Victorian power stations and biochar opportunities

This case study explores how a supply chain approach to turning underutilised brown coal combustion products is resulting in the identification of new biochar product opportunities and new business partnerships for brown coal power stations.

A series of supply chain workshops with TRUenergy, Loy Yang Power, International Power and industry stakeholders in the CCPs sector were conducted by the Ash Development Association of Australia and Link Strategy.

Ash Development Association of Australia

Link Strategy

The ADAA is working with industry to support sustainable product development and build capacity in the CCPs supply chain.

Brown coal in Victoria

- ~65 million tonnes pa of coal used per annum to generate power
- Brown coal is a higher emitter of CO_2 because it has a much higher moisture content compared with black coal
- Burning coal produces waste by-products that have reuse potential
- Coal is generally perceived as being a “dirty” product by the community
- More than 1.3 million tonnes pa of CCP are not effectively utilised

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Coal is the fuel used to generate 90 per cent[1] of Australia’s electricity. Burning of coal for electricity generation creates large quantities of greenhouse gases and management of these emissions will continue to be a major challenge for the power stations and Victoria.

Burning coal produces by-products called coal combustion products (CCPs). CCPs are a valuable and underutilised recoverable mineral resource. There are several reasons for this underutilisation, including lack of awareness and understanding of the resource properties and characteristics, unidentified areas for reuse and associated commercial and environmental benefits.

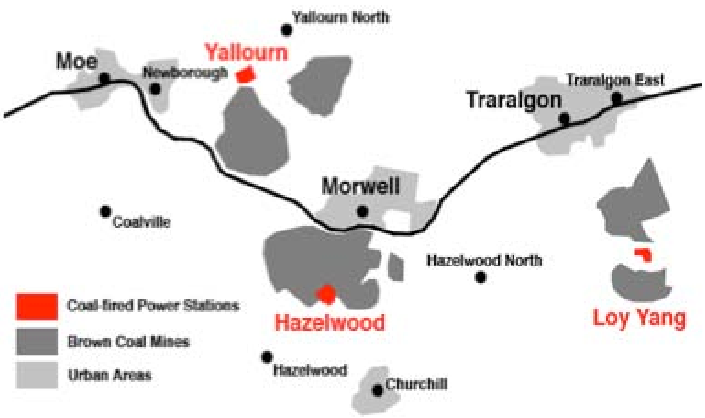
Effective utilisation* of these resources by associated industries has the potential to benefit business economically and provide significant carbon reduction benefits when used to replace other traditional ‘larger carbon footprint’ products.

The Ash Development Association of Australia (ADAA), with Link Strategy, has conducted a series of supply chain workshops with industry stakeholders in the CCPs sector. These companies recognised that real benefits would accrue from the program only if they tackled the inherent complexity of the supply chain and challenged old assumptions and practices about utilising the CCPs currently going to storage in ash dams.

The workshops were supported with funding from Sustainability Victoria through its Business Partnerships program, which supports industry associations and business networks in delivering sustainability programs specific to member needs.

The ADAA program aims to achieve sustainability improvements by finding beneficial reuses for an industry by-product which is not currently being effectively utilised.

* ‘’Effective utilisation’’ is the sale or utilisation of recoverable mineral resources into a valued added construction application that provide both commercial returns (revenue), return on investment or avoided expense, and use is consistent with the criteria of ecological sustainable development (ESD) principles.



International Power Australia

Is a subsidiary of International Power plc, a global company which has business in 21 countries, has a majority interest in Hazelwood (including Hazelwood mine) and Loy Yang B. International Power entered the Australian energy industry in 1996 and has grown to become the country's largest private generator of electricity with 3,723MW (gross) of renewable, gas-fired and brown coal-fired generating plants in Victoria, South Australia and Western Australia.

Loy Yang Power

Is owned by the Great Energy Alliance Corporation, and operates a 2,200MW power station and adjacent brown coal mine in Victoria's Latrobe Valley. The power station is the largest in Victoria, capable of providing approximately one third of Victoria's electricity demand. The open cut brown coal mine is the largest in Australia, also supplying the nearby Loy Yang B power station. The mine's annual coal excavation of 30 million tonnes fuels approximately 50 per cent of Victoria's power requirements.

TRUenergy

A wholly owned subsidiary of China Light and Power Group (a Hong Kong based company), operates power stations in the Latrobe Valley (Yallourn) in Victoria, in Jamestown (Hallett) in South Australia and near Wollongong in NSW (Tallawarra). TRUenergy also services around 1.3 million household and business electricity and gas accounts throughout the eastern seaboard. At the moment, TRUenergy relies on coal resources for approximately 80 per cent of the energy it generates and sells. In July 2007 TRUenergy launched a Climate Change Strategy that commits the company to reduce their emissions intensity, culminating in a long term goal of a 60 per cent by 2050.

