Course: MSc Engineering Project Management

Module: ACEA7008 MSc Lean and Agile Operations.

Assignment: Materials Handling Evaluation for Company Operations

University number: 1809810

Date submitted: 21/12/23

Word count: TBA

Contents

1. Executive Summary 5

2. Introduction 6

3. Material Handling Considerations 7

4. Material Handling Solutions 8
4.1. Train Line 11
4.2. Coal Log Pipeline 12
4.3. Conveyor Belt 12

5. Evaluation of Solutions 14
5.1. Train Line Evaluation 14
5.2. Log Pipeline Evaluation 15

6. Procurement Considerations 17

7. Conclusion & Recommendations 19

8. References 20

Table of Figures

Figure 1 - Deep Mine Extraction Methods 9
Figure 2 – Coal Transport by Rail 11
Figure 3 – Coal Log Pipeline 12
Figure 4 – Coal Conveyor Belt 13
Figure 5 - Circular Economy 17

Table of Tables

Table 1 – Train Line SWOT Analysis 14
Table 2 - Coal Log Pipeline SWOT Analysis 15
Table 3 - Conveyor Belt SWOT Analysis 16

1. Executive Summary

In the absence of significant developments in blast furnace development, coal coke mining remains a crucial part of steel making in the UK. Deep coal mining, involving extraction and transportation, however, carries with it several challenges, not limited to environmental impact, social impact and health and safety concerns.

Such challenges were evident in the scenario presented, where a new deep-coal mine, despite being subject to a successful planning application, had several constraints imposed relating predominately to minimising environmental and social impact. The most stringent of these related to transportation of the coal from the mine to the steel plant, two miles away, which was not permitted to utilise public roads, whilst ensuring that any methods used also minimised visual and audible intrusiveness to the surrounding area.

To optimise coal extraction and transport and ensure efficient, cost effective and safe operation is achieved, specific considerations around material handling must also be made. Coat dust generation is a particular challenge on several levels, resulting in product loss, negative environmental impact and health and safety risks, however simple solutions such as use of water to prevent generation result in increased costs and new environmental pressures. Choice therefore of extraction and transport method with such considerations in mind prove key to meeting the industry needs whilst meeting planning constraints. Although number of deep-mine shaft methods can be used, shaft or slope method was recommended in this instance with the knowledge that the are visually more aesthetically pleasing. Extraction methods were limited to soft-rock extraction using either Room and Pillar or Long Wall methods, however it was the decision over the transportation of the coal to the end-user, the steel plant, that presented the biggest challenge. A SWOT analysis was undertaken to assess potential transport methods. Despite rail being the most used transport method, this would be visually intrusive and require significant water usage to reduce dust generation, particularly on loading. Coal log pipeline offered a more novel approach, with the added benefit of being visually optimal as pipelines would be buried, however as with trainlines, high water usage is required to enable smooth flow of the material and subsequent drying on arrival at the steel plant. The overheads and additional pressure on an essential commodity are considerable. After considerable review of the advantages and disadvantages, the recommended transport method was by conveyer belt which due to its design and adaptability, it is capable of traversing various terrains with minimal impact on the local environment compared to other material handling solutions. Use of covers and enclosures would further reduce visual intrusiveness on the local environment. As part of the decision making process, an optimal procurement strategy must be adopted to ensure reliability, financial sustainability, and compliance with an ethical business approach.

2. Introduction

Coal mining is currently an essential pre-requisite for steel manufacture, the carbon required for steelmaking generated from the mining of 'coking' coal. The steel industry however is under significant scrutiny and pressure to demonstrate sustainable development plans with the current drive for decarbonization and the knowledge that coking coal mines significantly contribute to global warming because of methane emission. The challenges facing the coal industry do not end there, with the environmental, both form a visual and audible perspective, and social impacts being subject to several standards and regulations, in addition to the known health and safety risks associated with coal extraction which remain relatively unchanged. Despite this, with the predicted increase in steel demand and associated need for iron ore, there remains a need for large-scale mines. Companies need to therefore need to place greater consideration on providing mining operations and systems that remain cost-effective, providing efficient methods of extraction and transport, that also minimise environmental impact and risk of associated environmental degradation, along with managing direct risks that mining coal presents, all whilst remaining compliant with stringent regulations and restrictions imposed.

