Progress of Algal Mass Cultivation and CO$_2$ Sequestration at ENN’s Algal Demonstration Facility in China
Founded in 1989, ENN's mission is to innovate the process of providing and producing clean energy; our vision is to become a respected global clean energy company.

In 2006, ENN Research and Development Co., Ltd. is formed and a world leading low-carbon technology system for clean energy production from coal was put into testing.

- Underground coal gasification
- Catalytic Coal gasification
- Bio-absorption and bioenergy
- Full-Spectrum Solar Energy Technology
Bioenergy Center: 7 Years of Intensive R&D

The Research Building of ENN’s State Key Laboratory of Coal-based Low Carbon Energy

The Bioenergy Research and Development Center located in Langfang, Hebei

A Pilot Base of Eco-city for micro-algae cultivation in Langfang, Hebei

ENN’s Algal Demonstration facility in Darlat, Inner Mongolia
ENN’s Proprietary Algal Technologies

- **ENN high-performing algal strain collections:**
  Over 200 strains collected for various products. Some strains’ oil contents higher than 50%, with great industrial potential.

- **High-efficiency PBRs:**
  With ENN’s low-costing microalgae cultivation technology, its productivity about 26g/m2/d.

- **Waste utilization technology:**
  Microalgae was grown by utilization of flue gas CO₂, RO brine and low-grade waste heat in a desert area for a full growth season.

- **Low-cost microalgae harvesting and oil extraction technology**
  10 tons of algae oil were obtained for jet oil
Diverse Cultivation Systems
Industrial Scale D/S Processing Capacity
ENN algal bank consists of above 200 microalgae strains, aiming at development of biofuel, animal and fish feed, high-value products etc.
High-performing Strains for Oil Production
-Advanced HTS technology

Algal Strain Screening

ENN2203A

ENN1401A

High oil content and stress tolerance

Total hydrocarbon content of 49%, growth rate of 0.5g/d and biomass concentration as high as 8g/L
The mutant CL-39 selected from 2460 mutants is resistant to drug & high temperature and used in pilot scale test.

The vectors can be modified for other strains to enhance the fatty acids content.
Co-location with a Coal Gasification Plant

- Utilization of waste CO2, water, and heat as resources by algae

- Full utilization of waste CO2, waste water, and waste heat from a Coal Gasification Plant through highly productive algal cultivation.

- Complete reuse of supernatant generated during harvesting.

Coal gasification plant

Continuous algal cultivation

Supernatant treatment for recycling
Consistent Improvement in Biomass Yield
-Continued breakthroughs in cultivation technology

Increase in vertical circulation of culture + Effective control of contaminants + Dynamic regulation

Algal biomass productivity more than doubled from 2011 to 2014
Long-term Stable Outdoor Cultivation
-Enabled by effective contamination control

-Dynamic and effective contamination control methods were developed by understanding the interrelationships of the key protozoa and bacteria in the algal ponds

-Long term (whole production season) stable outdoor cultivation in a 1200m2 pond at the demonstration facility was achieved.
Low-cost Harvesting Technology
-A two-step dewatering process

- High efficiency separation, with biomass concentration reaching 30g/L at first step
- Followed by a centrifugation, generating paste with 25-30% solids
Proprietary Oil Extraction Technology
-Subcritical wet extraction

Sub-critical Oil Extraction Technology can extract 99% total lipids from algae sudge

Separation of Oil(organic) phase and algae residuals(water) phase after extraction

Oil content in organic phase:
- 79.26% at 130°C
- 92.71% at 135°C
- 98.98% at 137°C
- 96.61% at 140°C

Oil content in water phase:
- 0% at 130°C
- 0% at 135°C
- 0% at 137°C
- 0% at 140°C

Oil components of algae:
- C14:0: 7%
- C16:0: 26%
- C18:2: 58%
- C22:6: 4%
- Others: 5%
Ten Metric Tons of Algal Oil Produced
-Used for the development of aviation oil and biodiesel
From Algae to Multi-products (C4F)

Algae CO$_2$ fixation → Multi-products → Markets and Value

- Carbon dioxide
- Salt water
- Desert land
- ENN algal strains

Mass cultivation → Fuel → Jet fuel, Biodiesel, Bio-oil, EPA

Mass cultivation → Food → DHA, β-carotene, Astaxanthin, Food additive

Mass cultivation → Feeds → Aquatic feed, CO$_2$ fixation
ENN’s Algal R&D Team

ENN microalgae research team consists of more than 40 senior engineers and scientists in Langfang research center with over 200 support employees; And over 30 engineers and works in demonstration facility in Inner Mongolia.