Raw Materials:
Study on Innovative Technologies and Possible Pilot Plants

Ton Bastein, TNO

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Ramintech Project Goals

• To enable the EC to discriminate and ultimately select technological areas for pilot plant suggestions.
  – On the basis of a set of criteria, indicators and methodologies to allow further assessment of proposals.

• To evaluate and map a long-list of innovative technologies and pilot plant suggestions
  – having the potential for significantly improving sustainability and supply of raw materials along the entire value chain.

• In depth analysis of up to 10 pilots
Pilot plant suggestions

• “innovation consists of the successful production, assimilation and exploitation of new ideas in the economic and social spheres”

• “Innovation is the commercial introduction of a new or significantly improved product or service”

• “pilot plants are demonstration installations where technical processes can be demonstrated on a large scale
Development and logic of the study

• Set-up for obtaining criteria:
  – Initial set of Criteria proposed by consortium
  – Web-based questionnaire based on set of criteria and providing initial validation (‘dry runs’)
    • Improved criteria
  – Consultation stakeholders in 1\textsuperscript{st} workshop
    • Support and validation of direction
    • Improved criteria
    • Discrimination between areas
  – Consultation experts in 2\textsuperscript{nd} workshop
    • Based on ‘pilot assessment’
    • Relevance and practicality criteria
    • Improved criteria
  – Definitive set of criteria
Criteria, pilot collection, stakeholder consultation

- Criteria
- Collected Pilots
- 1st workshop
- 2nd workshop
Stakeholder and expert consultation

- Criteria discussed during 1\textsuperscript{st} and 2\textsuperscript{nd} workshop
- General consensus on main and sub-criteria
- General comments:
  - Economic criterion overall judged most important
  - Replace criticality by RM availability
  - Add social and health aspects
Stakeholder and expert consultation

Diagram showing various factors such as Economic Benefit, criticality, environment, innovation, and their impact on different sectors like Substitution, recycling, processing, and mining.
Sub-Criterion: impact on Integral cost price

• Aim is reduction of ICP for raw and processed materials and final products, including all steps along the chain
  – Competitiveness on a global market

• How to evaluate?
  – CAPEX + OPEX + capacity
  – Learning and up-scaling

• …or by:
  – Analogues
  – Benchmarks

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Sub-criterion

Absolute Economic Benefit

• Even if benefit on cost price is marginal, the economic benefit can be positive
  – E.g. by increasing

• benefits beyond the pilot
  – Upstream
  – Downstream
  – Spin-off

• Total potential contribution to European economy
## Final set of criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sub Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economy</strong></td>
<td>Impact on Cost Price</td>
</tr>
<tr>
<td></td>
<td>Absolute Economic Benefit</td>
</tr>
<tr>
<td></td>
<td>Jobs created in the EU</td>
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<tr>
<td></td>
<td>Impact on skills and knowledge</td>
</tr>
<tr>
<td><strong>Raw Material Availability</strong></td>
<td>Does the pilot increase the availability of RM within the EU-27</td>
</tr>
<tr>
<td><strong>Environment, health and safety</strong></td>
<td>Environmental Performance</td>
</tr>
<tr>
<td></td>
<td>Health and Safety aspects</td>
</tr>
<tr>
<td><strong>Stage of innovation</strong></td>
<td>Impact on relevant challenges</td>
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<td></td>
<td>Technology readiness TRL</td>
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<tr>
<td></td>
<td>Dealing with barriers for innovation</td>
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<td></td>
<td>Clarification for government support</td>
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</table>
Development and logic of the study

- Identifying possible innovative plants:
  - Bottom-up approach
    - IP and literature search do not yield comprehensive picture
  - Web-based questionnaire sent to:
    - European organisations and associations
    - ERA-MIN
    - National Contact Points
    - ... to be distributed to their members and stakeholders
  - Overall results presented to stakeholders in 1st workshop (22nd October 2012, Brussels)
Pilot plant suggestions

- 113 pilot plants descriptions collected
- 140 opinions on challenges are available (from 130 stakeholders)
- More than 300 stakeholders actively involved
- Analysis presented/reported on:
  - Countries/sectors/type partners involved
  - Raw materials addressed (all)
  - Part of value chain (processing and recycling dominant)
  - Environmental aspects (mostly improvements)
  - Investments suggested (large range up to 300 MEUR)
  - Technology status (and improvement during pilot phase) (range from 3 to 9; 3 and 7 dominant)
Pilot plant suggestions

**Country**

- DE 20%
- ES 9%
- NL 8%
- IT 7%
- BE 7%
- GR 3%
- AT 4%
- FI 4%
- EU 4%
- SK 4%
- GB 7%
- NO 7%
- PT 4%
- Non-EU other 3%
- EU-27 Other 7%

**Materials**

- Forest-based materials (wood, paper) 8%
- Aggregates/Dimensional stones 10%
- Industrial Minerals 9%
- Others 6%
- Metals 67%

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Pilot plant suggestions

Diagram: Pie chart showing percentages of Substitution (9%), Recycling (39%), Processing and Refinement (38%), Exploration (6%), and Exploitation (8%).

