AUTHOR'S NOTE

This book providesexamples of some of the game changing innovations that are occurring in themining industry today, and lays out a vision of where the industry is heading in the year 2030. Mining is a capital intensive industry with long range capital projectplanning cycles. More often than not,because of this long-time horizon, the professionals who plan and conceiveprojects are seldom the same ones who develop and operate them. For mining organizationsto succeed in this environment, they need people in their ranks who are imbuedwith a high sense of integrity, commitment, creativity and vision, temperedwith clear eyed practicality.

Humanity's need for the "stuff" ofmining is increasing, yet, the supply of our natural resources is finite. Onemight say that all the easily mineable commodities are gone, and it is gettingmore difficult and costly to extract what is needed to support life for sevenbillion of inhabitants on the planet. There are other challenges to the miningindustry. Gaining the "public license" to mine has never been more difficultbecause of common perceptions of mining as a dirty business. Unfortunately the press and Hollywood are nothelping the matter. James Cameron's movie, *Avatar*, depicted a mining company asthe most evil antagonist, bent on destruction. *Mining 2030* provides a unique counterbalanceto the "miner as evil antagonist" theme which runs through popular culture. Without mining, it will become more difficultfor the seven billion inhabitants of the earth to feed themselves. Energy is a very large input to our highlyproductive industrialized food system. And the envisioned renewable energy infrastructure will require large amounts of basicminerals to build. So, if we want a sustainable planet for our descendants toinhabit, we need mining.

Mike Vallez, P.E.
January 2013

CONTENTS

1.
Introduction

The mining industry is on the threshold of major changes, the likes of which we have not seen since ponies were taken out of underground mines.

Part of this change is driven by energy. One of the largest cost centers in a mining operation is diesel fuel. The cost to produce a unit of the finished commodity is rising, and so is the proportion of that cost attributable to diesel fuel. This is not just because of the rising cost of fuel, but also because more energy per unit of final production is required as lower grade deposits are developed. At the same time, the marginal cost to extract and produce diesel fuel is increasing. With this "squeeze" in place, the need for electrification is not a matter of if, but when and how.

In response to the rising cost of finite hydrocarbon fuels, the world is embarking on a transformation in the way it produces, transports, and uses energy. Beginning with the

United States, Europe, and China, plans are being implemented for intercontinental high voltage transmission grids to create distributed energy networks which will power electric motors where internal combustion engines once served. In addition, the existing electricity conductor infrastructure at all levels is being enhanced to support the added demands placed on it by the emerging all-electric economies. These changes will not happen overnight, but mining is an industry where long term investments are made. And in terms of the energy future, long term starts now.

This electrification of the world economy will rely on a vibrant mining industry to produce the materials needed to make the renewable energy machines and build the new infrastructure that relies on copper, steel, molybdenum, aluminum, rare earth elements, and other resources. Yet, across the globe, the mining industry is in crisis due to a lack of reliable electric power. This can and will change with a strategy to transition to renewable and inexhaustible energy. This trend has begun. In 2009, for the first time, the global investment in renewable power generation exceeded the amount invested in conventional carbon based generation.

Activities in Chile are a harbinger of things to come. With nearly forty percent of the world's copper production, Chile is the "Saudi Arabia of Copper." Interestingly, the mining industry and government in Chile are catching on to the ultimate need for electrification, and for the change to sustainable energy. In May of 2012, Spain's Eosol Energy announced plans to build a $615 million, 193 MW solar energy project in Tocopilla, a town in northern Chile. Power produced at the solar energy park will be sold to the

Norte Grande Interconnected System, which supplies power to mines in northern Chile. In July 2012, Solarpack, a Spanish multinational developer and builder of photovoltaic solar power plants, announced that it has been selected by Compañía Minera Doña Inés de Collahuasi to build, develop, and manage two solar photovoltaic plants in Chile's Tarapacá region. The 25 MW projects strengthen the presence of Solarpack in Chile, where the company recently opened a 1 MW solar plant in Calama. Chinese renewable energy company Sky Solar, state-backed China Development Bank, and Chilean industrial group Sago Kippers plan to make a Chinese firm's biggest investment in the Andean country: a $900 million, 300 MW solar energy park, as announced by export promotion agency Parochial on June 26th, 2012.

Although mining companies around the world are embracing renewable power, the newly announced projects in Chile may represent a milestone in the industry. The lesson from Tocopilla, Chile and from the worldwide shift to electrification is this: Electricity is more cost- effective, abundant, and enduring than diesel fuel in the long run.

Some may feel that the mining industry is too stagnant to change. But that is not the history of mining. In 1710, Thomas Newcomen became known as the father of the industrial revolution when he invented the first steam engine to pump water from deep mines in Cornwall, England. This led to the development of the steam hoist, and ever deeper mines throughout the world. Today, the spirit of invention is widely evident in the mining industry.

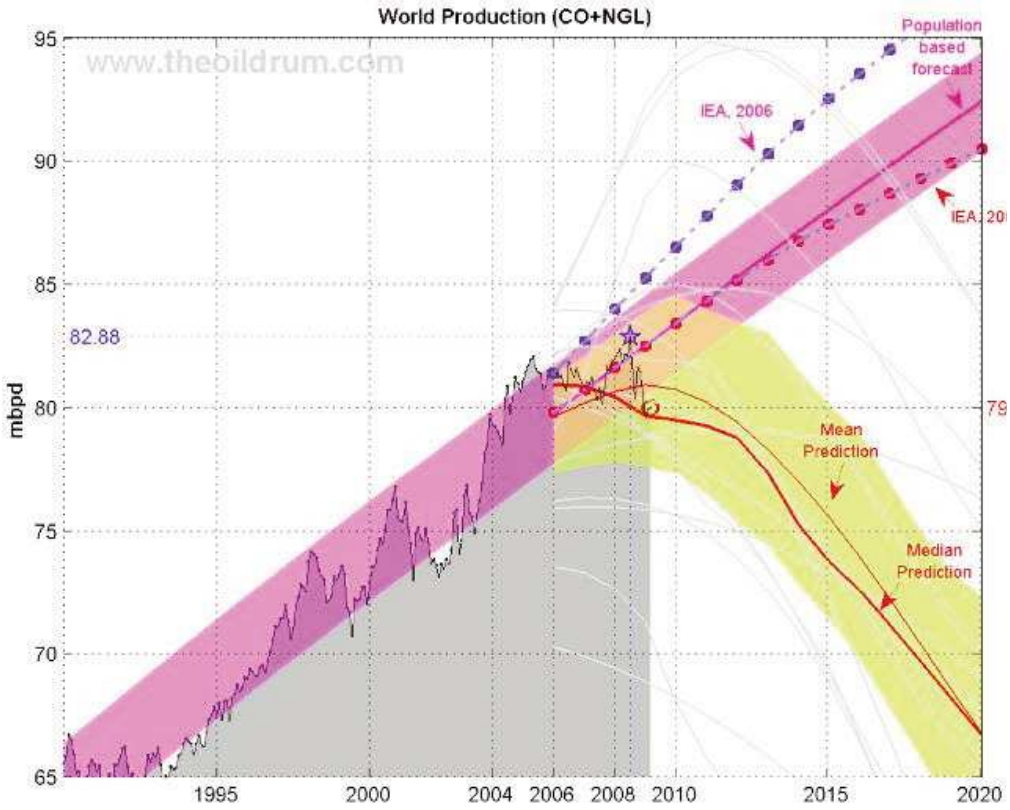
2.
Why Sustainable?

Using the literal meaning of the word “sustainable” to describe an industry that extracts finite resources from the earth is an oxymoron. In resource-extraction industries, the meaning of the term “sustainable” has been broadened. The term “sustainable development” has come to mean and describe a mode of operation in which an entity aims to carry out its actions in a manner which meets the needs of current society, while preserving resources and environments for use by future generations. Therefore, in many organizations, creating good community relations in areas of operations has been thought of as part of the overarching theme of sustainability.

In terms of this work, we use the word” sustainable” to describe a way of operating which can endure beyond the use of finite consumable resources. In particular, we are referring to = development through the use of electricity as a major energy carrier, whether that electricity is generated by sustainable means or not--because the fact is, electrification is the long term pathway to sustainable energy.

Electricity is becoming the substitute energy for finite hydrocarbon fuels.

The activity of mining base metals, fertilizers, and other resources needed to support life and development for 9 billion of Earth's inhabitants will be continuing beyond the time span of economically viable oil production. There will always be oil in the ground. But a day will come when the cost to extract that oil will exceed the market price of that commodity for all but the most special uses. And when that day comes, civilization will still need to continue to extract other resources through mining. So, developing sustainable mining practices, as we define them here, is necessary for the survival and maintenance of Earth as a livable place for its inhabitants. There is no other choice.



Global Oil Production Forecasts

3.
Why Rapid?

Demand

The need to substitute electricity for oil and other non-renewable fuels becomes more evident as the cost of oil extraction rises and the cost of generating sustainable electricity falls. In the basic economic model of of supply and demand, the higher the price of a commodity or product rises, the more supply the market will provide. But in the case of a finite resource like oil, the law of supply and demand breaks down because, no matter how high the price gets, the supply of that resource can only reach a certain peak before its production begins to fall.

In 1956, M. King Hubert developed a model that showed U.S. oil production peaking in about 1970, then diminishing, and finally running out entirely. People in the industry laughed at him. Then in 1971, they looked back and, sure enough, oil production in the U.S. had peaked. Now, decades later, the world as a whole is facing the same kind of peak that the U.S. faced in 1971. The exact year of this world oil peak is the subject of much debate within the

energy community, including private think tanks, corporations, and government sponsored agencies. But one thing is clear: The cost of oil, and its derivative diesel fuel, is rising in real terms, and it is a finite resource.

Mining involves long term capital investments. Many of the major surface mines in the world are starting to reach their economic "tipping point" where the shift to underground mining is more economical than "moving mountains." At the same time, we are approaching the down slope of global production of gas and oil, and the world demand for the "sustainability metals" is shifting higher.

