Delivering Solutions for Sustainable Mining in Solomon Iron Ore Project through SUSOP®

Farzin Rabiee
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Glossary

BID Bedded iron deposits
CID Channel iron deposits
DID Detrital iron deposits
DIDO Drive- in-drive-out
EDR Economic demonstrated resources
EEO Energy Efficiency Opportunities
EIA Environmental Impact Assessments
ESD Environmental Sustainable Development
FIFO Fly-in/Fly-out
FMG Fortescue Metals Group Limited
GHG Greenhouse gas
GJ Gigajoule
GW Gigawatt
HSE Health, Safety and Environment
ICMM International Council on Mining and Metals
JHEP Jack Hills Expansion Project
kL Kiloliter
Mt Megaton
MW Megawatt
NOₓ Nitrogen oxides
PV Photovoltaic
SD Sustainable development
SDR Subeconomic demonstrated resources
SOₓ Sulphur oxides
SUSID™ Sustainability opportunities and risks identification element
SUSOP® SUStainable OPerations
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FARZIN RABIEE


Abstract

Responsible and prudent use of natural resources has been identified as one of the most challenging global issues, which makes using sustainability principles in mining an increasingly popular topic. Mining operations are generally associated with a range of environmental and social impacts negatively affecting local communities. There is a growing importance to better understand the environmental, social, and commercial factors that affect the development of new resources projects. Although innovative resource conservation in mining projects satisfies the aims of corporate sustainability principles, such capabilities are often bypassed in favour of tried and tested solutions that are recognized to have lower technical and financial risks. This is, in part, a result of a lack of an appropriate methodical and strict framework in project management systems that allows sustainability to be properly considered, analysed, and assessed in projects. While there are a number of tools and methodologies that incorporate sustainability in design, only rarely can one find a consistent, integrated, and robust method to support mineral projects by incorporating a high level of sustainability principle into the design process. In an attempt to resolve this issue, a research team has developed the Sustainable Operations framework, SUSOP®. SUSOP® is an integrated and robust framework for project management system through which the sustainability concept can be applied effectively without compromising financial rigor. To demonstrate the robustness of this framework and investigate the opportunities or risks that could emerge from applying the SUSOP® framework, a case study on the Fortescue Metals Group Solomon Iron Ore Mine Project was conducted. This case study was chosen after investigation of numerous cases all around Australia. This case study applies the SUSOP® framework retrospectively for integrating sustainability concepts into Solomon Project in design, construction, and operation phases without workshop element. The framework is applied to identify innovative opportunities and uncover additional risks that do not appear to have been identified or mentioned in the public domain and data have been applied on the project.

Keywords: Sustainable Development, SUSOP®, Environmental, Energy, Resource

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Summary

There is a growing desire by communities, governments, industries, and other stakeholders to contribute efficiently to a sustainable society, and there is very strong evidence that we — globally — are living beyond Earth’s capacity (Strange & Bayley, 2008). Reduction of resource consumption, reduction of carbon and ecological footprints, and minimisation of the negative impacts of industrial activities are key points in projects. Many stakeholders, including those in the resource industry, desire to implement their own sustainable development objectives into the design and operation of their businesses (Institute for Sustainable Development, 2012). Integrating these principles into the design and operation of our industries is a controversial topic. To overcome this challenge the Sustainable Operations framework, or SUSOP®, was created and developed. This project intends to represent the application of the SUSOP® framework to the Fortescue Metals Group Solomon Iron Ore Mine Project in Western Australia. SUSOP® is a framework that identifies opportunities and threats in the early phases (concept study, pre-feasibility, and feasibility) of industrial projects (mining, chemical, oil, gas, etc.). It integrates sustainable development considerations within the corporate decision-making process as the basis for identifying innovative opportunities to improve environmental, social, and economical outcomes as well as identifying threats. SUSOP® aims to use a holistic and systematic mechanism to provide a standard approach to utilise sustainability principles in operating practices and design processes without compromising financial outcomes. The approach uses a structured process of multi-disciplinary workshops, analysis, and decision support systems.

Keywords: Sustainable Development, SUSOP®, Environmental, Energy, Resource

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1 Introduction

1.1 Background

The minerals sector of Australia plays a vital role in the economy of the country. In recent years, Australia has become significantly dependent on the export of mineral resources, and mining is a significant export industry and contributor to the Australia economy. Australia is the world’s leading producer of bauxite and iron ore; the second largest producer of alumina, lead, and manganese; the third largest producer of brown coal, gold, nickel, zinc, and uranium; the fourth largest producer of aluminium, black coal, and silver; and the fifth largest producer of tin (Minerals Council of Australia, 2011). In the context of sustainable development in the mining and metal sector, the Minerals Council of Australia (2005) states “investments in minerals projects should be financially profitable, technically appropriate, environmentally sound and socially responsible”. It means the mining business can be sustained only if these criteria are met.

Fig 1.1. Value of major mineral commodity exports of Australia (Australian Bureau of Agricultural and Resource Economics and Sciences, 2011)

Stakeholders need to ensure that the Australian minerals sector sustainably prospers, and national benefit continues to be derived from it. The goals of economic development must be defined in terms of sustainability, whether that be centrally planned economy or market-oriented economy. In a planned economy decisions regarding investment and manufacturing are embodied in an overall plan formulated by a central authority, whereas in a market-oriented economy decisions regarding investment, manufacturing, and distribution are based on supply and demand. Interpretations will vary but must share certain general features and must flow from a consensus on the basic concept of sustainable development and on a broad strategic framework for achieving it.

The impact of the minerals industry on the economy of Australia is significant. Mining has added hundreds of billions of dollars in export earnings to Australia’s wealth in the last two decades, and this is currently increasing. The value of mineral exports (excluding oil and gas) exceeded $163b in 2011–12. During 2011–12, sales and service income for the mining industry was $218.3b, of which iron ore mining accounted for 31.3% (or $68.3b), coal mining 26.8% (or $58.6b), and oil and gas extraction 16.1% (or $35.2b) (Australian Bureau of Statistics, 2014).

Australia’s Minerals Resource Rent Tax Repeal and Other Measures Bill 2013 states “The mining industry has contributed an estimated $117 billion in company tax and royalty revenues since 2006–07. In addition to $21 billion in company tax and royalties paid in 2011–12, the minerals industry spent more than $34 billion on community projects and spending with local businesses. The industry is a vital part of Australia’s economy with benefits flowing throughout the economy accounting for 18 percent of GDP including direct flow on benefits to
mining-related activities, almost half the value of Australia’s exports of goods and services and employing almost 250,000 Australians directly” (Dale et al., 2013).

There are some significant sustainability issues for both Australia and mineral companies such as

- greenhouse gas emissions due to mining activities
- minimising or eliminating all other deleterious discharges from operational sites
- air, water, and soil toxicity issues and discernments
- social and economical impacts of mine development on local communities
- end of life mine closure and mine site rehabilitation
- commodity price fluctuations, specifically falling
- declining relative attraction of mineral sector employment due to insecurity of employment, downsizing, outsourcing, and changed working conditions such as fly-in/fly-out (FIFO) arrangements
- occupational health and safety (Hancock, 2001)

The mining sector has made a strong public commitment to sustainable development and sustainability. The websites of industry bodies (such as the International Council on Mining and Metals and the Minerals Council of Australia) and major mining companies and the companies’ annual sustainability reports pronounce and demonstrate this commitment (XSTRATA, 2009; Anglo American, 2011; Rio Tinto, 2013; BHP Billiton, 2013; Vale 2011). The main challenge is to incorporate the fundamental principles of sustainable development at the early stage of design and operation of minerals processes (Corder et al., 2010). Essentially, practicing engineers’ activities on new project developments or their conducting the day-to-day activities at an operational site are not readily assisted by these principles and policies. Despite shown commitment to sustainable development in the documents, new operations in the minerals industry are routinely designed, constructed, and run in a manner similar to existing operations. Primarily, sustainability principles and policies do not assist the engineering activities in design, construction, and operation processes at a mining site. Design, construction and operation activities in the mineral industry normally follow routine procedures, despite the fact that mining industry documents demonstrate commitment to the sustainable development concept.

The previously tested solutions that are recognized to have lower technical and financial risks are normally preferred and chosen over more innovative solutions that have higher alignment with the sustainability principles and policies goals. Normally these policies and principles are incorporated to ensure that the project or operation is at best compliant once all major decisions are made, leaving little room for innovative initiatives that could improve sustainability. In the absence of an applicable systematic and rigorous framework to allow proper consideration, analysis, and assessment of sustainability aligned initiatives in project management systems, new mining projects will continue to follow the pattern of existing mining operations with only modest improvement to satisfy corporate sustainability principles (Corder et al., 2012).

1.2 Objective
The aim of this project is to apply the sustainability framework SUStainable OPerations (SUSOP®) (Corder et al., 2010) retrospectively for integrating sustainability concepts into mining projects by conducting a case study on the Solomon Iron Ore Mine Project without the multi-disciplinary workshops elements. This project tests the robustness of SUSOP® thorough offline analysis. In this study the SUSOP® framework will be applied to identify innovative opportunities and uncover additional risks that do not appear to have been recognized or mentioned in the public domain information and data that have been supplied on the project.

1.3 Methodology
In this case study, the author will use Solomon Iron Ore Mine project literature and will rely on public domain information. For further gathering of information, an informal interview via email was also conducted with the Senior Environmental Advisor of Fortescue Metals Group to get more data that have not been shown in publically released documents. The study is based on the Five Capitals Model of sustainability, dealing with
natural, human, social, manufactured, and financial capitals of the mining. The aim of the project is to identify new opportunities and risks and compare these with public documentation by using the sustainability opportunities and risks identification element (SUSID™) of the SUSOP® framework. Finally, the processed data will be provided to the SUSOP® framework with the input that leads to extracting SD Balance Sheets™.

