CIRCULAR ECONOMY: RESOURCES AND OPPORTUNITIES

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ISWA
International Solid Waste Association

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The International Solid Waste Association (ISWA) is a global, independent and non-profit making association, working in the public interest to promote and develop sustainable waste management.

ISWA has members in more than 60 countries and is the only worldwide association promoting sustainable, comprehensive and professional waste management

ISWA's objective is the worldwide exchange of information and experience on all aspects of waste management. The association promotes the adoption of acceptable systems of professional waste management through technological development and improvement of practices for the protection of human life, health and the environment as well as the conservation of materials and energy resources.

ISWA's vision is an Earth where no waste exists. Waste should be reused and reduced to a minimum, then collected, recycled and treated properly. Residual matter should be disposed of in a safely engineered way, ensuring a clean and healthy environment. All people on Earth should have the right to enjoy an environment with clean air, earth, seas and soils. To be able to achieve this, we need to work together.

Foreword

The Resource Management Task Force highlights the paradoxes facing the world economy. As I write, in 2015, rising consumption levels due to a growing population, growing wealth in developing countries, and a rapid increase in urbanisation, should all be leading to pressure on supplies and prices of raw materials fed into our industries. Today, the contrary is true.

Until the economic crisis of 2008 oil prices rose steadily and steeply, prices for metals, plastics and pulp for paper production all grew, along with pressure on resources caused by growing demand from above all China. This continued pressure gave renewed drive to the development of circular economy thinking as companies and governments grew concerned about raw material supply. New thinking took hold on the need to recover and re-use materials in our economies, reduce resource consumption and waste, provide resource security and reduce dependence upon imports.

But commodity prices are unpredictable. Since 2010 a different narrative has developed as raw material values have fallen across the spectrum often to levels not seen for a decade. When commodity prices are falling the full inequality between primary and secondary raw material markets is laid bare. Recycled plastics cost more than competing virgin plastics. In the USA the waste management industry talks of the "end of recycling" while major investors in the waste industry have pulled back from investing in recycling plants to concentrate on energy recovery.

All commodity markets have price risks but the immature nature of markets for secondary raw materials and the lack of instruments to effectively manage those risks places such markets at a competitive disadvantage. The volatility of these markets makes long-term investments a high-risk and it is to this risk that the waste industry must address its attention today, looking to provide a long-term landscape for sustainable material recovery and energy. Because as our studies make clear effective recovery of secondary raw materials and resource management is the future of our industry. We cannot guarantee that economic development will make commodity prices shoot through the roof, but all the evidence shows that industries that use resources efficiently, recover them and ensure supply security, will be those that survive. The challenge for our industry is to make secondary raw materials the priority raw materials for the future.

This can be achieved by targeting the production of secondary raw materials that are required by manufacturers to a price, quality and quantity unsurpassed by conventional markets. By working together we can raise the quality and quantity levels of recycled materials reprocessed in our industries. We need to ensure products are recyclable, reduce their recovery costs and eliminate, where possible, non-recyclables from the product chain. However, until the environmental and climate impact of the usage of virgin raw materials are internalised into production costs and subsidies on production and consumption of fossil fuels are removed, commodity markets will be biased towards the use of virgin raw materials and fossil fuels. Changing this paradigm will take time and therefore, in the meantime, enabling policy drivers are needed to support the development of sustainable resource management. Finally, we should re-evaluate the essential need to return nutrients and organic matter to soil. We can encourage a reduction in food waste by up to 40% and the recovery of unavoidable food waste both for its energy and carbon sequestration value. We do not yet receive the full economic value for the benefits of returning organic matter to our soils nor the full value for the fertiliser equivalent we provide. If we ensure that the full value can be returned to our industry we can then make a major contribution to the enhancement of soil fertility and reduction in greenhouse gas emissions.

Waste management is uniquely positioned to support all these approaches as we have been at the forefront of resource and energy recovery for more than a century, but still 70% of waste globally is landfilled. This is an unacceptable state of affairs. As waste managers we will need to develop new skills, innovation and business models to ensure development of sustainable resource management; while the task force work focuses on OECD countries, the markets we supply are global and initiatives in resource management are happening everywhere, not least China. So our overall focus needs to be global too.

Our Resource Management Task Force has worked hard over a year to address these issues from new angles including markets, the realities of cascading materials use, and the role of energy recovery. I have strongly supported this work and the ISWA Board has financed it adequately to ensure delivery within a rapid time frame. Congratulations to the team, the authors and contributors, for their work which lay out our choices for the future very clearly.

David Newman,
ISWA President

Prepared by the ISWA Task Force on Resource Management

Report editor:
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Former Technical Manager at ISWA,
New Zealand

Rachael Williams-Gaul holds a master's degree with first class honours in Natural Resource Management and Ecological Engineering. Rachael has eight years of experience in waste and resource management. She has held positions at the Regional Government, International and Academic Level.

Rachael previously held the position of Technical Manager at the General Secretariat of the International Solid Waste Association. Through this position Rachel was involved in the management of ISWAs technical programmes & projects. She was also responsible for the project management of technical projects with international organisations and other external entities particularly regarding Waste & Climate Change. Rachael is currently working for the Department of Conservation in New Zealand.

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Introduction

The potential for effective resource management and in particular the circular economy to drive economic growth has caught the imagination of leading thinkers across the globe.

National environmental policies to reduce landfill and landfill gas emissions are being overtaken by demands to rethink industrial processes. The waste industry has been driven to find new markets for secondary raw materials as across OECD countries landfill, as a sink of last resort is banned or all but priced out of the market.

The unintended implication of these changes has been a global surge in secondary raw materials seeking markets. New patterns of global trade have emerged for recovered paper, plastics, textiles and waste derived fuels despite strongly fluctuating commodity prices. As the risks to raw material supply have become evident government and business interests have invested growing research funding into how to change current operating business models and to secure investment in new treatment technologies.

In recognition of these challenges, the ISWA Board established the ISWA Task Force on Resource Management in June 2014. The task force has prepared a study into the current trends and a series of reports to help the waste industry to respond to these unprecedented pressures.

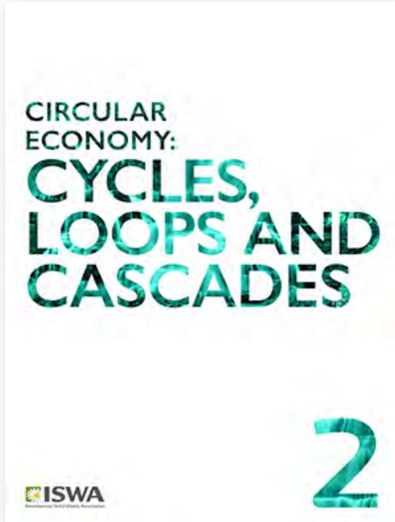
This report pulls together the main findings of the five investigative reports that were prepared by the Task Force to better understand the contributions of the waste management sector to resource management and the circular economy.

The six reports prepared by the Task Force on Resource Management


CIRCULAR ECONOMY: TRENDS AND EMERGING IDEAS
1
ISWA

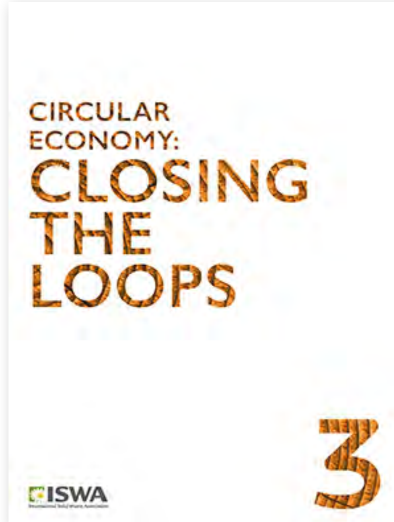
Martin Brocklehurst, Kempley Green Consultants

Exploring the key drivers responsible for the upsurge in changes by business and governments to re-think our current linear economy and the impact this is having on the waste industry.


CIRCULAR ECONOMY: CYCLES, LOOPS AND CASCADES
2
ISWA

Andreas Bartl, Technical University Vienna

Examining the benefits and limitations of recycling, its role in the circular economy and introducing cascade utilisation.


CIRCULAR ECONOMY: CLOSING THE LOOPS
3
ISWA

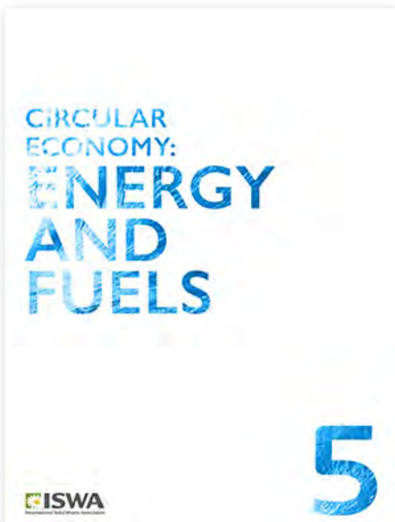
Costas Velis, et al, University of Leeds

Dealing with the problems of closing material loops through an in depth consideration of the recycling of two key materials polypropylene and paper & board.


CIRCULAR ECONOMY: CARBON, NUTRIENTS AND SOIL
4
ISWA

Jane Gilbert, Carbon Clarity

A description of the ways in which carbon and plant nutrients in organic waste can be recycled to conserve resources, reduce environmental effects and displace fossil fuels.


CIRCULAR ECONOMY: ENERGY AND FUELS
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ISWA

Tore Hulgaard, Ramboll

Investigating the potential for the recovery of energy and fuels from waste and the contribution that such energy recovery can have in a circular economy.


CIRCULAR ECONOMY: RESOURCES AND OPPORTUNITIES
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ISWA

Editor: Rachael Williams-Gaul, Former Technical Manager at ISWA

Pulling together the main findings of the five investigative reports prepared by the Task Force and describing the contributions of the waste management sector to resource management and the circular economy.

ISWA's key messages on resource management

Sustainable waste management has a crucial role to play

ISWA believes that resource management is central to sustainable development and that the waste management sector has a crucial role to play in optimising material and energy use within the circular economy. The circular economy is an opportunity for the waste management sector. It is a catalyst for new skills, innovation, knowledge and development; and will result in new technologies, business models and partnerships. To reach its potential, the waste management sector has to develop its own roadmap towards the circular economy, while recognising the need for cross-sector collaboration.

Sustainable waste management provides more goods and less environmental impact

The waste management sector is already making a pivotal contribution to the field of sustainable materials and energy management. This is achieved by providing secondary raw materials for production; carbon matter and nutrients for improving and fertilizing soil; and carbon neutral energy for electricity production, heating, cooling and transportation. Hereby, the sector is significantly reducing the environmental impact associated with raw material extraction and production as well as reducing the emission of greenhouse gases. The waste management sector has the skills and knowledge needed to facilitate the drive to a circular economy throughout the value chain.

The first step starts with waste prevention

Effective waste prevention measures are key to resource efficiency and the circular economy. The waste management sector is already engaged in waste prevention initiatives, but the concept is not yet a fully integrated part of waste management systems. Therefore, in order to support, facilitate and operate efficient and effective waste prevention initiatives, the waste management sector has to develop and integrate waste prevention activities, such as awareness training, feedback to designers and manufacturers as well as reuse and refurbishing, into the business models of the sector.

