THE POTENTIAL FOR HIGH-VALUE REUSE IN A CIRCULAR ECONOMY

2015

NEDERLAND CIRCULAIR!

circle economy

MVO NEDERLAND

Het Groene Brein
wetenschappers voor een duurzame economie

ABOUT THE AUTHORS

About Circle Economy

Circle Economy is a non-profit social enterprise that aims to accelerate the transition towards a circular economy. We strive for an economy that is self-sufficient, abundant, everlasting and regenerative. Together with our partners we move away from our current linear economy by collaborating on concrete circular projects and by building the knowledge and skills that are needed to redesign our society. We are a fast-paced startup that is collaborating with a diverse group of stakeholders - from startups to multinationals (such as Philips and DSM), from knowledge institutions to governmental organizations (such as our MP and Dutch municipalities), and from NGOs to individual change agents.

About MVO Nederland

MVO Nederland inspires, connects and strengthens companies and sectors to take far-reaching steps in the field of corporate social responsibility (CSR). MVO Nederland is developing a dynamic and fast-growing business network, counting not only beginners among its members, but also advanced users and leaders, both SMEs and big business. MVO Nederland shows them the market opportunities of CSR, facilitates mutual collaboration and gives practical information on actually getting to grips with CSR.

CONTRIBUTORS

About Het Groene Brein

Het Groene Brein is an innovative scientific network. It connects driven scientists and lecturers who, within their own discipline or field, accelerate sustainability and are actively seeking cooperation with sustainable business. Het Groene Brein aims to increase knowledge in the field of business and sustainability by connecting and immediately applying this knowledge in practice with front-running companies, through publications, projects and studies.

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1. INTRODUCTION

The Circular Economy

The term 'circular economy' has become a buzzword in policy and business circles in recent years. The concept presents an inspiring landscape of opportunity that could be gained through moving towards a 'circular economy', which can be broadly defined as an economy that is regenerative and waste-free by design.

Governments recognise this new philosophy as an opportunity for job creation and for stimulating alternative business models and purchasing patterns that could structurally support the recycling and reuse of products, components and materials, such as leasing models and advanced approaches to extended producer responsibility. This enthusiasm with governments, particularly in Europe, has led to the establishment of government programs that take on circular economy objectives. The concept appeals particularly to the business community due to the vast financial gains that it may bring i.e. as presented by the Ellen MacArthur foundation in 2011. This financial gain can theoretically be achieved by recovering all raw materials that are currently disposed of in the linear 'take, make, and waste' system.

In their study of 12 primary sectors, the Ellen MacArthur Foundation (2012) reported that, "based on detailed product level modeling, the report estimates that the circular economy represents a net material cost saving opportunity of $340 to $380 billion per year at EU level for a 'transition scenario' and $520 to $630 billion per year for an 'advanced scenario." For the Netherlands, TNO estimated the total market opportunities of a more circular economy to be nearly €7.3 billion a year, roughly 1.4% of the GDP, and approximately 54,000 jobs. The majority of these benefits, nearly €3.3 billion per year could be achieved in the short-term (Bastein et. al., 2013).

The challenge is to translate the 'circular economy' concept into a set of operational measures that go beyond the currently established broad principles e.g. 'designing out waste' and 'thinking in systems'. The goal is to connect the main objectives of the circular economy with the daily decisions that companies and policy makers face regarding material selection, product design, business models, recycling policies, and many other key decision points. It is clear that there remains a great deal of complexity to work out in order to come up with applicable and consistent guidelines.

Realising the Acceleration towards a Circular Economy

In order to capture the opportunities identified within the circular economy and develop the guidelines through public-private partnerships, the Dutch government initiated the RACE program - Realising the Acceleration towards a Circular Economy - in September 2014. With the Dutch Ministry for Infrastructure and the Environment (Dutch: Infrastructuur en Milieu), a group of research and not-for-profit organisations came together to form the RACE coalition in order to identify how the Netherlands can become a frontrunner in creating a circular economy.

The RACE coalition focused on 7 different themes in the acceleration towards a circular economy:

- Theme 1: Defining and stimulating circular design
- Theme 2: Studying and stimulating high-value reuse
- Theme 3: Making an inventory of (perceived) barriers

- Theme 4: Stimulating and accelerating new value chains
- Theme 5: Creating a portfolio of circular project examples
- Theme 6: Raising public awareness around the topic of circular economy
- Theme 7: Involving young people in the transition towards a circular economy

The main goal of Theme 2 within RACE is to encourage greater reuse of products and components in order to preserve the value and complexity of products in the most economically feasible way. In order to achieve this goal, the RACE Theme 2 program aims to:

1. Identify the need for high-value reuse in the context of the circular economy, the barriers and role of the Ministry in stimulating high-value reuse, and definition and potential of high-value reuse
2. Develop a product typology framework and do-it-yourself kit for companies that can be used for self-assessment to identify high-value reuse strategies and view case studies for each strategy
3. Finalize and start 3 pilot projects with a strong business case for high-value reuse and a clear outlook on how tangible results will be achieved to promote greater reuse within 3 product groups

This report addresses the first objective of the RACE Theme 2 program.

2. NEED FOR HIGH-VALUE REUSE

Destruction of Value in the Current State

The production of products and services requires the extraction of resources to supply materials, energy, and sustain labor. Products are produced by fabricating parts and components from these materials, manufacturing products using parts and components, and marketing and selling them to consumers. Each of these steps increases the value of the product through the additive expenditures of materials, energy, and labor utilized in the production process, as shown in figure 1.

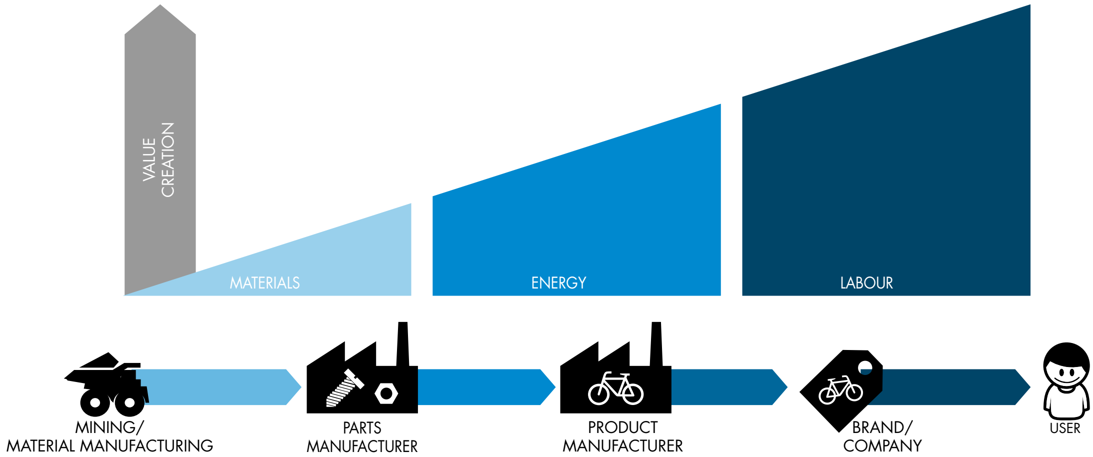

Figure 1. Value creation in the production process

Once the product reaches its end-of-use, however, the value created during the production process is almost completely lost given current waste management practices. In 2010, total waste production in the EU, which is very progressive compared to other parts of the world, amounted to 2,520 million tons. From this total only a limited share, around 36%, is recycled, while the rest is landfilled or incinerated. Six Member States have already effectively eliminated the landfilling, reducing it from 90% to less than 5% in the past 20 years and reaching recycling rates of 85% in certain regions. In others, however, over 90% of waste is still landfilled and less than 5% is recycled (European Commission, 2014). Landfilling and incinerating products represents a significant destruction of value, as shown in figure 2, since the product's' value is either disposed or completely destroyed.

