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# The opportunities of a circular economy for Finland

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# Foreword

The circular economy is a hot topic globally and is expected to have huge economic potential. According to estimates by the Ellen MacArthur Foundation, the global circular economy markets are worth more than one thousand billion dollars. Together with McKinsey, the Finnish Innovation Fund Sitra has conducted the first assessment of the circular economy's potential for Finland: even conservative estimates value such potential at around EUR 1.5–2.5 billion.

The circular economy is not just about the efficient use and recycling of materials; it involves a wholly new economic model. The vision underlying the circular economy is zero waste creation: discarded material becomes raw material for the next player. Products will be designed to enable their reuse and recycling, non-renewable natural resources will be replaced by renewables, services will replace products, and energy production will be based on renewable energy sources. Goods and services will be shared, not owned, by individuals and industry.

Companies will find huge economic potential and an opportunity for renewal in the circular economy. Pioneer companies will be able to make efficient use of their material flows and benefit from new, user-oriented business models. As an alternative to owning goods, such business models can be used to provide added value and services for customers. Forerunners in exploiting opportunities will win a large slice of the global market.

Only action will make the circular economy a reality. This report presents consumers, businesses and Finland as a whole with tangible opportunities for action. A long but exciting march towards the circular economy lies ahead of us. But a first step is required in order to begin even the longest journeys. I hope that this study will encourage many players to take such a step.

The circular economy has become a major theme in Finland since Sitra published its report on the topic in November 2014. It was selected as one of the spearhead projects of Prime Minister Juha Sipilä's government programme, which involves a Government investment of EUR 40 million in the circular economy. The related actions are mainly targeted at further improvement of the good ecological status of the Baltic Sea, reduction of the nutrient load in waterways in general, enhancing the nutrient and energy self-sufficiency of agriculture, the growth of circular economy businesses, and the creation of new jobs in general. Meanwhile, the European Union is preparing a new, more ambitious Circular Economy Package aimed at creating an operating environment enabling the transfer to a circular economy.

Sitra is contributing to these developments by fostering a shared strategic intent aimed at moving Finland towards a circular economy. Tools to this end include trial projects related to concrete business models, as well as the sharing of best practices. Sitra studies form part of a Europe-wide network of analyses aimed at assessing the outlook for the circular economy in various sectors, while enabling experiments providing reliable data on the functioning and feasibility of different operating models. Such measures are currently underway in the textile industry, in nutrient cycling, and within cities and technology and export companies. For example, in September 2015 Sitra and Gaia Consulting Oy published a report on the economic value and opportunities of nutrient cycling for Finland.

This work is in its initial stages. The potential of the circular economy has been explored in only a few sectors. Although several major international companies have reshaped their businesses accordingly, we still need more information, research and experiments in relation to the circular economy. All of these elements are vital to the inevitable transformation that lies ahead for mankind.

Helsinki, 1 October 2015

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Sitra Studies 100
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# 1 Introduction

The circular economy presents us with a major opportunity to improve Finland's long-term competitiveness. Global population growth will significantly increase demand for resources, raising the price of raw materials while reducing their availability. Adopting the principles of the circular economy will afford us partial protection from this development trend, by allowing us to step up our reuse of produced resources. At best, this will have a positive impact on Finland's economic competitiveness and our opportunities to create value in various sectors.

The circular economy and its opportunities have long been a topic of discussion in Finland. Such discussion has mainly centred around making optimal use of organic side streams and the recycling of waste.[1]

For instance, together with trade unions, environmental organisations, waste sector operators and the Finnish Innovation Fund Sitra, in the summer of 2014 a coalition of organisations gathered together by the Association of Finnish Environmental Industries and Services (YTP) published a joint statement *Towards the circular economy – Finland's recipe for success*. The ARVI research project recently launched by Cleen-SHOK also focuses on the materials cycle.

In terms of value creation, raw material flows and waste do not represent the circular economy's greatest potential. Far more valuable than these are practices such as the maintenance, reuse and remanufacture of equipment. Raw materials account for only part of the costs and values of products. To enable sustainable resource circulation, all materials should be recycled, but this is only worth doing at the point where no other value recovery processes are economically viable. The starting point should be value and waste prevention of the highest possible efficiency, rather than exploiting the greatest possible waste quantities for raw materials or energy.

A conservative estimate suggests that, by 2030, the circular economy will have value creation potential of EUR 1.5–2.5 billion for Finland's national economy. The huge progress made by Finland in introducing the circular approach to various sectors is already factored into this estimate. The energy-efficiency of the paper industry or investments in modularity in production activities are good examples of this. However, we still generate approximately 90 tonnes of waste a year, 54% of which is not recycled or reused.

We based our assessment of the circular economy's overall potential for Finland on two approaches. (1) *New, individual business opportunities*. We sought these by analysing the material flows and value creation practices of various Finnish sectors. As a result, we identified EUR 1.5 billion in individual business opportunities. This figure covers only those measures whose potential we try to assess in this report. (2) *Based on the Ellen MacArthur Foundation's estimate of the total potential for Europe*. The resulting crude estimate – which nevertheless takes account of Finland's starting point – of the circular economy's potential for Finland is in the same 'ballpark': EUR 1.7–2.5 billion. Our estimate ignores the potential of sectors other than those we cover in detail. It also pays no attention to the opportunities presented by new, yet unknown technologies.

This study aims to present the economic potential of the circular economy, while providing examples of new business opportunities. It seeks to map out the tangible opportunities, particularly for companies, which already lie before us.

1 Exceptions include the DemaNET research project by VTT Technical Research Centre of Finland Ltd. – the first domestic project with a broader focus on remanufacturing.

# 2 What is the circular economy?

The circular economy is based on the sustainable use of resources. This means monitoring, minimising and eliminating waste flows by circulating, rather than just consuming, materials. In practice, this could mean not adding substances to raw materials that could prevent recycling at the end of the product life cycle, or product design that facilitates the efficient end-of-life sorting of constituent materials. The circular economy seeks to base itself on renewable energy. It goes further than the production and consumption of goods or services.

Economic systems tend to be based on a linear "take-make-dispose" production model. Products and production are based only on the initial use of the product and recycling is segregated from production. For the circular economy, however, there is a difference between the consumption and use of materials. Consumed materials become waste, but the circular economy aims to reduce waste through the efficient use of materials and other resources.

From the perspective of the circular economy, current operating models waste value at three key points (Figure 1): **I)** Sub-optimal material efficiency in production. This is largely a matter of how efficiently raw materials are used in end products and waste is minimised during production. **II)** Lost value in waste due to economic activities. A major share of materials become waste following their consumption and use. But the raw materials and reuse value retained in such waste is lost. **III)** Lost value in capturing the value of used material and parts through too low value circle, i.e., recycling the raw material of a part that could have been reused efficiently. We often view recycling as the recycling of raw materials. However, a greater proportion of the product's value can be retained in the economic cycle, by recycling for reuse or remanufacture. The circulation of products and raw materials can be promoted in five ways:

1. **Maintain**: Build products to last longer without repairs and offer maintenance services to prolong product life cycles enabling longer use by the same owner.
2. **Reuse/redistribute**: Reuse the product for the same purpose on the resale markets.
3. **Remanufacture/refurbish**: Plan the product life cycle as several life cycles and resell the product after thoroughgoing refurbishment or remanufacture.
4. **Recycle**: Recycle product materials for reuse and design products so that their materials are easy to sort. For biological materials, it would also be important to consider how to ensure the safe and sustainable return of nutrients to the nutrient cycle following their optimal use.
5. **Cascade**: Make use of a material or parts of it in another value chain, when it can no longer be used in the original sector.

This approach can only be applied in practice if all components and principles of the system support circular rather than linear economic activity. According to the report by the Ellen MacArthur Foundation, this requires adherence to five simple principles forming the basis of the circular economy[2]:

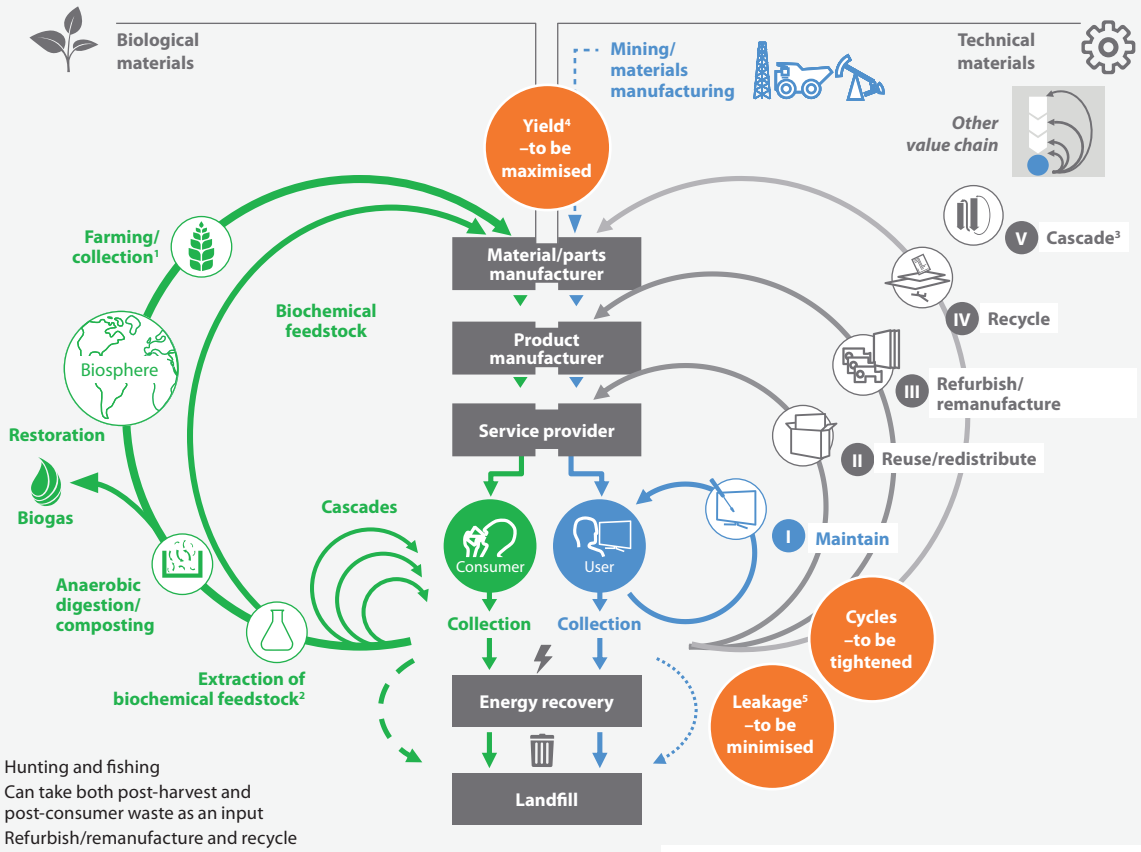
a. **Design out waste:** Waste would be prevented if products and services were designed for reuse, remanufacture or recycling as secondary materials. The goal is to retain the maximum possible value, related to production and the used materials, within the circular economy.
b. **Create resilience through diversity:** In a fast-evolving world, modularity, versatility and adaptability are key features if we are to develop and improve products without totally rebuilding them.
c. **Rely on energy from renewable sources:** Because recycling is already an intrinsic to it, energy from renewable sources is perfect for fuelling the circular economy.
d. **Think in terms of systems:** All parts of the circular economy must be viewed in terms of their interrelationships, rather than as single elements within a system. Only then can all genuine opportunities be identified.
e. **Waste is food:** In terms of nutrients, the ability to safely and cleanly recycle waste from products and services back into the biosphere is fundamental to the circular economy.

The circular economy therefore seeks to make more efficient use of resources and materials, for the better recycling of their value and raw materials. Naturally, this boosts energy-efficiency, promoting the carbon-neutrality of the economy. Reuse or remanufacture of a product saves much of the energy used in the original production process. Recycling of raw materials also reduces the energy

2 Ellen MacArthur Foundation: "Towards Circular Economy Vol.1"

## Figure 1. The circular economy provides three key ways of adding and maintaining value

Source: Ellen MacArthur Foundation CE team




1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input
3 Refurbish/remanufacture and recycle materials and parts in other value chains
4 Clean production scrap is typically recycled on-site or in a closed cycle at the supplier and not all of it is captured in waste statistics. Action has already been taken by the company; hence, this is out of scope
5 While CE principles apply to other waste fractions such as emissions to air and water, the scope of this project is solid waste

### Two primary pathways for circular economy in the focus of this work

- Minimising leakage to recover as much of the intrinsic value of raw materials as possible
- Tighter circular economy loops for improved value-add recovery

used in primary production, such as in excavation and further processing.

For companies, adopting the circular economy mindset would create opportunities to cut costs, grow their businesses and reposition themselves strategically. Resource and energy efficiency are precisely the places where cost savings are most often achieved. Correspondingly, the circular economy provides companies with more earning opportunities for each manufactured product.

From a national perspective, the circular economy is about changing a linear economy into a circular one rather than reducing the amount of economy activity. In fact, the circular economy would boost GDP growth in many respects, by increasing sectoral competitiveness and the number of innovations.

Neither is the circular economy about lower consumption or, more precisely, living standards. It is more about a shifting the nature of consumption towards use. Rather than wearing products out, we will use them in an environment where thorough consideration has been given to their service lives and potential for reuse.

The main question of this report is: What opportunities does the circular economy present for the Finnish economy?

# 2.1 The circular economy offers new growth opportunities

In the coming decades, the business environment will change in terms of the availability, price and use of resources. Rising raw material prices are driving companies to improve their material efficiency in the design phase, production process and at the end of the product's life. Population growth, rising living standards in developing countries and urbanisation will increase demand for raw materials in the coming decades. But even greater changes lie ahead in business models and thinking.

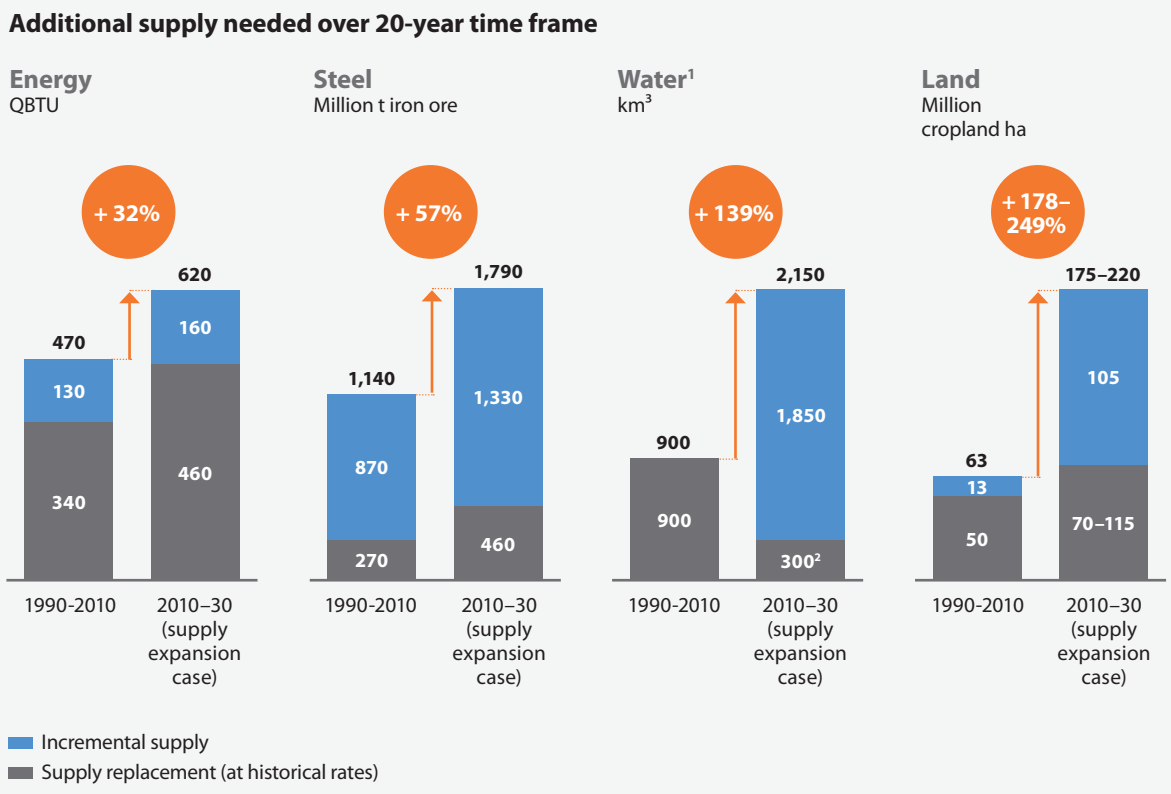
The Earth's population will grow by 1.5 billion people in the next 15–20 years. In the same period, three billion new consumers will join the middle classes. According to estimates, by 2050 more than 70% of the world's population will be living in cities with over 10 million residents.

Figure 2 below demonstrates the scale of resource demand growth in the next 20 years, and how challenging it will be to satisfy this growing demand through current measures. For example, to satisfy demand for iron ore in 2030, mining capacity will need to increase by 57% between 2010–2030 compared to the previous two decades (1990–2010).

This should concern us, even if the economic growth of Finland and other developed countries is not dependant on growth in raw material use. The Finnish economy too will be affected by a rise in raw material prices. Higher demand for natural resources will raise their value in manufacturing and design, thus lowering our standard of living and reducing the growth potential of technological development.

**Figure 2. Satisfying growing demand for raw materials will be challenging**

Source: McKinsey




1 Water supply will need to increase by a further 300 km³ to meet accessible, sustainable, reliable supply

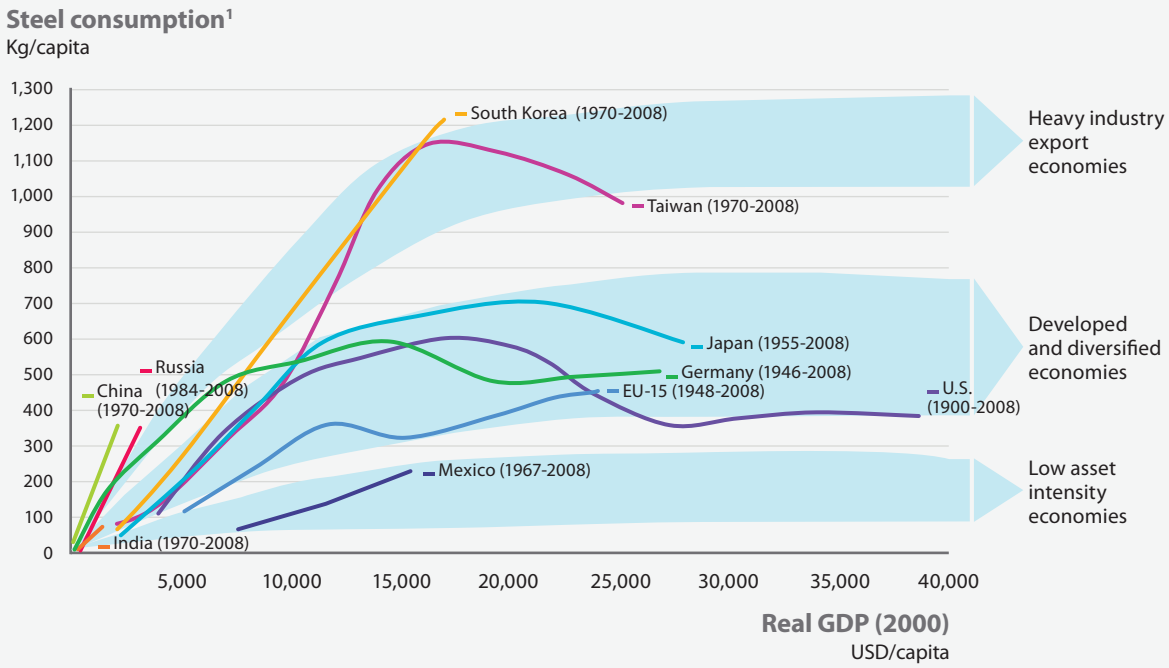
Used in vehicles, production equipment and the building stock, steel is one the world economy's key raw materials. Figure 3 below shows the connection between economic development (GDP per capita) and steel consumption. Once around two-thirds of the average GDP of a Western country has been reached, demand for steel falls. In practice, this follows a strong resource-intensive economic development phase, like that taking place in countries such as China. Such a development phase also involves the binding of large quantities of raw materials into the community structure. These return to the material cycle at the end-of-life stage. In Western countries, the proportion of reused materials in steel already exceeds one third, but the percentage of metal recycled from the building or equipment stocks remains much lower in developing countries.

The consumption of many other raw materials is also represented by a corresponding, inverted U-curve. Figure 3 clearly demonstrates how resource intensity increases as the standard of living improves in developing economies. The rise of the middle class is not just about growth in private consumption; it is also about building and maintaining the infrastructure required for a higher standard of living. In the long term, this dynamic will impact on the scarcity of raw materials.

Despite the constraints described above, we are wasting a very high percentage of raw materials. Many recycling chains work in theory only.

## Figure 3. Steel consumption typically follows an inverted U-curve during the economic development phase

Sources: WSA; Global Insight; IMF; USGS; McKinsey




1 Crude steel equivalent

In Finland, 34% of the 90 million tonnes of waste collected is reused, while the average for developed economies is around 40% (Figure 4). A further 12% of collected waste is recovered for use as an energy source. On the other hand, the figures for Finland are distorted by the classification of soil excavated by the mining sector as waste, contrary to statistical practices in most other countries. Excluding mining industry waste, of the remaining 37 tonnes of collected waste 33% is recycled, 28% is recovered for energy use and 39% is transferred to refuse heaps, incinerators or landfills.

We tend to think that recycling is enough. The PET materials cycle is a prime example of how recycling does not always add up to circularity (Figure 5). In 2010, 54.9 million tonnes of virgin PET were produced worldwide, but only 4.8 million tonnes were recycled. Furthermore, only 0.6 million tonnes of recycled PET entered a closed loop. In reality, a major part of recycled PET from plastic bottles, 4.2 million tonnes, ends up as raw material for non-bottle applications. Correspondingly, the recycling rate of such products is significantly lower than for bottles. It should be noted, however, that even a higher recycling rate in such a cycle would not reduce the amount of virgin PET required by the economy in the long run. It would only move back the schedule slightly for the additional production of PET.

Only by transforming PET recycling into a closed loop can we reduce demand for virgin PET.

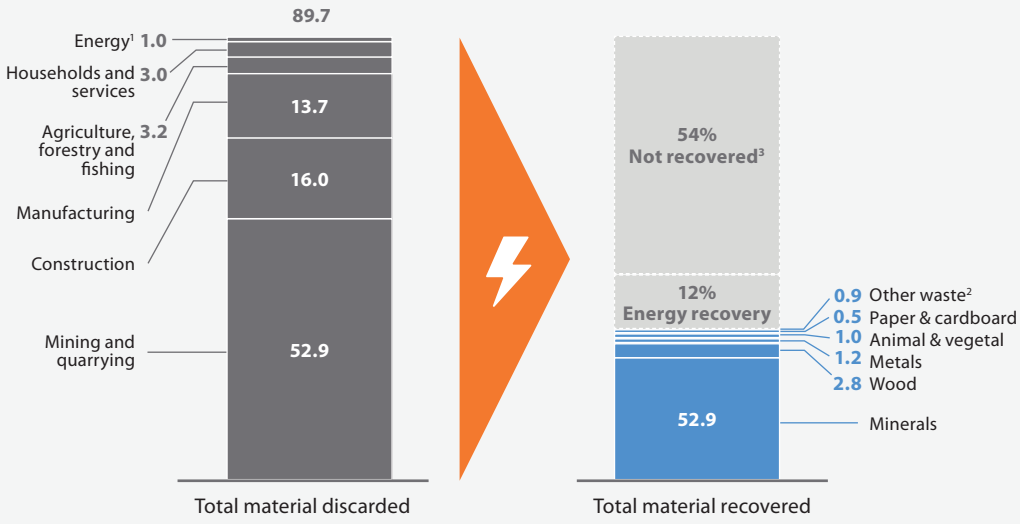
Destroying our living environment through consumption will benefit no one. Circular economy models are emerging alongside linear consumption on the initiative of companies, as well as due to competition for resources. Those who make viable use of such models first will have the edge over other players and will change the game. For example, from the buyer's point of view Rolls Royce's leasing programme for aircraft engines is a tempting alternative based on paying for use. A consumer-oriented sharing economy and the reuse of consumables are already

## Figure 4. Of the ~90 million tonnes of waste collected in Finland annually, ~54% sees no value recovery, while ~12% is used for energy

Source: Statistic Finland (2012), EMF Report: Towards the circular economy, 2013

### Total waste generated in Finland in 2012, by economic activity and waste type

Million tonnes




1 Electricity, gas, steam and air conditioning supply

2 Includes sludge, chemical waste, glass, plastics and rubber waste and other

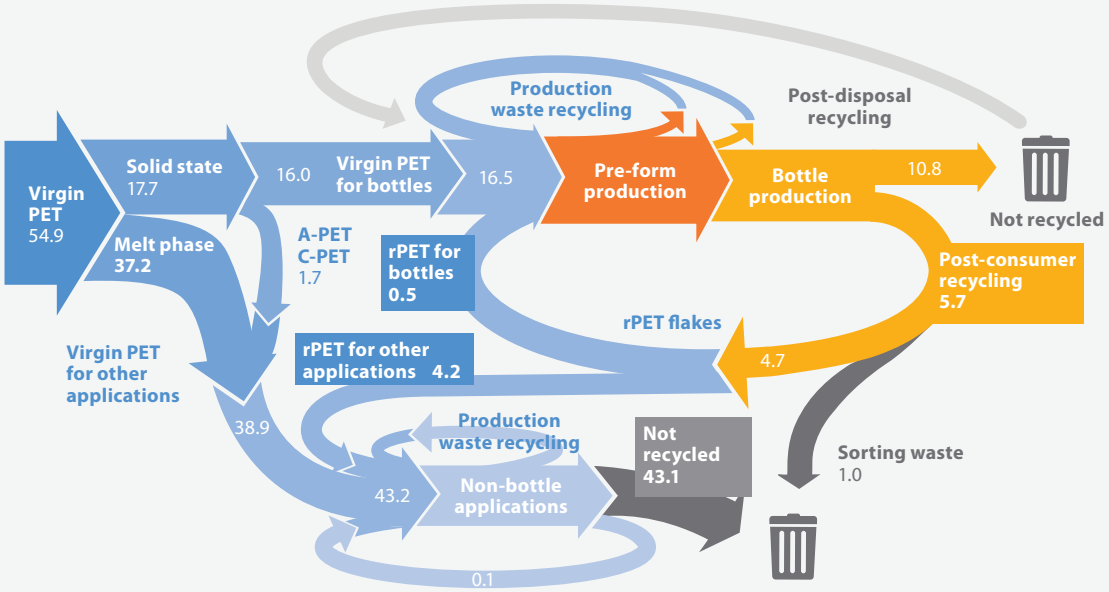
3 Waste transferred to a refuce heap, incinerator or landfill

gaining momentum due to the lowering of technical and cultural barriers. AirBnB and Uber have been very effective in creating their own market segment, which has weakened the position of existing operators.

