
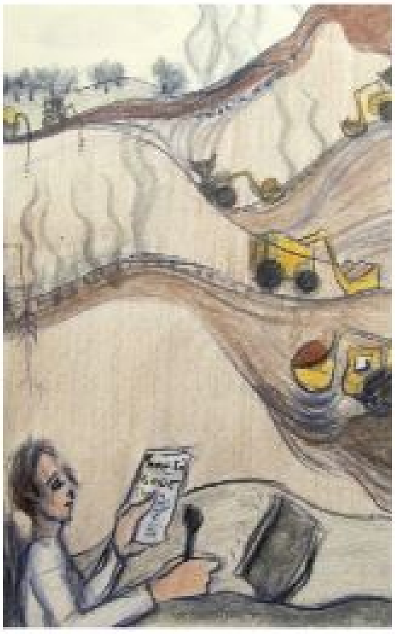


# Designing Mining Technology For Social Outcomes: Final Report of the Technology Futures Project

National Research FLAGSHIPS Minerals Down Under
CSIRO
The University of Queensland Australia
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# ABOUT THE AUTHORS

## Centre for Social Responsibility in Mining

The Centre for Social Responsibility in Mining (CSRM) is a centre within the Sustainable Minerals Institute, University of Queensland, Australia. CSRM works with companies, communities and governments to respond to the socio-economic and political challenges brought about by resource extraction. The Centre's aim is to help build the capacity of these stakeholders to manage change in more effective ways. CSRM has global reach, with particular experience in Australia and the Asia-Pacific. For more information visit our website at: http://www.csrm.uq.edu.au.

## Minerals Industry Safety and Health Centre

The Minerals Industry Safety and Health Centre (MISHC) is an internationally recognised world-class centre of excellence and a leading provider of Minerals Industry Risk Management education for the global Minerals Industry. Established in 1998 MISHC integrates risk management knowledge into postgraduate and continuing education programs delivered to the minerals industry internationally. For more information visit our website at: http://www.mishc.uq.edu.au

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Corresponding author: Dr Daniel Franks, D.Franks@uq.edu.au, +61 7 33463164.

Mineral Futures Cluster Leader: Professor David Brereton

Technology Futures Project Leader: Dr Daniel Franks

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# EXECUTIVE SUMMARY

The Technology Futures Project was a three-year research study to develop and trial technology assessment as part of the Minerals Futures Cluster, a collaboration between 5 Australian Universities and the Australian Commonwealth Scientific Industrial Research Organisation's (CSIRO) Minerals Down Under Research Flagship (MDU). The project was lead by the Centre for Social Responsibility in Mining and the Minerals Industry Safety and Health Centre at the University of Queensland.

The project developed a Technology Assessment framework, called Social Licence in Design, to assist CSIRO and other technology developers to anticipate and respond to the social implications of new mining and mineral processing technologies. The efficacy of the framework was then demonstrated through application to three emerging mining technologies. This report summarises the main findings of the research. The report should be read in conjunction with a second final report 'Exploring the social dimensions of autonomous and remote operation mining: Applying Social Licence in Design'.

New technologies have the potential to generate social and environmental changes ranging from issues of public health and safety, land-use change, pollution, employment, social conflict, and economics. Changes can manifest as opportunities, but also as social risks for communities and business risks for companies. They can also jeopardise or present opportunities for the overall sustainability of new technologies. Constructive Technology Assessment is a process for considering the implications of a new technology during the design phase, when there is still scope to make modification to address any issues identified. It aims to increase the likelihood of successful implementation of new technology by a) developing ways for new technologies to be used in a manner consistent with stakeholder values, reducing the potential for conflict and b) generating and sharing understandings about the impacts and management of any potential opportunities and risks.

The Social Licence in Design framework was developed following a dedicated effort to understand the institutional context in which the technology assessment would be implemented. Through interviews and consultation with senior MDU staff (research scientists, managers, social scientists and technologists) the opportunities and constraints to the practical implementation of CTA within the flagship were explored. The Social Licence in Design framework was then applied to three emerging mining technologies, automation, the use of biomass in iron ore smelting, and in-place leaching. In the automation case technology assessment consisted of scenario planning methods and a multi-stakeholder public dialogue to identify and respond to the potential social change processes arising from implementation of the technology. For the biomass case the project worked with MDU research scientists and technology developers to identify the implications of a number of potential technology scenarios using social life cycle assessment, with the findings informing the research into the future implementation of the technology. The in-place leaching case applied a social risk assessment method during a multi-disciplinary workshop and engaged with key stakeholders to identify risks. This process identified previously unrecognised risks that lead to a reshaping of the program of technology development.

CSIRO has drawn on the findings of this project to develop a technology assessment framework for application within the Minerals Down Under Flagship. Further details of this work can be found in Lacey and Moffat (2012), 'A framework for technology assessment in the Minerals Down Under Flagship: Integrating Life Cycle Assessment and social analysis of mining technologies'.

# 1. INTRODUCTION

Australian mining and processing technologies are changing in response to demands for greater efficiency and environmental performance. Simultaneously there is growing recognition that social constraints are becoming the most significant impediment to continued high levels of mineral production in Australia. The social performance of mining technologies can greatly influence how individuals, communities and political organisations, respond to different mining processes or individual mine sites. In general people are more accepting of mining processes and systems that support their values and needs or are not in direct opposition to them.

