Current situation of the use and substitutability of CRMs

Webinar 1 of 2, Dr Peter Clark, KTN UK
<table>
<thead>
<tr>
<th>Time</th>
<th>Title of Presentation</th>
<th>Presenter</th>
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<tbody>
<tr>
<td>12:00-12:05</td>
<td>Welcome &amp; Introduction to SCRREEN Project</td>
<td>Peter Clark, KTN</td>
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<td>12:05-12:20</td>
<td>CRM Substitution Profiles</td>
<td>Luis Tercero, Fraunhofer</td>
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<td>12:20-12:35</td>
<td>Introduction to the Sustainability Index</td>
<td>Etienne Bouyer, CEA</td>
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<td>12:35-12:50</td>
<td>What do organisations see as the most critical CRM risks – sharing outcomes from recent Survey &amp; Interviews</td>
<td>Peter Clark, KTN</td>
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<td>12:50-13:00</td>
<td>Q&amp;A from audience then Close</td>
<td>Natalie Withenshaw, KTN</td>
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<td>Peter Clark, KTN</td>
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The Context

Raw materials are crucial to Europe’s economy and essential to maintaining and improving our quality of life. Securing reliable and unhindered access to certain raw materials is a growing concern within the EU and across the globe.

antimony, baryte, beryllium, bismuth, borate, cobalt, coking coal, fluorspar, gallium, germanium, hafnium, helium, indium, magnesium, natural graphite, natural rubber, niobium, phosphate rock, phosphorus, scandium, silicon metal, tantalum, tungsten, vanadium, platinum group metals, heavy rare earths, light rare earths

The Context

Existing challenges...

- Lack of a single umbrella under which all associated stakeholders exist
- Lack of accessible knowledge
- Lack of continuity or availability of longer term investments
- Lack of harmonised regulations and standardisation
- Several CRMs and their value chains are today poorly addressed in European R&D&I projects
The Project

Over the course of the project, SCRREEN will:

- Identify primary and secondary resources as well as substitutes of CRMs
- Estimate the expected EU demand for various CRMs in the future and identify major trends
- Provide policy and technology recommendations and actions for the production of various primary and secondary CRMs
- Provide a plan for transparent consultation with relevant external stakeholders
The Partners

SCRREEN comprises 30 recognised key actors from 15 countries on the topics of primary and secondary CRMs as well as on the substitution of CRMs.
Project Objectives

Establish an EU Expert Network that covers the whole value chain for present and future critical raw materials.

Analyse pathways and barriers for innovation, and identify the solutions for overcoming these barriers.

Study the regulatory, policy and economic framework for the development of these technologies.

Identify the knowledge gained over the last years and ease the access to the data while developing a knowledge data portal.
WP5 Objectives

• Map applications of CRMs and their substitutability
• Analyse substitution strategies in light of existing and emerging markets, technologies and policies
• Economic assessment of substitution opportunities, taking account of value chains
• Educate stakeholders across the CRM value chain and support dialogue between CRM key actors
CRM substitution profiles

Luis Tercero • Fraunhofer ISI
SCRREEN Webinar • May 2019
Why substitution?
Substitutability and criticality

Substitutability is a common element in criticality assessments

- EU definition (COM(2008) 699) “… three main reasons why some raw materials […] are particularly critical: […] a lack of substitutes”
- Element in the “Supply risk” dimension of EU criticality exercises 2010 and 2014, element in both dimensions of EU criticality exercise 2017
- All other methodologies consider substitutability in some way

**Need for updated assessments of substitution option for raw materials in their key applications**
Assessing substitution is notoriously difficult

How to quantify based on limited information
Potential substitutes with low TRL/MRL
Confidentiality issues for industry developments
How can SCRREEN contribute?

The CRM_InnoNet Project
Extend summary assessment with pertinent technical information:

Profiles available (2013, with community input 2015)

SCRREEN
• Build upon CRM_InnoNet
• Keep information up-to-date
• Put into context of other assessments
## Review (1/2)

Substitutability of industrial minerals, compounds and biotic materials

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Legend:
- difficult or impossible
- low substitutability
- middle substitutability
- high substitutability
- not possible
- adequate
- easy/complete
- no substitute/NA
- high addn't cost/perform. loss
- high addn't cost/perform. loss poor
- high addn't cost/perform. loss good
- high addn't cost/perform. loss exemplary
- little addn't cost/perform. loss
### Review (2/2)

Metals/elements are more often assessed
The SCRREEN substitution profiles

Structure
1. Short intro to CRM
2. Graphical summary of uses
3. Prose on each use and assessment of substitutability
4. Graphical summary of substitutability

Coverage
Antimony
Beryllium
Borates
Cobalt
Coking coal
Fluorspar
Gallium
Germanium
Indium
Natural graphite
Niobium
PGM
Phosphate rock
Rare earths (heavy)
Rare earths (light)
Silicon metal
Tantalum
Tungsten
Vanadium
Summary

