

# **Mining engineering education and its role in the sustainable development of mineral resources industry**

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## **1. Introduction**

India has a long history of mining of minerals, probably dates back to Vedic times. Mineral resources always had a direct contribution to the economic growth of a country and played an important role in improving a Nation's standard of living. Through technological developments there has been a continuing evolution and expansion in the minerals we consume and the range of uses to which they are put. Minerals are basic and essential raw materials for:

- **Construction** to develop, maintain and enhance our built environment and transport infrastructure
- **Manufacturing** for the production of a wide range of industrial and consumer goods
- **Transportation and electricity generation** for use in the home, industry and commerce and
- **Agriculture** to improve the productivity of the soil

A classification of the major group of economic minerals in terms of the downstream industries in which they are consumed (Figure 1) serve to illustrate the dependence of many critical sections of the economy on the minerals and their products.

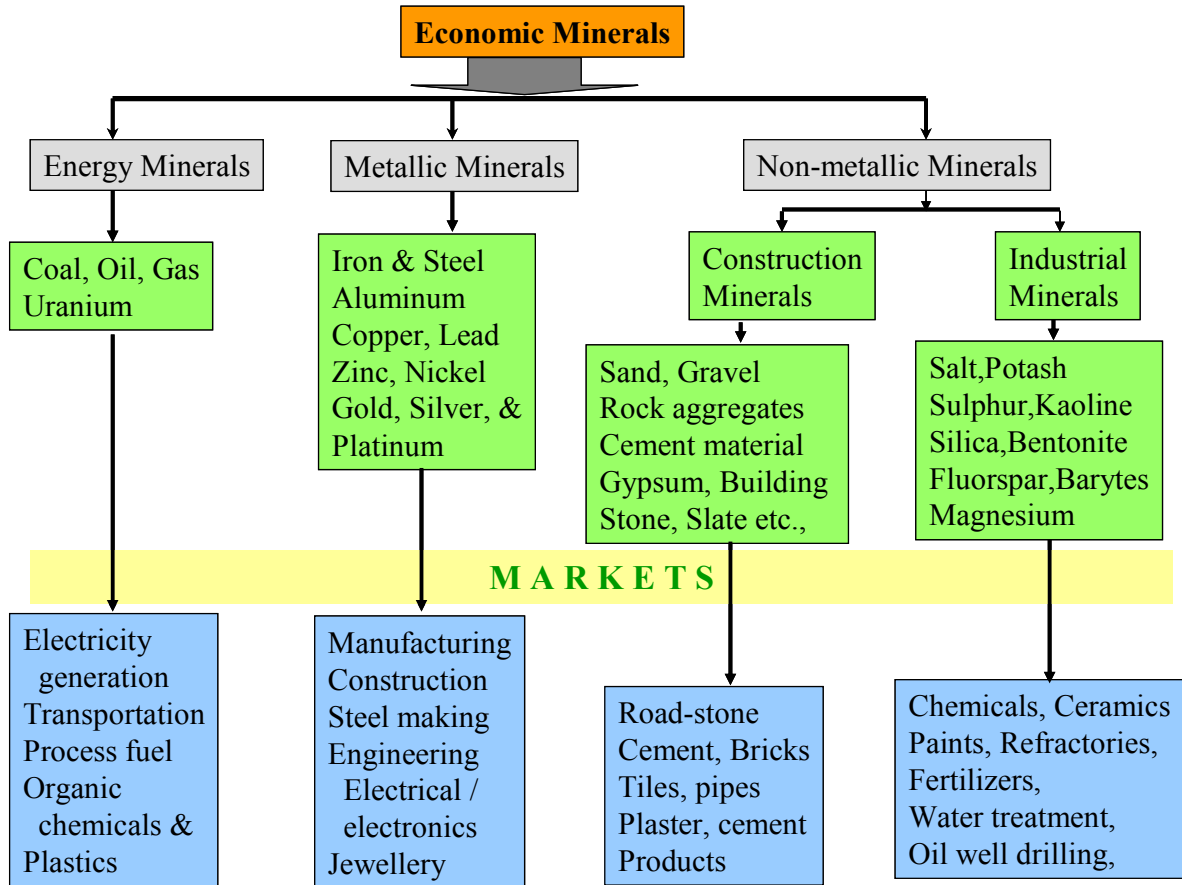


Figure 1 Economic Minerals and Selected Sectors of the Economy in which they are Consumed [1]