Attempts to understand the social implications that may result from the implementation of novel technologies are underdeveloped or undervalued. There are limited examples of efforts to design and/or implement technologies that meet sustainability criteria and are also considerate of social concerns. Research and development institutions, as well as their industry clients, have a responsibility to ensure that novel technologies enhance the positive aspects of development and anticipate, avoid and reduce any potential negative impacts. Technology assessment – a structured and forward looking impact assessment and adaptive management process – is one due diligence tool to provide foresight and opportunities to modify the design or implementation of technology. By embedding technology assessment within R&D institutions a broader set of design criteria relevant to broader society and potential stakeholders can be identified and acted upon.

Technology assessment can also improve the technical functionality of technologies, reduce business risk associated with implementing controversial technologies and improve the value of technologies for R&D organisations, the mining industry, the nation and local communities. For social scientists, technology assessment is a research agenda that gets at the heart of dynamic, evolving, community-technology relationships.

# 2. RESEARCH CONTEXT

The Mineral Futures Collaboration Cluster brought together researchers from The University of Queensland, Curtin University of Technology, University of Technology, Sydney, Australian National University, CQUniversity, Monash University and the CSIRO to explore large and complex future sustainability issues in the minerals industry across regional, national and global scales.

The Cluster collaboration was a A$3.17 million research program funded by CSIRO's Flagship Collaboration Fund with in-kind contributions from cluster partners bringing the total investment in the research to A$8.63 million (net of GST) over three years.

The program of work consisted of three integrated projects:

Commodity Futures – investigating the macro-scale challenges, dynamics and drivers of change facing the Australian minerals industry through scenarios and monitoring of peak minerals.

Technology Futures – investigating the potential social and environmental impacts of, and community responses to, innovative new technologies being developed through the Minerals Down Under Flagship and the wider mineral industry.

Regional Futures – addressing the inter-linkages between social and economic impacts of new mining technologies at a regional level emphasising land use change in sensitive environmental settings.

One of the strategic goals of the CSIRO Minerals Down Under Flagship is to deliver national benefit and an ongoing license to operate for the Australian minerals industry through innovative solutions that cross business and discipline boundaries to reduce environmental impact and increase social dividend. The Mineral Futures Collaboration Cluster enabled the Flagship to focus a significant proportion of its research and development on achieving this goal.

The Technology Futures Project developed and trialled a technology assessment process called Social Licence in Design within the CSIRO and more broadly. The objectives of the Technology Futures Project were to:

- assist a process of technology assessment to be incorporated into future technology design processes within CSIRO, and the Minerals Down Under Flagship; and
- enable future Minerals Down Under Flagship technologies to be designed to consider and enhance environmental and community outcomes and thus increase the likelihood that the technologies will be accepted by the community.

# 3. SOCIAL LICENCE IN DESIGN

## 3.1. RESEARCH PROBLEM: SOCIAL RISK AND MINING TECHNOLOGY

Technological innovations such as the large-scale adoption of automated and remote operated mining technologies may entirely change the nature of mining. Such large-scale changes affect how and in which environments mining occurs and how local communities and the mining workforce engage with mines. Such changes can alter the value proposition that mining presents for local communities as well as the nation as a whole. The problem is that minerals technology innovation is often approached in a technical manner abstracted from the social sphere. Also, technological design is often undertaken by technical staff with highly specialised knowledge sets but a limited understanding of the social context in which the technology will be implemented.

Although no technology could ever be designed to be risk free, constructive technology assessment (i.e. undertaking technology assessment directly with technology developers) can reduce risks to businesses and communities and arrive at solutions that make technologies more socially acceptable and generate shared value. This goal is achieved by helping technological organisations understand the values and needs of stakeholders and how the technologies that they are working on influence and impact, existing social and environmental criteria. The challenge is how to achieve this within existing organisational structures and in multi-disciplinary research environments.

To enable technological organisations to understand the needs and concerns of people who are most affected by the implementation of their technologies and to design products (technologies and processes) that are responsive to these concerns requires a reconfiguration of the current technological development process within R&D institutions to include technology assessment methods. Such methods may range between socio-economic analysis through to more participatory engagement processes. Technology assessment methods need to be carried out throughout the entire technology development phase (from concept to implementation). Outcomes of these activities should then be incorporated into the design or implementation of technologies.

Technology assessment that considers social aspects would necessarily be a cross-disciplinary endeavour. It is critical that the process is structured so that it is valued by all staff members and fits within the institutional structure of the organisation. The opportunity for technologists to reduce the potential controversy and business risk of technologies they are developing, or to come to better understand a technical aspect, is incentive for them to participate in such a process. For social scientists the value lies in working in the area of technological innovation; an area that dramatically affects the face of mining-community relations and in which tangible benefits for communities can be achieved. For this to be realised the technology assessment process would need to result in actualised change to technologies and not become a risk management process aimed at public information dissemination. Translating information from the technology assessment process into tangible technical change or change in how technologies are implemented is needed to fulfil the aspirations of both technical and social scientists.