The following study reviews various considerations for the implementation of a new deep coal mine that has been subject to several planning constraints as part of local authority approval, the most stringent relating to the transportation of coal from the mine to the local steel plant, two miles away. This planning caveat has restricted the transportation in an attempt to minimise any environmental impact; preventing the use of public roads, whilst stipulating visual and sound intrusiveness to the surrounding area must be minimised. 266

3. Material Handling Considerations

Material handling is a crucial consideration for various industries, particularly the coal mining industry. Effective material handling can improve efficiency, reduce costs, improve safety, and optimise operations. The handling of coal products is no different, having its own unique factors to consider. Maintaining a safe working environment whist complying with the necessary regulatory requirements is critical, and whilst safety standards of coal mines are in general known to be high, operators are subject to stringent requirements and standards. Focus on maintaining a low environmental impact is a requirement from regulatory and public standing. Advancement in material handling technology with regards to carbon capture storage and flue gas desulfurization, allow for industries such as coal mining to achieve this, offering reduced environmental impact whilst complying with stringent industry regulations. (Cielec, 2017)

Coal dust is a frequent challenge; in addition to product loss, coal dust can be a hazard for the working environment, causing safety concerns and air pollution. Ensuring dust is controlled is therefore a key objective (Baxter, 2023). With coal dust build up being particularly vulnerable to spontaneous combustion, it represents a significant fire hazard, and therefore the coal handling systems must be designed with minimising dust as one of its key safety features in mind (Young, 2023). Risk of fire, however, is not limited to generation of coal dust, with further risk presented during storage because of coal oxidation. Suitable operational procedures can minimise this risk dictating actions such as regular inventory turnover, as can the use of certain chemicals to reduce the risk of spontaneous combustion. Several methods for detecting oxidation in coal can aid early intervention, the most effective proven to be carbon monoxide detection. This method offers a fast and reliable detection of oxidising coal, as the oxidising process produces large volumes of carbon monoxide which a precursor to fire. (Amtek, 2018)

Although ensuring sufficient moisture content is required to suppress the formation of coal, this feature forms an important consideration in the design and selection of the material handling system. Moisture content of the coal will influence to the quantity of coal the system can withstand, influencing mechanical and structural components chosen. Close regulation of the moisture content is therefore required to provide sufficient protection from coal dust whilst reducing material weight and preventing sticking in the processing areas (Baxter, 2023).

Product throughput: the quantity of coal anticipated to be extracted, processed, and transported is a key consideration for the type of material handling and storage capacity required. Furthermore, addressing issues

such as equipment efficiency, energy efficiency, product quality, product demand and forecasting, can enhance product throughput, improve operational efficiency and better meet market demands. (Pryor, 2021)

4. Material Handling Solutions

Underground mining, also known as deep mining, is categorised based on the type of shaft used, the extraction technique and the process used to access the coal deposits (Smith, 2019). Shaft methods include: Drift Mining, where a horizontal tunnel is dug into a mountain or hillside; Slope Mining, where a tunnel is excavated at a downward angle, typically carried out when it is too dangerous to dig straight down; and finally Shaft Mine, where a vertical shaft is excavated or sunk to the coal seam from the surface (American Mine Services, 2023). Given the planning restraints set by the local authorities, the mine in question is likely to be slope or shaft mine as these mining methods are less visually intrusive.

Several extraction methods can be used depending on the mineral composition. For hard rock mining, a Block Caving Mining method can be used. This involves drilling a section below the bottom of the deposit where explosives can then be placed and detonated, causing the mineral deposit to collapse. For soft rock mining, of which coal is classed as, mining methods used can include Room-and-Pillar Mining, where pillars are constructed within the mine to support the structural its integrity while the surrounding material is extracted. This mining method typically results in 75% of mineral extraction. Another soft rock mining method is Long Wall Mining, a near fully automated system where a shearer is attached to a self-advancing roof and conveyor system, that will extract and transport the coal whilst maintaining the structural integrity of the mine. This method typically results in 90% of mineral extraction, however, due to installation of temporary structural supports which are later removed, it is more prone to surface subsidence following mineral extraction. (Planete Energies, 2015) (American Mine Services, 2023)