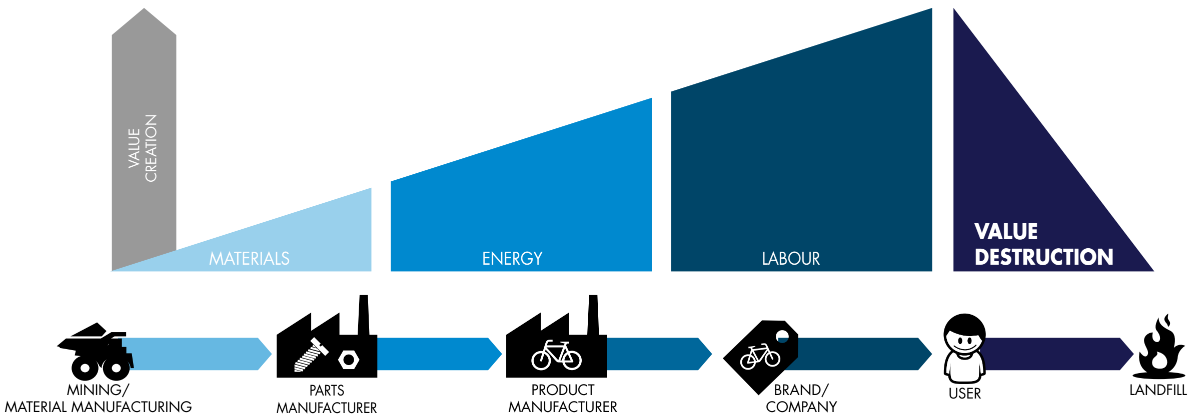

Figure 2. Value destruction in through landfilling and incineration

The destruction of value in current end-of-use waste management scenarios means that significant amounts of resources are wasted throughout the production process from extraction to disposal. As a result, more primary resources are required in order to meet the ever growing needs of society. However, over the past decade, there has been a dramatic increase in price volatility and the supply risk of essential resources - , which have critical impacts on environmental sustainability and economic prosperity (Benton & Hazell, 2013), and this trend is expected to continue.

Projections suggest there is a large demand growth for major resources – from fossil fuels to food, minerals, fertilizers and timber – until at least 2030. The scope and size of resource consumption globally are significant enough to risk overwhelming the ability of states, markets and technology to adapt. Expanding the supply of these resources requires dramatic shifts that increase the resource intensity of production and further exacerbate the problem. In addition, given the interconnected nature of the global economy, local disruptions – whether from extreme weather or labour unrest – can rapidly translate into higher resource prices in international market, making price volatility and resource scarcity the new normal (Lee et. al., 2012). Thus, there is a direct need to reduce the destruction of value of existing products and the dependence on primary resources.

In this context, the Netherlands can be seen as one of the leaders in end-of-use waste management. Though the total amount of waste generated only amounts to 3% of the EU total, nearly 77 million tons annually, the Netherlands has a recycling percentage of 67% (52 million tons) while only 15% (11 million tons) is incinerated or disposed (Central Bureau of Statistics, 2014). As figure 3 highlights, recycling ensures that a significant part of the value created in the production process is somewhat preserved instead of completely lost through landfilling or incineration.

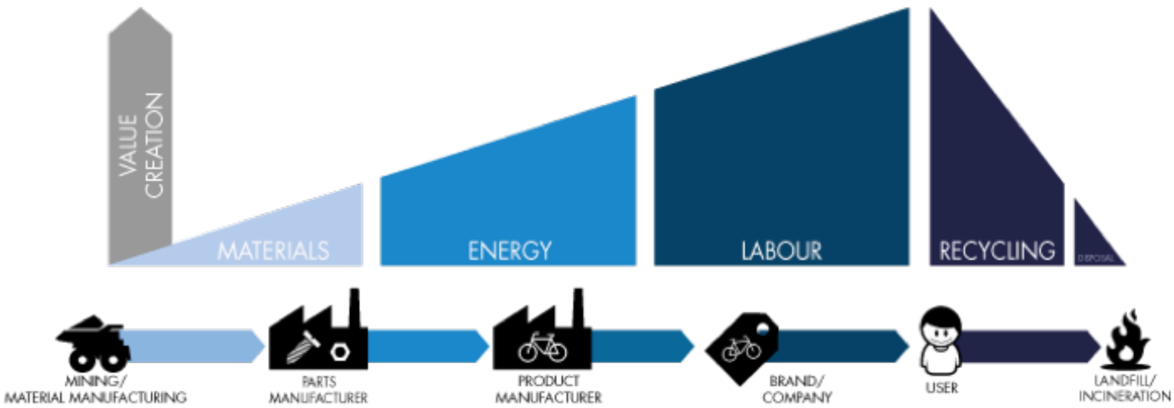

Figure 3. Value preservation through recycling

Recycling, however, is limited in its ability to preserve the value of products only at the material level. In many cases value could be preserved at the level of components or even complete products, thus wasting less of the energy and labour that was put into making the products. Thus, recycling can only tackle some of the issues related to resource scarcity and price volatility (Benton & Hazell, 2013). There are opportunities to preserve the value of products, such that not only the material value is recovered, but the labor, energy, investment and other types of inputs are recovered as well.

Greater Preservation of Value through Reuse

At its best, higher value preservation through reuse within a circular economy restores products and components that have reached their end-of-use back to their original state in a way that consumes the least amount of resources to deliver the same or improved function. In this way, the value of products are preserved at the highest level, reducing the level of risk associated with price volatility, resource scarcity, energy demand, and environmental impact.

For example, let's take a very simple product such as steel beams. Data from the International Iron and Steel Institute and the UK Steel Construction Institute show that the lifecycle costs and energy requirements for reuse are significantly lower than for recycling. While recycling reduces costs by 10% and energy use by 50%, reuse reduces costs by nearly 40% and energy use by nearly 80%. Figure 4 highlights the results from this study in the California Management Review. (Geyer & Jackson, 2004).

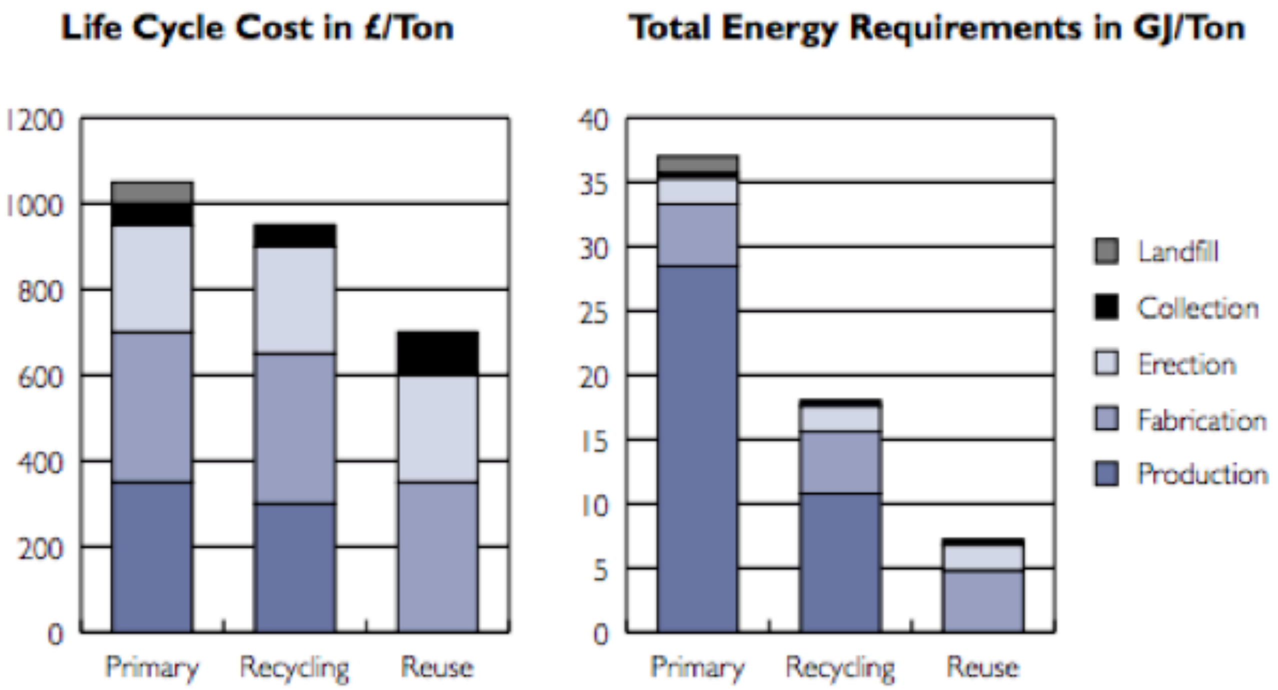

Figure 4. Benefits of reuse over recycling of steel beams (Geyer and Jackson, 2004)

