GREAT LAKES BIOENERGY RESEARCH CENTER

Script for Life Cycle Assessment of Biofuel Energy Powerpoint and Video

Slide 1: Life Cycle Assessment of Biofuel Energy

Slide 2: A life cycle assessment, or "cradle to grave" study, is an analysis of materials and/or energy moving through a process, in this case, the production and consumption of ethanol. A life cycle assessment can help to weigh the pros and cons of using ethanol over gasoline in terms of energy use, carbon dioxide emissions and other environmental factors. It's not just about how much energy is in one gallon of gasoline compared to one gallon of ethanol. It's looking at all the steps along the way, from planting a crop, to harvesting it, to transporting it, to refining it, to vehicle use.

There are many different steps in the production of ethanol. We're following its path all the way from the sun's input to the plant to the engine in your car. In this video, watch for where the energy is put into the cycle, what form it takes, and how it is used.

Slide 3: We'll start with photosynthesis. The sun provides energy to the plants, which photosynthesize and create biomass. Biomass can be anything from trunks of poplar trees, to corn stalks, to blades of switchgrass. The energy in biomass is stored in the chemical bonds of carbohydrate molecules, which can be simple sugars, starches or cellulose. This biomass will eventually be used to create ethanol.

Slide 4: Once the biomass crop reaches maturity, it is harvested and transported to a refinery, where it will be turned into ethanol.

Slide 5: In a traditional ethanol refinery, the biomass passes through many complex steps. We'll explain the details later on. This slide demonstrates the transformation of the chemical energy in carbohydrate molecules into ethanol. Most of today's refineries use yeast or E. coli to ferment the plant sugars, such as glucose, into ethanol, with carbon dioxide and heat energy as biproducts of the reaction. The ethanol still carries most of the energy the plants harvested from the sun.

Slide 6: The ethanol from the refinery is then transported to gas stations and other places where it can be put into vehicles.

Slide 7: When you fill up your gas tank and start your car, ethanol is burned in your engine, releasing chemical energy in a process called combustion. Combustion converts chemical energy into kinetic energy, the energy of motion. This process is not 100% efficient. Heat energy, water, and carbon dioxide also are released in the process.

Slide 8: As with creating petroleum products, making ethanol is energy-intensive.
Energy plays an even bigger role in this process than we've already described. So far we showed how plants took in energy from the sun to grow more biomass. That biomass was harvested and taken to a refinery where it was fermented into ethanol. That ethanol was then taken to a gas station, where you filled your tank and drove away. The life cycle assessment calculates those inputs, but also considers energy inputs that aren't always obvious to us in our everyday lives. Let's look at other places energy is used in this system.

Slide 9: We started the process with photosynthesis and the growing of a biomass crop. Farmers put a great deal of energy into growing those crops. For example, many fertilizers farmers use are created using natural gas. Farm machinery used to plant, weed, and harvest crops normally run on fossil fuels like diesel. We often forget that farming is a process that requires a lot of chemical energy.

Slide 10: As we mentioned earlier, refining biomass into ethanol is complex. First, the biomass is chopped up or ground so it can be refined more easily. Chemicals and enzymes are added to further break down the plant matter into simpler molecules, then yeast or E. coli are used to ferment the carbohydrates into ethanol. The last step of refining is distillation, which results in highly concentrated ethanol for use in a vehicle. A great deal of energy from heat and electricity is used throughout this process to convert the energy in the plant biomass into ethanol.

Traditionally, electrical energy is supplied by coal, nuclear energy and natural gas. These fuel sources are used to light the plant, run the equipment, and refine the biomass.
In a cellulosic operation the refinery may instead burn waste biomass for heat or electrical generation and may actually become net producers of electricity on the grid. Knowing that a life cycle assessment looks at the balance between inputs and outputs, this means that by burning biomass, the refinery potentially becomes an electricity producer instead of a consumer.

Slide 11: Another energy user often overlooked is the transportation system that moves raw materials and finished products. Harvested crops are transported to the refinery and ethanol is transported to gas stations. Petroleum is normally used to fuel the vehicles in this system. The energy in this step is released through combustion, which converts chemical energy into kinetic energy of motion and heat energy. Water and carbon dioxide, with their corresponding bond energies, are also released during this process.

Slide 12: For our life cycle assessment we traced the energy inputs and outputs through our ethanol production system. It started with the sun, moved through the plants to the refinery, and ended with your ethanol-powered vehicle. Along the way inputs from farming practices, transportation systems and the refinery itself changed the energy balance of the system. Scientists are currently researching ways to increase the efficiency of the process and reduce fossil fuel inputs into the system.

Reviewing the entire process, how would you make this system more efficient?