Bryony Bennett explores the potential of biomass, the renewable energy source otherwise known as waste.

Bioenergy beckons

Top: Australia's sugar mills generate power and process heat from bagasse, a by-product of sugar extraction.
Inset: David Heck of Rocky Point Sugar Mill is banking on the future of biomass energy.

David Heck, director of south-east Queensland's Rocky Point Sugar Mill, is braced for a bold new venture. His family-owned company, after 110 years of milling sugar, is taking a serious plunge into power generation.

It's not the technology that will be Heck's major challenge.

Rocky Point, like the rest of Australia's 30-odd sugar mills, has been generating its own power and process heat since the 1930s, using boilers fuelled by bagasse, the organic waste remaining after juice extraction.

What will be daunting is the scale of the enterprise.

The plan is to invest in new boiler and turbo-alternator technology, raising the mill's generating capacity from three to 30 megawatts (MW). More efficient processing equipment will also be installed, minimising the steam required to run motors, pumps and the milling train, and maximising the steam available to generate power. Heck says the conversion will cost $35 million, employing 25 people for the construction phase, and seven operational staff.

'It was time to look at upgrading our plant, so we decided to increase its size and efficiency and produce electricity for the grid,' Heck says. 'The larger plant would not be commercially viable by itself – either for the factory, or as a stand-alone power generator – but by combining the two we can achieve a lower production cost per MW hour.'

In 2000, when the new plant comes on line, Rocky Point will shift from seasonal to year-round power generation. The core business will still be sugar, but electricity will run a close second. Some 200 gigawatt hours of excess electricity will be generated annually, enough to power almost 30 000 households. It will be sold as renewable energy, predominantly by Queensland-based electricity retailer, Energex.

Heck says the sugar mill usually burns some 110 000 tonnes of bagasse in the July-December crushing season. The new boiler will burn stored bagasse, supplemented by other organic wastes. 'We'll focus on renewable fuels,' Heck says. 'That includes timber residues, municipal green waste, palm oil fibre and macadamia shells. We're even looking at potential waste streams from crops that could be alternated with sugarcane, such as hemp grown for fibre.' A viability study of fuel alternatives has been completed with funding from the Australian Greenhouse Office, under its Renewable Energy Industry Program.

Rocky Point's new venture reflects a growing demand for green power: electricity that reduces greenhouse gas emissions by displacing fossil fuels. About 9% of Australia's power comes from renewable energy sources, and the Federal Government wants this figure to rise 2% by 2010. In New South Wales, electricity retailers are required to develop 'green power' options in their strategic planning, and a green power scheme is a key component of the Victorian Government's greenhouse policy. In response, retailers have begun packaging renewable energy as a premium product for domestic and business consumers.

Hydro-electricity provides most of Australia's renewable energy. Solar and wind power are gaining ground, but are costly due to their intermittent nature and diffuse energy source. The other renewable attracting interest is biomass: fuel derived from non-fossilised organic materials.

Biomass fuels include wood and wood processing residues, woody weeds, agricultural residues (such as bagasse), sewage and animal manures, landfill gas, a major component of municipal solid waste, refuse-derived fuel, black liquors and purpose-grown short rotation crops, including forest plantations. All these materials are storehouses of solar energy which has been captured in chemical bonds during photosynthesis. This chemical energy can be converted to steam or gas and used to generate electricity, or converted to liquid alcohol fuels such as ethanol.

Biomass energy is often referred to as greenhouse neutral. While carbon dioxide is emitted during biomass combustion, an equal amount of carbon dioxide is absorbed from the atmosphere during the plant's growth phase. In this way biomass fuels 'recycle' atmospheric carbon. If biomass is cultivated and harvested in a sustainable cycle that is repeated, there is little net contribution to global warming.

In fact, greenhouse gas emissions can be reduced through biomass energy production, because the natural decomposition of biomass can generate methane (a more potent greenhouse gas than carbon dioxide). As well, biomass energy replaces energy that would otherwise be sourced from fossil fuels. Other environmental benefits that can accrue from biomass production and use are the recycling of water and nutrients, and the reduction of pollution from waste streams.

According to the International Energy Agency, biomass residues and wastes provide about 14% of the world's energy supplies, and have the potential to meet up to 50% of global energy demands next century. Biomass is an important energy source in less developed countries (mostly through direct burning of wood and agricultural wastes), and is increasingly being considered in industrialised nations. In the United States, biomass is the greatest source of renewable energy besides large hydro-power, with an installed capacity of about 8000 MW, way in excess of wind and solar energy.

