THE POWER OF THE MINE

A TRANSFORMATIVE OPPORTUNITY FOR SUB-SAHARAN AFRICA

Sudeshna Ghosh Banerjee, Zayra Romo, Gary McMahon
Perrine Toledano, Peter Robinson

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**SSA’s Power Deficit is Crippling Despite Huge Energy Resources**

By 2030, 990 million people will be without electricity, with 655 million in SSA.

- Share of firms identifying electricity as a major constraint (%)
  - SAS: 54%
  - MNA: 55%
  - SSA: 49%
  - EAP: 22%
  - ECA: 34%
  - LAC: 38%

Hydro potential: 400GW
Geothermal potential: 16GW
Natural Gas reserves: 329 tcf

- UN electrified population, millions
  - 2010: 590
  - 2030: 418

- 335

- 30

- 13
### SSA’s Mining Industry Could Be an Opportunity to Unlock These Resources

#### Investment and Forecasted Investment ($ billions)

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Zambia</td>
<td>5.0</td>
<td>11.6</td>
</tr>
<tr>
<td>Tanzania</td>
<td>5.0</td>
<td>11.5</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>4.5</td>
<td>16.0</td>
</tr>
<tr>
<td>Niger</td>
<td>1.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Namibia</td>
<td>3.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Mozambique</td>
<td>4.0</td>
<td>11.6</td>
</tr>
<tr>
<td>Mauritania</td>
<td>4.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Liberia</td>
<td>1.25</td>
<td>10.5</td>
</tr>
<tr>
<td>Guinea</td>
<td>1.25</td>
<td>16.0</td>
</tr>
<tr>
<td>Ghana</td>
<td>1.25</td>
<td>6.0</td>
</tr>
<tr>
<td>DRC</td>
<td>1.25</td>
<td>11.5</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>2.0</td>
<td>19%</td>
</tr>
</tbody>
</table>

#### Forecast Investment (2013-20) as a % of GDP, 2012

- **Burkina Faso**: 19%
- **DRC**: 11.5%
- **Guinea**: 2%
- **Liberia**: 3%
- **Mauritania**: 6%
- **Mozambique**: 25%
- **Namibia**: 6%
- **Niger**: 12%
- **Sierra Leone**: 6%
- **Tanzania**: 91%
- **Zambia**: 118%

#### Mining Exports as % of Total Exports (2010)

- **Burkina Faso**: 68%
- **DRC**: 91%
- **Guinea**: 48%
- **Liberia**: 41%
- **Mauritania**: 36%
- **Mozambique**: 21%
- **Namibia**: 2%
- **Niger**: 6%
- **Sierra Leone**: 23%
- **Tanzania**: 78%

#### Mining Fiscal Revenues as % of Total Revenues (2010)

- **Burkina Faso**: na
- **DRC**: na
- **Guinea**: na
- **Liberia**: 27%
- **Mauritania**: 19%
- **Mozambique**: 64%
- **Namibia**: na
- **Niger**: 64%
- **Sierra Leone**: 6%
- **Tanzania**: 11%

#### Mining Development

**Opportunity for exports**

+ Domestic use for growth

+ Anchor for economic and infrastructure development

SSA is largely unexplored - absolute amount of spending on exploration increased by more than 700% between 2000 and 2012
Power needs depend on the type of mineral but even more on the amount of processing.

Aluminum smelting is by far the most power-intensive mining activity.

Power cost is a substantial component of operating cost (rarely below 10 percent).

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Annual production (t)</th>
<th>Required power capacity, MW (maximum beneficiation)</th>
<th>Electricity costs as % of operating costs (maximum beneficiation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bauxite</td>
<td>2 million</td>
<td>177</td>
<td>29</td>
</tr>
<tr>
<td>Aluminum</td>
<td>200,000</td>
<td>443</td>
<td>117</td>
</tr>
<tr>
<td>Coal</td>
<td>10 million</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>Cobalt</td>
<td>20,000</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>Copper</td>
<td>100,000</td>
<td>95</td>
<td>15</td>
</tr>
<tr>
<td>Diamonds</td>
<td>0.6</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>Gold (open pit)</td>
<td>12</td>
<td>45</td>
<td>9</td>
</tr>
<tr>
<td>Gold (underground)</td>
<td>12</td>
<td>80</td>
<td>16</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>300,000</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Iron ore/steel</td>
<td>3 million</td>
<td>338</td>
<td>16</td>
</tr>
<tr>
<td>Manganese</td>
<td>50,000</td>
<td>121</td>
<td>11</td>
</tr>
<tr>
<td>Nickel</td>
<td>30,000</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Platinum Group Metals</td>
<td>5.6</td>
<td>41</td>
<td>14</td>
</tr>
<tr>
<td>Metals</td>
<td>1,814</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>Uranium</td>
<td>200,000</td>
<td>31</td>
<td>8</td>
</tr>
</tbody>
</table>

