Biomass

Basics

Energy from the sun, via photosynthesis in plants

This is the same energy we use as food

This is the same energy that made fossil fuels; fossil fuels are concentrated over time by the heat and pressure within the Earth.

The oldest form of energy used by humans: wood fire.

Efficiency

Plants use only a tiny amount of the sun's energy for photosynthesis, less than 1%.

The efficiency of photosynthesis is low, about 5% maximum (solar energy to energy in sugar).

- Corn field: about 1 to 2% efficient
- Pine forest: less than 1% efficient

Efficiency of burning biomass to electricity is about the same as with fossil fuels

Potential

Potential is impressive

United States:

•If we harvest all crops for energy on all land currently under cultivation in the United States, the amount of energy available at 100% conversion efficiency is about equal to the total annual energy used in the United States.

•At more realistic conversions, biomass maximum is about 30% at today's use rate

Potential

<u>The world</u>

The amount of energy in the global biomass is about 8 times more than the amount of energy currently used globally.

These are maximum estimates:

- We need biomass for food as well
- We cannot (should not?) cultivate all land surfaces
- Burning efficiency needs to be considered

What is biomass?

Chemically:

Plant material is a combination of cellulose (about 60%), lignin (about 30%), and other organic materials (about 10%).

Cellulose is the structural material in plants (fibers)

Lignin is the glue that holds the cellulose together

Both start with simple sugars (glucose) made in photosynthesis

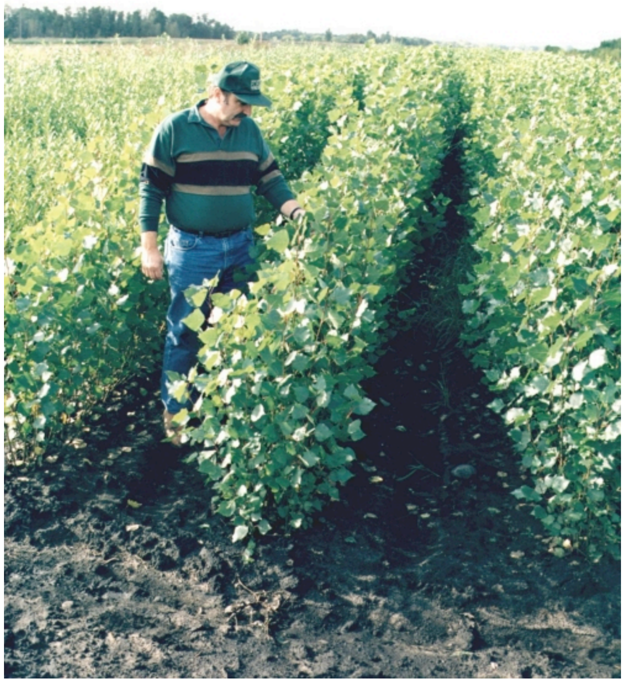
What is biomass?

Physically:

Any plant tissue can be used for energy, but the faster the plant grows, the more useful it is.

Growing **energy crops**.

Poplar trees grown for energy.
These are 2 year old seedlings.
Genetically engineered and bred for fast growth.



What is biomass?

Trees: poplar and willow can be grown to large size very rapidly: 7 year old poplars in picture.

