This report was written by members of the Ellen MacArthur Foundation network

Horses for Courses

Circular economy: one size does not fit all

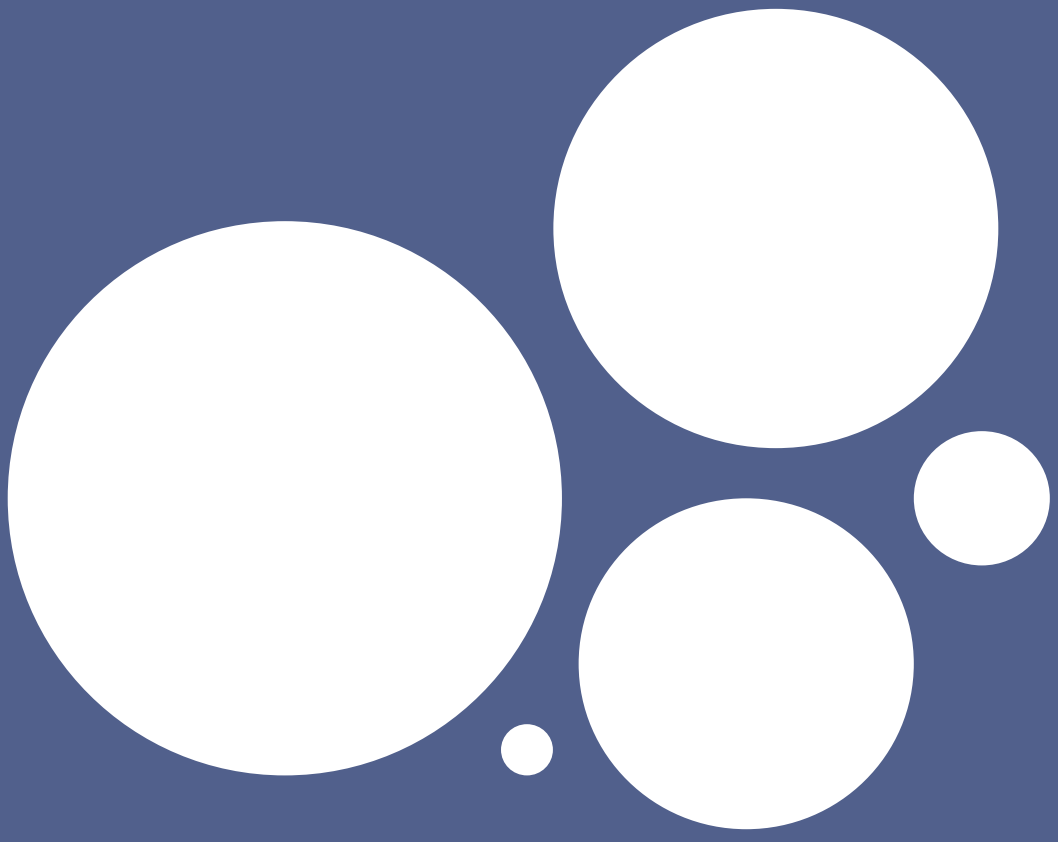

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Table of Contents

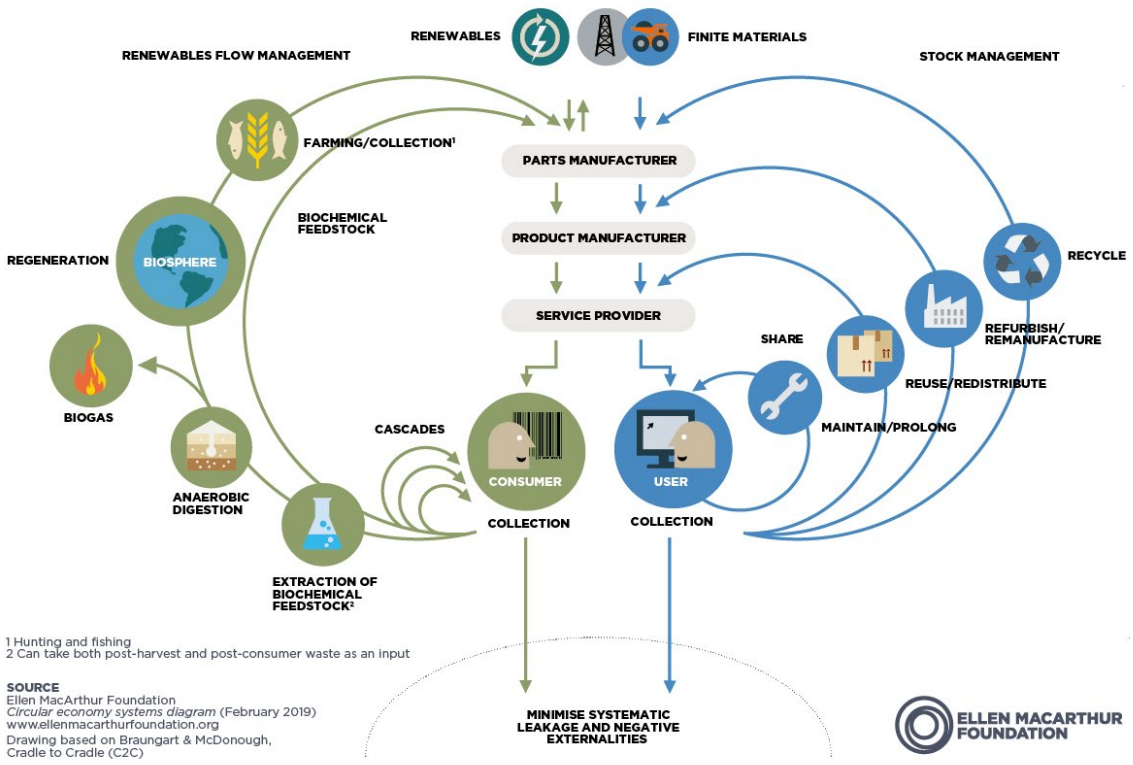
Introduction

Around the world, nations are suffering not only the health implications of the Covid-19 pandemic but also the economic consequences. As governments look to rebuild following such a crisis, policymakers will play a crucial role in stimulating recovery and building resilience into systems.