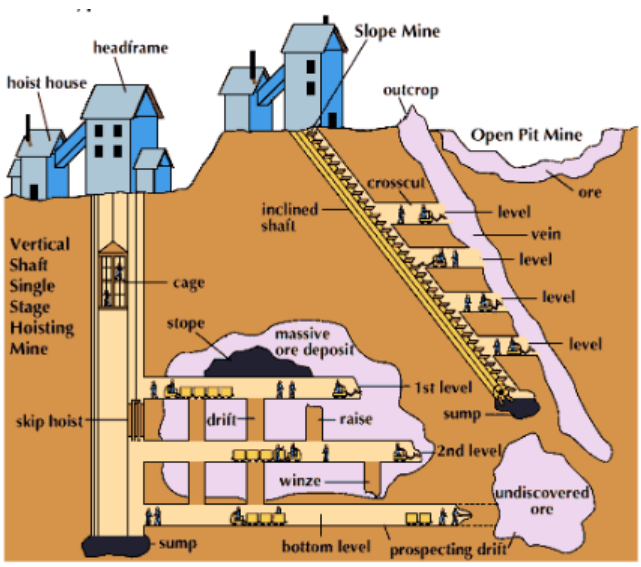

Figure 1 - Deep Mine Extraction Methods

(Britannica, 2023)

Typically for both mining methods, conveyors or railway cars will transport the coal from the coal seam to the extraction area, however as technological advancements have been made, a conveyor belt system is the most suitable and efficient method. Removing coal from the extraction area will differ for both mining methods. For slope mining, conveyors will continue to remove the coal from the mine to the surface and to the processing area, whereas for shaft mining, the coal will be extracted to the surface by use of a coal lift where it will be transported to the coal processing area. (Vega, 2023)

Prior to being stored or transported the coal will need to be processed. Firstly the coal is crushed and screened in a two-stage process, by use of a feeder breaker, a chain conveyor used to break the largest pieces, followed by passing through a sizer, trailed by a screening process that separates it into different sizes (RPM Solve, 2023). At this stage the coal will typically contain dirt, ash, mud, rock and sulphur, amongst other unwanted materials and minerals. Following screening the coal will be washed before being placed into a solution of water and magnetite particles. This solution will further remove impurities; coal will float in the water-based solution, impurities such as rock will sink, impurities such as mud and ash will dissolve. The coal will undergo a further two stages of dewatering followed by thermal drying (Ramani, 2021). Following drying, the coal is then transported or stored in silos in readiness for transportation.

There are several tried and tested methods of transporting coal from a coal mine to its destination. Selecting a suitable transportation for the coal is crucial. Network design is utilised in supply chains for effective use of transport and transportation equipment with a goal maximising delivery quality and quantity, whilst reducing transportation and logistics expenditures (Randy Logistics, 2023). Several factors need to be considered when selecting suitable transportation mode from the coal mine to the steel plant, such as budget, terrain, volume and reliability. For transportation from the mine to the steel plant, each suitable method has its own challenges with regards to costing, noise, terrain, and visual intrusiveness. Furthermore transportation costs can be substantial and can account for a large element of the total material cost. The following three solutions are considered suitable for transporting coal from the coal mine to the steel plant two miles away, whilst adhering to the local authority's planning restrictions of minimising noise pollution and visual impact, along with refraining from using local roads. 698

4.1. Train Line

Rail transportation is by far the most commonly used method for transporting coal. Rail transportation is used to transport coal over vast distances; however, it requires a large capital investment in the rail bed and track infrastructure as well as the railcars. The longevity and durability of the rail infrastructure along with relatively trouble-free operation and minimal maintenance requirements, and the large volume shipments, make the investment in transportation by rail a good investment for the transportation of coal. (Britannica, 2023)

Figure 2 – Coal Transport by Rail

(Grist, 2013)

Loading of the train cars can be achieved without further requirement of additional handling of the coal. The train line loading area can be constructed directly under the storage silos and the empty carriages automatically filled from the overhead silos, allowing for each train carriage to be filled in turn. Dust suppression by use of water jets will be required for the loading process. Coal from the silos will fall through water jets to the train carriage, suppressing dust and reducing potential combustion of the coal due to heat from friction. Further water dousing areas for the train carriages will also be placed along the railway route to mitigate combustion. When the coal arrives at the steel plant, the train carriages will need to be emptied by use of rotary dump (Ballaban, 2018), where the coal can then be used or transported to the plant's storage area. 224

4.2. Coal Log Pipeline

Although coal log pipeline is a relatively new method of coal transportation compared to more conventional methods of train and lorry transportation, the pipeline can be buried underground, offering a more economical and environmentally friendly option. (Marrrero, 1994)

Coal log pipeline can be used to transport coal over reasonably short distances. Firstly, the coal will be processed and compacted into logs at the coal mine to a diameter of 5 to 10% less that the pipeline diameter. Coal logs typically twice the length of the pipeline dimeter, are then placed into the pipeline, with water used to suspend and transport the coal logs. The coal logs are propelled by a pump by-pass system and travel butted together; dependant on the pipeline length there can be a number of pumping stations along the route in order to maintain pressure in the pipeline. (Howgego, Unknown).

