1. THE NEED FOR A NEW WASTE MANAGEMENT MODEL

The amount of waste generated has risen ceaselessly since the dawn of the consumer society. This growth is expected to continue with the urbanization of developing countries. In 2018, the world produced two billion metric tons of municipal waste, a figure set to increase by a further 70% by 2050 if there is no change of model. Most of the waste is produced in East Asia and the Pacific, followed by South Asia, neck-and-neck with Europe and Central Asia. The environmental and social impacts are increasingly visible. There is a solution at hand: the circular economy, defined in opposition to the linear take-make-waste model. However, the world's economy in 2020 had a level of circularity of just 8.6%. A number of initiatives exist, but many challenges remain ahead if we are to make the circular transition.

ORIGINS OF THE CIRCULAR ECONOMY

If we step back slightly from all the buzz that surrounds the circular economy, it is reasonable to ask ourselves, particularly the older members of our societies, just what is so innovative. Isn't recycling and reusing material just plain common sense? Reflexes from an age when objects were manufactured essentially using human energy alone, imbuing them with a value that made the idea of mindlessly casting them aside unimaginable. The very concept of waste is a relatively recent one in our societies. What is the history of this waste which didn't use to exist, appeared in modern times, and is now being asked to disappear again in favor of a circular modern world? Franck Aggeri, professor of management at MINES ParisTech, offers an historical perspective that leads us to the idea of urban mines, while Jacques Vernier, former president of ADEME (France's environment and energy agency), writes about the Extended Producer Responsibility (EPR) principle that has underpinned European waste management strategies since the 1990s.

DIFFICULTIES IN THE CIRCULAR ECONOMY

In a circular economy, the challenge is to exploit and recover value from urban mines, i.e. urban waste deposits, under conditions that are economically, environmentally and socially acceptable. But with globalization and far more complex exchanges and technologies making today's world so different from the past, the path back to circularity is strewn with obstacles. As well as value, waste also contains pollutants (heavy metals, refrigerant liquids, etc.) that generate costs for depollution and treatment before any materials or components can be recovered. This embedded value attracts unscrupulous actors that ignore all environmental standards to maximize their profits. Katie Olley, a waste shipment specialist for the Scottish Environment Protection Agency, gives us an illuminating overview of illegal waste trafficking around the world. But there are also difficulties encountered in official treatment and processing sectors. The increasing complexity of products, caused primarily by the ever-growing number of electronic components, makes them difficult and expensive to recycle. Thomas Graedel, professor emeritus of industrial ecology at Yale University, examines the reasons behind low rates of reuse and recycling and suggests ways they could be improved. Then there is the question of waste that has already been buried. Is it possible to recover and reuse this waste to produce secondary materials for reinjection into the economy, as well as to free up brownfield sites for rehabilitation? It certainly makes sense in terms of unimproved former landfills that slowly pollute the soil over the long term. The idea looks attractive on paper, but in practice there are numerous hurdles and limitations. Joakim Krook, professor of industrial ecology at Linköping University in Sweden, describes the most recent work in this field.

OPPORTUNITIES IN THE CIRCULAR ECONOMY

At a time when countries with developed economies are starting to grasp the scale of the commitment to circular transition required after decades of ecological denial, emerging economies are facing two possible paths. They can either follow developed economies' path of excessive growth, which will lead humanity to a point of no return. Or they can immediately start to invent another pathway to low-carbon growth that will deliver far more lasting benefits in terms of innovation, job creation and collaboration. The African Circular Economy Network (ACEN) understands what is at stake and is working to ensure that the circular economy is an opportunity for Africa to boost its resilience in the face of social and climate pressures, pressures that will impact it more heavily and more rapidly than anywhere else on the planet. Alexandre Lemille, co-founder of the ACEN network, offers us an optimistic assessment based on the numerous initiatives emerging across Africa that will build the foundations for the circular models every country in the world needs to move toward.

Helen Micheaux,
issue coordinator

FROM WASTE TO URBAN MINES: a historical perspective on the circular economy

Franck Aggeri
Professor at MINES ParisTech

Ragpicker in the 19th century

Franck Aggeri is a professor of management at MINES ParisTech, PSL University and researcher at CGS-i3, UMR 9217. He is co-director of the Mines Urbaines chair on the circular economy and head of the PhD program in management at MINES ParisTech. His research interests and teaching focus on the circular economy, CSR and the ecological transition in businesses. In May 2021, he co-organized a seminar at Cerisy on the theme of the circular economy. He has published books about the circular economy and several research papers, especially in the Journal of Cleaner Production and the review *Gérer & Comprendre*. He is also a columnist for the French magazine *Alternatives économiques*.

Contrary to a commonly held belief, the circular economy was the dominant economic model for a long period. Nothing was lost or discarded, everything was systematically recovered and reused. At the end of the 19th century, it was superseded by the linear economic model, based on extracting new raw materials and disposing of waste in landfills, that accompanied the industrial revolution and rise of the hygienist movement followed by the growth of the consumer society. The present-day challenge is to develop a new approach to the circular economy that meets expectations in terms of quality and traceability as well as exploring new economic models that are less resource-intensive. But while innovations are certainly needed, in recycling, for example, as a strategy it is not a magic bullet. This is because recycling corresponds to a weak circularity model that fails to challenge how we produce and consume. For a strong and less resource-intensive circularity model to emerge, we need to explore services-based strategies that seek to extend product lives via repair, reuse or rental, all of which require upstream efforts in terms of eco-designing products to improve their repairability and durability.

INTRODUCTION

Over the past decade or so, the circular economy has become a hot topic among policymakers, the media, social and economic actors, and the public in general. The narrative surrounding the circular economy is summed up in this short promotional film released by the European Union.[1] Every European consumes a growing quantity of products that contain raw materials (14 metric tons per person in Europe) and generate a growing amount of waste (5 metric tons per person in Europe). But products, raw materials and waste could equally be repaired, reused or recycled. This is the circular economy principle. The film explains that this ever-expanding material footprint is the result of the linear economic model founded on the idea that we live in a world of infinite resources we can limitlessly exploit to transform into products which we then consume then dispose of in landfill. Conversely, the circular economy model seeks to create looped flows of materials and energy that circulate through the economy. Several strategies are possible within this model: reduce the quantities of energy and materials used to produce goods; share, repair and reuse products to extend their lifespans, and recycle component materials at the end of a product's useful life, forming an endless cycle.

The film emphasizes the dominant messaging surrounding the circular economy: it is presented in utopian terms, promising that a new, less resource-intensive growth model rooted in the circulation of products and materials

1 https://www.europarl.europa.eu/news/en/headlines/priorities/circular-economy/20151201STO05603/circular-economy-definition-importance-and-benefits

is possible and compatible with an ecologically sustainable model of society.

The notion is undeniably meeting with success, as witnessed by the adoption of countless laws and plans for the circular economy in Europe and Asia, and the number of businesses converting to the model. In 2000, Japan became the first country to adopt a framework law based on principles close to the circular economy, the Basic Act for Establishing a Sound Material-Cycle Society. The aim was to reduce the amount of waste generated by products, use the waste generated as a resource in appropriate ways (reuse and recycle), and properly dispose of waste that could not be reused in any form. In 2008, China enacted a framework law to promote the circular economy. The European Union adopted a circular economy action plan in 2016, and France passed its law on the circular economy and combatting waste (AGEC) in 2020.

THE CIRCULAR ECONOMY: A TRULY NEW MODEL?

The circular economy model is presented as being something new, but is this true? Conceptually, there is nothing new about the idea of circularity. It was outlined in 1966 in a book by Kenneth Boulding,[2] who stated that humanity must find its place in a cyclical ecological system which is capable of continuous reproduction of material forms. The concept of the circular economy itself was explicitly cited for the first time in a 1989 book on the environmental economy.[3]

Contemporary problematization of the circular economy borrows heavily from industrial ecology and cradle-to-cradle[4] approaches based on looping flows of materials and energy, with symbioses from the natural world as their model.

In terms of practices, the circular economy model is an ancient one, as shown in the works of many historians. It is reasonable to state that it was the dominant model until the end of the 19th century. The term waste was little employed at the time. Everything was either reused or left to decay naturally. An entire parallel economy, based on rag-pickers and other actors, retrieved all the material available. Rags were reused to make paper, manure and sewage became fertilizer, animal bones had numerous uses, in glues and smelling salts or for whitening beet sugar, fats were used in candle making, and so on. Sabine Barles[5] emphasizes that materials circulated spontaneously between city, industry and agriculture until around 1870.

In terms of practices, the circular economy model is an ancient one, as shown in the works of many historians. It is reasonable to state that it was the dominant model until the end of the 19th century

CIRCULAR ECONOMY MODELS: FROM MODE 1 TO MODE 2

The historical circular economy model, or mode 1,[6] disappeared progressively in response to three major shifts. The first was the emergence of the industrial revolution and coal-fired steam engines, making it possible to generate cheap energy and stimulating the development of new forms of locomotion (trains and boats). The cost of extracting raw materials fell dramatically, while the second industrial revolution, particularly with the development of chemicals and electrification, led to the spread of new synthetic materials, such as chemical fertilizers and cellulose paper pulp, which supplanted previously recovered materials.

A second major shift proved fatal to recovered products and materials: the rise of the hygienist movement in the wake of the pasteurization revolution of the late 19th century. The hygienist movement stigmatized the circulation of waste and organic matter, claiming it to be the primary cause of epidemics. Eugène Poubelle was the Prefect of the Seine region of France in 1884 when, in a famous decree, he ordered landlords to provide tenants with recipients for their household waste, in the process giving French the word poubelle (waste bin). This ushered in an era of waste containment inventions that led to the rise of landfill as the 20th century's dominant waste processing solution.

The third major shift began in the 1930s: the growth of the consumer society, i.e. a lifestyle where modern people began to live their lives in terms of objects consumed or owned, a shift that led to a society of plenty.

REINVENTING THE WASTE MANAGEMENT MODEL

The linear economy model is primarily the one that developed in the 30 years following the Second World War, an era when rapidly expanding economies led to huge increases in the consumption of raw materials and resources and the amount of resultant waste. Landfill was the dominant waste processing solution at the time, followed by the massive development of incineration from the 1970s to recover energy from organic waste. As landfill sites filled up and public opposition to the construction of new sites and incinerators grew, the model faced a crisis caused

2 Boulding, K.E. (1966). *The Economics of the Coming Spaceship Earth*, in: H. Jarrett (ed.) 1966. *Environmental Quality in a Growing Economy*, pp. 3-14.Baltimore, MD: Resources for the Future/Johns Hopkins University Press.

3 Pearce, D.W. and Turner, R.K. (1989). *Economics of Natural Resources and the Environment*, John Hopkins University Press.

4 McDonough, W., & Braungart, M. (2005). *Cradle to Cradle*, McGraw-Hill Education; Ayres, R. U., & Ayres, L. (Eds.). (2002). *A Handbook of Industrial Ecology*, Edward Elgar Publishing.

