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# Review of commercial wood-fuelled electricity and heat generation technologies

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## Introduction

This summary of a review of commercial wood-to-energy technologies conducted with Forestry Tasmania considers commercial wood-to-energy plants in the 1MW to 25MW range for use in Tasmania and the Northern Territory. The review covered factors such as costs and inputs to guide possible internal and external investment in these systems.

## Commercial technologies identified

Wood-to-energy systems generate electricity, heat and steam. Northern European nations have invested significantly in these systems over the last few decades as a means of providing renewable energy and energy security, and, more recently, North America has followed suit. For example, 50 per cent of Sweden's residential heating is now produced from biomass, much of which is wood. A large percentage of this heat is generated from boilers that supply apartment blocks and district heating schemes in villages and towns.

An International Energy Agency (IEA) bioenergy status report[1] published in mid-2009 identified the following wood-to-energy technologies as fully commercial:

- combustion in Steam Rankine Cycle (SRC) plants for electricity generation (SRC is the technology used in large coal-fired base-load power stations)
- direct co-firing with fossil fuels, in which wood is burned simultaneously with other fuels such as natural gas or coal
- thermal systems, which generate hot-water and/or steam from combustion for use in heating or for use in industrial processes.

Wood to energy systems can be used to produce electricity alone using a turbine. Greater efficiency of total energy recovery can be achieved by burning wood in thermal and combined heat and power (CHP) systems (Figure 1, next page).

[1] IEA Bioenergy (2009). 'Bioenergy a Sustainable and Reliable Energy Source. A review of status and prospects'. (International Energy Agency) (available at www.ieabioenergy.com).

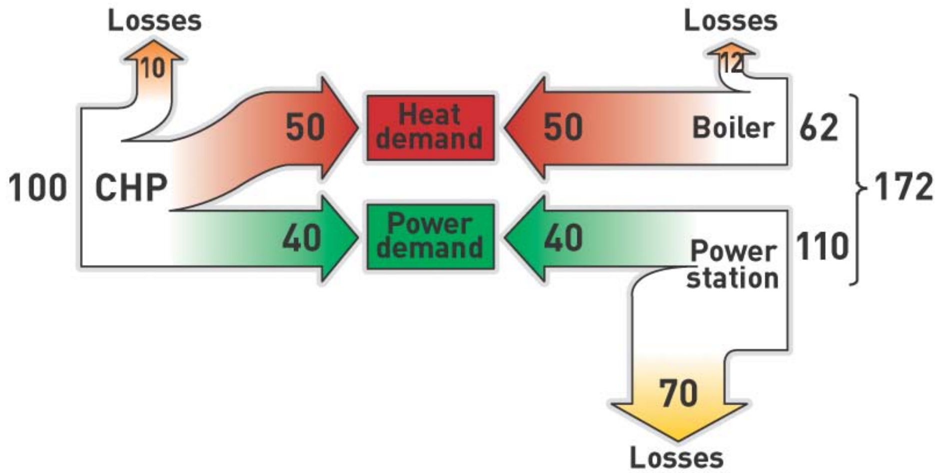


***Figure 1.***
Indicative efficiencies for CHP systems, conventional power stations and boilers used for heat alone[2]

Biomass gasification features strongly in the current biomass utilisation discussion, but in the 2009 status report the IEA states that biomass gasification technology is still in the demonstration to early-commercial phase. As a wood-to-energy technology that offers very efficient options for both small- and large-scale applications, the fact that many wood gasification system vendors claim their systems now or soon will meet IEA commercial criteria suggests that wood gasification systems are likely to be a commercial option in the near future. They could not, however, be included in this study as it only considered technologies deemed commercial by the IEA.

## Energy costs

The useable energy available from wood can be calculated by taking into account the energy used to vaporise the moisture content of the wood and the water created in the combustion reaction. Drier wood has more energy available to heat the boiler. The CSIRO has developed a database showing the energy available from various timbers (oven-dry). The annual quantity of fuel needed to run an energy system can be calculated from the energy available from the wood, the energy output of the system, the efficiency of the system and the number of hours the system runs per year.

The federal government recognises the greenhouse benefits of using wood to replace fossil fuels for electricity generation under the Mandatory Renewable Energy Target scheme. Under this scheme a percentage of the power sold by electricity retailers must be from renewable sources. Renewable energy certificates (RECs) represent 1MWh of renewable electricity. RECs were sold in 2009 for around $30 to $60 each.

