



## EUROPEAN COMMISSION

DIRECTORATE-GENERAL ENTERPRISE AND INDUSTRY  
Directorate F Resources Based, Manufacturing and Consumer Goods Industries

# US-Japan-EU trilateral workshop on Critical Raw Materials

## Workshop report / minutes

02 December 2013, Brussels, Belgium, 09:00 – 20:00

09:30-09:45 **Welcome and setting the scene**

Gwenole Cozigou, Director, Resources Based, Manufacturing and Consumer Goods Industries, DG Enterprise and Industry, European Commission

Participants were welcomed and thanked for having accepted the invitation to participate at the interactive US-Japan-EU workshop on critical raw materials.

Mr Cozigou reiterated that concerns have been growing over recent years concerning reliable and undistorted access to raw materials world-wide, particularly to non-energy raw materials, and on the impact restrictions to access could have on the economies of the US, Japan and the EU. The competition for the access to resources has also intensified. Supply of rare earth has also been limited by export restrictions applied by supplier countries resulting in substantial price differences between those that could avail themselves of these materials and those that had difficulties obtaining them. These concerns led to the raw materials strategy on improving access and use of raw materials, called the European Raw Materials Initiative.

The workshop was organised by DG Enterprise and Industry as part of the European Raw Materials Diplomacy events. These events are being planned on a regular basis with the EU's closest partners including the US and Japan. All parties agreed that this relatively young trilateral collaboration was successful so far. Trilateral conferences on critical materials are becoming a tradition, the last one having taken place in Brussels in May 2013 and organised by DG RTD. The dialogue facilitates the exchange of best practices and discussions on possible common approaches. The common calls for proposals between EU and Japan in the area of research on developing new materials substituting critical metals were given as an example of the excellent cooperation.

The purposes of the workshop were to exchange information on the upcoming review of the critical raw materials list, to inform on the progress and to possibly compare analysis and data on critical raw materials. The review of the EU list enters its final stage and therefore the opportunity was taken to comment and discuss the preliminary results.

In 2010, of 41 raw materials analysed, 14 were identified as critical to the EU. The list is regularly being updated on a three years basis and is currently being revised with the support of the European experts group "Ad-hoc working group on Defining Critical Raw Materials". The revised list will be published 2014. The basis for the exercise has now been enlarged to 54 raw materials. The methodology applied was maintained in order to allow comparability with the first list. The study identifies further potential elements that might constitute challenges such as ore grades indicators; land use; time horizons; mining governance; by-products dynamics; or country concentration.

Another workshop objective was to review progress made on the joint data inventory and materials information systems database being set up by JRC in close consultation with US

administrations. The objective is to exchange information how the US, Japan, and the EU can further deepen their cooperation and foster the dialogue on different policy areas related to critical raw materials at all stages of the value chain from exploration, over mining, and refining, to end-use.

09:45-11:00 **Session 1: "Respective approaches to critical/strategic raw materials/metals: progress and shortcomings"** (chaired by Roderick Eggert, Professor Colorado School of Mines)

- The Japan perspective: Kentaro Morita, Deputy General Manager, London Office, Japan Oil, Gas and Metals National Corporation

The first session dealt with respective approaches to critical/strategic raw materials/metals: progress and shortcomings.

A presentation on Japan's mineral policy was given. Within the Ministry of Economy, Trade and Industry (METI), a ministry with nine bureaus and three agencies, two bureaus and one agency deal with Japan's minerals policy. The first one is the Industrial Science and Technology Policy and Environment Bureau in charge of technology development. It holds the division on Recycling Promotion.

The second one is the Manufacturing Industries Bureau in charge of industrial promotion strengthening Japanese industry. It hosts the division on Nonferrous Metals in charge of non-ferrous industries in Japan. The third governmental function is covered by the Agency for Natural Resources and Energy. The Agency holds the Mineral and Natural Resources division to which the Japan Oil, Gas and Metals National Corporation (JOGMEC) belongs. JOGMEC is in charge of ensuring supply of natural resources to Japan.

The methodology on defining critical materials was shared. JOGMEC annually conducts a material flow survey on various elements including base metals and rare metals. The survey informs on material flow diagrams, on both national and world-wide supply and demand trends, on export and import trends, and on the share of recycled (secondary) products in the domestic consumption. 22 (groups of) elements were investigated in 2012.

In Japan there are three main strategies to secure natural resources supply: Firstly, the Strategy for Securing Rare Metals focuses on policy measures to ensure supply of strategic materials since 2009. Strategic materials are chosen based on the stability of supply such as supply and demand trends, trends in developing mines, or misdistribution of resources. Secondly, since 2010 the Energy Base Plan sets numeric targets to increase the metal supply from mines and recycling. Likewise base metals (aluminum, copper, iron, lead, tin, and zinc) should increase from 40 % to over 80 % by 2030. Also strategic rare metals are to increase from 0 % to over 50 %. Thirdly since 2012 the Strategy for Securing Natural Resources identifies "Strategic Mineral Resources" to focus policy measures on supplying these. Not only rare metals but also base metals which have concerns about rapidly increasing demand in emerging countries and non-metal elements which are essential for industries the same as rare metals were considered. The criteria for criticality are: the importance of mineral resources for Japanese industries, the possibility of a failure in mineral resources supply, and the feasibility of securing supply resources by taking apart in. 30 elements were identified.

- The US perspective: Alexander H. King, Director of the Critical Materials Institute

The US speaker underlined he is not presenting US government position but his position as Director of the newly established Critical Materials Institute.

The US is both a producer and user of raw materials, both critical and non-critical ones. The US is producer of some critical materials. In the Mountain Pass mine it produces rare earth and finished goods that contain rare earth.

There is no single US critical materials policy or strategy. Rather various government agencies represent differing interests. The main players are the Department of Energy, that finances the Critical Materials Institute, and that relates to supply of materials needed for clean energy technology; the Department of the Interior that has the responsibility for the US Geological Survey; and the Department of Defense. At the White House, the National Science and Technology Council (NSTC) has established a Subcommittee on Critical and Strategic Mineral Supply Chains that co-ordinates the critical materials activities.

Since the last US-Japan-EU trilateral workshop even a gridlocked Congress dealt with a critical material issue: the shortage of Helium. According to a study conducted by the American Physical Society helium is a truly critical material in the US required for healthcare (Magnetic Resonance Imaging), in defense, and in research. On 02.10.2013 an act providing for continuation of helium sales by auction until the US reserve is gradually depleted was signed into law.

With regard to critical solid minerals, a variety of legislation is under consideration in Congress. Both the Senate and the House are considering legislation that would result in setting up a national list of critical minerals/ materials. They also address simplification of mine permitting processes that are perceived to delay the establishment of new sources of critical materials. They also discuss encouragement of recycling; workforce development; international collaborations; and actions on specific elements, e.g. lead.

