Future Latrobe Valley Scenarios for a Carbon-Constrained World: Industrial Ecology, Environmental Impacts and Property Rights

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ABSTRACT
The Latrobe Valley has substantial brown coal deposits which are currently mined for use in coal-fired power stations which supply 85% of Victoria's electricity. This paper considers the role that industrial ecology could play in underpinning the future structure (2050-2100) of the Latrobe valley industry base in a carbon-constrained world. Potential future scenarios for industry clusters were developed around three themes: bio-industries and renewables (no coal usage); electricity from coal with carbon capture and storage (low to high coal use options exist within this scenario); coal to products (e.g. hydrogen, ammonia, diesel, methanol, plastics, char with medium to high overall coal use relative to current levels). This research uses life cycle thinking to characterise the potential water, greenhouse gas and property rights impacts across life cycle stages.

INTRODUCTION

In an era of 'carbon constraint' (Garnaut 2008), humanity is in the process of imagining, developing and trialling a range of mechanisms to address the complexity of competing demands on limited resources. Our management of these limited resources links the issues of climate change, rapid global urbanisation and sustainable production and consumption.

Industrial ecology and its application provides a powerful mechanism for realising the future structure of industry in a carbon-constrained world (see, for example, Clift, 2006, Deutz et al., 2007). Likewise, the creation, nature and distribution of carbon property rights have been identified as critical in determining how carbon pollution, e.g. greenhouse gases (GHG) are used (United Nations 1998) and conserved (Boydell et al. 2009a). Despite the importance and overlap of the mechanisms provided by industrial ecology and carbon property, to date there has been scant discussion of the relationship between them. Core texts in the field of industrial ecology make no mention of property rights (Socolow 1994; Ayres and Ayres 1996; Graedel and Allenby 1998; Allenby 1999; Manahan 1999) with only a fleeting acknowledgement in the most recent works (see, for example, Ayres and Ayres 2009).

This paper seeks to explore and make explicit the important relationship between industrial ecology and contemporary property rights, using the emergence of carbon property rights as a focus. Following the introduction, a conceptual discussion is provided of the ideologies and metaphors that are used to understand and visualise contemporary forms of industrial ecology and property rights. These lenses are then use to explore three future scenarios for the currently 'carbon intensive' Latrobe Valley, 150km south-west of Melbourne. The scenario-based research design uses life cycle thinking to analyse the profile of the environmental risks/impacts with respect to their surface and groundwater intensity and greenhouse gas emissions and property rights . The paper concludes by summarising the outcomes and offers future directions for research.

INDUSTRIAL ECOLOGY IN A CARBON CONSTRAINED WORLD

Since its emergence in the late 1980s, Industrial ecology has been represented through the metaphor of a cyclical system of raw materials extraction, manufacturing processes, product use, and waste disposal that ultimately mimic the cycling of materials in natural ecosystems (Socolow 1994). Industries are seen as 'webs' of producers, consumers, and scavengers, while symbiotic relationships between companies and industries are encouraged. As Frosch and Gallopoulos (1989) note: "why would not our industrial system behave like an ecosystem, where the wastes of a species may be resource to another species? Why would not the outputs of an industry be the inputs of another, thus reducing use of raw materials, pollution, and saving on waste treatment?"

Building on this metaphor the ultimate goal of industrial ecologists is that products and bi-products should be reused, repaired, recovered, remanufactured or recycled. Within the context of applying industrial ecology over the past few decades two key approaches have emerged - 'product-based systems approach' or 'geographical systems approach' (Ayres and Ayres 1996; Manahan 1999; Korhonen 2002; see also Ayres and Ayres 2009).

This 'product-based systems approach' focuses on the potential environmental effects that a product generates, taking into consideration its entire life and all of the processes along the life cycle. The 'geographical systems approach' that is engaged to develop the scenarios later in this paper, explores the way in which a collection of industrial actors in a geographically defined area may act together to form an industrial ecosystem. Such an ecosystem is the product "co-operation and interdependency, they use each other's waste material (recycling of matter) and waste energy (cascading of energy) to substitute for resources" (Korhonen 2002, p.2).

Within the scenario analysis, an exploration of property rights is interwoven alongside industrial ecology, within the context of a 'geographical systems approach'. This approach is applied to the Latrobe Valley, Victoria, with a specific emphasis on promoting environmental benefits where possible. The next section introduces real property rights, with a particular focus on carbon property rights, to provide an appreciation of their interrelationship with the metaphor of industrial ecology.