The cost per unit of energy output (kWhe, kWhth) can be derived using the levelised cost of energy (LEC) formula. The LEC calculation includes the costs over the lifetime of the energy-generating system. These costs comprise the initial investment, any subsequent investments, operations and maintenance, cost of fuel and the cost of capital as expressed in a discount rate. These factors are used in a net present value calculation that is solved so that for the chosen value of the LEC, the net present value is zero. Hence the LEC represents the minimum sale price per unit of energy such that the energy project will break even.

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2 Source: EUBIA (n.d.). 'Cogeneration at small scale: Simultaneous production of electricity and heat' (European Biomass Industry Association: Brussels) p. 3 (available at http://www.eubia.org/uploads/media/RESTMAC_-_Cogeneration_at_Small_Scale.pdf).

Electricity can be consumed onsite by co-located industries or sold into the grid. For the electricity generator to be profitable, the fuel cost from the timber harvester including collection, transport and comminution[3] must be at a level where the levelised energy cost using this fuel is less than the tariff the co-located energy user would otherwise pay and/or less than the grid operator is prepared to pay. Similar considerations apply to thermal systems substituting for fossil fuels such as LPG and natural gas.

Tables 1, 2 and 3 below show sensitivity to varying fuel costs and installation costs with and without benefit from RECs.

Table 1 shows the effect of varying plant installation prices for a 25MWe SRC plant operating for 8000 hours per annum at 33% efficiency over a 20-year lifetime, using a discount rate of 10% (5% cash rate and 5% risk premium), operations and maintenance of 7% of original capital expenditure per annum, 45%-moisture-content stringybark residue containing 18.7MJ/kg (dry), and inflating operating and maintenance costs and fuel cost by 2.5% annually.

Table 2 shows the same data adjusted for the return from RECs sold for $40 ($0.04/kWh). Replacing some of the equity with debt reduces the LEC.

Table 3 shows LEC for a 5MWe plant with RECs at $40.

### *Key to Tables 1, 2 and 3*

| | |
|---|---|
| (medium grey) | indicates that the plant is profitable or is breaking even selling to co-sited customers at an indicative off-peak price of $50/MWh. |
| (light grey) | indicates that the plant is profitable or is breaking even selling into the grid at $55/MWh. |
| (dark grey) | indicates that the plant is profitable or is breaking even selling to co-sited customers at an indicative peak price of $100/MWh. |

### *Table 1. Levelised cost/kWh for a range of plant prices and fuel costs for a 25MWe plant, with fuel use of 260kt/annum (45% MC)*

| Plant cost | Fuel cost per tonne | | |
|---|---|---|---|
| | $10 | $30 | $50 |
| $60 million | $0.072 | $0.103 | $0.133 |
| $80 million | $0.091 | $0.122 | $0.152 |
| $100 million | $0.110 | $0.141 | $0.171 |

### *Table 2. Data in Table 1 adjusted for RECs sold at $40*

| Plant cost | Fuel cost per tonne | | |
|---|---|---|---|
| | $10 | $30 | $50 |
| $60 million | $0.032 | $0.063 | $0.093 |
| $80 million | $0.051 | $0.082 | $0.112 |
| $100 million | $0.070 | $0.101 | $0.131 |

3 Depending on the combustion technology, wood-to-energy systems burn wood that has been comminuted to a particle size in the 1 mm to 120 mm range.

***Table 3. Levelised cost/kWh for a range of plant prices and fuel costs for a 5MWe plant adjusted for RECs at $40, with fuel use at 71kt/annum (45% MC)***

| Plant cost | Fuel cost per tonne | | |
|---|---|---|---|
| | $10 | $30 | $50 |
| $20 million | $0.076 | $0.118 | $0.160 |
| $22 million | $0.085 | $0.127 | $0.169 |
| $24 million | $0.095 | $0.137 | $0.179 |
| $25 million | $0.100 | $0.142 | $0.184 |

Based on Tables 1, 2 and 3, the scenario most likely to offer a competitive value of $30 or more for biomass from the forest is the larger 25MWe with REC value (Table 2). For the smaller 5MWe plant (Table 3) or the larger 25 MWe plant without REC value (Table 1), the $10/t value is not likely to be an attractive option for plantation owners as the cost of harvest and transport is likely to exceed this value.

## Take-home message

Wood can be competitive with other energy sources for generating electricity and heat energy. Wood-to-energy systems could present an opportunity for forest companies to sell currently unutilised wood from harvest operations for an added value recovery, particularly with larger plants that can gain REC value.

## Organisations supporting this science

This research was undertaken in partnership with Forestry Tasmania.

## More information

See the CRC for Forestry website: http://www.crcforestry.com.au/research/programme-three/index.html

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