Graph: Line graph showing CAPEX (EUR) decreasing over time from 100,000,000 to 10,000,000 to 1,000,000.
Pilot plant suggestions

- Maturity = TRL
- Many pilots still early research

- Mostly 2-3 years lead time for pilot
From pilots to pilot areas

- Pilot analysis and mapping:
  - Many pilots have rough data and show overlapping fields of interest
  - Grouping pilots provides insight in direction of European innovation direction
  - Description at level of ‘clustered pilots provides ‘degrees of freedom’ for future calls

= pilot areas
From pilots to pilot areas

- In-depth analysis of up to ten pilot areas
  - Based on *hot spots of attention* of stakeholders
  - … not on prioritization of merits
  - Originating from areas:
    - Exploration and exploitation
    - Processing and recycling
    - Substitution
## Pilot Areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep sea Exploration / Exploitation</td>
<td></td>
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<tr>
<td>Deep underground Exploration / Exploitation</td>
<td></td>
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<tr>
<td>Processing of Aggregates / Dimensional stone with improved efficiency and recycling of construction materials</td>
<td></td>
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<tr>
<td>Processing of Industrial minerals with improved efficiency</td>
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<tr>
<td>Treatment of Mining and Processing Waste, Low Grade and Complex Ores</td>
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<tr>
<td>Recycling of Industrial manufacturing wastes and End-of-life products</td>
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<tr>
<td>Metallurgy processes</td>
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<tr>
<td>Resource efficient Paper Processing / Recycling</td>
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<tr>
<td>Application-led substitution</td>
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<tr>
<td>Material-led substitution</td>
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</table>
Discussion points per area

• Strength, Weakness, Opportunity, Threats: SWOT analysis
• Additional barriers: innovation analysis
Dealing with barriers for innovation

<table>
<thead>
<tr>
<th>Area for Evaluation</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacities and capabilities</td>
<td>Skills pipeline</td>
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<tr>
<td></td>
<td>Skilled human resources available (e.g. industrial and academic)</td>
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<td></td>
<td>Innovation champion/internal competition and commitment?</td>
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<td></td>
<td>Entrepreneurial culture (quality, mindset, risk taking)</td>
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<tr>
<td>Technological</td>
<td>Need for additional fundamental / applied research</td>
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<td></td>
<td>Technological standards needed to use the innovation</td>
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<td></td>
<td>Need for additional Infrastructure</td>
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<tr>
<td>Network characteristics</td>
<td>Organizational capacity for cooperation in development (network)</td>
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<tr>
<td></td>
<td>Convergence of activities / communities (is there a common opinion forming?)</td>
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<tr>
<td></td>
<td>Network quality (e.g. PPPs, ETPs, communities of entrepreneurs)</td>
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<tr>
<td>Market prospects</td>
<td>Access to financial resources (public funds or own industrial investment resources)</td>
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<td></td>
<td>Market structure (e.g. fiscal support / entry barriers)</td>
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<td></td>
<td>Predictability of the Market (e.g. volatility)</td>
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<tr>
<td></td>
<td>Competition in market</td>
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<tr>
<td>Law, regulation and politics</td>
<td>Regulation influencing development or use of the innovation</td>
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<tr>
<td></td>
<td>Existing (EU) intellectual property rights in the innovation area</td>
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<td></td>
<td>Policy measures supporting the innovation</td>
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<td></td>
<td>Political attention to the innovation area</td>
</tr>
<tr>
<td>Social</td>
<td>Societal acceptance of the innovation by end-users</td>
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<tr>
<td></td>
<td>Impact of industrial associations and professional bodies</td>
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<tr>
<td></td>
<td>Impact of advocacy coalitions (NGOs, environmental org., special interest org.)</td>
</tr>
</tbody>
</table>
Innovation systems analysis

- Values > 0: driver for innovation
- Values < 0: Barriers for innovation identified
- Identifies action paths
### Deep underground Mining

#### Strength
- **S1:** High technological, innovative industry within the EU (transfer of knowledge from other industries e.g. the oil/gas industry to the mining industry)
- **S2:** Technological R&D capacities of EU
- **S3:** Competitiveness of the EU industry (big mining houses are headquartered in the EU)
- **S4:** World-class geological competences in several EU geological surveys

#### Weakness
- **W1:** OPEX and CAPEX are significantly higher than for surface or shallow underground mining
- **W2:** Lack of appropriate skilled workforce (Engineers but also workers)
- **W3:** State of the Art regarding deep underground mining in the EU
- **W4:** Weak geological database in many EU areas due to insufficient public investment in data acquisition (geophysics, deep drill-hole, geochemistry partly too old did not look at rare metals)

#### Opportunities
- **O1:** New mineral deposit exploitable and increase of RM availability
- **O2:** Need for new jobs
- **O3:** Transfer of knowledge from other companies and countries who are leader in that area like the advanced mining countries, South Africa, Canada etc.