In their study on a Resource Resilient UK, the Green Alliance noted that the value of both complex finished products, such as cars and phones, as well as more simple products like shirts are many times greater than the raw materials or components in them due to the creation of value during the production process. When looking at the preservation of this value at the end-of-use, the study found that for many of the products, reuse instead of recycling provided the highest value recovery to businesses and the greatest mitigation of risk, as shown in figure 5 (Benton & Hazell, 2013). For example, for a smartphone, reusing the products provides a value of 290 British pounds (about half of the original product value), whereas the recycling value is only 72 pence.

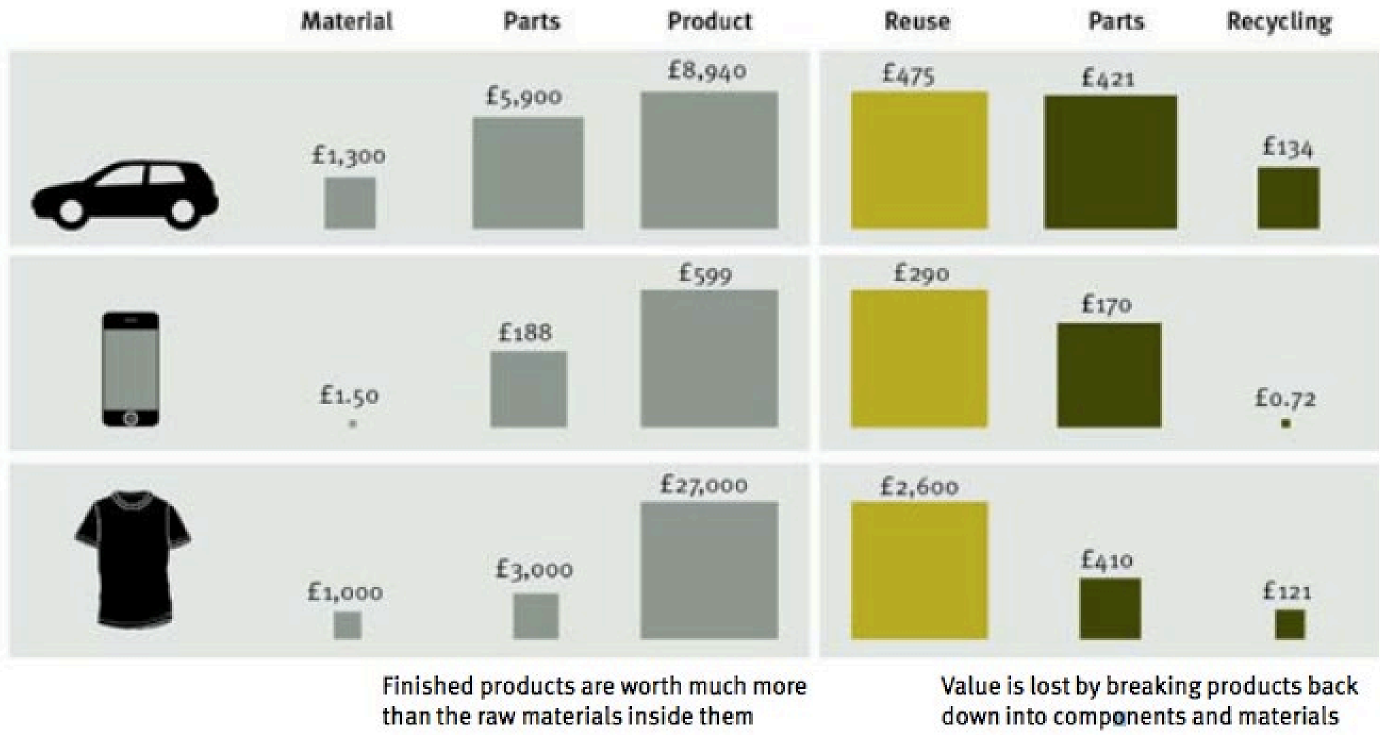

Figure 5. Creation and preservation of value along the product chain (Benton & Hazell, 2013)

Similarly, in their report on the opportunities for a circular economy, TNO conducted an analysis of the metal and electrical sector comparing the value of reuse and recycling. Summarized in figure 6, the analysis shows that currently the majority of products in these two sectors is recycled, but recycling has a significantly lower value compared to reuse. The report found that this is because the monetary value of raw materials derived from recycling a product is generally only a fraction of the monetary value of the product if it is reused. Thus, the value created by the costs of labour, energy and capital goods during production naturally disappears when products are recycled instead of reused (Bastein et. al., 2013).

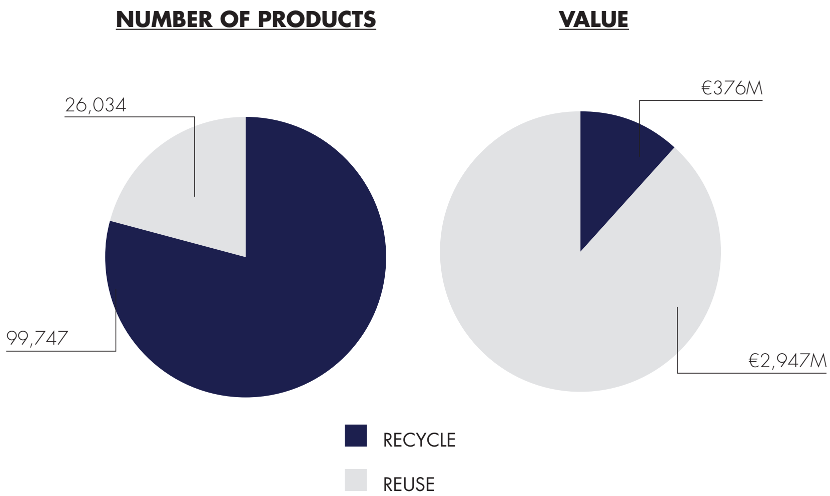

Figure 6. Reuse vs. recycling in the metal and electrical products sector (Bastein et. al., 2013)

Thus, high-value reuse offers a much better preservation of value compared to recycling, while also providing reduced economic and environmental impacts.

Greater Job Creation Potential of Reuse

Studies have emphasized that for every percentage point reduction in resource consumption globally, nearly 100,000– 200,000 new jobs can be created. This could mean that by 2020, nearly 1.4 - 2.8 million jobs could be created within the European Union (European Commission, 2015). A large part of this job creation comes from the greater labor needs of reuse.

In a report by Dervojeda et al. (2014) based on interviews of CEOs, on average, 75% of the energy required to generate a product is used for raw materials production, whereas only 25% is used for actual manufacturing. However, when considering the labor requirements to generate a product, 25% is needed for raw materials production and 75% for manufacturing. Reuse of products such as remanufacturing and repair are even more labour intensive than manufacturing. As a result, greater reuse will lead to significantly higher labor inputs, creating more jobs in the economy (Dervojeda, et al., 2014).

