COALTECH TRANSPORT INVESTIGATION

DECEMBER 2009

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Project 10.1

Coal Transport Investigation

By

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EXECUTIVE SUMMARY

Coaltech commissioned an independent coal transport investigation to identify alternative transport modes and technologies, with the aim of determining which technologies are best suited for specific coal transport requirements. These transport requirements may vary according to the lead distance, terrain, throughput requirements and geographical location, to name but a few factors. It is the intention of the study however, to provide guidance on a very high level, in terms of selecting the most appropriate technology that would best satisfy these requirements in a cost effective and safe manner, while minimising any negative socio-economic impacts.

This coal transport research was based on a hybrid research strategy. The first stage comprised a phenomenological based, inductive approach to evaluating the literature available on different coal transport technologies, but moreover to conduct primary evaluative research into the subject. The second positivist based, deductive approach included primary research, based on the outcome of the first stage, aimed at fully evaluating, understanding and quantifying the characteristics, capacities, costs and socio-economic impacts of each transport mode. Due to the research being based on this hybrid strategy, it required a multi-method data gathering approach, which included focused desktop research and more than 15 general interviews with various senior managers from a number of different organisations within the coal and transport industries. Based on the initial information garnered, selected technology modal specialists were targeted for in-depth interviews, further data gathering, cross referencing and validation. In total, 16 specialist interviews and targeted discussions were completed.

Different transport options are generally classified into modes, based on the infrastructure that is required to enable such transport. Similar guidelines have been used during this coal transport investigation and the 18 identified transport modes were grouped as indicated in **Table 1** below.

Table 1: Available Transport Modes

Transport Mode	In Commercial Use	Feasible in SA
Road Based Transport Options		
Current Road Transport	Yes	Yes
Quantum 1 Road Transport	Yes	Yes
PBS Vehicles	Yes	Yes
Roadtrains	Yes	Yes
Rail Based Transport Options		
General Freight Rail Transport	Yes	Yes
Heavy Haul Rail Transport	Yes	Yes
Magnetic Levitation Systems	Not for Freight	No
Pipeline and Tube Based Transport Options		
Coal Log Pipelines	No	To Be Validated
Slurry Pipelines	Yes	To Be Validated
Tube Freight Transportation System	Not for Bulk Materials	No
Continuous Articulated Rail in a Tube (CARIAT)	No	To Be Validated
Conveyor and Cable Transport Options		

Transport Mode	In Commercial Use	Feasible in SA
Overland Conveyor Systems	Yes	Yes
Aerial Ropeway Systems	Yes	Yes
Rope Conveyor Systems	Yes	Yes
Combination Transport Options		
Rail-Veyor System	Yes	Yes
Bimodal Transport Options	Yes	Yes
Other Transport Options		
Water Based Transport Options	Yes	No
Air Transport Options	Yes	No

Eleven of these identified transport options are already being used commercially and are applicable under South African conditions, while a further three options need further evaluation and testing before a definitive answer can be provided.

To accurately compare transport modes against each other, it was imperative that these technologies be evaluated using the same criteria. To achieve this objective, the evaluation criteria were structured according to the physical system characteristics, the socio-economic impacts of each system, its local applicability and any further research requirements that were uncovered. In order to coherently report on and logically compare each option, based on these criteria, the completed evaluation matrices for the physical system characteristics, the system capacities and the socio-economic impacts can be viewed under section 9 of this document. The subsequent section 10 contains the evaluation from a capital, operating and maintenance cost perspective. Section 11 then presents the cost comparisons, based on the transport unit cost, at various lead distances ranging from 1 to 1,000 kilometres, based on three distinct freight volume scenarios of 1, 5 and 50 Million Tonnes per Annum (MTPA), respectively. This comparison is summarised and the transport options are ranked in order of economic competitiveness in **Table 2** below.

