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SDIMI2013
30 June - 3 July

# Assessing the progress of mining industry towards sustainability:
## In need of new methodological frameworks

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# Contents

# Aim of the study



a) Discuss the **effectiveness of the existing methodologies** for assessing the sustainability of mining industries.

b) Identify the **potential characteristics** of a well defined, robust and holistic sustainability assessment framework.

# Sustainability and Industry

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➢ Sustainability requires the industry to develop a strategy that accepts and understands its **responsibility** towards society and environment **both in regional and worldwide level** (Labuschagne et al., 2005).

➢ Achieving sustainability in an industry, engage the challenge of **providing competitive results and products in the short time**, while trying to **protect and preserve natural and human resources in the long term** (Artiach et al., 2010).

➢ More and more, industries have started to realize the **benefits derive from adopting sustainable practices** whereas the **legislation** in national and international level **is reformed to promote sustainable development** in corporations (Azapagic, 2004).


Labuschagne, C., Brent, A.C., & R.P.G. van Erck. (2005). Assessing the sustainability performances of industries. *Journal of Cleaner Production*, 13, 373-385.

Artiach, T., Lee, D., Nelson, D., & Walker, L. (2010). The determinants of corporate sustainability performance. *Accounting and Finance*, 50, 31-51.

Azapagic, A. (2004). Developing a framework for the sustainable development indicators for the mining and minerals industry. *Journal of Cleaner Production*, 12, 639-662.

# Sustainability assessment

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A simple definition of sustainability assessment is "**a process that guides decision making towards sustainability**" (Hacking and Guthrie, 2008).

- Assessment of the sustainability is a **particularly complex procedure** due to the complexity of the systems to be assessed (Gasparatos et al., 2008).

The **special characteristics** of the **mining industries** such as:

- ✓ Large amounts of incoming/outgoing materials
- ✓ Significant area of coverage of their facilities
- ✓ Need to cope with issues such as biodiversity, restoration etc.

**further hinder** the application of evaluation frameworks for assessing their sustainability.


Hacking, T., & Guthrie, P. (2008). A framework for clarifying the meaning of Triple Bottom-Line, Integrated and Sustainability Assessment. Environmental Impact Assessment Review, 28, 73-89.

Gasparatos, A., El-Haram, M., & Horner, M., (2008). A critical review of reductionist approaches for assessing the progress towards sustainability. Environmental Impact Assessment Review, 28, 286-311.

# State-of-the art



➢ Understanding the **values and attitudes of the stakeholders** related with the industry**, strengthens** the possibility of choosing the suitable assessment method.

➢ The current methods for assessing the sustainability of industries could be sorted in various categories according to their specific characteristics.

➢ **Classification of methods according to**:

- ✓ their functionality,
- ✓ their complexity,
- ✓ their time reference (ability of the method to evaluate past activities or to forecast future sustainability assessments),
- ✓ their focus-orientation (anthropocentric or ecocentric methods),
- ✓ their area of coverage (product, facility etc.).