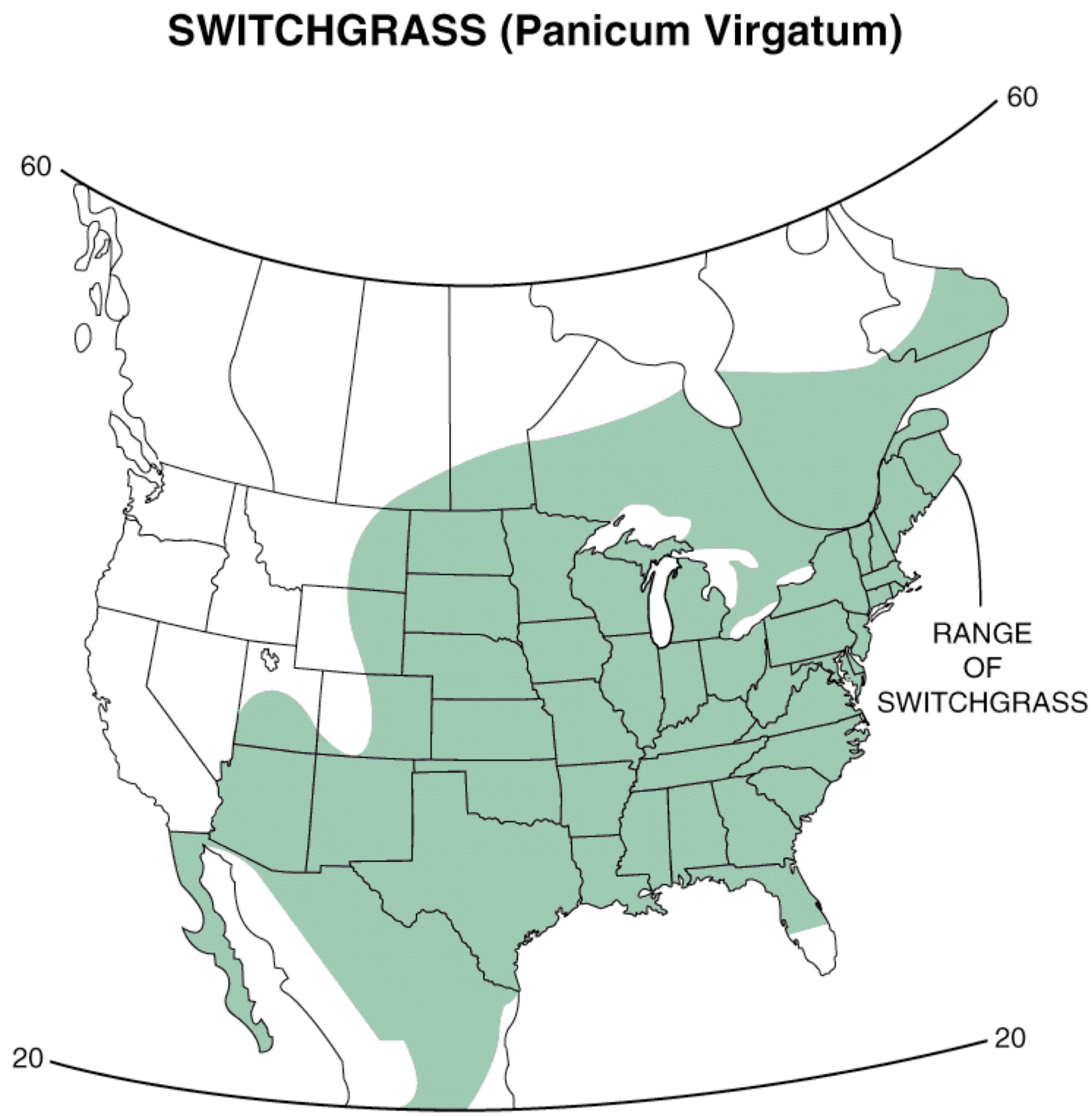
Harvesting trees is done using standard forestry equipment.

