Supply chain approach for developing new coal combustion product opportunities

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This paper discusses how a supply chain approach to turning under utilised coal combustion product resources into solutions is resulting in new networks, new collaborations and new products. This paper discusses how the industry is exploring new product options using a supply chain approach with participants.

The Sustainability Capacity Building Program has elements of both innovation and organisational change because it engages corporations in thinking about sustainability issues, their culture, their business environment, their desired future and new product opportunities. Depending on the position of the organisation in the coal combustion product (CCPs) supply chain, there are different imperatives, trade-offs and barriers.

To build understanding across the supply chain a staged approach was undertaken. Stage one (1) establishes mutual understanding about their different business models and operational imperatives. Stage two (2) was to learn about the production processes, constraints and opportunities. Stage three (3) focused on the developing strategic interventions to fill the knowledge gaps with the ultimate objective of increasing the utilisation of CCPs in products. Documenting lessons learned and implementing organisational wide changes underpinned all stages.

This paper discusses the staged approach using survey’s, workshops and webinars to establish new products and systemic learning with industry stakeholders in the CCPs supply chain.

INTRODUCTION

Sustainability issues are often very complex and associated with high levels of uncertainty (Woodhead et al 2009). Consequently, making decisions about new products and services becomes more complex when integrating sustainability issues into current production systems. This is because in addition to economic and market issues, when taking into account sustainability issues, consideration needs to be given to social and environmental as well as organisational systems (e.g. corporations, business units, government agencies), that interact with the proposed new product or service.
Developing a sustainable labelled product is particularly challenging because it is placing a new product into an existing market, with sustainability reporting requirements, and this can have unintended outcomes. Therefore it is essential to understand the complexity of the interactions across the entire supply chain. Organisations need to understand they are part of a larger system (Senge et al 2008). They need to interrogate the credibility of their product claims across the entire supply chain, or risk the label of green wash (Woodhead 2009). Sustainability issues should therefore be managed as core issues, integral to corporate operations (Lee 2010).

A supply chain is a “network of facilities and distribution channels that encompasses the procurement of materials, production and assembly, and delivery of product or service to the customer” (OECD 2002, p2). Supply chain management is the process of planning, implementing and controlling the operations of the supply chain. This includes the movement and storage of raw materials, operations, and all processes that are required to process goods from origin to consumption. The value chain refers to the value adding activities that an organisation provides to support the efficient operation of the supply chain. These can include infrastructure management, human resources, research and development, sales and marketing.

A sustainable supply chain, for the purposes of this paper, is defined as a supply chain that explicitly considers the social and environmental, as well as the financial benefits and costs of its operation. Taking a sustainable approach to product development in the CCPs supply chain, therefore, involves engaging producers\(^1\) processors, value adders\(^2\), customers\(^3\) and researcher/s\(^4\) in discussion about the opportunities and challenges of the product. It involves ‘closed loop’ methods, whereby the waste of one product becomes the material for another product (World Economic Forum and Deloitte 2010). Depending on the position of the organisation in the CCPs supply chain, there are different imperatives, trade-offs and barriers, all of which influence the time and resources needed to develop new products.

The concept, critical systems thinking, acknowledges the limitations of traditional scientific inquiry in dealing with the complex reality of social institutions interacting with natural phenomena (Flood & Romm 1996). Traditional inquiry breaks an issue down into manageable units. This approach can yield valuable insights, but does not lend itself to situations that are interconnected, complex and dynamic. It doesn’t reveal the richness of the social interactions among numerous events and actors over time that form the behaviour of a complex system.

This Link Strategy Thinking Systems diagram (Figure 1) (Woodhead 2009) shows a supply chain (represented by the black line) connecting suppliers (the small red circles) which are all part of a larger system (the large red circle). Each system and sub-system

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1 Producer – means a company whose primary business is to produce CCP as a by-product – who supplies CCP to a value adders or customers.
2 Value adder – means a company who processes, mixes, blends, or otherwise incorporates CCP into a material for supply to customers. A value adder brings intellectual property to CCP.
3 Customer – use or manufacture products that incorporate CCP for their unique physical or chemical properties.
4 Researchers – provide research support to the sector at various stages of the supply chain
has social, environmental and economic elements (indicated by the icons). The red and black arrows show the potential points in a system where one-way and two-way interactions occur between different systems. Each organisation has a range of tools (the spanners) for managing internal and external issues (sales, audits, certification, training and so forth).

Figure 1 - Link Strategy Thinking Systems diagram.