# State-of-the art

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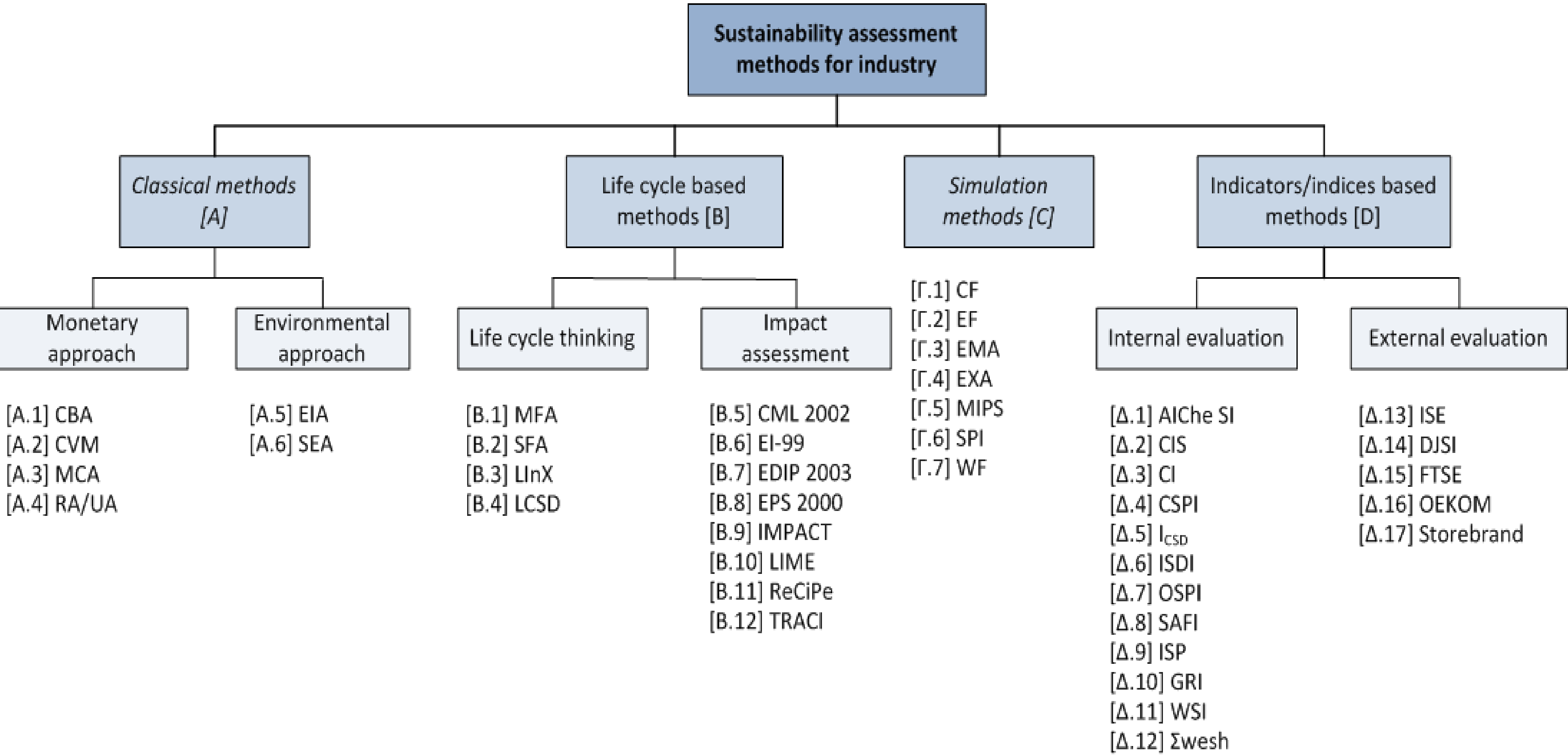
- We separated the **42 methods** analyzed so far in **four (4) categories** based on their basic concept of development.



# State-of-the art



## A) Classical methods

- The specific category includes classical approaches that were basically developed to assess policies and projects.

- Most of these approaches were developed way before the need to assess sustainability.

- Mostly used as supporting assessment tools rather than as independent ones.

*Monetary approaches (based on WTP, WTA)*

***[A.1]*** *Cost-benefit analysis (CBA)*

***[A.2]*** *Contingent valuation method (CVM)*

***[A.3]*** *Multi-criteria analysis (MCA)*

***[A.4]*** *Risk/Uncertainty analysis (RA/UA)*

*Environmental approaches (based on impact)*

***[A.5]*** *Environmental impact assessment (EIA)*

***[A.6]*** *Strategic environmental assessment (SEA)*

# State-of-the art



## B) Life cycle based methods

➢ Life cycle thinking takes into account all life cycle stages while assessing the performance of a system, including the extraction of raw materials, processing, production, use and disposal.

➢ The integration of Life Cycle Assessment (LCA) in sustainability assessment **is necessary** in order to achieve reliable data (Finkbeiner et al., 2010).

