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Social dimensions of energy supply alternatives in steelmaking: comparison of biomass and coal production scenarios in Australia

Fitsum S. Weldegiorgis*, Daniel M. Franks[1]

Centre for Social Responsibility in Mining, The University of Queensland, Sustainable Minerals Institute, St. Lucia, Brisbane, Queensland 4072, Australia

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ABSTRACT

Global climatic change is driving research and development in low emissions technologies. One such technology is the use of charcoal from biomass in steelmaking. This paper adapts social life cycle assessment methodologies to analyse the social dimensions of energy supply alternatives in steelmaking using regionalised production scenarios in Australia. Three energy supply alternatives are investigated: charcoal produced from Radiata pine plantation forestry; charcoal produced from Mallee eucalypt revegetation on agricultural land; and metallurgical coal. Impact indicators analysed include land-use, employment, workplace health & safety and a qualitative analysis of identified stakeholder issues. The research finds that biomass alternatives are significant generators of direct employment at the regional level; have concomitantly higher rates of workplace injuries and represent a significant change in land-use. Charcoal produced from Mallee biomass planted as a conservation measure on farmland, however, has the benefit of representing a shared land-use that provides an additional farm revenue stream and assists dryland salinity management. The paper finds that full substitution of coal by pine or Mallee charcoal does not provide a unique solution for optimising the social performance of the energy supply alternatives across all indicators.

1. Introduction

Climate change is driving interest in low emissions energy sources and new technologies (Fruehan, 2005). One possibility is the use of renewable charcoal production from biomass as a replacement for metallurgical coal in steelmaking (Piketty et al., 2009). Steelmaking has traditionally involved the use of coke made from coal as feedstock in blast furnaces. The industry contributed 6.7% of total global CO_2 emissions in 2010, and metallurgical coal is responsible for 93% of all steel industry greenhouse gas emissions (Worldsteel Association, 2011, 2013).

The Australian steel industry produces around 6.9 million tonnes of steel each year (ABARE-BRS, 2010b), consuming around 3.9 million tonnes of metallurgical coal. The vast majority of this coal is sourced locally and the industry is responsible for 14 million tonnes of greenhouse gas emissions (CO_2e) a year (CSIRO, 2012). In Australia, wood charcoal is not widely used in steelmaking due to low production and high price (EnergyAsia, 2011). The Australian Commonwealth Scientific Industrial Research Organisation (CSIRO) has a program of research that is investigating the use of biomass within the steel industry. The carbonisation process of the technology involves thermo-chemical decomposition (pyrolysis) of biomass at low temperature in the absence of oxygen. This produces charcoal that is injected into a blast furnace and used in low emission sintering to make steel. Biomass for the production of charcoal can be sourced from timber as well as forestry residue.

Previous studies have assessed the environmental and economic viability of using charcoal in steelmaking (Norgate and Langberg, 2009; Norgate et al., 2011). Norgate et al. (2011) found that charcoal used in steelmaking could result in greenhouse gas reductions of 5.3 and 4.5 CO_2e/t steel respectively, assuming full substitution of charcoal for coal or coke with electricity and eucalyptus oil co-product credits included for charcoal production. From a social perspective, however, transitioning to biomass technologies may generate complexities. Factors such as limited availability of land for biomass plantation, competing demand for agricultural land, and lack of suitable and cost-effective biomass have been identified as challenges with other bio-energy technologies (Selfa et al., 2011; van der Horst and Vermeylen, 2011).

This paper adapts social life cycle assessment methodologies to analyse the social dimensions of energy supply alternatives in steelmaking using regionalised production scenarios in Australia.

* Corresponding author. Tel.: +61 7 3346 4041; fax: +61 7 3346 4045.
E-mail addresses: f.weldegiorgis@uq.edu.au, fitsumsm@yahoo.com (F.S. Weldegiorgis), d.franks@uq.edu.au (D.M. Franks).
[1] Tel.: +61 7 3346 3164; fax: +61 7 3346 4045.

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The paper is structured as follows. Section-two presents a brief overview of technology assessment using the concept of 'Social License in Design'. Section three outlines the method used in the study and describes the three technology scenarios analysed. Section four presents the results across three quantitative indicators (land-use, employment, workplace health & safety) and a qualitative analysis of identified stakeholder issues. Section-five discusses the results followed by conclusion in section six.

2. Social License in Design

There is a growing understanding by the energy and minerals industry about the need to address the social dimensions of projects and to gain social acceptance – commonly referred to as a 'social license to operate'. Social license to operate (SLO) refers to the intangible and unwritten, tacit, contract with society, or a social group, which enables an extraction or processing operation to enter a community, start, and continue operations (Thomson and Boutilier, 2011).