## 3.2. THEORETICAL FRAMEWORK: CONSTRUCTIVE TECHNOLOGY ASSESSMENT

Technology assessment has a long history as a method to inform research, development and decision-making. Constructive Technology Assessment (CTA) refers to a particular form of technology assessment that seeks to influence the design process of technology through dialogue and interaction with and between technology developers (Schot and Rip, 1997). Guston and Sarewitz (2002) define CTA to include three particular analytical components these being socio-technical mapping, early and controlled experimentation and identification of unanticipated impacts, and communication between technology proponents and the public. These components allow social aspects to become additional design criteria of technologies (Schot, 1992). In practical terms CTA can illicit information on the values, perspectives and background of potential stakeholders and anticipate likely stakeholder responses to the change that a new technology may bring and in so doing, reduce the uncertainty associated with novel or emerging technologies (van Merkerk and Smits, 2008).

CTA seeks to affect technological developments by considering values and ideas that may exist outside of the concerns of narrowly defined technological trajectories and shaping technologies in response to these values. Drawing on Beck’s notion of reflexive modernisation (Beck et al., 2003; Beck et al., 1994) Voß and Kemp (2006) argue that to avoid unintended consequences and second- order problems the isolated perspectives in which problems are often addressed must be widened to include external filters of relevance. They argue that CTA is a way of creating interaction between various rationalities and taking into account the complexity of social, technological and ecological interrelationships (Voß, R. Kemp, 2006). In this way technology (and technologists) can become reflexive as social rationalities are reflected in technological outcomes and technologies (and technologists) reflect inwardly on, and hopefully transcend, the factors (structures) that shape technological pathways (see Rip, 2006 and Stirling, 2006). As many have argued this bringing together of insights needs to happen at the outset of technology design while technologies are still in the innovative stages and are thus malleable to new possibilities and potentialities (Guston and

Sarewitz, 2002; van Merkerk and Smits, 2008; Un and Price, 2011). Early intervention can potentially address the gap that often exists between technologically driven prototypes and various adaptations suggested by investors based on people oriented market research or critical business drivers such as health and safety (Un and Price, 2011).

The process in which differing rationalities are brought together impacts greatly on the success of any CTA project (van Merkerk and Smits, 2008). Van Merkerk and Smits (2008) describe managing the convergence of different actors and their values systems in CTA projects as a facilitation of interfaces. They argue that a carefully managed interface needs to account for the differences between various actors and should, in enabling a constructive environment for dialogue, broaden each actor's knowledge and perspectives in regards to the sociotechnical dynamics of the technology at hand.

The facilitation of interfaces in the minerals sector must therefore be embedded within the unique features of minerals technology development and cognisant of the landscape changes that are invoked by mineral extraction. Mining and community interactions are best viewed as a set of technological, economic, political and cultural relationships (Bridge, 2004). Mining interacts with and shapes environments, economies and individuals in complex ways. How people experience and situate change influences how they react to such change. As Bridge (2004) argues: 'to understand contemporary debates over mining and the environment ... it is necessary to recognise how mineral development is unavoidably situated within a moral landscape.'

The future environmental, social, economic and safety outcomes of a mining operation are, to a certain extent, built into technologies during their design phase. These traits, and the societal reactions that they manifest, are thus embedded within technologies. The technologies in turn become embedded in the physical and social landscape and once they are sunk into that landscape they become difficult and costly to retrofit. The likelihood that these traits manifest into conflict, support, or other social responses, depends on the social and environmental context of the landscape in which they are sunk. This technological aspect of social performance shifts the domain of focus from mining companies who implement technology to also include the R&D institutions involved in technology development (see Figure 1).

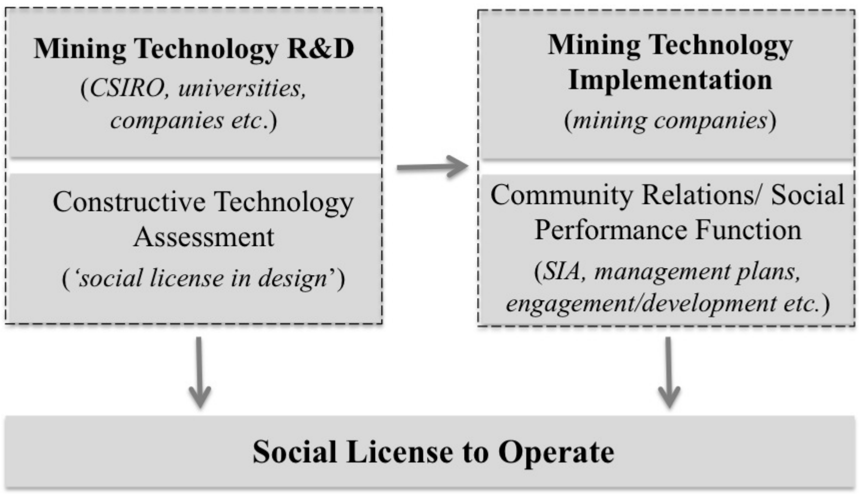


Figure 1. Theoretical Framework: CTA as a means to embed social performance into the design of new mining technology

Increasingly R&D institutions are shaping their investments to address environmental sustainability and safety challenges in response to industry drivers (CSIRO, 2006; SMI, 2006). The fields of Safety in Design (also known as Safe Design, or Prevention through Design), Resilience Engineering, Sustainable Design and Sustainable Operations (SUSOP) have articulated conceptual and practical methods to encourage the development of extraction and processing technologies that are responsive to environment and safety criteria (Corder and McLellan, 2010; Hollnagel et al., 2006; Horberry et al., 2010; McLellan et al., 2009). Less focus has been devoted to conceptual design processes that respond to social challenges (notable exceptions include Russell et al. 2010 and Geels and Schot, 2007). Even fewer examples exist of efforts to practically embed such social design processes into minerals R&D institutions (Katz and Solomon, 2008).