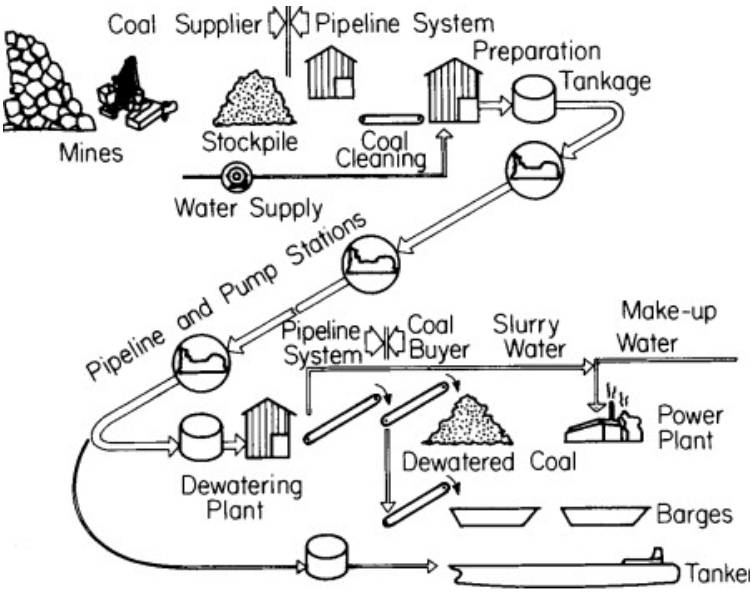

Figure 3 – Coal Log Pipeline

(Rieber, 2013)

Following initial processing further preparation by one of two methods is required to form the coal logs, with and without binder. Coal logs made without the binder require the coal to be heated to temperatures in excess of 100°C before the coal is compacted into logs. (Howgego, 1996). In contrast, inclusion of a bitumen binder means temperatures less than 100°C can be used, the binder also acting as a lubricant for when the coal is transported (Marrrero, 1994). When the logs arrive at the steel works, further processing still is required, with dewatering followed by thermal drying. 232

4.3. Conveyor Belt

Efficiency and safety are vital in the coal industry, the conveyor belt offering advantages to both, revolutionising the industry by streamlining material transportation. Conveyor systems are used to transport large quantities of material over long distances and are able to connect the coal mine to the steel plant. The conveyor belt can traverse difficult terrain with greater ease than other material handling solutions. (TS Global Pty Ltd, 2023)

Figure 4 – Coal Conveyor Belt

(Sawhney industries , 2022)

Loading of the conveyor can also be achieved without additional handling of the coal. The conveyor can be constructed directly under, or connected to the storage silos, which can maintain a continuous funnelled supply of coal to the conveyor. Dust suppression by use of water jets will be required for the loading process, spraying water onto the coal to suppress dust generation reducing combustion risk (see section 3). Further dousing areas will also be required along the conveyer route at strategic places, such as change of terrain or change of direction i.e., areas likely to increase agitation and friction, speeding up the drying process and generating dust. When the coal arrives at the steel plant, the conveyor can transport the coal directly for use or it can dump the coal at the steel plants coal storage area. 200

5. Evaluation of Solutions

In addressing the challenges of transporting coal from the mine to the steel plant, three viable solutions have been identified. Each solution brings its unique set of advantages and disadvantages, with considerations to effectiveness, efficiency, feasibility and adaptability. Further considerations to viable solution implementation include implementation and operational costs and long-term sustainability as well as adherence to the planning restrictions. 60

5.1. Train Line Evaluation

Strengths	Weaknesses
• Suitable for transporting large quantities of coal at a time. • Stable infrastructure following initial investment. • Reliable operation. • Low maintenance requirements. • Tried and tested method. • Longevity of infrastructure. • More fuel efficient and produces less emissions per ton per mile than road transport. • Designed for bulk cargo transportation. • Operate on dedicated lines, reducing the impact of traffic congestion compared to certain transportation methods. • Tailored railcars to suit specific needs for transporting coal.	• Large initial investment required. • Large area of land required. • Multiple locomotives and train cars required. • Numerous tracks required for efficient and consistent flow of materials. (Minimum of 2 tracks to allow for travel to and from steel plant without disruption). • Multiple tracks required, allowing for breakdowns and maintenance to take place without stopping material transportation. • Distance between mine and plant reduces fuel efficiency of operation. • Rail length reduces cargo possibilities for transportation. • Construction, particularly in ecologically sensitive areas, can have environmental impacts.
Opportunities	**Threats**
• Employment opportunities to the local area. • Local attraction. • Visitors centre. • Possibility of steam train to be operated.	• Visually striking. Tains are large structures, will not be possible to go unnoticed. • Noise from locomotive and rail cars. • Large area of land required for infrastructure. • High dependency on fuel for operation. • Current high energy costs for fuel. • Environmental concerns with accidental fuel leaks or spills having a potentially significant impact on the local environment. • Obtaining necessary permits and wayleaves can be a lengthy and complex process

