Thrust 2: Sustainability Assessment of the New PV Technology and Production

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Robert Phillips, Undergraduate Student (Civil Engineering)
PROJECT DESCRIPTION
CURRENT THRUST II FOCUS
# Possible Parameters Related to Each Life Cycle Sustainable Assessment Phase

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Parameters related to:</td>
<td>Raw material type</td>
<td>Chemical reaction approach (e.g., inverse micellar vs. thermal injection) Solvent type</td>
<td>Thin-film deposition method Type of material used Material thickness Device efficiency</td>
<td>Required module interconnections, support structure, inverters and transformers, concrete</td>
<td>System lifetimes, maintenance requirements</td>
<td>Disassembly, material recovery processes, materials sent to landfills</td>
</tr>
</tbody>
</table>
CURRENT PROCEDURE

Environmental Sustainability Metrics

- Cell Components
- Material Acquisition
- Manufacturing Process

Mineral Resources
- Location
- Production
- Consumption
- Reserves

Mineral Cost
- Price Volatility
- Domestic
- Import

5/15/2013
FOCUS HIERARCHY

Proposed Compounds
• Copper Zinc Tin Sulfide (CZTS)
• Zinc Phosphide
• Copper (II) Sulfide
• Iron Sulfide
• Copper (II) Oxide
• Copper (I) Oxide
• Nickel Sulfide
• Amorphous Silicon

Raw Material
• Copper
• Zinc
• Tin
• Sulfur
• Selenium
• Phosphorous
• Iron
• Nickel
• Silicon
DOMESTIC ANALYSIS
2012 Production Statistics

![Graph showing production statistics for different materials.](image)
2010 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS

- Copper
- Zinc
- Tin
- Sulfur
- Selenium
- Phosphorous
- Iron
- Nickel
- Silicon
### Material Costs

#### Average 2012 U.S. Prices for Materials of Interest

<table>
<thead>
<tr>
<th>Material</th>
<th>Price (per kg)</th>
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<tbody>
<tr>
<td>Selenium</td>
<td>$127.60</td>
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<tr>
<td>Tin</td>
<td>$27.94</td>
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<tr>
<td>Nickel</td>
<td>$17.58</td>
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<td>Copper</td>
<td>$8.14</td>
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<tr>
<td>Silicon</td>
<td>$2.86</td>
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<tr>
<td>Zinc</td>
<td>$2.05</td>
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<tr>
<td>Sulfur</td>
<td>$0.22</td>
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<tr>
<td>Phosphate Rock</td>
<td>$0.11</td>
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</tbody>
</table>
Active Mining Operation
Copper Zinc Tin Sulfide (CZTS)
Active Mining Operations

Zinc Phosphate $\text{Zn}_3\text{P}_2$
Active Mining Operations
Copper Sulfide Cu₂S
Active Mining Operations
Iron Sulfide (FeS$_2$)
Active Mining Operations

Copper (I/II) Oxide (Cu_\text{x}O)
Active Mining Operations
Nickel Sulfide (NiS)
Active Mining Operations
amorphous Silicon (a-Si)
## United States Geologic Survey

### Example Data

<table>
<thead>
<tr>
<th>Id</th>
<th>Commodity</th>
<th>Compound</th>
<th>Site_name</th>
<th>Company_na</th>
<th>State_loca</th>
<th>County</th>
<th>Latitude</th>
<th>Longitude</th>
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</thead>
<tbody>
<tr>
<td>575</td>
<td>Copper</td>
<td>CZTS, Cu2S, Cu2O, CuO</td>
<td>Copper Queen Branch Mine</td>
<td>Phelps Dodge Corp</td>
<td>Arizona</td>
<td>Cochise</td>
<td>31.429</td>
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<td>Nord Resources Corp</td>
<td>Arizona</td>
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<td>Arizona</td>
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<td>32.001</td>
<td>-111.053</td>
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</table>
Carbon Sinks Versus Carbon Sources

Scenario 1 - Copper Mine in High NEE Location

Scenario 2 - Copper Mine in Low NEE Location

Unit: g/m² per year

NEE
High: 800
Low: -800

5/15/2013
Carbon Sequestration Scenario

Assumptions:
1. 30 Acres
2. High NEE
   Location: 600
3. Low NEE
   Location: -600