Table 2: Summary of Feasible Transport Options per Scenario

SHORT (<10 KM)					
Scenario A 1 MTPA	Rank	Scenario B 5 MTPA	Rank	Scenario C 50 MTPA	Rank
Rail-Veyor	1	Rail-Veyor	1	Conveyor	1
Roadtrain (180 t)	2	Aerial Ropeway	2	Pipe Conveyor	2
Roadtrain (105 t)	3	Conveyor	3	Rail-Veyor	3
PBS Vehicles (48 t)	4	Pipe Conveyor	4	Rope Conveyor	4
Aerial Ropeway	5	Roadtrain (180 t)	5	Aerial Ropeway	5
Quantum 1 Road (38 t)	6	Roadtrain (105 t)	6	Roadtrain (180 t)	6
Conveyor	7	PBS Vehicles (48 t)	7	Roadtrain (105 t)	7
Current Road (31 t)	8	Quantum 1 Road (38 t)	8	PBS Vehicles (48 t)	8
Pipe Conveyor	9	Current Road (31 t)	9	Quantum 1 Road (38 t)	9
Rope Conveyor	10	Rope Conveyor	10	Current Road (31 t)	10

INTERMEDIATE (10 - 100 KM)					
Scenario A 1 MTPA	Rank	Scenario B 5 MTPA	Rank	Scenario C 50 MTPA	Rank
Heavy Haul Rail (Current Rates)	1	Rail-Veyor	1	Conveyor	1
PBS Vehicles (48 t)	2	Heavy Haul Rail (Current Rates)	2	Pipe Conveyor	2
Quantum 1 Road (38 t)	3	Roadtrain (180 t)	3	Rail-Veyor	3
GFB Rail (Current Rates)	4	Conveyor	4	Rope Conveyor	4
Roadtrain (180 t)	5	Coal Log Pipeline	5	Coal Log Pipeline	5
Roadtrain (105 t)	6	Roadtrain (105 t)	6	Roadtrain (180 t)	6
Current Road (31 t)	7	PBS Vehicles (48 t)	7	Heavy Haul Rail (Current Rates)	7
Coal Log Pipeline	8	Aerial Ropeway	8	Roadtrain (105 t)	8
Rail-Veyor	9	GFB Rail (Current Rates)	9	Heavy Haul Rail (Private)	9
Conveyor	10	Pipe Conveyor	10	PBS Vehicles (48 t)	10
Aerial Ropeway	11	Quantum 1 Road (38 t)	11	GFB Rail (Current Rates)	11
Pipe Conveyor	12	Slurry Pipeline	12	GFB Rail (Private)	12
Slurry Pipeline	13	Current Road (31 t)	13	Quantum 1 Road (38 t)	13
GFB Rail (Private)	14	Heavy Haul Rail (Private)	14	Slurry Pipeline	14
Heavy Haul Rail (Private)	15	GFB Rail (Private)	15	Current Road (31 t)	15
Rope Conveyor	16	Rope Conveyor	16	Aerial Ropeway	16

LONG (100 - 1,000 km)					
Scenario A 1 MTPA	Rank	Scenario B 5 MTPA	Rank	Scenario C 50 MTPA	Rank
Heavy Haul Rail (Current Rates)	1	Heavy Haul Rail (Current Rates)	1	Coal Log Pipeline	1
GFB Rail (Current Rates)	2	Coal Log Pipeline	2	Rail-Veyor	2
Coal Log Pipeline	3	Slurry Pipeline	3	Heavy Haul Rail (Current Rates)	3
PBS Vehicles (48 t)	4	GFB Rail (Current Rates)	4	Slurry Pipeline	4
Quantum 1 Road (38 t)	5	Rail-Veyor	5	Heavy Haul Rail (Private)	5
Roadtrain (180 t)	6	Roadtrain (180 t)	6	GFB Rail (Current Rates)	6
Current Road (31 t)	7	PBS Vehicles (48 t)	7	GFB Rail (Private)	7
Slurry Pipeline	8	Roadtrain (105 t)	8	Roadtrain (180 t)	8
Roadtrain (105 t)	9	Quantum 1 Road (38 t)	9	Roadtrain (105 t)	9
Rail-Veyor	10	Current Road (31 t)	10	PBS Vehicles (48 t)	10
GFB Rail (Private)	11	GFB Rail (Private)	11	Quantum 1 Road (38 t)	11
Heavy Haul Rail (Private)	12	Heavy Haul Rail (Private)	12	Current Road (31 t)	12

