



PEEL

People for Energy and  
Environmental Literacy  
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# Biomass Energy

2018

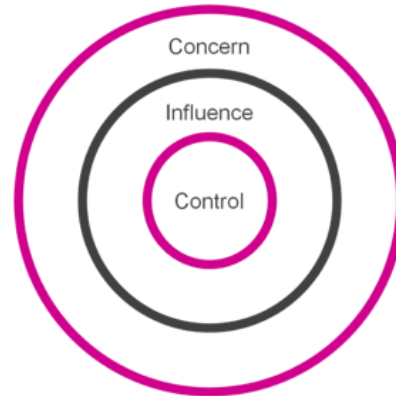
Lesson 9 – Basic Level

Special thanks to: Leonard Sanche, P.Eng.  
Plant Manager at Capstone Infrastructure

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## Circle of Concern, Control and Influence

- **Circle of concern** - things we may not have direct control over.
- **Circle of influence** - things that I can influence and others can do something.
- **Circle of control** - things I can actually do



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It can be easy for kids to become overwhelmed by the issue of climate change. Using the circle of control, influence and concern helps students to discern what they can affect.

This lesson is focused on the circle of concern.

## This is Biomass!

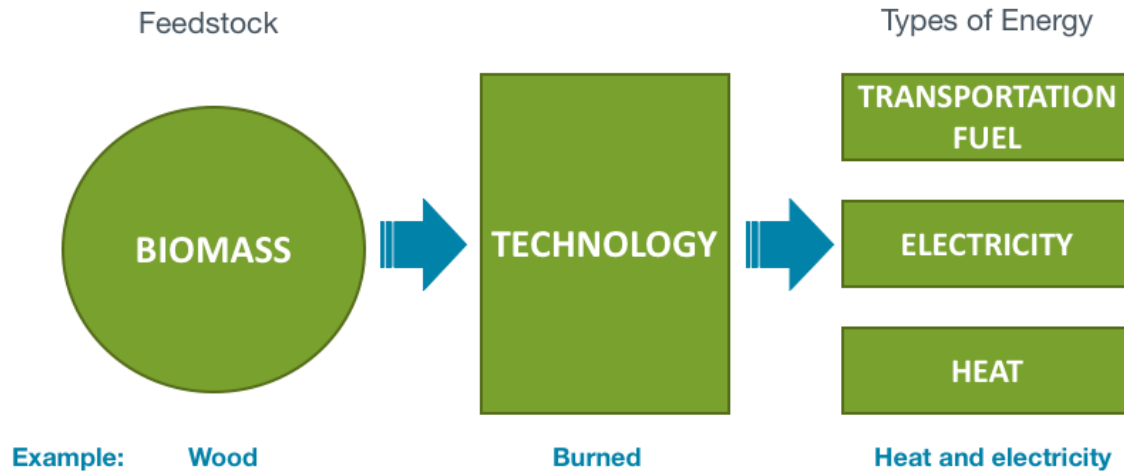
- Biomass uses the **stored energy** from the **sun** in organic material
- Biomass is the **feedstock** for energy production, and includes:
  - Food waste
  - Municipal solid waste (MSW)
  - Forest waste
  - Crops for Energy
  - Animal waste



Biomass is a **feedstock** for energy production.

Biomass comes in many variations, which will be explored in the following slides. Biomass is found in living or recently living plants, and in wastes (i.e., agricultural and municipal solid waste). Biomass can be directly burned to produce heat to boil water. The steam of the water is used to turn a turbine which powers a generator to produce electricity.

## How Biomass is Used in Creating Energy



Creating energy from biomass can be considered in three stages.

The first stage, is the raw biomass, which is the source of energy. This is called the feedstock.

The feedstock then goes into a technology to be converted to energy. One of the many process possible is combustion (feedstock is burned)

The product of the conversion process is transportation fuel, electricity or heat.

The product formed is dependent on the feedstock and technology used.