The circular economy is about the possibility of reusing created value or a product several times in a controlled manner, in place of the linear "take > make > dispose" consumption model. In certain sectors, OEMs have already incorporated remanufacturing and the used products market in their business operations. Resources used once can be profitably reused for a second or third time.

**Figure 5. Even our recycling success stories are not based on the circular economy – what is wrong with this picture?**

Source: McKinsey analysis; SRI; CMAI; TECNON; expert interviews




# 2.2 Finland's special features in relation to the circular economy

The ideological shift from a linear model to a feedback-rich circular system is not an entirely new idea. We are not introducing a completely new element to Finnish thinking. Finland has already benefited greatly from many elements of the circular economy, such as energy and resource-efficiency. However, current measures do not cover the entire spectrum of the circular economy. For example, the energy and resource-efficiency of production processes in the technical nutrient sector only involve one of the three primary ways of realising the circular economy. No attention is being paid to incorporating the value of production side streams and manufactured products into the circular economy system after the first product cycle.

We have already learned some of the basic lessons of the circular economy, but new opportunities would be created by wholesale promotion of the idea and additional 'courses'.

In promoting the circular economy, the crucial issue is to identify how much of each sector's value chain Finnish companies can influence and the sectoral potential offered

by the circular economy. Within Finnish society, the potential of the circular economy is affected by certain special characteristics of the country's economy.

Firstly, in sectors such as the paper and mining industry, most raw materials produced in Finland are further processed and exported. Secondly, food is the only consumer good that is primarily produced here. Thirdly, Finland's industrial activities are increasingly centred around the immaterial section of the value chain and production has been offshored.

Most production in the paper industry is based on domestic raw materials, but the products are consumed abroad. From the perspective of the circular economy, this means that Finland should focus on side streams rather than wondering how to promote the recycling of end products.

In the food product value chain, the flow of materials is more domestic than in many other developed economies. A large percentage of food products is also consumed domestically. These factors increase the potential to influence how materials and nutrients are circulated, which enables promotion of the circular approach throughout the chain.

In industrial production, the circular approach is less about promoting the concept and more about identifying how Finnish companies can use the principles of the circular economy to improve their international competitiveness. The machinery and equipment industry focuses on capital assets, i.e. the manufacture of production equipment. Such assets have longer service lives and innovation cycles than consumables. This also means a much lower volume of products and materials than consumables, which poses challenges to the creation of tighter loops. On the other hand, a longer service life would increase the opportunities offered by modularity and leasing.

Despite the challenges posed by the special features of our economic system, characteristics such as our domestically oriented food chain, the strong position of our machinery and equipment industry within narrow segments, or the technological leadership of our paper industry provide many of the opportunities presented by the circular economy.

## 2.3 The big picture, based on five sectors

We decided to focus on five sectors based on their economic weighting and circular economy potential (value of raw materials and potential for tighter loops). These five sectors are:

1. **Manufacture of machinery and equipment:** The machinery and equipment industry plays a major role in Finland's national economy and the creation of wellbeing. Many companies in the industry are also global leaders in their segments and have already embraced some of the opportunities presented by the circular economy.
2. **The forestry-wood chain, from forest management to paper production:** Forest industry products form one of two major Finnish exports. In the forest industry, side stream volumes account for a large share of material flows.
3. **The food chain, from agriculture to retail and restaurant services:** The degree of domestic origin means that Finland's food chain is ideally placed to foster the circular economy at local level.
4. **Construction**: The construction sector is second only to the mining industry in terms of waste generation. A major part of society's raw materials is tied to construction. Construction waste is a significant source of scrap metal.
5. **Private consumption:** A major part of material flows belongs to private consumption. Post-consumer waste is the type of waste most likely to be sent to landfills unsorted. Hopefully, this situation will change in the near future due to new regulations.

Figure 6 presents an overview of bases for prioritisation within the Finnish economy, by sector. Prioritisation of the selected sectors does not exclude the possibility of discovering potential in other areas.

## Figure 6. Prioritisation of sectors

Source: Eurostat,
European Pollutant Emissions Register,
Statistics Finland, McKinsey

| | Gross value added (GVA) | Waste collected; tonnes | Importance for the national economy a1-3: GVA EUR mn | Importance for the national economy a1-3: Hours worked | Importance for the national economy a1-3: Degree of control | Intrinsic material value not recovered b1: Value/ton | Intrinsic material value not recovered b1: Ease of capture | Potential for tighter loops b2: Value-add potential | Potential for tighter loops b2: Ease of capture | Further remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| **Agriculture, forestry and fishing**[1] | 4,711 | 3,155[1] | | | | | | | | Potential in biofuels, biochemicals |
| **Mining and quarring** | 717 | 52,880 | | | | | | | | Volume of waste |
| **Food products and beverages** | 2,509 | 5,342 | | | | | | | | Potential in biofuels, biochemicals |
| **Manufacturing textiles** | 394 | 8 | | | | | | | | |
| **Wood and wood products** | 1,137 | 5,342 | | | | | | | | Improvement of material-efficiency |
| **Paper and paper products** | 3,507 | 4,402 | | | | | | | | Volume of waste, ease of capture |
| **Coke and refined petroleum** | 624 | 28 | | | | | | | | |
| **Chemicals** | 3,731 | 564 | | | | | | | | Potential in sidestreams and for other sectors (e.g. paper) |
| **Non-metallic mineral products** | 1,113 | 507 | | | | | | | | |
| **Basic metals and metal products** | 3,716 | 1,877 | | | | | | | | |
| **Machinery and equipment** | 9,691 | 98 | | | | | | | | Value of raw materials, ease of capture |
| **Manufacturing n.e.c.** | 654 | 9 | | | | | | | | |
| **Electricity, gas, steam and air conditioning** | 3,742 | 1,010 | | | | | | | | |
| **Construction** | 11,018 | 16,027 | | | | | | | | National importance, volume of waste, modularity in elements |
| **Households and services** | N/A | 2,992 | N/A | N/A | N/A | | | | | Share of waste transferred to landfills |
| **Wholesale and retail trade** | 16,760 | | | | | N/A | N/A | N/A | N/A | National importance |
| **Healthcare & social serv.** | 16,159 | | | | | N/A | N/A | N/A | N/A | National importance |

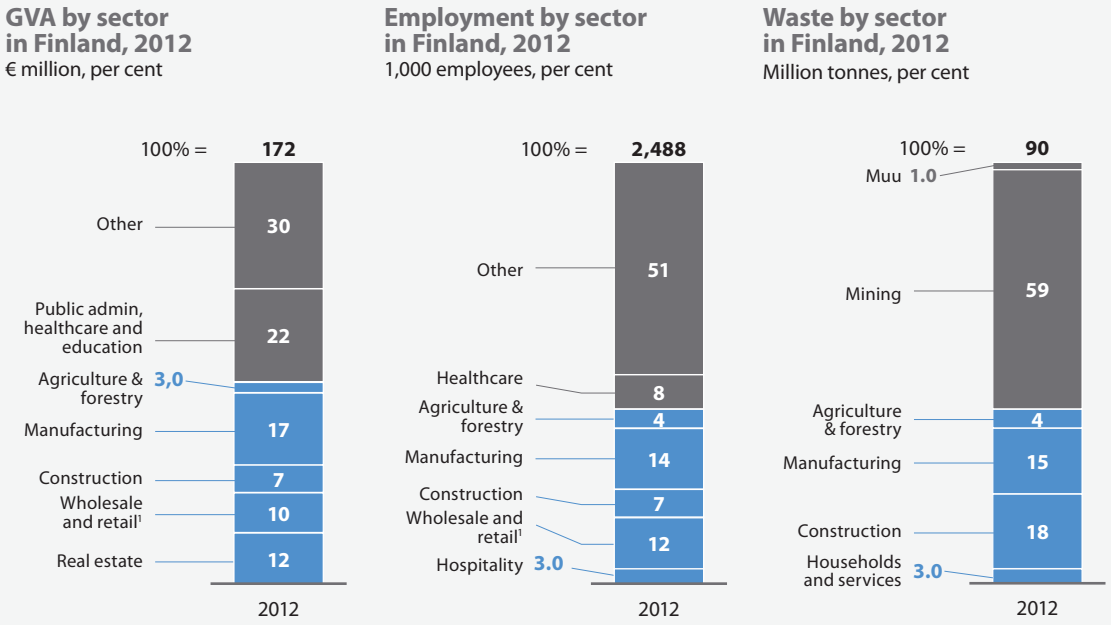
1 only including wood waste

High value / easy  Medium value / moderate  Low value / hard

The sectors we have prioritised account for approximately 50% of GVA, 40% of employment and 40% of waste (Figure 7). Studying them will provide a clear overall picture of the opportunities presented by the circular economy in Finland.

## Figure 7. The sectors in focus account for ~50% of GVA, ~40% of employment, and 40% of waste

Source: Statistics Finland; McKinsey




1 Covering retail and wholesale trade

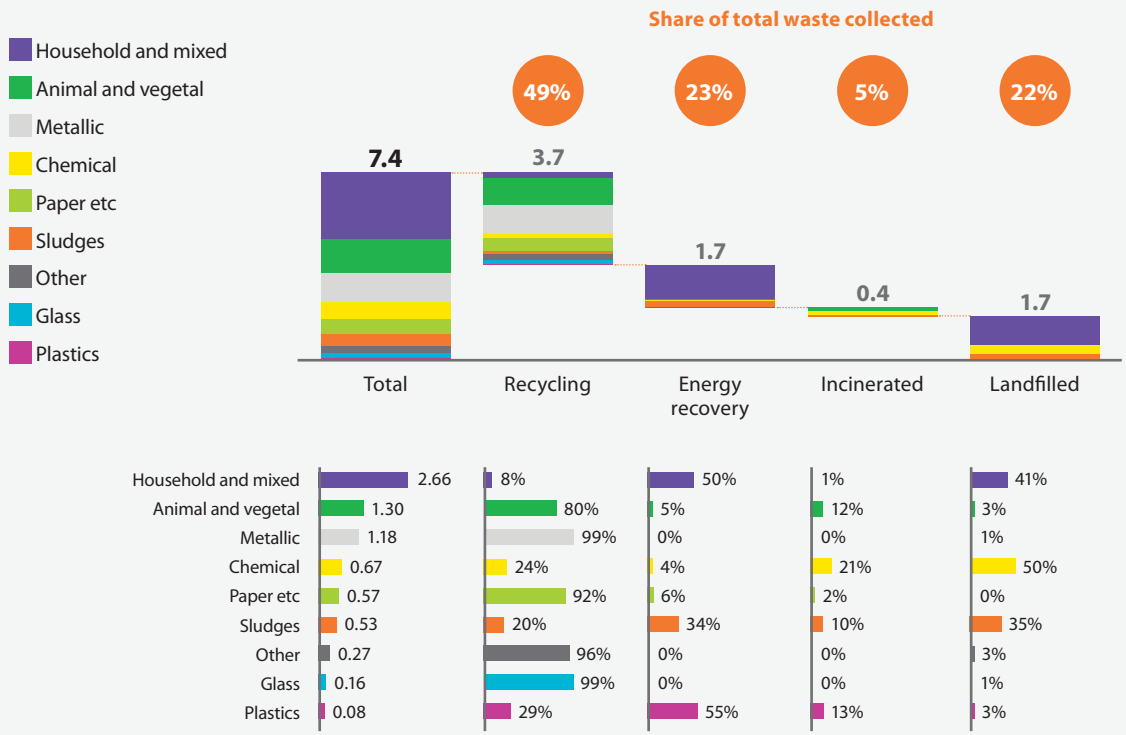
# 2.4 Starting point from the perspective of waste and side streams

A closer look reveals which sectors generate the largest shares of total waste transferred to refuse heaps (Figure 8); household and mixed waste and metallic waste (basic metals and metal products) are at the top. Most waste generated by the wood, paper and forest industries is recovered for use in energy production. This also applies to waste generated by food production and the machinery and equipment industry. Figure 8 does not include the mining industry and construction sector; most waste generated by these comprises minerals from excavation, which are either dumped or used in earthworks.

A comparison by waste type (in Figure 9) shows that household and mixed waste, chemicals and sludge stand out among all landfilled waste. Plastics also stand out due to their high level of use in energy production. The high recycling rate of other waste types is similarly noteworthy. Excluded from the figure are minerals, which are primarily generated by the construction sector, and wood, which is primarily incinerated for energy purposes. In the statistics, only waste whose volume can be itemised is included in each specific category. For example, metal waste includes waste whose metal content has been itemised. This explains why metals have a 99% recycling rate. However, mixed waste also includes unitemised metals that are not recycled. This should be borne in mind when using current statistics to assess the circular economy's potential in Finland.

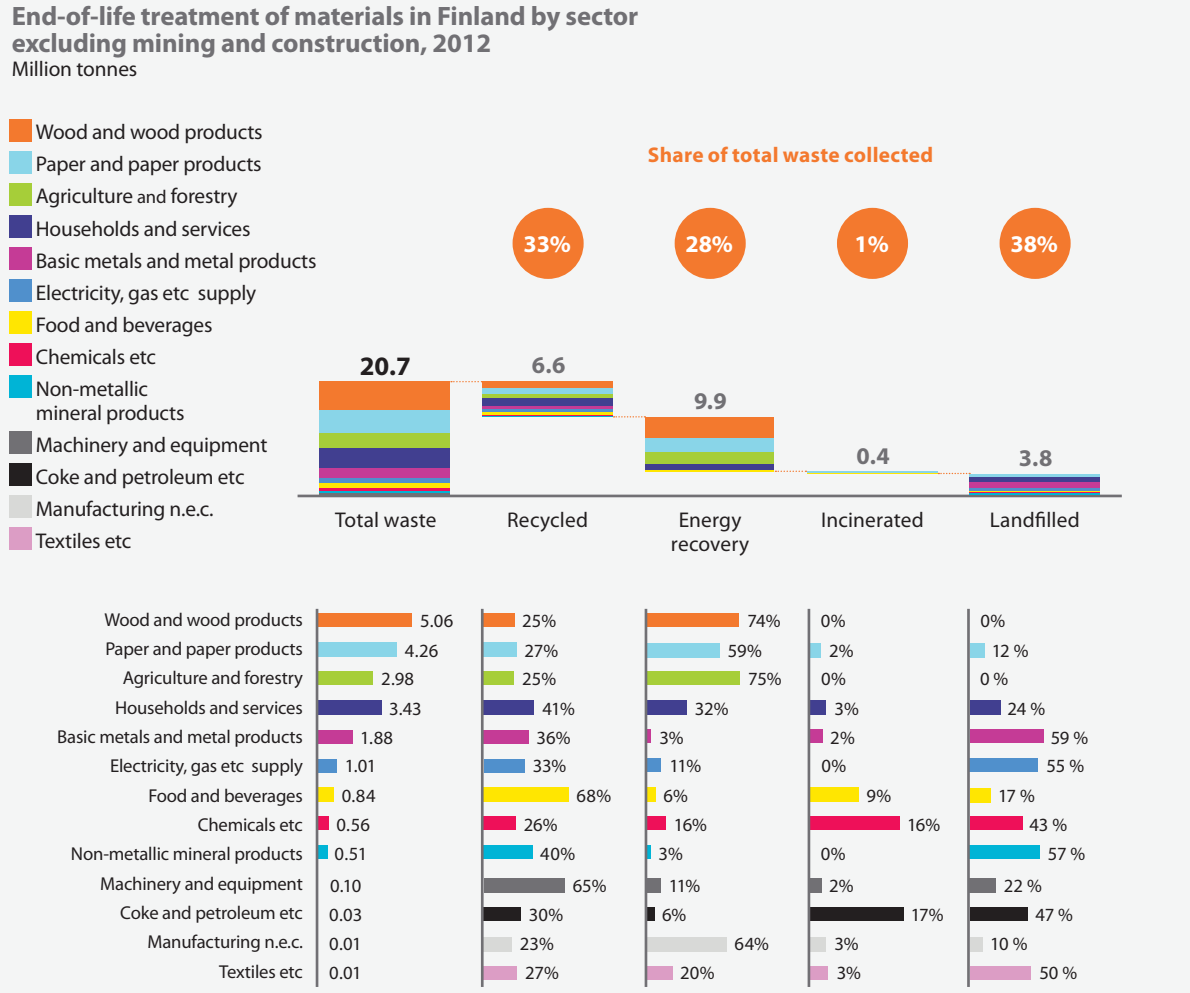
**Figure 8. Majority of valuable material is recycled, but mixed waste is either burned or landfilled**

Source: Statistics Finland, Jätetilasto 2012, McKinsey



## Figure 9. Excluding mining and construction waste, most waste in Finland is used for recycling or for energy recovery

Source: Statistics Finland, Jätetilasto 2012, McKinsey




Despite our high recycling rate for many types of waste, much remains to be done in order to make the circular economy a reality in Finland. In addition, the recycling rate takes no account of how much product value has been recovered through recycling.

Despite the mining industry's significant share of total waste, we excluded the sector from our analysis. In 2012, the mining industry generated 52.9 million tonnes of mineral waste, or 59% of all waste included in the figures. Mineral waste is generated through the extraction of natural stones (e.g. soapstone and industrial rocks), carbonate stones, industrial minerals (e.g. talc and apatite) and metal ore (e.g. chromium, copper, nickel and gold). Of these, metal ores and industrial minerals account for most waste generated by the extractive industry. Due to statistical practices, however, this waste mainly comprises soil and gangue, and is primarily used as material for earthworks within the mining area.

If sustainable or otherwise practical ways of utilising quarrying by-products can be found, they should be used. Unfortunately, Finland's key mines are located far from major population centres, limiting the potential for utilising side streams. Finnish mines already focus on collecting metals other than their main product, if this is profitable.

The next section of the report discusses the five prioritised sectors in more detail.

# 3 Sector-specific opportunities

## 3.1 The circular economy improves competitiveness in the machinery and equipment industry

A conservative estimate suggests that the circular economy represents growth potential of EUR 300–450 million for the machinery and equipment industry. This estimate is based on the additional sales generated by new business models using the circular economy approach. The circular economy presents companies with a major opportunity to boost their growth and competitiveness and better meet customer needs. Such a change can already be seen in companies such as Caterpillar, Rolls-Royce, Renault and Kingfisher. The game-changers in each business sector will reap the greatest rewards.

In this section, we will discuss what the circular economy means to the machinery and equipment industry. At the end-of-life stage, there is still plenty of value to capture in sold machinery and equipment, but few companies view the circular economy as an opportunity to expand into new customer segments, improve profitability or reduce reputation risk.

Many of the factors discussed in this section have already been incorporated as individual elements in companies' business models. Taken together, such factors could foster the competitiveness of companies and the circular economy even more effectively. Remanufacturing is not possible if the equipment in question does not return to the OEM. The efficiency of remanufacturing can be enhanced through improved modularity. In turn, leasing models are supported by both of these. Within the circular economy, leasing programmes, modularity and remanufacturing are all mutually supportive. Success in one of these three areas has a positive effect on the others. Combining these with real-time remote monitoring of equipment enables a new, long-term business perspective: equipment can be manufactured, serviced, repaired or remanufactured, and resold. This process can be repeated once or many times. In this sense, the circular economy provides a perspective on the development of business models, technology and cost efficiency.

## Machinery and equipment manufacturers are well-placed to adopt a circular model

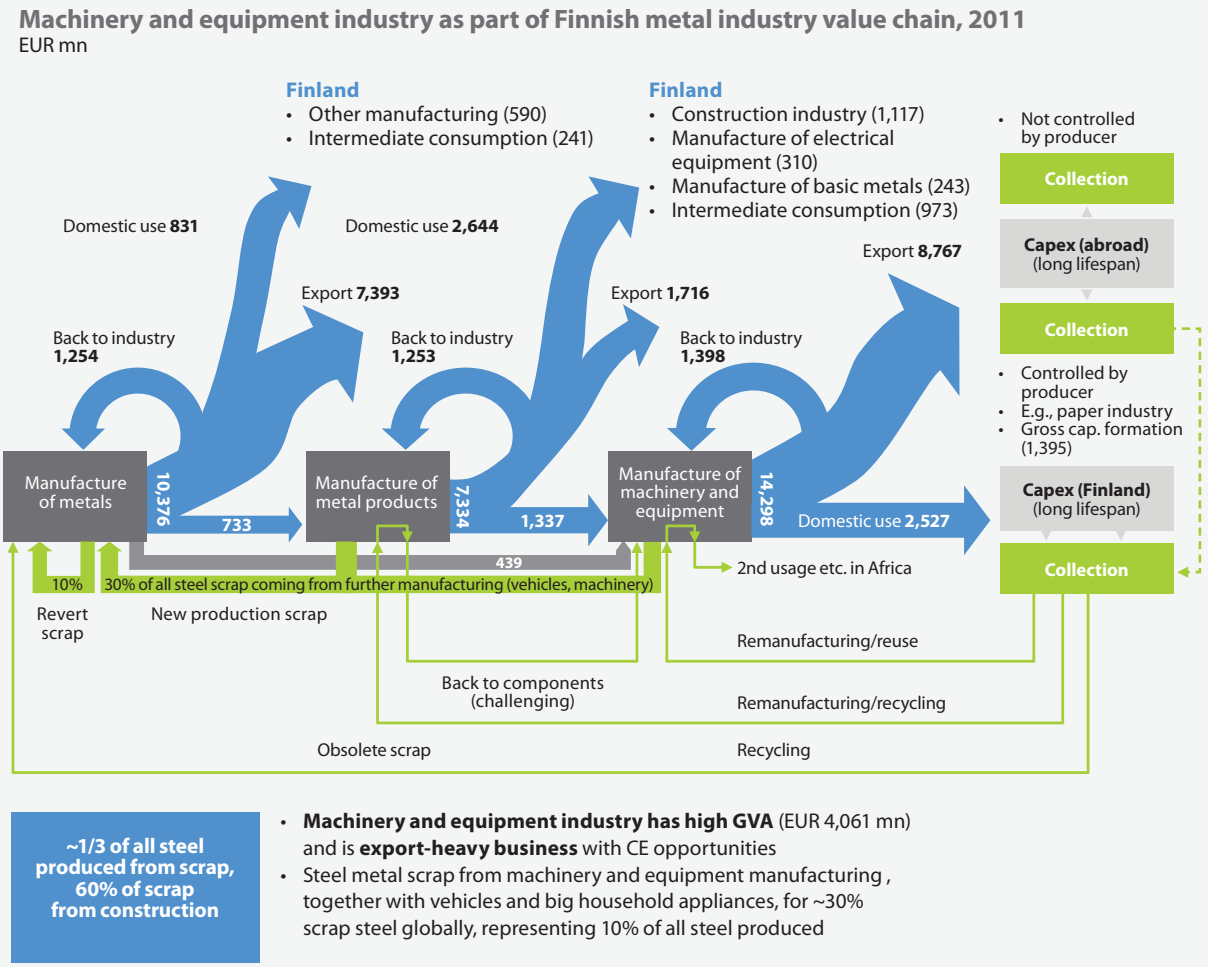
Finland has traditionally had a strong machinery and equipment industry, accounting for a major share of exports (EUR 8.9bn in 2011)[3] and serving the domestic forestry and mining sectors in particular. While the industry's domestic turnover (EUR 14.3bn in 2011)[4] is low in relation to its global turnover (EUR 2,253bn in 2012)[5], in individual product categories, the share is often as high as 15–25%.

In recent years, the service business segment has also grown into a major contributor to turnover. The machinery and equipment industry has grown in importance within the Finnish technology sector since the mobile phone industry's decline in the new millennium.

The value chains and material flows of the Finnish machinery and equipment industry are presented in Figure 10. Most output ends up abroad.

### Figure 10. Most of the machinery and equipment industry's products end up abroad

Source: Eurostat, ODIN, Statistics Finland, Team analysis




**~1/3 of all steel produced from scrap, 60% of scrap from construction**

- **Machinery and equipment industry has high GVA** (EUR 4,061 mn) and is **export-heavy business** with CE opportunities
- Steel metal scrap from machinery and equipment manufacturing , together with vehicles and big household appliances, for ~30% scrap steel globally, representing 10% of all steel produced

3 Statistics Finland
4 Statistics Finland
5 McKinsey's estimate

Unlike in the U.S. or Germany, in practice the Finnish machinery and equipment sector comprises ten major companies and their subcontractors. The expertise of these companies is based on forests and minerals. Companies that manufacture products for the forest industry include Ponsse (harvesters and transport vehicles) and Valmet (paper machines). Rivals of Ponsse under foreign ownership – John Deere and Andritz (systems and equipment for the paper industry) – also have major business activities in Finland. At global level in the mining and construction industries, Metso's strength lies in crushers, among other products, while Normet's strong point is tunnelling machines. In turn, the Swedish-owned Sandvik has strong expertise in areas such as equipment for mineral quarrying and loading, while Outotec's strengths lie in mining technology and plant construction projects.

Equipment needed for the transport of machinery for the forest, mining and construction industries has been in demand. Shipbuilding has declined in Finland, but Cargotec and Konecranes are major players in cargo handling. In addition, these two companies act as suppliers in other sectors, such as the metal industry (including the Finnish companies Rautaruukki and Outokumpu). Wärtsilä, in turn, is a market leader in medium-speed engines for ships and a key offshore supplier. Kone, the largest company in the Finnish machinery and equipment sector, also supplies lifting equipment. In addition, depending on the company, a significant share of intermediary products come from smaller, domestic subcontractors. These are often highly specialised but fairly dependent on their principal clients.

Companies in this sector have narrow expertise and competition is quality-driven. Competitors include other companies serving the global markets. In many cases, when compared at product level, domestic machinery and equipment manufacturers are market leaders or among the top three in their segment. The history of Finnish industry lies in focus areas – their relationship to domestic production remains solid, despite the demand-driven offshoring of production, particularly to China.[6]

The typical lifespan of machinery, equipment and components in customer use is 5–25 years and maintenance services account for 30–50% of many companies' total turnover[7]. The customer base includes international or domestic top firms such as Rio Tinto in the mining industry or Stora Enso in the paper industry; equipment leasing companies, such as Cramo and Ramirent; or self-employed loggers.

The key inputs of the machinery and equipment sector mainly consist of the labour input of engineers, as well as components, services and steel. The sector has taken its place at the far end of the metal industry value chain, exporting its products or selling them to Finnish industry. In terms of resource use, the key raw material is steel; thanks to a highly functional market, the raw material cycle in this sector almost forms a closed loop. In the circular economy, the most important feedback is that leading back to the OEM. In addition, we should not ignore the potential role of subcontractors in the refurbishing of components or in scrap metal flows.

## The circular economy approach accelerates the development of new business models

As described in the Introduction section, choosing business models based on the circular economy over the conventional "old, re-sold equipment is not for us" approach would create huge potential for the machinery and equipment industry. Leasing models, modularity and remanufacturing would provide ways of increasing turnover and the margins on current output.

With respect to the circular economy, an overall picture is required of the diversity of the machinery and equipment industry and the life cycles of its various products. But we can also generalise up to a point. The key differentiating factors include production volumes and the size, disassembly and service life of equipment. These factors affect the standardisation of processes, the logistics of re-selling, and the relevance and condition of the equipment when the user changes.

