Solid waste to energy opportunities; theory and experience with the beneficial use of burnable wastes as fuel in NZ

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Abstract
Successfully burning woody residues and solid waste materials for energy supply is a challenge that is not for the inexperienced.

A successful project requires the proponent to find a host site that can utilise the produced energy, develop a lowest cost solution compared to (say) landfilling, build a plant that performs to expectations, secure a long term fuel supply, meet environmental requirements and ensure the plant is well maintained, often in a very tough environment. Energy for Industry (EFI) has been doing this for the last 8 years.

This paper discusses the drivers and barriers for solid waste to energy projects in NZ, the options available for beneficial use or disposal of this material and provides case studies on two recent projects undertaken by EFI. It also puts the case for project partnering with specialists such as EFI who can introduce innovation and efficiency, provide the necessary expertise and experience needed for a successful project outcome and share the associated project risks.

Introduction
This paper:

- Considers the opportunities in NZ to beneficially use a range of burnable wastes as fuel for Waste to Energy (WtE) projects;
- Discusses the drivers and barriers for these types of projects, primarily from a commercial perspective;
- Outlines the case for partnering with a specialist project proponent such as Energy for Industry (EFI); and
- presents case studies for two of EFI’s recent WtE projects

Profile of EFI
Energy for Industry (EFI) delivers energy and utility services from assets we own and operate, or manage on behalf of others. Our core business is long-term partnerships with customers: building and operating energy and utility plants under Build, Own and Operate (BOO) arrangements.

EFI is part of Meridian Energy Limited and has invested in excess of $35 million in energy plants over the last 8 years. We currently have six long term partnerships in place supplying services to a range of customers. This portfolio includes the development of four bio-energy plants since 2000.
EFI’s expertise in energy plant development has been recognised several times by EECA. In 2006 EFI won EECA EnergyWise awards for both our ADHB and WPI projects. In 2007, EFI’s Nelson LFG project was commended in these EECA awards.

For further information on EFI and our existing partnerships please refer to our website: www.energyforindustry.co.nz.

Wastes resources

Burnable wastes that have sufficient volumes to warrant commercial scale WtE projects in NZ include:

- Timber processing residues – bark, sawdust, shavings and sawmill off-cuts. These have traditionally been landfilled or burnt for onsite process heat, but are now becoming sought after for other uses. Sawdust can be recycled into particle board manufacture, bark and sawdust are used for farm stock pads, and sawdust and shavings are now being used for pellet fuel manufacture;

- Forest residues – larger waste log pieces can be recovered from skid sites and there is now growing interest in recovering more of the other woody residues left scattered in the forest – thinnings and branches; and

- Energy trees and crops. This is another material that is seen to have promise as a woody fuel, applying technology and forestry practices developed in Europe where flat land and subsidies make it viable. In NZ the economics are gradually improving and technology transfer programmes and pilot trials are underway.

These materials are already being reasonably well utilised but there are other materials that are available although much more difficult to burn. These include:

- Process wastes and sludges from other industries. This material has typically been discharged in untreated waste water or separated, dewatered and landfilled. Much of this material has fuel value and with appropriate pre-treatment can be used beneficially as a fuel in bio-mass heat plants;

- Contaminated wood wastes. This is wood residue that is contaminated, or may be contaminated: either with excessive levels of inert material (such as rock, soils and metal waste) or with chemical residues. If it contains chemical residues, it cannot be burnt in standard biomass heat plants because the trace elements in the fuel may result in harmful emissions. As a result it goes into landfill, and there are older fill sites where large volumes of this type of material has been dumped in the past;

- Bio-solids. This is the polite name for sewerage sludge from municipal waste water treatment plants. This material is typically dewatered, in some cases dried and then landfilled or it is composted with green waste diverted from landfills. While not dissimilar in fuel value to other
biological wastes, it cannot be burnt in standard bio-mass heat plants because of the trace contaminants it contains; and

- Sorted municipal wastes stream. Potential fuel streams include sorted paper, plastic and used tyres. Despite these fuels being accepted and used as fuel overseas, even in Europe where environmental standards are much higher than in NZ, they are currently not used here. Current public perception and RMA processes will make it very difficult to utilise these waste streams.