It was underlined that materials' criticality is affecting us today while solutions (development of mines or substitute materials) may take effect in up to twenty years. For instance shortages in europium (Eu) or terbium (Tb) delay the transition to high-output T5 fluorescent lamps in buildings, hereby preventing energy savings of around 50 % in lighting. Also shortages in neodymium (Nd) or dysprosium (Dy) needed for high-strength magnets prevent the substitution of wind turbine's gearboxes (the dominant cause of downtime) by direct-drive units.

It will be necessary to anticipate critical materials needs and to respond to emerging needs much more quickly in the future. Research and technology challenges involve rare earth smelting (currently mine outputs (oxide in ores) from US mines need to be converted to metals in Asia); notoriously difficult and inefficient rare earth separation (be it from ores or recycling), and the scientific understanding of the f-electron as a basis for separating or substituting for rare earths.

- Defining Critical Raw Materials: The EU perspective: Mattia Pellegrini, Head of Unit Raw Materials, Metals, Minerals and Forest-based Industries, DG Enterprise and Industry

The EU Raw Materials Strategy is coordinated by DG Enterprise and Industry.

The EU Raw Materials Strategy was launched in 2008 and was reinforced in 2011. The strategy is based on three pillars: The first pillar deals with fair and sustainable supply from global market and it covers three branches: raw materials diplomacy, trade relations, and development relations with the African Union. The second pillar is on fostering sustainable supply from European sources comprising improved mining conditions. The third pillar deals with boosting resource efficiency and recycling. Also the 2012 European Innovation Partnership on raw materials concentrates on how to foster innovation at all stages along the value chain.

Part of the overall strategy is the set up and three-yearly update of a list of critical raw materials. The revision of the 2010 list on critical raw materials that was adopted in 2011 is currently taking place.

The methodology of the critical raw materials list is based on two main criteria: One criterion is the economic importance of each raw material for a given mega sector combined with the gross value added of the mega sector. The other criterion is the supply risk in terms of governance and environmental performance of the supplier country taking into account two assumed factors that mitigate the risk, namely the potential for substitution and the level of recyclability.

The 2010 analysis suggests three groups of 41 analyzed raw materials: The group of 14 critical material scores high both in economic importance and in supply risk and it comprises rare earths and platinum group metals. Another group includes a number of elements used in steel and metal production extremely important for EU economy. Contrary to Japan's list of 30 strategic mineral resources no risk of supply of ferrous and non-ferrous base metals was so far identified. A third group comprises nearly critical raw materials. The list is used to raise awareness; to promote and coordinate national policies; to decide priorities in trade negotiations and vis-a-vis WTO; to advise on research priorities; to promote access to deposits in the EU; or to take measures on illegal exports of end of life products. Reference was made to a complementary study done by the EU including the US and Japan: Many of the critical raw materials are by-products of copper, lead, zinc and nickel. Now individual assessments of the by-products are being started.

In the 2013 revision of the critical raw materials list fifty four non-energy, non-food materials are analysed using the same methodology as the previous study: critical raw materials experience a combination of high economic importance and high supply risk relative to the other candidate materials, and are defined using thresholds for each measure set during the previous study. The extended candidate list includes new abiotic and biotic materials. In addition, greater detail is provided to the rare earth elements by splitting them into heavy and light categories and scandium.

It was announced that the report will be adopted and published in the first half of 2014. It will comprise various annexes: dedicated element fiches will include supply chain data. Another annex will give a detailed calculation example. Moreover one annex will deal with specific related criticality in defence, energy and ICT sectors. One annex with recommendations on how to expand the methodology taking into account potential other influences on the critical character of a raw material, e.g. ore grades, company concentration, land use, or by-products dynamics. It was announced the work on the extended methodology could start in 2014. The experience exchange and the dedicated discussion during the trilateral US-Japan-EU CRM workshop were considered valuable. The audience was invited to collaborate in the methodology development.

- Debate and exchange of views with US, Japan, European Commission and the Ad-Hoc Working Group on Defining Critical Raw Materials (10.15 - 11.00)

One question dealt with was why Japan had included some base metals such as zinc as strategic materials. The reason for including it in spite of a relatively easy supply lies in its big importance for the Japanese industry.

Another question enquired the reasons why in the US there is no single national strategy on CRM. The fact that there is no national strategy is not a deliberate choice. Agencies pursue the needs of the industries in their sphere of responsibility. Certainly there is considerable

overlap of the needs of energy industry by the department of energy with those of the departments of defence or commerce.

A third question enquired why in the US recycling is much less prominent compared to Japan or the EU. Recycling is included in one of three pillars of the department of energy's strategy, the more efficient use of supply including both higher efficiency in manufacturing and recycling both in manufacturing process and of post-consumer waste. Great potential is seen in recycling of some materials, but not of all. Fluorescent tubes are already being recycled to keep the mercury out of the environment. In this established recycling path europium and terbium are being recycled. However establishing an entire new recycling path of a new product would be difficult. In some parts of the US recycling is not part of the mentality/ social structure.

A fourth question enquired about the need of neodymium and dysprosium to equip all US wind parks with direct-driven units. In wind parks there operate around 100 wind turbines. Each wind turbine of unit requires a two tons magnet containing around 700 kg neodymium and less than 100 kg of dysprosium. To obtain that much material would require recycling around 400.000 PCs. Until there is a clear supply of these materials it will be continued to install indirect systems with gearboxes.

A fifth question enquired about the possibility of bringing down the time needed for substitution of a new material. Based on observations it takes around 18-20 years from definition to eventual insertion of a new material in military applications. The invention step is relatively fast but the new material must be qualified and proven successful in the application for which they are intended.

A sixth question required clarification of the third criterion of selecting a "strategic mineral resource" in Japan, namely "the feasibility of securing supply resources" by providing effective support measures. Once the Japanese government declares a mineral 'strategic' it provides a series of feasible support for its supply (budget, equity, R&D, human resources, etc).

11.00-11.30      *Coffee break*

11.30-12.30      **Session 2: Critical Raw Materials** (chaired by Mattia Pellegrini, Head of Unit Raw Materials, Metals, Minerals and Forest-based Industries, DG Enterprise and Industry)

- Presentation of the EU review on Critical Raw Materials 2013, Luis Tercero, Fraunhofer Institute

As per communication of the Critical Raw Materials Initiative in 2008 there were three reasons given why a material is critical. Firstly, it has a significant economic importance for key sectors; secondly, the EU is faced with high supply risks; and thirdly, there is currently a lack of substitutes. It was needed to transform these three points into a ranking algorithm by finding the right metrics (set of indicators) for approximating these three points. A 2 D graph was produced with combined points 2 and 3 in the vertical, and with point 1 in the horizontal axis.