In this paper we discuss the implementation of a critical systems approach with the CCPs supply chain. CCPs are by-products from the production of energy from coal. At the Latrobe Valley Generators\(^5\) power plants approximately 1.1 million tonnes of brown CCPs are produced and stored in ash dams each year (Heidrich & Woodhead 2010). Extensive literature (Woodhead et al 2002) suggests the lack of action on the ground is due to social and institutional issues rather than a lack of scientific solutions. Therefore the challenge with increasing effective utilisation of recoverable resources, i.e. new CCPs applications, is to assess the social, environmental and operational feasibility, as well as the current market opportunities, with a range of producers and customers, and then work out where, and how to influence change in the CCPs supply chain.

Making decisions on major investments for new product development opportunities requires strategic analysis of the entire production process and the development of new supply chain partnerships (Berns et al 2009). While there are many challenges both in understanding the inherent complexities of the relationships within and between supply chain companies, there are also substantial immediate and long term benefits. Companies who take a systemic, sustainable, whole of supply chain approach reduce the risk of product failure, and increase the likelihood of establishing long term effective business partnerships (Woodhead et al 2009). In the next section we discuss the systemic approach taken to building capacity and to understanding and developing new products with the Victorian CCPs supply chain.

\(^5\) International Power, Loy Yang Power and TRUenergy
THE CCPs PROGRAM

In 2009 the ADAA, with the specialist assistance of Link Strategy, commenced a Sustainability Capacity Building Program ‘the program’, being partly funded by the Victorian State Government through Sustainability Victoria and its Business Partnerships program, supporting industry associations and business networks in delivering sustainability programs specific to participants needs.

The overriding aim of the project was to establish mutual understanding about the production of brown CCPs, with the ultimate objective of increasing the utilisation of CCPs into new sustainable products. The key objectives of the program were to:

- determine who are the key stakeholders and their roles
- identify products, supply chain processes and sustainability initiatives
- assess potential economic benefits for new CCPs and review likely consumer responses (local government and VicRoads)
- report on initiatives towards a sustainable CCPs supply chain to the funding body, and;
- provide advice on opportunities for enhancing the adoption of CCPs practices, collaboration and communication among stakeholders in the CCPs supply chain.

The project had dual capacity building objectives, firstly to build shared knowledge among participants about sustainability issues in the CCPs supply chain and secondly to achieve sustainability improvements by identifying beneficial reuses for CCPs generated in Victoria, which are not currently being effectively utilised⁶. The capacity building supply chain approach was monitored and its effectiveness discussed and evaluated by the steering committee (ADAA, Link Strategy and Sustainability Victoria).

Over 14 organisations, made up of 33 participants, were involved in various stages of the project. In the producer section of the CCPs supply chain the companies of particular interest during the project were the generators in the Latrobe Valley. Value adders and customers in the CCPs supply chain were represented by a broad range of corporate entities and government agencies with an interest of developing new market opportunities for CCPs.

SUPPLY CHAIN CAPACITY BUILDING APPROACH

Every individual and corporation in the supply chain differs in the way they value, perceive and define social, economic and environmental issues (Woodhead 2009). Each link in the supply chain provides different services and processes and employs skilled professionals appropriate to each operation. Therefore the way sustainability issues are defined and acted upon differs, as does how risk and mutual benefit is perceived. To

⁶ “Effective utilisation” is the sale or utilisation recoverable mineral resources into a valued added construction application that provides both commercial returns [revenue] return on investment or an economic profit [avoided expense] and use is consistent with the criteria of ecologically sustainable development (EDS) principles
add value therefore requires a deeper understanding of the interactions and interdependencies, and a deeper understanding of individual values and motivations.

In broad terms, there are three (3) stages to implementing a capacity building project with multi-stakeholder groups (Woodhead et al 2009, Woodhead et al 2000)

1. building mutual understanding about diversity and establishing base line information,
2. analysis and strategic thinking and finally
3. transformation to a new state.

At all stages there is an ongoing cycle of reflection and discussion about the process. In this section we explore how these stages applied to the project and we discuss the outcomes from each stage.

The first stage is to understand the diversity of the group by establishing baseline information and sharing perspectives and knowledge among the group participants. With a multi-disciplinary, multi-corporation project it is particularly important to build mutual understanding of how different entities connect, networks, who knows who, which companies have commercial relationships, the historical context and potential implications.

