Victors Gasification

# Wood as a Fuel Source

**Characteristics**
By far the most popular and easiest to obtain fuel source is wood. Wood has some very important characteristics that make it a good fuel source for small scale gasification:
- Readily available in many parts of the world.
- Wood residue is a waste stream.
- Wood is generally low in nitrogen when compared to crops like grasses.
- Many woods have a low ash content.
- Wood is low in sulfur, making it possible to run engines without destroying them. (tar permitting)
- Wood is dense and occupies minimal space.
- Wood waste is cost effective.

The downside to wood:
- When it is gasified it creates tars that have to be either thermally cracked or filtered.
- Wood has to be prepared in a uniform size and moisture content to be usable in most gasifier designs.
- Bridging can occur with small wood chips. Bridging is when the fuel heats up and sticks together, no longer allowing it to pass through to the hearth zone.

**Fuel Preparation**
Wood can be chipped into blocks the size of your thumb or pelletized into a densified and uniform shape.
Moisture content of 20% or less is important to operation in small downdraft units.
Industrial scale units with fluidized beds can handle moisture contents of up to 50%.

Tagged
--------------------------------------

# Charcoal as a Fuel Source

**Characteristics**
Charcoal is an ideal fuel for gasification because:
- It's easily made from wood
- Generally runs tar free
- It runs cooler
- It operates in more design types
- Charcoal can be steam injected to create a hydrogen rich syngas

The downside to charcoal:
- Half of the wood's energy is lost in the process
- No distribution or waste channel
- It's evil blood sucking carbon. Quick call Al Gore over to nag it to death.

**Fuel Preparation**
Charcoal can be easily created by putting large chunks of wood in a sealed drum and heating it to 500 degrees for several hours until the volatile gases can burn off and turn the wood into charcoal.

# Energy Crops

**Examples of high yield energy crops:**
Hybrid Poplar

Switch Grass
Miscanthus Gigantus
Hemp
Willow

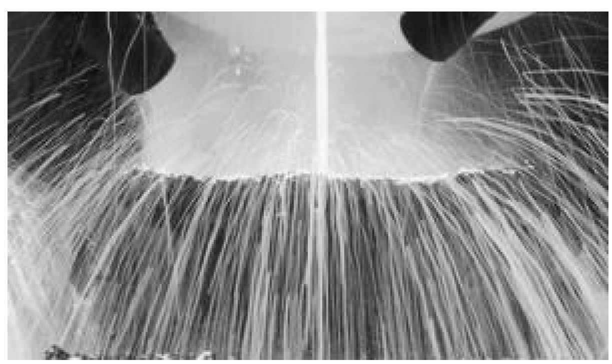
The leading criteria for selecting biomass energy crops is tons per acre. Also to be considered are energy input, BTU value, ash formation and nitrogen content as well as moisture content when harvested.

**The Benfits:**
- Crops like switch grass actually deposit nitrogen into the soil, making it healthier.
- Energy crops can act as buffer zones that filter excess nitrogen from water runoff before it reaches lakes and rivers.
- Energy crops can usually be harvested with existing equipment.
- Energy crops are carbon neutral.

**Potential Drawbacks:**
- Energy crops get planted in place of food crops, causing food shortages.
- Distance of biomass from point of use is too far.
- Low BTU or high ash content.

# Waste

Waste streams ranging from agricultural byproducts to municipal waste are excellent fuel sources for large scale gasification. In many circumstances the gasification plant can receive disposal fees along with sales of metal and glass slag and electricity fed to the grid.



The upside to waste gasification is the destruction of landfill materials. However the downside is the high cost and complexity involved with running such a large plant.

Here is a video about a company having success with waste gasification:

# Downdraft Gasifier

The most popular gasifier design for personal use is the downdraft gasifier. There are many good reasons for this:

1) The Imbert design was used to power parts of Europe during the war. This includes everything from cars to homes and factories. Over a million were in use.

2) Downdraft gasifiers are easy to build.

3) Downdraft gasifiers are great for common fuels like wood because they can crack the tars that are formed.