The key steps are

1. Review project literature on the Solomon Iron Ore Mine project listing key sustainability features including risks
2. Apply modified SUSID™ (without workshops) from the SUSOP® framework to elicit opportunities and risks
3. Group opportunities and risks together in ‘concepts’
4. Compare and contrast with results from 1 and attempt to use SD Balance Sheets™ to illustrate the comparison

1.4 Boundaries
The boundaries of this study are set by using the SUSOP® framework retrospectively on the Solomon Iron Ore Mine project to identify risks and opportunities for sustainability within the scope of the Five Capitals Model of sustainability. Focus has been put on underscoring additional risks and opportunities that were not identified through the regular project management process and do not appear to have been presented in the public domain information. The studied period stretches from the initial time of the Solomon Iron Ore Mine project definition to the preparation of this thesis.

1.5 Limitations
There are some limitations that acted as obstacles during the case study. These include

- Mining is correlated with a wide range of topics that cannot be investigated and analysed in a limited time frame in conducting the research in this thesis
- Some technical topics in mining need to be analysed by a specialist, e.g., concentration of iron ore. This matter would be more important when the case study is done without workshops and lacks input from project stakeholders
- There are some important ideas and discussion regarding this project that are not necessarily documented or available on the internet
- There are differences in availability of information within the Five Capitals Model of sustainability. Information and numbers about economic and environmental matters on this project seem easier to find than issues concerning social aspects. This might create an imbalance within the study among the Five Capitals, placing more emphasis on economic and environmental risks and opportunities

The above limitations affect the validity of the assumptions and numeric figures for using in this case study. With a greater range of investigated topics in a longer time frame, access to additional required data regarding the project, and appropriate input from stakeholders, the results will be more accurate.

2 Solomon Iron Ore Project background

Global demand for iron ore has been growing significantly in recent years, primarily driven by China’s rapid economic growth (Atkins & Connolly, 2013). Worldwide demand has caused significant increase in iron ore mining projects within Western Australia.

Fortescue Metals Group Limited (FMG) proposes to develop and operate two new mines in the Pilbara region of Western Australia within the Solomon Project. The Solomon Project includes the development of new mining in addition to the Chichester mines already operated by Fortescue at Cloudbreak and Christmas Creek. The project
is the first of two phases of development proposed for the Solomon Hub. Fortescue’s existing mining operations in the Chichester Ranges, the Cloudbreak and Christmas Creek mines, are collectively referred to as the Chichester Hub.

This project includes two new iron ore mines at deposits known as Firetail and Kings, on greenfield sites approximately 60 km north of Tom Price (Figure 2.1). The deposits will produce a combined total of up to 80 Mt of iron ore per annum. The Firetail deposit will produce up to 30 Mt per annum of Brockman fines, comprising a blend of bedded iron deposits (BID) and detrital iron deposits (DID). The Kings deposit will produce up to 50 Mt of ore per annum, comprising mostly channel iron deposits (CID) with some Brockman and detrital ore. Ore from both the Firetail and Kings deposits will be mined by conventional truck and shovel methods using a discrete pit mining concept of placing overburden and waste into mined-out areas.

Fortescue also proposes to develop the Solomon rail line, which will link the two new Fortescue mines to an existing north–south rail line approximately 127 km to the east. An additional 15 km rail spur between the Firetail and Kings deposits will also be constructed. Processed ore will be transported to Fortescue’s existing Herb Elliott Port facilities in Port Hedland for export. The proposed rail corridor is represented in Figure 2.1 (Fortescue Metals Group Limited, 2010).

The nearest population centre is Tom Price, which is located approximately 60 km south of Solomon Hub. Tom Price is a Rio Tinto operated town, so the vast majority of residents work for Rio Tinto or associated services. Fortescue has a programme (Vocational Training and Employment Centre (VTEC) programme) to train indigenous people to work on FMG operations. There will be some residential workforce on Solomon (living in Tom Price, and FMG has purchased several houses there), but the majority of the workforce will be FIFO. The Solomon Project needs almost 1500 people for the operation, and FMG forecasts 95% of them will be FIFO. Primary environmental approvals of the project were achieved by April 2011, and the construction stage for rail and mine components of the project commenced shortly. The detailed design phase was completed during the approvals phase. An 85 MW dual fuel power station that supplies power for Solomon Hub is being designed to operate on both diesel and gas. Diesel will be used in the short term, after which there will be a switch to gas once a supply is sourced. The mine is on Unallocated Crown Land, and Native Title Claimants are paid a royalty for use of the claim areas.¹

The development of the Solomon Project can contribute effectively to provide important state and national benefits including

- Rail infrastructure with possibility for third party access in Pilbara that removes the further need for the third party to invest and construct additional rail infrastructure, consequently reducing cumulative adverse environmental impacts in the region
- Contribution to the local community, as benefits derived from mining activity provide more opportunities in the region (Fortescue Metals Group Limited, 2010)

¹Interview with S. Grein, Senior Environmental Advisor at Fortescue Metals Group Ltd. in June 2011 (F. Rabiee, Interviewer).
3 A guiding framework for sustainable development

3.1 General overview
SUSOP® is a guiding framework for projects that enables a proper contribution to sustainability by the industrial facilities being studied, designed, built, or operated. By adopting the SUSOP® framework organisations can expect

- Integration of environmental design criteria into project processes
- Integration of social context into project processes
- Correct interfacing with legislative processes, Environmental Impact Assessments (EIA), and Health, Safety and Environment (HSE) best practice
- Development of design and project management ideas (Corder & Green, 2011)

4 SUSOP® key elements

The SUSOP® framework has three major elements:

1. **Sustainability opportunities and risks identification (SUSID™)**, which includes a significant characteristic, ‘new ideas’ generation, and is made up of four steps:

   Step (i) Familiarisation with Sustainability Concepts and Project Context,
   Step (ii) Goal Scoping and Opportunities and Risks Identification;
   Step (iii) Analysis of Sustainability Opportunities and Risks;
   Step (iv) Prioritisation of Sustainability Opportunities and Risks.
Step (i) requires multi-disciplinary workshops. This step was eliminated in this case study; as this project aims to test the robustness of SUSOP® thorough offline analysis.

2. **Sustainable Development (SD) Assessment** for conducting a detailed evaluation of the shortlisted or high-priority opportunities and risks.

3. **Decision Support** for providing assistance with decision making at project toll gates.

All the above elements are supported by the SUSOP® Knowledge Base which includes information on sustainability frameworks and principles, details on case studies, relevant SD tools and databases to assist in the evaluation and assessment stages, and relevant public domain information and data. Figure 4.1 shows a schematic summarising the SUSOP® framework (Corder, 2013).

The main outputs from SUSOP® are as below:

1. Opportunities for improving the contribution to societal sustainability and business performance of the project
2. Supporting SD Balance Sheets™ for top ranking opportunities to schematically show the positive and negative impacts across the chosen sustainability framework (the default is the Five Capitals Sustainability Framework, which comprises natural, human, social, manufactured, and financial capitals (Forum for the Future, 2005))
3. Sustainability risks that could potentially impact the project’s viability.
4. Action plans for each item (opportunities and risks) in the register before proceeding through the next project toll gates.

A schematic summarising the framework is presented in Figure 4.1.

![Schematic summarising the SUSOP® framework](image)

This project aims to apply the SUSOP® concepts to the Solomon Iron Ore Mine Project without the multi-disciplinary workshops elements. As a result, modifications have been made in the steps that are shown in Table 4.1.
The first step, Familiarisation with Sustainability Concepts and Project Context, is designed to create a common understanding of the project context and core sustainability knowledge amongst the workshop participants. The participants are mainly project stakeholders such as project environmental specialist and/or sustainability specialist, senior risk manager, project community/social specialist, client consulting engineering team member, etc. While no workshop will be held in this case study; still the author has to become familiar with the project context. Positive and negative impacts analysis has been done and elements of step 1 achieved.

Step 2, Goal Scoping and Opportunities and Risks Identification, has been designed to identify appropriate, practical, and achievable sustainability goals in the project through workshops. The same workshop participants as in step 1 will contribute to address the sustainability goals and mitigate sustainability risks that may affect the project’s viability. Although this step was not performed using the structured techniques of the framework with workshop groups, it was still possible to identify opportunities and risks through literature review and interviews. It is likely that this approach will limit the number of opportunities and risks that can be identified in a huge mining project but can bring some ideas to the project that might not be identified in the routine workshops.

Step 3, Analysis of Sustainability Opportunities and Risks, is a desk-top analysis and does not utilise workshops. This step that has been shown in grey in Figure 4.1 and needs to be done by a SUSOP® practitioner. Although this step does not need the workshop element, eliminating the workshop prevents liaising with the project stakeholders and accessing data that are required for investigating more opportunities.

Step 4, Prioritisation of Sustainability Opportunities and Risks, has been designed to validate and confirm a shortlist of opportunities and risks for future evaluation and assessment. In SUSOP® framework, this step has been considered to be done through workshops with the same participants in step 1. In this study this step has not been skipped but has been modified to be completed by the person who is doing the case study, relying on the available data and using the results emerging from this study.