In July 1997, The Australian Biomass Taskforce was set up to promote the use of biomass in manufacturing and electricity generation. Its members include the Rural Industries Research and Development Corporation, the Australian Greenhouse Office, the Department of Industry, Science and Resources, the Forest Products Association of NSW, Pacific Power, Delta Electricity, Macquarie Generation, the Bureau of Resource Sciences, the CSIRO Division of Energy Technology, the Sustainable Energy Development Authority of NSW, Waste Service NSW and Forestry Tasmania.

Canegrowe

Manager of the Biomass Taskforce, Dr Stephen Schuck, says Australia's electricity industry will have to find an extra 9000 gigawatt hours of renewable energy by 2010 to meet Federal Government targets. He says biomass has the potential to be Australia's cheapest renewable energy source, and could generate broader environmental, social and economic benefits.

Australia is brimming with biomass. Existing supplies include forestry and agricultural residues and municipal and animal wastes, and future supplies could flow from dedicated energy crops including short-rotation plantations. Schuck says development of these resources would assist landcare initiatives, create industry and employment, particularly in rural areas, and help realise government goals of reducing greenhouse gas emissions, reducing landfill waste, and tripling the national plantation forest estate by 2020.

Wollongong finds power in garbage


Energy Developments

A model of the proposed waste facility.

IN MID 1999, residents of Wollongong in New South Wales will begin receiving 'green power' generated from their own household rubbish and garden waste.

Instead of being consigned to landfill, all the rubbish, green waste and recyclable materials collected in the City of Wollongong will end up at the council's Solid Waste Energy Recycling Facility (SWERF).

Here, the unsorted waste will be sterilised and pulped in a autoclave, and separated into organic materials (biomass) and recyclable non-organics such as glass, aluminium and metals. The solid pulp will be converted to synthetic fuel gas in Australia's first commercial-scale biomass gasifier. The gas will be mixed with methane piped from the nearby Whytes Gully landfill and used to generate electricity for local supplier, Integral Energy.

The SWERF is being installed by Australian waste-fuel specialist Energy Developments Ltd in partnership with US manufacturer Brightstar Synfuels. Energy Developments operates 24 power plants, in Australia and the United Kingdom, and is developing a further 22 projects in Australia, the UK, Taiwan and the United States. The company maximises the efficiency of landfill gas and coal seam methane plants by using modular designs which can be scaled up or down according to fuel availability.

The Wollongong facility will consist of one, 1 MW unit. If successful, it will be scaled up to 8-10 MW, converting all of Wollongong's household waste (150 000 tonnes) to electricity by 2001. This will achieve a 90% reduction of landfilled household waste.

Because of the facility's high capital cost, 50-70% of the revenue stream must be met by the authority or business responsible for waste disposal – in this case the Wollongong City Council. Energy Developments has similar arrangements in other urban areas, particularly where landfill space is limited.

Australia has enough bagasse to generate 3000 MW of electricity, or meet 8% of Australia's existing generation capacity.

Schuck believes one of the fastest ways to increase Australia's use of biomass energy would be to introduce biomass fuels into existing coal-fired power plants. He says co-firing may reduce slightly the plants' overall thermal efficiency, but the benefits would include capital cost savings through using existing plant and infrastructure, and reductions in carbon dioxide, sulfur dioxide and nitrous oxide emissions.

Colin Paulson of CSIRO Energy Technology says several coal-fired power stations in the US burn up to 5% biomass – mainly sawdust and processing wastes – after minor modifications to operating conditions. But this can only be economic when the biomass resource is near the power station. The high collection and transportation costs can account for up to 40% of the electricity price in dedicated biomass plants.

Another option supported by Schuck and Paulson is the development of distributed, embedded systems which cogenerate process heat and power using waste streams from associated harvesting and manufacturing enterprises. Embedded systems have the advantages of minimising transport costs and maximising the energy recovered from the biomass resource. And, as is the plan at Rocky Point, electricity generation can complement existing enterprises.

Cogeneration results in net fuel use efficiencies of more than 60% compared with about 37% for simple combustion. In Australia, sugar and timber residues are primary candidates for embedded cogeneration systems and research is under way to improve the biomass energy potential of both industries.

A major challenge will be to improve efficiency of bioenergy conversion in order to be more cost competitive with coal-fired power stations. In an effort to compete, the sugar and timber industries are turning to an advanced energy cycle in which biomass fuels are gasified for use in a gas turbine, rather than burned directly in a boiler to generate steam.

