Comparison of social costs of underground and open-cast coal mining

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Abstract

This paper presents a methodology for assessment of socio-economic costs from underground and open-cast coal mining. It can be used for comparison of social costs of specific coal mining projects.

1. Introduction

While coal mining might contribute significantly to a country's export and GDP, it has a lesser impact on national employment and income. On the other hand, mining can create several adverse environmental impacts including air, water and soil pollution, deforestation, negatively affect wildlife and contribute to some socio-economic problems such as community displacement, housing pressures, ill-health and child labour.

The total cost of mining includes the direct mining cost and social cost. The social costs include the impacts to the environment and socio-economic systems. According to the estimates for the complete costs of coal, coal mining only accounts for 22% of total social (external or "hidden") costs of coal (Epstein, Buonocore et al., 2011). The rest is attributed to the coal transportation, coal combustion, waste disposal, electricity transmission and climate change.

Social costs of mining vary substantially in both underground (UG) and open cast (OC) mining, depending on many factors such as the geological position of the deposits, the technology used, the characteristics of overburden, the scale of the mining, the proximity of the villages and townships. In general, OC mining is considered to be safer and more productive but having a higher environmental impacts than UG mining (World Bank 1998; Sahu, Prakash et al. 2015).

The valuation of social costs can be accomplished using different market and non-market valuation techniques (Ivanova, Rolfe et al. 2007, Ivanova and Rolfe 2011, Ivanova 2014). However, it can be hard to assign economic values to all socio-economic impacts from UG and OC mining. This paper provides a methodology for comparison of the social and economic costs of UG and OC mining.

Section 2 of this paper presents an overview of some potential impacts of coal mining on environmental, social and economic systems focusing on UG and OC mining. Section 3 compares the UG and OC mining impacts using arbitrary values. Section 4 provides summary and conclusion.

2. UG and OC coal mining: impacts

The impacts of mining are numerous. They include changes to physical environment, such as landslide and land subsidence, soil erosion, changes in existing topography and visual impacts of an open pit or waste dump. In addition to removing vegetation and changing the existing topography, OC mining produces large amounts of solid waste.

Altun et al. (2010) stated that the main physical impacts of UG mining are subsidence and slope deformation which in turn affect ground and surface water, land surface (including buildings, services and communications). Malgot and Baliak (2004) suggested that the impact of subsidence can extend beyond than the mining area.
Mining can change the quantity of surface and underground water and affect its quality. Acid mine drainage (AMD) or acid rock drainage (ARD) can be generated by discard dumps including those rehabilitated. The outflow of acidic water can happen 5 to 20 years after closure (Munnik, Hochmann et al. 2010). ADM can result in the deterioration of the water quality, health issues, damaged flora and fauna.

The noise and vibration from blasting can damage houses, other buildings and infrastructure. It can affect people and wildlife (Epstein, Buonocore et al. 2011, Dukka, Mahatha et al. 2004).

Mining can change the diversity of productivity of vegetation, impact on rare or endangered species, impact animal or fish population and present a barrier to the animal migration (Dukka, Mahatha et al. 2004).

Coal mine fires can occur in both UG and OC mines. They can be caused by lightening, forest fires, mine subsidence, the burning of trash, and electrical sparks from equipment (Sisodia 2013). Coal mine fires have serious social, ecological, and economic impacts. For example, the Centralia fire in Pennsylvania cost over $30 million, with most of the costs going toward relocation of residents (PADEP 2008, PADEP 1996).

The change to physical environment affect the land use. It is likely that the activity such as farming that was performed before OC mining took place can no longer be carried out. That include cessation of farming, tourism, reliance on the forest/nature for hunting/food and water supply.

The health and safety impacts of coal mining at workplace are significant. There are potential health hazards; risk of accidents from explosion, release of oil, radioactive materials, toxic substances (Dukka, Mahatha et al. 2004). Generally, the number of accidents and fatalities in the UG mines are higher than in OC mining (Mintz 1976, Joyce 1998, Harris, Kirsch et al. 2014).

Mining can have a positive effect on the local economy in terms of providing employment and income to the workers. However, the impact on local economy might be overstated as Fernandes (2007) noted that most mining jobs went to outsiders since the local population (predominantly tribal) lacked the required skills. Furthermore, the presence of a coal mine does not necessarily translates into the increase in income level in the community. Epstein et al. (2011) argued that in Appalachia, as the levels of mining increased, so did the poverty rates and unemployment rates. They stated that at the same time educational attainment and household income levels declined.

Mining induced displacement and resettlement is higher at OC mines. For example, in India these phenomena increased substantially since the 1970s as the country's coal production shifted from UG to OC mining, increasing the negative impacts on communities such as joblessness, homelessness, marginalization, food insecurity, loss of common lands and resources, increased health risks, social disarticulation, the disruption of formal educational activities, and the loss of civil and human rights (Downing 2002).

Since some of the negative impacts from coal mining are not paid for by the coal mining companies, UG and OC coal mining creates a burden on a local, state or national government in the form of additional costs of healthcare, water treatment, reclamation (if not reclaimed or partially reclaimed by mining company), welfare support due to unaffordable housing.

3. Comparison of UG and OC mining impacts

Using GHD (2013) social impact risk matrix, the following classification of social and environmental consequences of UG and OC mines is used to compare the impacts.

Table 1. Social impact risk matrix (GHD 2013).