Katz and Solomon (2008) have observed that within CSIRO there is tendency to acknowledge the part played by economic and political forces in decisions about technology investment. Despite this they argue that there remains a tendency to treat technology as if it were neutral by separating technological research projects from social influences. To overcome this functional separation would necessarily involve bringing together diverse actors from a multitude of disciplinary backgrounds including various technical and social scientists. This approach, whilst not being completely novel to CSIRO (see Katz and Solomon, 2008), is not currently practised within MDU. As Guston and Sarewitz (2002) propose, and as evidenced by our interview results, this convergence of rationalities needs to happen in Real-Time – in which natural science and engineering projects are integrated with social science and policy research from the beginning. The interface should be one in which both social science and technical personnel are working towards a shared and clearly articulated goal without having to give up their own disciplinary objectives and rationales. The idea is to collaboratively nurture the development of technologies that are both functionally and socially appropriate. This means that engineers need to be able to convert intangible aspects, such as stakeholder's needs and values, into technological functionalities and applications (Un and Price, 2007).

The inclusion of various external stakeholders in technology assessment processes also needs careful planning and facilitation to ensure that outcomes are effective. Participatory technology assessment is seen to be beneficial for both normative (it is the right thing to do) and functional reasons (it is the best thing to do). However there are challenges to where participation might best feature within the technology development process. Among these are legitimate concerns that during the conceptual and experimental stages the application and functionality of technologies are not yet clearly articulated. At this early stage there is great uncertainty around where technologies will be implemented and who is likely to be affected by them as well as sensitivities about confidentiality. Involving the lay public in the technology assessment at this stage, especially in relation to mining technologies, may create unnecessary anxiety in communities about the application of the technology or be inconsistent with commercial and other institutional constraints. These issues are explored further below.

The widespread use of the term Social License to Operate within the minerals industry provides one potential avenue to achieve Van Merkerk and Smits' (2008) facilitation of interfaces. CTA if explicitly linked to the discourse on Social License to Operate may provide a means to extend the consideration of social performance issues to the domain of minerals technology R&D. Social license to operate is a term that reflects the realisation that whilst necessary, compliance with statutory regulations is often insufficient to meet societal expectations (Bridge, 2004). Expectations of affected and concerned communities frequently exceed the regulatory bar. Social License to Operate refers to the intangible and unwritten, tacit, social contract with society, or a social group, which enables an extraction or processing operation to enter a community, start, and continue operations (Joyce and Thomson, 2000; Thomson and Boutilier, 2011). The term was first proposed in 1997 by Jim Cooney, then Director of International and Public Affairs, Placer Dome (Thomson and Boutilier, 2011). Social License to Operate is not an agreement between communities and operations that can be formalised in any way but, rather, must be thought about as a descriptor of the state of the relationship between a proponent and the community in which the proponent is operating and, therefore, as a process of continual negotiation. Social License to Operate is a complement to regulatory licenses but is not a product that can be granted by civil authorities, political structures or the legal system (Solomon et al., 2008).

Due to the close relationship between Social License to Operate and technology there is an impetus to address future social challenges within the design stage of technology development through forecasting processes such as CTA. As Russell et al. (2010) note social impacts are not simply side effects of technology but are core dimensions of new technologies and technological development. This premise makes the issue of social acceptance of technologies a responsibility of R&D organisations whereas previously it was thought to fall on technology clients developing controls at the implementation phase. Such an approach opens the opportunity to take social issues further down the technology chain and encourage technology developers to reflect on the state of social license required by potential technology users and the stakeholder behaviour that influences Social License to Operate.

Technologies designed in consideration of health and safety issues and ‘green’ technologies are increasingly seen as having competitive advantages for minerals R&D institutions whose customers are increasingly concerned about these issues on the mine site (Poliakoff et al., 2002; Shrivastava, 1995). The process of Social Licence in Design works on the same premise: that designing technologies with explicit consideration of Social License to Operate could be seen as a competitive advantage for R&D organisations. The widespread use of the term Social License to Operate by the minerals industry makes it appropriate to adopt in this context. Whilst this does not necessarily address the moral argument that demands the democratisation of technology assessment processes it is appropriate to the technology development process and the institutional context of MDU whose explicit aim is to create new knowledge and transformational technologies for the mineral sector and ensure that there are appropriate pathways for the transfer of that knowledge and technologies to industry in order to improve Australia’s global competitive position.

## 3.3. SITUATING TECHNOLOGY ASSESSMENT WITHIN THE INSTITUTIONAL CONTEXT

The Social Licence in Design framework was developed following in-depth interviews and consultation with senior MDU staff (research scientists, managers, social scientists and technologists) to understand the institutional context and identify the opportunities and constraints to the practical implementation of CTA within the flagship. The following considerations were identified and incorporated in the Social License in Design framework:

A technology assessment process must be flexible and recognise that community participation in the assessment process is likely to become more effective as technologies progress from the conceptual towards the implementation stage but that technologies are more easily altered in response to articulated concerns early in the design phase rather than during implementation. This means that public engagement might be best understood as a progression from engagement with ‘critical friends’ when the technology is in early stages towards representative and then actual community engagement once elements of a technology are more concretised.