Details on the methodology applied both in the 2010 exercise and its 2013 update to assess criticality were given. Very different elements had to be compared: for instance while of iron 1 bn plus tons plus are produced yearly in the world, of gallium only hundreds of tons per year are needed. At the example of lithium the methodology of assessing the economic importance was given: percentages of end uses of the element in the European economy

were identified, and were multiplied with the gross value added of the assigned “mega-sectors”. The weighted sum indicates the value of the importance of a material to European economy. Also at the example of lithium the methodology of assessing supply risk was given. It bases on the assumption that risk arises if primary production is concentrated in countries characterized by poor governance (as per world governance index published by the World Bank) and by low environmental standards (as per environmental performance index published by Yale university). The example of China’s export ban of rare earths was given. The assumed risk reducing filter of recycling and substitutability were then applied.

Possible quantitative refinements to the methodology were given. Moreover additional influences not in the quantitative methodology were mentioned and reference to later dedicated sessions was given. The audience was invited to comment on the methodology.

- Exchange of views with US, Japan, the European Commission and the Ad-Hoc Working Group on Defining Critical Raw Materials (11.55-12.30)

The audience acknowledged the considerable enhancement of the methodology.

Two questions dealt with the environmental indicator. At the example of Lynas’ rare earth processing plant in Malaysia the concern would not be poor or strong environmental performance. Rather the threat would be a possible change in more stringent environmental regulation that may result in supply shortage. One comment suggested that low environmental standards in a country are not accepted by public opinion and might result in import resistance. If a producing country has low environmental standards there is the assumption that the risk of an accident is higher, possibly leading to disrupting of supply. Also the lower a country is on an environmental scale it, the higher the risk a country eventually realises that the environmental burden is costing something so that it increases more stringent regulation. The production may be reduced or stopped on that ground. In several cases countries yielded higher market shares by paying for the environmental burden caused by mining and processing, and by not passing environmental costs on to consumers. The example of magnesium was given. Magnesium can be produced by an electrolytic process (as was done in Europe or in the US) or thermally (as done in China). China currently does not (yet?) put the costs for the environmental burden on to consumers. The electrolytic production facilities in Europe and in the US could economically not compete with the thermal production facilities used in China. As a consequence the production of magnesium is now concentrated in China.

A second comment was on the axis of the economic importance. The US Department of Energy follows a different methodology in developing its list of critical elements. It does not focus on incurred economic importance but rather on potential importance to an emerging technology based largely on qualitative judgement. It was acknowledged there are various choices depending on who is asking the question. In the presented exercise DG Enterprise and Industry had asked the question for the overall European industry, while JRC looking at green energy follows a similar approach as the Department of Energy. The importance from a technology point of view will be addressed in an annex where the work of JRC on energy technology and an assessment of defence technology will be included.

A third question enquired about the reasons why the criticality of beryllium was going up. The issue was discussed over coffee break. In any event the question is similar to why niobium horizontally moved left in the economic importance scale. This is due to data allowing better assessment of economic usage. While in 2010 niobium had been assigned to the then largest mega-sector metal, in the 2013 exercise it was possible to trace niobium’s end uses in construction and automobiles. At the example of tantalum changes in the vertical axis are due to changes in production concentration. Also upon request evidence was provided on how different elements have moved from 2010 to 2013 during lunch break.

A fourth question required clarification on statistics. Is it based on EU or worldwide statistics? On the side of supply risk worldwide statistics was used. On the side of economic importance European statistics was used as much as possible. At the example of beryllium in the US it would not be a critical material but in the EU it is due to more usage in mechanical equipment and in cars for high liability components.

A fifth question enquired on how the critical materials list is used for designing policy measures. As mentioned earlier the list is used to raise awareness: many Member States developed a national strategy after 2008. Also the list is used by DG Trade, e.g. for trade agreements, or when deciding priorities in litigation with WTO. Moreover the list is used to set priorities in the raw materials dialogue or in research: within Horizon 2020 for the first time there is a dedicated budget for raw materials with projects on substitution of raw materials. Finally, the list is used for environmental legislation. For example, the list is used to explore how to include critical materials in waste targets of the EU that so far focus only on quantitative targets. As a second example the list will be used in the current revision of the eco-design directive that to date considers only energy efficiency and not (yet) material use.

A sixth question enquired whether the methodology on top of company concentration can also consider long term contracts. As an example a Northern Sweden iron-ore mining company was mentioned that will provide 15 years of its entire supply to China following a commercial agreement. It was put forward that cartel behaviour in industry may restrict access to, e.g. natural rubber. There is no elaborated respective methodology. The criticality exercise is data driven. Likewise criteria will be investigated that can be applied across all elements. However some doubt was expressed if enough corporate knowledge can be identified to carry out an overall assessment.

12.30-13.30            Lunch break

13.30-15:00            **Session 3: Additional influences on Criticality at different stages of the value chain** (chaired by Alexander H. King, Director of the Critical Materials Institute)

- Short intro by Patrice Christmann, BRGM, member of Ad-Hoc Working Group on Defining Critical Raw Materials

A view on the future of minerals and metals criticality assessments was shared. The current approaches to criticality were found backward looking. They focus on the geography of mineral raw materials production, and on related issues, from the point of view of the end-user of the criticality assessment. They mostly use one, or a few years, of publicly available data. They consider only a very limited number of factors that can cause short-term criticality. However having in mind the long lead times in innovation presented by the Critical Materials Institute it is important to evolve methodologies to forecast medium/long-term (5-20 years) scenarios.

Risks and issues all along the supply chain from geology to end-user goods need to be identified and addressed from a sustainability perspective. Many factors may determine criticality such as demography, changing life styles, development levels, rise and deaths of innovations, regulations and policies, prices, or tariff and non-tariff trade barriers. They point to areas of future work in public geological infrastructure, in the mineral exploration/ mine development, in mining and processing, in metallurgy and refining, in international trade, or in framework conditions.

As a way forward to a sustainable, global mineral resources supply there is a need of an international collaborative effort to develop a methodology on future scenarios; and to collect, store and analyse long time (50 years +) data series. Long time series are needed to identify important trends. An inherent difficulty lies in the lack of data from China, now a leader of the global mines and metals industry.

An EU FP7 co-funded project “Minerals4EU” runs until end 2015 and brings together EU geological surveys and other partners. A funded collaborative research effort could be envisaged (EU-US-Japan common initiative? UNEP? International metals study groups? Other?) to bring together geological surveys, industry associations, materials science experts, and initiatives such as Extractive Industries Transparency Initiative (EITI) or Global Reporting Initiative (GRI). The transparency, accountability of states and companies need to be further fostered and rewarded.

