Small Scale Biomass Gasification

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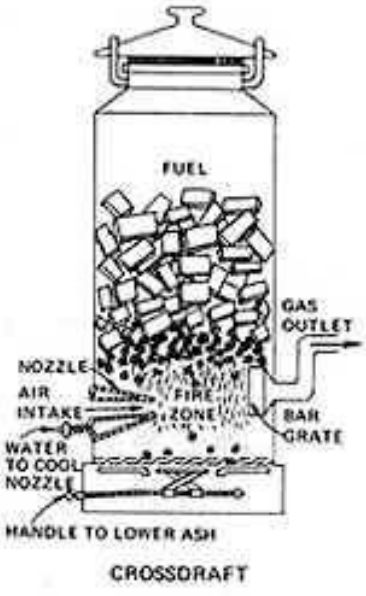
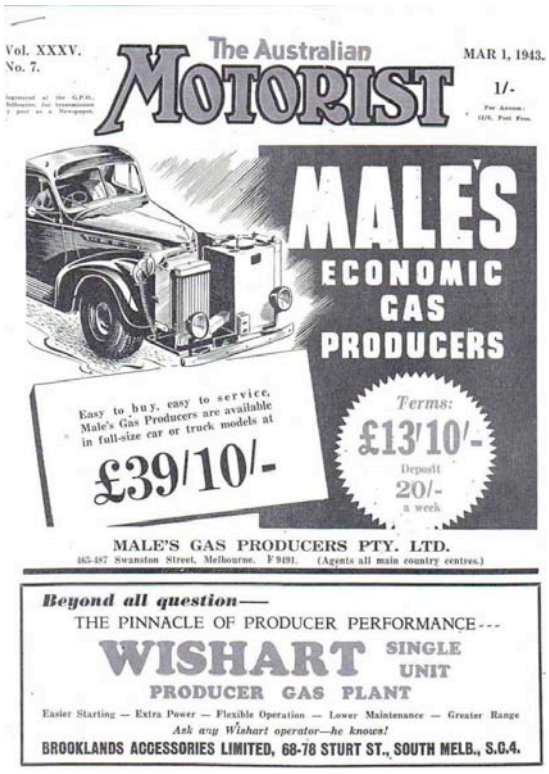
Overview

In conjunction with Fluidyne Gasification New Zealand, we have developed a small wood gasification system designed to drive internal combustion engines for the purpose of on-demand power generation in off-grid areas where petroleum fuels are expensive. Our process development gasifier module consumes up to 20 kg/hr of small wood pieces, powering a 3-litre piston engine driving a 15 kW alternator (sufficient power available for around 6 houses). With a minimum of controls and instrumentation our aim is to provide a robust technology suitable for rural applications and off-grid power supply anywhere in the world.

Technology, History and Context

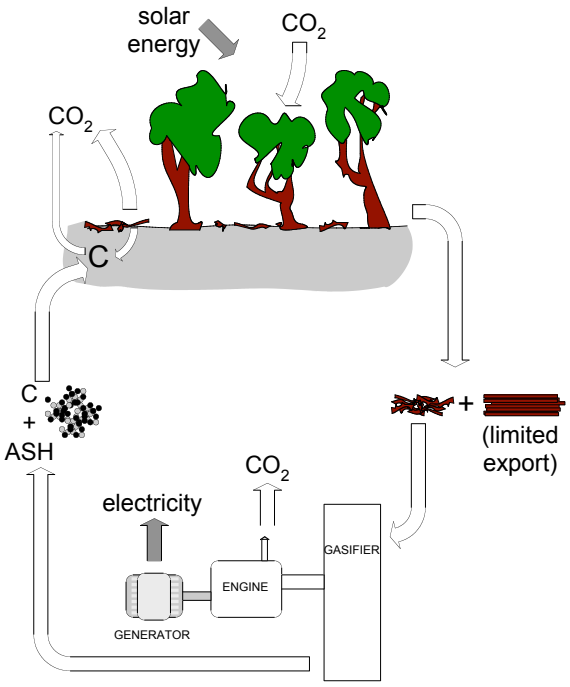
The concept of gasification isn't new; rather it is more of a "forgotten art", thanks to the present abundance of hydrocarbon fuels. The wood (or any solid carbon-containing fuel) is partially combusted in limited air and the flammable gases produced in the process ("producer gas" or "wood gas") are extracted for use as fuel. The device is called a "gasifier", or "gas producer".





The process was widely used with charcoal, rather than wood, during the Second World War, when petrol was scarce. Over 1 million cars ran on charcoal in Europe, and an estimated 72,000 Australian cars were converted to charcoal power. But because of the significantly reduced

engine power, in the transport context this really is a technology of desperation, when there is no other way to power an internal combustion engine.



Wood gasification is a mature, but little-known renewable energy technology. Running an engine on producer gas requires far less land area or technical infrastructure than that required for running on biodiesel or ethanol; it does not require monoculture crops and can utilise indigenous species (indeed, wood of any sort). Thus the technology is suitable for integration with re-vegetation programs designed to enhance biodiversity. And, as it provides energy on demand, we think it can be an important part of the future renewable energy mix, complementing the more variable generation profiles of wind or solar photovoltaic generating systems.