Table 1 – Train Line SWOT Analysis

(Britannica, 2023)

5.2. Log Pipeline Evaluation

Strengths	Weaknesses
• Reduced transportation costs. Can be cost effective compared to more traditional transportation methods • Consistent transport, adverse weather conditions are unlikely to affect the transportation. • Lower infrastructure costs compared to the more traditional transportation methods. • Reduced infrastructure footprint, pipeline requires less land for transportation. • Suitable to be completely buried all be eliminating its visual intrusiveness. • Reduced risk of accidents can offer safer transport mode. • Versatile, can be adapted to different topographies and operational requirements.	• Environmental concerns with accidental leaks or spills having a potentially significant impact on the local environment. • High initial investment for infrastructure and increased costs for burring pipeline. • High energy and resource (Water) demands for transporting coal. Changes in terrain will require further pumphouses for increases or maintained pressure. • Limited flexibility once the pipeline has been established. • Significant water usage required for operation. • Pipeline corrosion and wear and tear, the abrasive nature of coal can contribute to increased wear on the pipeline. • High energy, resource and increased operation requirements to process coal for transportation.
Opportunities	**Threats**
• Employment opportunities to the local area. • Implementation of new technology. • Less infrastructure and visual intrusiveness compared to some transport methods. • Versatile, can be adapted to different topographies and operational requirements	• Acquiring the necessary land for the pipelines right of way may lead to disputes with landowners, resulting in costly delays or settlements. • Environmental concerns with accidental leaks or spills having a potentially significant impact on the local environment. • High energy demands with current high energy costs. Changes in terrain will require further pumphouses for increases or maintained pressure, resulting in higher energy usage. • Obtaining necessary permits for pipeline can be a lengthy and complex process. • Construction, particularly in ecologically sensitive areas, can have environmental impacts. Excavation, land clearing, and alteration of natural watercourses during the installation process may affect local ecosystems.

Table 2 - Coal Log Pipeline SWOT Analysis

(Jinfeng Wang, 2022)

5.3. Conveyor Belt Evaluation

Strengths	Weaknesses
• Suitable for transporting large quantities of coal. • Highly efficient • Reliable operation • Fully automated operation, allowing for precise management of the transportation process • Reduced infrastructure compared to other more traditional transportation methods. • Can be installed in challenging terrain such as hill or valleys without the need for extensive and costly modifications to the landscape. • Versatile, can be adapted to different topographies and operational requirements. • Less energy consumption than use of other transportation methods. • Designed with safety, and a reduction of human interaction. Minimising the requirement of manual handling	• Large initial investment required. • Require regular inspection and maintenance. Wear and tear, material spillage, equipment breakdown led to increased maintenance costs and downtime. • Can face terrain challenges with steep inclines, rough topography or obstacles such as rivers. • Construction, particularly in ecologically sensitive areas, can have environmental impacts. Excavation, land clearing, and alteration of natural watercourses during the installation process may affect local ecosystems. • Require substantial infrastructure including support structures, transfer points, leading and unloading facilities. • Vulnerable to external factors such as extreme weather conditions
Opportunities	**Threats**
• Employment opportunities to the local area. • Implementation of new technology. • Less infrastructure and visual intrusiveness compared to some transport methods. • Versatile, can be adapted to different topographies and operational requirements	• Can be visually intrusive. • Constant operation can led to increased noise pollution. • High energy dependency, with high energy costs in current cost of living operation costs will be high. • Construction, particularly in ecologically sensitive areas, can have environmental impacts. Excavation, land clearing, and alteration of natural watercourses during the installation process may affect local ecosystems. • Require substantial infrastructure including support structures, transfer points, leading and unloading facilities. • Vulnerable to external factors such as extreme weather conditions. • Obtaining necessary permits and wayleaves can be a lengthy and complex process.