Embedding circular economy strategies into recovery plans is vital. The concept and application of circular economy continues to gain momentum. There is a growing awareness that most industries follow a "take-make-waste" linear model and thus lack a strong focus on repair, reuse, and recycling. There also seems to be a tendency to only focus on recycling when considering circular economy initiatives and a perception that 'one size fits all' affecting the development of related guidelines, governance, incentives and standards.

Given the scale of the efforts required to move from a linear economy to a circular economy, policymakers often focus on one problem at a time, for example by exploring possible regulations aimed at enforcing a greater use of recycled content. However, the circular economy framework encompasses much more than just waste recycling and incorporating recycled content into products, even though these are important in their own rights and make sense for specific sectors.

There is tremendous material and financial value to be captured by employing 'inner-loop' strategies as well. The circular economy system diagram below depicts the circular loops which can be deployed for a product or a system value to be maintained. The outer loop, recycling, is the loop of last resort.



This document intends to show that inner-loop circular strategies, such as those that focus on maintenance, reuse and extension of a product's life, are crucial and are in fact more important in specific sectors and for certain activities.

Objective & Scope

While recycling of materials and recycled content address the “outer circle” of a circular economy model, the authors of this document recommend that a similar, if not stronger, focus should be placed on industrial strategies that address the “inner loops” of the technical cycles.

These inner loop strategies include, but are not limited to:

- Maintenance
- Shared use
- Reuse of products, parts or components
- Repair, refurbishment, remanufacturing and upgrade

As encapsulated through its title “Horses for courses”, this document aims at highlighting the need for a differentiated approach to define policies in relation to the circular economy. The authors of this document, gathering experts from the chemical and plastics (Solvay) and the recycling (Suez) industries, together with a provider of energy and automation digital solutions (Schneider Electric), a leading provider of aftermarket lifecycle services for electronics (Reconext), and a multinational energy company (ENEL) all agree that “one size does not fit all” when it comes to regulations for a circular economy

While the team welcomes current and future progress by policymakers in promoting, facilitating and incentivising circular business practices, as well as efforts in reducing or penalising unsustainable linear practices, it argues that certain criteria should be considered when drafting regulations in order to maximise their impact while minimising unintended consequences.

As further detailed in this document, the main criteria are:

- Sector, category, and products (including related health and safety concerns)
- Prior use of product or parts put on the market
- Access to recycled material and/or alternative material
- Durability of product
- Mass balance

We would also invite anyone interested in the topic to refer to the report of another Ellen MacArthur Foundation network-led collaborative project entitled “Better than new: Designing new products for many lives”, which offers more quantitative information on the potential impact of remanufacturing activities and similarly promotes the value of such inner loop strategies.

To achieve a circular economy, there are multiple levers to consider:

- Design products and materials that can easily be separated and recycled,
- Design products for reuse,
- Develop retrofit solutions that extend the lifetime of products,
- Innovate advanced recycling technologies to increase the value retrieved from items that often become waste,
- Incorporate alternative feedstocks that take waste or by-products from other sectors and processes

Making products and materials more circular will require a reshaping of associated systems (business models, product design, etc.) with a holistic approach.

Here below, we list five headline business models supporting the circular economy transition:

- Circular supply models: by replacing traditional material inputs derived from virgin resources with bio-based, renewable, or recycled materials, it reduces demand for virgin resource extraction
- Recycling models turn waste into secondary raw materials, thereby diverting waste from landfill or incineration while reducing the extraction of virgin natural resources
- Product life extension models prolong the use period of existing products, slow the flow of constituent materials through the economy, and reduce the rate of resource extraction and waste generation
- Sharing models facilitate the sharing of under-utilised products, and can therefore reduce demand for new products and the raw materials they are made from
- Product-as-a-service models, where the manufacturer keeps ownership of a product and provides access to users, incentivises the manufacturer to produce durable goods and maintain them for as long as possible.

This non-exhaustive list shows how diverse and rich the path to create a more circular economy can be. No option should be discarded from the beginning. Instead, circular economy strategies should be adopted according to each sector, each product, and user needs. There is no one-size-fits-all solution.

Setting the stage

Focus on inner loop strategies

All products have functionalities, which they deliver to the customers, and many have sub-functionalities which together create the whole product experience.

For example, the functionality of a car is to enable passengers and freight to move from one place to another comfortably, safely and in a reasonable amount of time. The sub-functionalities enabling the car to do this include an engine, an energy tank, seats, a chassis, and more.

Should we wish to apply inner loop strategies to the car today, we would find that:

- Each functionality of the car is not designed to enable upgrades (but in most cases is designed for replacement)
- The car's components are usually not designed to enable disassembly and recycling

Inner loops include but are not limited to:

- Product maintenance – which includes repair, so that a product can be used for longer
- Remanufacturing – using an existing product that can no longer be used in its original form (or a sub-product) to create the same product again or to manufacture a new product
- Revamping – restoring or upgrading a product so that it provides the sub-functionality of a new product or provides the sub-functionality of the initial product again. This can apply to a whole product or part of a product
- Reuse – of products, parts and components for the same purpose or a similar purpose again by one person or by many (as part of a sharing model

Whatever the inner loop strategy and objective for the product is, each product ultimately reaches a stage where it is no longer repairable, reusable or suitable for remanufacturing.

This means answering the following questions to optimise the design for disassembly:

- Can the product be disassembled in an energy and cost efficient way?
- What is the best proposed end destination of the smallest disassembled component - in terms of environmental impact and value retention?
- Can all of the parts or materials of a product be reused, recycled or composted after they have been disassembled?

Producers and designers can ensure their different products are made to be part of a circular economy and thereby prevent the product becoming waste after its first use. Eventually, the subcomponents of the product will need to be collected, sorted, and transformed (into recyclates, aggregates, compost etc.)..

