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Advances in Conveyor Technology

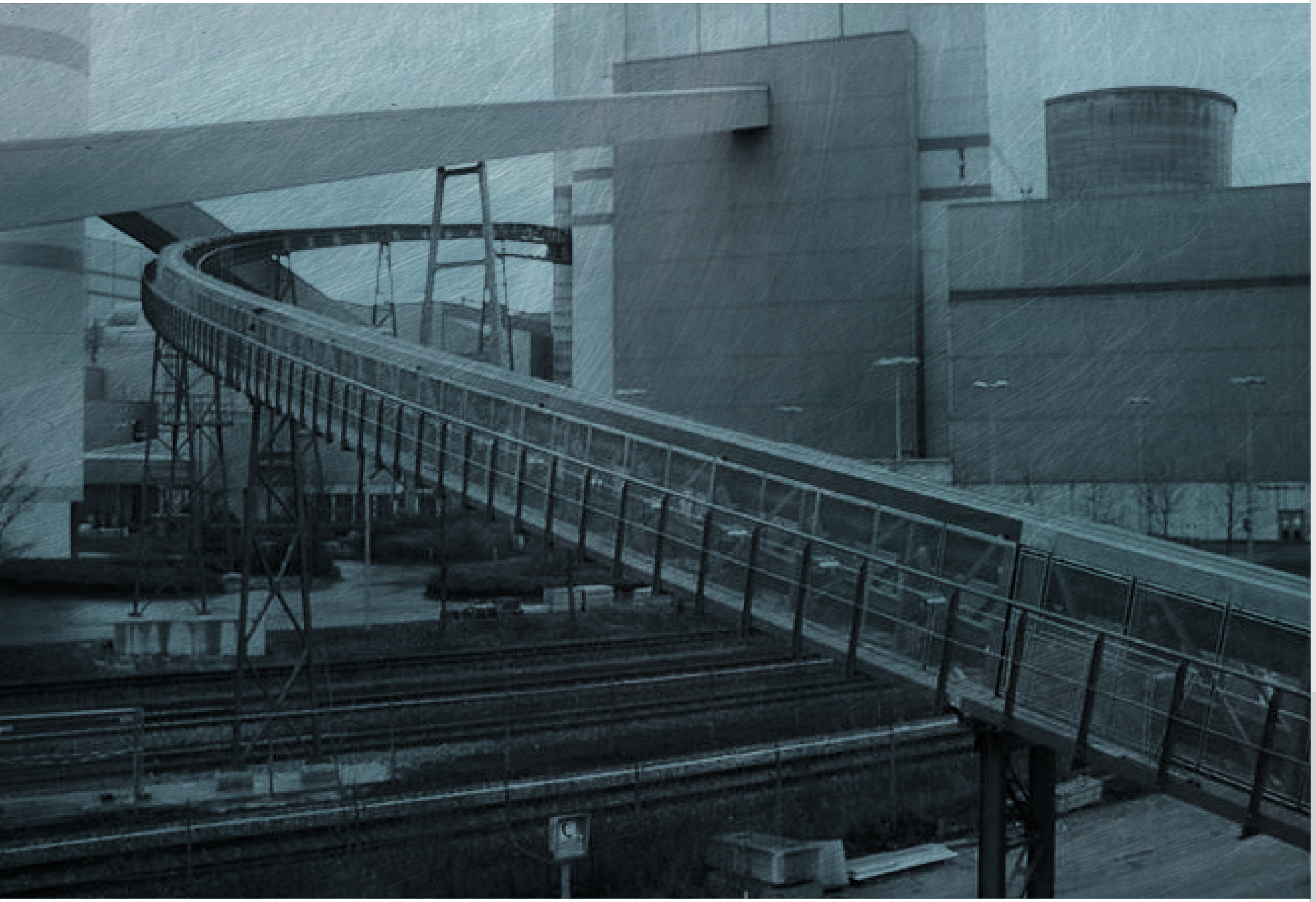
Introduction

The modern industrial process plant is often more sophisticated than the bulk transport method connecting it to its raw materials. Advances in overland conveyor technology have improved efficiency, capital and operating costs, and made the conveying process more environmentally friendly and sustainable. This makes overland conveying considerably more attractive and economically feasible versus trucking.