The standard SUSOP® process was modified for use in this case study. Table 4.1 presents the standard process versus the modified process that has been used in this study.
## Table 4.1. Standard SUSOP® process vs. modified SUSOP® process

<table>
<thead>
<tr>
<th>Standard SUSOP® Process</th>
<th>Modified SUSOP® Process</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Sustainability Opportunities and Risks Identification (SUSID™)</td>
<td>1) Sustainability Opportunities and Risks Identification (SUSID™)</td>
<td>The standard process used</td>
</tr>
<tr>
<td>SUSID™ Step 1: Familiarisation with Sustainability Concepts and Project Context</td>
<td>SUSID™ Step 1: Familiarisation with Sustainability Concept Project Context through literature review</td>
<td>In the absence of the workshop element, familiarisation with the project context done through literature review</td>
</tr>
<tr>
<td>SUSID™ Step 2: Goal Scoping and Opportunities and Risks Identification</td>
<td>SUSID™ Step 2: Goal Scoping and Opportunities and Risks Identification without the workshop element</td>
<td>In absence of the workshop element, available data released by stakeholders and public media reviewed to identify sustainability goals, risks, and opportunities</td>
</tr>
<tr>
<td>SUSID™ Step 3: Analysis of Sustainability Opportunities and Risks</td>
<td>SUSID™ Step 3: Analysis of Sustainability Opportunities and Risks</td>
<td>10 steps in standard process decreased to 5 steps in modified process. There are two main reasons for this change: 1. Some steps can be merged, e.g., step (ii) necessarily means step (i) should be completed 2. A simplified process was suitable for analysing the limited number of opportunities and risks that have been identified and reviewed in this case study</td>
</tr>
<tr>
<td>i) Review opportunities and risks in Sustainability Register™</td>
<td>i) Categorise opportunities and risks into themes</td>
<td></td>
</tr>
<tr>
<td>ii) Categorise opportunities and risks into themes</td>
<td>ii) Establish linkages between opportunities across themes</td>
<td></td>
</tr>
<tr>
<td>iii) Additional information on opportunities and risks</td>
<td>iii) Review risks against clusters</td>
<td></td>
</tr>
<tr>
<td>iv) Establish linkages between opportunities across themes</td>
<td>iv) Assign impact ratings for base case options</td>
<td></td>
</tr>
<tr>
<td>v) Review risks against clusters</td>
<td>v) Generate SD Balance Sheets™</td>
<td></td>
</tr>
<tr>
<td>vi) Form clusters into concepts</td>
<td>vi)</td>
<td></td>
</tr>
<tr>
<td>vii) Identify relevant indicators</td>
<td>vii)</td>
<td></td>
</tr>
<tr>
<td>viii) Assign impact ratings for base case options</td>
<td>viii)</td>
<td></td>
</tr>
<tr>
<td>ix) Generate SD Balance Sheets™</td>
<td>ix)</td>
<td></td>
</tr>
<tr>
<td>x) Rank concepts</td>
<td>x)</td>
<td></td>
</tr>
<tr>
<td>SUSID™ Step 4: Prioritisation of Sustainability Opportunities and Risks</td>
<td>Not applicable</td>
<td>SUSID™ Step 4 aims to provide a shortlist of opportunities and risks for future evaluation and assessment. This list will be evaluated and assessed through a workshop with the SUSOP® Team. This step is skipped as this study does not include the workshop elements</td>
</tr>
<tr>
<td>2) Preparation of action plans</td>
<td>Not applicable</td>
<td>No action plan was applicable for this case study. This case study does not aim to evaluate any further shortlisted or high-priority opportunities and risks</td>
</tr>
<tr>
<td>3) Decision support</td>
<td>Not applicable</td>
<td>This step has been designed for providing assistance with decision making at project toll gates. This step was not applicable in this case study</td>
</tr>
</tbody>
</table>
4.1 SUSOP® Key Element 1. Sustainability opportunity and risks identification (SUSID™)

Potential positive impacts and the potential negative impacts of the project identified across the Five Capitals Model. The Five Capitals model, developed by an independent non-profit organisation, Forum for the Future, utilises the concept of capitals, briefly described below, to provide a basis for understanding sustainability (Forum for the Future, 2005).

Fig 4.2. Five types of sustainable capital (Forum for the Future, 2005)

- **Natural Capital** is the basis not only of production but of life itself and is any stock or flow of energy and material that produces goods and services. It includes
  - Resources (renewable and non-renewable materials)
  - Sinks (that absorb, neutralise, or recycle wastes)
  - Processes (such as climate regulation)
- **Human Capital** consists of people's health, knowledge, skills, and motivation. All these things are needed for productive work.
- **Social Capital** concerns the institutions that help us maintain and develop human capital in partnership with others, e.g., families, communities, businesses, trade unions, schools, and voluntary organisations.
- **Manufactured Capital** comprises material goods or fixed assets which contribute to the production process rather than being the output itself, e.g., tools, machines, and buildings.
- **Financial Capital** plays an important role in our economy, enabling the other types of capital to be owned and traded. But unlike the other types, it has no real value itself but is representative of natural, human, social, or manufactured capital, e.g., shares, bonds, or banknotes.

These possible positive and negative impacts will be identified and considered to scope out the range of issues that could affect the project. This then formed a sound basis for the next step in SUSID™, i.e., goal scoping and identifying opportunities and risks. Identified risks and opportunities are shown in SUSID™ Step 2.

4.1.1 SUSID™ Step (1) — Familiarisation with the project context through literature review

The aim of SUSID™ Step 1 (in standard process) is to gather project stakeholders through a workshop to create a common understanding of the project context and core sustainability knowledge amongst the study team. Complexity and size of the project are two main factors that determine which participants and for how long they need to attend the workshop. It can be conducted either over a half day or a full day.
This step was modified in this case study as this project aims to study this case without conducting any workshop. Step 1 has some undeniable advantages, such as using the knowledge of the group of people who are involved in this specific project, which can bring forth many ideas on the concept of sustainability. However, modifying this step does not make a major change in establishing linkage between the project and the sustainability concept. Familiarisation with project context has been done through literature review and interviews, which has already been described in section 2 (Solomon Iron Ore Project background). The outcome of this step is used in step 2, goal scoping and opportunities and risks identification, by establishing the linkage between the different aspects of this project and sustainability concept across the Five Capitals Model.

4.1.2 SUSID™ Step (2) — Goal scoping and opportunities and risks identification

The aim of this step is identifying opportunities and risks through conducting a workshop. In the absence of the workshop element, available data are reviewed to identify:

- Appropriate, practical, and achievable sustainability goals for the project (i.e., identifying which outcomes would be considered successful and how this would be measured or quantified)
- Opportunities to potentially achieve the goals and sustainability risks that might threaten the goals or affect the project’s viability (Corder & Green, 2011)

Sustainability goals should be compatible with the FMG’s sustainability principles and policies and provide the platform for the identification of opportunities and risks. Sustainability opportunities and risks are identified through reviewing available data released by stakeholder and public media. The chosen opportunities should be potentially achievable and mitigate the negative impacts that may affect the projects’s viability. The framework is flexible enough to be used in any kind of project and is not limited to mining projects. However, owing to the nature of mining projects, where appropriate, corporate sustainability principles or policies — that in many cases are very similar — or mining industry body sustainability principles should be used to assist in bringing about the sustainability goals along with the proposed suggestions.

The International Council on Mining and Metals (ICMM) has developed 10 sustainable development principles that are widely used in this case study to identify and address sustainability opportunities in the Solomon Project as a mining project. ICMM 10 principles are

“1. Implement and maintain ethical business practices and sound systems of corporate governance.
2. Integrate sustainable development considerations within the corporate decision-making process.
3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
4. Implement risk management strategies based on valid data and sound science.
5. Seek continual improvement of our health and safety performance.
6. Seek continual improvement of our environmental performance.
7. Contribute to conservation of biodiversity and integrated approaches to land use planning.
8. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.
9. Contribute to the social, economic and institutional development of the communities in which we operate.
10. Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders” (International Council on Mining and Metals, 2003).

The 10 principles were used and the sustainability goals organised around the Five Capitals to group the sustainability goals for each Capital. These goals are presented in Table 4.2.
In the normal SUSOP® process, through workshops typically 20 to 30 goals are identified (Corder, 2013). In this study a couple of goals have been shown; but this project does not aim to investigate all the goals presented in Table 4.2. Goals can be similar for the mining projects that are located in the same region and operate as per the same legislation, codes, and standards, e.g., iron ore mines in Western Australia. In many cases Table 4.2 can be used as a standard template for iron ore mining projects in Western Australia that will be modified for each particular project to reflect the company’s sustainability policies as well as other goals that might differ from one project to another. It would be ideal that goals are defined by specific numeric targets (e.g., 20% greenhouse gas reduction emissions by 2020; 15% local workforce by 2018). In this study, applicable numeric figures have been used to show the level of improvement in each item.

The sustainability goals have been used as a basis for the identification of opportunities and risks. Some identified opportunities can achieve more than one goal as well as risks that could act as an obstacle to achieve one or more goals. There are a wide range of sustainability goals in a mining project that lead to many opportunities; however, owing to limitations this study concentrates only on some critical items that can make a considerable improvement to test the robustness of SUSOP® without the workshop element. Also, this study does not aim to address the main issues that have already been addressed. Questions for identification of opportunities and risks that are organised around the Five Capitals Model are given in Table 4.3.