This goes beyond focusing on increasing recycled content in products. Some of the examples below give inspiration on the way forward.

Case studies

1 **Schneider Electric –** Retrofit services contributing to circular economy

2 **Reconext –** Demonstration of circular economy for data storage devices

3 **Solvay –** Enhancing durability with specialty polymers

4 **Suez –** Loop initiative with TerraCycle

5 **Enel –** Second Life for Electric Vehicle Batteries

1 Schneider Electric

Retrofit services contributing to circular economy

One of the key circular offers of Schneider Electric is the retrofit solution, ECOFIT™. This program was developed to facilitate equipment upgrades by replacing only certain key components, rather than replacing a whole system. In addition to extending the equipment's useful life at a fraction of the cost of outright replacement, these upgrades also typically boost functionality, add communication capabilities and enable networking, maintaining — or even increasing— utility for years to come.

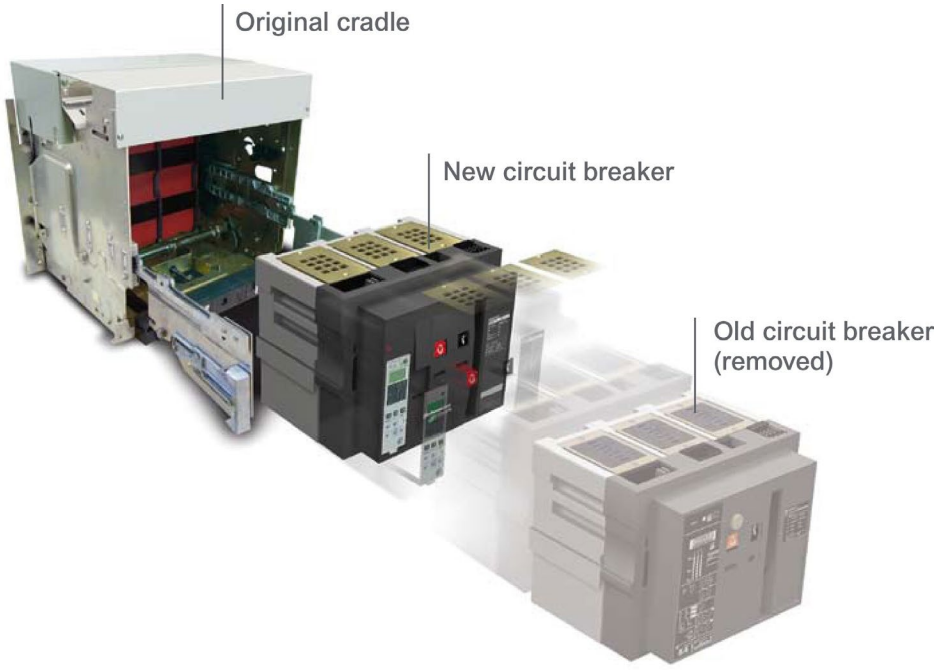
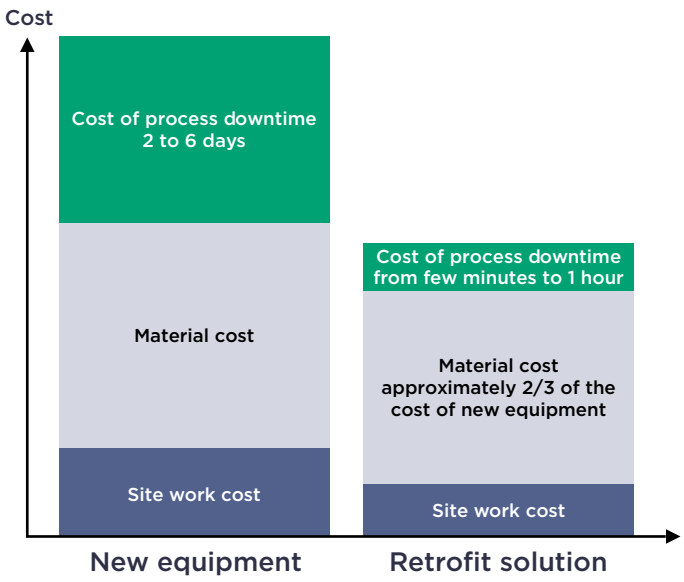


Figure: An aging circuit breaker is replaced by a modern circuit breaker, while maintaining it's original cradle.

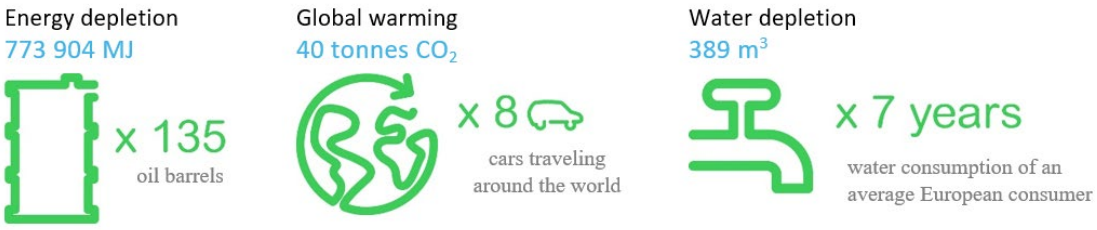
This typically results in spending less money, using fewer natural resources, causing less process disruption, and increasing the resilience of the business or operation.

The results clearly favour retrofit solutions, with savings ranging from 43% to 65%.

Retrofitting electrical distribution switchboards (circuit breakers, contactors and protection relays) fits well within the concept of circular economy. Retrofit solutions reduce their environmental impact in comparison to simply installing new products



Economical comparison between new equipment and retrofit solution.



Environmental benefits of a typical primary distribution retrofit solution (calculated using Product Environmental Profiles)

This is a typical example of an inner loop with clear and quantified circular benefits.