CARBON PROPERTY RIGHTS

Real property rights (as opposed to intellectual property rights) mean the formal and informal institutions and arrangements that govern access to land, buildings and other resources. These 'other' resources include water and carbon (e.g. terrestrial carbon and also in greenhouse gases:CO_2 and CH_4), as well as the resulting claims – by individuals, corporations and countries, amongst others – that are held on those resources and on the benefits they generate. Property rights arise from law, custom, and the operation of markets. Property rights, obligations and restrictions can be found in and change across the full range of human societies, both in time and space (Herskovits 1940; Hoebel 1954; Horwitz 1992; Hann 1998; Emigh 1999).

The recent emergence of carbon property rights have been promoted as one potential mechanism through which carbon emissions(or more correctly six GHGs including CO2) can be managed and governed (Hepburn 2007). Once established, effective carbon property rights are intended to enable the recording, transfer and trade arrangements required to provide a stable, secure and clear foundation for the exchange of rights in carbon. This is for those who develop carbon sinks through sequestering carbon in soil, trees, water or through geo-sequestration, subject to sciences ability to quantify such sequestration (API 2007; Sheehan and Kanas 2008; Boydell et al. 2009a).

Over the past decade carbon property rights have emerged at the state level within Australia, with legislation in place in all States – but not Territories - to define Carbon Sequestration Rights (CSRs) (Boydell et al. 2009a). CSRs have also been promoted at the national and international level as part of the mechanisms that have been set up in response to the Kyoto protocol (Hepburn 2007; Boydell et al. 2009a). For example, as part of its commitment to the Kyoto protocol Australia's Federal government is in the process of developing a Carbon Pollution Reduction Scheme and drafting associated legislation highlighting that "carbon tradability requires secure and clearly defined property rights and mechanisms for recording changes in ownership" (The Parliament of the Commonwealth of Australia 2009, p.8-1).
Critical to this process in Australia, the emergence of secure and clearly defined carbon property rights are still marked by a diversity of hurdles which range from appropriate legal frameworks (Boydell et al. 2009a; Hepburn 2009) through to the fact that science is currently unable to define it sufficiently (API 2007; Sheehan and Kanas 2008). These challenges and constraints facing emergent carbon property rights will be explored in greater detail in the later parts of this paper.

The promotion of the use of carbon property rights in the Kyoto protocol (Boydell et al. 2009a), is an example of one way in which property rights have begun to emerge as a tool that is designed to contribute to management of global ecosystems, a somewhat different example is the development of fishery rights at the level of nation states to protect biodiversity and ecosystems within oceans and rivers (FAO 2000; Hannesson 2005). The use of property rights in such ecosystem-management approaches means a dramatic departure from traditional notions of property right. Arnold (2002, p.281, 283) argues that the traditional metaphor of a 'bundle of rights' is unable to address the interconnectedness of people and their physical environment – a new consciousness that is apparent in emergent property rights such as those emerging in carbon or water.

In response to the evident limitations of the arcane 'bundle', scholars have called for the formulation of alternative metaphors, such as a 'web of interests' (Arnold 2002) and more recently 'constellations of relations and interests' (Boydell et al. 2009b) that address the "concepts of interconnection, thingness (object-regard), and the uniqueness of the object of property" (Arnold 2002, p.283). This contemporary lens is used here to view emergent carbon property rights related to both bio-sequestration and geo-sequestration. The next section focuses this lens to analyse and reflect on the role industrial ecology could play in underpinning the future prosperity of the Latrobe Valley.

THE LATROBE VALLEY: INDUSTRIAL ECOLOGY SCENARIOS AND CARBON PROPERTY RIGHTS

Latrobe Valley Context

The Latrobe Valley has substantial brown coal deposits which are currently mined for use in coal-fired power stations which supply 85% of Victoria's electricity. A carbon constrained society places demands on the 'carbon intense' industries in the Latrobe Valley for a just transition to a greener future (see, for example, Evans 2007; Evans 2008; Giurco et al. 2009). Such approaches are being prompted by several responses at both the Federal (national) and state government level in Australia.