The Power of the Mine
Landscape analysis

Why?
• To establish demand for power from mining since 2000 and project to 2020 (high probability and low probability)
• To create a typology of power-sourcing arrangements of mines

What has been done?
Africa Power-Mining Database, 2013—a database of 455 mining projects in 28 Sub-Saharan countries with value of the ore reserve assessed to be more than $250 million

Case-study analysis

Why?
• To do a deep dive for eight mineral rich economies at different levels of power-mining synergies to explore win-win scenarios
• To analyze barriers to realizing integration scenarios

What has been done?
Cameroon, Democratic Republic of Congo, Ghana, Guinea, Mauritania, Mozambique, Tanzania, and Zambia are the case study countries
THE OPPORTUNITY – POTENTIAL OF POWER-MINING INTEGRATION
MINING DEMAND FOR POWER CAN BE UP TO 23 GW IN 2020

Growth rate of power demand from mining: 2012-2020
South Africa = 3.5%
SSA, excluding South Africa = 9.2%

Mining demand for power over time

Pre-2000 2012 2020 (High probability) 2020 (High and low probability)
MW 5,568 10,005 12,999 13,122
CAGR=4.5% CAGR=5.5% CAGR=5.6%

South Africa SSA, excluding South Africa

Note: CAGR=Compound Annual Growth Rate

The Power of the Mine
A FEW MINERALS AND STAGE OF BENEFICIATION WILL DETERMINE POWER DEMAND FROM MINING

Iron ore and PGM will experience the largest increase in power demand. Refining and smelting together are almost two-thirds of the total power demand.
Comparison of mining and nonmining demand

The Power of the Mine

Note: CAGR = Compound annual growth rate
## There are Six Distinct Intermediate Power Sourcing Arrangements

<table>
<thead>
<tr>
<th>Description</th>
<th>Main Generation drivers</th>
<th>Presence</th>
<th>Grid supply</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-supply</strong></td>
<td>Diesel HFO</td>
<td>Mali and Guinea (hydro)</td>
<td></td>
</tr>
<tr>
<td><strong>Self-supply + CSR</strong></td>
<td>Diesel HFO</td>
<td>Guinea</td>
<td></td>
</tr>
<tr>
<td><strong>Self-supply + sell to the grid</strong></td>
<td>Coal, Gas, Hydro</td>
<td>Zimbabwe and Mozambique</td>
<td></td>
</tr>
<tr>
<td><strong>Grid supply + self supply backup</strong></td>
<td>Diesel HFO</td>
<td>Democratic Republic of Congo</td>
<td></td>
</tr>
<tr>
<td><strong>Mines sell collectively to grid</strong></td>
<td>Diesel, HFO, Solar</td>
<td>Ghana</td>
<td></td>
</tr>
<tr>
<td><strong>Mines invest in grid</strong></td>
<td>Hydro, Gas</td>
<td>Niger Democratic Republic of Congo</td>
<td></td>
</tr>
<tr>
<td><strong>Mines serve as anchor demand for IPP</strong></td>
<td>Any</td>
<td>South Africa</td>
<td></td>
</tr>
<tr>
<td><strong>Mine does not produce any power, but buys 100% from the grid</strong></td>
<td>Any</td>
<td>Mozambique</td>
<td></td>
</tr>
</tbody>
</table>

**Presence**:
- Mali and Guinea (hydro)
- Sierra Leone and Liberia (oil)
- Guinea
- Madagascar
- Zimbabwe
- Mozambique
- Democratic Republic of Congo
- Tanzania
- Ghana
- Niger Democratic Republic of Congo
- South Africa
- Mozambique