The individual transport modes were ranked per lead distance segment for each of the three volume scenarios and then averaged per distance grouping, which resulted in the overall ranking indicated in **Table 2**. From **Table 2** it is possible to ascertain which transport mode, based on cost only, is the most competitive option at a given lead distance and for a specified product throughput.

It should be noted that six transport options, which are applicable to the Medium lead distance applications, were omitted from **Table 2** for the Short lead distance applications below 10 km, as these rail and pipeline type options are simply not competitive at such short distances. Similarly, four transport options were also omitted from the Long lead distance applications above 100 km, as conveyor type technologies are not practically suited to such long distances.

The outcome of the research broadly conformed to expectations, where conveyor type technologies are suitable across shorter lead distances, with the flexibility and scalability of road transport ensuring that it remains an option in most applications. The different versions of rail transport further indicated that it is very competitive at intermediate to long lead distances, while the pipeline based technologies also seemed to be an option at mid-volume and long lead distance applications. The most surprising outcome of this research, however, is the comprehensively competitive possibilities of the Rail-Veyor system, which proved to be the only technology that was competitive under every single scenario. However, the selection of a specific transport mode is not a simple economic calculation, but rather a complex decision based on various influencing factors including the availability of infrastructures, individual system characteristics, system integration possibilities and various socio-economic implications.

The main conclusion from this research is therefore that no single transport technology exists that could cost effectively satisfy all the divergent transport requirements, across all distances, at different volumes and across all types of terrain. The optimum coal distribution solution lies in the effective combination of all the available transport options into an integrated and well managed network, where individual technologies are applied on merit. This approach allows for the safest and most cost effective transport application for each individual route, with the lowest socio-economic impact, while protecting and enhancing the available transport infrastructure.

The research was conducted at a very high level and intentionally kept as generic as possible. The results are valuable and adequate for guiding selected transport and distribution related decisions, in cases where the lead distance, basic geography and product volumes are known. However, a logical next step in this field of research would be to investigate the integrative and cooperative approaches that could be followed to improve distribution productivity, efficiency, reliability and cost effectiveness of the coal supply chain at an industry level. The introduction of an industry wide supply chain network optimisation initiative and the establishment of coal hubs are two possible options to achieve this level of cooperation, which warrants further investigation.

8.5 COMBINATION TRANSPORT OPTIONS

Combination transport options have been grouped as those transport modes that combine the system characteristics and individual elements of two or more transport options into a new, feasible system. Each of these transport modes are briefly described in the following sections.

8.5.1 Rail-Veyor System

The Rail-Veyor™ Transport system, indicated in ***Figure 19***, represents a novel, practical approach to moving materials economically over short, intermediate and long distances. This technology is described in significant detail in **Appendix L**.

Figure 19: *Example of a Rail-Veyor Vehicle*

The Rail-Veyor™ moves materials by use of a light rail track system with a series of two wheeled, inter-connected cars that effectively represent a long, open trough moving along the track. Each car is connected to the car in front with a connection that allows articulated movement for curves and dumping. Sealing of the gap between cars is maintained by the use of overlapping urethane flaps, which prevent leakage of the material and act as a discharge chute for dumping loads after being transported.

The driving force to move the train consists of a series of equally spaced, dual stationary drive stations. AC motors and gear reducers turn horizontal, foam filled tyres against the side drive plates of the cars, providing forward thrust. Speed is controlled by an inverter, which allows operation in either forward or reverse directions with sufficient power to start a loaded train from any position on the track. These drive stations shut down when the train is not in contact and a sensor based system starts the drive up again upon arrival of a train from a previous station, which significantly reduces the energy required to power the system.