According to TNO estimates, a more circular economy will yield nearly 54,000 jobs in the Netherlands (Bastein et. al., 2013). While the recycling sector will be responsible for a substantial number of these jobs created, reuse through the repair and remanufacturing of broken and obsolete equipment is estimated to generate significantly more jobs compared to landfilling or recycling (Dervojeda, et al., 2014). As figure 7 illustrates, for every 10000 tons of used goods, reuse creates nearly 300 jobs, 10 times the number of jobs created by recycling and nearly 100 times the number of jobs created by incineration (RReuse, 2015).

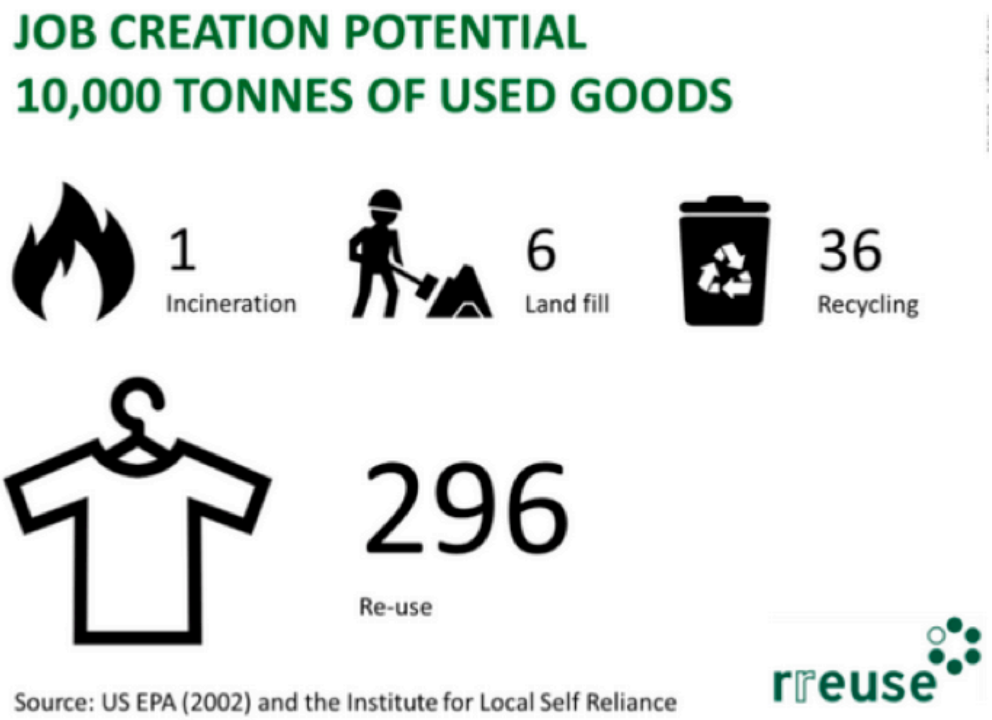

Figure 7. Job creation through reuse (RReuse, 2015)

In addition, greater reuse creates higher-skilled jobs, improving the quality of jobs created. Recycling and waste management offer a larger proportion of low or intermediate skilled employment in the areas of collection, handling, and processing. However, reuse requires more skilled and semi-skilled workers. Furthermore, reuse through more remanufacturing, servitisation and repair, creates employment near existing manufacturing sites where unemployment tends to be higher, giving these areas a significant boost (Green Alliance & WRAP, 2015).

3. OVERCOMING BARRIERS TO GREATER REUSE

Barriers to Achieving Potential of High-Value Reuse

Given the potential for greater reuse, there is the question of why such activities are not currently occurring. From an economic standpoint assuming perfect markets and perfect information, if there are opportunities for reuse, then they will be fully exploited by the market. Following this line of reasoning, one can wrongly assume that there must not be a business case for reuse. However, businesses have struggled to take full advantage of reuse because of barriers within the current linear economy. The underlying rules of the current system make it challenging to capture the complete range of benefits that result from greater reuse.

There are 5 key categories of barriers hindering high-value reuse. These barriers were adapted from the work on RACE Theme 3 by Freek van Eijk to fit the specific challenges of high-value reuse (RACE Theme 3, 2015). The barriers are outlined in the table below and expanded upon in the following sub-sections.

Barrier Type	Description
Knowledge	there is a lack of knowledge to understand the full extent of high-value reuse opportunities and their impacts
Technology	the technology to pursue high-value reuse is either not available or still in development
Market	the dynamics of the market including costs, taxation, incentives, and vested interests makes it difficult to adopt high-value reuse opportunities
Legal	the regulations surrounding the classification and management of waste and end-of-life products prevents reuse activities from being fully utilized
Culture	the nature of consumer behavior and and mindset regarding end-of-life and reuse of products is hard to change to encourage more high-value reuse

Knowledge Barriers

One of the barriers preventing the implementation of high-value reuse is a lack of information on how products can be most effectively reused. Product chains are incredibly complex, involving multiple tiers of suppliers. As a result, intellectual property concerns and heavy competition throughout the product chain create knowledge barriers. In many cases, businesses do not have the right decision making tools or access to the right information, such as the composition of products, in order to make the right tradeoffs. This prevents companies from pursuing end-of-life management and high-value reuse options that are most impactful. (Bastein et. al. 2013) (European Commission, 2014).

Technological Barriers

In cases where a knowledge gap does not exist, a technology gap usually does. The increasing complexity of products makes the effective and efficient recovery and reuse of products and components a massive challenge (European Commission, 2014). Products today use an increasing level of materials and components that are specialized to serve unique functions. In these cases, high-value reuse is not possible because the appropriate technology does not exist to disassemble and appropriately treat the end-of-life streams of products and components in order to reuse them (Vet, 2014).

Market Barriers

In addition, the structure of the traditional linear market presents underlying barriers for why reuse isn't happening as quickly as it could. Fundamentally, companies are not yet convinced about the business case for high-value reuse activities, as they believe that the reuse of products will cannibalize new products (Bastein et. al, 2013). This is largely due to the fact that current levels of resource and input pricing, greater taxes on resources rather than labor, and insufficient internalisation of external costs and externalities prevent companies from taking advantage of the benefits of greater reuse (European Commission, 2014) (Bastein et. al., 2013). Moreover, insufficient access and infrastructure for reuse, split incentives for reuse among actors along the value chain, as well as vested interests in deeply rooted current systems make it more difficult for companies to adopt high-value reuse (European Commission, 2014) (Circle Economy & IMSA, 2013).

Legal Barriers

Often high-value reuse opportunities are hindered by legal and institutional barriers though the knowledge and the technology is available to capture reuse opportunities. There are many challenges in moving to more circular reuse and recovery models from a legal and policy perspective. For one, distorted subsidies and lack of defined waste classifications as "by-products" instead of "waste" prevent current waste streams from being optimally reused such as through component harvesting. In many cases, the lack of clarity encourages incineration or recycling over reuse (RACE Theme 3, 2015). In addition, strict EU regulations around increasing recycling rates has incentivised the export of waste out of the EU. This increasing level of trade of waste streams has resulted in the loss of valuable resources that could be reused, such as the loss of platinum group metals exported from Europe in used cars to countries that lack the recycling rules and technologies to recover them (EEA, 2012). Regulation around ownership also poses an issue for taking advantage of reuse opportunities, particularly in cases of insolvency for leasing constructions or permanently fixed assets (RACE Theme 3, 2015). Since service providers cannot legally retain ownership of a sold product, it becomes a more difficult proposition for them to be able to take-back products for reuse (Worrell, 2014).

Cultural Barriers

From a social perspective, there is also a big barrier in terms of consumer awareness and consumer perception towards products and components that are reused. There is an ingrained pattern of behaviour and perception that reused products are worse than new products. This mainly comes from quality, safety, and health concerns which spark a desire for new rather than used products. Oftentimes, these concerns are unwarranted, since products that are reused are often of the same or sometimes even better quality and safety level than new products (Worrell, 2014).

Role of the Ministry and the RACE Program

To address the barriers to reuse described in the previous section, the Dutch Ministry of Infrastructure and Environment and the RACE Program consortium can work together with businesses and key stakeholders to develop resources, tools, guidelines, and policies that ease or remove these barriers and encourage greater high-value reuse. These opportunities are described in the table below.

