

Bioenergy

ALS 3133

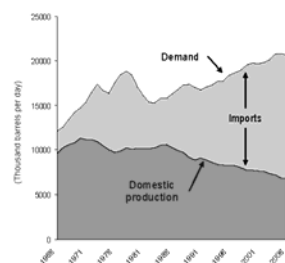
Bioenergy

- Technologies use renewable biomass resources to produce an array of energy related products including:
 - Electricity
 - liquid, solid, and gaseous fuels
 - Heat
 - chemicals and other materials
- Bioenergy ranks 2nd (to hydropower) in renewable US primary energy production & accounts for 3% of the primary energy production in the US

Why Bioenergy?

- Huge opportunity to use domestic and sustainable resources to provide fuel, power, & chemical from plants and plant-derived (organic) materials.

Figure 1: U.S. petroleum production capacity and demand



Bioenergy forms

- **Biogas** is produced by certain strains of bacteria. In the absence of oxygen, these bacteria break down biomass, such as animal manure and landfill waste, to produce a combustible gas made of CH₄ (methane) and CO₂. Biogas may be used as a natural gas alternative for heat and electricity.
- **Biodiesel** is produced from new/recycled vegetable oils, tall oils, algae
- **Bioethanol** is produced from starch and cellulose components in biomass.

Biomass

- "Biomass" means any plant derived organic matter available on a renewable basis
 - energy crops, aquatic plants, trees
 - agricultural food and feed crops
 - agricultural crop wastes, animal wastes
 - wood wastes and residues,
 - municipal wastes, other waste materials

Biogas as Energy Source

- Disposal & treatment of organic waste represent - major challenge
- anaerobic fermentation is a superior alternative to composting - wide range of organic substances from agriculture, foodstuff or feed industries
- Biogas – a mixture of methane and carbon dioxide – is created during anaerobic fermentation and serves as a high-energy, CO₂-neutral fuel
- Biogas-fueled gas engines improve waste

Generation of Biogas

- Biogas results from anaerobic fermentation of organic materials as a metabolic product of the participating methane bacteria
 - Needs lack of oxygen
 - pH value from 6.5 to 7.5
 - constant temperature of 15°C (psychrophile), **35°C (mesophile)** or 55°C (thermophile)
- Fermentation period ranges from 10 days for thermophiles, 25 to 30 days for mesophiles and 90 to 120 days for psychrophile bacteria.

Juehnde

A Bioenergy Village



- Biogas from liquid manure and locally grown energy plants is used to generate electricity and heat.
- The waste heat from electricity production is used to heat water to 176°F which is piped to the participating households for warm water supply and central heating
 - Summer, excess heat is used to dry wood chips.
 - Winter, additional heat is produced from burning wood chips in a block heating/generating plant.

Generation of Biogas

- The gas mixture produced in the digester consists of 60 – 70% methane (CH₄) and 30 – 40% carbon dioxide (CO₂).
- makes biogas well suited for combustion in gas engines
- The generated electrical energy can be utilized for the treatment plant as well as to supply the public power grid.
- The thermal energy can be used for heating the digester or to offset the heat requirements of the treatment plant.

Juehnde

Current annual energy consumption:

- 2 mil kWh electricity & 4.5 mil kWh heat energy

Annual biomass consumption:

- 2.4 million gallons of liquid manure
- 330 ha (25% of total farmland) energy crops
- 300 MT wood chips from local forest

Annual CO₂ reduction: 3,300 MT = 60% CO₂ reduct/person



Juehnde

A Bioenergy Village

- 750 inhabitants – (70% participate)
- 9 farmers
- 3211 acres farmland, 25 % is used to grow wheat, rye, triticale, corn, and sunflower for biomass/energy production
- 1976 acres forests, 10 % annual growth used for heat production
- 3000 cubic meters fermenter (anaerobic digestion plant)
- 700 kW combined heat and power station - biomass (annual production: ~5 mil kWh)
- 550 kW central heating plant based on wood chips (operating only in winter)
- 5.5 km (3.4 miles) hot water pipeline system



Biofuels

- Biofuels are produced from living organisms or from metabolic by-products (organic or food waste products).
- In order to be considered a biofuel the fuel must contain over 80 percent renewable materials.
- derived from the photosynthesis process and can therefore often be referred to as a solar energy source

Biofuels

- Plant remove CO₂ from the atmosphere and give up the same amount when burnt.
- time scale of one or two years for the biofuels, whereas the fossil fuels -time scale measured in millions of years.
- "CO₂ neutral"- not adding to the carbon dioxide level in the atmosphere

Research Focus

- Main focus in research - creation of plant matter with distinct characteristics, engineered specifically for biodiesel production
- Oil from Algae

Fellsmere Algae

http://www.youtube.com/watch?v=n9_-ZquuhBw&feature=related/

Biodiesel

- Produced by extracting oils from oilseed crops, recycling used cooking oils, or converting biomass residues into tall oils using high temperatures.
- Abundant and here in US
- Every diesel engine, whether in vehicles or stationary equipment, can run on biodiesel.
- Significantly reduces emissions



Jatropha curcas, a plant native to Mexico that is being widely grown for fuel and medicine in some parts of the world, is a tree that produces golf ball-sized fruit. Inside each fruit are three seeds full of oil that can be pressed to make biodiesel.

<http://news.ufl.edu/2007/10/24/new-alternative-fuel/>



Camelina is an annual crop

- Planted on marginally productive cropland
- can be grown in arid conditions
- Doesn't require significant levels of inputs such as fertilizer
- oil will produce a high quality biodiesel.
- approximately 38 to 40% oil

Biodiesel

- Proven technology
- Many make fuel at home
- 2004 – 25 million gallons
- 2007 – 500 million gallons
- 2008- displaced 20 million barrels of petroleum & added over \$4 billion to the US economy
- annual contribution to reducing greenhouse gas emissions is now equal to removing 700,000 passenger vehicles from America's roadways

• SEBAC at UF

• <http://www.youtube.com/watch?v=KvfA-4bTXMc>

Feedstocks for fuel

- 1st generation feedstocks include corn for ethanol and soybeans for biodiesel.
- 2nd generation feedstocks consist of the residues or "left-overs" from crop and forest harvests
 - development of cellulosic conversion technologies
- 3rd generation feedstocks are crops which require further R&D to commercialize
 - "Energy crops" - perennial grasses, fast growing trees, & algae
 - Designed exclusively for fuel production

Feedstocks for Fuel

- Do not disrupt current production paradigms and sustain the critical natural resource assets required for production (water, air, & soil)
 - effect of feedstock production on soil, water & air quality
 - market implications of increased production of 1st generation feedstocks
 - Plant siting opportunities
 - “energy crops” developed to increase drought and stress tolerance; increase fertilizer and water use efficiencies; and provide for efficient conversion.

Ethanol



- produced from agricultural crops, sugar cane or bio-mass
- Cars running on BioEthanol vs gasoline
 - both emit CO₂, as consequence of the combustion process.
 - burning ethanol, in effect, recycles the CO₂ because it has already been removed from the atmosphere by photosynthesis during the natural growth process.
 - Gasoline injects into the atmosphere additional new quantities of CO₂ which have lain fixed underground in oil deposits for millions of years.

More Bioenergy

- GRU Biomass plant
- Gainesville Regional Utilities (GRU) discussing a 100-MW project with Nacogdoches Power LLC that could be constructed at the existing Deerhaven Generating Station
- Biomass-generated power is considered carbon neutral because it releases carbon dioxide consumed by trees back into the air
- Cost of biomass ?????