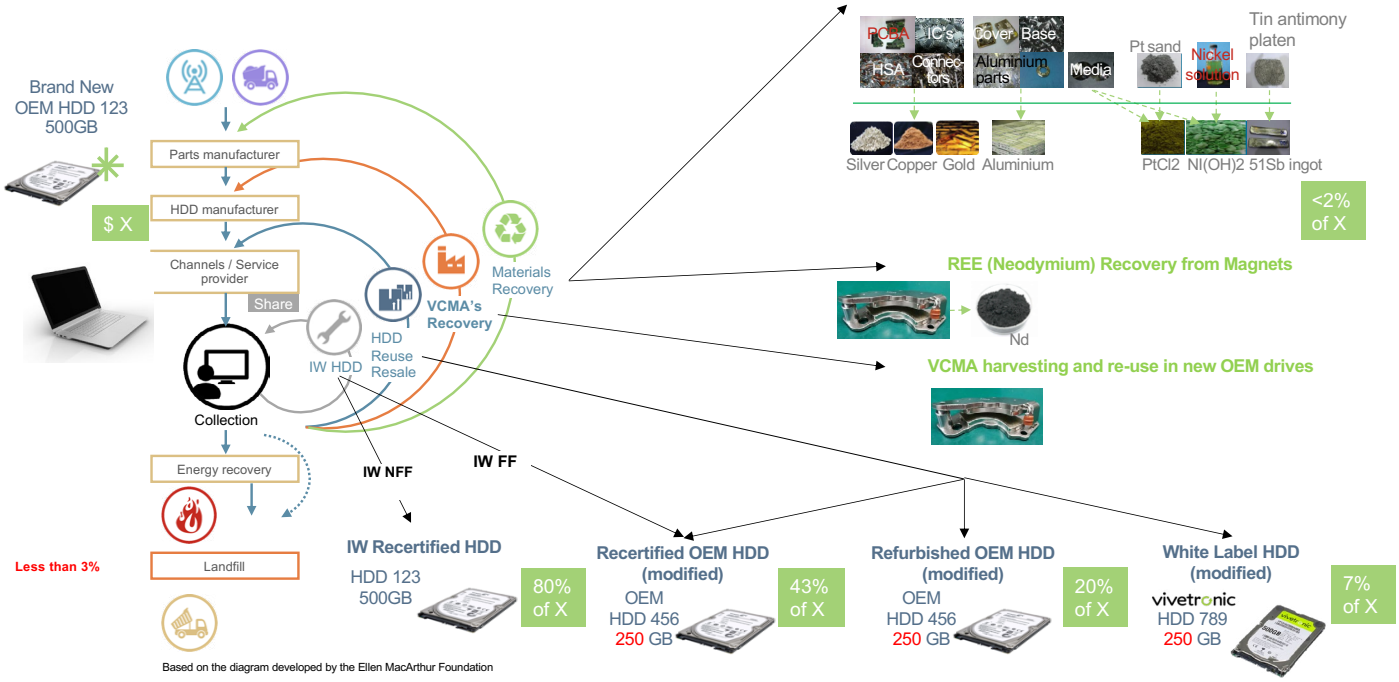
Reference: Giovanni Zaccaro, "Retrofit Versus Replace: What Should You Do with Our Power Distribution Equipment?" Schneider Electric Blog, March 14, 2018, https://blog.se.com/electricity-ompanies/2018/03/14/retrofit-versus-replace-what-should-you-do-with-your-power-distribution-equipment/

2 Reconext

Demonstration of circular economy for data storage devices

Various factors are driving an exponential increase in data storage capacity. At the same time, the industry continues to destroy millions of units that could have a reuse potential. Reconext has developed and continues to develop solutions to maximise utilisation, value recovery, and minimise the waste resulting from this product.

Circularity in practice: The HDD example

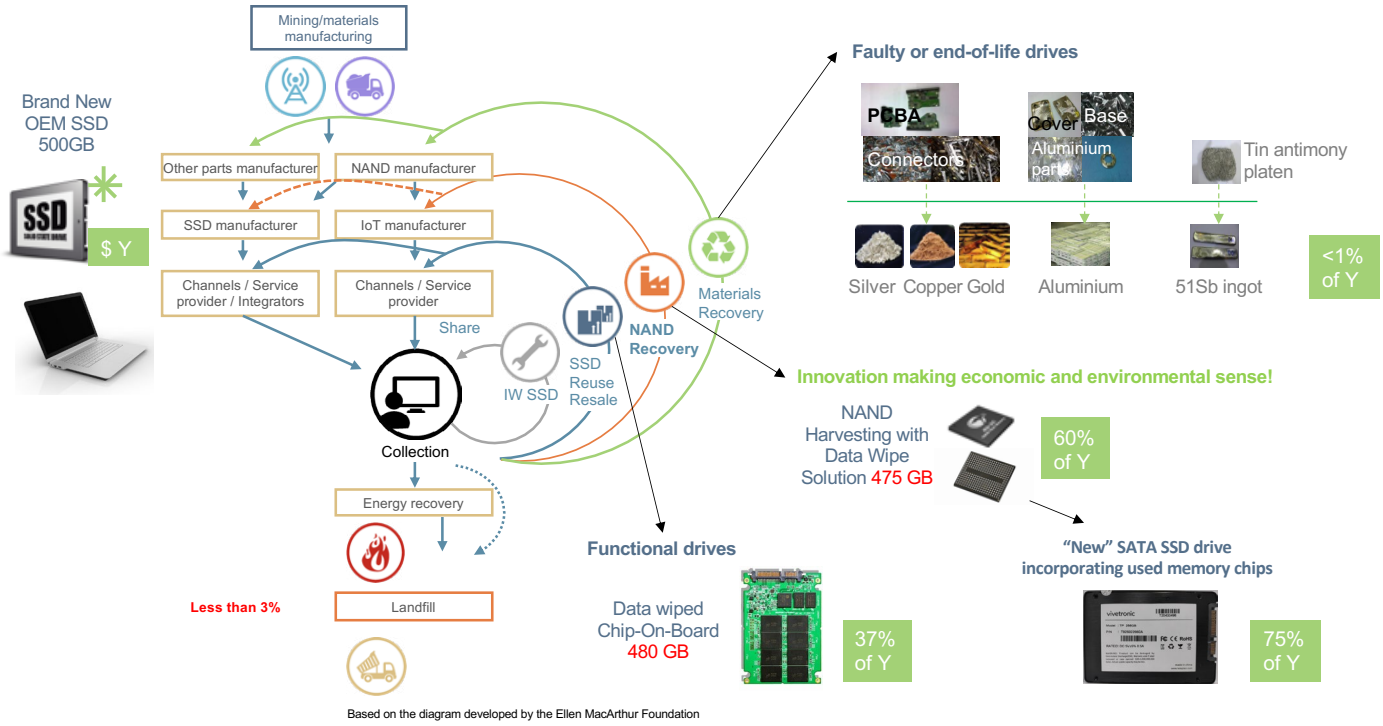


Per the figure above, Reconext's cascading approach can be described as follows:

