



Funded by  
the European Union



**CRM\_InnoNet**  
Substitution of Critical Raw Materials

## Introduction

**CRM\_InnoNet, substitution of Critical Raw Materials** is a Coordination and Support Action (CSA), funded by the European Commission's (EC) 7<sup>th</sup> Framework Programme. The project started in November 2012 with the objective of creating an integrated community that could drive innovation in the field of **Critical Raw Materials (CRM) Substitution**: the CRM-Innovation Network. An assessment of the 14 CRM from the EU 2010 list and their substitutability in three selected sectors and applications - Energy, Transport, and ICT and Electronics - have been the main objectives of the project.

### In achieving this goal the project has:

- | Developed a **methodology** to establish the criteria for the identification and prioritisation of CRM applications which are at "threat" - *(Work Package 2)*.
- | Mapped the **CRM landscape**: an overview of the CRM and related technologies subject to substitution complemented by an analysis of the EU-28 plus other relevant countries' strategies on Raw Materials with a special focus on substitution - *(Work Package 3)*.
- | CRM are important for EU industry, therefore an assessment of which specific **CRM applications** in the value chains of the selected sectors are likely to face problems and bottlenecks was carried out. An analysis of the current risk provision strategies and opportunities of industries with a projection until 2030 completed this task - *(Work Package 4)*.
- | Research & Innovation Roadmaps of **CRM substitution strategies** in the prioritised applications from the results of the previous activities, enriched with the knowledge of industry experts and their business evolution expectations - *(Work Package 5)*.
- | Finally a set of **policy recommendations** have been identified. Taking no action will lead Europe to an even more significant external supply dependence and/ or the loss of certain important industrial activities, while implementing the recommendations will help to address the Raw Materials challenge under an integrated perspective looking at supply issues and other important aspects including Europe's objectives in energy; sustainable technologies; digital Europe; etc. In addition the recommendations highlight financial aspects, incentives and educational requirements - *(Work Package 8)*.
- | To secure the continuity of the identified actions and to link them to other activities related to Substitution of Critical Raw Materials taking place in Europe, the **CRM Innovation Network** has been created, which is intended to grow in expertise and undertake outreach activities - *(Work Package 6)*.
- | A wide and comprehensive **communication and dissemination strategy** has been implemented throughout the project's life and its activities have been achieved by the following means: a dedicated website, flyers, posters, participation in conferences, analysis reports, exhibitions, video, etc. - *(Work Package 7)*

## Context

Critical raw materials are vital to key European industries such as electronics, aerospace and clean energy, but are often entirely imported from outside Europe.

In 2010, the European Commission published "Critical Raw Materials for Europe", a report of the Ad-hoc Working Group on defining critical raw materials. The Ad-hoc Working Group was a sub-group of the Raw Materials Supply Group chaired by the European Commission. The original scope of this project was the 14 materials on the 2010 list (see Figure 1), not the 20 currently listed, therefore the work of the project developed regarding mapping end-uses, possible substitutes, technologies and value chains was limited to the materials from the original list. However, the exercise carried out in CRM\_InnoNet fits perfectly in the revised list of 2014, since 13 out of the 14, with the exception of Tantalum remain as CRM for Europe. Thus, the substitution mapping work performed within the project remains entirely relevant.

Figure 1 - 14 Critical Raw Materials

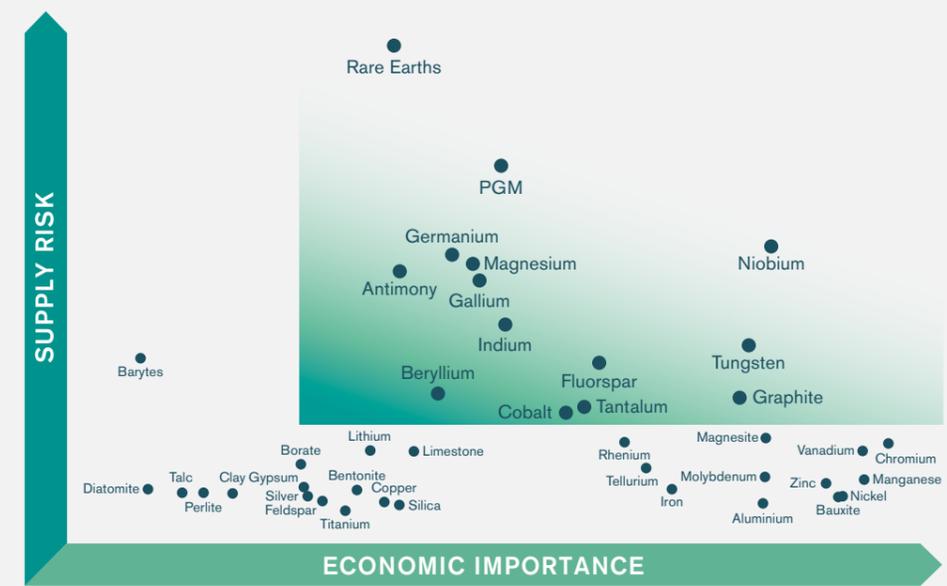


Figure 1 - Ad-hoc Working Group, 2010. The list has been revised and the new version published in 2014 includes 20 CRM. Tantalum is not classified as critical in the 2014 revision.

