1	0.094
JP-8	16.5	13.2	3.0	0.12



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