Prose on each main application available in D5.1

- most 3-4 pages per profile
- download full report from [http://scrreen.eu/results/](http://scrreen.eu/results/)
Substitution profile: Antimony

- Wire and cable
- Textiles
- Electrical & electronic equipment
- Alloys incl. batteries

Substitute merit:
- excellent
- good
- adequate
- poor
- none
Substitution profile: Beryllium

- Telecom / Electronics: 60% use
- Industrial components: 30% use
- Auto electronics: 20% use
- Aerospace / Defence: 10% use
- Others: 0% use

Substitute merit: excellent, good, adequate, poor, none
Substitution profile: Borates

- Wood preservatives
- Metals
- Chemicals
- Others
- Fertilizers
- Frits and ceramics
- Glass

Substitute merit:
- excellent
- good
- adequate
- poor
- none

% Use
Substitution profile: Cobalt
Substitution profile: Coking coal
Substitution profile: Fluorspar

- Alkylation process for oil refining
- Nuclear energy production
- Pickling/etching applications
- Fluoraromatics
- Other dissipative applications
- Inorganic fluorine compounds
- Aluminium making

Fluorocarbons & fluoropolymers

% Use

Substitute merit:
- excellent
- good
- adequate
- poor
- none
Substitution profile: Gallium

- Applications using permanent magnets
- Sensor applications (mostly for military uses)

% Use

- Substitute merit:
  - excellent
  - good
  - adequate
  - poor
  - none
Substitution profile: Germanium

- Satellite solar cells
- Optical fibres
- IR optics

Substitute merit:
- excellent
- good
- adequate
- poor
- none

% Use
Substitution profile: Indium
Substitution profile: Natural graphite

- Lubricant
- Batteries
- Friction products
- Refractories for foundry
- Others
- Refractories for steelmaking

Substitute merit:
- excellent
- good
- adequate
- poor
- none

% Use
Substitution profile: Niobium

- Stainless steel
- Other
- Superalloys
- HSLA steels: Pipeline
- HSLA steels: Automotive
- HSLA steels: Structural

% Use
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Substitute merit:
- excellent
- good
- adequate
- poor
- none
Substitution profile: Palladium (PGM)
Substitution profile: Platinum (PGM)
Substitution profile: Phosphate rock
Substitution profile: Rare earths (heavy)

- Optical applications
- Glass
- Magnets
- Alloys
- Other
- Ceramics
- Lighting

Substitute merit:
- excellent
- good
- adequate
- poor
- none

% Use
Substitution profile: Rare earths (light)
Substitution profile: Tantalum
Substitution profile: Tungsten

- Steel alloys
- Mill products
- Others
- Cemented carbides

% Use

Substitute merit:
- excellent
- good
- adequate
- poor
- none
Substitution profile: Vanadium

- Special alloys (mainly catalysts)
- Others
- Special steels
- HSLA steels

Substitute merit:
- excellent
- good
- adequate
- poor
- none

% Use
Thank you!

Get in touch for more information!
luis.tercero@isi.fraunhofer.de

All of the reports produced in the project will be available for download on the SCRREEN website.

Project coordinator: Stephane Bourg, CEA
Contact us: contact@scrreen.eu

Visit our website: www.scrreen.eu

Follow us on Twitter!
@SCRREEN_EU
Introduction to Substitution Readiness Level (SRL)

SCRREEN Webinar, May 8th 2019
E. Bouyer, CEA

This project has received funding from the EU’s Horizon 2020 research and innovation programme under Grant Agreement No. 730227
Why do we implement material substitution activities?

In practice, 4 main driving forces are initiating works on substitution:

- Potential or existing shortage on given substance leading to a price increase and/or supply difficulties (CRM)

- Banishment of a substance due to regulations (caused by toxicity,...) \( \text{Cd, Cr}^{VI} \)

- Novel (abundant & non toxic) materials/precursors opening new applications

- Continuous need of material with enhanced specific properties (performance, durability,... and cost reduction)
Paths to address substitution

Substitution act as a mitigation strategy to overcome the potential disruption in the supply of critical raw materials: it covers the partial substitution (minimization of CRM) to the complete substitution (full replacement).
**Substitution & substitutability**

![Periodic Table](image)

*lanthanides* | La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu
---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75 | 60 | 41 | 41 | 38 | 161 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |

**actinides** | Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr
---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 232 | 239 | 235 | 237 | 239 | 244 | 244 | 247 | 251 | 253 | 257 | 259 | 261 | 262 | 262 |

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**Substitute Performance**

Excellent | Poor
---|---
0 | 100

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[SCRREEN](image)
Current situation

Limit of the current substitutability indicator:
- static image of the substitutability/substitution
- no measurement of the remaining effort to be done in term of R&D&I to implement the solution

Need to be more operational (to put oneself in the position of the users, the industrial that use/need substitute, the policy makers), more efficient, more useful
A SRL for what?