Power in the valley

The Latrobe Valley is 155 kilometres east of Melbourne. Three power companies situated in the valley generate approximately 90 per cent of Victoria's electricity.

International Power

Power generation
Hazelwood 1600MW
Loy Yang B 1000MW

Annual output of coal
17 million tonnes (Hazelwood)

Annual CCP output
300,000 tonnes

Employees at site
660

LOY YANG power

Power generation
2,200MW

Annual output of coal
30 million tonnes

Annual CCP output
600,000 tonnes

Employees at site
550

TRU energy

Power generation
1,480MW

Annual output of coal
18 million tonnes

Annual CCP output
230,000 tonnes

Employees at site
232

The ADAA sustainability capacity building project focused on developing new products to increase the effective utilisation of CCPs.

New product applications developed can:

- Reduce CCPs stored in ash dams
- Reduce the carbon footprint
- Create product diversification opportunities and new income streams

The workshop participants recognised that developing new products from brown coal CCPs was a complicated process with numerous inputs, uses and specifications.

The supply chain approach to product development

By boosting sustainability efforts throughout the supply chain, significant upstream and downstream payoff can be achieved from reduction in waste and the development of new low carbon products. Many organisations are starting to reap financial and brand positioning benefits by adopting a holistic, systematic analysis of their supply chains.[2]

Taking a supply chain approach to sustainability is both rewarding and challenging. Supply chains have a complex array of relationships and drivers, numerous influences and interdependencies.

The project workshops and site visits aimed to create an environment where everyone could discuss their services and products and their operational environments. Once the participants had discussed their organisational history and expertise, the problems, challenges and opportunities became clearer. New ideas for projects started to emerge. Eventually a list of products was developed and by the end of the second workshop the barriers and incentives for each product and corporate partnerships were taking shape.

Some product development ideas tended towards a research and development focus, such as biochar from paper mill waste or bio-solids combined with CCPs. Other product ideas involved operational changes and new equipment, such as quarrying the ash dam for road base aggregates. This case study explores the biochar product stream.

About biochar

Biochar is a charcoal-like product from the slow-pyrolysis of biomass. Biochar can be made from virtually any source of biomass or combination of biomass and post combustion products. Biochar can be produced at power stations from biomass combined with loss of ignition (LOI) products, carbon materials that have not combusted during the burning of coal from electricity generation. The LOI material at the power stations is generally less than 5 per cent of coal combustion products produced annually. Coal combustion products are typically made up of:

1. Fly Ash (90-95% of volume)
2. Furnace Bottom Ash and Char (5-10% of volume)
3. Stored Ash (combination of the above)

Materials suitable for biochar feedstock are mainly found in the char, but smaller particles can be extracted from the Fly Ash.

The climate mitigation and agricultural value of biochar arises from the stability of carbon when it is applied to soil, and the various interactions with the soil chemistry, physics and biology. When biochar is applied to soil, it is anticipated to last in the order of 100-2,000 years, thus providing a sink for atmospheric carbon dioxide. Biochar can supplement nutrient content in soil by replacing chemical fertilizers such as nitrogen and phosphate. Along with increasing soil carbon, nutrient storage in soil can also increase. 75 per cent of Australian soil contains less than 1 per cent carbon. Total carbon content of biochar range in the order of 30-90 per cent. Applying 10 tonnes/ha of a typical biochar will immediately increase soil carbon by around 0.5 per cent in the topsoil.

In regard to the energy value of biochar, the properties and energy yield are a function of feedstock type, feedstock moisture and pyrolysis processing conditions. High energy (low moisture, high ash) feedstocks, can produce in the order of 1.3MWh syn gas per tonne dry feed (or ca. 0.5 MWh electricity).

Climate mitigation results from

- Conversion of carbon that breaks down rapidly (from biomass) to stable carbon (in the form of biochar)
- Offsetting fossil fuels
- Reducing biomass entering landfills
- Improved soil fertility resulting in greater biomass (and food) production
- Reduced requirements of nitrogen[3] fertilisers, thus reducing greenhouse gas emissions
- Reduced greenhouse gas emissions from soils[4]

Slow-pyrolysis is the only technology that has a high yield of biochar, while still achieving energy production.

- Determining the best source of feedstock for biochar requires testing a range of feedstock combinations
- Most feedstocks will result in a biochar yield of 30-50 per cent

The pyrolysis process

Pyrolysis is an engineering process that heats biomass to temperatures typically in the range of 350-650°C in a controlled low oxygen environment, resulting in both production of energy and biochar. The desired product output (ratio energy to biochar) determines the technology type and temperature.