## 2. Role of Minerals in the developing economy of India

The globalization of industries and the consequent reforms initiated in India have led to rapid economic progress and better growth rates. Studies by several academics and consultants forecast continued high growth rate for the next several decades. India today stands at the defining point with its foreign trade of both goods and services reaching a new peak, helping the country in its continuing quest to advance in

terms of not only material prosperity but also human welfare for an improved quality of life to its people.

Growth in economy is made possible by several inputs, of which the two most important are energy and human resource. Energy is the engine for growth. To sustain the growth rate in economy, energy supply has to grow in tandem. For a large country like India with its over one billion population and rapid economic growth rate, it is projected that the commercial energy requirements for the year 2031-32 [2] at 7% rate of growth, would be over 5.5 times that of today and at 8% growth the energy requirement would be over 7 times the present level [2]. The electricity requirements are likely to go up from 633 BkWhr to over 3000BkWhr [2]. No single energy resource or technology will be able to address all issues related to availability of fuel supplies, environmental impact, particularly, climate change, and health externalities. However, coal seems a single major source of energy for the next couple of decades and it is expected to contribute 78% of the total energy demand. The corresponding projections of production of coal, both from underground and opencast mining show an increase from 415 million tons in 2004-05 to 2.7 billion tons in 2031-32 [2]. These are the projections of one of the major sectors that are energy sector. A similar increase in the other metallic and non-metallic minerals is expected to make their contribution for a sustainable growth of Indian economy.

### **3. Mining – from the past to the future**

The fluctuations of demand and supply in global market for the natural mineral resources often influence the scope of mining engineering discipline. The last two decades saw mining engineering at its low in India. In metallic mineral sector, legendary gold mines of Kolar Gold Fields (KGF), the glory of copper mining in Ghatshila of Hindustan Copper Limited, and the promising lead-zinc mines of Hindustan Zinc Limited and Asia's biggest open pit iron ore mines of Kudremukh Iron Ore Company Limited (KIOCL) vanished from the Indian mining horizons. Thousands of mine workers and many executives lost their jobs and once the prosperous and lively townships of these companies turned into war ravaged sites. The standard of living in these areas experienced a nose dive and the poverty and unemployment led to the

growth of unsocial and criminal activities in those places which at one time were the neighborhood's envy. It is expected that the future mining industries take a leaf or two from the past to see that such experiences are never to be faced by the next generations.

Once again the good times for mining industry are not too far. This is true, in particular reference to Indian sub-continent. The increasing demand for mineral resources is slowly getting the mining industry back from the brink. Over the next few decades the need for mineral resources is likely to be more than what has been mined in the last few decades. However, the potential growth of the sector is endangered by public concerns about the environmental impacts of the mining industries. The public has long criticised the health and safety risks posed by mining. The recent episodes of land subsidence of grand trunk roads and other public facilities in Asansol region in India stand tall in the public opinion of the total environmental impact of mining. Environmental concerns exist both around small and large scale mining operations, albeit of a different nature.

This declining public trust in the mining industries is indeed affecting the industrial growth opportunities in India in two distinct ways. First, approval processes for new ventures are becoming more complex, expensive and time-consuming, example the POSCO mining project in Orissa and the withdrawal of Tata Motors from Singur, in west Bengal. Second, public concern about the mining industry has a negative impact on the ability of the sector to attract high caliber graduates and professionals, who play necessary roles for new ventures to be designed, operated and managed in an environmentally acceptable manner right from the start.

