European Commission

LIFE and the Circular Economy

LIFE *Environment*

Environment

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The contents of the publication "LIFE & the Circular economy" do not necessarily reflect the opinions of the institutions of the European Union.

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Foreword

Photo: European Commission

Karmenu Vella
European Commissioner for Environment, Maritime Affairs and Fisheries

The EU Circular Economy Package adopted by the European Commission in December 2015 is a key milestone on the road to a low carbon, resource efficient future. The circular economy is the most important deliverable of the EU's Roadmap to a Resource Efficient Europe, which sets out a vision for the structural and technological changes needed in order to transform Europe's economy into a sustainable one by 2050.

Europe needs to move away from a 'linear' economic model that is resource intensive and unsustainable towards a more 'circular' approach, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised. This transition is an essential requirement to ensure a sustainable, low carbon, resource efficient and competitive economy.

Getting maximum value from resources requires action at all stages of the life-cycle of products, from the extraction of raw materials to product design, production and distribution of goods and through increasing use of secondary raw materials. Economic actors, such as business and consumers, are key to driving this process.

LIFE - the EU financial instrument supporting environmental, nature conservation and climate action - is playing an important role in supporting the transition to a circular economy.

This publication features more than 100 LIFE projects that illustrate how the circular economy works in practice. These projects have mobilised some €270 million in favour of the circular economy, and the EU has contributed more than €110 million of this total. For instance, LIFE has helped to increase citizens' awareness and to establish new processes for preventing waste. LIFE has also contributed to 'closing the loop' upstream in areas such as product design, new production processes, consumer awareness and new value chains.

Since 2014, LIFE Environment and Resource Efficiency projects have prioritised the shift towards a circular and green economy through actions spanning the value chain, industrial symbiosis and the use of secondary resources. This has been done through projects that promote environmental footprint methodology and green public procurement and projects linking regulatory, financial or reputational incentives to environmental performance.

There are tremendous opportunities for business development and job creation in a circular economy. The LIFE projects featured in this publication illustrate how the application of circular economy principles not only contributes to the protection of our environment but leads to market solutions and new employment. Such experiences should serve as references for replication in other regions, countries and sectors.

I hope that you will be inspired by reading LIFE and the Circular economy!

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INTRODUCTION

The goals of a circular economy

The Circular Economy Package provides an EU framework for the transition to a circular economy, in which the value of products, materials and resources is maintained, and waste is minimised. It is supported by several inter-linking policies related to sustainable development.

At the launch of the Circular Economy Package, Commission First Vice-President Frans Timmermans said: "Our planet and our economy cannot survive if we continue with the 'take, make, use and throw away' approach. The circular economy is about reducing waste and protecting the environment, but it is also about a profound transformation of the way our entire economy works. By rethinking the way we produce, work and buy we can generate new opportunities and create new jobs."

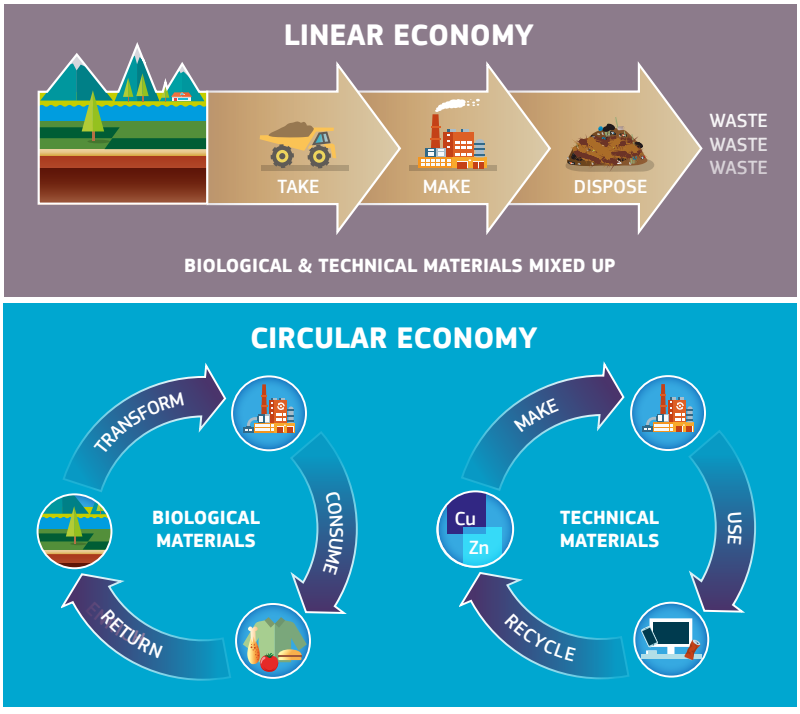
Adopted in December 2015, the package sets out a concrete and ambitious mandate to stimulate and support the transition towards a circular economy. It consists of an Action Plan with concrete actions that can be implemented during the mandate of this Commission and revised proposals for waste legislation. It will contribute to closing material loops within product life-cycles by increasing rates of reuse and recycling, to benefit both the European economy and the environment.

Moving towards circularity

Transitioning to a more circular economy, where the value of products, materials and resources is maintained for as long as possible and the generation of waste is minimised, is an essential contribution to the EU's long-term efforts to develop a competitive, sustainable, low-carbon and resource-efficient economy (see box).

The Action Plan will require the active involvement of Member States, regions and municipalities, business communities and citizens. Its implementation will boost the EU's competitiveness by protecting against resource scarcity and volatile prices, and helping create new business opportunities through innovative and more efficient production methods. Local jobs will be created at all skills levels, with opportunities for social integration and cohesion. At the same time, the circular economy will save energy and prevent the over-exploitation of finite resources, by optimising the use of raw materials and fully exploiting the resources embedded in valuable waste streams. These actions will bring benefits in terms of biodiversity, climate change mitigation, and the reduction of air, soil and water pollution.

The Action Plan for the Circular Economy is organised into five key areas of action and five priority sectors, with measures covering the whole life-cycle of products, from production and consumption to waste management and the market for recovered secondary raw materials. For each of them, it proposes a blend of smart regulations and incentives to help businesses, consumers, and national, regional and local authorities to drive the transformation to a circular economy.



Closing the loop

At the start of a product's life, both the design and the production process impact on resource use and waste generation. The Action Plan puts a strong emphasis on promoting ecodesign principles for making products more durable and easier to repair, upgrade or remanufacture. The Action Plan promotes incentives, such as extended producer responsibility, to overcome a key barrier, namely that the interests of producers, users and recyclers are not aligned. At the same time, the Action Plan will support more resource-efficient production processes by creating a European Resource Efficiency Centre, by clarifying rules on by-products and on the end of waste status and by further integrating resource-efficient technologies in a range of industrial sectors through 'best available technique reference documents' (BREFs).

Photo: LIFE13 ENV/UK/000579/SEPA

LIFE projects are helping Member States to reach long-term targets in waste management, reuse and recycling

Choices made by consumers have the potential to either support or hamper the process of developing a circular economy. Through the Action Plan, the Commission is working with stakeholders to make green claims more trustworthy, to develop Product Environmental Footprint (PEF) methodologies, and to increase the effectiveness of the EU Ecolabel, ultimately to change consumption patterns. The Action Plan also promotes green public procurement (GPP) and encourages Member States to provide incentives so that product prices reflect environmental costs more realistically.

The road to the Circular Economy Package

The foundation for the European Union's Circular Economy Package was laid within the Europe 2020 strategy and the Eco-Innovation Action Plan (EcoAP). Europe 2020 was launched in 2010 to provide a 10-year jobs and growth strategy for the EU, with the aim of creating favourable conditions for "smart, sustainable and inclusive growth". One of its seven Flagship Initiatives was the Resource Efficiency Flagship, of which a key action was to draw up the Roadmap to a Resource Efficient Europe (COM(2011) 571).

The Roadmap proposed ways to decouple economic growth from resource use and its associated environmental impacts, in order to achieve a sustainable European economy by 2050. It set milestones for the structural and technological changes needed by 2020 to ensure Europe is on track for the 2050 target.

The European Commission adopted the EcoAP in December 2011 to place green technologies at the heart of EU policies. This Action Plan recognises eco-innovation as vital for delivering the objectives of the Europe 2020 strategy, and is aligned with the EU's 7th Environment Action Programme (7EAP) vision of "turning the Union into a resource-efficient, green, and competitive low-carbon economy by 2050". The EcoAP addresses ways of overcoming the barriers to the technological change needed for the transition to a circular economy. In turn, eco-innovation will make European companies more competitive in the global marketplace.

SMEs make a key contribution to the circular economy, as they are particularly active in areas such as innovation, reuse and recycling. The Commission adopted the Green Action Plan (GAP) for SMEs to help small businesses exploit opportunities arising from the transition to a green economy, thereby strengthening the actions of the EcoAP.

The GAP for SMEs notes that improvements along value chains could reduce material inputs by 17-24% by 2030, and that the 60% of waste currently not recycled, composted or reused in the EU represents an enormous leakage of valuable resources. It also recognises that SMEs are often unable to exploit the opportunities afforded by better resource efficiency and waste material recovery. To address this, the GAP sets out a series of objectives and lists actions to be implemented at European level within the Multiannual Financial Framework 2014-2020. These include facilitating technology-transfer mechanisms and access to relevant finance; supporting green entrepreneurship to foster new business ideas, such as developments in 'upcycling' (combining recycling with design); facilitating cross-sectoral and cross-national collaborations; and helping SMEs gain access to EU and international markets. These actions will help SMEs become more sustainable and more competitive.

Revised legislation on waste, adopted together with the Action Plan, sets out clear long-term targets for waste management, reuse and recycling along with concrete measures to address practical obstacles and the different situations across Member States. Key targets include recycling 65% of municipal waste, recycling 75% of packaging waste, and reducing landfill to a maximum of 10% of municipal waste by 2030. These actions will help implement the EU waste hierarchy, which establishes a priority order from prevention, followed by preparation for reuse, recycling, energy recovery, and lastly disposal. The long-term targets should also lead Member States to converge on best-practice levels and encourage the requisite investment in waste management.

Once recycled, the circular economy relies on materials being reinjected back into product cycles as secondary raw materials. What was once considered waste can become a valuable resource. Uncertainty about the quality and safety of secondary raw materials in comparison to virgin materials is a barrier to the development of markets for these types of materials. The Circular Economy Action Plan is addressing this through the development of EU-wide quality standards for secondary raw materials and assessment of how chemicals products and waste legislation can best work together. The Action Plan also proposes a series of actions specifically aimed at improving water reuse efficiency and looking at the whole life-cycle of products.

The final section of the Action Plan outlines how the Commission, in close cooperation with the European Environmental Agency (EEA), will monitor progress along the road to achieving a truly circular economy.

Financing the circular economy

Innovation is a key driver in the transition towards a circular economy. In this context, LIFE has financed projects demonstrating the viability of the circular economy since 1992, including over 700 waste reduction, recycling and re-use projects that equate to an overall investment of more than €1 billion. This positive trend of supporting the circular economy continues under the new LIFE Programme 2014-2020 with some €100 million invested in more than 80 projects in the first two years. The Commission will further boost the transition through funding from the LIFE programme, COSME and €5.5 billion under structural funds for waste management. Horizon 2020, the EU's research and innovation programme, includes a specific call with a budget of €650 million for projects supporting the transition to a circular economy.

The top priority of President Juncker's Commission is to get Europe's economy growing and to create new jobs. To this end, the EU Investment Plan, with the European Fund for Strategic Investments (EFSI), supports investments in infrastructure, education, research and innovation, as well as risk finance for small and medium-sized enterprises (SMEs).

Priority areas

Five sectors are addressed as priority areas in the Circular Economy Action Plan: plastics, critical raw materials, food waste, biomass and bio-based products, and construction and demolition waste. The Action Plan, for instance, foresees the adoption of a strategy on plastics that addresses issues of recyclability and biodegradability, the presence of hazardous substances, and marine litter. Critical raw materials, of high economic importance but vulnerable to supply disruption, typically occur in electronic devices with low recycling rates, so the Action Plan initiates actions to encourage their recovery. Actions on food waste include improved labelling and tools to help meet the global sustainable development goal of halving food waste by 2030. For the efficient use of bio-based resources, key actions include guidance on the cascading use of biomass and support for innovation in the bio-economy.

LIFE is acting to reduce the amount of plastic in our seas and oceans

Photo: LIFE15 GIE/IT/000099/Eleonora de Sabata

€1B

Invested since 1992 in over 700 circular economy projects on reuse, waste prevention and recycling

Green jobs and skills

LIFE projects have helped to develop **green skills and sustainable green jobs**

Public-private partnerships

Local & regional authorities and SMEs have built successful partnerships to lead **two thirds** of all circular economy **projects**

Marine litter

LIFE projects addressing marine litter will help **clear our seas** of discarded **plastic bags, unwanted fishing gear** and **microplastics in textiles**

€30 million invested in plastics projects

LIFE projects show how to **improve recycling** rates, **upcycle** materials and substitute **bio-materials** for plastics

€21 million for end-of-life vehicles

LIFE has funded efficient and environmentally-friendly projects that help companies reach **targets for end-of-life vehicles**

and the Circular economy

€100 M

Invested since 2014 in more than 80 projects contributing to the circular economy

Industrial symbiosis & secondary raw materials

€40 million invested in **upcycling** and **industrial symbiosis** has created new green business models and led to the uptake of **secondary raw material markets**

Consumer action

LIFE is inspiring citizens to share, repair and reuse products, and to reduce waste. The **European Week for Waste Reduction,** a LIFE project, has inspired more than **70 000 actions** to **reduce, reuse** and **recycle**

Food waste

8 LIFE projects in Italy helped to **change national legislation** on **food waste prevention** and **donation**

Disclaimer: Figures shown are for projects featured in this brochure only. Other circular economy-related projects may be excluded

INTRODUCTION

LIFE and the circular economy

LIFE is one of the main funding sources for demonstration projects that facilitate the implementation of the EU Circular Economy Package. In so doing it has provided good examples of green business opportunities and green jobs and skills.

The LIFE programme is making an important contribution to Europe's transition away from a linear economic model. This publication details more than 100 circular economy related projects that have been co-funded by LIFE and which have mobilised some €270 million in total, including an EU contribution of more than €110 million. Solutions developed by these projects are widely transferable across the EU.

Since the beginning of the seven-year multiannual financial framework in 2014, LIFE has further increased its support for circular economy-related actions, helping to fund over 80 projects, a total EU investment of some €100 million. There is more to come, further strengthening LIFE's focus on the circular economy and related projects under various priority areas via action grants for innovative or demonstrative projects and large-scale Integrated Projects, such as LIFE IP CIRCWASTE-FINLAND (see box), which is expected to provide a major boost to the delivery of circular economy policy in the country.

One of the strengths of the LIFE programme is not only that it helps to implement EU environmental legislation, but that, through the projects it supports, it can assist in the design and review of legislation as well. The projects featured in this publication give a clear demonstration of the programme's strength, offering an array of best practices that are replicable and transferable across the EU. LIFE is thus helping to implement policy and to create a circular economy.

LIFE projects are known and valued for enabling collaboration between diverse stakeholders. This is important for all environment projects, but it is fundamental for those that are helping to develop a circular economy, since the creation of closed loop economies and markets depends on public-private partnerships and all stakeholders working

LIFE is investing in the circular economy and in close-to-market projects that contribute to green growth and jobs

An Integrated Project for Finland

LIFE Integrated Projects take a holistic approach to major barriers to implementation, allowing cooperation among heterogeneous stakeholders. This complementary approach is reinforced by the mobilisation of complementary sources of public and private sector funding.

The aim of the LIFE IP CIRCWASTE-FINLAND project is to implement the Finnish National Waste Plan (NWP). The NWP is a means of meeting Finland's obligations under the Waste Framework Directive (2008/98). Specifically, it includes both waste management plans and waste prevention programmes.

The LIFE Integrated Project will respond two main challenges: the removal of bottlenecks to achieving national and EU targets in waste management, and planning for 2016-2023 to be able to respond to the requirements of the Roadmap to a Resource Efficient Europe and Circular Economy Package. To this end, the project will provide new waste management concepts, enhance capacity building and cooperation within the waste management sector and with different stakeholders in order to prevent waste, keep materials circulating in the economy for longer and encourage the re-use of by-products. LIFE IP CIRCWASTE-FINLAND will also take into consideration other environmental, economic and social impacts, as well as green procurement.

