What does this group do?

- **What are biofuels?** Fuels made from biomass.
- **What is biomass?** All material that comes from living things like plants and animals.
- **Why are biofuels better than fossil fuels?**
  - *Biofuels are renewable!* The source that they come from – biomass – can regenerate quickly.
  - *Biofuels avoid carbon pollution!* The carbon dioxide put into the air when biofuels are made and used is taken out of the air by plants as they grow.

**BIOFUELS RESEARCH!**

- Biofuels Carbon Cycle
  - *Biofuels are carbon neutral*
    - CO₂ uptake via photosynthesis
    - Feedstock production
    - Feedstock transportation
    - Biofuel production
    - Biofuel distribution
    - Combustion is offset

- Fossil Fuel Carbon Cycle
  - Extraction
  - Refining
  - Distribution
  - Combustion
  - The petroleum process emits previously sequestered below ground carbonaceous compounds into the atmosphere

The biofuels process *recycles* atmospheric carbon.
Ongoing projects: Algae

Flue gas → Raw algae → Crude algae oil → Purified algae oil → Fuel-like hydrocarbons

Protein, phospholipids, etc. → Chlorophyll → CO\textsubscript{x} & propane

1. Flue gas from coal-fired power plants
2. Algae (0-10% CO\textsubscript{x})
3. Lipid extraction
4. Lipid purification
5. Lipid upgrading
6. Protein, phospholipids, etc.
7. Chlorophyll
8. CO\textsubscript{x} & propane
## Ongoing projects: Catalysis

### Semi-batch deoxygenation of tristearin over Ni-containing catalysts at 260 °C

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Conversion (%)</th>
<th>Selectivity to C10-C17 (%)</th>
<th>Selectivity to C17 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% Ni/Al$_2$O$_3$</td>
<td>26</td>
<td>87 [23]</td>
<td>72 [11]</td>
</tr>
<tr>
<td>20% Ni-1% Cu/Al$_2$O$_3$</td>
<td>29</td>
<td>94 [24]</td>
<td>56 [16]</td>
</tr>
<tr>
<td>20% Ni-2% Cu/Al$_2$O$_3$</td>
<td>85</td>
<td>95 [80]</td>
<td>65 [56]</td>
</tr>
<tr>
<td>20% Ni-5% Cu/Al$_2$O$_3$</td>
<td>&gt;99</td>
<td>99 [98]</td>
<td>71 [71]</td>
</tr>
</tbody>
</table>

Boiling point distribution plots of two feeds and their continuous deoxygenation products at 260 °C

Catalyst characterization via XPS
### What skills and expertise can you acquire?

<table>
<thead>
<tr>
<th>Engineering Area</th>
<th>Algae Skills</th>
<th>Catalyst Skills</th>
</tr>
</thead>
</table>
| **Chemical Engineering**                  | • Reactor design  
• Reactor operation  
• Power Plant Integration | • Experiment design  
• Reactor operation  
• Processing and analysis |
| **Materials Engineering**                 | • Reactor cost reduction  
• Materials optimization  
• Materials interactions | • Catalyst synthesis  
• Catalyst characterization  
• Materials development |
| **Biosystems Engineering**                | • Algae culturing  
• Algae processing  
• Algal biofuels synthesis | • Biofuels synthesis  
• Analysis of feeds and products  
• Biomaterials processing |
| **Mechanical Engineering**                | • Equipment design  
• Parts development  
• Reactor construction | • Equipment design  
• Equipment modifications  
• Equipment repair and upkeep |
Additional info

• Where does the biofuels group get funding from?
  
  National Science Foundation  
  U.S. Department of Energy  
  KY Dept. of Energy Development & Independence  
  U.S.-China Clean Energy Research Center

• Where does the biofuels group publish?
  
  Chemical Engineering Journal  
  Industrial & Engineering Chemistry Research  
  Fuel  
  Catalysis Today  
  Energy & Fuels  
  Applied Catalysis  
  RSC Advances  
  Bioenergy Research

• Where does the biofuels group present its results?
  
  North American Catalysis Society Meeting  
  American Chemical Society National Meeting  
  International Conference of Environmental Catalysis

• Where do students that work in the biofuels group go afterwards?
  
  Industry (e.g. Eastman, Charah, Big Ass Solutions)  
  Government (e.g. EPA, National Labs)  
  Graduate or Medical School  
  Academia (e.g. Utrecht University, U. Wisconsin – Madison)