In the era of mechanization, automation and robotics, the mining engineering has undergone a morphological change, from the galleries of art to the portals of science and technology. It indeed is demanding additional skills over and above the traditional mining skills. To meet this predicted increase in demand for quality engineers, and for the industry to grow as an internationally competitive sector supported by innovation and technology, the industry requires competent professionals possessing sophisticated knowledge and advanced technical and leadership skills. To achieve this it is essential to look at the product to reevaluate its strengths and weaknesses. It is therefore the time for the teachers / mentors / educationists and the visionaries to put the mining engineering discipline on the anvil to redesign the course structure.

### 3.1. Sustainable Development in relation to Mining of Mineral Resources (SDMMR)

The concept of sustainable development embodies the interplay of (1) economic, environmental and social responsibilities, (2) the goal of trying to develop and maintain long-term objectives while undertaking what are essentially short-term development activities [3] and (3) to enable the society to view mining as a desirable activity which can earn the public's consent. This gives due regard to maintaining the integrity of our (ecological) life support systems while protecting or enhancing the quality of human life (health / culture).

The sustainable development – the Brundtland definition from 1992 Rio summit [4] is that “Current generations meeting their needs without compromising on the ability of future generations to meet their needs”. It in fact implies that

- Future generations have right over resources and that the current generation has a duty to include future generations' needs in its decision-making.
- Proper accounting of social and environmental impacts.

### 3.2. Salient features of National Mineral Policy – 2008

Mineral wealth, though finite and non-renewable in the long term, is a major resource for development. The need for a well planned program of survey and exploration, management of resources which have already been discovered and those which are in the process of discovery and their optimal, economical and timely use are matters of national importance. Considering the need for the sustainable development of mineral resources the government of India has revised the National Mineral Policy -1994 and the salient features of NMP-2008 are [5]:

- Create new reserves
- Conservation of mineral development
- Scientific methods of mining
- Mining as an industry with linkages

*(Mining contributes to the generation of wealth and creation of employment*

*independently and should therefore be treated as an economic activity in its own right and not merely as an ancillary activity of manufacturing industry. The mineral processing unit should not only get an assured supply of the mineral raw material but should also have close links with the production and marketing agencies of the mineral based end products. Mining as a backward linkage and Value addition within the same state as a forward linkage will, therefore, be encouraged.)*

- Mining Equipment and machinery

*(Indigenous industry for manufacture of mining equipment and machinery shall be strengthened. Induction of foreign technology and participation for this purpose will be encouraged. Use of equipment and machinery which improve the efficiency, productivity and economics of mining operations and safety and health of persons working in the mines and surrounding areas shall be encouraged. Import of such equipment and machinery shall be freely allowed).*

- Skilled man power development
- Infrastructure development
- Financial support for mining
- Small scale mining
- Mineral development and protection of environment
- Relief & rehabilitation of displaced and affected persons
- Systematic mine closure plans
- Mine safety
- Research & Development division in the areas of Mining, Mineral Processing and beneficiation,
- Development of automated equipment
- Deep sea mining.

#### 4. Mining Engineering Education and Sustainable Development – an Indian Scenario

Mining in these years is much more than a simple technical process. It has transformed into a profession requiring a high degree of technical & managerial skills, social & environmental awareness and liability. Having realized these needs of the mining industry, the teaching institutes are making required changes in mining curriculum.

The curriculum should focus, on building analytical, problem solving and communication skills in which an essential component would be basic literacy in contemporary Sustainable Development (SD) languages and definitions. Students should be given a perception of an over-all system (environmental system) into which they will be able to integrate new situations and knowledge.

There are a few minimum requirements in terms of basic science and engineering, engineering design, industry experience and research projects which may remain essentially the same, while new requirements in the fields of communication skills, management, minerals economics, information technology, mining law and environmental issues are introduced in the form of core and elective subjects.

At many universities abroad mining engineering education is undergoing or has undergone a complete overhaul, primarily in three forms. First, there is a gradual increase of environmental content in existing mining programmes. Second, several of the leading international mining schools are coming out of mining and are starting to offer integrated courses in earth sciences or resource oriented engineering. Third, several smaller mining schools have almost completely changed over to environmental curricula and offer mining only as a subject of specialization towards the end of the undergraduate program or through graduate studies. In these programs mining related subjects are no longer part of the core and are being absorbed into broader fields of engineering education that serve a functional rather than an industry need. This must be justifying for few countries, because this is taken as a normal evolution, dictated by the demand of industry for excellence and by the instinct of institutions to survive. Although we may not always agree in general but may be good for a few specific cases.

