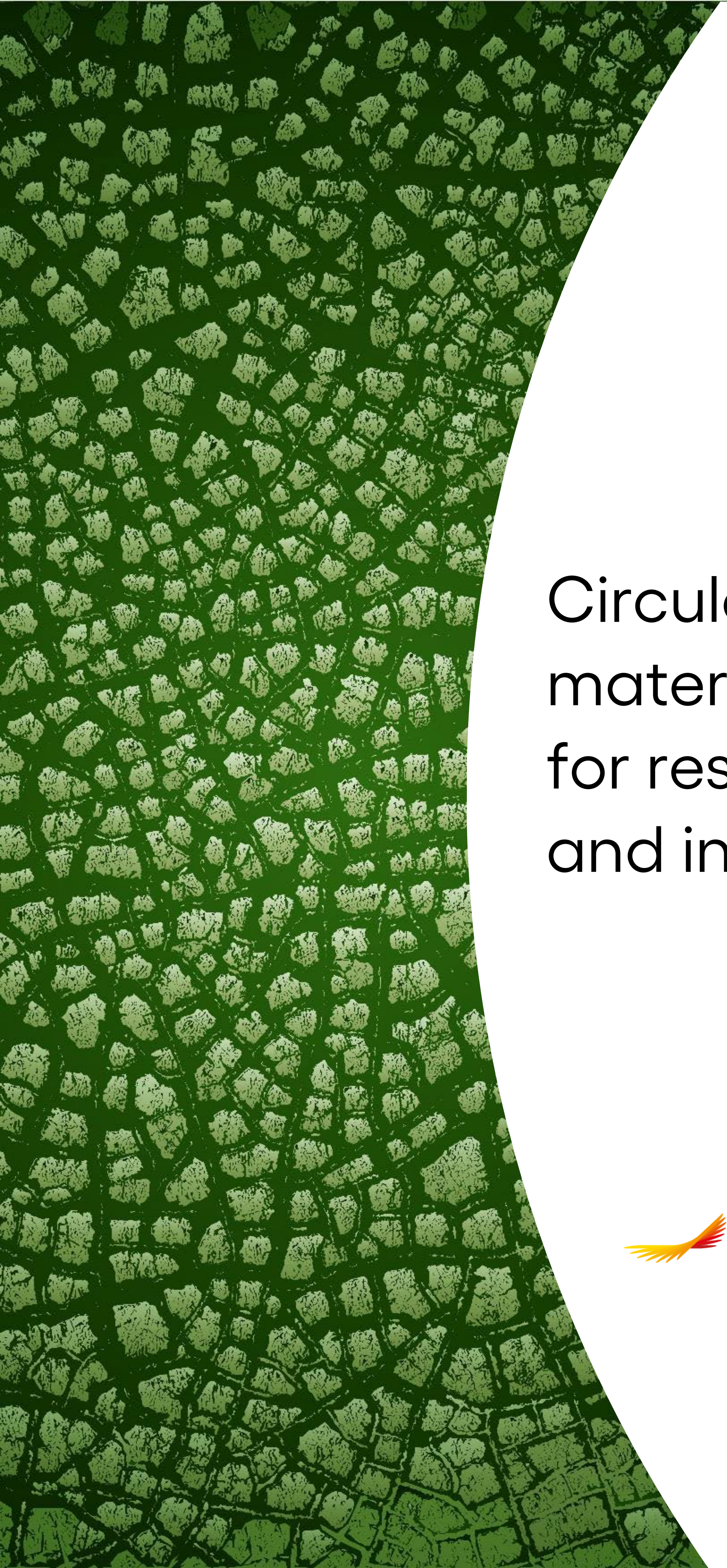

Circular material flows for research and innovation

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SWEDISH ENTERPRISE

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1. Background

This policy brief intends to shed a light on practical and regulatory issues companies encounter in the context of shipping waste for research and innovation purposes. It is a thought starter that was launched at the 2023 World Circular Economy Forum in Helsinki.

The circular economy aims to optimise resource efficiency by keeping products and materials in use for as long as possible, minimising the amount of waste that is created.