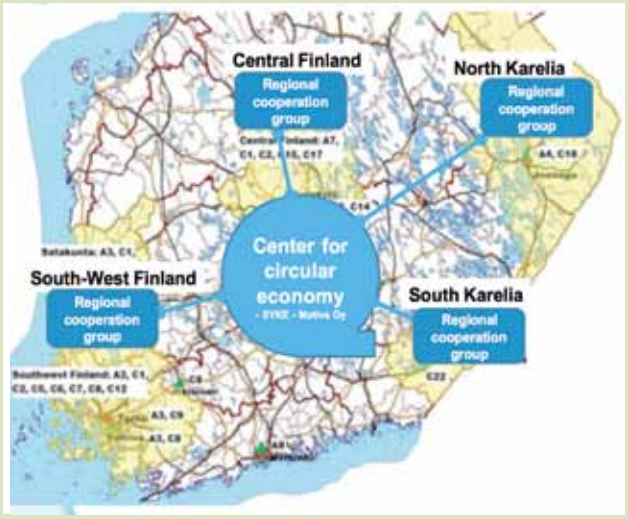


Photo: LIFE15 IPE/FI/000004

The project will take place in five regions of Finland. By covering both urban environments and sparsely-populated rural areas where a range of different economic interests are represented, this LIFE Integrated Project is expected to be able to serve as a model for other parts of the country and the EU.

together. Indeed, the LIFE programme's role as a conduit between smaller businesses and local and regional authorities was highlighted at a Committee of the Regions workshop in Brussels in October 2016.

The 2014-2020 programming period provides an opportunity to finance projects that improve or extend best practices developed by earlier LIFE projects in a number of areas relevant to the circular economy. These include promoting resource efficient businesses, thus furthering the processes of upcycling and industrial symbiosis (IS). LIFE can also help in the development of waste mining and the recovery of critical raw materials; it can foster greater innovation in plastics; demonstrate how the public and private sector can work together to create markets for secondary raw materials; promote the repairability, durability and upgradability of products; and facilitate informed choices by consumers.

Product design and production processes

To date there have been 24 LIFE projects on product design and sustainable production processes, with a total budget of €38 million (including an EU contribution of some €19 million). There has been a notable increase in the number of such projects funded in 2014 and 2015.

Some €11 million of the €38 million has funded industrial symbiosis projects for a diversity of industrial waste streams. LIFE has helped provide high-quality secondary raw materials to industries such as plastic, tanneries, food and pulp and paper. Such projects have also focused on creating networks to help identify ways of using resources and by-products through the creation of mutually beneficial partnerships. New green jobs and green skills are another important outcome (see box).

Chemical substitution in the production phase has been another area where LIFE has made its mark, with five projects mobilising €11 million in total, including projects to develop new biopolymers and to help SMEs adapt to regulatory demands (CLP Regulation, MSDS guidelines).

LIFE has supported ecodesign principles for many years. A 1999 project for instance, promoted sustainable product design to industries in Flanders. The programme has since funded more solutions/approaches/practices that are transferable to all industrial sectors.

How circular is our product or business? This is an important question that a pioneering LIFE project is helping European businesses answer by developing metrics to assess circularity. The methodology is now being further developed to define standards for the circular economy in partnership with the British Standards Institution (BSI) (see pp. 26-29).

Circular consumption

LIFE has co-funded 21 projects focused on increasing circularity in consumption, mobilising €41 million, including €19 million from the EU. Much of this support has been focused on the application of ecolabels and other means of helping consumers make informed choices (e.g. the Product Environmental Footprint – PEF). Identifying eco-friendly products is the first step to expanding the market for these goods. LIFE has also shown how economic incentives such as "pay as you throw" can help in persuading to prevent waste generation. Changing consumer behaviour and raising awareness is fundamental for waste prevention.

Initiatives such as the European Week for Waste Reduction, developed by two related LIFE Information and Communication projects show that in terms of influencing consumer behaviour, a lot can be achieved with a small financial outlay. With a total budget of some €4 million, the two projects have reached millions of consumers with their annual waste prevention campaign focused on the '3Rs' - reduce, reuse and recycle. Since 2009, the projects have carried out more than 70 000 activities, including 12 255 actions in 32 countries last year. By working extensively with young people, the campaign is expected to have a long-term impact on attitudes to waste prevention.

A circular economy will reuse more goods and LIFE projects are demonstrating how this could function in practice. For instance, REPURPOSE LIFE is

Jobs and skills in the circular economy

The projects featured in this publication have helped to create green skills in a range of sectors, from waste handling to farming, industry, enterprise and the public sector. One particular project has helped train designers in ecodesign to facilitate the recovery and re-use of parts that would previously have become waste. It aims to achieve 72 new product concepts, with the involvement of 40 young designers. Other projects have helped create sustainable jobs. One industrial symbiosis project alone managed to create 28 new jobs and guarantee 10 existing jobs. In the packaging sector, Paperfoam has grown from a LIFE project to a successful medium-sized enterprise with clients worldwide.

Labour-intensive recovery, reuse and repair could make a useful contribution to the EU's jobs and social agenda. Several LIFE projects in this sector have created employment. Some 16 people are employed thanks to the PRISCA project's two waste reuse centres, while the Belgian project RCYCL directly created 15 jobs through its scheme for the collection and reuse of bulky waste. By working with employment services to train unemployed and disadvantaged groups in green skills, a further 100 people have found employment. LIFE has also shown how in the demolition waste sector, dismantling buildings rather than demolishing them is likely to create unskilled work and expert jobs (for building auditors). Europe already has a competitive advantage in green technology and by continuing to incentivise its development, the LIFE programme can have a beneficial impact on the EU jobs market.

Photo: LIFE99 ENV/B/000640/Tim Hudson

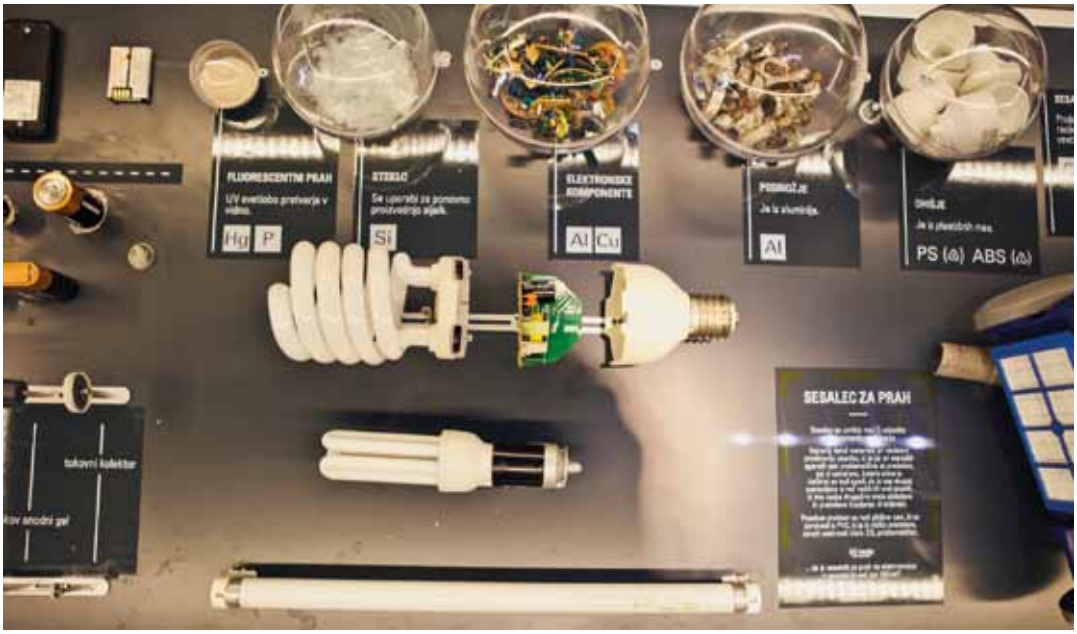


Photo: LIFE10 INF/SI/000139

LIFE has developed innovative techniques for the recovery of critical raw materials

supporting local social enterprises to create and promote 'reuse hubs' on five housing estates in London. Another project in Italy has set up reuse and repair centres for bulky waste that would otherwise end up in landfill. The demonstration value of LIFE projects that establish local markets for recycled materials with economically-sustainable supply chains are creating a certain impact in terms of growth. LIFE has shown that new forms of entrepreneurship are possible, with the potential to create jobs and boost local economies.

Another important group of consumers are public authorities. In recognition of this, LIFE has focused on helping local and regional authorities (LRAs) to include circular economy thinking into green public procurement (GPP) processes. This has involved training authorities on how to prepare calls for tender and incorporating concepts such as durability and reparability. LIFE could fund further projects to show how GPP could be used more widely for products or markets that have high relevance for the circular economy.

Waste management

Waste is a thematic priority of the LIFE programme, under which over 700 waste reduction, recycling and re-use projects have been financed: an overall investment of more than €1 billion.

LIFE's investment in waste management projects has increased significantly since 2007 and since 2010 projects have been more closely aligned with what would become the main priorities of the Circular Economy Action Plan, including upcycling of raw materials (€17 million invested). LIFE has also mobilised €21 million of investment in projects on end-of-life vehicles and €13 million of investment in packaging waste projects.

LIFE projects have contributed to EU municipal waste management objectives by developing better collection systems, raising awareness and increasing public participation in separate waste collection and recycling schemes. They have also pioneered the use of economic incentives to increase reuse and recycling rates, in line with the EU waste hierarchy.

LIFE funding has been used to develop technologies that produce new high-value products. Packaging waste projects have helped develop new biodegradable materials and natural fibres, other waste management projects have focused on finding economic value in 'car fluff', the residual material in end-of-life vehicles (ELVs) that typically goes to landfill, and on a range of approaches to recycling of WEEE. These include information campaigns, take-back schemes, new recommendations for manufacturers and recyclers, the development of innovative techniques for the recovery of critical materials, and the creation of new economically-viable markets for recovered materials. Future projects could focus on simplifying the dismantling of ELVs to facilitate greater recovery and reuse or on improved product design to make it more viable to recover WEEE.

Photo: LIFE12 INF/BE/000459

The LIFE programme has raised awareness of waste prevention, changing the behaviour of millions of EU citizens

Waste crime is another area where LIFE is making a contribution already and has the potential to do more. Two current projects (see pp.61-62) are identifying the drivers and enablers of waste crime at all levels. This will enable them to build specific interventions such as using electronic tracking devices and remote sensing technologies to map and detect waste crime, looking at how regulators can use horizon scanning and predictive analysis to better prepare for likely threats.

LIFE could also make a greater contribution in the treatment of hazardous waste. More funding is needed to develop processes that remove hazardous substances from material loops and prevent contamination accumulating during recycling, thus reducing the quality of recycled materials. Where waste cannot be prevented, reused or recycled, it can be burned to produce energy. LIFE can continue to demonstrate new waste to energy solutions as an alternative to landfill.

Market for secondary raw materials

There have been 20 LIFE projects relating to the creation of markets for secondary raw materials. These have a total budget of €64 million with an EU contribution of approximately €25 million.

Projects focusing on upcycling account for more than half of the budget that LIFE projects have spent on helping to create markets for secondary raw materials (i.e. €40 million of a total of €62 million). These upcycling projects have applied technologies to produce commercially-viable secondary raw materials, allowing manufacturers to substitute virgin materials without having a negative effect on end-product quality. LIFE projects have addressed the issues of whether upcycled materials are safe and available in sufficient quantities, in particular with regard to the glass, ceramic and copper industries.

The LIFE programme has been instrumental in showing how a dynamic market for secondary raw materials can be established and stimulated. It has done so by showing, for some industrial sectors, how a consistent supply of quality materials is possible and how the use of non-toxic material cycles and better tracking of chemicals of concern in products will facilitate recycling and improve the uptake of secondary raw materials. Projects have developed ways of matching waste materials from one industry or enterprise with the raw material needs of other companies; they have identified complete supply chains for waste in municipal collection and separation streams; and they have shown the value of voluntary agreements and fiscal incentives and awareness-raising campaigns.

More future funding could be invested in projects that facilitate the circulation of secondary raw materials and which enable the public and private sector to work together to create local economies based on short value chains.

Recycled nutrients present in organic waste material can be returned to soil as fertiliser. LIFE projects are providing concrete examples of applications of organic wastes to agricultural soils, helping in the development of markets for these nutrients, addressing barriers such as varying rules on use, environmental standards and qualities in different Member States.

LIFE has also helped industries reuse water, generating cost savings and improving firms' competitiveness. In agriculture, techniques for reusing water for irrigation have been applied and validated. These will help to tackle climate change and water scarcity in Mediterranean countries, as well as having economic benefits.

Priority sectors

The Circular Economy Action Plan highlights five priority sectors that face specific challenges and need targeted action: plastics, critical raw materials (CRMs), food waste, biomass and bio-based products, and construction and demolition waste (CDW). LIFE has invested €68 million in 31 projects on these sectors (EU contribution: €30 million), with plastic waste and CDW the two main areas.

Projects on plastics have shown techniques to improve recycling rates, to upcycle materials and to substitute bio-materials for plastics. They have also identified barriers to market growth such as the need to improve the quality and quantity of sorted plastic waste and cultural reluctance to use recycled plastic among manufacturers. Marine litter is identified as a priority issue and LIFE projects are finding solutions to reduce the impact of discarded plastic bags and fishing gear as well as microplastics in textiles.

LIFE has funded a cluster of projects dealing with critical raw materials that have a big demonstration value. For instance, by showing that CRMs can be extracted in sufficient quantities to make a viable business case for their reuse. One project has recovered and reused 90% of rare earths from light bulbs, creating a new business line employing 30 people. Another project is currently developing a European-wide model of the flow of WEEE through the recovery system and will make recommendations on infrastructure needed to develop this aspect of the circular economy.

LIFE funding could be invested in ecodesign projects for more effective dismantling and recovery, improved collection of waste containing critical raw materials, or high-quality recycling processes. Projects could also raise awareness of the economic value of recycled critical raw materials.

The six food waste projects that have been co-funded by LIFE offer useful lessons on how to create a circular economy for this material. Some projects have focused on educating citizens to waste less, others have developed local markets for 'imperfect' fruit and vegetables that would otherwise be discarded. Eight LIFE projects in Italy helped to change national legislation on food waste prevention and donation, enabling supermarkets and restaurants to donate unsold food that is past its 'best before' date to charity.

The 2015 LIFE call has funded a new project, LIFE TRiFOCAL London (**LIFE15 GIE/UK/000867**) which will make Londoners aware of ways to reduce food waste, recycle unavoidable food waste and eat healthily and sustainably. It will also create a 'food waste behavioural change resource bank', which can be used to help other European cities replicate the lessons of the project.

LIFE has funded more than 50 projects on biomass production for energy use. The projects featured in this brochure are burning biomass for energy only when other options for recycling and reuse are exhausted and future projects should follow suit.

Construction and demolition waste projects have helped set up processes for collection, separation and recycling of CDW and for its conversion into useful materials such as aggregates. One of the positive impacts has been to significantly reduce the number of illegal landfill sites and incidence of illegal dumping in the project areas. Other projects have developed best practice guidelines for separate collection at source based on scientific analysis of the composition of CDW. LIFE has also helped identify barriers to greater reuse of this waste stream, including inconsistent volumes and quality, the need for legislative measures and improvements in municipal collection.

LIFE projects are finding solutions to reduce marine litter such as discarded plastic bags, fishing gear and microplastics in textiles

Photo: LIFE15 GIE/IT/000099/Eleonora de Sabata

EXPERT INTERVIEW

The circular economy: **DG Environment's perspective**

Daniel Calleja Crespo is the European Commission's Director-General for Environment. In this interview, he speaks about the importance of moving towards a circular economy and the LIFE programme's role in achieving this.

Mr Calleja describes the EU's Circular Economy Package, adopted on 2 December 2015, as an extremely important initiative: "With it, we are thinking long term about the future of Europe and also, more importantly, the future of the planet." With Europe consuming more than it produces, it is vulnerable. "So either we change our model of production and consumption into something more sustainable, or we will not be able to continue developing in the same way. The circular model is the best way forward to develop in a sustainable manner," he says.