- Short intro by Michelle Wyart-Remy, Secretary General, IMA-Europe AISB, member of Ad-Hoc Working Group on Defining Critical Raw Materials

Based on other relevant studies, previous study feedback and input from the Commission, the Ad-Hoc Working Group on Defining Critical Raw Materials and others, the following factors influencing criticality along the supply chain were presented:

#### Exploration:

##### Ore grades:

For industrial minerals some ore grades (e.g. of lime stone or quartzite) have different criticality than others. However only for few minerals sufficient available relevant data exist. As a conclusion assessing ore grades criticality remains difficult.

##### Land use:

Assessing potential land competition between mining and other uses is important in assessing access to a resource. Protected areas (NATURA 2000) and known and predicted resources data (Geographic Information Systems (GIS)-based ProMine) were compared. Around 100 out of 1435 relevant mineral deposits in Natura 2000 areas are under development or operating. It is not quite clear whether this indicates a problem or the absence of a problem. As a conclusion competing land uses deserve further analysis.

#### Mining:

##### Mining governance:

The World Governance Index (WGI) was used.

Other political risk indicators are considered more directly linked to mining namely:

Extractive Industries Transparency Initiative (EITI),

Fraser Institute Policy Potential Index (PPI),

Revenue Watch Institute's Resource Governance index (RGI).

However, countries' coverage is still too limited (EITI, RGI) or the index assesses mining development attractiveness rather than mining risk (PPI). As a conclusion WGIs are fine, however the potential of the EITI could be followed up.

##### Corporate Concentration:

The Herfindahl-Hirschman-Index (HHI) was used. Initial investigations analysing corporate concentration potential impact on supply risk should be further developed to identify the possible quantification of the issue of corporate concentration.

However, a case-by-case approach is necessary since concentration does not automatically lead companies to exercise market power. As a conclusion corporate concentration is not de facto a risk cause, if of interest, specific analysis of the cases is required.



## Refining:

### Upstream processing:

Supply risks may be different between products at different refining stages. This may help end-users to better mitigate their own risks. For most raw materials, quantitative data is not available for both mining and refining; only for a few a separate analysis is possible. The impact is sometimes high, sometimes negligible. As a conclusion assessing products at different stages of refinery may be useful but should be restricted to specific analysis.

### By-product dynamics:

Several CRMs are by-products of base metals: e.g. Co, Ga, Ge, In, and to some extent rare earths and PGM. Additional analysis has been conducted on the link between by-product status and raw materials criticality. In some cases, by-product metal may show reduced supply risk. However by-products are also exposed to some additional risks. The information will be presented in the specific raw materials fiches of the 2013 report. As a conclusion refined product and its parent ore may show a different criticality. In case the parent is not critical, criticality is determined by refinery sector factors.

## End-use:

### Price Volatility:

Low price volatility might act as a 'risk-reducing filter', in the same way as recycling rates and substitutability. It requires collating historic price fluctuation data across all raw materials. A decision, however, would be needed on the precise mathematical derivation and formula to be applied. As a conclusion price volatility could be further analysed in the future.

### Environmental regulation:

Potential influence on criticality of product regulations such as Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and Classification, Labelling and Packaging of substances and mixtures (CLP) were analysed. The analysis shows that the greatest impact is on downstream markets and the impact on criticality is uncertain. As a conclusion environmental regulation may influence access to raw materials and criticality. Further analysis is needed, but requires in depth understanding of supply chains.

In conclusion the current methodology is considered solid and relatively simple to apply. It is applicable to all considered raw materials. Results are reproducible and consistent. If change is observed, this change can be explained.

Adding indicators would require in-depth analysis and reflexion. This could not be driven by specific outcome objectives. Considering additional influences needs testing. If not applicable to all raw materials, additional influences should preferably be disregarded. They could be useful for a specific case, but could not be applied for the entire batch of raw materials. Input from practitioners, e.g. producers, transformers, users, and market analysts, is essential.

- Mamoru Nakamura, Director Materials Research Institute for Sustainable Development, National Institute of Advanced Industrial Science and Technology AIST (Japan)

The AIST organisation chart was presented. The Materials Research Institute for Sustainable Development in the nanotechnology, materials, and manufacturing department is one of 42 research organizations that in total employ over 2200 researchers.

Since 2006 researchers of five research institutes started integrated research in a rare metals task force to enhance rare metals supply security for the Japanese industry across the material flow from exploration, material usage efficiency, recycling to substitution. Exchange of information happens in two-monthly meetings and yearly symposia.

Research Activities on Critical Materials of the Materials Research Institute for Sustainable Development comprise development of magnetic materials. A main target is dysprosium-free high performance permanent magnets, such as sintered Sm-Fe-N magnets. Also they carry out research and development for reduction of rare metal (tungsten, cobalt) use in hard materials, such as WC-Co cutting tools and molds. Moreover research is conducted on reduction and effective utilization of critical metals such as platinum group metals (PGMs), in heterogeneous catalysts. Furthermore basic research on the recycling process of Nd-Fe-B magnets is conducted.

Contents of rare earth elements in ores produced in mines in the world are different from each other. It is difficult that the supply of each element corresponds with the demand for each material. The development of substitution technologies for Nd-Fe-B magnets containing Dy or Tb used for motors for driving in hybrid electric vehicles, electric vehicles and fuel cell vehicles is essential. Also recycling technologies for phosphors containing Y, La, Ce, Eu and Tb are essential. Researchers of AIST have been developing both technologies.

Mine production of PGM elements (Pt, Pd, Rh, Ir, Ru, Os) concentrate in South Africa and Russia. Both countries contain a supply risk due to labor problems, to electric power shortage (South Africa), and to Pd stockpile (Russia). However the consumption of Pd for automobile catalysts has doubled over the last decade. Emission standards in China will change due to serious air pollution. AIST has been developing new catalysts for exhaust gas from vehicles, aiming at reduction and effective utilization of platinum group metals (PGMs).

A large part of cobalt resource concentrates in the Democratic Republic of the Congo (DRC) that suffers from an ongoing civil war (supply risk). A large amount of cobalt might be used for Li-ion battery (unstable demand). The automobile industries in the world increase the consumption of WC-Co (Tungsten Carbide-Cobalt) cutting tools (increase in demand). The International Agency for Research on Cancer (IARC) reported that cobalt and cobalt compounds may cause cancer (health risk). Therefore substitution of cobalt is wished for. AIST is developing substitution for cobalt in WC-Co cutting tools and molds.

85% of bismuth mine production and 83% of refinery production of the world concentrate in China. Bismuth is a by-product of smelting of lead ores. Australia has the largest reserve of lead. However, a development of new lead mines is difficult in democratic countries due to environmental problems. Bismuth is an environmentally friendly substitute for lead in free-machining alloy such as steel and copper alloy for plumbing, soldering alloys, cosmetics and pharmaceuticals (increase in demand). Therefore, developments of technologies for more efficient usage or of substitution materials are wished for. AIST is developing a reduction technology for bismuth in copper alloys as additives.