**Main Generation drivers**: Diesel, HFO

**Self-supply**
- Mine produces its own power for its own needs
- Mine provides power to community through mini-grids or off-grid solutions
- Mine produces its own power and sells excess power to the grid
- The mine is first connected to the grid and is moving into own-generation when more economical
- Coordinated investment by a group of mines, producers, and users in one large power plant off-site connected to the grid
- Mine invests with government in new, or in the upgrading of, power assets under different arrangements
- Mine buys power from an independent power producer and serves as an anchor customer
- Mine does not produce any power, but buys 100% from the grid

**Intermediate**:
- Grid supply + self supply backup
Average annual energy consumption has increased only for Intermediate options.

CAGR for the three arrangements (pre-2000 to 2020):
- Self-supply: 11.4%
- Intermediate: 6.04%
- Grid supply: 5.09%

Average energy consumption is expected to rise for Intermediate arrangements.
A COMPLEX MIX OF FACTORS - RELIABILITY, FUEL MIX, TARIFFS - DECIDE POWER SOURCING ARRANGEMENT

The Power of the Mine
SELF-SUPPLY IS A LOSS TO UTILITY, MINES—AND THE COUNTRY

Utility
- Loss of large customers
- Loss of an opportunity to use the mines as anchor customers exhibiting economies of scale

Mines
- Direct cost of self-supply is generally much higher (offset by continuous supply and consistent product quality)
- Weak utility

Country
- Loss of exports and tax revenues
- Negative impact on GDP, and reduced employment opportunities

Mines investment in self-supply power infrastructure:
- 2000-2012: $1.3 billion
- 2013-2020: $1.4 - $3.3 billion
The Power of the Mine

SCENARIOS OF POWER-MINING INTEGRATION – A WIN-WIN
- Three scenarios -
  - Mines self-supply
  - Shared power plant among mines
  - Shared plant also serves neighboring communities (as in Guinea and Mauritania) or sells excess to the grid (as in Tanzania)

- Projects could be developed for a higher capacity to meet the electrification needs of the neighboring communities

- Electrification for community: Guinea → 5% of total population and Mauritania → 4% of the population

- Cost savings for mines: Around $600 million in Guinea and around $1 billion in Mauritania.

Guinea

<table>
<thead>
<tr>
<th>Scenario</th>
<th>c/kWh</th>
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</thead>
<tbody>
<tr>
<td>Mines Self-supply</td>
<td>24.5</td>
</tr>
<tr>
<td>Shared hydro plant - Mines supply</td>
<td>4.9</td>
</tr>
<tr>
<td>Shared hydro plant - Mines and towns supply</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Mauritania

<table>
<thead>
<tr>
<th>Scenario</th>
<th>c/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines self-supply</td>
<td>25.0</td>
</tr>
<tr>
<td>Shared CCGT plant - Mines supply</td>
<td>9.1</td>
</tr>
<tr>
<td>Shared CCGT plant - Mines and towns supply</td>
<td>9.2</td>
</tr>
</tbody>
</table>

Tanzania

<table>
<thead>
<tr>
<th>Scenario</th>
<th>c/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines self-supply</td>
<td>29.4</td>
</tr>
<tr>
<td>Shared hydro plant</td>
<td>4.9</td>
</tr>
<tr>
<td>Shared gas plant</td>
<td>12.3</td>
</tr>
<tr>
<td>Shared coal plant</td>
<td>6.0</td>
</tr>
<tr>
<td>Shared coal plant - Mines and sell excess to grid</td>
<td>5.3</td>
</tr>
<tr>
<td>Shared gas plant - Mines and sell excess to grid</td>
<td>5.9</td>
</tr>
<tr>
<td>Shared coal plant - Mines and sell excess to grid</td>
<td>5.2</td>
</tr>
</tbody>
</table>
• **Mozambique**
  – Mines produce high-quality coking coal for export, and the discard coal is available for power generation.
  – Additional power generation capacity can be allocated either for the national or regional markets, or for an aluminum smelter.
  – Two scenarios explored:
    - Mines self-supply
    - Mines produce electricity from discard coal to supply to aluminum smelter

• **Cameroon**
  – Innovative framework requires a long-term planning and investment commitment by large power users to developing the country’s hydropower resources.