In India mining is a major contributor to the economy and so mining engineering is still an important field of study. There are around 14 government institutes offering mining engineering (IIT- under MHRD; 6 National Institutes; and 7 state universities). The undergraduate programs are given more importance in the country since a sizeable number of students join the parent industry though a few best students from these institutes go overseas for higher studies. Many of these graduated students stay in the host country after they have obtained their degrees, and compete in that job market.

#### 4.1. Mining Research and Development

Another critical element that has not yet received adequate attention in this review of education is the status of research, both basic and applied, much of which is carried out by university professors, doctoral and postgraduate students. It appears that considering the issues of sustainable development, mining may appear difficult since it is not possible to extract minerals from the earth's crust without creating a certain minimum damage to the environs. And this minimum so long it is not clearly defined keeps the mining industry in suspense. Further there is a need to focus the research and technology on two main fronts to survive the pressures of sustainable development. First is to develop processes and technologies to recover minerals from waste streams or low grade ores and emphasize a clean technology, and the second is to develop alternative materials to replace current applications of different minerals. In any case, the sustainable development concept reinforces the need for ongoing and progressive improvements of the mineral and energy efficiency of mining and minerals processing operations.

#### 4.2 The concept of a Dual Degree

As mineral development is becoming more complex the mining engineers may see advantage in knowing more than mining engineering, and programs have to be developed to meet this need. In IIT KGP there is a scope for a mining engineering student to take two degrees, the basic four year program gives him a degree in the engineering discipline and one year program in Management & Business Administration (MBA) or in Safety Engineering and Disaster Management in Mines.

#### 4.3 Regional Centers of Excellence:

The concept of networking of a series of universities / institutions as national or regional centers of Excellence is receiving much thought at present. In Australia three mining schools have formed a consortium. The objective here is that the premier institutes work complimentary to each other rather than compete with each other. It may work well at the postgraduate level and research level. There can be a common course



structure at these institutes at the graduate level / doctoral level. One of the particular interests is in preparing the next generation mining engineers to the imposing needs of sustainable development of mineral resources.

#### 4.4 Faculty exchange Programs

The research which is currently being carried out should also look into the industry. In comparison to many developed countries, in India the financial support from the industry for research in mining is the least. More scholarships / internships funded by the company can be made available for carrying out research in institutes. It has long term benefits. And the professionals from the industry share their experiences with the students through their lectures. The duration of these lectures may be planned based on the time availability of the concerned person / persons. The vocational training centers of the industry need to grow in quality and indeed should be opened for the teachers to train the executives and the executives to teach knowledge gained from their practical experience to the students.

#### 4.5 Industry and Institution interaction

Interactions between technical institutes and industry are mutually beneficial. The starting point of this interaction is in the fact that the institute prepares future industry leaders to the industry. It forms a conduit to transfer the results of the academic research to the real life problems and the industry's problems to the institute, *vis-e-versa*. So the industry needs a continuous technical support from the institute and with particular reference to mining industry, the industry may acquire a fundamental knowledge to manage sustainable development issues, and to balance environmental, social and economic considerations. On the side of the institute, this will have great bearing on the development of curriculum, exposure of industrial atmosphere to the students and subsequent placement of young graduating engineers in industries across the country. These objectives can only be achieved well by bridging the gap between industry and the academic institute.

To promote Industry - Institute Interaction following schemes are being undertaken

- Establishment of Industry-Institute Partnership /interaction Cell
- Organizing Workshops, conferences and symposia with joint participation of the faculty and the industries
- Encouraging engineers from industry to visit institutes to deliver lectures
- Participation of experts from industry in curriculum development
- Professional consultancy by the faculty to industries.
- Joint research programs and field studies by faculty and people from industries.
- Memoranda of Understanding between the Institute and industries.
- Collaborative degree programs.
- Undergraduate and graduate projects/dissertation work in industries under joint guidance of the faculty and experts from industry.
- Practicing engineers taking up part-time Graduate/Doctoral programs.
- Visiting faculty/professors from industries.
- Professorial Chairs sponsored by industries at the Institute.
- R&D Laboratories sponsored by industries at the Institute.
- Scholarships/fellowships instituted by industries at the Institute for students.
- Practical training of students in industries.