Technology decision matrix

	Temperature	Vapour Residence Time	Bio-oil %	Biochar %	Syngas %
Fast pyrolysis	~500°C	~1 second	75	12	13
Slow pyrolysis	~500°C	~5-30 minutes	30	35	35
Gasification	~750°C	~10-20 seconds	5	10	85

Adapted from Brown (2009)[5].

Each pyrolysis technology produces different percentages of bio-oil, biochar and syngas. Both fast pyrolysis and gasification require high feedstock preparation, while slow pyrolysis has the advantage of low feedstock processing. The slow pyrolysis decision support matrix below highlights some of the key variables for determining the characteristics of the end products.

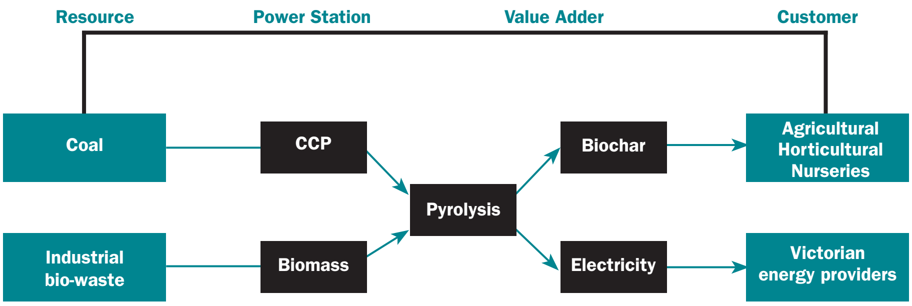
Slow pyrolysis decision matrix

Processing temperature	**low (350°C)** →	**high(650°C)**
	High biochar yield	Low biochar yield
	Low energy yield	High energy yield
	Biochar stability medium	Biochar stability high
Feedstock moisture	**low** →	**high**
	Biochar yield unaffected	Biochar yield unaffected
	High energy yield	Low energy yield

Biochar products and potential markets

Market opportunities for biochar in Australia are growing. Bagged biochar is used extensively in the nursery industry, but it is not commonly produced in Australia. There is a lot of interest in developing biochar products for agriculture as a wide range of agricultural soils may benefit from increased soil carbon associated with the application of biochar. Consistency of biochar products is essential for end user satisfaction and consumer confidence that biochar will deliver the desired results. Chemical composition of biochar can be highly variable (for example brown coal feed stock varies with geology). Also, poorly manufactured biochar may leave undesirable residuals in the soil. Product certification, branding and marketing are in early stages of development to ensure a consistent product and message for customers.

Biochar product supply chain



There are many challenges to developing successful biochar products, but the key issue is to identify the best sources of local feedstocks that will deliver the desired results in a format and price that is attractive to potential buyers. The market value of biochar ranges from $100 per tonne for broadacre production through to $1500 per tonne for bagged products. The potential local market for biochar is extensive and diverse. The Latrobe valley has dairy, beef, horticulture and nursery industries. There are feedstock sources of wood chips, biosolids, paper pulp and council green waste in close proximity to the power stations.

Taking a supply chain approach can provide significant upstream and downstream payoffs from reduction in waste and the development of new low carbon products

Key challenges with developing products in the CCP supply chain:

- Managing research and development and product development time spans and obtaining adequate financial backing
- Building trust between supply chain members
- Developing knowledge about sustainable product design, such as life cycle analysis, transport, standards, marketing and branding
- Differing stakeholder and societal expectations about desirable products and outcomes
- Negotiating vested commercial interests and industry groups priorities

Companies who take a supply chain approach to sustainability can find opportunities to further improve their development of low carbon products.

What next

As society increasingly puts a price on carbon, smart companies are focusing on their supply chains. They are preparing for tougher regulatory policies and they see advantages from creating new products from underutilised resources such as CCPs.

Try and fail CCPs projects had created a sense of powerlessness and inertia in the brown coal power sector. The past failure to develop sustainable CCPs end uses can be partly attributed to the perception of brown coal as 'dirty' by the community and customers.

Workshop discussions led to some agreement that sustainable use of CCPs needs to be better integrated into the everyday thinking of business development and sustainability managers, product design and operational changes, the same as environmental management is routinely incorporated now. While the immediate financial feasibility rests on how easy it is to extract and develop sustainable product streams, long term sustainability will also rely on the realisable environmental benefits and changed social perceptions of CCPs.

This case study demonstrates that companies who take a supply chain approach to sustainability can find new opportunities and partners to further improve their ability to develop low carbon products. It also highlights the value of using external expertise, government and association partnerships to challenge the status quo and encourage innovative thinking about new products, partnerships and under utilised resources.

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Disclaimer

The information contained in this case study is based on knowledge and understanding at the time of writing (August 2010).