  – The full potential of the hydropower site could be developed by the mine, with the surplus being sold to the grid at cost-recovery tariffs.

  – The surplus could be first absorbed in the domestic market, for later on export to the Central African Power Pool.
• At least $6 billion in private–public investment opportunities in Guinea, Mauritania, Tanzania, Mozambique
  
  – Mozambique option – Power plant along with the smelter - $4.5 billion.
  – Guinea option - 300 MW hydro plant – $595 million
  – Mauritania option – 150 MW combined cycle plant – $142 million
  – Tanzania option – 300 MW hydro, coal, gas-fired ~ $400 million

• With a desirable investment climate, potentially viable projects exist for the independent power producers and the governments.
RISKS IN POWER-MINING INTEGRATION – OPTIONS FOR POLICYMAKERS
Risks to Integration Remain

Commodities’ price:
Investments may not materialize - price swings, difficulties in raising capital, optimistic geological assessments, and political instability.

Planning:
Different time horizons for planning mining and power investments. Power investments will need other customers who may not materialize.

Joint strategy:
Resource pooling and joint strategy among mines is difficult to achieve given the highly competitive environment.

Incentives:
Little incentive to construct power plants with greater capacity than the mining demand—need for regulatory and commercial incentives and transmission network.

CSR:
Power supply to local communities is not attractive unless mines integrate that as part of their Corporate Social Responsibility (CSR) or unless they are contractually required to do so.

Viable partners:
Public utilities are often not a viable partner for the private sector.
## Transmission Links and Financial State of Utility Are Common Constraints

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Countries</th>
<th>Remedial policy actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate national transmission grid</td>
<td>Cameroon, Democratic Republic of Congo, Guinea, Mauritania, Mozambique,</td>
<td>Transmission reinforcement projects</td>
</tr>
<tr>
<td></td>
<td>Tanzania, and Zambia</td>
<td></td>
</tr>
<tr>
<td>Irregular fuel supplies and water flows</td>
<td>Cameroon and Ghana</td>
<td>Completion of Lom Pangar project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back-feed to West African Gas Pipeline from Jubilee Field;</td>
</tr>
<tr>
<td>Weak national utility</td>
<td>Democratic Republic of Congo, Guinea, Mauritania, and Tanzania</td>
<td>Utility and sector capacity building; strengthening regulators and their ability to raise</td>
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<tr>
<td></td>
<td></td>
<td>tariffs to commercial viability levels</td>
</tr>
<tr>
<td>Rail and port infrastructure lacking for bulk mineral exports</td>
<td>Guinea and Mozambique</td>
<td>Rail and port projects</td>
</tr>
<tr>
<td>Regional market and interconnector capacity constraints</td>
<td>Democratic Republic of Congo, Mozambique, and Zambia</td>
<td>Reinforcement of regional market institutions and regional interconnectors</td>
</tr>
</tbody>
</table>
SUGGESTIONS FOR POLICYMAKERS

- **Strengthen power sector finances**: establishing the utility as a viable partner with a stable investment framework and effective regulation is critical.

- **Support the operating environment for IPPs**: power sector sufficiently liberalized to allow for IPPs in generation, and encourage private sector to invest in transmission.

- **Integrate mining demand in power sector planning**: only Tanzania and the West Africa Power Pool do so
  - Involve the Ministry of Mining—Cameroon, Mauritania, and Tanzania share the same Ministry
  - Integrate power requirements into Mining Law: Focus on dialogue, not on mandated actions

- **Source expertise**: take a long-term perspective and identify potential synergies, and the actions that will create an attractive enabling environment. Many institutional arrangements are possible; one size does not fit all.

- **Strengthen regulatory mechanisms**: in setting cost recovery tariffs, managing risks and regulating access. Effective regulators enforce contracts and strengthen the utilities.

- **Regular review of mining tariffs**: large mining operations as anchor customers is very promising but approach with caution
  - Do not subsidize mines and be prepared for time when non-mining demands also will want this power

- **Careful drafting of CSR contracts**: develop model concession agreements mandating the provision of electricity within some radius to increase certainty for investors, and enhance the accountability of government as the contract enforcement authority.

