

Wood Gas Wizard

By Richard Freudenberger

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Back in 2004, Wayne Keith drew a line in the sand at \$1.50. That's the price at which the Alabama native would no longer buy a gallon of gasoline. Keith, who makes his living raising cows, growing hay and milling timber in a small town about 30 miles northeast of Birmingham, wasn't bluffing. He knew he had an alternative fuel in his backyard: the hundreds of pounds of scrap wood he generates every time he runs his sawmill.

Since 2004, Keith has powered his trucks with wood. Sound strange? Trust me, this is no pipe dream. Many years ago, when I managed the MOTHER EARTH NEWS research facilities in North Carolina, we built wood-powered vehicles for the same reasons Keith does today. But Keith has taken wood gasification well beyond what I could've imagined. This unassuming, down-to-earth farmer is an energy and transportation pioneer, with more than 250,000 miles of wood gas driving under his belt and about \$40,000 saved by using wood chunks instead of gasoline.

"My Dodge Dakota truck gets about 5,200 miles per cord," Keith says in his easygoing Southern drawl. (A cord is a common measurement for wood, meaning a wood stack 4 feet deep by 4 feet high by 8 feet long.) "I paid for my farm in the early 1990s by selling wood at \$27 per cord. Today a cord costs about \$50 [wholesale] in this area. I burn scrap wood from my sawmill, but if I had to buy wood, I could still travel for less than a penny a mile."

For comparison, if gasoline costs \$3.50 a gallon, your vehicle would have to achieve nearly 350 miles per gallon for its driving cost to be a penny per mile.

4 Reasons for Wood Gas

The idea of powering vehicles with wood or other biomass energy is nothing new. Trucks, cars, motorcycles, boats, tractors and even airplanes have been adapted to burn wood. By the end of World War II, when there were critical shortages of petroleum, there were more than 1 million wood gas civilian vehicles operating in Asia and Europe.



Fig. 1: Alabama woodgas wizard Wayne Keith hasn't used more than a few gallons of gasoline since 2004, thus saving about \$40,000.

PHOTO: RICHARD FREUDENBERGER

After the energy crisis of the late 1970s, MEN revisited woodgas as a homegrown fuel option. We heard from several readers who built their own wood gasifiers. Eventually, we had all of these running on woodgas: a Chevy pickup, a sawmill, a 12.5-kilowatt electric generator for remote power. But why would anyone want to use wood for motor fuel?

1. Abundant Biomass. Wood is biomass that, well, literally grows on trees. In many areas, there are more wood resources than you can shake a stick at. And you don't need firewood splits to do this—small branches, construction tailings and other wood scraps make the best fuel.

2. Wood Is Carbon-Neutral. Unlike coal or petroleum, which become environmental problems when they are extracted, refined and burned, a tree absorbs carbon dioxide from the air as it grows. When a tree dies, whether it is burned or left to rot, the carbon dioxide is released back into the atmosphere.

3. Biochar to Enrich Your Garden. When wood is consumed for motor fuel, it creates a byproduct known as *biochar*. This carbon-rich char is used as a soil amendment to decrease acidity and reduce nutrient leaching while improving tilth and



Fig. 2: Woodgas trucks, from left: '95 Dodge Ram 2500 V10; '84 Ford F250 V8; '93 Dodge Dakota V8; '92 Dakota V8 (conversion in progress)

PHOTO: WAYNE KEITH



Fig. 4: from right: gasifier, heat exchanger, filter.

PHOTO: RICHARD FREUDENBERGER

productivity. (Read about biochar for gardening in [Make Biochar](#))

4. Energy Independence. Perhaps the best benefit of wood gas is that wood is a renewable, homegrown fuel. If you have moderate metalworking skills and access to a sawmill, using a wood gasifier can be a major step forward in sustainable, self-reliant living. Wood gasification isn't for everyone, but it certainly is within reach for many MOTHER EARTH NEWS readers.