Table 3 - Conveyor Belt SWOT Analysis

(Asgco, 2023)

6. Procurement Considerations

For each of the viable material handling solutions, there are several procurement considerations, from which a procurement strategy needs to be established. An appropriate procurement strategy plays an integral role in procurement process' success. Long term procurement strategy, typically reserved for a small number of vendors, has several advantages that can reduce overall expenditure, provide financial stability and offer incentives for vendors to provide lower costs for sustained custom. Long term procurement strategy does however have limited flexibility in its operation. Short term procurement strategy in contrast has high flexibility in its operation, where purchasing can be carried out with several vendors, typically with short lead times for supplies. Typically, this strategy does however encounter higher costs from vendors. (Arie Bagus Wibowo, 2018)

In addition to the above, several other areas need to be considered as part of the strategy. An increasing awareness to sustainable business practices has led to companies implementing sustainable procurement practices in line with ISO 20400. By following the guidelines set by ISO 20400, only necessary items will be purchased, creating the best value for money for the company, customers and communities. Sustainability will be considered in very procurement decision, taking into account environmental, economic and social impacts of products and services, from product design, material selection and manufacture, transportation, construction, usage, and disposal. (PECB, 2023)

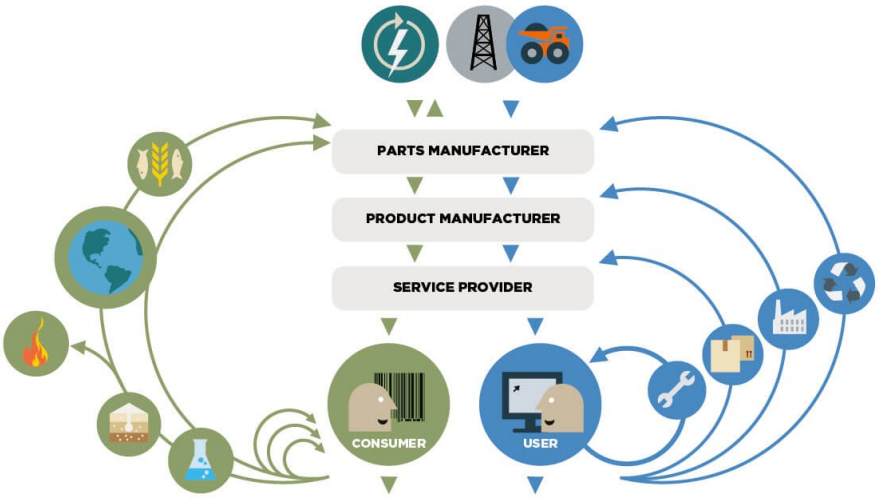

Figure 5 - Circular Economy

(Ellen Macarthur Foundation, 2019)

Further procurement considerations for the materials and equipment required for the material handling solutions are ethical sourcing, which considers the impacts the purchased products have on the people and communities (Sedex, 2023). Circular economy, preserving value in the form of materials, energy and workforce, materials are

designed for durability, reclaim and recycling, keeping materials and components circulating in the economy (Ellen Macarthur Foundation, 2019). Packaging and waste management regulations dictate that materials used for packaging must be kept to a minimum to reduce waste (NI Business Info, 2023). Environmental management involves taking steps to reduce energy consumption and business operations from negatively impacting the environment (Acc-Emotion, 2022). Human rights and labour standards support rights for equal pay for equal work, a fair salary, participation in collective bargaining and protection from forced labour (Equality and Human Rights Commission, 2014). Within these principles, relevant vendors and contractors will be required to comply with several requirements and certification schemes such as BES6001, ISO 14001 or Principles of modern slavery act 2015. (Balfour Beatty, 2020) 350

7. Conclusion & Recommendations

The evaluation of three distinct material handling solutions reveals a nuanced landscape, where each of the solutions offer unique advantages and considerations. The optimal material handling solution hinges on specific requirements of the desired operation, whether prioritising overall solution expenditure, transportation speed or quantity of material transported provided by each solution. Careful considerations of the pros and cons of each solution against their unique operational function and context must be made, whilst considering and complying with the stringent planning restrictions set by the local authorities.

Each of the proposed material handling solutions will encounter similar issues to varying degrees. Each solution must travel across privately owned land as well as traversing public roads and the local environment. Of the considered solutions, no material handling solutions is able adhere to every requirement of the mining company whilst adhering to the imposed planning restrictions. The conveyor belt solution however is considered the most suitable, commercially, and financially viable for this application.

