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A Sustainable Approach to the Harmonization of Electric Power Availability with the Mining Industry in Africa: A Case Study of Mozambique

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Abstract

It remains for a sustainability study to consider how to meet social needs for energy services in the realization of sustainable development, because globally about 2 billion people still have no access to modern energy. It is therefore necessary to draw attention to energy access – two million deaths annually are associated with the indoor burning of solid fuels.

Energy-supply infrastructure globally needs a cumulative investment of US$25.6 trillion for the period 2008-2030, and the African portion of this investment is estimated at US$454 billion. Power generation that is dependent on the mining industry seems to be a worthwhile subject for considering the combination of energy availability with national development, so this strategy is discussed, with the focus on a case study of Mozambique: it can be estimated that the self-supply system in the mining industry actually exports a certain amount of power to national and regional markets, and there may be an opportunity to generate low-cost power through the use of discard coal from coking coal export operations. However, Mozambique should prevent discard coal from becoming a hazardous load: mercury is one of the most toxic elements in coal and its by-products. Political strategies that solve a socio-economic problem but cause an environmental one should be avoided if sustainable development is to be properly realized.

Keywords: electrification, discard coal, mining industry, mercury, Mozambique, sustainable development

1. Introduction

The classic definition of sustainable development is proposed as follows (World Commission on Environment and Development, 1987): “meeting the needs of the present without compromising the ability of future generations to meet their needs”. The main principle of sustainable development harmoniously encompasses the environment, the economy and the social sphere (Nath et al., 1996); to put it differently, sustainable development aims to achieve a balance between these various components that make up a community by enabling its residents to meet their present and future needs.

How society meets its needs for energy services is central to the prospects for sustainable development and one of the most critical challenges facing humanity today (Science Council of Japan, 2003). Energy resources are rich in Africa, but they are not sufficiently utilized. Just one-third of Africans have access to energy, so this low accessibility slows economic growth on the continent as well as seriously limits human potential and degrades the quality of well-being (review in Banerjee et al., 2015).

If nothing changes, Sub-Saharan Africa will actually see the number of people without electricity increase from 590 million in 2013 to 655 million by 2030 (review in Banerjee et al., 2015). Given that access to electricity is a key factor in national development, it seems to be a worthwhile subject to consider how to improve the energy supply, expand access and reduce the economic burden. This subject is therefore discussed, with attention mainly focused on the African region.

2. Lack of Access to Modern Energy

Rapid economic growth has given rise to increasing demand for modern energy in developing countries, but globally nearly 2 billion people still have no access to modern energy (Davis, 1995) and about 1.6 billion people live without electricity (Ahuja & Tatsutani, 2009). Expanding access to modern energy services in order to enhance the welfare of people and improve the national economy is an enormous challenge for developing countries, especially for those that are the least developed or in Africa. It is therefore necessary to draw attention to energy access. The following problems are noted: (i) it is reported that two million deaths are caused annually by the burning of solid fuels in unventilated kitchens – about 45% of these deaths are in children, and among adult deaths, 60% are women (United Nations Development Programme [UNDP], 2009); (ii) 600 million people are living without electricity in Sub-Saharan Africa (United States Agency for International Development, 2015), that is, although electricity is the backbone of national development, the African continent lags far behind the world on its electrification; and (iii) it follows from Fig. 4 that electrification levels are comparatively low in rural areas in particular. There may be some reasons for this low rate of electrification – operating companies are less interested in rural electrification, the cost of line construction is high because of the unnecessarily expensive type of line used, and there are onerous restrictions on the extension of rural lines.

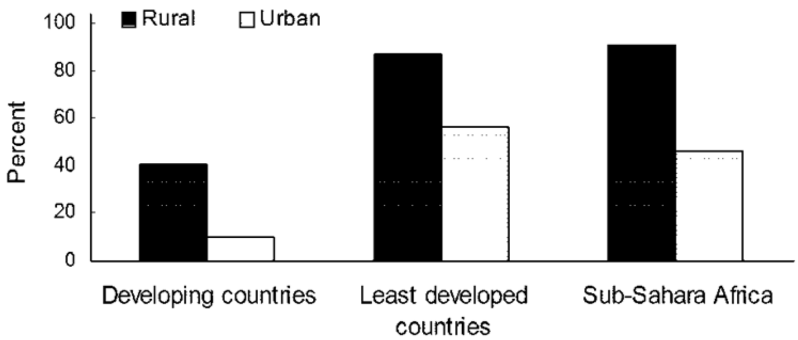

Figure 1. Population rate without electricity access by area in developing countries, least developed countries and Sub-Saharan Africa (redrawn from UNDP, 2009; International Energy Agency [IEA], 2009)