There is a need for the evaluation, for monitoring/tracking the maturity of a substitution solution/approach.

The maturity can be understood as the ability to implement the substitution solution, to make it real.

This is crucial for actors (R&D players and industrials, users/customers, policy makers) to measure the effort, the investment to be done in order to uptake the substitution solution

- aims to provide decision makers with a view of a project’s maturity in a simple way - with a single score.

- is the material/technology ready to be brought to market, and if not, what can be practically done to accelerate its entry and subsequent uptake within a group of constituent users or customers?
A SRL for what?

SRL would:
- Provide a common and comprehensive state of a particular substitution technology
- Manage the risk
- Help to take decision on substitution technology development
- Help to take decision on substitution technology transfer
How to measure it?

What kind of parameters should be integrated in this SRL, hereafter are some (non exhaustive) relevant items:

- The performance reached by the substitution solution versus the current one
- The substitute availability
- The substitute processability, compatibility with the current production & manufacturing facilities/lines
- The price ratio
- The acceptability of industrial actors to uptake the substitution solution (MRL)
- The easiness to implement the substitution solution
Define & establish a SRL scale

We must harness the potential of this idea. The SRL is a declination of the TRL (and MRL), the substitution technology level measures the path, the effort to be done till the market introduction.

The scale can range from 1 to 9.
TRL: Technology Readiness Level
# MRL: Manufacturing Readiness Level

<table>
<thead>
<tr>
<th>MRL</th>
<th>Definition</th>
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<tbody>
<tr>
<td>1</td>
<td>Basic manufacturing implications identified</td>
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<tr>
<td>2</td>
<td>Manufacturing concepts identified</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing proof of concept developed</td>
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<tr>
<td>4</td>
<td>Capability to produce the technology in a laboratory environment.</td>
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<tr>
<td>5</td>
<td>Capability to produce prototype components in a production relevant environment.</td>
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<tr>
<td>6</td>
<td>Capability to produce a prototype system or subsystem in a production relevant environment.</td>
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<tr>
<td>7</td>
<td>Capability to produce systems, subsystems or components in a production representative environment.</td>
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<tr>
<td>8</td>
<td>Pilot line capability demonstrated. Ready to begin low rate production.</td>
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<tr>
<td>9</td>
<td>Low rate production demonstrated. Capability in place to begin Full Rate Production.</td>
</tr>
<tr>
<td>10</td>
<td>Full rate production demonstrated and lean production practices in place.</td>
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</table>
## SRL: Substitution Readiness Level (1/2)

<table>
<thead>
<tr>
<th>1. Basic principle observed and reported for the substitution solution</th>
<th>Lowest SRL. Scientific research starts to move towards applied research. Examples could include paper studies and basic properties of the substitution solution that compare the current solution.</th>
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<tbody>
<tr>
<td>2. Concepts or applications of the substitution solution formulated</td>
<td>Shaping of the substitution solution starts, application could be identified. Examples are still limited to paper studies.</td>
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<tr>
<td>3. Proof of concept of the substitution solution</td>
<td>Active R&amp;D on the substitution solution are initiated. This include laboratory studies to evaluate the substitution solution (check the provided function in comparison to the current solution to be replaced). Examples cover components that are not yet fully integrated nor representative.</td>
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<tr>
<td>4. Laboratory validation of the substitution solution</td>
<td>Components of the substitution solution are integrated in order to verify they can operate together. Examples include ad hoc integration of substitution solution at laboratory scale.</td>
</tr>
<tr>
<td>5. Validation in a relevant environment of the substitution solution</td>
<td>The maturity of the substitution solution grow significantly. Tests like comparison with the current solution are done at laboratory scale.</td>
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### SRL: Substitution Readiness Level (2/2)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tr>
<td>6.</td>
<td>Demonstration in a relevant environment of the substitution solution</td>
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<td>The substitution solution is tested in a relevant environment, it means that industrial (manufacturing) tools are available to make real this substitution solution. This is a major step forward for the substitution solution maturity. Examples cover prototype test in at least simulated operational environment.</td>
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<td>7.</td>
<td>Demonstration of the substitution solution in operational environment</td>
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<td>The substitution solution is tested at prototype scale to demonstrate its soundness and viability in an operational environment. At this stage the existence and the robustness of the substitution solution supply chain is assessed.</td>
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<tr>
<td>8.</td>
<td>Full substitution solution qualified</td>
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<td>Proof has been furnished that substitution solution brings the same performance than the original solution (to be substituted) at full scale. The functional specification for the substitution solution are fulfilled at the real scale. This scale represents the end of development stage.</td>
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<tr>
<td>9.</td>
<td>Full substitution solution approved, accepted and deployed</td>
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<td>Highest SRL. All the conditions for the large scale (e.g. industrial) deployment of the substitution solution are fulfilled: Readiness of the industrial tool to produce/provide cost competitive substitution solution, acceptance of the customers to uptake the solution. This is at least true for a substitution solution applied in a given specific sector, i.e. this is not generic since not applicable to all sectors where the substitution solution could apply.</td>
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Conclusions