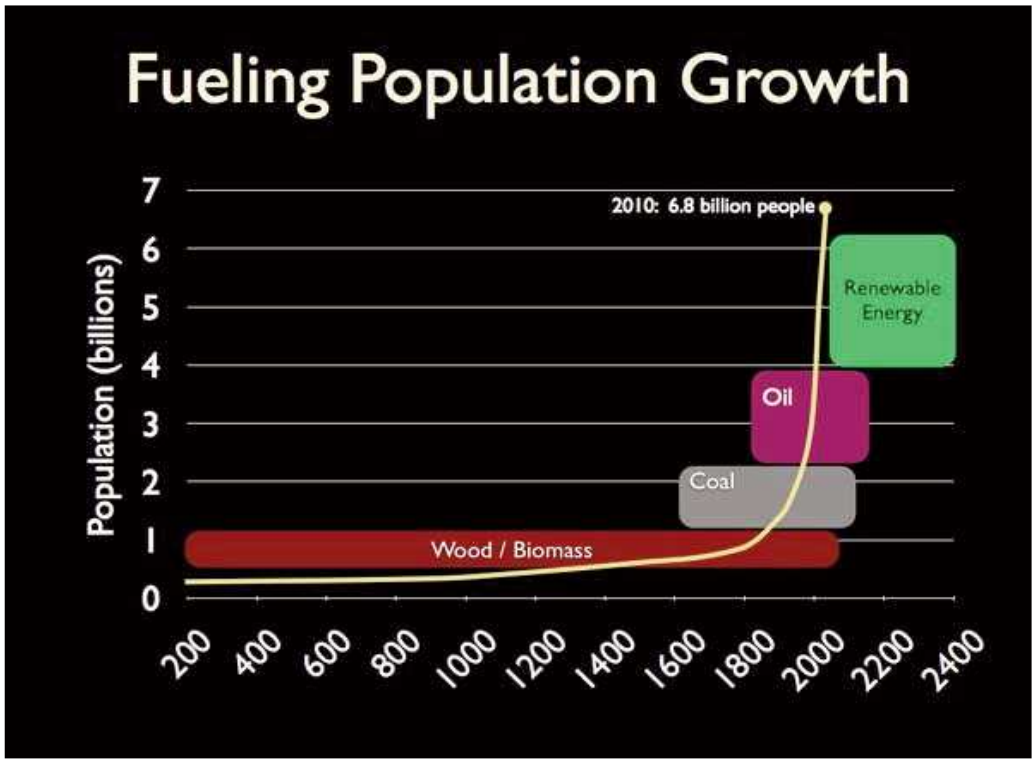
Higher demand, lower grades, longer term capital intensive projects – these all point to the need for more rapid underground mine development. Time is money, and the simple economic equations of capital return on investment are adding to the drive for more rapid development.

Food

Wendell Berry said "The way we eat determines, to a great extent, the way the world is used."

Today, up to 75% of all the food we eat is produced by large corporations that grow; process, package and sell in the most efficient way they can. And in the developed world, we cannot deny that they have kept prices down; we spend, on average less than 10% of our income on food, down from 24% in the 1930's. And, fewer of us have to work in agriculture to feed ourselves. In colonial times, about 70% of the American population engaged in farming – similar to what we see in some developing countries. Today, that number is down to 1% in the U.S.

This complex agricultural, food processing, and distribution system is very costly in terms of energy inputs, and it



requires ten calories of hydrocarbon fuels for every calorie of food we eat. Indeed, the agricultural revolution which has supported the world population boom has been highly dependent on mechanized agriculture, hydrocarbon=-based fertilizers, and hydrocarbon fuels for motive power, and generation of electricity. Supporting life on the planet for the current population of 7 billion people, and the forecast 9 billion by 2050, will require a continued ability to provide food energy inputs at a high level. Many analysts argue that the planet does not have enough alternative energy base resources (copper, steel, etc.) to fully replace the energy produced by oil. Considering that it requires 500 tons of steel to produce a 2 GW wind turbine and tower, this is a credible argument. So conservation will be necessary, along with the substitution of electricity for oil.

This changing energy-to-food equation will, in itself, drive a continuation of and increasing demand for renewable

energy commodities. In a world of shrinking resources, the human instinct for survival and food will tend to drive a larger portion of incomes toward food production, and this will result in a continued demand for the inputs required for food production.

Besides energy, the other key inputs to food production include fertilizer and water. Synthetic nitrogen is a key fertilizer which is produced from natural gas. This commodity is becoming sought after as a substitute for coal and oil in both energy production and transportation. So, as an end use of natural gas, fertilizer for food is competing with gas demands for electricity production; space heating; industrial processes; and transportation.
The demand for potash fertilizer, extracted through underground mines, is forecast to continue rising in the future as the result of its substitution for synthetic petrochemical-based fertilizers, and the rising worldwide demand for food.

World Population Forecast at 9 Billion by 2050

4.
The Electrification Trend

Understand the Uses of Energy

Developing a sustainable mining operation, or converting an existing operation to sustainability, requires a thorough understanding of energy uses and energy sources.

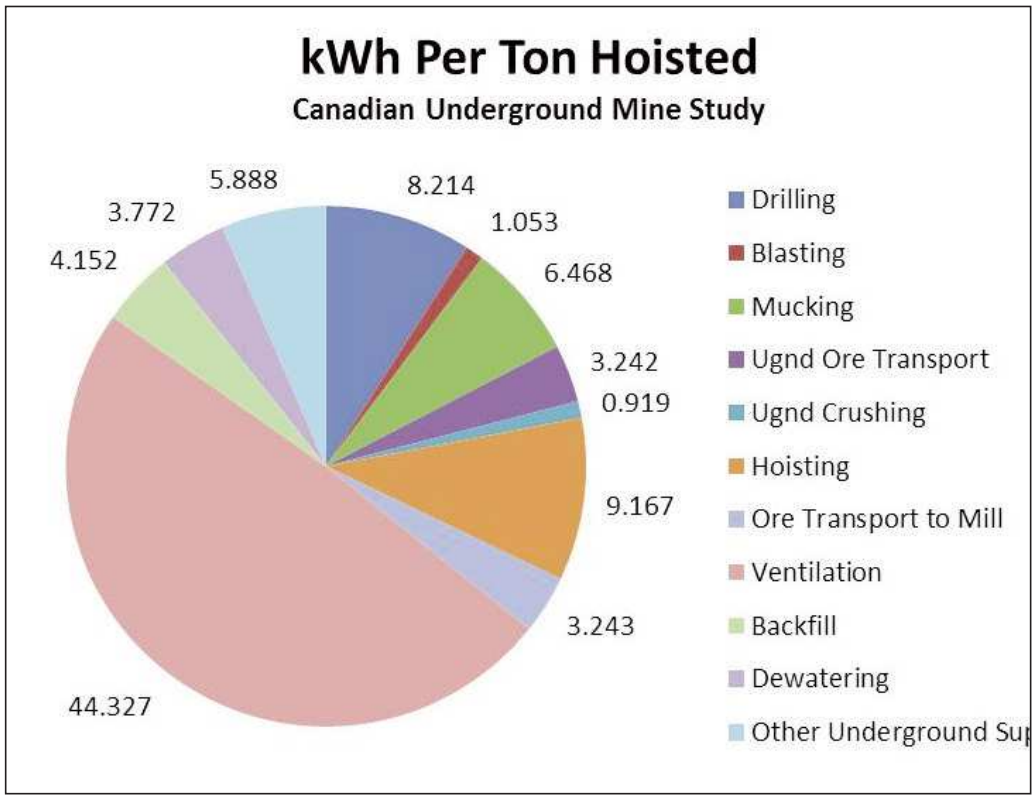
A recent study performed by the Canadian Government compared the energy use at ten underground mines in Canada. This study provides a model for evaluating and benchmarking energy use at other underground mining operations. It takes the various kinds of fuel and energy, and converts them into kilowatt hour equivalents.

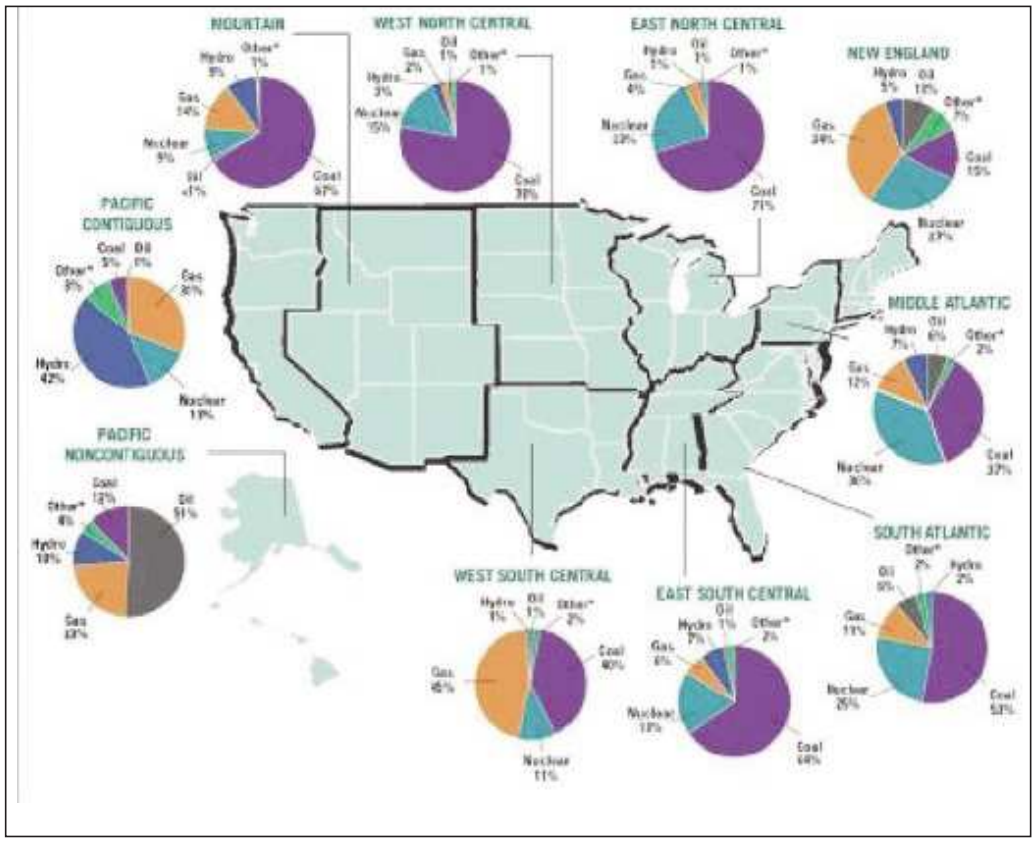
Understanding the Sources of Energy

The grid-tied energy generation fuel mix varies significantly across the world and regions. Every plan for a new mine, or efforts to increase efficiency at an existing mine, should include an evaluation and identification of the energy generation fuel mix. This is essential in the era of actual and potential carbon taxes, and the desire to understand and

Activity	kWh	$0.10/kWh	$0.15/kWh	$0.20/kWh
Drilling	8.214	$0.82	$1.23	$1.64
Blasting	1.053	$0.11	$0.16	$0.21
Mucking	6.468	$0.65	$0.97	$1.29
Ugnd Ore Transport	3.242	$0.32	$0.49	$0.65
Ugnd Crushing	0.919	$0.09	$0.14	$0.18
Hoisting	9.167	$0.92	$1.38	$1.83
Ore Transport to Mill	3.243	$0.32	$0.49	$0.65
Ventilation	44.327	$4.43	$6.65	$8.87
Backfill	4.152	$0.42	$0.62	$0.83
Dewatering	3.772	$0.38	$0.57	$0.75
Other Underground Support	5.888	$0.59	$0.88	$1.18
TOTAL	90.445	$9.04	$13.57	$18.09

Average Cost of Ton of Ore Hoisted for Various Energy Cost Equivalents





Energy Generation by Fuel Mix. Source EEI

measure the carbon footprint of mining operations.