There is a huge volume of literature available on bio-mass fuels, equipment to utilise them and project profiles. There are many enthusiasts pushing particular technologies and often painting wildly optimistic pictures of their feasibility and economics. Unfortunately, when it comes to finding someone to fund their project and take on the associated risks, these projects rarely stand up to robust assessment.

However, with proven technology, sound economic fundamentals and a project developer with the right expertise, resources and experience (i.e. as provided by EFI), the outlook for WtE projects in NZ is improving.

**Options for Beneficial Use of Solid Wastes**

When considering the options for the beneficial use or disposal of burnable solid wastes, there are a number of options, including:

- Recycling it into wood products or high grade fuels. For clean sawmill residues such as sawdust and shavings, this option is likely to displace the more traditional fuel use option;

- Burning it. For the easy fuels this is typically the BAU option, but for the more challenging materials this much more difficult;

- Landfill is often the other BAU option, particularly for sludge and contaminated wood residues but increasing charges (now up to $140/tonnes in some parts of NZ), problems with landfilling un-dried sludge and the NZ waste minimization policy that is now actively discouraging landfilling (including a recently introduced levy on landfilling) is making this option less and less attractive;

- Composting. This is increasingly popular as an alternative to landfill. However it requires a relatively large area and there may be odour problems. Sludge and biosolids, need to be blending with wood waste to achieve the required C/N ratio. This extra material may need to be purchased. And recently, the value of compost has decreased because of increased supply;

- Bio-digestion. There are some real enthusiasts for this option but generally it is uneconomic unless it is part of large scale waste water treatment process such as at a Municipal Waste Water Treatment Plant. As a stand alone proposition, it is capital intensive, produces only modest energy revenues, and therefore relies on long term gate fees to support the economics; and

- Novel technologies such as bio-gasification, ethanol production and Fisher Tropsch liquids – turning this biomass into higher value renewable gas or liquid fuels. Again these options have
enthusiastic promoters but the technology is novel, complex and unproven for mainstream industrial applications where energy supply interruption is not acceptable. We see these options as being many years away from commercial reality.

Drivers

In the last 10 years the base economics of WtE projects in NZ have been average to poor. Until recently even some sawmills, where heat load and wood residue from the site are normally in balance, have continued to use gas for process energy, while at the same time dumping their wood residues.

Economic drivers

However in the last 5 years there has been a fundamental step change improvement in the economics of WtE projects driven by changes in energy and resource costs.

This is illustrated by the recent trends in NZ wholesale energy price indices published by MED and MAF, as shown below

These are real price movements excluding the effects of inflation, which is additional to these increases. Over the five year period to March 2008, in real terms, the wholesale price of electricity has increase by 32%, diesel by 50%, LFO by 29% and gas by 37%. This compared with pulp wood which has increase in price by 52%.

The indices show how electricity and non-renewable fuels have increased in real terms much faster than the price of wood. Unfortunately there is no NZ price index for coal but we are aware from our own operations of similar relatively large increases.

In specific circumstances, the changes have been even more pronounced, with companies experiencing large step changes in fuel prices when their supply contracts come up for renewal.

There has also been a significant increase in the short term price volatility of these non-renewable fuels as their supply is constrained and pricing is more closely linked to overseas spot markets. This volatility tends to be masked in the price indices.
While the picture for WtE projects is looking brighter as a result, it may not stay this way. The NZ currency is trending down and resource costs, particularly steel prices are rising. These changes are eroding the viability of WtE projects because of their capital intensive nature.

The following trends from RBNZ and Statistics NZ data illustrates how strongly plant capital costs are rising, event while the NZ currency has remained relatively strong up until mid 2008. Over the same five year period plant costs have increased by 28% (nominal) compared with a CPI increase of 14% and despite the currency strengthening by 18%.

Monitising other benefits

Project economics can be improved, if the “soft” benefits can be monitised and captured. This is a challenge but is essential if these “soft” benefits are to be recognized as tangible value in a business case. Once the value has been quantified in dollar terms, standard financial analysis can be used to reflect the holistic picture.

