Energy Solutions For Industry

Living Energy

Dependable • Sustainable • Cost Effective
Session 4: Innovation in Biofuels

Utilising Wood Waste for on-site Energy Production

Rob Mallinson
Managing Director, Living Energy Limited

16th September 2008
Contents

- Introduction to Living Energy
- Other Technologies for Power Generation
  - Power and Heat : Via Gasification
  - Power and Heat : Via ORC
- Other “densification” Options
  - Bio-Oil, Ethanol
  - Briquette, Pelletise, Fire-Logs
- Conventional Heat & Power Production
- Recommendations
1 – Living Energy

Established in 2003
Emerged out of Carter Holt Harvey (origins in 2000)
Partnered with Visdamax and with Binder
Installed 9MW system last year and 22.5MW system this year
Installing 6 wood chip boilers in the next 7 months
Non-Traditional Technologies for Power Generation from wood

Gasification
Gasification

- Well-established technology (WW1)
  - Heating wood in the partial absence of $O_2$
- 8MW electrical plant at Gusseng in Austria
- Mount Maunganui : 3MWth
- West Coast
- Powerhearth 300kWe ?
- Canterbury University : 300kWth
- AES : Ankur
ENERGY FROM
BIOMASS

Technical Marketing Company
Specialize in Pyrolysis systems for CHP
Ankur Gasifiers 800 units in Service
ABRI (Advanced Bio Refineries) Bio oil from wood waste.
ENERGY FROM BIOMASS

DIRECT COMBUSTION  PYROLYSIS  WOOD PELLETS  ETHANOL

1 tonne demonstration plant
In New Zealand this Year

800 plants in service
From 10 kWe to 3.2 MW
Application Evaluation Tools

Link to an application tool - Excel exercise considering plant performance

Wood Innovations 2008
ANKUR GASIFICATION

PYROLYSIS PROCESS
75% (Total Efficiency)

HEAT
30KWth to 5.5MW
OR
GENERATION
RANGE 10Kwe -2.2Mwe
via
ENGINES (Reciprocating)
GAS TURBINES
(under development)
Wood Innovations 2008

GASIFICATION

Electrical Energy Deliverable: 200Kwe
Heat Energy (not Generating): 1 Mwth

Feed stock conditioning and storage
Gasifier and Filters 250,000
Burning
Cooling pond and Conditioning
Gas Burner, Delivery Lines: 250,000

Engineering
Gas Set 283,000
Synchronizing & Switch Gear
Building
SCADA
EECA Grant up to 200,000
PreStudy Grant 50,000

Direct Fired Kiln Energy from Boiler
Steam heated Kiln Energy from Boiler

Dual fueled or gas Genet

FEEDER, DRYER + STORAGE

Wood Innovations 2008
Contact: Gavin Hedley on 021 740-490
Organic Rankine Cycle “ORC”

Key Energy Limited
Organic Rankine Cycle: “ORC”

- 300kW to 1600kW electricity
- Invented by a Scot (William Rankine) in 1859
- Uses a condensable vapour as the thermal fluid
- Ormat use this widely in the geothermal industry
- Uses non corrosive silica fluid as the medium
- Silica oil has superior thermal properties
  
  So lower pressure, high efficiency, less R&M etc
Adoratec ORC power plants

Adoratec is a leading provider for ORC power plant solutions
Based in Mannheim, Germany
Decades of experience in turbine and steam power solutions
Now owned by Maxxtec