## Project Results

Substituting a critical raw material for a less scarce resource, a new technology or service, is one approach to reducing Europe's dependence on CRM imports. Substitution is considered as the third pillar complementing other supply options: domestic Primary resources and Recycling. Reduction and Reuse are also additional alternatives that could be further developed in Europe.



The increased attention given to substitution is strongly related to concerns about the steady and secure supply of Critical Raw Materials for the European industry; substitution is expected to play a strategic role in Europe's long term policies in areas such as energy technologies. There are many technological sectors that are potentially threatened by supply disruptions and solutions may be found by substituting vital functions through innovative materials, components, products, processes or services.

## Selected applications

CRM\_InnoNet explored where the strategy of substitution has the best economic and technological potential for European industry. Following the prioritisation analysis the following application areas were selected:

- 1 Motors and drives
- 2 High value alloys
- 3 Printed Circuit Boards (PCBs) and electronics
- 4 Batteries and accumulators
- 5 Photonics and high end optics

Figure 2 - Materials vs applications substitution alternatives

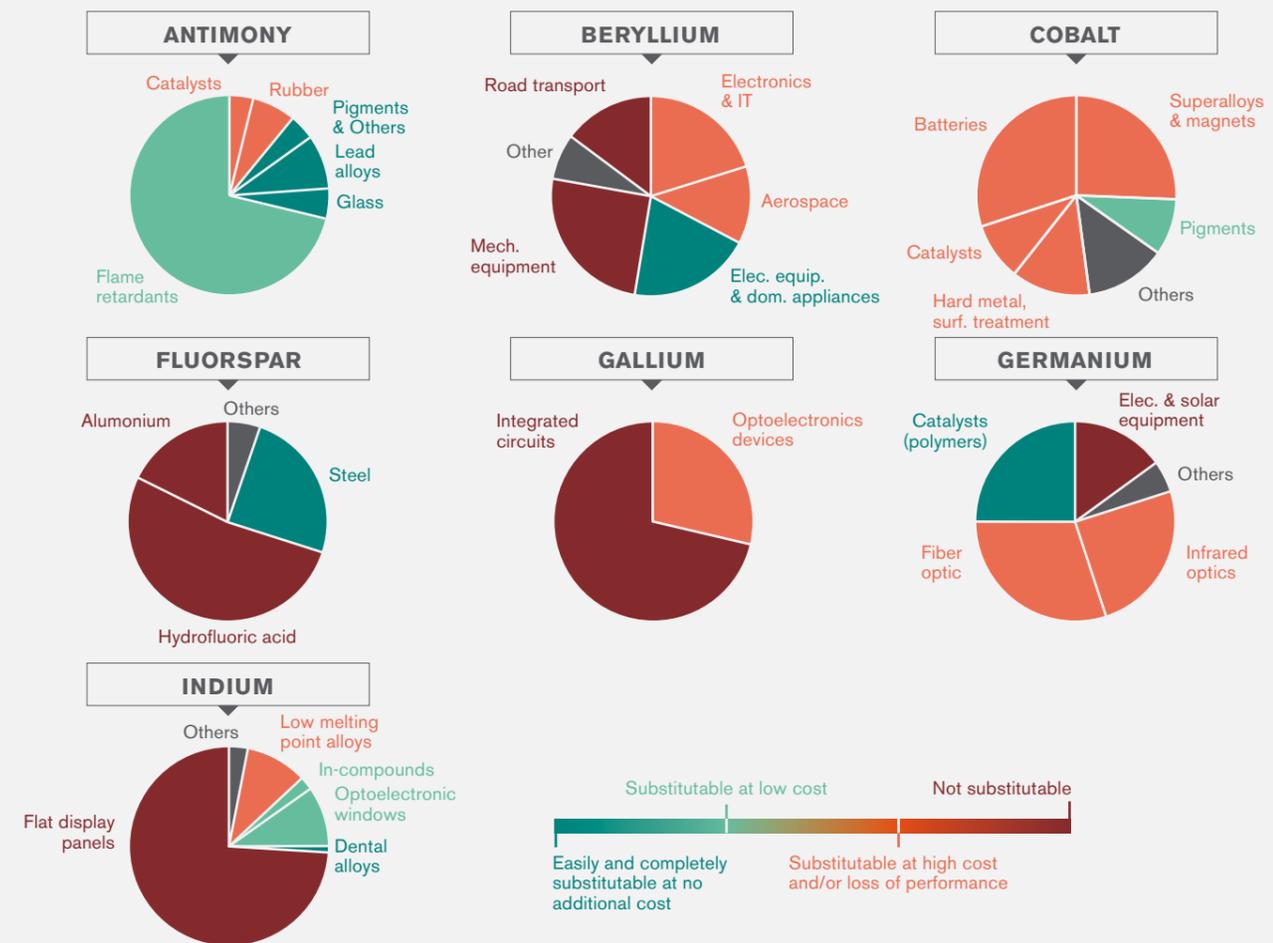
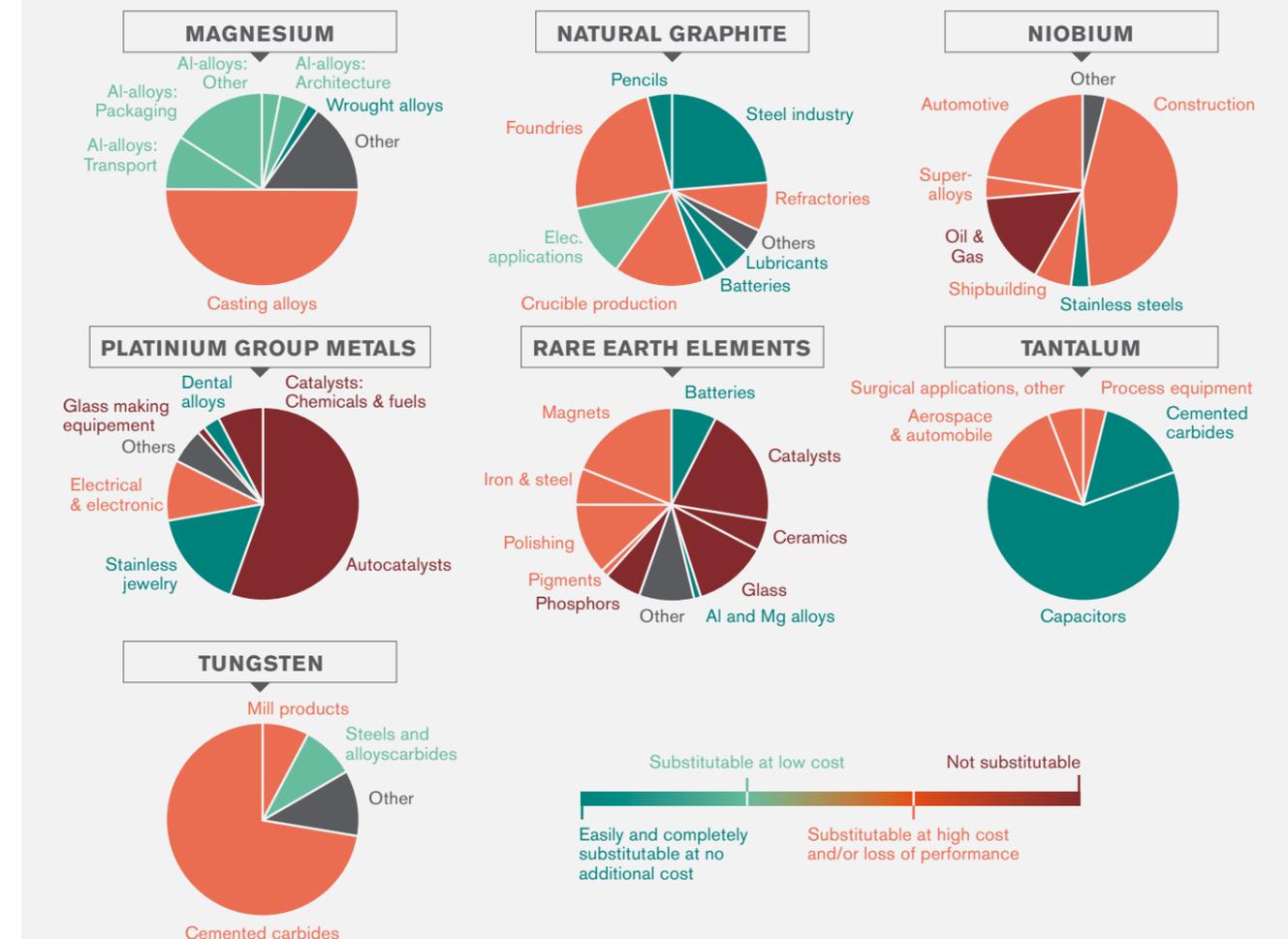


Figure 2 - For more details see "Critical Raw Materials substitution profiles" at [www.criticalrawmaterials.eu](http://www.criticalrawmaterials.eu)

## Materials profiles: applications versus substitutability

In order to understand the opportunities and challenges presented by CRM and the areas where substitution could offer a solution, it was important to look at each CRM individually. A summary of the analysis of the end uses of the materials and the current substitution options - where alternatives might be easily developed and when substitution is not an option for the time being - are shown in figure 2.

Figure 2 - Materials vs applications substitution alternatives



## Country policies on CRM substitution

To fully understand the situation regarding CRM substitution in Europe, the strategies and the relevant research and technology development funding policies of the 28 EU Member States have been analysed. To complete the scenario, a number of additional countries relevant in the field of critical raw materials have been included in the analysis. These are: Brazil, China, Japan, Mexico and the United States.