<table>
<thead>
<tr>
<th>Capital</th>
<th>Sustainability Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>• environmental impacts, e.g., greenhouse gas emissions, noise, and vibration, visual amenity, etc.</td>
</tr>
<tr>
<td></td>
<td>• water consumption or production</td>
</tr>
<tr>
<td></td>
<td>• energy saving or production</td>
</tr>
<tr>
<td>Human</td>
<td>• local employment</td>
</tr>
<tr>
<td></td>
<td>• training, skills development, life-long learning, and capture and sharing of knowledge</td>
</tr>
<tr>
<td></td>
<td>• understand and respect human values and their different cultural contexts</td>
</tr>
<tr>
<td></td>
<td>• gender equity</td>
</tr>
<tr>
<td></td>
<td>• health and safety plan</td>
</tr>
<tr>
<td>Social</td>
<td>• accommodation village</td>
</tr>
<tr>
<td></td>
<td>• efficient communication systems throughout the organisation</td>
</tr>
<tr>
<td></td>
<td>• providing benefits to the local community</td>
</tr>
<tr>
<td>Manufactured</td>
<td>• shared use of infrastructure, e.g., airport, rail, power station, fuel transport facilities, etc.</td>
</tr>
<tr>
<td></td>
<td>• zero waste and zero emissions production systems</td>
</tr>
<tr>
<td></td>
<td>• improvements in product systems (eco-efficiency and eco-innovation)</td>
</tr>
<tr>
<td></td>
<td>• sustainable construction techniques</td>
</tr>
<tr>
<td>Financial</td>
<td>• honour relationships with suppliers and customers/citizens</td>
</tr>
<tr>
<td></td>
<td>• assess the wider economic impacts of the organisation’s activities, products, and services on society, e.g., in creating wealth in the communities in which the organisation operates</td>
</tr>
</tbody>
</table>

Table 4.2. Sample sustainability goals
**Capital Opportunities and Risks Prompting Questions**

<table>
<thead>
<tr>
<th>Capital</th>
<th>Opportunities and Risks Prompting Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>How can greenhouse gas emissions be reduced?</td>
</tr>
<tr>
<td></td>
<td>How can energy consumption be reduced?</td>
</tr>
<tr>
<td></td>
<td>What are the possible renewable energy options?</td>
</tr>
<tr>
<td>Human</td>
<td>How can gender equality be promoted?</td>
</tr>
<tr>
<td></td>
<td>What opportunities are there to enhance local skills?</td>
</tr>
<tr>
<td></td>
<td>How can we prevent potential risks to employee health, safety, and wellbeing?</td>
</tr>
<tr>
<td>Social</td>
<td>How can the local community benefit from the Solomon Project?</td>
</tr>
<tr>
<td></td>
<td>What are the risks to members of the local community, their lifestyles, and their heritage?</td>
</tr>
<tr>
<td></td>
<td>How can the project enhance the infrastructure to be beneficial for both FMG and the local community?</td>
</tr>
<tr>
<td>Manufactured</td>
<td>What technology/concept can be used to enhance eco-efficiency?</td>
</tr>
<tr>
<td></td>
<td>How can large assets (both new and existing) be utilised to their maximum extent?</td>
</tr>
<tr>
<td>Financial</td>
<td>Are there opportunities that deliver greater and wider benefits to all stakeholders and establish more positive relationship with stakeholders, e.g., Aboriginals?</td>
</tr>
<tr>
<td></td>
<td>What are the risks that could prevent the project from being on time and on budget?</td>
</tr>
</tbody>
</table>

*Table 4.3. Opportunities and risks questions*

Opportunities and risks as well as simplified supporting analysis for each of the items that identified in the Solomon Project are given in Tables 4.4 and 4.5. Supporting analysis is discussed in section 4.1.3.5.

<table>
<thead>
<tr>
<th>No.</th>
<th>Opportunity</th>
<th>Simplified Supporting Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>Energy use reduction in haul trucks</td>
<td>Energy saving</td>
</tr>
<tr>
<td>O2</td>
<td>Reducing of unnecessarily stopping of haul trucks</td>
<td>Energy saving, GHG emissions reduction, operating cost reduction</td>
</tr>
<tr>
<td>O3</td>
<td>Optimising payload of haul trucks</td>
<td>Energy saving, GHG emissions reduction, operating cost reduction</td>
</tr>
<tr>
<td>O4</td>
<td>Optimising road grade</td>
<td>Energy saving, GHG emissions reduction, operating cost reduction</td>
</tr>
<tr>
<td>O5</td>
<td>Change to the engine control unit of the haul trucks to optimise the operation</td>
<td>Energy saving, GHG emissions reduction, operating cost reduction</td>
</tr>
<tr>
<td>O6</td>
<td>Switching from diesel to gas power generation</td>
<td>GHG emissions reduction, operating cost reduction, enhances infrastructure such as gas pipeline</td>
</tr>
<tr>
<td>O7</td>
<td>Using the ecovillage concept to build accommodation camps</td>
<td>Enhances eco-efficiency, minimises negative environmental impacts, water consumption reduction</td>
</tr>
<tr>
<td>O8</td>
<td>Using renewable energy sources such as solar energy in accommodation camps</td>
<td>Energy saving, GHG emissions reduction, operating cost reduction</td>
</tr>
<tr>
<td>O9</td>
<td>More efficient waste management in accommodation camps</td>
<td>Minimises negative environmental impacts</td>
</tr>
<tr>
<td>O10</td>
<td>Changing the fixed contract with Yindjibarndi Aboriginal to uncapped contract</td>
<td>Enhances the corporation reputation, creates wealth in local community</td>
</tr>
<tr>
<td>O11</td>
<td>Local enterprises to support operation, e.g., tradespeople and local small businesses</td>
<td>Creates wealth in local community, local employment increase, FIFO reduction, operating cost reduction</td>
</tr>
<tr>
<td>O12</td>
<td>Best practice rehabilitation</td>
<td>Stable and functioning landform after mine closure, minimises negative impacts on local communities</td>
</tr>
</tbody>
</table>

*Table 4.4. Identified opportunities with simplified supporting analysis*
<table>
<thead>
<tr>
<th>No.</th>
<th>Risk</th>
<th>Link with Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Capital cost increase</td>
<td>O6</td>
</tr>
<tr>
<td>R2</td>
<td>Operation cost increase</td>
<td>O9</td>
</tr>
<tr>
<td>R3</td>
<td>Negative environmental impacts</td>
<td>O6</td>
</tr>
<tr>
<td>R4</td>
<td>Change in landscape</td>
<td>O6</td>
</tr>
<tr>
<td>R6</td>
<td>Negative impact on corporation reputation</td>
<td>O12</td>
</tr>
</tbody>
</table>

Table 4.5. Identified risks and linkage between opportunities and risks

In SUSOP® with workshop elements, participants vote on the listed opportunities and risks. Each participant has limited selections through the list that he/she considers would have a high ‘positive impact’. “Each participant is then allowed to select up to ten opportunities that he or she considers would have a high ‘achievability’ – that is, there is good potential to implement the opportunity now or in the near future. Achievability is a broad term and is related to a series of factors including cost, resources, timing, logistics etc. For example, a cost effective commercially proven, broadly accepted technology with minimal environment impact could be considered to have a high ‘achievability’ rating” (Corder, 2013).

A similar process will be conducted for the risks. For risks, ‘positive impact’ and ‘achievability’ will be replaced with ‘negative impact’ and ‘likelihood’. Voting results on opportunities and risks will then be plotted to provide a graph. Sample graphs have been shown in Figures 4.3 and 4.4.

This process has been eliminated in this study, as this case study has been done without workshop elements. Although the process has been eliminated; the concept has been used to identify the opportunities with high ‘positive impact’ and high ‘achievability’ and risks with high ‘negative impact’ and high ‘likelihood’ for further investigation. For example, ecovillage has many positive impacts and is achievable. This opportunity is considered Hi-Hi. Also, energy saving in haul trucks has positive environmental and financial impacts and is achievable in the operation stage. The Hi-Hi opportunities and risks will be used as input for Step 3.

![Figure 4.3: Example graph of positive impact vs. achievability for opportunities (Corder, 2013)](image-url)
4.1.3 SUSID™ Step (3) — Analysis of sustainability opportunities and risks

In this step opportunities from the previous step that could make the biggest contributions to sustainability and risks that could potentially have significant adverse impacts on sustainability are short listed.

This step has been designed to be conducted off-line in SUSOP®, so there is not much difference between the routine process and what has been done in this project. A structured process is used in SUSOP® to conduct the analysis that has 10 steps as follows.

i) Review of Opportunities and Risks in Sustainability Register™
ii) Categorise Opportunities and Risks into Themes
iii) Additional Information on Opportunities and Risks
iv) Establish Linkages between Opportunities across Themes
v) Review Risks against Clusters
vi) Form Clusters into Concepts
vii) Identify Relevant Indicators
viii) Assign Impact Ratings for Base Case Options
ix) Generate SD Balance Sheets™
x) Ranking of Concepts (Corder, 2013)

These steps have been modified and in some cases merged to be applicable for using in this project.

4.2 Categorise opportunities and risks into themes

To develop a more holistic understanding of the potential contribution the identified opportunities can make to sustainable development, opportunities are grouped into clusters. Opportunities that are related to one topic can be grouped in one cluster. However, there is no limitation on the number of the clusters. For example, all opportunities for the energy efficiency can be grouped in one cluster.
4.3 Establish linkages between opportunities across themes
Linkage between opportunities in clusters are established to show the potential dependencies between opportunities, such as using the ecovillage concept in an accommodation site that decreases waste and provides opportunities for utilisation of alternative renewable energy.

4.4 Review risks against clusters
Potential risks are then reviewed for each cluster. These risks investigated to determine if they could be totally mitigated or their adverse impacts reduced. The opportunities and risks are discussed in section 4.6.