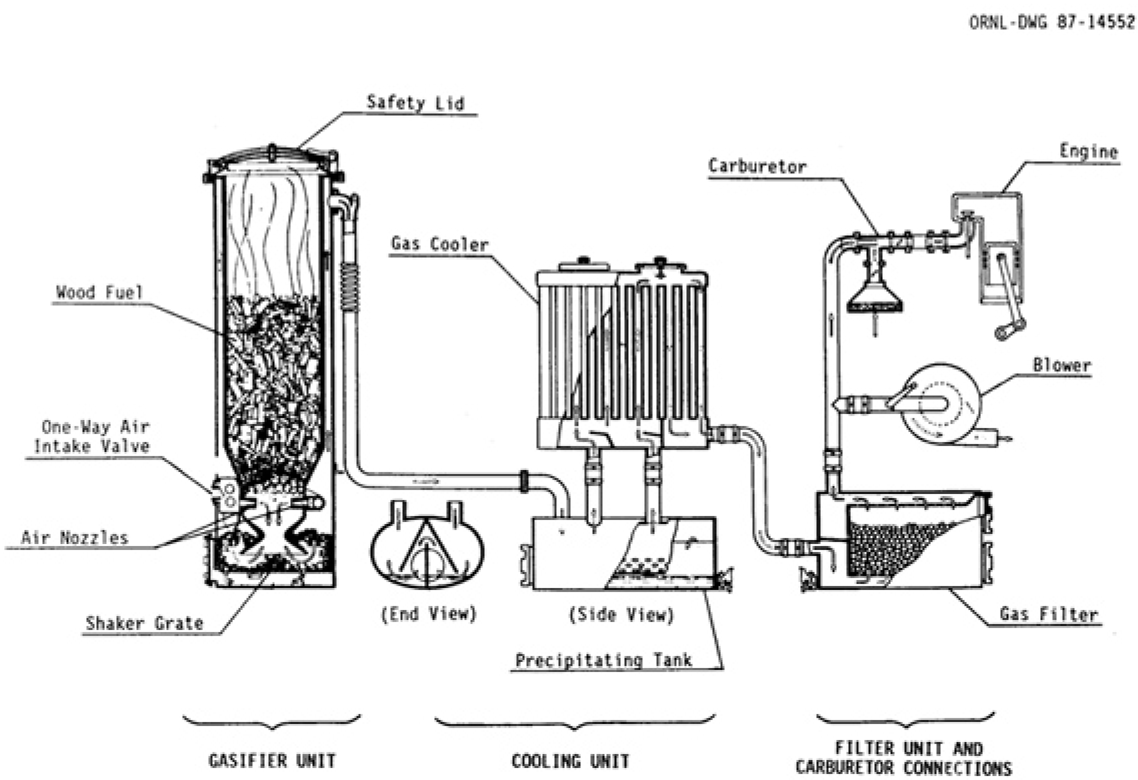


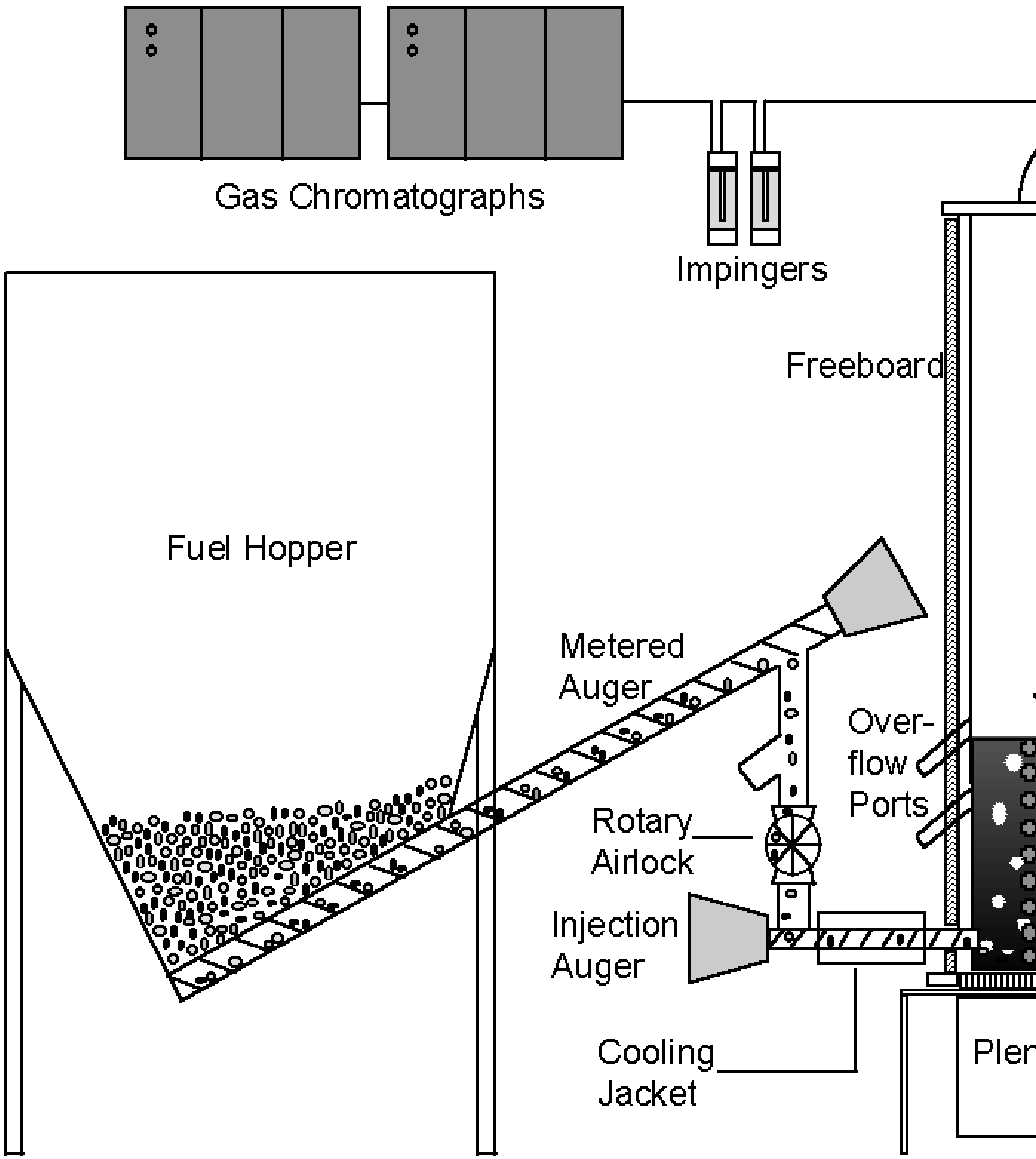

**Fig. 1-2. Schematic view of the World War II, Imbert gasifier.**

In a downdraft gasifier the fuel is loaded at the top and a fire is lit in the bottom. A suction blower draws in air either through an air jacket like in the Imbert design or down through the top like the FEMA design. The incoming air allows combustion to take place in the lower hearth area. The heat from that combustion produces pyrolysis above and reduction below.