The belt conveyor is the most reliable and proven method to transfer bulk materials long distances at a low cost per ton. The cost per ton is really not a consideration for short in plant conveyors moving materials short distances. These short in-plant conveyors, if properly designed, can run for years with little maintenance or repair and the cost per ton is usually not a consideration.

Some sophisticated operations move bulk materials long distances which demand a level of control, flexibility and environmental management that significantly exceeds the capabilities of the standard in-plant belt conveyor. Today technology exists that enables belt conveyors to transfer difficult materials in a totally enclosed manner which provides low operating costs per ton, environmental protection, routing flexibility and reliability that outclass not only the traditional belt but also, all transfer formats including trucking. Distance, route and material are no longer an obstacle to this application. Materials can be transferred spillage free in both directions adding a level of flexibility unimaginable in the past.

The two most flexible types of overland conveyors are the pipe conveyor and curved trough conveyor. The advantages of both types are discussed in the following pages. In general the overland curved trough conveyor can carry a higher capacity of material than the pipe conveyor but the pipe conveyor can turn corners with shorter radii. Both have their place in the overland conveying of bulk solids and both can save civil costs of installation and reduce the operating costs when compared to trucking.



The Limitations of Existing Belt Conveyors

A modern belt conveyor has the ability to handle a range of bulk materials that behave in a certain way. As the material becomes more fluid in behavior or contains more moisture the standard belt conveyor becomes less applicable. The ability to mitigate dusting at feed points, during transfer and at the discharge point with conventional conveyors is problematic. Unavoidably, the nature of the design means that with some materials you run the risk of blowing dust and spillage impacting the environment.

Straight belt conveyors can convey unbroken over long straight distances, but require costly transfer towers to change direction. Each time a direction change is needed the material has to be discharged and fed onto the next downstream conveyor. This creates transfer points and risk of dust escaping. This may also create material degradation due to the impact associated with the transfer which increases dusting from degradation and drives wear when handling abrasive materials. Straight belt conveyors can easily reach a maximum inclination angle, depending on the material this can often be at little more than 12°.

The exact layout of a conveying system, particularly in plant conveying systems, now depends on many factors and many different types of conveyors. But still, the elimination of transfer towers is a prime goal of any design. For overland conveyors the distance has to be greater to enjoy the benefits. Sometimes in plant conveyors must include multiple transfer points.

Belt conveyors providing interplant transfer as shown in the system at right are highly viable and often employed successfully across multiple industries.

The limitations of the traditional belt conveyor really start to show over increasing distances as changing topography creates more difficult and costly elevated sections of conveyor. Creating long straight conveyor runs over distance is simply more problematic and expensive. Frequently the decision to avoid belt conveyors entirely is made and the easier solution of trucking is taken. But often this misses an opportunity to save money over time in the form of reduced costs per ton.

Belt Conveying vs. Trucking

Assessing the costs of conveying versus trucking is easy but is often not done because of perceived complexities. This misses a major opportunity to save money. Table 1 shows a brief comparison of the advantages of each.

	TRUCKING	TRADITIONAL BELT CONVEYING
Installation Cost	No fixed installation needed	Installation required
Power Requirement	Less efficient diesel engines	Highly efficient electric motors on drives
Capacity	Depending on truck numbers high	High capacity levels attainable
Level of Enclosure	Limited or none	Enclosed
Cost per Ton Moved	High	Low
Maintenance Cost	High and frequent	Low and limited
Routing	Very flexible, subject to road conditions	Very flexible
Environmental Impact	High	Low

TABLE 1

This does not mean trucking is dead either, but it does mean that assessing the needs and defining if modern belt conveying techniques can help is essential. One should model the net present value of the cost savings of conveying versus trucking whenever the volume is significant i.e. where it is possible to save money via conveying.