4.5 Assign impact ratings for base case options
The groups of linked opportunities and identified risks that could be mitigated by the opportunities need to be rated to provide a numerical model for assessing the weight of each opportunity. The concepts are rated against a set of the Global Reporting Initiative™ (Global reporting Initiative, 2012) indicators and nature of the project. Indicators are given an impact rating from −5 to 5, as illustrated in Figure 4.6, which is accumulated into an overall impact for each of the Five Capitals. The outcome of these ratings is then used to prioritise the concepts in preparation for SUSID™ Step 4.
4.6 Generate SD Balance Sheets™

Opportunities and risks are discussed in detail in this section. Outcome of the discussion and appropriate indicators for each part were used to assign an impact rating to each cluster (group of opportunities).

4.6.1 Saving diesel use in haul trucks

In Solomon Mine, excavators will be employed to dig the material from working mine faces. Material will be loaded into haul trucks by excavators for transport to either waste dumps or ore stockpile locations (Fortescue Metals Group Limited, 2010).

Three Australian mining companies that contribute in the Energy Efficiency Opportunities (EEO) Program, identified energy-savings opportunities by collecting and analysing energy use in haul trucks. The investigation of the energy efficiency of a haul truck should not be limited to the analysis of vehicle specific parameters. Mining industries can often find greater benefits by expanding the analysis to include many other factors that affect the amount of energy used across the entire fleet, including road gradient and elevation.

As of 2008–09, 40 Australian companies in the mining sector that have contributed to the EEO Program consumed 308 PJ of energy, of which 52.5 PJ was diesel (17%) for haulage and electricity generation. These EEO mining companies had identified 3 PJ (or 6%) worth of savings directly related to diesel use. These companies adopted 66% of these identified savings in diesel use.

Trucks are used in an iron mine to haul overburden and ore from the pit to a dump site, stockpile, or to the next stage of the mining process. Truck utilisation is scheduled in conjunction with that of other mining machinery,
such as diggers, excavators, and loaders, according to the production capacity and site layout. Mining trucks use a significant amount of diesel and are expensive to supply and maintain. Energy use and maintenance costs depend on trucks’ operating procedures. Also, vehicle velocity, cornering speeds, braking patterns, and road surface conditions can affect tyre wear and replacement costs.

Through this study it was identified that the energy costs associated with stopping haul trucks unnecessarily equated to 361 kL (13,935 GJ) of diesel per annum for the Caterpillar 777 fleet and 407 kL (15,710 GJ) of diesel per annum for the Terex 3700 AC fleet for a single stop sign per payload cycle. These two mining trucks use in FMG mines includes the Solomon Project. Also, considerable energy savings through a change to the engine control unit of the haul trucks was identified. Modelling showed a 2.3% reduction in fuel consumption, with an increase in cycle time of 1.8%, resulting in a fleet-wide fuel savings of 232 kL (8,955 GJ) of diesel per annum (Energy Efficiency Opportunities, 2011).

Elevation changes on a specific mine route have been studied and modelled to identify the impact on energy saving. The modeling provides a more consistent measure of true energy performance, enabling the mining company to track energy intensity over time. The Commodore open cut coal mine in South East Queensland has been used as the pilot site for energy efficiency improvements by Downer EDI. The energy intensity of the Commodore mine has improved by 18.2% over five years.
Fig 4.11. Comparison of monthly excavation energy use for three sample mines (Energy Efficiency Opportunities, 2011)

The ‘Best Truck Ratio model’ has been developed to evaluate and benchmark the efficiency of truck operations across a single mine site and multiple operations, where the nature of the work undertaken varied greatly. This model provides an indication of how efficient the fleet is in comparison with what is practically and realistically possible. It is providing a robust analytical tool which Leighton is using to support decision-making processes.

Fig 4.12. Optimising payload and truck selection using the Leighton contractors best truck ratio (Energy Efficiency Opportunities, 2011)
Conclusion
Fortescue has already identified and quantified the energy costs associated with stopping haul trucks unnecessarily. Also, energy saving through a change to the engine control unit of the haul trucks has already been found by Fortescue. The additional energy saving opportunities in haul trucks are identified using the Best Truck Ratio model to evaluate and benchmark the efficiency of fleet operations across the mining site and develop performance indicators for tracking energy intensity over time.

The SD Balance Sheet™ for haul trucks energy saving option was generated as follows:

**Financial Capital:** As of 2008–09, 17% of energy used by Australian mining companies that have contributed to the EEO Program was in the form of diesel for haulage and electricity generation. Energy saving that causes less diesel consumption has a moderate positive impact on financial capital.

**Manufacturing Capital:** Reduction in diesel consumption causes a decrease in greenhouse gas emissions and enhances eco-efficiency. Fuel consumption reduction has been considered as a moderate positive impact on manufacturing capital.

**Social Capital:** Opportunities regarding the energy saving in haul trucks do not have any considerable impact on social capital.

**Human Capital:** Opportunities regarding the energy saving in haul trucks does not have any considerable impact on human capital. Because of less greenhouse gas emission, it might help to increase employees health and safety, but this impact can be considered negligible.

**Natural Capital:** Energy saving reduces negative environmental impacts. Minor positive impacts on natural capital considered.
4.6.2 Switching from diesel to gas power generation

Fortescue Metals Group intends to supply the power for the Solomon Hub from 85 MW dual fuel power. The power station is being designed to operate on both diesel and gas. This section discusses the advantages of switching from diesel to gas power generation.

There are a couple of reasons why gas conversion in this project can improve the sustainability parameters. Although normally in the majority of cases the main driver for converting to gas is significant emission reduction, the consequentially reduced fees, and the reductions in fuel costs cannot be simply ignored. While the use of natural gas does have environmental consequences as a fossil fuel, it is attractive because it is relatively clean-burning.

Benefits of using gas as a fuel for power generation have been indicated below:

**Pricing**

There is considerable price difference between natural gas and oil that often makes gas an attractive alternative. Nevertheless, the cost of providing the fuel is not limited only to the fuel price. In remote areas cost of construction of infrastructures for gas transmission and distribution should always be considered. FMG needs to build a gas pipeline for this purpose; this will cost approximately A$180m.

“Fortescue is the world’s fourth largest producer of iron ore and a significant energy user. At its current production capacity of 155 million tonnes a year, Fortescue has forecast energy costs of more than US$800 million in FY15. Deloitte Access Economics found the strict implementation of the retention lease policy guidelines should lead to a drop in the long term domestic gas price of A$3.20/Gigajoule by 2020 and A$5.74 by 2025” (Fortescue Metals Group Limited, 2014). It is expected that by switching from diesel to gas power
generation, FMG is able to save A$20m per annum. Considering the Solomon Iron Ore Mine life that is at least 20 years, by switching from diesel to gas FMG can save A$400m during the production period.

Another financial advantage of switching to gas is maintenance cost. Gas fuelled engines with cleaner combustion means lower maintenance costs than with other fuels (Wärtsilä Corporation, 2013).

The cleanest fossil fuel
Decrease of greenhouse gas emission is a concern in all industrial projects. Natural gas is seen by many as an important fuel in initiatives to address environmental concerns. Natural gas is one of the cleanest burning alternative fuels available. The combustion of natural gas releases virtually no sulphur dioxide and ash or particulate matter and very small amounts of nitrogen oxides (NO\textsubscript{x}). Natural gas emits 22% less carbon dioxide than oil and 40% less than coal. NO\textsubscript{x} is reduced by more than 90% and SO\textsubscript{x} by more than 95% (Wärtsilä Corporation, 2013)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Natural Gas</th>
<th>Oil</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>117,000</td>
<td>164,000</td>
<td>208,000</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>40</td>
<td>33</td>
<td>208</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>92</td>
<td>448</td>
<td>457</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>1</td>
<td>1,122</td>
<td>2,591</td>
</tr>
<tr>
<td>Particulates</td>
<td>7</td>
<td>84</td>
<td>2,744</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.000</td>
<td>0.007</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Table 4.6. Fossil fuel emission levels — pounds per billion Btu of energy input (Energy Information Administration, 1999)

Availability
Australia has significant gas resources and there are plentiful reserves of gas in Western Australia to meet both projected domestic and LNG export demand for the foreseeable future.

“In 2008, Australia’s economic demonstrated resources (EDR) and subeconimic demonstrated resources (SDR) of conventional gas were estimated at 180 400 Petajoules (164 tcf). At current production rates there are sufficient EDR (122 100 PJ, 111 tcf) of conventional gas to last another 63 years” (Australian Bureau of Agricultural and Resource Economics and Sciences, 2008).
Conclusion

Fortescue has shown that it has a plan for switching from diesel to gas power generation in the long term. However, no time frame has been indicated for this change. This section aims to demonstrate positive and negative impacts of switching from diesel to gas power with numbers. It was identified that this opportunity has considerable positive impact.

SD Balance Sheet™ for power generation option is generated as follows:

**Financial Capital:** By switching from diesel to gas power generation, FMG is able to save A$20m per annum. Considering that the Solomon Iron Ore Mine life is at least 20 years, by switching from diesel to gas FMG can save A$400m during production period. This has significant positive impact on financial capital.

**Manufacturing Capital:** Switching from diesel to natural gas for power generation causes a decrease in greenhouse gas emissions and enhances eco-efficiency. Also, there will be opportunity for shared use of infrastructure for the natural gas transmission and distribution. This is considered a significant positive impact on manufacturing capital.

**Social Capital:** Switching from diesel to gas power generation enhances infrastructure and provides benefit to the local community. This has a moderate positive impact on social capital.

**Human Capital:** Less carbon dioxide, NO\textsubscript{x}, and SO\textsubscript{x} emission can increase the health and safety of employees. This has a moderate positive impact on human capital.