Photo: European Commission

Daniel Calleja Crespo

Opportunities abound

"Europe has much to gain from shifting to a circular economy in which resources are maximised and waste minimized. We have the potential to become the most efficient region in the world", says Mr Calleja. The benefits for the economy, the environment and society are very significant. Lower resource costs and the introduction of innovative business models can make companies more efficient and competitive. The Circular Economy could lead to reductions in greenhouse gases of between 2-4% and boost employment in 'green' sectors. Recent estimates show that up to 2 million new jobs could be created in Europe in the coming years thanks to the circular economy if we change our current development scenario. The opportunities are boundless for European companies, many of which are already world leaders in areas such as waste and water treatment, clean transport and renewable energy", he adds. "The sectors that best weathered the 2008 financial crisis are those which invested in the circular economy and in resource efficiency".

To facilitate and further stimulate the transition, in December 2015 the Commission presented a strategy with 54 concrete measures covering all sectors and the entire product life-cycle. "We have already proposed or adopted 18 measures, with more in the pipeline ", says Mr Calleja.

The Commission also proposed to revise EU waste legislation to better align it to the needs of a circular economy. More recently, as part of the Commission's proposed package on 'Clean Energy for All', a new Ecodesign Working Plan was included which will take into account not only energy efficiency but also resource efficiency, reparability, recyclability and durability of products.

In addition to legislative actions, guidance documents have been adopted in the areas of industrial emissions, water management, unfair commercial practices and green public procurement. Pilot projects have been selected for so-called "innovation deals" to allow innovators in the area of water treatment and waste electrical and electronic equipment sectors to swiftly address legislative obstacles and shorten the time to market uptake.

The strategy also covers specific sectors, such as construction and demolition waste, critical raw materials,

Photo: LIFE12 INF/BE/000459/ARC

The European Week for Waste Reduction has inspired more than 70 000 actions, reaching millions of consumers

food waste, plastics and biomass. For example, Mr Calleja says "we are in favour of actions from the Member States to support reuse of materials from buildings to be demolished, as this could have a major impact on the construction industry." For plastics, the Commission will unveil a strategy that will include measures to tackle marine litter. "If we do not take action, in 2050 there will be, by weight, more plastics than fish in the oceans," the Director-General explains. On the chemicals side, he explains that the Commission is assessing the interface between products, chemicals and waste legislation to prevent toxic material entering the production cycle if more products are to be re-used. A platform on food waste and food losses has also been set up to develop an EU methodology on measuring food waste.

Europe can also help other countries around the world become more sustainable. "Now, the world faces a dramatic situation with emerging countries consuming more, with large movements of populations to cities and with big demographic increases," notes Mr Calleja.

"This is why we have launched EU circular economy missions to third countries, to carry our message beyond Europe" The first missions took place in Chile and China in 2016 and more are planned for 2017 to Africa, Asia and Latin America. "These are a way of sharing our experience with third countries so they can develop in a sustainable way and offering at the same time new markets for European companies. It's a win-win for both sides."

The role of LIFE

"LIFE has delivered great benefits for nature, the environment and the climate," says Mr Calleja. With its support for innovative projects, the programme has an important role to play in facilitating the move towards a circular economy, in areas such as waste, energy efficiency, industrial symbiosis and clean transport. Such solutions will create opportunities for innovation by eco-entrepreneurs and SMEs that translate into green growth and jobs.

The Director-General highlights the importance of LIFE Integrated Projects: "They can deliver significant benefits based on pooling to achieve a critical mass." As an example, he cites a new Finnish project - covering 24% of the country's population and 20% of its territory - which involves five different regions working together to increase the efficiency of waste treatment, collection and recycling. "This is an example that we would like to see all over Europe: more and more regions working together, delivering Integrated Projects."

Mr Calleja believes the LIFE Best Project Awards also have a role to play. These are presented each year to the most outstanding projects completed in the previous 12 months and, as well as drawing attention to important initiatives, they could encourage others to undertake projects and help communicate and disseminate circular practices. "LIFE should help us explain that by becoming circular you are more efficient and that the environment and sustainable development should not be seen as a barrier, but as a great opportunity," he notes.

The Director-General considers that a flexible LIFE programme, more Integrated Projects and dissemination of best practices will help to spread the circular economy 'revolution' throughout Europe. "The circular economy will only happen if we have the awareness of citizens, as it implies consuming in a more rational way, and if the economic operators, including SMEs, buy into this model. This is the great challenge and opportunity for us," he concludes.

EXPERT INTERVIEW

Making the shift to a circular economy: **an MEP's view**

Finnish MEP Sirpa Pietkäinen fought hard for the Circular Economy Package adopted in December 2015. In this interview, she discusses the importance of the EU's transition to a circular model and what should be done to achieve this.

Part of the European People's Party group, Ms Pietkäinen was a member of the European Resource Efficiency Platform established by former European Commissioner for Environment, Janez Potočnik. The objective of the platform, which ran from 2012 to 2014, was to provide high-level guidance to the Commission, Member States and private actors on the transition to a more resource-efficient economy.

Ms Pietkäinen welcomes the Circular Economy Package adopted by the Commission, in particular its innovation and research aspects. Going forward, she believes that even more can be done to support the circular economy, for instance, the development of indicators to measure impacts on ecosystem services and resource use. "The information already exists," the MEP points out, "so it only remains to decide how it will be used." The compulsory use of such indicators would ensure harmonised reporting of this information and, therefore, comparability. Ms Pietkäinen anticipates legislation on ecological or resource accounting and indicators will be needed at some point to achieve this.

Raising the ambition level further is also important, the MEP believes, to make the shift to a circular economy. Currently, humanity is consuming the resources of 1.5 planets. "According to forecasts, in 30 years we will need the equivalent of four planets' worth of resources to run the economy as it is. This is not sustainable," she says. Consequently, the ambition should be to cut resource use now: "Figures from the scientific community suggest that, to be sustainable, we would need to use a tenth of the resources we are now to produce the same wealth and income growth without harming ecosystems. If we do this, it will generate out-of-the-box thinking which drives economic performance."

Sirpa Pietkäinen

Better design

Ms Pietkäinen also believes the Ecodesign Directive (2009/125/EC) should be amended to support the circular economy by promoting the design of products which can be upgraded, repaired, reused, utilised for parts and then recycled: "We don't only want to increase recycling and lose quality materials." She expects this would have a major impact on production, with manufacturers gradually shifting to more circular production patterns. The effect would likely be seen on manufacturers from other regions as well, since they would not want to lose access to the large European market, hence the EU could drive up standards elsewhere.

The MEP says more can be done at Member State level, encouraged by the EU, to help the transition to a circular economy. For example, not all countries have national circular economy strategies,

which Ms Pietkäinen believes are necessary, since they can provide a long-term perspective and "the right benchmark for what is needed". She also highlights several sectors where action to promote the circular economy could have a big impact: public procurement, food, transportation, energy and buildings. Public procurement has the potential to drive a great deal of investment in the circular economy, as it accounts for 20% of spending in Europe. As a result, Ms Pietkäinen recommends Member States make circular requirements compulsory in their procurement legislation.

She also singles out the food sector as an area for pushing change, since this is easy for the general public to understand and support. When it comes to sustainability in this area, the focus is often on food waste from shops and restaurants. But the MEP says the whole value chain should be taken into consideration, for example encouraging more consumption of local and seasonal produce. She explains, "We need to concentrate not only on what is left over, but also on why there are leftovers, what they are, and what produce we should be eating."

Targeting funding

Ms Pietkäinen applauds the Commission's financing of innovations and new research, such as through the LIFE programme. She notes, though, that some public funding could be better targeted to support the circular economy, especially in times of straitened budgets. The MEP believes EU financing could be used to support several types of initiative to facilitate a circular economy.

Many exemplary LIFE projects have focused on plastic upcycling, substitution and reducing plastic litter in our seas

Photo: LIFE15 GIE/IT/000099/Eleonora de Sabata

The food sector could benefit greatly from actions to promote a circular economy in line with the food waste hierarchy

For example, progressive companies could form cross-industry groups to generate new ideas and business models: "They would set their own ambition levels and targets, such as considering what actions are needed to ensure their businesses are completely sustainable by 2050." Ms Pietkäinen says companies should be able to receive some EU funding towards this type of initiative, such as through Horizon 2020 and the LIFE programme.

Urban authorities could also work together to consider how to improve the sustainability of metropolitan areas (e.g. through the organisation of transport and use of green infrastructure). In addition, digital platforms have a lot of potential to promote the circular economy, according to the MEP. "Information about materials – their locations, their routes in real time – can help with planning material flows," she notes, while from a consumer perspective they have the potential to enable circular activities, such as car sharing, product leasing and repairs.

Ms Pietkäinen stresses that the circular economy involves a paradigm shift, and achieving it requires a change in mindset. "If you think linear, you end up with the wrong solutions," she cautions, concluding, "The big question for politicians is how to find the braveness, the understanding and the tools to make this paradigm shift."

EXPERT INTERVIEW

The Ellen MacArthur Foundation's perspective on the circular economy

Jocelyn Blériot is head of Editorial & European affairs at the Ellen MacArthur Foundation, whose mission is to accelerate the transition to a circular economy. In this interview, he talks about the benefits of a circular economy and the challenges ahead.

Mr Blériot welcomes the Circular Economy Package adopted by the European Commission in December 2015, an action plan with measures covering the whole cycle from production and consumption to waste management and the market for secondary raw materials. "Through it, the circular economy is treated as a priority," he says, applauding the fact that the package targets upstream areas (e.g. promoting better product design and changing production processes and materials), as well as more traditional areas like waste management.

An important aspect of the package could be the revision of existing legislation to encourage the shift to a circular economy, for example the Ecodesign Directive. New regulations will also be drawn up where needed. The first piece of legislation to come out of the package, aimed at boosting the use of organic and waste-based fertilisers, was proposed in March 2016. The existing Fertilisers Regulation ensures free movement in the EU mainly for conventional, non-organic fertilisers.

Jocelyn Blériot

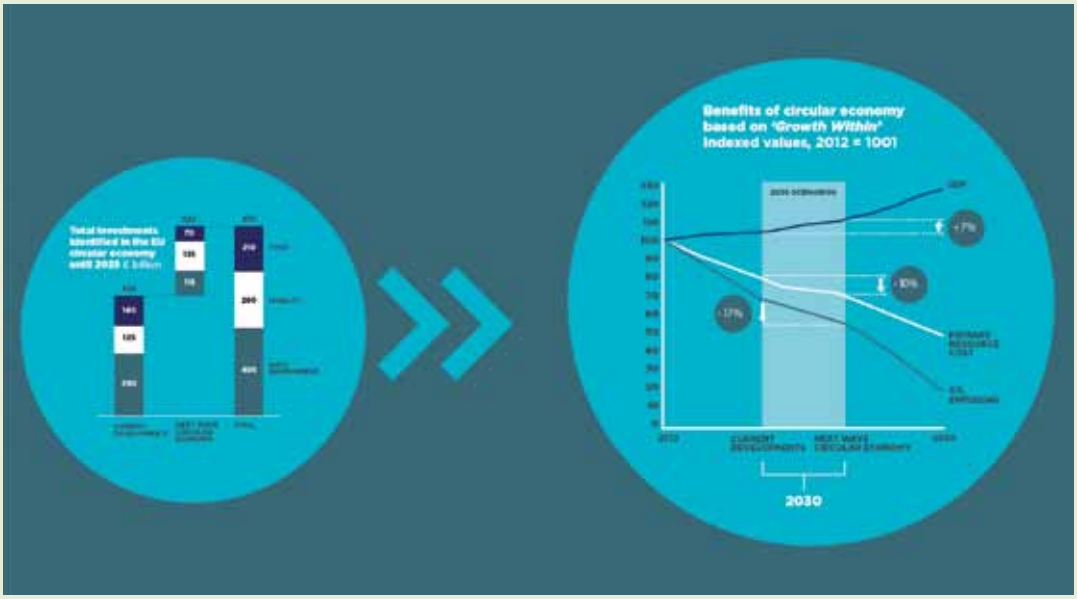
Photo: LIFE12 ENV/UK/000966/Ellen MacArthur Foundation

The proposed new regulation would significantly ease the access of organic and waste-based fertilisers to the market, putting them on a level playing field with traditional, non-organic fertilisers. Mr Blériot says this legislation is "very important when you think about looking at restoring nutrient cycles and [tackling] the phosphate issue". The regulation sets out common rules on converting bio-waste into raw materials that can be used to manufacture fertilising products and introduces strict limits for cadmium in phosphate fertilisers.

Barriers and benefits

Making the transition to a circular economy involves overcoming both regulatory and technical challenges. On the regulatory side, Mr Blériot highlights the difficulty in legislating for 28 Member States with "completely different levels of materials handling". The EU must ensure that legislation is ambitious enough for Member States at the top of the scale but not unrealistic and unachievable for those nearer the bottom end.

From a technical point of view, the quality and quantity of secondary raw materials on the market is still a barrier for the circular economy. Currently, this feedstock is of insufficient quality or the volumes are too small or non-existent. However, Mr Blériot says a stream of materials can be created



The investments required to achieve circular economy benefits

Sources: 'Growth Within': SYSTEMIQ.

by identifying and tracking product information, which would also help design choices for example, by using the circularity indicators and tool developed for the project LIFE+ CEMs – Circular Economy Metrics (see pp.30-33). The Ellen MacArthur Foundation was the coordinating beneficiary for the project; it developed a tool that helps score the circularity of products and allows users to determine which material strategies need to be prioritised in order to achieve circularity.

There are many benefits in moving to a circular economy, "a systemic shift that has a strong economic rationale", according to Mr Blériot. "It's about moving from one system that relies on the consumption of raw materials to generate revenue to one where materials are used but not used up. And then you derive value from maximising the utility and closing those productive material loops." For instance, lower net costs for materials means reduced vulnerability to supply risk. As Mr Blériot points out, "As a market, Europe is the greatest importer on the planet: about 62% of all that we produce is made from imported material." Plus, he notes that energy consumption is reduced, since remanufacturing has a lower energy intake when compared with making the same products from scratch.

A circular economy also means lower compliance costs for businesses, because it entails them moving towards developing products which "do not have a negative environmental impact on the market [and therefore they] do not have to pay for the clean-up". There are advantages in terms of job creation as well, although this is difficult to quantify since it depends on how the circular economy and green jobs are defined. According to Mr Blériot, research carried out for the foundation found that "all the evidence points towards benefits in terms of job creation".

Building impetus

Momentum towards a circular economy has increased in recent years, and not only at the EU level. "We have more and more companies asking us how they could make the transition to circular practices," says Mr Blériot. "There is an increasing amount of interest among businesses in moving towards the circular economy." To reach the tipping point, he believes it is vital to identify and invest in the innovators of today and the future: "We need to invest in education in order to have the right skills and create the fertile ground for innovation to emerge."

Nearer term, Mr Blériot considers that more projects dealing with the bio-cycle side of the circular economy would be useful, such as those funded under the LIFE programme, since the material flows and the business models around products such as metals and polymers have been well-developed already. "Some projects elucidating the potential of the bio-economy within the circular economy restorative model would be beneficial." Mr Blériot concludes by saying he is very encouraged by the Commission's approach to the circular economy so far.

Introducing **circularity at the production phase**

The production phase accounts for most of a product's costs, and determines most of its lifetime environmental impacts. LIFE projects have helped to close material loops at this phase, through ecodesign, more sustainable production processes such as industrial symbiosis and chemical substitution.

The Circular Economy Action Plan recognises that the transition to a circular economy must start at the very beginning of a product's life. Decisions taken at this stage by designers and developers have a decisive impact on resource use and waste generation. The European Commission is providing instruments and incentives to improve the production phase through legislation such as the Ecodesign Directive, voluntary tools for small and medium-sized enterprises (SMEs), and other actions.

Better design, greener products

Ecodesign can deliver products that are more durable and longer lasting and easier to repair, upgrade and remanufacture; or that are easier to disassemble so their components and materials can be reused or recycled. It leads to greener products that consume less energy and resources during manufacture, generate less waste and pollution at their end-of-life stages, incorporate no hazardous materials, create new markets for

An example of industrial symbiosis, BREAD4PLA developed a 100% biodegradable plastic material from industrial bakery waste

Photo: LIFE10 ENV/ES/000479/Charo Pascual

secondary raw materials, and open up new business opportunities that create jobs.

However, market signals may not always be enough and the interests of producers, users and recyclers may not be aligned. In these cases, it is essential to provide incentives to kick-start more sustainable product design. To this end, the revised legislative proposals on waste management that accompany the Circular Economy Action Plan are creating economic incentives for better product design, through Extended Producer Responsibility (EPR) schemes that take into account the end-of-life costs of products.