Technical challenges to closing the loop

Due to technological and scientific challenges, such as material deterioration and the lingering presence of hazardous substances, it is not possible to fully close the loops without substantial technological advances, which will take considerable time to reach. Meanwhile, the effective life of materials can be extended through optimal cascade utilisation before they are recovered for energy or finally disposed in a safe way.

Energy for the circular economy

The circular economy relies on energy as much as it does on material feedstock. Circular flows will always have a residual waste stream, either due to market conditions, technologies available or social barriers. This residual waste stream shall be considered as an important energy resource, along with the biodegradable fraction of municipal solid waste and industrial wastes.

Time for innovation and research

The successful emergence of the circular economy calls for research and development involving multiple disciplines, cross-sector technologies, economic considerations and the natural and social sciences. The work will find effective and viable means to overcome challenges and barriers on the road towards the circular economy as well as develop a robust systemic approach to the circular economy itself. The waste management sector's experience in developing and operating solutions for material and energy recovery as well as its everyday experience of facing the challenges of taking care of the residues of the linear economy will make a valuable contribution to this task.

Markets for materials

Well-functioning markets are crucial for sustainable resource management and the circular economy. The preconditions for such markets are well defined and commonly agreed quality standards, testing methods, trading conditions and dispute resolution mechanisms. Furthermore, trading systems and exchanges providing transparent and open trading information will reduce price volatility and transactions risk and make the trade more attractive and viable. The waste management sector, can together with the other actors in the value chain, support the establishment of such conditions and markets mechanisms.

Policies for resource management

There is a need for revised, consistent long-term policy, legal and fiscal frameworks to support the emerging circular economy and the development of sustainable resource management. Such frameworks have to supplement the supply-pushing material recovery targets in place today with incentives to create sound market demand for recovered materials. In addition, they have to secure an unbiased relation between virgin materials and new products on one side and recovered resources and refurbished products on the other, as well as foster research and development within the field of resource management and the circular economy.

Teamwork of actors

All actors in the value chain need to interact and be involved in the transition toward a circular economy – designers, producers, manufacturers, consumers, policy makers, and the waste management sector. The waste management sector wants to engage proactively with all actors along the value chain.

From linear to circular

The linear economy

A linear economy follows the straightforward path of extract-make-use-dispose. This approach not only places pressure on the earth's limited resources, but also on its ability to act as a sink to absorb waste. The life of materials in a linear economy tends to be very short, with 80-90% of goods produced becoming waste within less than one year.[1] Every year OECD estimate the equivalent of about one fifth of global material extraction becomes waste[2] and ISWA estimate 70% is disposed in landfills.[3]

Not only do materials follow this linear approach, but also the surrounding health, safety and environmental legislation and market conditions in place, generally support this model. In such an economy, OECD estimates suggest that municipal solid waste will rise by 0.69% for every 1% increase in national income. Economic development generates more waste and produces more pressure on virgin supplies, i.e. the earth's stock of natural resources.

[1] See World Economic Forum briefing paper: http://www.weforum.org/pdf/sustainableconsumption/DSC%20Overview%20Briefing%20-%20Closed%20Loop%20Systems.pdf
[2] OECD (2011) Resource Productivity in the G8 and the OECD
[3] ISWA,(2015), Globalisation and Waste Management – Final Report from the ISWA Task Force, Vienna, Austria.

Resources

As defined by United Nations Environment Programme (UNEP), "resources are the naturally occurring assets that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits one day) and that are subject primarily to quantitative depletion through human use".

Fig. 1 | **Linear Economy**

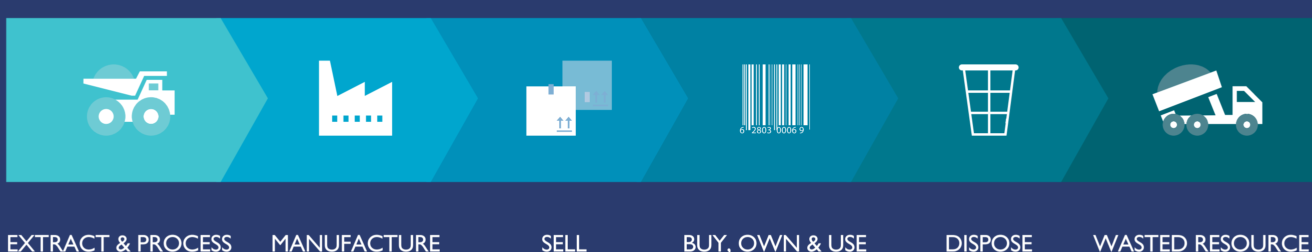


Fig. 2 | Consequences of a linear economy

WASTE IS CREATED AT EACH STEP OF THE VALUE CHAIN

Raw materials

- Subsidised fossil fuels make raw materials cheaper to extract and more attractive than secondary materials
- Environmental externalities of raw material extraction are not included in raw material prices, distorting markets
- Growing volumes of overburden waste per tonne of raw materials extracted

Design / Production

- Manufacturers seek to make more profit from selling more goods and drive consumer demand by placing newer better products on the market at very short intervals
- Composites and complex design hinder or add cost to resource recovery

Distribution / Consumption

- As economies grow volumes of waste rise. Regulatory barriers to recovery add to costs and distort markets
- Product, health, safety and environmental legislation in OECD countries, often assumes materials will be used and discarded

Waste

- Around 80-90% of what we consume in a linear economy becomes waste in less than 12 months
- About 1/5th of equivalent global material extraction becomes waste each year
- 64 million people are affected by open burning & dumpsites

The circular economy

The circular economy concept has developed from the recognition that a linear economy is unsustainable and the need for an alternative approach, which values raw materials differently. The general aim of the circular economy is to utilise the maximum value of resources and keep them in use for as long as possible. In a circular economy, materials and products are designed with waste prevention in mind, and are re-used, recycled or recovered. When the raw materials they contain can no longer be re-used the energy they contain is extracted to displace virgin fuels and residues are safely disposed to landfill.

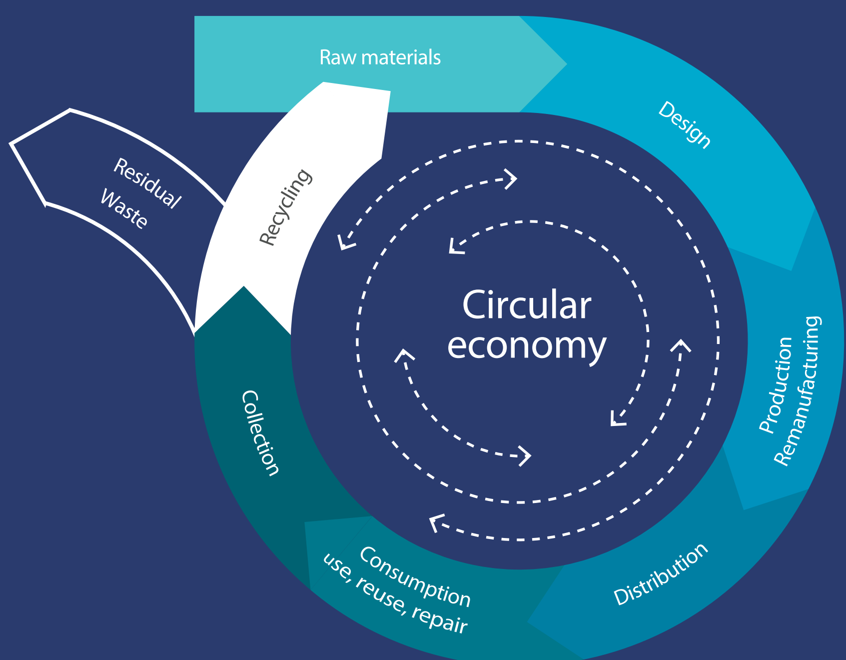
In order for the circular economy to function effectively, enabling policy and market conditions are needed across all sectors.

The views of governments and businesses are changing as the need to increase resource efficiency, reduce cost and environmental effects become clear. Policy shifts and different business models are being tested that challenge the linear economy as the scale of the economic and jobs opportunity of the circular economy become clear. The contributions this change can make to climate change mitigation, and volatility in commodity prices have added impetus to the need for new thinking. Despite the positive economic gains shown by early adopters of the circular economy model change has not yet reached a commercial tipping point.

The circular economy brings new growth and job opportunities

According to the European Commission using resources more efficiently will bring new growth and job opportunities. Better eco-design, waste prevention and reuse can bring net savings for EU businesses of up to EUR 600 billion, while also reducing total annual greenhouse gas emissions. Additional measures to increase resource productivity by 30% by 2030 could boost GDP by nearly 1%, while creating 2 million additional jobs

Fig. 3 | The EU Model of Resource Efficiency



Source EU – Towards a circular economy: A zero waste programme for Europe.
Brussels 2.7.2014 COM (2014) 398 Final.

Fig. 4 | Key drivers of the circular economy

Systematic challenges of the circular economy

Recycling and maintaining materials in a perpetual cycle, or fully closing the loop is not possible.

This is due to a number of technical reasons which relate to the integral properties of materials and also the processing steps involved in production and during the recycling of secondary raw materials.

Materials lose their quality and integrity over time for three main reasons

Material losses through dissipation

A certain fraction of material is released throughout its life cycle (including during recycling) into unrecoverable forms. Examples of this is the corrosion of copper from roofs and water pipes and oxidation of aluminium; around 4% of aluminium is lost through dissipation during recycling. The dissipation of elements may cause environmental damage and harm to health when released. These losses are no longer available to be recycled; meaning a recycling rate of 100 % can never be reached.