Once the gas leaves the hearth it's piped out to the cooling and filtration system before being used for work

# Fluidized Bed Gasifier

To meet the challenges of fuel sensitivity in gasification, the fluidized bed gasifier was created. Used for industrial scale gasification, this type of gasifier can accept a wide range of fuel types, sizes and moisture contents.


Gas Chromatographs
Impingers
Freeboard
Fuel Hopper
Metered
Auger
Over-
flow
Ports
Rotary
Airlock
Injection
Auger
Cooling
Jacket

In a fluidized bed gasifier, a granular sand-like material is fluidized by the upward passage of air from a porous plate structure below the sand bed and preheated to 1200 F. The size of the “sand” particles is chosen such that the passage of air through the bed moves and agitates the “sand bed” giving it a fluid like character. The bed resembles a rapidly boiling pot of water. The boiling action assures good mixing of the fuel and air. The bed also acts a very efficient “thermal flywheel” smoothing out variations in the fuel supply heat values. In normal operations the bed is typically about 98 - 99% by weight 'sand' and only 1 - 2% fuel, thus the behavior of the bed (including the passage of air and gas through the bed) is determined by the character of the sand bed, and not by the character of the fuel particles.

Moisture content of fuels can reach as high as 50% with the right design, but the 25-30% range is more ideal. Because tars are created, many systems directly fire the syngas in a CHP set up instead of using the syngas to power internal combustion engines.

# Updraft Gasifier

The updraft gasifier consists of a top fed fuel bed through which the "gasification agent" (steam, oxygen and/or air) flows in from the bottom and exits through the top as gas. Updraft gasifiers are thermally efficient because the ascending gases pyrolyze and dry the incoming biomass, transferring heat so that the exiting gases leave very cool.

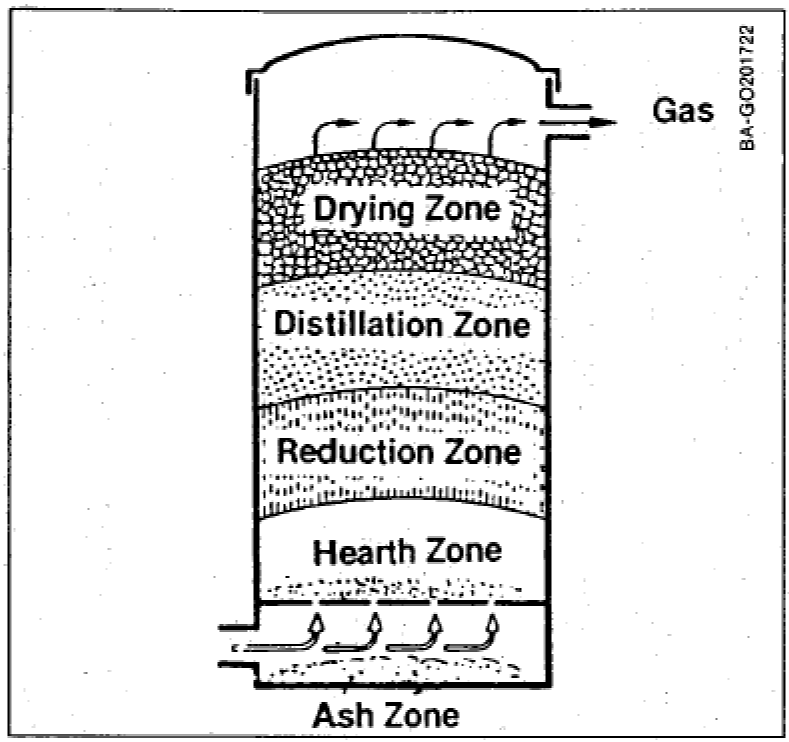
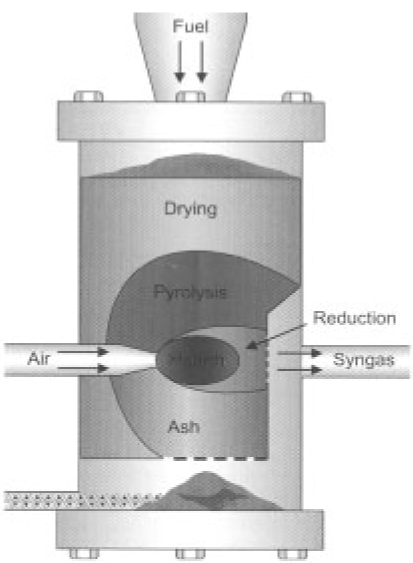



*Fig. 5-3. Diagram of updraft gasification (Source: Skov 1974 Fig. 9. © 1974. Used with permission of Biomass Energy Foundation, Inc.)*

The updraft gasifier has been the standard of coal gasification for 150 years and it's also popular in biomass cook stoves.