Ecodesign can help close material loops and contribute to more efficient use of resources and reduced waste. This can be achieved for example by designing for product longevity or durability, or by enabling the effective extension of product life through reuse, maintenance/repair or technical upgrading. To close material loops, eco-design can help turn waste into secondary raw materials and maximise material recovery and recyclability.[1] Integrating circular economy concerns at the earliest possible stage of product design is important, because once product specifications are agreed and resources committed it is difficult to then make anything other than minor changes.

The Circular Economy Action Plan puts further emphasis on the role of ecodesign in promoting the material and resource efficiency of products. The Ecodesign Directive (2009/125/EC) aims to improve the efficiency and environmental performance of energy-related products. To date, it has mainly targeted energy efficiency but as a result of the Action Plan's ecodesign working plan for 2016-2019, actions under the Ecodesign Directive will in future systematically also focus on conserving resources through durability, reparability, upgradability, reuse and recycling.

A design for life

LIFE projects have been demonstrating ecodesign principles for many years. At the turn of the millennium, the ECO DESIGN project (**LIFE99 ENV/B/000639**), for instance, promoted sustainable product design to Flemish industries at a time when very few enterprises had considered this approach. The project produced a handbook on ecodesign that not only looked at energy efficiency, but also took all life stages of the product into consideration - from the extraction of raw materials to production, product use, through to waste disposal.

Photo: LIFE08 ENV/E/000158

Through a life-cycle assessment, BOATCYCLE identified the main environmental impacts of recreational boats, from raw material extraction to waste disposal

In 2001, the Commission adopted a Green Paper on Integrated Product Policy (IPP) to reduce the environmental impacts of products throughout their life-cycles. IPP provides a framework for taking actions where they are most effective, by bringing together different legislative strands and promoting a wide variety of voluntary and mandatory tools. The IPP TEL project (**LIFE04 ENV/GR/000138**) redesigned telecommunication devices so that they were easier to disassemble for recycling. Following the IPP approach, the project concluded from its life-cycle assessment (LCA) of two devices that the main environmental impacts were due to the end-of-life release of heavy metals. To address this at the design stage, the project produced 200 copies of a prototype device. This contributed valuable information about product disassembly, which informed both ecodesign and proposed eco-labelling criteria.

Ecodesign principles can make the dismantling of recreational boats easier, thereby recovering materials for use as secondary raw materials. The BOATCYCLE project (**LIFE08 ENV/E/000158**) developed a guide for the sustainable production and ecodesign of yachts, sailing and inflatable boats, and helped turn four waste streams from boat scrapyards (fibreglass, neoprene, wood and PVC) into a

1 Nancy M. P. Bocken, Ingrid de Pauw, Conny Bakker & Bram van der Grinten (2016) Product design and business model strategies for a circular economy, Journal of Industrial and Production Engineering, 33:5, 308-320, DOI: 10.1080/21681015.2016.1172124.

resource. LCA results showed that recycling these materials could reduce environmental impacts by around 50%. The guide is helping in the development of innovative ecodesign approaches for boatyards. More recently, the LifeCiP project (**LIFE12 ENV/FR/001113**) has used ecodesign and LCA approaches to reduce environmental impacts in three industrial sectors (see box).

Ecodesign approaches can benefit all industrial sectors. LIFE ECOLAC (**LIFE13 ENV/ES/000615**) is developing an IT tool to analyse the environmental impacts of production processes for dairy products, so that improvements can be made through ecodesign. The project's LCA has identified priority areas and key opportunities for improving environmental performance in the dairy industry. Its software is helping to implement ecodesign approaches in these priority areas, by providing information for carbon footprint, water footprint, biodiversity loss, and other indicators. This is being tested on six dairy products, in order to produce a manual of good practices in ecodesign applications for food products. The project is also carrying out a study on consumer behaviour concerning eco-designed food products, which will help raise consumer awareness and inform the development of future products. Meanwhile, the LIFE+ CEMs (**LIFE12 ENV/UK/000966**) project is designing and developing a web-based tool, involving circularity indicators, to enable European businesses to measure their effectiveness in moving towards the circular economy (see pp 30-33).

Helping businesses become resource efficient

Even when products are well-designed, if resources are used inefficiently in the production process, it will lead to unnecessary waste and potentially to lost business opportunities. Resource-efficient technologies and solutions necessarily differ from one sector to another. The Commission is integrating circular economy aspects, particularly in relation to water and waste management, into the process of drafting and revising Best Available Techniques Reference documents (BREFs). Member States need to take these into consideration when issuing permits for new industrial installations.

Organisational barriers can hinder companies who wish to exchange linear for circular business models. The LIFE REBus project (**LIFE12 ENV/UK/000608**) is demonstrating how businesses and their supply chains can overcome such obstacles by implementing resource efficient business

Life-cycle in practice

The LifeCiP (LCiP) project helped SMEs in France, Belgium, Portugal and Spain to reduce the environmental impacts of their products and services in three sectors: buildings and construction, waste management, and energy equipment. A total of 32 SMEs implemented 'life-cycle thinking' (LCT) over a six-month period, which involved LCA and the building of strategic plans for the companies. "This often ends with a new version of the product optimised economically and environmentally," says project manager Aubin Roy, an adviser on LCA and eco-design. For instance, building and energy sector SMEs from the building, have been helped to ecodesign their products with a view to improved end-of-life recycling.

Photo: LIFE12 ENV/FR/001113

Mr Roy believes that investment is necessary to help businesses prioritise ecodesign, including in skills, software and through economic incentives (e.g. tax breaks). "It is also important to build-up a business ecosystem, especially for SMEs, with access to resources and training on life-cycle thinking, as this concept is quite new," he says.

"We tested a dashboard developed in the context of the project. It is a simple tool - free and available online - which aims to gather information about the company's life-cycle approach," explains Mr Roy. The dashboard will help companies monitor and manage improvements in the environmental, economic and social performance of products. Regional physical resource centres, where dashboard data and information about project tools are collected, will facilitate follow-up work.

The project thought about replicability from the outset. "The feedback from the 32 SMEs has been collected and compiled in videos, case studies and a guide on how to conduct life-cycle approaches," says Mr Roy. "These testimonies are important for sharing the knowledge created and for inspiring other businesses to implement LCT in the context of new regulations: the Product Environmental Footprint (PEF) and the Circular Economy Package," he adds. At the physical resource centres, new projects are ongoing with SMEs from other sectors, such as wood and textiles.

EMAS – Eco-management made easier

EMAS is an environment management tool designed to help registered organisations enhance their environmental performance. It operates through incentives that reward commitments to sustainability. However, regulatory burdens can become excessively complicated or time-consuming, especially for SMEs, making it harder for them to comply with environmental legislation.

B.R.A.V.E. (**LIFE10 ENV/IT/000423**) supported the full integration of EMAS (and other voluntary certification schemes) into environmental legislation in Spain and Italy, with the aim of reducing the costs and administrative burdens for EMAS-registered organisations. The project's guidelines and measures for regulatory relief have helped companies implement environmental legislation, with the result that more SMEs have become EMAS-registered.

"EMAS drives the circular economy," says Sara Tessitore of the B.R.A.V.E. project team. By improving environmental management, EMAS supports companies in their efforts to produce 'circularity'. "EMAS-registered organisations providing materials reduce the volume of their waste and thereby experience fewer costs associated with its management and treatment; the recipients, in turn, reduce their procurement costs by gaining new access to resources," she explains.

"In the framework of B.R.A.V.E., about 100 simplification proposals were developed affecting both national and regional legislation, engaging policy-makers of many regions," says Ms Tessitore. These proposals were shared with over 200 stakeholders and experts through frequent working groups and subsequently promoted for adoption in meetings with regional, national and local administrations.

Significant improvements in terms of environmental legislation were achieved for

Photo: LIFE10 ENV/IT/000423

EMAS organisations. A total of 18 measures have been adopted at regional level (eight in Tuscany, five in Liguria, four in Lombardy and 1 in Valencia), as well as five at national level in Italy. The project also drafted guidelines introducing the simplification tools to promote EMAS, which can also benefit public administrations, government agencies and other stakeholders working in this area.

The follow-on project LIFE B.R.A.V.E.R. (**LIFE15 ENV/IT/000509**) aims to encourage the adoption of measures for regulatory relief to support EMAS adoption in more countries, regions and sectors.

models (REBMs). The project has worked with enterprises of all sizes in four sectors: electrical and electronic products, clothing, furniture and construction products.

The Commission is helping SMEs to benefit from the new business opportunities created by improved resource management, for example, with the creation of the European Resource Efficiency Excellence Centre and by improving the uptake of the EU Eco-Management and Audit Scheme (EMAS), a tool for reducing the regulatory burden of implementing environmental legislation (see box). Another initiative is the promotion of best practices for mining waste.

Yesterday's rubbish, tomorrow's resource

Landfill sites contain many valuable materials that are worth recovering. The LIFE RECLAIM project (**LIFE12 ENV/GR/000427**) constructed a pilot system for mining existing landfills to produce ferrous and non-ferrous products for metallurgical processes. "The processing unit was equipped with a cylindrical trommel sieve to separate waste fractions from the screening of rocks and ores, with hand-sorting and a magnet for ferrous materials," says project manager Zoi Gaitanarou. "Additionally, the project explored the potential of extracting rare metals from e-waste using beneficiation methods that are used in the mining industry."

During the pilot phase in 2015, the project recovered 32.57 tonnes of soft plastic, 28.7 tonnes of soil material, 19.47 tonnes of plastic bottles, 6.22 tonnes of ferrous metallic materials, 1.68 tonnes of glass and 1.6 tonnes of aluminium from 580

The LIFE RECLAIM technique makes it possible to recover land for human use or nature

Photo: LIFE12 ENV/GR/000427

Photo: LIFE13 ENV/ES/001165

WALEVA is creating an economically-viable new use for ice straw as a raw material in the production of EVA (levulinic acid)

tonnes of extracted waste. The recovered soil can be used as landfill cover, while the other materials can be sold to recyclers, especially when cleaned in the pilot system's industrial washing unit.

"The accompanying socio-economic analysis showed that these revenues can support the landfill mining process," says Ms Gaitanarou, although she cautions that, "the recyclables market is subject to many fluctuations."

The technology can be replicated on a large-scale, with only minor modifications, and there is a significant market opportunity. "Landfill mining can be used to empty out old historic landfills, an estimated 150 000 to 500 000 in Europe, thus there is huge potential for waste recovery," explains Ms Gaitanarou.

Industrial waste tips, and soils that are unsuitable for agriculture because of their heavy metal content, are among the other areas where waste mining could bring environmental benefits and economic gains. The LIFE-AGROMINE project (**LIFE15 ENV/FR/000512**) is demonstrating phytomining (also called agromining) to recover high-value metals, especially nickel, from soils over sub-economic ores. The project's approach uses plants to accumulate trace metals from soils, which can be harvested from their shoots. By-products generated by the process can be used as soil improvers. The project's methodology could be applied to waste tips to recover metals for reinjection into product life-cycles.

Smarter industrial cooperation

In the Circular Economy Action Plan, the Commission stresses the importance of innovative industrial processes for improving resource use efficiency, in particular, the implementation of industrial symbiosis (IS). This occurs when traditionally separated industries are bought together in a collaborative approach that provides competitive advantages for all parties, often with the involvement of public sector bodies. It involves the physical exchange of materials, energy and water, wastes and by-products, and also the sharing of assets and expertise. Industrial symbiosis is part of a new industrial ecology paradigm, based on the study of material and energy flows through industrial systems, using the analogy of natural ecosystems where everything is recycled. IS provides a framework for describing how a network of diverse organisations can foster eco-innovation, and business culture and technological change, to create mutually profitable transactions.

In the revisions to the Waste Framework Directive, the Commission proposed clarified rules on industrial by-products to facilitate industrial symbiosis, which also helps to create a level playing field across the EU. Of particular relevance to the circular economy is the use of one industry's waste

or by-products as another industry's secondary raw material. In many cases, waste can be diverted from landfill or incineration to become a valuable new resource. This reduces costs relating to raw materials and disposal, reduces environmental impacts and carbon emissions arising from landfill, provides a new source of revenue, and opens up new business opportunities.

LIFE has been an innovator in this regard. Since 2007, the programme has been funding projects that have created networks and platforms to enable industrial symbiosis or to create a symbiosis between industries, turning the waste products of one industry into raw materials for another. For instance, ECOREG (**LIFE07 ENV/RO/000690**) established an industrial symbiosis network in the Suceava region of northern Romania, with the goal of enabling regional development to occur with minimal environmental impact.

The project organised four IS workshops to identify how resources could be reused, and by-products utilised, through the creation of mutually beneficial partnerships. All participating companies filled out 'have' and 'want' IS forms, which enabled the project to identify 246 potential synergies and 638 resource flows. Out of these, 194 industrial synergies were finalised, whereas 52 were tested but failed at the commercial negotiation stage. 'Synergies involving a single 'want' company and multiple 'have' companies were considered to have the potential for highest outputs. The project demonstrated environmental benefits, by reducing the amount of natural resources used as raw materials, which created new business opportunities with the creation of 28 new jobs and the safeguarding of 10 more.

Industrial symbiosis can play an important role in reducing the amount of residential and commercial urban waste that goes to landfill. A demonstration Greek project, eSYMBIOSIS (**LIFE09 ENV/GR/000300**) created a web-based platform to divert residential and commercial waste from landfill in Viotia. The replicable platform facilitated communication between potential partners and offered automated partner matching, with a particular focus on increasing the participation of public authorities and SMEs in IS activities. The project also trained SMEs to engage in IS and identify new sources of secondary raw materials for use in production.

The ongoing project LIFE M3P (**LIFE15 ENV/IT/000697**) is connecting clusters of SMEs to foster alternative uses of their wastes, in line with the Circular Economy Package and the Resource Efficiency Roadmap. It is identifying and characterising at least 500 industrial waste streams, and through a European-level online platform called M3P (Material Match Making Platform) is helping to turn them into secondary raw materials for other SMEs in the local area. It aims to involve at least 230 SMEs - 100 in Lombardy (Italy), 100 in Flanders (Belgium), 10 in Asturias (Spain), and 25 in West Macedonia (Greece).

LIFE M3P is also demonstrating the feasibility of more efficient uses of raw materials, through the

LIFECITRUS is developing an innovative and chemical-free process for obtaining natural food ingredients from discarded parts of citrus fruits: lemons, oranges, grapefruits and tangerines

Photo: LIFE14 ENV/ES/000326

systematic application of ecodesign techniques, to facilitate the recovery and re-use of parts that would previously have become waste. It aims to achieve 72 new product concepts, with the involvement of 40 young designers. Furthermore, it aims to promote two innovative instruments that are at the pilot development stage, namely Environmental Technology Verification (ETV) and Product Environmental Footprint (see consumption chapter – pp. 30-39).

Symbiosis: networks linking diverse industries

PODEBA (**LIFE10 ENV/IT/000365**) took waste material from the poultry industry and utilised it in the leather tanning industry (see box), while waste from the tannery industry was itself recovered by LIFE MICROTAN (**LIFE12 ENV/ES/000568**) for the production of microencapsulated products. The latter project isolated collagen and gelatine from solid tannery wastes, with the remaining fraction sent for composting, and demonstrated the feasibility of using these by-products for making microcapsules that are widely used in the food, photographic, cosmetic and pharmaceutical industries.

Industrial symbiosis between the paper and plastic sectors is being established by LIFE ECO-PULPLAST (**LIFE14 ENV/IT/001050**). The project aims to reduce to zero the amount of waste sent to landfills and incinerators, by demonstrating the feasibility of an innovative technology to recycle it into new plastic compounds and products. At the project's pilot plant, industrial waste from paper mills that use recovered paper is being used to manufacture eco-sustainable plastic pallets, for use within the same paper district, thereby creating a local circular economy.

PODEBA – a new use for fowl manure

The PODEBA project demonstrated industrial symbiosis by using deodourised poultry manure as a new chemical softening (bating) agent, called DPM P120, for leather tanning. By replacing the enzymes traditionally used to soften hides, the project's approach saves money and reduces a tannery's environmental impacts.

Manure from the poultry industry was treated with plant enzymes, according to a patented process, to deodourise it and improve its quality for the tanning industry.