Issues identified in the process become design considerations and can be used to reshape technologies depending on the stage of development of technologies (see Figure 2). Not all technologies can be redesigned. In extreme cases the best option may be to cease development because a technology is too risky. Other options include conditional implementation of a technology for example not in contexts where is likely to manifest.

To meet the needs of both technical and social scientists it was found that Social Licence in Design should be an iterative technology assessment process led by the technologist but guided by technically literate social scientists. Technology managers should be responsible for triggering the process by identifying the need for technology assessment and, with the help of social scientists, choosing and participating in technology assessment methods that best suit their needs (see Figure 3). The process is continued, utilising different methods, until the project leader is satisfied, and can justify, that they have satisfactorily understood the social risks associated with their technology.

Appropriate selection of methods depends on the individual context and the specific technology under development, the scale of its potential implementation and impact and the level of public involvement required in the assessment. Social Licence in Design therefore utilises a multitude of methods tailored to the individual circumstances of the technology under consideration. Methods may include social risk assessment workshops, focus groups, scenario planning, citizen juries, social profiling, social life cycle assessment and interviews.

Technology assessment that is led by technologists in conjunction with social scientists is more likely to result in actualised technology improvement and to be sufficiently valued and resourced. The more that technical staff are involved in the process the more value they get from the process. The focus is not for social scientists to provide recommendations to technical scientists. Rather, it is to expose those designing technologies to the context in which the technology may be situated and encourage reflection and incorporation of such values, perceptions and realities into the technologies under consideration; effectively designing Social Licence to Operate into technologies. The need for technical staff to instigate the process and consider what they would like to get out of the technology assessment process and to work with social scientists to achieve these outcomes can help overcome some of the problems of interdisciplinary work such as miscommunication across domains. The involvement of social scientists from the outset to help design the research process ensures that social science does not become a service discipline to technical staff.

The above considerations were incorporated into an iterative Social Licence in Design process outlined in Figure 4.

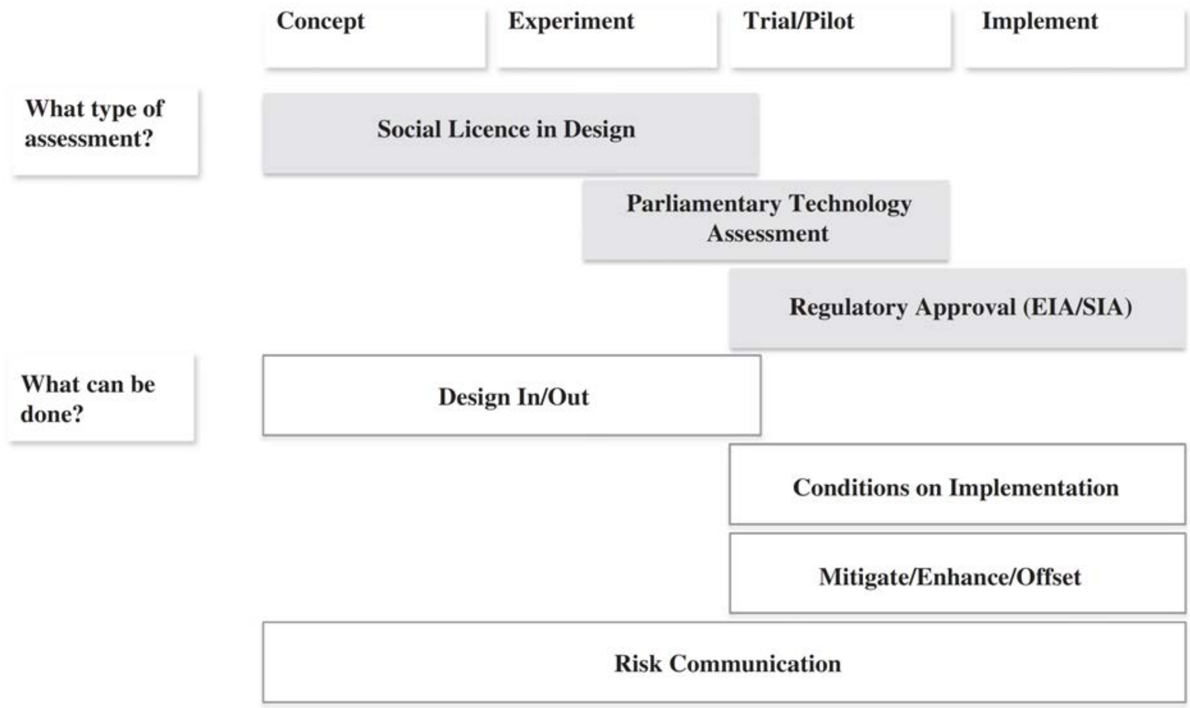


Figure 2. The relationship between technology assessment and available controls.