In the category of light-weight machine tools and forklifts, there are similarities with the auto industry. Product line volumes for such equipment are calculated in hundreds or thousands, whereas process equipment is often made in single units. In the case of smaller equipment, transport and installation costs account for a much lower share of the total cost than in the case of loading cranes, for example. In addition to the size of the equipment, the permanence of the installation (mining equipment, paper machines and ship engines) and the usage period are key variables when considering issues such as product maintenance and the used products market. While machine tools can end up on the used products market after three to five years of use, a ship engine can be used for 25 years. On the other hand, machinery enhances the effectiveness of customers' business activities and older equipment stock can be updated as soon as greater efficiency makes this economically viable.

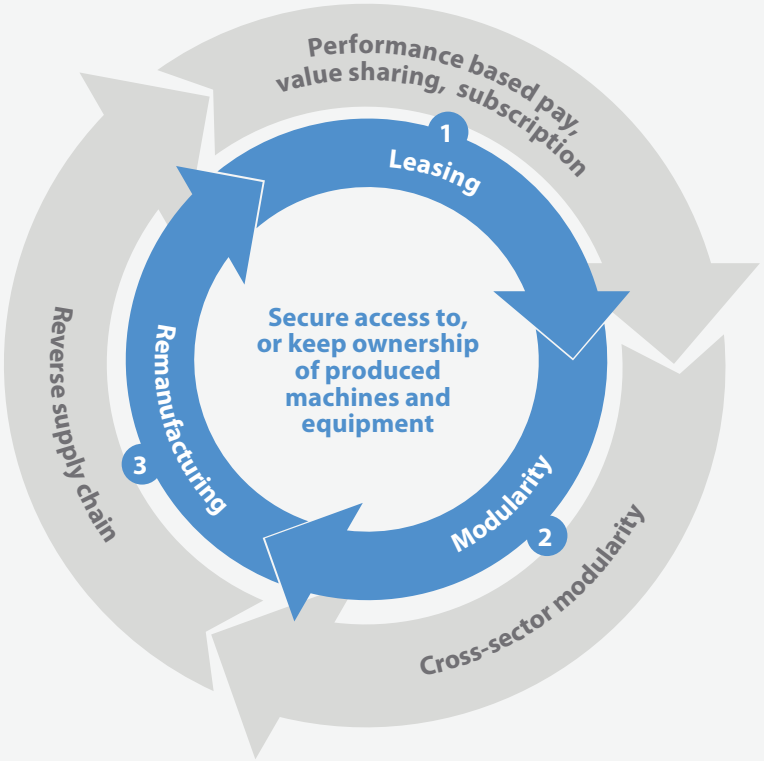
At best, a margin can be achieved more than once on the same output. The broad-based implementation of remanufacturing requires capacities developed for the purpose. Leasing and other service models, modularity and

6 Interviews

7 Companies' annual reports, interviews

## Figure 11. Machinery and equipment industry: Leasing, modularity and remanufacturing are closely interlinked

Source: McKinsey




**+ Internet of things as an enabler**

### 1. Leasing & other service models

- **Opportunity:** Securing access to products with contracts or with leasing model, enabling refurbishing
- **Industry leader practice:** Optimise revenue model through, e.g., performance-based pay, value sharing or subscription models
- **Benefits:** If leased, less investments required from clients > increased sales and stability for cash flow, incentives to implement modularisation further

### 2. Modularity

- **Opportunity:** Significant cost savings attainable in design, parts purchasing and assembly phases
- **Industry leader practice:** Stronger cooperation with suppliers (cluster)
- **Benefits:** Helps reduce maintenance/service costs; enables refurbishing with leasing

### 3. Remanufacturing & reverse supply chain

- **Opportunity:** Reputation risk could be mitigated, aftermarket exists anyhow; significant value added put into products, which could be taken back; cost-efficiency in re-selling once sold machine
- **Industry leader practice:** Reverse supply chains, products go through re-manufacturing process, significant value captured
- **Benefits:** Sales expansion (new market segments); manufacturer has control of reputation risk

1 Service leasing: maintenance included; after usage the equipment is returned or sold forward in accordance with the conditions set by the producer

remanufacturing are all closely interlinked, creating a self-reinforcing, positive loop. The graph in Figure 11 depicts this dynamic.

Firstly, business models based on leasing contracts can support the circular economy approach by increasing the return rate of end-products for refurbishing and optimising their durability while bearing their prospective refurbishment in mind. Secondly, refurbishing should be economically viable. This means that disassembly and remanufacturing must be taken into account in the design phase and modularity should be applied. With these two capacities in place, it would be possible to begin building Reman (short for *remanufacturing*) concepts more systematically, while developing reverse supply chains. "Reman" refers to the OEM's own product line of used equipment or spare parts, currently offered by firms such as Caterpillar and John Deere. In addition, remanufacturing needs are often taken into account in the original design of equipment. The use history of equipment is crucial to lowering the risks associated with purchasing refurbished equipment and to ensuring an efficient refurbishing process. The benefits of the industrial internet are therefore not limited to the usage period.

In the machinery and equipment industry, this model functions best in the case of light-weight work machines and transport equipment, but potential also exists in heavy industry. Although some operators in the Finnish machinery and equipment sector have already adopted these practices, every company has the potential to improve in one or more areas. To analyse this potential in more detail, we need a better understanding of the structure and dynamics of the sector.

Despite the differences mentioned above, the existing market for used goods, often out of reach for manufacturers, is fairly uniform. In a typical scenario, after the first user a device ends up in the hands of a smaller operator, after which the final usage period often takes place in countries or continents, such as Russia or Africa, with lower productivity and labour costs. Larger items of equipment with longer lifespans end up in the scrapyard or are sold to developing economies. Leased work machines may have several users during their life cycle, but the same used products market involving 3–4 re-sales applies in their case.[8]

It is true that the Finnish machinery and equipment industry is a pioneer in many respects. The maintenance segment has become a key contributor to the turnover of many companies, which can control more of the maintenance market than accounted for by their own equipment. Many machine tool manufacturers have been selling and refurbishing spare parts and refurbishing equipment for decades. From the perspective of the machinery and equipment industry, the question is how this can be done better, what does it require, and what are the long-term opportunities for remanufacturing? The circular economy is primarily a tool for understanding business based on a cyclical rather than a linear model.

We need to understand what potential a circular approach offers in addition to solving practical challenges. If the equipment stock is designed for reuse, if the usage history of the equipment is known and if logistic chains support remanufacturing, this will enable the Finnish machinery and equipment industry to make use of once-used intermediary products and the work of engineers many times over. The combined impact of leasing, modularity and remanufacturing could create a positive loop that will significantly boost the competitiveness of companies in the long run. All of this will increase the turnover and productivity of companies.

The target level could be set at ensuring that a significant share of machinery and equipment industry companies are able to monitor the equipment stock they have produced throughout the product life cycle, know how to take account of reuse in the design phase, have created systematic processes for remanufacturing and selling on the after-market, and know how to monitor their productivity.

## Leasing: Pricing, service and business models that bring sales growth

Leasing models in the machinery and equipment industry promote the circular economy by extending the service life and durability of products. This increases the producer's control over the equipment, as well as the prospect of controlling it on the used products market and thereby supporting remanufacturing as a business model.

Various business models that include maintenance agreements have rapidly gained in popularity; maintenance agreements account for 30–50% of total turnover in many machinery and equipment industry companies. Pricing models based on output (*pay-per-use/cost-per-tonne*) have also been used by Finnish companies[9], and compensation systems based on actual cost savings are included in the tendered pricing models of at least some companies, although little use has been made of them so far[10]. However, the benefits can be substantial. For example, the following case involving a foreign mining company demonstrates the cost savings accumulated using an output-based business-model.

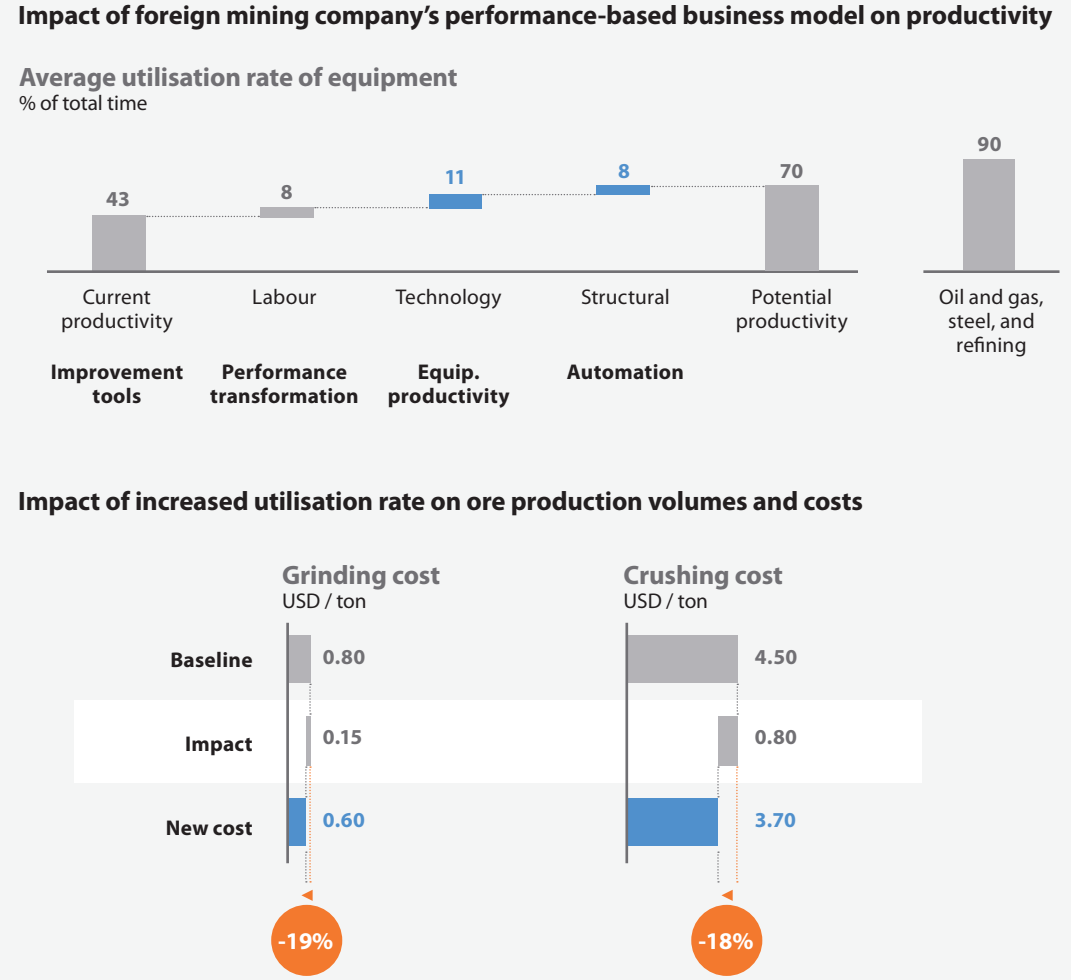
8 Interviews

9 Companies' annual reports

10 Interviews

## Figure 12. The impact of service-based business models on productivity and costs – Case: mining industry machinery

Source: McKinsey




Cases abound of successful pricing models used by foreign companies. For example, Komatsu, British Petroleum and Rolls-Royce have successfully used business models alongside their customers based on leasing, shared savings and production growth. The offering of a smaller Finnish operator in the machinery and equipment sector, Kemppi, includes the HumanWeld service, based on which the company hires out capacity, contributing both the machines and skilled users. On the other hand, Rolls-Royce has come up with a pricing model that benefits its customers, based on the length of time for which an aircraft turbine engine is used.

Such business models increase shared incentives to improve the performance capacity of equipment. The OEM can use this model to move one step closer to value creation for the customer, which not only solidifies but adds value to customer relationships. The challenge may lie in the customer's ability to purchase products based on unconventional sales models, particularly in the emerging markets. On the other hand, for the seller's balance sheet to benefit from equipment based on the leasing model, the management would have to pursue the transformation of its business models as a strategic objective, identifying suitable solutions alongside financiers.

Combined with production volumes, actual savings, use efficiency and other factors, the new pricing solutions would provide a more general boost to the competitiveness of machinery and equipment manufacturers and their customers. At best, the industrial internet enables equipment suppliers to become indispensable to the day-to-day business operations of their customers, or to make software integral alongside the equipment supplied.

### Leasing process products from subcontractors

The leasing model also works well with purchases intended for use in production. For example, Renault has achieved significant savings by leasing its cutting fluids from a chemicals company. The supplier was integrated deeper into the business operations of Renault and suggested exchanging the fluids for a more expensive solution which would require less equipment cleaning and use of chemicals. Since the adjustment of the operating model and properties of the oil used, the cutting fluids have been circulated within a closed loop. As a result, Renault's total purchasing costs for cutting fluids have fallen by more than 20%.[11]

## Modularisation: Modularity in design improves the potential for reuse

Modularisation assists in achieving the preconditions for a circular economy by facilitating reuse and refurbishment.

Spreading from the auto industry to the machinery and equipment industry in recent decades, modularity has been bolstering the cost-efficiency of Finnish machinery and equipment manufacturers. Despite this, when designing equipment only a few companies offering Reman products have considered how to maintain value when the life cycle reaches its end-point. On the other hand, few companies have benefited from the full potential of standardisation. This would be possible not just for the auto industry, but also for project-based manufacturers of small product lines in the machinery and equipment sector. The key would be to adjust and design modularity and standardisation in accordance with the product type.

Recycling can be taken into account in design work, in addition to maintenance and remanufacturing. For example, Renault has partnered with Suez Environmental in design catering for the easy disassembly of used vehicles[12].

Modularity can also be viewed as a long-term goal. It has enabled many machinery and equipment manufacturers to achieve cost savings of 5–10%. Major benefits include a reduced design work load, savings in subcontracting costs and a reduction in assembly costs[13].

Partnering with other players in the machinery and equipment sector can also bring cost savings in the long run, if compatibility between components enables the centralisation of purchases. A stronger role for subcontractors in the design process can also be beneficial to development work or bring cost savings to the manufacturing process.

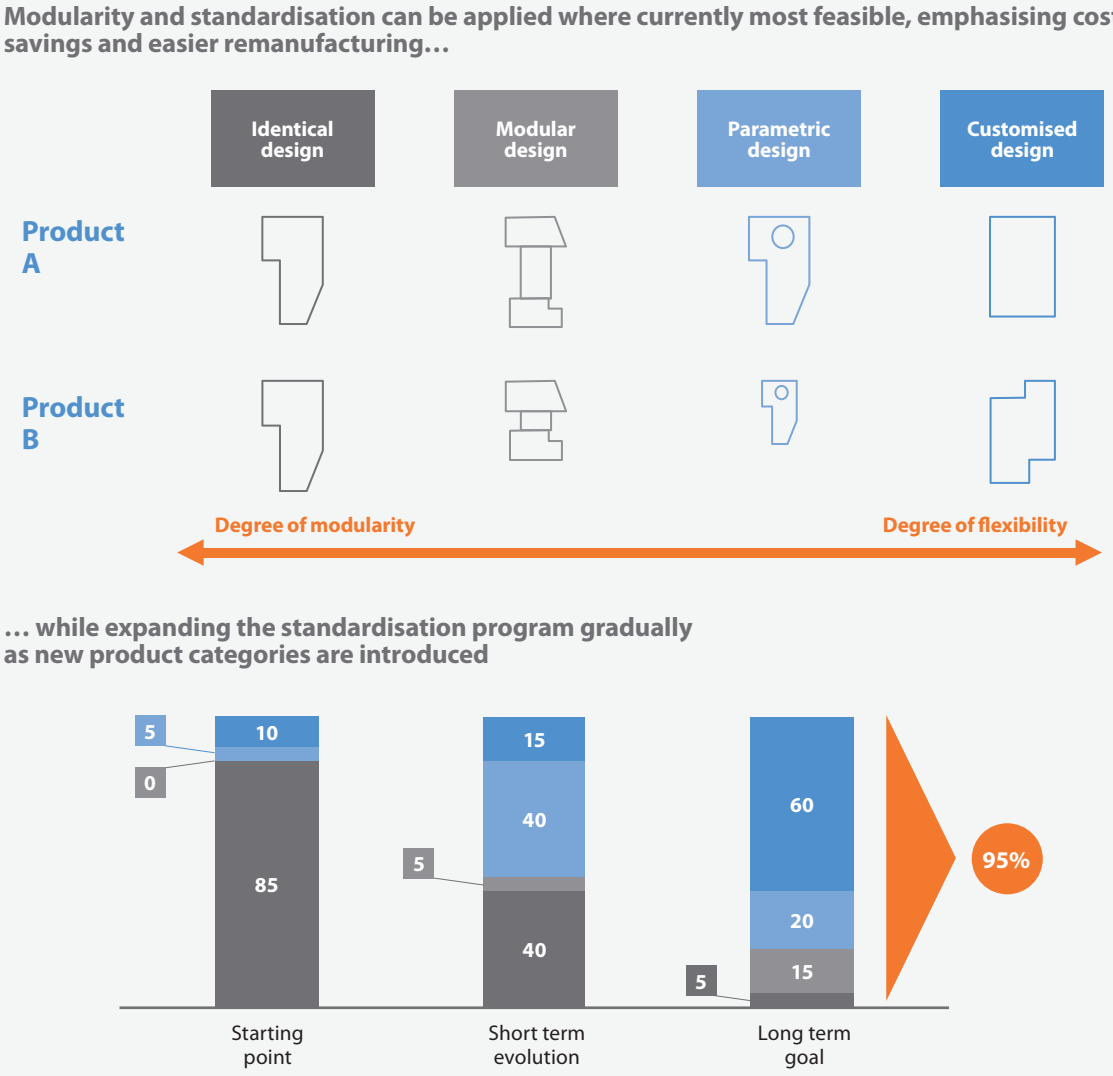
11 McKinsey, Ellen MacArthur Foundation, interviews

12 Ellen MacArthur Foundation

13 McKinsey

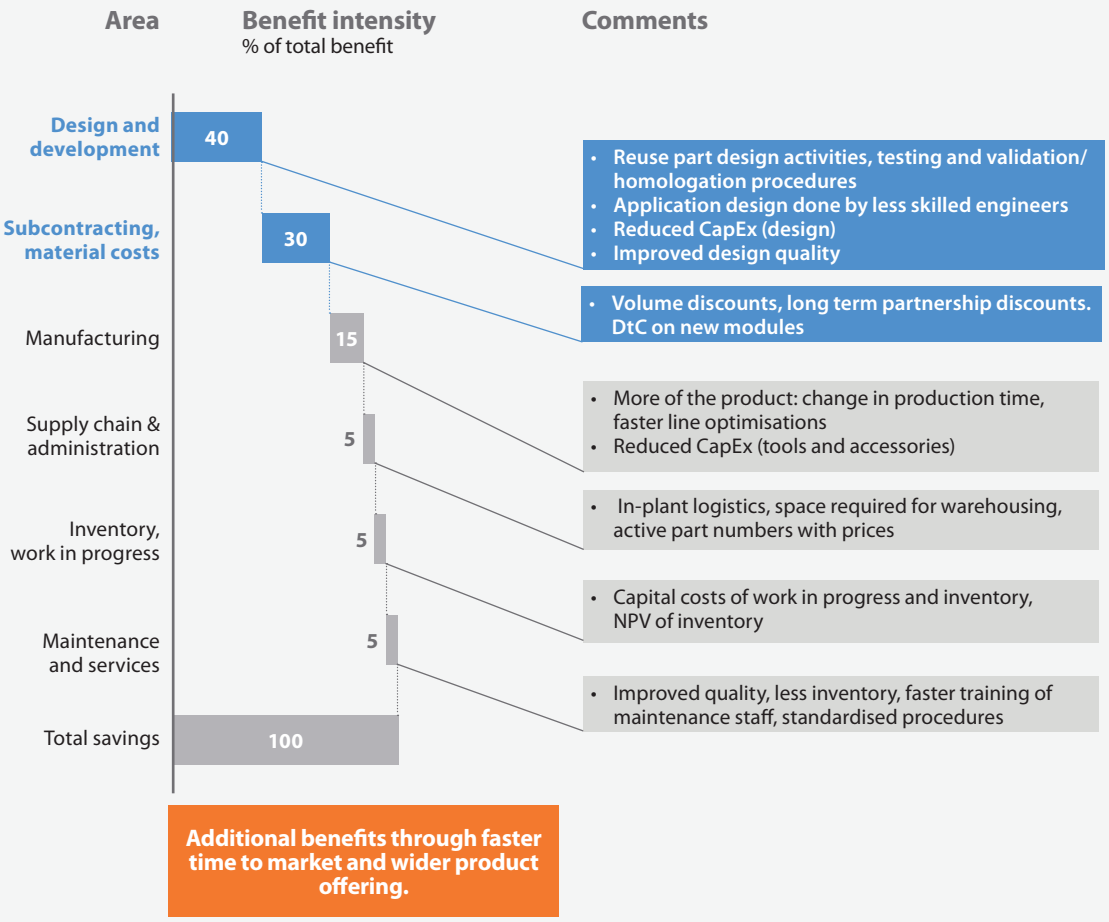
## Figure 13.

Source: McKinsey



## Figure 14. Modularisation can bring significant cost savings

Source: McKinsey



## Remanufacturing: Remanufacturing reduces loss of value

The previous section discussed modularity and leasing-based pay-per-use service models. Remanufacturing can also be economically viable without these two elements, but taking them into account makes it much easier to ensure the feasibility and profitability of remanufacturing activities. In this context, the used products market is about reselling in particular.

Major international players in the machinery and equipment sector and auto industry have already begun to build reverse supply chains, and separate remanufacturing processes and plants. For example, Hitachi Construction Machinery in Zambia is engaged in the remanufacture of components and equipment maintenance[14]. The key components of most forestry and mining industry equipment, such as hydraulics systems, are valuable. At best, their remanufacture can be more profitable than their first usage period.

Control of the used products market is most effective on the machine tools side, especially within agriculture and the forest industry. Valtra (AGCO), which is under foreign ownership, and John Deere offer factory serviced spare parts and refurbished machines[15], whose resale price is often 60–70% of the original price.

However, economies of scale and reverse logistics form practical challenges to building an efficient remanufacturing system. The Finnish forest machine manufacturer, Ponsse, exports roughly half of its output to countries outside the Nordic region. Heavy machinery is expensive to transport and products often end up far from logistics centres. Ponsse has a global network of around 150 maintenance and spare part centres for servicing equipment and extending its service life. There is a lively used products market, in which Ponsse is a major Nordic player, for equipment.

One way of improving profitability would involve improved monitoring of the profitability of reselling and the greater standardisation of processes. Taking greater account of remanufacturing during the design phase and bringing the resale of exported equipment under the control of the OEM (through reverse logistics) would be concrete steps towards a strong circular economy.[16]

Demand for used machines also exists in the heavier-than-forest-machine category. For example, Wärtsilä's four-stroke engines are sold on the Chinese portal Alibaba.com. In global terms, the machinery and equipment sector has traditionally tended to marginalise the used products market. However, some global market leaders have begun to systematically step up their role in reselling. Caterpillar is one of the best-known examples of this. Best practices have been sought by the auto industry in particular, where Renault has managed to successfully build a plant that specialises in remanufacturing, achieving a turnover of EUR 200 million.

Remanufacturing processes are a development focus in some companies. Reselling provides new insights on growth and how to improve competitiveness.

Transport costs play a key role in reverse logistics. These costs are influenced by the size of the equipment, transportability and the distances involved. Whereas small machine tools can be shipped overseas in a TEU container for EUR 1,000, the transport costs of large harbour cranes can be a thousand-fold higher and much greater in relation to the value of the sold equipment. For example, it can cost more than EUR 1 million to load four cranes valued at EUR 10 million each, not including two months of day-to-day and fuel costs associated with overseas transport. These additional costs can easily amount to 10–15% of the total cost of the equipment.[17]

However, local production or locating remanufacturing capacity closer to the customer can help to reduce fuel costs and the time spent refurbishing and remanufacturing, shipping included. Retaining control of the remanufacture of heavy structures and equipment and their used products market can be more challenging than in the case of machine tools. On the other hand, the long-term potential of material-adding techniques could become substantial in the manufacture of spare parts. Although the stress resistance of metal 3D printing has improved and the price has fallen since the days of early-stage experiments, large scale commercial exploitation will not be possible in the near future[18].

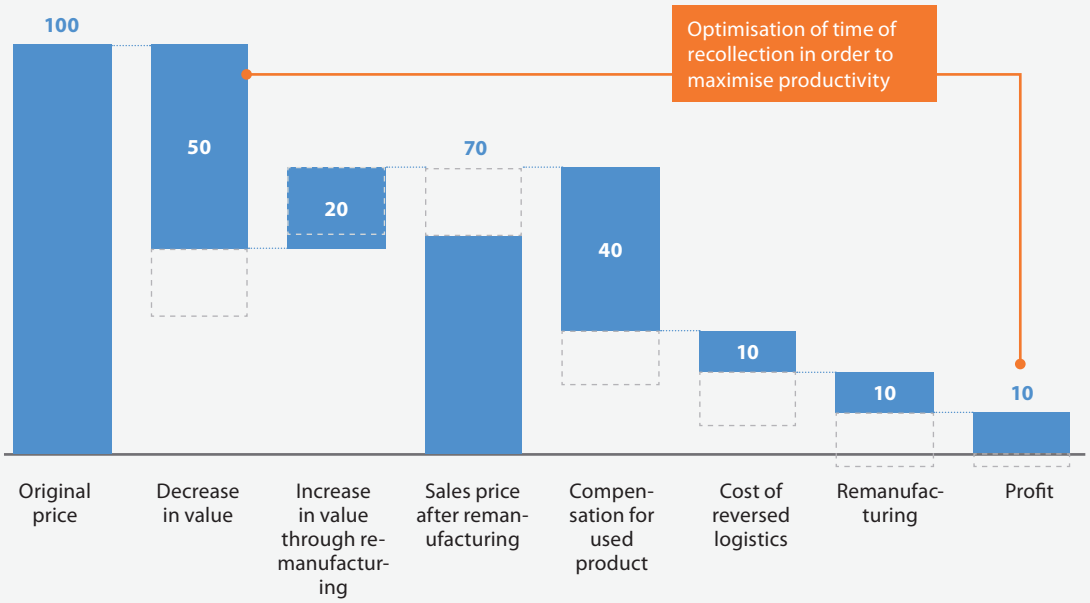
The remanufacture of equipment requires not only cost monitoring, but also the creation of incentives for customers to ensure that the product can be resold at an appropriate stage in its life cycle. Figure 15 describes the optimisation of the remanufacturing process. In this example, the key is to identify the optimum ratio between the service life of the equipment and the remanufacturing costs. If the equipment is in service too long, the remanufacturing costs will become too high in relation to the price obtained for the resold equipment. It would therefore be important to repurchase the equipment at a sufficiently early stage so that, despite the higher purchase price, the cost of remanufacturing is lower, making the resale of the equipment profitable.