The project team concluded that the patented process can translate into a business with an excellent cost/benefit ratio "The tannery can save an average of 30% on the purchase of new lipase agents for bating," says project manager Alice Dall'Ara. "A cost of €0.46 per kilo of PODEBA bating agent was estimated, which represents a reduction of €5.9 per tonne of salted leather with respect to the industrial product, but there is also an indirect saving in treatment costs. There is also the possibility to tap into new market niches for 'green' leather products with excellent characteristics."

A life-cycle analysis of the application of DPM P120 as a softening agent showed a positive effect on a range of environmental impacts, such as odour. For example, ammonia emissions were reduced by 96% both in dry (poultry farm) and in wet (tannery) conditions. Wastewater pollution, energy and resource consumption, waste products and greenhouse gas emission were also reduced.

Annual savings of around €300 000 in Italy and €600 000 in Europe are predicted if DPM P120 were to replace only 10% of the common industrial bating agents. Project consortium members are working on the possibility of promoting the project's results as Best Available Techniques (BATs).

"The results obtained suggest this treatment is feasible for even thin and delicate skins, without risk of damage. The finished leathers have no smell and appear very similar to those obtained with traditional methods. It is applicable to different hides, for example, cattle and sheep, and for different end uses: shoes, bags, clothing and furniture," says Ms Dall'Ara.

Photo: INESCOP

Photo: LIFE12 ENV/ES/000568

Collagen and gelatine from tannery waste were used to make microcapsules for the food, photographic, cosmetic and pharmaceutical industries

Adding value to food and farming waste

Several LIFE projects have established industrial symbiosis by demonstrating how food industry and agricultural waste can be turned into new secondary raw materials for industrial use.

The BREAD4PLA project (**LIFE10 ENV/ES/000479**) proved that bakery waste is a suitable raw material for making compostable plastic packaging for use within the bakery industry. The biodegradable thermoplastic PLA (polylactic acid) used for packaging is typically made from plant materials such as corn starch, tapioca or sugarcane. The BREAD4PLA process for "cradle-to-cradle" management brings direct environmental benefits by effectively closing the loop for industrial bakery waste. The waste is recovered using a clean enzymatic biotechnology to polymerise the PLA material.

Project manager Raquel Giner Borrull explains that through conversations with commercial producers of lactic acid and lactides (an intermediate substance between lactic acid and PLA), the project determined that three conditions were necessary for turning the pilot process into a viable industry: the bakery waste must be available in sufficient quantities; the supply must be constant; and it should be sourced from as few locations as possible to simplify logistics, minimise transport costs and ensure consistency of quality.

"The fermentation of waste bread enables the production of 0.35 kg of lactic acid per kg of bread, similar to other feedstocks. PLA yields of 48% were achieved at the pilot plant," she says. The BREAD-4PLA team calculates that this would increase to 77% at industrial scale, and that the cost of using bakery waste would be significantly lower than the cost of using other feedstocks, such as corn or tapioca.

The project analysed data supplied by large bakeries in Spain and the UK and concluded that they could divert up to 25% of their food waste to manufacture packaging (the other 75% being used for animal feed). "This amount of waste, some 4 000 tonnes/yr, would convert to 680 tonnes/yr of PLA from a single large bakery, cost-effectively replacing the equivalent amount of conventional plastics," says Ms Borrull. "Since Germany and the UK generate the most bakery waste in the EU, they are the countries where the industrial-scale plant is most likely to be implemented. With some modifications, the process piloted by this LIFE project could also be used to produce biodegradable packaging from fruit and vegetable waste."

Rice straw is usually burnt, emitting greenhouse gases and causing air pollution. LIFE WALEVA (**LIFE13 ENV/ES/001165**) is demonstrating how these environmental impacts can be eliminated, by creating an economically-viable new use for rice straw as a raw material in the production of LEVA (levulinic acid). This chemical is in demand because of its multiple uses in the pharmaceuticals, chemical and food industrial sectors. The process also produces marketable xylose, and bio-charcoal that can be used to power the process.

Photo: LIFE12 ENV/GR/001135

LIFE READ is developing effective methods for communicating safety information about hazardous products

The processing of fruit generates a significant amount of waste with little commercial value. This has some use as animal feed, but much is underutilised and discarded. LIFECITRUS (**LIFE14 ENV/ES/000326**) is demonstrating an innovative industrial process for obtaining natural food ingredients from citrus fruit discards. This waste can be treated and transformed to recover hesperidin, essential oils, sugars and a gelling agent for the food industry. The new process, installed in the project beneficiary's processing plant in Murcia (Spain), is expected to reduce waste by 80% (by mass and volume). The project is also organising training courses on the technology for agro-food industries technicians, and assessing the suitability of the process for other fruit and vegetable residues.

Chemical substitution

A significant barrier to closing material loops is the presence of hazardous or problematic substances that cannot be reused or recycled. A cluster of LIFE projects has addressed this issue, by helping companies to identify alternative chemicals for use in their products. This has gained in relevance in recent years, as the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation (EC 1907/2006) is restricting or banning an increasing number of chemicals ("substances of very high concern"), where suitable alternatives have been identified. Facilitating the substitution of chemicals of concern at the production stage is one of the actions noted in the Circular Economy Action Plan to help SMEs exploit business opportunities arising from increased resource use efficiency during the transition to a circular economy. Maintaining or improving the quality of recycled materials facilitates upcycling, and growth in the reuse and recycling sectors.

In order to provide companies with information on substituting hazardous substances with safer alternatives, the SUBSPORT project (**LIFE08 ENV/D/000027**) developed an innovative 'substitution support' web portal (www.subsport.eu), containing hundreds of case studies, as well as lists of restricted and priority substances, links to tools that can help facilitate substitution and training materials. It continues to be updated. More recently, LIFE Fit for REACH (**LIFE14 ENV/LV/000174**) has produced a management package to help SMEs find alternatives to restricted substances (see box, p. 29).

More effective methods for communicating safety information about hazardous products are essential. This is why the LIFE READ project (**LIFE12 ENV/GR/001135**) developed a public database to generate Safety Data Sheets (SDSs) and workplace instruction cards for detergents. The outcome is improved safety information on products used in the tourism and construction industries in Greece, which covers the entire supply chain from manufacturers and importers, producers and wholesale distributors, to professional end users. The information provided includes whether the product contains any hazardous environmental pollutants, its carbon footprint, and if it has any environmental certification (e.g. EU Ecolabel).

Products of petrochemical origin, and in particular chlorinated compounds, have been widely used in the leather defatting process. They are preferred mainly because of their chemical stability, low cost and good performance. Yet, there are increasing concerns over their high chlorine content and low biodegradability potential. LIFE ECODEFATTING (**LIFE13 ENV/IT/000470**) is replacing hazardous

chemical products with more environmentally-friendly products in the degreasing phase of the leather tanning cycle. It will specifically eliminate defatting agents which contain chlorinated molecules, and replace them with natural products that penetrate better the leather, so enhancing performance. This will reduce wastewater pollution, and enable leather manufacturers to contribute to production of products bearing the EU Ecolabel.

The BIOPOL project (**LIFE15 ENV/IT/000654**) is also improving the environmental performance of the leather tanning sector, by demonstrating an innovative process for producing new biopolymers from the waste biomass generated by the tanning process and by agro-food industries. Substituting conventional chemical agents used in the tanning process with these 'green chemicals' reduces hazardous substance use by 70-90%.

Making LIFE Fit for REACH

The LIFE Fit for REACH project is offering SMEs a full 'chemicals management package' to help them find substitutes for hazardous substances. This includes capacity building in line with the CLP regulation (Classification, Labelling and Packaging of substances and mixtures) and MSDS (Material Safety Data Sheet) guidelines, information on chemical inventories and general management practices, guidance on how to follow legal obligations on specific substances, and proposals on how to implement substitution as a core action to reduce environmental impacts.

Tools are being developed for SMEs in Baltic countries to help them identify potential candidate chemicals for substitution, build in-house chemical inventories, and give guidance on initiating substitution processes. "Data shows that there are alternatives for most of the restricted hazardous substances, even if they are not numerous," says project manager Valters Toropovs. Although alternatives can be found, he explains, in most cases some degree of change in the formulation and/or technological processes will be necessary.

"The project involves six industrial companies as direct partner with complex substitution cases. They receive individual consultations from experts, small investments - for example, in substitution technology - and will find out during the project if and how the concrete substitution succeeds," explains Mr Toropovs. SMEs with smaller substitution cases will also receive consultations and, potentially, small investments as an incentive to substitute.

"Introducing alternatives and substitution processes might seem costly and resource-consuming, but in the longer term they are often cost-efficient, especially when talking about replacing substances that face legal restrictions," says Mr Toropovs. "We plan to pro-actively promote replication by publishing successful cases, by media involvement, information days and direct contact with other enterprises."

Photo: Rita Norvaišaite

PRODUCTION

Developing metrics for the circular economy

The LIFE+ CEMs project designed and developed a set of indicators and a web-based tool that will enable Europe's businesses to assess their effectiveness in making the transition from a 'linear' to a 'circular' economy.

Many businesses are recognising that an economy based on a linear model of resource consumption presents higher risks, is more exposed to volatile resource prices and supply disruptions and generates negative externalities. A circular economy approach that aims to decouple economic growth and development from the consumption of finite resources helps mitigate risks from volatility in the supply and price of materials. For medium-lived complex goods this could equate to savings in material costs of some $630 billion per annum in the EU alone.

Major strides have been made in improving resource efficiency and exploring new forms of energy. However, less has been done in terms of systemically designing out material leakage and disposal and in measuring the circularity of products or processes.

In 2012, the Ellen MacArthur Foundation applied for LIFE funding to help deliver a project that would address a clear business need. "We knew that companies were setting up circular economy initiatives," says the Foundation's Stuart Whitman. "We knew that they were using metrics and tools in all aspects of their business, from product to design to reporting. We started wondering how companies were measuring circularity effectively. How were they benchmarking their products?"

The aim of the LIFE+ CEMs project (**LIFE12 ENV/UK/000966**) was to provide businesses with the means to measure their circularity.

The company CHEP is increasing the circularity of its main products thanks to the Material Circularity Indicator tool

Filling the gap

The first task was to develop a set of indicators. "We pretty quickly thought that we should focus on some specific aspects of circularity and materials flows," says Sven Herrmann, a project manager for the Ellen MacArthur Foundation.

The result was the Material Circularity Indicator (MCI), a tool that measures the extent to which a product or company's material flows are restorative. The indicators are focused on technical cycles and non-renewable materials. Complementary indicators allow additional impacts and risks - such as toxicity, scarcity and energy - to be taken into account where relevant (e.g. if a company uses a scarce or toxic material in its production processes).

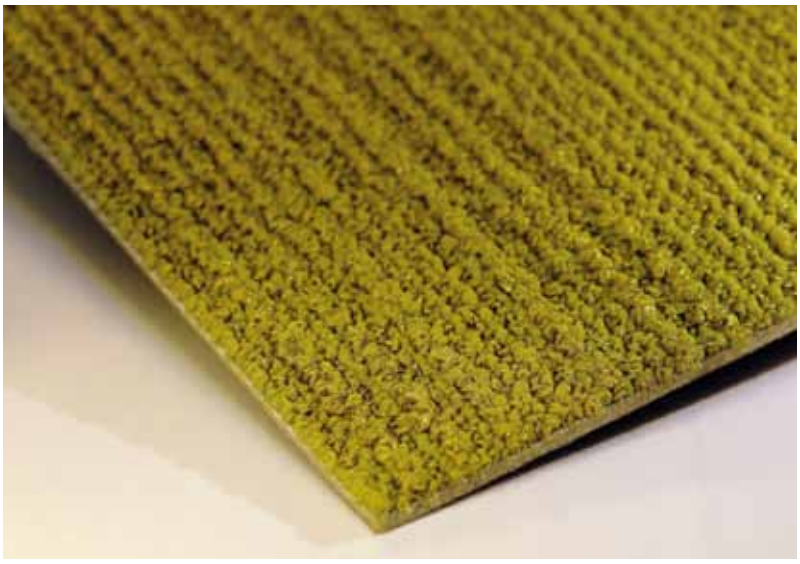
The methodology was developed in collaboration with leading European businesses, who provided product data to test (see box), and other stakeholders including universities and investors who worked with the project team to develop, test and refine the measurement system to ensure its robustness and relevance.

"We collaborated with an array of companies to show that the methodology could work with various businesses and products," says Mr Herrmann. "We also wanted to test it on products that were complex. For instance, for Nespresso and its coffee machine, there were many electronic components that needed to be itemised. Again we wanted the circularity to deal with that level of complexity," adds Mr Whitman, who managed the project.

How is product circularity calculated?

MCI is calculated as a score between 0 and 1: the closer to 1, the higher the circularity of the product. In order to determine the score, the following vectors are calculated: material inputs in the production process (e.g. virgin or recycled materials); utility during use phase (lifetime and intensity of use, taking into account durability of products, repair/maintenance and shared consumption business models); destination after use (landfill, recycling, component reuse); and efficiency of the recycling process.

Accurate scoring depends upon knowing all the materials and components used. The benefit for the business of providing this information is that the MCI gives a clear understanding of where the manufacturer can intervene in the product cycle in order to improve circularity.



Companies from a wide variety of sectors took part in the project: from Nespresso and Rolls-Royce to Desso, a producer of carpets

"One of the limitations that we found when trialling the tool with the companies wasn't so much about data security but data availability," says Mr Whitman, "There is still an issue of missing data in most companies, or issues of how to retrieve it within the units of a company. They are still reluctant to disclose information."

Businesses can also use optional complementary risk indicators that offer additional insights into potential risks in relation to business priorities (such as material price variation, material supply chain risks, material scarcity and toxicity). Complementary impact indicators show the effect of changing levels of circularity on other areas of interest, such as energy usage and CO_2 emissions.

Companies that took part in the project

Company	Product(s)
CHEP	EU Pallet
Cisco	Cisco UCS B420 Blade Server; N20-C6508 Chassis, 2 PS, fan module
Desso	Airmaster and Airmaster Ecobase® carpet tiles
Dorel	Baby buggies (two types); pads (two types)
HP	Ink cartridge
Kingfisher	14.4V drill driver; 18V hammer drill; plastic bucket
Nespresso	Pulse coffee machine for Nespresso capsules
Rolls-Royce	Compressor blisk (bladed disk); turbine blades

Circular companies

The MCI can also be used to measure the circularity of a company as a whole, by aggregating the score for a number of products. “In most cases it is not practical to undertake an MCI assessment for every single product a company produces,” explains Mr Herrmann. Instead, the company’s score is obtained by taking a weighted average for a list of reference products.

Complementary indicators for companies can either be built up in a similar way from product-level complementary indicators, or those already established at the company level, for example, using indicators from the Global Reporting Initiative (GRI) guidelines.

A new web tool

In order to increase the usefulness of the MCI, the LIFE project saw the Ellen MacArthur Foundation work with Granta Design to create a web-based tool for measuring circularity. The tool, known as ‘MI: Product Intelligence’ combines the Foundation’s methodology with Granta’s material intelligence database, which has data on material extraction and production. “We had the knowledge on the circular economy and Granta had the data/materials knowledge and database. So this partnership and combination was part of the secret to our success,” says Mr Whitman.

The MI: Product Intelligence web tool enables users to obtain information not only on product/company circularity, but also on material extraction, recycling rates and recycling efficiency. It can provide a list of alternative materials that could be used to achieve a higher circularity rate. “The system provides businesses with the tools required to track their progress in delivering a circular economy-based business model,” explains Mr Herrmann.

Companies can import, build and edit bills of materials for products or designs. And, by connecting the GRANTA MI database to their own database, the company can apply that data to its products and product designs and generate information on environmental, regulatory and supply chain risks alongside the Material Circularity Indicator. A range of complementary indicators can be used to assess other risks and impacts relating to material use, and to prioritise product improvements. “The company will receive an overall summary for the product as a whole, an initial breakdown for parts and sub-assemblies that are immediately below the product level, and a full breakdown for material components used in the product,” says Mr Herrmann.

An important aspect of the LIFE project involved assisting the participating companies to find the appropriate formula in order to raise their circularity, whether by changing materials, increasing the durability of a product, or other factors.