ELECTRIFICATION STRATEGIES

Much work is being done around the world to shift away from carbon fuels, and towards the electrification of mining operations. Here are a few examples that we see emerging in various applications.

Clean Energy Options in Underground Mining Equipment

As found in the Canadian Study of energy used in underground mines, ventilation costs an average of about $4.00 per ton of ore, assuming an electricity cost of $0.10 per kWh. And a large part of this ventilation is required to meet the requirements to dilute the emissions from diesel equipment operating underground. So there are large economic and

Electric Trolley Assist for Mine Haul Trucks

environmental incentives to electrify underground equipment fleets and use low emission technologies.

"To reduce polluting emissions from mining vehicles and improve the air quality in mines, all mining companies must look to new clean energy solutions,"

Marc Bétournay, Natural Resources Canada's Green Mining Vehicles, Green Energy Road Map initiative.

To meet this need, CanmetMINING (CMIN), together with

Closeup of a hybrid battery-diesel supply system in a Canadian loader by Mining Technologies International

various technological specialists, is implementing emission reducing technologies such as hybrid diesel-electric loaders and fuel cell systems. The following is from a report by By Emmanuelle Brière in May, 2012:

> "For optimal performance, diesel engines must operate at a constant high speed. In a mining environment, the loaders accelerate and decelerate often. These changes in speed cause an increase in harmful emission concentrations and a decrease in diesel vehicle efficiency.
>
> "To tackle this problem, CMIN has developed the first hybrid diesel-electric loader. Working in collaboration with Canadian manufacturer Mining Technologies International (MTI) of Sudbury, this new mining loader's electric motor is powerful enough to perform the tasks of a diesel loader. While running on diesel, it charges its battery for the electric motor, eliminating the need to be stopped to recharge. This prototype enables a decrease in noxious gas emissions of between 40% to 70%, and combined with a high-efficiency particulate filter, enables a decrease in breathable combustible dust emissions of 95%. In addition, these decreases could result in a 20%-to-40% reduction in the energy required to ventilate a mine."
>
> "This is just one solution among many using entirely clean substitute energy, including hydrogen fuel cells and lithium batteries. In order to speed up the implementation of these clean technologies, CMIN is preparing a roadmap that will provide mining companies with a variety of alternative energy system options, depending on potential application, possible changes to mining legislation and the companies' energy strategies. According to Marc, "The purpose of this initiative is to replace diesel fuel with clean alternative energy sources, a considerable change in energy and environmental terms for the mining industry."

> "Together with mining companies, regulatory agencies, and alternative energy technology experts, CMIN will help develop projects from the needs assessment stage to end use. The roadmap is backed by the Canada Mining Innovation Council, as well as companies involved in a related industry consortium, the Hydrogen Mine Introduction Initiative. The next step will be to confirm the participation of other mining companies to officially launch the projects in this green plan, which will span over two years."

The Hydrogen Mine Introduction Initiative is taking a proactive approach to developing "proof of concept" demonstrations. Participants in the study include: CANMET MMSL, FPI, Newmont, Placer Dome, Ontario MOL, CSST Quebec, U.S. MSHA, Caterpillar, University of Nevada, Carleton University, Stuart Energy Systems, AeroVironment, Westinghouse Safety Management, Nuvera, Modine, Ergenics, HATCH. $13M value (U.S. DOE, NRCan ETP, Canada Action Plan 2000 Climate Change, Newmont & Placer Dome funding, task shared). The ultimate goal of the work is to address the following five important industry issues:

- Improved health benefits
- Automation, higher productivity, lower mine costs
- Reductions in GHGs
- Reduction in energy consumption (electricity, natural gas, diesel)
- Reduction in underground mine development cost due to reduced need for ventilation pathways.

An order of magnitude country wide estimate of the incremental increase in electricity demand for deployment of these two applications will be a part of this study.

Electrification of Mine Haulage

One pathway of electrification is to replace haul trucks with electrically-driven conveyors. DMC Mining Services recently designed and installed an underground crusher and mine-to-stockpile conveyor system for Graymont's Pleasant Gap Pennsylvania Limestone Mine. This mine optimization project produced an attractive IRR by substituting the use of diesel powered haul trucks from its underground mine with electrically driven conveyors. This project met the corporate threshold for rate of return, and it is an example of rising diesel costs driving the electrification trend. The reduction in ventilation cost was a major factor in the feasibility of this project, as was the savings in diesel fuel, and ownership, operation, and maintenance cost of its haul truck fleet.

Graymont engaged DMC Mining Services, subsidiary of KGHM International, to provide turnkey design and construction of this project.

Graymont Mine Optimization Project

Truck haulage, before

Conveyor system, after

Stacker System

Reclaim System

Innovative Material Haulage: The Rail-Veyor® System

The expanding need for cost effective and productive mining solutions is leading to some innovations in material handling. One example is the Rail-Veyor® System.

"Rail-Veyor® Global is a reliable, cost-effective, environmentally responsible bulk material haulage alternative to its target industries. Rail-Veyor® Global provides material haulage solutions to a broad range of customers, including the global, multi-billion tonne mining, aggregates and energy sectors.

"Material haulage is a key contributor to productivity and cost performance in many industries. The Rail-Veyor® system combines the best of conventional rail haulage and conveyors to create a uniquely flexible and functional alternative for materials transport. Semi-cylindrical cars are linked by flexible flaps, preventing leakage and forming an open trough capable of continuous movement along light rail track. Energy efficient electrical drive stations are distributed along the rail line, providing forward thrust by driving horizontal tires in contact with the car side plates.

"Rail-Veyor® systems offer a high degree of design flexibility, competitive capital cost (due to use of light rail and system layout flexibilityoperational at grades up to 20%, reducing infrastructure preparation time and cost relative to grade-limited rail and truck haulage/short turning radius of 30m reduces rail footprint and cost), low operating and maintenance costs, high reliability, safe automated continuous operation, ease of maintenance, energy efficiency, and superior environmental performance (both local emissions and carbon footprint) relative to to competing

technologies. Independent studies have found the Rail-Veyor® system to be the preferred alternative in bulk materials handling." (Source: Company web page)

The History of Innovation

Mike Dibble, the primary inventor of the Rail-Veyor® System, told us the story of its rapid development. He first created a demo of the concept at a phosphate mine in Florida in 2001. From 2001 to 2003, he refined the design, and formed Rail-Veyor® Systems in 2003. The first commercial installation was for Harmony Gold in South Africa in 2007.

The latest Rail-Veyor® installation is at Vale's Creighton Mine 114 ore body in Sudbury, Canada. DMC Mining Services teamed up with Rail-Veyor® to provide the design and construction of this system, in conjunction with completion of the associated underground development work. Here are some facts of this installation according to the Company.

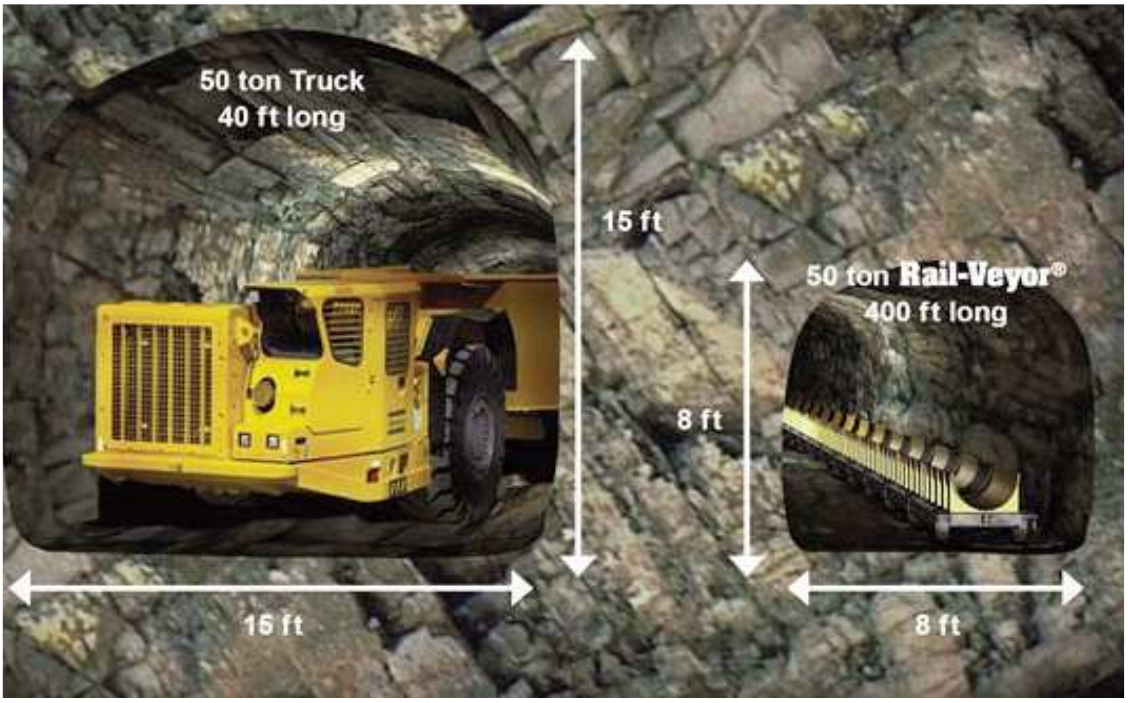
1. Vale's Rail-Veyor® project was in full development mode within six months of the project installation The Rail-Veyor® commissioning began in November 2011 and was completed by April of 2012.

2. A total of 12,500 man hours were invested in this project with a perfect safety record.

3. The Rail-Veyor® system experienced a smooth transition over to DMC Mining who is continuing to advance the Rail-Veyor® system into the mine with the completion of the first phase of the development project to be completed by the 4th quarter of 2012 at which time the mine switches into its production stage.

4. Vale's team chose a single dump loop configuration for their material haulage solution. Each system can be custom designed for dump capacities, routing, train speed, dump loop design, track positioning and energy regeneration. The system can be

Raily-veyor System



Smaller Drifts--One Advantage of Rail-Veyor® System

adapted to many types of applications.

5. The usual development advance rates that Vale achieves in their underground mines are close to 200 feet per week. The Rail-VeyronVeyor® System at 114 ore body was designed to support a development advance rate of 400 feet per week. That's a significant step change.

6. The 114 ore body was originally engineered at a production rate of 1,250 tons per day, and with the incorporation of the Rail-VeyronVeyor ® Material Haulage System, Vale is now able to mine 2,500 tons per day and they believe up to 4,000 or 6,000 tons per day later on.

7. Instead of using 40 or 50 tons trucks for material haulage, Vale uses the Rail-Veyron (veyor?)® Material Haulage System and takes that same payload and distributes it over 400 feet down the length of the Rail-Veyor® cars and enables you to go with a much smaller 8' x 8 ' drifts but for ventilation purposes Vale uses 10' x 12' drifts.

8. Each car on a typical train is capable of carrying up to a tone of payload, which is very high in comparison to the actual weight of the individual cars themselves.

9. Energy Costs – Rail-Veyor® achieves the lowest energy costs compared to other haulage systems with 0.2 kilowatt-hours per tonne-kilometre with a 15% gradient and significantly better results on level terrain.

