# Integrating sustainability in coal mining operations

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ABSTRACT

It is widely recognized that coal is and will continue to be a crucial element in a modern, balanced energy portfolio, providing a bridge to the future as an important low cost and secure energy solution to sustainability challenges. In response, the global coal and energy production industries have begun a major effort to identify and accelerate the deployment and further development of innovative, advanced, efficient, cleaner coal technologies. A number of coal producers are also involved in sustainable development activities, including economic support of communities and regions, environmental restoration and social well-being. These companies have corporate sustainable development policies and guidelines in place that provide guidance for operations, and report annually on their contributions to sustainability.

This paper will discuss the integration of public policy, law, environmental management and engineering, particularly as it relates to the recovery of energy and mineral resources. This paper suggests that the legal, social and environmental requirements for mining operations fully integrated into the mining and reclamation plan. Treating SD and engineering considerations as complementary parameters will result in optimized mining operations. Such a systematic approach is necessary in order to achieve economic and environmental sustainability, environmental protection and restoration, and effective, efficient and economically sound mining and reclamation.

## 1. INTRODUCTION

The importance of sustainable development principles has been increasing within the mining sector over the past two decades. Early work focused mainly on mining metals and commodities other than coal and energy fuels. Because sustainability, however, is an important consideration for all human endeavors in the 21$^{st}$ century (Gibson et al., 2005), the coal industry has become active in sustainability efforts. A number of global coal mining companies have embraced sustainability as a key aspect of corporate philosophy.

Continued production of minerals and fossil energy fuels may not fit into commonly understood definitions of sustainability. Mineral and energy extraction and reclamation operations do, however, contribute significantly to sustainability through the benefits they provide to society, when they are conducted in a manner that supports sustainable economies, social structures and environments throughout all phases of mining, including closure. Significant progress can also be made through the inclusion of sustainability concepts in the original design of the operation, as well as in ongoing operations. Innovative engineering, mining and reclamation operations can be optimized through consideration of environmental and economic sustainability goals, side-by-side with traditional technical mining engineering considerations.

## 2. CURRENT ISSUES

### *2.1 The future of coal extraction*

It is widely recognized that coal is and will continue to be a crucial element in a modern, balanced energy portfolio, providing a bridge to the future as an important low cost and secure energy solution to sustainability challenges. A review of the Annual Energy Outlook 2007 report from the Energy Information Administration (EIA, 2007) indicates that US energy demand is expected to grow at an average annual rate of 1.1% for the next 25 years. Almost every energy source is expected to grow, with coal, petroleum and natural gas dominating the energy mix. US electricity generation relies heavily on fossil fuels. Coal is the dominant component, with a share of about 50% in 2004, which is expected to increase to 57% by 2030.

Similar increases in coal utilization are anticipated worldwide. Overall, world use of coal is projected to grow by 44 % by 2025 (Waddell and Pruitt, 2005). Total world energy usage will increase by 34 % over that same period (IEA, 2004). In China, the International Energy Agency projected that the demand for coal to generate electricity will increase by 2.2 % annually, and coal-fired power will represent 72 % of China’s generation in 2030 (IEA, 2004).

In addition, coal and crude oil can both be used as feed stock for conversion into liquid fuels and the choice depends on the price of feed stock. Energy economists maintain that coal liquefaction is viable for crude oil prices greater than $40 per barrel. EIA predicts that Coal-to-Liquids will be the largest contributor of “unconventional” fuels, up to 7% of national supply. These potential demands will necessitate an increase in US coal production from the current level of just over 1.1 billion tons per year to almost 1.8 billion tons by the year 2030.

### *2.2 Corporate policies*

The global coal and energy production industries have recently begun a major effort to identify and accelerate the deployment and further development of innovative, advanced, efficient, cleaner coal technologies. A number of US coal producers are also involved in sustainable development activities, including economic support of communities and regions and environmental protection and restoration. These companies have corporate sustainable development policies in place that provide guidance for operations, and some report annually on their contributions to sustainability following the Global Reporting Initiative (GRI, 2007) or other guidelines. The US coal industry is also very active in the World Coal Institute and its efforts related to sustainability (WCI, 2007).

The World Business Council on Sustainable Development working with the International Institute for Environment and Development created the Mining, Minerals and Sustainable Development (MMSD) project in 1999. This project published its report in 2002 (IIED and WBCSD, 2002). The report includes an agenda for change and outlines nine sustainable development challenges facing mining:

- ensuring the long-term viability of the minerals industry,
- control, use, and management of land,
- using minerals to assist with economic development,
- making a positive impact on local communities,
- managing the environmental impact of mines,
- integrating the approach to using minerals so as to reduce waste and inefficiency,
- giving stakeholders access to information to build trust and cooperation,
- managing the relationship between large companies and small-scale mining,
- sector governance: clearly defining the roles, responsibilities, and instruments for change expected of all stakeholders.

### *2.3 Traditional mine design considerations*

Most mine designs are based on traditional mining engineering factors, such as the quality of the commodity being mined, the geology, topography, hydrology, land ownership, geography, infrastructure, etc. Currently, environmental compliance and sustainability are considered in mine design and operation as a modifying factor to those designs. A cursory review of a few permit applications received by state and federal regulatory agencies in the US suggested that the designs used environmental requirements as constraints or modifiers on the plan, not as co-equal considerations. While practices may become more responsive to sustainability, mine design continues to be governed by established mining engineering approaches.