- **Use regional platforms**: a regional approach will often be required to fully benefit from new arrangements
THANK YOU!

Questions or comments?

Gary McMahon
Senior Mining Specialist
gmcmahon@worldbank.org
http://www.worldbank.org/energy/
Background Slides
## Leveraging Power-Mining Synergies Can Be Win-Win in Any Situation

**Opportunity for integration: How can the power sector leverage the mining energy demand?**

<table>
<thead>
<tr>
<th>Situations</th>
<th>Cost savings for the mine</th>
<th>Increased welfare for the host state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid: Too remote</td>
<td>Leveraging decentralized energy for rural electrification (off grid or mini-grid)</td>
<td>Save the social license to operate</td>
</tr>
<tr>
<td>Mine: Builds its own generation (&quot;Self-supply&quot; and &quot;Self-supply and CSR&quot;)</td>
<td></td>
<td>Accelerate effort of electrification</td>
</tr>
<tr>
<td>Grid: Too expensive or too unstable</td>
<td>Leveraging for increased generation:</td>
<td></td>
</tr>
<tr>
<td>Mine: Builds its own generation (&quot;Self-supply,&quot; &quot;Self-supply and sell to the grid,&quot; &quot;Mines sell collectively to grid,&quot; and &quot;Mines serve as anchor demand for an IPP&quot;)</td>
<td>- If the mine produces excess and sells back to the grid</td>
<td>Either additional revenues</td>
</tr>
<tr>
<td></td>
<td>- If anchor demand for IPPs; if mines build bigger collective power plant</td>
<td>Or diminished costs of energy needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional sources of generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost of generation drops</td>
</tr>
<tr>
<td>Grid: Hydro-based (gas-based) and very cheap</td>
<td>Leveraging for more robust grid:</td>
<td></td>
</tr>
<tr>
<td>Mine: Wants to source from the grid</td>
<td>- If mines participate in upgrading the grid</td>
<td>Stable access to very cheap electricity</td>
</tr>
<tr>
<td>(&quot;Grid supply and self-supply backup,&quot; &quot;Mines sell collectively to grid,&quot; &quot;Mines invest in grid,&quot; and &quot;Grid supply&quot;)</td>
<td>- If mines leverage the idle capacity of emergency generators to alleviate the grid</td>
<td>Opportunity for additional revenues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility can gain in efficiency; infrastructure upgrading</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avoid saturation of the grid</td>
</tr>
</tbody>
</table>
## Supporting Conditions for Power-Mine Integration

<table>
<thead>
<tr>
<th>Power-Mine Synergy</th>
<th>Supporting Conditions</th>
</tr>
</thead>
</table>
| Mines supplies power to the communities (rural electrification) | Contractual requirement  
Coordination between mining companies & donors/govts/NGOs  
Clear framework allocating responsibilities  
Each party has sufficient capacity  
Presence of local govt/utility in rural areas  
Effective demand/willingness to pay |
| Mines sells excess power to the grid | Liberalized power market with clear legislative & regulatory framework  
Excess capacity built in at design phase  
Commercially viable offtake agreement between company & utility  
Credible state-owned company (if offtaker)  
Adequate transmission infrastructure  
Demand for excess power |
| Mines as an anchor for IPP | Liberalized power market with clear legislative & regulatory framework  
Sufficient IPP power supply for mining demand and national grid  
Sufficiently low cost & reliable power supply (relative to self-supply)  
Power plant and mine on same timetable  
Investment in transmission infrastructure to supply power to mine  
Utility is credible partial offtaker of power from IPP |
| Mines source from grid | Sufficient & reliable national power supply  
Cost of power low enough to act as disincentive to self-supply but high enough to achieve cost recovery  
Transmission infrastructure in place or manageable investment  
Management of mines’ power demand so as not to saturate the grid  
Commercial frameworks provide incentive for mines to participate in infrastructure upgrades & development of power generation capacity |

Source: Toledano, Perrine; Sophie Thomashausen; Nicolas Maennling; and Alpa Shah (forthcoming), A Framework to Approach Shared Use of Mining-Related Infrastructure, Vale Columbia Center on Sustainable International Investment, New York, New York.