- Roderick Eggert, Professor Colorado School of Mines

The idea of a reasonable simple transparent replicable algorithm/formula for criticality was very much supported. On the other hand the audience was invited to consider two potential additional influences on criticality: Price volatility and co-production.

There are two types of supply-chain risks: physical availability and price. In the short term physical availability is largely a function of existing capacity in industry structure. It includes industry concentration both at country and company level. In the long term, prices and availability are functions of geological crustal abundance; of technology for extraction, recovery and recycling; and of investment in those technologies.

Price contains two types of supply-chain risks: level and volatility. Price level may change if a powerful producer and supplier imposes export controls hereby disadvantaging consumers

outside of the producing region. Also different relative prices may influence the choice of materials. For instance indium and tellurium may be the two elements of choice for potential important uses in photovoltaic materials because of the properties they provide. However a competing material that is commercially cheaper such as crystalline silicon may be selected even if technologically inferior.

Price volatility independent of the actual price level may discourage adoption of and investment in technologies that otherwise would be encouraged. Some preliminary work on price volatility of exchange traded and non-exchange traded metals over one, three and five year periods were presented. The data support the view that minor (non-traded) metals exhibit greater price volatility than major (exchange-traded) metals.

It may be noted that by-products arising in co-production of main products such as Zn or Cu create additional fragility to the market. By-product's availability is a function of the associated main product. Availability may be unresponsive to increase in price of the by-product, but may be very responsive to a fall in price of the main product.

Even for the rarest of the rare metal there is no indication that we are "running out" either in a physical or in an economic sense. Instead the critical issues are rather quantities and costs associated with incremental supplies should demand increase.

Indium and tellurium play an important role in certain emerging photovoltaic materials. An important new use may lead to an explosion in demand. Increased recovery efficiency and new sources of supply can shift and extend the supply curve over the medium to long run. A critical element supply curve for incremental supply versus price was shown. Existing production at existing efficiencies are the cheapest option, followed by increasing recovery efficiency; recycling of consumer waste; additional recovery circuit to existing refineries that to date do not recover by-products. The most expensive option is the development of indium or tellurium mines, rather than of zinc and copper mines that happen to extract indium and tellurium as by-products.

Indium and tellurium are potentially critical to solar energy. The question is how many GW of new capacity could these elements support at prices comparable to recent prices in the medium term to meet the expected need in 2015 per consensus forecast. The prices of indium and tellurium over the last twenty years were indicated. Medium term availability calculations on indium and tellurium in the mid-term were given. The potential exists to meet conceivable demand at prices not much different from recent prices from by-products alone. However there are risks of insufficient investment in process engineering; or of insufficient growth in main-product capacity (e.g. of Zn or Cu). Also photovoltaic producers might be out-competed by other uses of indium or tellurium. It may be observed that recycling end-of-life products is not a significant source of supply anytime soon.

- Debate and exchange of views with US, Japan, European Commission and the Ad Hoc Working Group on Defining Critical Raw Materials (14.20-15.00)

A first question was to the BRGM delegate who had given importance both on primary production and also on refining at the example of copper that is mined in the Republic of Congo and that is moved to China to be smelted. How can the two factors be combined in the methodology of the Critical Raw Materials methodology of the Commission that currently includes only concentration data on where mining operation takes place?

The BRGM delegate confirmed that it is not easy to identify all smelters around the world. There is a lot of data e.g. a paid database by the international metal study group on location of copper and zinc smelters. Also it was not considered difficult to obtain data for aluminium or for cobalt.

The way forward would have to be working with relevant organisations, e.g. with the metal study group, and with organisations like the minor metals trade association or the cobalt institute etc. to build knowledge. Confidentiality will need to be respected to yield aggregated data.

A second question went to the AIST delegate to enquire how much money is spent on PGM substitution compared to PGM recycling. Of course the search for substitution of PGM depends on its usage. In the case of PGM application in the automobile sector requiring high performance at high temperatures over long time it was doubted that PGM can be substituted by other materials. It was added that METI annually finances R&D on reducing usage of palladium and platinum with several million US Dollars.

A third question went to Roderick Eggert to clarify the lines in the medium-term indium availability slide. The dashed line indicates primary (not recycled) production of the by-product indium from production of the main product, zinc. The solid line adds the additional indium retrieval either by metallurgic technological improvements or by extracting indium in existing zinc smelters that do not yet extract it.

Also a clarification on the time line of recycling was asked for. At the example of tellurium it was shown that recycling may only become an important source of supply after 2013. It was also acknowledged that additional volumes will bring cost reductions.

A fourth question went to Roderick Eggert to enquire the reason for the price increase of indium starting 2001. Was the reason a technology shift? If so is there a way to predict how a shift in technology can affect criticality? Does policy on criticality drive a shift in technology? The price spike in indium was directly linked to its usage in flat panel television and computer display components. At the time manufacturing efficiency was somewhat low. Due to price increase of indium manufacturers increased manufacturing efficiency so that much less material needs to be purchased to obtain the same output. It appears that magnet manufacturers undertake similar efforts to enhancing efficiency of Ny and Dy usage. The (difficult to assess) ingenuity of engineers shows (almost) endless creativity to work around when prices go up.

A fifth comment was on complexity of the notion of criticality. If new supplies lead to decreasing prices this price decline may increase social instability in a third country that may specialise on production of the respective material. It was underlined that a raw materials mapping exercise with focus on development is being carried out.

A sixth comment was on concentration of countries. It appeared that monopolies process huge proportions of rare earth in China. The governance of these large companies may lead to political interferences. One delegate agreed that it does not suffice to look at geographic or corporate concentration. The various relationships and agreements need to be taken into account too as they affect criticality. However this is not easily done as the analysis has to be transparent. It was advised to look into this aspect over time.

A seventh comment was on a major paradigm shift. OECD countries tend to still rely on free undistorted markets of unprocessed raw materials to import and process in OECD territories. At the example of China a growing number of countries realises the strategic value of “commodities” to develop value-added industries in their own territories. China is not only a producer but also an importer of raw materials. China’s strategy is not to make commodities world-wide available but to sell final products. This is the major challenge.

15:00-16.00

**Session 4: A joint data inventory and discussion on the Materials Information System database. Which opportunities for further**

**cooperation?** (chaired by Stathis Peteves; Head of Unit, Joint Research Centre Petten)

- Gian Andrea Blengini and Lucia Mancini, JRC Ispra: Joint Data Inventory on Raw Materials and Critical Raw Materials

An outline of JRC-IES activities for enhancing the knowledge base on raw materials and CRMs was presented. They include data and methods for the assessment of CRMs flows at supply chain and EU economy level. They cover indicators for end-of-life management strategies. They deal with approaches to support eco-design and innovation for increased recovery of secondary CRMs. And they compile data on minerals extraction.