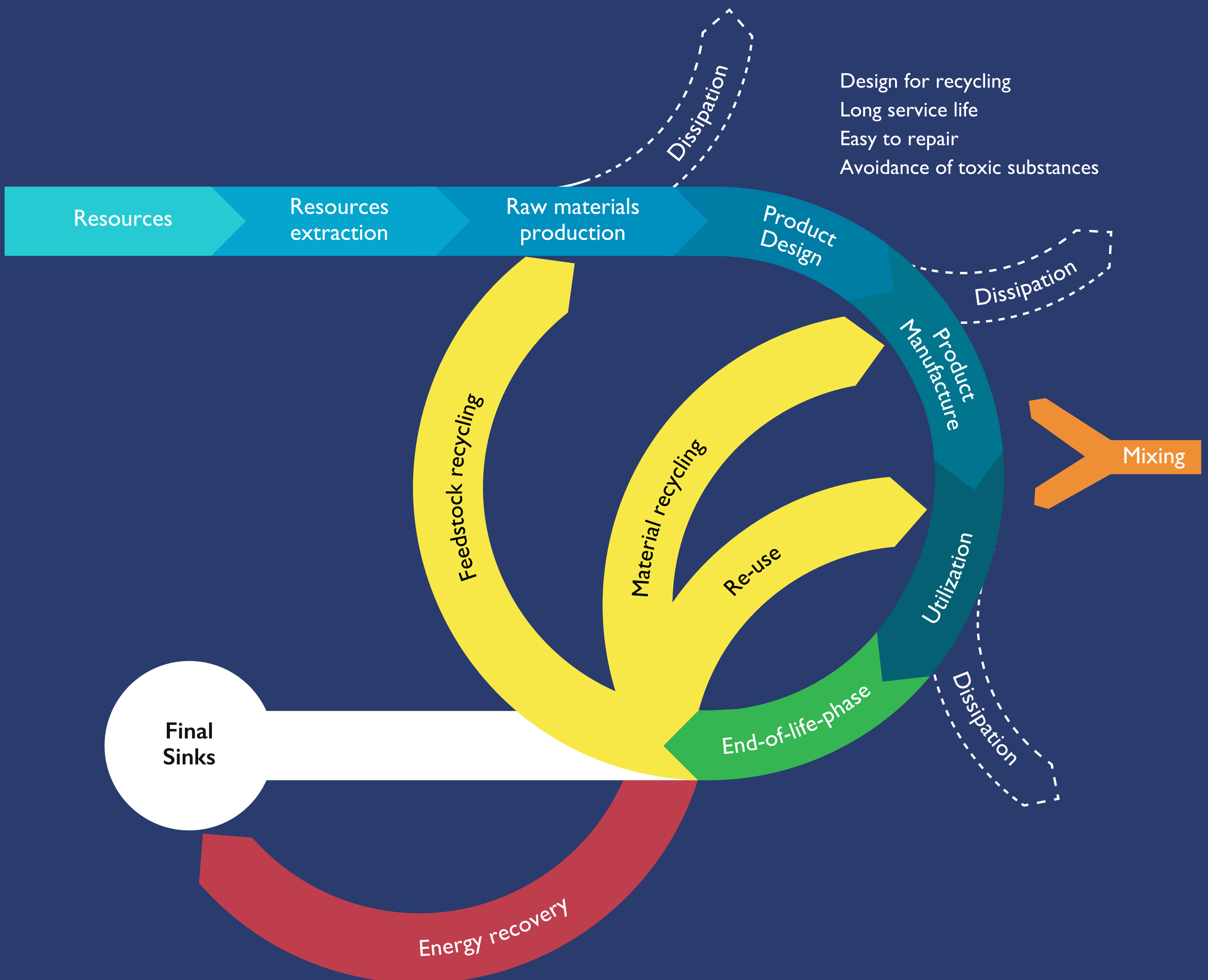
Contamination from irreversible mixing with other materials

An undesired contamination of materials may occur when they are mixed that cannot be reversed. An example of this is steel products containing other metals such as copper and tin which reduce the ductility of steel. In particular scrap recovered from end-of-life vehicles may contain considerable amounts of copper. If such scrap is mixed with other, cleaner steel scrap grades when melted, it will impact the quality of recycled steel. Contamination can be minimised during design and production processes by maintaining pure materials as well as by keeping different grades separate during the recycling processes. However, such contamination of materials means that closed loop recycling is frequently impossible.

Degradation or destruction

Materials may degrade during processing and use. In particular some materials due to their molecular properties are sensitive to heat (e.g. during melting), radiation (e.g. UV radiation during use) or mechanical impacts, which lead to their degradation or destruction. In extreme cases this degradation can make recycling impossible. Reprocessing of cellulose fibres and polymers are examples of the degradation process. Cellulose fibres for example reduce in length and strength each time they are reprocessed and also rubber and some plastics when exposed to UV- light become brittle, limiting the number of cycles that are possible.

Fig. 5 | Technical challenges to closing loops



The cascade model

The cascade model accounts for a loss in quality and or quantity during the sequential re-use, recycling or recovery of raw materials, to produce secondary raw materials and energy. The cascade can be likened to a waterfall; whereby there is a drop in quality or quantity each time a material is used and then recycled.

These loses in the integrity of a material are due to the processes outlined in the section above, these natural processes limit the future options available for recycling until the point that a material can no longer be effectively recycled.

Understanding the cascade model is important to help maximise the material life of products. Rather than just considering the impact of a single processing step, it is important to take into consideration the impacts of the complete cascade chain. The aim is to wring out the maximum material use of each resource, resulting in the least environmental impact. Biogenic materials as well as plastics are composed of carbon and therefore the ideal final step (at the point when further material or nutrient utilization is no longer effectively possible) is to terminate the cascade with energy recovery. The aim of cascade utilisation therefore is to maximise the life of a material, by selecting the optimal cascade path and where technically possible to finalise the cascade with waste to energy. The challenge is to define the optimal cascade utilisation of a material in order to minimise resource and energy consumption as well as environmental impact.

Because of their properties some materials have a longer cascade utilisation potential than others, and can more easily be reused or recycled for an extended number of cycles, such as iron. Whereas others degrade more quickly, such as UV sensitive plastics. Iron as a metal does not degrade, but loses its quality due to contamination with other elements as part of the production process. In the case of iron, the cascade is obviously not terminated by incineration. Iron can theoretically, be infinitely recycled but in practice unavoidable losses means that additional input of virgin materials are needed.

The presence of hazardous substances in compound materials complicates material cycles and the ability to close material loops. Hazardous substances, which may arise in waste streams even long after they are no longer used in production, need to be clearly understood. This de-pollution of material cycles, results in some inevitable losses and sets another limit to what can be sustainably recycled

Due to the differences in recycling processes, recycling efficiency in terms of material quality, energy consumption, environmental impact and material losses can all be quite different depending on the process. Even similar recycling technologies will show differences in efficiency depending on the properties of the input material.

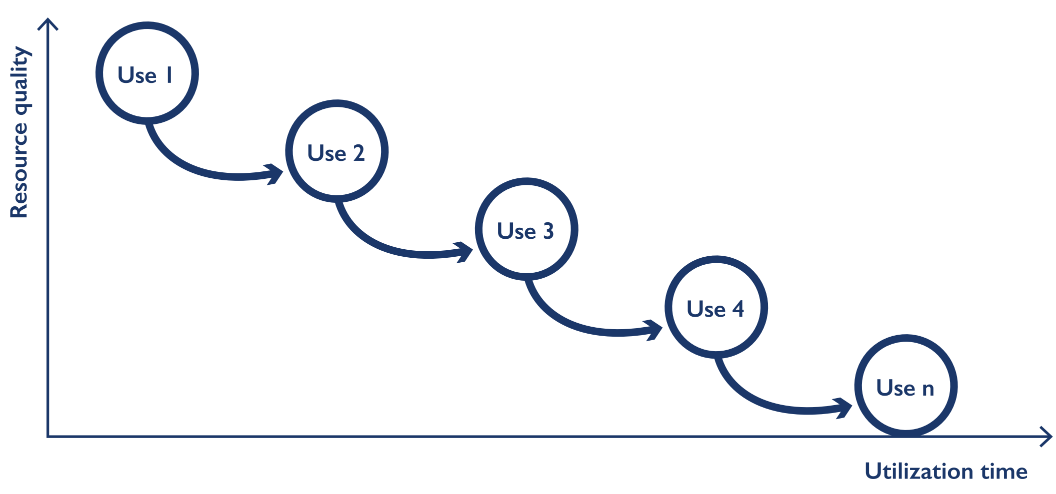
Materials can also be cycled back to the top of the cascade again, if additional energy is added. For example food waste may be used for pet food or to feed livestock (first cascade utilisation), the manure is then composted into a fertiliser (second cascade utilisation), and finally the nutrient value is then re-circulated back to the top of the food cascade through the nutrient cycle and additional energy from the sun. In this way the cascading becomes a cycle process and the nutrient value is not lost.

Bio-refining of waste organic materials, using energy and pressure in combination with catalysts is also another way to produce high quality fuels and chemical feedstocks, pushing them back up the cascade.

As the cascade model demonstrates, circular flows will always result in a residual waste stream, i.e. materials falling out of the cycle or cascade. This may occur as a first step, in the case of single use products or as a final step of a cascade, following several recycling cycles. As outlined above, where possible this waste stream should be converted from waste to energy. Not all residual materials can be thermally treated or anaerobically digested and therefore landfills are important for helping to manage residual streams where no other treatment options are available.

Efficient energy recovery from residual waste is an important and valuable contribution to sustainable development. Energy is required as a critical resource at every step in the product value chain. The majority of the energy used in production is currently being produced by the burning of fossil fuels, resulting in CO2 emissions and climate change.

Fig. 6 | Concept of cascading by repeated using of a resource at decreasing quality



Case study - Veolia Plastics Recycling Facility United Kingdom

Location
Rainham, Essex, United Kingdom.

Date commissioned
A €9 million plastics recovery facility that became operational in 2012.

Capacity
50,000 tonnes per annum sorting plastics into 9 different grades of polymers.

Good provided - raw materials
The plant provides recycled PET/HDPE plastics for bottles and PP & PE for industrial applications, including waste bins and recycled films for plastic bags.

Avoided disposal to landfill
Up to 50,000 tonnes of plastics diverted from landfill. A saving of €7 million based on a median landfill gate fee for non-hazardous material of around £100 per tonne.

CO_2 reduction
50,000 tonnes of CO_2 per year saved as a result of displacing virgin plastics.

Market value of good
According to WRAP, the value of plastics recovered in the UK reached nearly €210 million in 2012. Tonnage rose to over 842,000 in 2014 with 39% (or 328,000 tonnes) processed in the UK.[1]

Key drivers
Commercial profit and EU targets on household waste recycling (50% by 2020), packaging (57% of plastic packaging by 2017) and obligations for separate collection of plastics by 2015.

Barriers that have been overcome
Planning approvals & operational permits.

Barriers to overcome
Securing markets for product outputs during a time of volatile plastic pricing.

Actions to improve market access
Installation of state of the art optical sorting equipment to separate 9 grades of plastic polymers and colours, sorting materials ranging from bottles, yogurt tubs and trays. The process ensures high standards of segregation for end users and contributes to addressing the shortage of domestic plastic reprocessing facilities in the UK.

Additional benefits
Veolia is developing plastics streams that can be freely traded, developing standards and specifications to meet the needs of plastic reprocessors and industrial manufacturers.

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[1] https://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx UK National Packaging Waste Data Base

Waste prevention and resource management

Waste prevention is critical to sustainable resource management. It involves any activity that helps to reduce generation of waste in the first place, during the design, production and consumption phases. Waste prevention also involves reducing the amount of harmful materials that are used in the production of goods and products.

As the waste management sector is predominantly occupied with materials that have already entered the waste stream, waste prevention has not yet been fully integrated into the activities and business models of the sector. The move toward a circular economy requires efficient and effective waste prevention initiatives, this means that ultimately less materials will enter the waste stream. This is a real issue already faced by waste management companies who have to deal with fluctuating demand when planning for future waste collection and treatment. A good example is food waste where in Korea and in a reversal of global trends, experiments with pricing systems in the City of Gimcheon have reduced food waste by 40%.

In order to embrace this change, the waste management sector needs to gain new competencies and provide new services that support circular business models. Accenture, based on an analysis of 120 case studies of businesses involved in improving resource productivity, identified five circular business models in its circular advantage report:

- Circular Supplies: Provide renewable energy, bio based- or fully recyclable input material to replace single-lifecycle inputs;
- Resource Recovery: Recover useful resources/energy out of disposed products or by-products;
- Product Life Extension: Extend working lifecycle of products and components by repairing, upgrading and reselling;
- Sharing Platforms: Enable increased utilisation rate of products by making possible shared use/access/ownership;
- Product as a Service: Offer product access and retain ownership to internalise benefits of circular resource productivity;

All of these business models fit within the scope of waste prevention measures. The specialised knowledge, logistical and operational skills of the waste management sector, present numerous opportunities for the sector to become more actively involved in new business models.