Remanufactured products would not necessarily reduce the size of the market. Many Finnish machinery and equipment manufacturers sell equipment of the highest quality

14 Hitachi website
15 DemaNET/VTT
16 Interviews
17 Interviews, McKinsey
18 Interviews

**Figure 15. The key is to identify the optimum ratio between the service life of the equipment (loss of value) and the remanufacturing costs**

Source: McKinsey




rating, but in Asia and Africa in particular, the mid-market provides refurbished products that are in good condition with a new lease of life. During remanufacturing activities, it is possible to refurbish old equipment stock for remote maintenance purposes, thus providing new business models based on the use of current equipment base. Gaining entry to new market segments and managing reputation risk by exercising control over the used products market segment under the company's own Reman brand are important in this respect.[19]

Remanufacturing would promote the circular economy by keeping a larger share of the original product's value in the economic cycle for longer. Such business models would also promote product design in which the starting point would be making products more durable and their repair and refurbishment more cost-effective.

## The potential in the machinery and equipment industry amounts to EUR 300–450 million

Based on a conservative estimate, the operating models described above represent a potential turnover of EUR 300–450 million in the machinery and equipment industry (Figure 16). For many companies, more extensive remanufacturing would not necessarily be possible or viable as a single objective. However, in combination with service models, pre-emptive design and smart systems, the prospects are much improved.

In typical circumstances, modularity can save 5–10% of total costs. Within the machinery and equipment industry, which is highly raw material and intermediary use intensive (these often account for more than 50% of total costs), savings can be generated in design work, purchasing and manufacturing[20]. Based on firms' current circumstances and the fact that some operate on a smaller scale, even the most conservative estimates put the savings potential of modularity at EUR 60–100 for the biggest players in the industry. This assumes a 5–15% increase in the degree of modularity for certain companies and anticipated cost savings of 3.5% when only design work and manufacturing are included. The potential for value creation would be markedly higher if the target were full-scale modularity.

New pricing and service models, the indirect benefits of which are included in these calculations, would bring additional sales and new, continuous cash flows. Based on a conservative estimate, the additional long-term sales potential would be EUR 135–225 million[21]. In practice, the benefits to individual companies could be even greater, if the transition from selling equipment to optimal use of all equipment is achievable within production itself in

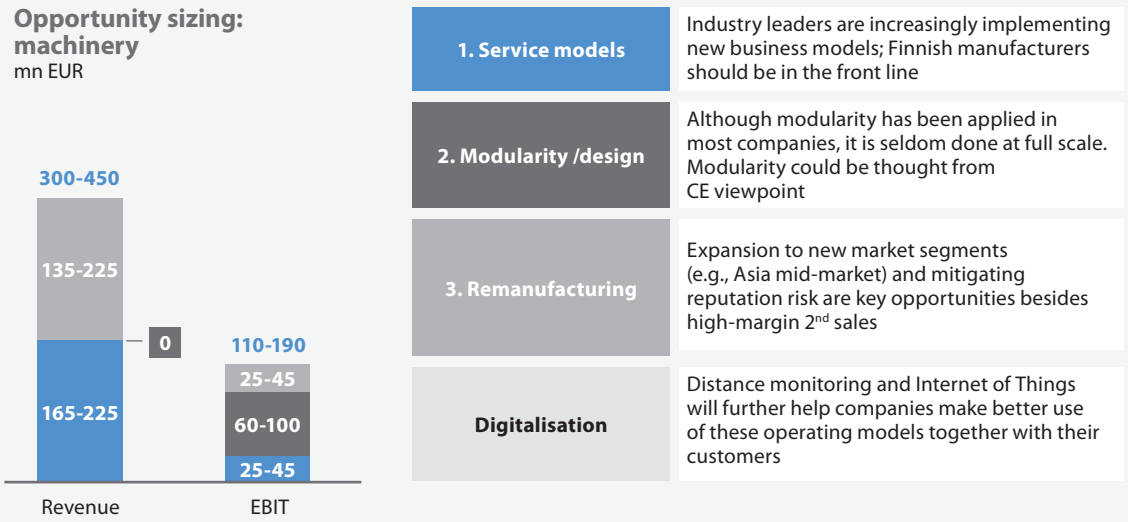
19 Interviews, Ellen MacArthur Foundation

20 McKinsey

21 An analysis of the biggest operators in the sector: 3–5% long-term relative increase in sales for 20–30% of products, taking account of different product life cycles, technological advances and the challenges of re-selling

## Figure 16. Within the machinery and equipment industry, circular economy principles represent an opportunity worth EUR 110–190mn/year

Source: USITC, Policy connect, EMF, Technical Research Centre of Finland Ltd, Annual reports and public interviews, websites, McKinsey




areas such as the process industry or warehouse and port operations.

Based on a more conservative scenario, if the preconditions for remanufacturing exist, the Finnish machinery and equipment industry could achieve EUR 165–225 million in additional sales. This estimate takes account of a 5–40% resale value and a higher share, by 10–25 percentage points, accorded to the resale of products operated by the company itself[22]. In practice, the resale value of many work machines can be 60–70% of the original price, while a range of 5–20% is often the most conservative estimate, even for heavier equipment.

It is estimated that the combined turnover of leasing and reselling amounts to EUR 300–450 million, but this can be higher in the long term depending on the level of application. Assuming typical 10–15% EBIT levels and efficient capture of value at a level 5% higher than the original[23], for this sector the EBIT potential amounts to EUR 110–190 million when cost savings due to modularity are counted in.[24]

## How can we reap the full benefits of the circular economy?

The biggest companies in each sector are the key players in realising the opportunities of the circular economy, while a smaller role is played by their subcontracting chains.

The circular economy is creating a narrative and interlocking a high number of single projects involving issues such as modularity and service model renewal. If a company can assume cost-efficient control of the resale and remanufacture of its own products, it will be well on its way to joining the circular economy. The main benefits include:

- Faster growth; new business models will capture more value from existing customer relationships and remanufacturing will see the customer portfolio expand into the mid-market.
- Maintained and improved competitiveness; manufacturing processes will become more efficient and digitalisation will support maintenance, resale and product development activities, as well as the development of new business models and opportunities, such as expanding into software.

22 The analysis takes account of the special features of the companies' production and products with respect to resale; products at the extreme ends of the scale in terms of resale include various drivable work machines, as opposed to heavy lifting cranes or fixed mining equipment.

23 Systematically structured remanufacturing can be more profitable than the initial sale in the long term, particularly for equipment that can be resold for more than 60% of the new product's price. The priority here is to combine the industrial internet with the monitoring of cost-efficiency at equipment level.

24 In EBIT calculations, the savings potential of modularisation also covers increased sales through leasing, while a higher degree of modularity is assumed when calculating the cost-efficiency of remanufacturing.

- Customer requirements can be met more flexibly; modularisation makes updating and servicing equipment easier, and digitisation helps to improve understanding and provides opportunities to help customers boost their production.

The structure of Finland's machinery and equipment industry would help more than hinder the adoption of a circular economic model. A high degree of specialisation in narrow product segments and adherence to the quality perspective testify to the control exercised within subcontracting chains. The biggest players on the market are also best equipped to introduce new business models to customers.

The circular economy provides a perspective based on which control can be exercised over service models, modularisation and the overall recycling of used products through the industrial internet. This is about more than just internal choices in companies – it involves a wider understanding of long-term trends. Competitors have already begun to develop their remanufacturing capacities; once life-cycle thinking becomes mainstream, as demonstrated by Renault, Caterpillar or Rolls-Royce, it will have the potential to transform the entire business sector.

## Machinery and equipment industry: what should the private sector do?

**Action:** Assess the long-term requirements and opportunities represented by the circular economy and incorporate a long-term, circular economy perspective into the strategic process. Encourage companies to utilise new business models, modularity and remanufacturing. Reshape business models so that they enable reuse and build reversible logistics chains. Piloting can be based on the factory, product type or market segment.

a. To promote the circular economy, the private sector must begin by identifying profitable business models based on the circular economy approach. The circular economy offers a new perspective on how to rethink operating models in order to improve competitiveness.
b. Within companies, practical changes are focused on developing reverse logistics chains in order to enable remanufacturing.
c. Naturally, this will require the design of products and operating models in a way that supports remanufacturing. However, the best starting point would be to tap into the used products market for the company's own products. Building new business activities on this basis would help to launch the transition.
d. New skills in remanufacturing and process development, with an eye on reselling, will be required in order to develop a new operating model.

**Outcome:** Success stories of companies that have made the transition to circular business models. These will inspire other companies.

**Action:** Take account of multiple product life cycles and material recycling in product design. Invite subcontractors with the relevant skills and external specialists to participate in design work.

a. Product design plays an important role in promoting the circular economy. Companies can change the design of products and the materials used in them in order to promote their reuse.

**Outcome:** Improved circulation of products and materials.

## Machinery and equipment industry: what should the public sector do?

**Action:** Promote the circular economy through research and provide communication channels between private sector actors.

a. The main role of research institutions and industrial coalitions is to develop process know-how in cooperation with companies, while facilitating the related development work. For example, Linköping University in Sweden and the University of Bayreuth in Germany have developed expertise on remanufacturing. This learning process also covers the cleantech sector – particularly equipment manufacture.
b. Ongoing research projects, such as VTT's DemaNET, the SHOK programmes FIMECC and ARVI, Sitra's Industrial Symbiosis, and many others provide information and communication channels for companies. Other important discussion forums include industrial organisations and other associations.

**Outcome:** Research provides improved understanding of the circular economy among companies and removes circular economy bottlenecks.

# 3.2 Major potential in paper industry side streams

A conservative estimate suggests that the circular economy represents potential added value of around EUR 220–240 million for the pulp and paper industry. Of course, in many ways the Finnish paper industry is already applying circular economy principles: energy-efficiency is high, good use is being made of side streams and recycled raw materials, such as recycled paper, are being used in production.

An overview of the wood value chain in Finland is presented in Figure 17. In Finland, wood is mainly used in construction or the manufacture of paper and paper products. The sector has two key areas of interest for the circular economy. Firstly, the recovery of paper fibre for reuse accounts for a significant share of the total material flow. Secondly, whether it originates in sawmills, forest harvesting or construction, most wood waste in Finland ends up being used as an energy source. It is important to consider whether energy use is always the most profitable route. From the viewpoint of the circular economy, the best opportunities lie in improving the circulation of paper fibres and the utilisation of side streams.

However, Finnish paper producers do not have control over the paper recycling chain as a whole, because a significant share of paper produced in Finland is exported. For this reason, a more interesting opportunity to promote Finland's circular economy lies in production side streams.

The paper industry already has the right mindset to benefit from the circular economy and by-products: Efficient application of the circular economy approach is crucial to the profitability of companies in the pulp and paper industry, due to their large material flows and energy-intensity. Even small improvements in efficiency or the recovery and utilisation of side streams creates major savings or new business for pulp and paper mills. In fact, the preferred term in the industry is side streams rather than process waste.

A good example of internal recycling is the recovery of black liquor, which plays a key role in the energy balance of any chemical pulp mill. Efficient use of black liquor and other energy sources makes many pulp manufacturers self-sufficient in electricity. Waste paper from paper making processes is efficiently looped back into production on a similar basis. Another aim is to recover energy from sludge for use in production.

## The circular economy represents a host of opportunities for the paper industry

The paper industry is undergoing a transformation. Digitalisation is continuously lowering demand for traditional newsprints and printing paper. In particular, newsprint's share of total production has plummeted in the new millennium. Although the share of packaging materials and speciality papers has slowly increased, competition in these segments is also intensifying.

Profits are also being diminished by increasing competition from countries with lower production costs. This competition is no longer just about lower prices; quality keeps improving. In addition, traditional value chains are transforming: A pulp mill may be located in South America, close to raw materials, from where the pulp is transported for further processing to China, closer to customers. With growth in demand and efficient production of raw materials occurring elsewhere, Finland needs to find ways of remaining competitive.

Since the peak years of the 2000s, production volumes and the employment rate in the paper industry have fallen dramatically. In 2000, the sector provided added value of 2.4% to Finland's economy; by 2013 this figure had fallen to 1.9%. In the same period, employment has fallen from 1.7 % to 0.8%. The sector is also facing major challenges in relation to profitability. Traditional solutions, such as cost cutting, may improve the situation slightly, but major remedies must be sought elsewhere. This transformation lends even greater emphasis to the importance of efficient resource exploitation in the pulp and paper industry.

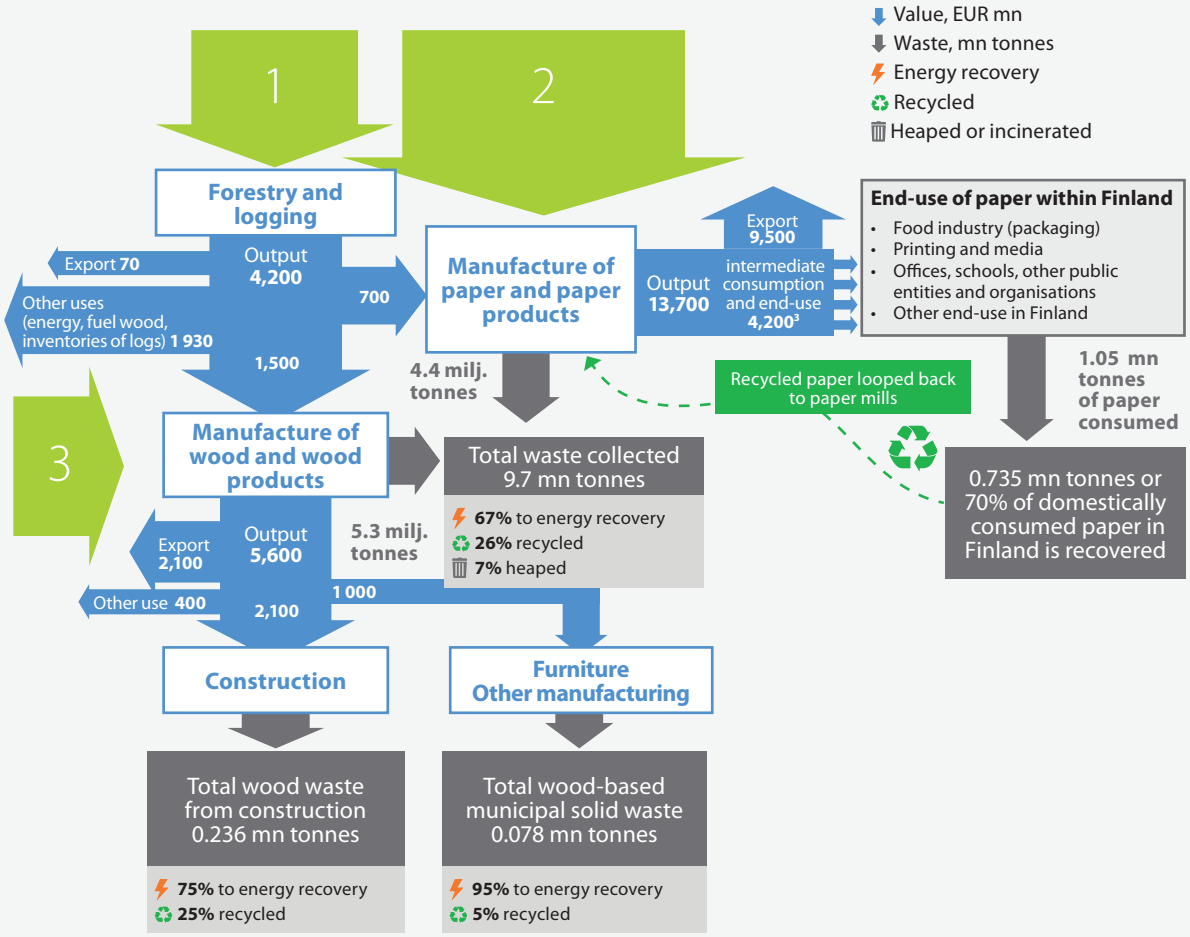
The size of material flows of forest industry by-products alone represents a major opportunity for the paper industry. While certain by-products have been further processed for many years, plenty of untapped potential remains. In addition, forest industry companies have a deep understanding of the characteristics of wood and wood processing practices. Because the sector already applies many circular economy principles, the next step will be to maximise the value of recovered materials and use renewable natural resources in other chains.

## Figure 17. Output from forestry, wood and paper is mainly exported, waste is burned for energy or recycled

Source: Eurostat, Finnish Forest Industries Federation, Finnish Forest Research institute, European Pollutant Emissions Register, McKinsey

### Overview of forestry, wood and paper value chain in Finland 2011

EUR mn, mn tonnes




**1**

**Inputs[1] 1,400[2]**
- Forestry and logging 54%
- Coke & petroleum 5%
- Chemicals 2%
- Imports 10%
- Others (e.g. transport, electricity) 20%

**2**

**Inputs 10,600**
- Manufacture of paper and paper products (pulp) 17%[4]
- Imports 19%
- Warehousing and transport 20%
- Electricity 10%
- Forestry and agriculture 7%
- Chemicals 5%
- Manufacture of wood and wood products 3%

**3**

**Inputs 4,500**
- Forestry and logging 34%
- Manufacture of wood and wood products 15%
- Electricity 3%
- Transport and warehousing 11%

1 Inputs are determined here as intermediary consumption to sector, excludes labour costs

2 Breakdown by input will not add up to total as only largest inputs per sector are listed

3 Calculated as total output minus exports. Majority of Intermediary consumption of paper by service-related sectors and retail is likely to reach end-of-life stage within Finland

4 Manufacture of paper and paper products as an input is pulp going into paper production within the sector in this case

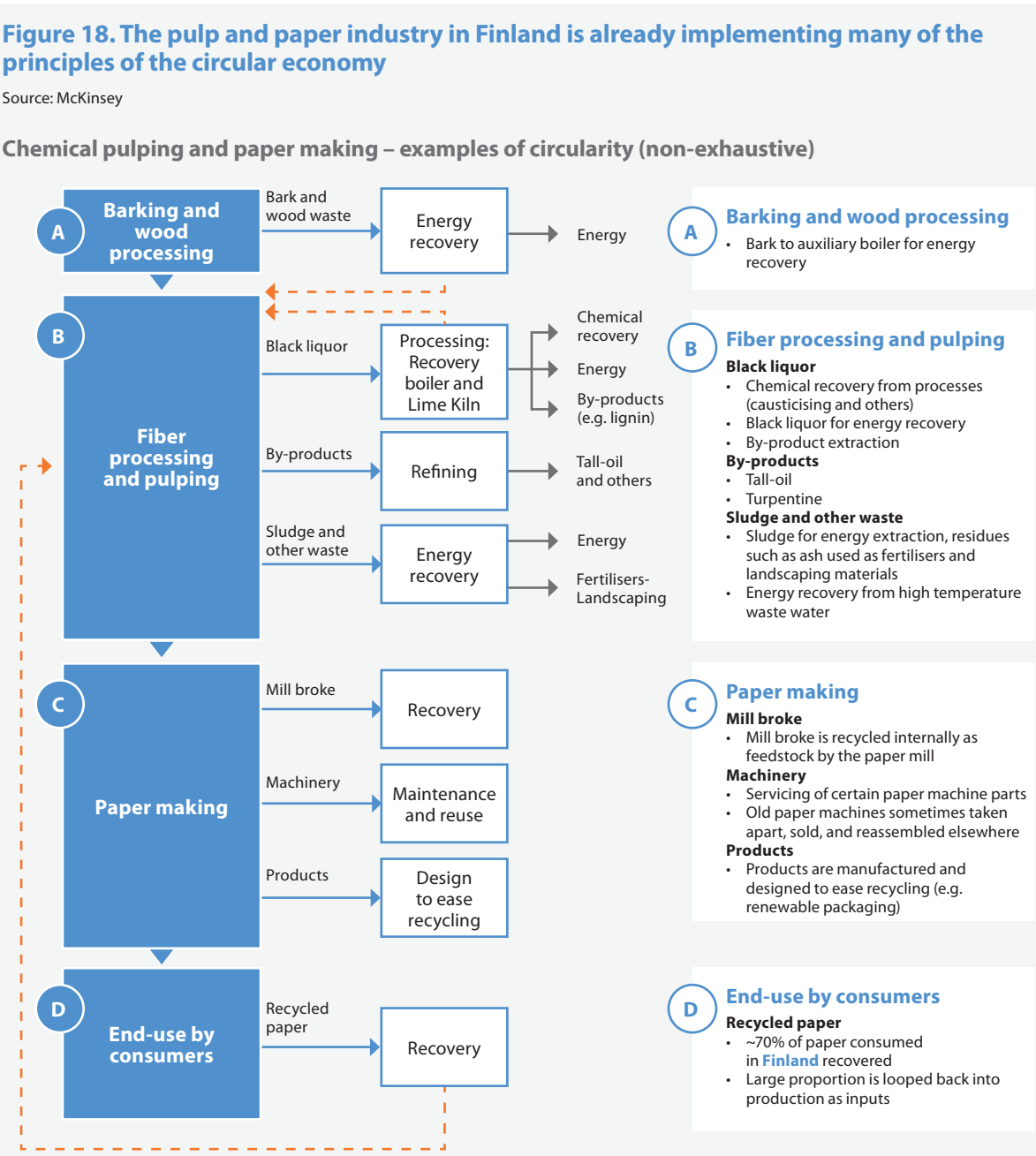
## Why by-products?

By-products account for a major share of the paper production process. Wood is roughly two-thirds glucose and lignin, and one-third fibres. Although fibres are being used in paper production, the two other side streams are not being used to their full potential.

Lignin is an example of a side stream with the potential for even higher added value. Some 25% of lignin could be extracted without disturbing a mill's energy balance, even though the lignin in black liquor is already being burned for energy. Through further processing, this could be used

### Figure 18. The pulp and paper industry in Finland is already implementing many of the principles of the circular economy

Source: McKinsey




**The pulp and paper industry is already implementing principles of circularity – materials are often looped back into processes, by-products extracted and energy efficiency optimised**

## In some cases, forest-based by-products can be classified into two categories:

**1)** drop-in solutions, in which the developed molecule is exactly the same as another existing product (e.g. second-generation biodiesel), and

**2)** new functional products, in which the molecule is different and has a new, modified feature (e.g. a slightly stronger bio-based reinforcement agent for cement)

to manufacture various raw materials for other industries. However, side streams offer potential solutions well beyond lignin; the possibilities are endless, because wood is a highly versatile material offering plenty of opportunities for other applications.

By manufacturing by-products for other value chains, the paper industry could raise the volume of renewable materials in the Finnish economy – for example by replacing epoxy with a lignin-based product. In many segments, demand for replacement products based on renewable raw materials is being promoted by regulations on end-product emissions or safety. The paper industry can respond to this growing demand. Although this is not a new idea, the large-scale commercialisation of new opportunities remains in its early stages. On the other hand, the manufacture of tall oil products has been underway for a long time.

In the long run, finding new sources of revenue will also promote the growth of the industry as a whole. No corresponding growth opportunities lie in increasing the share of recycled paper or minimising sludge.

## At least EUR 220–240 million of annual potential for the pulp and paper industry

Side streams have major economic potential. Many of the assumptions used in the analysis may change in the long run and no specific application or market value has been determined for some products. This means that the baseline for estimates should be as conservative as possible. The estimate given below is nevertheless based on the use of functional products – considering the possible drop-in solutions among biofuels and biochemicals, the true potential of by-products is likely to be much greater.

Efficient utilisation of by-products and the commercialisation of applications clearly represent a major opportunity for the paper industry.

Our estimate of the circular economy's potential in this regard is based on the current production volume of chemical pulp in Finland. Lignin was the product chosen for the basic scenario – the total volume of potential lignin production is relatively large, while the technology used in lignin manufacture and the product's potential applications are at a more advanced stage than other product application options. This makes an assessment of the long-term opportunities more realistic.

The assumed amount of recovered lignin was 25%. This accounted for maintaining the pulp mill's energy balance, since lignin is a key element in the combustion process for black liquor. It has also been estimated that use could be made of one third of Finland's chemical pulp in by-product applications. The possible applications of isolated lignin have been evaluated on the basis of a breakdown into various value classes: high-value applications, such as food industry chemicals; mid-value applications, such as use as a bonding agent; and low-value applications, such as further processing of lignin into fuel.[25]

The current market prices of fossil alternative products were used to determine the possible price of the end-product. The cost of further processing was estimated to be around 75% of the product's market price. On this basis, lignin would have a final potential of around EUR 60–70 million.

The median potential of lignin has been extrapolated to cover other possible by-product applications. The assumption is that the value breakdown of applications for the other side streams is roughly the same as for lignin. Assuming that even the smallest side streams can be utilised, the total estimated volume of other by-products is around 2–2.5 times that of lignin. This makes the total value of other by-products roughly EUR 140–150 million, while the combined total potential amounts to EUR 210–220 million.

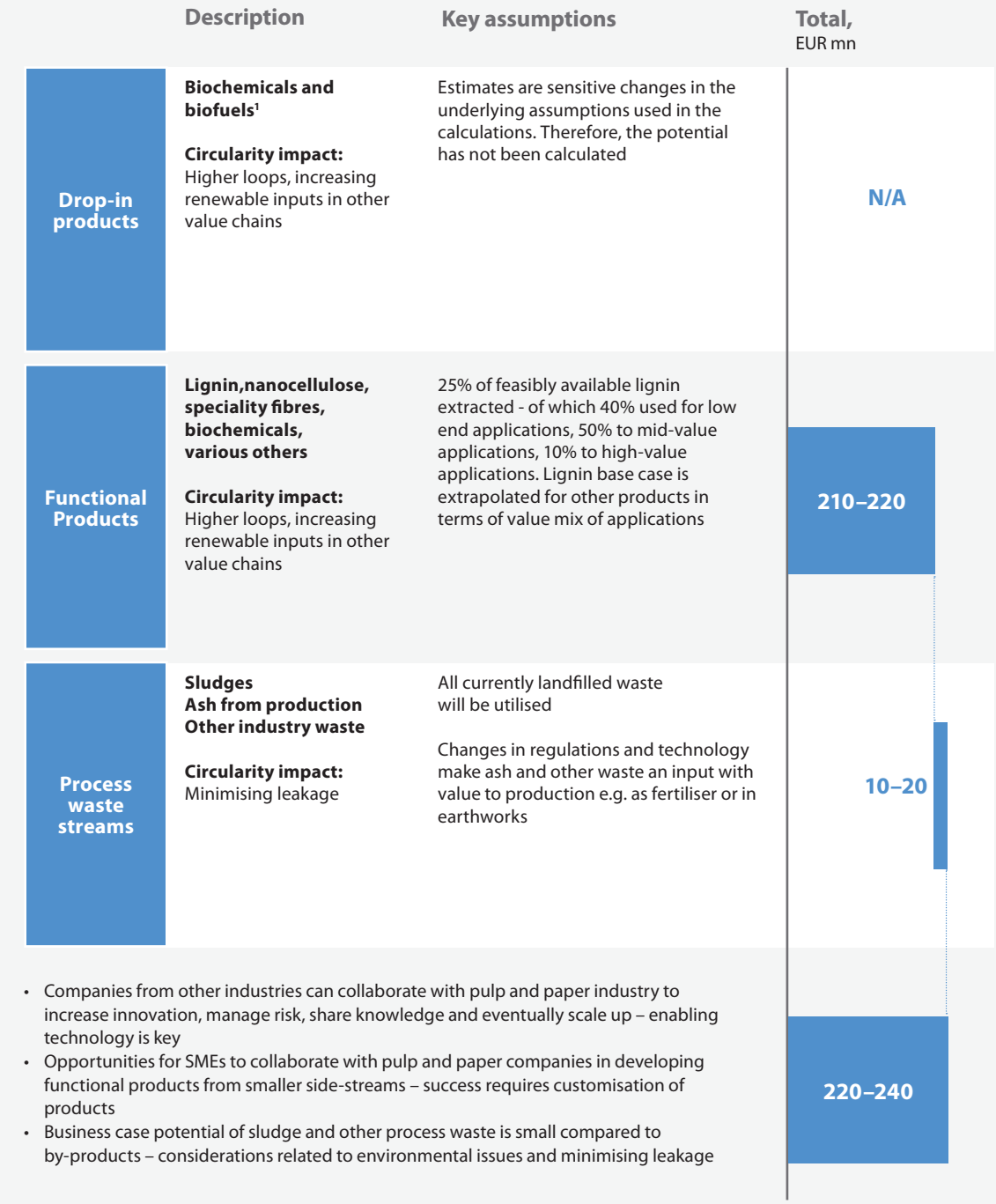
The calculations covered the utilisation potential of various sludges in addition to by-products. The assumption was that all sludges destined for landfills and green liquor sludge can be recovered for use as, say, energy sources or fertilisers. It was also assumed that ash can be utilised in earthworks without the necessary permits, meaning that no extra costs will arise from the disposal of ash and other such materials. Based on a 30% margin of error, the estimated total potential is EUR 10–20 million.

