Advances in Small Gasifiers for Residential Cooking and Other Small-scale Heat Applications

Plenary Presentation to the LAMNET International Workshop on "Bioenergy for a Sustainable Development," 8-10 Nov 2004, Viña del Mar, Chile

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For additional details, refer to the text article in the proceedings of the LAMNET International Workshop on "Bioenergy for a Sustainable Development," 8-10 Nov 2004, Viña del Mar, Chile

Biomass Gasification:

Clean Residential Stoves, Commercial Power Generation, and Global Impacts

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Abundant Renewable Dry Biomass

(but people only use a highly selective small fraction for energy)

Wood is the main biomass fuel. (Its appeal can lead to the problems of deforestation exactly in the most environmentally sensitive locations.)

Tree-wastes (sawdust, trimmings, twigs, seedpods, leaves, coconut shells/husks/fronds, etc.),

Agro-wastes (stems, hulls, husks, roots, cobs, by-products of production, etc.),

Municipal wastes (discarded combustibles including paper/cardboard and dried sewage),

Environmental excesses (bamboo, dried aquatic invaders, etc.).

Wood (and other dry biomass) does not combust.

Only gases, vapors and char from heated wood can be combusted.

Terminology (to simplify, not confuse)

"Woodgas" is defined as the combustible gases that can be created from wood and other dry biomass via heat-related processes.

Woodgas is a biogas, but "biogas" is commonly reserved for gases from anaerobic digestion of wet biomass.

Dry biomass can be gasified.

Wet biomass can be digested.

The full "burning" of dry biomass involves the creation of the gases and combustion of those gases.

Creation = Gasification = Pyrolysis + "Carbolysis"

The first part of gasification is

PYROLYSIS

Pyrolysis occurs as biomass is heated until it is fully charred to the core, that is, having given up all volatiles.

Typical Yield Of Pyrolysis:

- 1/3 Char (Pure Carbon plus “ash”)
- 1/3 Burnable Vapors/Tars
  (condensable at ambient temp.)
- 1/3 Permanent Gases
  (CO, CO_2, H_2, CH_4, N_2)

The second part is

CHAR gasification

[“Carbolysis”]

$C + O_2 \rightarrow CO_2 + \text{Heat}$

$\text{Heat} + CO_2 + C \rightarrow 2CO$

$\text{Heat} + H_2O + C \rightarrow CO + H_2$

Gasifiers

are devices in which

dry biomass is transformed into combustible gases in processes *distinctly and controllably separate in time and location* from the eventual combustion of the gases.

Historical notes

A. Early 1800s, serious gasification of coal begins.

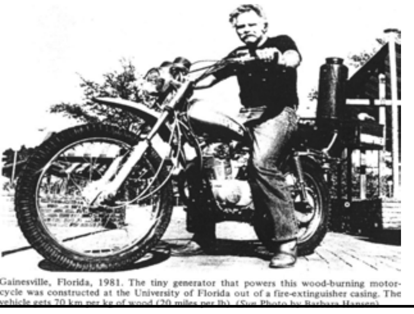
B. By 1850, gas services (from coal) in London and Paris.

C. Petroleum and natural gas are not used seriously until the 20th Century.

D. Gasification of wood is in smaller quantities, incl. for WWII vehicles.

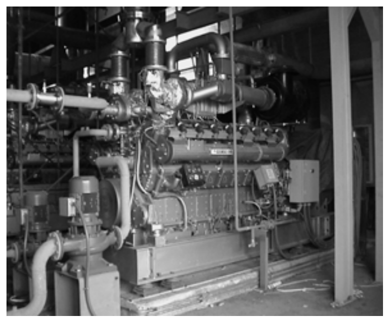
Vehicles Powered by Woodgas

1979. This wood-burning 1978 Chevrolet Malibu station wagon (from which the fuel tank has been removed) drove 4,320 km (2,700 miles) from Jacksonville, Florida, to Los Angeles, California, fueled entirely by scrap wood. The generator holds enough wood for about 160 km (100 miles) of travel. On the open highway the vehicle easily cruised at 91 kph (55 mph) and reached a top speed of 108 kph (65 mph). Fuel economy averaged about 3.5 km per kg of wood (1 mile per lb), a considerable savings in fuel cost over gasoline. Body-mounted 1981 versions of the wood-powered generator are shown below. (Ben Russell, President, ECON, P.O. Box 828, Alexander City, Alabama 35010, USA)



Gainesville, Florida, 1981. The tiny generator that powers this wood-burning motorcycle was constructed at the University of Florida out of a fire-extinguisher casing. The vehicle gets 70 km per kg of wood (20 miles per lb). (Sun Photo by Barbara Hansen)