The waste management sector has prime access to specialised data and knowledge on materials that are being effectively re-

An innovative service leading to the prevention of waste

Selling Services over Products: Rather than continuously purchasing new solvents and creating waste, companies effectively reuse their solvents through the leasing of a service from Veolia Environment. Veolia Environment has established a network of four solvent processing units in France, Switzerland and the United Kingdom and an additional four in North America. Several new economic models have been developed for solvent reclamation, reuse, or tolling. In tolling contracts, the solvents are collected directly from the industrial installations, where they are again made available to the same clients after the solvents have been regenerated to their set specifications. The solvents are collected and consolidated for treatment at a unit based in Picardy, France, and redistributed throughout Europe. The benefits to the customer of this leasing model include: maximized performance, guaranteed supply and quality, budget management, and reduced environmental impact.

covered and those that are being disposed and therefore lost from the material cycle. This information is key to identifying and supporting the design and manufacture of products that where relevant allow for extended life, effective re-use and full material recovery. In addition to providing information on what is fully recyclable, the waste management sector can also inform on material properties and production methods that reduce prevent or limit material recoverability such as the use of inks, labels, composite materials, presence of hazardous substances etc.

The waste management sectors specialised skills set, makes the sector well positioned to become involved in the support of product life extension, products as a service and sharing platforms. This can be achieved by forming new partnerships with producers and offering logistical skills to aid the collection and distribution of goods destined for these services. By gaining new product specific skills the waste management sector can also become directly involved in preparing products for re-use and providing products as services as given in the example from Veolia. The provision of product packaging, a major MSW waste stream, could also potentially be offered as a service, in the form of re-usable packaging provided by the waste sector, to help close the loop.

Influencing consumer decisions and perceptions

More effort is needed to change consumer behaviour, toward valuing refurbished products, opting for products as services and using shared platforms, as alternatives to the traditional ownership model. The waste management sector is is ready to play an active role in education and awareness raising related to waste prevention. This can be achieved by providing information on not only how producers but also how institutions and citizens can reduce the amount of waste that they produce, through the way they consume and act. In recent years a lot of effort has been made to prevent food waste and many initiatives and programmes have been established within and outside of the waste management sector. Such an example is the Think Eat Save initiative[4] which is actively sharing tools and results of successful projects and actions to raise awareness and accelerate action on reducing food waste globally. This follows the release of a study on Global Food Losses and Waste by the Food and Agriculture Organisation (FAO) that revealed that about one third of all food production world-wide gets lost or wasted in the food production and consumption systems, amounting to 1.3 billion tonnes.

[4] http://www.thinkeatsave.org) Established by UNEP, FAO and Messe Düsseldorf.

The waste management sector influencing product design

A project funded by ISWA was conducted to reduce the waste footprint of Blue Jeans through improved design. The project used an innovative product chain approach, where all the environmental impacts of jeans during the production, use and end of life phase where evaluated and discussed with representatives from the different parts of the jeans production chain. With the knowledge of waste experts, designers were able to recognise the many bottlenecks resulting in unnecessary waste that exist that could be prevented by changing details during the design phase like zippers, buttons, labels, seams etc.

The waste sector delivering resource management

The waste management sector is already contributing considerable services and expertise toward sustainable material and energy management. Most recognised and of particular significance, is the provision of secondary raw materials that can substitute virgin materials, replacements for fossil fuels and the return of carbon matter & nutrients to soils. Secondary goods can in many cases be delivered at a much lower environmental cost, when considering land use, water and energy inputs and biodiversity impacts compared to raw material and fossil fuel extraction. Such goods can be delivered with substantial carbon emission reductions and make a major contribution to reducing climate change gas emissions.

Resource management is not new to the solid waste management sector. There has almost always been some trade in select secondary materials or goods. During the first industrial revolution the recovery of secondary materials really began to develop. This market and material-value based form of resource management later began to fade as crude oil was extensively utilised, making it possible to extract virgin raw materials at a scale never before possible.

Historically, the main driver for keeping a selection of resources, such as metals, in circulation has been a simple matter of economics. More recently an increased environmental awareness, focus on climate change mitigation and concerns on energy and material scarcity have added further drivers. Resource Management is also becoming a standalone driver for capturing material value from waste. In all these cases economic sustainability depends on secure markets for the recovered raw materials.

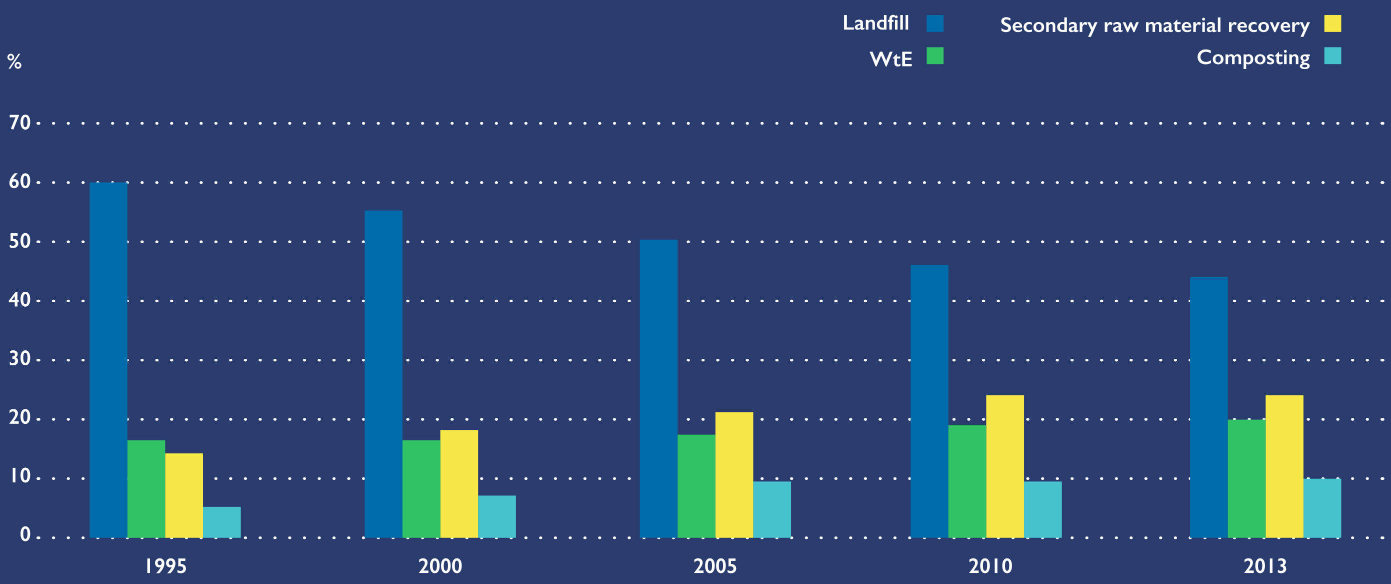
Key Examples

The economic opportunity the waste industry is creating through effective resource management is growing. These changes represent early success in what is estimated by the World Economic Forum to be a €0.9 trillion additional annual opportunity to the global economy through adoption of the circular economy. Figures for Europe are equally impressive at €475-574 billion per annum on the most advanced transition scenario predicted by the Ellen MacArthur Foundation. At national state level work commissioned by Veolia predicts a contribution of €40 million or 1.8% GDP growth and the creation of 175,000 new jobs for the UK economy. All these studies by reputable economists and academics are consistent in their predictions.

The specific materials highlighted by the Task Force work give some idea of the potential across all OECD countries.

Fig. 7 | Growth in material and energy recovery across the OECD

Successful policies have supported a move away from landfilling toward more material recovery (composting and secondary raw material recovery) and energy recovery across the OECD



Source: OECD Stats, 2015

Delivering organic materials

For waste organics the waste industry has the potential to:

- increase collection tonnages from 66 to 248 million tonnes and to produce 82 million tonnes of compost/digestate;
- increase the value of compost from €110-410 million, assuming current compost/digestate can be sold for its real fertiliser equivalent value. (Currently values are only 54% of the equivalent in real fertiliser value);
- add 12 million tonnes of stable carbon and 24 million tonnes of total carbon every year to improve soils;
- displace nearly a quarter of the traditional nitrogen fertilisers currently applied to land; and
- grow the markets for biodegradeable-plastics to 2.8 million tonnes and grow bio-lubricants and bio-composites nearly three fold.

Delivering energy

For energy the waste industry has the potential to:

- more than double the amount of municipal waste (MSW) used to produce energy and heat from 145 to 330 million tonnes;
- quadruple the amount of electricity produced from MSW from 75-300 TWh/year;
- more than quadruple the amount of heat energy produced from MSW from 70-400 TWh/year; and
- increase the value of energy from waste to more than €25 billion per year

Delivering raw materials for manufacturing

For recycling the industry is already responsible for:

- 40% of global raw production material needs;
- 58% of the raw materials used in paper manufacture
- 37% of the raw materials used in steel manufacture; and
- circa 5% of raw materials used in plastics manufacture

Opportunities clearly exist for a major growth in plastics recycling. For rigid polypropylene (PP) for instance changes to peelable in-mould labels could increase rigid PP suitable for food grade recycling to around 72,500t/y at 50% recycling rates.

Secondary raw materials

Goods delivered

The waste management sector delivers considerable volumes of secondary raw materials, the most common being various metals, paper and card, plastics and glass.

Secondary materials undergo either material recycling (where the chemical constitution of a material is maintained and only the physical elements are changed, e.g. in the melting and reprocessing of metals) or feedstock recycling (both the physical and chemical are changes, e.g. de-polymerisation of plastics).

According to the Bureau of International Recycling (BIR), recycled materials supply 40% of the global raw production material needs.

Current and potential contribution

Growth in secondary raw materials recovery, when averaged across the OECD has remained relatively stable in recent years and is currently 24%.

The amounts of secondary raw materials delivered and used in production vary significantly from material to material. A relative success story is paper and board. The overall quantity of recovered paper and board traded nationally has more than doubled since 2000 and around 58% of secondary raw paper and card is used in the production of new paper.

As countries move toward resource management, production and consumption patterns will change; meaning fewer materials will be available for recovery. The OECD has already reported that the average per capita material consumption has reduced by 12 % since 2000. Despite these changes, there still remains considerable opportunity for growth in secondary raw material recovery and recycling. These opportunities are presented by the global nature of the market and the potential to achieve higher recovery levels across more materials.

GLOBAL PRODUCTION AND SECONDARY RAW MATERIAL INPUTS

	CURRENT TOTAL PRODUCTION	SECONDARY RAW MATERIAL USED IN PRODUCTION	% OF SECONDARY RAW MATERIAL USED IN PRODUCTION
		million tonnes/year	
Paper (2012)	400	230.53	58%
Plastic (2012)	288	15*	~5%
Steel (2012)	1547	570	37%

*based on global trade, excludes domestic production of China.