1. Ensuring No Fault Found (NFF) drives that were wrongly suspected of being defective are used as replacement units for future warranty exchanges.
2. Where some faulty sectors are identified, Reconext can isolate these sectors and the drive can be made available to the market as a perfectly functioning drive of lower capacity.
3. Where a drive is faulty and cannot be repaired, Reconext has pioneered a process to extract or harvest key components for reuse in the production of new drives.
4. Only when all these avenues have been exhausted (i.e. the drive is beyond repair or its technology no longer has a demand in the market), Reconext proceeds with the recycling of materials through a specialised recycling partner.

Circularity in practice: The SSD example

An additional example of how “one size does not fit all”, for another type of pervasive data storage device, the Solid State Drive or SSD.



Applying the same principles as the previous example, the cascading approach in this case can be described as follows:

1. Ensuring No Fault Found (NFF) drives that were wrongly suspected of being defective are used as replacement units for future warranty exchanges.
2. Where functional SSD drives are no longer needed to support the warranty maintenance, these can be re-sold for reuse.
3. Where the drive is faulty, Reconext has pioneered a process whereby NAND chips are extracted from the board, tested, erased and used to remanufacture new SSD drives or sold for use in other devices.
4. As for the HDD example, when all of these avenues have been exhausted, Reconext proceeds with the recovery of materials through a specialised recycling partner.

Note: Data erasure applies in all cases of the two examples above.

Impact of such circular activities

Assuming that every device that can be put back onto the market for reuse replaces the need for a new similar device to be manufactured, we estimate the average impact of each device to be:

For an average HDD unit:	For an average SSD unit:
CO_2e = 17.7 Kg	CO_2e = 6.7 Kg
Energy = 219 MJ	Energy = 90 MJ
Water = 134 m3	Water = 60 m3.
Reconext enables the reuse of several millions of units annually.	Reconext enables the reuse of several millions of units annually.

For every 1 million HDDs + 1 million SSDs processed, Reconext estimates the following environmental benefits:

18,732t CO2e - Equivalent to **19,412 air passenger journeys** between the US west coast and Europe, or 46 jumbo jets on same route

237,409,191 MJ of energy – Equivalent to **powering 6,010 US household** for a year

153,067,175 m3 of water – Equivalent to **61,227 Olympic-size swimming pools**

3 Solvay

Enhancing durability with specialty polymers

Perfluoropolyethers (PFPEs) are a straight polymeric chain, which offers unmatched technical performance thanks to their extremely high thermal stability, low evaporation weight loss, excellent low temperature behavior (-80°C) and safety (oxygen stability, chemical inert-ness, non-flammability). This class of polymeric oils can be used directly as lubricants or as base oils for making greases and can dramatically enhance the durability of a moving part, such as a bearing, to the extent that no maintenance is needed during its entire lifetime. Because of that outstanding durability, coupled with excellent lubricating properties, the quantity of product needed for the entire life of the bearing also goes down considerably.

Below are examples of oil applications in Sintered Metal Bearing (SMB) and greases in ball bearings, (oil or fluid ensures permanent lubrication of these bearings)

Bearing application: Lubrication of electric motors for cooling fan in automotive and home appliance [1].

Table 1: Lifetime comparison at 130°C of electric motors each with two Sintered Metal Bearings impregnated with a PFPE (0.25 g oil / SMB) vs. electric motors with two bearing lubricated with silicone oil and polyalphaolefin (0.15 g oil / bearing + 1.7 g oil / reservoir)

Lubricant	Silicone oil	Polyalphaolefin	PFPE
Running time	1280 h	500 h	> 2880 h
Lifetime	44.4%	17.4%	100%
Oil quantity / motor	3.70 g	3.70 g	0.50 g
Total oil consumption	8.32 g	21.3 g	0.50 g

PFPE far exceeds performance compared to other oils, which results in lower consumption of lubricant per electric motor in the presence of PFPE (0.50 g) vs 8.32 g with silicone and 21.3 g with polyalphaolefin and no need for maintenance or much lower frequency of maintenance over the life cycle of the bearings.