This means that the circular economy's total potential for the forest sector is around EUR 220–240 million.

25 The purpose of use of lignin can be broken down by value class as follows: low-value applications 40%, lower medium-value applications 25%, higher medium-value applications 25% and high-value applications 10%

## Figure 19. The potential for by-products and process waste utilisation could amount to at least EUR 220–240 million annually

Source: Finnish Forest Industries Federation, Statistics Finland, McKinsey




1 Excluding calculations on bioethanol and other biofuels

This estimate is relatively conservative – in an ideal situation, the value breakdown between applications would even tip the scale towards high-value applications. It is even more important to note that the drop-in solution markets excluded from the analysis are very large in comparison to the size of the chemical industry and the global fuel markets.

## Stepping up to the next level

Better utilisation of by-products – whether these be bioethanols, biochemicals or cellulose fibre – are included in the future plans of every forest industry company.

Although major forest industry companies already have a new mindset and are actively exploring the possibilities of side streams and by-products, large-scale commercial

### Figure 20. Further innovations are already being pursued in the utilisation of by-products and waste streams within the Finnish pulp and paper industry

Source: McKinsey, www.upm.com, www.storaenso.com, www.metsagroup.fi

| | UPM | Stora Enso | Metsä |
|---|---|---|---|
| **Biostrategy quotes** | **UPM – the Biofore company:** "Innovations are at the forefront in the creation and development of new products that can be used to replace non-renewable materials with renewable, recyclable and low-impact alternatives and provide resource-efficient alternatives for the future" | **Stora Enso Biomaterials:** "The mission of Biomaterials is to find new, innovative ways to utilise the valuable raw material, wood while simultaneously running existing pulp and by-products businesses as efficiently as possible, based on customers' needs" | **Bioenergy producer and supplier:** **"**Metsä Group is one of the leaders in bioenergy production within the industry. We have systematically increased the share of bioenergy in energy sourcing. Over the last few years we have also increasingly expanded our operations to supply wood biomass fuels to third parties**"** |
| **Biorefinery plants and other bio-initiatives** | **Biorefinery in Lappeenranta** Operations to commence in 2014<br>• Biorefinery for wood-based renewable diesel.<br>• Developing biofuels, biocomposites, biofibrils | **Nordic biorefinery plants:** Sunila (lignin extraction facilities), Enocell (dissolving pulp)<br><br>**Stora Enso Virdia:** Focus on developing new applications and technology for lignin and hemicellulose | **Bio product mill in Ääneskoski Finland:** Pulp mill with integrated production of pine oil, bioelectricity and wood fuels and efficient use of side streams |
| **Products (current and under development)** | • BioPiva and Domtar Biochoice (Lignin)<br>• Biofibrils (Nanocellulose)<br>• BioVerno Diesel | • Mircro Cellulose<br>• Lignin based products<br>• Biochemicals<br>• Biofuels | • Lignin based products<br>• Biochemicals<br>• Biofuels |
| | **UPM is developing biofuels and various other applications** | **Stora Enso is developing a wide range of by-product technologies and applications** | **Metsä Group offers a range of bioenergy solutions and renewable packaging materials** |

## Use of wood-based products and by-products in higher-value applications

In a circular economy, consideration must always be given to whether products can be cascaded into higher-value chains. In the case of wood-based products and by-products, for example, tall oil can be used to manufacture biofuels, but also specialty chemicals and other products with a higher intrinsic value. Similarly, the use of wood materials, such as sawdust, in the manufacture of fibreboard presents an alternative to burning such materials for energy. On the other hand, the significance of a higher-value application is also heavily dependent on the market situation – a higher-value chain can lack sufficient demand for applications.

production is still lacking. Biostrategies figure very prominently in annual reports and marketing, but have yet to find a place in companies' financial statements.

Different bottlenecks affect different products. In the case of drop-in solutions, the main determinants are advanced technology and the prices of alternative products (e.g. bioethanol and oil). Companies have no influence over the prices of alternative products. This means that technological advancement is the key determinant in the cost-efficient manufacture of such solutions. In addition, functional products need to be customised in line with the customer's processes and to achieve clear improvements in product features.

Of course, technological advances take time, particularly when a completely new product enters the market. At any rate, given the huge potential of these products and the plight of forest industry companies, such advances are needed sooner rather than later. The overall size of the material flows of forest industry by-products represents a major opportunity for the paper industry. But despite years of research on the further processing of many products, the industry has yet to reach a level at which it can fully exploit and commercialise the potential of these products.

Examples of direct investment in the development of by-products can be found among both foreign competitors and domestic operators. For example, the paper company Domtar, which invests in the development of bioproducts, understood the new significance of by-products and the transformation of the paper industry at an early stage. So far, alongside FP Investments (CelluForce), the company has invested in a plant specialising in lignin production and a research institution focusing on nanocellulose. Another foreign example is the Dissolving Pulp segment of the Sappi Group, which manufactures special cellulose as a raw material in the manufacture of wood-based synthetic fibres. In Finland, companies such as UPM and Stora Enso are making significant, far-sighted investments in bioeconomy projects, such as the LignoBoost lignin separation plant in Sunila.

Finnish companies have yet to achieve the same size category as their foreign competitors.

The Sappi Group is already engaged in the large-scale production of Dissolving Pulp products for use as a raw material in the textile industry. In addition, Domtar installed lignin production equipment back in 2013, for example. The forest industry cannot be blamed for lack of innovations; it is continuously improving its existing products (e.g. the properties of fibre). But there is plenty of room for improvement in the utilisation of by-products.

### The bottleneck in R&D

To better understand the reasons behind the challenges in product development, we need to examine the structure of the innovation process. Roughly speaking, R&D can be viewed as a chain with three stages. In the first stage, small product volumes are developed in a laboratory and interesting properties are sought. In the second stage, the idea's sales potential and production efficiency are tested through piloting. The third and final stage focuses on scaling up the product for sales and production on a commercial basis.

The key challenges concern the second stage of the research chain. Decision-makers rarely have the power to take an invention straight into large-scale production from the test tube and laboratory tests. In a way, this is understandable. The financial risk is significant and investments can be large. Many interesting products do not make it to the production stage. A larger share of the resources reserved for development work should be allocated to the piloting stage, and piloting itself should be made more flexible.

Due to the incentive models used in public-sector financing, research project funding is focused on early-stage laboratory testing. Public financing models place a heavy emphasis on early-stage research and the terms and conditions of financial support can be less than beneficial to a company hoping to swiftly commercialise its findings. Providing financial support for piloting, which could

be regarded as distorting commercial competition, is challenging for the state. Across the EU area, research tends to be about high-level university studies, while concrete applications receive less attention.

## Demand, strategy and competition are key elements of by-product development

The commercialisation of by-products is difficult. Manufacture of a product from renewable raw materials is not enough; the product's price must be competitive in relation to non-renewable options. Price is almost always the deciding factor for the customer, especially if legislation or regulations have no influence on the purchasing decision.

The product must also have a strong advantage over existing products, or the price must be much lower. If a material or molecule differs significantly from a currently used product, switching to the new product will involve costs if changes are required in the process or manufacturing technology. The more different the material or solution, the higher the threshold to switching to the new product. From this viewpoint, drop-in solutions are a simple option: when the cost-efficiency of molecule production has reached a competitive level, in principle the customer should have no trouble switching products. However, account must still be taken of the customer's established supply chains and familiarity with the properties of older raw materials.

Some forest industry side streams are relatively small in relation to by-product volumes – products can be good and saleable but, from the viewpoint of large companies, commercialisation is not profitable; it would be more viable to focus resources on areas with better potential in terms of volumes. Small companies, on the other hand, may have the interest and expertise required to further process smaller side streams, but challenges can arise in the cost level of patents, the utilisation of side streams and achieving sufficient production volumes. In place of large companies, smaller operators can commercialise such innovations through partnerships, for example.

Legislation also plays a part in this puzzle, especially with respect to side streams. For example, the pulp and paper industry views the utilisation of sludge side streams as an attractive prospect and is continuously focusing research on more effective ways of exploiting them. In many cases, however, the problem lies in legislation on waste, which increases waste management costs and hinders the development of applications, thereby impeding innovation. Some bio-sludges which, regardless of the fact that they contain hardly any harmful bacteria, are bound by some of the same legislative criteria as waste headed for sewers, are examples of this problem. Another example is the ash generated by the pulp and paper industry. In practice, ash is a good material for earthworks and for use as fertiliser in, say, forests. However, using it in this way is difficult – obtaining the necessary environmental permits is a relatively slow process that must be repeated for each individual batch. In addition, the use of ash is restricted by limit values, despite the lack of clarity on whether exceeding the set limits for heavy metal concentrations, for example, actually causes harm when ash is used for purposes such as forest fertilisation.

The restrictions on the use of paper industry sludges and ash demonstrate that a rethink may be needed on parts of the permit process for side-stream use. If certain criteria are met on limit values, it should be possible to use ash from side streams as a material in earthworks or, for example, as a fertiliser, regardless of the target site. This would enable maximisation of the utilisation of ash, for example.

## Greater cooperation in production could make commercialisation easier.

The forest industry is already co-developing by-product applications with potential customers. In addition to cooperation with customers, production side partnerships should also be considered – not just with other forest industry companies, but with other industrial sectors too. Arizona Chemicals, for example, has long been utilising tall oil in chemicals production. Greater cooperation with other producers could also prove sensible in terms of risk mitigation, investment sharing and the targeting of product development resources.

Many by-product applications are not directly linked to areas familiar to the forest industry: for example, the applications of many promising products are centred around chemical or materials industry processes. Even if the forest industry has the necessary raw materials and resources for manufacturing certain products, the sales logic behind the material can seem unfamiliar. In addition, the creation of customer relationships may take longer due to established supply chains. To manufacture products successfully, it may be advisable to bring in expertise from other sectors – close cooperation with other producers could help to solve some of these problems.

Cross-sectoral ventures between two major producers may be a way of accelerating the commercialisation process and lowering the threshold to piloting, while increasing the chances of success. For example, in biochemicals development the forest industry could find suitable partners among chemical industry players.

## Success stories from Finland and elsewhere

### Arizona Chemical

Arizona Chemical is an example of a company that has succeeded in developing a broad selection of industrial chemicals from wood-based products. It is a leading producer of pine chemicals, manufacturing a wide range of chemicals and additives based on renewable materials for various uses, from coating and packaging materials to adhesives in car tyres.

Arizona Chemical's origins are of particular interest to the paper industry. The company was established in 1930, when International Paper and American Cyanamid partnered to open a salt mine in Arizona. After the mine was closed in 1936, the company began producing turpentine and pine oil. By 1946, pine oil had become Arizona Chemical's main product.

The company continued to grow – and persist with product development – throughout the 1960s and 1970s. Demand for pine oil and other environmentally friendly alternatives, such as pine-based resins, grew alongside the related research and development. In 1984, International Paper gained full ownership of Arizona Chemical and began a series of acquisitions of chemical industry companies worldwide, boosting the company's growth and expansion strategy. The company was sold to a private equity company in 2007, but International Paper retained a 10% share. While this is not an example of direct partnership between two separate companies, one issue should be noted – Arizona Chemical was originally owned by International Paper, a paper industry company, whereas Arizona Chemical clearly specialises in chemicals.

Through its parent company, Arizona Chemical gained knowledge of pulp production and the potential of paper industry products, while probably having access to a steady material flow. On the other hand, the utilisation and growth of applications for pine oil, which was a by-product, would probably never have been as efficient if International Paper had acted alone. Cooperation between these two distinctive companies in the wood-based chemicals sector clearly contributed to this story of growth and success.

**Key success factors:** Cooperation with the paper industry parent company and the resulting access to know-how and raw materials; clear specialisation in the chemicals industry.

### Lyocell

Lyocell is an example of a wood-based specialty product whose large-scale commercialisation has been successful. Lyocell is a form of rayon, made from dissolving pulp (bleached wood pulp). The fibres are durable, but can be used to manufacture silk-like fabrics, for example. In addition, lyocell is fully biodegradable in a relatively short time, making it an environmentally friendly alternative to many synthetic fibres.

A key contributor to the wider use of lyocell is the Austria-based Lenzing, a maker of man-made cellulose fibres. Lyocell was produced for the first time in 1980 – on a very small scale and not by Lenzing. How was the product scaled up so successfully?

From the outset, Lenzing has specialised in fibre production for the textile industry – it already had the necessary know-how in the target customer's sector and knew how the industry worked. Lenzing also had a rather aggressive expansion strategy with regard to lyocell and took risks: in 2005, for example, it acquired a company called Tencel, thereby tripling its production of lyocell. The share of fibre in relation to total production was originally small and the figures were not published, but fibre now accounts for more than 20% of production. An aggressive market strategy has clearly paid off.

On the product side, the reasons for success lie in the special properties of the fibre, combined with prices that are more competitive than other regular fibres. Interest has also increased in the product because it is made of renewable raw materials and is environmentally friendly; Lenzing continues to make much of this in its marketing. Many leading clothing chains currently include clothes made from lyocell fabrics in their selections.

**Key success factors:** The product's competitive price, aggressive market expansion, specialisation in textiles, emphasis on special properties and environmental friendliness in marketing.

## What should the private sector do?

**Action:** Forest industry companies must expand into product development, understand the needs of new markets, and increase production-related cooperation with other industries. Such cooperation should not be limited to discussions and negotiations with potential target customers; it would be equally important to build partnerships between the production and R&D sides and the target sectors' existing producers and suppliers.

In practice, this could translate into close cooperation throughout the product development process with a chemical industry company which is currently producing fossil-based chemicals. Instead of competing against each other, the chemical industry and forest industry company could begin co-developing an improved, renewable alternative. Chemical industry companies understand the chemicals market, the properties of the related products and chemistry-related issues in general. They know their customers' needs inside out and have established supply chains and the necessary relationships between themselves. What they lack is the capacity or knowledge required to expand their operations to unfamiliar raw materials, or to gain access to the necessary material flows.

In the future, the platform for cooperation could be expanded to include the development of renewable chemicals.

a. **Large companies:** Major product development projects related to biochemicals and carried out in cooperation with the chemicals industry could bring the required breakthroughs. This also applies to other possible bio-based products, whose producers manufacture fossil-based alternatives or have the related expertise – biochemicals are only one of many opportunities.
b. **SMEs:** Large pulp and paper mills do not always have the interest, the required knowledge or the resources to develop applications for functional products based on smaller side streams. To make better use of the opportunities represented by small-scale but interesting side streams, practical cooperation with SMEs and the generation of spin-offs should be promoted more strongly. In practice, such cooperation could be built around a mutual agreement that the forest industry company share the necessary patent and internal side streams with a smaller company. In exchange, the forest industry company would gain access to the SME's sectoral expertise, customer relationships and resources.

**Outcome:** This would help to combine **1)** the in-depth know-how of the Finnish forest industry on the properties of wood, **2)** the capacity of pulp mills to produce bio-products, and **3)** other sectors' expertise, understanding of customer needs, supply chains and process know-how in areas unfamiliar to the forest industry.

Market entry and commercialisation would be facilitated through a closer link between knowledge, skills and risks, and the threshold to piloting would be lowered. This would in turn increase the value of side streams to the economy.

**Action:** A long-term strategic approach to the development of by-products must be placed on companies' agendas at the application development stage. Sufficient resources must also be allocated to developing the practical implementation of such solutions and easy product adoption, as well as research on technological solutions.

a. The products to be developed must generate sufficient cost savings or be improvements on the alternatives. This will ensure that established supply chains and processes do not prevent the switch between products.
b. The product must be as close to the original (fossil) alternative as possible, to incentivise its adoption by the customer in production or end use.
c. Applications intended for commercialisation may benefit from being directed, where possible, to less competitive markets.

A practical example of this could be the development of bio-based plastics. Such an application would be targeted at a specific type of plastic without many renewable alternatives, rather than developing an alternative to a type of plastic already facing competition from renewable agricultural products, for example.

The properties of the new type of plastic should be clearly better – manufacture using renewable raw materials is not a sufficient selling point. Additionally, even if the new type of plastic is cost-efficient, its properties should not differ too greatly from those of the original. Otherwise, its other raw materials and components may not be compatible with the new material.

Targeting should also take account of products and markets for which, due either to legislation or customer preferences, being renewable is itself a requirement and something for which people are willing to pay. With respect to packaging plastics and plastic bags, for example,

consumers want to know whether they are made of renewable materials or are biodegradable. Most consumers do not worry about such issues when purchasing electronics.

**Outcome:** Commercialisation of by-products is more successful if the customer perspective and strategic dimensions are carefully targeted and included in the design phase.

## What should the public sector do?

**Action:** Support for research should be more focused on practical applications and strategic projects should be provided with more support from a combination of funding options, in support of projects requiring major investment. Funding should therefore shift from research to product piloting on the market, which is often viewed as a commercial activity.

In addition to research on technological solutions, funding should be allocated to developing the practical implementation of solutions and facilitating product adoption.

a. In practice, this would mean that, when granting funding and providing financial support for research, large Finnish institutions involved in research funding, such as the Centres for Economic Development, Transport and the Environment, Tekes and Finnish foundations would place greater emphasis on research into practical applications. The criteria for granting research funding could also cover the financial potential of the product and, at least in part, its strategic perspectives.
b. More funds will be needed, given that substantial investments are often required for research and commercial-phase testing. Major investors in research could, for example, establish a separate combined fund for research carried out during the piloting phase of forest-related projects.

On the other hand, companies themselves should apply for more EU-funding for larger projects. Sources of EU-funding include the European Research Council (ERC), the European Science Foundation (ESF) and Horizon2020, the EU Framework Programme for Research and Innovation. In 2014–2015, Horizon2020 will allocate EUR 80 billion to research projects within EU Member States; companies should consider this a possible source of research funding.

**Outcome:** Companies would be more likely to engage in piloting if more financial support were made available for this part of the commercialisation phase. If decision-makers invested more and placed a greater emphasis on research into practical applications, research might also shift in this direction. This would enable promising products to enter the commercialisation phase more often.

**Action:** Waste laws need to be critically reviewed from the viewpoint of exploiting paper industry side streams and facilitating innovation.

a. Obstacles to the utilisation of forest industry by-products such as sludges and ash in particular should be minimised. At present, the efficient utilisation of ash in earthworks, for example, is hampered by a lengthy environmental permit application process.
b. Based on research data, knowledge of the limit values and concentrations of certain compounds should be increased in order to clarify whether the limit values of sludges and ash really justify these substances' coverage by the current legislation. More information is required on issues such as whether using ash as a fertiliser in forests really has adverse environmental effects when certain limit values are exceeded.
c. Permit application procedures should be harmonised and streamlined to prevent them from being site-specific. For example, depending on the target site, a separate permit is required for each batch of ash. The system should be harmonised so that, when certain limit values are met, ash can be used as a material in earthworks or fertiliser regardless of the site.

**Outcome:** The utilisation and refining of forest industry side streams, such as sludges and coal ash, can be promoted if the related regulations can be improved in cooperation with the forest industry.

# 3.3 Food industry's opportunities to reduce loss of value

The food value chain includes two factors crucial to the circular economy: how well the original raw material is utilised – whether for its primary purpose or as production side streams – and the way in which nutrients are reintroduced into the nutrient cycle. Our assessment will focus on loss and waste arising from the food production chain and consumption.

The circular economy views all food waste generated throughout the food chain as loss of value; the national economy would benefit most if this loss could be minimised before waste is generated. The key sources of food waste include all operators in the food chain, from primary production to consumer. However, the value of food is greatest at the extreme ends of the chain, in the service sector and households, despite the fact that food production and the retail sector generate almost as much food waste in kilogrammes. Key actions for realising the estimated potential gain of EUR 150–200 million should focus on the minimisation of food waste generated by households and hospitality services, and capturing the maximal value of inedible food waste rather than incinerating it.

Emissions from food waste are equivalent to the annual emissions of 200,000 passenger vehicles. The discharge of fertilisers into water bodies has major, adverse environmental effects. The sufficiency of the global food supply and the regional effects of intensive farming on soil health are among the key environmental arguments supporting the circular economy approach on a wider scale.

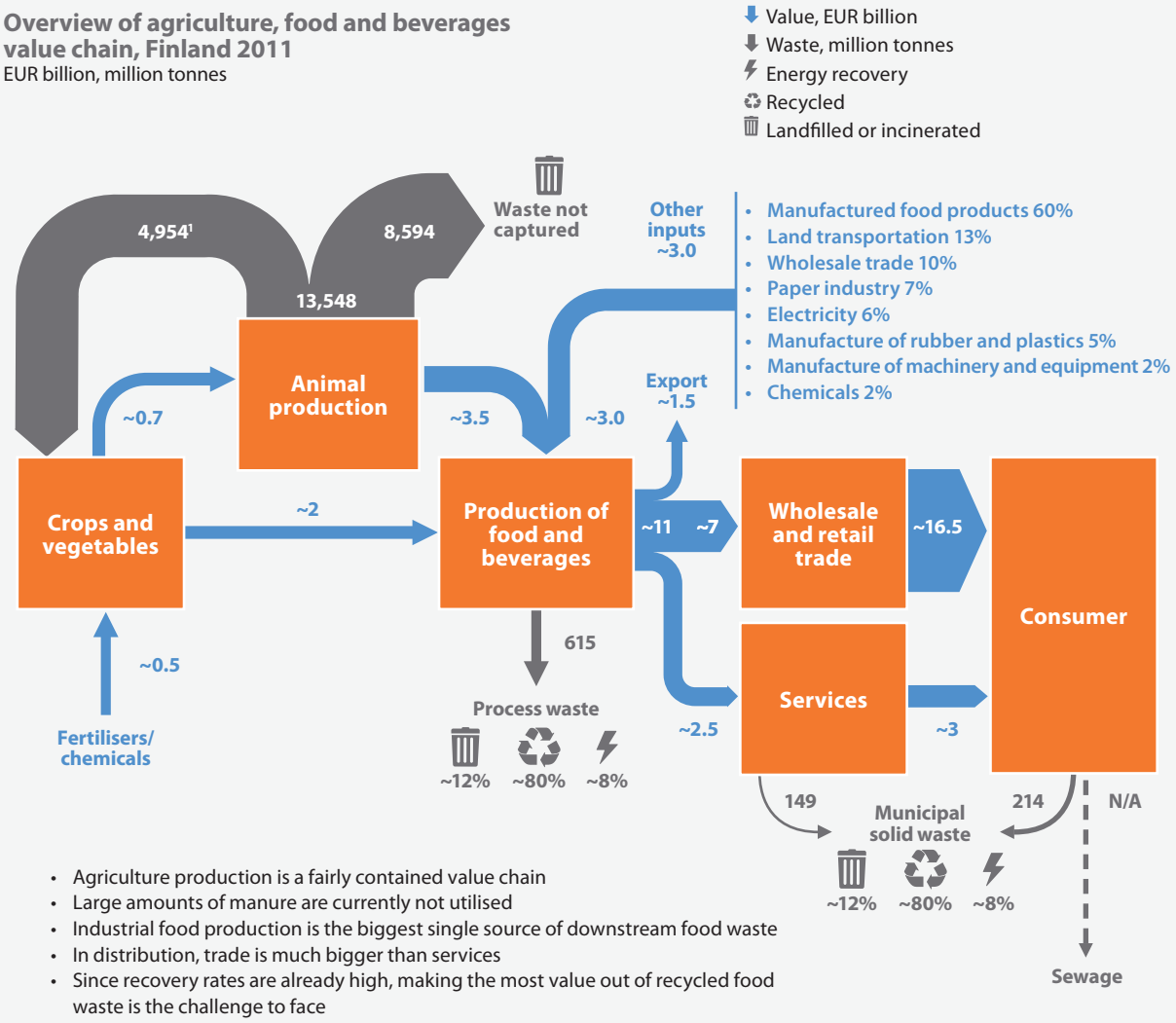
To better understand the importance of reducing food waste, we need to examine both the food value chain itself and the waste that it generates. This section begins by briefly describing the structure of the food value chain and the scale of food waste. We then move on to discuss the role played by various operators in the food value chain in generating food waste and list the opportunities for waste reduction.

## Finland has high self-sufficiency in the food value chain

With respect to food production, Finland is relatively self-sufficient compared to other European countries. Key fresh consumer products, such as meat, dairy products and bread, are mainly domestic. Primary production and the processing of these products is mainly domestic, while further processing is more or less centralised in a few key firms, such as Valio, Fazer, Vaasa, Atria and HKScan. A proportion of dairy products in particular is also exploited. In the import of fresh produce, the main emphasis is on fruit, winter vegetables, and certain meat, fish and dairy products. Alongside logistics, Finland's centralised and domestic retail trade has an impact on the high rate of domesticity. Around EUR 7 billion of processed food enters the retail trade, while the service sector receives roughly EUR 2 billion of processed food and EUR 1.5 billion is exported (Figure 21). Households spend approximately EUR 16.5 billion on food purchases from grocery stores, while some EUR 3 billion is spent on food provided via services.