Stuart Whitman and Sven Herrmann - Ellen MacArthur Foundation

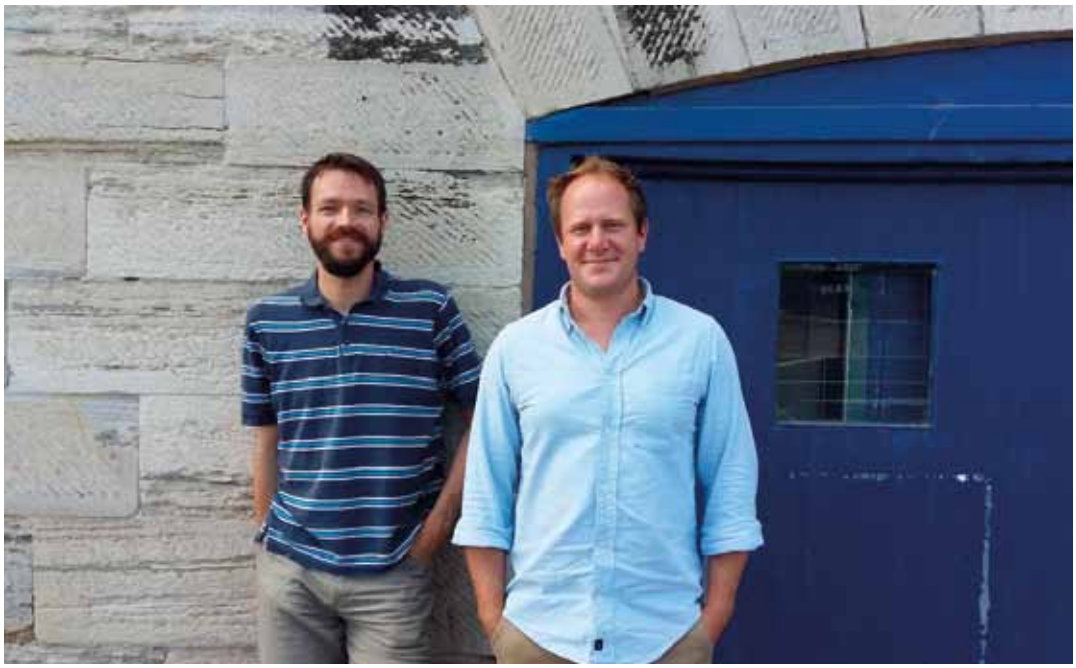


Photo: NEEMO EEIG/Gabriella Camarsa

CHEP's circular business

CHEP provides pallet and container pooling services for a number of industries, including aerospace, automotive and fresh food. "Our company pays great attention to the circular economy, and most importantly to being able to scientifically understand the circularity of our products and services," explains CHEP's sustainability director, Iñigo Canalejo Lasarte. "This was one of the reasons why we participated in the LIFE+ CEMs project."

For the project, CHEP tested the circularity of its main products, such as its wooden pallets, which achieved an MCI score of 0.87 out of 1. Mr Canalejo says that while the company's business model, which is based on the sharing and reuse of assets, shows that it is embracing the main drivers of the circular economy, there are, "ways to increase that circularity, such as increasing timber reuse ratios at our repair process for CHEP pallets." Other initiatives include the IFCO returnable plastic crate, which is used for fresh produce. This crate is made from broken returnable plastic crates, "taking product life extension and upcycling to a new level," says Mr Canalejo. "Higher recycling rates will also improve product circularity," he says.

CHEP believes that the CEM project's indicators now need to become a recognised global standard, in the same way that life-cycle assessment has become a standard for calculating a product's environmental impact. "That will allow us to also compare our results to those of other less circular alternatives in the market, further demonstrating the sustainable value we bring to our customers," concludes Mr Canalejo.

Wider use

One useful unanticipated outcome of the project's real-world trials was the discovery that there is a shortage of appropriate secondary raw materials in some segments of the economy. "There is a problem having enough feedstock for the circular economy to become a reality," explains Mr Herrmann. "We either have a situation in which the feedstock is present in low quantities or a situation in which it is readily available but low quality."

Whilst the MCI and MI: Product Intelligence web tool can help identify such barriers to circularity, the remedy requires cooperation along the value chain. "There is a need for more collaboration between the end-user of a product and the manufacturer...sectors and stakeholders need to work together to develop circularity," says Mr Herrmann.

The Ellen MacArthur Foundation is now using the MCI methodology to define standards for the circular economy in partnership with the British Standards Institution (BSI). "We view it as a baseline for organisations to take forward. The methodology is open and can be adapted to more businesses," says Mr Whitman.

Granta Design is continuing to develop and promote the MI: Product Intelligence web tool, which can also be used for procurement and investment decisions. Variants or extensions of the circularity indicators developed by this LIFE project could be used in education, research, rating or policy-making. For instance, one future use could be as a means to help policy-makers measure the circularity of a region or nation state, or to set targets for whole industries.

Project number: LIFE12 ENV/UK/000966
Title: LIFE+ CEMs - Circular Economy Metrics
Beneficiary: Ellen MacArthur Foundation
Contact: Stuart Whitman

Email: stuart.whitman@ellenmacarthurfoundation.org
Website: www.ellenmacarthurfoundation.org/programmes/insight/circularity-indicators
Period: 01-Jul-2013 to 30-Jun-2015
Total budget: €382 000
LIFE contribution: €191 000

CONSUMPTION

Making **consumption more sustainable**

The LIFE programme has helped support the circular economy by informing and encouraging consumers to make more sustainable choices and by providing them with clear information on products' environmental footprints. It has also facilitated green public procurement and promoted repair and reuse in place of waste.

The consumption decisions of EU citizens, businesses and governments can help or hinder progress towards a circular economy. These decisions are influenced by several factors, including the information available, the range and price of products on offer, and the regulatory framework in place. Price is a key factor in purchasing decisions. Consequently, the EU's Circular Economy Action Plan encourages Member States to provide economic incentives and use instruments such as taxation to ensure that product prices better reflect their environmental costs. Guarantees are also important since they protect consumers against defective items and can contribute to products' durability and reparability, preventing them from being thrown away.

Information is vital to enable consumers to make choices that support the circular economy. Labelling can be a useful source of information about

By addressing both production and consumption of goods and services, LIFE has helped to green the habits of EU consumers

Photo: LIFE10 ENV/IT/000404

a product's environmental credentials. However, when faced with a profusion of labels or environmental claims, consumers often find it difficult to differentiate between products and to trust the information available. In addition, some green claims may not meet the legal requirements for reliability, accuracy and clarity.

The EU Ecolabel is a voluntary scheme that identifies products with a reduced environmental impact throughout their life-cycle, from the extraction of raw material through to production, use and disposal. Recognised throughout Europe, the EU Ecolabel promotes environmental excellence that can be trusted. It is a voluntary scheme, which means that producers, importers and retailers can choose to apply for the label for their products. When developing EU Ecolabel criteria for products, the focus is on the stages where the product has the highest environmental impact, and this differs from product to product. In the textiles industry, for instance, fabrics have strong environmental impacts when they are dyed, printed and bleached. So, experts have designed the criteria for textiles to reduce harm at the manufacturing stage as much as possible. For detergents, the substances that go into the products are a priority. Other products, such as electronic equipment, have a very high environmental impact during their use phase, so the criteria focus on efficient energy consumption. In addition, product-specific criteria ensure that any product bearing the EU Ecolabel is of good quality with a high environmental performance.

Informed consumption

The LIFE programme has co-funded two projects - GREEN-PRO and PROMISE - that helped consumers identify green purchasing options when faced with a plethora of choices.

GREEN-PRO (**LIFE08 INF/RO/000507**) conducted a campaign to promote consumption of green products in the Bacau region of Romania, especially those conforming to the EU Ecolabel and other environmental schemes (such as EMAS, Energy Star and Carbon Neutral). Green products have less impact on the environment since they use fewer primary raw materials, reduce packaging and make use of recycled or renewable resources. Increased consumption of such products can therefore cut the amount of waste sent to landfill. GREEN-PRO aimed to help consumers better identify eco-friendly products as a first step to expanding the

Photo: LIFE08 INF/IT/000312

LIFE PROMISE raised awareness on EU Ecolabel products

market for these goods. First, the project conducted market research to identify available green products. It also produced a blacklist of items that are not environmentally friendly but could be perceived as such.

The project produced a TV spot that was broadcast on local stations in Bacau. It highlighted the environmental and financial benefits for consumers of using green products.

To further raise awareness, it created an online 'showroom' of 625 items with widely-recognised ecolabels, highlighting 20 as being particularly green. The website carried information about the products and about how to recognise and understand different ecolabels.

Finally, the project organised workshops and seminars for purchasers in public and private sector organisations, pointing out the financial benefits of green products.

The Italian project, PROMISE (**LIFE08 INF/IT/000312**) ran an information campaign aimed at boosting awareness and consumption of green household and agri-food items. This encompassed not only consumers (600 000 in total), but producers, retailers and public authorities as well. The project conducted surveys of each target group to identify information gaps and target communications campaigns accordingly.

In the case of consumers, this meant helping them to identify green products particularly ecolabelled products (they are figuring out ecolabelled products, don't change the meaning). The producer

campaign was based on demonstrating that investments in green products or certification could boost business, turnover and consumer satisfaction. Some 200 enterprises adopted ecodesign initiatives, while the involvement of 8 000 stores in the Coop supermarket chain led to a 19.5% increase in the presence of green products in those shops. Sales of green items rose by 21.1%.

Putting PEF to the test

The extraction/production and supply of raw materials or components tend to be the biggest contributors to a product's environmental footprint. However, for many companies, particularly SMEs, it can be hard to obtain the relevant data on the supply chain, particularly upstream.

Life PREFER (**LIFE12 ENV/IT/000393**) has used a cluster approach to overcome these issues and enable local businesses in Italy to adopt the PEF. This involves sharing a set of tools and resources with the participating companies to help them apply the PEF methodology and improve their environmental performance. According to project manager, Francesco Test, participating businesses "have the opportunity to get a life-cycle assessment of the flow of resources and waste that go through their gates, to identify the environmental hotspots of their production processes, carry out specific actions to reduce their impact on the environment and transparently communicate the environmental performance of the product on the market."

Thanks to Life PREFER, 38 companies have implemented the PEF and used the results to improve the environmental footprint of their products. For instance, by adopting new technology to reduce water use, redesigning production facilities or processes to cut their environmental impact, installing new low-energy lighting and introducing photovoltaic energy production.

Mr Testa notes that the PEF brings a range of socio-economic benefits to companies that adopt the methodology, including "cost reductions, for example through less energy consumption," an increase in skills and know how and improved market reputation, which can enhance overall competitiveness. PEF also brings new green job opportunities.

Life PREFER's approach is applicable elsewhere. Indeed, the project has already taken action to spread the PEF methodology and support tools for SMEs, promoting them in Romania and Spain, in the fields of tanning, textiles and wine.

Thanks to the project, some 300 local authorities increased their knowhow on suppliers, costs, ecolabels and preparing green public procurement (GPP) tenders. GPP increased by 15% among the participants, a follow-up survey revealed.

Certified green

In order for consumption of green products to increase, such products have to be on the market in the first place. LIFE has contributed to these efforts by co-funding projects that have helped achieve environmental accreditation for particular product groups, such as wines through Product Category Rules (PCRs) (see HAproWINE feature article, pp. 44-46) and rubber products made from end-of-life (EOL) tyres through the EU Ecolabel.

The DEPOTEC project (**LIFE10 ENV/IE/000695**) constructed a demonstration plant to recycle waste tyres using depolymerisation, making products that can be used as substitute carbon filler materials in the rubber manufacturing process. The project contributed to the development of a comprehensive series of environmental standards to facilitate the accreditation of products made from EOL tyres through the EU Ecolabel.

Around 3.2 million tonnes of used tyres are generated in Europe every year. The introduction of standards for products derived from these tyres is key to their recognition as an alternative energy source or secondary raw material. DEPOTEC found that while there is a considerable amount of legislation in place for the management and use of EOL tyres, the implementation and use of this legislation needs to be simplified to ensure high-quality new products can be safely made in the quantities demanded by the market.

The Product Environmental Footprint (PEF) is another avenue for helping consumers make choices that support the circular economy. The PEF has been developed under the Commission's Single Market for Green Products Initiative as a common way of measuring environmental performance. This harmonised metric incorporates a wide range of environmental criteria and uses a life-cycle approach, from the acquisition of raw materials to processing, distribution, use and end-of-life processes, as well as all the relevant related environmental impacts, health effects and resource-related threats. A LIFE project in Italy has tested PEF's effectiveness within different sectors (see box).

Influencing consumer choices

Changing consumer behaviour is an important aspect of transitioning to a circular economy. There are several ways to achieve this, from enabling consumers to opt for green products (including items with longer guarantees or that are reusable) to encouraging alternative forms of consumption, thus reducing waste generation. A number of LIFE projects have focused on shaping consumer behaviour.

For example, IDEAL 79 (**LIFE05 ENV/F/000063**) promoted sustainable consumption and reduction of waste in the Deux Sèvres region of France. A guide on how to purchase eco-products and services was distributed to 160 000 homes in the area; it contained vouchers for price reductions on numerous items and services to help persuade householders to make greener choices, as well as an example shopping list of green goods that cut the quantity and toxicity of consumer waste. Thirty-two stores committed to stocking these products in prominent positions on their shelves. The project increased sales of eco-products by 19% on average in large supermarkets. In addition, nine families took part in an 'eco-citizen' initiative, under which they bought green products and services that reduced the amount of waste they generated, thus acting as good examples for others to follow. After 12 months, the families' annual residual household waste production fell by 34% from 350 kg to 230 kg on average.

Changing consumer behaviour to prevent waste was the goal of the Finnish project, WASTEPrevKit (**LIFE05 ENV/FIN/000539**). It targeted a wide audience with a major information campaign, from day-care centres and schools, to vocational institutions, households, enterprises and the public administration in the Helsinki metropolitan area. The project published manuals and developed a web portal to disseminate information about waste prevention practices, whilst teaching materials were provided to schools and training institutions. By the end of the project, the amount of waste generated by offices and grocery stores was showing a downward trend.

Retailers and local authorities can play an important role in waste reduction The NO.WA project (**LIFE10 ENV/IT/000307**) ran an awareness-raising campaign in the Italian city of Reggio Emilia to encourage the buying and selling of recycled

Photo: LIFE05 ENV/F/000063

IDEAL 79 focused on activities that prevent household waste generation

products and those which use less packaging. It highlighted these products by displaying banners and labels in supermarkets. Such initiatives can provide cost savings for consumers, for example, by giving them the possibility of purchasing unpackaged (and consequently less expensive) items. They can also help retailers attract environmentally-conscious consumers, thus benefiting from their efforts to buy and sell low-waste products.

In Ireland, WISER LIFE (**LIFE13 ENV/IE/000763**) aims to influence consumers by highlighting the best practices in waste reuse and preparation for reuse. It expects to achieve this through the creation of an innovative centre in Ireland to demonstrate excellence in reuse at every level of interaction, supported by an eco-cluster of resource-efficient enterprises. This will be complemented by a '3-D textbook' education centre containing various teaching tools on sustainability which aim to persuade consumers to reduce resource consumption. The goal is to promote behavioural change with respect to waste generation, the use of natural resources and recognising the value of waste. The project plans to educate 4 500 people over three years, and many more afterwards, about a series of resource-efficiency themes and persuade 25% of visitors to the centre to change their behaviour.

Households are responsible for billions of tonnes of waste every year. The European Week for Waste Reduction (EWWR) project (**LIFE07 INF/F/000185**) and its follow-up Life EWWR+ (**LIFE12 INF/BE/000459**) have raised consumer awareness about waste prevention through various actions

focused on the '3Rs' - reduce, reuse and recycle. The European Week for Waste Reduction takes place every year, with people and organisations throughout Europe and beyond organising activities aimed at influencing the behaviour of citizens to cut waste generation. "These actions can take several forms, from the simplest one, such as convincing your neighbours to use 'No advertising' stickers on their mailboxes, to big awareness-raising campaigns. In 2015, more than 12 000 actions were implemented in the name of waste reduction, bringing the total number of actions to 61 556 since the start of the European campaign in 2009," says project and communication officer, Maëva Voltz.

Surveys show that most participants plan to continue actions to cut waste. Over 80% of those involved in the 2015 campaign said it has improved their understanding of the difference between waste prevention and recycling and that they would act in a more environmentally-friendly manner in future. The 2015 EWWR resulted in over 2 700 tonnes of waste being prevented. Long-lasting impacts are also expected in terms of behavioural changes as a result of the campaign.