Gasification involves the high-temperature (800°C) conversion of biomass, in the presence of a small amount of oxygen and steam, to produce a synthetic gas (containing hydrogen, methane, carbon dioxide, carbon monoxide, nitrogen and water vapour, depending on the process) that can be used in a similar way to natural gas or LPG. Gasified biomass can also be used in fuel cells such as are being developed by Ceramic Fuel Cells Limited, a venture in which CSIRO is playing a major role.

An added advantage of gasification is that it enables the application of combined cycle technology, a system in which the hot exhaust gas is cycled to a waste-heat boiler where steam is generated to drive a steam turbine (see diagrams). This achieves further generation efficiencies

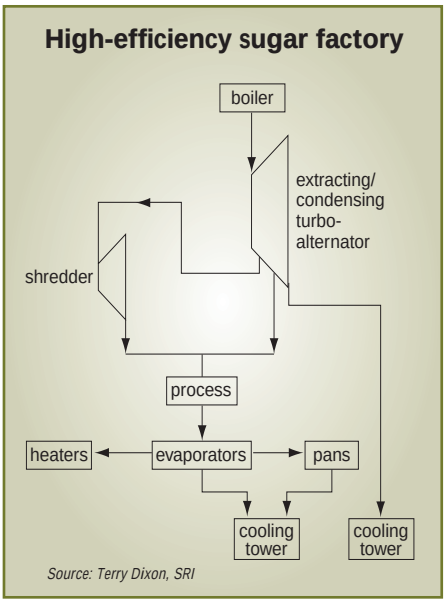
Advances in gasification technology have been identified by Queensland's Mackay-based Sugar Research Institute (SRI) as vital to the Australian sugar industry's expansion into cogeneration. Leader of the SRI Engineering Research Group, Dr Terry Dixon, says the industry has the advantages of a concentrated, local fuel supply, synergies between power generation and sugar manufacture, and location near major load centres of the electricity transmission grid.

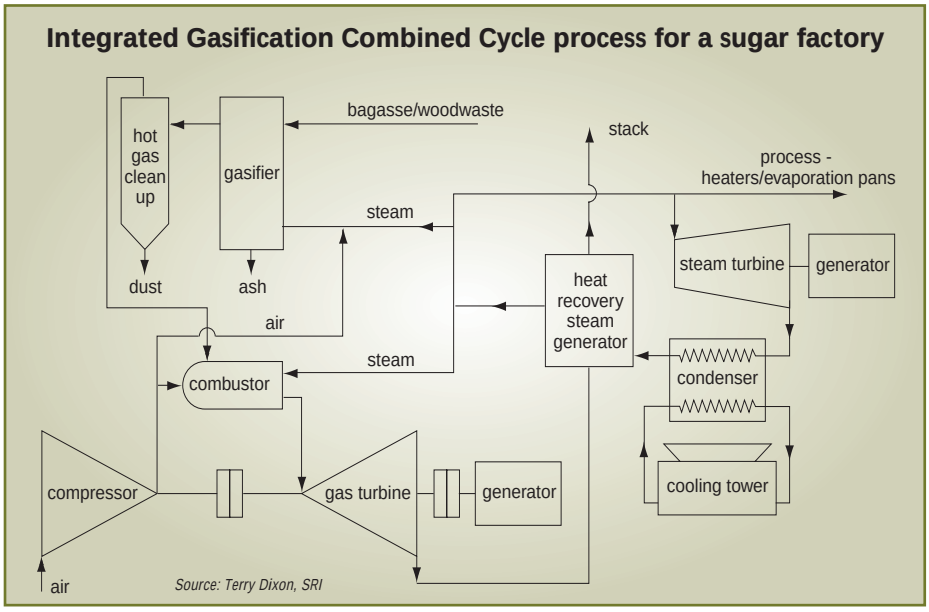
Gasification enables the application of combined cycle technology, a system in which the hot exhaust gas is cycled to a waste-heat boiler where steam is generated to drive a steam turbine. The potential for developing and adopting this technology is being explored by the sugar industry.

Dixon says the sugar industry's future expansion into electricity production will largely depend on enhancing the synergy between sugar manufacture and cogeneration, improving large-scale bagasse handling and storage techniques, and recovering additional canefield residues.

He says enough bagasse is produced by the sugar industry to generate 3000 MW of electricity. That's about 8% of Australia's total generating capacity. This in turn would displace some 16 million tonnes of greenhouse gas emissions a year. But the potential to raise this capacity is enormous, and it's these longer-term prospects that have the SRI considering new research directions.

The SRI has identified a range of biomass resources in Queensland that could be used to supplement bagasse. They include cotton trash, macadamia nut shells, cattle dung,





fruit pips, tomato refuse and municipal waste. Timber residues are plentiful and are concentrated in the state's south-east.