Trucking vs Conveying Model

There are a number of good models to predict trucking cost per ton but most operators know their trucking costs. They either use company owned trucks or they contract out the trucking. Today there is a move toward complete contracted trucking where the trucking company makes the investment in the trucks and takes the accelerated tax depreciation benefits. To the operating company the investment becomes part of their operating cost per ton. But trucking is inherently less efficient than conveying due to the amount of labor needed per ton being moved and less efficient gasoline and diesel engines used on trucks as compared to electric motors driving conveyor drives. The order of magnitude of operating costs per ton is significantly different between conveying and trucking as Tables 2 and 3 illustrate.

Most trucking in smaller plant sites with relatively short hauls occur in 20 ton to 40 ton trucks. The biggest variable in terms of cost per ton is how many roundtrips this truck makes per hour i.e. how many tons per hour for the hourly cost to operate the truck including labor. We show the estimated cost per ton for two truck sizes in the table below. The 20 ton truck is considered an over the road truck but the 40 ton truck is considered an off road truck. Two cases are shown in Table 2 for trucking cost which assumes the truck must travel to a landfill to dump 3 miles from the plant.

Cost per Ton Calculation for 20 Ton Over the Road Truck vs. 40 Ton Off Road Trucks

Terrain to destination	3 mile flat	3 mile flat
Capacity (tons)	20	40
Hourly cost, all in	$85.00	$200.00
Tons per load for CCR waste	16	34
Percentage full assumption	80%	85%
One roundtrip per hour $/ton	**$5.31**	**$5.86**
Two roundtrips oer hour $/ton	**$2.66**	**$2.94**
Three roundtrips per hour $/ton	**$1.77**	**$1.96**
With costs added for road maintenance and dust control @ 15%		
One roundtrip per hour	**$6.11**	**$6.76**
Two roundtrips per hour	**$3.05**	**$3.38**
Three roundtrips per hour	**$2.04**	**$2.25**

TABLE 2

If the haul distance is short and direct then the cost per ton is much lower but when the distance is long and indirect then the number of roundtrips per hour is reduced and the cost per ton becomes further elevated.

Table 3 shows that the cost per ton for the conveyor option is far lower than the cost per ton for the trucking option. This difference must pay out the capital required to build the conveyor.

Conveyor Operating Costs per Ton for 3 mile Overland

Conveyor Type	Conventional	Pipe Conveyor	
Power cost	$0.049	$0.066	Assumes 900 kW for conventional, 1200 kW for pipe & 5 cents per kWH
Maintenance	$0.075	$0.075	Assumes $1500,000 per year for maintenance expenses
Operating labor	$0.075	$0.075	Assumes 1 man at total burdened cost of $150,000 per year
Outage inspection	$0.010	$0.010	Assumes yearly inspection costs of $20,000
Total Cost per Ton	**$0.209**	**$0.226**	All costs divided by 2,000,000 tons per year of volume

TABLE 3

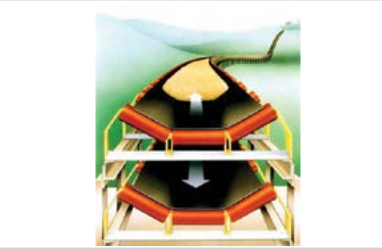
Obviously the project criteria must fit the costs on a case by case basis but once the project volume becomes high, an evaluation of the capital costs that can be justified is warranted.

Introduction to Advanced Overland Belt Conveying Systems

Overland Conveyor systems eliminate the restrictions commonly found with the traditional straight belt conveyor design. The technology options allow miles of continuous conveying without the need for transfer points.

Modern systems can be fully enclosed and overcome significant topographical obstacles including steep elevations. Now it is easy to handle materials too difficult for traditional conveyors. Conveying can replace fleets of noisy, environmentally harmful trucks and eliminate the impossible new routes with tough topographical challenges.

