Waste woody biomass: cost-effective, low carbon, renewable energy

Biomass is often the forgotten renewable energy. David Coote explains how woody biomass has been used in Europe to meet renewable energy targets. Can it be embraced in Australia?

hile in Australia photovoltaics, solar hot water, wind and more recently concentrating solar thermal tend to be the renewable energy technologies du jour, the last 20 years have seen massive investment in systems producing energy from biomass in the northern hemisphere. The scientific community, the IPCC, the WWF and governments across Europe, North America and the southern hemisphere, including Australia and New Zealand, regard wood from sustainable sources as a low carbon, renewable energy.

Wood is currently by far the most important renewable energy with the International Energy Agency reporting that of the 13% of the world's primary energy supplied by renewable energy, 77% is supplied by biomass of which over 85% is woody biomass.

Nations in Northern Europe and in North America have installed substantial biomass energy capacity to generate renewable, low-carbon energy and increase energy security. For example, 50% of Sweden's residential heating is now from district heating schemes (DHS) with most using biomass.

More than a little surprising is how competitive the cost of energy from wood can be when compared to fossil fuels. There is a very strong case for wood to make a much larger contribution to Australia's renewable energy portfolio. This article outlines some of the technologies involved, the scales at which they can operate and potential feedstocks.



Inside the combustion chamber of a district heating system fuelled by woody biomass.

Energy from wood

When wood is burnt directly, or when wood is gasified and the gas burnt, energy is released. The energy can be used in a variety of ways: space heating or absorption cooling/refrigeration; low temperature and pressure steam to generate electricity from an Organic Rankine Cycle turbine; and higher pressure and temperature steam to generate electricity from a turbine using the Steam Rankine Cycle (SRC). Wood gas can be used to generate electricity from a cheap commodity generator or via gas turbines and other more technically advanced means such as the Integrated Gasification Combined Cycle. The most common commercial wood energy systems in Europe are boilers producing thermal output and SRC systems, so this article will focus on these technologies.

Advanced wood combustion systems

Some archaeologists think there's evidence to suggest that hominid species started using fire over a million years ago. After all this time it's remarkable that in the last 30 years the efficiency with which commercial systems can turn wood into heat has risen from around 50% to nearly 100% (not including distribution network losses). With this climb in efficiency has come a dramatic drop in pollutants emitted. Smoke control areas in Europe have strict regulations on emissions. There are commercially available wood energy systems from residential scale



Both the apartments at right and the kindergarten below are heated by woody biomass systems.



upwards that meet these requirements. It's common to see wood energy systems embedded in European villages and towns with the only sign of their existence a faint heat haze at the top of the chimney. Advanced Wood Combustion (AWC) systems operate in Europe at scales from residential to large utility supplying thermal demands. The automated fuel feed systems also contribute to low operations and maintenance expenses.

Feedstocks

Clearly, the furore over native forest harvesting has dominated the debate in Australia over any use of wood. However, there are numerous sources of waste woody biomass that have nothing to do with native forests. We heat our house in suburban Melbourne using a wood insert combustion system fuelled by locally obtained arborist waste. Other waste streams include timber industry processing waste, orchard management, agroforestry and plantation harvest residues, roadside wildfire fuel reduction, firebreaks, local council tree management, senescent fence-line farm trees and construction and demolition waste. (For local supply of fuelwood there is also potential for multiple-species, multiple objective woodlots using approaches such as Multi-Functional Agriculture and Analogue Forestry, but that's outside the scope of this article.) In Australia much of this waste cur"...there are numerous sources of waste woody biomass that have nothing to do with native forests."

rently goes to landfill or is piled up and burnt. It strikes the European policy makers (and the author) as a considerably better outcome to substitute this woody biomass for fossil fuels.

Waste woody biomass streams can be used as fuel in the form of fuelwood (aka firewood), pellets and chips. Fuelwood is simple to process, but as anyone with a wood heater will know, requires regular operator application of wood to fire. Pellets are an engineered product with quality standards for size, mechanical stability, energy and moisture content and ash fusion temperature. Pellets meeting quality standards allow combustion systems with automated ignition and feed, thermostatically controlled output and simple storage. Pellets are more expensive than fuelwood and chip and require pellet manufacturers and a supply chain. Wood chip for use in wood combustion systems is produced



Left: Pellets are delivered by truck and pumped into the pellet storage area. Right top and bottom: wood chips are moved from the chip store to the heater using augers.

by a method similar to making mulch except generally with tighter restrictions on particle size. Chip heaters share similar characteristics with pellet heaters although the storage silo tends to be larger and they are more expensive.