3. Demographic Influence

Demography has a direct influence on the amount of and trends in energy demand, and energy access in turn spurs economic growth and national development (IEA, 2009). As seen in Fig. 2, the pattern of population growth in Africa is different from that in other areas – the African pattern is characterized by a high rate of population growth (high fertility). Population growth in 2000-2030 in Eastern, Middle and Western Africa will be two times greater than the 1950-2000 increase (United Nations, 2004). Combined, these African regions already account for the largest share of the population in developing countries, the least developed countries, and Sub-Saharan Africa, and this population share will continue to increase from 72% in 2000 to 80% in 2050: the population in these regions will reach one billion shortly after 2025, and two billion by 2100, from only 150 million people in 1950.

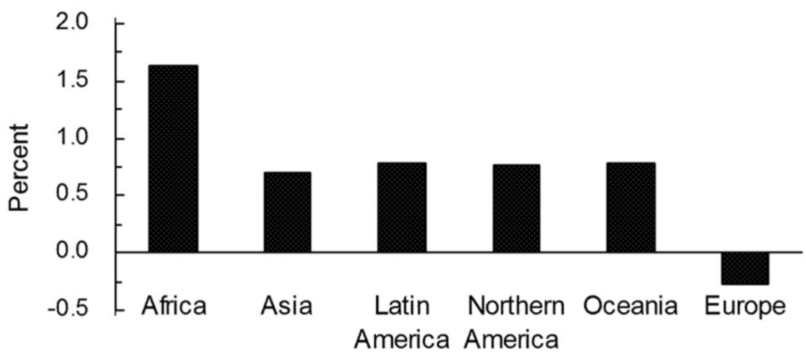

Figure 2. Average annual rate of population growth during 2000–2050 by major area (United Nations, 2004)

4. Prospects of Power Accessibility in Africa

Although the availability of modern energy helps to reduce poverty, provide educational opportunities and aid gender equality (United Nations [UN], 2009), 70% of the population in Sub-Saharan Africa still has no access to electricity (see section 3). On the basis of published data (IEA, 2009), it is estimated that the global population without electricity access will fall from 1.5 billion in 2008 to 1.3 billion in 2030 (see Fig. 3); this indicates that the electrification rate will improve from 78% in 2008 to 84% in 2013.

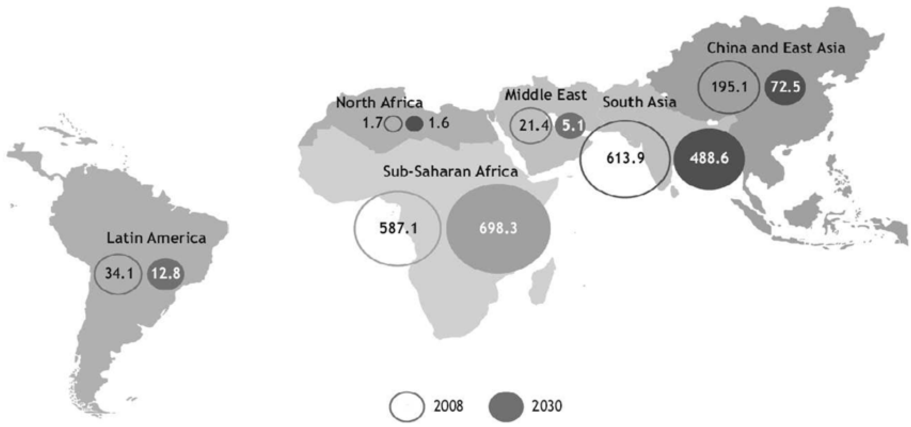

Figure 3. Global population (millions) without electricity access in 2008 and 2030 (redrawn from IEA, 2009)

However, it follows from Fig. 3 that a large number of people without access to electricity in 2030 will be in Sub-Saharan Africa, and most of them live in rural areas. In Sub-Saharan Africa, the foreseeable rate of electrification will improve from 29% in 2008 to 47% in 2030, but the population without electricity access will increase to 111 million by 2030 (refer to Fig. 3). These estimated figures depend on assumptions about incomes and electricity prices (IEA, 2009); hence, if new policies are introduced to Sub-Saharan Africa in order to alleviate this energy poverty, it may be possible to achieve a high rate of electrification in the future.