*Life cycle thinking based methods*

***[B.1]*** *Material flow analysis (MFA)*

***[B.2]*** *Substance flow analysis (SFA)*

***[B.3]*** *Life Cycle Index (LInX)*

***[B.4]*** *Life Cycle Sustainability Dashboard (LCSD)*

*Methods incl. impact assessment step*

***[B.5]*** *CML 2002*

***[B.6]*** *Eco-indicator 99 (EI-99)*

***[B.7]*** *EDIP 2003*

***[B.8]*** *EPS 2000*

***[B.9]*** *IMPACT 2002+*

***[B.10]*** *LIME*

***[B.11]*** *ReCiPe*

***[B.12]*** *TRACI*

# State-of-the art



## C) Simulation methods

➢ The specific category includes tools and methodologies that try to express sustainability through **the quantification of a relative attribute** (e.g. energy consumption), or by trying to **simulate a biophysical model**.

***[C.1]*** *Carbon footprint (CF)*

***[C.2]*** *Ecological footprint (EF)*

***[C.3]*** *Emergy analysis (EMA)*

***[C.4]*** *Exergy analysis (EXA)*

***[C.5]*** *Material input per service (MIPS)*

***[C.6]*** *Sustainable process index (SPI)*

***[C.7]*** *Water footprint (WF)*

# State-of-the art



## D) Indicators/indices based methods

- Sustainability assessment indicators and indices are rapidly **emerging tools** for decision making and communication of the performance of industries in terms on environmental, economical and social improvement (Singh et al., 2012).

- Indicators utilization was found to be the most common way for a mining industry to express its sustainability performance, **especially through the adoption of the GRI report.**

*Internal assessment*

***[D.1]*** *AIChe Sustainability Index (AIChe SI)*

***[D.2]*** *Compass Index of Sustainability (CIS)*

***[D.3]*** *Compliment index (CI)*

***[D.4]*** *Composite Sustainability Performance Index (CSPI)*

***[D.5]*** *Composite Sustainable Development Index* ($I_{CSD}$)

***[D.6]*** *Indicators of Sustainable Development in Industry (ISDI)*

***[D.7]*** *Organizational Sustainability Performance Index (OSPI)*

***[D.8]*** *Sustainability Assessment Framework for Industries (SAFI)*

***[D.9]*** *Sustainability Assessment of Industrial Systems (ISP)*

***[D.10]*** *Sustainability Reporting Guidelines (GRI)*

***[D.11]*** *Wuppertal Sustainability Indicators (WSI)*

***[D.12]*** *Σwesh*

*External assessment*

***[D.13]*** *Bovespa Corporate Sustainability Index (ISE)*

***[D.14]*** *Dow Jones Sustainability World Index (DJSI)*

***[D.15]*** *FTSE4Good Index (FTSE)*

***[D.16]*** *OEKOM Corporate Rating (OEKOM)*

***[D.17]*** *Storebrand Sustainability Rating (Storebrand)*

# Shortcomings



- Based on the background theoretical evaluation of the methods, **the shortcomings of current sustainability assessment methods were identified**.

- Every tool and methodology mentioned in the previous section has its pros and cons, however **most of them exhibit one or more of the following weaknesses**.

❖ **Focus on accountability**

- Most of the methodologies examined **do not provide a threshold value** (value for which an indicator expresses sustainability) or just examine the increase/reduction of the value of the examined indicator in comparison with previous years.

- Assessing the sustainability performance through the accountability assessment entails a high level of risk and uncertainty, since **no certain correlation between accountability and performance has been identified.**