5 Barles, S. (2005). *L'invention des déchets urbains: France, 1790-1870 (The Invention of Urban Waste: France, 1790-1870)*, Champ Vallon.

6 Aggeri, F. (2020). *The Circular Economy: Historical Perspective and Contemporary Issues*, in: Delchet-Cochet, K. (Ed.). (2020). *Circular Economy: From Waste Reduction to Value Creation*. John Wiley & Sons.

by its incompatibility with the precepts of sustainable development.

The popularity of the circular economy concept can be dated to the late 2000s, a time when three simultaneous events combined to create a favorable reception for the new concept: first was the steep rise in commodity prices, which increased fourfold between 2000 and 2010, serving as a reminder to policymakers and businesses of their economic dependency on natural resources; second was China's embargo on the rare earth metals vital to numerous high-tech applications, creating panic among politicians and businesses; third was the constant rise in alarming environmental indicators, underlining the urgency of the ecological catastrophe.

The narrative surrounding the circular economy, outlined in the introduction, was popularized by reports issued by the Ellen MacArthur Foundation and McKinsey.[7] It seemed a plausible response to the three-pronged crisis. The appeal of this narrative is not really about the originality of a concept that, as we have shown, is far from new. It lies more in clever storytelling that recycles various concepts within an integrating framework inspired by the analogy with natural symbioses. This storytelling is also rooted in mechanisms for constructing a utopia that appear to be realistic, rational even.

So, whether for repair, reuse or recycling, the modern circular economy depends on the development of a quality economy where strict respect for specifications and traceability standards must go hand-in-hand with actor upskilling and the structuring of new industrial and business ecosystems

According to Jean-Louis Metzger, a rational utopia is constructed around three registers: an inspirational narrative that articulates both a critique of the current situation (e.g.: the linear economy) and a description of an ideal (e.g.: the circular economy); a set of powerful images designed to permeate collective beliefs (e.g.: the butterfly diagram with its looped strategies), and tools and models that guide collective action (e.g.: circularity indicators, norms and tools for managing the circular economy). A rational utopia, therefore, corresponds to the problematized narrative of an ideal society based on images that touch the imagination as well as on rational components (reasoning, modeling, calculations) that are meant to embed it in the domain of the deliverable. Rational utopias thus combine the inspirational properties of utopia with the reassuring properties of reason. This being the case, it is a matter of building collective promises that can pull together and mobilize a wide variety of different actors.

The spread of these rational utopias is all the stronger because they are produced in ways that are collective and anonymous, in line with the European Union's narrative. They appear to the public as neutral constructions, depoliticized and open to multiple interpretations, i.e. free of references to ideologies or particular authors, and can be subject to wide variety of possible appropriations.

TOWARD THE MODE 2 CIRCULAR ECONOMY

Modern-day issues with the circular economy clearly do not involve a return to the historical mode 1 model, but entail the invention of a new, less resource-intensive growth model that respects the need for traceability, hygiene and quality with lower environmental impacts.

Health and hygiene issues remain key, as evidenced in regulations like the European REACH directive that aim to trace substances that are potentially harmful to health and are found in chemical and household products. Ensuring that recycling and reuse comply with these regulations is a key challenge. Plastics with brominated flame retardants are a good illustration of the problem. These plastics, used extensively in electrical and electronic devices, perform an important function as they are designed to prevent devices with batteries that can overheat from catching fire. But they come with a major drawback: they contain chromium, a heavy metal that is potentially harmful to health. This means that recovering them is forbidden and they have to be sent to landfill. But automated plastics sorting at modern waste processing centers is not 100% effective and certain brominated plastic residues can end up mixed in with other plastics for recycling.

So, whether for repair, reuse or recycling, the modern circular economy depends on the development of a quality economy where strict respect for specifications and traceability standards must go hand-in-hand with actor upskilling and structuring new industrial and business ecosystems.

TRANSFORMING WASTE INTO RESOURCES: NEW APPROACHES FOR A CIRCULAR ECONOMY

There is no reason for the transition to the circular economy to happen naturally. The consumer society is now deeply embedded in our behaviors, and the intensive pace of innovation drives businesses to accelerate their products' renewal rates so that they can retain a temporary advantage over their competitors. The combination of these two forces leads to endless expansion in the amount of materials consumed and waste generated.

7 Ellen MacArthur Foundation. (2012). *Towards the Circular Economy*. Ellen MacArthur Foundation.

WHAT SOLUTIONS ARE LIKELY TO REVERSE THIS TREND?

One of the first solutions lies in developing innovations, especially technological, for exploiting the potential value contained in recovered waste and end-of-life products. This is the challenge of what are known as urban mines, highlighting the fact that our waste contains potential value to exploit. For example, a metric ton of smartphones contains concentrations of gold two or three times greater than occurs naturally in a mine.

At present, the most frequently recovered metals are the most common ones (steel, aluminum, copper), as well as precious metals for which recycling technologies and industries have been developed that make possible recycling rates of 50% or more. However, effective recycling rates rarely exceed 50%. For all materials, the rate of circularity in Europe was just 11.7% in 2017 (source: Eurostat). For plastics, a recent study by the Ellen MacArthur Foundation claims that just 14% of plastics are recycled, 14% used for energy recovery, 40% go to landfill and 32% end up in the environment.[8] The development of closed loop recycling systems, i.e. for the same applications, is important for protecting value and is an innovation pathway of interest to manufacturers. For rare earth metals, used extensively in high-tech applications (electronic boards, wind turbines and batteries), the recycling rate is below 1%. Securing supplies of materials such as these by developing new recycling sectors is critical to reducing dependency on high-risk countries where these materials are extracted. The challenges are not just technological. They also involve structuring new industrial ecosystems and new regional mechanisms for collecting, sorting, processing and recycling waste so that it can be reused.

But recycling is not a magic bullet. It corresponds to a weak form of circularity that fails to significantly reduce environmental impacts. Even if we assume that technological progress will drive an improvement in recycling rates, it remains the case that the volume of new products consumed will continue to grow, meaning that recycling can only be a partial solution for reducing environmental impacts. Good quality recycling is also hampered by trafficking and illegal exports that represent the fourth largest source of income for organized crime, after narcotics, prostitution and gambling. Traffickers have a decisive advantage over legal operators because they do not have to pay the associated overheads, taxes and pollution clean-up costs. Trafficking is also a source of diffuse pollution, because traffickers only recover parts or materials that interest them, discarding other polluted parts in nature. Finally, from a technical standpoint, not all materials can be recycled indefinitely. Certain materials, plastics for instance, lose their properties, meaning that only a limited number of cycles are possible.

CONDITIONS NEEDED FOR A PARADIGM SHIFT

Not all circularity strategies are equally promising from the environmental perspective and in terms of their potential for creating jobs. Apart from recycling, how can we promote a strong circularity model that is less intensive in terms of materials and resources? Circularity strategies focusing on reusing and repairing, or the functional economy, as ways to promote extended product lifespans and durability are promising avenues to explore when seeking to reduce the material footprint of our economic activities, but also for creating locally based jobs. For businesses, these services-based strategies require upstream work on eco-designing products to improve their ease of disassembly and product durability, and a downstream network with new skills able to roll out services-based solutions across an entire region. These are new business models that have to be invented and lastingly embedded, supplanting models centered on selling products. Consumer behavior must change if this is to happen. Consumers need to be happy with repaired, second-life or rented products rather than constantly buying new. Recent changes seem to suggest this shift may happen, particularly among younger generations who seem less attached to the concept of owning things.[9] The rise of digital platforms like Back Market, specializing in selling refurbished products, is further evidence of this change in behavior. In this regard, the introduction of new incentive mechanisms, such as France's law on the circular economy and combatting waste, may help accelerate these transitions both by making it easier to access information on repairability performance and by encouraging people to purchase repaired or second-life products. These new strategies for strong circularity (repair, reuse and the functional economy) herald sweeping changes to business models and lifestyles.

These new strategies for strong circularity (repair, reuse and the functional economy) herald sweeping changes to business models and lifestyles

8 Ellen MacArthur Foundation (2016). *The New Plastics Economy: Rethinking the Future of Plastics & Catalysing Action.*

9 Guillard V. (2019). *Du gaspillage à la sobriété: avoir moins et vivre mieux? (From Waste to Sobriety: Having Less and Living Better?)*, De Boeck Superieur.

RESOURCE REUSE AND RECYCLING: LIMITATIONS AND POTENTIAL OPPORTUNITIES

Thomas Graedel
Professor Emeritus of Industrial Ecology at Yale University

A typical display of fireworks. The brilliant colors are produced by compounds of copper, barium, calcium, magnesium, strontium, and others

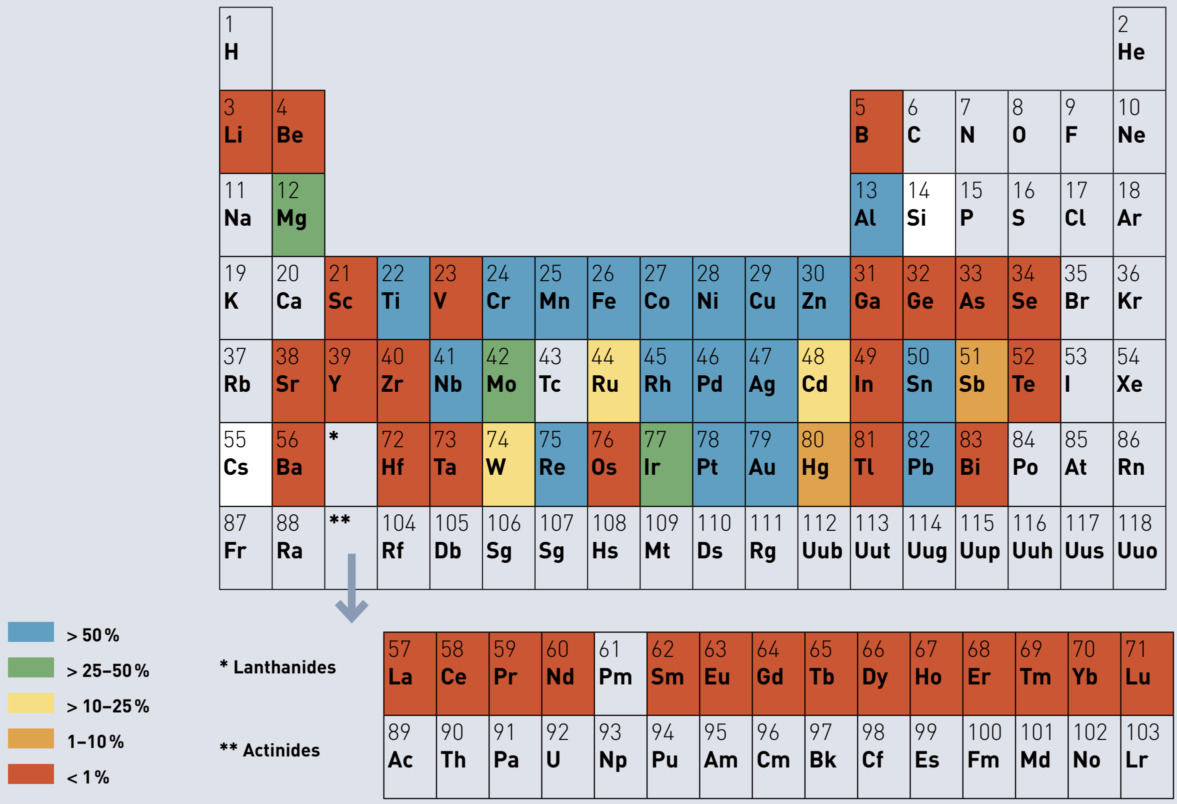
T.E. Graedel joined Yale University in 1997 after 27 years at AT&T Bell Laboratories and is currently Professor Emeritus of Industrial Ecology at Yale. One of the founders of the field of industrial ecology, he co-authored the first textbook in that specialty and has lectured widely on industrial ecology's implementation and implications. His characterizations of the cycles of industrially-used metals have explored aspects of resource availability, potential environmental impacts, opportunities for recycling and reuse, materials criticality, and resources policy. He was the inaugural President of the International Society for Industrial Ecology from 2002-2004 and winner of the 2007 ISIE Society Prize for excellence in industrial ecology research. He served three terms on the United Nations International Resource Panel, and was elected to the U.S. National Academy of Engineering in 2002.