Sources: Paper & Steel data from Bureau of International Recycling, 2014; Plastic data, ISWA 2014

SECONDARY RAW MATERIAL RECOVERY AS A % OF WASTE ARISING, OECD, 2015

1995	2000	2005	2010	2013
14%	18%	21%	24%	24%

Sources: OECD, 2015

Market factors

The quality of secondary raw materials and how similar they are to the virgin material they are substituting are key market factors. There is wide variation between and within countries in the quality criteria for secondary raw materials; this is particularly challenging for global trade in secondary materials. The grading system for paper, the EN643 grading schedule for example, is known and used widely, but often the Chinese paper mills define quality and set rough levels for acceptable contamination without the use of this standard.

Price

The price of secondary materials fluctuates significantly and is influenced by the value of the virgin material it is substituting. The price of fossil fuels has a strong influence on the price of secondary raw materials, so too does the quality of the material. Additionally price for secondary material is driven by demand. The demand from developing markets such as China has a significant impact on prices.

Main challenges

Achieving consistency in quality and volume as demanded by the market is a major challenge. Manufactured products are always evolving and becoming more diverse and complex in their makeup. This means that there is a need for continued development in collection infrastructure, new sorting and processing technologies. These developments can be very costly and in some cases financially unsustainable.

The most challenging secondary materials to recover are complex/composite materials and materials that vary in their quality, types of items and sectors. Polypropylene (PP) for example is used for a wide variety of applications across different sectors (such as packaging, automotive and in electrical & electronic equipment), is mixed with a variety of additives and exhibits extreme differences in material qualities. Even what would appear as simple secondary raw materials to obtain, such as from scrap paper and card, face technical challenges for sorting and processing due to innovations in new materials, additives and printing technologies.

As touched on above there are also numerous challenges due to the nature of the global market for secondary raw materials and direct competition with virgin raw materials.

Looking forward

Innovations and investment in new collection infrastructure, sorting and processing technologies will be needed for the waste management sector to deliver a wider selection and higher quality of secondary raw materials. This will allow materials to be more efficiently cascaded, harnessing their optimal resource value at the lowest environmental impact.

New synergies are likely to emerge, where a range of outputs will be delivered from scrap materials at integrated or co-located treatment plants including, electricity, fuels, green chemicals and secondary raw materials.

There is likely to be a move toward more feedstock recycling for contaminated and very heterogeneous mixes of scrap materials.

Carbon matter and nutrients

Goods delivered

Compost and digestate used as nutrients to build soil productivity.

Bio-based, fine and speciality chemicals used in relatively small amounts for high-technology applications and also commodity chemicals, bioplastics, biogas, struvite, fibreboard and cellulose.

Current and potential contribution

The global market is potentially massive and is estimated at billions of Euro's annually. However the goods obtained from organic waste that contain the greatest value, such as through bio refining, are not yet well established technologies; significant investment in R&D and capital infrastructure are needed to realise their potential.

The potential amount of organic waste that could be processed in the OECD is double that currently produced. The resources contained within this increased amount is substantial, between 0.1-3 million tonnes of nitrogen and 4 to 41 million tonnes of carbon. That is equal to about 14% of the nitrogen that was applied across 23 OECD countries in 2009.

CURRENT CONTRIBUTION IN OECD COUNTRIES

ORGANIC FRACTION OF MSW TREATED	COMPOST/ DIGESTATE PRODUCED*	NUTRIENT VALUE
million tonnes/year		M €
66	22	110

POTENTIAL CONTRIBUTION IN OECD COUNTRIES

ORGANIC FRACTION OF MSW TREATED	COMPOST/ DIGESTATE PRODUCED*	NUTRIENT VALUE	NUTRIENT VALUE BY 2020
million tonnes/year			M €
124	41	0.1-3 Nitrogen 4 – 41 Carbon	207

*based on 66% mass loss.

these figures only include MSW, however as much waste as this can also be assumed from commercial and agriculture sectors

Market factors

High quality and an independent quality assurance (such as national quality standards and end of waste criteria) are key and necessary for the sale of compost and digestate. Standards and certification schemes exist in some, but not all, OECD countries.

In addition to quality, sales of both compost and digestate are dependent upon a number of factors, such as the relative price of inorganic fertilizers, which is linked to the cost of fossil fuels, the season, transport distances between place of production and end use, and spreading costs.

Price

The price received depends on the quality of the final product. Bulk sales of screened compost are sold to landscapers, horticulture and gardeners for between €4.6 - 13.7 / tonne. Compost used for agriculture fetches lower prices and is mostly sold for somewhere between €0.9-4.6 / tonne.

A lot of compost is given away for free.

Main challenges

The Legislative framework often poses a challenge for selling of compost and digestate. In some cases more stringent controls are placed on handlers of organic waste than are applied to non-waste primary products.

Compost and digestate are undervalued in monetary terms and the substantial external benefits of using the products are not reflected in their internal pricing. The organic matter produced provides value far beyond the price it is sold for with respect to soil carbon sequestration, improved tillage and water holding capacity.

It is also challenging from an operational and service provision, to deliver high quality and consistency, due to challenges in obtaining clean (uncontaminated) feedstock from waste producers.

Looking forward

The technical competence of the waste management sector in collecting, transporting and treatment of organic wastes needs to be further developed and extended to maximise the value obtained, such as the processing of more bio-based chemicals and nutrients.

To fully embrace the potential opportunities available through manufacturing higher value products, synergies could be realised by co-locating waste processing plants alongside more sophisticated biorefinery operations. This has the potential to realise significant capital and operational cost savings.

To grow and diversify its operations, the waste management sector will need to build partnerships with other complementary sectors (such as chemicals and agriculture) and expand its core competencies, by diversifying its operational standards and qualifications, and extend training across all occupational levels.

Case study - Roskilde, Denmark: Converting waste to energy

Location
Roskilde, Denmark.

When the operation started
The KARA/NOVEREN, unit 6, 'Energitårnet' (the Energy Tower) WtE plant was established in 2013.

Good provided
Electricity and heat for district-heating, with maximum utilisation of energy resources from waste (almost 100%).

Amount of waste treated
The plant has the capacity to treat 600 tonnes of MSW and commercial/industrial waste per day or 200,000 tonnes per year.

Electricity produced per year
The net production of electricity is 140 GWh (140,000,000 kWh) per year.
The facility covers the electricity consumption of around 44,000 households.

Heat produced per year
The amount of heat produced is 450 GWh (450,000,000 kWh) per year.
The facility covers the heat consumption of around 26,000 households.

Market value of good
45 EUR/MWh for electricity and 30 EUR/MWh for heat (net, i.e. excluding tax).

Driver's for the activity taking place
Public ownership allows modest requirements on the return on investment providing frames for investments that maximise energy output. Existence of a large heat market (Greater Copenhagen) that can utilise virtually all generated heat year round.

Barriers that have been overcome
No major barriers were faced in the implementation of this project.

Actions that have been undertaken to improve market access
Regional heat planning has taken place over many years to promote the development and use of district-heating networks.

Avoided disposal to Landfill
In principle 200,000 tonnes per year. The facility replaced transfer of waste to neighbouring WtE facilities and two old smaller WtE units at Roskilde (which have been taken out of operation). Landfilling only takes place on a very small scale in Denmark.

Additional benefits
Saved consumption of fossil fuels and the emission of associated greenhouse gasses (GHGs). Around 30,000 tonnes of bottom ash is used in road construction per year. 2-3,000 tonnes of metals are recovered from the bottom ash per year.

Energy

Goods delivered

Electricity and heat from thermal treatment with energy recovery (here on referred to as WtE).

Bio gas for production of electricity (and heat) on site or distributed for use elsewhere e.g. for heating, chemical processes or used as transportation fuel from Anaerobic digestion (AD) and the capture of methane from landfills.

Energy recovery facilities are dual purpose; replacing other energy resources and providing effective waste management. A common benefit of energy and fuels from waste is that these outputs replace other energy resources, particularly fossil fuels and thereby their associated emissions of carbon dioxide. Energy recovery facilities also contribute to material and nutrient management. AD is combined with the production of digestate which is a nutrient source and metals that are not easily recycled can be recovered from the bottom ash of WtE facilities.

Current and potential contribution

The potential MSW available for WtE and AD with biogas collection across the OECD is significantly greater than what is currently processed. Energy production could more than double from WtE. The potential from household biological waste is estimated to be 0.3% of the current natural gas consumption. Wood and other biomass based feedstocks account for around one third of all new investment in waste technologies, reflecting a move away from traditional power generation in many countries.

CURRENT CONTRIBUTION IN OECD COUNTRIES

GOOD DELIVERED	MSW PROCESSED MILLION TONNES/YEAR	AMOUNT OF ENERGY TWh**/YEAR
Electricity from WtE	145	75
Heating from WtE		70
Biogas/methane from AD	8*	5
Landfill gas (LFG)	100 (estimated)	50

POTENTIAL CONTRIBUTION IN OECD COUNTRIES

GOOD DELIVERED	MSW PROCESSED MILLION TONNES/YEAR	AMOUNT OF ENERGY TWh**/YEAR	VALUE B€/YEAR
Electricity from WtE	330	300	15
Heating from WtE		400	8
Biogas/methane from AD	50	40	1.2-1.6
Landfill gas (LFG)	300	20***/130****	0.6-0.8

* This is an estimated number provided by ISWA experts using published data from OECD, industrial sources and detailed knowledge of this developing industry.

** TWh is the energy content of around 90 million m³ of natural gas, or around 300,000 households' annual electricity consumption for lighting and appliances.

*** from MSW, only and after diversion of waste for WtE and

**** assuming improved gas collection 70% collection efficiency and no change in landfilled amounts.

Case study - Sermonde, Vila Nova de Gaia, Portugal: Converting landfill gas to energy

Location
Sermonde, Vila Nova de Gaia, Portugal.

When the operation started
The collection of biogas from the Sermonde Landfill, by Suldouro, began in 2004.

Good provided
Electricity: biogas collected at the landfill is converted to electricity in an internal combustion engine. Engine exhaust gas is used for the organic rankine cycle (ORC) at the MBT plant to generate electricity.

Good provided
Heating: heat from the water jacket is used in building heating, hot water, and heating digesters (MBT anaerobic digesters). The heating is used locally at the plant.

Amount of MSW treated per year
169,000 ton of MSW treated per year.
111,000 tonnes goes to landfill and 58,000 tonnes goes to MBT.

Energy produced per year
Electricity 49,513,000 kwh 46,540,000 from landfill plus 2,973,000 from MBT.
The electricity supplies 16,000 households, which amounts to 12% of the domestic consumption of Vila Nova de Gaia.

Market value of good
The electricity is sold to the national grid. The price is 0,123€/kwh from landfill and 0,119€/kwh from MBT. The difference in price relates to different contracts.

Driver's for the activity taking place
Legislation requirement to treat biogas emissions DL183/2009 heating cost reductions and profits from electricity production have been identified as the best return on investment for the use of biogas contracts.

Barriers that have been overcome
The process to gain a license for energy production is complicated. Authorisation from the electrical national grid company (EDP) is needed, and from the government energy department (DGEG). Normally the time required for this is very long (several years).

Actions that have been undertaken to improve market access
All of the electricity produced is sold to the grid. At present there is no policy, nor financial incentive for other profits from biogas. Licences need to be obtained from the government energy department and from the national grid company to sell electricity. The license sets the limit on the amount of electricity that can be delivered.