CRM\_InnoNet is not aware of a strategy which has CRM substitution as its primary goal. However, in the EU-28 some countries have developed strategic plans that include a substitution element. In contrast to the small number of strategies covering CRM substitution, a number of Research and Technology Development programmes and calls are relevant to the topic throughout Europe.

For more details: see report "Country profiles" at [www.criticalrawmaterials.eu](http://www.criticalrawmaterials.eu)

## Supply chain analysis methodology

The value chain analysis was performed by examining the CRM related supply chains of every selected key application in each sector using a common methodology.

It focused on the most relevant applications by screening based on the following criteria:

### Exposure to CRM risk

The use of one or more CRM (EU 2010 list) in the application

### Current economic importance

Share of EU production of the value consumed or used in Europe

### Share of the application production in the sector.

The actual supply chain analysis consisted of:

Statistical analysis of European production, import, export and jobs describing the economic relevance of the application.

Analysis of criticality, strategic relevance and development of vulnerability in the future, based on technical and market reports as well as via interviews with experts.

These supply chain analyses were complemented by industry interviews focusing on current risks and risk provision strategies associated with CRM relevant applications.

The supply chain analysis focused on the following applications:

### Energy sector

Photovoltaics (Copper-Indium-Gallium-di-Selenide (CIGS)-technology), wind turbines and energy storage (Li-ion and NiMH batteries)

### ICT and electronics sector

LED lighting, magnetic resonance imaging (MRI), displays and screens, optical fibre, large household appliances (such as washing machines), printed circuit boards (PCB) and electronic components

### Transport sector

Automobiles, heavy vehicles and commercial aircraft.

For more details: see reports: Value chain analysis for selected applications at [www.criticalrawmaterials.eu](http://www.criticalrawmaterials.eu)