At the national level, the Australian Government has drafted legislation for its Carbon Pollution Reduction Scheme (CPRS), which incorporates an emissions trading scheme for planned introduction from approximately 2012 (The Parliament of the Commonwealth of Australia 2009). It proposes compensation plans (including free permits) for emission-intensive trade-exposed sectors (EITES), which includes coal exports, but not coal fired electricity (a separate compensatory scheme is proposed for domestic coal fired electricity). At the same time, the Victorian State Government has committed to reducing emissions by 60% by 2050 (based on 2000 levels). Victoria has established a Near Zero Emissions Policy Framework to provide a high level strategic policy framework for the development of the brown coal resources in the State with near zero greenhouse gas emissions (Victorian Government Department of Premier and Cabinet 2009).

In response, the Victorian Government has indicated the need to transform the Latrobe Valley into a "hub for clean coal research and development and exploring technologies and building expertise in carbon capture and storage methods, such as geo-sequestration" (Victorian Government Department of Premier and Cabinet 2009, p.52) to help businesses and communities within this vulnerable region to adjust to a carbon price (Victorian Government Department of Premier and Cabinet 2009, p.2). Trial carbon capture and geological storage (CCS) – geo-sequestration – is already underway in the Latrobe Valley.

Overview of research design
In the following sections, building on research commissioned by the Victorian Government (Giurco et al. 2009), this paper considers the role that industrial ecology could play in underpinning the future structure (2050-2100) of industrial activity in the Latrobe Valley, incorporating a subsequent analysis of the property rights (particularly those of carbon) that must be conceived and adapted in three discrete scenarios.

Potential future scenarios for industry clusters are centred on three themes:
- bio-industries and renewables (no coal usage);
- electricity from coal with carbon capture and storage (low to high coal use options exist within this scenario); and
- coal to products (e.g. hydrogen, ammonia, diesel, methanol, plastics, char with medium to high overall coal use relative to current levels).

The research design engages life cycle thinking to examine the challenges, opportunities, and constraints that emergent carbon property rights provide to the realisation of these scenarios. Through these scenarios, this paper explores the carbon constrained management of resources and seek to stimulate discussion about the interdependence of applied industrial ecology and emergent property rights.

Approach to assessment of scenarios
Life Cycle Assessment (LCA) has a useful role to play in assessment of scenarios (Pesonen et al. 2000; Fukushima and Hirao 2002). However, it demands a level of information detail too complex for the uncertainty associated with these scenarios. The level of information detail utilised in the scenarios presented in this paper is more akin to that present in sustainability assessments (Nijkamp and Vreeker, 2000).

This is limitation, or challenge, of seeking to apply formal LCA processes here, namely, there is no common 'functional unit' between the three scenarios presented – some produce energy, some produce products, some both and at varying potential scales. Instead, the assessment of scenarios used in this work is based on a life cycle thinking perspective (Ayres and Ayres 1996; Guinée 2002; Heiskanen 2002; Ayres and Ayres 2009), implying that the whole coal value chain is considered in the analysis, with a view to highlighting impacts at the life cycle stages of:
- mining / raw material inputs
- production / processing
- use / disposal.

Rather than an absolute comparison of impacts between scenarios (as for Life Cycle Impact Assessment), the assessment in this paper seeks to characterise the profile of the environmental risks and impacts with respect to their water intensity and greenhouse gas emissions. Additional impacts would be considered in a more comprehensive assessment. In some cases environmental impacts are manifested and need to be managed locally – for example, carbon dioxide emissions arising from coal based power generation; whereas for exported fuel products (e.g. diesel), the primary significant impacts occur during use across national borders, necessitating a different strategy for managing impact and responsibility.

Articulating the different sustainability impact profiles provides a basis for informed discussion with stakeholders of the elements in each scenario that become a priority for further development.

The assessment has the following basis framed around life cycle stages:

- each stage of each activity is characterised in terms of its degree of impact on the abatement of, or contribution to, greenhouse gas emissions or water use. These impacts are denoted as −−/− and +/++ respectively, in tabular format. That is, in terms of GHG, a negative contribution in greenhouse gas emissions represents abatement, while a positive contribution represents an emission. Likewise, for water use a --/- represents a saving, whilst +/++ represents an increased consumption (irrespective of the supply constraints that prevail for water property rights)
- brief comments on technical, social and economic and property rights considerations are represented in tabular format
- the value of products and services associated with each scenario is described
- challenges associated with the transition from current to future scenario are described.

The innovative aspect of this work is thus the use of life cycle thinking to contrast sustainability impacts of future scenarios across life cycle stages and discussion of associated property rights issues.

RESULTS

Scenario Analysis A – Bio-Industry & Renewable Focus

The configuration of cluster elements in Scenario A is given in Figure 1.
Scenario A is bio-focused, in terms of both energy generation and product perspectives. Other renewable technologies will be drawn upon to supplement energy production. These include solar, wind and geothermal power.