The cost of Green House Gas (GHG) emissions is a good example of how what was a soft value has now hardened to a very real value. Five years ago no value was attributed to carbon in our business cases, more recently under the Government’s now defunct carbon tax proposal a value of $5 to $10/t CO$_2$e was justified, and now under the Governments proposed Emission trading Scheme (ETS) a value of $30 to $50/t CO$_2$e is plausible. However this is only for the first Kyoto commitment period. There is no reasonable certainty that this value stream will continue beyond 2012.

Other areas where soft benefits may be converted to tangible value include:

- Recognising the true cost of the “business as usual” (BAU) solution. Often these costs are hidden in other cost centers and the management overhead associated with BAU operation is often not fully recognised. In fact many operators do not know their true unit costs of delivered energy;

- Emission to air reduction. WtE projects can displace older technology burning coal or petroleum based fuel. In this circumstance there should be a reduction in air pollution - both fine particulates and sulphur dioxide. Without the WtE project proceeding the existing plant will at...
some stage require an emissions upgrade and/or modernization, so the future avoided capital should be recognised in the WtE project analysis;

- Price volatility. Energy intensive businesses are already exposed to unpredictable and volatile energy prices, and currency movement risks. In the future they will also be exposed to significant GHG emission costs that, based on experience to date, will also be volatile and unpredictable. The Government's ETS scheme passes on the GHG cost volatility to the end user – this will make accurate forecast budgeting even more difficult. WtE projects are capital intensive and have relatively low fuel costs. This means that they can assist significantly in this area by providing more stable and predictable delivered energy costs. This is analogous to buying an energy price hedge and should be valued as such; and

- Voluntary carbon credits. Despite what seems to be quite a common perception, that the owner of "green" plant can create and sell the "credits" from their project - this is currently a non-starter and unfortunately may remain so. Prior to redesigning its approach last year, the Government did allow this for some selected projects under their “Project to Reduce Emissions” (PRE) scheme. This scheme created a framework for recognising “additional” projects and allocated the project owner the Kyoto credits for the first commitment period (CP1), and this also allowed the units from the project operation outside the CP1 to be sold on the voluntary market. But this opportunity no longer exists in NZ, and this is unlikely to change unless there is another major change in the Government's direction.

**Site factors**

Specific WtE project economics can also be improved by a range of site characteristics. For improved economics, projects require:

- Stable site operations and host company. This should provide a secure long term future for the project and secure a customer for the plant energy outputs - electricity and heat;

- Reasonable scale. The bigger the better. In a NZ context of scale, the fixed overheads may swamp the economic of smaller projects;

- Adequate site demand for cogenerated heat. Project scale is normally determined by the base heat demand which is available on site. A matching site electricity demand is much less important, as electricity can be exported with only small loss of value;

- High plant utilisation factor. Again the more the better because of the capital intensive nature of these projects. Operation in excess of 6000 hours per year is preferred;

- Location factors. This is particularly important in selecting the best region for a WtE project. Projects are best located close to the waste fuel resource and in regions where the next best utilisation alternative is a long way away. Regions having higher gas or coal fuel and electricity costs because of their location are also preferred; and

- Other site specific and embedding benefits may also be significant if they can be secured as an accepted project benefit.

**Social responsibility**

And finally Companies are changing their attitude when considering these types of project. Five years ago the typical attitude was that a "green" project has risks and, to be seriously considered, needed to provide a significant cost reduction to their BAU position. Today the more typical thinking is that a cost neutral position is enough, and going forward there is a view that for some projects there will be quantifiable brand value and increased sales margin achievable for sustainably manufactured goods.
Barriers

On the other side of the coin, we need to recognize that there are some significant barriers to these types of projects in NZ.