5. Financial Problems in Improvement of Electrification Rate

As stated in section 4, it is estimated that the global population without electricity will fall from 1.5 billion to 1.3 billion in 2030. However, energy-supply infrastructure globally needs a cumulative investment of US$25.6 trillion for the period 2008–2030, and the African portion of this investment is estimated at US$454 billion (IEA, 2009). Financial problems lie in the following points (New Partnership for African Development [NPAD], 2010): (i) since it takes 15–20 years to recover an infrastructure investment, this long-term recovery is a poor risk to investors; (ii) since the established infrastructure is for the exclusive use of power generation, its use is strictly restricted on the grounds that it cannot be utilized in any application other than for its original purpose, and this makes the whole contract susceptible to leverage application; and (iii) the electric power industry is a capital-intensive business – that is, a huge amount of capital is required, and the financing mechanisms for infrastructure projects for energy supply are burdensome.

6. Discussion Based on Mozambique

It should be emphasized that 70% of the population of Sub-Saharan Africa is without electricity (cf. section 2 and Fig. 1). If new policies are introduced to Sub-Saharan Africa in order to alleviate this energy poverty, it will be possible to achieve a high rate of electrification in the future. On the other hand, mines in this region have spent about US$15 billion since 2000 in order to cover their investment and operation for electricity generation and have installed 1,590 MW of generation capacity; however, none of this power makes it onto a national grid (Banerjee et al., 2015). Power generation that is dependent on the mining industry is discussed, with the focus on a case study of Mozambique.

6.1 Electricity

Electricidade de Moçambique (EDM) is an integrated company responsible for supplying electricity in Mozambique; it has an installed capacity of 2,428 MW and an electrification rate of 12% (Banerjee et al., 2015). The government has launched several large investment initiatives to harness the country’s energy potential to meet its rapidly growing demand for electricity and export power to the Southern African Power Pool (SAPP) market, particularly to meet South Africa’s heavy demand. These initiatives consider the development of large power-generation projects, focused primarily on hydropower generation (1,500 MW at Mphanda Nkuwa, and 1,245 MW at Cahora Bassa North Bank), and the construction of high voltage direct current and high-voltage alternating current transmission lines for evacuating relatively low-cost power (Banerjee et al., 2015). The transmission system is owned and operated by a special-purpose vehicle, known as Sociedade Nacional de Transporte de Energía (STE) (Banerjee et al., 2015).

6.2 Mining Industry

Mining is one of the more important industries in Sub-Saharan Africa. It contributes to exports, fiscal revenues, and gross domestic product (GDP), accounting for more than half of total exports in Burkina Faso, the Democratic Republic of Congo, Guinea, Mauritania, Mozambique, and Zambia (Wilburn and Stanley, 2013; World Bank, 2012). Mining investment by selected country is represented in Figure 4.

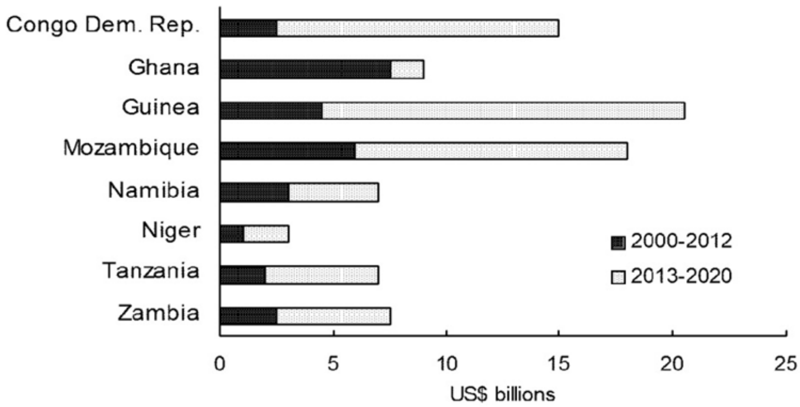

Figure 4. Past and forecast investments of the mining industry in Africa (redrawn from World Bank, 2012)

Mozambique is well endowed with mineral resources (Banerjee et al., 2015): (i) the coking coal reserves in Tete province are especially large and of exceptional quality – for example, Minas Moatize coal mine in Tete has proven reserves of 25.45 million tons and probable reserves of 17.2 million tons (see also Fig. 5). Moreover, the estimated mineable reserves are 42.65 million tons and marketable reserves are 23.45 million tons (Koble Intelligence, 2015); (ii) it is expected to supply as much as one-quarter of the world's coking coal by 2025; and (iii) 190 MW of new mining demand is expected to emerge, driven by coal and iron ore in 2013-2020.