# Shortcomings

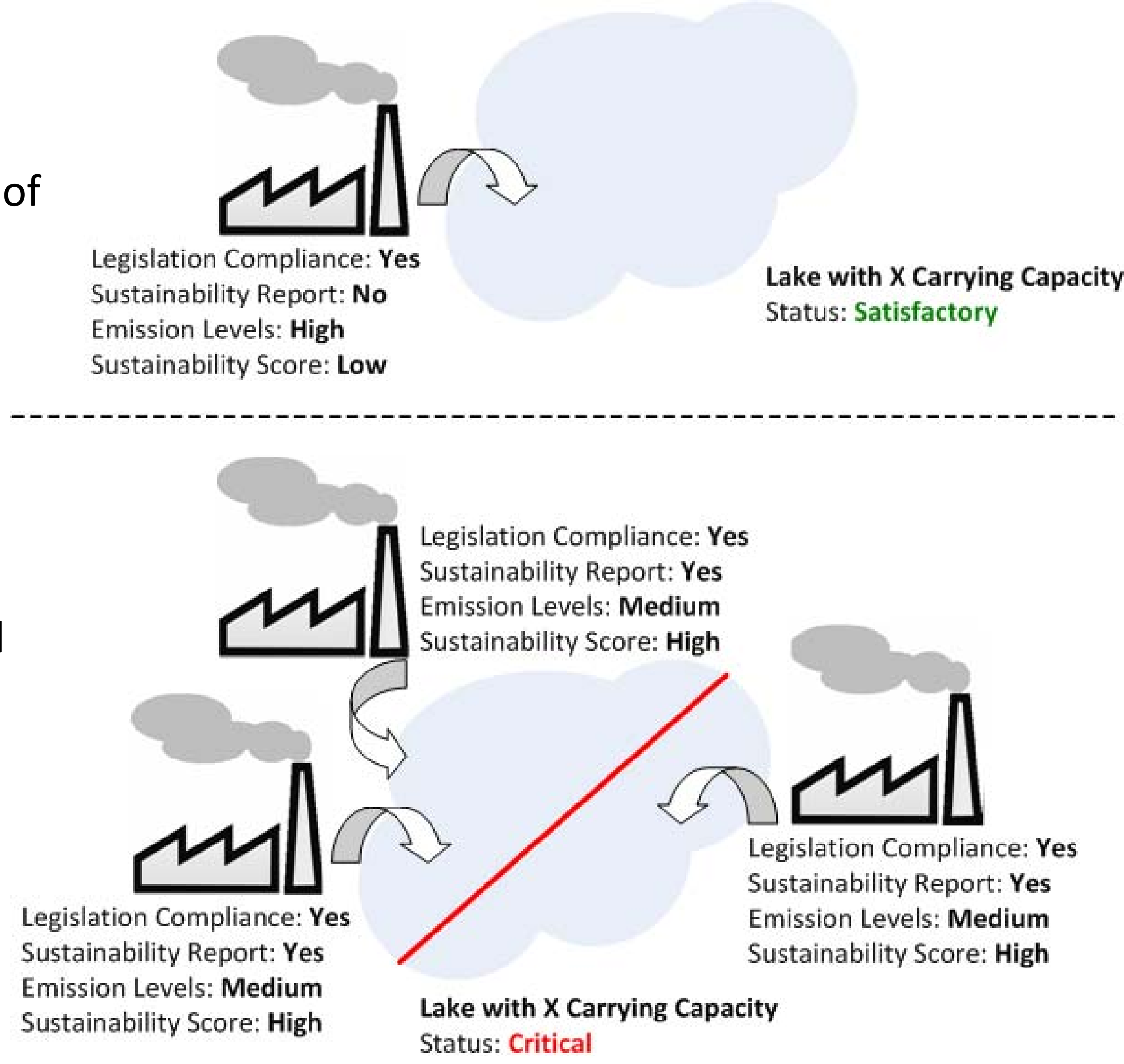


❖ **Integration of spatial and temporal characteristics**

➢ The environmental performance of a facility is highly related with its geographical region and its spatial characteristics.

➢ Not all industries should be enforced to exhibit similar performance since they operate at locations with different background conditions.

➢ Sustainability assessment tools should assess not only the performance/accountability of the examined industry, but also the concern/impact in regional, national and international level.



# Shortcomings



❖ **Over – reductionism**

➢ Many developers/analysts have **reduced the level of complexity** of their methods in order **to increase apprehension and applicability** by non experts.

Note: **over – holistic** approaches may also result in **ineffective** tools and methodologies.

❖ **Development challenges and uncertainties**

➢ A number of weaknesses arise due to **poor choices during method development**.