- Technical and development risk. These types of projects often have very high technical risk. Serious problems can occur with combustion and emission control issues, ash fusion and slagging, and achieving reliable operation. The risks are very well illustrated by some spectacular demonstration project failures overseas;

- Resource Management regulatory barriers make consenting these types of projects costly and time consuming. Policy around solid waste management also discourages the beneficial use of some of the more challenging solid waste materials;

- High NZ labour costs mean that the labour intensive activities around the management of waste fuel and plant operation will remain a barrier. These can be a significant part of overall operating cost;

- Policy uncertainty around energy and GHG reduction remains a major problem with no immediate prospect of better clarity; and

- Few incentives – there are now small capital grants available, although these are contestable. Other positive incentives such as feed in tariffs would assist in getting demonstration projects underway.

Delivery Model

Principles of partnering

Successful partnering requires that the partnership creates “value for money” that would not otherwise be obtained. This can happen through a range of value adders.

The Australian Government has developed detailed guidelines for Public Private Partnerships – which are a similar to EFI’s partnering model. They describe value for money as “the best available outcome after taking account of all benefits, costs and risks over the whole life of the procurement”.

For the end user partnership can, in appropriate circumstances, provide value for money through:

- **Lower cost.** Delivery of the supply or service at a lower life cycle cost – rather than being determined by a short term asset cost mentality. This also results in transparent cost signals to the end user that fully account for lifecycle cost and, consequentially, demand side behaviour change;

- **Greater financial certainty.** This outcome is achieved by the transfer of exposure to significant risks; such as the risk of asset development, performance, on-going operation, future asset obsolescence and external market costs;

- **Innovation and efficiency.** The encouragement of innovation and efficiency by the service provider through a focus on service delivery and outputs rather than asset procurement and inputs. This allows a specialist and experienced service provider to identify and deliver additional value;

- **Sharing capacity.** Both in terms of asset utilisation through supply to multiple end users, and in terms of the expertise, experience and support services required to operate a portfolio of similar assets over a range of sites;
• **Bundling.** A one-stop shop service supply approach can lower the end user's overheads; and

• **Earlier delivery of benefits.** Partnering can allow a project to proceed funded by the service provider, where the project would not otherwise gain funding support from the end user's management.

**EFI BOO model**

EFI's partnering approach is similar to the PPP model and models used in other sectors.

EFI typically:

• Evaluates the on-site energy supply options in co-operation with our partner;

• Develops the preferred solution and gains pre-commitments from all of the project stakeholders;

• Establishes the BOO arrangement with our partner;

• Builds and funds the new plant required to deliver the agreed service, in the process taking on all of the associated plant performance, quality and construction risks;

• Operates and maintains the plant for the agreed term, optimising and/or expanding it as required;

• Shares the project benefit and risk with our partner in the agreed way; and

• At the end of the term – renews the arrangement, sells the plant back to our partner or removes it.
EFI Case study: Karioi Pulp Heat Plant

Partner: Winstone Pulp International Ltd

Site: Karioi Mill Site, Central North Island

Fuel: Bark, chip fines, site pulp sludge and imported assorted saw mill residues

Plant: 12MW thermal fluid Heater, sludge dewatering and drying system and fuel blending.

Commissioned: 2005

Outcomes:
- Improved heat supply availability (over 95%)
- Increased heating capacity (12 MW)
- Reduced energy supply costs – LPG use reduced by ~ 4m litres/y
- Reduced landfill – by ~ 6,000t/y
- Reduced GHG emissions – estimated by ~ 30,000t CO₂e/y.
- Modernised heat plant and sludge handling system
- Reduced operating labour

WPI produces mechanical pulp for export. This requires up to 35MW of electricity, predominantly for pulp grinding and 12MW of heat predominately for pulp drying.

In 2003 WPI and EFI initiated a partnership with EFI supplying WPI with electricity from the grid and heat from a new heat plant, built by EFI to replace a smaller obsolete unit.

The combustion system uses innovative technology originally developed by Easteel Industries for the NZ timber industry and adapted for this project. This technology can burn very wet bio fuels with up to 62% w/w moisture content (wet basis) containing up to 40% w/w pulp sludges. It uses a vibrating water cooled grate with preheated primary combustion air. It also incorporates a flue gas recirculation system to limit radiant heat flux and control slagging on heat transfer surfaces.
This is the first time the system has been used in NZ. It was developed after a detailed engineering investigation by EFI and Easteel to find a solution to suit WPI’s difficult-to-burn biofuels, i.e. very wet and abrasive wood residues with relatively low ash fusion limits.