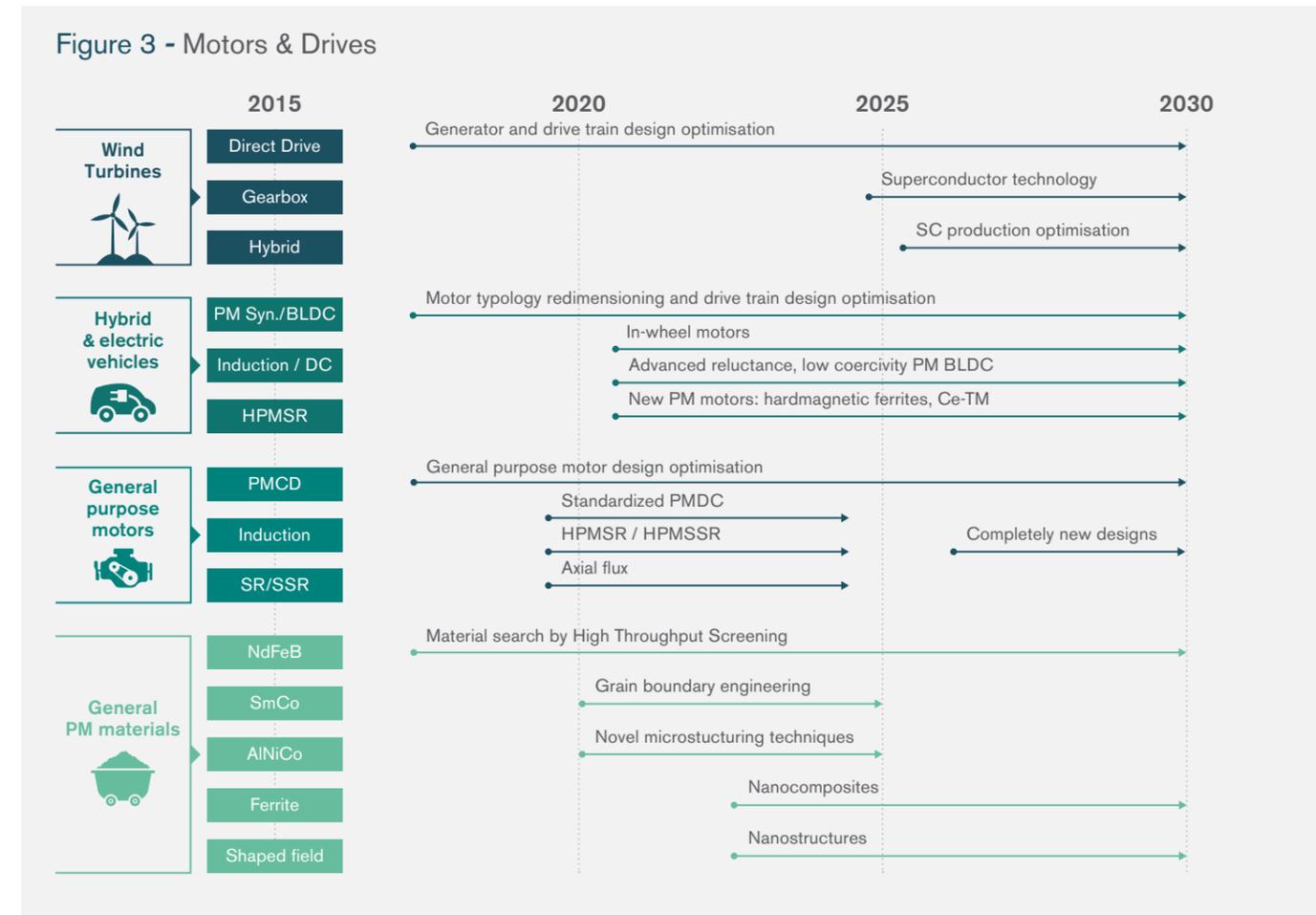


## Research and Innovation Roadmaps for Substitution of CRM

The roadmaps elaborated in the context of this project focus on five applications, which have been considered to be of strategic importance for the European industry and describe promising pathways for reducing or eliminating reliance on imported CRMs over the next 10 to 15 years.