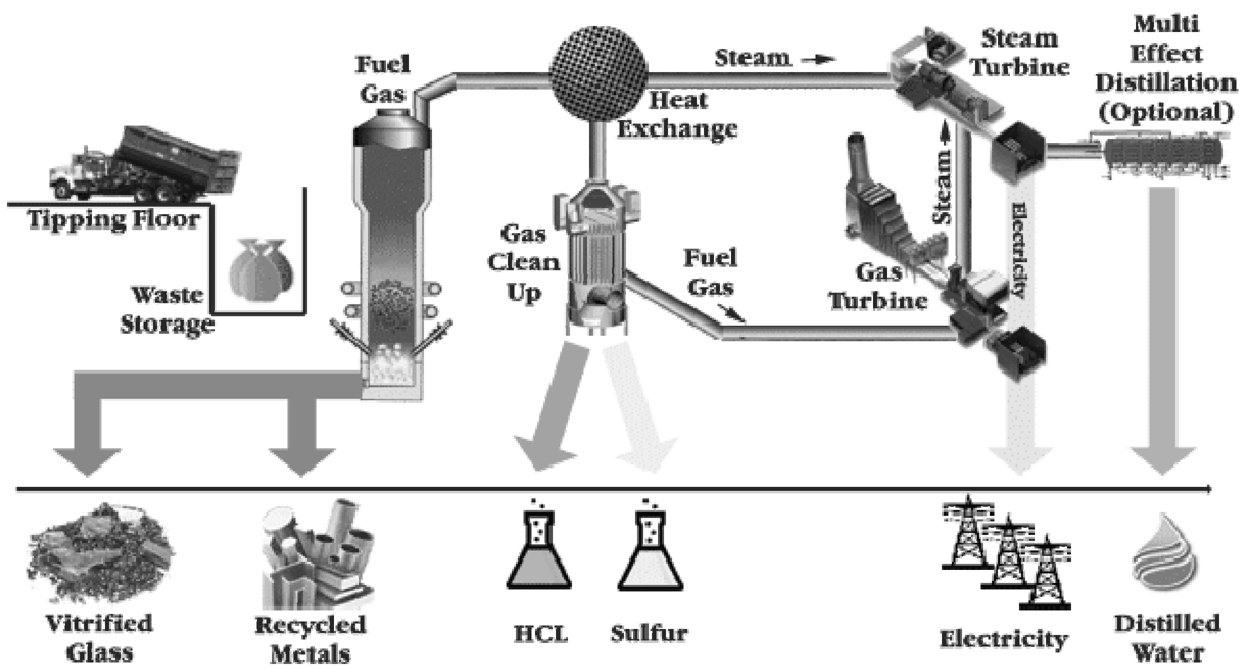
# Cross Draft Gasifier



In a cross draft gasifier the air enters from one side of gasifier reactor and gas is taken out from other side.The cross draft gasifier is one of the simplest gasifier designs. It has a quick start time and reaches high temperatures which may require air or water cooled nozzles.

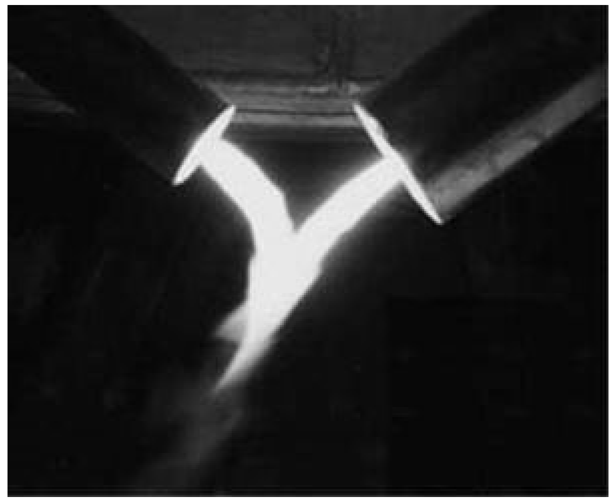
The cross draft gasifier requires low tar fuels like charcoal and like most gasifiers, fuel size is very important to avoid bridging. Cross draft gasifiers aren't used all that often because other gasifier designs offer more flexibility and better performance across fuel types

# Plasma Gasifier




Plasma gasification departs from typical gasification by the addition of electricity to the combustion chamber. In plasma gasification, fuel or waste is fed to a reactor vessel where an electrically generated plasma at a temperature of 20,000 C° is present. When the fuel or waste is exposed to the plasma it is heated to a very high temperature (>2,000C°), which causes the organic compounds in the fuel or waste to dissociate into very simple molecules such as hydrogen, carbon monoxide, carbon dioxide, water vapour and methane. These simple molecules, that are all gases, are allowed to continuously flow from the reactor to gas cooling and cleaning equipment. Ash and other inorganic material present in the fuel or waste is melted down to a complex liquid silicate that flows to the bottom of the reaction vessel. Metals that are present also melt and flow to the bottom of the reactor vessel, where they can either mix with the silicate, or if present in a large enough quantity, float on the bottom of it as a separate layer. The liquid melt is allowed to flow continuously from the vessel to a water quench where the liquid silicate melt is cooled to a non leachable, non toxic, obsidian like solid silicate. Some metals are not melted. Instead, they vapourise and pass out of the reactor vessel with the gases formed by the organic material.

When they enter the cooling equipment for the gases, they condense to fine metal particulates. Halogen and sulphur compounds present in the fuel are converted to hydrogen halides and hydrogen sulphide, and pass out of the reactor with the other gases.