Materials today are often discarded after their first use. This is especially true of those materials in uses that are inherently dissipative, in complex assemblages where elements in low but vital concentrations are often lost in recycling, and for useful but toxic materials. The status of reuse and recycling as well as five opportunities for improvement are presented: (1) eliminate dissipative uses of materials; (2) develop advanced technologies for reuse and recycling; (3) create suitable repositories for materials unsuitable for a circular economy; (4) Design new products for circularity at end of life; (5) create and support international collaborative shipping and recycling chains.

INTRODUCTION

The basic idea of the circular economy is to transform our material society from the traditional material use approach ("dig it up, use it, dispose of it") to one in which materials retained in the inner circles of the "generic" circular economy diagram by the Ellen MacArthur Foundation require less energy and fewer or no new resources to reuse them than would be needed for similar actions in the outer circles. The idea is inherently attractive; the challenge is to determine the degree to which such a transition from the present approach is possible and desirable from technological, economic, social, and political perspectives. Several major issues involving product design, recycling technology, material toxicity, and spatial impediments to effective reuse pose significant challenges to achieving a fully circular economy.

End of life functional recycling rates of sixty elements, with the individual elements categorized into one of five ranges



(International Resource Panel, Recycling Rates of Metals, ISBN 978-92-807-3161-3, United Nations Environment Programme, Nairobi, Kenya, 2011).

Figure 1

RECYCLING STATISTICS

Before deciding where the world is going so far as recycling is concerned, one should assess how the world is doing at present. Unfortunately, the situation, with a few notable exceptions, is not very encouraging. Almost a decade ago a committee of the United Nations International Resource Panel assigned the "best-estimate" end-of-life functional recycling rate of the elements of the periodic table to one of five percentage ranges, as shown in Figure 1. It is easy to see that only fifteen to twenty elements have rates above 50% (and the committee states that few appear to be above 75%). Perhaps more dramatic are the more than thirty elements with essentially no functional recycling at all. Only a few elements were assigned values in between 0% and 50%. Thus, a majority of the elements employed in technology were used once and then lost to technology forever, a sad fate given the energy and effort expended to acquire them in the first place.

Recycling statistics have never been very good, as no regulations require them to be collected. As a consequence, the best current estimates of EOL-RR (end-of-life recycling rates) values remain those of the International Resource Panel of 2011 (see Figure 1). This would seem to call for a more structured data-driven approach to routinely quantifying recycling rates. It would be hoped that such an approach could be put in place in the future; at present all end-of-life recycling rates must be considered "informed estimates based on minimal data".

HOW MATERIALS ARE USED

Why can't materials that are incorporated in products of various kinds be reused when the use of those products is finished? This seemingly obvious inquiry can be addressed, at least to some extent, by realizing that the forms of use of resources can be divided into four categories: "in-use dissipated", "currently unrecyclable", "potentially recyclable", and "unspecified" (generally small-scale uses whose low volumes do not justify tracking them). The "in-use dissipated" category includes uses that may seem beneficial (vehicle brake pads, fireworks, etc.) but offer little or no prospects for material recovery and reuse. Some other applications, such as the use of rare earth elements in polishing powders, could be recyclable if a technological approach had been developed, but often no suitable

The delaying effect of material in product stocks in use

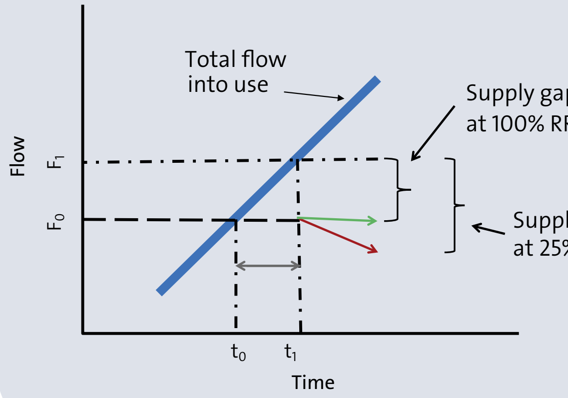


Figure 2

technologies exist at present. In the "potentially recyclable" category, recycling methods are known to exist although they are sometimes not employed for reasons of cost, inconvenience, or lack of sufficient incentives.

In the ideal world, material available through recycling would satisfy the demand for the same material and no new resource extraction would be needed. However, materials enter service and remain there for extended periods, often decades, while all the while demand is increasing. This situation is termed the "delaying effect of stocks", a consequence of which is that in a world of increasing demand even perfect recycling is not enough to meet supply (Figure 2). Even then, some materials may not immediately undergo reprocessing and reuse. Personal electronics are famous for being retained in a bedroom drawer for as long as a decade – these are sometimes termed "hibernating stocks". A related category is "comatose stocks" – material that is stored in such a way that it may never be recovered. For example, power distribution cables that have been disconnected from service but left in place because the benefits of recovery do not offset the effort and expense involved provide an example. Finally, there are stocks that are designed never to be recovered and reused, such as the foundation pilings under tall buildings and harbor structures; these might be termed "abandoned stocks".

In a world of increasing demand even perfect recycling is not enough to meet supply.

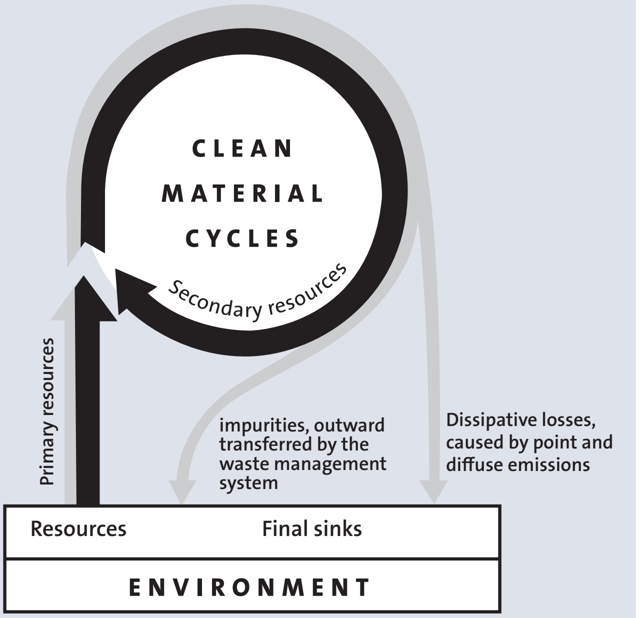
Imagine, however, that a decision has been made to discard a product containing potentially recyclable material. Many steps may be involved in actually carrying out technologically appropriate recycling, as discussed below in some detail.

Reuse and recycling sound as if they are sensible approaches to deal with the accumulation of discarded products, and in general they are. However, there are instances where routine reuse and recycling may not be the ideal approach. One of the most obvious is where a discarded product contains a material that would not now be desired in the economy, particularly materials or assemblages not regarded as hazardous when first employed but now of significant concern: toxic metals such as cadmium in aircraft landing gear, lead in paint, or carcinogenic materials such as polychlorinated biphenyls in transformers. Ulrich Kral and colleagues from the Technical University of Vienna suggest that new product designs need to avoid such constituents, and that older products leaving service or hazardous material dissipated during use should eventually reach a "final sink": a repository that either destroys an unwanted substance completely or retains it for a long time period so that it can be considered in the future. The process is suggested schematically by Figure 3.

In a world of increasing demand even perfect recycling is not enough to meet supply

Examples of the establishment of final sinks are the deep repositories set up by some countries to responsibly contain waste material from nuclear power reactors. Because those materials are potentially hazardous such repositories tend to be controversial, especially to those living nearby.

Material flows based on a clean cycle strategy



(Reprinted with permission from U. Kral, K. Kellner, and P.H. Brunner, Science of the Total Environment, 461-462, 819-822, 2013; Copyright, 2013).

Figure 3

Despite the societal challenges, however, it is clearly inappropriate to utilize materials known or suspected of toxicity and then to provide no way to deal with them when they are no longer desired. If these materials are deemed so beneficial to modern technology that society wishes to use them, the challenges to doing so need to be recognized, and provision made for approaches that do not follow a circular economy approach.

THE CHALLENGES OF PRODUCTS COMPLEXITY

It is worth considering the scope of what a truly circular economy would demand of the medical device industry. As an example, the diversity of elements used by manufacturers of medical devices is thought to include at least seventy different elements for purposes of imaging, robotic surgery, artificial joints, and many more. This incredible elemental diversity is similar to that of modern electronics.