Incentivising consumers to waste less

Economic incentives have proven particularly effective as a means of reducing the amount of household waste. For example, HEC PAYT (**LIFE07 ENV/GR/000271**) introduced a 'pay as you throw' (PAYT) system in Greece, the first in the country. The pilot involved 1 500 households in Elefsina. Equipment was installed on municipal refuse lorries to weigh the recycling and general waste bins of participating households, with fees dependent upon the amount of general waste produced.

European Week for Waste Reduction activities focused on the '3Rs' - reduce, reuse and recycle

Photo: LIFE07 INF/F/000185/IBGE-BIM

Aside from the environmental benefits, "it's a fairer waste-charging system," says project manager, Evangelia Makri. "Citizens pay municipal fees according to the garbage which they produce."

HEC PAYT, recognised as a Best LIFE Environment project in 2012, was highly successful: 25.8% of municipal waste was diverted from landfill, 56% of packaging waste recycled and 17.1% of organic waste composted. Each participant recycled 4.6 kg of waste electrical and electronic equipment (WEEE) on average. The project also provided guidance on how PAYT schemes could be implemented elsewhere in Greece, and in Estonia and Cyprus, where no such systems existed. Replicability depends on citizens buying-in to the concept (which may require an awareness-raising campaign) and on a "conducive policy framework in which the polluter's responsibility, waste avoidance and material recycling take priority," says Ms Makri.

WASTE ON A DIET (**LIFE11 ENV/FR/000751**) used both financial incentives and information campaigns to shape consumer behaviour. In September 2012, Grand Besançon in France became the first conurbation with over 50 000 inhabitants to adopt a PAYT scheme. Radio frequency identification chips were installed on residual waste bins, enabling the city to charge residents according to the quantity and weight of waste sent for incineration. However, 70% of the city's population lives in collective housing, where the cost of waste management is not billed directly to individual households, diluting the impact of the PAYT scheme. Consequently, WASTE ON A DIET carried out information campaigns to raise awareness about waste prevention in collective housing.

The transient nature of the collective housing population, along with significant social and cultural diversity, makes traditional communication tools less effective. Yet production of residual waste is highest in these households. WASTE ON A DIET targeted residents with campaigns explaining the PAYT scheme and related charges. Project staff overcame barriers by running practical workshops on waste reduction, covering themes such as shopping, preparing meals, redesigning clothes and furniture, and purchasing second-hand goods. The initiatives proved to be successful, with Grand Besançon seeing a 21% reduction of residual waste production in collective housing between 2008 and 2014 (from 267 to 210 kg/inhabitant/year).

Reuse hubs

Recycling and reuse levels of key household products, such as furniture, clothes and electrical equipment, are very low in urban housing estates in the UK. The REPURPOSE LIFE project (**LIFE13 ENV/UK/000493**) is taking steps to promote a culture of reuse in five housing estates in London, by supporting local social enterprises to create reuse hubs in redundant spaces in the heart of the estates. The goal is to enable the collection, repair and distribution of bulky items suitable for reuse, thus providing an alternative to illegal dumping.

"Five reuse hubs, each known as The Loop, have been set up in different ways - making use of underground garages, caretaker storage areas and even shipping containers," explains Richard Featherstone, reuse specialist adviser to the project.

The hubs offer a range of services including pre-booked doorstep collection, repairs, cleaning, sales and distribution of reuse products to the next owner. They also organise and participate in community events on the estates, "to promote reuse activity while also enhancing the messages about recycling and waste prevention," says Mr Featherstone. It is hoped such regular engagement and behaviour-change measures will tackle the root causes of fly-tipping and encourage positive environmental action.

The project has met some obstacles along the way, such as a lack of appropriate space for operating the reuse service as well as finding and retaining volunteers to help run each hub. In addition, balancing the plentiful supply of discarded furniture with those wanting to reuse it has been a challenge. "More efforts need to be made to increase sales by setting up a referral system with housing officers and social workers," says Mr Featherstone. "We also need to circulate reuse stock with the wider reuse network of projects in London and the charity shops in the locality."

"The reuse coordinators have to multi-task to address a variety of day-to-day priorities, not necessarily reuse related but inherent to the culture of the estates," explains project manager Rebekah Phillips, from coordinating beneficiary Groundwork London.

REPURPOSE LIFE will evaluate the different reuse initiatives set up during the project to see whether they provide economically-viable solutions. "The intention is to review the various scenarios to find a range of financially-sustainable solutions as a legacy for the project. We think viable reuse and recycling options will emerge depending on the size of the estate," Mr Featherstone concludes. At the end of the project, REPURPOSE LIFE will create a toolkit containing guidelines for other estates and collaborative economy projects, both in the UK and across the EU.

Photo: LIFE13 ENV/UK/000493

Benefits of collaborative consumption

Collaborative consumption is based on sharing, swapping, bartering, trading or leasing products and other assets, such as land or time. The positive effects include access for consumers to a broad selection of goods and services without the liabilities and risks associated with ownership. The environmental benefits include a decrease in the use of natural resources, energy and emissions (during both production and consumption stages), based on longer or more intensive use of existing products. The success of collaborative platforms can be challenging for existing market operators and practices, but by enabling individual citizens to offer services, they also promote new employment opportunities, flexible working arrangements and new sources of income. However, the collaborative economy often raises issues with regard to the application of existing legal frameworks, blurring established lines between consumer and provider, employee and self-employed, or the professional and non-professional provision of services. This can result in uncertainty over applicable rules, especially when combined with regulatory fragmentation stemming from divergent approaches at national or local level.

In June 2016, the Commission adopted the Communication "A European agenda for the collaborative economy". This provides guidance for Member States to review and where appropriate revise existing legislation so that consumers, businesses and public authorities can engage confidently in the collaborative economy.

Opportunities in GPP

Public procurement contracts account for approx. 14% of European GDP. As a tool for changing methods of consumption, green public procurement has therefore the potential to play a key role in the circular economy. The European Commission is developing GPP criteria for priority product groups such as transport, buildings and food & catering. They can be used by public authorities on a voluntary basis. The Commission plans to emphasise aspects relevant to the circular economy, such as durability and reparability, when setting out or revising GPP criteria in future. It will also support greater uptake of these criteria by public authorities and consider how green public procurement could be used more widely across the EU, in particular for products or markets with high relevance for the circular economy. Lastly, the Commission intends to lead by example, by ensuring that GPP is used as much as possible in its own procurement processes and by reinforcing its use in EU funding.

The LIFE programme has financed projects which provided guidelines and training for public authorities on how to prepare calls for tender incorporating GPP, including both GPPnet (**LIFE02 ENV/IT/000023**) and its follow-up, GPPinfoNET (**LIFE07 INF/IT/000410**). The 2002 project created a GPP network among the province of Cremona and 13 of its municipalities, promoting concepts such as closed-loop circles and developing guidelines on how to prepare calls. The project encouraged the development of criteria that take into account the characteristics of a specific product/service along its whole life-cycle.

Photo: LIFE08 INF/IT/000312

Greening public procurement is essential for a more sustainable EU economy

LIFE+Ecoedicion developed criteria for producing more sustainable printed material

Photo: LIFE08 ENV/E/000124

GPPinfoNET expanded on this work by establishing networks among the local public administrations of nine regions - six in Italy, and one each in Poland, Romania and Spain - with the aim of filling in information gaps and sharing the solutions and strategies necessary to overcome the obstacles to implementing GPP. In particular, it promoted the Integrated Product Policy (IPP) as a means of encouraging the development of a market for more ecological products and to raise consumer awareness. The project also indicated the primary tools to be used for promoting an IPP: ecolabels; Environmental Product Declarations; and Environmental Management Systems (EMAS or ISO 14001).

Another project, Leap (**LIFE03 ENV/UK/000613**) developed a toolkit consisting of eight different tools to help public authorities include environmental criteria in their procurement procedures. In addition, it produced criteria for evaluating building materials in terms of environmental impact on a scale from 1 to 5. This covered aspects such as raw materials, the building phase, the use phase, demolition and the interior environment.

The LIFE REBus project (**LIFE12 ENV/UK/000608**) set out to demonstrate how sustainability can be incorporated into procurement processes. Actions focused on both the supply side (companies) and the demand side (primarily government procurement) in

the Netherlands to determine how procurement policies can be used to stimulate demand for resource-efficient business models (REMBs). Through the government agency Rijkswaterstaat, it participated in the Green Deal on Circular Procurement, an initiative which encourages the purchase of goods produced in a more circular way. LIFE REBus supported REBM pilots run by companies involved in the Green Deal, which were expected to deliver the following cumulative benefits per annum: 5 000 tonnes of direct material savings; 20 000 tonnes of greenhouse gas emissions savings; and financial benefits of €12 million.

The breadth of items needed by public sector organisations means there is scope for very specific advice on green procurement. For instance, administrations publish lots of information leaflets, posters and brochures. The project LIFE+Ecoedición (**LIFE08 ENV/E/000124**) focused on developing and testing innovative procurement approaches to enable them to produce more sustainable publications. Life-cycle assessment (LCA) was used to calculate the environmental impact of printed material, focusing on typical publications from the regional government of Andalusia as an example. The project created a manual containing criteria for producing more sustainable printed material, focusing on factors such as paper and ink type. It also launched an ecoedition ecolabel to enable consumers to recognise publications that take environmental issues into account during their production life-cycle.

Boosting reuse and repair

Reuse and repair can extend the lifetime of individual products, thus reducing consumption and avoiding waste. The previous chapter highlighted the importance of ecodesign in avoiding unnecessary obsolescence of goods by making them easier to repair, upgrade or remanufacture.

To promote this, the Commission plans to emphasise the circular economy aspects of future design requirements under the Ecodesign Directive and to explore the possibility of establishing more product specific requirements in areas such as durability (e.g. minimum life-time of products or critical components), reparability (e.g. availability of spare parts and repair manuals, design for repair), upgradeability, design for disassembly (e.g. easy removal of certain components). Since 'planned obsolescence' practices can limit the useful lifetime of products, thus increasing consumption and waste, the Commission will initiate work to identify practices leading to premature obsolescence and consider ways to address them. In addition, the revised legislative proposals on waste include new provisions to boost preparation for reuse activities.

RCYCL set up a scheme for the collection and reuse of bulky waste under the auspices of a social enterprise

Photo: LIFE99 ENV/B/000640/Tim Hudson

Photo: LIFE99 ENV/B/000640/Tim Hudson

RCYCL's bulky waste collection and reuse scheme created green jobs and skills

Member States and regional and local authorities also have an important role in encouraging reuse and repair; some have already taken initiatives in this area.

A number of LIFE projects have promoted and facilitated repair and/or reuse, such as the already-mentioned REPURPOSE LIFE (see box, p.39).

In Italy, the PRISCA project (**LIFE11 ENV/IT/000277**) established waste reuse centres in Vicenza and San Benedetto del Tronto to increase the recovery and reuse of bulky waste. More than 60% of the incoming material at both sites was reused, thus cutting the flow of waste and goods going to landfill. Selected as one of the best LIFE Environment projects for 2015, it also carried out awareness-raising activities aimed at citizens living near the two sites, focusing on citizen involvement in waste management and sustainable consumption behaviour. The PRISCA model proved to be an economically-sustainable supply chain that supports waste prevention in the long term, integrating the second-hand product sector and the reuse supply chain into its solid urban waste management system.

Similarly, RCYCL (**LIFE99 ENV/B/000640**) set up a scheme for the collection and reuse of bulky waste in seven municipalities of Belgium's German-speaking community, under the auspices of a social enterprise. It introduced a range of services such as repair of furniture, electrical appliances and other household goods, toys and textiles, as well as reconditioning furniture seats and creating new products from recycled parts. The project combined social benefits with the environmental service delivered: it created 15 jobs directly and worked with employment services to train unemployed and disadvantaged groups in green skills, leading to employment for a further 100 people. "We recruit men and women, old and young, and we have people from all over the world working

PRISCA's reuse centres increased the recovery and reuse of materials

Photo: LIFE11 ENV/IT/000277

with us. These include people who were previously refugees and others who have had to deal with challenges that limit their ability to find work," says project manager Michael Mockel. "LIFE gave us the start we needed to prove that this type of environmental social enterprise was viable. Its success led to our RCYCL model being copied by other towns in Belgium. Thus the LIFE project was a key contributor to around 100 or more green jobs like ours overall," he explains.

Jobs and skills

Reuse and repair centres can also make a useful contribution to the EU's jobs and social agenda. The PRISCA project's two waste reuse centres created 16 jobs, some of which have become permanent. On the social side, by allowing the re-entry of used goods onto the market at lower prices than new items, the project ensured that those with lower incomes had access to them. REPURPOSE aims to create jobs for local people within the reuse hubs it has established in five housing estates in London. The project has developed a training programme tailored to three target audiences: housing and waste professionals; social housing residents; and unemployed social housing residents or those seeking a career in the reuse sector. The LOWASTE project increased employment by involving local companies in the market for recycled materials it developed in Italy (see box). In addition, disadvantaged people helped to develop and create products made from recycled materials, through local social cooperatives. The market provides a good basis for the emergence of new forms of entrepreneurship (e.g. start-ups, young cooperatives). Long term, it is expected to have an impact on the local economy, creating further new business opportunities and jobs.

Local markets for recycled products

The LOWaste project (**LIFE10 ENV/IT/000373**) aimed to reduce urban waste and preserve natural resources by developing a local market for recycled materials in Emilia-Romagna, Italy. Several methods were used to achieve these goals, such as promoting waste prevention and encouraging the use of recovered materials, as well as raising awareness of how waste can be cut through reuse or the purchase of recycled products, thus influencing consumption patterns. In addition, the coordinating beneficiary, the municipality of Ferrara, developed a green public procurement programme that linked buying procedures to the eco-design of products. For instance, using recycled aggregates for road construction and maintenance.

"The most important action was a contest - LOWaste for action - to create products with market appeal," says the project's external technical support manager, Alessandra Vaccari. "More than 70 designers, start-ups and other companies worked together with the local authorities to create new products from scraps and waste." This enabled the project to set up markets for so-called 're-products' in four categories - textiles, inert building waste, urban furnishings and play equipment, and food residues. Textiles were recycled to produce goods such as shoes, bags, furniture coverings and toys. Inert building waste was used as base material for roads, or mixed with cement in prototype panelling produced by a private sector building company. Urban furnishings and play equipment were refurbished or used for spare-parts storage, while food residues were collected in a local school and transformed into compost, which was reused in the school garden.

The re-products markets brought a range of environmental benefits, including: direct waste reductions of up to 11 400 tonnes per year; indirect resource savings due to the use of secondary raw materials of around 11 200 tonnes of raw materials per year; estimated reductions of up to 3 000 tonnes of CO_2 per year due to non-disposal of waste and the use of secondary raw materials; and a reduced water footprint of more than 230 000 m^3. Ms Vaccari says the LOWaste model is easily replicable elsewhere, "but the creation of re-products depends on the materials and resources available in each territory and on the presence of stakeholders that can enhance those materials."

CONSUMPTION

Establishing **a circular economy in the wine industry**

The HAproWINE project developed a methodology to establish if a wine has been produced sustainably, enabling consumers to make greener purchasing decisions. In an act of industrial symbiosis, it also showed that waste from the wine-making process can be transformed into a by-product with commercial uses.

Spain is an important player in the EU wine industry, in terms of the area of land cultivated, the quantity of wine produced and the sector's economic significance. With over 650 wineries, the Castile and León region in the north-west of the country is a major contributor. Although attempts have been made to improve the sustainability of the Spanish wine industry, more could be done.

The HAproWINE project was conceived to develop a more integrated approach to wine production and waste management, based on the entire life-cycle, and to provide sound information about the final products, in order to promote 'greener' wines to consumers. To that end, the project aimed to embed waste management and life-cycle assessment (LCA) tools in the Castile and León regional wine industry, reducing its environmental impact.

The main objectives were threefold: firstly, to encourage the supply and demand of greener goods, promoting products with lower environmental impacts, through ecolabelling, and providing consumers with accurate and scientifically based information; secondly, to encourage the recovery and recycling of winery waste, and promote the rational and sustainable use of natural resources with a life-cycle approach; and thirdly, to demonstrate industrial symbiosis by identifying the best by-products that can be obtained from wine waste.