Barrier Type	Opportunity to Address Barrier
Knowledge	Put forward tools, guidelines, and frameworks to educate municipalities, businesses, consumers about reuse
Technology	Incentivize and support programs to research and innovate technological solutions for greater reuse
Market	Collaborate with other Ministries to enact new legislation and modify existing legislation to promote greater reuse activities
Legal	Promote public-private partnerships that encourage and sustain cooperation between businesses around reuse
Culture	Create awareness programs to shift the mindset of consumers towards greater reuse

As part of the objectives of RACE Theme 2, Circle Economy and MVO Nederland have worked with the Ministry to develop the necessary tools and resources to define high-value reuse and measure its potential. Disseminating these tools to the broader business community, society, and policy makers can play a vital role in encouraging greater adoption of reuse over recycling in the Netherlands and abroad.

Another objective of Circle Economy and MVO Nederland within RACE Theme 2 is to initiate pilots with private sector around high-value reuse for 3 product groups. By planning and implementing successful pilots, the RACE Theme 2 program will be able to highlight examples of high-value reuse, raise awareness of the potential for high-value reuse, and act as a catalyst for broader adoption of high-value reuse.

4. PRESERVATION OF VALUE THROUGH REUSE

Strategies for Reuse

Unlike recycling, within the concept of reuse there are a variety of strategies for the preservation of value of products and components upon their end-of-use.

In their report outlining a roadmap to remanufacturing, InnovatieZuid describe a variety of processes that enable product recovery management (PRM). In addition to recycling, five separate reuse processes are identified. These processes are described in figure 8 below (InnovatieZuid, 2013).

Process PRM	Objective	Disas-sembly	Quality	Result
Direct Reuse	The re-use of the product	No	Remains unchanged, but cleaning and damage control	Cleaned used product
Repair	To recover the product to a usable state	Product level	Restore the product to an usable state	Some parts repaired or replaced
Refurbishment	To recover the used product to a specified quality level	Module level	Inspection of all modules and recovery to specified quality level	Some modules repaired or replaced, upgrading possible
Remanufacturing	To recover the used product to the quality level of a new product	Part level	Inspection of all modules and parts, recover to the quality level of a new product	Used and new modules combined into a new product, upgrading possible
Parts harvesting	Recovery of usable components and modules for reuse	Selective recovery of parts	Depends on where the reusable components are deployed	Some parts reused, the others recycled
Recycling	Recovery of the material of components and modules for reuse	Raw material level	Depends on where the material is applied	Material reused for manufacturing new parts

Figure 8. Processes of Product Recovery Management (InnovatieZuid, 2013).

Similarly, in a report on Reuse Design by Upstyle Industries (2014), reuse is expanded into different forms based on how much of the original product is reused and for what purpose - direct reuse, upgrade, creative reuse, and remanufacturing.

Circle Economy and MVO Nederland expanded on these ideas along with definitions from other literature to create a set of strategies for the reuse of products and components. These strategies are highlighted in figure 9 and explained in further detail in the following subsections.

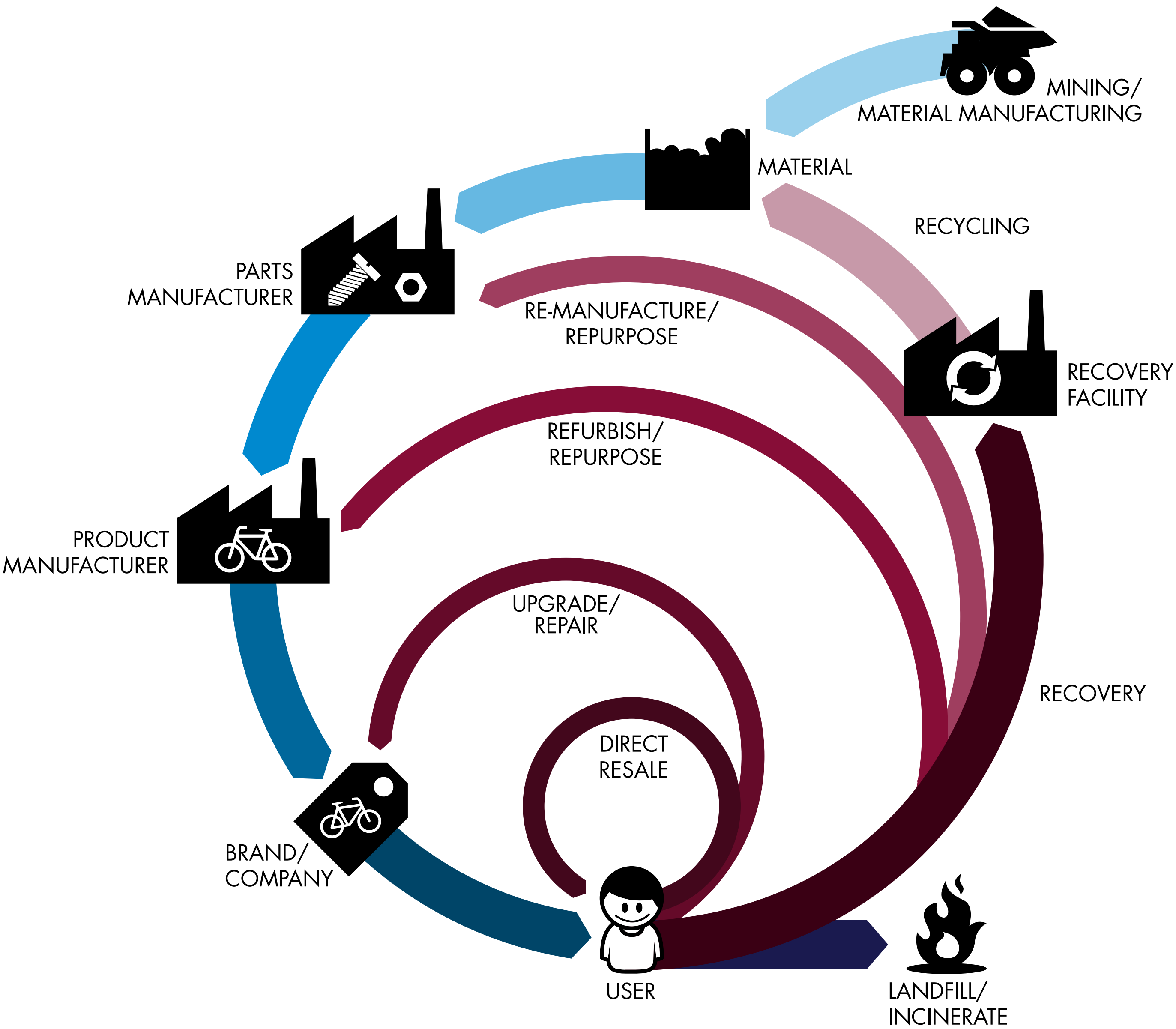

Figure 9. Strategies for high-value reuse of products and components

Direct Resale

Direct resale is the reuse of a product or component in the same form for the same function (Hollander & Bakker, 2012). This pathway is relevant when the product is still functional and has remaining useful life upon end-of-use. Direct resale typically takes place through second-hand markets and product take-back schemes after sale or after the end of lease periods.

For example, EcoATM is a network of automated electronics recycling kiosks, currently deployed nationwide in the United States. When a device is deposited into an EcoATM kiosk, it is scanned for type, serial number, and condition. The EcoATM will then search for the highest price among a network of buyers, and ask if you agree to sell your device. If so, money is exchanged on the spot after proof of identity is provided (EcoATM, 2015).

Repair

Repair involves returning a faulty or broken product back to a useable state. All the original components of a product are maintained and restored in order to bring the product back to working order (Bakker et. al., 2014). This pathway is relevant when the product is no longer functional upon end-of-use. Repair typically takes place through maintenance and repair warranties or companies offering repair services.