10. With the Rail-Veyor® system Vale can get very close to the ore body and moves the muck in a continuous manner.

11. Due to the Rail-Veyor System's simple track, modular design and drive stations, the Rail-Veyor® System is able to be constructed quickly to keep up with the rate of development.

12. The Rail-Veyor® Technology is completely scalable. Once the infrastructure of the rail system and the drive stations are in place to increase through put the mine capacity can be increased very quickly by adding on a second or even third Rail-Veyor® train on that same existing infrastructure."

Rail-Veyor®
TECHNOLOGIES GLOBAL INC.

Redefining Material Haulage

Rail-Veyor Comparison Chart

	Rail-Veyor	Truck Haulage	Rail Haulage	Conveyor
Automated, intrinsically safe	✔	✗	✗	✔
No diesel particulate emissions	✔	✗	✗	✔
Minimal labour costs	✔	✗	✗	✔
Simple mechanical maintenance	✔	✗	✔	✗
Low equipment maintenance costs	✔	✗	✗	✗
Low right of way maintenance costs	✔	✗	✗	✔
Continuous load & unload capability	✔	✗	✗	✔
Minimal ground pressure, simple roadbed	✔	✗	✗	✗
High estimated lifetime on equipment	✔	✗	✔	✗
Low OPEX per tonne	✔	✗	✔	✔
Low CAPEX per kilometer	✔	✔	✗	✔
Flexible travel in difficult terrain	✔	✔	✗	✗
Gradients up to 20%	✔	✗	✗	✔
30 metre (100 ft.) radius horizontal curves	✔	✔	✗	✗
Minimal environmental impact	✔	✗	✗	✔
Modular & easy to re-locate	✔	✔	✗	✗
Capable of multiple speeds on same circuit	✔	✔	✔	✗
No need for transfer points	✔	✔	✔	✗
No spillage/clean up	✔	✔	✗	✗

New Energy Options

Although it may not be readily apparent, mining has always been an industry where innovation was a key to commercial success. Thomas Newcomen's invention of the steam pump is recognized as the first instance where hydrocarbon fuel (coal) was used to produce mechanical work, not just heat. The steam pump technology led to the development of steam driven mine hoists, and these two inventions were exported around the world during the great global mining expansion that occurred in the 17th Century.

The steam locomotive evolved from Newcomen's simple invention, and the railroads revolutionized transportation. The electric power and light industry emerged toward the end of the "coal age," when Thomas Edison created the first commercial and coal fired electric generating station on Pearl Street in Lower lower Manhattan, New York.

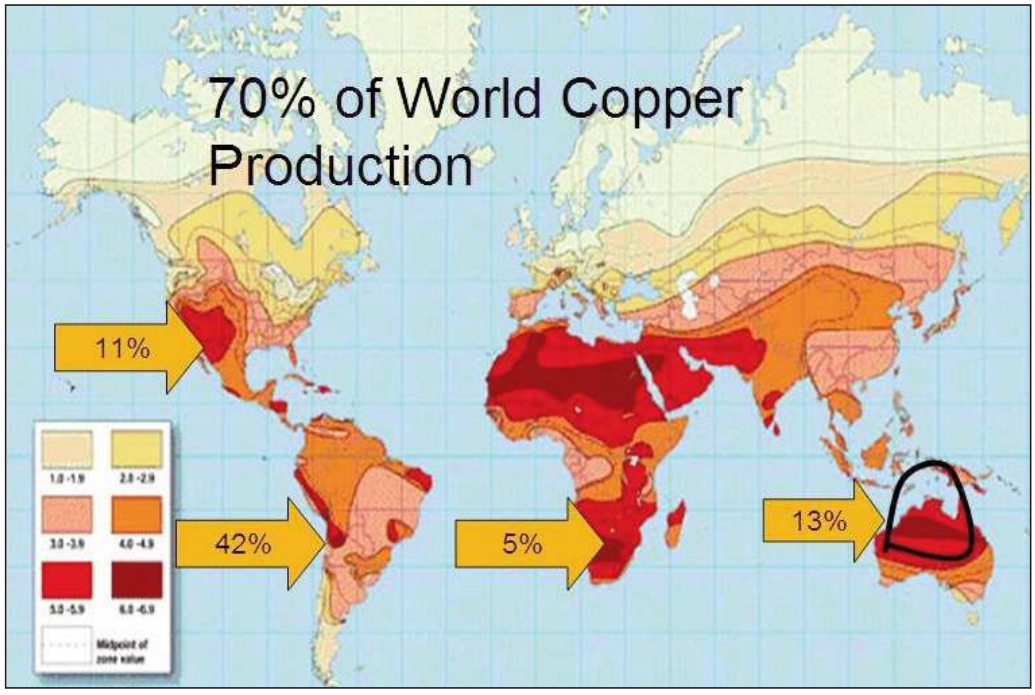
The Case of Chile

One of our inquiries as Project Engineer and Engineering Manager for Rio Tinto's planned block cave mine in Utah's Bingham mine was related to energy. We estimated that a 100,000 TPD mine would require in the range of 150-200 MW of new electrical power, and Rocky Mountain Power Company could not commit to providing it. So we looked around the region to see what kind of renewable sources of energy were in the area. There was a large and abundant wind resource about 100 km away in Wyoming, and a wind resource to the south and west of the area, in the valley south of Tooele. There was an abundant local solar resource. Geothermal energy had been developed about 100 miles south of Utah County near Milford, Utah. Ultimately, a natural gas power plant was planned due to its low capital cost and because these renewable resources could not be easily transmitted from their sources.

Each mine has its own renewable energy challenges, opportunities, and constraints. Solar is available at some times of day. Wind is available when there is wind. Geothermal is constant, as is hydroelectric. Although natural gas is not renewable, the supply / demand / pricing situation with natural gas, relative to diesel fuel, warrants consideration.

For remote mines which are off the grid, generation of electricity with diesel or fuel oil costs over $0.20 per kWh. Renewables can be below this cost, depending on the local character of renewable resources.

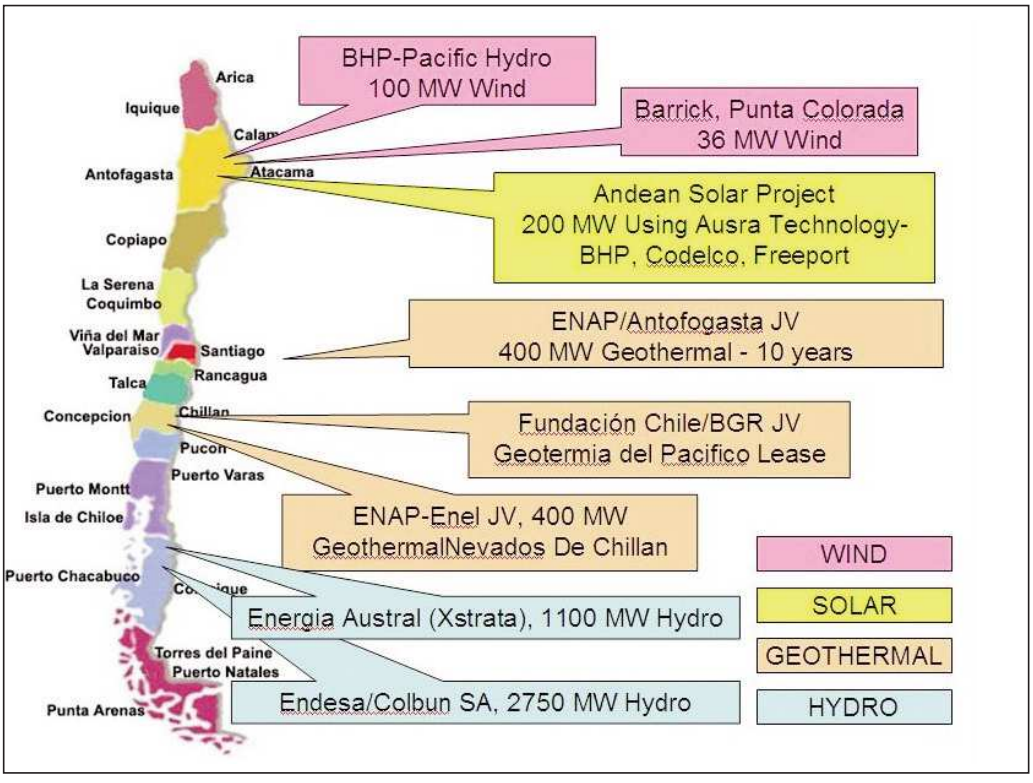
Copper is an essential commodity to enable the conversion of the global energy system from one based on finite carbon fuels, to a system based on renewable and long term sustainability. The copper mining industry in Chile produces approximately 36% of the total world copper supply, and is under threat of contraction unless short and long term solutions are found for supplying reliable and cost effective



Mine Proximity to Solar Resources

energy to this industry. Chile has long depended on natural gas from Argentina for fueling its power plants. Since 2004, Argentina has curtailed its shipments of natural gas to Chile due to its own energy crisis. As a result, Chile and its industry have substituted natural gas with petroleum based fuels to generate electricity. Retail pricing of electricity jumped by 300% in Chile in 2008-2009 as a result, and mining companies have reported reductions in mine output as a result of power shortages.

With peak oil and the associated contraction of global oil and gas production, the switch to petroleum based-fuel for generating electricity in Chile puts the viability of the mining industry in Chile under threat. Leaders in industry and government are beginning to recognize this threat and are taking steps to plan for a transition to greater diversification of its fuel mix, including renewable energy sources. For example, BHP Billiton and Pacific Hydro have collabo-