The horizon for the roadmap exercise was established at the outset of the project at 2030, since in this timescale currently emerging technologies can be taken to commercial maturity.

Figures 3 to 7 summarise the proposed paths for the five selected applications.



Authors: TecNALIA - Fraunhofer ISI

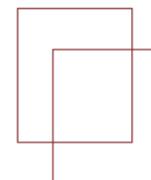
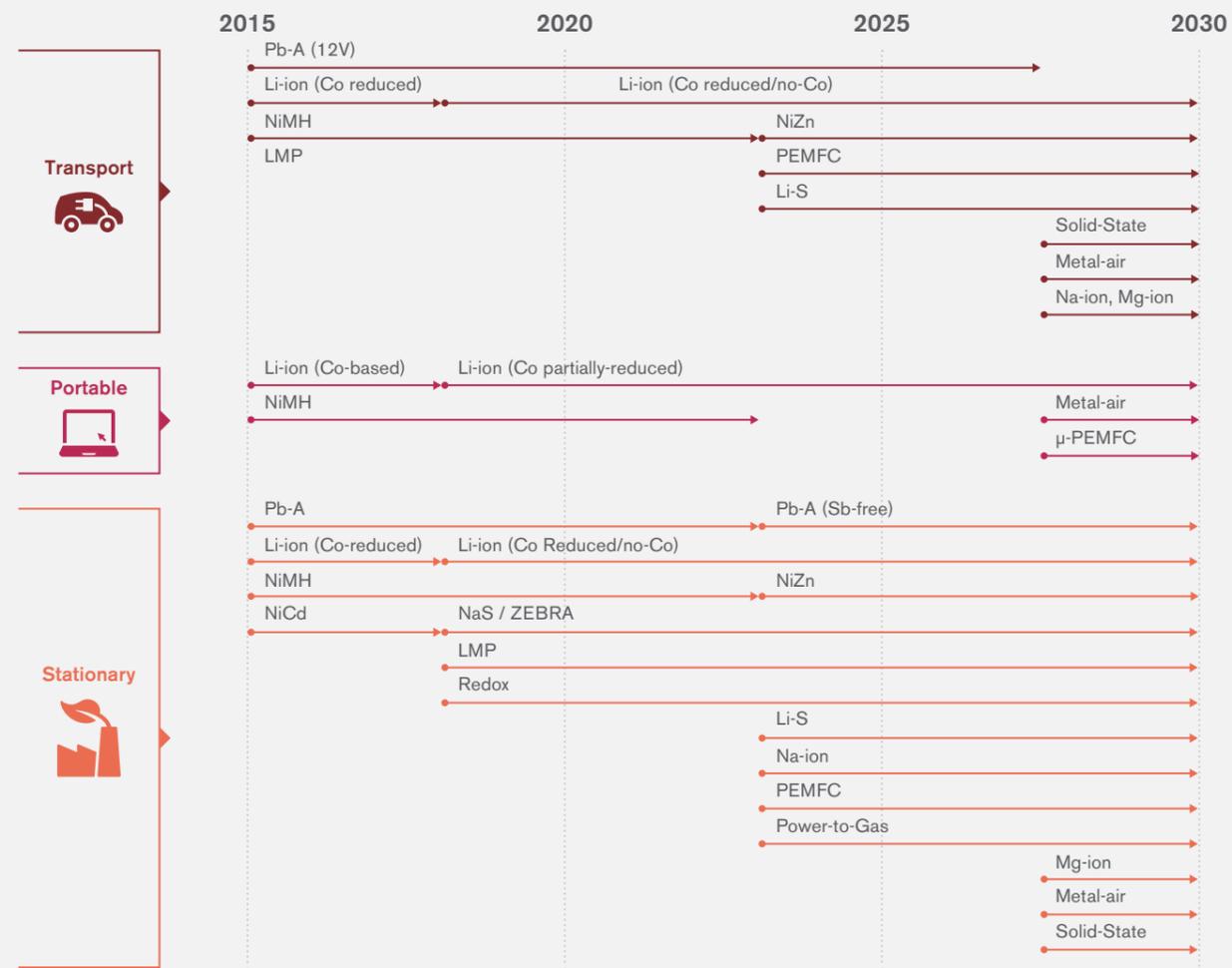
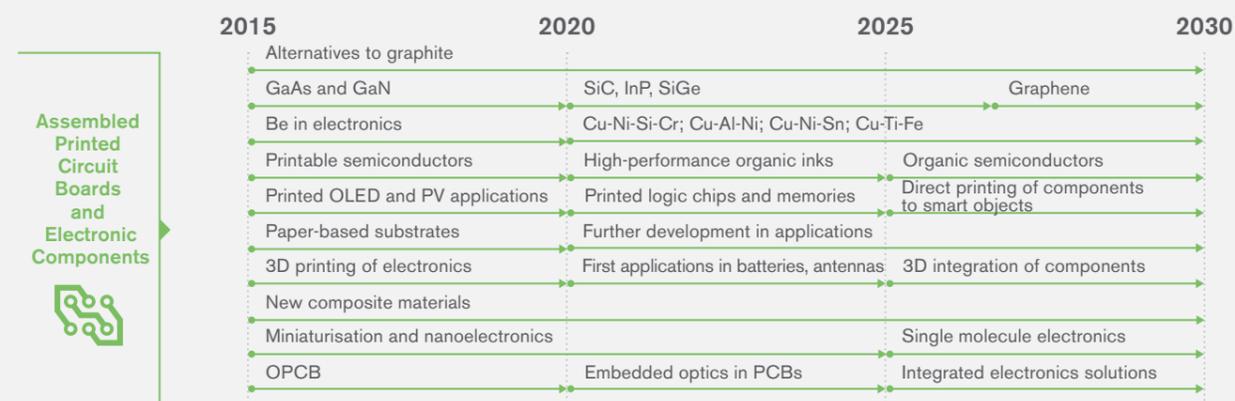