For example, Wetering Rotterdam is one of the oldest ship repair companies in North West Europe. Based in Rotterdam, one of the largest ports in the world, Wetering Rotterdam offers a wide range of ship repair and service activities (Wetering Rotterdam, 2015).

Upgrade

Upgrade involves improving the quality or performance of a product (Hollander & Bakker, 2012). The value of the product is preserved by still keeping the original form of the product and only replacing certain parts and components within a product with newer versions. This pathway is relevant when the product has a high level of technological change or design cycle with new innovations, which allows for parts to be upgraded. Upgrade typically takes place when manufacturers or third parties offer upgrade services for products that reach their end-of-use.

For example, Schurgers Design located in Cruquius, Netherlands worked in close collaboration with Dutch Police to upgrade over 350 police bikes across 11 squads to improve their performance and provide additional safety and comfort (Schurgers Design, 2014).

Refurbish

Refurbishment is more extensive than repair, as it involves disassembling products and inspecting parts and components to return the whole product to a satisfactory condition (Bakker et. al., 2014). Unlike repair, where the original parts and components are retained, refurbishment necessitates rebuilding or replacing the original parts. This pathway is relevant when the product has multiple components that have varying lifetimes. Refurbishment typically takes place when product manufacturers take back their products after end-of-use.

For example, Holland Hardware based in Haarlem, Netherlands, refurbishes and sells IT hardware and infrastructure from various brands - Cisco, HP, IBM, etc. They also offer to buy equipment, which have reached their end-of-use, to refurbish and resell them (Holland Hardware, 2014).

Remanufacture

Remanufacturing is similar to refurbishment in that it involves disassembly of products to the component level and repairing those components (Trask, 2006). It differs from refurbishment since it involves either making products with the same quality level of a new product using remanufactured components or selling those components as spare parts. This pathway is relevant for products have multiple independently functioning parts and components. Remanufacturing typically takes place when manufacturers take back their products after end-of-use or when third party companies recover products from the waste stream.

For example, VEGE, a Dutch engine manufacturer located in Spijkenisse, Netherlands purchases defective engines from used vehicles and remanufactures them into new engines. The company also produces a variety of remanufactured vehicle components as spare parts (VEGE, 2014).

Repurpose

Repurposing refers to when products that reach their end-of-use are adapted for a different or entirely new purpose than which they were originally designed (Park, 2014). Repurposing can occur at different levels - entire products can be repurposed and used for new contexts or components of products can be harvested and used to serve a new purpose in a different product. Repurposing can be referred to as "downcycling" when the new purpose of the product or component is at a lower level than the original use, or it can be referred to as "upcycling" when the new purpose of the product or component is at the same or higher level than the original use (Wang, 2011).

For example, SuperUse Studios based in Rotterdam, Netherlands is an architecture firm that has been involved in a number of projects that repurpose products and components. The firm recovers products and components such as wind turbine blades, drive shafts, PVC cable reels, etc. and transforms them into playgrounds, storage spaces, and other uses (SuperUse Studios, 2014).

Level of Value Preservation Along Reuse Strategies

The reuse activities defined above preserve the value of products and components at different levels. Thus, they can be organized and prioritized into a hierarchy based on their value retention capacity. The hierarchy is based partly on the EU Waste Framework Directive, which lays down basic waste management principles and highlights the preference of waste prevention and reuse over recycling and disposal (EU Waste Framework Directive, 2015), as well as the "Circularity Ladder" of end-of-life strategies proposed in a report by De Groene Zaak (2015). As the figure 10 illustrates, these strategies are still much better than recycling and disposal in terms of value preservation.

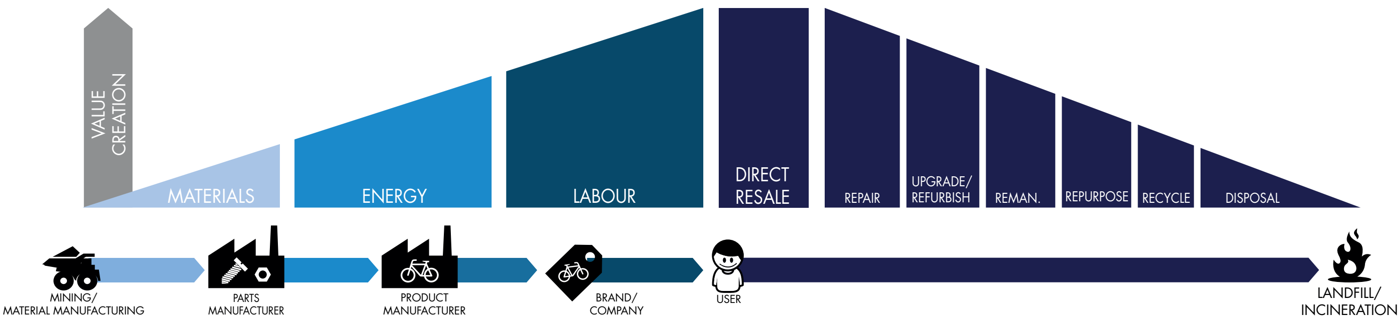

Figure 10. Value preservation hierarchy for reuse strategies

The value created during the production process of a product is preserved at the highest level through direct resale after end-of-use and the second highest level through repair. In both of these cases, the original parts and components are maintained, preserving the value of the products and components. Direct resale preserves a higher level of value than repair, since it keeps the product intact and requires no additional efforts to modify the product.

Upgrading and refurbishing come next in the hierarchy, since they require some level of breaking down the product and replacing the original components and parts. In the case of upgrade, these original parts are replaced with newer models, while in the case of refurbishment, they are replaced with new parts of the same model. As a result, the value created during the production process of the original product is not preserved as well as direct resale or repair.

Remanufacturing and repurposing come towards the end in the hierarchy. In the case of remanufacturing, value created during the production process isn't recovered as highly because it involves breaking down products to the component level. In the case of repurposing, since the product or component is used for an entirely new purpose than it was originally designed, the value created for a product to meet its original function isn't preserved at a high level.

Though the above hierarchy shows how the various strategies for reuse preserve different levels of value, it does not always mean they are the most feasible option currently. The business case and economic feasibility for these strategies may differ from their value preservation potential depending on the characteristics of the product, the dynamics of the market, and other factors. For example, although repair preserves a higher level of value compared to remanufacturing, the business case for remanufacturing for a particular product type could reveal that it is more economically feasible given current market conditions to remanufacture rather than repair.

In order to identify the potential of various reuse strategies to determine the ideal pathway and its economic feasibility, a set of tools and guidelines are required. These tools are described in further detail in section 5.

5. IDENTIFYING THE POTENTIAL OF HIGH-VALUE REUSE

As part of RACE Theme 2, various tools are being developed and tested to uncover the potential for high-value reuse. First, a Product Reuse Framework has been developed, which identifies the various reuse strategies possible based on specific characteristics of a product. In addition, Circle Economy has developed the Assessing Circular Tradeoffs (ACT) Tool, which can be used to identify the economic potential of these reuse strategies.

Product Reuse Framework

While the various strategies for reuse exist, they are not always applicable for all products. Different reuse strategies exist for products depending on their characteristics. For example, strategies of repair, refurbishment, etc. are not applicable for a product that maintains its functionality after end-of-use and upgrade is not applicable for a product that doesn't have fast technological development.

In order to determine which reuse strategies are appropriate given various product characteristics, Circle Economy has developed the Product Reuse Framework, shown in figure 11.