Pipe Belt and Horizontal Curve Trough Belts Conveyors allow us to meet modern demands for distance transfer. They also allow maximized optimization of the conveying format irrespective of installation site.

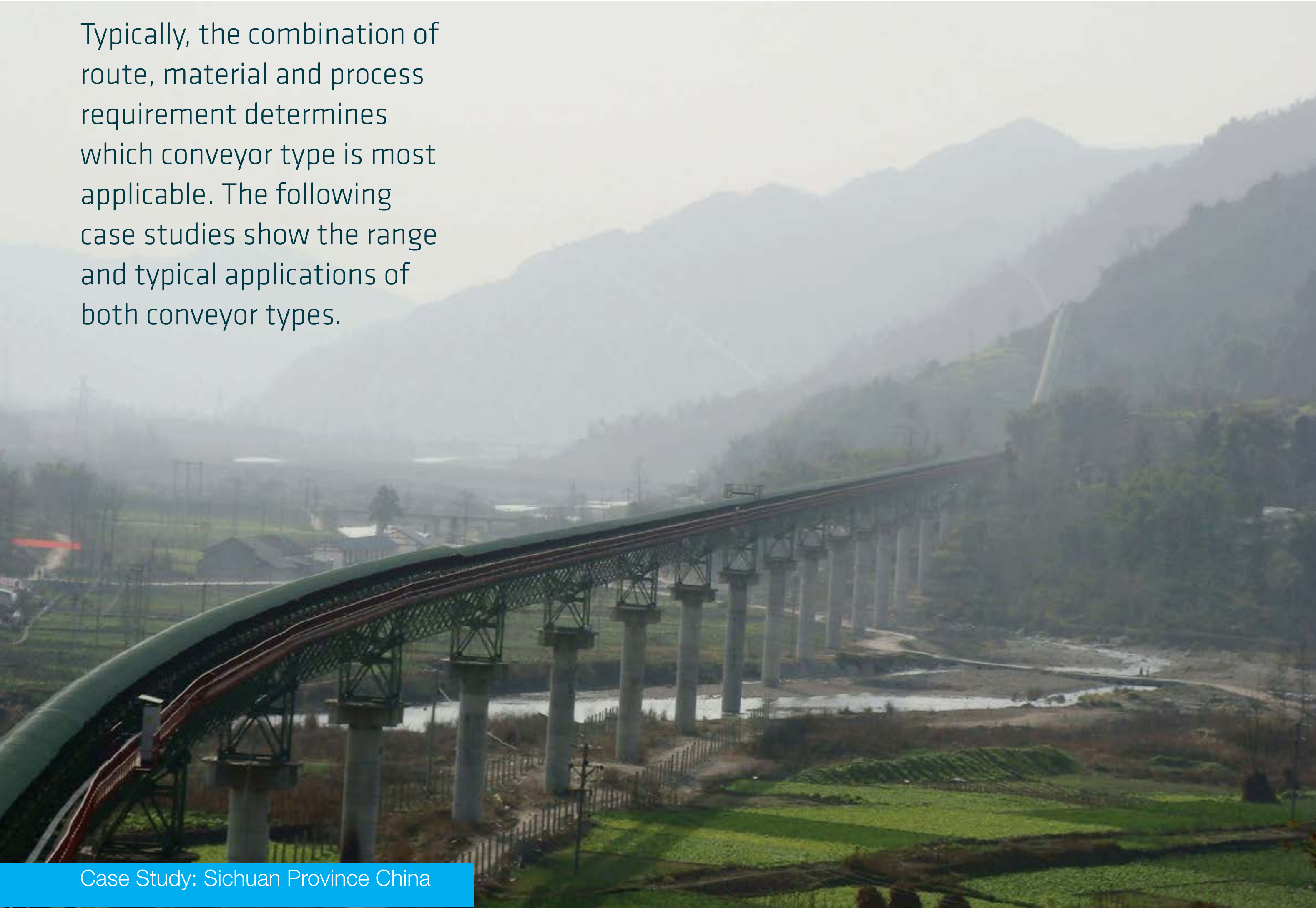


	PIPE CONVEYOR	HORIZONTAL CURVE BELT
Typical Capacity Range	50 to 2000 tph Bi direction conveying capable	500 to 10,000 tph Bi direction conveying capable
Transfer Tower Requirement	None	None
Curves Possible	Yes horizontal and vertical	Yes horizontal and vertical
Fully Enclosed	Yes fully enclosed	Can be enclosed with hood covers or jumbo covers
Overcoming Topography Challenges	Yes with maximum incline and decline angles	Yes with limits to incline and decline angles
Spillage Free	Yes on entire length	Best achieved with belt turning stations at each end
Advantages	• Material conveyed fully enclosed inside the formed tube • No material spillage - Material and environment are protected • Capable of steep inclines and declines • Capable of making vertical and horizontal curves - Eliminates transfer towers • Tight curve radii	• Capable of vertical and horizontal curves with longer radii • High capacity limit on upside • Belt turning stations eliminates spillage on return strand • Capable of extremely long distances and difficult topography • Very cost competitive and uses less power to move a ton of material

TABLE 4

Application Case Studies