Grasses

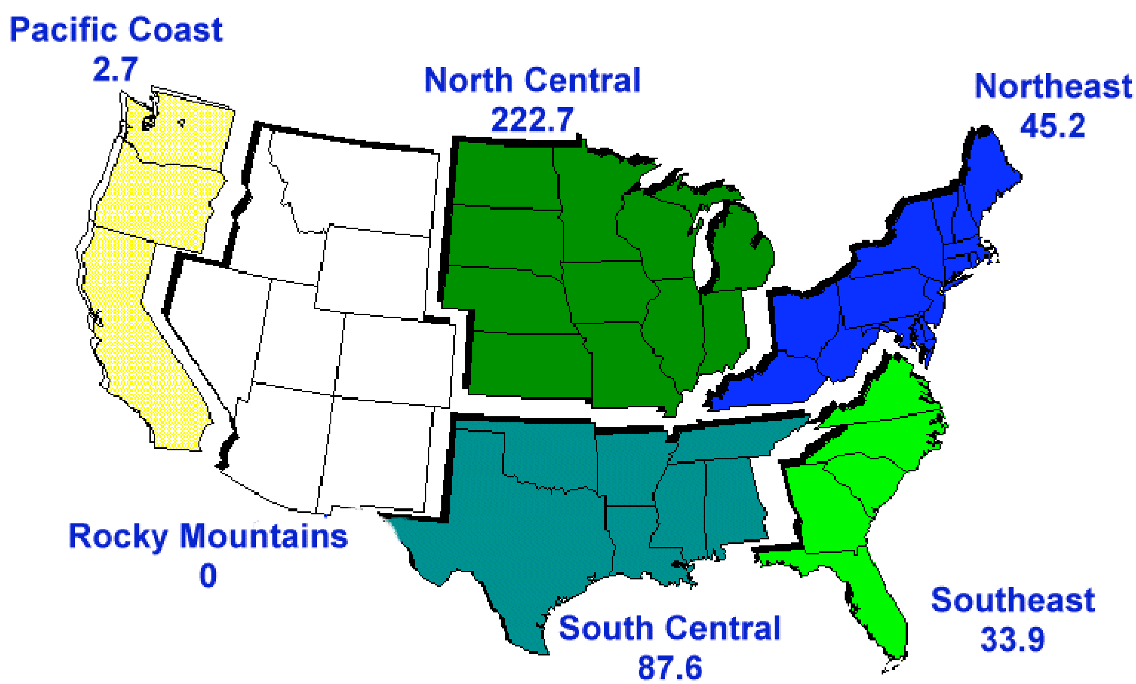
Switchgrass can be grown rapidly (one season), and harvested using standard farm implements.

Grasses

Grasses are attractive also because they can be grown in climates unfavorable to trees.



The overall area of land in the US suitable for energy crops:



392 million acres of land is potententially available/suitable for energy crops

Growing plants

This illustrates that plants need more than sunlight to grow. They need sunlight and

- Carbon dioxide
- Water
- Macronutrients (nitrogen and phosphorous)
- Micronutrients (for example, iron)

Growing plants

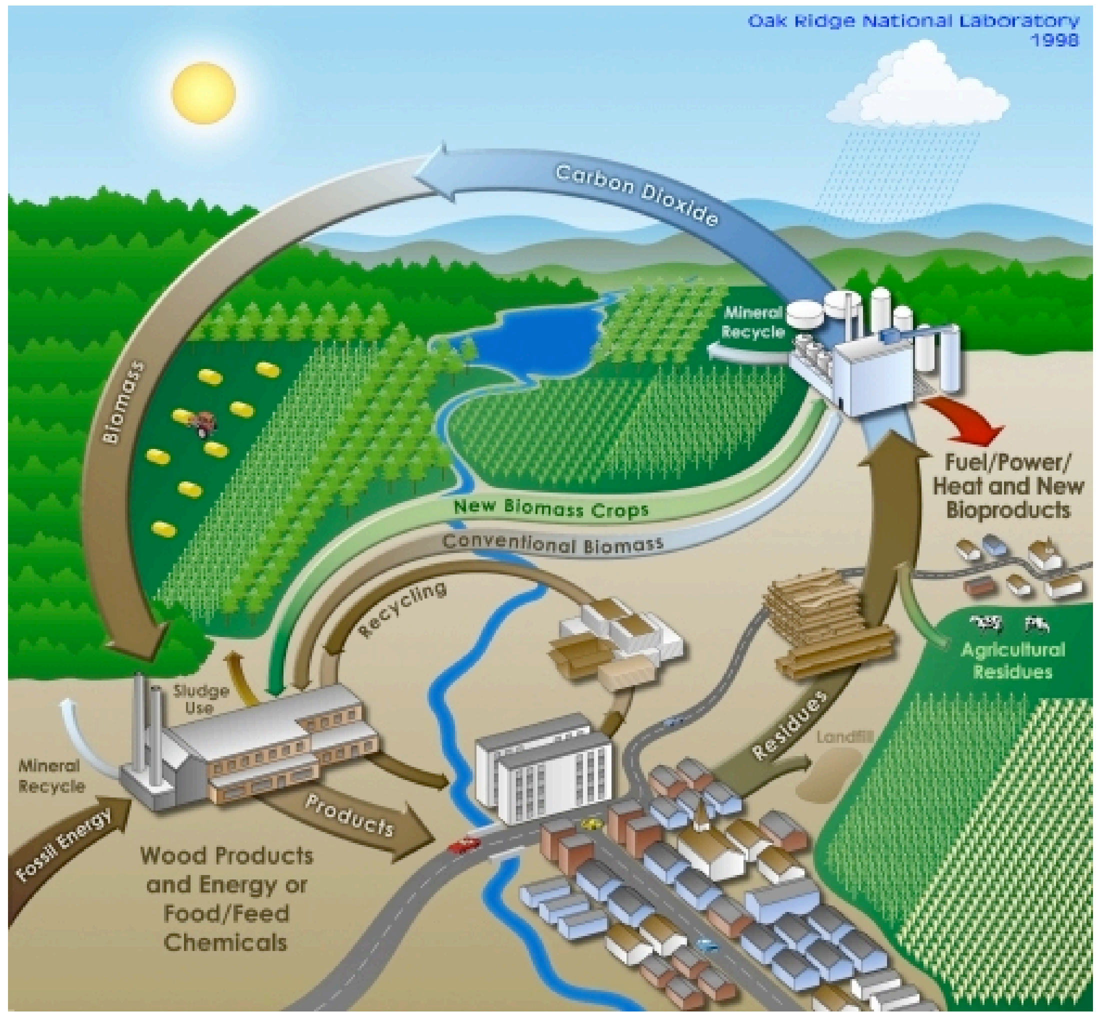
Keep in mind that faster growing plants need more of all of these. You don't get something for nothing!