In order to supply the necessary biomass, the agricultural and forestry sectors will be expanded to include specific, purpose-grown crops. In this scenario, residues and crops are used to fuel the co-generation plant and provide inputs for producing ethanol and methane. Residential waste can also provide inputs to produce algae.

With such innovative industries, this scenario could also attract yet more new industries to the region. For example, knowledge-based research and development companies may be drawn to the Latrobe Valley, attracted by the opportunity to develop and invest in new technologies. The opportunity could exist for the region to become, for example, a hub for renewable energy technology development.

Wind, geothermal and solar systems can produce energy for the region and export any unused electricity to the national grid, thereby creating an additional revenue stream. Local manufacturing firms can benefit from lower distribution costs and the skills that exist in the aviation industry could be used to design and manufacture wind turbines.

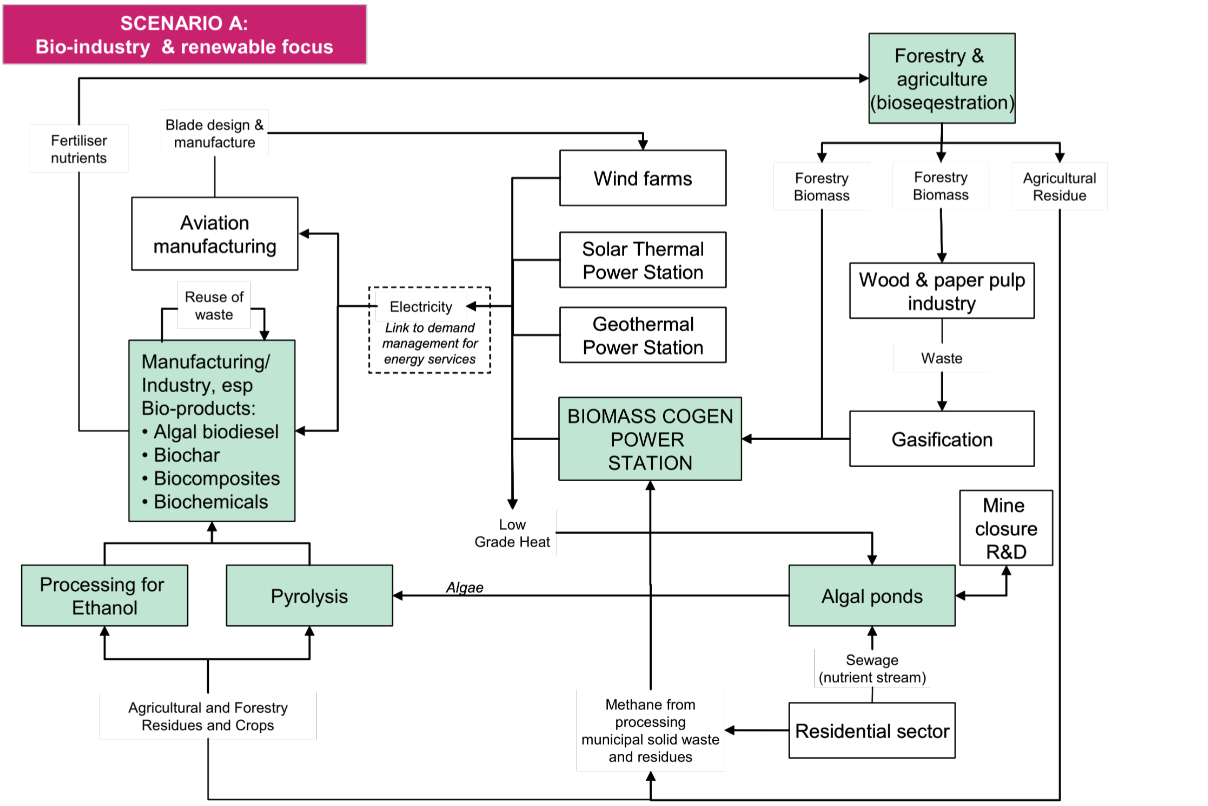

Figure 1. Configuration of Scenario A: Bio-industry & renewable focus

In addition to this energy production, there is a focus on products. Biodiesel and bioethanol will be manufactured, as will inputs into processes making chemicals, plastics and other composites. Biochar will also be manufactured and used both to sequester carbon and improve soil quality in the region.