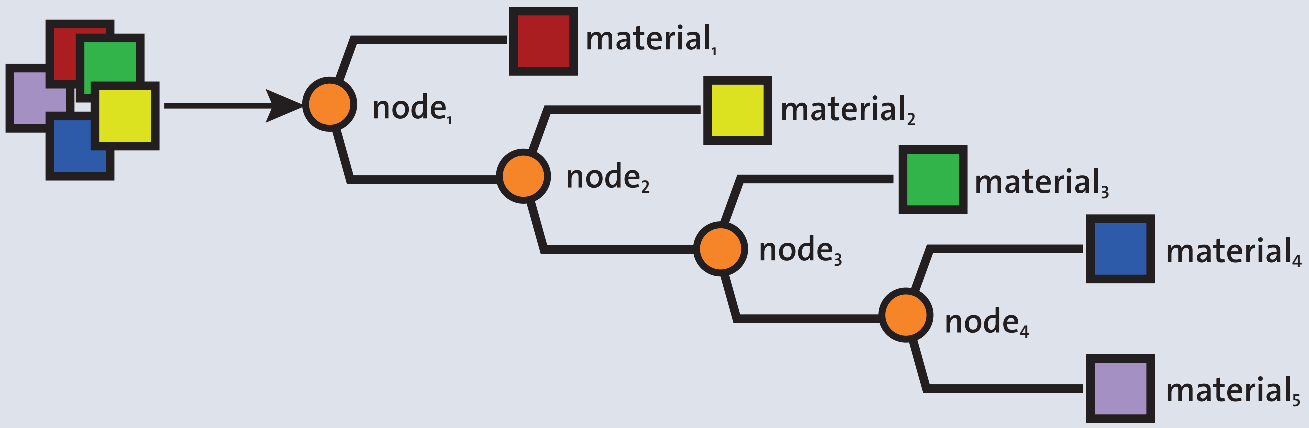
Each element's use in medical devices or for electronics has a purpose, of course: better imaging of body organs, faster storage and retrieval of information, etc. A device maker adhering dogmatically to the circular economy vision would thus have to not only deal with contamination and sterilization issues, but also with the reprocessing of essentially the entire suite of the elements. This would be a major commitment for designers, product manufacturers, and executives, and suggests that dogmatism regarding advanced devices of all kinds so far as the circular economy is concerned is perhaps an unrealistic goal.

Assume, however, that a material (contained in a product) is not subject to any of the constraints to recycling and reuse discussed above and that the material has been discarded. A stepwise sequence is then involved in successful disassembly and recycling of a product, as shown in Figure 4, but incomplete disassembly or the failure to capture components once disassembly is complete occurs all along the recovery and recycling sequence.

Given the estimated current probabilities for successful processing at each stage, the efficiency of the overall total product recycling process turns out to be quite low. Improving this situation requires efforts at all stages of the recycling process, but also in the original product design process. Some of the main points are summarized below:

- If possible, capture a product before discard and seek to use it elsewhere (this is termed 'relocation');
- If relocation is not feasible, seek to remanufacture the product so as to return it to its original condition and capabilities or, better yet, upgrade it to the most recent capabilities of similar products (this is termed 'remanufacture');

A four-node separation sequence for disassembly of a generic product



Reprinted with permission from J.B. Dahmus and T.G. Gutowski, Environmental Science & Technology, 41, 7543-7550, 2007. Copyright 2007 American Chemical Society

Figure 4

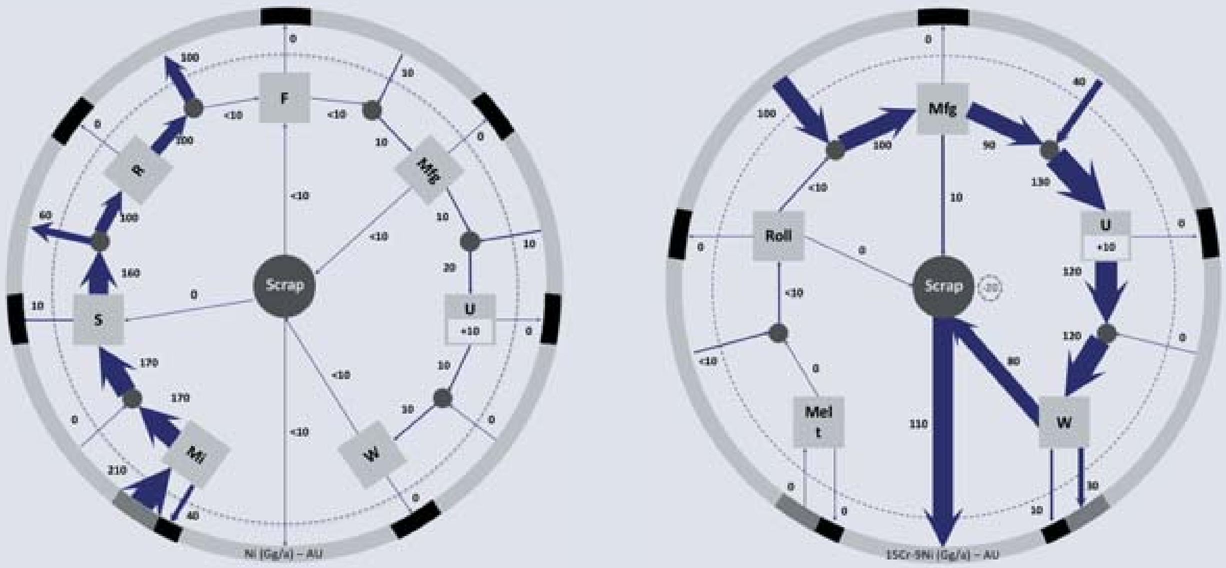
- If remanufacturing is not practical, disassemble the product and reuse the components. This step will be enabled by efficiently identifying the components and researching opportunities for their redeployment. Disassembly is best addressed at the product design stage by minimizing the steps needed for disassembly.
- Components and assemblages that cannot readily be disassembled, or where doing so is not economically or practically feasible, may or may not be shredded, but in any case are sent on to sorting facilities, followed by treatment in chemical or metallurgical reactors.

> *The efficiency of the overall total product recycling process turns out to be quite low. Improving this situation requires efforts at all stages of the recycling process, but also in the original product design process*

SPATIAL LOGISTICS

One issue not commonly discussed by circular economy advocates is where the reuse, remanufacturing, and recycling should or can happen. In a technological world where diverse and complex products are often manufactured in a small number of specialized facilities, sold to users around the world, perhaps later resold or re-leased, and eventually discarded, product complexity and recycling technology cannot be assumed to exist everywhere in order to enable local remanufacturing and reuse. Ideally, one would capture the end-of-life products once they are obsolete but before they become degraded and disassembled and then ensure that

The Australian cycles of (left) nickel and (right) stainless steel in 2010



The units are Gigagrams (thousand metric tons) of metallic equivalent per year (Graedel, T.E., B.K. Reck, L. Ciacci, and F. Passarini, On the spatial dimension of the circular economy, Resources, 8, 32 doi:10.3390/resources8010032, 2019).

Figure 5

they are transported to a facility fully capable of their remanufacture or recycling. For more complex products there will likely be few such facilities in the world, and the challenges of identification, transportation, and economics quickly become daunting.

The locational issues can be illustrated by a simple example, that of nickel in Australia, whose nickel material cycle is shown in Figure 5 (left). Australia has very large metal deposits and a vigorous mining industry. As a result, nickel extraction and ore processing is substantial, but the resulting refined metal is largely exported. Much of this nickel goes to be utilized in stainless steel production elsewhere (Australia does not produce stainless steel, an alloy of nickel with about 74 parts iron, 15 parts chromium, and 9 parts nickel), so does not have the technology in place to reprocess it – that has to happen elsewhere if at all. Thus, stainless steel imports to Australia must themselves be exported if they are to be reused (Figure 5, right). The message here is that in a global economy it is very unlikely that the facilities to enable a circular economy will be available everywhere and for every product, no matter how complex; rather, extensive ocean shipping and international political and scientific coordination would almost certainly be required.

CONCLUSION

The challenges discussed in this article simultaneously suggest five opportunities for improvement. They are as follows:

- Decrease or eliminate dissipative uses of materials;
- Invent and develop reuse and recycling technologies that are currently inadequate or do not now exist for many materials and products;
- Develop national and regional repositories for materials unsuitable for retention in a circular economy because of toxicity, radioactivity, or other undesirable property;
- Design new products for circularity at end of life, not disposal;
- Optimize the collection of components and products that are difficult to remanufacture or recycle and develop an international system to transport such objects to facilities capable of rendering them fit for reuse in one form or another.

None of these improvement opportunities will be easy to accomplish. Indeed, some are likely to be quite challenging. However, the same could have been said about the activities and technological approaches that made them necessary in the first place. Some of the opportunities will require new thinking in product design, materials processing, and recycling. Others will require collaborative actions by governments. Making even modest steps in these directions will generate significant improvement in circularity, however. A moral judgement would seem appropriate: A technological society whose activities have caused these challenges to exist should feel responsible for responding to them.

ENHANCED LANDFILL MINING, CONCEPT AND CHALLENGES

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Enhanced landfill mining (ELFM) is an emerging concept that connects the vision of circular economy with the need to use land more effectively and for purposes that contribute to sustainable development. It bears on the fact that Europe holds more than 500,000 landfills of which the majority is non-sanitary municipal solid waste landfills, lacking modern environmental technology. Beyond that these poorly equipped deposits generate local, regional and global environmental impacts as well as drosscapes of urban land, they contain massive amounts of obsolete materials that could be brought back to use in society.

To prevent unwanted environmental and health effects, many of these old landfills will sooner or later need extensive remediation and aftercare. So far, however, Europe does not have any coherent strategy for their future management. The EU Landfill Directive, for instance, has no bearing on their management as most of them predate its enforcement. In many countries, the available public funding for taking care of such old landfills is also insufficient making any kind of future remediation effort financially challenging and unattractive.

For a share of these landfills, ELFM could offer a more sustainable management option. The potential of this emerging concept lies in its integrated approach, where remediation is combined with the excavation, processing and recovery of the deposited waste. In essence, such a strategy could reduce the cost for remediation of malfunctioning landfills, reclaim valuable urban land and recover significant amounts of dormant materials and energy carriers. To this end, ELFM embraces the use of innovative technologies to transform and upcycle the extracted resources to high-value commodities such as metals, syngas, fuel-grade H2 and low-carbon building materials.