4 Suez

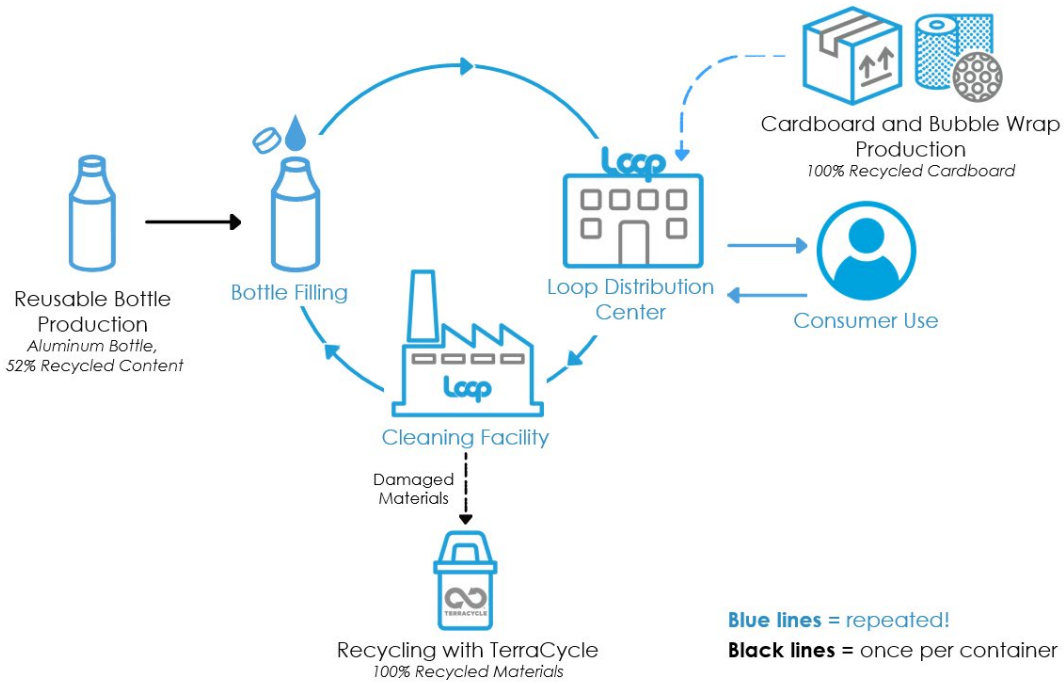
Loop initiative with TerraCycle

Today, a high proportion of waste comes from packaging and this is therefore a high focus area in public policy, with many policymakers looking to eliminate single use plastic packaging and/or encourage higher rates of recycling. Reuse is an additional way to achieve the same objective. To this end, Suez has been supporting TerraCycle with the LOOP initiative since 2017, starting with the US and France.

Loop is a new global shopping platform aimed at eliminating waste and greatly improving the delivery, design and features of products. The system is the first-ever global platform to partner with major brands and retailers with the objective of shifting from a disposable to a durable supply chain where manufacturers own their packaging in the long term and thus, are incentivised to reuse it, or effectively recycle it when reuse is no longer an option. Customers don't own the packaging. Instead, they pay a small deposit on the packaging, which is returned to them when they return the empty packaging item.

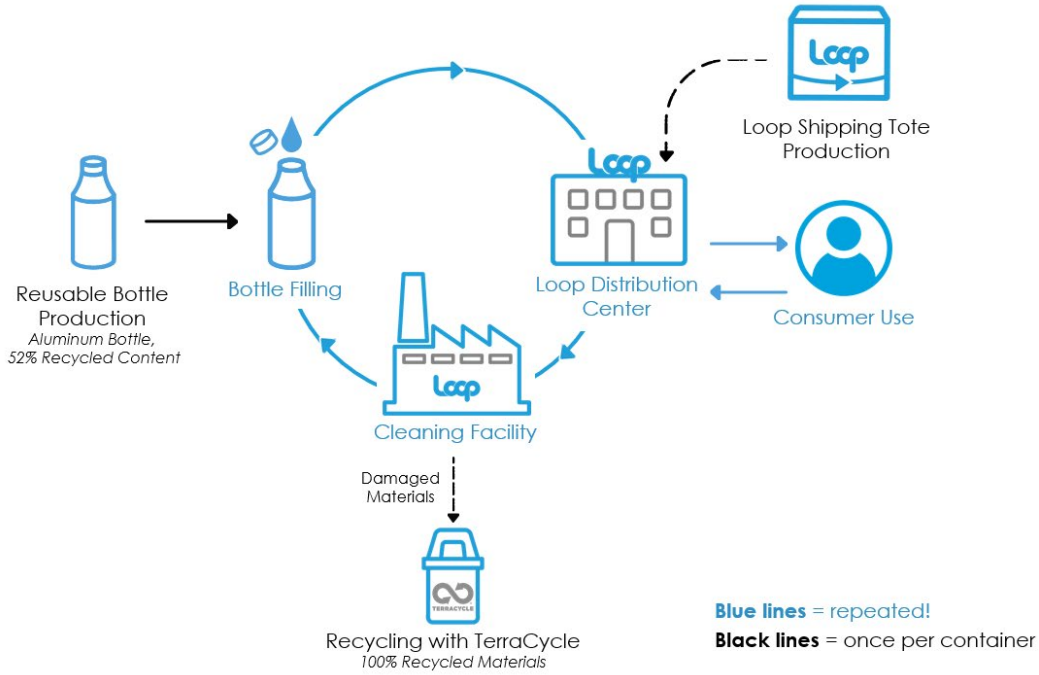
E-commerce models

The traditional e-commerce model:



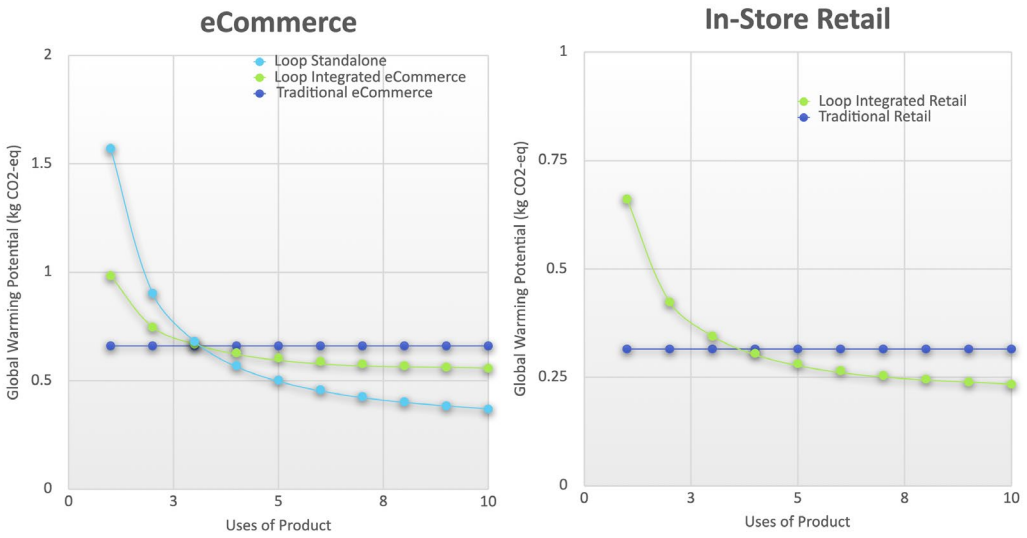
Consumers purchase products online in disposable, single-use packaging and, most often, receive those packaged products in cardboard boxes with bubble wrap or polystyrene. When consumers are done, **they dispose of the product packaging and shipping packaging in bins for landfill, incineration, or recycling.**

Loop can be developed in a Stand-Alone or Retail eCommerce Model.