➢ Deficiencies and mistakes during **indicator selection-**categorization-normalization-weighting and aggregation of the results may significantly reduce the quality of the assessment.

# Towards a new method



To sum up, a sustainability assessment method should:

✓ Take into account the spatial characteristics of the examined industrial systems and assess the progress towards sustainability over time (temporal characteristics).

✓ Assess the industry both in terms of performance and accountability, and provide threshold values for each and every indicator applied.

✓ Ensure a balance between the level of complexity and the adequate coverage of key sustainability issues.

✓ Emphasize clearly the assumptions applied and minimize the weaknesses arise during its development.

✓ Involve various levels of difficulty of application to serve both SME and very large industries.

✓ Be dynamic and flexible in order to potentially include all aspects of sustainability or at least that it can be combined with other methods to perform a full assessment.

# Towards a new method



➢ The relative literature review indicated the **need for additional methods** to be developed.

➢ In an attempt to deal with some of the shortcomings described above, we have developed a **screening-tool** based on the principles of **Industrial Ecology**.

➢ Characteristic principles of Industrial Ecology:

- ✓minimum utilization of raw material,
- ✓maximum recycling,
- ✓material flow analysis,
- ✓life cycle thinking,
- ✓renewable energy utilization,
- ✓dematerialization and
- ✓energy and water consumption efficiency,
- ✓holistic approach.

➢ The tool tries to incorporate these principles through relative and interconnected indicators and by favouring those industries that exhibit high performance regarding these issues.

# Towards a new method



Development of a generic methodological framework *

- with m*ajor adaptations*
- *specific to mining industry*
- *increased level of detail*
- *Software implementation*
- *At the moment focusing only in environmental sustainability*

→ **Tool of this study**

* *Gaidajis G. and Angelakoglou K., "Development of a holistic tool for assessing the environmental sustainability of mining facilities", 5th International Conference Sustainable Development in the minerals industry, SDIMI 2011, June 14-17, 2011, Aachen, Germany.*

# Towards a new method



- The basic idea behind this method is that if the **utilization rate/hazard/concern** of each material/aspect and its environmental impact potential are both known, **a simple matrix-type representation can be established**.

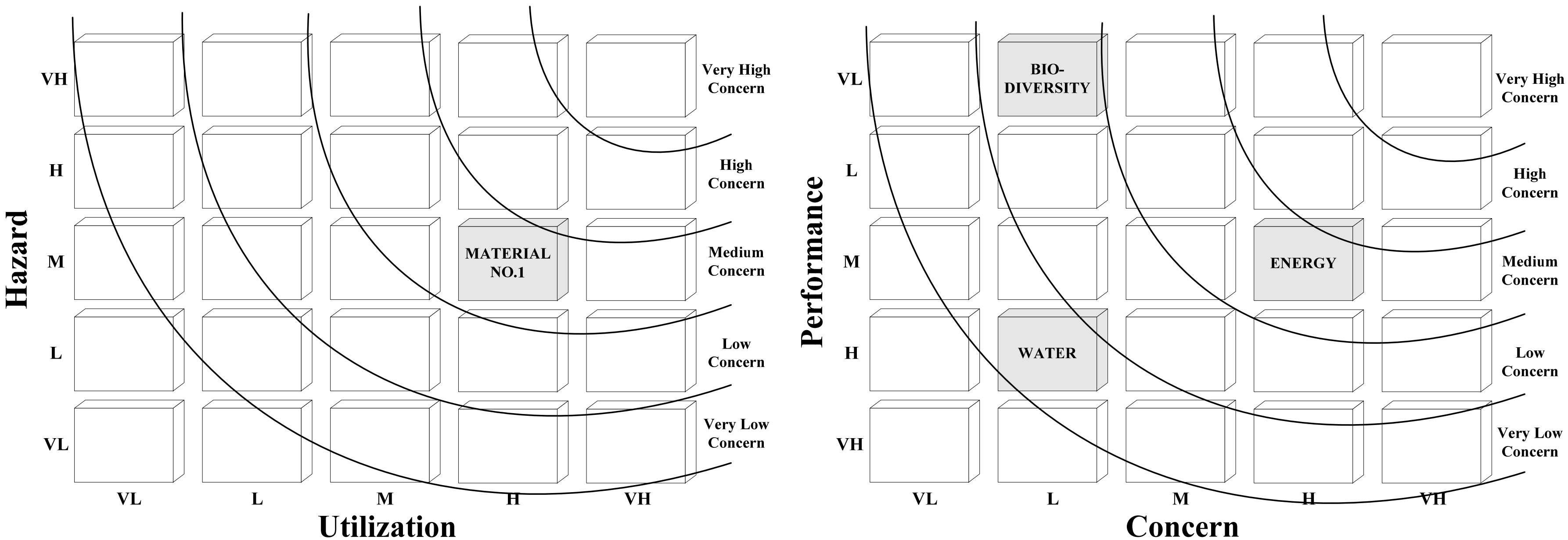
- Each component can be graded as **very high**, **high**, **medium**, **low** or **very low**.