Poplar and switchgrass, for example, need intensive fertilizing and plenty of water to achieve the high growth rates

Pros

•Relatively low pollution.

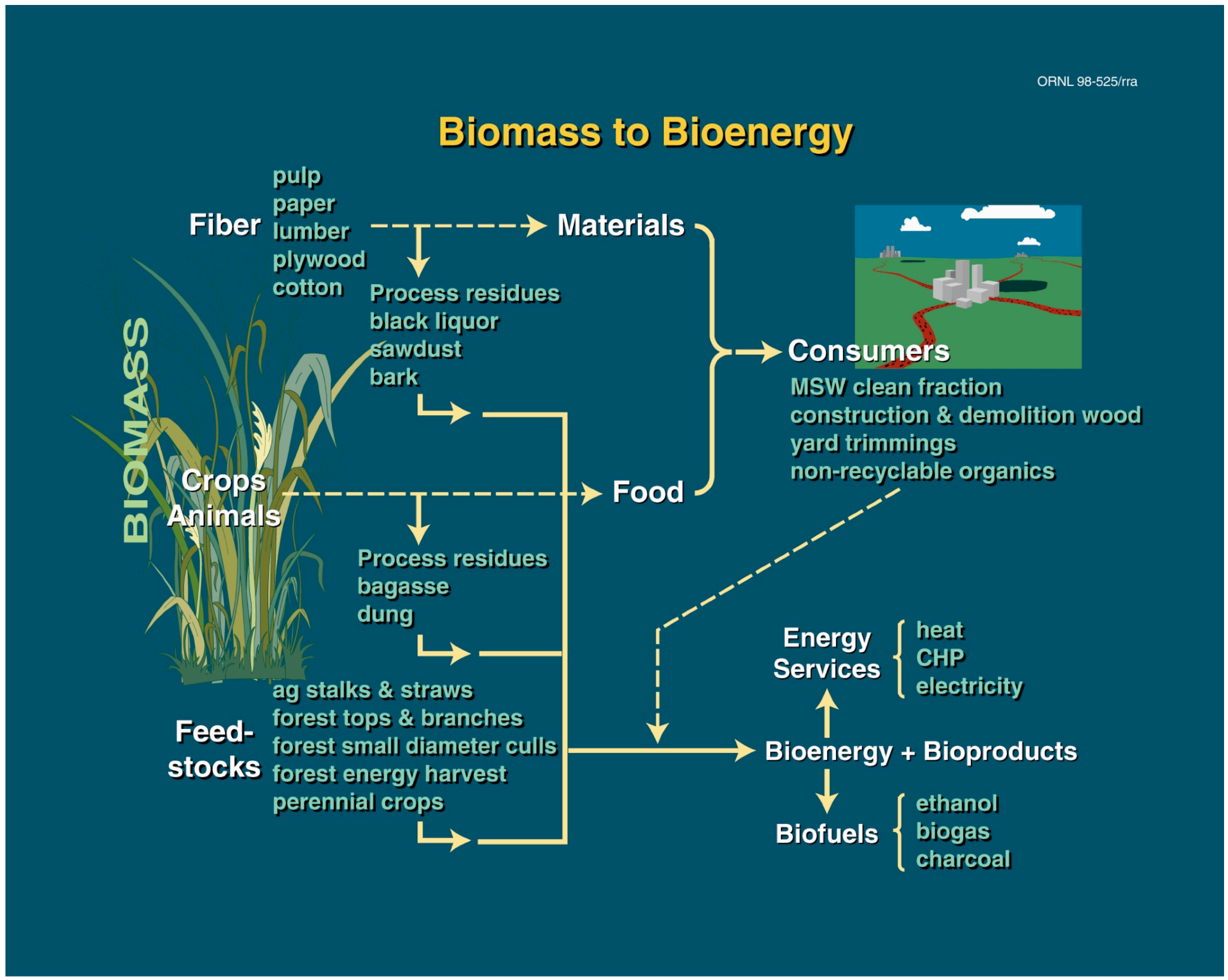
•Carbon dioxide released is converted back to plants (carbon dioxide neutral)