Likelihood	Consequence (at current practice)				
	Catastrophic	Major	Moderate	Minor	Insignificant
Almost certain (>=95%)	Extreme	Extreme	High	Medium	Medium
Likely (50-95%)	Extreme	Extreme	High	Medium	Medium
Possible (20-50%)	High	High	Medium	Medium	Low
Unlikely (5-20%)	High	Medium	Medium	Low	Low
Rare (<5%)	Medium	Medium	Medium	Low	Low

Table 2 presents the likelihood and the consequences of the UG and OC mining impacts, the impacts significance and the nature of the impacts based on GHD (2013) classifications and literature review.

The following numbers were assigned to the consequences of social impacts: extreme=4, high=3, moderate=2 and low=1. If the impacts are negative, then the sign of the consequences of impacts are negative, if the impacts are positive, then the sign of the consequences of impacts are positive, if the impacts are neutral, then the impacts are multiplied by zero. By applying this scoring convention to the criteria presenting it Table 2, the negative impacts of mining are -47 for the OC mining and -40 for the UG mining. That means that the social costs of OC mining (given the scenarios) are 15% more than the social costs of UG mining. It should be noted that the impacts and their consequences are not weighted. That means that the environmental damage is assumed to be equal in importance to the human displacement or fatalities. However, depending on how weights are assigned the results of the analysis will likely change. For example, if higher weightings are applied to workplace safety and damage from AMD, then the social cost of UG mining would be higher than from the OC mining. It should be pointed out that some impacts in table 2 are overlapping (e.g. water quality and healthcare), therefore a care needs to be taken to separate those impacts for each individual project.

This method allows to compare the social costs from UG and OC mining from proposed projects during the impact assessment stage of approval process. The next step is to collect data for economic evaluation methods for the full socio-economic impact assessment of the proposed projects.

Table 2. Comparison of impacts significants[1] of hypothetical UG and OC mines.

Impact	Open-cast (OC)				Underground (UG)			
	Likelihood	Consequence	Impact significance	Nature of the impact	Likelihood	Consequence	Impact significance	Nature of the impact
Topography; visual; soil erosion	Almost certain	Catastrophic	Extreme	Negative	Likely	Catastrophic	Extreme	Negative
Landslide and subsidence	Rare	Minor	Low	Negative	Likely	Major	Extreme	Negative
Solid waste	Possible	Minor	Medium	Negative	Unlikely	Minor	Low	Negative
Surface water	Almost certain	Catastrophic	Extreme	Negative	Unlikely	Catastrophic	High	Negative
Groundwater	Likely	Major	Extreme	Negative	Possible	Major	High	Negative
Noise and vibration	Likely	Moderate	High	Negative	Unlikely	Moderate	Medium	Negative
Biological flora/fauna	Almost certain	Catastrophic	Extreme	Negative	Possible	Moderate	Medium	Negative
Air pollution (methane)	Almost certain	Major	Extreme	Negative	Almost certain	Major	Extreme	Negative
Acid water drainage	Possible	Major	High	Negative	Possible	Major	High	Negative
Coal mine fires	Possible	Major	High	Negative	Possible	Major	High	Negative
Land use (e.g. farming, fishing)	Almost certain	Catastrophic	Extreme	Negative	Unlikely	Catastrophic	High	Negative
Recreation, Aesthetics	Almost certain	Catastrophic	Extreme	Negative	Possible	Insignificant	Low	Negative
Workplace health and safety	Unlikely	Major	Medium	Negative	Likely	Catastrophic	Extreme	Negative
Employment, income	Almost certain	Moderate	High	Positive	Almost certain	Moderate	High	Positive
Healthcare	Likely	Moderate	High	Negative	Unlikely	Minor	Low	Negative
Society	Possible	Minor	Medium	Negative	Possible	Minor	Medium	Negative
Cultural, displacement	Possible	Major	High	Negative	Possible	Major	High	Negative
Change in housing	Possible	Minor	Medium	Neutral	Possible	Minor	Medium	Neutral

[1] For definitions of likelihood of impacts and consequences of impacts see GHD (2013).

4. Summary and recommendations

Coal mining has a strong impact on environment, social and economic systems. Both UG and OC coal mining create substantial social costs. UG mining is generally associated with AMD, subsidence and occupational hazards such as accidents and coal workers' pneumoconiosis. OC mining is generally associated with the following impacts: fugitive dust, destruction of the environment, failed reclamation of mined land, noise and vibration, and accidents. Coal mine fires can occur in both OC and UG mines and in some abandoned mines fires can burn for many years potentially impacting vegetation, wildlife, and contributing to GHG emissions.

While air pollution from dust is higher in OC mines, the UG workers have a higher rates of pneumoconiosis than OC workers due to a higher exposure to the coal dust. Furthermore, methane emissions are higher from the UG mines than from OC mines. Methane emissions contribute to the global warming and can be a workplace hazard due to their toxicity and potential to explode.

Additional costs such as the costs of healthcare, water treatment, air pollution, not efficient reclamation, displacement are likely to be met by local, state or national government.

The full social costs of coal mining can be estimated using a range of market and non-market valuation techniques. When data are not available, then the comparison analysis can be performed. This paper suggests a methodology that can be used to compare impacts for specific coal mining projects. In the example provided the social cost of UG mining is less than the social cost of OC mining if no weighting to the costs are assigned. However, if accidents and subsidence are weighted higher than other costs, then the social cost of UG mining is higher than the social cost of OC mining.

Provided that social cost of mining is only a part of the full social cost of coal, social costs of coal mining should be considered as a part of the full life cycle of coal where the impacts of coal transportation, combustion, waste disposal, electricity transmission and climate change are taken into consideration. The full social cost of coal should also be compared with the full social cost of renewable energy generating technologies such as solar, wind and biomass.

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