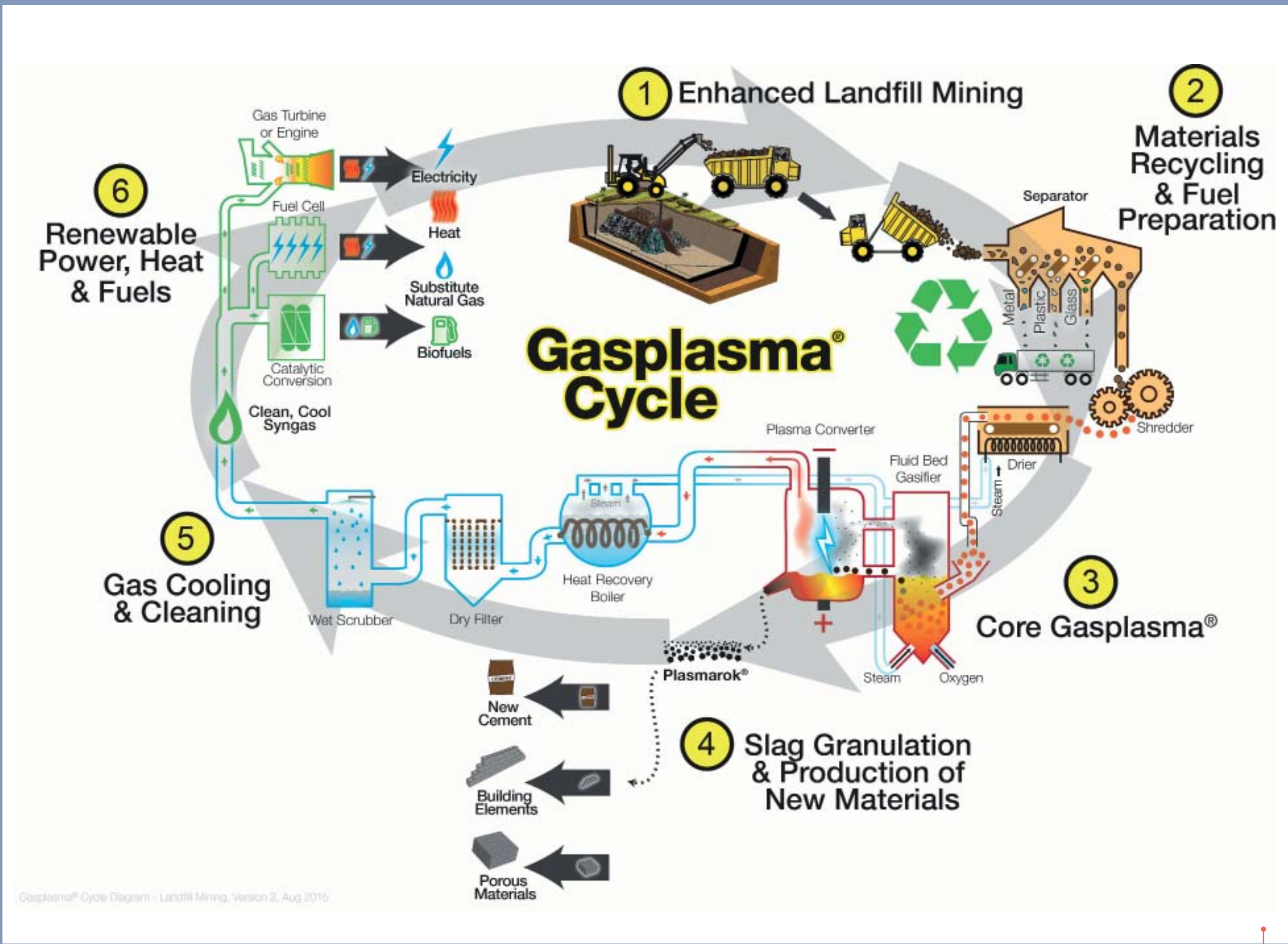
Although ELFM displays a high societal potential, there is a lack of real-life projects validating the sustainability consequences and feasibility of the concept. The so far most concerted efforts are the Closing-the-Circle project in Belgium[1] and the “NEW-MINE” Training Network[2]. NEW-MINE involved 15 early-stage researchers working on technological innovations along the whole value chain of ELFM and multi-criteria assessments for evaluating the sustainability consequences of such yet unconventional projects.

The findings from these early-stage initiatives are promising but also point at several challenges that need to be addressed to facilitate the further development of ELFM. When it comes to the technical feasibility of resource recovery, for instance, it has been demonstrated that it is possible to upcycle and produce high-quality commodities from deposited waste in laboratory scale. However, further investments are needed to improve the technology-readiness-level of these processes before we know what high-value and marketable commodities can be recovered on an industrial scale.

Recent assessments show that developing cost-efficient and sustainable ELFM projects is indeed challenging. It is possible, but it relies on a strategic selection of suitable landfills for mining, carefully tailored project set-ups and in most cases also altered policy and market conditions. Cost-efficiency is particularly difficult to obtain, where most markets involve a low demand and willingness to pay for secondary resources.

1 https://machiels.com/en/division/europe/environmental-services/landfill-mining-solutions/

2 https://new-mine.eu/



A schematic illustration of the ELFM concept

This means that resource recovery alone cannot motivate ELFM financially, but other tangible values also need to be created such as avoided costs for extensive landfill remediation or revenues from reclamation of highly valuable urban land.

As for other sustainability-driven innovations, the further development of ELFM relies on a clear political support as current market conditions are simply not adjusted for such unconventional practices. Several potential policies to decrease investment risks for industrial actors and improve the economic and environmental performance and public acceptance of such projects have also been highlighted in research. However, before political support can be considered, the concept of ELFM needs to be officially recognized, and for this to happen, the level of knowledge in the field needs to progress. Beyond small-scale trials, it is time to demonstrate that there is a real interest in implementing these practices on a large scale.

EXTENDED PRODUCER RESPONSIBILITY (EPR) IN FRANCE

Jacques Vernier
President of the French Extended Producer Responsibility Waste Schemes Commission

Jacques Vernier has spent his entire career defending the environment in France: as head of the Artois-Picardie regional water agency and president of ADEME (French Agency for Ecological Transition) then INERIS (French National Institute for Industrial Environment and Risks). He currently heads both the High Council for Prevention of Technological Risks and the Extended Producer Responsibility Waste Schemes Commission. As a member of the National Assembly, he presented the reports on the "Environmental law" and "Air protection" law in the early 1990s.

Extended Producer Responsibility (EPR) has been voted in France since 1975. The law states that producers, importers and distributors may be required to contribute to the disposal of waste from their products. It was only in 1992 that this law was applied for the first time to household waste and the number of EPR channels has only increased since then in France and in Europe. The efficiency of these channels is indisputable: in 20 years the collection rate of batteries has reached 80%, whereas they were not collected before.

Thanks to the law on the circular economy passed in 2020, this system is developing even further and has modified and strengthened the EPR system with 10 new channels. In addition, there is a stronger incentive for eco-modulation, funds dedicated to repair, reuse, and many other proposals favorable to the evolution of consumption patterns.

As head of the Extended Producer Responsibility Waste Schemes Commission since 2016, you are involved in creating and developing these schemes in France. Can you talk us through the emergence of this waste management model?

Jacques Vernier: On July 15, 1975, a French law and an EU directive formalized the principle of producers being responsible for managing waste generated by their products. The law said almost all there was to say on the subject: "Producers, importers and distributors of these products or the elements and materials used for their manufacture may be obliged to pay for or contribute to the disposal of the waste generated by them." The wording in the current Environmental Code (Article L541-10) has barely changed.

But it was not until almost twenty years later, in 1992, that this principle was first applied to household packaging waste.

For the next 28 years, France's extended producer responsibility schemes expanded considerably, to the extent that there are now 12 mandatory schemes (shortly to rise to 22), whereas until recently there were only three across the European Union. The 12 mandatory schemes concern:

1. batteries*
2. electrical and electronic equipment* (WEEE)
3. end-of-life vehicles*
4. household packaging
5. unused medicines
6. vehicle tires
7. writing paper
8. textiles and footwear
9. household chemicals
10. furniture
11. end-of-life boats
12. sharp self-administration medical devices used by patients

*European scheme

In practical terms, what do the EPR mechanisms consist of, and what results do they deliver in terms of recycling and reducing waste volumes?

JV: The EPR system is designed to ensure that producers pay for or contribute to waste management. Specifically, this means that producers can deal with their waste themselves, running an individual system, but this is extremely rare. Or they can delegate the task to a collective body, called a PRO (Producers Responsibility Organisation) to which they contribute (by paying an eco-contribution). This eco-contribution can be modulated, increased or decreased, according to how difficult it is to manage waste created by the product: in theory, this eco-modulation is intended to foster the eco-design of products. However, this encouragement is limited, as we will see below.

In France, PROs are private companies with a public service purpose. They have to follow terms of reference imposed by the State. Some schemes have only one PRO (packaging, paper, boats, etc.), but there can be more than one (two for WEEE, batteries, furniture, etc.) if producers have decided not to "put all their eggs in the same basket".

PROs can contract with operators for collection, transport, sorting and processing.

In these cases, we designate the schemes as "operational".

But for certain types of waste that are already collected, possibly also sorted and processed by local authorities, rather than dealing with their own waste in collaboration with operators, producers and PROs may choose to use (and therefore finance) all or part of the municipal system:

- municipal waste collection services (because they already collect waste packaging and paper);
- municipal garbage dumps (because they already handle WEEE, furniture, household chemicals, etc.);
- municipal waste sorting centers.

In these cases, we designate the schemes as "financial", the most important factor being that producers finance the local authorities that already do the work.

There can be no arguing with the impressive efficiency of the EPR approach. The figures speak for themselves:

- in the past 28 years, the recycling rate* for household packaging waste has risen from 18% to 70%;
- in the past 13 years, the collection rate* for household WEEE has risen from almost nothing to 53%, and 74% of waste collected is recycled into new materials or reused;
- in the past 20 years, the collection rate for batteries has risen from almost nothing to 49%, and 80% of waste collected is recycled into new materials.

Caution! The rates claimed by the various schemes can be misleading. As we have shown above, recycling or recovery[1] rates for material collected can be very impressive (WEEE, batteries, end-of-life vehicles, textiles, etc.). However, collection rates (relative to the quantity of a product sold in any given year) can be low: under 40% for furniture, around 50% (see above) for WEEE and batteries. We can only make a vague estimate for end-of-life vehicles as it is thought that between one-in-two and one-in-three cars never enter the compulsory collection scheme! In summary:

- R (effective recycling rate) = R^1 (collection rate) x R^2 (recycling rate for the material collected).
- When the vehicle scheme claims a recycling rate of 87%, this is merely an R^2.
- When the packaging scheme claims a recycling rate of 70%, this is the effective rate, R.

1 As a reminder, "recovery" includes "recycling" material and recovering energy.

The EPR scheme for cigarette butts means that, from 2021, producers will have to contribute to paying for city streets to be cleaned.

A new law on the circular economy was adopted on February 10, 2020. What progress has been made in terms of EPR?

JV: The law introduces sweeping changes to the EPR regime, including:

1. 10 new EPR schemes (Article L541-10-1 of the Environmental Code)
   From 2021 to 2025, 10 new EPR schemes will be added to the 12 existing ones:
   1. building construction products and materials
   2. commercial packaging*
   3. toys
   4. sports and leisure items
   5. DIY and gardening items
   6. motor oils
   7. plastic-tipped tobacco products*
   8. synthetic chewing gum
   9. single-use sanitary textiles, including pre-soaked wipes*
   10. fishing gear that contains plastics*

*European schemes

And the scope of certain existing ERP sectors will be extended: for example, the EPR scheme for vehicles will now include two-wheelers.
The cigarette butt EPR will be the first of the new EPR schemes to be set up, as of mid-2021.