Figure 4 - Batteries



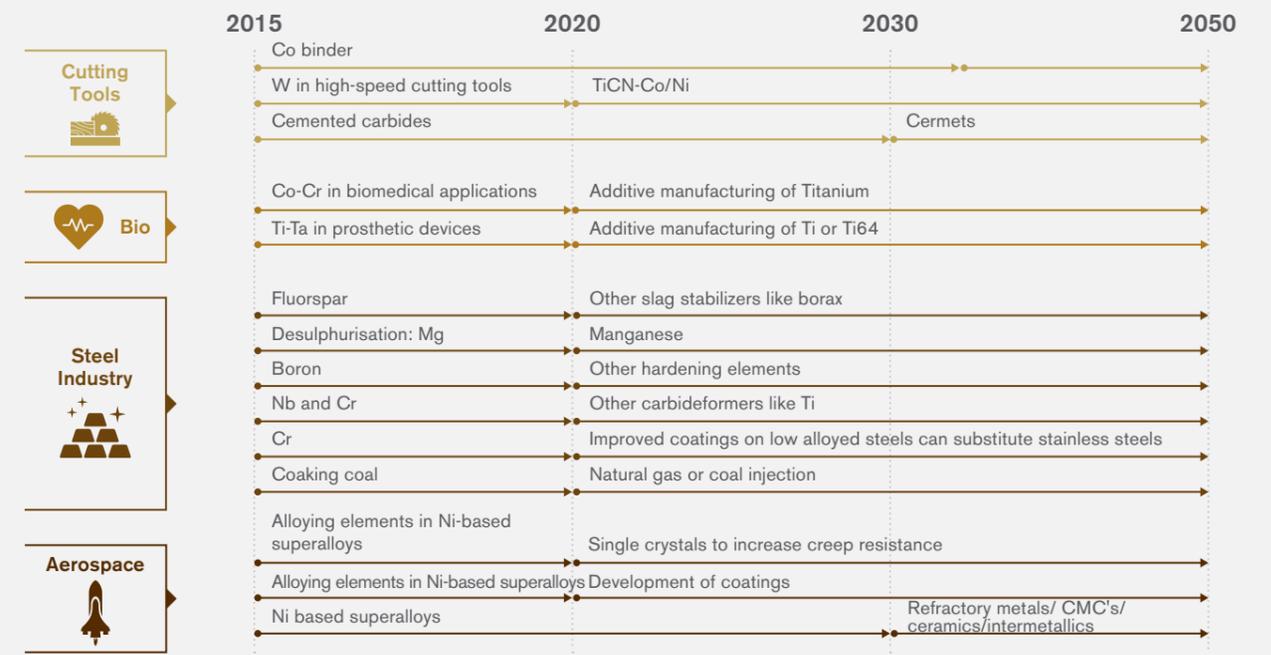
Authors: TecNALIA - CEA

Figure 5 - Printed Circuit Boards & Electronic Components



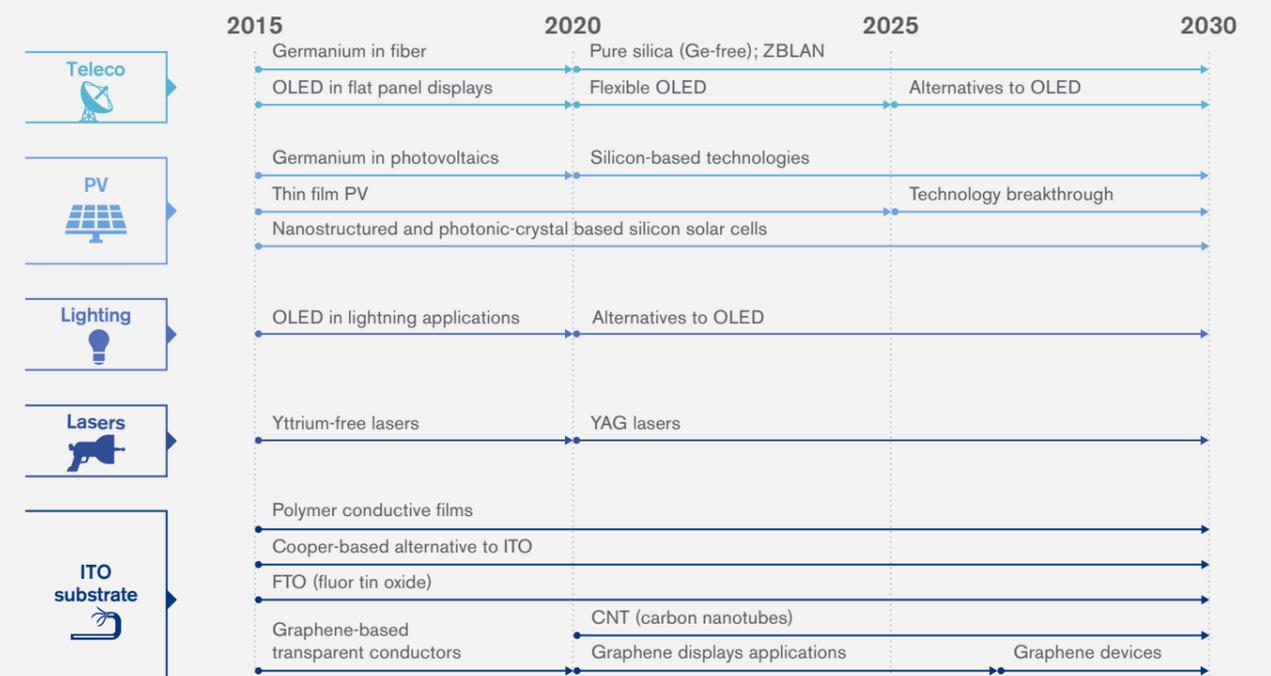
Authors: TecNALIA - VTT

Figure 6 - High value alloys



Authors: TecNALIA - Sintef

Figure 7 - Photonics



Authors: TecNALIA - TU Delft

## Key recommendations

### How can substitution reduce Europe's dependency on externally supplied Critical Raw Materials?

The CRM\_InnoNet project has developed an assessment and prioritisation model for the substitution of some CRM in specific applications. This analysis revealed that, although often feasible, substitution is rarely considered as an option by industry. In many cases substitution was considered to be a difficult process due to lack of scientific expertise (in material science), market supply uncertainties, and the substantial investments required from companies.

### Policy strategy recommendations

The Raw Materials challenge in Europe can only be solved with a strategy that combines the three supply alternatives: Primary, Secondary (recycling) and Substitution, complemented by initiatives to Reduce and Reuse. Future European policy needs:

- | A **harmonised or coordinated strategy** on CRM including substitution for EU and its Member States.
- | To ensure European leadership, **coordination of different instruments** (the SET plan, Circular Economy, the development of "green technologies", Digital Europe, etc.) that rely on CRM is needed to ensure the achievement of goals set in and for Europe - renewed industrialisation, competitiveness, and growth.
- | A **more predictable regulatory and economic scenario** is needed to build investment confidence and encourage more research & innovation activities.

### Industry & Value Chain recommendations

Industry has the following **preferences for CRM supply**:

- 1 Primary
- 2 Recycling
- 3 Reducing (although this places a limitation on recycling)
- 4 Reuse (mainly as components not materials)
- 5 Substitution

| A **shortened timeframe to innovation** is crucial to increase effectiveness and success rates through: more basic research in materials science; use of modelling and simulation technologies; and closer collaboration between academia and industry.

| Integration at early stages of **development of materials and product design experts**.

| Development of **new business models** such as leasing, service for product; etc.

| Investing in substitution is a risky decision for companies in terms of cost, time, safety, etc. To encourage substitution innovation the following factors will have a positive impact: **CRM stable market conditions; a harmonised approach within the value chains (awareness); supply/demand evolution.**

### Research & innovation recommendations

| **Support research and innovation** in substitution, based on feasibility analysis (materials versus applications) through EU financing mechanisms including Horizon 2020 ; the SME Instrument; Structural funds; EIB; EIF; Private investment, etc.

| **Facilitate knowledge transfer and data collection** on the state of the art in substitution.