**Natural Capital:** Switching from diesel to gas power generation reduces negative environmental impacts. This can change the moderate negative impact on natural capital to minor negative impact.

*Fig 4.17. SD Balance Sheet™ power generation option*
4.6.3 Positive relationships between FMG and local communities

“Increasingly, local communities expect that companies will avoid social harm, minimise adverse impacts, maximise benefits and respond to their complaints and grievances respectfully and systematically, using processes that the communities know and trust” (Kemp & Gotzmann, 2009).

Contributing to the social, economic, and institutional development of the communities in which mining companies operate is one of the principles that ICMM has addressed in 10 sustainable development principles. This principle has been defined with the measures below.

- “engage at the earliest practical stage with likely affected parties to discuss and respond to issues and conflicts concerning the management of social impacts
- ensure that appropriate systems are in place for ongoing interaction with affected parties, making sure that minorities and other marginalized groups have equitable and culturally appropriate means of engagement
- contribute to community development from project development through closure in collaboration with host communities and their representatives
- encourage partnerships with governments and non-governmental organizations to ensure that programs (such as community health, education, local business development) are well designed and effectively delivered
- enhance social and economic development by seeking opportunities to address poverty” (International Council on Mining and Metals, 2003)

Fortescue Metals Group has access to a massive chunk of land in Western Australia that is mineral rich. Part of the Solomon Project mining land belongs to Aboriginals called Yindjibarndi people in Western Australia. Yindjibarndi people effectively hold Native Title rights to the land in question. They have been involved in negotiation with FMG for a long time to agree on a compensation package that could make both the company and the local community rich.

“In mining terms it’s called Solomon Hub, a body of land 200 kilometres south of Roebourne on the north-west coast of Western Australia. It’s estimated the land holds iron ore worth $280 billion dollars at current prices (2011). Over the next 40 years FMG is hoping to scrape some 2.4 billion tonnes of ore from the land. The infrastructure and people that come with this type of development will inevitably reduce much of the country to an industrial landscape” (Australian Broadcasting Corporation, 2011).

Yindjibarndi people, or at least a large number of them, believe that the land use ‘agreement’ FMG offer requires the Yindjibarndi to waive their Native Title Rights and provide approval for mining activities FMG wants to undertake on sacred Yindjibarndi land. They believe the offered compensation is radically below the level that generally is offered to traditional owners by other mining companies operating in the Pilbara region. (Yindjibarndi Aboriginal Corporation, 2011). The Western Australian Pilbara is an expansive region, rich in Aboriginal tradition. This is the spiritual homeland of the Aboriginals, including Yindjibarndi people, the heart of their culture and religion. Aborigines have lived and died in this country for more than 35,000 years (Mayman, 2011). The Yindjibarndi people won a 10-year fight for native title recognition over the northern section of their land in 2005, after proving their unbroken cultural connection to the land. FMG has applied for 43 exploration licences, 4 mining leases, and more than 100 miscellaneous licences in Yindjibarndi Country, covering half of the 13,000 sq km of Yindjibarndi land (Indigenous Peoples Issues and Resources, 2011).

The negotiations between the Yindjibarndi Aboriginal Corporation and FMG over access to land for mining began in 2007. The Yindjibarndi requested a 5% royalty, then worth an estimated $150 million a year. Then they offered a compromise of a 2.5% royalty, but FMG insisted that any royalty be capped at a maximum of $2.8 million a year, and FMG would spend an extra $2 million on training future Indigenous workers. “FMG the latest offer was a $500,000 signing fee, a fixed or capped $4 million a year in cash, plus up to $6.5 million a
year in staff housing, jobs, training and business opportunities. This is in return for allowing all future mining activity on all Yindjibarndi land” (Australian Broadcasting Corporation, 2011).

Almost at the same time Rio Tinto reached an agreement with Pilbara indigenous groups that will deliver jobs and economic development benefits while enabling the company to rapidly expand mining operations in the region. The estimated value of this agreement could be $2 billion over the next 40 years. Also, the other giant mining company BHP is believed to be offering a broadly similar 0.5% deal in its native title negotiations, though it has a floor as well as a ceiling, with comparable economic benefits. FMG aims to be the lowest cost producer and has consistently paid fixed dollar compensation well below this share, arguing that such deals amount to “mining welfare” (Cleary, 2011).

**Conclusion**

Many Yindjibarndi live in the town of Roebourne, located north of their traditional country. The town has approximately 1100 residents; almost 75% of them are Aboriginal. The unemployment rate in this city is high, and the local prison is overcrowded. FMG committed to train Aboriginals for working in the Solomon Project. This could be mutually beneficial for FMG and local communities. It can reduce FIFO and empower the local economy, but Yindjibarndi want a fair share in the mineral wealth of their traditional country, to create their own businesses and jobs. This way they will not be dependent completely on the mining company and can sustainably develop the infrastructure for the community and the next generation even after stopping mining activities in this region. To reach an agreement that keeps both sides happy can accelerate FMG activities in this Solomon Hub and has a direct positive impact on social and human capitals.

SD Balance Sheet™ for the relation between FMG and local communities option generated as follows:

**Financial Capital:** This is an opportunity that delivers greater and wider benefits to all stakeholders and establishes more positive relationships with stakeholders. While increasing wealth in the local community, FMG operation costs can be reduced by decreasing FIFO and using skilled local labour. Also, positive relations with local communities enhance the corporation reputation, which is a valuable asset. This has medium positive impact on financial capital.

**Manufacturing Capital:** This opportunity does not have any considerable impact on manufacturing capital.

**Social Capital:** This provides benefits to the local community, and sustainability empowers local businesses. This has high positive impact on social capital.

**Human Capital:** This opportunity increases local employment. Also, it improves training, skills development and life long learning, and capture and sharing knowledge. This has significant positive impact on human capital.

**Natural Capital:** This opportunity does not have any considerable impact on natural capital.
4.6.4 Ecovillage concept for building the accommodation camp

Over the last decades, the Australian mining and resource sectors have experienced rapid growth, which has created employment opportunities in remote Australia. This large-scaled fly-in/fly-out (FIFO) or drive-in/drive-out (DIDO) workforce phenomenon has put great pressure on local towns in mining areas to respond to the needs of workforce accommodation. In addition, increased mining activities have led to a sharp rise in accommodation demand in both permanent and temporary units close to local towns.

There are different types of non-resident worker accommodation or ‘mining camps’ in forms and scales. They may also include a combination of temporary and permanent housing suitable for singles, couples, or families.

There are some essential public facilities that must be provided on site for workers including dining, laundry, and recreational facilities as well as restaurants available for the general public or just occupants of the accommodation. “Worker accommodation facilities may also vary in terms of the intended period of operation, for example, from one to five to ten years or more, depending on whether the facilities cater for construction or operational workforces” (The State of Queensland, 2014).

The quality of worker accommodation may have both positive and negative impacts on local communities. The quality of buildings, their integration with the existing building form in the town, “provision of services and facilities that compete with those provided in the town, or conversely excessive demands being placed on the town’s existing services and facilities are some of the perceptions commonly associated with non-resident worker accommodation facilities” (The State of Queensland, 2014).

However, the traditional non-resident worker accommodation development, as the base of many mining communities, is not an efficient and sustainable long-term option for vibrant modern communities. In non-resident worker accommodation development, consideration of more cost-effective and sustainable principles in the form of an ecovillage may be appropriate with the aim of high-quality achievement.
Ecovillage was defined by Gilman (1991) as: “human-scale full-featured settlement in which human activities are harmlessly integrated into the natural world in a way that is supportive of healthy human development, and can be successfully continued into the indefinite future”.

It is a small community, 500–1000 persons, in which people know each other and are able to influence the community’s decision making (Gilman, 1991). In his eco-village definition, Gilman pointed out a “full featured settlement”, which means all the main functions of people living normally, including leisure, social life, and residence may be in balanced proportions. Most existing human settlements, like urban and suburban, are divided by function, such as residential, shopping, or industrial, etc., which is not sustainable. On the contrary, ecovillages are ideally multifunctioned, where people can live and work in the same area. However, in this mining camp project, since a majority of the residents are mining workers, it may not be defined as multifunctional, as other ecovillages.

One of the most important features of ecovillages is “the ideal of equality between humans and other forms of life, so that humans do not attempt to dominate over nature but rather find their place within it” as well as efficient use of material resources. This approach leads ecovillages to the use of renewable energy resources rather than fossil fuels as well as the composting of organic wastes in order to reduce the negative environmental impact (Gilman, 1991). The last principle of ecovillages and also the sustainable development concept consider today’s world, human, nature, and all future life.

As mentioned before, ecovillage is a traditional community using social, ecological, and cultural dimensions of sustainability to revive and increase social and environmental aspects (Ecovillage, 2014). Therefore, in non-resident worker accommodation as an ecovillage, workers know each other and feel supported by others. As they are small groups, they may feel safe, seen, and heard, and they also participate in making decisions by sharing and expressing their visions and ideas for their own community, even a temporary one.

In terms of ecological principle of sustainability, in ecovillages people will experience their interaction with the earth and nature by protecting nature and wilderness areas. They respect ‘the cycles of nature’ while they provide their daily needs and use a renewable energy system and local material in creating their homes. They also support organic food production, which may not be applicable in this project of a temporary mining camp.

Hågaby: A real-life ecovillage
Hågaby [Hawgabii] is a historical sustainable neighbourhood located west of Uppsala, Sweden, only 4 km from the Uppsala city center. Since 1998, the area was rebuilt using sustainability aspects, and it has become a significant example of an ecovillage with the goal of sustainable development principles achievement (Berg, 2002). In other word, it has been identified as “a place where people live together in a sustainable society and in harmony with nature” (Mikusinska, 2011).