Here's our original test setup in Footscray. The gasifier powers a Holden 186 Red motor driving a 15 kW MeccAlte generator. At full power, we go through around 20 kg of wood per hour and

generate 15 kW of electricity. Apart from the tall cylindrical hopper where the wood is converted to gas, the rest of the unit is for cleaning the gas to remove moisture and fine carbon dust to make it suitable for use in the engine. (Mark is at the controls.) We added a governor to control the throttle and maintain the engine speed at 1500 rpm. When the whole system is running, it is the suction from the engine's inlet that provides the force to draw the air into the gasifier and maintain the gas-making process. The harder the engine is working, the harder it sucks and the more gas the gasifier produces.

When the gasifier is first started up, we use a fan and run the gas to a burner rather than the engine. You can tell a lot about the process from looking at the flame. This beautiful pink/purple flame shows that we are making really good clean gas. An orange colour would indicate particulates; yellow and/or smoky on the other hand usually indicates un-cracked hydrocarbons or tars are present, which would damage the engine.

The wood we use should preferably be dried to around 30% moisture – we do this using waste heat from our engine exhaust. The gasifier really loves nice even chunks of wood, to provide an open bed of reactive charcoal in the heart of the process. A bucket of wood weighing 5kg is, for us, the energy equivalent of 1.7 litres of petrol. (At a wood consumption of 20 kg/hour we can light 1000 compact fluorescent lamps.)

We use the sawdust and wood-shavings from cutting up the fuel as the filter material in the final stage of the gas-cleaning process (left photo). It does an exceptionally good job. Once this filter material has captured all the fine char it can hold, we replace it with fresh material, and put the used material back into the soil. We also collect some condensed water from the gas cooling system, which is slightly alkaline (pH around 8.2) and contains very fine char particles. Ash and low-grade activated carbon is the solid remnant of the wood which went in (right photo). We get a small amount of this accumulating over time in the bottom part of the gasifier vessel and it is ideal for filtering the condensate water, before returning to the soil.

“Must look like the Sun.” Learning the trade of gasifier operation, you remember these key phrases. In the above picture, we’re looking directly into the gasifier hearth through an air nozzle, where the temperature peaks at 1200 - 1500 degrees Celsius. We like to keep an eye on the “fire” in there and make sure it does look like the Sun. If it goes dim it can mean we’re not getting enough airflow, or the fuel has stopped feeding for some reason.

Here are some stills from a video of our first road-test of the HX Kingswood ute on wood power. Air comes through the air filter and mixes with gas from the gasifier at a tee piece. The mixed fuel and air goes into the engine through the original air filter position. (Total cost of engine modifications = around 80 bucks worth of plumbing parts.) We put the gasifier on the tray of the ute. We took the bonnet off because there wasn't enough room for the plumbing and hoses. Having a fuel with only half the energy of petrol, combined with an extra half a tonne of gasifier on the back didn't make for lightning speed, we only managed 50km/h (but in theory 80km/h should have been possible if we'd been bothered enough to do a bit of engine tuning and maybe pumped up the tyres a bit…)

Project Details

We started this project in mid-2005. We are self-funded, with key aspects of the gas-making technology licensed from Fluidyne Gasification New Zealand.

The timeline for our project so far has been as follows:

2005		
	June:	Initial idea to build a wood gasifier
	July:	Scoping study researching the technology locally and overseas
	October:	Established a license agreement with Fluidyne NZ
	November:	Gasifier Mk1 design
2006		
	February:	Construction of Mk1 prototype
	August:	Commissioning and testing of Mk1 gasifier
	September:	Construction of Mk2 gasifier
	October:	Testing of Mk2 gasifier, incorporation of Gasification Australia Pty Ltd
	November:	Commenced long-term test campaign of feedstocks, system operability etc…
2007		
	May:	Visit to 2MW scaled-up version - Mega-Class gasifier in Winnipeg, Canada
	June:	Commence establishing first demonstration facility near Broadford
	July:	Commence design for Mk 3 gasifier
	August:	Finalise Mk 2 system for demonstrations
	September	Import producer gas genset from Prakash Diesel (India) for Mk 3 system.

The major benefits to us so far have been a ground-up education on the design, construction and operation of high-performance wood gasifiers. Also heaps of free, on-demand electricity and the ability to boast to our friends about driving around in a wood-powered vehicle.

The next steps for us are

- Getting the Mk3 system completed and commercial-ready
- Use the gasifier to demonstrate dual-fuelling a diesel engine on woodgas
- Commencing an education program to provide practical guidance and encouragement those that want to build their own gasification systems

Conclusion and Reflections

We would encourage others to try wood gasification as a simple and low-capital-cost means of easily generating many kiloWatts of electricity whenever you want it. Start with a proven design such as a throated downdraft gasifier and get used to the smell of woodsmoke!

The project has, for us, been an empowering experience. We have proved to ourselves that with a sustainably-managed supply of waste wood, we can generate sufficient on-demand electricity to run a small village, farm or factory, and, should the need arise, power vehicles in the absence of petroleum. All with zero net greenhouse gas emissions and by-products that make a great soil conditioner.

Once we decided to ignore the literature and “go-for-it” under the guidance of Doug Williams from Fluidyne, we were amazed at how simple and easy it was to get a reliable and efficient process for running engines on wood.

We see a future for this technology in a number of niche areas due to its low capital cost per kW, and because it is an on-demand power system it has the ability to complement other renewable generation systems such as wind and solar PV.

So there you are. In a nutshell, our experience of power from wood. From the backyard power station to transport of delight. We think that wood gasification has a lot to offer in terms of regional and small-scale on-demand power generation. And maybe if you’re really really desperate, it’ll get you from A to B as well.