Road base applications using Victorian power station ash

This case study explores how a supply chain approach to turning underutilised brown coal combustion products is resulting in the identification of new construction material product opportunities in large scale civil road base applications and new business partnerships for Victorian 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 to explore low carbon product development opportunities.

Ash Development Association of Australia

Link Strategy

Increasing the capacity of power generators to develop new CCP applications with supply chain partners will reduce CCPs stored in ash dams, offset the carbon footprint, create product diversification opportunities and new income streams.

This case study focuses on the potential uses of CCPs in coarse and fine aggregate road base applications in areas adjacent to power stations in the Latrobe Valley and considers broader applications of the material in other markets.

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, management of these emissions will continue to be a major challenge for the power stations and Victoria.

The Ash Development Association of Australia (ADAA), with Link Strategy, has conducted a series of supply chain workshops with industry stakeholders in the coal combustion products (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 are not currently being effectively utilised.

Potential large scale, high volume use of brown coal CCPs in coarse and fine aggregate applications include:

- Concrete (as a normal coarse or fine aggregate)
- Emerging geopolymer applications
- Engineering fills – structural and non structural, and lightweight aggregate and sand replacement
- Building materials – insulation and acoustic panels
- Filter materials for water treatment and agricultural applications

Written By

Alice Woodhead
Link Strategy

Craig Heidrich
Ash Development Association
of Australia

The supply chain approach

The program aims were to increase understanding about CCPs and to accelerate the deployment of affordable, secure low-carbon products by demonstrating technologies and developing knowledge and skills across supply chains. Strategic, successful change requires a commitment to exploring and challenging assumptions about 'business as usual'. To enable new product diversification partnerships, many organisations are starting to adopt a holistic, systemic analysis of their supply chains[2] with current and potential trading partners. The project workshops and site visits therefore aimed to create an environment where everyone could frankly discuss the issues, their services, products and their operational environments.

Opportunities to utilise CCPs are diverse, however, the ability of generators and value adders to increase the utilisation of CCPs is restricted by current knowledge.

Knowledge barriers are not unique to the Victorian power sector. The industry has highlighted certain issues that need further consideration to enhance use of CCPs in products, including:

- Developing information about the material characteristics and environmental benefits
- Defining environmental classification status and aligning CCPs with potential product applications
- Building market intelligence about customers requirements and product options
- Streamlining experimental processes to improve efficacy of CCPs applications in trials

Quarrying potentially suitable CCPs in onsite storage dams has the potential to provide a substantial resource for Victoria. The value of inter-organisational conversations and taking a supply chain approach, with value adders and customers, to developing low carbon products is that it has enabled the power sector to identify the knowledge gaps and to create new partnerships.

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

The long-term stewardship costs for continued storage in onsite collection dams are a major incentive to increase CCP utilisation.

Each year up to 1.3 million tonnes of CCPs are stored in Latrobe Valley ash collection dams.

International Power

Power generation
Hazelwood 1600MW
Loy Yang B 1000MW

Annual coal use
17 million tonnes (Hazelwood)

Annual CCP output up to
300,000 tonnes

LOY YANG power

Power generation
2,200MW

Annual coal use
30 million tonnes

Annual CCP output up to
600,000 tonnes

TRU energy

Power generation
1,480MW

Annual coal use
18 million tonnes

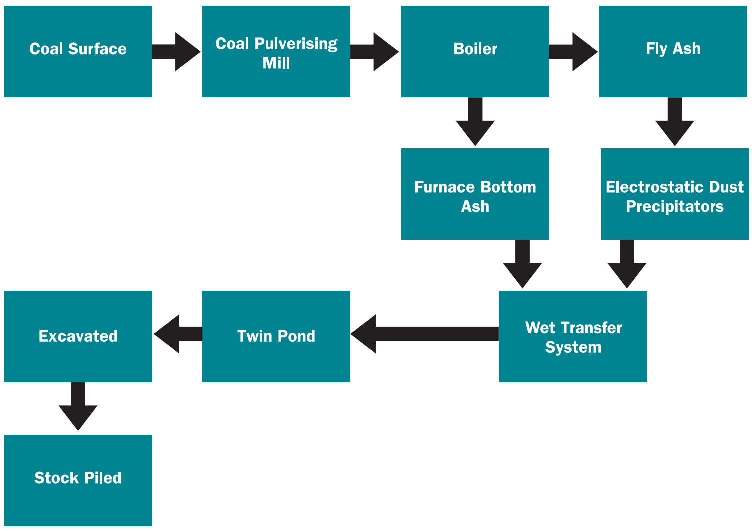
Annual CCP output up to
230,000 tonnes

About CCPs

CCPs are the solid inorganic particles that remain after the combustion of coal within the furnace of a coal fired power station. The CCPs produced in Victorian coal fired power stations are typically mid-grey to ochre or redish in colour. Fly ash particle sizes range from fine, less than 1 µm (micrometer), to coarse, 200 µm, and typically represents 80-90 percent of the total CCPs volume. Furnace bottom ash can comprise 10 to 20 percent of the CCPs produced and range in grain size from fine sand to coarse lump similar to natural quarried aggregates.