- For the reliable application of the tool, a **minimal amount of analytical data** regarding basic components of the examined system, i.e.
  - ✓ **quantities of the incoming materials and outgoing wastes**
  - ✓ **their hazardousness and scarcity**
  - ✓ **the utilization of water and energy resources**
  - ✓ **biodiversity**

# Towards a new method



*The matrix-type representation*




**Five assessment levels** can be established namely:

1) **Hazard Level**: Matrix plot of material utilization vs. material hazard
2) **Scarcity Level**: Matrix plot of material utilization vs. material scarcity
3) **Water Level**: Matrix plot of water performance vs. water concern
4) **Energy Level**: Matrix plot of energy performance vs. energy concern
5) **Biodiversity Level**: Matrix plot of biodiversity performance vs. concern

# Towards a new method



- Every component of each level is assessed through a number of relative **indicators**.

- Most of the data required to assess the specific indicators can be found from the reports of the facility, whereas for some of the indicators the application of external data from specific agencies is required.

| No. | Issue Examined | Sub-Issue | No. | Indicator |
|---|---|---|---|---|
| 1 | Hazard Level | Material Hazard | 1.1 | Material Scorecard |
| | | | 1.2 | Global Warming Potential |
| | | | 1.3 | Ozone Depletion Potential |
| | | | 1.4 | Specialist Opinion |
| | | Material Utilization | 1.5 | Main Material |
| | | | 1.6 | Secondary Material |
| 2 | Scarcity Level | Material Scarcity | 2.1 | Material Depletion Time |
| | | Material Utilization | 2.2 | Main material |
| | | | 2.3 | Secondary material |
| 3 | Water Level | Water Performance | 3.1 | Water Consumption |
| | | | 3.2 | Waste Water Treatment |
| | | | 3.3 | Water Reuse |
| | | Water Concern | 3.4 | National Concern |
| | | | 3.5 | Regional Concern |
| | | | 3.6 | Sectoral Concern |
| 4 | Energy Level | Energy Performance | 4.1 | Energy Consumption |
| | | | 4.2 | Energy Source |
| | | | 4.3 | Energy Technology |
| | | Energy Concern | 4.4 | National Concern |
| | | | 4.5 | Regional Concern |
| | | | 4.6 | Sectoral Concern |
| 5 | Biodiversity Level | Biodiversity Performance | 5.1 | Financing Biodiversity |
| | | | 5.2 | Restoration |
| | | | 5.3 | Biodiversity Personnel |
| | | Biodiversity Concern | 5.4 | Fauna Concern |
| | | | 5.5 | Flora Concern |
| | | | 5.6 | Environmental Proximity |

# Towards a new method

- In order for the results to be more understandable, being able to conduct internal comparisons (performance of the facility for different years) or comparisons between different facilities of the same type-sector, a **quantitative scoring system** was developed

- The tool applies a scale of **0-100 points**, with zero (0) indicating the minimum environmental sustainability performance and **100 representing the ideal result**.