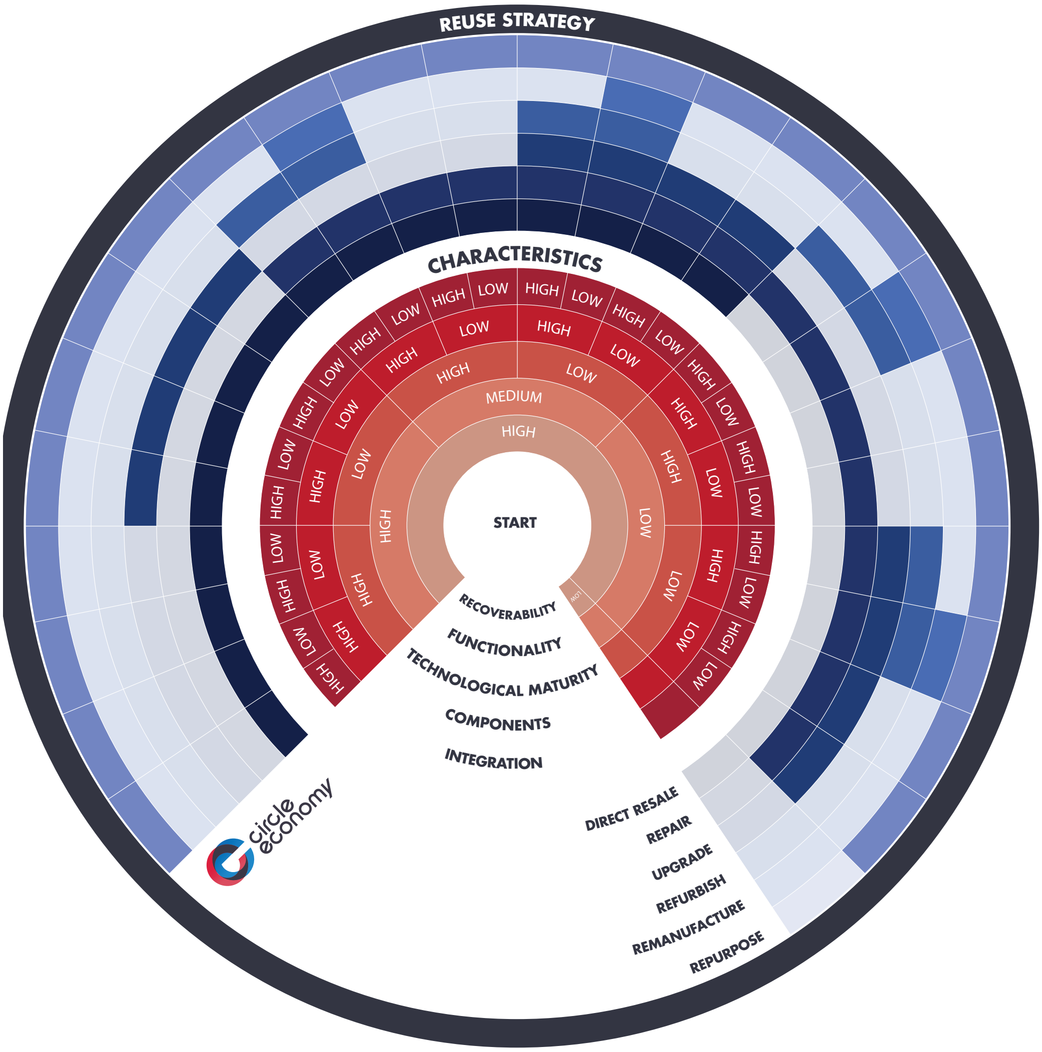

Figure 11. Product Reuse Framework

The framework was developed by reviewing a variety of other frameworks in literature, such as end-of-life design strategies (Rose et. al., 1998), the End-of-Life Design Advisor (Rose, 2000), and the Remanufacturing Engineering Potential (Morley, 2006).

The design characteristics that determine the various reuse strategies are:

- *Recoverability:* measures whether the product can be recovered after use. For example a battery can be recovered after its use, while food or household cleaning agents cannot be recovered after use
- *Functionality:* the average remaining useful life of a product at end-of-use compared to its designed lifetime. For example, a baby stroller designed with a lifetime of 10 years, but reaches its end-of-use after 5 years is still functional and has a remaining useful life of 5 years.
- *Technological Maturity:* the degree of technological change or cycle of new generations of the product. For example, the iPhone has a degree of technological change and cycle of new generations every year, while a table or chair is much more mature technologically.
- *Components:* the number of unique parts made of different materials in the product. For example, a computer is a product with a very high number of components, while a chair is a product with a relatively low number of components.
- *Level of integration:* the independence of product components. If the product has a small share of components that serve the main function, then the level of integration is high, such as for example a water kettle. On the contrary, the product has a large share of components with unique functions, then the level of integration is low, such as for example a car.

As part of the objectives of RACE Theme 2, the Product Reuse Framework will be further explained and developed into a do-it-yourself toolkit in order to act as a resource for companies around high-value reuse. Based on the design characteristics of their products, the product reuse framework will provide companies with an indication of what the most applicable high value reuse strategies are. For example with laptops, as highlighted in figure 12, the characteristics are as follows:

- *Recoverability:* high, since laptops can be recovered after use
- *Functionality:* medium, since laptops typically reach their end of use before their designed lifetime and may not be functional
- *Technological Maturity:* low, since laptops have a fast technological cycle and newer generations are technologically superior to older generations
- *Components:* high, since there are a many unique parts in a laptop made of different materials
- *Level of integration:* high, since there are a small share of components that serve the main function a laptop such as the microprocessor and the hard disk

The toolkit will also include examples of available case studies where businesses have successfully implemented the various reuse strategies for the set of characteristics.