Efficiencies scales and costs

Thermal systems are cheap to run and scale from a few kilowatts up to hundreds of megawatts. In Australia, the levelised energy cost per kWh from thermal systems can be cost-effective against heat supplied by using LPG or electricity. SRC systems can use wood as the fuel to generate electricity. I've visited 2MW and 25MW SRC plants in Austria. At this size, SRC generators (whatever fuel is used) are expensive per kW installed, relatively inefficient with respect to electrical generation and the high pressures and temperatures involved lead to considerable operation and maintenance costs. To feed into the grid in competition with power from fossil sources in Australia, small SRC systems would tend to require subsidies, a high carbon price or cheap fuel. There is, however, potential for SRC systems to be competitive in supplying remote grids currently using expensive diesel generation if woody biomass is available.

Another possibility is colocation with an electricity customer prepared to pay commercial electricity rates. Also relevant are cogeneration or combined heat and power applications where heat can be sold that would otherwise be wasted. But finding a use for tens of megawatts of thermal capacity at a single site with sufficient woody biomass available would be a challenge in Australia.

European experience

In June 2010 I visited Austria for a short course on Systems Analysis of Biomass Supply Chains at a university in Vienna and wood energy system site visits in Eastern Austria. In May this year I attended a seminar on biomass heating in Linz (Upper Austria) run largely for commercial wood energy sector participants and a biomass energy workshop in Finland attended by 50 researchers from across Europe and Russia. These events included lectures from policy makers, environmental NGOs, system installers, visits to wood heating system



manufacturers, pellet and heating chip manufacturers and distributors and operating wood energy systems.

Wood energy systems are seen as a key contributor to greenhouse mitigation efforts in Europe. Christiane Egger, the Deputy Manager of the O.Ö. Energiesparverband (Energy Agency of Upper Austria) told me that they're aiming for 100% of residential heating in Upper Austria to be supplied by renewables by 2030. This will be primarily from woody biomass and rooftop solar thermal. Of course, the remarkable achievements in housing energy efficiency in Austria make this more achievable. One DHS cooperative manager in rural Austria told me that with modern houses getting down to 5kW heating requirement it was becoming uneconomic to attach them

to his DHS. That's 5kW in Austria's comparatively harsh climate, whereas a house in Australia's generally milder climate would require tens of kilowatts!

Austria already generates 15% of its primary energy from biomass. Finland generates over 20% of its primary energy from biomass and is heading towards 25%. The UK has just announced very ambitious carbon dioxide emission reduction plans. As part of this initiative they have introduced the Renewable Heating Initiative which aims to increase the proportion of space heating supplied by renewables. The UK contractors I met in Linz were there to learn about wood heating systems as these are seen as the cheapest way to supply space heating from active renewable energy systems (as against passive mechanisms).

District Heating Systems are to some extent the standout application for efficient thermal energy demand in Europe. Cost effectively managaing heat loss is a concern for DHS operators. Smaller installations will have one or more boilers supplying heat up to a few kilometres via hot water reticulated around a campus, large building, apartment block and multiple buildings. Larger DHS installations with more elaborate piping and infrastructure may supply thermal grids across a town or city up to several hundred kilometres in length.

The systems I've visited in rural Europe have often been run by farmer co-operatives and use local agroforestry harvest residues. It's very common for farms in many parts of Europe to have some portion of their land used for growing trees. These are typically harvested on rotations of up to 100 years. They provide habitat, biodiversity, shelter, timber and an alternative income stream to the farmers.

One notable aspect in systems using woody biomass in Europe is the attention to reliable supply chains and ease of use for residential systems. The owner of one large pellet boiler manufacturer told me that he wouldn't sell his boilers into a market unless there were good quality pellets available and local bulk delivery capability. Pellet systems in Europe can now be supplied by delivery from a truck once a year where the pellets are pumped into a silo. With automated feed from the silo by an auger, as far as the homeowner is concerned, from an ease of use perspective there is little difference between using a pellet system and gas or electricity. There are even wood heaters for sale using fuelwood that automatically feed wood into the combustion chamber!

Other benefits

As thermal systems produce energy that is consumed locally they don't have any of the problems that can arise from attaching decentralised electricity generators to the grid. For example, at the time of writing (September 2011), industry sources have suggested that there are around a dozen tri-generation systems using natural gas in Melbourne's CBD that haven't been turned on as the CBD grid has not been designed to accept electricity. If all these buildings had wood fuelled boilers they could have been supplying energy for their space heating and cooling as soon as required.

As with any decentralised energy system, wood thermal installations provide significant energy resilience. And economic resilience. One repeated theme I've heard at these community scale installations during site visits in Finland and Austria is the regional benefit from spending money locally on producing energy rather than exporting the money to a distant energy source.

These systems allow incremental investment by both private individuals and communities. They are relatively simple to install and are readily available. They range in price from a few thousand dollars for an efficient residential pellet heater to a hundred thousand dollars or so upwards for a system that could supply heat to a community, campus or large building. This price range and the low maintenance and operation requirements for good quality equipment ideally suit a community based co-operative.

David Coote has been involved with renewable energy one way or another for many years. He thinks building a low carbon economy is a lot more likely if we get on with it.



Larger heating systems can look a little complex, but all this heavily insulated pipework helps to maintain high overall DHS efficiency.