Life Cycle Assessment (LCA) is carried out for CRMs in product life cycles (supply, use, end-of-life) allowing modeling of the supply chain and associated environmental burdens of CRMs. This allows comparison of environmental performance of different CRMs having the same function and it facilitates their substitution.

The list of current coverage of CRMs used in impact assessment used in life cycle assessment was presented. It may be noted that the materials were selected on scarcity, not on criticality.

Resource Life Cycle Indicators provide insight into the total environmental impact of the European Union (and Member States), also in relation to economic growth. Following the LCA approach they combine macro-level territorial resource extraction and emission inventories with the life cycle inventory data for imported and exported products, drawing on trade statistics. Environmental impacts are assessed using Life Cycle Impact Assessment methodologies.

Both resource indicators of CRMs and EU-27 waste management indicators were presented. The integration of resource efficiency and waste management criteria for improving CRM recovery leads to development of methods for assessing resource efficiency of products based on a set of parameters. This is to yield to eco-design requirements and eco-innovation opportunities for policy and business.

It was announced to fuel the CRM exercise by support for the inclusion of Life Cycle and Environmental / Sustainability issues in the methodology for CRM identification. This will include ore grade/depletion indicators; competition for land use; life cycle based environment indicators; and social impacts in raw materials supply chains.

- Evangelos Tzimas, JRC Petten: Material Information System (MIS)

JRC/IET supports the implementation of the European energy technology policy. It manages and operates the Commission's Information System on energy technologies (SETIS). SETIS provides validated information and scientific analyses on low-carbon energy technologies with the aim to assess their development and deployment. An early SETIS analysis (2009) highlighted that the availability of certain metals could become a bottleneck to the large scale deployment of low-carbon energy technologies.

The importance of raw materials for the energy sector was underlined at the examples of wind turbines and electric vehicles. The strain on CRMs was once more underlined. The assessment shows the CRM's role as a potential bottleneck to the transition to a low-carbon economy through the analysis of supply and projected demand of raw materials used in energy technologies, and to a lesser extent in other sectors (e.g. transport) that compete for the same materials. JRC/IET evaluates mitigation strategies, with a focus on substitution and its impact on technology performance. The development of a Materials Information System (MIS) aims at underpinning these activities.

For the identification of critical materials for the energy sector 60 metals were mapped. 32 of these are used in significant amount in low-carbon technologies. Out of these eight metals (namely Dy, Eu, Tb, Y, Nd, Pr, Ga, and Te) carry serious supply risks.

The importance of reliable data was underlined and JRC's respective recommendations were presented. The aims of the Materials Information System are to gather, store and disseminate information about materials that are used in low-carbon energy technologies through a user-friendly, easily navigable web-based system, and to improve (not only) Europe's raw materials knowledge base. The impacts of the MIS are to provide a common framework to understand material needs and applications, to enable in-depth understanding of the whole material supply chain, to contribute to the early identification of upcoming issues in the supply chain and to the formulation of sound recommendations, and to raise awareness to policy makers, industrial stakeholders, academia and the public.

The contents of MIS focus predominantly on the demand. MIS brings together publicly available information on current and future demand and main applications, current and future usage in energy technologies, and current supply. MIS includes analytical tools for data processing, which combine MIS contents with energy technology performance information and energy market scenarios.

It is expected MIS will have the capacities to host data from relevant EU-funded projects, and to provide a framework for hosting a reference inventory of data on critical and strategic raw materials, shared between interested parties.

- Lawrence Meinert, Head of Natural Resources Program, United States Geological Survey (USGS)

The global trends in raising population, iron ore production, and consumption between 1990 and 2011 were presented. It was also underlined that since the last hundred years the population raised by 400 per cent, the iron consumption by 600 per cent, and the iron ore production by 2600 per cent world-wide. Similar trends exist for most other mineral commodities.

The analysis of world trade looking at the US import reliance suggests that although the US is a major producer and exporter of many commodities such as molybdenum and beryllium, it relies on world trade for most mineral resources and is over 90% reliant on imports for 24 commodities, including rare earth elements. The collaboration with the EU was valued in the exchange of information.

A lot of material flow studies are undertaken. The material flow studies in the energy area previously presented in the workshop were acknowledged. The audience was invited to take natural and social disasters into account. One USGS study deals with the effect of the 2011 Japan earthquake on mines and mineral processing facilities. Another USGS study investigates the effect of South African labor unrest on PGM supply. What supply risk would occur if a tsunami struck some of the five major Chinese ports through which a large amount of critical materials moves in and out the country? Such scenario analyses go way beyond price, mineral resource availability on the ground, or recycling.

The PGM supply chain analysis was presented. The mines, the smelters, the refineries, and the manufacturers have their own vulnerabilities.

Emerging and related Issues comprise sustainability to include full life cycle responsibility for the resources consumed, and this is somewhat similar to global tracking and responsibility for conflict minerals. These issues appear increasingly on the radar screen for what we need to track and understand. Mineral resources are the building blocks of our civilization.

World reserves of most critical materials are adequate but production is limited, dominated by a few sources such as China and South Africa, and susceptible to supply disruptions. Several bills currently pending in Congress concern rare earth elements, such as Senate Bill 1600 - Critical Minerals Policy Act of 2013- that authorizes USGS definition, listing, and assessment of critical materials. Future Federal policy guided by the work of several ongoing White House (OSTP) studies comprise: Critical Materials - Criteria & prioritization; Critical Materials information – sources, gaps, needs; Critical Materials - Long term R&D strategy & needs; and Materials Genome Initiative.

USGS developed a new analytical method to detect the entire periodic table (minus H, He, N, O and F) in a single rapid analysis. This (firstly) allows answering the question what else apart from the main element is contained in a mine or deposit. It revealed some mines have potential additional ore grades of other elements. Also USGS produced the US soil map that gives additional indications on the distribution and abundance of various elements.

- Debate and exchange of views with US, Japan, European Commission and the Ad-Hoc Working Group on Defining Critical Raw Materials (15.45-16.00)

Due to time constraints it was decided that individual questions were asked over coffee. The plea was to share the outcome relevant to an eventual exchange on the information systems that are currently being developed in the US, EU and possibly in Japan in the next session.