Loop Stand-Alone eCommerce Model: Customers purchase products online, on Loop e-commerce platform, in durable, reusable packaging and receive them in reusable Loop shipping Tote. When consumers are done with the products, the containers and Loop Tote are shipped back by a delivering partner to Loop to be checked-in triggering the deposit refund to the consumer. Once sorted and cleaned by Loop, the containers are sent back to the brand to be refilled

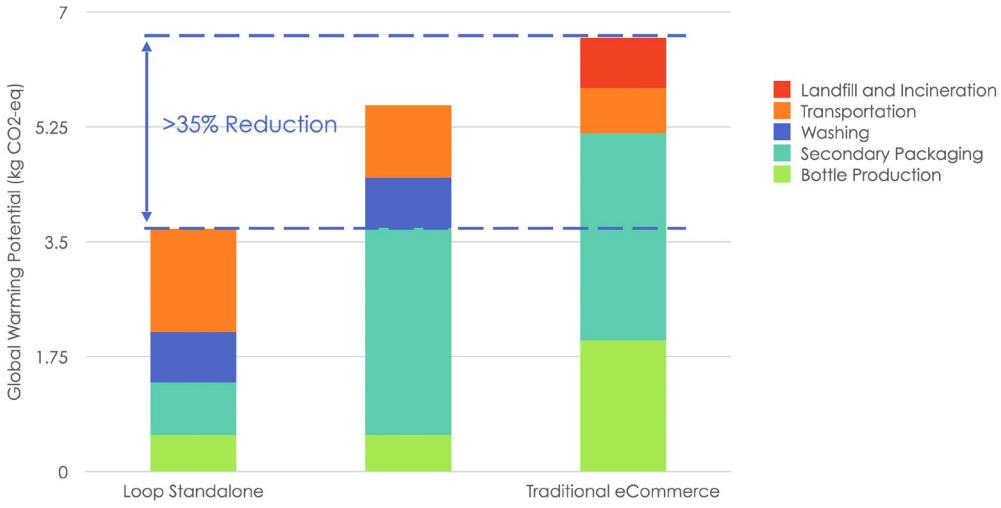
Loop integrated in the Retail eCommerce differs with the retailer's e-commerce platform and shipping being used for the logistics.



Using Loop helps reduce carbon emissions significantly. At 3-4 uses, Loop beats traditional linear models by reducing environmental impact, whether via e-commerce or in-store retail.

The number of uses of a durable packaging is the biggest factor for its environmental impact. The more a packaging can be used, the lower its impact per use.

And after 10 cycles, Loop ecommerce models show >35% reduction compared to other e-commerce models



Source: Life Cycle Assessment of Loop as compared to e-commerce and retail – reviewed by LTS (Long Trail Sustainability) in 2019

For packaging, reuse is the most impactful solution from an environmental perspective, when implemented with the appropriate logistics process and packaging design.

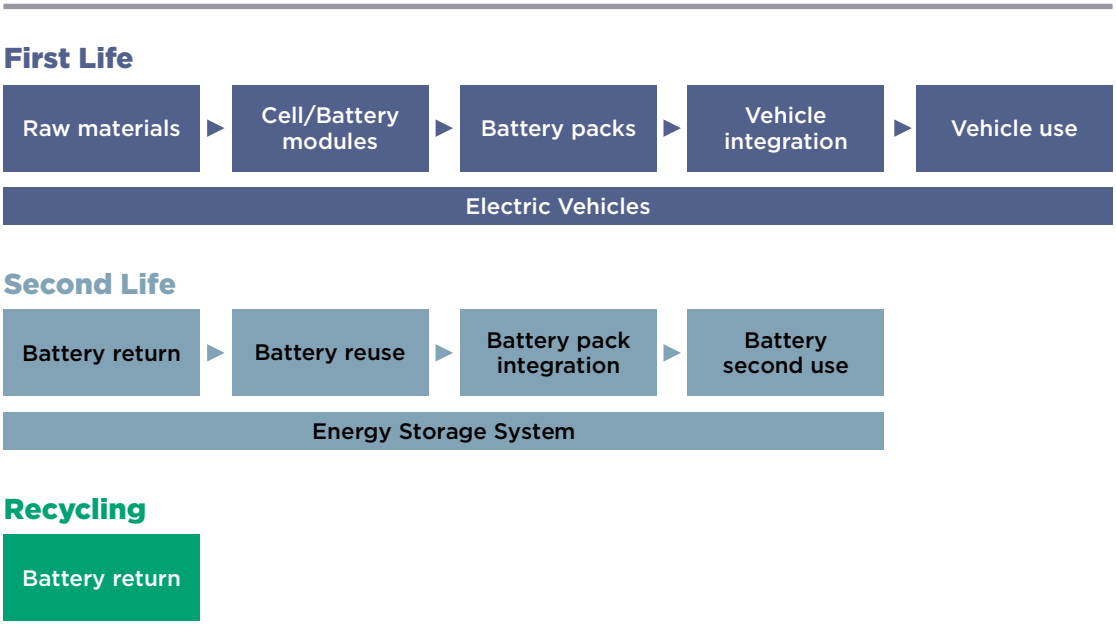
5 Enel

Second Life for Electric Vehicle Batteries

One of the challenges that the Enel Group is tackling, with the objective to encourage the responsible use of resources and environmental concerns, involves end-of-life management of energy storage systems using a circular economy framework.