Loading and Tipping Loops are erected at the ends of the Rail-Veyor™ system, to accommodate loading and offloading while the train is moving. When tipping, the train enters the loop in the upright position on a horizontal plane and as it moves through the loop the train turns 180 degrees on a vertical plane, effectively inverting the train, based on rollercoaster technology. During this movement the loaded cars discharge the material by means of gravity, similar to normal conveyor belts. The train is then returned to the upright position for reloading.

The Rail-Veyor™ system has the advantage that it combines the best aspects of conventional conveyors and conventional rail, at a fraction of the capital and operating costs of these technologies. This is based on the fact that it provides an almost continuous material throughput rate, while it operates on a very lightweight rail track, which is significantly cheaper to construct and maintain than conventional railways. The system is fully automated and is controlled from a central control room.

The optimum operating conditions for the Rail-Veyor™ system would be similar to those of a conventional conveyor or rail system, with the advantage that it can operate at inclines of up to 11% and it can negotiate bends of up to 30 degrees at relatively high speeds. The small-scale and lightweight system also allows for relatively simple bridging and tunnelling over and under roadways, rivers and other obstructions.

There are no theoretical limits on the size of the Rail-Veyor™ cars, which means that the unit train lengths and the number of trains on the system will directly influence capacity. The maximum operational speed has not been established, but based on torque, gear ratios and drive tyre diameters; speeds of up to 12 m/s or 32 km/h are realistic. During system tests in South Africa and Canada, pilot 2.4 m long cars, with a 610 mm radius and 203 mm sideboards were fabricated for demonstration purposes. Utilising these cars, in a series of trains totalling 500 equally sized cars, it loaded, moved and dumped nearly 11,000 t/h of material over a 1.6 km haulage distance. This equates to a throughput potential of 76 MTPA. To maintain this throughput rate at longer distances, additional trains will be added to the system.

The system has been proven to provide an economical, practical approach to moving materials over short, intermediate and long distances from 400 meters to 100 km. The maximum feasible transport distance has not been established and the system has not been proven at excessively long distances, nor has it been costed for longer than 100 km. However, the system designers claim that it is quite feasible to run the system economically at distances of up to 800 km.

As indicated previously, the capital investment cost of the Rail-Veyor™ system is extremely competitive, while the operating costs, which are dominated by energy charges, are significantly reduced by shutting down the drive stations when they are not in use. Based on the fact that each loaded car weighs less than 3 t, the maintenance charges on the fixed infrastructure is also significantly reduced.

The Rail-Veyor™ system is currently in operation at the Harmony Gold Phakisa Mine. A pilot system was first built in 2005 and ran as a test system on the surface for six months, in order to resolve any potential system issues, during which time no failures were recorded. After successfully running the surface system, the Rail-Veyor™ was installed underground, where it transports ore across a lead distance of approximately 5.1 km. The system was finally commissioned in April 2007 and it is still operational at full production capacity.

The mine indicated that originally, the system was operating at R3.58/t delivered. However, since the introduction of a second train in September 2008, the operating costs have been reduced to R3/t delivered, and the mine management feels that at full capacity of 3.5 MTPA, this cost could drop below R2/t.

It can be concluded that the Rail-Veyor™ system is one of the most prominent new bulk transport systems that have recently become available and that it seemingly remains competitive from very short to very long lead distances, which is rather unique. The major limiting factor, however, is that the system has not been commercially applied for distances longer than 5 km, and there is only one reference site available locally.

However, the potential benefits of the system warrant further detailed research and investigation into the overall characteristics and specific applicability of this system, while the integration possibilities of multiple Rail-Veyors™ also need to be tested. From the information available, it seems that the system can fulfil the unique function of providing economic long distance transport where no other infrastructure is available, while also being suitable for short distance, high volume transfers into final destinations.