16.00-16:15      *Coffee break*

16.15-17.45      **Plenary discussion on future cooperation between the US-Japan and the EU** (chaired by Lawrence Meinert, Head of Natural Resources Program, United States Geological Survey)

Setting the scene:

- Alexander H. King, Director of the Critical Materials Institute

A perspective of the Critical Materials Institute was given. It had been set up by the US Department of Energy and started operations in June 2013 following a competition launched in spring 2012. Back then there was no clear policy regarding international collaboration for organisations like the Critical Materials Institute. A procedure for establishing international collaborations has now been established by DOE. The de facto policy is that the Institute is encouraged to engage in international collaboration. The Institute engages in collaborations in support of US interests. The Institute does so for the reason that its budget of 120 million US Dollars for five years is not enough to carry out all of the projects and programmes it deems necessary.

The easiest form of collaboration is information exchange, according to the US representative, but it is necessary to understand that not all information is directly comparable. For example, the US defines critical materials in a different way than the EU or Japan do. There is currently no US national list, but a sectoral list for the energy sector does exist. This list is forward looking: it tries to be a prediction.

The Critical Materials Institute is one of five energy innovation hubs supported by DOE. One of the other four hubs is known as the Joint Center for Energy Storage Research, JCESR, or “the battery hub”. Their goal is to create a new battery that will enable an electric vehicle to travel as far on a single charge of a battery as one currently travels on a single tank of gasoline. Whatever the battery material will be (maybe or maybe not lithium) suddenly thousands of tons of it will be needed per year so it will probably become critical within about three to five years. The potential impacts of emerging technologies like this make looking

forward and sharing information very important. Even simple sharing of information at this level requires a degree of confidentiality that requires non-disclosure agreements, memoranda of understanding, etc that require approval, so it has some bureaucratic overhead. The sharing of negative results (such as materials that do *not* meet specified needs) is important as it helps to eliminate duplication of research, thereby reducing the cost of finding effective substitutes for critical materials.

A second level of collaboration is research collaboration. This is more difficult to do. Historically international research collaborations have been performed on projects that were not the first priority for either of the partners. Collaborating with a researcher in another country, working on other priorities with different funding conditions, potentially puts one's own research at risk, and it is necessary to find ways to overcome this barrier. Especially in the area of critical materials it must be assured that the highest priority research projects are the ones that are subjects of collaboration. Achieving this requires a high level of commitment. In the simplest cases, two institutes share exactly the same goals and divide research tasks between themselves. The US encourages engaging in collaboration of this kind, to perform research at lower cost or at greater speed. It does not encourage engaging in so-called "mission creep" - collaborations that go beyond the existing goals. Projects that extend or go completely outside the existing missions must be fully funded from outside sources.

The third level of collaboration would involve harmonization of regulatory actions like the EU's REACH and various US regulations. One successful collaboration of this kind, though perhaps not at the level of establishing regulations, has taken place in the form of actions taken by the trilateral group in the WTO. Another opportunity exists in the setting of standards, which has potential for helping to reduce demand for critical materials and to encourage recycling if it is done in a manner that is applicable world-wide.

- Sebastian Zaleski, Policy Officer, Presentation of the ERECON initiative, Raw Materials, Metals, Minerals and Forest-based Industries, DG Enterprise and Industry

The European Rare Earth Competency Network (ERECON) was started in autumn 2013 with the budgetary contribution of the European Parliament.

The general objective of ERECON is to establish a network that should bring together experts from Europe's universities, research institutes, policy-makers, think tanks, industry and experts from outside the EU to advance exchange of best-practice on rare earth elements (REE), to increase the understanding of the special properties of REE, to make recommendations on research, and to promote the sustainable mining, recyclability and substitution of REE.

The main purpose of ERECON should therefore be to provide a framework that would enable participants to effectively contribute with their knowledge and expertise to discussions on rare earths in the above fields. ERECON should aim to ensure in depth understanding of the recycling and substitution of rare earth materials, but also covering aspects of their value chain, including exploration, extraction, processing, and refining, which are relevant to the sustainable supply of the EU.

ERECON's organisational structure comprises a Steering Group and three Working Groups. The Steering Group is composed of high-level rare earth experts from universities, research institutes and industry as well as the European Commission. The Steering Group makes proposals on participation and priority setting within ERECON. Observers from third countries will be invited at a later stage.



The steering group guides discussions in the working groups and ensures co-ordination and creation of synergies within the network. If necessary, the steering group may also create further sub-groups within each working group to support focussed discussions on the different uses and applications of REE.

Three Working Groups are composed of experts in the field of rare earths that signed up to a call for expression of interest corresponding to 3 key areas. They provide the core expertise by contributing to technical and scientific discussion within the network.

Within each working group, sub-groups could be created to allow for more focussed discussions as appropriate. To keep the number of groups within a manageable level maximum three possible Sub-Groups should be created. The number of participants in the WG - limited to number for which funding (travel expenses) is foreseen. In case sub-groups are created, this should not lead to an increase in the total number of WG participants.

Working Group 1 on REE mining focuses discussions on exploration and sustainable mining and mineral processing of REE (e.g. to develop options within the EU and its close neighbourhood, improve technological solutions including the handling of radioactive minerals and their process residuals).

Working Group 2 on REE as process enablers focuses discussions on recycling (including collecting & sorting) and substitution of REE, e.g. in automotive catalytic convertors and polishing media (of glass, mirrors, TV screens, computer displays and the wafers used to produce silicon chips).

Working Group 3 on REE in key applications / end users focuses discussions on recycling (including collecting & sorting) and substitution of REE, e.g. used in permanent magnets, permanent-magnet motors (PMMs) and generators (PMGs); in energy storage devices (La-Ni-H based batteries), in phosphors applications for liquid crystal displays (LCDs), plasma screen displays, light-emitting diodes (LEDs) and compact fluorescent lamps (CFLs) and as glass additives to remove coloration, reduce UV light penetration or increase the refractive index of glass lenses.

ERECON also has a Secretariat to assist and facilitate functioning of the entire project, to support steering group & WGs as well as the organisation of any meetings and a conference. The secretariat will provide technical and administrative support to the steering group and Working Groups; it will manage the project's web-site and will provide documentation and reporting services. The secretariat will also ensure seamless co-ordination and reporting on the network's activities.

ERECON gives recommendations to the European Commission on how policies, including the EU's raw materials strategy and the EU's research agenda, could enhance sustainable mining of rare earths, how rare earths could be used more efficiently as process enablers and in key applications (such as in permanent magnets) and how rare earths recycling could be increased. The results and findings from the Network will also fuel the European Innovation Partnership on raw materials.

Delegates were invited to participate as observers in the Working Group meetings indicatively scheduled for 16 April 2014 and 2 July 2014. Also they were invited to participate in ERECON final conference indicatively scheduled to take place in December 2014 in Milan, Italy.