The gas from the reactor has a low to medium calorific value, and is therefore suitable as the fuel for a gas fired power generation unit. However, after leaving the reactor, the gas is still contaminated with a number of undesirable compounds, such as hydrogen chloride and metal particulates, that can cause damage to machinery and the environment. The gas is therefore cleaned in various process equipment. The cleaned gas, similar in quality to natural gas, is then fed to a compressor and storage facility ready for use. The most typical use of the gas is as fuel for power generation, although it can also be used as a feedstock for chemical processes. For example, the production of methanol. When used as a fuel for power generation, more power is usually produced than is consumed by the gasifier. Therefore, electrical power can be exported for sale, or used for onsite purposes. For high calorific value wastes and fuels the power exported can be four times that consumed by the gasifier. For more information visit safewasteandpower.

# FAQ

**Q:** How much wood (biomass) does it take to run a generator?
**A:** 20 pounds of wood is equal to 1 gallon of gas. A bag of pellets is 40 + pounds. One load will usually go for several hours or more.

**Q:** Is gasification eco-friendly?
**A:** Yes, the energy is made locally from waste streams such as wood and

agricultural residue. It's carbon neutral. The remaining biochar is excellent as a soil amendment.

**Q:** Is this methane gas?
**A:** No, this is syngas. It's created under pyrolysis and not anaerobic digestion. Gasification is much faster.

**Q:** Can I run my house off the grid with this?
**A:** It depends on you. Are you going to crack and filter out any tars. Are you going to prepare your fuel in a uniform way? If you mind the details, then "Yes" you can run your house.

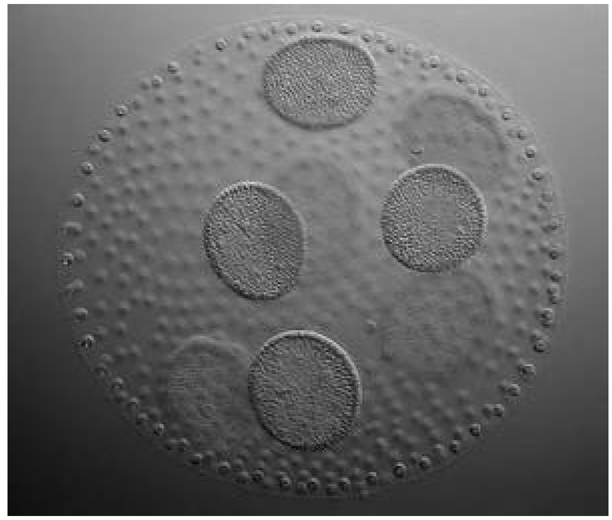
**Q:** How much power can I make?
**A:** Probably way more than you need. Gasification scales up in size much easier and cheaper than solar or wind. 10 kw would be easy with off the shelf parts.

**Q:** Can I gasify my household paper and yard waste?
**A:** If you pelletize it you can.

**Q:** How do I address tar formation?
**A:** Tars are best converted to energy at around 1000 degrees centigrade in the combustion zone. Residual tars should be filtered.

# Algae Biomass Gasification

Algae has been a hot topic lately as a possible solution to most of our fuel and food needs. Nearly half of an alga's mass is made up of lipids (think veggie oil) that can be used in the production of biofuels. With projected yields that trump other crops and the ability to be grown on marginal lands, algae is getting alot of people excited.



So what do you do with the other half of the biomass? Well, that is where gasification comes into play. Algae biomass can be densified and used as a fuel source to create even more bio-fuel. Gasification exhaust, mainly carbon dioxide and nitrogen, can be used to enhance the algae's growth rate and lower emissions, thus making a productive symbiotic relationship.

Here is a video with a bit of background on algae. It's a little light on the gasification aspects, but it is still an interesting watch:

More info see: http://victorygasworks.ning.com/

--------------------------------------------------

**Slide 1:** Engine Operation Using Wood Gas Bill Olsen St. Lawrence University

**Slide 2:** Biomass Fuels Biomass is the term to describe all biologically produced matter (wood, crops, algae, manure, etc.) The Sun provides the initial energy, which is stored in the biomass Biomass resources fall into two categories: Wet biomass – manure, starches, corn, MSW Dry biomass – woody and agricultural materials Wet biomass is better for biological processing Dry biomass is well suited for thermal processes

**Slide 3:** Why Gasify? Renewable Fuel Efficient Combustion Continuous Operation Clean Combustion Power Generation Chemical Synthesis Carbon Neutral Domestic Fuel It’s Fun

**Slide 4:** Theory of Gasification Simply stated, gasification is the conversion of a solid to a gas using a thermal process (heat) The simplest thermal process is combustion which yields only heat, $H20$ and $CO2$ Gasification involves three processes: Combustion Pyrolysis Reduction

**Slide 5:** Basic Gasifier Design Air is admitted in limited quantity A Solid fuel is heated and combustible gases are produced Air, steam and tar are forced through the reduction zone Reduced to $CO$ and $H2$

**Slide 6:** Combustion Occurs where the incoming air meets the fuel Generates the high temperatures necessary for pyrolysis 25% of fuel burns to produce the heat to pyrolyze the rest

**Slide 7:** Pyrolysis Pyro = Fire Lysis = to break down Takes place at 350° - 500° C (600 – 900° F) Yields charcoal (C), gases ($CO$, $CO2$, $H2$, $H2O$, $CH4$) and tar vapors ($CH1.2O0.5$) Uses the heat of combustion

**Slide 8:** Reduction When water vapor is drawn over glowing charcoal it is reduced to hydrogen and carbon monoxide The Water Gas Reaction $C + H20 = 2CO + H2$ The Boudouard Reaction $C + CO2 = 2\ CO$ Both of these reactions require heat