Table 1 presents an assessment of the first scenario: bio-industry and renewables.

Table 1. Scenario A Analysis: Bio-industry & renewable focus

		Life Cycle Stage			Analysis of Property Rights (PR)	Summary
		Mining / Raw Materials	Production / Processing	Use / Disposal		
Environmental impacts	Greenhouse gas Emissions	+ aviation manufacturing + other manufacturing –– forestry and agriculture –– algae production	+ aviation manufacturing + other manufacturing + wood and paper pulp industry + bio-based processing	–– renewable energy –– biochar + biodiesel ––biocomposites –– waste management	Contested PR over wind farm access & value impact PR in soils as yet unproven as a separate right Bio-sequestration & carbon sink PR potential in forests PR implications for future generations in waste management – contamination risks in nutrient streams	Overall major contribution to abatement through bio-based focus and renewable energy
	Water consumption	++ forestry and agriculture ++ fish farming ++ algae production	++ wood and paper pulp industry + cooling for biomass power station	no major impacts of use and disposal	Contested water PR Contested PR in rights based fishing	Water requirements increased from bio-based focus
	Other	–– fertiliser use from biochar			PR in soils as yet unproven as a separate right	

Scenario A makes considerable environmental gains, together with economic growth. Under this scenario the region would act as a carbon sink (absorber of carbon) for Victoria, thereby significantly contributing to a no- or low-carbon future. Socially, the risks associated with a move to this scenario are in a transition from the workforce going from a large employer to greater activity at the small-medium enterprise level, providing opportunities for local entrepreneurs with appropriate skills. As with other scenarios, some breakthrough technologies are required to get the maximum benefit from this scenario and this could require high levels of investment in research and development.

Scenario B – Electricity from coal focus
The configuration of cluster elements for Scenario B is given in Figure 2.

This scenario is based upon coal-fired power generation. Carbon emissions are then captured and stored underground. Some carbon dioxide is also used to manufacture chemical products and (with the use of some of the waste heat) crops, such as hydroponic tomatoes. Currently there is a trial of using CO2 to grow algae in the Latrobe Valley; this could also be added to this scenario. The ash produced as a by-product of the energy generation can also be used in products such as glass, ceramics and soil conditioners.