More information can be found at

[http://ec.europa.eu/jpg/design/templates/commission/index\\_en.htm](http://ec.europa.eu/jpg/design/templates/commission/index_en.htm)

17:45-18:00

### **Way forward and closing remarks**

Gwenole Cozigou, Director, Resources Based, Manufacturing and Consumer Goods Industries, DG Enterprise and Industry, European Commission

Major points made at the workshop were highlighted:

In the morning session, the various approaches from the EU and Japan, and one of the US approaches were shared. The US, Japan and the EU have indeed different approaches towards critical/strategic raw materials. Nevertheless it was striking to observe the similarities and the possibilities for synergies.

In his presentation, Mr Kentaro Morita from JOGMEC, referred to the four pillars for securing mineral resources (securing mineral interest, deep sea mining, stockpiling and resource efficiency/substitution). The approach and methodology is comparable to the EU methodology of the three pillars of the Raw Materials Initiative (the external dimension, the internal dimension and the resource efficiency/recycling one). Japan focuses not only on rare metals but also on certain base metals for which concerns exist due to the rapidly increase in demand in emerging countries. Japan selected 30 elements as "Strategic Mineral Resources" in the light of following factors: the criticality of mineral resources for Japanese industries, the possibility of a failure in mineral resources supply and the feasibility of securing supply resources. From the US intervention it was recalled that there is no single US critical materials policy or strategy but that there is a wide variety of legislation under consideration in Congress with maybe a future national list of critical minerals / materials or simplification of mine permitting processes. Also the observation of Dr Alexander King on the potentially distorting role of stockpiling on free-markets leading to supply shortage at the example of helium, was recalled.

In session three, it was made clear that a wide range of factors influence the criticality of raw materials. Identifying "additional influences" is key to improve the different methodologies that are being used by the US, Japan and the EU. Thanks were expressed to Mamoru Nakamura from the National Institute of Advanced Industrial Science and Technology (AIST) for having provided information on their important work in the field of the development of technologies for recycling and substitution of raw materials such as PGMs, cobalt and bismuth. Thanks were also expressed to Professor Roderick Eggert from the Colorado School of Mines for his intervention and his recommendations to take into account additional influences namely price volatility and co-production. Also the interventions of the European experts Dr Patrice Christmann and Dr Michelle Wyart-Remy pointing out the necessity of taking smelting into more careful consideration were appreciated. The European Commission will carefully assess how these recommendations can be embraced in next criticality exercises.

In session four, the audience had the opportunity of obtaining information on the activities of JRC Petten. It was highlighted how raw materials (and in particular critical raw materials) are key for the energy sector. Thanks were also expressed to JRC Ispra for having shared their activities in the field a Joint Data Inventory on raw material and critical raw materials. It was suggested to investigate how these activities can be interlinked and shared with the Japanese and US colleagues.

Thanks were expressed to Professor Larry Meinert for having shared materials flow studies. Appreciation was also expressed for his deliberation on the importance of information and the assessment of additional supply risks related to natural disasters and the critical need to assess quantity and quality of minerals deposits.

Finally the plenary session demonstrated that Japan, the US and Europe should pursue the path of further cooperation in the field critical raw materials.

**The US and Japan delegates would also be requested to nominate one central contact point that would be dealing with the follow-up of the meeting. Also an indicative timetable for a next meeting would be proposed.**

**Specific conclusions on criticality assessment(s) made by Mr Cozigou and Mr Mattia Pellegrini were:**

The suggestion of including price volatility and co-production into the methodology of assessing critical raw materials was well taken note of. It was noted that these very influences had also been identified as possible additional refinements to the methodology by the Ad-Hoc Working Group on defining Critical Raw Materials.

Also the suggestion to embrace metallurgical/ smelting operations into the methodology made by various delegates was well received. It was particularly welcomed that suggestions on how to collect relevant data were made.

One point broadly agreed was that, whatever refinements are made to the methodology, care must be taken to avoid adding material specific criteria which artificially change the list in favour of one element against other elements.

It was discussed how the activities of JRC in life cycle assessment or material flows can be linked with the activities of USGS in the collection of data. With the US a comprehensive view on all projects going on at US and EU side was exchanged. The same should be achieved with the Japanese side. It was noted that the practicality of joint data inventory is to be discussed and assessed.

The EU, the Japan national lists and the US sectoral list on critical materials differ in geographic or sectoral scope, and in backward versus forward looking approaches. One common element in the three lists is that they are dynamic and evolve with the evolution of markets and technology. This reinforces the EU's plan to update its CRM list every three years.

It was noted that the list of CRM helped the EU, Japan and US in defending common interests in the WTO. As per Financial Times the trilateral action was considered a success.

The timing related to the revised list of critical raw materials was announced: the Ad Hoc Working Group on defining Critical Raw Materials intends to publish its report in the beginning of 2014. Later in 2014 the list will be officially published by the European Commission. Workshop delegates will receive a copy.

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**General conclusions related to further cooperation by Mr Cozigou and Mr Mattia Pellegrini:**

Information exchange makes sense. There is no self-sufficient country in the world with regard to supply of raw materials. The three economic blocks face similar challenges. Vivid information exchange took place at the workshop.

Information on on-going projects should be exchanged. The EU publishes its research priorities. The new calls for proposals in the new EU Framework Programme for Research and Innovation, Horizon 2020, are published. Insights on the R&D priorities in the raw materials area can be gained.

It was agreed that joint calls are more complicated as agenda and timing of calls must be agreed. However in 2012 joint calls on materials substitution were accomplished between the EU and Japan.

There was an agreement on the three levels of possible international collaboration (information exchange; collaborative research, and collaboration on regulation).

Standardisation is another potential area for collaboration to avoid creating barriers for the future. The format may differ from Information Technology Implementation Prototype (ITIP).

Delegates were invited to join the ERECON Working Group meetings on 16 April 2014 and on 2 July 2014.

Also the discussions and proposals on how to improve the trilateral collaboration were presented. It was noted that the Japanese delegates were not in a position to contribute to the last session as this would have required a level of commitment that could not have been agreed prior to the workshop. The Japanese delegates were invited to intervene at any stage. Indeed the good relations with the Japanese delegates were praised. The EU is counting on their contribution to a fruitful trilateral dialogue also in the future.

Attention was drawn to the next trilateral US-Japan-EU conference on innovation and substitution in CRMs. The last conference was held in May 2013 in Brussels. It was announced that the Commission will contact its Japanese (METI and NEDO) and US (US Department of Energy) counterparts to agree on the venue of the forthcoming conference, taking into account that the cycle of conferences was Washington, Tokyo, and Brussels.

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Thanks were expressed to the chairmen and speakers. In recent discussions with advisers and European leaders it revealed that due to falling prices of raw materials interest tends to be somewhat lower. The trilateral meetings are found of importance to maintain efforts to keep CRM on the agenda of industry.

Delegates were invited to the following networking cocktail and to take the opportunity to exchange contact details with the respective counterparts and to continue discussions in a more informal way.