To further enhance baseline, shared knowledge about CCP production and potential product applications, the first of three supply chain workshops also focused on discussing operational environments, resources, data and information sources. Diagrams such as Figure 2, were used to help establish boundaries and define supply chain sectors. Participants then defined and agreed on boundaries around knowledge sharing to ensure that future discussions were informed and constructive.

The CCP product supply chain and issues boundaries

From a cultural perspective a major challenge when working across a supply chain with competing companies and companies with a range of trading relationships, is to create an environment of trust and partnership. Only by achieving this can the group soften the
inter-organisational boundaries and benefit from the gains of a cooperating supply chain network. Establishing a culture of trust and collaboration was therefore a key aim of the first workshop, but was a constant underpinning theme throughout the project.

The second stage is to assess the current state, to define the barriers, the boundaries of systems and sub-systems and to understand the historical context. Once these have been discussed, participants can determine what is a desired future state and develop strategies to change the current state to a new state. That is, to determine how and where to add value to the CCPs supply chain. In the context of the project, as discussed above, the key objective was to achieve increased utilisation of CCPs, whether in existing products or in new products. Therefore after assessing the baseline information, the group decided that an initial strategy was to focus on engaging more customers in the next two workshops and to develop performance criteria and fundamental information about CCP to raise customer awareness of their beneficial characteristics and potential applications.

CCP can be utilised in various applications because of their material properties, Victorian brown coal 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 lumps similar to quarried aggregates. CCPs have potential to replace, supplement and improve other natural, quarried materials. CCPs are well suited for use in road base construction. 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. CCPs can complement the use of local quarried materials in large-scale civil applications. The use of CCPs has environmental benefits in allowing the conservation of depleting natural resources (Heidrich, Hinczak et al. 2005).

Potential medium and high value construction end uses identified during the workshops for fine and coarse CCPs included:

- Aggregates (non concrete)
- Geopolymer binders
- Road base and engineered fills (were identified as having most potential use for CCPs during workshops, given the limitations on expanding local natural quarries)
- Rare earth metals extraction,
- Biochar,
- Carpet underlay,
- Blended cements,
- Geopolymers and
- Fertilizers and soil ameliorants.

Systemic, supply chain challenges highlighted during workshops discussions included uncertainty about climate policy directions and associated carbon trading cost implications in Australia, constraints imposed by environmental regulations, limited
incentives, performance specifications and procurement policies. Specifically for the value adders, the key challenges with developing products in the CCP supply chain were:

- Managing R&D and product development time spans and obtaining adequate financial backing.
- Developing performance standards with customers
- Building knowledge about sustainable product design, such as life cycle analysis, transport, standards, marketing and branding.
- Negotiating around vested commercial interests and industry groups

Engaging more customers in workshop discussions meant that the group was; a) able to gain a deeper understanding about customers perceptions about these issues, and b) they were able to consider and explore the development of collaborative research projects with customers. This meant they could address these challenges more effectively than if they had been operating alone in the role of a value adder.

The third stage is implementation. This requires changing current practices to achieve the desired outcomes, greater utilisation of CCPs. Implementation includes a range of initiatives from internal training to achieve behavioural change, through to new corporate partnerships, product design as well as developing performance standards, technical information and standard operating procedures to support product claims and applications.

Procurement policies and purchasing criteria are now differentiating products based on sustainability criteria as well as traditional performance criteria such as price and quality. The lack of appropriate performance specifications for CCPs, both sustainability and fit-for-purpose criteria, were considered a key barrier to increasing CCPs procurement by customers or ‘gate keepers’, such as local government and VicRoads, and therefore became a focus of the project.

Customers at the workshops noted that many of the potential end use applications held significant technical and commercial risks. 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. Customers had a poor understanding of CCPs, exemplified by the fact that CCPs are not currently addressed or specifically allowed for in key product specifications. Current specifications are focused on quarried materials and not recoverable resources such as CCPs. Local governments engaged were particularly risk adverse to new products and defaulted to VicRoads specifications and approved products in the majority of cases.

While the quantity of CCPs available in Victoria is relatively small, the evolving sustainability procurement requirements of government customers towards more

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7 State Government Road Authority
sustainable purchasing practices afforded new unexplored opportunities. New procurement policies require increased use of 'low carbon footprint' and 'recycled' materials in road construction and other applications where appropriate. These emerging sustainability and procurement policies were key drivers for customers to become involved in the project. Recoverable or recycled materials could lower the CO$_2$-e in road construction processes, provided they meet specified performance criteria, including minimum design life expectancies within the road structure.