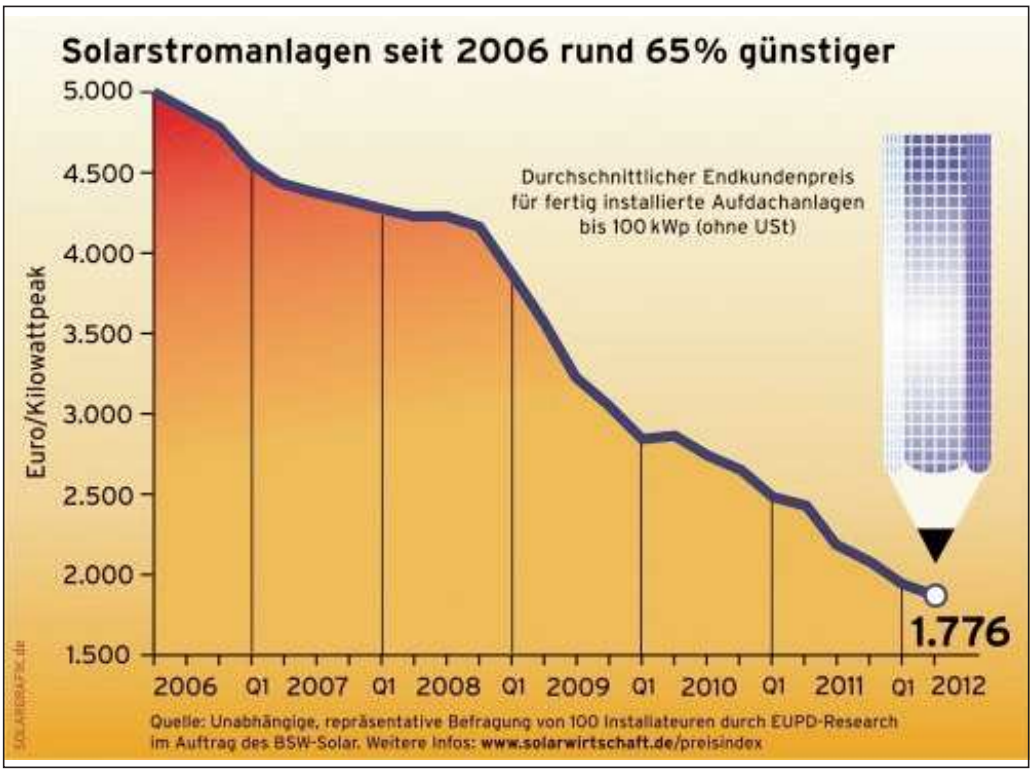


rated on development of a 100 MW wind plant. Barrick Gold has commissioned the 20 MW Punta Colorada Wind Project, and has applied for an expansion to 36 MW. Chilean President Michelle Bachelet traveled to Nevada in June 2008 to visit the world's third-largest solar plant which powers part of Las Vegas. According to Bachelet, developing solar power in the Atacama Desert region of Chile, where the bulk of Chile's mines are located, would support her goal of producing 20% of Chile's power from renewable energy. Finally, in May of 2012, Spain's Eosol Energy announced plans to build a $615 million, 193 MW solar energy project in Tocopilla, a town in northern Chile. Power produced at the solar energy park will be sold to the Norte Grande Interconnected System, which supplies power to mines in northern Chile.

Chilean Sustainable Power Project Outlook, circa 2009

In addition to the efforts to develop new and renewable energy sources, the industry recently signed on to an energy efficiency deal as reported on November 19, 2008 in Business News Americas: "The deal includes efficiency incentives and aims to promote research into best practices. Participants of the agreement also aim to share efficiency techniques and results of pilot programs. The following mining companies signed the deal: Anglo American, Barrick Gold, BHP Billiton, CAP, Codelco, Collahuasi, Enami, Freeport-McMoRan Copper & Gold, Minera Los Pelambres, SQM and Xstrata Copper, a division of Xstrata. Chile's mining council, and private miners association Sonami also signed the deal."

The outlook for renewable power development in Chile has evolved since 2009, with the reduction in cost for PV electricity.



In July 2012, Solarpack, a Spanish multinational developer and builder of photovoltaic solar power plants, announced that it has been selected by Compañía Minera Doña Inés de Collahuasi to build, develop and manage two solar photovoltaic plants in the Tarapacá region, Chile. The 25 MW projects strengthens the presence of Solarpack in Chile, where the company recently opened a 1 MW solar plant in Calama. Chinese renewable energy company Sky Solar, state-backed China Development Bank and Chilean industrial group Sigdo Koppers plan to make a Chinese firm's biggest investment in the Andean country: a $900 million, 300 MW solar energy park, export promotion agency ProChile announced on June 26th, 2012.

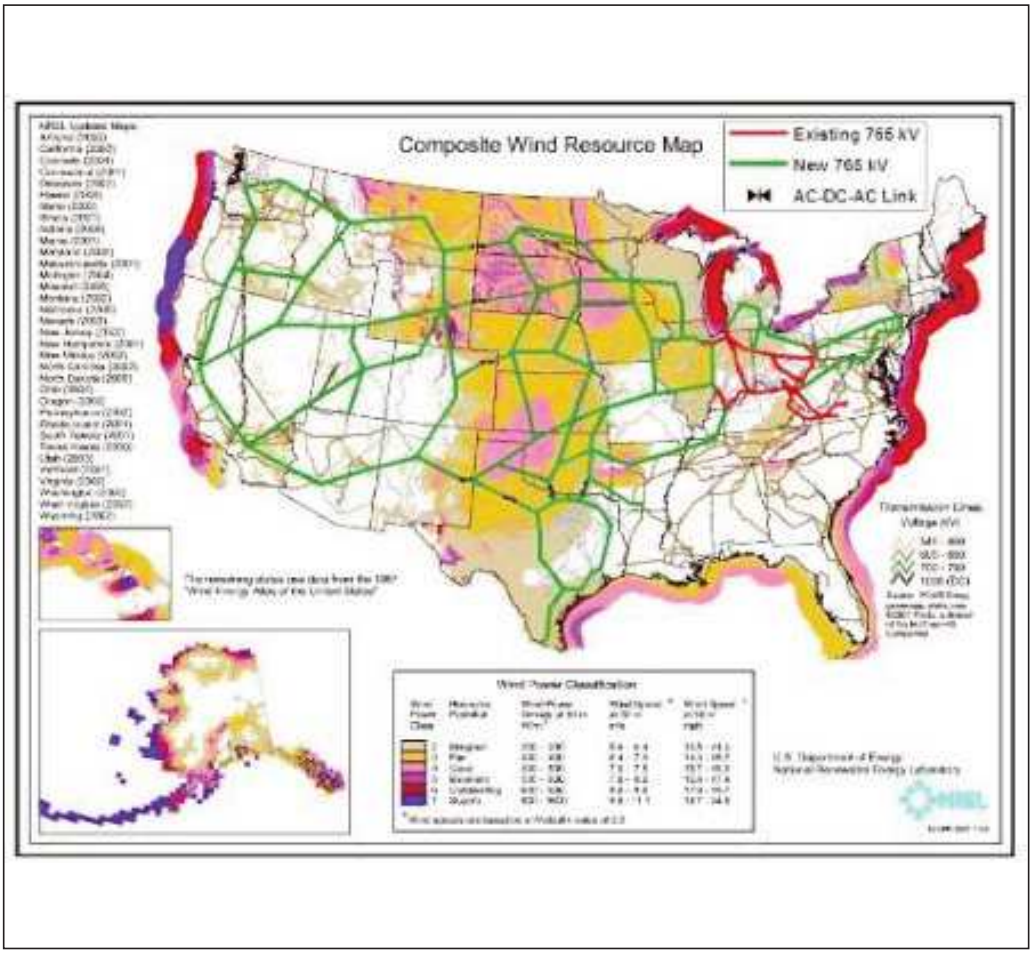
Integrating with Smart Grids/Super Grids

United States: Since the year 2000, the idea of creating a national super grid in the US has taken shape. In 2008, the

Department of Energy issued its outlook for energy transmission for the coming decade. A discussion of renewable energy is important to the mining sector, because if we are considering substitution of electricity for non-renewable fuels like diesel, we need to know if there are sufficient electrical generating resources available, and can it be transmitted to the user markets.

This vision is becoming a reality with a series of private transmission ventures.

Colorado Oil Billionaire Phil Anchutz, has acquired the developments rights to the Transwest Express Transmission



Department of Energy Vision for US High Voltage Grid

Project, a $3 Billion, 3,000 MW transmission line project between Southern California and Wyoming where he owns 9 million acres along the Utah Wyoming border, and plans a 2,000 MW wind farm. Utility companies and corporate energy users will be able to purchase power from this project. Exactly how this venture will interact with independent energy producers or the federal high voltage grid is not clear.

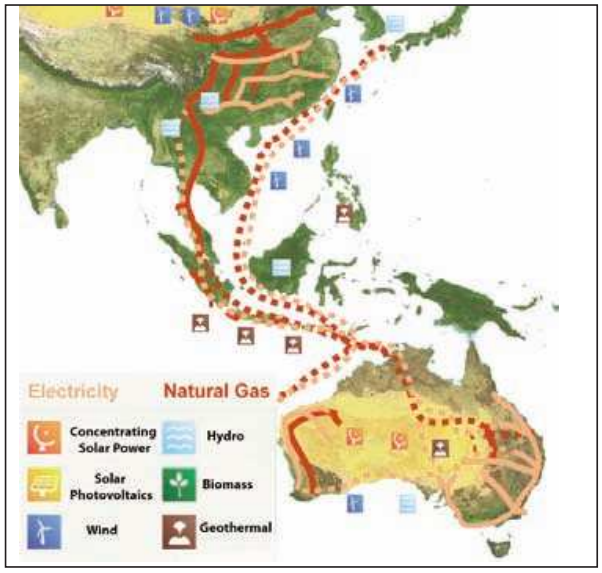
ITC Holdings is developing the Green Power Express, a 3,000 mile network of 765 KW high voltage transmission lines to bring 12,000 KW of renewable power from the upper Great Plains to population centers in the Midwest and eastern U.S.

The Grain Belt Express Clean Line will deliver 3,500 megawatts of wind power from western Kansas to communities in Missouri, Illinois, Indiana, ,and points farther east that have strong demand for clean, reliable energy. The clean energy will be transported via an approximately 700-mile overhead, high-voltage direct current transmission (HVDC) line. Clean Line's investors include the Houston-based Zilkha family, funds associated with ZBI Ventures, and National Grid. Clean Line is engaged in planning other high voltage lines in the US.

Europe and Africa: "DESERTEC is a project supported by a foundation of the same name and the consortium DII (Desertec industrial initiative) created in Germany as a limited liability company. The project aims at creating a global renewable energy plan based on the concept of harnessing sustainable power from sites where renewable sources of energy are more abundant and transferring it through high-voltage direct current transmission to consumption centers. All kinds of renewable energy sources are envi-

sioned ,but the sun-rich deserts of the world play a special role. By taking into account land and water use, DESERTEC is intended to offer an integrated solution to food and water shortages in the coming decades." (*WikipediaAsi*a): The DESERTEC concept has been applied to a vision for a pan-Asian energy grid

The conclusion that can be drawn from this global activity toward renewable power generation and transmission is this: The shift to electrification of mining operations will be supported by the electrical infrastructure. The trend toward global electrification is in place, and will continue.



DESERTECH, Asia Vision

5.
Mechanization Trend

The years from 1980 to 2000 saw little new in the adaptation of new technology in mine development. Many large scale mines were developed in the 1970's and early 1980's, and the demand for new mine development services waned during that time. But since the turn of the millennium, the need for new production of mined commodities has increased, as the existing resources are being depleted, and head grades in existing mines is reducing. So there is renewed interest in finding ways to develop and operate mines more quickly, safely, and cost effectively.

Mechanized Shaft Sinking

When I began my field construction career on a major shaft sinking project, there was a rule of thumb that said you would lose a life for every 1,000 feet of shaft sunk. Clearly, times have changed for the better, but shaft sinking and other types of underground development work remain the most hazardous of professions. The shift to mechanization supports high production rates, but it is also a path to a safer way of doing business.

BHP Billiton has engaged DMC Mining Services to sink shafts for its Jansen Potash mine in Saskatchewan with the use of a shaft sinking machine designed and built by Herrenkenecht of Germany. This remarkable technology and system has been developed and proven for over twenty20 years in the sinking of civil shafts in Europe. It has been adapted for the deep shaft sinking environment for underground mine development.