A more conventional solution, given the range of fuels, would have been a bubbling fluidized bed combustor but this was not possible due to the high alkaline content of the fuels which would have caused solid ash agglomeration in the fluid bed.

EFI is currently developing a new heat recovery system at the site under an expanded partnership arrangement to recover waste heat from the pulp grinding plant to further reduce LPG usage at the site.

**EFI Case Study: Finegand Bubbling Fluidised Boiler**

**Partner:** Silver Fern Farms Limited (previously PPCS)

**Site:** Finegand meat processing plant, Balclutha, Otago

**Fuel:** dewatered WWTP sludge and imported sawmill wood residues

**Plant:** 8.5MW bubbling fluidised bed boiler

**Commissioned:** 2008

**Outcome:**
- Reduced energy costs
- Provides ~35,000t/y steam from renewable fuel
- Reduced coal consumption - by ~ 6,000t/y
- Reduced Particulate emissions - by ~ 22t/y
- Reduced SO$_2$ emissions - by ~ 110 t/y
- Avoided composting operation required for 15,000t/y sludge and associated anaerobic methane emissions
- Modernised site boiler plant
- Reduced GHG emissions – by ~12,000t/y CO$_2$e

The project opportunity arose when SFF were required to upgrade the site waste water treatment plant (WWTP) to meet new consent requirements for treated effluent discharge into the Clutha River. This resulted in much larger volumes of WWTP sludge, which SFF had planned to dispose of using a new composting operation. However the BFB boiler project was much preferred because it offered major environmental and operational advantages.
The primary purpose of the plant is to incinerate sludge from the site’s waste water treatment plant (WWTP), utilising the fuel value in this sludge to displace coal. The sludge fuel needs to be supplemented with a secondary fuel and this will normally be imported sawmill wood residues.

The amount of imported sawmill woods residues required for composting or the preferred BFB boiler option was the same for both options, at around 9,000t/y, so the fuel risk was identical.

Under the BOO arrangement agreement, EFI developed the solution, funded, built, owns and will operate the plant for 15 years.

BFB boiler technology was selected for this application because it offers the ability to burn a wide variety of ‘difficult’ fuels including wet, high ash and high fines fuels having relatively low calorific value. Although well proven overseas the technology at this small scale and in this application is new to New Zealand. The only other BFB boiler in New Zealand is a 40MW unit burning mill wood residues at Pan Pac Forest Products mill near Napier.

This project is the first in NZ to use meat processing sludge as a fuel, and has potential to be replicated at other meat processing sites around the country and, potentially for other problematic sludges or bio-solids.

Benefits from an EFI Partnership

The benefits for EFI partnership model include:

- EFI is a very sound and well resourced counter-party. We stand behind our projects and have a demonstrated track record in WtE field, including the introduction of new technologies into this sector;
- EFI acts the project catalyst – with the time and resources to drive a project through its investigation, project definition and approval stages. Without this drive projects are often parked indefinitely or their window of opportunity closes;
- EFI’s know-how, and experience creates more value within the project for the partners to share. EFI generates this value for money through the innovation, expertise and efficiency that EFI brings to the partnership. This ensures that project proposals are soundly based, long term life cycle costs are fully recognized, benefits are maximized and risks are understood, mitigated and managed;
- EFI understands the industrial energy market and can leverage off Meridian’s electricity market expertise, allowing the anticipated forward price paths to be projected and associated risks managed;
- EFI’s involvement ensures the project is implemented in an effective and timely way with minimal input needed from our partner;
• Risk transfer. Under the model EFI takes on many of the risks and liabilities of facility development, operation and maintenance;

• No capital outlay. EFI normally fully funds the project, allowing our partners to share in the project benefits without putting their capital at risk. This freed up capital can be used by our partners to develop other projects; and

• Benefit sharing. Depending on the agreed commercial approach. EFI offers a benefit sharing mechanism offering our partners a share of any upside in the actual project benefits over the base business case.