**Slide 9:** Gas Composition Nitrogen $N2$ 50.9% Carbon monoxide $CO$ 27.0% Hydrogen $H2$ 14.0% Carbon dioxide $CO2$ 4.5% Methane $CH4$ 3.0% Oxygen $O2$ 0.6%

**Slide 10:** Energy Content 150 BTU/ft3 Compare to natural gas at 1000 BTU/ft3 Woodgas has 1/7 the energy content of natural gas Seven time harder to compress Seven times more storage needed

**Slide 11:** Chemical Compositions Petroleum $C8H18$ Coal C with some Sulfur Wood $CH2O$ Ethanol $C2H6O$ Biodiesel $CH3OH$ Natural Gas $CH4$

**Slide 12:** Fuel Requirements Moisture Content must be low Loose bark, twigs, sawdust must be removed Chips or blocks must easily pass through the fire tube Hardwoods preferred

**Slide 13:** Bridging of Wood Shavings

**Slide 14:** Charcoal Gasifiers Charcoal manufacture wastes 50% of the energy in the wood and requires more labor More ash content raises slagging rate (ash melting)

**Slide 15:** Using Charcoal

**Slide 16:** Stationary Applications Glass, Lime, Steel and Brick Manufacture Water Pumping Heating Steam Generation Synthetic Fuel Production Electric Power Generation Chemical Synthesis

**Slide 17:** Mobile Applications Cars Trucks Buses Tractors Motorcycles Boats

**Slide 18:** Mobile Applications Motor Transport Charcoal Gasifiers Good for small engines Lightweight Does not require tar destroying hearth Less need for filtering Wood Gasifiers More fuel efficient Generally used for larger engines

**Slide 19:** Necessary Equipment The Generator Heats the fuel and produces the gas The Cooler Cools the gas The Filter Cleans the gas The Blower Used for starting and idling Gas Mixing Valve Mixes the gas for the engine

**Slide 21:** Gasifier Designs Updraft Use only for direct combustion Crossdraft Good for charcoal gasifiers Downdraft Use with wood fuel with low moisture content Kalle Suitable for small car charcoal gasifiers Fluidized Bed For industrial applications

**Slide 22:** Main Gasifier Types

**Slide 24:** Imbert Gasifier Developed by Georges Imbert around 1920 Became the dominant design for WWII Europe Uses wood chunks as fuel Less than 1% tar Self Regulating

**Slide 26:** Imbert Removable Hearth Inset Air distribution ring

**Slide 27:** Stratified Downdraft Simplest gasifier to build Low tar Not thoroughly road tested The so-called emergency gasifier

**Slide 35:** The Cooler Also called a radiator Hot gas takes up more space When the gas cools it increases in density Condensation of Water Vapor

**Slide 36:** Filters Filter media must be heat resistant if before the cooler Cyclone filters remove 80% of larger particles Cloth filters Wood chip filters Glass Fiber

**Slide 37:** Blower and Flare Used for starting the generator Suction Pressure used mostly Pressure fans can be used Usually vented to the flare stack When gas burns blue the engine is ready to start

**Slide 38:** Methods for Engine Adaptation

**Slide 41:** History Discovered independently in France and England around 1798 John Clayton and William Murdoch discovered the “spirit of the wood” Amused friend by lighting coal gas in teapots Gaslighting 1800 – 1930 Town Gas piped to cities for lighting, cooking, heating etc.

**Slide 42:** World War I Demonstrated to Europe that they could not rely on petroleum alone Severe gas and oil shortages Producer Gas developed to be used in mobile units

**Slide 43:** Between the Wars Germany developed Domestic Fuels Program Sponsored races using producer gas 38 10 ton trucks raced from Rome to Paris using Coal Wood Peat Charcoal

**Slide 44:** World War Two 1939 - The German Blockade of Europe Halted oil imports into Europe Confiscation of all oil and diesel fuel in Norway Sweden Denmark France Etc.

**Slide 45:** Civilian Use of Producer Gas in Europe France 100,000 trucks 30,000 tractors Hundreds of boats and rail cars Sweden 28,000 trucks 35,000 cars 3,500 buses Germany Denmark Soviet Union Europe at Large 80 percent of trucks 26 percent of cars

**Slide 46:** Other Countries Australia 45,000 gas producers in use by 1943 Japan Manufactured producer gas cars only from about 1942 Brazil, New Zealand, India and China Various amounts United States and Canada 6 Total

**Slide 56:** Synthetic Fuel Development Germans develop process to convert producer gas to liquid fuel Fischer-Tropsch Process Produces both synthetic gas and diesel Can use various feedstocks

**Slide 57:** Post World War II Gasifiers quickly lose favor and most go into the scrap heap Gasifiers are forgotten until 1973

**Slide 58:** OPEC Oil Embargo 1973 Oil exports from OPEC countries halted to the U.S Produced shortages and price increases Revived Interest in Gasification

**Slide 61:** Current Gasifier Projects Most gasification work is for large scale power plants Small Scale gasifiers Finland Sweden Thailand India USA

**Slide 73:** The Cigar a Fire

**Slide 93:** Advantages of Biomass Gasification Practical and Proven Fuel Generators are simple to make Has many applications Requires little or no modifications to spark engines (gasoline) They use Renewable Fuels Can be combined with gasoline