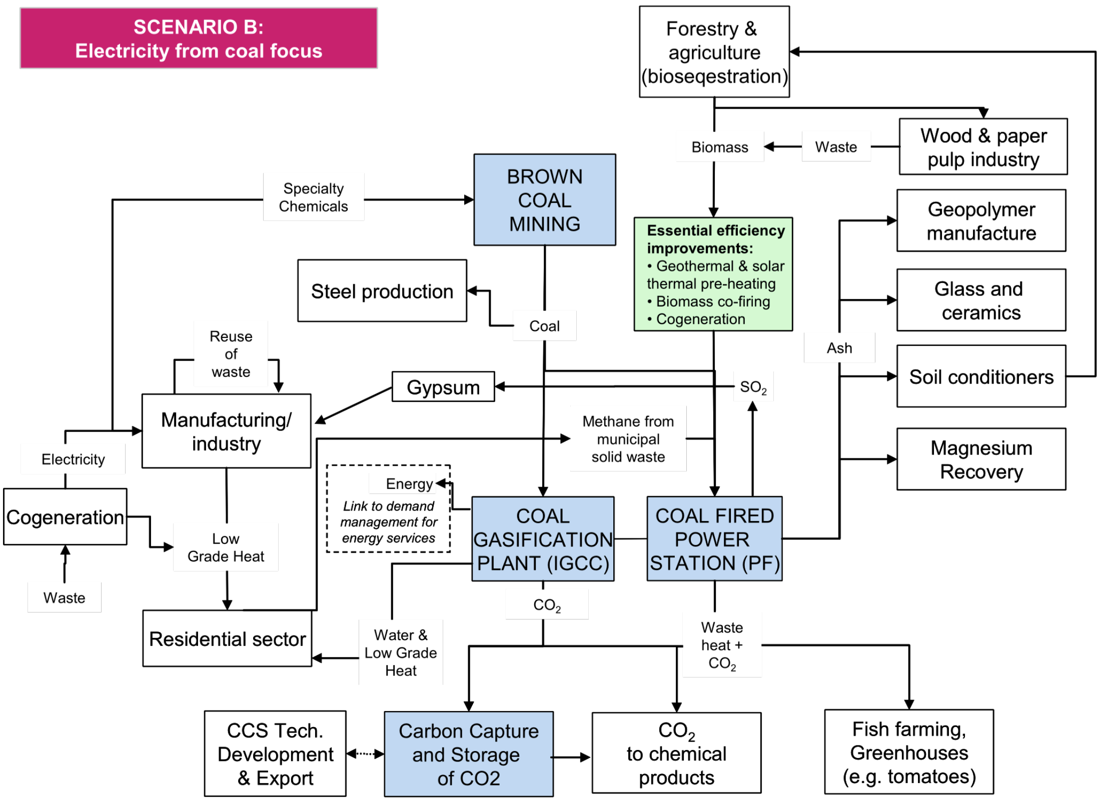

Figure 2. Configuration of Scenario B: Energy from Coal focus

Forecasts described in the LV2100 report (GHD 2005) are listed below. They assume that technology such as carbon capture and storage, will be sufficiently developed to enable new coal-based power generation to meet greenhouse gas emissions reduction targets.

- Forecast 1: earlier phase out of coal power stations than planned and electricity generation by renewable energy and gas
- Forecast 2: existing plants phased out 5 years later than in scenario 1 and greater dependence on coal

- Forecast 3: Existing plants remain in base load service to current shutdown dates. Renewable energy and natural gas each provide about 10% of power demand by 2050, plus coal is used to make other products

In this analysis, it is assumed that the cluster elements for each of the LV2100 scenarios will be similar; it will just be the scale of coal's contribution to the energy mix between forecasts 1, 2 and 3 which will differ and forecast 3 will also include aspects of ‘coal to products’ described in Scenario C. Table 2 presents an assessment of the second scenario focussed on electricity from coal.

Table 2: Scenario B Analysis: Electricity from coal

		Life Cycle Stage			Analysis of Property Rights (PR)	Summary
		Mining / Raw Materials	Production / Processing	Use / Disposal		
Environmental impacts	GHG Emissions	+ Brown Coal mining – Forestry / agriculture	++ Coal gasifi-cation plant ++ Coal fired power station ++ Cement manufacture (+ Geopolymers) – CO_2 to chemicals – Solar thermal pre-heating – Greenhouses	–– CCS	Unclear PR for CCS – resource sector has extraction rather than geo-sequestration rights Bio-sequestration PR in forest carbon sinks	Low overall emissions
	Water consumption	+ Brown Coal mining + Forestry / agriculture	++ Coal gasifi-cation plant ++ Coal fired power station + Paper and pulp industry + Greenhouses	- for residential (coming from IGCC)	Bio-sequestration PR in forest carbon sinks Carbon offsets (requiring carbon PR) required for power station & gasification	Moderate water usage, depends on newer technology
	Other	Mined land impacts	Fly ash, heat, air emissions		Multiple PR over mining and exploration interests	

This scenario, which is an extension of the current situation, has impacts primarily in the Latrobe Valley. The principal risk for this scenario is the technological risk associated with CCS becoming cost-competitive and large-scale storage areas being located to enable energy production with lower emissions. This scenario offers possibilities to introduce technologies that reduce impacts in the short term (e.g. solar or geothermal preheating) as well as the longer term (carbon capture and storage).

Scenario C – Coal to products focus

The cluster configuration for Scenario C is shown in Figure 3, This scenario has a focus on the manufacture of products from coal, rather than electricity generation. This scenario uses various processes to make a range of products, including hydrogen, ammonia, diesel, methanol, plastics and char briquettes from coal.

Despite this focus on using coal to create products, the Latrobe Valley will still be the major provider of electrical energy to Victoria. This electricity production could be achieved through a combination of geothermal, renewable or coal with carbon capture and storage. The motivation for describing this scenario distinctly (and independent of the type of electricity production to which it is linked) is to highlight the different impact and risk profile associated with a coal-to-products focus. Table 3 presents the analysis of the third scenario focussed on coal to products (with unspecified mix for energy provision).