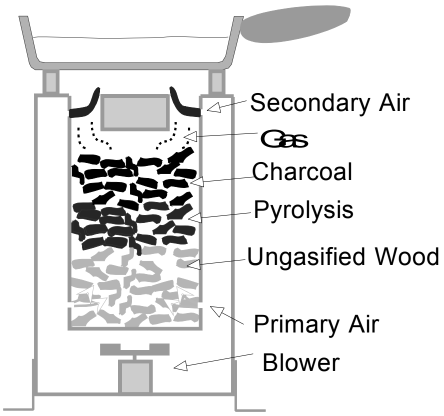
Large Gasification Installations



Top-Lit Up-Draft (TLUD) Small Gasifiers

- Background: 1985 to 2004
- Close-coupled combustion
- Versions for forced air or natural draft
- Three parts:
  - –Fuel chamber
  - –Air base
  - –Fan or blower

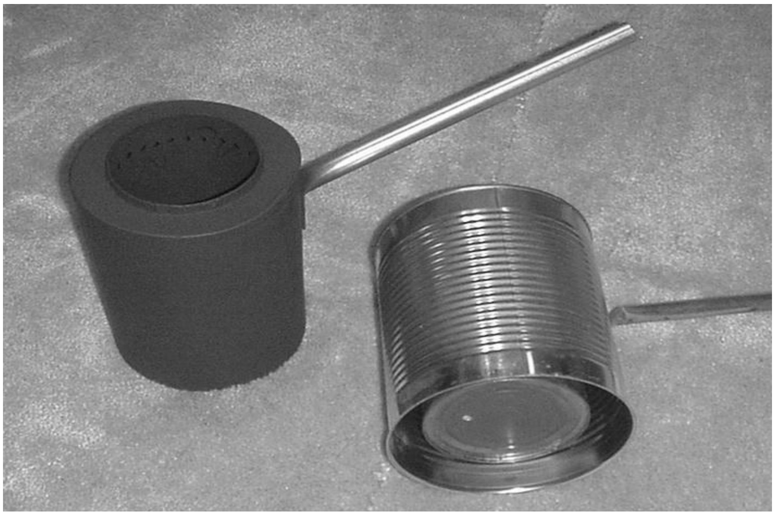
Reed’s Woodgas Campstove



Ward, Colorado

Three-burner woodgas stove. Individually adjustable burners. Removable tincanium fuel magazines have lasted 3 years.

Two Views of Fuel Chambers in Anderson´s Juntos Gasifiers



Two Air Bases with a Fan and a Blower

Assembled Juntos Gasifier

with expanded steel mesh to support the pan

Assembled Juntos Gasifier

with improvised “3-stone” support for pan

Assembled Juntos Gasifier

with improvised free-standing support for pan

The LAMNET article provides basic instructions for making and operating a Juntos-style small gasifier for single-pot cooking.

Those instructions are also available at:

http://www.repp.org/discussiongroups/resources/stoves/

Eleven benefits

1) Reduced smoke (IAP) yields better personal health;

2) Improved personal safety;

3) Reduced drudgery for women & children;

4) Home benefits incl. room heating;

5) Job creation;

6) Available energy for societal development;

7) Probable provision of lighting via woodgas;

8) Reduced deforestation;

9) Reduced dependence on fossil fuels;

10) Improved air quality;

11) Assisting the "carbon cycle" for climatic stability.

Financing and Implementation

- **Kyoto and CDM** lead to payment for CO_2 or C.
- CO_2 = US$6/ ton, becomes **$24/ton of solid C.**
- Household gasifier to **produce ½ ton C / year.**
- Therefore **~$10-12 per household per year** available to finance the stoves usage.
- **Verifiable sequestration** of C in scattered burial.
- "Dark Earth" (terra preta) **soils have greater fertility**, therefore more food, health, and social stability.

Latosol vs. Terra Preta (Dark Earth)

Nine clear "wins"

and no evident "loses"

A. Families use low-value biomass and cut fewer trees, reducing deforestation WIN

B. Society observes less CO_2 entering the atmosphere (via charcoal co-product) WIN

C. Kyoto/CDM "carbon credit" is generated by this charcoal and reforestation WIN

D. Impoverished families receive improved cookstoves to motivate A & B WIN

Nine clear "wins" (continued)

E. Reduced Indoor Air Pollution (IAP) yields better health for biomass users — WIN

F. Verifiable permanent sequestration of carbon via scattered burial — WIN

G. Soil fertility is improved, crops are better (with improved food and health) — WIN

H. Appropriate sustainable technology creates employment & capacity building — WIN

I. De-centralized implementation allows maximum localized adaptations — WIN

Four Essential Components

- **Fuels** (store energy)
- **Combustion devices** (release energy)
- **Applications** (utilize energy)
- **Human factors** (justify energy)

Actions and Invitations

- The creators of the Reed-Anderson Woodgas and Juntos small gasifiers are making the technology available to all.
- Variations can be done world-wide, with sharing of improvements and methods.
- 600 million households using dry biomass daily could participate and benefit.
- Options for implementation are welcome.

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