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity</th>
<th>Comm. Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruckmühl</td>
<td>1.520 kWel</td>
<td>first half 2006</td>
</tr>
<tr>
<td>Germany</td>
<td>6.775 kWth</td>
<td></td>
</tr>
<tr>
<td>Schöneck</td>
<td>555 kWel</td>
<td>first half 2006</td>
</tr>
<tr>
<td>Germany</td>
<td>2.390 kWth</td>
<td></td>
</tr>
<tr>
<td>Bokholt</td>
<td>315 kWel</td>
<td>second half 2006</td>
</tr>
<tr>
<td>Germany</td>
<td>1.495 kWth</td>
<td></td>
</tr>
<tr>
<td>Stockach</td>
<td>310 kWel</td>
<td>second half 2006</td>
</tr>
<tr>
<td>Germany</td>
<td>1.850 kWth</td>
<td></td>
</tr>
<tr>
<td>Bayreuth</td>
<td>340 kWel</td>
<td>second half 2006</td>
</tr>
<tr>
<td>Germany</td>
<td>1.675 kWth</td>
<td></td>
</tr>
<tr>
<td>Allentsteig</td>
<td>850 kWel</td>
<td>first half 2007</td>
</tr>
<tr>
<td>Austria</td>
<td>3.880 kWth</td>
<td></td>
</tr>
<tr>
<td>Oberwart</td>
<td>420 kWel</td>
<td>second half 2007</td>
</tr>
<tr>
<td>Austria</td>
<td>1.890 kWth</td>
<td></td>
</tr>
<tr>
<td>Bad Tölz</td>
<td>355 kWel</td>
<td>second half 2007</td>
</tr>
<tr>
<td>Germany</td>
<td>1.740 kWth</td>
<td></td>
</tr>
<tr>
<td>Olang</td>
<td>688 kWel</td>
<td>second half 2007</td>
</tr>
<tr>
<td>Italy</td>
<td>3.170 kWth</td>
<td></td>
</tr>
</tbody>
</table>
Multiple fuels as wood, coal, gas or heat sources as exhaust or solar

Thermal oil for controlled heat transfer

Organic fluid evaporator

Efficient turbine & generator from 300kW to 1.5MW

Turbine @ 3000 rpm, no gear box (except the 2 smallest units)

Broad operating range (20% - 100%)

Good efficiency even at 50% capacity

Condenser with internal heat recovery

Variable hot water output for CHP

No water usage or treatment

ORC technology basics

• no internal corrosion
• low in maintenance
• low running costs
• no manning
• remote management
Organic Rankine Cycle

Advantages

• High Efficiency of Turbine
• Easy Control of Turbine
• Wide Operating Range (10…20 - 100%)
• High Efficiency over the complete Range
• Low Temperatures and Pressures
• Simple and compact Plant Design
• Low Operating Costs
• Low Demand on Repair and Maintenance
• Low RPM (3000/min) and no gear box
• Unattended Operation possible
• Well tested by Industry
• Easy to insert into existing Plants
• Modular growth of Power Plant possible

Disadvantages

• Not suitable for High Temperature Process Heat Production
• Not suitable for large Power Plants (max. 1,5 MWel per Module)
The AD1600 unit will be delivered in 3 parts:
- Regenerator (Condenser)
- Turbine 15m x 4m x 4m
- Evaporator 10m x 2.5m x 2.5m
- Pump + rest

Total weight 105 tons
Units up to AD 650 are skid mounted
Kiln drying with ORC CHP

Depending on power use pattern, size of ORC plant (600 - 1,500kW el) & thermal oil plant efficiency, the power produced will vary accordingly.
Depending on heat load pattern, the excess heat can be used to increase the electrical output. The ORC plant can generate between 20% to 100% with little loss on efficiency.
Using kiln swing load for power production

- Using swing loads for power production allows the heat plant to operate on constant load.
- So excess heat can be used for ORC CHP to reduce the power bill.
- Depending on the temperature requirement, the condenser output can be 90°C to 130°C.
Process steam and hot water

• Hot oil steam generator

• Burner
• Furnace
• Thermal oil

• Conditioner
• Meatworks
• Fish processing
• Food processing
• Brewery
• Milk processing
• Chemical plant
• Pharmaceutical plant
NZ contact details

Key Energy Ltd
keyenergy@xtra.co.nz
07 574-8258

We’ll come back to Conventional CHP....
Densification

Other ways to maximise the value of excess on-site wood
Densification

- Various Technologies:
  - Pelletise
  - Fire Logs
  - Briquette
  - Bio-oil
  - Ethanol