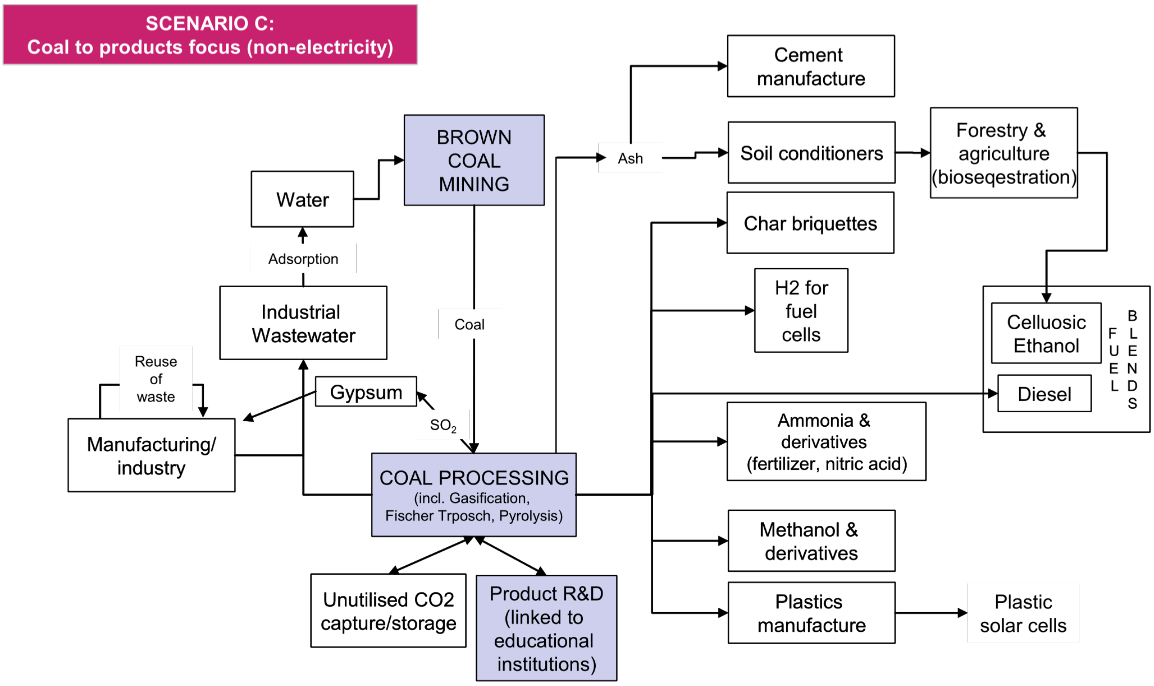

Figure 3. Cluster configuration for Scenario C: Products from coal (non-electricity)

Impacts in this scenario occur both within and outside the Latrobe Valley, especially in products that are exported and may be used elsewhere (e.g. diesel). Actual impacts will also depend on the source of electricity generation for this scenario. This scenario requires CCS to be working effectively to cope with any remaining carbon dioxide. It also results in impacts which would manifest in locations outside of the Latrobe Valley (e.g. from the combustion of exported diesel). The energy mix in this scenario could be from coal and/or another source.

The synergies that occur between the cluster companies in this scenario are very effective as they are so tightly linked and dependent upon each other. External influences are difficult to predict, but they could have big implications for the market for this scenario. Influences could include the declining supply of oil or the size of any future economy based around hydrogen as an energy carrier. Transport infrastructure will also need to be upgraded so that products can be moved quickly and efficiently.

Table 2: Scenario C Analysis: Coal to products

		Life Cycle Stage			Analysis of Property Rights (PR)	Summary
		Mining / Raw Materials	Production / Processing	Use / Disposal		
Environmental impacts	GHG Emissions	+ Brown Coal mining	+ Coal processing + Geopolymers (or ++ if cement manufacture) + Plastics manufacture	– CCS + Char briquettes + When diesel combusted	Unclear PR for CCS – resource sector has extraction rather than geo-sequestration rights PR in soils as yet unproven as a separate right	Product focus has additional emissions associated with transport
	Water consumption	+ Brown Coal mining	+ Coal processing	+ when H2 used in fuel cells (inside or outside Latrobe)	Risks to contested water PR	Moderate water usage
	Other	Mined land impacts	Ash	Impacts of fertilizer, plastics	Multiple PR over mining and exploration interests	

DISCUSSION

Climate change, carbon trading and the push for carbon neutrality will affect the way the Latrobe Valley does business in the future. In addition, uncertainty about how regulation, technology and property right will change how the Latrobe Valley considers options to steer it towards a prosperous future.

This paper does not intended to recommend, or favour, one unique scenario. Rather, the risk profiles for each scenario have been explicitly detailed to guide further discussion regarding preferred futures. For the first time in this type of analysis, this paper has interwoven an exploration of property rights alongside industrial ecology..