Wayne's Wood Gas World

"Wayne's truck is 67 percent cleaner than an electric vehicle charged on the Alabama grid, because 67 percent of the electricity in Alabama comes from fossil fuels," Bransby says. "Specifically, 59 percent coal and 8 percent natural gas."

Wood Gasification 101

Just like gasoline or diesel, wood is a carbon-based fuel. But because wood is solid, it must be converted to a gas before it can power an engine, much like gasoline or diesel must be atomized before they can be ignited. Traditional burning isn't sufficient—wood must be heated in a high-temperature, oxygen-starved environment in order to chemically convert and produce the ideal mix of combustible gases in a process called *pyrolysis*.

When that conversion happens, wood gas is more effective than gasoline. Wood has less BTU "punch" than gasoline to start with, but gasoline loses some of its BTU punch in conversion to a mist. In Bransby's 2010 tests, the Dakota achieved 21 mpg on gasoline and 29 "mpg" on wood gas.

Like any typical wood gasification system, Keith's setup has three basic components: a gasifier, a radiator and a filter.

The wood gasifier consists of upper and lower chambers in the form of drums connected in the middle by a heavy spacer.



Fig. 3: No shortage of power or towing capacity in woodgas trucks.

PHOTO: WAYNE KEITH

The upper drum is a lidded hopper where the wood chunks are held. There is an internal air inlet manifold that introduces oxygen a few inches from a restriction, which causes a high temperature (about 2,700 degrees) to be created in a small environment. This is where the gasification takes place.

Hot gases go from the gasifier to a heat exchanger, where gaseous fuel is cooled with fresh air. Incoming air piped to the gasifier's inlet never comes in contact with the exiting fuel gases.

Next, the gases go to a radiator, or cooler, which Keith has skillfully camouflaged as a bed rack. There are two inlets and two outlets, so each side of the rack has cooling capacity. Here, the gas temperatures drop below the dew point, and the condensation drains into small tanks.

The third component, the filter, is simply a clamped-lid barrel filled with hay. This removes most of the particulate matter contamination in the wood gas.

After being cooled and filtered, woodgas is pulled through two branches of PVC piping to the engine compartment. Homemade "slingshot" filters separate any remaining moisture and particulate matter from the incoming gas stream.

Cooled, clean woodgas is directed to fittings Keith installed in



Fig. 4: PVC piping directs cooled and filtered woodgas to the engine.

PHOTO: RICHARD FREUDENBERGER

the engine's air cleaner housing. Two inlets are dedicated to fuel gas and two to fresh air, which is drawn in through separate canister filters. Each of the four inlets includes a butterfly valve that Keith adjusts manually with controls on the dash.

World's Fastest Wood Gasification Truck

Impressive as the old Ford was, I was eager to see Keith's seventh wood gas truck conversion, the '93 Dakota. Just days before I arrived, Wayne and his son Tally had returned from the Bonneville Salt Flats in Utah, where MOTHER EARTH NEWS sponsored Keith in the famous World of Speed time trials. Not only was Keith's Dodge Dakota the only wood-powered vehicle there, he was the only competitor to actually drive (not trailer) the vehicle to the event—a distance of about 2,000 miles.

"We made 73.09 mph in the measured mile," Keith says. "I beat 12 other vehicles running [in other categories] on gasoline, and beat the team with the prior woodgas record of 47.7 mph."

To start the Dakota, Keith flipped switches on a two small in-line bilge blowers and opened the gasifier lid to reveal remnants

Woodgas Sets New Speed Record: 73mph

Read to learn more.

But 73mph isn't the Dakota's top speed. MEN Managing Editor John Rockhold took a ride that had to slow down at 84 mph. Read about and watch it in [I Went 84mph in a Woodgas Truck](#)

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Fig. 6: Wood chunks that power Wayne Keith's trucks.

PHOTO: RICHARD FREUDENBERGER

of cold char, which he ignited with a propane torch.