### Non-technological recommendations

| **Regulation and standardisation:** harmonisation at EU level will facilitate approval of new substitution solutions (materials; technologies; services).

| **Financial aspects:** more public-private financing initiatives; EIB; private investors supporting substitution projects. Incentives for companies to invest in substitution (such as tax deductions for innovation).

| **Public procurement:** to faster market uptake and support wider implementation.

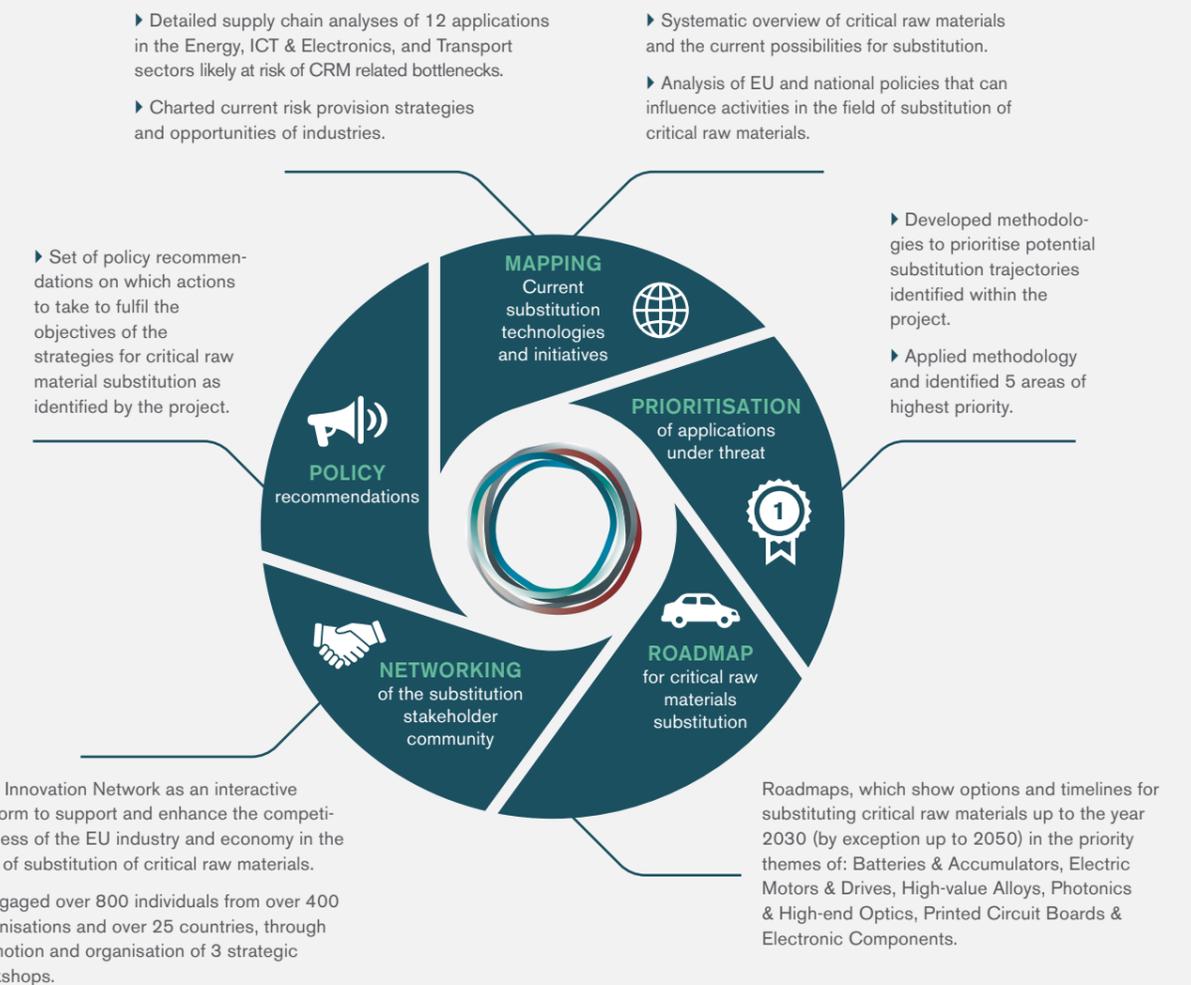
| **Skills and education:** new education and training programmes should be devised with a focus on applied knowledge: materials for applications; new "reduced CRM" design etc.

| **Boost international collaboration and exchange of best practices**, especially at early stages of development of technologies and strategies.

**Substitution means Evolution**, this is a fact of history. We have seen how new products, technologies and services have replaced existing ones and brought more comfort to our lives. This trend will continue whether the result of pre-defined global strategies, breakthrough discoveries, or the rejuvenation of a company's product portfolio to improve their competitiveness and market share.

**We just need to make sure it happens in Europe!**

Figure 8 - Summary of CRM\_InnoNet Project Activities





[www.criticalrawmaterials.eu](http://www.criticalrawmaterials.eu)

[criticalrawmaterials@ktn-uk.org](mailto:criticalrawmaterials@ktn-uk.org)



@CRM\_InnoNet