Pros

•Multiple uses of biomass.

•Bioproducts include plastics, medicines and other materials traditionally produced from oil.



Pros

- Reduce waste, and save landfill space.

  About 85% of material put into landfills is plant material that could be combusted for energy. Paper alone is about 55%.

  Key is waste separation. It is expensive to separate paper from paint, for example; and burning paper contaminated with paint creates toxic wastes that get into the atmosphere.

  About 15% of waste is currently burned, (for energy or, in most cases, for waste reduction).

Pros

•Relatively cheap.

Costs today are about 9 cents per kilowatt hour. *This is about the same, or less, as energy from fossil fuels*.

Costs are expected to be even less in the future as crops grown for fuel become more available.

How does it work?

How do we convert biomass energy to useful forms of energy?

- Direct burning
- Gasification
- Cofiring
- Fermentation

Direct burning

Direct burning is as it sounds. Plant material is chipped, dried, and then burned to boil water, make steam, and then electricity.

This is a relatively inefficient technology and the most polluting method of energy from biomass.

Gasification

Gasification is the conversion of biomass into a gas and carbon powder.

Process begins with pyrolysis. Biomass is combined with hot sand (800˚C). This reduces biomass to gases and carbon powder.

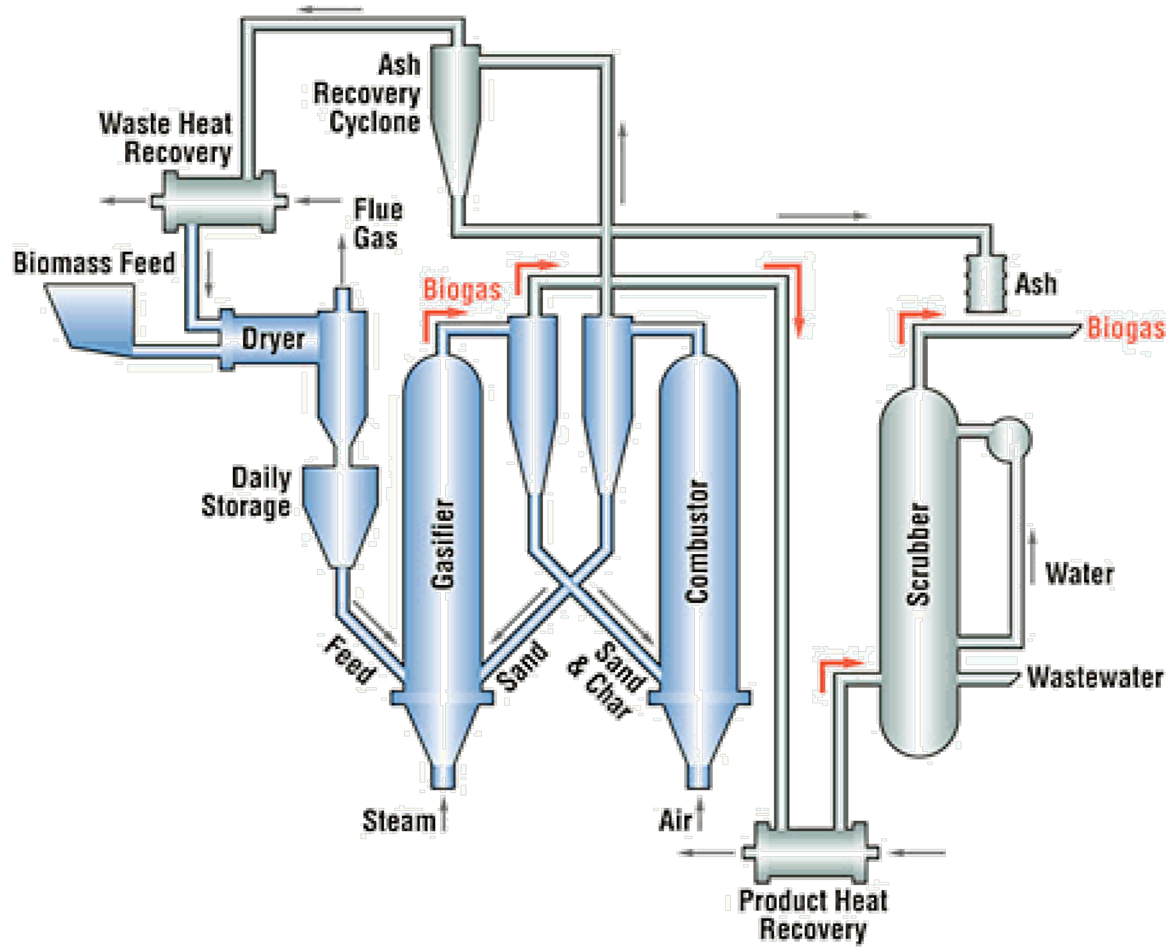
The gases are used to run a turbine. They are then recycled back to be burned for fuel. *Increases overall efficiency*

Gasification

Advantages are:

•Cleaner (but still ash to deal with)

•More efficient, 40% demonstrated, 50% possible



Cofiring

Cofiring is the use of biomass in combination with coal.

Advantages are:

- Biomass cheaper than coal, so cofiring is cheaper than burning coal alone
- Less sulfur oxides (less coal burned); pollution and cost savings
- Easy to adapt current systems to cofiring

Fermentation