"With a poker rod I make a little void that goes down to the center of the hearth," Keith says. "I've got blower switches fixed so I can either blow or suck air through to get the wood going."

After pouring a sack (about 12.5 pounds) of dried wood chunks into the chamber, he sealed the lid and started the truck on gasoline. We drove about a quarter of a mile on gasoline, then he switched over to wood gas with the touch of a lever.

"On this truck, a sensor and gauge monitor exhaust gas, telling me if it's too rich, too lean, or just right," Keith says. "Also, vacuum and temperature gauges—like a doctor's stethoscope and blood pressure monitor—that let me keep an eye on what's going on. Since wood gas is slow-burning, it helps to advance the timing a bit. The older Ford does that with a cable, but newer models are smart enough to automatically adjust to the fuel."

On a straight stretch of road, we cruised at 75 mph. Other than monitoring the gauges, Keith did not spend much time making adjustments. Aside from the occasional flick of extra levers and the barrels in the truck bed, you wouldn't know this truck runs on wood instead of gasoline.

As far as how the wood gas system performs throughout the year, Keith says the vehicle performs slightly better on crisp days, when humidity is lower.

"The gasifier works fine in hot weather," he says. "It increases in power a bit the colder it gets. In very cold weather there could be issues with the condensation freezing, so you'd have to design for that."

As far as driving range, Keith sized the Dakota's wood gasifier to allow 50 to 75 miles on one fill. Some of his earlier gasifiers were sized to allow 100 miles or more, but that required more conspicuous tanks.

Wood Gas Revolution?

Clearly there is untapped potential in wood gasification for transportation, but whether it can ever be more than a fringe movement remains to be seen. Making it work isn't easy. Even Wayne Keith—arguably the best advocate for wood gas—says

that 75 percent of success comes down to operator knowledge and experience; the system itself accounts for the remaining 25 percent.

Despite all the money that Keith has saved via wood gas, it's the self-reliance that is the most satisfying benefit.

"The big plus for me—beyond the clean driving and financial benefits—is being dependent on no one but myself for fuel."

Wayne's Wood Gasification Conversion Tips

Choose a truck with ample room under the hood, and around the engine and chassis. Electronic fuel-injected engines with streamlined air intakes convert better than carbureted engines.

Multi-port fuel injection is preferred to throttle-body injection. Generally, trucks built after the mid-1980s use fuel injection.

Large-displacement engines have more power and give better results on wood gas.

High compression improves performance with wood gas: It burns slowly and has great antiknock qualities. Wood gas supports a compression ratio of up to 16:1.

It is possible to convert diesel engines to use wood gas, if given the correct compression ratio. But the injector pump has to furnish the ignition with at least 5 percent diesel.

Ignition timing should be advanced because of the slower-burning gas. Modern engines with electronic ignition will automatically advance the timing.

It takes about 200 to 300 hours to convert a truck to wood gas. Keith's record-setting Dodge Dakota took 250 hours of work.

The cost of materials to convert is about \$500. Many components can be found free.

Tools needed: basic mechanic's tools, a sheet metal nibbler, a metal-cutting reciprocal saw, a power hacksaw, a drill press, a cutting torch, small wire-feed welder, a solid workbench, and a sturdy vise. The gasifier should be built to match the size of the engine and its airflow volume.

Wood chunk size affects engine performance. Small chunks react faster to give better performance, but fuel is consumed faster. Hardwood has greater energy density, and thus delivers more range per fill than softwood.

Ongoing maintenance: flushing the cooler and draining the condensation traps every 2,000 miles. Ash residue should be removed every 1,200 miles and filter media changed once a year.



Fig. 7: Homemade "wood chucker" (made from remains of an old truck) slices scrap wood

PHOTO: RICHARD FREUDENBERGER

Moisture content of wood chunks should be less than 25%.

Wayne Keith's Wood Gas Wonders

About 250,000 miles driven, almost exclusively on woodgas, since 2004. About \$40,000 saved not buying gasoline.