Typically, the combination of route, material and process requirement determines which conveyor type is most applicable. The following case studies show the range and typical applications of both conveyor types.



Case Study: Sichuan Province China

Long Distance Horizontal Curved Trough Belt Conveyor in China

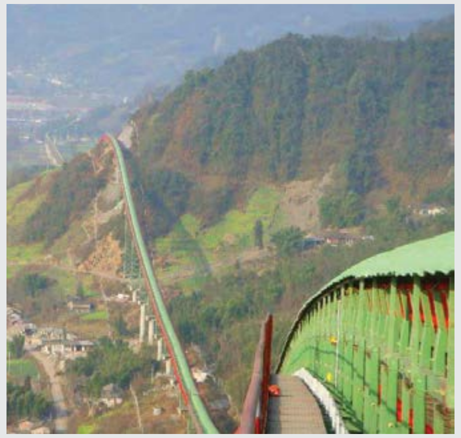
The application case study looks at a long distance curved trough belt conveyor installed in a mountainous region of Sichuan Province in China. The conveyor has to navigate multiple incline and decline sections as it maneuvers over three large hills. This makes the drive system technically complex requiring a powerful drive system and a controlled braking system.

The conveyor transfers 2000 mtph of limestone over 12.5 km in total conveying distance. The single belt maintains stability using a plc-controlled winch that constantly monitors belt tension to set it at the optimum level for prevailing conditions.

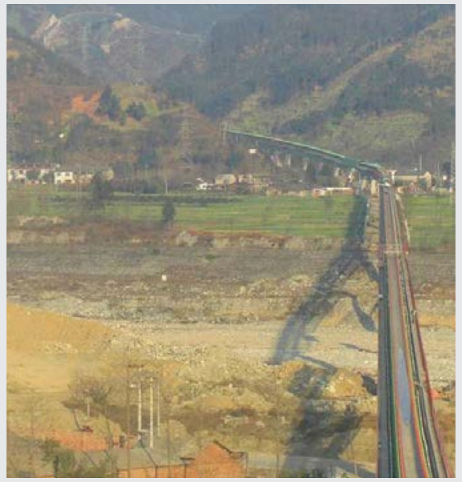
The conveyor has two drives at the feeding end of the conveyor and two drives at the discharge end of the conveyor. The conveyor has no additional drives along the intermediate length. The conveyor makes a total elevation change of more than 100m and has eight curves along the entire length. The system, commissioned in 2009 remains one of the premier examples of advanced conveying technology globally.