In the renewal process of Hågaby, all the sustainability features, social, economical, and environmental, were considered and applied. “The renewal of Hågaby thus comprises a total of 100 dwelling units aside from the existing 14 old small houses and three smaller farms. In all of Hågaby there are 350 people, including 120 children up to 16 years of age. The renewed or newly built parts are two administratively separate areas, but in practice all their residents belong to the same community or neighbourhood. There are common systems for solar heating, wastewater purification, semi-automatic composting, traffic planning and land use” (Berg, 2002). Hågaby residents also co-operate in a community council by sharing cars, supporting local food, and biodynamic farming to increase the sense of community as well as reducing energy consumption and improving environmental sustainability.
In terms of environmental sustainability, there are two significant features that were considered in the Hågaby rebuild process. The first one is reducing the use of heat, electricity, and water. Currently, in Hågaby the rates of using heat, electricity, and water are lower than Swedish standards as a result of “construction of resource efficient buildings and appliances” (Berg, 2004) such as using extra-insulated walls and windows in building construction to reduce the need of heating during colder months of the year, as “more than half of the total energy consumption in a Swedish household goes to heating” (Mikusinska, 2011). Change of residents’ lifestyles is another important feature that could also decrease the use of resources through social inspiration among neighbours.

The second one is the change from using fossil fuels to renewable energy like solar collectors and wood fuels, which have been gradually used in individual houses since 1998. Furthermore, in 2002, 85% of the people started using ethanol fuel for running their cars (Berg, 2004).

There are other elements in the Hågaby neighbourhood that increase people’s interaction towards more social sustainability issues such as office space, a convenience store, a private elementary school, all within a five-minute walk from houses, as well as an organic restaurant and a public place with a local stage for special events and local concerts where people watch, meet others, talk, and share their visions to increase their sense of community and improve the quality of their neighbourhood as well (Ecoregion Project, 2011).

In reality, life in an ecovillage like Hågaby is comfortable and attractive; but there are still many challenges that residents are facing every day to become an entirely sustainable community.

**SomerVille: first ecovillage in Perth**

SomerVille Ecovillage is located in Childlow in the Perth Hills in Western Australia, which has been known as the first ecovillage in West of Australia. The land (399 acres) was purchased in 2002, and rezoning of it was achieved in 2007 (SomerVille Ecovillage, 2009).

The ecovillage layout is community centered, with all facilities and public services located within five minutes walking distance from houses, which makes the village center pedestrianized and reduces the need of using cars (SomerVille Ecovillage, 2014).
This is a community-based project that is built on the basis of three pillars (environmental, economic and social) of the sustainable development concept. The SomerVille Vision is “A vibrant village where community flourishes, in which every person is supported and contributes in balance with a sustainable ecological ethic” (SomerVille Ecovillage, 2009).

Using natural resources like solar or wind for power generation and installing water collectors to provide water are important factors which were considered in the SomerVille development. As Mr. Carlino, Director at ecovillage developer Greenedge Projects, said “Environmentally, the installation of solar panels and 60,000L rainwater tanks at every home, and design guidelines ensuring that each house will attain a thermal performance rating of at least seven stars are just the beginning of the environmental measures being implemented at SomerVille” (Green Magazine, 2007). The SomerVille project also considers and encourages community engagement as fundamental. It aims to develop a community where people are inspired to actively participate in the visioning, planning, decision making, and governance of their community. It has also provided facilities and spaces that promote the people’s interaction. “This includes facilities such as community buildings, amphitheatres, children's playgrounds, quiet spaces, and natural and garden settings that encourage the link between people and nature, all the time respecting privacy, yet promoting healthy community interaction” (SomerVille Ecovillage, 2014).

Creating a significant number of long-term direct and indirect jobs within the community was another achievement of the SomerVille project from an economic point of view. As Mr. Carlino points out “Much of this work will come through the SomerVille Enterprise Champion Program, which assists budding entrepreneurs to establish businesses in fields like education, health and wellbeing, IT and media and community supported agriculture” (SomerVille Ecovillage, 2009).

The Solomon Project may require both temporary accommodation for the construction phase and permanent accommodation and facilities to support the operation phase for approximately 1500 people. Analyzing the project conditions and comparing with similar projects like Crosslands Jack Hills Expansion Project (JHEP) in the Murchison Region, Western Australia, shows that there are many opportunities for good environmental practices, including energy usage, water saving, and waste management in a cost effective way for the proposed ecovillage.
According to JHEP, “maximum economic savings can be expected from reductions in energy use. Particular attention should be given to ‘Energy’ and the ‘Building Materials and Design’ areas of investigation. Maximum localized environmental savings can be expected from the implementation of ‘Water’ and the ‘Waste’ areas of investigation” (Lisle & Sim, 2010).

In this project, four areas will be investigated, including energy, water, waste and building material, with the goal of creating a cost-effective and resource-efficient ecovillage, which provides safe, pleasant, and durable accommodation for workers.

Regarding Environmental Sustainable Development (ESD), the following design principles will be considered:

1. Building orientation to maximize the use of wind and sunlight for natural ventilation and lighting
2. Efficient insulation and seals for floors, walls, and roofs, of building to save energy and minimize heat transfer between the inside and outside of buildings
3. Use of external shading devices to control direct sunlight
4. Use of energy efficient lighting and HVAC plants and equipment
5. Use of solar energy and solar hot water systems
6. Native flora landscaping located to provide shade to building exteriors to control direct sunlight (Lisle & Sim, 2010)
7. Energy

Increasing energy consumption has significant environmental impact, which leads to resource depletion and greenhouse gas emission. Thus, this section suggests a range of energy alternatives and technologies to decrease the use of energy and associated production costs.

**Installation of renewable energy technologies**

Using renewable energy sources could minimize GHG emission, a noticeable contributor to climate change phenomenon. The figures in Table 4.7 show that GHG emission would be drastically reduced by using more renewable energy rather than fossil fuels. Therefore, the installation of renewable energy technologies could be considered as clean and green energy provider, which will be more common and efficient energy sources in the future. Use of renewable energy will also decrease the amount of natural gas consumption and preserve it for future generations; this aligns with the sustainable development concept.

<table>
<thead>
<tr>
<th>Power Generation</th>
<th>Grams CO\textsubscript{2} (eq)/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>&gt; 960</td>
</tr>
<tr>
<td>Diesel</td>
<td>&gt; 778</td>
</tr>
<tr>
<td>Natural gas</td>
<td>&gt; 400-600</td>
</tr>
<tr>
<td>Solar</td>
<td>&gt; 25–32</td>
</tr>
<tr>
<td>Wind</td>
<td>&gt; 11</td>
</tr>
<tr>
<td>Bio-waste</td>
<td>&gt; 11</td>
</tr>
</tbody>
</table>

*Table 4.7. Lifecycle greenhouse gas emissions estimates for power generation technologies (Lisle & Sim, 2010)*

In this project, two renewable energy alternatives, solar and wind, will be analyzed. The calculations for renewable energy are “based on the peak energy requirements of 2.1MW” in a similar project, the JHEP in the Murchison Region, Western Australia. It should be considered that “economies of scale will reduce the required capacity of energy generation, particularly with the installation of energy efficient appliances and building design optimization” (Lisle & Sim, 2010).

**Solar energy**

Solar energy is the most abundant energy resource on Earth and may be used in most regions of the world, e.g., north and sub-Saharan Africa and the Middle East. In addition, according to the second edition of *Australian Energy Resource Assessment* (Geoscience Australia, 2014), “Australia has one of the highest average solar radiation per square meter of any continent in the world.” The use of solar energy has risen significantly in the
world in recent years specifically in the United States, China and some of the European countries. “Total solar energy capacity grew by 73.3 per cent from 2007 to 2011 to 63.4 gigawatts (GW). In 2012, solar energy capacity rose to 104 GW” (Geoscience Australia, 2014).

Figure 4.21 shows that in the northwest and center of Australia solar energy resources are greater in areas that do not have access to the national electricity grid (Geoscience Australia, 2014).

Solar energy is generated from sunlight, so solar radiation is not consistent because of daily and seasonal variation. Yet the correlation between solar radiation and daytime peak electricity requirements means that solar energy has the strong potential to generate electricity during peak demand times.

There are different solar energy technologies, including rooftop solar photovoltaic systems and direct-use solar water heaters, which are considered as developed technologies at a small scale. Solar panels are usually installed on roofs or places that have the most sun exposure with a particular angle to ensure that “the glass face of the modules is positioned at 90 degrees to the sun for most of the day” (Lisle & Sim, 2010). The solar panels capture energy from the sun and turn it into DC power and then into AC power through the inverter and can be used in everyday operations of the village. Solar cells lose their efficiency over time; however, they are sold with a 25-year performance guarantee which points out that the cell will have 85% efficiency after 25 years.

Photovoltaic (PV) systems are “well suited to off-grid electricity generation applications” and where costs of electricity generation from other sources are high (such as in remote communities). In some areas, such as the
Pilbara region of Western Australia, solar PV is either at or approaching parity with diesel for off-grid energy supply (Geoscience Australia, 2014).

Research shows that solar photovoltaic systems have increased “in Australia from 100 megawatt capacity in 2008 to about 2 gigawatt of capacity in 2012” (Geoscience Australia, 2014). This significant rise is the result of reducing costs for photovoltaic panels, making the panels increasingly economical for many household and off-grid installations. As the Crosslands Jack Hills Expansion Project (JHEP) analyses says regarding the Midwest solar farm information southeast of Geraldton, “the installation of a single panel costs roughly AU$1,450. It is expected that the solar panels will produce 28 million kWh/year” (Lisle & Sim, 2010).