Another possibility is to utilise the leaves, trash and tops from the cane that are left in the field at harvest. SRI research indicates that 80% of this residual field biomass could be recovered, more than doubling the cogeneration potential of the existing cane crop. A longer term goal would be the breeding of new cane varieties with higher fibre levels to produce more bagasse.

Dixon says there is plenty of scope to improve the energy efficiency of sugar manufacture, but it will prove a major challenge for the mills. Energy conservation has not been an industry priority, because burning bagasse has traditionally been an exercise in waste handling and disposal, he says. The sugar industry has learned to 'waste energy very efficiently'.

'We've shown that by moving to the advanced technology of integrated gasification combined cycle power generation, the amount of electricity generated can be increased by a factor of two,' Dixon says. 'That's the foundation of our move into gasification technology for bagasse.

'We need to develop and prove new candidate technologies, as all existing ones have deficiencies of one form or other. The technology doesn't exist in a commercially proven form and our initial judgement is that large-scale commercial applications using gasification won't be developed for another five to 10 years.'

Advances in gasification technology also underpin the expanded use of wood waste as a fuel for both small-scale electricity production and cogeneration.

A research team led by Dr Paul Fung at the CSIRO Forest Products Laboratory in Clayton, Victoria, began working on wood gasification in the 1970s, prompted by fuel price rises after the Middle East oil crisis. The team developed a prototype gasifier that produced gas from woodchips, peanut shells and pelletised rice hulls. They wanted to develop equipment that could be retrofitted to fuel oil burners, with the cheaper wood gas either replacing or supplementing the oil. But when fuel prices dropped the work was mothballed.

Early in the 1990s, as interest in renewable energy gathered momentum, Fung decided to rekindle the gasifier project. His team is now developing 30-200 kW units that couple a wood gasifier with a new type of gas 'micro-turbine' developed in the US. Fung says the micro-turbines more than match the efficiency of conventional coal-fired power stations, offering a practical alternative to petrol or diesel generators.

Fung says the units' generating capacity will suit small towns, communities and farms in regions where wood residues are available at low cost, or where fuelwood plantations could be developed. They could also provide electricity and process heating for less energy-intensive rural industries such as dairies, food processing and abattoirs. In some areas the units could be connected to the transmission grid, allowing operators to draw on the grid at times of excessive demand, and to sell surplus electricity.

The units will consume wood at a rate of slightly less than one kilogram per kilowatt-hour of electricity generated. That translates to about 13 kg of wood a day to meet a typical household's average electricity demand of less than five tonnes a year. During periods of excess demand, electricity could be imported from the grid.

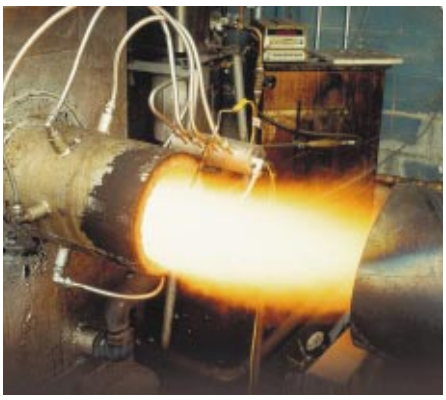
Approximate cost of electricity generation cents/kWh

Coal-fired	3 - 4
Gas	4 - 6
Bagasse	4.5 - 7
Other Biomass	5 - 12
Mini/Micro Hydro	2 - 10
Wind	6 -15
Solar PV (thin film	12 - 13 (target)
Solar PV (crystal)	40 - 50

In 1996, Fung surveyed the cost of different fuels per unit of energy produced. The survey confirmed the economic attraction of wood as a fuel in areas with a reliable supply, showing that energy from some wood residues, such as sawdust, can be cheaper than using coal.

Linking longer-term plantings of hardwood timber plantations for sawn timber with biomass electricity generation provides several environmental and economic benefits. If one million hectares of ex-grazing lands were planted with fast-growing eucalypt species (less than 3% of the pasture area in Australia), they could sequester some 6 million tonnes of carbon a year, equivalent to a 5% reduction in Australia's national greenhouse gas emissions.

Another environmental advantage is the reduction of timber waste. Fung says that sometimes up to 40% of the tree is left in the forest as non-sawlog residue. And in sawmills, 65% of the log ends up as sawdust,



Below: The CSIRO prototype gasifier. A research team led by Dr Paul Fung is developing 30-200 kW units that couple a gasifier with a new type of gas micro-turbine developed in the United States.
Left: The units will suit industries or communities near to a source of wood waste.