2 Much bigger eco-modulations (Article L541-10-3)
The following table shows that eco-contributions sometimes account for a tiny amount of the overall price of the product. Previously, even where the eco-contribution was modulated to double in value, It would still represent an infinitesimally small amount, doing nothing to encourage eco-design.

Items	Eco-contribution	Average product price	Percentage contribution/ price
Textiles	€0.007	€18	0.04%
Smartphones	€0.02 to €0.04	€280	0.007%
1.5-liter bottle of water	€0.01	€0.62	1.6%
Car tires	€1.25	€70	1.8%
Refrigerators	€20	€440	4.5%
Washing machines	€10	€370	3.2%

Amount of the eco-contribution compared to the price of the product (by the author, 2018)

The new law introduces two major modifications to correct this failure. No longer will eco-modulations be calculated solely according to the difficulty of processing the waste (the end-of-life approach), but according to a wide range of criteria based on the product's environmental performance (the lifecycle approach): "quantity of material used, incorporation of recycled material, use of renewable resources, durability, repairability, possibility of being reused, etc."

Modulations, whether up or down, can now exceed the eco-contribution paid by producers, amounting for as much as 20% of retail price.

► These two modifications will be applied for the first time in 2021, to the household packaging scheme. Eco-modulation now makes it possible to reward manufacturers of plastic packaging that incorporate recycled raw materials, and the bonus applied can exceed the amount of the eco-contribution paid by the producer.

3. **Repair funds** (Article L541-10-4)
The new law places great emphasis on the repairability of certain products and it states that in a number of EPR schemes (such as WEEE, furniture, textiles, toys, sports and leisure items, DIY and gardening items), PROs will have to finance a repair fund. However, the law fails to set an exact amount.

4. **Reuse and reemploy funds** (Article L541-10-5)
Reemploying or reusing a product is far better than creating waste, even when materials are recycled. This is why the new law stipulates that in some EPR schemes (those cited in point 3, above) 5% of PROs' budgets must be used to finance a reuse and reemploy fund.
The State was already able to set minimum reuse thresholds in the PROs' terms of reference. This mechanism was little used in the past but will likely be more widespread in future. The law also specifically requires that 5% of packaging must be reused by 2023, 10% by 2027 (Article L541-1).

5. **Retailers required to take back certain products** (Article L541-10-8)
Retailers of electrical equipment, household appliances, electronics and bottled gas were already required to take back used products at no cost. The new law will extend this obligation to other schemes: household chemicals, furniture, toys, sports and leisure items, DIY and gardening items.

6. **Distance-selling electronic marketplaces are now subject to EPR** (Article L541-10-9)

The law now states that if an organisation acts as intermediary in the sale of goods to a third party, it is the organisation that is subject to EPR, unless the organisation can show that the third party has already fulfilled its EPR obligations.

7. **Sanctions, specifically in the event of failure to meet targets** (Article L541-9-6)
One of the key criticisms levelled at existing EPR schemes is that there are barely any sanctions if PROs fail to hit the targets set out in their terms of reference, such as for minimum collection or recycling rates. In future, the new law states that if a PRO fails to meet one of its targets, it may be required to put forward an adjustment plan, funded according to budget minimums set out by law. Finally, if it fails to deliver its plan, or in the event of other breaches of its terms of reference, it can be fined a significant amount (10% of its budget, which could amount to several million euros) or have to pay a daily fine (€20,000 per day).
However, there are two impending challenges:
   - in financial schemes,[1] PROs do not intervene directly; rather, they subsidise local authorities that do the actual work. Some PROs have already stated that under these conditions they cannot accept responsibility;
   - the sanctions described above apply to PROs. But what happens if producers (perhaps in one of the new schemes) have not created a PRO? The sanctions regime for infringing producers created by the former law (unmodified by the new law) has been shown to have limited effect.

8. **Producers required to present five-year waste prevention plans** (Article L541-10-12)
Following the Belgian example, every five years producers will be required to present a plan for the eco-design of their products, reducing and improving the recyclability of their waste, increasing the use of recycled raw materials, etc. Producers can do this by themselves or collectively, for example, by asking a PRO to do it on their behalf.

9. **Waste management contracts agreed by ecobodies** (Article L541-10-6)
One of the main criticisms of the EPR system is that in operational schemes[2] it grants a monopoly (sometimes an oligopoly) to a PRO that is responsible for managing waste for the entire scheme. This means that it, and it alone, agrees all the contracts with operators that collect, transport, sort and recycle the waste. This creates a situation of dominance that operators sometimes complain of.
The new law establishes a number of safeguards: non-discrimination clauses for tenders, more separate lots to encourage greater competition and to allow SME to bid, processing to take place locally, employment opportunities for people on job integration schemes, etc. Specifically, under the new law it will be the PROs (and by extension the producers) that will have to absorb fluctuations in raw material prices, not the waste processing operators.

10. **Substituting a PRO in the case of failure by another PRO** (Article L541-10-7)
As described above, EPR schemes contribute to financing a portion of local authorities' waste management costs.[3] In the past, failures on the part of a PRO have deprived local authorities of the corresponding revenue. In the future, the new law stipulates that in such situations the state can nominate an existing PRO to take over from the failing PRO.

11. **Mediation**
In the event of a dispute between a PRO and a stakeholder, the parties can turn to the Business Mediator.[4] This system will be trialed for three years.

1 See above for an explanation of the difference between financial and operational schemes.

2 Ibid

3 Ibid

4 France's Business Mediator was established a dozen years ago to provide mediation between private bodies, or between private and public bodies.

ILLEGAL WASTE SHIPMENT: AN OVERVIEW

Katie Olley
Waste Shipment Specialist, Scottish Environment Protection Agency

Example of a shipbreaking beach taken in 2014 in Bangladesh
©NGO Shipbreaking Platform 2014.

Katie Olley is a specialist in waste shipments for the Scottish Environment Protection Agency, working in the field as a policy maker and operational lead for over 20 years. She is the Project Leader for IMPEL's (Network for the Implementation and Enforcement of European Environmental Law) flagship Shipments of Waste Enforcement Actions Project, and is currently the Chair of the Basel Convention's ENFORCE Network.

There have been fundamental shifts in the shipment of waste around the world over the last two decades. This article describes these, their causes, and the recent acceleration in the shift in illegal shipments to countries least able to deal with them. It also discusses enforcement gaps and how they might be addressed.

INTRODUCTION

The extent of illegal waste exports is difficult to assess. Since 2011 until 2020 approximately 19-22% of shipments inspected within Europe violated the Waste Shipment Regulation (according to IMPEL's Enforcement Action Project series[1]). The violation rates do not just reflect the level of illegal activity but also the ability of competent authorities, who police this trade, to identify problematic waste shipments and intervene accordingly. Waste electrical and electronic goods, metals and plastic and paper from household sources made up 34% of all violations. The main destination regions of European waste, outside Europe, are Africa and Asia.

1 SWEAP inspection results 2018 – 2020. https://www.sweap.eu/wp-content/uploads/2020/07/SWEAP-inspection-results-2018-2020-updated.pdf

BACKGROUND

Waste shipments are a double-edged sword. If properly carried out – in an environmentally sound manner – they can deliver resources to industries that need them. However, inadequate treatment of waste can cause severe damage to the environment and human health. This has been well-documented over several decades. The World Health Organization has stated that "available scientific evidence on the waste-related health effects is not conclusive, but suggests the possible occurrence of serious adverse effects, including mortality, cancer, reproductive health, and milder effects affecting well-being."[2] Health risks from the improper processing of waste can also be indirect, if harmful toxins accumulate in ecosystems, agricultural crops, livestock and eventually humans.[3] The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1992) was established following a number of the high-profile cases, which had devastating impact on the populations and environments that received hazardous wastes.

THE RISE OF WASTE SHIPMENTS TO DEVELOPING COUNTRIES

Increasingly demanding governmental waste recycling targets, landfill bans, rising landfill taxes in developed countries, and containerisation have led to the rapid rise of global waste shipments, mostly to developing countries. This is mostly due to the lower labour costs and environmental standards in receiving countries. Nowhere is this more visible than on the shipbreaking beaches of the Indian subcontinent.

The informal waste management sector in developing countries can be vast. In 2015, there were approximately 857 recycling companies authorised by Chinese authorities to carry out recycling of imported plastic waste. In comparison, there were literally thousands of informal and therefore unregulated recycling sites.[4] These are labour-intensive operations using basic equipment and often operating under poor safety standards. Recycling residues are usually dumped or openly burned, thereby releasing harmful compounds such as furans, dioxins and carbon monoxide into the atmosphere, and contaminating wastewater.

When looking at plastic waste for instance, its low value, the lack of industries in most developed countries that produce plastic goods and the avoidance costs of adequate treatment, mean that it is appealing to the less conscientious waste broker to exported it illegally. Highly contaminated waste is often shipped fraudulently through falsification of customs forms, or fraud through over- or under invoicing costs and mis-declaring income. The waste itself may even be concealed behind good quality material when being loaded into containers, and it is also common that the ultimate final destination is not revealed to authorities.

China has been implementing increasingly rigid waste import policies since 2010 in an effort to increase its national collection and recycling infrastructure, but also to push back on the poor wastes it was receiving from many European countries and the US. In 2017, China announced a new import policy that would permanently ban the import of many recyclates.[5] Since 2017, the number of illegal shipments of European waste destined directly for China has been decreasing. Household wastes were the most common problem wastes at that point, whereas metals and plastics have now become the waste streams most frequently stopped by European competent authorities heading for China.[2] Since the introduction of China's new import restrictions in 2018, neighbouring countries have inevitably been targeted by waste criminals. This is a familiar pattern with waste crime.