Advances in Conveyor Technology

System Owner	Sichuan Yadong Cement
Application	Limestone from Quarry to Plant
Location	Sichuan Province China
Conveying Distance	12.4km single belt with no transfer points
Topography Description	Mountainous region with multiple horizontal and vertical curves
Conveying Rate	Raised with successive upgrades to 2100tph
Installed Power	3000kw
Notes	A second conveyor is in engineering and will go into construction soon to link the first one to the nearby shipping terminal over more than 14km distance



View from the highest point on the route.



View from curves 7 and 8.

Case Study: Ghent Kentucky

Long Distance Pipe Conveyor Moving Ash to a Dry Landfill

The application case study looks at a long distance pipe conveyor installed within the plant boundary of a major US power generator. This pipe conveyor transfers gypsum, fly ash and bottom ash from the plant to a new landfill location for safe disposal. The pipe conveyor adapts to the distance and overcomes topographical and environmental performance requirements impossible with conventional conveyors. Some of the curves require short radius bends which would be impossible with other conveyor types.

The conveyor is approximately 7800 feet long. With a transfer rate capability maximum of 1200 tph, the single belt is fed with material and then formed into a pipe shape that is maintained until the discharge end. The conveyor utilizes a plc-controlled winch that constantly monitors belt tension to set it at the optimum level for prevailing conveying conditions.

The conveyor has two different feed points at the loading end and discharges into three different points at the discharge end. The conveyor has no intermediate drives along the length and makes a total elevation change of more than 400 feet with 12 curves along route. The system, commissioned in 2013 handles CCR to landfill and is the most significant utility pipe conveyor installation in the USA in the last 5 years.

Advances in Conveyor Technology

System Owner
LGE KU Ghent Station

Application
Gypsum and ash by products to landfill

Location
Ghent Kentucky

Conveying Distance
3.4km single belt with no transfer points

Topography Description
Multiple horizontal and vertical curves

Conveying Rate
1200 stph

Installed Power
1750 kW

Notes
Two thirds of hp is at discharge end on one third is at loading end.

Pipe Conveyor Inlet and first curve view.

Reviewing looking down pipe conveyor route from first curve into uphill sections

View looking down hill towards plant and final incline towards discharge pipe conveyor.

Close up views pipe conveyor.

Conclusions

In both cases of the overland conveyors highlighted the client saved millions of dollars over time to install conveying instead of trucking. While the costs do not always agree with the examples of trucking costs and conveying costs shown in this paper, the examples of costs for trucking is usually at least $2.00 per ton higher than conveying and is often $3.00 per ton more than conveying. So projects with significant volume are able to pay out the capital investment required in a relatively short period.