Queensland electricity retailer Energex is one of several retailers promoting 'green power' schemes to premium-paying customers.

shavings or slabs. These are sometimes just either burnt or left to rot, so the energy embodied in these residues is wasted.

Like any business venture, the success of biomass energy ultimately will boil down to economics. Australia has sufficient biomass fuels to meet medium-term renewable energy targets, and the cost of generating bioenergy, though mostly higher than coal and gas, can compare favourably with other green energy options (see table).

The renewables market is a hive of competitive activity. Retailers are assessing potential energy sources, forming alliances with suppliers, and proclaiming their commitment to green power schemes. But there is a view that the 2% target is overly optimistic, particularly as renewable energy can often cost more than that of electricity from coal. The question is who will pay.

A B S T R A C T

Biomass is finding favour in Australia as a source of renewable energy. Biomass energy costs less to produce than most other renewable power sources and the environmental and potential social benefits are substantial, provided the fuel resource is sustainably managed. The feasibility of biomass energy production is being considered by a number of industries (sugar, timber, waste management), by electricity providers, and by electricity retailers keen to expand their 'green power' portfolio. Sugar processors, which already generate power and heat from bagasse, are assessing the potential for expanding their electricity production. Development of the industry is likely to depend on government policy, development of gasification technology, and the synergies of cogeneration.

Keywords: **Sugar mills; power generation; bagasse; biomass fuels; waste utilisation; renewable energy; green power; Rocky Point Sugar Mill, Qld.**

Will a select group of premium-paying customers foot the bill? Or will all Australians have to pay more for their electricity to stimulate the renewables industry? Until Federal Government policies supporting the 2% renewables target and other commitments related to the recent Kyoto Protocol are revealed, the evolution of the renewable energy market in the next decade – including development of bioenergy – will be difficult to predict.

Project development manager with Australian waste-fuel company Energy Developments, Perry Toms, believes the biomass energy market will expand slowly in Australia and the US because conventional forms of energy are so cheap. But there will be special pockets of development, such as in remote locations, or where waste managers are prepared to pay a disposal fee.

'It will take political and social will on the part of communities to pay the real cost of renewable energy,' Toms says. 'Until the environmental cost of hydrocarbons is reflected in the price, they will always be underpriced. Biomass will always be more expensive because you're paying for a closed carbon loop.'

Toms says the extra dollars paid by consumers of green power schemes don't cover the extra cost. 'In the UK, everyone pays a 1-2% tax to support a 2% renewable energy target,' he says. 'But in Australia those market signals are not apparent. Do we as a society wish to take a leadership role and spread the load?'

Terry Dixon believes government intervention will be necessary to fully develop the massive renewable energy potential of the sugar industry.

'Free enterprise alone will not make bagasse cogeneration viable,' Dixon says. 'Renewables haven't been able to compete, and the situation will remain that way for some time. If left to the free market, we'd never have renewable energy. It just doesn't pay. There has to be a price premium and it has to be guaranteed for the long term. Until that happens there will only be small increases in renewable energy.'

In the meantime, Rocky Point Sugar Mill is forging ahead, comforted by the knowledge that to be first has its advantages. 'We're the trailblazers,' Heck says. 'It was tempting to stick to our core business, but we couldn't let a golden opportunity slip by.'

More about biomass energy

The Australian Biomass Taskforce Homepage is: http://www.users.bigpond.com/steve.schuck/ABT

Briquetting biomass

NEW SOUTH WALES company Biomass Energy Services and Technology (BEST) has established a demonstration biomass briquetting plant at its Somersby factory.

BEST director, Dr Stephen Joseph, says briquetting helps to reduce the cost of transporting and storing biomass residues, which often are bulky and seasonal in supply. The process also upgrades the quality of the fuel.

A number of biomass residues are being tested for their suitability to briquetting. One is *Mimosa pigra*, the woody weed that is ravaging Northern Territory floodplains. Joseph says the weed could be briquetted at sites of major infestation, then transported down waterways to a central location. Also being trialled are timber industry residues and a blend of paper residues and municipal green waste.

Joseph says the briquettes could be used as a domestic fuel for fireplaces and slow-combustion ovens. 'Sydney could supply all its home heating with its waste,' he says.

Other options being considered by the company include the conversion of biomass residues to charcoal briquettes for industrial uses such as mineral processing, and for use by power stations and home barbecues. Joseph foresees export demand for such a product.

A biomass-fired clinical waste gasifier developed by BEST which sterilises and decomposes hospital waste has found a steady market in Asian and Pacific countries. BEST is also developing a biomass gasifier which could be coupled with the briquetting plant.

BEST

A range of biomass fuel sources will be briquetted at the demonstration plant.