### Figure 21. Agriculture, food and beverages form part of a fairly self-contained value chain

Source: McKinsey, National accounts, report on "Forkful of facts 2014", Waste statistics




- Agriculture production is a fairly contained value chain
- Large amounts of manure are currently not utilised
- Industrial food production is the biggest single source of downstream food waste
- In distribution, trade is much bigger than services
- Since recovery rates are already high, making the most value out of recycled food waste is the challenge to face

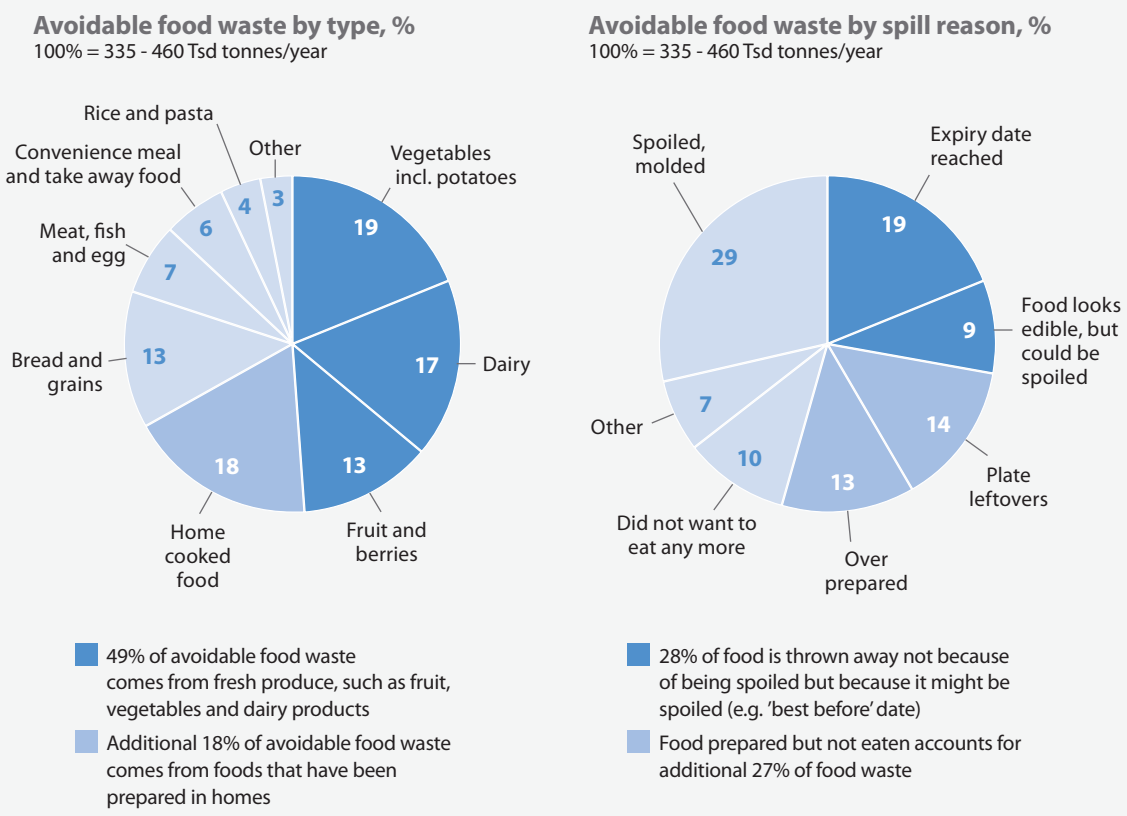
1 Capture possible – actual captured amount n/a

MTT Agrifood Research Finland (now part of the Natural Resources Institute Finland, Luke) estimates that the Finnish food chain throws away an average of 330–460 million kilogrammes of edible food each year. Nearly 49% of this wasted food comprises vegetables, dairy products, fruit and berries. 55% of food waste occurs because the food has reached its "best before" date, the food looked spoiled, or more food was prepared than eaten (Figure 22).

We will now discuss the various opportunities to reduce and make use of food waste from the perspectives of households, services, retail and the food industry. The main focus of this analysis will be on retail, but the behaviour patterns of consumers and service providers have the greatest impact.

## Figure 22. Fresh produce and home cooked food account more than half of food waste in Finland – 28% is thrown away because it might be spoiled

Source: MTT study "Foodspill 2010-2012"



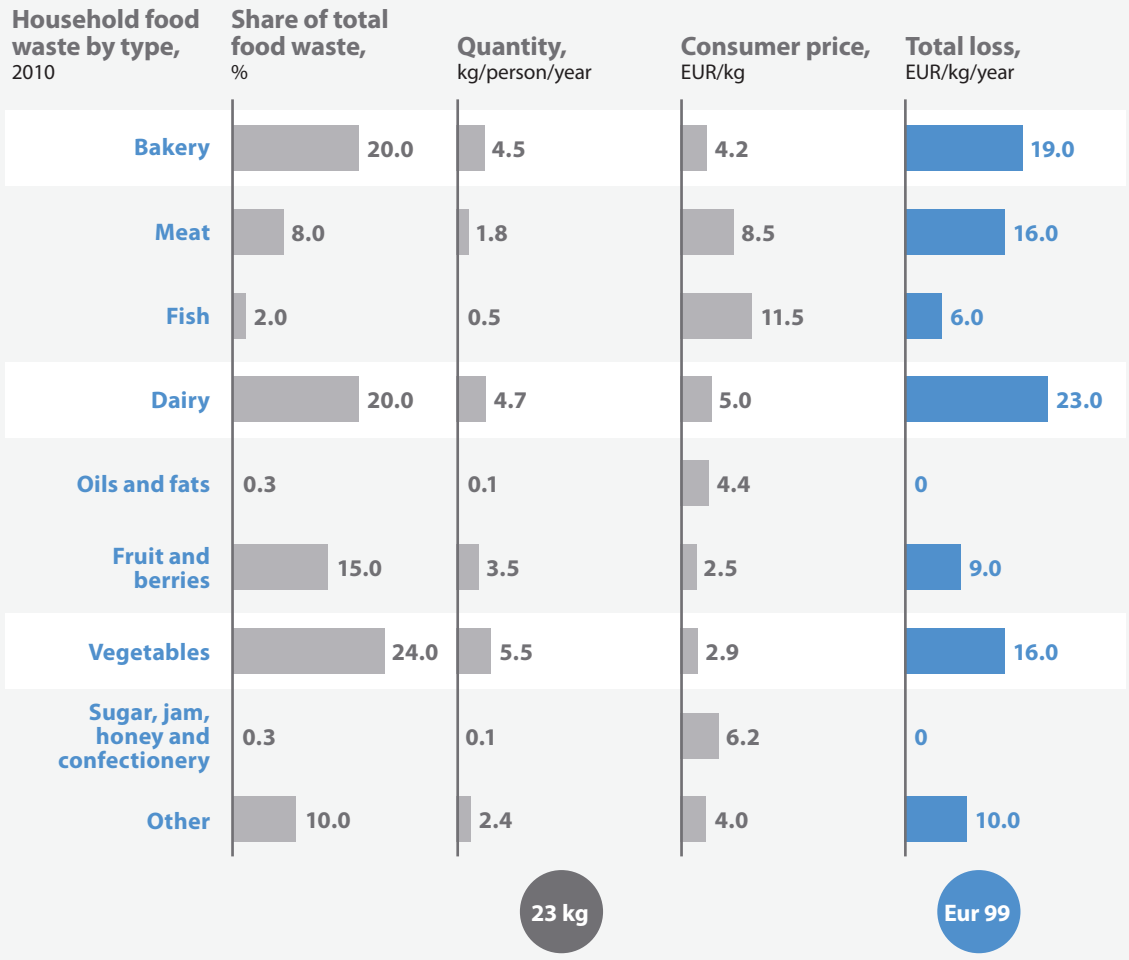
## Consumers would be assisted by changes to the date labelling on pre-packaged foods

Households generate nearly 130 million kilogrammes of food waste a year, which equals roughly 23 kilogrammes per person, and accounts for 35% of Finland's total annual food waste. Household food waste covers all discarded food that could have been consumed at some stage if stored or prepared in a different manner.

Around 50% of food waste is fresh produce. Only 29% of thrown away food was spoiled or mouldy, and roughly 19% had reached its expiry date. The reasons given for throwing away food included: plate leftovers and excessive prepared food (27%), unwillingness to eat any more (10%) and suspecting that the food was spoiled (9%). The annual economic loss due to food waste is approximately EUR 400–500 million (Figure 23).

### Figure 23. Household food waste mainly consists of bakery products, dairy and vegetables, representing an annual loss of EUR ~400-500 million

Source: MTT, Cost of food waste to public administration and households




- Vegetables, dairy and bakery products represent up to ~65% of total food waste
- Single households represent largest source of waste
- Total annual loss amounts to an average of 99 euros per person, or **EUR ~400-500 million** in total[1]

1 Depending on assumptions about average consumer; high variation observed among consumers, 0-160 kg annual food waste / person

Most potential for reducing this loss lies in changing the consumption habits and practices of consumers. Changing the date labelling of pre-packaged foods and providing households with information through campaigns are concrete measures best taken by the public sector. The Finnish Food Safety Authority Evira plays an important role in the date labelling of pre-packaged foods, but some regulations are set by the EU. Decision-making processes must identify and take account of the dynamic effects of regulations. Removing the "best before" date in certain product categories has been discussed at EU level, because consumers tend to confuse this with the "use by" date.

Many players from the public sector and NGOs play an important role in educating consumers. In Finland, for example, the "saa syödä" (ok to eat) campaign has gathered information and methods, including money saving tips and recipe sharing, on waste reduction. Similar initiatives, such as the Matvett.non "Leftover Thursdays" in Norway or the German website zugutfuerdietonne.de which seeks to educate consumers in the spirit of the "ok to eat" campaign, have been launched all over the world. So far, these campaigns have had a minimal impact on people's habits.

Packaging material and package sizes play just as important a role in reducing food waste. If the goal is the optimal recycling of organic waste instead of waste prevention, this would be supported by smaller package sizes and recyclable packaging materials.

"Herkkupesä" is a food sharing system for housing companies or other small communities, aimed at providing a systematic method of reducing food waste. The Herkkupesä concept was tested for three months in Helsinki in 2012–2013. The practical trial was a success and the housing company decided to continue sharing food independently.

**www.saasyoda.fi/perusta-herkkupesä**

## Finding ways of reducing food waste brings new business to restaurants

Restaurants are the second largest source of food waste after households, generating approximately 75–85 million kilogrammes of food waste, or up to 20% of total food waste, per year. The amount of wasted food corresponds directly to the type of service – in fast food restaurants, the share can be as low as 5–10%, while up to 25–30% of buffet food can end up being thrown away. In the food service sector, the percentage of loss is significant in relation to the sector's total turnover of around EUR 3 billion.

Food waste in the sector is split into two categories: edible food material and inedible food material, such as peel and coffee grounds. The first step towards reducing food waste lies in careful monitoring and measurement. Many restaurants and food services make use of technologies that have created new business opportunities elsewhere in the world. For example, the London-based Winnows provides restaurants with X-ray devices to be installed inside refuse bins. These enable restaurant owners to monitor what goes in the bins, how often and why. Winnows also uses the collected data to offer concrete solutions, such as staff training, for minimising food waste. Winnows has helped restaurants to reduce their food waste, bringing them savings of 30–70%.

## The retail sector knows how to minimise food waste

The amount of food waste in retail varies from store to store, but has been estimated at around 65–76 million kilogrammes a year, accounting for 4–5% of total annual food waste. Most discarded food products are fresh produce, such as bread, fruit, vegetables, meat and fish, dairy products, convenience meals and take away food. For stores, cutting the expenses arising from food waste increases the profit margin. On an international scale, loss prevention is fairly effective, despite significant variation at chain or store level.

In the retail sector, waste recovery can be performed in a more centralised and itemised manner than by end consumers. However, in the evaluation of grocery store losses, it should be recognised that all food disposed of by stores is counted as food waste – including waste, such as peel and bones, generated through food preparation. Loss of value is rather difficult to avoid in this area but, due to economies of scale, alternative uses are of interest in this regard.

Regulations have long hindered the use of a cascading approach in waste management. The Finnish Food Safety Authority Evira's changes to regulations in July 2013 enabled store owners to donate pre-packaged food with a "best before" date to charity, rather than throwing it away. This applies to products such as bread. At present, the S Group donates some 10% of its unsold bread to charity on a national scale. It is not the only retail store or chain to make donations to charity. In the Helsinki Capital Region, some unsold bread is delivered to ST1's bioethanol production plant for use as feedstock. Vegetables and food products of animal origin are usually sent to waste

management facilities and composting for the manufacture of garden soil.

Both in Finland and abroad, methods that work in the retail sector include efficient sales forecasting, order processes and logistics, the limited display of fresh produce, and product markdowns close to the expiry date. While the size of the store and technological applications can improve the ordering process, the retail sector operators interviewed highlighted the role played by skilled staff in keeping wastage and loss to a minimum. For example, weather forecasts for the weekend and local sports or cultural events should be taken into account when anticipating demand.

Consumer habits also play an important role – more wastage is inevitable if consumers expect mountains of fruit and vegetables and fresh bread to be available until closing time. To solve this problem, stores have used removable platforms underneath fruit and vegetables and have stopped baking bread a few hours before closing time.

The markdown of food products close to their expiry date has proven an efficient wastage reduction method; however, stores and chains follow their own practices when using red discount labels. The interviewees believed that the recession had made stores more likely to mark down their products.

In addition to the favourable environmental impact, reducing food waste in the retail trade brings significant financial benefits, particularly through direct savings.

## Figure 24. Wastage reduction programmes are typically based on a range of factors

Source: McKinsey; Sanitised client example

**Typical shrink reduction programmes are articulated around multiple dimensions …**

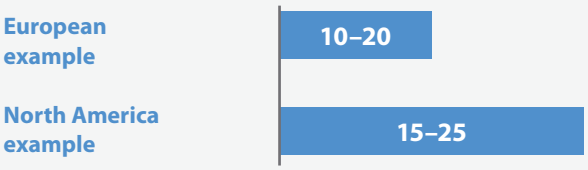
1. Optimise shelf space allocation
2. Review ordering/production scheduling process
3. Optimise core processes such as stocking, shelving, markdown
4. Closely monitor shrink
5. Organise work accordingly
6. Capture short-term impact by improving cold chain in DC/delivery system

+

7. (Long-term) Radical revision of supply chain/DC structure

**… and have proved to deliver significant results at major retailers**

**Range of shrink/waste savings**
Percent




- **Additional freshness** due to better ordering and more adequate layout: **-20% on fresh product stock days**
- **Collateral effect** of improved freshness: **+7% sales before and after change**
- **Labour costs:** reduction up to -15%

## Incineration is not the best waste management solution for the food industry

The food industry has several side streams, in which food waste refers to lost materials suitable for food production or human consumption. Defining food waste would require an industry-specific analysis and it is hard to know where to draw the line (e.g. whey production, animal by-products in meat production).

The food industry generates around 100 million kilogrammes of food waste, accounting for around 3% of total production. Most food waste is generated by dairy production, but even there the average is around 3%. Due to the scale of the food industry, side streams and waste utilisation represent an interesting opportunity, even in the most technologically challenging solutions such as protein use in non-food industrial applications. However, the food industry has progressed relatively far in minimising food waste.

From the perspective of the circular economy, the most fascinating opportunities perhaps lie in the remaining side streams, such as animal by-products and their use. Although targeted research programmes may open up interesting new opportunities in making use of these side streams, in areas such as energy production most value is lost when valuable nutrients are converted into thermal energy. Waste should not be automatically incinerated; the most valuable way of using it should be found.

## The food value chain has economic potential of EUR 150–200 million

In Finland, food waste reduction efforts are focused on households and the food service sector. The trade and food industry could enhance its operations, but has already exploited most opportunities for economic gains. Assuming that 50% of household food waste is avoidable and half of this could be avoided by changing consumption patterns, the potential annual savings in the Finnish food value chain would be EUR 130 million. In addition, cutting the average food waste in food services by half, from 20% to 10%, would generate annual savings of approximately EUR 33 million. Minimisation of food waste in the food services sector in particular would also provide important business opportunities for various new technology and service companies that also operate abroad. Targets should be set at a level that enables these savings to be achieved in practice.

Minimisation of food waste is primarily based on changing consumption patterns. This is a long and difficult process, but social trends, such as increased health awareness, also support waste reduction efforts. The state and third sector organisations play an important role in increasing awareness.

### Limonene

Limonene is a success story: a compound that has been transformed from process waste into a valuable by-product. It is derived from orange peel, previously regarded as food waste. Application innovation led to limonene being recognised as a valuable raw material for the perfume and cosmetics industry.

Quantities are sufficient for use in commercial production. For example, orange peel and pulp generated in orange juice production account for roughly 50% of total limonene production. When the production costs of limonene fell due to more advanced collection and processing techniques, the potential for the use of this by-product grew, raising its value in the eyes of orange juice producers.

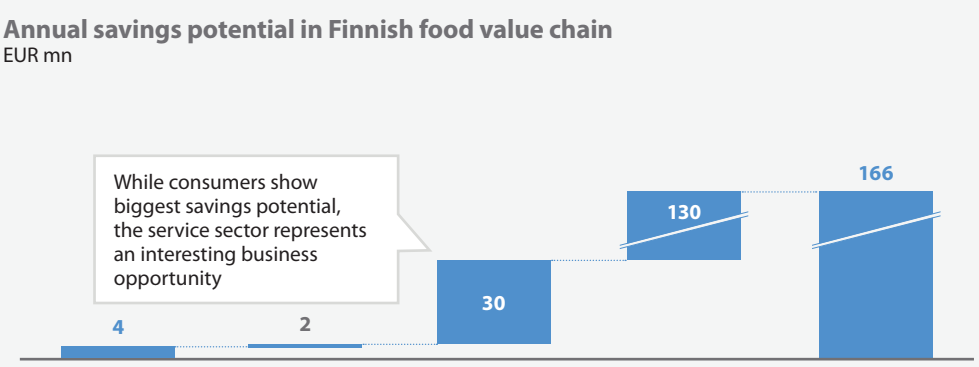
The sufficiently high value of the compound, the homogeneity of the raw material, and the concentrated structure and scale of orange juice production have favoured the use of limonene. A major producer of the compound is Citrosuco.

**Key success factors:** A concentrated production system for the by-product, the homogeneity of the product, the high value of the compound.

The EU intends to reduce the amount of food waste in the food value chain by half by 2020. International comparison is difficult because no specific definition of food waste has been set by the EU. At EU level, the goal is now to harmonise definitions and measurement mechanisms; further research is required in order to achieve this.

## Figure 25. The annual savings potential in the food value chain could amount to EUR 150-200 million

Source: MTT; McKinsey




| A<br>Minimising food waste in production | B<br>Minimising food waste in retail | C<br>Minimising food waste in food services | D<br>Minimising household food waste | TOTAL |
|---|---|---|---|---|
| • Assumes 1% reduction in food processing waste, based on more efficient utilisation of e.g. animal parts in meat production | • Assumes 0.5% reduction in average retail chain food waste (3-4%) | • Assumes 50% of the 20% waste in food services can be reduced through e.g. more efficient monitoring including new technology, and reduction of food served in buffets etc. | • Assumes 30% of household food waste could be reduced by 2020<br>• Finland is already performing well at 20-30 kg/pers/yr against EU average of 76kg/pers/yr | • Achieving the potential requires significant changes, particularly in consumption patterns<br>• Key enablers for the food value chain include identifying and addressing key regulatory barriers (e.g. legislation regarding best before dates) |

## Food industry: What should the private sector do?

**Action:** Service-sector companies should pay more attention to reducing food waste in their operations.

a. New solutions should be actively sought for utilising edible food on the basis, for example, of technological solutions (such as the collection and use of data in order to minimise food waste; X-ray devices installed inside refuse bins).

**Outcome:** The reduction of food waste could bring significant savings to restaurants and catering service companies – food waste can be as high as 25–30%. Solutions for minimising food waste could create new business opportunities for various new technology and service companies.

**Action:** Food retailers should continue to reduce food waste, despite performing well in this area already.

a. The development of sales forecast and order processes, product display and other wastage reduction methods should continue. Because staff often play a key role in this regard, they should be provided with the relevant training.
b. Where appropriate, greater amounts of food destined for disposal should be donated to charity.

**Outcome:** Companies could increase their savings potential even further by minimising food waste and through staff training. Due to variation between stores, there may be potential for further savings in cases where waste in specific stores is high. If products close to their expiry date were donated to charity, they would enter a higher-value chain instead of being dumped on a compost heap or in an incinerator.

## Food industry: What should the public sector do?

**Action:** The public sector should use regulations and campaigns to do what it can to influence the awareness and habits of private consumers. Policies on the date labelling of pre-packaged food should become more uniform in Finland and at EU level. Campaigns and other ways of disseminating information on reducing food waste must continue.

a. Removing the "best before" date in certain product categories should be considered at EU level.
b. Insofar as possible within the framework of current EU policy, the Finnish Food Safety Authority Evira should clarify the guidelines on the date labelling of pre-packaged food. An alternative would be to clarify date labelling practices (e.g. by adding a label that reminds consumers that the "best before" date is not the same as the "use by" date, thus making it easier to determine whether the product is edible).
c. Public organisations should continue to campaign determinedly against food waste. Knowledge should be increased of how long foods last and inventive ways of using them. In addition, we need more campaigns on initiatives such as "leftover day" and "food sharing", aimed at private consumers and various public sector operators (such as schools and offices).

**Outcome:** Long-term campaigns and public sector activities would gradually begin to influence consumption patterns and increase awareness. The changing of date labelling practices on pre-packaged food would end the confusion amongst consumers between "best before" and "use by" and reduce the related food waste.

# 3.4 Business potential of private consumption centred on the sharing economy

The annual consumption of Finnish households totals around EUR 104 billion. This market presents the circular economy with many opportunities. These opportunities should be evaluated from the perspective of household consumption, because most commodities are produced outside Finland but have major potential value in second hand use if no remanufacturing is needed. Such an evaluation would also help us to understand the service and product-based value streams with major potential in terms of the sharing economy. This section will not address direct ways of reducing household waste, which is an important aspect of the circular economy.

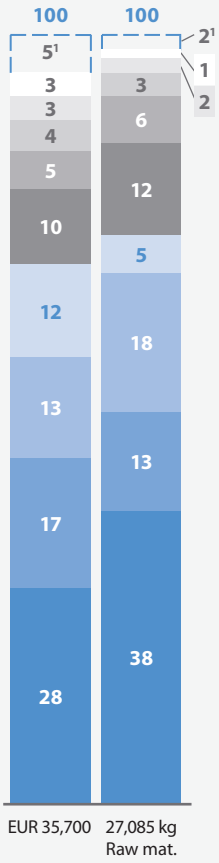
Three dimensions of household consumption are of particular interest from the perspective of the circular economy. The first is the sharing economy: a global, rising trend enabled by digitalisation. The impact of this trend has began to extend beyond consumables since the 2010s. AirBnB, a service through which private individuals rent out their homes like hotel rooms, is one of the most successful and most copied players. Secondly, there is the second hand market, which has been significantly boosted by new Internet age businesses such as Amazon and eBay. And thirdly, despite heavy investment in the recycling system, most household waste ends up, unsorted, either in an incinerator, landfill or lying around the house unused. The first two could help prevent the third scenario.

Measured in terms of the value and weight of raw materials, housing, transport and food are the largest categories of private consumption (Figure 26). Furniture, electronics and clothing are next in line. The opportunities represented by the sharing economy and second hand market are common to all of these categories. In the case of many consumer products, easing the recycling of materials by improving their purity would assist markedly in promoting the circular economy.

The operating models of the sharing economy and the operations of the second hand market are more than just a playground for growth companies – top firms can also

## Figure 26. The sharing economy and second hand market represent key consumer-centric opportunities

Source: Statistics Finland, Websites, McKinsey




| Household consumption in value and weight of raw materials, %, 2012 | Key items / description % of hh. own at least one | Trends (CE perspective) | CE opportunitiest | Primary Actor | | Opp. Size |
|---|---|---|---|---|---|---|
| **Communica-tions** | • Mobile phones<br>• Internet | • Decreasing device prices in the long term | • 2nd usage<br>• EOL design perspective | ✓ | ✓ | ● |
| **Clothing and footwear** | • Clothing<br>• Footwear | • E-commerce | • 2nd usage | | ✓ | ● |
| **Hotels and restaurants** | • Restaurants<br>• Hotels | • Increased usage of services<br>• Disruption from Airbnb | • Minimise energy and food waste<br>• Apartments as hotels | ✓ | ✓ | ● |
| **Furniture, appliances etc.** | • Furniture<br>• Dishwasher (65%) | • Scarcity of resources<br>• Increasing purchasing power | • CE design perspective<br>• Sharing, 2nd usage | ✓ | ✓ | ● |
| **Culture and recreation** | • Electronics (TV etc)<br>• Durables for sports | • Increasing purchasing power | • Sharing<br>• 2nd usage | | ✓ | ● |
| **Other goods and services[2]** | • Other personal items<br>• Insurances etc. | • Increasing purchasing power | • Sharing<br>• 2nd usage | | ✓ | ● |
| **Food and non-alcoholic beverages** | • Food, beverages | • Scarcity of resources | • Intelligent fridges (IoT)<br>• Packaging awareness | | ✓ | ● |
| **Transport** | • Public transportation<br>• Car (72%) | • Urbanisation | • Car sharing<br>• Kutsuplus etc. | ✓ | ✓ | ● |
| **Housing and energy[3]** | • Housing; sauna (62%)<br>• Cottage (26%) | • Smart home / IoT | • Energy optimisation<br>• Facility sharing | ✓ | ✓ | ● |

✓ Consumer-led opportunities
✓ Industry-led opportunities

● Major opportunity
● Smaller opportunity
● Future-shaping opportunity

1 Other: health, education and alcohol and tobacco
2 Includes e.g., other personal durable goods not included elsewhere
3 No physical buildings

find important business opportunities there. Figure 27 shows the opportunities represented by the sharing economy and second hand market for various consumer product categories in Finland. The choice between ownership, sharing and selling on the second hand market largely depends on the product's cost, frequency of use and privacy of use. Sharing comes most naturally in the case of high-cost items that are rarely used. Correspondingly, selling on the second hand market works for many low-cost items. Privacy of use may affect the willingness to share in particular, but this is also a factor when selling on the second hand market.

Generally speaking, there is a potential market for most non-personal items, and a potential rental market for valuable commodities (the sharing economy). If more reliable payment systems brought a sense of security, if it were easy to hook up buyers with sellers, and if logistics were made easy, the conditions would exist for a much wider sharing economy.

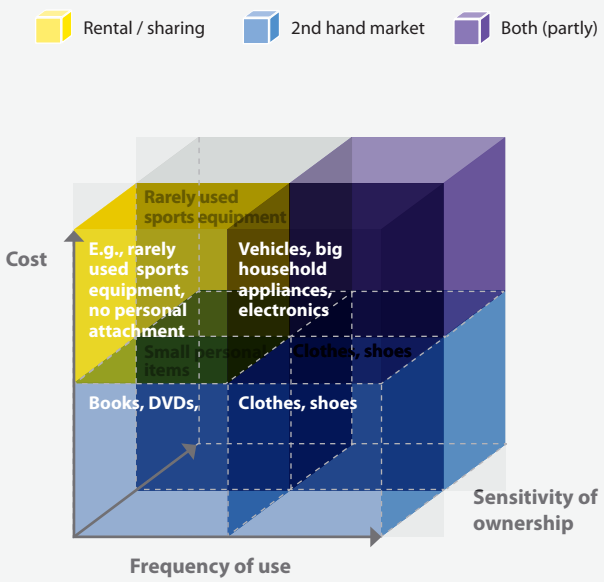
From the perspective of the circular economy, the key issue for both the sharing economy and second hand market would be to find a design method that maximises the service life of products and the number of resells. The key would be to minimise loss of value when the product is resold. However, Finnish industry has very little influence over most consumer products and their design. This means that private consumption can only be examined from the perspective of methods for improving the circulation of existing products.