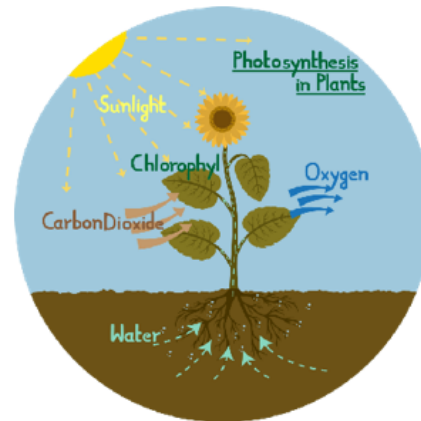
For example:

Wood products can be used as a heat source to boil water into steam. This steam is used to turn a turbine and generator in a similar fashion as other renewable energy alternatives.

If a biomass facility is attached to a paper and wood manufacturing factory, the energy generated can be used internally to reduce emissions at the facility. This acts as a way to reduce the carbon footprint.

# Photosynthesis

- Photosynthesis is an important life cycle process for plants



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**Photosynthesis** is a chemical conversion process used by plants to get nutrients from the sun's energy. Glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) is a sugar and the product of photosynthesis. Glucose acts as stored energy for the plant.

Biomass releases this energy in the form of heat by burning the organic material, which breaks the chemical bonds. The energy conversion process in biomass is chemical to electrical.

Picture source: <https://www.pbslearningmedia.org/resource/494000753-plants-animals/photosynthesis-diagram-of-a-flower-plants-and-animals/#.W2HjpdhKiFO>

## How is Biomass a Renewable Source?

- “Renewable energy is derived from natural processes that are replenished at a rate that is equal or faster than the rate at which they are consumed”
  - Natural Resources Canada Definition
- Since biomass is continuously replenished, it is considered a renewable source



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As biomass is consumed for energy use, more trees can be planted to help replenish the source.

This is also a way you can contribute to mitigating the impacts of logging, and reduce emissions



# Biomass Sources

Wood, Garbage, Crops, Alcohol Fuels, Landfill Gas



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This is some of the feedstock used in the conversion processes we just looked at.

## Biomass Feedstock – Wood

- Wood is the most common form of biomass
- It has been used for many years to heat homes
- Today, wood waste is commonly used for heating and generating electricity
- Wood and paper manufacturing plants commonly use their waste for heating and electricity generation to save cost



One of the most common forms of biomass is wood waste.

Whitecourt Power Biomass Facility, in Alberta, uses this feedstock for its energy production

This type of biomass uses many forms of wood including:

- logs, trees, timber
- wood shavings, sawdust
- wood chips, tree bark
- wood pellets, wood briquettes

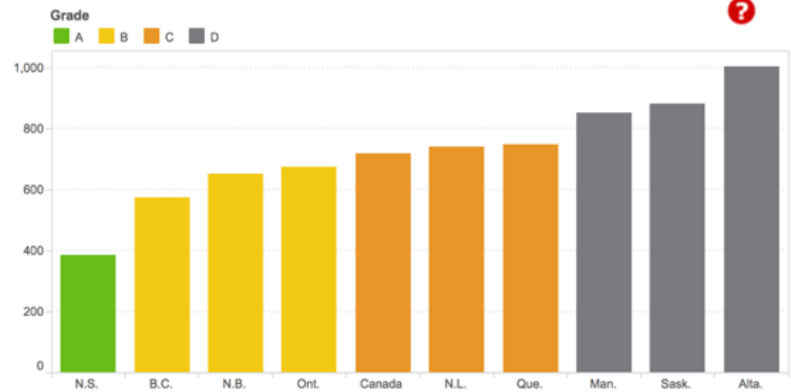


## Biomass Feedstock– Garbage

- Also called **Municipal Solid Waste (MSW)**
- Alberta has the highest amount of waste per person of all the Canadian provinces at 1,007 kg per person per year



Waste Generation, Canada and Provinces, 2012  
(kilograms un-diverted waste per capita)



Sources: The Conference Board of Canada; Statistics Canada.

Source: conferenceboard.ca



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Garbage can also be used as a biomass source. Garbage is essentially anything that is thrown in the garbage can and sent to the landfill. The materials in the garbage that are combustible are used to generate energy.