CCPs are collected continuously from the boilers via mechanical collection systems and at less frequent intervals from the bottom of the furnace hoppers. Materials are mixed with recovered water to create a slurry (approximately 3 percent CCPs, 97 percent water). The slurry is then transported, via a pipeline, to the interim storage site, then recovered and transported to final storage.

Typical CCPs Process Flow



Water used in the wet transfer system, transporting CCPs to storage, is principally sourced from the brown coal mining operations. Brown coal has 60 percent moisture content and is dewatered once removed from the mine site.

Environmental regulations in Victoria aim to provide practical assistance to industry on how to avoid generating waste, also providing mechanisms for assessment and classification of industrial by-products. Legal certainty for the reuse and recycling of industrial waste resources is essential. Based on material assessments using the ‘General Criteria for Hazard Classification’, all Victorian CCPs sources are significantly below nominated thresholds and therefore should be considered non-prescribed industrial by-products.

Storing CCPs and construction materials

CCPs can potentially be collected at two points, as dry conditioned materials after collection at the power station via mechanical separation systems or once transported to the storage dam, as a wet ash product.

Dry CCPs collected and stored in silos ready for dispatch to processors or customers is preferred method. Dry CCPs have less material emissions (water and energy) than wet ash. Wet ash material being combined with large quantities of water are pumped via pipelines into large collection ponds. Once these ponds are full the materials are recovered and transported to a final storage destination within the site, adding more costs and associated emissions.

The chemical composition of stored materials can be variable partly because brown coal feed stock varies with coal geology. Therefore it is essential to develop and maintain laboratory data about CCP properties for fine and coarse aggregates, and to establish procedures to reduce variability when recovering materials. Consistent coarse and fine material properties enable customers to confidently purchase aggregate materials that are fit for purpose.

Unlike black CCPs, brown CCPs need additional processing before use as a cement replacement material for reinforced concrete applications. Material properties of brown CCPs are generally suitable for large-scale civil, road base applications. To develop this market there needs to be research undertaken about key properties, processing and logistics costs prior to the development of a sound business model for reuse.

Materials for large scale civil and road base applications are controlled through customer defined specifications. Processing equipment is required to grade these materials into suitable end use products. Logistics issues include interim storage, access to feedstocks, collection points, drying of materials and transport costs.

Developing collection systems and interim storage points is a key consideration when developing new product applications.

Potential end use applications can have significant technical risks.

Customers want to know that their products:

- Have consistent performance properties and fit for purpose over the life of the project;
- Are not adversely impacting on the environment;
- Have recycled or low emission content; and
- Are produced using socially responsible practices

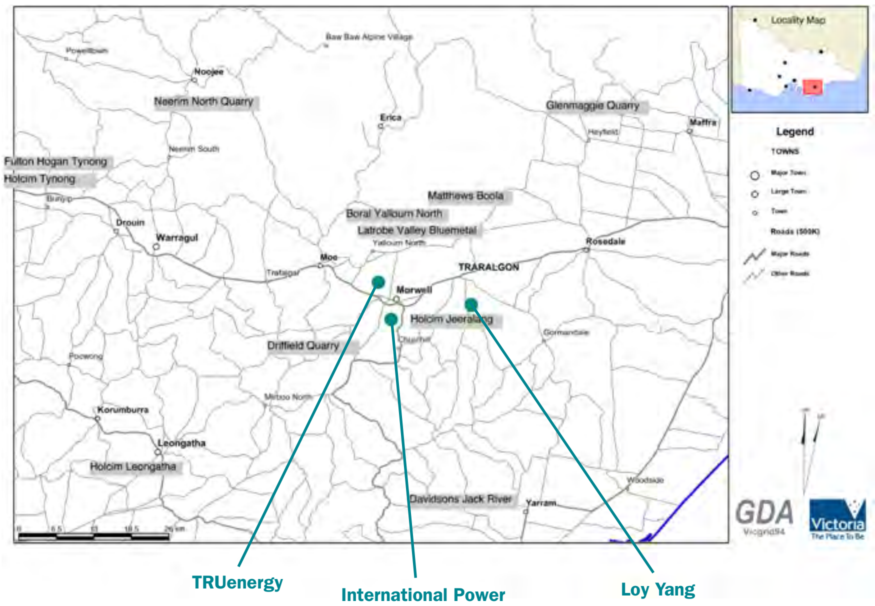
CCPs have significant potential to lower the CO_2 footprint over natural quarried materials provided they meet specified performance criteria.