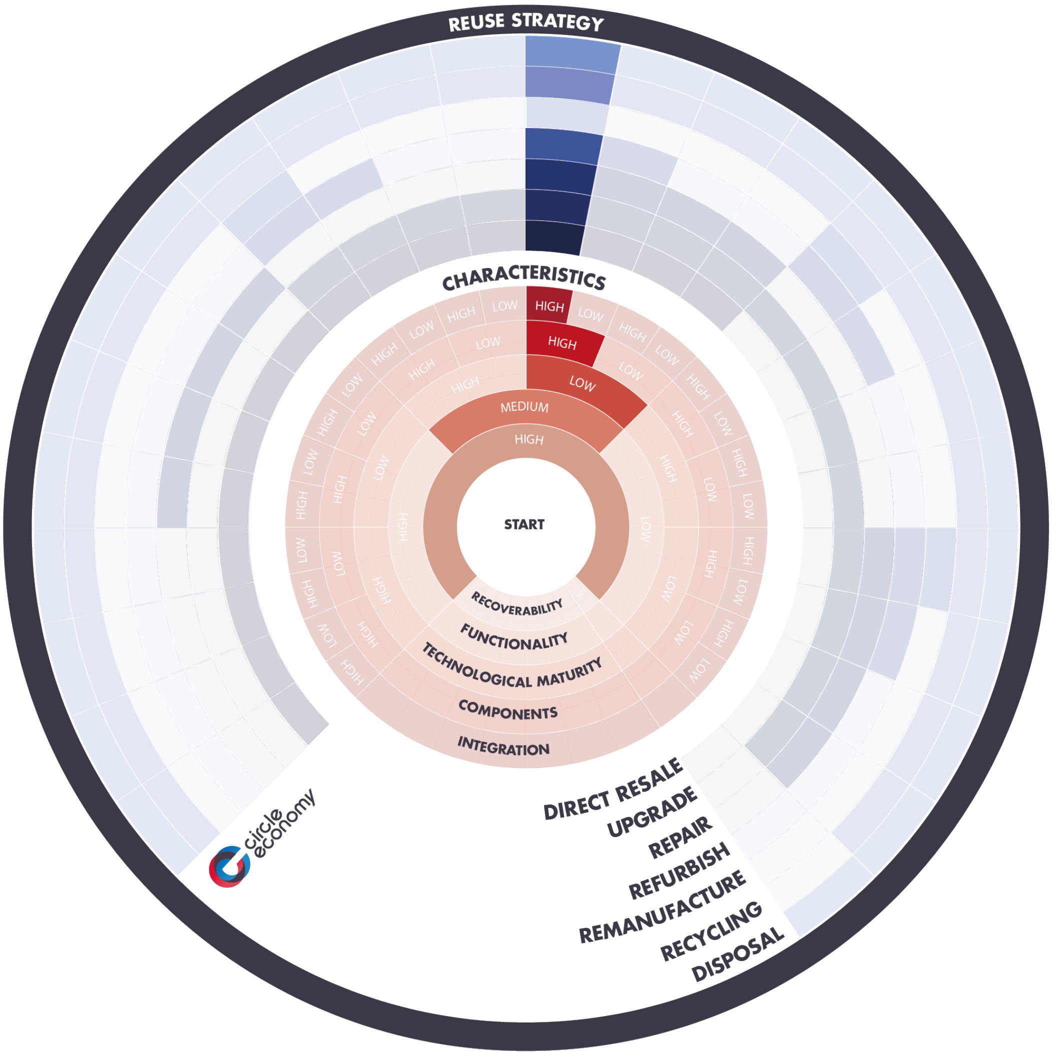

Figure 12. Product Reuse Framework for Laptops

Assessing Circular Trade-offs (ACT) Tool

As mentioned earlier, the reuse strategy with the highest level of value preservation does not always equate to the reuse strategy that is the most feasible due to legislation and market dynamics. In order to identify which reuse options have the strongest business case given current policies and market conditions, and to also determine the various trade-offs and market conditions necessary to promote greater reuse, Circle Economy has developed the Assessing Circular Trade-offs (ACT) Tool.

The tool works by taking into account various production inputs that are used to create value in the production process. Factors such as resource prices, labour costs, resource and labour taxes, energy prices, etc. are accounted for to understand how value is created during the production process and more importantly how this value can be retained through the various reuse strategies, as shown in figure 13.

Using the tool, various actors in the supply chain can understand the business case for them to engage in high-value reuse and identify which reuse strategies that preserve the greatest value also have the strongest business case. These insights will help start discussions around how the value

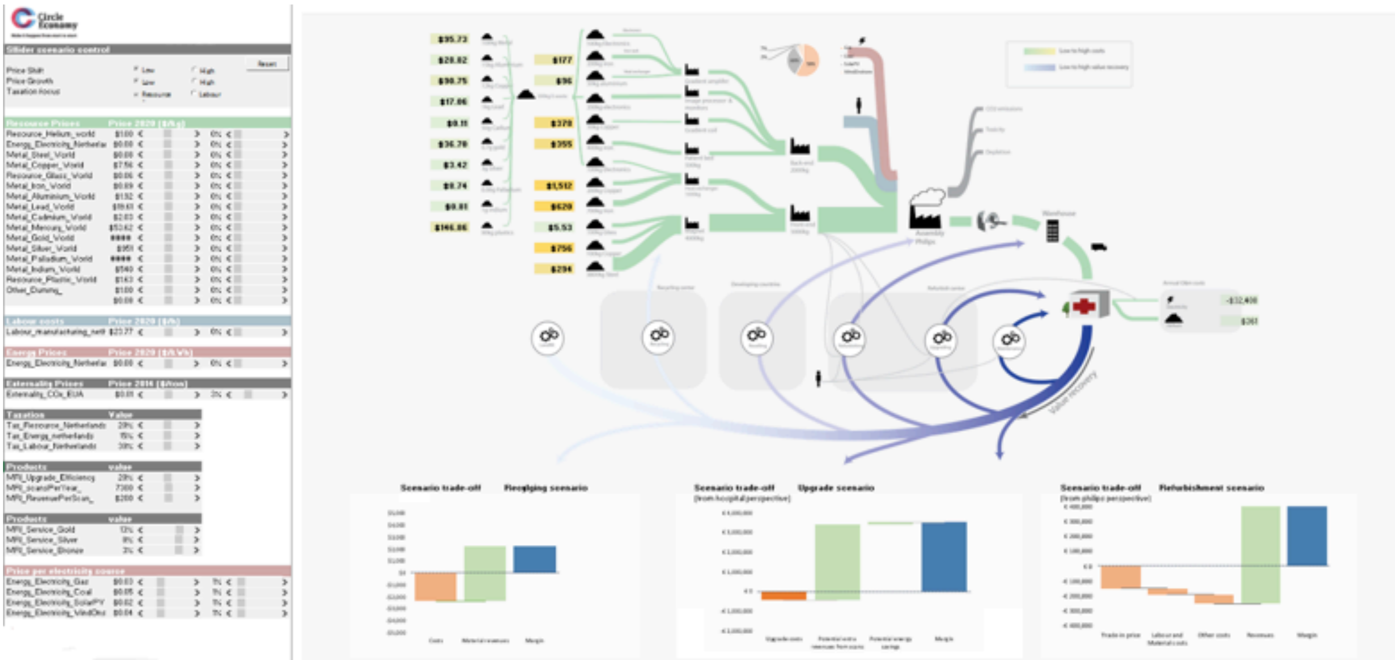

Figure 13. Assessing Circular Trade-offs (ACT) Tool

chain can collaborate to take advantage of the opportunities for reuse, while addressing the various barriers outlined in section 3.

In addition, through the use of sliders, as shown in figure 14, the tool is also able to simulate changes in market conditions and policies to promote reuse strategies that are currently infeasible. Through developing new scenarios, policy makers can work together with the private sector to identify what the enabling conditions are to promote higher value reuse such that there is a sufficient business case for all the actors involved.

Taxation	Value		
Tax_Transport_Netherlands	30%	<	>
Tax_Resource_Netherlands	30%	<	>
Tax_Energy_netherlands	23%	<	>
Tax_Labour_Netherlands	15%	<	>

Resource Prices	Price 2020 ($/kg)					
Resource_Helium_world	$1.49	<	>	1%	<	>
Energy_Electricity_Netherlands	$0.12	<	>	1%	<	>
Metal_Steel_World	$0.11	<	>	1%	<	>

Figure 14. Scenario development to test different market conditions

As part of one of the objectives of RACE Theme 2 to develop pilot projects for 3 product groups, the ACT tool will be central to identify the business case for high-value reuse strategies. During the development and planning of these pilot projects, Circle Economy and MVO Nederland will hold interactive sessions to engage with relevant stakeholders. In these sessions, the ACT tool will be used to identify the business case for high-value reuse strategies under current market conditions, and potential for greater reuse under changing market circumstances.

6. CONCLUSION

From this report we conclude that there is a significant economic & social potential for high-value reuse, and that it is a key element to making the Netherlands a frontrunner in creating a circular economy. But, there are significant barriers that need to be addressed to encourage greater reuse and realize this potential.

The additive expenditures of materials, energy, and labor utilized in the production process increases the value of a product. This value is now almost completely lost given current waste management practices of landfilling and incineration. Though recycling ensures that a significant part of the value created in the production process is preserved, it is limited in its ability to preserve the value of products only at the material level.

High-value reuse within a circular economy restores products and components that have reached their end-of-use back to their original state in a way that consumes the least amount of resources to deliver the same or improved function. In this way, the value of products are preserved at the highest level, reducing the level of risk associated with price volatility, resource scarcity, energy demand, and environmental impact. In addition, high-value reuse also creates more skilled jobs, particularly near manufacturing areas which have higher levels of unemployment.

However, the underlying rules of the current linear economy make it challenging to capture the complete range of benefits that result from greater reuse. There are key knowledge, technological, legal, market, and social barriers that must be addressed for greater adoption of high-value reuse. To address these barriers, the objectives of Theme 2 of the RACE program has a significant role to play.

With this report of the RACE Theme 2 program, Circle Economy and MVO Nederland have defined high-value reuse and developed the beginnings of tools and resources that can be disseminated to the broader business community, society, and policy makers. Circle Economy and MVO Nederland plan to further develop these tools and frameworks within RACE Theme 2 to create a DIY Toolkit for SMEs and companies and encourage greater adoption of reuse over recycling in the Netherlands and abroad.

In addition, Circle Economy and MVO Nederland are in the process of initiating pilots with the private sector around high-value reuse for 3 product groups. By planning and implementing successful pilots, the RACE Theme 2 program will be able to highlight examples of opportunities from high-value reuse. We hope this will act as a catalyst to engage broader collaboration to realize the benefits of high-value reuse.

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