Various approaches to Technology Assessment (TA) have emphasised the need to incorporate social context into decision-making. However, it has been argued that public participation on its own does not necessarily lead to deeper understandings of the social context (Russell et al., 2010). Constructive TA (CTA) seeks to evaluate the social effects of technological development by facilitating information sharing through dialogue and interaction between developers of technology and other relevant stakeholders (Schot and Rip, 1997).

The assessment of technology during its development provides an opportunity to influence the design of the technology in a manner that social context is incorporated. Franks and Cohen (2012) developed a process of CTA, which they termed as the 'Social License in Design'. They argued that the design traits of the technologies employed to extract and process mineral resources and the interplay between these traits and their environmental and social context have a significant influence on technology performance.

Social License in Design is an ongoing iterative process of social inquiry and reflection utilising different assessment methods. By tailoring the methods to individual circumstances of the technology under consideration, developers are encouraged to reflect and incorporate the values, perceptions and realities of the context in which the technology may be situated. Public involvement in planning processes and the extent of trust placed in the perspectives and values of social actors have been identified as significant issues that affect public attitudes toward renewable energy technologies (Aitken, 2010). In this paper we apply the Social License in Design process to the development of biomass technology in steelmaking using Social Life Cycle Assessment methods (SLCA). Consistent with CTA this study worked closely with CSIRO researchers developing biomass technologies in steelmaking to inform future design and technology configuration.

3. Methodology

In this paper we adapt SLCA methods for use within technology assessment. Life Cycle Assessment has been applied extensively to assess the environmental performance of products (Biswas and Lund, 2008; Udo de Haes and Heijungs, 2007). More recently LCA has responded to an identified need to include the social and economic dimensions (Benoît et al., 2010), with social and socio-economic criteria in LCA signalling a paradigm shift in sustainability assessment. According to Benoît and Mazijn (2009) SLCA refers to: "a social impact assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their lifecycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal."

SLCA is an emerging field with few studies having used a SLCA approach to analyse the performance of products in the energy and minerals industry (Jørgensen et al., 2008). Kloepffer (2008) reviewed SLCA literature and identified methodological challenges such as: relating existing quantitatively indicators to the functional unit of the system; obtaining specific data for regionalised SLCA; deciding between indicators; quantifying all impacts properly; and evaluating the results. SLCA is further complicated by ambiguity as to whether impacts are related to the type of product used or, as Dreyer et al. (2006) argue, the way the company interacts with its stakeholders.

Application of SLCA to technology assessment introduces a number of complexities. Shifting the focus of the analysis from products to technology alternatives and from actual to hypothetical technology systems (a form of 'consequential LCA') requires some flexibility in the application of the method. Further and consistent with the Social License in Design process outlined earlier, impact categories have the potential to be experienced differently by different social groups and in different geographical contexts.

The adaptation of SLCA methods used here attempts to ground energy supply alternatives within the social context in which the technology is likely to be situated. The functional unit of the study is one tonne of steel – though we also consider the scale effects that are likely to be significant at different production levels. The system boundaries of the analysis range from the production of the energy source (biomass or coal) to the blast furnace that produces steel – a form of cradle-to-gate study. In this paper, only selective components of the cradle (plantation establishment) stage are considered in part due to difficulties in sourcing data for regionalised parameters. Other cradle-to-gate components not considered include transportation of the energy sources (biomass or coal), and the potential use of forestry residue, which would increase the productive capacity of forestry biomass for each given hectare. In the following sections we introduce the technology scenarios investigated and impact indicators selected in this study.

3.1. Energy supply alternatives for iron ore reduction in steelmaking

Three energy supply alternatives are investigated for iron ore reduction in steelmaking. Regionalised scenarios have been chosen to ground the energy supply alternatives under investigation. The scenarios are based on the most likely technology configurations in the Australian context.

The scenarios are:

1) *Biomass from Radiata pine plantation forestry (Macquarie Region, New South Wales)*. The Macquarie Region is part of the Central Tablelands of NSW and comprises plantations managed by Forests NSW. The wider Macquarie Region covers approximately 1,825,871 ha. The Forests NSW estate in the Macquarie Region represents about 73,719 ha of pine forest plantation and about 79,603 ha of native forest centred around Oberon, Lithgow, Sunny Corner and Orange.

Approximately 15 tonnes of wet biomass are produced per hectare per year at the end of a 30-year rotation age for Radiata pine (Norgate and Langberg, 2009). The Macquarie region grows 1.15 million tonnes of commercial timber per annum on 71,477 ha of land, of a total land area of 1,825,871 ha (Forests NSW, 2008). This represents an approximately equal amount of wet biomass produced per hectare per year as reported by Norgate and Langberg (2009).

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