Additional benefits
This energy production is stable and adjustable (it is not dependent on wind or sun intensity) and can be useful to equilibrate the grid. The electrical production from biogas avoids the consumption of other resources if compared with flare treatment. The installation leads to a reduction in GHG emissions of 18,600 ton CO_2 equivalent/year.

Market factors

The technologies for WtE, AD-plants and landfill gas recovery are fully developed, and energy and biogas markets are readily available. Many plants operate as combined heat and power plants, whenever the heat infrastructure is available. It is however essential to have a local demand for heat or cooling and a connection to a district-heating or district-cooling network. AD of organic waste also produces digestate that has nutrient and carbon value. The digestate needs to have a clean (source separated) feedstock in order to have market value.

Electricity is easily transferred from the energy recovery facility to the local power grid. In some areas (e.g. USA and parts of Europe) there is a separate market for green electricity, including electricity from AD and WtE, comprising at least parts of the produced electricity and also for green gas, particularly for biogas that has been upgraded to natural gas quality and transferred to the natural gas network.

Methane from digestion of wastes typically needs upgrading and pressurising for transfer to a local natural gas network or for transport to a gas station for sale for road transport usage.

Price

The price of electricity from WtE is determined by a range of additional price elements such as network cost, subscription fees, green electricity fee, energy specific tax and sales tax. The EU-average cost of "energy and supply" (not including network) is listed as around 70-80 €/MWh in 2012.

The price for methane is linked to the price of natural gas, although sometimes subsidies apply. The average price of natural gas (Energy and supply) in Europe is listed in the range 30-40 EURO/MWh in 2012 for industry and households (European Commission, 2014)

Main challenges

In order to reach the greatest potential of energy from waste, synergies and cooperation across waste and energy policies is needed. In many countries waste is handled by the Environmental Ministry and energy planning and distribution by the Ministry of Energy.

Arranging contracts to feed electricity to the main grid and securing consistent supplies of feedstock suited to the plant's capacity.

Coping with price uncertainty and fluctuations for electricity and heat depending on consumer demand.

Looking forward

There are many issues affecting the future availability of waste for energy and fuels. It is likely that the diversion of waste from landfills will continue and the incentive of abolishing fossil fuels will make WtE and AD important contributors to future waste management and energy systems.WtE facilities are continuously reaching for higher efficiencies, helping to replace fossil fuels.

Need for innovation

A range of reports have spelt out the economic opportunity and jobs potential open to the waste industry as it makes the journey from being a waste disposal to materials management industry. The waste industry currently controls a vast array of secondary raw materials. They are becoming more complex as the speed of materials and technical innovation gathers pace but their value will also continue to grow as we understand how to exploit them. To secure this benefit research and development will be required. New skills will be required to develop secondary raw material supplies, de-bottleneck supply chains, optimise price controls and deliver key components to time, specification and budget.

This work will build on the substantial knowledge and know-how developed in the handling, implementation and operation of different waste management and resource recovery systems. The knowledge and skills gained, will pave the way for further developing potential within the waste management sector.

Innovation will particularly be required to improve the efficiency of recovery and the quality of the goods provided by the waste management sector and to work with pioneer companies who adopt the circular economy business model. Further sector work will be required to optimise opportunities similar to that in the work on textiles recovery and re-use undertaken by ISWA.

Extending the current supply of goods by the waste management sector

Significant variability exists in secondary raw material recovery across different materials. It is striking that for several materials the recycling rates are quite low or virtually at zero. One such example is polypropylene (PP), one of the most used global polymers. Even the best performing recycling rates are not as high as they could be, such as paper, which achieves rates of around 58%. High value bio-based chemicals can be processed from organic waste, but are not yet commercially viable. The potential delivery of carbon matter, nutrients and waste to energy are significantly higher than levels currently achieved. The gap between current supply of energy, and carbon and nutrients from waste, compared with available waste streams presents major commercial opportunities. New partnerships are required with leading manufacturers to secure those opportunities and share commercial risks. The economic opportunities for early movers to secure feedstock and displace primary raw material suppliers are substantial.

Technology and materials design

A very important area for innovation is to improve the quality of secondary goods, so that they are of a quality comparable to primary raw material. The quality achieved will be determined by every step, starting from the design of the original product, through to the processing into a recyclable material, nutrient, chemical feedstock, energy or fuel. If for example the original product involves the mixing of different materials, then the quality achievable through recycling is already compromised or at least challenged from the outset. Early business pioneers of the circular economy are already undertaking research to for example substitute hazardous chemicals in floor covering materials or to understand the toleration levels of metal contamination in recovered aluminium. The waste industry needs to be part of such processes and to become the supplier of choice in the recovery process.

With organic waste, improvements in processing technologies to reduce contamination in compost and digestate are required. Significant research and development is also crucial to improve pre-processing, for the effective conversion of organic waste into green chemicals, so that higher value products can be obtained from organic materials.

The waste management sector therefore needs to develop, test and commercialise new technologies alongside the chemical and petrochemical business sector so that it becomes possible to maximise the quality and thus value of all secondary goods at every step, from collection to recycling.

To support innovation in the design phase, new platforms need to be developed to facilitate interaction of waste professionals with designers and manufacturers, to find new solutions for manufacturing products with sustainable material management in mind. Technological advances in new design processes for the manufacture of materials and products (structure and types of materials used) have a key influence on their recyclability. The waste management sector does not only need to become more innovative regarding technologies to improve the extractability and quality of secondary materials, carbon, nutrients and energy from waste, but also how the sector cooperates with other actors in the value chain.

Key partners in this process will be organisations such as the European Innovation Partnership on Raw Materials (Resources) which aims to establish 5 new secondary sources of raw materials, fund 64 new business start ups and optimise recycling and material chains for end of life products. In the USA the Ames Laboratory Critical Raw Materials Institute is pioneering new recycling techniques for rare earths from old electronics. ISWA has a critical role spreading knowledge to ensure across the global waste industry key lessons are learnt and we accelerate the recovery processes and minimise waste to landfill.

New platforms are forming to bring all key actors together

The 42nd G7 Summit held in June 2015 identified and addressed Resource Efficiency as a key issue. The outcome was the establishment of a G7 Alliance on Resource Efficiency. The alliance aims to provide a forum to exchange and promote best practices and foster innovation together with business (Business 7) and other stakeholders, including from the public sector, research institutions, academia, consumers and civil society. The G7 Alliance on Resource Efficiency aims to promote an exchange of concepts on how to address the challenges of resource efficiency, to share best practices and experience, and to create information networks.

The Ellen MacArthur Foundation CE 100 where 90 companies (including waste management companies) work together throughout the value chain exchange to find solutions to accelerate the transition to a circular economy.

Information technology for resource management

New advances in information technology offer opportunities to the waste management sector to access to real time accurate data and communications on secondary material flows, secondary and raw material prices and market demand. Innovations such as the smart grid for the electricity supply industry need to be mirrored in the waste industry. Real time data systems are emerging in Korea, Australia, Japan and across the European Union. Data are key to maximising resource management and making the economic case for further development and new investment. Such systems need to be international in their application and will require pubic private commercial partnerships to be successful. Such data systems need to support the emergence of commodity markets for secondary raw materials.

Business and market development

A multidisciplinary approach to finding new solutions and overcoming business and market barriers is needed by the waste management sector. The sector also needs to transfer and develop new skills, in optimising operating procedures and market conditions. This can be achieved through developing synergies and commercial partnerships with other related industries (e.g. chemicals) and working closer with economists and marketing experts. New business models are needed, for example the co-location of waste processing plants treating different fractions of waste or alongside more sophisticated biorefinery operations, to reduce capital and operational costs. Changes are also needed in manufacturing and processing infrastructure so that materials can flow out of waste cycles and into other materials processing cycles. A new business mind set is required to underpin this role for the industry in supplying priority secondary raw materials from waste, to the manufacturing sector.

Developments in social sciences are needed to improve the understanding of consumer behaviours and how to position secondary materials so that they are valued alongside primary materials. Compost highlights the need for market development. In some instances, compost and digestate may be given away free of charge. This generally occurs where compost plant managers do not understand the needs of the various potential markets they can serve.

Professional communication

Communication will be a key skill for the sector as we seek to explain our role to all key actors. This is crucial as we work with different cultures to explain our concepts, ideas or actions. In dealing with the public, we must understanding the best way to deliver our message. Professional communication is needed from the beginning of each project, in order to keep focus and deliver our messages.

The challenges of recycling polypropylene: A prime case for innovation.

Polypropylene (PP) is in abundant supply. Currently PP comprises around a quarter of current global plastics production and overall global demand is expected to continue to grow. PP is used in many diverse applications across a number of different sectors such as for packaging, automotive components, electrical and electronic equipment, building and construction. Yet, due to the converging of many challenges (technical, economic and environmental), only a very low level is recycled. Data on how low the actual level is, are not available, demonstrating a lack of reliable and widely available information, which is a challenge in itself. For Europe it is estimated that 15% of the PP arising is collected for recycling and 36% for energy recovery. Innovation and developments to ensure PP can be viably recycled in the near future is essential, to avoid continued extensive volume losses of this material and the virgin oil used in its manufacture.

Challenges

- High transport costs for collection, due to high volume compared to weight. This is particularly a problem when the PP is a minor part of a product.
- PP is very difficult to identify and mechanically separate from other polymers, due to being mixed with other polymers, or with different grades of the same polymer or with different colours. Food-grade PP and Black PP for example cannot yet be sorted with current sorting technology.
- There are numerous technical barriers that limit mechanical recovery, such as incompatibilities with other polymers (such as different melting points), limitations of co-mingled collection, contamination (hazardous substances, food, oils, adhesives etc.), degradation throughout its life-cycle, light weighting.

- Advanced technology is needed meaning high investment costs for sorting and recycling and large volumes of material throughput are needed to be profitable.
- Perception of low quality which affects the development of PP recycling. There are no globally accepted standards for recycled PP. This reduces trust in recycled materials and increases transaction costs.
- Lack of information and data on levels and prices of trade in recycled PP, lack of transparency in pricing, direct competition with virgin PP.
- Unstable and volatile prices. The price is linked to virgin plastics, rather than cost of production. For all plastic polymers, the price is linked to oil.

Innovation and developments needed

- Innovation in the structure and type of materials used in manufacturing and how they can be disassembled.
- Innovation in collection logistics, sorting and processing technologies (e.g. to distinguish between food grade and non-food-grade plastics and black PP) and reaching effective economies of scale.
- Innovation in raw input (materials and additives) selection and production processes, so that clean single polymers can be more easily separated.
- Technical developments in feedstock recycling for contaminated or tainted polymers.

- Accessible investment finance.
- Innovation to improve quality. Establishment of widely accepted quality standards and testing. Better information on recycled PP.
- Improvements in: material flows data, information on suppliers and buyers, organisation of suppliers, quality, price transparency and trading conditions.
- Incentives to use secondary raw materials over virgin material in production.
- Improved understanding and risk management for volatility in prices.

Markets for materials

The environmental and economic arguments for using secondary raw materials are extremely strong but mature market mechanisms to support such a change are still not in place.