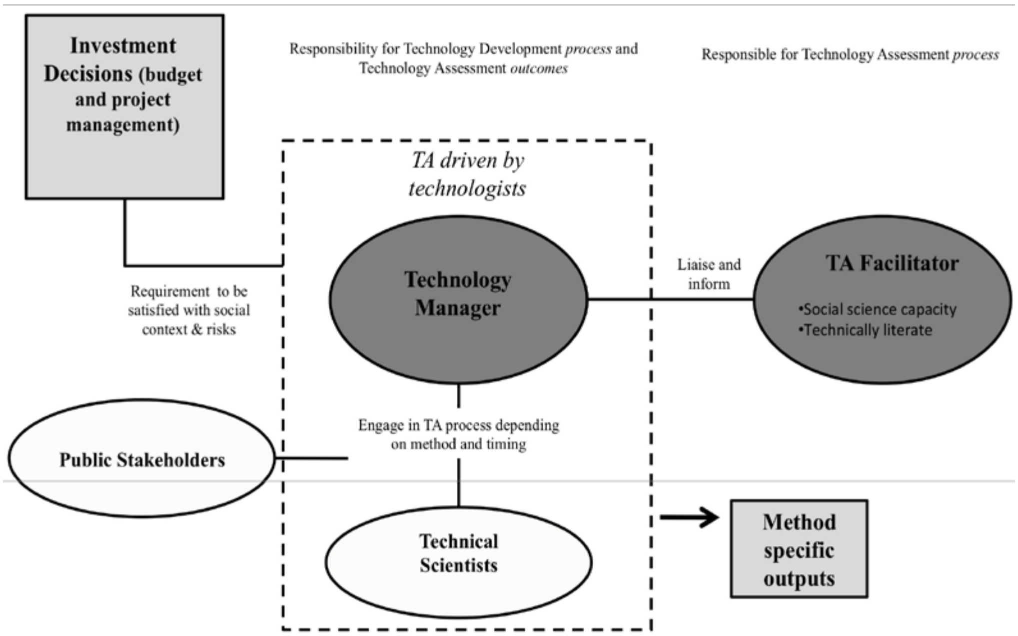


Figure 3. Roles and responsibilities for a Social Licence in Design CTA process.


Figure 4. Potential issues to be considered during an iterative Social Licence in Design CTA process.

# 4. TRIALLING TECHNOLOGY ASSESSMENT

The SLID framework was applied to three emerging mining technologies, automation, the use of biomass in iron ore smelting, and in-place leaching.

## 4.1. AUTOMATION AND REMOTE OPERATION TECHNOLOGY

Autonomous and remote operation technologies allow for the full or partial replacement of human in the mining process, delivering gains in efficiency and integration. These gains have the potential to help maintain the competitiveness of Australian mining in the face of several challenges such as: declining ore grades; increasingly remote reserves; a high Australian dollar; and a labour shortage. The development of fully autonomous haul trucks would involve a shift in operator roles to control centres in capital cities, far removed from where mining is conducted. Other technologies under development include remote control blast-hole drills, tele-remote rock breakers, driverless ore trains, and tele-remote ship loaders. While these technologies potentially hold significant economic benefits for Australian society, they also hold a range of possible social implications – both beneficial and otherwise. These implications stem from changes in the type and location of mining employment and related development opportunities, and are potentially significant for women and Aboriginal Australians.

At the time the Cluster Collaboration was launched (in 2009) and in its early years, there had been little public discussion about the social aspects of these technologies. Public discussion was predominantly the domain of technologists and focussed on the emerging technical advances. The application of technology assessment in this case used scenario planning methods and a multi- stakeholder public dialogue to identify and respond to the potential social change processes arising from implementation of the technology (see Table 1).

Table 1. Summary of the automation case study findings

| | Autonomous and remote operation mining |
|---|---|
| What type of assessment? | Technology stage: Early implementation<br>TA method: Scenario planning<br>Public involvement: Public multi-stakeholder roundtable convened to promote dialogue beyond the domain of technology developers and to identify social change processes. Four scenarios considered. This work was complemented by economic modeling and workplace observations. |
| What is the technology? | Autonomous and remote operation technologies: fully autonomous haul trucks, remote control blast-hole drills, tele-remote rock breakers and ship loaders, and driver-less ore trains. |
| Where will it be implemented? | Automation is particularly relevant in the production of bulk commodities, such as iron ore and coal, and for underground mass mining (caving). In Australia automation technologies are most advanced in the iron-ore sector, particularly the Pilbara region of Western Australia. |
| Who will it affect?<br>How will it affect them?<br>What is the magnitude? | Changed employment arrangements have potential for disproportionate impact on Aboriginal employees as more than half of workforce employed in roles earmarked for replacement. Changes in overall workforce size and location will likely impact demographics of towns, business development and supply chains, and the distribution of economic benefits. Higher order skills required for new roles. Potential for increased participation by women and older workers. |
| What can be done? | Communication and mitigation/offset: The TA process anticipated shifts in regional benefits and disproportionate employment effects. Alternate strategies were recommended to address these issues and engage a wider group of stakeholders beyond technology developers. |

Automation and remote operation technologies are at the early stages implementation and trials and as such the technology assessment process was best focussed on informing and promoting a public dialogue beyond the domain of technical specialists. By 2012, a broad range of stakeholders had been engaged in the topic including education and training providers, the mining workforce, economists, investment banks and commentators in the mainstream media. It is clear from the research that a more strategic approach is required to the further development and implementation of autonomous and remote operation technologies in Australian mining. In particular, there is the potential for social impacts – and opportunities – to be overlooked in 'the rush to innovate'. This is not about slowing the pace of technological change; experience has shown that such attempts rarely, if ever, succeed. The challenge, rather, is to ensure that the benefits of innovation are broadly distributed and adverse consequences are minimised. The research identified strategies to meet this challenge, improve societal outcomes and improve the acceptability of new mining technology to the public and mining workforce.

Further details on this case study are reported in McNab et al., (2013), 'Exploring the social dimensions of autonomous and remote operation mining: Applying Social Licence in Design'.