This method of material handling offers a near fully automated material handling solution, capable of transporting coal from the deep mine to the steel plant. Due to its numerous designs and adaptability, it is capable of traversing various terrains with minimal impact on the local environment compared to other material handling solutions. Although transporting coal by train typically offers a higher volume of material transportation, the distance between the mine and steel plant vastly reduces the efficiency and practicality of this transportation method.

The conveyor belt system also provides options and flexibility with regards to covers and enclosures, reducing its visual intrusiveness on the local environment. Although it will not be possible for the conveyor belt to go completely unnoticed from the mine to the steel plant, unlike the coal log pipeline which is suitable to be buried the entire length of the route, the log pipeline does also require strategically placed pumphouses to maintain pipeline pressures and consistent material flow which will be visible albeit blended as best they can. The energy required to transport coal by conveyor belt is vastly less than that required to transport and process the coal as part of the log pipeline, a factor that needs serious consideration in the current economic climate. In addition, there is also an increased risk of an environmental hazard by coal log pipeline transportation, system failure resulting in the contaminated water used for the transportation process contaminating the local environment and causing a potential environmental catastrophe; a risk not posed by the conveyor belt system. 416

8. References

Acc-Emotion, 2022. *www.acc-emotion.com.* [Online]
Available at: https://www.acc-emotion.com/stories/what-environmental-management-and-how-are-we-applying-it-acc-infographic#:~:text=Environmental%20management%20is%20a%20multi,the%20environment%20by%20industrial%20activities.
[Accessed 12 12 2023].

American Mine Services, 2023. *www.americanmineservices.com.* [Online]
Available at: https://americanmineservices.com/underground-mining-development/
[Accessed 05 12 2023].

Amtek, 2018. *www.ametek-land.com.* [Online]
Available at: https://www.ametek-land.com/-/media/ameteklandinstruments/documentation/products/carbonmonoxidedetectors/millwatch/ametek_land_coal_handling_safety_application_note_rev_1_en.pdf
[Accessed 09 12 2023].

Arie Bagus Wibowo, I. N. P., 2018. *www.ieomsociety.org.* [Online]
Available at: https://ieomsociety.org/ieom2018/papers/673.pdf
[Accessed 10 12 2023].

Asgco, 2023. *www.asgco.com.* [Online]
Available at: https://www.asgco.com/articles/benefits-of-a-conveyor/#:~:text=Any%20time%20you%20need%20a,have%20to%20worry%20about%20logistics.
[Accessed 07 12 2023].

Balfour Beatty, 2020. *www.balfourbeatty.com.* [Online]
Available at: https://www.balfourbeatty.com/media/s5bpbhtc/sustainable-procurement-supply-chain-requirements-december-2020-1.pdf
[Accessed 10 12 2023].

Ballaban, M., 2018. *www.jalopnik.com.* [Online]
Available at: https://jalopnik.com/this-is-how-they-unload-coal-trains-1831342511
[Accessed 07 12 2023].

Baxter, D., 2023. *www.feeco.com.* [Online]
Available at: https://feeco.com/ensuring-efficient-handling-of-coal-coke-products/
[Accessed 08 12 2023].

Britannica, 2023. *https://www.britannica.com/technology/coal-mining/Coal-transportation.* [Online]
Available at: https://www.britannica.com/technology/coal-mining/Coal-transportation
[Accessed 26 11 2023].

Britannica, 2023. *www.kids.britannica.com.* [Online]
Available at: https://kids.britannica.com/students/assembly/view/53672
[Accessed 05 12 2023].

Cielec, L., 2017. *www.blog.midwestind.com.* [Online]
Available at: https://blog.midwestind.com/proper-coal-handling/
[Accessed 08 12 2023].

Ellen Macarthur Foundation, 2019. *www.ellenmacarthurfoundation.org.* [Online]
Available at: https://www.ellenmacarthurfoundation.org/the-circular-economy-in-detail-deep-dive#:~:text=A%20circular%20economy%20favours%20activities,materials%20circulating%20in%20the%20economy.
[Accessed 12 12 2023].

Equality and Human Rights Commission, 2014. *www.equalityhumanrights.com.* [Online]
Available at:
https://www.equalityhumanrights.com/sites/default/files/a_guide_to_business_and_human_rights_1_1.pdf
[Accessed 12 12 2023].

Grist, 2013. *www.grist.org.* [Online]
Available at: https://grist.org/climate-energy/crowdfunded-science-suggests-that-coal-hauling-trains-cause-air-pollution/
[Accessed 26 11 2023].

