Programme memorandum

Circular Economy in Cities – Critical Materials (TYÖNIMI)

1 Background

The global economy and the associated megatrend of urbanisation are continuing to increase the demand for natural resources. To ensure the functionality of cities, it is essential to have access to critical materials not only for households, building structures and infrastructures, but also for high technology products. Critical materials must be reclaimed for recycling and reuse towards the end of the product lifecycle. In particular, the reserves of rare natural resources are being rapidly depleted.

It is increasingly important to have reliable and secure access to the metals needed in ICT and new environmental and energy technology applications. The batteries used in electric cars, the panels used in solar energy production and the high-power permanent magnets used in wind energy production all include rare earth metals that are classified as critical and other critical elements of the future.

Difficulties accessing these strategically important metals and other elements may be due to several reasons. Mineral resources may be scarce or concentrated in geographically problematic areas (e.g. rare earth metals), the use of metals relative to identified natural resources may be increasing exponentially with the development of new applications (Li, Co, Ag), or it may only be possible to reclaim metals from the by-products of base metal production (e.g. In, Ga). In some critical and technology metals, recycling is not economically viable because of the small quantities present in certain products.

The world's mineral deposits are concentrated in certain specific areas. As production is heavily concentrated, the availability and price trends of metals are a real and worrying concern for the future. For instance, China is the absolute world leader in rare earth metals, with a world market share in excess of 90%. China is also the world's leading producer of permanent magnets. The world's cobalt reserves, then, are largely concentrated in the Democratic Republic of Congo. Not only in Finland but across the EU, there is a growing recognition of the key strategic importance and the enormous business potential of critical metals and their value chains.

The European Commission's aim is to secure unhindered, sustainable and affordable access to raw materials. The European mining industry is unable to secure the raw materials required by all technologies. Efficient metal recycling is therefore paramount to the security of raw material supply. Poor raw material substitutability and the low recycling rate currently present an increasing production risk. The European Commission maintains and updates a list of critical raw materials, which is subject to review every three years. The number of raw materials identified as critical has increased with every update. The 2017 list identifies 27 critical raw materials, most of which are metals.

One way of trying to secure access to the raw materials needed in production is by recovering usable metals from urban waste, or urban mining. Electronics waste, for instance, often has several times higher concentrations of certain metals than crude ore (e.g. Cu, Au, Pt, Pd, Ag in circuit boards), and indeed urban mining can be a more cost-effective method of recovery than primary ore

mining. On the other hand, certain products contain only very small quantities of certain technology metals (e.g. In in flat screens, Co in circuit boards), and therefore large amounts of elements are lost in recycling processes. In these cases, new innovations are needed to enhance the economic viability of recovery. The efficient recovery of metals requires new and better methods for analysing and processing waste from energy technology.

Many materials currently end up in places where they shouldn't (for instance in countries with inadequate waste processing capacity), which breaks the cycle of circular economy. Cities should play a stronger role in ensuring that all materials are eventually recycled.

The effective reuse of materials recovered from urban structures (buildings, infrastructure, including underground cabling and piping, electrical and electronics waste) requires an understanding of the functionality of cities and the composition of different materials. The challenge for research is to determine how specific elements can be reclaimed from very different kinds of waste materials in an environmentally friendly and economically viable way, or how otherwise to organise materials recycling and reuse. Effective circular economy is central to achieving the goals of sustainable development.

Materials recycling is often hampered by considerations of economic profitability because it is viewed from too narrow a perspective. In response to the demands of active consumers, companies are realigning their business operations and investing in recycling, at the same time as urban governance is contributing to facilitate recycling and reuse. Circular economy calls for the introduction of new technologies, products and recycling mechanisms.

2 OBJECTIVES

The Academy Programme's primary objectives are to

- produce new scientific information in the programme's thematic areas
- steer research towards areas of application that are relevant to circular economy in cities
- strengthen basic research expertise with a view to facilitating the development of circular economy in cities.

Furthermore, the programme's social and operational objectives are to

- steer research towards resolving problems central to the research theme and to facilitate the mass-scale application of these solutions
- steer research towards the goals of the UN Sustainable Development Agenda 2030
- set up new multidisciplinary research teams and national and international networks of research collaboration
- increase the mobility of doctoral students and researchers
- strengthen the cooperation and international competitiveness of academia and industry and to enhance urban vitality
- promote open science and research.