For shafts ranging between 4.5 and 12 meters in diameter, this machine promises to revolutionize underground mine development. The cutting face of this machine is a vertically mounted road header which operates in a rotating sweeping motion from the center of the shaft outward to the desired diameter.

Cross Section of the Herrenknecht Shaft Sinker

Drilling

Rock Drilling has come a very long way since the beginning of mining.

Man working hand steel

Man using a jackleg drill

Today's drill jumbos come with highly sophisticated software and hardware options to assist in the automated gathering and evaluation of drilling data. They can automatically position themselves into the proper position for drilling, and automatically drill out the round while the miner/operator observes. I have observed significant advances in conventional "drill and blast" technologies since the 1970's, and these developments continue.

Road Headers

The next advancement in mine development was also first developed and used in civil projects, and that is the road header. The first road header patent was applied for in 1949 by Dr. Z. Ajtay in Hungary.

Selecting the correct machine is vital to achieve the benefits of mechanization with this technology. First, the cut-ability of the rock should be studied, as well as the consistency

AtlasCopco Jumbo

Sandvic Jumbo

and presence of faults and fissures. From an analysis of the rock, and required opening size, the following selection criteria should be considered:

- Applicable maximun torque
- Applicable maximum boom forces
- Cutting capacity (Cutting rate)
- Horizontal and vertical stability
- Maximum cutting width and height
- Travelling speed
- The pressure applying on the ground
- Maximum working gradient

Ref: Analytical hierarchy process for selection of roadheaders, O. Acaroglu, H. Ergin, and S. Eskikaya; The Journal of The South African Institute of Mining and Metallurgy, Vol 106, Aug 2006.

Sandvic MH 620 with Drill Rig and Extended Conveyor

Tunnel Boring Machines in Hard Rock

Tunnel Boring Machines, or TBM's, have been under development since 1825 when the first successful tunneling shield was used to excavate the Thames Tunnel. This did not include a complete boring machine, but only a shield.

Boring machines for mining applications typically involve hard rock. Hard rock machines use a cutter head with disc cutters mounted on it to create compressive stress fractures in the rock face. This causes the rock to chip away from the rock directly in front of the machine. The muck is carried away through holes in the cutter head to a conveyor which carries it out to the haulage system from the TBM to the portal, or other waste location.

In competent rock, open type TBM's are used and they have no shield, leaving the area immediately behind the cutter head open for rock support. Ground support methods include rock bolts, ring beams, wire mesh, shotcrete, steel straps and ring steel sets.
In more fractured rock, shielded hard rock TBM's are used,

World's Largest TBM: Dual Mode Herrenknecht EPBM at Launch Site

and concrete segments are installed behind the head as the machine progresses forward.

Traditional TMB machines for civil projects typically have long length production assemblies behind the head, and large turning radii. Herrenknecht AG holds the distinction of building the largest diameter soft ground TBM at 19.25 meters, for constructing the Orlovski Tunnel in St. Petersburg, Russia. The Robbins Company holds the record for a hard rock machine at 14.4 meters diameter, for Canada's NiagaraNiagara Tunnel project.

A newly developed dual-mode Herrenknecht TBM that can be adjusted inside the tunnel for different soil conditions has broken through the Vosges Mountains in France two months ahead of schedule. *Ref: Tunneltalk.com Sep, 2012*

Using TBM technology in the mining sector requires different capabilities and demands for flexibility than the civil sector. Tighter radius turns, varying ground conditions, quick set up and tear down, are some of the demands of mining applications.

The latest application and use of Tunnel Boring Machines in mining is at Rio Tinto's Northpark Copper / Gold Mine in Australia.

As reported by Lawrence Williams on Mineweb, Friday, April 5, 2013:

"Together with Rio Tinto, Aker Wirth has developed a new, innovative tunnel boring system for underground mining and tunnellingtunneling, the Mobile Tunnel Miner (MTM). The machine concept combines the flexibility of a road-header with the robustness of a conventional tunnel boring machine (TBM). To build this machine, knowledge gained

from a previous version that Aker Wirth had developed and tested has been built on. With the MTM, excavation performance is reckoned to be more than double the rate that can be achieved with drill and blast tunneling."

This application of TBM technology in mining may mark an historic turn in the industry, just as the invention of jack-legs, drill jumbos, and road headers have been in the past.

Aker Wirth TBM at Rio's Northpark Mine

This machine has a reported turning radius of 30 meters, and the features of a road header and TMB combined.

6.
Human Performance: Safety and Productivity

Construction and mining have long been considered among the more dangerous occupations in the world. As far back as 400 years BC, Hippocrates, the father of contemporary medicine, realized the respiratory problems of Greek stonecutters were linked to the rock dust that surrounded them.

Construction and mining sites present numerous opportunities for accidents and injury: heavy machinery, open pits, exposed electrical wiring, falling objects, toxic chemicals, and ear-shattering noise.

Early attempts at worker safety regulation in the US were met with resistance. In 1904, Maryland's attempt to force employers to compensate their employees for on-the-job injuries was overturned by the Supreme Court, which

declared the state's workers' compensation law to be unconstitutional.

As the 20th century progressed, a more humanitarian view began to emerge. In 1936, the Secretary of Labor, Frances Perkins, called for a federal occupational safety and health law, although it took until 1970 for President Nixon to sign into law the Occupational Safety and Health Act (OSHA). Still, many employers believed that rules and regulations would inhibit performance and slow down productivity.

By the time I entered the work force in the mid 1970's, employers' main concern was how to comply with the new regulations and, difficult though it may be to believe now, convey the importance of wearing hard hats on the site. An entire new body of knowledge, including environmental studies, began to accumulate. There was still not much understanding of how occupational health and safety meshed with the other priorities of line supervision. In 1977, recognizing the unique nature of mining environments, the United States enacted the Federal Mine Safety and Health Act, which is administered by the Mine Safety and Health Administration (MSHA), which is an agency of the United States Department of Labor.

In addition to the United States, other developed countries around the world, including Canada and Europe, have instituted national laws and regulations which advance worker health and safety. The adoption and implementation of these health and safety laws vary considerably between developed and developing counties. However, one of the highly developed trends is the universal corporate adoption of health and safety standards by global companies involved in the industrial and extractive industries.

And, the countries in which they operate are adopting legislative and enforcement mechanisms at a rapid rate.

> "Wrap your mind around this – in only the last 4 years, environment, health and safety regulation around the world increased by 35 percent, major global enforcement activity doubled and EHS legislation in Africa and the Middle East amplified by an alarming 300 percent."
> Now is a key moment to be honest with ourselves. The increasing amount of global environment, health and safety regulation is utterly nerve-wracking. As an EHS leader, you might be bewildered by the notion that so much can happen so quickly.
>
> There have been exponential climbs in unexpected areas of the world and across topic issues you may not have been prepared to address. However, now is not the time to let intimidation run the show. It's time to be in full control of compliance by understanding what truly is happening globally.
> *Mar. 29, 2013 Virginia Shaffer and Tjeerd Hendel-Blackford*
> *http://ehstoday.com/safety/then-and-now-difference-4-years-can-make-ehs-regulatory-focus-around-world*

To illustrate how some global corporations have advanced the state of human safety in their organizations, I will use four examples to show the progress. These include: DuPont; BHP Billiton; Rio Tinto; and the mine developer, DMC Mining Services.

DuPont STOP

In the early 1980's, I was tapped to spend four years of my career on the business development side of Dravo Corporation, once an International Engineering and

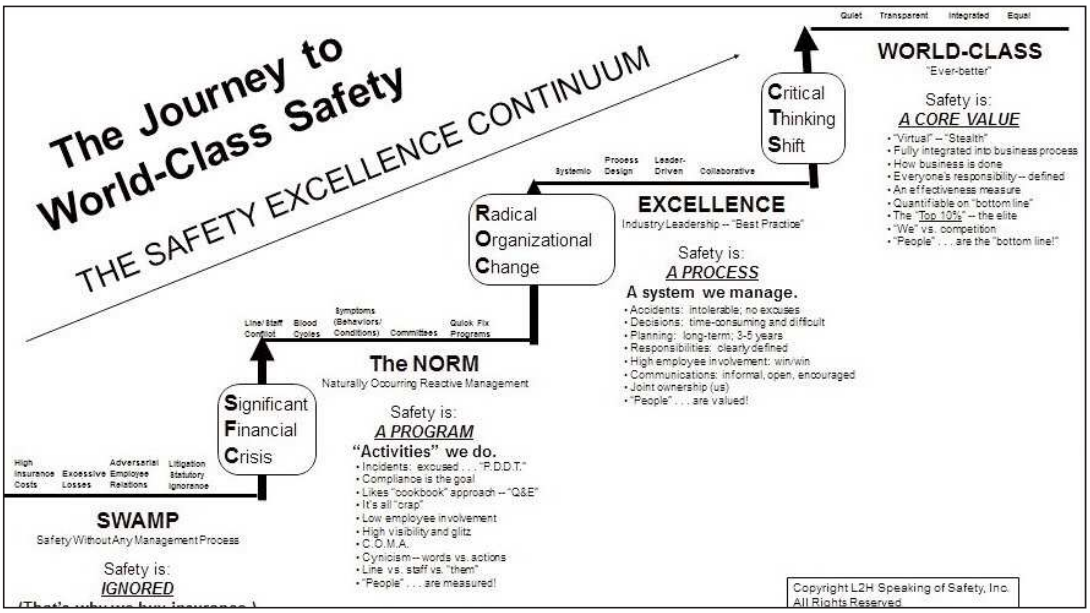
Construction firm operating in the US and 19 foreign countries. In that role, I served as a liaison between Dravo and its Fortune 500 clients to design and implement client service and project approaches. At that time, the DuPont STOP (Safety Training Observation Program) program was recognized as one of the leading programs available for public use. DuPont had created a library of support materials and courses for anyone interested in implementing the STOP program, so STOP served as a model for my work at Dravo.

As its name implies, STOP was highly focused on supervisory training in the areas of work observation, inspection, and prevention of accidents through the control of unsafe conditions and practices. In the 1970's and 1980's it was largely the responsibility of the people whose job titles had "safety" in them.

Behavioral Safety

Since the 1980's, the most successful safety results have come in organizations where safety is a line responsibility, with safety personnel taking an "advisory" role within organizations. Increasingly, the concepts of "behavioral safety" have gained prominence. Moving beyond the supervisor; a hallmark of behavioral safety programs is a high level of employee involvement in defining what it takes to create and maintain a safe work environment, including rules and dos and don'ts. Behavioral safety places a greater emphasis on behaviors, thought processes, and mental states.

Implementing a safety culture change in an organization is not easy. Larry L. Hansen has created the above model to recognize and identify the present state of safety awareness, which might be used to identify which next steps might be used to move forward.



Kennecott Utah Copper/Rio Tinto

The Utah operation of Rio Tinto's/Kennecott Utah Copper Bingham Canyon Mine, Concentrator and Smelter is recognized as the safest mine in America. The history of safety at Rio Tinto is worth examining.