#### 4.6. Mining Company's needs and graduates early job expectations

The mining and allied companies recognize that government and associated NGOs' will continue to demand progressive reductions in their environmental impacts and the associated human risk and are therefore expecting the technical and managerial recruits to have a minimum understanding of environmental pollution control measures and that they are able to take care of the health, safety, environmental and social expectations in their day-to-day roles. The fresh Graduate Engineers are recruited through a screening tests and group discussions. In order of decreasing importance, the

general recruitment criterion is: overall academic record; practical experience; awareness of environmental pollution control measures; communication and interpersonal skills; technical knowledge and managerial skills.

For many obvious reasons almost 100 % students from Indian Institute of Technology - Kharagpur join software jobs and a similar trend is seen of the students from Indian School of Mines University and Banaras Hindu University. And those who have joined the industry do not like to work in mines as their first choice. Often we realize that for a great majority there was no other option than to join the mines. Did the job ever motivate the mining engineers in the mines to get the best out of them? The mining industry still carries a negative image – the picture of the mining engineer as someone who works in remote places under difficult conditions. Certainly the image has improved since 1960's, but there is still a long way to go when it becomes the choice than it being thrust upon.

How do we improve the image of mining? In the case of mining engineering education this is fundamental. A concerted effort needs to be made by the complete mining fraternity to improve the image of mining and to strengthen and improve the mineral engineering education.

The facts about the teaching profession are that the salary structure makes the teaching post non-competitive, particularly with the software industry. The best postgraduate students have more attractive options.

#### 4.7 Role of industry:

The role of industry is very important because it is the place where a good percentage of mining engineers join. With the changing trends towards globalization and industry consolidation the potential of and for industry cooperation is apparent in all aspects of the problem, including education and research. It is essential for the survival of the industry.

Indian mining industry has to make giant strides in the recruitment of trained mining graduates and has to equip them to perform with in new technical and economical constraints due to the environment challenges. It is not too far when the standards at a global level are set for the mineral industry to follow if they have to

remain in the race. There may be a global code of conduct complimentary to the existing mine safety legislation. Offering industrial scholarships is one way of motivating the students to mining engineering.

#### 4.8 Salary incentives and training

It is as a first step the industry should sit to restructure the pay packages at par with the software companies. Improve the living standards, in terms of primary education, health and recreation. Have a regular tailor made short term courses organized by the educational institutions. As far as the short term courses are concerned it should not be in the present style, in the sense that most of the courses do not have any objective, neither to the organizer nor to the participants. A group of underground coal mining executives sit in the class of metal mining course. Rather it is important that a team from the industry comes /contacts the faculty to set the required curriculum to be covered over a period of time which is spread over a year. It may review the content and teaching approaches and may advise the faculty on the expected outcomes.

The educational and research institutes should set the stage for imparting required training for the executives of the industry in a more effective format. Accountability is what we have to have between the institute and industry. It is a win-win situation.

### 5. Conclusions

The issues of sustainable development such as health, safety and environmental protection, together with community values have taken a strong foothold in the decision making processes for exploitation, mine development, operating procedures, and reclamation and mine closure activities. The mineral industry is seeking to employ more skilled graduates who can take leadership in addressing these challenges in the decades to come.

The mining institutes on their side have responded accordingly to the calls of the industry by adding suitable course content to core curricula and introducing a dual degree programs to create an opportunity to the deserving students to acquire additional managerial skills. The success of mining institutes with their new curriculum to increase

the skills of their graduates and widen the scope of their employability depends on the availability of the faculty strength and the support from the industry.

The industry should capitalize on their interactions with the institute, in view of the changing dimensions of mining technology, in particular reference to the clean technology and sustainable development of mineral resources.

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