#### Threats
- **T1:** Social acceptance (regarding environmental impacts and safety risks related to the harsh working environment)
- **T2:** Lack of financial means
- **T3:** Characteristics of mined material (that could lead to a situation that the recovery in processing decreases significantly and makes the full project unprofitable)
- **T4:** Risk that EU mined raw materials goes to China for metallurgy and manufacturing
Deep underground Mining

- **Barriers:**
  - Skills
  - Societal acceptance
  - Research needs

- **Drivers**
  - Regulations favouring underground mining
  - Market demand
# Processing mining waste and complex, low grade ores

**Strength**

- S1: Innovation/Optimization can be exploited in many applications
- S2: EU capacity in research and equipment: EU has some world class research institutes and technology/equipment providers
- S3: Reduction of Environmental impact

**Weakness**

- W1: Fragmentation of EU research
- W2: Ownership issues (unclear status, lack of legislation)
- W3: HSE aspects

**Opportunities**

- O1: Generation of integrated process chains oriented to the minimization of wastes
- O2: Turning resources to reserves; increase of RM availability
- O3: Knowledge transfer to other sectors, e.g. recycling. Common factor for extractive industries, that will solve a wide range of issue

**Threats**

- T1: Environmental limitations (e.g. Natura)
- T2: Legislation about definition of waste. Change in the status of wastes into new produces key question for legislation
- T3: Process standardization difficult with variation in quality/composition of input waste.

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Processing mining waste and complex, low grade ores

• **Barriers**
  – Unpredictable prices
  – With competition from ‘normal’ operations
  – Worries about available skills and

• **Drivers**
  – Political attention
  – Social acceptance (mining waste)
  – Network formation
# Recycling

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle integration. Reduction of environmental impacts</td>
<td>Need of strong recycling infrastructure (collection system/treatment) and regulations (ownership of the added value) for EoL products</td>
</tr>
<tr>
<td>Large amount of waste available, high metal grade (vs. primary resources) type of resources</td>
<td>Business case for recycling of diluted materials</td>
</tr>
<tr>
<td>EU has world-class technologies and leading companies in this field</td>
<td>Resource (=waste) ownership and guaranteed availability and quality</td>
</tr>
<tr>
<td>Ambition to create flexible process technology, able to cope with varying sources</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of new equipment in Europe</td>
<td>Reduction of market share of certain materials/industries</td>
</tr>
<tr>
<td>Public and political pressure to keep own minerals and metals (in urban mine)</td>
<td>Need for integration with policy actions and logistic chains operations, network development</td>
</tr>
<tr>
<td>Increasing public awareness and concern about EoL issues</td>
<td>Competition between innovative treatment chain and already established ones</td>
</tr>
<tr>
<td>Recycling strongly supported by EC waste management policy</td>
<td>Rapid technology evolution, leading to very complex e.g. thin layers, multiple materials and fast changing waste composition. Need for material characterisation and flexibility in separation technologies</td>
</tr>
</tbody>
</table>
Recycling

• Barriers
  – Infrastructure for pre-processing
  – Market prices for minor elements

• Drivers
  – Social and political acceptance and interest
  – Network formation
  – Convergence of ideas
## Resource efficient Paper recycling Processes

### Strength
- S1: basic research done
- S2: mature and developed technology available
- S3: initiative not restricted to one location

### Weakness
- W1: IPR not secured: this hampers network formation or cross-selling technology
- W2: lack of available cash for investments

### Opportunities
- O1: Market opportunities for (products made with) waste materials
- O2: acceptance of resource efficient activities with NGO’s and the public
- O3: enough scope for additional volume: 10 Mton (out of 80 Mton) still wasted

### Threats
- T1: Cheap alternatives are available (such as landfilling or exporting waste paper)
- T2: No legislation preventing diverting waste streams

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Resource efficient Paper recycling Processes

- **Barriers**
  - Not much political attention
  - No IPR

- **Drivers**
  - Excellent network
  - Technological capacity
  - Infrastructure and underlying R&D available
  - No market volatility
  - Social acceptance
Concluding remarks

• Criteria for innovative pilot plants suggested
  – Economic aspects seen as most important
  – Criteria tested on suggested pilots
• Broad set of pilots suggested by stakeholders
• Gaps:
  – Some parts of value chain missing
  – Limited response from paper and wood sectors
  – Some major players missing
• Innovation also depends on non-technological issues