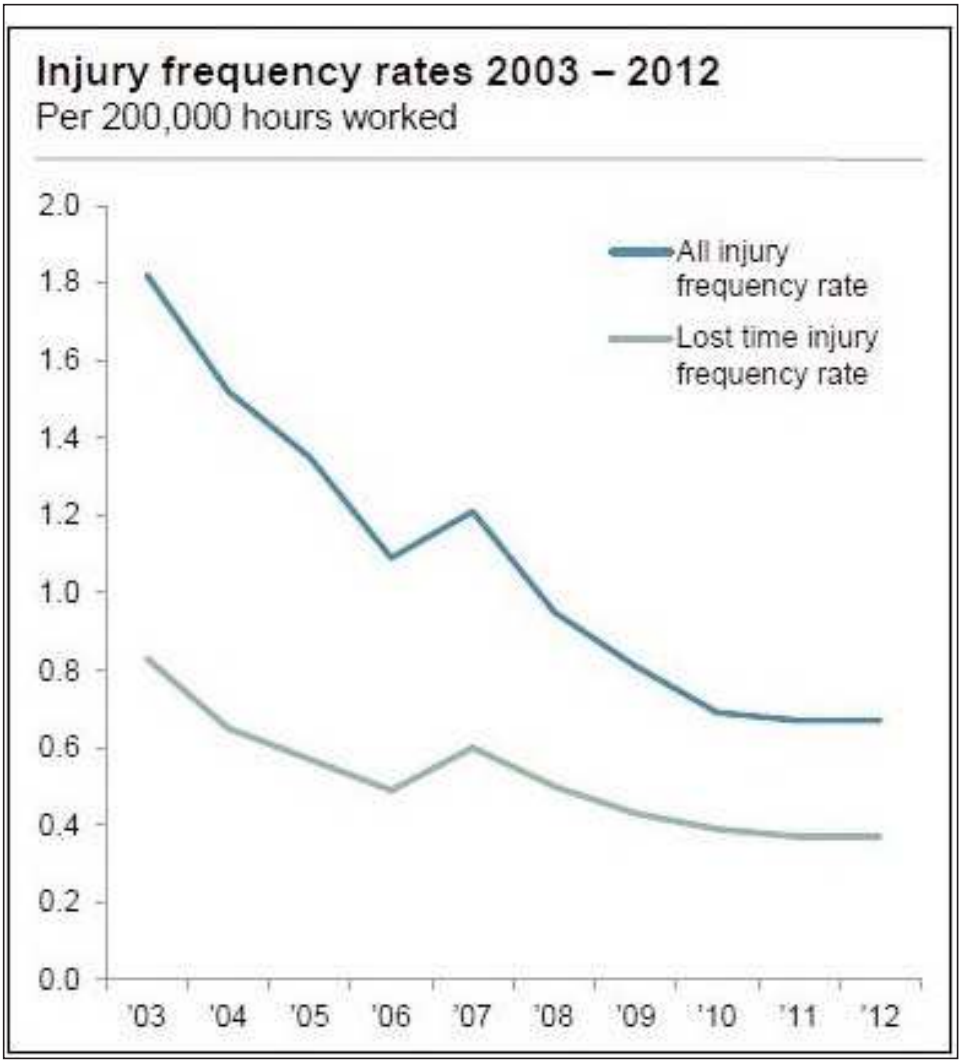
On September 18, 1998, the Austrian government issued a highly critical report about a mine disaster at Talc de Luzenac's Lassing mine where ten miners died when the roof collapsed. The report found that the disaster was caused by a management focus on profit over safety. This was a defining event in the history of Rio Tinto, Talc de Luzenac's parent company, and one of the largest and most diversified mining companies in the world. Nine years after the Lassing disaster, I had the opportunity to work for Rio Tinto as the project and engineering manager for their underground development at the Bingham Canyon mine in Utah. By that time, Rio Tinto and its worldwide subsidiaries had achieved some of the highest safety records in the mining industry. Through a concerted corporate commitment, Rio Tinto had created a corporate culture where

safety was the number one priority, and the safety value was embedded into every business process.
Some of the key elements of Kennecott's program include the following:

1. TRACK

They have implemented what they call the TRACK system. From their website, here is an outline:

An important safety element is for employees and contractors to conduct a pre-task risk assessments. A pre-task risk



Kennecott Utah Safety Record

assessment helps identify any hazards or deficiencies, and then allows the correction or mitigation of any issues prior to commencement of work. The following 'TRACK' system has been developed to assist employees and contractors when performing their pre-task risk assessments.

Think through the task(s)
Think about each step in the task(s)
List permits and authorizations needed to work
Define equipment and tools that are to be used
List area personnel that need to be notified

Recognize the hazards
Ensure that your work area is safe
Check that equipment and tools are safe
Check energies and substances isolation
Check above and below for potential hazards.

Assess the Risks
Could an injury or accident be avoided?
What equipment/systems could be damaged?
What are the likelihood and consequences?

Control the Hazards
Eliminate (remove the hazard)
Substitute (less hazardous chemicals)
Engineering (guards, covers, handrails)
Administration (JSAs, SOPs , permits, signage)
Correct PPE (harness, glasses, gloves)

Keep safety first in all tasks
Check for changes in work conditions (e.g., wind)
Monitor safety controls for effectiveness
If the task changes, reassess safety

Continually reassess work progress
Look after yourself and others

2. Safety Interactions

Every management employee is expected to perform a "safety interaction" at least once per week, with a front line worker or workers. This safety interaction is simple. The person conducting the interaction asks a few simple questions: What are you working on or doing? What are the risks and hazards involved? What are you doing to control the risks and hazards.=? This interaction must be recorded on the company intranet by the person conducting the interaction, and then the key to the delegation is this:rhe the system reports back the level of participation and compliance with the weekly interaction mandate – the percent participation is reported for the area manager.

3. Peer reviews

At periodic intervals, groups of individuals are flown around the world to conduct peer reviews of other operations around the company. These operational reviews invariably focus on safety as their number one priority.

4. Peer interactions

At one project, we had the hands perform interactions three times daily. Each worker had a small green card for every day of work that they filled out with a record of their interaction, and the signature of the person or persons they interacted with. Daily, these green cards were handed in with the time, and participation was monitored. Monthly, those who had perfect participation were eligible for a prize drawing.

5. Safety Training

In addition to special training sessions, every employee was expected to complete monthly training refreshers on special topics. Front line supervisors received annual certification in safety management and supervision.

6. Risk Analysis

Each program or project or operating group participated in the development of detailed risk management plans to cover overall project or program risks. Every month, the program or project leader was charged with updating the plan, and reviewing it with his up-line and project team. These risk management plans were "living documents."

7. Peer observations and reporting

In addition to the peer interactions, every employee was trained, empowered, and encouraged to report on any unsafe acts or conditions when they saw them, regardless of whether or not it was in their work area.

8. Feedback

At every group and level, there was measurement and broad internal reporting of near misses, incidents, accidents, and lost time accidents.

9. Safety shares

At the beginning of any and every meeting, someone would volunteer to give a "safety share," which could be anything from a personal experience of a safety issue at home, to a safety observation on the job, or a caution about driving home on a snowy road.

10. Internal and external benchmarking

Within Rio Tinto globally, and within each operating group, the safety performance of each unit was monitored, measured, and reported across the organization.

11. Safety inspections

Each week, every superintendent, project or program manager was expected to perform a safety inspection and report the results on the intranet.

Ref: Work Smart, Work Safe, *Mike Vallez, 2011*

These are certainly not all of the safety practices at Rio Tinto/Kennecott, but they illustrate the intensity required to achieve world class and award winning safety results.

DMC Mining Services

DMC is an international engineering and construction organization which has historically focused on the design and construction of underground mines, shafts, horizontal drifts, and mine infrastructure projects. It works in one of the most hazardous sectors in one of the most dangerous industries.

The old rule of thumb about mine shaft sinking: causing one life lost per every 1,000 feet of shaft sunk was not acceptable. For that reason, safety at DMC has become a core value. Its safety focus is recognized in its vision statement:

"Fueled by Safety, Driven by Success"

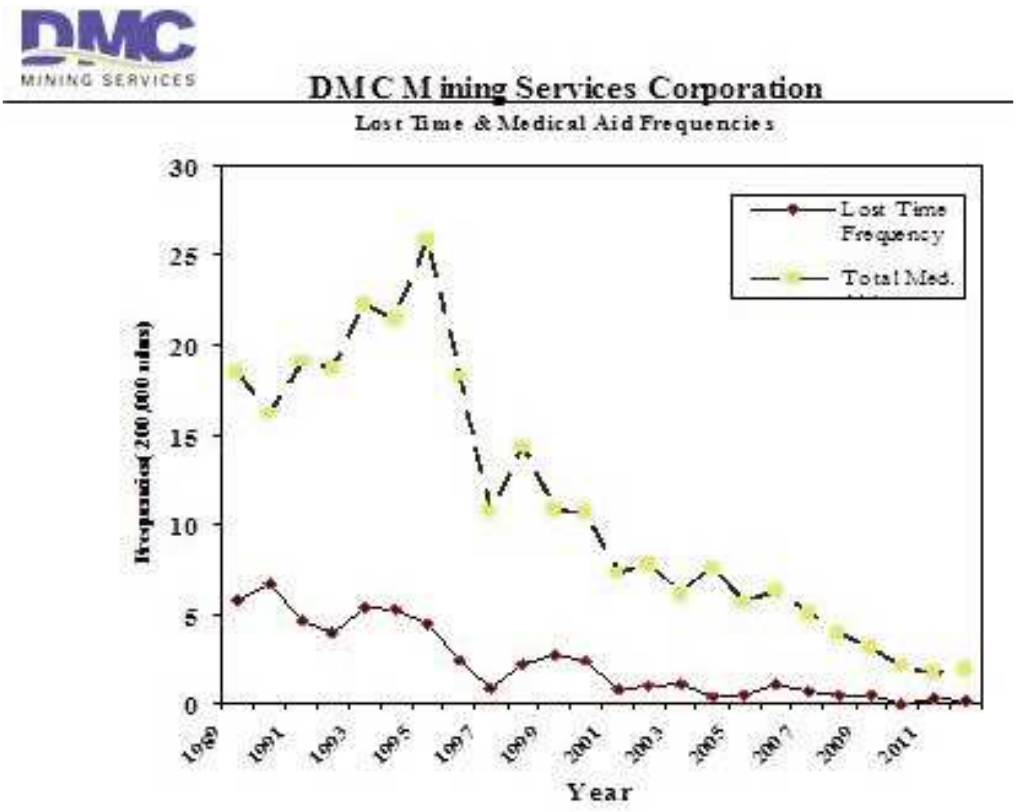
DMC's safety journey is not unlike that of many others. It always had a safety program with varying degrees of success. But in 2004, a significant safety incident occurred which changed the course of the company.

Today, DMC's safety record is among the highest in the underground development industry. Here are some of the elements of that program.