ENFORCEMENT ISSUES

All countries have competing pressures for executive and parliamentary time. The legislation to implement the provisions of the Basel Convention and provide powers to their national regulators can slip down the priority list. Where implementation has been relatively swift, for instance in the European Union, regulatory agencies may still lack the powers they need to prevent illegal shipments. Even where there is adequate enforcing legislation, most authorities lack the resources they need to control waste shipments. European Regulation (EC) No 1013/2006 on shipments of waste requires Member States to establish appropriate penalties and fines. Trying to convince a Prosecutor to take an environmental case can be very difficult though. There are very few countries with dedicated Prosecutors for environmental crime; England, The Netherlands, Sweden and soon France, are rare exceptions. Therefore, the number of infringements relating to waste shipment legislation brought before courts is low.[6] The levels of the actual penalties can also vary greatly.[7]

Since 2011 until 2020 approximately 19-22% of shipments inspected within Europe violated the Waste Shipment Regulation

2 2016, World Health Organization, Waste and human health: Evidence and needs. WHO Meeting Report 5–6 November 2015, Bonn, Germany

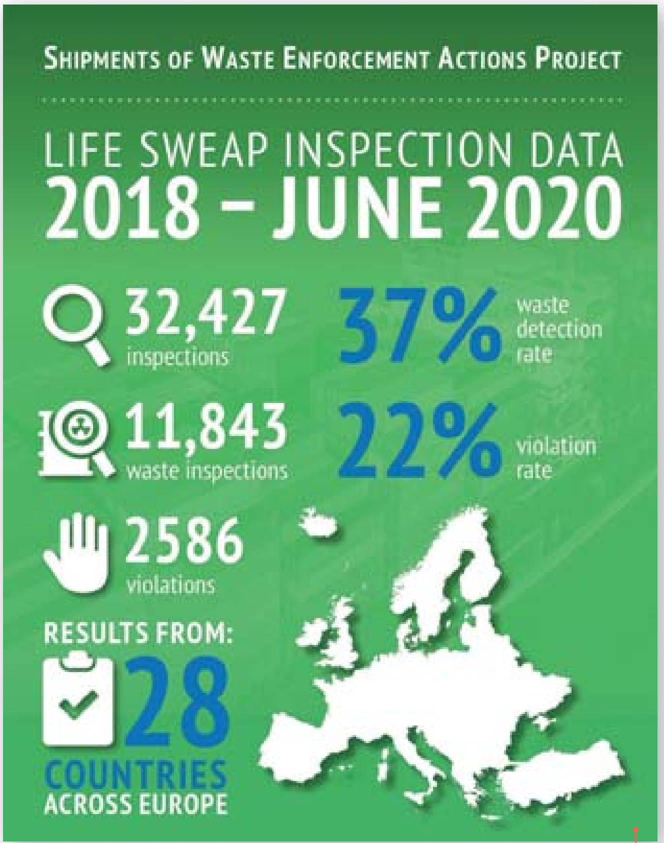
3 2012, ILO. The global impact of e-waste : Addressing the challenge. International Labour Office. Accessed 11 December 2020. http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_196105.pdf

4 2017, GRID-Adrenal. The Trade in Plastic Waste. Accessed 18 December 2020: https://www.grida.no/publications/333

5 2017, Chinese Ministry of Environmental Protection, "Announcement of releasing the Catalogues of Imported Wastes Management," (Announcement no. 39, 2017); www.mep.gov.cn/gkml/hbb/bgg/201708/t20170817_419811.htm?COLLCC=3069001657&.

6 2018, Gillan, L & Olley, K. IMPEL-TFS Enforcement Actions, Project Report 2016 –2017 Enforcement of the European Waste Shipment Regulation

7 2015, Geeraerts, K., Illes, A. and Schweizer. Illegal shipment of e-waste from the EU: A case study on illegal e-waste export from the EU to China. A study compiled as part of the EFFACE project. London: IEEP



Shipments of Waste Enforcement Actions Project (SWEAP) inspection data from 2018 to 2020.

Violation data from 2018 to 2020 (SWEAP)

Regulation of waste activities can be split across various national bodies, with one regulating waste shipments and another waste management licensing. These silos make it difficult to monitor waste shipments from cradle-to-grave, especially when the responsible parties may be 'waste tourists', locating themselves in an exporting country for sometimes only a few months, or a 'few shipments worth' at a time, shipping waste to their home country. This is typical for the waste electrical and electronic equipment trade, with west African countries being a major destination for over fifteen years.

Waste shipment inspectors may also be responsible for regulating other regimes, such as chemicals and producer responsibility legislation. It may seem easy to tell what is legal and what is illegal, but this is not always the case with legislative loopholes and 'grey areas', i.e. when officers have incomplete documentation in front of them, for example when inspecting a container with used electronic equipment, which seems to be too old to realistically be put back on the market. Organisations' priorities change depending on resources, political will and undeniably media pressure. The latter brought about the massive change to the controls surrounding shipments of plastics that will come into force on 1 January 2021.

The global trade in household recyclates involves many different players, such as recycling companies, waste traders, dealers and hauliers, making traceability and control of the waste difficult for investigating officers.

Curtain-siders move easily from western to eastern Europe, using a network of transport operators. Co-operation with other authorities regulating at national frontiers can also be lacking. Within the EU, co-operation with Customs authorities is relatively high, with 81% of environmental competent authorities having formal or informal working arrangements with Customs.[5] However, this still leaves a significant proportion of European authorities lacking the support of their national Customs. Anecdotally, the situation is much worse outside Europe. This makes the illegal waste trade a low risk business for criminals, enticing them to move high volumes to maximise profit.

Despite, 'intelligence-led' operations being the flavour of the day, and rightly vaunted by Police networks, many environmental authorities lack intelligence capacity. In a survey conducted by IMPEL (Network for the Implementation and Enforcement of European Environmental Law), only 44% of European agencies had access to intelligence systems.[5]

The nature of waste shipments crime is of course that they are transnational. Environmental regulators tend to be a collaborative and enthusiastic group. However, they work across different time zones, meaning it can be difficult to communicate easily. Coupled with this, authorities in developing countries may use personal email addresses because their own organisations cannot provide them with accounts. Although a seemingly minor issue, this can mean the exchange of information is immensely difficult or forbidden.

And then there is the issue of 'port hopping'; the practice whereby illegal waste shippers avoid frequently inspected transport hubs and move their waste through less well-regulated ports or roads. Like water, waste crime always finds the lowest level.

THE FUTURE OF ENFORCEMENT

So how is this situation to be improved? In the EU, the 2014 amendments to the Waste Shipment Regulation (WSR) addressed some fundamental issues for European regulators; namely, reversing the burden of proof on to shippers of waste and requiring each country to have an inspection plan. Enforcement can only be as strong as the weakest points in the regulatory chain however. The WSR is undergoing its next five-year review, with issues on reporting against inspection plans being addressed.

Further work is needed to improve the consistency of reporting inspection results. The Basel Convention Secretariat struggles annually to compile reliable statistics. Ways to streamline reporting have been invented but countries with numerous regulators involved in waste shipment controls will always find this difficult. The IMPEL Shipments of Waste Enforcement Actions Project[8], which runs from 2018 until 2023, will enable officers to report the same detailed data during inspections as their counterparts in other European countries. It will also 'flag' illegal shipments and vulnerable routes to authorities using real-time data. It's to be hoped that this initiative makes a crucial difference to the effectiveness of officers' time. The data will also be more robust and the high-level data (non-nominal) readily available to policy makers. Europol will have access to the nominal data and be able to assist authorities in joint operations, and possibly fill the gaps for environmental regulators without access to their own intelligence systems.

There are plenty of regulatory tools being developed by other European and UN-funded projects. For example, the WasteForce Project seeks to provide Prosecutors with training and guidance. The problem is embedding these ways of working and maintaining co-operation. It is recommended that environmental regulators co-operate more with customs, police and other regulatory authorities, and that formal service-level agreements be considered. Awareness-raising that waste crime is an important threat to security, people and the environment amongst enforcement communities needs to continue apace. Sharing cases on the involvement of other types of crimes, such as major tax fraud and tax avoidance may assist.

The involvement of existing international bodies such as the United Nations Office on Drugs and Crime (UNODC) and the World Customs Organization (WCO) is very welcomed and should continue. The WCO is ramping up its efforts to assist in enforcing the provisions of the Basel Convention, having recently joined the Basel Convention's ENFORCE network and running its Operation Demeters which have a joint focus on transboundary movement of hazardous waste.

Collaboration between different regions of the world tends to work well whilst key and enthusiastic officers are in place. Verification of sites of destination is a 'must' for exporting countries, and the channels of communication need to be as effective as possible. It is often the case that receiving countries are either unaware or unsure about invoking the 'repatriation requirement' whereby an illegal shipment should be taken back to the country of origin. If this was to become regular practice, it would surely act as a deterrent to parties involved in illegal exports and ensure those responsible for waste meet their 'duty of care' by checking downstream treatment operations. Strengthening regional and sub-regional enforcement approaches needs to be considered by reinstating networks such as the successful Regional Enforcement Network for Chemicals and Waste in the Asia and Pacific region, which share best practice.

Mapping of the scale, routes and hazardous nature of the waste involved can only help mount political pressure. This in particular has led to the recent focus on the illegal trade in waste plastics. Perhaps this can address the main issue at the base of all this illegal activity: the need to strengthen national legislative frameworks and regulatory agencies. All in all, there is a long way to go on the enforcement of waste shipments.

8 https://sweap.eu The Shipments of Waste Enforcement Actions Project (SWEAP) is co-funded by the European Commission LIFE fund and co-ordinated by the IMPEL Network. The overall purpose of the project is to support the circular economy by disrupting the illegal waste trade at the EU level.

CIRCULAR AFRICA: A MODEL FOR US ALL?

Alexandre Lemille
Co-founder of ACEN, the African Circular Economy Network

©Wayne Visser- Barloworld Caterpillar.

Alexandre Lemille co-founded the African Circular Economy Network (ACEN www.acen.africa) in 2016 with a group of experts from South Africa. ACEN now operates in 33 countries in Africa, with over 100 experts helping to build a vision for the circular economy in Africa.

Alexandre also uses his Circular Human sphere concept (#CircHumansphere) to trigger debate on the importance of never uncoupling circularity and social justice, and is an active proponent of the vital link between the circular economy and human development (publication: Elsevier Academic Journal). He lectures on the fair and circular economy at several international educational establishments.

He has a Master of Business Administration (MBA) degree from Hult International Business School, Boston (2011).

Today, the African continent faces a pivotal choice: to take advantage of the window of opportunity now open to it for committing to a model centered on the circular economy— better still, the fair and circular economy — or replicate the growth models that proved successful in the past for the Americas, Europe and Asia. This is a choice that only Africa can make and benefit from.

The African Development Bank (ABD), African Circular Economy Alliance (ACEA) and African Circular Economy Network (ACEN) are fully aware of the importance of this choice. They are working together to forge an ecosystem that will boost the emergence of a model as yet little-known in Africa. The task now is to set in place the foundations of a professional framework for extreme resilience in order to adapt the economy to the social and climate challenges that will impact the continent first of all.

Africa needs to show the way at a time of increasing resource scarcity worldwide and a climate emergency that will make living conditions harder than ever.

INTRODUCTION

Africa, like every other part of the world, is closely examining the new circular economy model. This is a collaborative economy that seeks to adapt to social, economic and environmental constraints. But is this really such a new thing for Africa, a continent that has always battled with all manner of constraints and has innovated throughout its history in order to improve the life of its peoples?

Africa today is at a turning point that nobody can deny. Just like India in the 1990s, even China in the 1980s, the race for economic growth is now underway. From Ethiopia to Ghana, growth rates are the envy of long-established economies. But is the rush for all-out growth really the path that Africa should take? In other words, should it move toward an economic model that has unsettled global markets, a growth model with rapacious energy demands that is the cause of vanishing fossil fuel reserves? These are big questions for a continent where over half the population is very young.

At a moment when the continent is seeing an economic slowdown caused by Covid, it is the only place on earth currently able to create a model for human progress based on an economy that acknowledges systemic challenges, in other words, an economy rooted in resilience from the very start of its industrialization phase.