- Main benefits are reduced transport costs and lower volumes
- If can find way into market, will boost revenues per tonne
AES ENERGY FROM BIOMASS

DIRECT COMBUSTION  PYROLYSIS  WOOD PELLETS  ETHANOL

BIO OIL
1 tonne demonstration plant
In New Zealand this Year

GASIFICATION
800 plants in service
From 10 Kwe to 3.2 Mw
BIO OIL
Physical Properties
Typical Values
Moisture Content  15-30%
  pH  2.5-3.0
  Specific Gravity  1.20

HHV 16-19 MJ/kg
  40% of Fuel Oil (w)
  Cost perhaps 20%
0.5-1 TPD PYROLYSIS
50 TPD PYROLYSIS
Co Fired Boiler
Biomass
Carbon (4)
Gas
DUAL FUEL BURNER
Synchronizing equipment and switch gear.
Filter
Dual fueled or gas Genset
Direct fired kiln
Energy from Boiler and Gas
Steam heated kiln
Energy from Gas Burner and 6 Steam
Electrical Energy Deliverable... 2.7 Mwe
Heat Energy (not Generating)... Mwth
Biooil
50 ton Biooil plant
4M
Building
Gas Burner, delivery lines etc
Engineering
Genset Biooil Turbine
6M
Synchronizing & Switch gear
Building
SCADA
Engineering
EECA Grant
up to 200 000
PreStudy Grant
100 000

Wood Innovations 2008
Prepared for
The Energy Efficiency and Conservation Authority
FIDA Engineering Solutions:
Remote Bio energy
Report
Bio-oil Option
Submitted by
Alternative Energy Solutions

Gavin Hedley AES September 07
Conventional Heat & Power
### Some NZ Boiler Statistics

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total NZ Boiler Capacity is just over 1kW per capita</td>
<td>4,900 MWth</td>
</tr>
<tr>
<td>Heat Plant in Wood Processing Sector</td>
<td>1,798 MWth (40%)</td>
</tr>
<tr>
<td>Wood-Fired Boilers in NZ Wood Processing Sector</td>
<td>1,323 MWth (27%)</td>
</tr>
<tr>
<td>% of boilers under 10MWth in WPS</td>
<td>80%</td>
</tr>
<tr>
<td>Median Heat Plant Size in WPS</td>
<td>4 MWth</td>
</tr>
<tr>
<td>Total Wood Fired Boilers outside WPS</td>
<td>8MW + 4MW + ?</td>
</tr>
<tr>
<td>“Heat Input” in WPS (above average load)</td>
<td>56% of NZ</td>
</tr>
<tr>
<td>Installed Turbine Capacity in WPS</td>
<td>Approx 120MW</td>
</tr>
<tr>
<td>Ratio in WP Sector of thermal:electrical</td>
<td>15:1</td>
</tr>
</tbody>
</table>

*Wood is well-utilised, mature technology in NZ’s WPS*

Source: 2008 Heat Plant Database, BANZ
## Conventional CHP in NZ

<table>
<thead>
<tr>
<th>Site</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinleith</td>
<td>45 bar steam, 160MW, 40MWe,</td>
</tr>
<tr>
<td>Kawerau</td>
<td>44 bar steam, 160MW &amp; 63MW, 60MW (?)</td>
</tr>
<tr>
<td>Pan Pac</td>
<td>60 bar steam, 40MW +20MW, 13MWe</td>
</tr>
<tr>
<td>Red Stag</td>
<td>42 bar steam, 2 x 20MW, 5MWe (?)</td>
</tr>
<tr>
<td>Blue Mountain Lumber</td>
<td>29 bar steam, 10MW, 1.5MWe (?)</td>
</tr>
<tr>
<td>Findlaters</td>
<td>6MW ?, 0.5MWe (?)</td>
</tr>
<tr>
<td>Others</td>
<td>(Kerikeri – 0.8MW, 10 bar, 100kW)</td>
</tr>
</tbody>
</table>

*Indicative numbers – to be verified*
Why not more CHP?