Companies' investments in research and innovation have fuelled an increasing number of circular economy approaches that allow more and more raw materials to be recovered and/or recycled. These solutions hold immense potential to further move away from linear modes of production that result in waste disposal.

Moreover, the supply of critical raw materials has become strategically important for many countries around the world and has spurred a race for supply solutions. Thus, recovering these critical raw materials from waste streams is increasingly needed to meet a growing demand and should be scaled up in efforts to parallel to the extractive industry.

2. Why the movement of waste is critical for research and innovation

Research and pilots are a pre-requisite for the design of circular solutions and are thus key to develop and adopt circular economy approaches.

Companies focusing on the recovery of raw materials from waste streams may need to import waste to develop or operate their businesses, leverage economies of scale or access waste that may not be available in their country.

However, there are inherent challenges to the movement of waste linked to existing import requirements. Some countries apply restrictions and prohibitions regarding the import of used, end-of-life goods, or "waste" in order to avoid the risk of being "dumped-on" or to be seen as a destination for dumping or disposal of such goods.

For the circular economy to have substantial impact, the deployment of circular solutions needs to be significantly scaled. To accomplish this, a paradigm shift is required to facilitate movements of raw waste or recovered materials across borders to different facilities.

For example, in the case of the European Union (EU) single market countries, at a minimum, these cross-border movements should be possible because it is not viable for each member state to maintain its own facilities for recycling and treatment. Companies are investing heavily to develop these facilities, but it is not feasible to build them in each country. This is particularly relevant for smaller countries, e.g. Luxembourg, Malta, Slovenia. More importantly, the cross-border movement of waste would allow countries to leverage comparative advantage and enable economies of scale.

Supporting and encouraging research is critical to the future growth of the circular economy to develop and accelerate its adoption. Companies undertake significant investments in research to discover innovative circular solutions.[1]

As part of the research, laboratory trials and pilot tests are needed to:

- validate the processes;
- obtain information to enable up-scaling;
- and advance the technical readiness level.

Finally, applications must be demonstrated to national authorities.

While for initial trials small amounts of raw materials, also referred to as "waste", can be sufficient, for pilot tests or trials, much larger volumes of raw material are often needed.

Moreover, system prototypes demonstrating the technology in an operational environment are crucial for a technology to reach the market. Demonstrating a technology often requires that the pilot corresponds to at least 5% of the full-scale plant, i.e., several tons of material are needed.

3. Slowing down circular solutions – regulatory and legislative barriers to moving waste for research and innovation

Laws and regulations are still geared towards the linear economy and are thus restricting the growth of a circular economy. Current laws inhibit the cross-border shipment of waste to reduce the risk of improper treatment and/or management of waste that may end up in landfills. Existing domestic legislation and regulations may be in place due to the implementation of international agreements in various countries.

This situation presents various issues for companies using circular economy approaches to solve the waste problem through the recovery of raw materials.

In the early 1980s, growing health and environmental concerns in relation to the inadequate management and illegal disposal of hazardous waste prompted the OECD to introduce several measures aimed at regulating cross-border waste movements. Specifically, the OECD Council Acts, including Resolution C(89)1(Final) on the Control of Transfrontier Movements of Hazardous Wastes (30 January 1989) and Resolution C(89)112(Final) on the Control of Transfrontier Movements of Hazardous Wastes (18-20 July 1989), laid the groundwork for the subsequent adoption of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal in 1989.

In 1992, the Basel Convention entered into force and has since been ratified by 190 parties, building on the foundation established by the OECD in regulating and managing the transboundary

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[1] See: Clay Boswell, "Advanced recycling: Path to plastics sustainability?". Chemical Week, 12/02/2023, https://chemweek.mydigitalpublication.com/february-13-20/page-19, p. 19-21, (30/05/23); "European Plastics Manufacturers Plan Over 7 Billion Euros Investment in Chemical Recycling." PlasticsEurope, 26/05/2023. https://legacy.plasticseurope.org/en/newsroom/press-releases/european-plastics-manufacturers-plan-over-7-billion-euros-investment-chemical-recycling, (30/05/2023); "Energy Storage: A $620 Billion Investment Opportunity to 2040." BloombergNEF, 06/11/2018. https://about.bnef.com/blog/energy-storage-620-billion-investment-opportunity-2040/, (22/05/23).

movements of hazardous wastes destined for recovery operations.[2] Thus, the Basel Convention applies to OECD and non-OECD member countries, whereas the OECD Decision of the Council on the Control of Transboundary Movements of Wastes Destined for Recovery Operations only applies to OECD member states.