3 THEMES

Critical material flows in circular economy

The first theme is concerned with researching the occurrence of critical metals and their chemical composition and properties in different matrices, and with developing economically viable and sustainable processes for metal beneficiation, separation, recovery and purification. Specific research subjects may include the circular economy of electronics, permanent magnets, batteries or solar cells. Another possible focus is the separation of precious metals from the combustion ashes of landfill waste. This subject may be addressed from the vantage point of process development and modelling, value creation in recycling, or from a systems theory or industrial ecology perspective.

Research questions relevant to circular economy include the following:

- In what kind of matrices are critical elements found?
- How to develop economically viable metal beneficiation, separation, recovery and purification processes?
- What kind of technological and other solutions can help to secure access to the raw materials needed for the production of electronics, permanent magnets, batteries or solar cells, for instance?
- How can material flows in circular economy be modelled?

High technology products and services in circular economy

The second theme is focused on product design and concept development that supports reuse and recycling and that allows for the optimum recovery of different materials at the end of the product lifecycle. Ultimately the aim is to minimise the amount of material that ends up in landfill, or the non-recyclable footprint of products. New product and service solutions generate added value for different groups of stakeholders.

Research questions relevant to circular economy include the following:

- What kinds of new products and services can be developed in line with the principles of sustainable development?
- How is the ownership of new products determined?
- What kinds of product-as-service models should be developed?
- What kinds of circularity-based delivery chains should be built?

Circular economy actors and governance

The circular economy revolution opens up a host of new business opportunities. The flow of raw materials is currently mainly from China and Africa to Europe, but recycling and circular economy can partly change the direction of these flows. Cities are also attracting an accumulation of different materials, which may have value for urban residents and other stakeholders. Research questions relevant to circular economy include the following:

- What kinds of local, national and international institutional arrangements could help to promote the circular economy of rare metals in cities?
- What is the role of the public, private and third sectors?

- What kind of new cooperation and organisation is needed among different stakeholders?
- What methods of economic and strategic influence could be applied to steer different stakeholders?
- What new business prospects and opportunities for value creation are presented by the development of urban circular economy?

Circular economy and urbanisation

The focus in this theme ranges from researching flows, processes and materials through to cities. Urbanisation provides a useful framework for studying processes of change and transition in society. Apart from a deeper understanding of consumer behaviour, new information is needed about the interaction of people and the environment, urban everyday life and the vulnerability of society. This brings into focus the city as an accumulation of materials and the city as a functional entity, the urban structure and different connections both within the urban region, between different ions and at the global level. In this way the programme aims to gain a deeper understanding of the functionality of urban regions and their role as circular economy platforms. Specific research questions relevant to circular economy include the following:

- What kinds of physical, immaterial and functional structures and processes in cities support the reserves and flows of urban circular economy?
- How is the city structured and organised as a built environment, space and platform of regional circular economy?
- How do people's ways of organising themselves, their networks and material flows change?
- What are the implications of these changes for the circulation of materials and for administrative and business solutions?

Applications to the programme are particularly encouraged from projects that combine natural sciences, engineering and social sciences research. Applicants are advised to take special note of the systemic nature of circular economy in cities. Projects may address both the structures and processes of urban circular economy. The programme especially encourages multidisciplinary teams that will be able to examine circular economy in cities both from the point of view of recyclable rare metals, entrepreneurship and organisation and from the point of view of societal institutions (legislation, culture, political decision-making, public governance).

4 Impact of programme

In order to reduce the consumption of non-renewable natural resources and to lower CO2 emissions caused by increasing mining operations and the manufacture of metals, it is necessary to take positive action to develop the reuse and recycling of materials, starting from the collection of electronic waste through to the recovery and reuse of critical raw materials. The development of recycling processes will also enable the recovery of several metals that are currently not recycled at all (e.g. Li, only less than 1% of rare earth metals are recycled globally). There is particularly large untapped potential in the area of battery recycling. At the moment only some five per cent of all lithium-ion batteries are recycled, while the target should be at least 95%.

The processing of electric and electronic waste at source in industrial countries supports the goals of sustainable development. For environmental and health reasons alone, this is a far better option than transporting them to developing countries for disassembly and disposal.

The research conducted in the programme will provide a foundation for new reuse and waste recycling solutions and create new industrial and commercial opportunities. Circular economy offers a genuine competitive advantage for Finland in key priority areas such as the manufacture of basic metals.