## Figure 27. The sharing economy and second hand market are shaped by several drivers

Source: Peter Coffee, Salesforce.com, websites, McKinsey

| Driver | | Description/examples |
|---|---|---|
| Societal | Changing values | • Ownership perceived less important<br>• Environmental aspects more important decision-making factor |
| Technology – enabled | Ease of discovery | • Help in finding services and products<br>• Craigslist (localised services), Airbnb (global housing) |
| | Economy of trust | • Escrow, transparency, ratings and processes help in building the critical trust<br>• eBay, Amazon, Airbnb |
| | Efficient payments | • Mobile phone – enabled payments (e.g., Apple pay) |
| | Accountable asset care | • Usage-based car insurance |

**Renting and 2nd hand sales are affected by costs, sensitivity and frequency of use**



## Potential of sharing economy

Households spend a great deal of money on transport – a sector brimming with opportunities for the sharing economy. Whereas the AirBnB model mainly involves tourism rather than housing, car sharing could change consumption habits in Finland. New Finnish public transport models, such as Kutsuplus, are innovative but their impact on car ownership is largely dependent on the infrastructures of cities and communities. Car sharing models based on the AirBnB model present a potential business model for the C2C sharing economy; however, the success of this will require new solutions from insurance institutions. B2C solutions, on the other hand, are rapidly gaining popularity in countries such as Germany.

Car manufacturers such as BMW (DriveNow) and Audi have invested in offering a sufficiently extensive car stock in city areas. The idea is to make occasional car use easy enough for extensive adoption. The strategy has been to make car use easy for young people, who are potential future car buyers. However, from the perspective of the Finnish national economy the answer lies in sharing-based services provided by local companies or consumers. The growth estimate for the traditional car rental market is a mere EUR 83 million by (Euromonitor), but the value of car purchases in 2012 was EUR 3.5 billion, of which EUR 2.2 billion came from households, including EUR 0.9 billion spent on new cars. Unlike its German counterpart, the Finnish City Car Club has been unable to create a profitable market. Regulation and the insurance market will play a key role in the development of a sharing economy in the vehicle market. Uber has transformed taxi services in the U.S. in particular, and will probably soon succeed in doing so in many other markets.

Housing typically accounts for 25–40% of total consumption. Many factors that affect housing and living lie n the construction industry's hands. However, in the long run the sharing economy and digitalisation will play a key role in this sector too. In Finland, 26% of households own a holiday home. Better resource distribution would reduce the need for spaces and building stock that are almost completely underused. Housing models based on communal living would also help to reduce the number of large household appliances and free up the capital sunk in them.

Renting real estate or rooms in place of hotel stays is perhaps the most successful of the sharing economy business models which are now quickly making ground. The couchsurfing, zero monetary compensation model was enabled by the social media and Internet in the 2000s, but AirBnB has grown rapidly since its establishment in 2008.

The sharing of smaller items has much less potential, but would benefit from progress in logistics and digitalisation. For example, kuinoma.fi provides a platform for renting rarely used items from private individuals. Such items include photography and sports equipment. Lending and bartering is also possible, via e.g. the Finnish Sharetribe. Such activities are still small-scale but could become more common as communal living and lifestyle changes catch on.

Remanufacturing now also applies to consumer goods. Apple has recently brought factory serviced, used iPhones to the market. What Apple has in common with Caterpillar or Ponsse is a well-known brand and high-quality product. Because the product is not designed for consumption but use, its attractiveness and value are retained for users second and third in line.

On the consumer goods side, however, factory servicing and remanufacturing have barely begun to be taken into account in product design. Despite its low degree of domestic manufacture of consumables, Finland could promote the circular economy by championing product design that takes account of circularity and the circular economy.

## The used products market for consumables boosts material recycling.

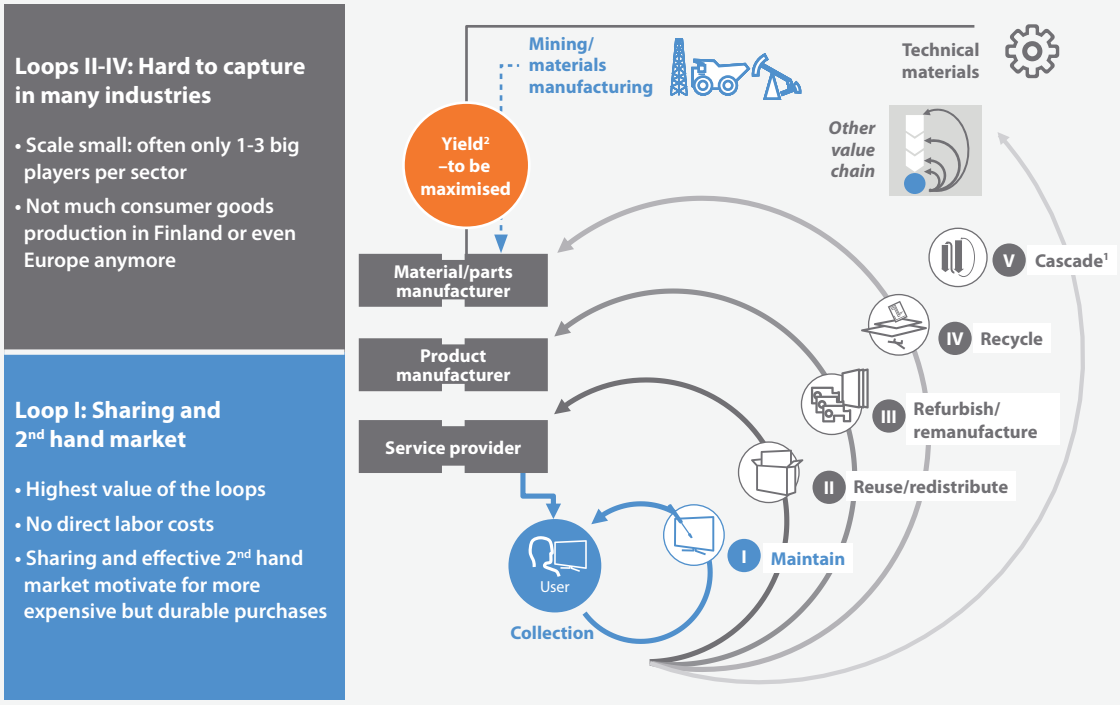
An efficient service model and logistics could help to recycle a much greater share of consumables back onto the market.

The traditional second hand market is mainly centred around books, clothes and used vehicles. These markets are small-scale due to inefficiency rather than lack of market potential. In 2012, consumers spent approximately EUR 8 billion on electronics, books, CDs and DVDs, clothes, shoes and a few other small consumables. Regardless of the exclusion of larger items, such as large household appliances, large items of furniture and vehicles, a huge potential market exists for used products. The current turnover of Huuto.net is roughly EUR 70 million, while selling second-hand clothes generates more than EUR 10 million for UFF and SPR. In addition to these, there are numerous local flee markets (>500) and small specialised web-based after-markets (e.g. Relaa for winter sports equipment). Care sales account for a significant share of the turnover of Tori.fi. Based on the USD 16 billion value of the U.S. second-hand market and the largest Finnish players, the value of Finland's second hand market can be estimated at around EUR 200–300 million. However, based on a residual value of 20% and the realisation, so far, of 25% of the used products market's potential, this sum could be closer to EUR 700 million by 2030.

How can the resale of commodities be facilitated through new business models? Within the world economy

### Figure 28. In consumer markets, the highest value recovery potential is often in C2C or B2C renting or reselling

Source: Ellen MacArthur Foundation CE team




1 Refurbish/remanufacture and recycle across value chains, i.e., materials do not reenter original value chain anymore

2 Production waste is typically recycled on-site or in a closed cycle at the supplier and is not captured in waste statistics. Stepping up production also reduces loss and improves profitability. The company has already taken action; hence, this is out of scope

and logistically speaking, Finland is a peripheral country in which, say, the centralised remanufacture of household appliances would make less sense than in Germany. However, in the case of products with a considerable resale value, lowering the threshold for selling could rapidly increase the circulation of products.

For example, better options exist for capturing the reuse value of mobile phones, tablets and computers than recycling based on producer responsibility. The challenges in reselling lie in data security and lowering the threshold for selling and buying. This means that a major opportunity to capture value can be found in joint-venture models alongside logistics companies (the former Itella, now Posti), IT leasing service providers (3StepIT), recycling companies (Kuusakoski) and (possibly) retailers. It has been calculated that, in Finland, fewer valuable electronics return to the cycle or are recycled than in many other European countries. When a new phone is purchased, a discarded smartphone costing EUR 300 still has most of its reuse value, whereas the value of the raw materials is only two to three euros.

## Figure 29. Case – the second hand market could be a major opportunity for a national logistics player

Source: Statistics Finland, websites, McKinsey

### Business model

Logistics company offering a turnkey solution for individuals to sell their old belongings over internet. Automised processes, focus in high-value items, revenue as revenue sharing.

### Market size

- US 2nd hand market: USD 16 bn. Relative to Finland: EUR ~250 mn
- Electronics, clothes, books etc. ~8% household consumption
- Household consumption: EUR ~35,000 p.a, total EUR 104 bn
  - Number of households: ~2.5 mn
  - EUR ~8 bn consumption
  - ~20% residual value
  - Attainable ~66%
  - Potential for 2nd hand market EUR 1 bn
- Huuto.net EUR ~70 mn turnover
- Target market: EUR 0.3-1.0 bn

### Process description

Customer wants to sell used items

Flea market and existing e-markets are time-consuming

Customer orders a cardboard box from website

Company delivers empty cardboard box

Customer fills up the box

Box is recollected from customer

Items are sorted, photographed, described, and uploaded to e-store

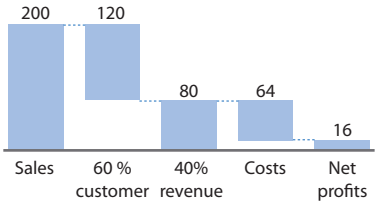
Customer receives ~60% of the revenue. Not sold items recycled

### Business case

**EUR millions**

- 50-100% share of target market
- Target market size: EUR 0.3-1.0 bn

**Scenario: successfully implemented**




- Average value of a 20kg box: EUR 100
- Inbound logistics costs: EUR 10-20
- Time to sort, photograph, and describe an item = 20 s. with EAN code, 1 min. without EAN code
  - EUR 0.3-1 with EUR 60/hr allocation
- Warehousing cost ~5% (1 month)
- Outbound logistics: EUR 1-2 + postage EUR 1-10 (paid by buyer)
  - With optimised process, >20% operating margin should be attainable

## Most value is captured in the used products market

WEEE raw materials present huge potential for capturing value (approximately EUR 2–3 billion) at European level, but the value of WEEE raw materials in Finland is low. For example, the 2.5 million mobile phones sold annually contain approximately EUR 2 worth of raw materials. This makes the total value of raw materials EUR 5 million, which mainly comes from gold, copper and other metals. While large amounts of steel (30kg of scrap steel, worth around EUR 10) are used to make household appliances, such as washing machines, the market value of the related WEEE

### Figure 30. Broken consumer electronics stored by households would provide multiple opportunities for the circular economy if collection rates were improved

Source: Elker Oy, SER-tuottajayhteisö ry; SYKE 20/2009, McKinsey

| | | Electronics sold | | Electronics waste collected | | |
|---|---|---|---|---|---|---|
| **Type** | **Description (examples)** | **Sales 2013 mn EUR** | **Weight 2011 tsd tonnes** | **Weight 2011 tsd tonnes** | **Percentage collected** | **Comments** |
| Big household appliances | Fridges, ovens, washing machines | 423 | 72.2 | 26.4 | 36 | Steel, other metals and plastics collected |
| Small household appliances | Coffee machines, toasters | 195 | 9.0 | 1.7 | 19 | Copper, aluminum, steel, plastics |
| Computers and other electronic devices | Phones, screens, laptops | 1,286 | 21.6 | 8,0 | 37 | Semiconductors with high (~30%) precious metal |
| Consumer electronics | Digital cameras | 375 | 10.4 | 13.9 | 132[1] | Plastics collected and sold to East Asia |
| Lamps, lights | Light bulbs, excluding incandescent bulbs | N/A | 1.7 | 0.9 | 55 | Contains mercury, treated by Ekokem |
| Tools | Screwdrivers, motor saws | N/A | 12.9 | 0.7 | 55 | Steel and plastics |
| Toys, sports equipment | Video consoles, toys, sports equipment | N/A | 2.0 | 0.1 | 5 | Comparable to consumer electronics |
| Healthcare devices | Includes healthcare sector devices | N/A | 0.9 | 0 | 7 | Part of waste hazardous |
| Other electronics | Household scales, fire alarms | N/A | 3.4 | 0.1 | 3 | Miscellaneous, harder to sort |

**~90% of collected e-waste is recycled,
most of recycling taking place in Finland.
Part of electronic equipment ends up in municipal solid waste.**

#### Opportunities presented by the circular economy

- Computers, phones and other consumer electronics are the most interesting types of electronic devices with various CE opportunities
  - Capturing remaining reuse value with new marketplaces
  - Collecting accumulated electronic waste from consumers for raw material or component recycling
- Leasing models and refunds for big household appliances would help tightening the raw material loop
- ~90 % of collected e-waste is recycled, most of recycling taking place in Finland.
- Part of electronic equipment ends up in municipal solid waste.

1 Average weight of consumer electronics devices is declining, recycling opportunities have improved

would be low if the residual value were lost. When there is little domestic production, the most sensible secondary use of a product for the national economy would be to sell it on.

Households have accumulated large volumes of electronic waste (according to one estimate, 10 million mobile phones are lying around unused), with a considerable overall raw material value. The new WEEE regulations and an improved collection network will help to solve this issue, but opportunities also exist for new business activities.

## Consumer behaviour continues to be driven by digital disruption

Among consumers, the greatest potential for promoting the sharing economy lies in sectors where the opportunities for digitalisation have not been fully exploited. Figure 31 sums up the degree and potential of digitalisation in various sectors. Many opportunities remain untapped.

### Figure 31. The effect of digital disruption, by sector

Source: Websites, Finnish Hospitality Association MaRa, The Economist, Euromonitor, European Vehicle Market Statistics, Statistics Finland, McKinsey

| | | Disrupted market | Selected examples | Winner takes-it-all business | Enablers/ challenges | Market and opportunity in Finland |
|---|---|---|---|---|---|---|
| **Physical space (by non-traditional parties)** | **Apartment rental** | • Hotels<br>• Short-term housing | • Airbnb: individuals renting their houses. Expanding rapidly also to Finland | ✓ | • Large volumes | • EUR 0.9 bn (2013) globally<br>• ~10% by 2016 with current growth |
| | **Special events** | • Conferences & meetings services<br>• Restaurants | • Venuu: matchmaker for event space. Quite unique case, still local. | | • Matchmaking harder for longer usage | • Small<br>• Scalable abroad |
| **Cars (by non-traditional parties)** | **Car rental Car sharing** | • Car rental<br>• Car sales | • DriveNow (from BMW): Use-based car rental, disrupting small car sales and locking in to premium segment<br>• City Car Club (Finland) | | • Requires new insurance solutions<br>• Localised | • Sales: EUR 3.5 bn<br>• Households EUR 2.2 bn<br>– New EUR 0.9 bn<br>– Old EUR 1.3 bn |
| **Secondhand market (books, electronics, clothing, furniture etc.)** | | • Flea market<br>• Retail | • eBay, Amazon (globally)<br>• Huuto.Net, Tori.fi, local players<br>• Specialised markets, e.g. Relaa (outdoors) | | • Transportation cost<br>• Time consuming to sell | • Currently EUR ~300mn<br>• Potential up to EUR 1 bn<br>• Room for new business models |
| **Item rental (expensive, rarely used, less personal items, e.g. videocam, sports equipment)** | | • Retail, specialised rental services | • Kuinoma.fi: individuals renting high-cost, rarely used items, e.g. avalanche protection bag EUR 100 per week vs. EUR 800 if purchased | | • Economy of trust<br>• Logistics/localisation | • Small |
| **Sharing** | **Goods** | • Tools, appliances, rarely used items | • Sharetribe | | • Economy of trust<br>• Shared space in apartments | • Not for profit |
| | **Services** | • E.g., restaurants | • Restaurant Day | | • Low legal barriers | • Not for profit |

## Private consumption: What should the private sector do?

**Action:** Develop new business models to promote the sharing economy and reuse.

a. Innovation and experimentation with new business models by individual companies will be needed to unlock much of the potential in private consumption. Companies play a key role in promoting the circular economy. Someone needs to understand and see this business potential and build a company on its basis. Defining common measures is a secondary issue.

**Outcome:** Improved circulation of consumer goods within the economy.

## Private consumption: What should the public sector do?

**Action:** Increase consumer awareness of the circular economy and its opportunities.

a. As demonstrated by AirBnB and Germany's auto industry car leasing cases, consumers find the business models that best support the circular economy attractive – no special measures are needed to change consumer behaviour. However, the public should be briefed on the circular economy approach; this will motivate consumers to foster the circular economy in the long term through their own behaviour.

**Outcome:** Broader understanding of the opportunities of the circular economy. Greater consumer interest in products based on the circular economy.

# 3.5 Major opportunities in construction

In terms of volume, the construction sector is the largest individual consumer of raw materials. Generating 16 million tonnes of waste per year, it is also the second largest producer of waste after the mining industry. With annual production worth EUR 30 billion, construction creates substantial long-term infrastructure for the state, businesses and households. From the viewpoint of the circular economy, both the sector's waste and the use of commercial and residential properties, in particular, should be examined.

## There is room for improvement in materials recovery

The construction industry accounts for 18% of all waste generated in Finland. Construction waste is generated during the building process and the demolition phase. It should be noted that 73% of Finnish construction waste, which is considered a by-product in most countries, comes from excavation. Most of the remaining share comprises non-metallic minerals such as concrete and bricks. In addition, 6% of all construction waste is wood, 2% is metal and less than 1% is rubber and plastics. Of total waste, including soil materials, 63% ends up in landfills or refuse heaps and 35% is incinerated, reflecting the relatively large share of wood (Figure 32).

The construction industry minimises its waste for financial reasons. Handling construction waste is costly (EUR 100–130 per tonne), while demolition-based companies such as Delete base their business models on efficient waste management processes and the recovery of valuable materials (e.g. metals).

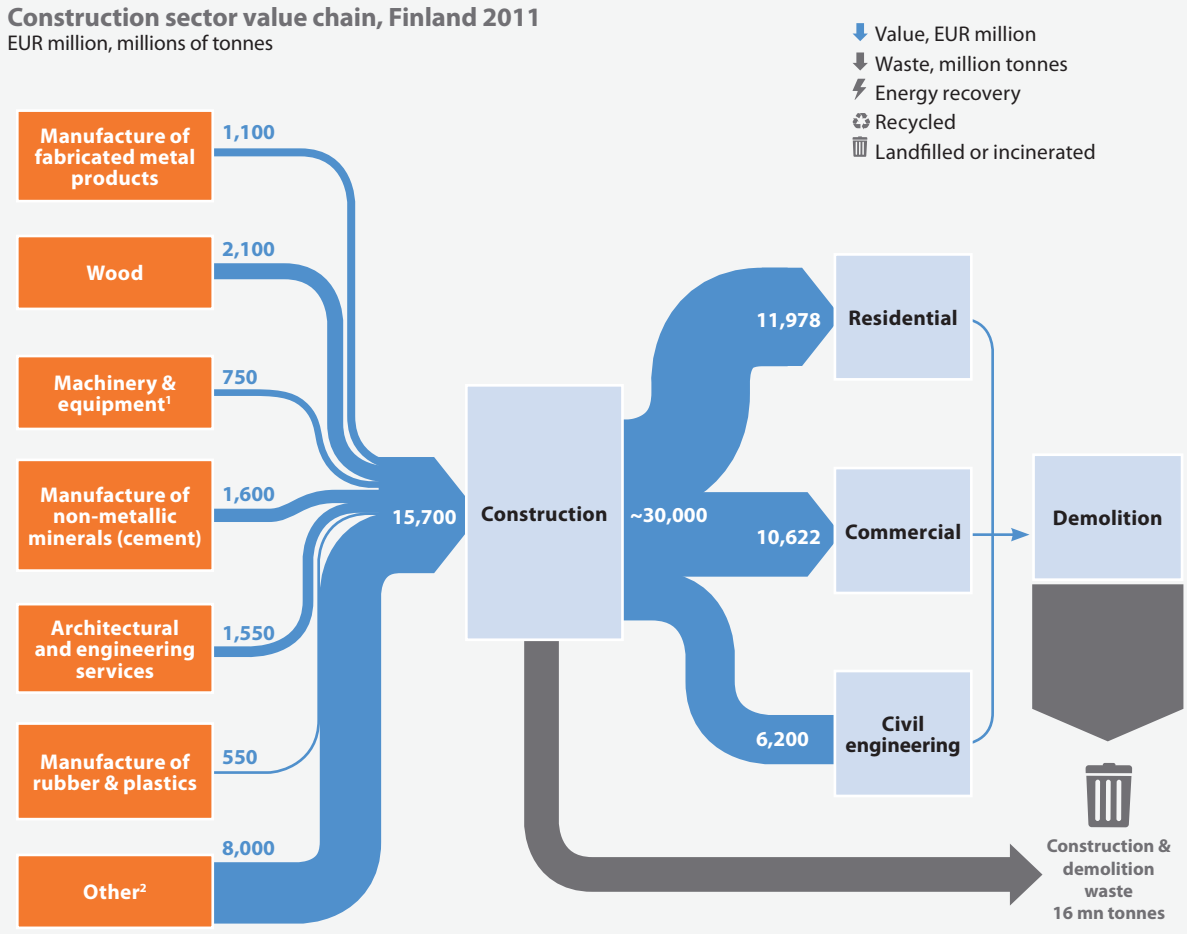
Construction accounts for two opportunities of interest to the circular economy. Firstly, the potential to improve the utilisation rate of real estate by making it easier to alter its use and introduce space sharing. An improved utilisation rate would reduce demand for raw materials. Secondly, exploitation of materials could be made easier still at the end-of-life phase.

## The annual benefits of deregulating change of use could amount to EUR 250 million

Waste recycling has almost been harnessed to its full potential and the current players have already committed to long-term development. This means that greater potential lies in maximising the value of the existing building stock. In the Helsinki area alone, there are currently 1.25 million $m^2$ of empty office space which, due to planning regulations, cannot currently be converted into residences. At the same time rents keep rising, especially for

## Figure 32. Construction is based on contributions from a number of sectors

Source: McKinsey, National accounts




1 Including electronic devices

2 Electricity, petroleum, chemicals, transportation, maintenance and repairs, wholesale trade, etc.

smaller apartments, with the current average rent being EUR 17/m$^2$. Planning reform would significantly improve the utilisation rate of real estate in the Helsinki Capital Region. A conservative estimate suggests that converting 1.25 million m$^2$ of empty office space into residences would create 16,700 new apartments (with an average size of 75m$^2$). Assuming that a third of this space could be converted by 2030, measured in rental income the value of such a conversion would be around EUR 255 million a year. In addition, by converting commercial properties for residential use in place of new construction, the national economy would save close to EUR 700 million.

On the other hand, regulations are also seriously hindering the efficient use of resources in residential properties. Policy-makers should therefore use their judgement to assess the resource and eco-efficiency impact of setting mean square-metre requirements on apartment sizes. Many construction regulations simply raise building costs and encourage the inefficient use of space. Supporting the production of large apartments contrary to actual demand has the effect of reducing potential profitability per square metre, while consuming more raw materials and other resources than necessary to meet current housing needs.

## Space sharing improves resource-efficiency

Most of the construction sector's opportunities to benefit from circularity involve optimised use of the building stock. From the viewpoint of the national economy, minor partial optimisation could be achieved through shared office space solutions and creative ways of sharing special-purpose spaces.

In the modern design and building of office premises, shared conference rooms and other special-purpose spaces reduce the need to build spaces with low utilisation rates. For example, the conference rooms of many office buildings constructed by NCC can be scaled down to fit the needs of even the smallest companies.

The use of special-purpose spaces in individual properties, such as banquet halls and seminar rooms, is harder to optimise. Many cafés and public or private venues, on the other hand, are empty outside opening hours. A Finnish start-up, Venuu, is providing a service that makes elusive facilities of this kind available to companies and private customers. These are small-scale solutions compared to the major opportunity facing policy makers in converting office spaces for residential use and setting mean square metre limits on apartment sizes.

## Further potential to improve material cycles in construction

Prefabrication and surface-mounting cabling, for example, represent typical ways – already in use – of reducing construction costs. They make materials recycling easier. This would be even more effective if account were taken of demolition in the design phase. For example, prior planning of the demolition phase could facilitate the sorting of steel. At the end-of-life phase, this would help to recover more of the value tied to building materials. In addition to savings on handling costs due to easier sorting of raw materials, prefabricated elements would be easier to reuse.

## Construction: What should the private sector do?

**Action:** To enable the recovery and reuse of materials during construction, the design and building phases should take more account of demolition.

a. The structural design of prefabricated elements and valuable materials, such as steel, should enable their easiest possible recovery during the demolition phase. Among engineering companies and architecture firms, for example, this means taking account of demolition during the design phase. Companies specialising in demolition should also contribute to the discussion of how best to achieve this in practice.
b. Construction companies should further develop solutions and technologies based on modularity.

**Outcome:** The development of modularity would not only support the demolition phase, but also create long-term cost savings for construction companies. If better design could make demolition technically easier and more profitable, construction companies might be tempted to create new business activities based on the demolition phase.

## Construction: What should the public sector do?

**Action:** Regulatory reforms are necessary in order to make it easier to change the use of vacant real estate.

a. Regulations should be amended to allow the conversion of office spaces into apartments, following the necessary renovation and alterations. Requirements should be relaxed on the features and average floor spaces of apartments.

**Outcome:** The utilisation rate of the building stock would increase. At present, lessors would be able to lease out their empty premises; for example, EUR 255 million in annual rental income would be generated by converting one third of the Helsinki region's vacant office spaces into rental apartments by 2030. This would also increase the supply of rental apartments and could reduce rents. The national economy would achieve savings in construction costs by creating rental apartments through conversion rather than new construction. Demand for renovation would increase as properties were converted from commercial to residential use.

**Action:** Regulations on building techniques and design should promote the principles of the circular economy in the construction sector.

a. Setting mean square metre limits on apartment sizes should be critically assessed from the perspective of resource and eco-efficiency, and the benefits of building smaller apartments should be considered. Support for building larger apartments should be reduced.
b. Regulations should steer and encourage the transformation of current building techniques toward making the recovery of materials easier during the demolition phase. Such changes might include requirements on the use of steel in interior structures and on the modularity of specific elements.
c. Regulations on the inclusion of renewable materials in building material and the construction phase should be adjusted to encourage the use of such materials whenever possible (for example, if a reasonably cost-efficient renewable alternative is available).

**Outcome:** Apartments would be designed and built in a cost-efficient and environmentally friendly manner, avoiding unnecessary ecological and material waste in building larger apartments than people want. This would also create savings in construction costs. Regulations anticipating the demolition phase would also enable the more efficient recovery of materials during demolition.

# 3.6 Opportunities in other sectors

Naturally, in addition to the five sectors discussed in greater detail in this report, there are many opportunities in other sectors. We will now engage in an overview of those opportunities.