Aside from the difference in their application in terms of the number of countries, their scope is also different. The Basel Convention takes a broader approach that encompasses the control and disposal of hazardous wastes, addressing a wider range of waste management aspects beyond recovery operations.

However, when it comes to moving hazardous waste for research and innovation purposes across borders, the OECD Decision of the Council on the Control of Transboundary Movements of Wastes Destined for Recovery Operations includes a limit on the amount that can be transported for research and laboratory analysis (II, D(1)c):

> *"Member countries may exempt a transboundary movement of a waste from the Amber control procedure, if it is explicitly destined for laboratory analysis to assess its physical or chemical characteristics or to determine its suitability for recovery operations. The amount of such waste so exempted shall be determined by the minimum quantity reasonably needed to adequately perform the analysis in each particular case, but not more than 25 kg."*

These provisions make it costly, difficult and administratively burdensome to transport waste for research purposes from one country to another.

Limiting transboundary movements of waste[3] falling under the Amber control procedure for laboratory analysis to a maximum of 25 kg hampers the development of vital innovations for the circular economy.

4. What does it mean in practice?

This chapter will look at a few examples to illustrate the practical implications of the current laws and regulations for companies that are investing in research and innovation for a more circular future. These examples are not necessarily exhaustive and we will update this paper periodically as other case studies are provided to us.

4.1. Deep dive into phosphorous recovery by Ragn-Sells

The first practical case that demonstrates the regulatory and legislative barriers to research and innovation is the development of new technologies to recover phosphorus, an element essential to life and a key nutrient for agriculture. Phosphorus is, however, becoming an increasingly scarce resource.

For example, the EU is largely dependent on the import (92%) of the material, as most phosphorus mines are located outside of Europe. Due to the limited availability of this scarce resource, the safe

[2] Basel Convention, " Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, http://www.basel.int/?tabid=4499#enote1, (30/05/2023).
[3] OECD LEGAL 0266: Decision-Recommendation of the Council on the Control of Transboundary Movements of Wastes Destined for Recovery Operations. Legal Instruments, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0266#appendix-4, (19/05/2023).

recycling of phosphorus needs to be a top priority with clear goals and actions in the transition to a circular economy.

The circular economy offers alternatives to mining for the extraction of phosphorus. One such way is to recover it from sewage sludge. The Swedish environment company Ragn-Sells and its innovation subsidiary EasyMining have developed a circular solution to recover resources from waste and wastewater to produce Precipitated Calcium Phosphate (PCP).

EasyMining's Ash2Phos process can extract phosphorus from sewage sludge ash and therefore secure an endless supply of the critical raw material. Moreover, it means that phosphorus can be produced locally, thereby contributing to making countries more sustainable and self-sufficient.

In general, the development of a chemical process, such as Ash2Phos or any other chemical recycling process, requires several steps, including testing, demonstration in the laboratory and pilots, before being able to design and build a full-scale plant (going from Technology Readiness Level [TRL] 1 to 9).

Each of the first two Ash2Phos plants is expected to treat 30,000 tons of sewage sludge ash per year. The development of the Ash2Phos process required performing several pilot runs, which consumed more than 5 tons of ash.

Such amounts of raw materials are often required for pilots to produce representative results which are used to develop the facilities.

Tests are also needed to optimise the equipment size (e.g., filter surface area, sizing of filters) and in many cases also to enable the specific design of the equipment such as evaporators, driers, and solid handling equipment. In addition to testing needed to design a full-scale plant, sufficient quantities of recovered products need to be produced for testing by downstream users.