## 4.2. BIOMASS AS AN IRON-ORE REDUCTANT IN STEELMAKING

The increasing importance of global climatic change is driving research and development in low emissions technologies. One such technology is the potential shift from the use of metallurgical coal in steel making to renewable sources of charcoal production from biomass. The technology assessment worked with CSIRO research scientists developing biomass technologies in steel-making to understand the social implications of various technological configurations. The assessment adapted social life cycle assessment methodologies. Three technology alternatives were investigated: charcoal produced from Radiata pine plantation forestry; charcoal produced from Mallee revegetation on agricultural land; and metallurgical coal.

Social life cycle assessment methods required adaptation for use within CTA as the analytical focus was shifted from products to technology alternatives, and from actual to hypothetical technology systems. Further, and consistent with the Social Licence in Design process outlined earlier, impact categories have the potential to be experienced differently by different social groups and therefore it is necessary to undertake an analysis from stakeholder perspectives. The geographic location of the technology scenarios were chosen based on their ability to represent current or likely future locations of production. A brief profiling of stakeholders affected or directly involved in the implementation of the technology was also undertaken to guide the qualitative identification of stakeholder issues. The adaptation of SLCA methods grounded the hypothetical technology alternatives within the social context in which the technology alternatives are likely to be situated. Table 2 summarises the main findings of the biomass case study.

Table 2. Summary of the biomass case study findings

| | Biomass use in steelmaking |
|---|---|
| What type of assessment? | Technology stage: Feasibility / trial<br>TA method:<br>Social life cycle assessment. Three quantitative indicators: land-use, employment, workplace health & safety. Quantitative categories supported by analysis of identified stakeholder issues.<br>Public involvement: Review of identified stakeholder issues. |
| What is the technology? | Replacement of coal by renewable sources of charcoal production from biomass for iron ore reduction in steelmaking. |
| Where will it be implemented? | Australian steel-making industry. Two main configurations for charcoal production.<br>1. Pine plantation – expansion of existing forestry, e.g. Macquarie Region, NSW<br>2. Mallee biomass – conservation measure on farmland, e.g. Wheatbelt Region, WA |
| Who will it affect?<br>How will it affect them?<br>What is the magnitude? | 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. Mallee biomass represents a shared land-use that provides additional farm revenue and assists dryland salinity management. |
| What can be done? | Implementation configuration: Prioritisation of Mallee technology configuration.<br>Further investigation of issues related to scale up and economics of technology.<br>Engagement with Wheatbelt farmers. |

Transitioning to biomass technologies may generate a number of 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 hindered progress in other areas of biomass energy production. Given the benefits and drawbacks, it is imperative to assess the stages of the process involved in the biomass use in steel-making in order to understand the viability of this particular alternative.

Impact indicators analysed included land-use, employment, workplace health & safety and a qualitative analysis of identified stakeholder issues. The research found that no unique solution exists for optimising the social performance of the technology alternatives across all of the indicators. Biomass alternatives were found to be significant generators of direct employment at the regional level. However, they were also identified as having concomitantly higher rates of workplace injuries. The scale effects of a shift to biomass technologies on land-use are significant. When compared to metallurgical coal, biomass alternatives represent a significant increase in land-use. Land-use conflicts have been associated with plantation forestry expansion, with even revegetation projects undertaken for conservation generating local level dissatisfaction and competition with other land-use in some cases. On the other hand, local level conflicts have also manifest from the community health and amenity impacts and subsidence effects associated with metallurgical coal mining, despite the relatively small area of land impacted. Charcoal produced from Mallee biomass planted as a conservation measure on farmland has the benefit; however, of representing a shared land-use that in turn supports farm employment through an additional revenue stream and the management of dryland salinity. Through specialised socio-economic analysis the scale of the impact was identified. This informed future research on the most appropriate technology configuration for further development of the technology.

Further details on this case study are reported in Weldegiorgis and Franks (2012), ‘The Social Dimensions of Charcoal Use in Steelmaking: Analysing Technology Alternatives’.

## 4.3. IN-PLACE LEACHING

The industrial scale leaching of gold ores has traditionally utilised leaching solutions that contain environmentally sensitive and potentially toxic compounds such as cyanide. CSIRO has been researching the development of novel non-toxic leaching solutions or ‘lixiviants’ (e.g. thiosulfate) for application within near-surface oxide gold deposits through in-place mining methods. In-place mining refers to mining whereby solutions are pumped in and out of the orebody through wells and the permeability of the rock is enhanced by artificial explosive and hydraulic fracturing methods (in contrast in-situ leaching does not usually involve permeability enhancement). Such mining could reduce impacts associated with traditional open-cut mining methods and surface infrastructure, however, there are potential risks particularly associated with impacts on groundwater.

The early conceptual stage of the technology development required care in the design of public engagement. The technology assessment methodology consisted of application of an internal multi-disciplinary social risk assessment workshop complemented by individual engagement with critical stakeholders to understand issues and perspectives. Preparation for the workshop included scoping the proposed technology and it's drivers, the potential geographic and social context where the technology could be implemented and identifying potential stakeholders. The Social Risk Assessment workshop identified risks to environments, communities and technology implementers and followed the methodology of Evans et al. (2007). Risks were prioritised according to consequences and control strategies. A summary of the findings of the case is presented in Table 3.