## Promoting biogas production

Biogas production provides opportunities to make use of materials such as food industry and household food waste, other bio-based side streams, sludges generated by wastewater treatment plants, and animal manure.

Biogas accounts for only a small share of total energy production in Finland. For example, other biogas (excluding the cheapest alternatives, such as wood-based ones) accounts for 0.5 TWh of the 2020 target set by the National Energy and Climate Strategy. However, this is a small share of Finland's total energy consumption, which came to around 380 TWh in 2012.

For environmental reasons, biogasification is still an important and useful way of converting bio-based waste into energy and reducing the related environmental load. For example, anaerobic biogasification of manure – prior to its processing into better fertilising material – reduces nutrient emissions into water bodies.

However, the installation of a biogas on a farm, for example, would be a major investment that would rarely be financially viable based on the current technology. The Ministry of Employment and the Economy has estimated that, to meet the 2020 target, biogas based on microbiological processes will need major financial support. Finland does, however, have operators such as Biovakka Suomi Oy, which produces biogas and fertilisers from organic waste. The company's operations have been profitable in recent years.

## More renewable raw materials in chemical industry value chains

The chemical industry is one of the EU area's largest industrial sectors. In 2013, its total turnover was approximately EUR 558 billion. The sector's global turnover in 2013 was estimated to be around EUR 3.13 trillion[26]. The size of the sector alone means that it plays a key role in increasing the amount of renewable materials in value chains. Products based on renewable materials can also be an improvement on fossil alternatives.

Examples of chemicals with a potentially major impact on the circular economy include adhesives and coating materials which do not impede the recycling processes of e.g. packaging materials.

In addition, the use of chemicals based on renewable alternatives in agriculture, for example, could lead to a major

26 The European Chemical Industry Council – Facts and Figures 2013

reduction in the environmental load. Since chemicals are used in nearly all industry sectors, the possible solutions are highly sector-specific.

Chemical leasing is an example of an interesting business model already used, to some extent, around the world. On the basis of the traditional operating model, the chemical supplier's goal is to sell the largest possible quantities of the product. However, the leasing model involves the provision of chemical management services rather than the sale of materials.

Payment is therefore based on the services provided using the chemicals rather than on their quantity: the amount of water purified by the chemical company rather than the quantity of chemicals used in purification. With payment based on the end result rather than sales quantities, the chemical company seeks to minimise the amount of chemicals used in manufacturing, the process becomes more efficient and the overall use of chemicals is reduced.

For example, AkzoNobel Powder Coating and Chemetall Italy have tried out a leasing model for powder-coating chemicals, alongside an Egyptian washing machine manufacturer. Before the switch to the leasing-based pricing model, the costs of the chemicals was calculated in euros per kilogrammes. It is now calculated on the basis of the number of completed washing machines. Naturally, this has incentivised the chemicals maker to minimise the quantities of chemicals used to produce each washing machine. The quantity of chemicals required for pre-treatment has fallen by 15–20%, while the chemicals used in the actual powder coating process fell by 50%.[27]

Leasing-based models for chemicals have already been tried out or could be used in wastewater treatment, the lubrication of industrial machinery, printing inks and the textile industry.

## The material flow for steel is almost a closed loop

A car typically contains around one tonne of scrap steel, whose global market value varies between EUR 300 and 500. As well as the frame, other metals, plastics, other materials and, where possible, detachable components can hold residual value. The cost of disassembly and the logistical location determine the economic viability of reuse; advance planning assists in the calculation of costs.

In terms of their scale and average price, passenger vehicles are different to heavier-duty equipment and drivable forklifts and machines manufactured by the machinery and equipment industry. However, best practices are still transferable via benchmarking. Regulations also have an impact: The scrappage programme (or: environmental premium) experiment in Germany has been considered in Finland (Government proposal in summer 2014). However, the bonus payment of EUR 1,000 was ultimately regarded as mainly representing an incentive to car dealers. In the meantime, a vehicle that is no longer drivable but could still hold some value based on refurbishment can easily end up in recycling, despite the potential to prolong its service life with the help of an efficient reverse logistics chain and remanufacturing.

Simultaneously, in Finland a significant share of our total vehicle stock of 4.9 million never enters the official recycling system. Our domestic vehicle stock is old by European standards and the average age of a recycled car is 20 years. The metal used to manufacture vehicles is a key source of scrap metal in consumer and service use, while the other sources such as clippings, demolition waste or large household appliances are related to industrial processes. A scrappage premium of EUR 200–500, tested in 2012 in a campaign by a Finnish auto-recycling company, Suomen Autokierrätys Oy, is an example of positive incentives promoting the recycling of Finland's vehicle stock.

Scrap metal plays a huge role in global steel production. Approximately one third of all steel in the world is produced from scrap metal. The after-market for this recycled metal also functions well, adjusting to the market price of steel while remaining about one third below it. In the last few years, one tonne of steel has been worth EUR 600–700, while one tonne of scrap steel has been worth EUR 300–500.

The price per tonne of scrap metal depends on the purity of the fraction. In the electronics industry, for example, copper fractions are valuable, worth around EUR 8,000 per tonne, and can contain other precious and earth metals. Whereas steel waste can easily be recovered from machines, equipment and building elements in large pieces of uniform quality, much more energy and a far larger production scale are required for the efficient capture of value and metal separation in the case of metal fractions harvested from electronics. In Finland, the Outokumpu Tornio Works uses scrap steel in its production processes, but not all metal waste flows through major steel producers. For example, rolling mills such as Componenta have a direct need for the industrial scrap metal flows collected by Kuusakoski.

27 UNIDO – United National Industrial Development Organization – Chemical leasing – A global success story

# 4 Promotion of the circular economy begins with concrete, profitable examples

Finland has been a forerunner in many areas of the circular economy. We have invested in energy-efficiency and our industry has succeeded in improving its resource-efficiency. Production side streams are being utilised and new opportunities are being actively explored.

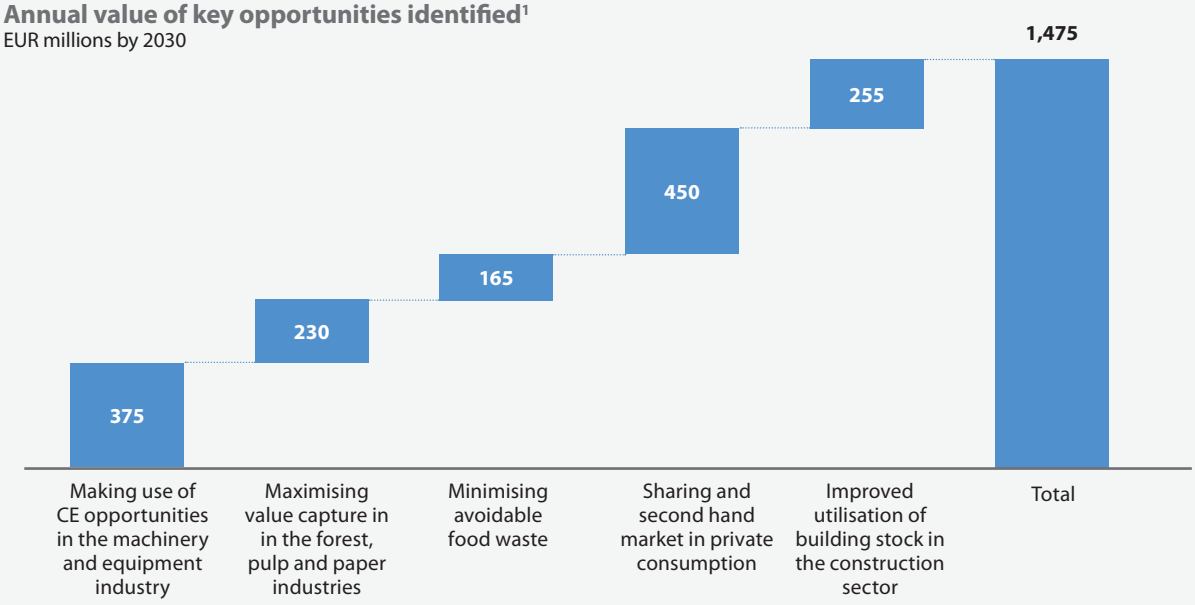
We estimate that potential new business opportunities presented by the circular economy could amount to EUR 1.5–2.5 billion (Figure 33). Now is the time to begin exploiting these opportunities.

As we mentioned at the beginning of this report, estimates of the potential value are based solely on the opportunities covered in detail in this report (focus sectors). Calculations on these opportunities yield figures representing an addition to the national economy's current growth trajectory. In our sector-specific estimates, we have primarily used the sector's added value in Finland as the baseline; this means that the combined potential at company level in Finland is higher than we suggest.

Figure 34 presents the entire list of ideas for promoting the circular economy identified in the four focus sectors. As the figure shows, the opportunities presented are much broader than suggested in this report. Assessing the potential of many of these ideas is difficult, because the profitability of each option remains unclear due to technological development. Other sectors provide additional opportunities for promoting the circular economy.

**Figure 33. Estimated value of the key CE opportunities identified in the focus sectors amounts to EUR ~1.5 billion**

Source: McKinsey




1 Based on lower end of range of opportunity identified for each sector

# 4.1 The building blocks of a circular economy

Four key building blocks are required in the promotion of the circular economy (Figure 35). The key common denominator across the sectors in question is the role of private sector companies in promoting new operating models. To operate successfully in the circular economy, companies must change their business models from linear to circular, either independently or in partnership with other companies. To enable this transition, it is crucial that companies learn how to design their products and production processes in a way that enables circular business models. Naturally, this will also require the renewal of actual business models and the steering of innovation towards the circular

**Figure 34. Following the initial analysis, the opportunities were prioritised on the basis of their feasibility and attractiveness**

Source: McKinsey

| | Opportunities covered in detail | | Opportunities covered more lightly | | | |
|---|---|---|---|---|---|---|
| 1 **Machinery, equipment and electronics** | 1.1 | Promote leasing models and other service-based business models | 1.4 | Rethink design from end-of-life perspective | 1.7 | Leasing models for household appliances and consumer electronics |
| | 1.2 | Increase product modularity | 1.5 | Rethink design through global, sector specific modularity | 1.8 | Import electronic waste for recycling from EU |
| | 1.3 | Integrate remanufacturing into the business model | 1.6 | Improve dismantling and recycling methods | 1.9 | New marketplaces for used consumer electronics |
| 2 **Forestry, wood and paper** | 2.1 | Step up the use of side streams in drop-in products in other value chains or the development of new applications | 2.3 | Switch over wood-based process waste from energy production to material recovery | 2.6 | Use end-of-life fibres in construction as insulation material |
| | 2.2 | Increase cascading of by-products | 2.4 | Increase collection rate of paper closer to international best-practice levels | 2.7 | Leasing of chemicals in production process |
| | | | 2.5 | Improve yield of recycled fibre | 2.8 | Capture excess energy within processes |
| | | | | | 2.9 | Energy recovery from paper and pulp industry side streams |
| 3 **Agriculture, food and beverages** | 3.1 | Reduce food waste in production | 3.5 | Further ideas related to cascaded usage in dairy production | 3.8 | Use food production waste as animal feed |
| | 3.2 | Reduce food waste in grocery retail | 3.6 | Use manure from meat and dairy production for biogas production | 3.9 | Distribute leftovers from meat production as pet food |
| | 3.3 | Reduce food waste in food service industries | 3.7 | Use leftovers from food production, distribution and consumers to create biogas | 3.10 | Create soil nutrients from waste |
| | 3.4 | Reduce avoidable food waste by households | | | 3.11 | Use animal by-products from meat production to create biogas |
| 4 **Construction** | 4.1 | Redistribute empty office space to housing market | 4.2 | Recycle lumber (from construction, facades, and interior finishing) instead of burning it | 4.5 | Make better use of concrete rubble |
| | | | 4.3 | Step up the recycling of metals | 4.6 | Use modularity in construction to save costs and adapt to changing needs |
| | | | 4.4 | Recycle glass from windows, lumber and plastics | 4.7 | Use ashes from energy production to replace material inputs into cement production ("clinker") |

economy, as already achieved by Rolls-Royce and AirBnB. In addition, in order to enable remanufacturing, the necessary skills in building reverse logistics are required. Even if a product and business model is designed in preparation for the circular economy, the value will be lost if the product does not return to its designated cycle, as we saw earlier in the case of PET.

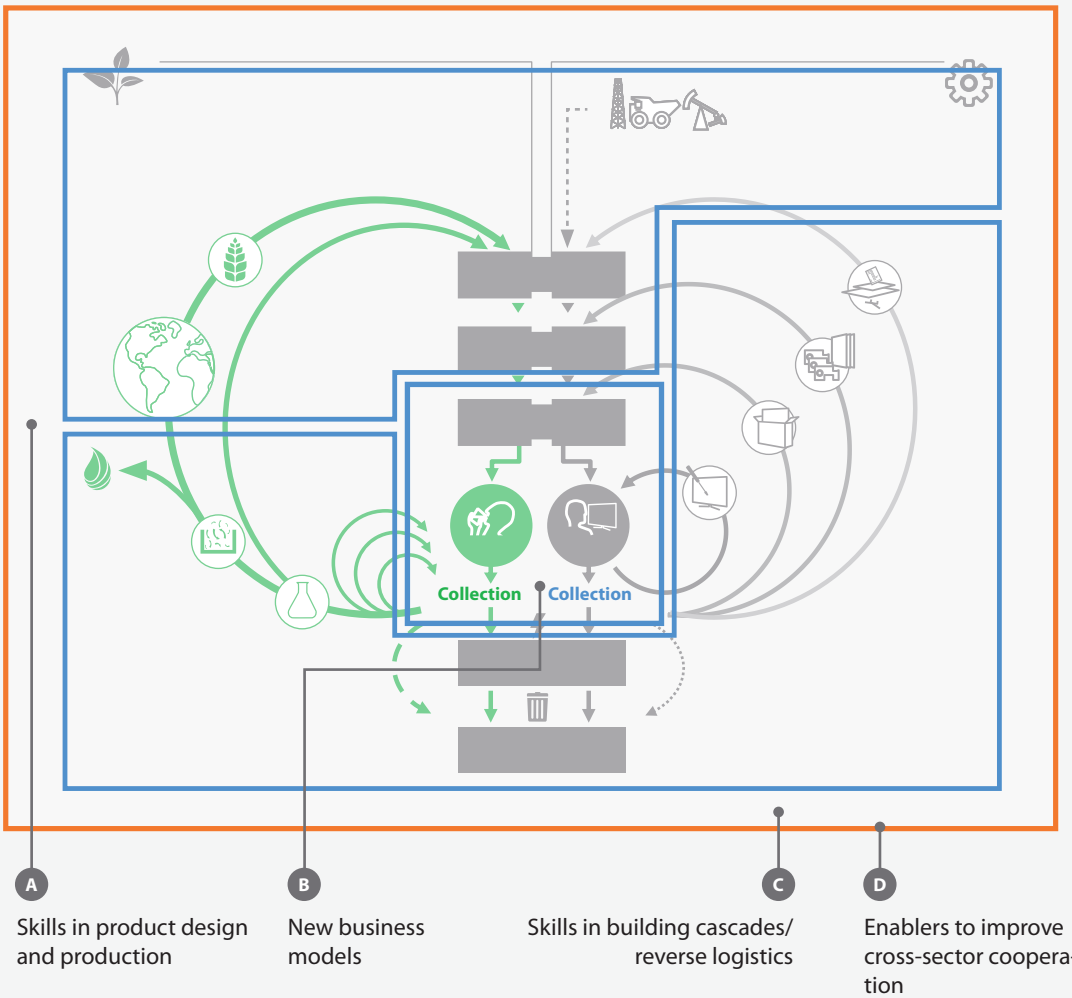
In many cases, the circular economy approach requires that we understand the value of different materials and how to use them in other value chains. Paper industry side streams are an excellent example of this. However, the circular economy does not present an internal challenge to any single company or sector. In many instances, cross-sectoral cooperation and easing up on public sector regulations play a key role in promoting the circular economy.

When seeking ways to exploit the circular economy opportunities discussed in this report, the starting point should be the value created in the examples we have covered.

In the machinery and equipment industry, most value is created by maintaining the value of most products beyond their first life cycle, or increasing the utilisation rate of manufactured products. In the forest industry, the potential represented by the circular economy in Finland is largely centred on better utilisation of side streams. Technological advances enabling the development of new products and business activities often form the greatest

**Figure 35. The building blocks of a circular economy**

Source: McKinsey



bottlenecks. Regulations also tend to restrict opportunities, as in the case of ash.

In the food value chain, potential is based on the reduction of loss and waste, and the better utilisation of food waste in other value chains. All food industry players, ranging from food producers to grocery stores and from restaurants to private consumers, have a key role to play in this. Changes in the behaviour of consumers and restaurants in particular could help to reduce the generation of food waste. Regulations may present a good way of encouraging such changes through waste management charges, for example.

In private consumption, the key potential presented by the circular economy relates to reselling and the sharing economy. Both sectors have exploited the opportunities offered by digitalisation. Regulations and other public sector measures have played either no role or have impeded progress. Development has been based on technological and business innovations.

In construction, the greatest additional potential has lain in improving the utilisation rate of existing real estate, or in change of use. Regulations play a key role in both.

When examining the overall scope of opportunities, both the private and public sectors have their own role to play in promoting the circular economy.

## 4.2 What can the private sector do?

Companies need to drive development. Each sector must consider how the circular economy approach can be used to improve the competitiveness and business model of the company in question, whether through waste reduction, product recyclability, or by increasing remanufacture. Practical changes can remain sparse if a company lacks a clear idea of how to create added value based on the circular economy.

Figure 36 provides a description of how a company can assess the potential of the circular economy for its own business activities. This framework will help companies to begin discussing the opportunities of the circular economy and how to make them a reality.

a. **Identifying the challenges posed by the current linear production model:** It is important to begin by understanding the challenges faced by the company's existing business model and how resource scarcity can pose problems for this model in the future. How would a rise in raw material prices impact on profit and value distribution within the value chain?
b. **Identifying lost value:** The second phase would involve the detailed identification of where the greatest amount of value is lost or wasted in the existing operating model. Consideration must be given to the operating model, the places where materials and energy are wasted, the value lying in untapped side streams and whether the product cycle can be tightened. Preliminary ideas should also be gathered on potential changes to the operating model. This would help in the identification of new sources of revenue and cost savings.
c. **Defining a circular business model:** Awareness of value loss or of individual ideas based on the current model are seldom sufficient for the full-scale realisation of the potential involved. In many cases, a broader transformation towards the circular economy requires a broader vision of the actual model in question. The key is to consider how a combination of product design, manufacturing, usage and reuse practices can help to move the company's business model towards the circular economy.
d. **Pragmatic design and the specification of changes to the business model:** In the final phase, the vision must be made concrete for the transition to begin.

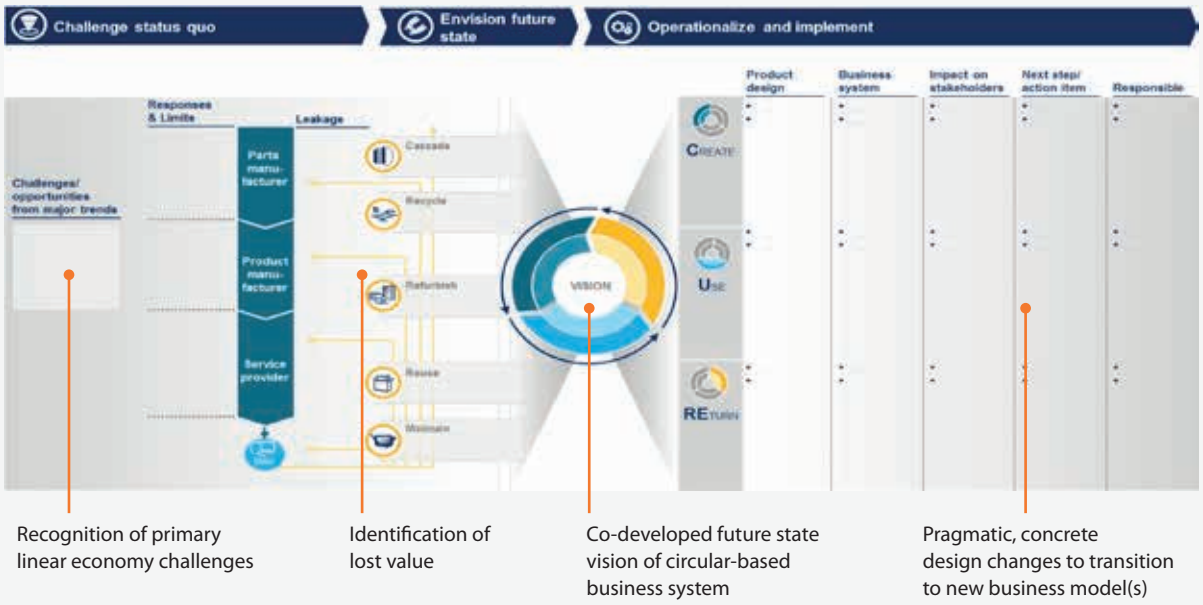
Providing examples of each phase help to clarify what we mean by company-level changes.

For Caterpillar, the challenges inherent in the linear model were related to reputation risk in the used engine market. They recognised that, regardless of the approach taken to the used engine market, their engines entered the market bearing the company's logo. For Rolls-Royce, recognising the opportunities presented by the leasing model was largely based on the idea that when they sold an engine, their knowledge of the engine's performance and understanding of its long-term durability was always dependent on the customer's willingness to share such information. In addition, the engines often ended up on the after-market. It was also challenging to adjust the price of the engine in line with the costs of productivity improvements. The leasing model provides the company with more direct control over information on the performance of its engines, which assists product development. The model also provides Rolls-Royce with clear incentives to improve engine durability. Rolls-Royce now has more control over its product throughout the latter's life cycle.

In both examples, the transition was led by the company's awareness of the potential in adding value and the related changes required in its operating model. This was

**Figure 36. The CE Corporate Transformation framework can be used in companies as a concrete tool for analysing, planning and implementing the CE perspective**

Source: McKinsey's CE Special Initiative




used as a basis for concrete actions aimed at implementing the changes in practice. For Caterpillar, these actions included developing a way of buying back its engines and the creation of a reverse logistics chain and a remanufacturing system. For Rolls-Royce, the key challenge was to secure funding for its leasing-based business model. In both examples, concrete action was prompted by the realisation that circular economy ideas would bring added value to the company and its customers.

The circular economy also changes funding model requirements. Leasing-based operating models require more working capital, because the basis of the company's cash flow shifts from lump-sum payments to monthly income. A closer examination of the difference between the linear and circular model reveals that the need for funding and the importance of rapid cash flows are motivating companies to shift to the linear model. It is more profitable to receive payment for a product as soon as it is handed over. As proven by the examples of Ponsse and Caterpillar, this does not prevent firms from using circular economy models. However, attention should also be paid to how the development of funding models can support the circular economy in the long run.

## 4.3 What can the public sector do?

The government has its own role to play in stimulating early-stage changes, by changing regulations and shifting the focus of long-term research towards promoting the circular economy. The public sector can:

a. Increase understanding among companies and consumers of the circular economy's potential.
b. Develop its own processes and operating models for the adoption of the circular economy model within public services.
c. Develop regulations that support the circular economy, particularly in areas where existing regulations are preventing the adoption of the circular operating model.
d. Allocate more research funding to the commercialisation phase of research promoting the circular economy.
e. Shift its purchasing practices towards supporting the circular economy. Public sector purchases tend to have a major impact on operational development among private-sector service providers. In the long

run, this purchasing power could be harnessed for the promotion of the circular economy. In the current financial situation, however, the public sector would be wise to ensure that incorporating circular economic models in procurement promotes cost-efficiency on both its own and the private producer's side.

f. Promote cooperation among various sectors and companies. In addition to changes made by individual companies, in many cases the circular economy will require long-term, systemic changes.

Promoting the circular economy therefore depends on pragmatic changes made to the company's operations. Progress will be slow, but plenty of financially tempting opportunities already exist, particularly in the case of potential based on technological advances. This means that we need to understand the time frames of the circular economy. Companies can begin the transition now and the public sector should offer its support.

## 4.4 The role of private consumers

Private consumption also plays a key role in promoting the circular economy. Naturally, companies can promote the creation of a more efficient sharing economy and used products market, but developing these will also require changes in consumption patterns and the value choices of consumers. The sale of remanufactured products in particular will require their acceptance as valid products among consumers. It will otherwise be very difficult to retain their value. It is, after all, challenging for companies to develop circular business models that are attractive enough for consumers. AirBnB and Uber have partially succeeded in doing so. Others can do the same. Private consumption is the key area in which new types of companies will emerge.

## 4.5 Time frames for the circular economy

The starting point for promoting the circular economy should lie in exploiting current business opportunities. Regulatory changes and technological advances will play a key role in the long run. We have defined a time frame for the future of the circular economy in Finland as follows:

a. **Short time frame (0–5 years):** In this report, we have covered several business opportunities based on a profitable business case now or in the short term. Based on a rough estimate, we believe that half of the related potential could be exploited within the next five years. Many leading companies are already taking advantage of these opportunities, such as the optimum utilisation of resources, leasing-models for the machinery and equipment industry or modularisation. Larger-scale promotion of such opportunities will therefore make the circular economy a natural part of business activities in various sectors. Changes in consumer habits will also play a key role in promoting the circular economy. Many models, such as the sharing economy, have already found their way to Finland. Promotion of such opportunities should begin right away.

b. **Medium time frame (3–8 years):** A range of profitable business opportunities are already based on the circular economy, but exploiting them will require changes to current regulations. Some of these regulations involve defining the purpose of commodities and materials. It is always worth remembering that regulations are created for a certain purpose at a certain time. However, such a purpose can become outdated – many regulations should be changed in order to promote the circular economy. Many opportunities also exist in sectors where technological development is nearing commercial profitability, but the full-scale realisation of their full potential has yet to be realised. The emphasis should be on promoting their commercialisation in the medium term. Roughly a quarter of the opportunities examined by this report can be grasped in the medium term.

c. **Long time frame (8–20 years):** The opportunities described in this report will not enable Finland to adopt the circular economy model in full. Such a transition will be dependent not only on the development of technologies and business models, but also on the desire of other countries to promote the principles of the circular economy. The remaining opportunities will require either the development of new technology or changes in consumer behaviour that enable long-term exploitation of the circular economy's potential.

Companies, the public sector and other players have roles to play in promoting the circular economy. It will be crucial to demonstrate the circular economy's potential based on concrete, revenue-generating examples. Once successful cases based on real life lead companies to understand the business potential of the circular economy, they will be more likely to make long-term investments in the related new business models and technologies.

The circular economy is a new economic model in which services and smart solutions are used in the recycling of materials and creation of added value for products. The global circular economy has a global market value of at least USD 1,000 billion. This report is the first to provide an estimate of Finland's potential share of that market.

It outlines the opportunities presented by the circular economy in five sectors: the machinery and equipment industry, paper industry, food industry, construction and private consumption. The report also presents the public and private sectors with recommendations on how to exploit the circular economy.

The circular economy could be a goldmine for Finland, a major opportunity to improve the competitiveness of its national economy.

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