2nd International ecoinvent Meeting
Lausanne, March 14, 2008

metals:

Gold & Silver

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Agenda

- Overview global gold and silver production
- Structure of the datasets
- Gold mining in Peru
- Secondary gold production
- Key figures
- Comparison of different datasets

Overview Gold & Silver production

Silver

- Primary silver from copper production (20%)
- Primary silver from lead and lead-zinc cycle (24%)
- Primary silver from argentiferous ores (22%)

Gold metal

- Recycling of scrap containing precious metals (21%)

Goldmetal

- Mining of gold bearing ores (38%)
- Artisanal mining of gold (13%)

Gold compounds

- Gold powder, from melt atomisation
- Gold powder, from precipitation

Silver compounds

- Silver powder for powder metallurgy

Galvanic applications

- Silver pastes, sintered films, p/m alloys
Overview - Gold

<table>
<thead>
<tr>
<th>Origin</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold, at refinery ZA</td>
<td>19%</td>
</tr>
<tr>
<td>Gold, at refinery AU</td>
<td>11%</td>
</tr>
<tr>
<td>Gold, at refinery US</td>
<td>12%</td>
</tr>
<tr>
<td>Gold, at refinery TZ</td>
<td>5%</td>
</tr>
<tr>
<td>Gold, at refinery CA</td>
<td>18%</td>
</tr>
<tr>
<td>Gold, from combined gold-silver production, at refinery CL</td>
<td>5%</td>
</tr>
<tr>
<td>Gold, from combined gold-silver production, at refinery PE</td>
<td>10%</td>
</tr>
<tr>
<td>Gold, from combined gold-silver production, at refinery PG</td>
<td>19%</td>
</tr>
<tr>
<td>Gold, from combined metal production, at refinery SE</td>
<td>1%</td>
</tr>
</tbody>
</table>

Overview - Silver

<table>
<thead>
<tr>
<th>Origin</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver, from combined gold-silver production, at refinery CL</td>
<td>32%</td>
</tr>
<tr>
<td>Silver, from combined gold-silver production, at refinery PE</td>
<td>31%</td>
</tr>
<tr>
<td>Silver, from combined gold-silver production, at refinery PG</td>
<td>15%</td>
</tr>
<tr>
<td>Silver, from combined metal production, at refinery SE</td>
<td>22%</td>
</tr>
<tr>
<td>Silver, from combined gold-silver production, at refinery GLO</td>
<td>15%</td>
</tr>
<tr>
<td>Silver, from lead production, at refinery GLO</td>
<td>32%</td>
</tr>
<tr>
<td>Silver, from copper production, at refinery GLO</td>
<td>26%</td>
</tr>
</tbody>
</table>
Modelling and Data Sources

- Economic allocation (metal multi-output processes)
- Primary Gold and Silver:
  - Mining infrastructure
  - Mining
  - Refining
- Data for primary metal production and are based on environmental reports
- Data for secondary metal production and silver from copper and lead production are based on industry and literature data

Gold mining in Peru
Secondary Gold

- Pyrometallurgical recovery of electronic scrap

![Diagram of pyrometallurgical recovery process]

Electronic scrap, to secondary copper plant

5882 kg

- Secondary copper conversion
  - 30.7% → 1804 kg Epoxies (co-combusted)
  - 31.0% → 1826 kg Slag, silica, at converter
  - 36.7% → 94 kg lead, secondary, from electronic and electric scrap recycling, at plant

2159 kg metal values from electric waste, in blister-copper, at converter

- Secondary copper refining
  - 24.66% → 532 kg Others (Al, Ca, Fe, Sn)
  - 9.1% → 196 kg nickel, secondary, from electronic and electric scrap recycling, at refinery

- 1.66% → 1384 kg copper, secondary, from electronic and electric scrap recycling, at refinery

- 65% → 1.82 kg palladium, secondary, at precious metal refinery

36 kg PM from electric waste, in anode slime, at refinery

- Precious metal refining, secondary copper
  - 5.10% → 33 kg silver, secondary, at precious metal refinery

- 92.1% → 1 kg gold, secondary, at precious metal refinery

Sybille Büsser
## Key figures

### Gold

<table>
<thead>
<tr>
<th>Gold</th>
<th>Unit</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>kWh/kg</td>
<td>3'264 - 32'603</td>
<td>19.3</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>MJ/kg</td>
<td>76 - 262'729</td>
<td>2.6</td>
</tr>
<tr>
<td>Diesel</td>
<td>MJ/kg</td>
<td>3'386 - 152'200</td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>g/t</td>
<td>0.2 - 7.5</td>
<td>490</td>
</tr>
</tbody>
</table>

### Silver

<table>
<thead>
<tr>
<th>Silver</th>
<th>Unit</th>
<th>From combined s-g</th>
<th>From lead</th>
<th>From copper</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>kWh/kg</td>
<td>54 - 559</td>
<td>1.5</td>
<td>6.6</td>
<td>0.33</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>MJ/kg</td>
<td>1 - 6'345</td>
<td>0.2</td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>Diesel</td>
<td>MJ/kg</td>
<td>58 - 3'676</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>g/t</td>
<td>0.5 - 41.6</td>
<td></td>
<td></td>
<td>5'600</td>
</tr>
</tbody>
</table>

### Graphs

1. **Graph 1:** Head grade [g/t] vs. CED [MJ-Eq]
   - **Chile**
   - **Papua Neuguinea**
   - **Tanzania**
   - **South Africa**
   - **Peru**

2. **Graph 2:** Head grade [g/t] vs. CED [MJ-Eq]
   - **Chile**
   - **Papua Neuguinea**
   - **Tanzania**
   - **South Africa**
   - **Peru**

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*Sybille Büsser*
Ecoindicator 99 - Gold production

Ecoindicator 99 - Silver production
Conclusion

- Datasets are meant to be used as background datasets
- Best practices for gold mining → underestimation
- Good data quality with respect to energy, cyanide and explosive consumption
- Data for water/air emissions are based on older environmental reports
- Differences between countries → based on technologies, head grade and assumptions made for emissions