In a mature market participants can expect: to buy and sell materials without needing to see them; price transparency; low transactional costs; regulatory certainty; and to have computerised data and information systems to underpin that market.

Secondary raw material commodity markets are in the main immature and lack: agreed global standards; effective dispute resolution processes; data and information flows on secondary raw materials; and effective price risk management strategies. Such immature markets are not places where participants will have confidence to buy without seeing the materials or having a close working relationship with the seller. It is in the interests of the waste management sector to pioneer mature markets for secondary raw materials and learn from effective examples such as the London Metals Market for scrap metals.

Market factors that the waste management sector can influence

Delivery of secondary goods to the market

In order to be a significant market maker, the sector first needs to be able to deliver. The waste management sector needs to deliver recycled and secondary raw materials to the right place, at the right time (considering the global nature of the market) with consistency in quality and quantity, as demanded by the market.

This can be better achieved for example by improving the organisation and cooperation amongst supply chain actors and having easily accessible, real time data on the availability of suppliers and materials.

Market barriers

The waste management sector needs to optimise its position in the market by reducing search and transaction costs for suppliers of waste materials to find recyclers and vice-versa. Transaction costs can be reduced by having readily available information and data that can be shared between buyers and sellers; improved organisation and cooperation amongst suppliers of similar materials; and quality assurance through agreed upon testing methods.
A weakness of the market is that it does not factor in externalities. Designers are under no economic pressure in the selection of materials and composites to consider end of life costs to recover the raw materials their products contain. Increased recovery costs are simply passed on to society and or the waste management sector. Their decisions can make recovery uneconomic. This is the case with Polypropylene highlighted earlier in this report. Closer cooperation by the waste management sector with designers and producers can help raise awareness and find solutions to these challenges.

Conditions of Trade

Fair conditions of trade are important for supporting and developing markets for secondary materials. If mechanisms are in place to install trust and price transparency, these can create an opportunity for buying and selling of materials sight unseen. Such mechanisms include quality assurance through agreed upon testing methods and environmental impact assessments, development of standardised contracts and dispute resolution mechanisms.

Quality assurance and common quality standards are needed

Many of the issues leading to a poor functioning market for secondary materials link back to quality. Quality standards already exist in many forms and on many levels, yet they do not necessarily result in reduced transaction costs for buyers. A wide variety of opportunities exist for secondary materials to be used in production. This results in considerable variance in quality demands.

When a good delivered by the waste management sector is more or less presented as a finished product, standards and grades can be very helpful and may be necessary, for example grades of compost. However establishing set quality standards, end of waste criteria or grades for secondary materials can also limit the potential use and application of secondary resources, such as plastics and metals. In such cases defining the quality of a secondary material and measures on how to test the material, allows for more diversity in application than establishing fixed grades or criteria.

Price volatility a market factor that the waste management sector cannot really influence

Prices for primary raw materials will naturally fluctuate on mature commodity markets. Such markets have in built mechanisms to share associated risks. Commodity markets for secondary raw materials are still developing and currently lack (except for scrap metals) the same mechanisms.

Although price fluctuations are beyond the control of the waste management sector, there are some mechanisms that can be established to help cope.

Price volatility as observed by virgin materials

The price for goods provided by the waste management sector is largely determined by the price of the virgin material that it is substituting, which is subject to price volatility. The price volatility for many virgin materials is heavily influenced by the price of natural gas and petroleum, available production capacity relative to demand and general economic conditions. This price volatility is a challenge the waste management sector needs to cope with, in much the same way as primary commodity markets do. Hedging is used to reduce any substantial losses suffered by an individual or an organization to deal with fluctuating prices over the long term. A supplier for example may sell futures contracts based on the material that can be delivered at an agreed price rather than the market price at the time the material is ready to be delivered. Diversifying and also creating security stocks or stock piling are also measures that businesses may use to cope with volatility in prices.

Price volatility of secondary materials over and above that observed for their virgin substitutes

Price volatility for recyclable materials is generally greater than price fluctuations for virgin materials which are close substitutes. The reasons for this are not clear, some proposed reasons are:

- mixed grades (heterogeneity) of secondary materials versus homogenous or high quality materials tend to be more subject to fluctuations. The less substitutable to its primary alternative the more likely the fluctuation;
- consequence of market barriers and failures;
- secondary materials are mostly in demand when there is a lack of supply of the primary raw material it is substituting, fluctuations in raw material prices therefore have a greater influence on secondary material prices; and
- due to speculation, investors attempting to profit from fluctuations in market value.

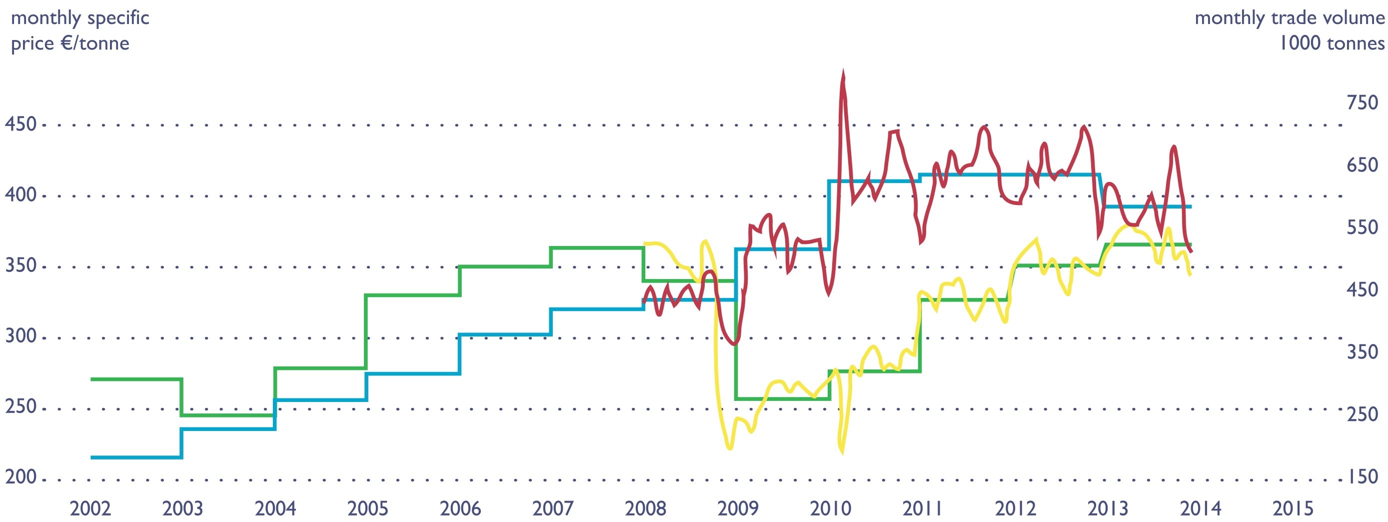
Price volatility will be reduced in relation to primary raw materials as markets become confident that the perceived and real risks in using secondary raw materials have been effectively tackled. It is therefore in the interests of the waste industry to develop effective commodity markets for key secondary raw materials even if in the early years such markets fail to cover their operating costs.

Only when secondary material prices and market uncertainties are addressed will investors be prepared to fund new sorting and processing plants, which improve access to and development of secondary materials markets.

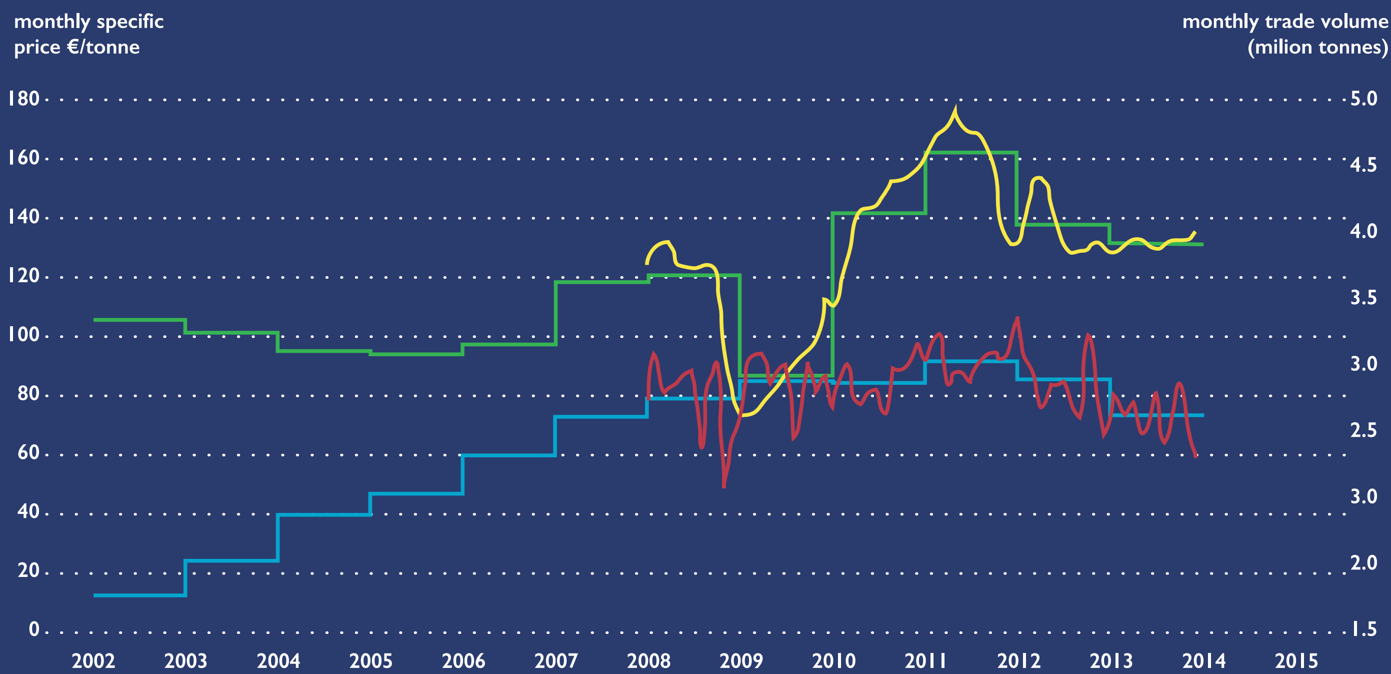
Fig. 8 | Price fluctuations for secondary materials in EU-28

Fluctuations in the prices for secondary materials are commonly observed. The price indicators shown here are averages across all grades, so do not reflect fluctuations of individual grades of secondary materials