**Slide 94:** Limitations of Biomass Gasification They generate Less Power Maintenance Cumbersome Fuel is Bulky Producer Gas can be hazardous Excessive use may increase deforestation Fuel Sources not available everywhere

**Slide 95:** Using Gasification Gasification Boilers ~87% Efficiency TARM Inc. Alternative Fuel Gasification Boilers Inc. Etc. Synthetic Fuels Still in commercial development Available for purchase 2009? Do it Yourself Vehicle Gasifiers Readily made using common sheet metal and welding techniques

**Slide 96:** Economics Gasifiers average about 1 mile per pound of wood 1 Cord dry Beech Costs ~ $45.00 And weighs ~3,000 pounds Equals about 3,000 miles/cord Cost to drive 3,000 miles on wood is $45.00 1.5 cents per mile

**Slide 97:** Economics Pickup Trucks get about 17 miles/gallon 1 gallon of gasoline costs ~$3.00 To drive 3,000 miles will use ~176 gallons of gasoline Cost will be about $529.00 17 cents per mile

**Slide 98:** Cost comparison over 1 Year Driving 10,000 miles per year Woodgas $150/year Gasoline $1,700/year Cost of professionally built Gasifier $3,000 Cost of Recycled Parts Gasifier <$1,000

**Slide 99:** Resources Internet Biomass Energy Foundation Renewable Energy Policy Project National Renewable Energy Laboratory Publications GENGAS: The Swedish Classic on Wood Fueled Vehicles Producer Gas for Motor Transport Handbook of Biomass Downdraft Gasifier Engine Systems Contact Info: bolsen@stlawu.edu

**Slide 100:** Wood gas is the only reasonable substitute for gasoline that is within the means of a private individual and does not threaten the world fuel supply. Gengas 1979

http://www.slideshare.net/ncenergy/operating-engines-on-woodgas-by-bill-olsen/

-------------------------

*www.princeton.edu/~energy/publications/pdf/1998/Small_scale_%20**gasification**.pdf –*

-----------------------------

## Books of Interest

Handbook of Biomass Downdraft Gasification
Thomas Reed and Agua Das, SERI/SP-271-3022, DE88001135, March 1988.
(available in print from BEF at http://woodgas.com/bookstore.htm. please support BEF. the entire BEF library is fabulous. buy the whole thing.)

FAO 72: Wood Gas as Engine Fuel
ISBN92-5-02436-7, UN Food and Agricultural Organization, 1986

FEMA Manual- Constructing a Simplified Wood Gas Generator for Fueling Internal Combustion Engines in a Petroleum Emergency
Henry LaFontaine, F.P. Zimmerman, March 1989
(available in print from http://woodgas.com/bookstore.htm. please support BEF. the entire BEF library is fabulous. buy the whole thing)

Biomass Gasifier "Tars": Their Nature, Formation and Conversion
T.A. Milne, R.J. Evans, N. Abatzoglou, NREL, November 1998
(available in print from http://woodgas.com/bookstore.htm. please support BEF. the entire BEF library is fabulous. buy the whole thing)

## Papers of Interest

Superficial Velocity- The Key to Downdraft Gasification
T. B. Reed, R. Walt, S. Ellis, A. Das, S. Deutch. Presented at 4th Biomass Conference of the Americas; Oakland, CA, 8/29/99
(mirrored from Biomass Energy Foundation, www.woodgas.net)

Monorator- Gasifier for Damp Fuel
Harald Kyrklund, Teknisk Tidskrift, July 21 1945.
(Translation 2000, Joacim Persson <joacim@artech.se>)
(mirrored from: http://www.hotel.ymex.net/~s-20222/gengas/)

Lutz: German Ideas on Improvements of Wood Gasifiers
Summary in Teknisk Tidskrift of a thesis by H. Lutz, published in ATZ. Ed CVNordenswan, Sept. 1941.
(Translation to English, 2000, Joacim Persson <joacim@ymex.net>).
(mirrored from: http://www.hotel.ymex.net/~s-20222/gengas/)

Comments on Lutz paper: Gasifier Efficiency
E. Hubendick, Teknisk Tidskrift, Dec, 1941
(Translation to English, 2000, Joacim Persson <joacim@ymex.net>)
(mirrored from: http://www.hotel.ymex.net/~s-20222/gengas/)

The Making of the Kalle Gasifier
Torsten Kalle, January-February 1942.
(Translation to English, 2000, Joacim Persson <joacim@ymex.net>)
(mirrored from: http://www.hotel.ymex.net/~s-20222/gengas/)

Modelling for Control of a Biomass Gasifier
Dorus van der Hoeven, Thesis 0474218, Technische Universiteit Eindhoven, January 2005

http://www.allpowerlabs.org/gasification/resources/index.html

--------------------------------

http://www.global-greenhouse-warming.com/gas-wood-generator.html

wood logs input

http://www.global-greenhouse-warming.com/wood-fuel-gas-producer.html

Wood fuel gas producer - As we consider the implications of peak oil and rising oil prices, both new and older technologies are again under the spotlight. This excerpt from a publication over 100 years old illustrates how some technologies have not changed a great deal.

"In Fig. 349 we illustrate a wood fuel gas producer, the design of M. Roche, Paris, France, which brings out the possibilities of utilization of saw-mill waste, slabs, and sawdust, and the waste of woodworking mills for the production of power-gas.