The technology assessment process assisted CSIRO research scientists to develop a clearer understanding of the specific social and environmental context in which the technology could potentially be applied and to generate foresight on potential priority risks. The process identified previously unrecognised risks that led to a reshaping of the program of technology development.

Table 3. Summary of the in-place leaching case study findings

| | Non-toxic lixiviant for in-place leaching |
|---|---|
| What type of assessment? | Technology stage: Concept<br>TA method: Social risk assessment workshop<br>Public involvement: Selected stakeholders (including regulator) involved in workshop alongside scientist and technology designers. Facilitation of meetings between technology researchers and critical stakeholders to identify and resolve issues. |
| What is the technology? | Development of a non-toxic 'lixiviant' for in-place (in-situ) leaching of oxide gold deposits. The lixiviant (leaching fluid) would replace the use of cyanide for gold leaching. |
| Where will it be implemented? | Target ore bodies located in the Western Australian goldfields and South Australia. The target regions are characterized by mostly arid climes with low agricultural productivity (grazing land). Groundwater in target area ranges from saline to potable. |
| Who will it affect?<br>How will it affect them?<br>What is the magnitude? | Identified stakeholders: graziers, existing mining companies, traditional owners, stygofauna advocates, ENGOs, peak agricultural bodies. Key risks: groundwater contamination (during operation and residual), subterranean flora, changed sense of place, limited local business opportunities, unplanned closure, sterilization of geological resource. Opportunities identified include: reduced surface presence, extended mine life, reduced GHG emissions. |
| What can be done? | Design out: The TA process identified a significant technical risk that was previously not considered. The R&D program was reshaped in response, thus designing out that particular risk. |

# 5. RECOMMENDATIONS AND FUTURE RESEARCH

Through application of the case studies the following recommendations were developed for future technology assessment research and implementation:

Social Licence in Design should become a component of existing project approval and financing systems of R&D organisations. Situating the process within existing project management and financing procedures will prevent unnecessary work thus reducing the chance of Social Licence in Design becoming another layer of red tape. Project leaders should be able to opt out of technology assessment processes if deemed unnecessary. In order to forgo technology assessment project leaders should have to justify their decision by demonstrating that they understand social risks associated with the technology project and how they aim to address these. The need to vouch for their understanding provides an incentive to seek additional support that empowers both technical and social professionals.

Institutional contexts need to facilitate in house technology assessment that is mutually beneficial to both technical and social scientists. Technology assessment must be of mutual benefit for both social and technical scientists. This is dependent on flexible work arrangements and the ability of social and technical scientists to align their work agendas to reach collaborative outcomes that result in actualised technology improvement and enhance the value of technologies for local communities. Social scientists must be involved from the outset and work together with technical scientists to understand the domain issues and to develop project components and deliverables. For this to be possible social science staff will need to be able to work across different projects which may have different funding and reporting avenues. Organisational structures may be able to facilitate this as long as the need is valued by senior project/management staff. There remains a cultural issue in R&D organisations in which social science is undervalued. This is often a result of miscommunication between disciplinary experts. Whilst the value of working with social scientists in a technology assessment process was recognised by all technical staff interviewed. This value needs to be demonstrated so that social science components are valued and sufficiently resourced.

Community involvement in technology assessment should depend on the stage of technology development. During the conceptual and experimental stages of technology development stakeholder values and views might be best expressed through representatives that fulfil the function of ‘critical friends’ to challenge assumptions. As technologies enter the later stages of development it is increasingly appropriate to seek the views of ‘critical outsiders’ and the broader public. At this stage actual stakeholders may be more easily identified as trials or pilot projects proceed.

Social Licence in Design can improve the functionality of new technologies, enhance technological uptake and value add to technologies. For example, Social Licence in Design, when applied to automation technologies, has shown the disparity between industry, employee and community perspectives of the technology.

Costs of technology assessment should be applied to project budgets. Although project costs are constrained the cost of technology assessment would present a relatively small upfront cost that is likely regained in positive value and can prevent costly retrofitting. Considering technology assessment at the project approval and financing stage can help avoid the potential for ineffective assessments. Research components and deliverables can be developed given the available resources.

Technology assessment may lead to the redesign of technologies, changes to how and where the technology is implemented (conditional implementation), the possibility of off-setting likely impacts of technologies or better communicating the risks involved. The characteristics of a technology, such as the stage of development, technical flexibility, and level of complexity, affect the ability to modify the technology in response to Social Licence in Design.

The adoption of in-house technology assessment is not a substitute for public policy focused technology assessment, or impact assessment processes that are usually a requirement of project approvals. It is unreasonable to expect that professionals undertaking and assisting technology assessment within institutions will have the same scope or remit to critically appraise technology as public policy focused technology assessment agencies. The institutions and professionals developing technology naturally have a stake in the success of the innovation. Instead, the purpose of technology assessment within institutions should be to enable the technologist to take advantage of a learning process about the technology under study and reflexively apply this learning to the design of the technology. The result is that the possibilities for responding to any issues are greatly enhanced.

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No. 2.2 Franks, D.M and Cohen, T. 2011. Investigating constructive technology assessment within the Minerals Down Under Flagship: Interview results. Report prepared for CSIRO Minerals Down Under National Research Flagship, Mineral Futures Cluster Collaboration by Centre for Social Responsibility in Mining, University of Queensland. Mineral Futures Cluster Research Report No. 2.2.

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