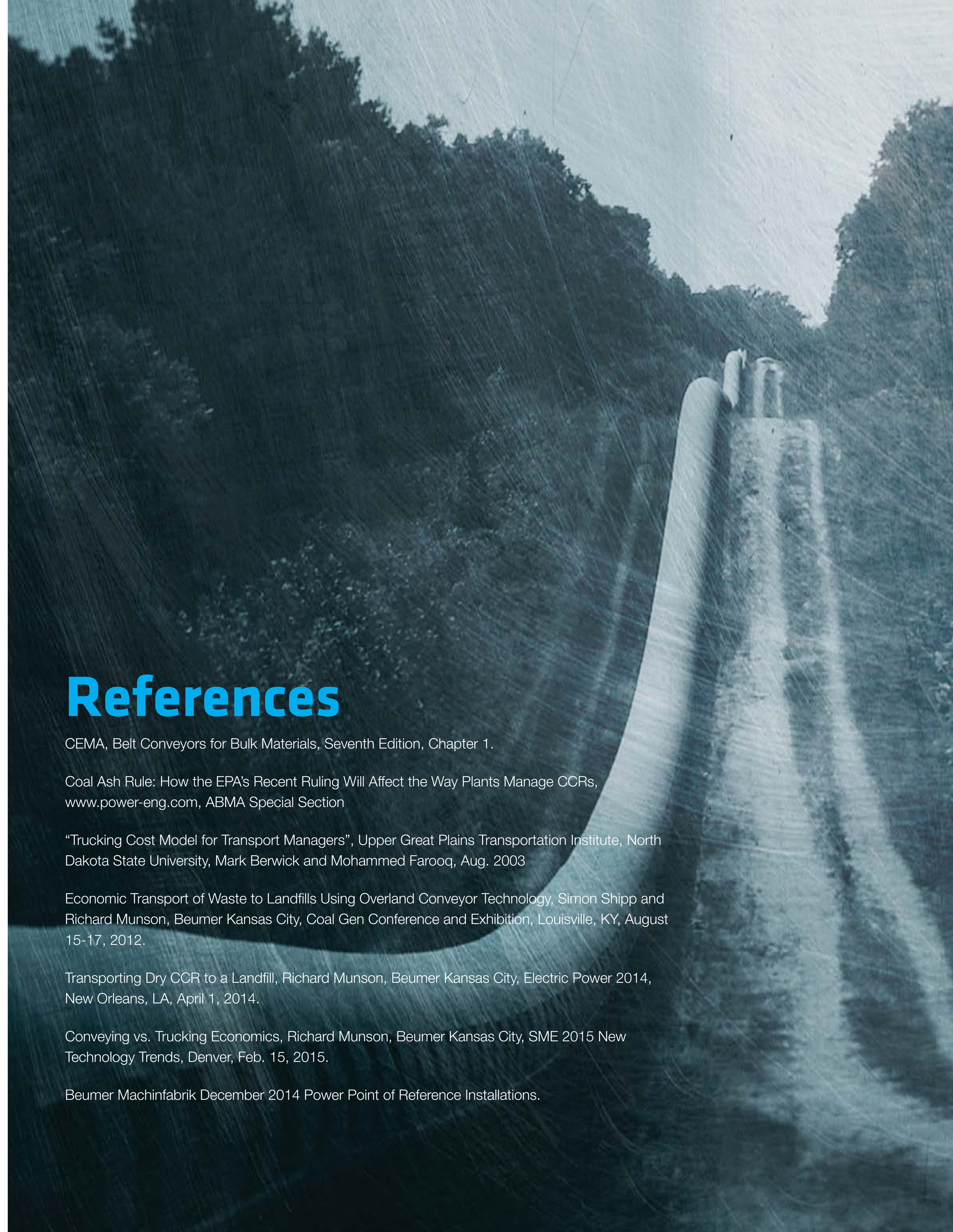
The revolution in advance belt conveyor design means we have options now to transfer without dust, no material spillage and safe with the knowledge that we can protect our environment. So the advantages are not just economic.

Modern belt conveyor technology enables more flexible angles, high rates, long distances and zero environmental impact belt conveying. Valuable materials can be kept from weather impact, reducing waste and ensuring consistent product quality. No business handling bulk materials can ignore this game changing technology.

Advanced conveyor design using pipe conveyors or curved trough conveyors means the client can transfer material with fewer transfer points at a lower capital cost. The overland conveyors discussed herein use a very low power cost per ton without spillage along the route. The elimination of multiple transfer towers reduces material degradation and dust generation and generally reduces maintenance costs over what they would have been with straight conveyors. With new control system technologies and variable speed drives the efficiency of the operating control is also higher than it has ever been heretofore.

Conveyor designers are now looking at ways to reduce construction costs through modular designs and the costs will continue to drop. While cost depends on the capacity of the conveyor and the overall length of the conveyor we see costs continually reducing. The curved conveyors allow the client to reduce civil and installation costs by following the contours of the topography. If a client has a significant volume to move over a multi-year period the savings of the conveyor option often easily pays out versus the higher operating costs of trucking. For those clients truly concerned about the environment it is prudent to examine the economics of conveying because it is also more sustainable and healthier for the environment.

Overland conveyor technology has improved to the point where the cost per foot for an overland system is low enough to create interest in overland conveyors of less than a mile in length to over ten miles in length. The economic payout of capital dollars to eliminate trucking costs for these overland systems are robust and worth evaluating.



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