*2.4 Optimization*

A cursory review of the available literature on engineering optimization does not reveal any focus on mine design, environmental protection associated with mines or sustainability. Mathematical multi-criteria optimization approaches, however, have previously been used in resource management (Stadler, 1988). Unfortunately, there is a paucity of literature about the practice.

As with any optimization problem, mine design optimization would need to consider all constraints, system parameters and characteristics and desired outcomes in order to build a useful and reliable model. Since optimization of mine design, and in particular coal mine design, to address sustainability along with other parameters has not been widely practiced, identifying the appropriate parameters for measurement and the mathematical or logical relationships between these parameters is not a trivial task.

*2.5 Public policy and legal framework*

Another important constraint on coal mining operations is the statutory and regulatory frameworks within which they are required to operate. Many of these legal and policy structures are based on a fundamental distrust of the regulated industry. In addition, while most have some means for public participation, the processes dictated by the laws and regulations are often ineffective at promoting meaningful public participation. Many of the laws tend to create an adversarial approach by instituting a system where one or more parties must respond to actions, proposals, decisions, etc. of another party. The participation is often late in the design process, or after design has been completed, and thus any change to mine or reclamation design necessary as a result of public or regulatory agency input creates a retrofitted design which cannot possibly be optimal.

## 3. SUGGESTED APPROACH

In order to optimize the design of coal mining and reclamation operations, traditional mining engineering considerations and environmental and sustainability goals must be accounted for simultaneously. It is essential to identify all of the parameters, relationships, constraints and desired outcomes related to the widely varying factors that contribute to mine design, as well as the additional factors that should be considered as a part of a new, sustainable design approach.

*3.1 Parameters*

For successful optimization of mine design, required parameters must be identified and measured as part of mine design and planning. To build an accurate model of those operations, data must be collected on ongoing operations. This data accounts for the modification of long-term designs as a part of permitting and the acquisition of information during mine operation. The design and operation of current coal mining properties should be evaluated by looking both at permitting documents and additional data which obtained from mining companies and other public and private sources. This data reflects the mining engineering, geologic, economic and other considerations currently integrated into the design and planning process.

It can then be determined how legal, policy, environmental protection and sustainability should be incorporated in mine design. Whenever possible, the effect of environmental and post-mining land use considerations on mine design and operation needs to be quantified in economic terms, so as to be on par with other engineering considerations.

*3.2 Relationships*

Once sufficient data is collected, it will be necessary to determine if and how these parameters influence one another and the desired outcomes for the specific mining operation. These relationships may be apparent based on scientific, engineering or other considerations, or may require detailed statistical analysis in order to determine them. It may not be possible to state the precise interrelationships between numerous parameters, particularly given the lack of complete independence of many of them. It may be possible, however, to derive qualitative rather than quantitative models for those relationships.

*3.3 Desired Outcomes*

In most cases, the ultimate desired outcomes are the profitability and long-term stability of the site. These are driven by corporate realities as well as the concern for long term liability. Coal mining is, after all, a business focused on profitability and long-term economic benefit for the shareholders or other owners. Additional outcomes for community economic benefits, enhanced environmental quality, and corporate image are also significant for many mining companies and in many locations.

The optimization approach must address the relative importance of these outcomes in order to weight them in the development of optimized models. For example, in an area with low availability of safe drinking water, protection of hydrologic resources may prove to be of primary significance, and thus of higher weight in the models, since it will greatly impact the feasibility and long-term profitability of the operation as well as the post-mining health of the community.

The nine factors related to sustainability in the minerals industry, identified by MMSD, can serve as the basis for desired sustainability outcomes. The first factor, industry viability, is addressed primarily through consideration of the economic profitability of an operation. Giving stakeholders access to information; defining the roles, responsibilities and instruments for change; managing the relationship between companies of different scales; benefiting local communities; and, promoting efficient use of minerals, are social factors which may be more difficult to measure and may not directly impact the design and operation of a specific mining property.

However, managing the environmental impact of mines and the control, use and management of lands are both more easily quantified and related to accepted practices and legal frameworks. Future work should focus on the parameters related to these goals. Many of these parameters may already be routinely measured as a part of environmental or other compliance mechanisms.

## 4. CONCLUSION

Many mining companies and operations are enhancing their commitment to sustainability and the long-term economic, social and environmental health of the communities in which they operate. In order to maximize the profitability of these operations and enhance the business case for sustainability, it is necessary to optimize mine designs. The designer of coal mining operations needs to simultaneously consider legal, environmental, and sustainability goals along with traditional mining engineering parameters as an integral part of the design process.

The role of coal in the global energy supply mix makes this of primary importance. There is a need for research into the parameters for mining design that allow the building of models for optimization, the relationships between those parameters, and the desired outcomes that the system is being optimized to produce. In addition to quantifying the economic viability of the operation, a number of sustainability goals should be built into the model and the relative importance of those goals determined.

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