- SRL is just a practical tool (it is not a goal, it is a mean) that accompany and could guide developers (scientists, researchers), decision makers such as industrials and end-users involved at different stage of the setting up of substitution solutions of CRM.

- The establishment of the SRL scale is inspired by other currently used scale such as TRL and MRL.

- One of the basic idea is to involve as soon as possible most the actors of the value chain to verify if all the bricks needed to deploy the substitution solution are existing and are connected between themselves.
What do organisations see as the most critical CRM risks?
Sharing outcomes from recent Survey & Interviews

Webinar 1 of 2, Dr Peter Clark, KTN UK
Purpose of this activity

• **Stimulate greater awareness of CRM supply chain issues** and in particular the **innovation potential provided by substitution**

• Focusing our activities on CRM value chains across: **Alloys; Magnets; Batteries; Electronic components; Catalysts** (automotive and major other uses)
Stakeholder Engagement Activities

Insights gained from:

• An on-line survey sent out in January 2019 to which +500 individuals were invited to contribute

• A short interactive survey that took place at the Materials Research Exchange Event, London 2018

• One-to-one interviews with experts from industry (SMEs, large companies, consultants)
Results of 2019 Survey & Interviews

Q: Which CRMs do you deem critical to your business?
Results of 2019 Survey & Interviews

Q: What is the most common issue experienced?

<table>
<thead>
<tr>
<th>Issues of Material Supply (multiple answers)</th>
<th>No. responses</th>
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<tr>
<td>Materials become subject to regulation</td>
<td>12</td>
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<tr>
<td>Quality not accepted and returned</td>
<td>8</td>
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<tr>
<td>Less delivered than expected</td>
<td>7</td>
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<tr>
<td>Sharp price rises</td>
<td>14</td>
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<tr>
<td>Over one month delay</td>
<td>9</td>
</tr>
<tr>
<td>Up to one month delay</td>
<td>6</td>
</tr>
<tr>
<td>Up to one week delay</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
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</table>

No. responses
Q: What mitigation steps might you take?

- Acquire part of your supply chain to secure your material: 2 responses
- Changed product / process: 10 responses
- Identified alternative materials within the product / process: 16 responses
- Investigated recycling / recovery / reuse of material within the supply chain: 15 responses
- Investigated recycling / recovery / reuse of material internally: 14 responses
- Added a second source of supply: 16 responses
- Changed source of supply: 8 responses
- No: 6 responses

No. responses: 55
Results of 2019 Survey & Interviews

Q: How do CRM risks compare with other business risks?
Results of 2019 Survey & Interviews

Q: What collective action would you take to reduce impact?

- Fund research and innovation into new products and materials: 6 responses
- Secure multi-country trade agreements: 5 responses
- Develop greater and more secure recycling and recovery routes for key materials: 8 responses
- Investigate increased extraction of materials within the EU: 3 responses
- Ensure new regulation is phased in over a reasonable period of time: 2 responses
- Ensure new regulation is compatible with existing practices: 3 responses
- Other: 0 responses
- None: 0 responses
Conclusions from Survey & Interviews

• Perception of CRM supply chain is dependent on where you sit in the supply chain
• The most common issues companies experience regarding CRM supply challenges is sharp price increases followed by materials becoming subject to regulation
• The most common way to manage this risk is to add a second source of supply and those companies that are most exposed to these risks work very closely with their suppliers and supply chain partners to spread risk
• A significant proportion of companies that are exposed are active in R&D in recycling/recovery and re-use. More innovation will be required in the future.
• There are a significant number of organisations that have looked into CRM supply chain risk but are not actively managing it. We should continue to raise awareness of CRM supply chain risks and opportunities to minimise risk to these organisations
Thank you!

Get in touch for more information!

All of the reports produced in the project will be available for download on the SCRREEN website.

Project coordinator: Stephane Bourg, CEA
Contact us: contact@scrreen.eu
Visit our website: www.scrreen.eu
Follow us on Twitter!
@SCRREEN_EU
Case Studies & Interviewees Wanted!

If you have any case studies of ‘substitution in action’ in the following theme areas: Alloys; Magnets; Batteries; Electronic components; Catalysts (automotive and major other uses) then please contact natalie.withenshaw@ktn-uk.org