Involves making high pressure steam which is put through a turbine, with lower pressure steam from the back-end used for process heat. It is very efficient (typically 80-85%)

• Reminder: Over 1,300MW of wood-fired boilers in WPS
• But:
  • The average size is only 4MWth
  • Many are hot water, so conventional turbine a non-starter
  • Competition for capital
  • Another barrier to uptake is fixed line charges

Unlike other countries, there is no Government Policy to encourage distributed generation
Does CHP suit most Sawmillers?

- Hot water is the easy choice for kiln drying
- Competitive boiler suppliers make it easy
- Hot water is better than steam (even for Hi-Temp)
  - Less complex
  - Less capital
  - Less water treatment
  - Less fuel

**Conclusion:** Unlikely to get more CHP unless policy is more helpful
Even 22.5MW of High Temp Kiln Drying is not economic for CHP...
Other Ways to Gain Value?
Conventional Combustion

Is NZ missing a trick ?

NZ has a lot of energy intensive industry
- Meat processing
- Wool scouring
- Milk processing
- etc

NZ has a lot of low value wood
- Log Making Residues
- Branchwood
- Pulp logs etc etc

Over 3,000MW of boilers
A lot of woody biomass is produced in NZ….
Automatic wood heating is now a major industry in most Northern European Countries

- Now over 100,000 installations in Austria alone
- Many hundreds of thousands of systems now operational across Europe
- From domestic scale to large industrial scale (10MW+)
- Austria installed $650m worth of automated woodfuel systems in 2006

Outside the WPS (schools, pools, hospitals, food processing, glasshouses etc etc)
Wood-fuel Systems – features

- Fully automatic feed
- Automatic ignition
- Remote monitoring
- Exhaust gas recirculation
- Automatic tube cleaning
- Automatic ash extraction
- Typical efficiency 90% +

As close to a fossil fuel boiler as possible!
Summary of Possibilities....
**Summary of Possibilities**

<table>
<thead>
<tr>
<th>Option</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORC</td>
<td>Low R&amp;M. Good if need hot water (up to 90°C). Good to 1.5 MWe.</td>
</tr>
<tr>
<td>Gasification</td>
<td>Now offered in NZ. Suits small scale (&lt;1 MWe) with heat needs.</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Various breakthroughs still needed. Pulp mill scale.</td>
</tr>
<tr>
<td>Bio-Oil</td>
<td>Now offered here. Creates high value product.</td>
</tr>
<tr>
<td>Pellets</td>
<td>Possible if lots of shavings. Standards being established. Hi value.</td>
</tr>
<tr>
<td>Briquettes</td>
<td>Much easier than pellets and lower capital.</td>
</tr>
<tr>
<td>Conventional CHP</td>
<td>Steam-based only stacks up at medium/large scale (above 3 MWe).</td>
</tr>
<tr>
<td>Off-site Sales</td>
<td>Zero capital needed. Can focus on core business. Needs a good partnership</td>
</tr>
</tbody>
</table>
**Recommendations**

- Stick to HPHW for kiln drying
- For small scale power: consider gasification
- If you only need 90°C hot water: consider ORC
- If you have scale: consider CHP (conventional)
- Try to upgrade any wood that is left over
  - Consider densification options, especially if lots of shavings
  - Consider using waste heat to dry chip
  - Chipping excess dry block may realise good returns
  - New trading platform will be launched soon via the BKC

*Only commit long term if you are getting a fair deal*
Thank You

www.bkc.co.nz

www.LivingEnergy.co.nz
E-mail : info@livingenergy.co.nz  Tel : 09 377-9007

Bio-Oil or Gasification : AES (Gavin Hedley) on 021 740-490
ORC : Key Energy Ltd, keyenergy@xtra.co.nz 07 574-8258