Fermentation is the production of alcohol (ethanol mainly) from sugars in biomass. The alcohol can be burned alone, or mixed with gasoline.

- Mixtures can range from 10% ethanol (often used to reduce pollution) to 100% ethanol
- Ethanol is more expensive than gasoline currently (although comparisons are hard to make due to the many subsidies for both).
- Net energy yield from ethanol is low, could be much better with cellulosic ethanol

Fermentation

Energy from ethanol is less than that from gasoline. But *it produces less pollution* (especially carbon monoxide) as it burns at a higher temperature, and thus more fully oxidizes.

Most ethanol is from corn (about 95%). The rest is from sugarcane. Brazil uses ethanol from sugarcane to power about 1/3 of its cars.

Keep in mind that energy is needed to produce ethanol, and that this energy currently comes form fossil fuels.

Conversion to methane

Conversion to methane

Methane production is most useful with animal and human wastes, as well as landfill wastes, where it happens naturally. This is attractive in rural areas, and can help reduce ethanol costs by supplying energy needed in the corn to ethanol process.

Potential

Currently we get less than much less than 1% of our energy in industrialized countries from biomass. This could be as high as 10%, mostly gasification or cofiring.

Ethanol could be more useful if cellulosic ethanol works. This will add to biomass potential. *But ethanol is unlikely to directly replace gasoline*. *(We will probably see a combination of technologies used to replace gasoline…)*

Developing countries already use biomass, but in a subsistence lifestyle. *Biomass in developing countries is non-renewable*.

Potential

Future of biomass energy depends strongly on land, water and nutrients available.

This means:

- *This source of energy must compete with food production.*
- *This energy source will have less dependability year to year as climate will affect crop yields.*