It is also important to test different waste streams and different countries' waste in the same pilot, to be able to build plants in more than one country. Hence, the transport of larger volumes of waste is needed for laboratory and pilot tests. Without access to these resources, each country needs to have their own pilot plant, which is neither economically nor in terms of the long timelines justifiable.

In the case of Ash2Phos, Ragn-Sells asked BIOFOS, a Danish sewage sludge ash producer, in 2018 to send 1 ton of ash from a deposit they had outside the city of Copenhagen to a pilot facility in Helsingborg just across the country border. It took around eight months, with parallel permit processes in both countries to get the allowance. This shows how current legislation is a direct barrier to using waste as a raw material and to hampering innovations.

During this eight-month period, the companies had to navigate the permitting process of each country, which is more complex when an operation is not yet up and running than when a company is testing and piloting.

In the absence of a harmonised permitting process, the process will differ from country to country, increasing the complexity for companies involved in the cross-border movement of hazardous waste.

4.2. Snapshot of what it means to transport waste by road

Concerning the transportation of batches of e-waste and of non-ferrous metal residues (solder paste, metal sludge) for recycling by road, the French Trade Federation of Recycling Companies (Fédération Professionnelle des Entreprises du Recyclage, short FEDEREC) shed a light on some of the practical difficulties their members are facing.

The notification procedure that is required for the transport of waste is complex and costly since countries require financial guarantees for repatriation and, additionally, many countries charge for administrative services.

The default requirement for financial guarantees is not always suitable for the movement of waste destined for tests as it is by default for 20 tons.

Practically, FEDEREC reported that due to the need to set up a financial guarantee coverage that is by default, 20 tons even though the actual amount of waste moved mostly involves smaller quantities (e.g., specifically for “multi-product” trucks that may transport only 1 ton per waste product but by default movement notification is for 20 tons).

This is having a major impact on companies in terms of the financial guarantees required, resulting in the exclusion of micro-, small- and medium-sized enterprises (MSMEs) from the market since bank insurance will no longer be available above a certain amount even though in reality less waste is being transported.

4.3. HaloSep AB: Closing the loop for waste-to-energy plants by turning fly ashes to valuable resources

HaloSep, a subsidiary of the Stena Metall Group originated from the Group’s R&D Department and is focused on managing and treating fly ash from incinerated waste from waste-to-energy plants.

While the production of heat and electricity through the incineration of waste is an efficient solution for waste that cannot be recycled, it generates flue gas waste, also known as scrubber liquid and fly ashes that contain heavy metals, chlorides and contaminated acid.

That is why, today, much of the hazardous fly ashes ends up in specific landfill sites. However, HaloSep has developed a sustainable solution to manage all issues related to fly ashes, by recovering salt and metals. Moreover, through the possibility to be installed “on-plant”, it eliminates transport costs and emissions for fly ashes that used to go to landfills.

The recovered materials are commercially ready for market entry, to be used for example in construction, infrastructure projects and manufacturing.

As part of the offer of HaloSep AB, the company operates a development plant to run R&D projects and materials for potential customers. The capacity of the plant is to run 0.5-1 ton per batch and customer. However, the import of fly ash from customers in other countries has proven to be costly and time consuming.

As in the previous example, it was stated that for research purposes 25 kg material shipments are sufficient but for the development aspect, to verify the performance of an industrial process, for HaloSep, preferably 0.5-1 ton shipments would be required.

5. Voices from the homeland of the World Circular Economy Forum – Finnish Scrapdealers Association

Currently, there is almost no production of modern recycling technology production facilities or machines in Finland.

Thus, Finnish scrapdealers are looking outward to invest in treatment plants. The member companies of the Fnnish Scrapdealers Association are committed to do significant investments to extract all possible metals, for example, from soil waste that comes as a by-product during a recycling process.

Through a survey, the association confirmed estimates in the tens of millions of euros that their member companies are ready to invest next year. However, the problem is that manufacturers cannot promise 100% reliability of their machines and factories if they are not able to test them with customer materials. Evidently, machines and factories are heavy, if not impossible, to send from country to country, especially if it cannot be confirmed beforehand if they fit the customers' needs. One recent case includes shipping waste between Finland and Italy.