It consists of a central furnace in which the fuel charge is burned and which is surrounded by a series of retorts. The fuel used is wood or wood-waste matter, and the products of combustion in the furnace F pass through the flue E and around the retort B. Fuel is fed to the upper part of this retort, which is sealed, and the gas is distilled off by the high temperature maintained. The only exit of the retort is at the bottom, and in travelling down through the retort the gases pass through the lower bed of fuel, which is at a very high temperature, being practically in a state of incandescence.

Any condensable gases or vapors in this part of the retort are broken up and fixed so that the gases which pass through the U-- shaped pipe L to the holder K are in the condition of permanent gases. When wood is used as fuel the composition of these gases is about 18 per cent, carbonic acid, 22 per cent, carbon monoxide, 15 per cent, methane, and 45 per cent, hydrogen.

The calorific value of the gas is about 346 British thermal units per cubic foot. While this is quite high it should be remembered that it is generated by distillation, and is therefore free from nitrogen, which usually forms about 50 per cent, of the volume of producer – gas and it also contains a larger proportion of hydrogen. The products of combustion in the furnace F, after circling around the retort, pass out the upper flue H, through the opening in the damper I, and out the exhaust-passage J."

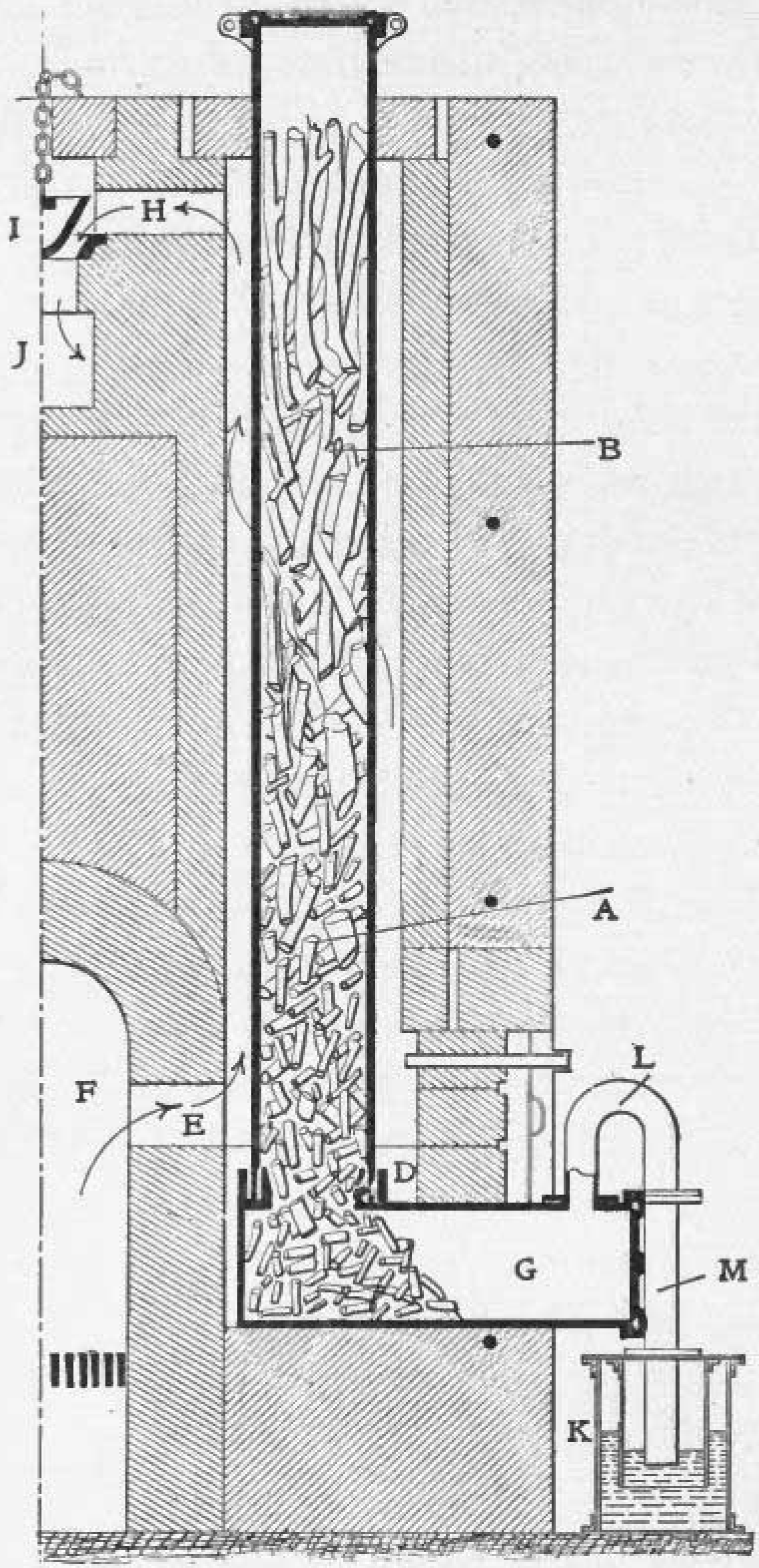



FIG. 349.—Riché distillation producer.

Source: GARDNER D. Hiscox, 1907, Gasoline and Oil-Engines Including Producer-Gas Plants, NEW YORK, THE NORMAN W. HENLEY PUBLISHING Co. 132 NASSAU STREET 1907, Page s393-394
-----------------------------

Fluidyne Gasification Archive – Since 1976

http://www.fluidynenz.250x.com/index.html

http://www.global-greenhouse-warming.com/gas-wood-generator.html