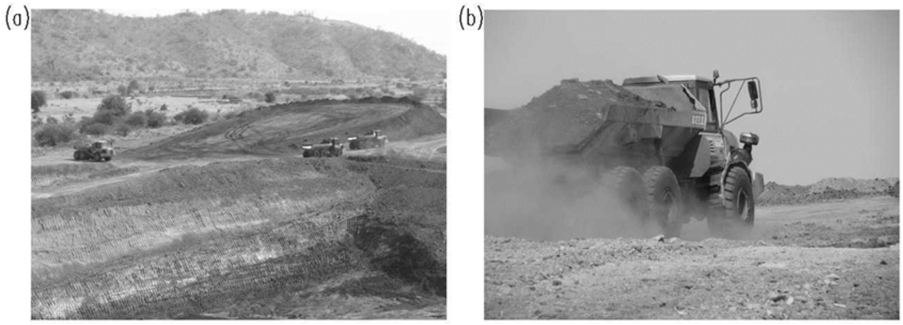

Figure 5. Minas Moatize coal mine in Mozambique (courtesy Kable Intelligence Ltd.): (a) open-pit mining; and (b) transport of coal from the mine to Beira port by truck

6.3 Integration of Mining Industry with Power Generation

As seen in Fig.4, a great amount of investment in the mining industry is expected in the near future. This will result in an increase in the demand of the mining sector for power. The current rate of electrification is low in Mozambique (12%, cf. section 6.1); what is even worse, there is a strong possibility that the power demand created by the foreseeable growth of the mining industry may overtake non-mining demand for power in Mozambique. However, a possible solution to this problem is the opportunity to generate low-cost power through the use of discard coal from coking coal export operations. It is considered that a separate option for creating a market for discard coal–fired power is simulated; e.g. a smelter plant at Macuze port (Banerjee et al., 2015). Generating electricity from discard coal has obvious benefits but some offsetting costs. In the immediate future, mines will avoid the costs of reburying coal, secure their own electricity supplies, and earn a return on the power station investment through selling the power. EDM obtains a secure source of baseload power (i.e. the minimum amount of power that a utility or distribution company must make available to its customers) to supply the northern grid, with some grid reinforcement and local distribution, but there may also be grid stability issues. Discard coal-fueled power plants at each mine theoretically meet only mine demand; however, it can be estimated that the mine self-supply in Mozambique actually exports a certain amount of power to national and regional markets (236 MW) according to a calculation based on published data (Banerjee et al., 2015; World Bank, 2015).

6.4 Environmental Attention

The emission of greenhouse gas is evaluated by means of the fuel emission factor, heat rates of the power plants and consumption volumes, so it is calculated as follows (Santley et al., 2013):

$$em = efi \times HRj \times Cm \tag{1}$$

where, em = kilograms of emitted carbon dioxide (kg-CO_2); efi = emission factor of fuel i (kg-CO_2 per gigajoule [GJ]); HRj = heat rate of power plant j (GJ per MWh); and Cm = present value of total mining consumption (MWh).

Although it is essential to reduce CO_2 emissions, it is more important that Mozambique should prevent discard coal from becoming a hazardous load. It is quite important for decision makers to know the potential impacts related with the presence and mobilization of trace elements in coal utilization and its by-products in order to formulate a proper control strategy. Mercury (Hg) is one of the most toxic elements in coal and a by-product that is cycled both in the terrestrial and aquatic environments on regional and global scales due to the volatile and persistent nature of Hg (cf. Schroeder and Munthe, 1998). Its bioaccumulation as methyl-mercury (Me-Hg) poses a great threat to public health (cf. Finkelman et al., 2002).

Mercury concentration in coal varies from mine to mine. The typical Hg concentration in coal is 0.05 to 0.20 mg/kg (Schwalb & Withum, 2003), but that in African coal is comparatively high, varying from 0.01 to 1.0 mg/kg (review in Mukherjee et al., 2008).

It is reported that two thirds (1.46 kilotons) of global Hg emissions originate from coal combustion (Pacyna et al., 2006). Furthermore, export of coal from the country where it is mined to another country results in relocation of the Hg that is present in the coal. Extensive efforts should be made to reduce Hg emissions from coal-fired power plants as well as from coal-related industries.

7. Remarking Conclusion

A requirement of sustainable development is to harmonize environmental, social, and economic sustainability in order to meet human needs. It is a key issue to expand access to modern energy in developing countries from the viewpoint of sustainability; nevertheless, considerable investment is necessary to improve energy-based sustainability because there is a high proportion of people without access to electricity and modern fuels in developing countries. A key problem is how to solve such situation.

The integration of the mining industry with power generation may not be a fundamental solution, but it suggests that cooperation among different sectors is important to solve the problem of the low electrification rate. There is a possibility that a public-private partnership may create a new energy system. When this system is considered, it is essential to give special attention to the reduction of environmental burdens such as Hg pollution. Political strategies that solve a socio-economic problem but cause an environmental one should be avoided if sustainable development is to be properly realized.

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