Scenario 1

- Net CO2 Sequestration rate
- 72.8 tonnes/year

Scenario 2

- Net CO2 Sequestration rate
- -72.8 tonnes/year

High Green House Effect
INTERNATIONAL ANALYSIS
Historical Copper Production Data (2013)

Based on Bloomberg Market Data

<table>
<thead>
<tr>
<th>Country</th>
<th>Kilotons</th>
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<tbody>
<tr>
<td>Australia</td>
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<td>Peru</td>
<td>979.2</td>
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<td>Brazil</td>
<td>233.688</td>
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<td>Canada</td>
<td>467.064</td>
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<td>Mexico</td>
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<td>Chile</td>
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kilotons
### International Metal Price

**From Bloomberg System**

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<th>Value</th>
<th>Unit</th>
<th>Frequency</th>
<th>Last</th>
<th>Product</th>
<th>Location</th>
<th>Data Type</th>
<th>Source</th>
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<th>High</th>
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<tr>
<td>CLPCTOTL</td>
<td>Index</td>
<td>Chile Copper Production Total</td>
<td>420207</td>
<td>Tons</td>
<td>Monthly</td>
<td>2/28/13</td>
<td>Copper</td>
<td>Chile</td>
<td>Production</td>
<td>Instituto Nacional de Estadistica de Chile (INE)</td>
<td>0.420M</td>
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<td>0.451M</td>
<td>0.356M</td>
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<td>CMINCOPR</td>
<td>Index</td>
<td>Chile Mineral Copper Export Data</td>
<td>MILLIO 3381 MTS</td>
<td>Monthly</td>
<td>3/31/13</td>
<td>Copper</td>
<td>Chile</td>
<td>Export</td>
<td>Banco Central de Chile</td>
<td>3192</td>
<td>4924.13</td>
<td>3170.42</td>
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<td>PRMMCOP</td>
<td>P Index</td>
<td>Central Reserve Bank Copper Production Data</td>
<td>1000</td>
<td>81.6 M.Tons</td>
<td>Monthly</td>
<td>1/31/13</td>
<td>Copper</td>
<td>Peru</td>
<td>Production</td>
<td>Banco Central de Reserva del Peru</td>
<td>81.6</td>
<td>106.2</td>
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<td>Total Nickel Metal Imports China</td>
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<td>12/31/13</td>
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<td>47262</td>
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<td>MXMMCOPR</td>
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<td>Mexico Copper Mining Production</td>
<td>33843</td>
<td>TONS</td>
<td>Monthly</td>
<td>1/31/13</td>
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<td>AUPRZINR</td>
<td>Index</td>
<td>ABARE Refined Zinc Australia Minerals &amp; Metals Production Data</td>
<td>525.4 kilotons</td>
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<td>12/31/13</td>
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<td>Australia</td>
<td>Production</td>
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<td>571.9</td>
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<td>CLPCREFI</td>
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<td>WMNXEXB</td>
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<td>Total Nickel Metal Exports Brazil</td>
<td>metric 0 tonne</td>
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*From Bloomberg System, 5/15/2013*
### Finding the Right Data

<table>
<thead>
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<th>Product type</th>
<th>Price</th>
<th>Data type</th>
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<tbody>
<tr>
<td>• Ore</td>
<td>• Spot Price</td>
<td>• Production</td>
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<tr>
<td>• Refined metal</td>
<td>• Fair Price</td>
<td>• Consumption</td>
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<tr>
<td></td>
<td>• Historical Price</td>
<td>• Export</td>
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<tr>
<td></td>
<td></td>
<td>• Import</td>
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Available market data in Bloomberg System of related material
Reference Sources

USGS Minerals Yearbook and Mineral Commodity Summaries

Literature review of previous analyses

Literature review of previous analyses

Bloomberg System - Current and historic mineral pricing
Project Webpage Structure

SEP-Thrust

People

Publication

Presentation

Opportunities

Data

Faculty

Staff

Student

Graduate

Undergraduate

Graduate

Undergraduate
Manufacturing Process
- Mining
- Smelting
- Refining
- Secondary Consumption (recycling)
- Transportation

Material Acquisition
- Ecological Impacts
- Economic Impacts
- Social Impacts
- Reserves
- Individual production rates
- Ore grade (historic trends)

Cell Components
- Analysis of components