In recent years, lithium batteries in particular have played a fundamental role in the energy transition away from fossil fuels and will continue to do so in the near future. For this reason, Enel is adopting an integrated approach towards the end of life for batteries, investigating various circular business models, including inner loops.

The concept underlying the Second Life project is that at the end of an e-car's life, the battery pack is removed from the vehicle and made available for other applications, or is recycled. For example, a battery pack with residual capacity greater than 65%, even if not matching minimum requirements in terms of autonomy (i.e. kilometers) needed for an automobile, can still be used efficiently in other applications.



Energy storage value chain: EV batteries second life

Specifically, the Second Life project developed by Enel Group involves reusing e-car batteries to create a stationary storage system integrated with a conventional power plant in the Spanish location of Melilla.

The project – developed in collaboration with Nissan as supplier of battery pack and Loccioni as the system integrator – promotes sustainable battery reuse. Once they have reached the end of their life in an e-vehicle, the e-car batteries from Nissan Leaf models are assembled into a large stationary electricity storage facility integrated with the conventional power plant in Melilla to improve grid reliability, ensuring service continuity for the local population.

The solution developed in Melilla involves reusing and interconnecting about eighty e-vehicle battery packs for a total power output of 4 MW and a maximum stored energy of 1.7 MWh.

From a circular economy point of view, reusing EV battery packs as stationary storage is a real application of product life extension that avoids the production of new batteries, thus leading to a lower environmental impact and the reduction of primary resource usage and waste production. In the specific case of the Melilla project, the reuse of EV batteries avoids the use of raw materials as listed in the following figure.

~1.600 Kg	150 Kg	
Manganese	Lithium	Cobalt, Aluminium, ...

Preliminary estimation (Source: Enel Internal Evaluation)

The cutting-edge Melilla Storage unit can serve as a model of technical feasibility for other installations of this kind, especially if we consider the sharp rise in the number of e-vehicles on the road expected over the next few years, with a consequent increase in the number of batteries available at the end of life.

Reference: Batteries on wheels: the role of battery electric cars in the EU power system and beyond + Technical Appendix (ElementEnergy) http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/06/Element_Energy_Batteries_on_wheels_Public-report_4th-June-2019.pdf

http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/06/Element-Energy_Batteries-on-wheels_Technical-appendix-_June-2019.pdf

Conclusions & Recommendations

As demonstrated in the examples provided, there is a lot of value to be captured with inner-loop strategies.

However, there seems to be a more persistent focus, especially by policymakers, on outer loops, i.e. incorporating recycled plastics into products, as evidenced by various pacts and commitments put in place for this.

We see a risk that the regulations under preparation may emerge as too "resource/waste centric". We believe that one of the biggest impacts of the circular economy will come from evolving business models allowing a longer product life span, including reparability, upgradability, "retrofit-ability" and maintenance.

Recommendations:

Taking all the above information into account, below are some recommendations to policymakers regarding potential future standards and regulations to enable a circular economy:

- A sector specific approach should be acknowledged and adopted for all ongoing and future circular economy regulations, to avoid a one-size-fits-all approach. Differentiation should particularly apply in recycled materials content: all resources are not equal in terms of thermal, mechanical, or electrical profile, for instance, and for a wide range of products virgin materials can't be replaced with recycled ones at a large scale. Rather, as highlighted by the case studies, there is a need to promote inner loops so that the products and materials are kept in-use and at their maximum value for as long as possible.
- Safety of people and assets must be top priority and go hand-in-hand with the inner loops of a circular economy. Leveraging the circular economy framework, we believe there is a fantastic opportunity to enable more repair, retrofit, and recycling services, provided concerned product categories are adequately maintained and serviced only by qualified and certified experts. This will ensure the security and safety of people and assets.
- Market surveillance: to increase liability and compliance of products placed onto the market, a strong focus has to be placed on market surveillance and the fight against disloyal practices. The organisations that follow the rules should not be penalised if other players are not doing the same and not being penalised for it.
- Review of any current regulations that prevent the use of functioning components during the refurbishment of professional equipment or the reuse of products or components (e.g. regulatory barriers to trade in used products destined for remanufacture or reuse) .
- Financial incentives to promote inner loops to further facilitate the development and adoption of such inner loops. There is a need for specific incentives, such as reduced VAT, lower social charges on labour costs, lower reverse logistics costs and favourable taxes on extension of product lifespan overtaking the recycling option. For example, public procurement policies promoting inner loops would help in further adoption.

About the Ellen MacArthur Foundation

The Ellen MacArthur Foundation was launched in 2010 with the aim of accelerating the transition to the circular economy. Since its creation, the charity has emerged as a global thought leader, putting the circular economy on the agenda of decision-makers around the world. The charity's work focuses on seven key areas: insight and analysis; business; institutions, governments, and cities; systemic initiatives; circular design; learning; and communications.

Further information: ellenmacarthurfoundation.org | @circulareconomy

About the circular economy

The current 'take, make, waste' extractive industrial model relies on the consumption of finite resources. The circular economy offers a positive way forward by redefining growth to focus on society-wide benefits. It entails redesigning material flows and production systems to build economic, natural and social capital. Underpinned by a transition to renewable energy sources, the circular economy is built on three principles: design out waste and pollution; keep products and materials in use; and regenerate natural capital.

The circular economy is gaining attention thanks to the opportunities it offers businesses to capture new value from existing operations and resources, for example by redesigning products and business models, building new relationships with customers, and harnessing technology to increase the utilisation of assets.

About the Ellen MacArthur Foundation network

The Ellen MacArthur Foundation's Network is the transition to a circular economy. It is the decisions that are made within the organisations that we work with, and those that we don't, that will mobilise a circular economy at scale. Creating a systemic shift of this nature will take pressure from all actors: businesses, governments, educators, innovators, investors, and beyond. The Foundation works with the world's leading and most influential organisations with transformative potential, across multiple sectors and industries, to demonstrate what is possible.

Further information: Our Network | network@ellenmacarthurfoundation.org