Additionally, the license for shipping waste is also quite expensive, even for companies who need to send lower amounts of waste for tests. For example, in Finland the price for the license is currently 1290€ and the item still needs to be treated and the fees from the recipient country added. This can pose challenges in particular for SMEs and hinder their innovation potential.

Currently, the average processing time for such licences are between one and three months which remains manageable. Another issue is that due to the testing materials in this business sector being classified as waste, the permit to export the 25 kg depends on the recipient having an environmental permit as well. However, most manufacturers are in fact metal workshops or machine manufacturers, who rarely possess the environmental permit.

There are currently discussions ongoing with the Finnish Environment Institute and the Ministry of the Environment regarding these issues caused by the international waste shipment restrictions in the hopes of finding a solution that will enable circular innovation.

6. What do we need?

The development of circular solutions happens through research and innovation and in light of the environmental challenges the world is facing, it is urgent for governments to create an enabling environment.

As the examples above highlight, there are significant barriers to trading waste for research and innovation purposes across borders, hindering the circular economy from scaling up meaningfully.

While there is increasing recognition of the need to adopt the regulatory frameworks, in practice, there are still many barriers that need to be addressed by policymakers. Moving from ambition to real implementation, ICC and Swedish Enterprise put forward the following recommendations:

1. **Establish a process for continuous private sector input**: Businesses are at the frontlines of research and innovation to find circular solutions and must be consulted during the policymaking process to ensure that regulations, directives, and laws are implementable and truly enabling for circular solutions. Such public-private sector collaboration helps

build workable solutions, and transparency and thereby build trust. Further, it will help prepare companies for what is coming, allowing for better preparation, resulting in higher compliance. Public-private dialogue will enable more harmonisation that both sides will benefit from.

2. **Prioritise quality over origin**: Make the quality of materials the determining regulatory factor to define its use, tradability and transportability rather than its origin.
3. **Promote the use of strategic material banks:** Although technological development and innovation are progressing rapidly and demand for recycled resources is increasing, there may yet be cases in which the most suitable course of action is to store resources for the future, when technology has matured or there is greater profitability in recycling. To ensure that resources with a potential value in the future are not wasted or destroyed in the present, there must be stronger legal provisions allowing extended storage periods for material that might be recyclable or extractable in the future. Governments should take measures to promote and scale up the use of strategic material banks for this purpose.
4. **Remove barriers and create incentives for circular innovation**: This is particularly relevant for businesses, not least because, in many cases, the sourcing of waste needs to be done from many countries to make it economically viable compared to primary mining. Yet, even within the domain of applied research, it remains particularly difficult and lengthy to have resources sent across borders.

Many circular solutions will significantly contribute to diversifying supply chains because they provide an alternative source for critical materials. Waste is a key raw material in circular economies and needs to be treated as such by waste and transport laws. Additionally, many materials sourced through circular solutions are cleaner (less contaminated; "higher quality") and their recovery process is less polluting for the environment compared with the virgin materials extracted from the ground. In fact, many circular solutions contribute to regenerating nature and protect biodiversity.

While the goal of a circular economy is to use resources more efficiently and to reduce waste, recovery operations are also critical since they enable the reduction of waste as well as the sourcing of raw materials.

Recycling materials reduces the demand for the extraction and processing of virgin materials, offering a key path to reducing greenhouse gas emissions. Today, about half of the global emission of greenhouse gases and about 90% of the challenges related to water stress and biodiversity loss are linked to the extraction and processing of virgin materials.[4] Yet, only 8,6 billion tons out of the about 100 billion tons of material entering the global economy are recycled materials. In an ideal circular economy, there would be no waste.[5]

ICC together with Swedish Enterprise stands ready to contribute with the voice of the real economy to making waste shipment regulations work for research and innovation for accelerating a circular economy.

[4] International Resource Panel: Global Resources Outlook, Reports, https://www.resourcepanel.org/reports/global-resources-outlook, (22/05/2023).
[5] Circularity Gap Report: The Circularity Gap Report 2020, Reports, https://www.circularity-gap.world/2020, (22/05/2023).

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