The consideration of property rights within an industrial ecology analysis reinforces the contention that the development of alternative metaphors, such as a 'web of interests' (Arnold 2002) and 'constellations of relations and interests' (Boydell *et al.* 2009b) must be prioritised to allow for an ideology (von Benda-Beckmann *et al.* 2006) responsive to a carbon constrained future to be visualised, then appropriately realised. The evolution from visualisation to realisation (and concretised property rights at a local level) is, of itself, an exercise in complexity – navigating multiple aspirations, and overcoming multiple perceptions of multiple stakeholders. A new way of conceiving of the range of factors surrounding carbon property rights needs to be presented and accepted, a conception that must not be limited by or adapted to pre-existing embedded legal interpretations (Hann 2007).

Likewise, the role of ongoing stakeholder engagement is critical to the success of the closed loop industrial ecology interpretations of the three future scenarios presented. Subsequent detailed frameworks for assessing the merits of different clusters needs to be developed based on agreed criteria, incorporating sustainability considerations, property rights, market potential and, in particular, the potential for adaptability.

OUTCOMES AND FUTURE DIRECTIONS

Drawing on life cycle thinking and the theoretical development of property rights, this paper has presented a pragmatic approach to the development and assessment of three carbon constrained future scenarios for the Latrobe Valley. This research is useful in several ways:

- to introduce a life cycle thinking aspect into the approach which futures methods (in particular scenarios) use to evaluate scenarios
- to highlight the shortcomings of current legal frameworks for carbon property rights and the importance of visualising and realising appropriate constellations to reflect and value the rights, obligations and restrictions on multiple stakeholders (locally, nationally, and internationally in the context of both sustainability and the CPRS)
- it explores an extension of the environmental focus within present within life cycle thinking to assessment of broader sustainability criteria

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BIOGRAPHIES

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Dr Jason Prior is a Senior Researcher with the Institute for Sustainable Futures, UTS. Jason's research focuses on issues concerning the development and planning of sustainable futures, with a particular focus on cultural and social sustainability. He is also a member of the recently formed Asia-Pacific Centre of Complex Real Property rights where is work focuses on emergent property rights in both water and carbon. He has a cross-disciplinary background in urban studies, planning, sociology, urban design, and architecture. He received the Byera Hadley Scholarship by the NSW Architects Registration Board for the contribution of his research to planning, architecture, and urban studies.

Professor Spike Boydell Is Professor of the Built Environment, Spike Boydell takes a leading role in developing the research directions and achievements of the construction, property, urban planning and project management disciplines. In 2009 Spike established the Asia-Pacific Centre for Complex Real Property Rights at UTS, leading a trans-disciplinary team that specialises in land tenure and property rights research, advocacy, public policy development and consultancy.

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Future Scenarios in the Latrobe Valley for a Carbon-Constrained World: Industrial Ecology, Life Cycle Thinking and Property Rights

- Dr Damien Giurco, Institute for Sustainable Futures, University of Technology, Sydney; Dr Jason Prior, Institute for Sustainable Futures, University of Technology, Sydney, Asia-Pacific Centre for Complex Real Property Rights, University of Technology, Sydney; Professor Spike Boydell, Asia-Pacific Centre for Complex Real Property Rights, University of Technology, Sydney

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The Latrobe Valley has substantial brown coal deposits which are currently mined for use in coal-fired power stations which supply 85% of Victoria's electricity. This paper considers the role that industrial ecology could play in underpinning the future structure (2050-2100) of the Latrobe valley industry base in a carbon-constrained world. Potential future scenarios for industry clusters were developed around three themes: bio-industries and renewables (no coal usage); electricity from coal with carbon capture and storage (low to high coal use options exist within this scenario); coal to products (e.g. hydrogen, ammonia, diesel, methanol, plastics, char with medium to high overall coal use relative to current levels). This research uses life cycle thinking to characterise the potential environmental, technological, socio-political and economic impacts of each scenario across life cycle stages and discusses implication of emergent mechanisms to constrain carbon usage (e.g. carbon property rights, bio-banking). The motivation for developing these scenarios is to stimulate discussion of alternate futures by the local community and other stakeholders with an understanding of the relative sustainability merits of each alternate future.

BIOS:

Dr Damien Giurco is a Research Director at the Institute for Sustainable Futures, UTS with research interests in industrial ecology, resource futures and sustainable production and consumption. He is currently leading the Mineral Futures program of work at UTS as part of a CSIRO-funded collaboration cluster and his PhD research was recently published as a book Copper Cycles: Modelling Material Flows, Technologies and Environmental Impacts (VDM-Verlag, 2009).

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