This process provides waste management opportunities to a city. It reduces the amount of waste that is sent to a landfill. If combined with recycling programs, the amount of waste produced can significantly decrease. However, depending on the waste burned, there could potentially be more harmful gases released into the environment, unless mitigation measures are applied.

This website (where the graph is from) discusses waste generation of all provinces in Canada. Unfortunately, Alberta produces the most waste in our country. However, this can be mitigated by converting the waste to energy.

[https://www.conferenceboard.ca/\(X\(1\)S\(vq4s0rhcdbmezshvtdzdm4jf\)\)/hcp/provincial/environment/waste.aspx?AspxAutoDetectCookieSupport=1](https://www.conferenceboard.ca/(X(1)S(vq4s0rhcdbmezshvtdzdm4jf))/hcp/provincial/environment/waste.aspx?AspxAutoDetectCookieSupport=1)

Most of this waste, however, comes from non-residential sources such as industrial activities.

## Biomass Feedstock– Crops

- Crops can be used to make biofuels such as bioethanol, which goes on to produce electricity and heat
- **Energy Crops** are either woody or herbaceous (not wood)

### WOODY CROP

- Willow
- Poplar

### HERBACEOUS CROP

- Maize
- Sudan grass
- Millet
- White sweet clover
- **Canola**



These crops are also known as **Energy Crops**.

In certain areas, sections of land are dedicated to growing crop designed specifically for biomass use. Crops used for this are identified in the tables on this slide.

These specific crops are used because they are fast growing, and can therefore be regenerated at a faster rate.

In Alberta, canola is a common crop used for energy production.

## Biomass Feedstock– Animal Waste



ANIMAL WASTE  
INCLUDES ANIMAL  
MANURE



MANURE IS USED  
AS A BIOMASS  
FEEDSTOCK TO  
PRODUCE BIOGAS



MANURE RELEASES  
METHANE



MANURE IS LEFT TO  
FERMENT, WHICH  
PRODUCES BIOGAS

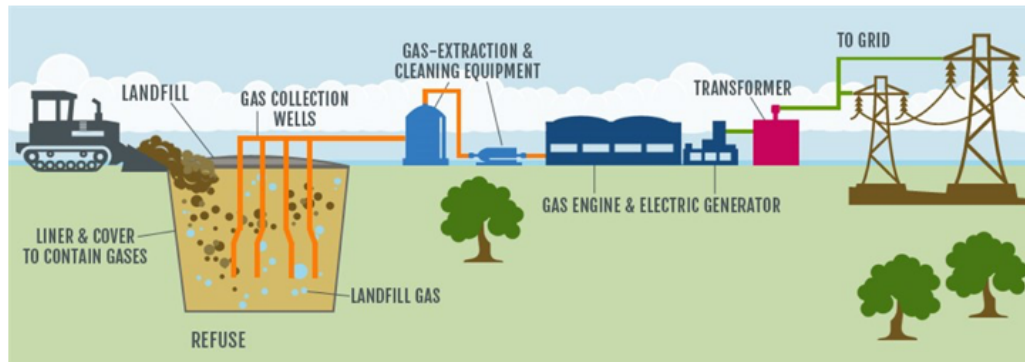
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Animal waste as a feedstock is a sustainable source that reuses a source that would be disposed of otherwise. Manure from livestock decomposes into methane. By using manure as an alternative source, methane can be used to generate electricity at a biomass facility, using anaerobic digestion.

## Biomass Feedstock– Landfill Gas

- **Landfill Gas:** gas that is produced from garbage that has been compressed and rotting over many years.
- Produced from agricultural waste, manure, municipal waste, plant material, sewage, green waste, food waste



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Biogas is one of the fermentation products of landfill waste. It is formed in the absence of oxygen and forms underground. At a landfill gas biomass facility, the landfill gas is brought up through the ground through gas collection wells and then treated to remove contaminants.

Alberta has a Biogas facility in the Edmonton area called Clover Bar Landfill Gas. This facility generates 5 MW of electricity.