Howgego, T., 1996. *www.timhowgego.wordpress.com.* [Online]
Available at: https://timhowgego.wordpress.com/capsule/library/documents/coal/
[Accessed 26 11 2023].

Howgego, T., Unknown. *https://timhowgego.wordpress.com/capsule/library/documents/facts_clp/.* [Online]
Available at: https://timhowgego.wordpress.com/capsule/library/documents/facts_clp/
[Accessed 26 11 2023].

Jinfeng Wang, L. F. K. L., 2022. *www.frontiersin.org.* [Online]
Available at: https://www.frontiersin.org/articles/10.3389/fenrg.2022.974747/full
[Accessed 07 12 2023].

Marrrero, T., 1994. *www.mospace.umsystem.edu.* [Online]
Available at:
https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/9946/PublishersBlurbLongDistance.pdf?sequence=8#:~:text=The%20coal%20log%20pipelines%20have,the%20end%20of%20the%20pipeline.&text=amount%20of%20space%20is%20required%20between%20these%20coal%20log%
[Accessed 26 11 2023].

NI Business Info, 2023. *www.nibusinessinfo.co.uk.* [Online]
Available at: https://www.nibusinessinfo.co.uk/content/packaging-and-packaging-waste-management
[Accessed 12 12 2023].

PECB, 2023. *www.pecb.com.* [Online]
Available at: https://pecb.com/en/education-and-certification-for-individuals/iso-20400-guidelines-for-sustainable-procurement#:~:text=ISO%2020400%20is%20an%20international,%2C%20economic%2C%20and%20environmental%20sustainability.
[Accessed 11 12 2023].

Planete Energies, 2015. *www.planete-energies.com.* [Online]
Available at: https://www.planete-energies.com/en/media/article/underground-and-surface-mines#:~:text=Conveyors%20or%20cars%20(railway%20wagons,water%20and%20tiny%20magnetite%20particles.
[Accessed 05 12 2023].

Pryor, R., 2021. *www.dometechnology.com.* [Online]
Available at: https://www.dometechnology.com/coal-storage-and-handling-three-key-considerations/
[Accessed 09 12 2023].

Ramani, R. V., 2021. *https://www.britannica.com/technology/coal-mining/Coal-preparation.* [Online]
Available at: https://www.britannica.com/technology/coal-mining/Coal-preparation
[Accessed 05 12 2023].

Randy Logistics, 2023. *www.randylogistics.com.* [Online]
Available at: https://randylogistics.com/five-things-to-take-into-consideration-before-choosing-a-mode-of-transport/
[Accessed 07 12 2023].

Rieber, S. S. &. M., 2013.
https://www.sciencedirect.com/science/article/abs/pii/B9780080293967500239. [Online]
Available at: https://www.sciencedirect.com/science/article/abs/pii/B9780080293967500239
[Accessed 26 11 2023].

RPM Solve, 2023. *www.rpmsolve.com.* [Online]
Available at: https://www.rpmsolve.com/coal-processing
[Accessed 05 12 2023].

Sawhney industries , 2022. *www.sawhneyindustries.in.* [Online]
Available at: https://www.sawhneyindustries.in/products/conveyorBelts/coal-handling-systems.html
[Accessed 26 11 2023].

Sedex, 2023. *www.sedex.com.* [Online]
Available at: https://www.sedex.com/blog/what-does-ethically-sourced-mean/#:~:text=Ethical%20sourcing%20is%20an%20approach,and%20communities%20who%20create%20them.
[Accessed 12 12 2023].

Smith, B., 2019. *www.azom.com.* [Online]
Available at: https://www.azom.com/article.aspx?ArticleID=18547
[Accessed 05 12 2023].

TS Global Pty Ltd, 2023. *www.linkedin.com.* [Online]
Available at: https://www.linkedin.com/pulse/conveyor-belts-mining-quarrying-revolutionising-material
[Accessed 29 11 2023].

Vega, S., 2023. *www.theassay.com.* [Online]
Available at: https://www.theassay.com/articles/the-assay-insights/underground-mining-guide/
[Accessed 05 12 2023].

Young, G., 2023. *www.pecconsultinggroup.com.* [Online]
Available at: https://pecconsultinggroup.com/coal-grinding-systems-safety-

considerations/#:~:text=All%20leaks%2C%20spills%2C%20and%20any,heat%20and%20start%20a%20fire
[Accessed 09 12 2023].