- Cardinal Rules a Condition of Employment

- Five Point Safety System
    - o Key opportunity for safety/ social contact
    - o Housekeeping audits
- Daily and Weekly Safety Meetings
- Accident / Incident Investigations
    - o People, parts, paper, positions
    - o Goal to determine basic causes (SCAT Analysis)
- Planned Inspections
    - o Formal and informal
    - o Housekeeping audits
- Job/Task Analysis
    - o Identify and rank critical tasks
- Job/Task Observations
    - o Hazard identification & risk assessment (HIRA)
- Management Audits
- OH&S Committee for larger projects
- Commitment to Supervisor Development and Training
    - o Soft skills training
    - o Focus on Responsibilities and Accountabilities
- Courageous Leadership Training and Zero Harm Training For All Employees

With an intense focus on safety, DMC has achieved results which are nothing short of pace setting for the underground mine development industry.



BHP Billiton, Escondida Copper Mine

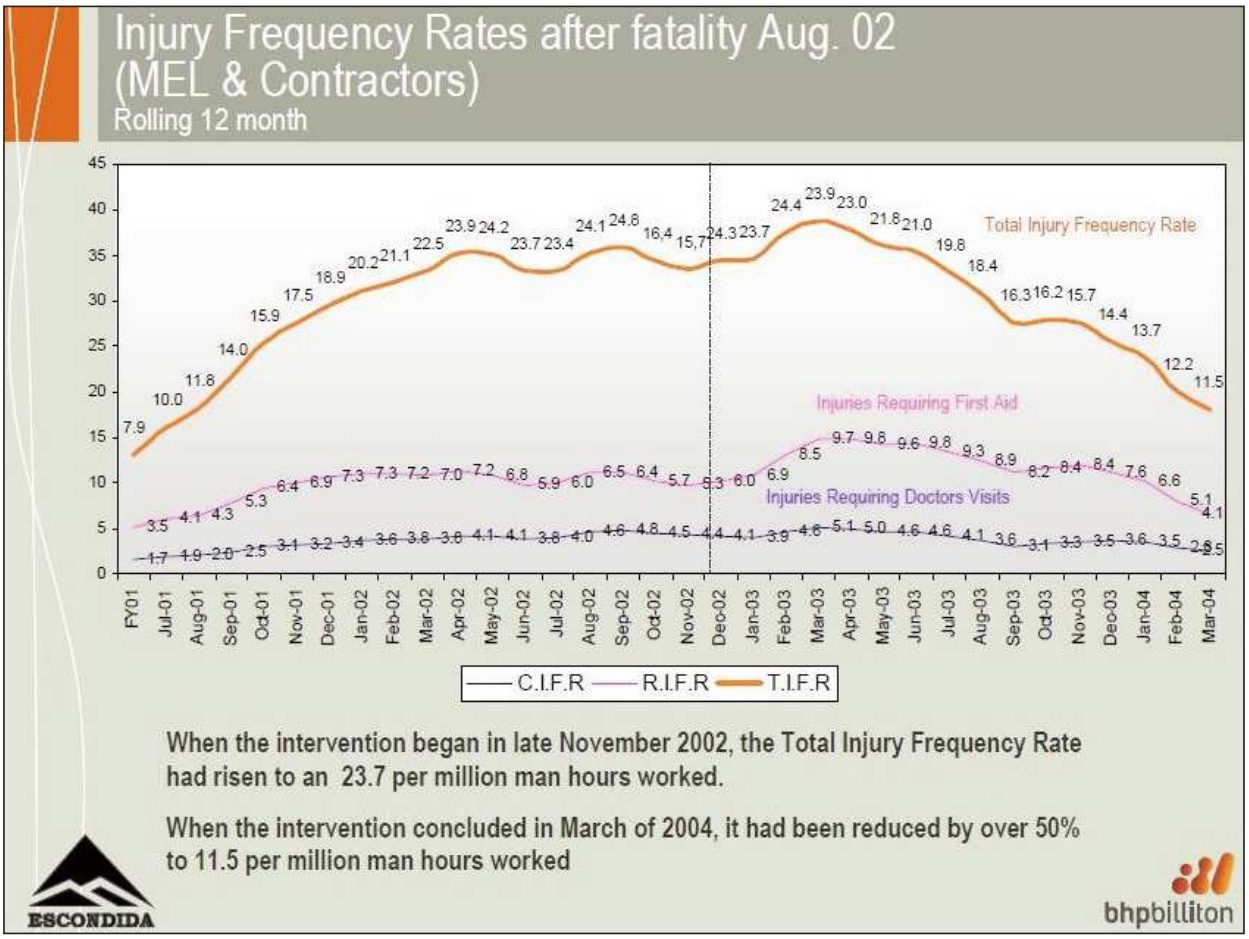
BHP Billiton is the largest mining company in the world, and managing partner of the Escondida Mine in Northern Chile. This giant open pit copper mine produces 9.5 % of the worlds copper supply and has about 5,000 employees. In 2002, BHP was facing an operational crisis at Escondida. Over a 12 month period leading up to a fatality, the mine experienced an 85% increase in first aids (RIFR); a 164% increase in monthly incidents requiring a doctor's visit (CIFR); and over a 300% increase in the Total Incident Frequency Rate (TIFR). Despite the fact that the mine had in place some world class safety systems, including STOP and Six Sigma, workplace safety conditions had deteriorated. The safety culture was lax, and the safety programs

were not being properly used or followed. As BHP's management consultant described:

> *"The mine personnel were not using the systems as designed, because a culture had developed in the mine where the local mine workforce distrusted the mine management and resisted systems and procedures they felt were being imposed on them."*
>
> *To counter this dismal safety culture that had developed, BHP brought in the Vanto Group to turn this situation around. Through application of Vanto's behavioral technology, the employees at Escondida were able to turn the situation around with some rapid results. When the intervention began in late November 2002, the TIFR had risen to 23.7 per million man-hours worked. When the intervention concluded in March of 2004, it had been reduced by over 50% to 11.5 per million man-hours worked.*

The successful Vanto intervention at Escondida included some basic elements:

- Vanto Group presented a series of programs which were offered to all levels of the workforce.
- This 15 month engagement began with a 4 day session in November of 2002.
- In the first 4 days a common language was created for producing breakthrough business results and setting up the preconditions that ensure that the engagement was successful.
    - o That people participated voluntarily
    - o That people were willing to be coached and take the coaching
- This altered the context inside of which all of these conversations for safety were had and in doing so, laid the groundwork for transforming the mine's culture from one of compliance to one of commitment. The safety proce-



Ref: Vanto Group Presentation: Journey to Zero Harm

dures went from being something that were being imposed on the workers to something that they embraced as their own.

- Following the initial program, Vanto Group designed a two day session that began in Feb 2003 and was delivered every 4 to 6 weeks until March of 2004. In the end the program was delivered to over 1000 people.

Leadership Development and Productivity

In April, 2010, the Deepwater Horizon drilling rig exploded in the Gulf of Mexico, killing 11 people, injuring 17 oth-

ers and starting a massive off-shore oil spill. The rig was owned by Transocean and was drilling for BP. Again, as in the case of Rio Tinto at Lassing, critics held top management responsible. The CEO of BP, Tony Hayward, lost his job over the disaster, and five new board members have been brought in. BP is still working through its internal corporate response to the spill. Time will tell whether or not BP gets it right.

These examples clearly show that the ultimate root cause of accidents is poor leadership. We have come a long way in our understanding of workplace health and safety since the construction of the Hoover Dam, Panama Canal, and Transcontinental Railroad. The world has little patience for leaders who prevail over teams and organizations which fail to provide a safe and healthy work environment for their workers.

Today, most employers have come to realize that safety, productivity and quality are not mutually exclusive. In fact, productivity can be greatly increased if people plan our out their tasks in advance; safety rules are adhered to; and a culture of interdependence and individual responsibility and integrity are created. (This topic is covered in detail in Work Smart, Work Safe!, which I wrote in 2011.)

The development of the "joint stock" companies, modern corporations, and mass industrial production and mining has brought about the need for better understanding of human performance in these relatively new (historically speaking) forms of human organization. Frederick W. Taylor (1856-1915) is considered the grandfather of scientific management, and was one of the first management consultants. In the area of human motivation theory, Taylor has

been followed by many others including:

- Abraham Maslow: Hierarchy of Needs Theory
- Frederick Herzberg: Motivation-Hygiene Theory
- Locke and Latham: Goal Setting Theory
- Mihaly Csikszentmihalyi: Flow
- Zaffron and Logan: Three Laws of Performance

There are others of course, too many to mention. One of the leading think tanks in human performance that we follow is the Social Science Research Network, associated with The Barbados Group. In a recently published paper by Werner Erhard and Michael Jensen, four key ways of being are identified for leaders and successful organizations:

"We argue here that the four ways of being we identify as constituting the foundation for being a leader and the effective exercise of leadership can also be seen as the foundations not only for great leadership, but also for a high quality personal life and an extraordinary organization. One can see this as a "value free" approach to values because,

1. Integrity as we define it (being whole and complete) is a purely positive phenomenon,

2. Authenticity is also a purely positive phenomenon (being and acting consistent with who you hold yourself out to be for others and who you hold yourself to be for yourself),

3. Being committed to something bigger than oneself is also a purely positive phenomenon (that says nothing about what that commitment should be other than it be bigger than oneself), and

4. Being cause in the matter as a declaration of the stand you take for yourself regarding everything in your life is also a purely positive phenomenon.

Ref: Four Ways of Being that Create the Foundations of A Great Personal Life, Great Leadership and A Great Organization*, by Werner Erhard and Michael C Jensen, March 2013. Harvard Business School NOM Unit Working Paper No. 13-078 Barbados Group Working Paper No. 13-01.*

Those of us who are engaged in the mineral extraction industry are in the midst of historic change in the way we develop, mine, and organize ourselves. A commitment to zero harm in our work environments and in the global mining industry can be one of those causes, greater than oneself, to which an individual or organization could make. Erhard and Jensen have identified four ways of being that can be foundations of every successful effort to create a high functioning mining organization in the areas of safety and productivity and work life quality. Just as Herrenknecht and DMC are leaders in rapid shaft sinking, Acker Wirth is a leader in the development of TBM machines for mining applications; the Vanto Group is the leader in applying the Three Laws of Performance, and embedding the four ways of being into mine operations for optimizing human performance, health and safety.

7.
Conclusions

The need for rapid, sustainable, safe and productive mining solutions has never been greater in human history. As the finite carbon fuel resources of the planet get consumed, we see the early signs of a turning point toward mining practices and technology that are truly sustainable, including electrification, mechanization, automation, and heightened human performance.

The phenomenon of human ingenuity and creativity are actively engaged in this pursuit of sustainable and rapid mine development. There is a high level of innovation occurring across all disciplines of the mining sector. At the same time, the need for education about and implementation of these innovative mechanical, electrical, and human technologies by current engineers is largely unmet.

Please contact me at DMC Mining Services, or:

Mike Vallez, P.E.
Email: mjvallez@gmail.com
Phone: 801-502-0951
Salt Lake City, Utah
USA