Nine trucks converted to wood gas since 2004. Regularly hauls loads of 15,000 pounds in farm work.

Completed the 2009 Bio-Truck Coast-to-Coast and Back tour, which ran from Alabama to Charleston, S.C., to Berkeley, Calif., and back to Alabama.

Completed 2009 Escape from Berkeley road rally, which ran from Berkeley, Calif., to Las Vegas. Finished second to Jack McCornack's MAX car (visit [100-mpg Car: MAX](#) to learn more), partly because of a flat tire on the wood chip trailer.

Set new speed record for wood gas (73 mph) in the 2011 World of Speed event at Utah's [Salt Flats](#). Read [73 MPH On Wood Gas Sets New Record](#) to learn more.

Wood Gas Resources

[MOTHER EARTH NEWS Wood Gas Adventures blog](#)

Learn more about gasification and see videos of various vehicles in action, including Wayne Keith's.

[Drive On Wood!](#)

Wayne Keith's website. Keith is working on a book with detailed plans for his system.

[Yahoo! Groups: Wood Gas](#)

The Wood Gas community group on Yahoo! has numerous wood gas veterans among its members, including moderator Mike LaRosa.

Richard Freudenberger was a Senior Editor at MOTHER EARTH NEWS from 1978 to 1990. He currently is the publisher for [BackHome magazine](#), and his most recent book is [Alcohol Fuel: A Guide to Making and Using Ethanol as a Renewable Fuel](#).



Make Biochar

Ancient Technique to Improve Your Soil

Charcoal made from brush can increase your soil's fertility and help slow climate change.

by **Barbara Pleasant**, MEN February/March 2009

What's biochar? Basically, it's organic matter that is burned slowly, with a restricted flow of oxygen, and then the fire is stopped when the material reaches the charcoal stage. Unlike tiny tidbits of ash, coarse lumps of charcoal are full of crevices and holes, which help them serve as life rafts to soil microorganisms. The carbon compounds in charcoal form loose chemical bonds with soluble plant nutrients so they are not as readily washed away by rain and irrigation. Biochar alone added to poor soil has little benefit to plants, but when used in combination with compost and organic fertilizers, it can dramatically improve plant growth while helping retain nutrients in the soil.

Amazonian Dark Earths

The idea of biochar comes from the Amazonian rain forests of Brazil, where a civilization thrived for 2,000 years, from about 500 B.C. until Spanish and Portuguese explorers introduced devastating European diseases in the mid-1500s. Using only their hands, sticks and stone axes, Amazonian tribes grew cassava, corn and numerous tree fruits in soil made rich with compost, mulch and smoldered plant matter.

Amazingly, these "dark earths" persist today as a testament to an ancient soil-building method you can use in your garden. Scientists disagree on whether the soils were created on purpose, in order to grow more food, or if they were an accidental byproduct of the biochar and compost generated in day-to-day village life along the banks of the Earth's biggest river. However they came to be, there is no doubt that Amazonian dark earths (often called *terra preta*) hold plant nutrients, including

nitrogen, phosphorous, calcium and magnesium, much more efficiently than unimproved soil. Even after 500 years of tropical temperatures and rainfall that averages 80 inches a year, the dark earths remain remarkably fertile.

Scientists around the world are working in labs and field trial plots to better understand how biochar works, and to unravel the many mysteries of *terra preta*. At Cornell University in Ithaca, N.Y., microbiologists have discovered bacteria in *terra preta* soils that are similar to strains that are active in hot compost piles. Overall populations of fungi and bacteria are high in *terra preta* soils, too, but the presence of abundant carbon makes the microorganisms live and reproduce at a slowed pace. The result is a reduction in the turnover rate of organic matter in the

soil, so composts and other soil-enriching forms of organic matter last longer.

Read more: <http://www.motheearthnews.com/Organic-Gardening/Make->