- Every level is of the same importance whereas **the maximum score for each level is 20 points**.

$$Hazard(Scarcity)\_Score = \frac{1}{5} \times (100) \times \left( 1 - \frac{\sum_{i,j \to 1}^{i,j \to 5} aij \times nij}{5 \times \sum_{i,j \to 1}^{i,j \to 5} nij} \right)$$

| | VL | L | M | H | VH |
|---|---|---|---|---|---|
| VH | 2 | 3 | 4 | 5 | 6 |
| H | 1 | 2 | 3 | 4 | 5 |
| M | 1 | 1 | 2 | 3 | 4 |
| L | 0 | 0 | 0 | 1 | 2 |
| VL | 0 | 0 | 0 | 0 | 1 |

*Weights of every cell*

Final score: $20 \times \left[ \left( Sum\_of\_six\_indicators \right) / 24 \right]$

# Towards a new method - Implementation



- We assessed two **(2) operating industrial-mining facilities** and one **(1) mining project in its permitting stage** in Greece, so as to examine the potential of the tool.

- The scope of the assessment was extended to include main and auxiliary facilities of the mining complexes (i.e. mine, ore transportation, beneficiation plant, loading and waste facilities, etc.).

- The data for the implementation of the tool were acquired from environmental impact assessment reports, sustainability reports and through facility visits and analytical discussions with the personnel.

# Towards a new method - Results



**Quantitative results** from the implementation of the proposed tool in three mining facilities

| Facility | Assessment Level | | | | | Total score | Improved Score |
|---|---|---|---|---|---|---|---|
| | Hazard score | Scarcity score | Water score | Energy score | Biodiversity score | | |
| Code 1 | 16 | 12 | 12 | 6 | 13 | 63 | 77 |
| Code 2 | 17.5 | 18 | 11 | 7.5 | 7 | 61 | 70 |
| Code 3 | 15 | 16 | 9 | 8 | 8 | 56 | 67 |

- Results ranged from **56 to 63 points** indicating a **medium ?? level of environmental sustainability performance**.

- The results are in the same order of magnitude due to the **similar spatial characteristics of the examined mining facilities (spatial level)**.

- The adoption of ameliorative actions could lead to an **improvement from 15%** (for facility code 2) **up to 22%** (for facility code 1).
    - installation of energy saving devices and renewable energy systems (RES),
    - reduction of water consumption
    - employment of biodiversity experts
    - collaboration with external agents.

## Towards a new method - Results



- Mining industries examined, **tend to focus mostly on the common identified issues** (e.g. tailings management, reagents utilization), **neglecting issues** such efficient energy management, RES utilization, air quality etc.

- The evaluation of energy level is further **undermined by the energy profile of Greece** which is characterized by high emission factors and low self-sufficiency.

- Input materials for production processes, not directly connected to production (e.g. tires of transportation vehicles), **may hide significant environmental burden**.

# Further Research



**Much work need to be done** in order to develop a well-structured, comprehensive tool that can efficiently cover most of the pre mentioned shortcomings. **We focus on:**

- **Identification of the key sustainability issues to be addressed**.

**not only** issues related with raw materials, water use, waste,, etc.
**more issues** such as energy utilization and production, biodiversity, offsets, etc.

- **Selection / development of the appropriate indicators.**

For every issue examined corresponding indicators need to be assigned.

- **Development of threshold values for every indicator.**

Extensive review of the sustainability reports of > 500 industries so as to extract the information needed to develop relative clusters of performance.

Further steps include **the weighting of the issues to be addressed by expertise with the utilization of an international survey** and the improvement of the representation of the results.

**Final method is expected in November 2013**

# Conclusions

- A research gap regarding current methods for assessing sustainability was identified.
- The combination of different assessment methods seems to be the optimum strategy for efficiently assessing the sustainability of industries. However this action entails significant amount of time, data and expertise to be performed.
- Much work needs to be done in order to develop a well-structured, comprehensive method that can efficiently cover most of the identified shortcomings.
- Sustainability is about positive change and should not just aim at the minimization of negative impacts.
- Industry and especially the mining industry need to redefine the current tools for the assessment of their environmental sustainability and to find other applicable tools focusing on the actual performance assessment.

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# Thank you for your attention

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