As mentioned above, interest in using the solar resource and solar technologies has increased recently in the Pilbara; despite there being no immediate plan for the large-scale investment.

**Wind energy**

Wind is another renewable energy source that is generated by atmospheric changes (temperature and pressure variability) making air move around the surface of the earth, which is caused by the sun. A wind turbine built of three propeller-like blades is called a rotor. “Wind energy is generated by converting wind currents into other forms of energy using wind turbines (Figure 4.23). Turbines extract energy from the passing air by converting kinetic energy from rotational movement via a rotor. The effectiveness of this conversion at any given site is commonly measured by its energy density or, alternatively, as a capacity factor” (Geoscience Australia, 2014). In order to capture the stronger winds, wind rotors are located on towers of almost 20 m. The lifetime of these structures is approximately 30 years (Lisle & Sim, 2010).

![Fig 4.23. A wind turbine (Geoscience Australia, 2014)](image)

Australia has some of the world’s best wind resources. Regarding the second edition of *Australian Energy Resource Assessment* (Geoscience Australia, 2014), “Wind energy is the fastest growing renewable energy source for electricity generation in Australia, increasing at an average annual rate of 35.9 per cent between 1999–2000 and 2011–12”.

In 2010, 1.6% of the world’s electricity generation was supplied through wind farms. This figure increased to 3.1% in 2011 owing to environmental issues as well as the simplicity of its technology. Wind farm greenhouse gas emission is also negligible, compared to fossil fuels (Geoscience Australia, 2014). However, wind energy is not as common as other renewable sources like solar energy, since it is not well known and understood.
Near the Pilbara coast in some certain locations wind speed is about 9 m/s at 80 m (Evans and Peck, 2011). This is more than the speed required for wind turbines to operate (5 m/s) (Lisle & Sim, 2010). Although in the Pilbara coast region wind has an extreme speed during cyclone events, when the distance between the project location and a suitable location for constructing the wind farm on a large scale — Pilbara coast — is considered, this solution does not look applicable. However, using some wind turbines in very limited numbers for some applications such as an ecovillage can be considered.

Bio-energy

Bio-energy is another source of energy; it is the use of biological-based resources for electricity or heat generation. Here, in this section, all of the bio-energy resources with details and technologies will not be covered, but just a brief overview will be given.

1. Bio-gas: Currently, bio-gas supplies almost 6% of Australia’s bio-energy use. It is “the use of off-gases from anaerobic digestion processes such as municipal land-fill, waste water treatment works and animal feed-lots for the creation of electricity or heat” (Evans and Peck, 2011)
2. Bio-fuels: these account for approximately 2% of Australia’s bio-energy use. Bio-fuels (fuels produced from living organisms) are a great replacement for liquid hydrocarbons (e.g., for transport fuels).
3. Bio-mass: Bio-mass is fuel from wood or plant material grown for a certain purpose such as energy production or “waste from another process (bagasse from sugar production, residue tree material from timber production or direct use of municipal waste are examples)”. It accounts for 92% of Australia’s bio-energy use (Evans and Peck, 2011).

Although bio-energy is considered as a renewable energy resource and sustainable, it could be unsustainable if bio-energy is produced from non-sustainable resources such as “old-growth forest, or results in deforestation, such as when planting of specific crops such as for palm oil, or where the resource impacts on human food production” (Evans and Peck, 2011). Thus, in this project bio-energy is not considered as a primary source of energy because of low rainfall and general lack of water.

In this section, only solar and wind energy resources are considered in small scale, just for an ecovillage, with the aim of being sustainable in energy production from renewable resources. The Pilbara is a complex energy area and also has excellent potential for using renewable energy such as solar, wind, bio-energy, and geothermal that should be acknowledged.

Conclusion

FMG has not shown any plan for using an ecovillage opportunity in this Solomon Project. Using the ecovillage concept can maximise economic saving by reduction in energy use during the construction and operation phases of the Solomon Project. Also, this will decrease adverse environmental impacts. Using this concept in design and construction of the accommodation camp will allow FIFO labour to live normally, with leisure, social life, and residence in balanced proportions.

SD Balance Sheet™ for accommodation camp option generated as follows:

Financial Capital: Using renewable sources and reduction in energy use can maximise economic saving. This has moderate positive impact on financial capital.

Manufacturing Capital: Ecovillage concept significantly enhances eco-efficiency (zero waste and zero emissions). It has significant positive impact on manufacturing capital.

Social Capital: This concept can improve communication between the camp residents. Also, the ecovillage concept can be used in local communities’ residential areas. This has moderate positive impact on social capital.

Human Capital: This opportunity increases health, safety, and wellbeing of residents. FIFO employees spend a long time in accommodation camps, and the ecovillage concept can provide better balance in their lives. This has significant positive impact on human capital.
Natural Capital: The ecovillage concept can significantly decrease the adverse environmental impacts of an accommodation camp.

5 Conclusions

As the sustainability concept is being adopted by mining companies this means these companies need to incorporate this concept into decision-making processes and operational activities. There is a missing link between the sustainable development concept that has been developed during the past decades and the mining industry. An appropriate tool is required for integrating the concept to an industrial project. The SUSOP® Framework has been developed to act as a link between the sustainability concept and mining projects. The framework has been designed as a procedure with defined steps that assists the stakeholders to identify opportunities and risks, analyse the identified items, and incorporate the opportunities into the project to mitigate or minimise the identified risks. It is critical for the mining companies to understand the links between financial results and the sustainability concept that effectively contributes to long- and short-term business success. Companies need to acting proactively in sustainability matters. This should be done as early as possible in the project life cycle.

SUSOP® Framework has already been applied in many projects, and the robustness of it has been tested. This study applied this framework retrospectively without workshop elements for integrating sustainability concepts into the Solomon Iron Ore Project. There were two main goals from this case study:

- Testing the robustness of SUSOP® thorough offline analysis by removing the workshop elements from the procedure and relying on public domain information
Revealing additional opportunities and risks that do not appear to have been recognized or mentioned in the public domain information and data that has been supplied on the project.

This case study identified the following opportunities and risks:

**Haul trucks energy saving:** Energy costs associated with stopping haul trucks unnecessarily and through a change to the engine control unit of the haul trucks have already been identified and quantified by Fortescue. The additional energy saving opportunities identified in this case study are modelling the Best Truck Ratio to evaluate and benchmark the efficiency of fleet operations across the mining site and developing performance indicators for tracking energy intensity over time.

**Switching from diesel to gas power generation:** Fortescue has a long-term plan for switching from diesel to gas power generation. However, no time frame has been indicated for this change. This case study showed the positive impacts of switching from diesel to gas power with numerical figures. There is a significant capital cost for enhancing required infrastructures for natural gas transmission and distribution, but this leads to decreasing operating costs.

**Positive relationships between FMG and local communities:** At first glance some identified opportunities in this section might look like additional costs for the mining company that only increase the operating cost and cause the increase of product prices; an example is changing the fixed contract with traditional land owners — local community — to an uncapped contract. It is vital for the mining companies to be open to new ideas and change the risk of conflicts with local communities to new opportunities. As CEO Anglo American chief executive, Mark Cutifani, says, “The simple fact is: in today’s world if we don’t bring people with us and if the majority of those living in host communities don’t benefit from our presence we won’t be allowed to mine” (Skoldeberg et al., 2013). Mining companies that operate in remote areas can decrease the operational cost by supplying the work force locally and thus reducing FIFO, which leads to cost reduction. Also, positive relations with local communities enhance the corporation’s reputation — a valuable asset.

**Using the ecovillage concept for accommodation camps:** It was recognised that some ideas that have been less known in the Australia mining industry can make a big change, e.g., the ecovillage concept in designing accommodation camps. This concept can decrease energy consumption and is financially beneficial. On the other hand this concept significantly decreases the adverse impacts on the environment and can improve the social life of workers who live in the accommodation camp far from their families.

The outcomes of conducting this case study were reviewed and compared with typical outcomes of SUSOP® case studies which included conducting workshops. Strengths and weaknesses of applying the framework without the workshop element were identified as follows:

**Strengths**
- Conducting the case study remotely without any need to communicate with the project stakeholders saves time and reduces costs
- There is no pressure from the project stakeholders to consider an opportunity or risk as important or unimportant
- Reviewing and analysing some opportunities and risks that might not be considered important or achievable from the project team perspective such as more positive dialogue with local communities or using a new and sustainable architectural concept in building the accommodation camp

**Weaknesses**
- A small number of identified opportunities and risks compared to case studies conducted with a workshop. However, this study did not aim to identify all opportunities and risks, but the ones that have not been recognized or mentioned in the public domain information may be omitted
- One person will not have the collective knowledge and experience of a group, and therefore the identified opportunities will be more limited
It is not possible to find some critical data in the public domain information. Project data are confidential and are not available, so in many cases assumptions decrease the accuracy of analysis.

Using SUSOP® without the workshop element isolates the practitioner from the stakeholders. The main impact of this change would be lack of enough data for identifying opportunities and risks. To overcome this weakness, the following methods are recommended:

- Contributing a small group of people with technically diverse backgrounds to identify and analyse the opportunities and risks
- Gathering data through sending questionnaires to project stakeholders, which helps to identify more opportunities and risks that have not been reflected in public media
- Conducting offline interviews with project stakeholders to reveal more opportunities and risks
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