Environmental benefits of CCPs:

- CCPs are a recovered resource
- Conservation of natural quarried resources
- Reduction in environmental and landscape impacts of mining quarried resources
- Recycling one tonne of CCPs saves 1.3 tonnes of raw materials and reduces CO_2 emissions by 25 percent[3]
- The reuse of one tonne of CCPs in cementitious applications reduces CO_2 emissions by 76 percent[3]

About coarse and fine aggregate road base applications

A wide variety of structures use natural earth or rock fills, including roadways, car parks and residential or commercial re-development sites. Roads, embankments and hardstand areas are common projects for large civil engineering construction firms. They require the use of engineered bulk materials and structural fill - coarse and fine aggregates - which are generally sourced from natural quarried materials. CCPs can complement the use of local quarried materials in large-scale civil applications.



The map shows quarry locations near the Latrobe Valley that currently supply VicRoads with materials for road construction (adapted by VicRoads from Department of Primary Industries).

CCPs, like quarried materials, must meet various physical property requirements so as to achieve compaction, performance and durability requirements[4]. Compaction is the process by which voids in the fill material are removed. Once compacted, soils and fills generally have predictable properties, with structural characteristics suitable for supporting many types of loads.

Suitable engineering properties, including a high internal angle of friction, low density compared to natural materials, low compressibility, and low rates of long-term settlement in a fill situation make CCPs a viable option.

Customers and developing markets

Working with customers can help suppliers establish knowledge about market opportunities outside of their core product expertise. Processors and value adders can help customers to understand the characteristics of the products and sustainability benefits. Conversely customers can educate suppliers about market entry criteria and supply and demand trends and product gaps.

While CCPs have considerable potential in large-scale civil applications, marketing and promotion of CCPs material is not considered to be core business by generators whose primary business is the generation of electricity. Consequently limited resources have been assigned to develop essential information about the material characteristics.

Product Value	Product type	Volume
High Value Add		
Carpet Underlay	Building Products	Low
Gasification	Mineral Processing	Low/Med
Biochar	Agriculture/fuel	Low
Blended Cements	Building Products	Med
Medium Value Add		
Cement feedstock	Mineral Processing	Low
Aggregates	Building Products	High
Geopolymers	Building Products	High
Concrete	Building Products	Med
Low Value Add		
Agricultural Lime susbstitute	Agriculture	High
Soil Stabilisation	Civil	Med
Engineered Fills	Civil	High
Road Bases	Civil	High
Storage(fill)	Civil	High

Road base and engineered fills were identified as having most potential use for CCPs during workshops, given the limitations on expanding local natural quarries. However, without well-understood technical characteristics potential customers cannot determine whether materials are fit for purpose.

There is limited published data about market and economic drivers and engineering characteristics of brown CCPs. This makes it difficult to develop product and technical information about CCPs in Victoria.

CCPs represent an opportunity for VicRoads to increase recycled or recovered content in large-scale civil road base applications.

VicRoads is increasingly focusing on the sustainability of their operations. VicRoads' Environmental Sustainability Policy (2008) establishes guidelines on

- Conserving natural resources
- Reducing carbon footprint
- Using goods and services that have minimal environmental impact, yet are value for money

High volume (low value) product applications are very sensitive to transporting distance and associated costs.

High value add (generally low CCPs volume) products include carpet underlay, metal recovery, blended cements and biochar

Medium value add products include concrete, cement feedstock and aggregates

Low value add (high CCPs volume) include road base and engineered fills

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

What next

Market opportunities for coarse and fine aggregates in Australia are more established for black CCPs than brown CCPs. This is due to many factors including, well characterised chemical and physical properties, customer confidence from more than 20 years of use and hence market and capital investment. This presents both opportunities for new markets and challenges for brown CCPs. The financial risk of developing new technologies at the back end of a power station is considered a key constraint, as is the lack of published information about brown CCPs. A collaborative partnership with specialist researchers, civil construction companies would bring expert knowledge from quarrying specialists that would complement the expertise at the power stations.

Participants at the workshops noted that many of the potential end use applications identified held significant technical risks. Try and fail CCP projects had created a sense of powerlessness and inertia in the brown coal power sector. Technically sound published data and best practice testing procedures for product development could help to reduce this risk and increase the likelihood of success when exploring new product applications with customers.

Turning underutilised CCPs resources into value add products can provide environmental, economic and social benefits to the industry and the community. For this to occur, new business partnerships need to be developed and fostered both to improve the technical expertise and to create new product applications. 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 understanding and documenting the environmental benefits and social perceptions of CCPs.

This case study highlights the need for further research into building new business partnerships and knowledge to increase the utilisation of brown CCPs in Victoria.

References

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