For more information on this facility, visit this website:

<https://www.capitalpower.com/generationportfolio/CA/Pages/CloverBarLandfillGas.aspx>

Picture source:

<https://www.advanceddisposal.com/for-mother-earth/education-zone/landfill-gas-to-energy.aspx>



# Biomass Conversion Process

## Combustion



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We are now going to take a look at the different processes that exists to convert the chemical energy stored in biomass to electrical energy.

## Biomass Conversion Processes

PROCESS	DESCRIPTION
Combustion	<ul style="list-style-type: none"><li>• Biomass burned in the presence of air</li><li>• Can heat steam for electricity generation</li></ul>



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There are five main types of biomass conversion processes (chemical energy to electrical energy). Not all feedstock are suitable for all processes.

- Combustion is the simplest, and most common type. Feedstock is burned in the presence of oxygen, which results in heat generation. This can either be used to heat a building, or to form steam for electricity generation.
- Fermentation involves the conversion of glucose to ethanol in the presence of yeast. The ethanol produced can be used as fuel in cars, to replace gasoline.
- Transesterification is a chemical process that modifies an ester (oils and fats) when reacted with an alcohol.
- Anaerobic digestion is a process used at landfills (waste-to-energy biomass). This process produces biogas by breaking down the feedstock in the absence of oxygen. A by-product called digestate, can be used as a fertilizer.
- Gasification applies heat, pressure and partial combustion to feedstock to produce syngas. This gas is a replacement for natural gas in energy production applications.
- Pyrolysis is a method that does not involve combustion. It heats the feedstock at high temperatures in the absence of oxygen. Three products are formed in this process: bio-oil, bio-char, and syngas.

## Combustion

### ELECTRICITY

- This is the most common process used for biomass in Alberta
- Typically, wood waste is used
  - Ex. Whitecourt powerplant in Alberta generates 25 MW of power from wood waste
- This process converts biomass fuels into hot air, hot water, steam and electricity
- Consider a furnace - this is an example of a combustion technology in your home.

**Feedstock:** wood, agricultural wastes, municipal solid waste (MSW), residential fuels

**Energy/Fuel produced:** heat, steam, electricity



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Combustion is the simplest of the conversion processes. This process burns the feedstock in a boiler. The heat produced is used to turn a steam turbine. As the turbine spins, a generator is powered, which produces electricity.

Combustion is a fancy word for burning.

For more information on the Whitecourt Biomass facility, visit the website below:

<http://www.capstoneinfrastructure.com/OurBusiness/PowerInfrastructure/OperatingFacilities/biomass/whitecourt>

## Advantages and Disadvantages of Biomass

### ADVANTAGES

- Renewable energy source
- Low environmental impact
- Net zero carbon emissions
- Reduces waste
- Not location specific
- Baseload generation

### DISADVANTAGES

- Requires water
- Produces non-GHG air emissions



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Biomass is considered a renewable source since the resource is continuously replenished within our lifetime. However, there are some environmental risks. There is a small amount of emissions associated to the energy generation process. These emissions are offset by the trees that take up the CO<sub>2</sub> in the air. Therefore, there is a net zero emission in the overall process. Precautionary measures are essential to ensure that there are no excess emissions released into the environment. Of particular note, combustion of biomass feedstock can be harmful to the environment since there may be contaminants, and could be a concern to air quality.





## Quiz!

Let's see what you know!



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## What is **not** considered biomass?

- A) Wood
- B) Crops
- C) Manure
- D) Stone



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Answer: Stone

True or false? Biomass is a net-zero emission cycle



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Answer: TRUE

## Where does the energy in Biomass come from?



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Sunlight, which is stored as a sugar in plants and other organic matter.



## ACTIVITY!



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Inflate a balloon with BIOMASS

See the lesson plan for instructions

## GreenLearning.ca Additional Resources

- Re-Energy: <http://www.greenlearning.ca/programs/re-energy/>



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If you would like to learn more about this topic, visit the links above.



## THANK YOU!

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