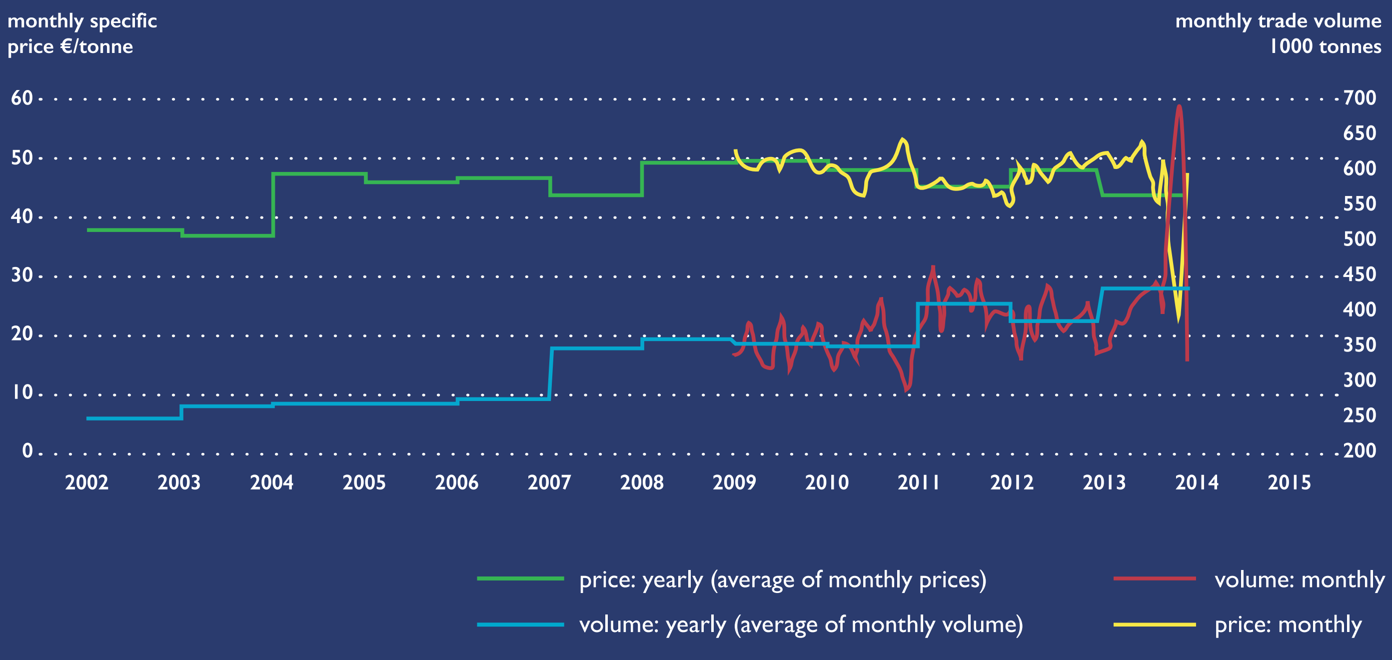
Plastic



Paper



Glass



Source: Eurostat (http://ec.europa.eu/eurostat/statistics-explained/index.php/Recycling_%E2%80%93_secondary_material_price_indicator)

Policies for resource management

Current policy across OECD countries has concentrated on driving secondary raw materials (waste) away from landfill and towards recovery for mainly environmental reasons. Fiscal policies have been successful in supporting this process, but very little support has been given to increase the demand for recovered materials. The success of countries that have reached less than 5% waste to landfill has been almost totally depended on waste to energy (displacing fossil fuels) or through establishing new export flows for secondary raw materials. Recycled plastics, paper and textiles have been exported to global manufacturing centres and waste derived fuels to where demand has emerged in heat and power generation plants. The proximity principle has been overturned for such recovered waste derived materials.

Innovation into new recovery and re-use technologies is strongly developing but is held back in many countries by the in built "roadblocks" in current waste and producer responsibility legislation. In Europe the scale the single market has to offer has not been exploited to its full potential for resources from waste. The 28 EU Member States continue to organise their waste streams along 28 (and often more due to regional variation) separated waste management infrastructures. In the USA the need for Materials Management Legislation that would put primary and secondary raw materials on a level playing field was recognised as long ago as 2003 but as yet little has been done. Only in Japan do we see evidence of a closed system in operation where 98% recycling levels are quoted for metals, 89% of materials for electrical items and 5% waste to landfill. Here as in other advanced waste management economies waste to energy plays a major part in the solution.

Even where good quality recovered materials are produced (such as organic materials to replace fertilisers) they fail to command equivalent prices in the market place in comparison to the products they seek to replace. This policy failure is laid bare when primary commodity market prices are falling and demand reducing. As a consequence without policy support the newly created recycling and recovery infrastructure is now seen to be at risk.

Without these mechanisms in place market demand is not currently strong enough to raise recycling levels, for most materials, to a point where secondary materials become the main priority materials able to replace primary raw materials in manufacturing processes. In the long run, internalising the environmental and climate impact of the usage of virgin raw materials into production costs and removing subsidies on production and consumption of fossil fuels are the most potent drivers for recycling. However, such changes will take time. Therefore, in the meantime, enabling policy drivers such as those put in place in China to reduce VAT on secondary raw materials are needed to support the development of sustainable resource management.

It is time for a major focus on policy change designed to produce materials management regulations. Such regulations must aim to develop a level playing field for the trade in both primary and secondary raw materials in which the real economic value of secondary raw materials is fully recognised. Markets will then decide the balance between primary and secondary raw materials used by manufacturers and between the volumes used for manufacturing and energy production.

Demand creating policies are crucial for the future of resource management and the circular economy and to avoid materials looking for markets, which could lead to low-value recycling and a waste management sector struggling to make a return on investment for material recovery activities.

Growth in market demand will raise the value of recovered materials as well as profit margins. Market pull could also drive customer focused research and development, supporting the development of secondary materials requested by the market and the circular economy.

Both push and pull policies have a place in the transition toward a circular economy. Supply pushing policies may be considered intermediate actions to provide impetus for circular material flows by increasing the supply of recovered materials. These policies may later be phased out, once market demand for secondary materials has become well established. An example of a predominantly push mechanism where consideration of pull mechanisms are also considered is outlined below for the City of Milan, converting food waste to compost, electricity and heat.

Fig. 9 | **Policy instruments for sustainable waste management**

PUSH

Push policies

Policies to push recovered materials onto the market:

- Landfill diversion targets or bans for landfilling of organic waste, recyclable material streams and combustible waste.
- Landfill Tax to encourage alternative treatment options such as energy recovery or recycling.
- Incineration Tax to encourage recycling above incineration.
- Recycling and Recovery targets for specific waste streams.
- Polluter pays policies, such as Extended Producer Responsibility (EPR). Such policies hold producers and importers responsible for the end of life of materials placed on the market and can help to internalise external costs involved in the recovery of secondary raw materials such as those arising from the increased complexity of products.

PULL

Pull policies

Policies that help to create market demand for secondary materials:

- Green taxes (eco-taxes) on consumption and production e.g., taxes on plastic carrying bags, packaging.
- Funds to support environmental performance. e.g. European Commission Eco-Innovation which has one of the aims to encourage the design of innovative products using recycled material and facilitate material recycling.
- Green Public procurement –public authorities to procure goods produced from or with a certain fraction of secondary raw materials.
- Industry target on use of recovered materials in production and manufacturing.
- Innovative fiscal changes to drive behaviour change such as reductions in VAT or tax credits for secondary raw materials, recycled products or accelerated depreciation for assets purchased for re-use of recycling of waste materials. Global examples now exist in China, Korea, Mexico and the USA.
- Waste sector engaging in waste prevention and newly emerging circular business models such as where companies offer products as services seeking to retain ownership and internalise benefits of circular resource productivity.

Case study - Milan, Italy: Delivering compost and energy from organic waste

Location
Milan, Italy.

When the operation started
In November 2012 the city began collecting residential food waste.

Good provided
Compost, electricity and heat from the treatment of organic waste. From 2015 bio-methane will also be produced.

Amount of waste treated
By June 2014 the scheme had been successfully rolled out to cover 100% of the population of Milan. All of the city's residential and commercial food waste is now collected separately, resulting in 120,000 tonnes of organic waste per year being diverted from landfill.

Volume of good produced
Milan treats 120,000 tonnes of organic waste annually, generating 5.4 MW of energy. The anaerobic digestion facility treats 285,000 tonnes overall, generating 12.8 MW of electricity. Almost all of that green energy is used to power a nearby plastic reprocessing plant.

Volume of good produced
About 15,000 tonnes of high quality compost are generated from Milan's food waste and sold for use in agriculture.

Market value of good
Compost is sold for 3-5 € per tonne.

Driver's for the activity taking place
Italy set a national material recovery target of 65% that needed to be implemented by 2012. The collection and treatment of food waste was an important step the city took toward fulfilling this target.

Barriers that have been overcome
Compost must fulfil the criteria for fertilizer to be sold in Italy. The city has worked with the Italian Compost Association to ensure quality compost is produced.

Actions that have been undertaken to improve market access
The Italian Compost Association promotes quality certification of composting plants to promote markets and guarantee final user.

Avoided disposal to landfill
120,000 tonnes.

Additional benefits
Producing compost from food waste helps the city to avoid methane emissions and close the carbon and nutrient cycle. It is estimated that emissions of 8,760 t CO_2 /year are saved due to this activity.

Further reading

Trends & Emerging Ideas

Towards the Circular Economy
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United Nations Environment Programme, 2014

Position Paper, Beyond RCRA. Waste and Materials Management in the year 2020
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Extending the limits of paper recycling: improvements along the paper value chain.
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European Compost Network Info Paper, 2010

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The Importance of soil organic matter: Key to drought-resistant soil and sustained food production
Food and Agricultural Organisation, 2005

The Bio economy to 2030: Designing a Policy Agenda Main Findings and Policy Conclusions
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Increased material recovery - What role will energy recovery play?
Avfall Sverige, 2015. ISSN 1103-4092.

Resources and Opportunities

Scoping study to identify potential circular economy actions, priority sectors, material floes and value chains.
European Commission, 2014

Improving Recycling Markets. OECD Policy Brief
OECD, 2007

Sustainable Materials Management: Making Better use of Resources
OECD, 2012

Waste Prevention, Waste Minimisation and Resource Management
ISWA, 2011

As part of the Task Force work to disseminate the results of its work a series of short video clips have been produced and are available in addition to the Task Force Reports on the ISWA website.

Task Force events

9 SEPTEMBER 2014
SAO PAULO, BRAZIL

Special session

Convened by Task Force at 2014 ISWA World Congress

Speakers

Björn Appelqvist, City of Copenhagen
David Beadle, CIWM President
Peter Börkey, OECD
Gary Crawford, Veolia
Antonis Mavropoulos, ISWA STC Chair
Rodrigo Sabatini, Institute of Zero Waste, Brazil
Costas Velis, University of Leeds

8-9 JUNE 2015
JOUY-LE-MOUTIER, FRANCE

Expert workshop

Convened by Task Force to exchange views & review content of Reports

Speakers

Björn Appelqvist, City of Copenhagen
Andreas Bartl, Vienna University of Technology
Martin Brocklehurst, KempleyGreen Consultants
Jane Gilbert, Carbon Clarity
Tore Hulgaard, Ramboll

8 SEPTEMBER 2015
ANTWERP, BELGIUM

Special session

Convened by Task Force at 2015 ISWA World Congress

Speakers and Panelists

Ana Loureiro, EGF (moderator)
Björn Appelqvist, City of Copenhagen
Martin Brocklehurst, KemplyGreen Consultants
Andreas Bartl, Vienna University of Technology
Costas Velis, University of Leeds
Jane Gilbert, Carbon Clarity
Tore Hulgaard, Ramboll
Elisa Tonda, UNEP
Peter Börkey, OECD
Gary Crawford, Veolia
David Newman, ISWA President
Antonis Mavropoulos, ISWA STC Chair

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