From insights gained using the supply chain capacity building approach, new 'low carbon footprint' opportunities were identified for CCPs. In particular, the project identified potential carbon emissions reductions for Victorian CCPs (Heidrich, Woodhead 2010). Natural aggregate carbon emissions are reported at 0.05 t tCO$_2$-e/tonne of processed product (Flower 2007).

No stage in the capacity building program is discreet. That is, while establishing baseline information during the first workshop, some analysis will naturally occur by participants, such as the implications of government regulations or barriers to product development. It is therefore necessary to develop a flexible, inclusive and systemic approach to the facilitation and analysis.

In addition to three workshops, participants engaged in Webinars\(^8\) between workshops to maintain contact and engagement, and were supplied with summary notes and a case study of the process. Participants and external experts were invited to address the workshops on specialist areas such as material properties, procurement policy, product development and logistics. Participants also shared their specialist expertise during a 'walk the supply chain' tour of TRUenergy and Loy Yang Power stations and ash dams.

Capturing discussions in summary notes establishes baseline information for mapping change and shares the deliberations with a broader audience, such as industry members that were not part of the project team. Three reports were published,

- two case studies that captured the essence of the discussions and highlighted two product opportunities that were discussed during the workshops, and
- benchmarking analysis (Heidrich & Woodhead 2010) based on a triple bottom line approach (Woodhead et al 2000) was undertaken to support the qualitative findings in workshops.

Finally, but most importantly, establishing a culture within the group that supports innovative thinking and encourages open debate on sensitive issues is imperative. For example product development has economic and intellectual property implications, therefore it is important for the group to acknowledge the boundaries of shared information. If participants are unwilling to collaborate, and share viewpoints, or can’t be trusted, then it becomes very difficult to move beyond certain topics, and to engage the

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group in meaningful consideration of complex product development issues that have economic and trade implications.

DISCUSSION

Market opportunities for CCPs in Australia are growing due to new pressure states within business, government, environmental and social operating environments. Effective utilisation by supply chain participants of recoverable or recyclable resources has the potential to benefit business economically and provide significant carbon reduction benefits when used to displace other traditional ‘larger carbon footprint products’. Societal expectations about cleaner, more energy efficient production systems are increasing influencing governments and corporation’s approaches to production practices and their products.

Supply chain management has come under increased scrutiny because products that customers purchase are now considered as the sum of all processes in the supply chain. Therefore, products can no longer be reduced to simply the trading relationship between one buyer and one seller. Rather the quality of a product is increasingly determined by the inclusion of carbon footprint data, by the stewardship of the product, and by the sustainability and corporate social responsibility credentials of the companies in the chain.

Traditional performance criteria and quality characteristics, such as durability and fit for purpose are now being supplemented with sustainability criteria, most specifically low carbon footprint and recovered or recycled content. However, key specifications, in the road construction sector need to adapt, they have preferred natural aggregates, and not adequately address recycled materials like CCPs. Performance standards that classify or at least seek to incorporate the use of CCPs in applications, are therefore essential for developing the new low carbon market opportunities.

In summary, the project provided opportunities for creating new data and knowledge about CCPs and new end use applications. The project formed a new supply chain network that enabled conversations between organisations that would not normally interact. Workshops, where participants share views and ideas and engage in discussion with invited experts, builds knowledge quickly and systemically among supply chain groups who would not normally discuss sustainability or low carbon product development issues. It also creates the potential to develop new partnerships with companies, thereby enabling low carbon product developers the opportunities to receive expert advice from the customers about the performance criteria.

Participants said that they gained invaluable insights about the drivers and barriers that govern why and how other companies in the supply chain make decisions. Supply chain workshops with multi-disciplinary participants enable strategic partnerships to be developed quickly, providing the facilitation, process and cultural environment is safe and conducive to constructive dialogue. It can reduce the costs, and increase the speed of product development cycles, as well as reducing market barriers for developing new CCPs applications. Suppliers can help customers to understand the characteristics of
the product applications and sustainability benefits. Conversely customers can educate suppliers about market entry criteria and supply and demand trends and product gaps.

The project highlighted significant knowledge gaps in the Victorian brown CCPs supply chain, gaps that hinder the utilisation of CCPs in new and existing product applications. By taking a sustainable and systemic supply chain approach to capacity building, the project achieved a rapid increase in knowledge about CCPs opportunities, a decrease in product development time, and created new research and business partnerships.

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REFERENCES