REMANUFACTURING AND REPAIRABILITY: MODELS WITH A FUTURE FOR AFRICAN INDUSTRY

Although often equated with an economy of survival — which has caused such suffering to so many Africans and continues to do so today in the informal recycling and improvisation economy — the circular economy aims to take us beyond recycling and toward a model that seeks to limits it as much as possible.

The circular economy perceives the resource-trading market through the prism of two dimensions: technical nutriments (or resources), our equipment based on metals and non-metals, and biological nutriments, which are material resources derived from our natural ecosystems. Innovative business models can ensure that these resources circulate for as long as possible in our exchange systems, while also rendering them economically viable. The ultimate objective is to generate no waste or pollution with minimal energy input. The continent's leaders must draw inspiration from this approach to apply the fundamentals of circularity principles to economies where the environmental footprint — despite strong growth — remains the smallest in the world.

Remanufacturing offers a threefold advantage: reusing large volumes of durable materials prior to their end of life, avoiding the creation of waste and pollution, and creating jobs that aim to extend the life, or lives, of the products

This might, for example, involve building infrastructure whose modularity is designed-in from the outset, making it simpler to adapt to suit other needs during future lifecycles. But this requires strong political will to change our current practices. Instead of creating a network of factories manufacturing goods that will flood the world with products made in Africa, the idea would be to create interlocking webs of remanufacturers meeting the needs of regional markets in Africa and beyond. Whereas today's factories operate on the basis of unlimited access to virgin materials, remanufacturing, or refabrication, consists of making new objects from non-virgin materials, i.e. that have already been extracted from underground. Flows of previously extracted materials are redirected toward factories, with the aim of reducing the impact of mining and avoiding materials that are still useable piling up in Africa's refuse tips. Remanufacturing offers a threefold advantage: reusing large volumes of durable materials prior to their end of life, avoiding the creation of waste and pollution, and creating jobs that aim to extend the life, or lives, of the products. According to Walter Stahel, one of the pioneers of the modern circular economy, this approach uses far less energy and creates a far higher need for labor than when a product is produced in the conventional manner. He introduced a metric for the labor/weight relationship, man-hours per kilogram (mh/kg), which is used to measure job creation compared to resource use. This enabled him to show that the ratio of man-hours per kilogram of resources used for a remanufactured vehicle engine, compared to manufacturing the same engine from virgin materials, is 270:1.

The impact on employment is enormous and offers Africa an exciting opportunity for the future: to become the remanufacturing hub, not necessarily for the whole world, but for a region that would include Europe and the Middle East, certainly for so long as transport remains a source of pollution (avoiding risks relating to future carbon taxes).

In any strategy for maintenance, repair, reconditioning or remanufacturing, employment, particularly in economies with young populations, becomes essential to the resilience of this type of model. Furthermore, one of the world's benchmark refabrication specialists is located in Africa: the Barloworld Caterpillar factory, where a third of activity centers on remanufacturing heavy equipment, as detailed in the documentary Closing the Loop presented by Wayne Visser, professor at the Antwerp Management School.

The other massive opportunity for Africa is using repairability and durability to extend the lives of products and their components. Repairability offers two economic opportunities: return functional objects to the trading cycle as rapidly as possible, and create jobs at the same time. When it comes to durability, the challenge is to design modular products with components that are accessible, ideally open source, and upgradeable. Africa needs to focus on this approach to professionalizing repairability. By way of illustration, the Fairphone smartphone is an example of a particularly virtuous product, one that every country, not just in Africa, should seek to have on its market. The Fairphone is not just circular but is also type II, meaning open source. The Fairphone is a good-looking 4G smartphone offering a comparable performance to other similar devices. The real innovation lies in its accessibility and upgradeability, thanks to unlimited access to every one of its components. Each component can be unscrewed and reintegrated into the economy. Accessibility of components makes access and repair easier. This could have two instant impacts: the creation of skilled local services that can repair, maintain or even upgrade objects, as well as securing access to certain metals that have become scarce to governments without reserves of their own. The impact on employment and stocks of materials would be considerable if all objects and their components were to become accessible in the markets where they were used.

THE CIRCULAR ECONOMY AS A LEVER FOR INNOVATION IN AFRICA

The circular economy is about perceptions of abundance. The challenge is to shift from the current paradigm of a quantitative abundance of reserves on a planet without limits to a qualitative abundance created by flows of materials. Recycling must be limited in a circular economy, even though we need it for the benefit of the generations to come. This is because recycling is an essentially linear

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concept based on creating waste that is then recovered. From a circularity standpoint, waste must be limited by setting up holistic strategies that promote the durability of objects, and therefore their various uses in their future lifecycles. During an object's design phase, it needs to be thought of as a service provided for a demand, for a function, shared, constantly evolving, perhaps by continually adding new functions. This is very far removed from the notion of recycling, where a pre-made glass bottle, embodying an investment of time, energy and human labor, is usually destroyed so it can be remade exactly the same. This amounts to an excessive and futile use of energy, investment (which could have benefited other solutions), and labor. Circularity is based on natural cycles where energy and material flows are constantly exchanged, continuously changing as they adapt to new contexts. Within this paradigm, the option using the least energy is often chosen. Recycling is therefore not the best solution.

This reasoning has seen the emergence of African businesses such as Agriprotein in South Africa. Influenced by permaculture principles that students at the Songhai Centre in Benin have been learning for several decades, Agriprotein realized that replicating natural cycles and applying them to human environments represents a major opportunity. By laying their larvae on food waste, solider flies ensure larvae can feed themselves. By growing as much as two hundred times their initial size, they serve, once dried, as staple food for a wide range of animals and their oil is used for biofuel or feed oil. The entire process lessens the impact of human food waste. By recreating the natural animal protein cycle, Agriprotein provides a sustainable solution in a market whose economic potential is estimated at a trillion dollars and, most importantly, a natural method for feeding animals while solving the issue of human food waste. Agriprotein is now part of the Insect Technology Group (ITG), a holding company comprising leading global companies such as Circular Organics, MultiCycle Technologies and ITG Bio-polymers. Time Magazine included AgriProtein on its Genius 50 list of businesses that are building the future.

However, setting up a circular business in Africa does not require a holding company. Throughout the continent, a host of soil restoration startups are thriving, protecting soil fertility through better understanding of biological cycles and how to adapt to them. This approach has been embraced by the head of Ecofertil in Morocco and the co-founders of Lono CI in Ivory Coast, where compost and biological products have become the green gold of tomorrow's Africa. As they pave the way in soil conservation and respect for biological cycles, these new-generation businesses are focusing on the authenticity of their approach to guarantee greater resilience for future farming systems.

Africa is currently home to over two hundred innovation and business incubation hubs identified by the African Circular Economy Network. These hubs have resulted in the emergence of numerous circular startups, with plenty of examples to cite. Hello Tractor in Nigeria provides access to shared agricultural equipment to hundreds of farmers. Also in Nigeria, the international Platform to Accelerate Circular Economy (PACE) has invested in various areas: retrieving precious materials contained in electronics once they are no longer in use so that they can be reused in local production processes; safe handling of dangerous components in electronic waste, and strengthening the conditions conducive to legislation on a self-sustaining system for extended producer responsibility in the electronics sector. In Ghana, Agbogbloshie Marketspace

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(AMP) is a platform that creates value from electronic waste by giving it a second life. Rwanda is proving to be a pioneering force, investing five billion dollars in a zero-waste urban project: the city of Wakanda will spread across 620 hectares without generating any waste. In Ivory Coast and Ghana, Coliba has developed a mobile application that municipalities can use to identify and monetize the locked-in value in waste. In Zambia, ICLEI Africa, an ACEN partner, is implementing a composting program in Lilongwe. Further north in Morocco, Fertidev is working on the development of fully Moroccan biotechnological solutions, optimized and adapted to Moroccan ecosystems and biodiversity to provide added value for agricultural products while protecting farmers, consumers and the environment. And Ethiopia has launched a national program to regenerate its agriculture. More broadly, Djouman is a social enterprise that organizes permaculture AgroBootCamps for the whole of west Africa. Biomimetics are being used to great effect to regenerate the Berg River in South Africa, irrigating the region's vineyards. It is also at the heart of a Nigerian project to create a new district, Abuja Centenary, where technical and biological flows are overlaid in perfect symbiosis.

Africa is truly brimming with inspiring innovations!

NEW FRAMEWORKS FOR A CIRCULAR REVOLUTION

But these initiatives are just the tip of the iceberg.

The continent has started on its path to circular conversion. It is ensuring it has the players, international bodies, incubation programs and, above all, legal frameworks needed to get circularity up and running. In May 2017, in collaboration with the European Union and ACEN, the governments of Nigeria, Rwanda and South Africa signed a cooperation agreement on the circular economy. Known as the African Circular Economy Alliance (ACEA), it now includes a significant number of countries in west, north and southern Africa, all of which have committed to passing laws to create a framework favoring an economic model that protects resources while reducing carbon emissions. The ACEA has an office at the African Development Bank in Abidjan and is in permanent discussions with stakeholders implementing relevant laws and regulations. In parallel, the African Development Bank (ADB) has created a program, the African Circular Economy Facility (ACEF), in partnership with the Finnish government, aimed at helping governments who have made less progress to implement regulatory instruments and tools for encouraging circularity. With the ACEF program, the ADB also intends to help the business world, small and large companies alike, by providing them with support in the form of incubation programs and initiatives promoting the circular economy with the overarching goal of speeding up transition.

In addition, ACEN provides them with technical support on the ground by identifying economic actors and businesses innovating in the circular economy, while sharing knowledge with as many businesses as possible.

CONCLUSION

What if we were bolder still? What if Africa showed the way to an economy that is both circular and fair?

The continent's population is young and forward-looking. The lack of infrastructure translates into limited effects on the biosphere. It boasts the world's lowest ecological footprint per capita and collaborative societies. African societies are marked by a culture of sharing and survival in the face of multiple challenges, making the continent one of the most innovative parts of the world. One of the only telecommunications companies to have succeeded in adapting to citizens' social needs, Celtel International founded by Mo Ibrahim, initiated the social innovations that have helped Africa to communicate and reinvent itself. One example is the Street Payphone — a pre-paid or post-paid cellphone distributed via street vendors and managed by women who can feed their families thanks to the wages the system provides — using free roaming zones shared across over ten countries. These innovations have been adapted to citizens' needs and their collaborative lifestyles. Seen in Europe as an enviable model, Africa could specialize in collaborative innovative services and develop business models that are still little-known in Europe.

Africa is at a crossroads, a place where the linear economy and the regeneration economy meet. The choice of path to take is Africa's alone. And it can make the choice without having to take drastic action to strip carbon out of its economy. The emergence of this virtuous model with its huge job-creation potential is a wonderful opportunity for the continent as a whole.