Wine-making waste

The main residues from the wine-making process are grape pomace (representing 62% of the total weight), wine lees (14%), grape stalks (12%) and wastewater sludge (12%). The project aimed to

HAproWINE developed an integrated approach to wine production and waste management which included Product Category Rules

identify high value-added compounds within these waste streams that could be used for raw materials in other sectors, thus creating new economic activity and providing additional revenue for wineries as well as reducing waste. Such industrial symbiosis is a cornerstone of the circular economy.

HAproWINE focused on grape pomace since it accounts for most waste. This can be used by distilleries in the distillation process, but as the project coordinator Soledad Gómez explains, "We wanted to consider some other ways to use the grape pomace and, at the same time, obtain money from it and change the waste into a by-product." Initially, HAproWINE investigated the possibility of transforming the organic matter from the grape pomace into a biopolymer via enzymatic conversion. However, laboratory tests showed that the material produced did not have sufficient resistance for industrial use, whilst the volumes made would be too small to be cost effective for less demanding applications. "The yield from the process at the laboratory scale was too low for a feasible valorisation strategy at the industrial scale," says Ms Gómez.

Instead, the project looked at using the lignocellulose from grape pomace, stalks and trimming shoots to reinforce ordinary polymers. "After many tests we found that the waste can be used to reinforce polymers in such a way that the mechanical properties are improved for certain uses," explains Ms Gómez. This material could be used to make items such as some vehicle parts and urban furniture (e.g. benches). "The final product is attractive," she adds. "The plastic is full of tiny fibres of lignocellulose. You can get different colours and surfaces. But the most important thing is that you have a cheap and easy way to reinforce polymers, giving the plastic interesting mechanical properties."

The material is not being used commercially as yet, but Ms Gómez believes there are opportunities for wineries if the logistics can be put in place. "A system for the recovery of all the waste, its treatment and the production of the reinforced polymer needs working on before industry can use the material," the project coordinator explains. She suggests that wineries could work together to sell the waste to another company that then produces the reinforced polymer for sale to suitable industries. "That would be the circular economy in action," Ms Gómez points out.

Communicating sustainability

Another key action of HAproWINE was establishing a methodology to determine if a wine has been produced sustainably. Specific calculation rules were created for the methodology, called Product Category Rules (PCRs), which were developed for use when conducting an LCA of a particular wine. "Designing the PCRs involved a huge amount of research on the levels of the different environmental impact categories at 16 of the participating wineries," says Ms Gómez. The project also developed a new ecolabel to denote environmentally-responsible wines. Although it is not being used commercially at present, in future it could help consumers make greener purchasing choices.

The methodology combines the advantages of type I ecolabels (as defined by ISO 14024), which distinguish products with lower environmental impacts, and type III ecolabels (as defined by ISO 14025), which provide quantified environmental data for a product's life-cycle that is verified by a qualified third party. The project opted for this combined approach as the participating wineries had different needs. While exporters required more detailed information on the environmental impact of their production processes, as this is demanded by their clients, "others wanted something to show their clients and consumers that they are doing well in terms of environmental performance," Ms Gómez explains.

Wineries can apply the Product Category Rules to an LCA and produce a report detailing the information

The project identified best practices for 'greening' all phases of wine production: planting, bottling, cooling, etc

Tests proved that lignocellulose from grape pomace, stalks and trimming shoots could be used as polymer reinforcer in other industries

enabling them to obtain (through external verification) an Environmental Product Declaration (EPD), a type III ecolabel. In addition, wineries can use the information to obtain a type I ecolabel (through a new process of external verification), if they comply with the environmental criteria. "Wineries can also publish this EPD containing all the information they want to communicate to consumers," adds Ms Gómez.

Determining best practices

HAproWINE also used the information gathered for the methodology and other research to establish the best practices for the different stages of the wine production process - planting, fertiliser and pesticide treatment, frost protection, harvesting, processing, bottling, cooling, cleaning and racking, and waste treatment. "We identified all the techniques, methods and machinery used, and then studied their economic, environmental and technical characteristics to obtain a list of the best and the worst, in terms of sustainability," the project coordinator notes.

The findings were published in a document entitled *Good Practices Guide and Best Environmental Techniques for the Wine Sector in Castilla y León*. This provides guidance for wineries and winemakers, in the region and elsewhere, who want to improve their environmental performance. Some of the wineries involved in the project have expressed interest in investing in new technology to adopt better practices but need to find the funding to do so. A number have also already adopted the guide's recommendations on simple, less costly changes: "how they wash the plants, what they do with this water, how they add certain products or how they manage purchasing to make it more efficient," notes Ms Gómez. "Many small wineries found they could do things in a more efficient way. Some are even working together to buy materials or sell certain by-products," she adds. The project team has disseminated the guidelines widely, sending them to various stakeholders and the regional designations of origin to pass on to their wineries. "The publication includes factsheets summarising the best practices for every stage of the wine production process," says Ms Gómez, "It's really easy for wineries to use these."

HAproWINE has great potential for replication, both within Spain and elsewhere. The project coordinator stresses that, although the information to develop the methodology was obtained from wineries in Castile and León, the methodology is widely applicable. Indeed, the International EPD System, based in Sweden, has already produced its own PCRs for wine, based on those developed by HAproWINE, while the Spanish standards organisation, AENOR, "has also shown interest in applying our methodology for the EPDs it wants to do for wine," explains Ms Gómez.

The project has also seen interest in its methodology and circular economy approach to raw materials from other sectors, including mining experts in Spain and the forestry sector in Finland. "This shows that the methodology can be adapted to other industries," concludes Ms Gómez. "We demonstrated the circular economy concept can be applied to real life."

Project number: LIFE08 ENV/E/000143

Title: HAproWINE - Integrated waste management and life cycle assessment in the wine industry: From waste to high-value products

Beneficiary: Fundación Patrimonio Natural de Castilla y León

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Period: 01-Jan-2010 to 31-Dec-2013

Total budget: €1 509 000

LIFE contribution: €661 000

WASTE MANAGEMENT

Managing waste to close material loops

LIFE projects are demonstrating innovations in waste management to increase rates of collection, reuse and recycling and enable the closing of material loops. Projects are also developing cost-effective applications for secondary raw materials and addressing barriers to material recovery, such as hazardous waste and waste crime.

The transition to a more circular economy, where the value of products, materials and resources is maintained for as long as possible and waste generated is minimised, is essential for achieving the key EU objective of developing a sustainable, low-carbon, resource-efficient and competitive economy.

The EU waste hierarchy

The Waste Framework Directive (WFD - EU Directive 2008/98/EC) established the EU waste hierarchy to prioritise the preferred order for waste management: from prevention, preparation for reuse, recycling, energy recovery, down to incineration without energy

LIFE projects have increased recycling and upcycling rates enabling the closing of material loops

Photo: LIFE12 ENV/NL/000792/Gemeente Arnhem/Ivo Hutten

Circular Economy Package and waste

The Circular Economy Package proposes revised legislation concerning waste management. Key elements include:

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;
- A binding target to reduce landfill to a maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately-collected waste;
- Promotion of economic instruments to discourage landfilling;
- Improved definitions and harmonised calculation methods for recycling rates;
- Measures to stimulate industrial symbiosis, turning one industry's by-product into another industry's raw material; and
- Economic incentives for producers to put greener products on the market and support recycling schemes.

recovery or disposal by landfilling. This principle encourages options that deliver the best environmental outcomes. The WFD was revised in 2015 (COM(2015) 595), with more emphasis on waste prevention and reuse, and increased restrictions on landfilling.

Waste management plays a central role in determining how the EU waste hierarchy is put into practice, by helping to divert materials from disposal into material loops in order to create a circular economy. Methods for collecting and managing waste can either lead to high rates of recycling and to valuable materials finding their way back into the economy, or to an inefficient system where most potentially recyclable waste ends up in landfill or is incinerated. The latter case leads to harmful environmental impacts and significant economic losses.

The Action Plan for the Circular Economy (COM(2015) 614 final), which forms part of the EU Circular Economy Package, sets out measures to improve waste management aimed at stimulating the transition towards a circular economy (see box opposite).

Waste prevention and recycling

In 2016, only around 40% of the total waste produced by EU households was recycled. This average masks wide variation between Member States and regions, with rates as high as 80% in some areas, and lower than 5% in others. Recent and proposed EU legislation is therefore aimed at facilitating a long-term vision for increasing recycling and reducing the landfilling of municipal waste, while taking account of differences between Member States.

There is a need to increase recycling rates for all types of waste streams, in order to reach the targets set out in the Circular Economy Package (see box).

We have already highlighted LIFE's efforts to prevent the generation of domestic and commercial waste and to promote reuse and repair (see consumption chapter, pp. 30-39). Some of the most successful prevention projects - such as CREWSOD (see box) - have taken an integrated approach where they jointly address prevention and recycling.

Tailored waste collection

The CREWSOD project (**LIFE10 ENV/IT/000314**) addressed two levels of the EU waste hierarchy: prevention and recycling. It worked with the public to minimise the amount of waste produced by offering tailored waste collection services - Service on Demand (SOD) and Self-Service on Demand (SSOD). These flexible tariff systems enabled households to pay only for the weight and volume of waste they generate, which proved an effective incentive to reduce waste. The project actions were implemented in seven Italian municipalities, where they increased amounts of separated waste suitable for recycling, and reduced waste disposal by landfill or incineration.

The project showed it is possible to reduce landfill and operating costs for local authorities, with subsequent savings for users (estimated at 22% on average). By introducing traceability of waste, the system also reduced instances of illegal dumping.

Recycling airbags

Airbags are made from composite materials that are difficult to recycle. As a result, 9 000 tonnes/yr of waste generated by the European airbag industry currently goes to landfill. The Move4earth project (**LIFE11 ENV/FR/000748**) was set up to take advantage of growing demand for the polyamides used in airbags. It is demonstrating a novel process for recycling and reusing polyamides from silicone-coated airbag cushions, to deliver a new high-grade material (PA 6.6) with comparable properties to nylon (polyamides in the marketplace).

"The purpose of our innovation is to find a technical solution to separate the two different components of the fabric: the main fibre component and the coating," says project director Richard Bourdon. "The aim is to bring something new to the industry by being able to achieve such a separation." The technology combines mechanical and chemical processes, including fine grinding followed by a chemical activation stage. "Chemical activation is the use of a chemical to cut the adhesive between the fibres and the coating, so that they can be completely separated by centrifugal washing. This is very new, and there is a patent registered for the process," he says.

A pilot plant has been built at project beneficiary Solvay's facility in Gorzów (Poland), which will be operational by late 2016. According to Mr Bourdon, after demonstrating the process with airbags, Solvay plans to apply it to other post-consumer textile wastes (e.g. polyamide/elastane fabrics).

Economic viability will depend on several factors. "Post-industrial waste already has a commercial value and you pay more, but post-consumer waste represents an added-value to industry or society," explains Mr Bourdon. "In general, beside this aspect, you have several key drivers. The first one is capital investment. Move4earth would not have been possible without LIFE funding because it is the first pilot project and the technology is not yet optimised, and it would have to be much bigger to be commercially viable. Then a second very important driver is the cost to collect and prepare the waste before it can be recycled for such a process."

Major environmental benefits could result from the recycling of polyamides. Provisional data from Solvay's experts (yet to be independently certified) suggest that for the production of one tonne of PA 6.6, the carbon footprint is reduced (26%), and less energy (47%) and water (69%) are consumed, due to the waste being diverted from incineration and landfill. PA 6.6 is an environmentally-friendly alternative to nylon made from virgin materials. "We are looking at all markets selling nylon compounds," says Mr Bourdon, "The biggest one is the automotive market, then you have electrical and electronic devices, and many consumer goods, because nylon can be a good material with very high flame-retardant properties."

The impact of LIFE

The LIFE pÒrogramme has funded around 100 projects addressing waste recycling for different waste streams, such as glass, plastic, packaging, textiles, construction and demolition waste (CDW), municipal solid waste (MSW) and organic waste. A number of recent projects have developed technologies that not only recycle but also upcycle (improving the properties of the recycled material), thus ensuring a high-quality end product. In combination with product design that facilitates recovery and separation, this will help increase the amount of recycled material used in production (closing material loops).

Projects have developed technologies to produce new high-value products from a range of waste materials, including specialist textiles, wood and rubber, household plastics and hazardous waste. The Move4earth project has demonstrated a solution for separating composite materials, which is a particular challenge (see box).

Another innovative LIFE project carried out the first European demonstration of the use of plastic polymer waste in asphalt mixes for roads. POLYMIX (**LIFE10 ENV/ES/000516**) designed and validated four asphalt mixes, incorporating polyethylene (PE), polypropylene (PP), polystyrene (PS) and end-of-life tyres (ELT). These were used to construct sections of a demonstration stretch of heavily-used

Photo: LIFE10 ENV/ES/000516/NEEMO EEIG/Stephen Nottingham

POLYMIX demonstrated asphalt mixes containing polymer wastes

road near Madrid. The performance of the asphalt mixes was monitored over 18 months, compared to conventional asphalt, to test technical feasibility and economic viability. Construction of the trial road sections involved the recycling of 20 tonnes of polymer waste and savings on the use of 60 tonnes of aggregate, with associated reductions in greenhouse gas emissions and less waste going to landfill.

In addition to the environmental benefits, the best-performing POLYMIX asphalts also improve road durability. The demonstration road helped to confirm laboratory tests, showing that polymer waste increases resistance to rutting (plastic deformation) and enhances asphalt stiffness, so the road is able to better resist stress. This should reduce road maintenance costs and potentially enable the thickness of the asphalt to be reduced. On the strength of the demonstration, project partner Acciona, an infrastructure development company, is offering the technology to clients.

"POLYMIX raises the possibility of construction companies using local municipal waste polymers, so that each asphalt plant would have its own regional supplier," suggests Irune Indacoechea of project beneficiary, the University of Cantabria (UNICAN) in Santander. This would lead to plastic polymer waste being diverted from landfill on a massive scale as a secondary raw material, similar to what has happened with end-of-life tyres (ELTs). "Ten years ago there were few applications for ELTs, but that changed and there are lots of innovative uses for the material. Now we need to find more applications for other polymers," says Ms Indacoechea.

Upcycling waste

LIFE projects have demonstrated the upcycling of waste materials to create secondary raw materials for use in value-added products. For instance, by using an innovative wet-laid technology, WETCOMP (**LIFE10 ENV/ES/000431**) made several types of non-woven materials from textile waste at beneficiary AITEX in Valencia (Spain). Recycled fibre material, with mechanical properties similar to virgin fibre, was made into composites with technical applications (e.g. automobile parts). Some prototypes were shown to be competitive with existing commercial products and further markets are being explored, such as the agriculture and footwear sectors.

Also in Spain, the WOODRUB project (**LIFE09 ENV/ES/000454**) developed recycled wood and rubber prototype panels, with different compositions of wastes and adhesives, for a range of applications, including acoustic panels, roadside barriers, pathways and interior partitions. Acoustic, thermal and mechanical properties of the composite materials

are in line with international standards. Not only can the recycled panels substitute for virgin materials, they also need less energy to manufacture (as a cogeneration power plant is fed with residual wood). According to coordinating beneficiary AIDIMA, each 1 m^2 panel uses about 900 kg of waste.

If scaled-up, both WET-COMP and WOODRUB have the potential to divert considerable amounts of waste from landfill, with subsequent reductions in water, air and soil pollution, as well as reducing operating costs associated with landfill fees and generating new revenues.

Municipal waste collection

The Circular Economy Package sets a target for recycling 65% of municipal waste by 2030. This forms part of a long-term vision, initiated by the Waste Framework Directive, for the sustainable management of MSW to reduce amounts sent to landfill. Initiatives to increase recycling rates for waste from households and industry, however, are often constrained by administrative capacity, a lack of investment in separate collection and recycling infrastructure, and insufficient use of economic instruments (e.g. landfill charges or pay-as-you-throw schemes). EU legislative proposals on waste management take into account these obstacles, by combining long-term and interim targets with the possibility of time-extensions and technical assistance for countries facing the biggest challenges in stepping up separate collection and recycling systems.

LIFE projects have contributed to EU municipal waste management objectives by developing better collection systems, raising awareness and increasing public participation in separate waste collection and recycling schemes. They have also pioneered the use of economic incentives to increase reuse and recycling rates, in line with the EU waste hierarchy (see box – incentivising 'reversed waste').

Incentivising 'reversed waste'

The Dutch project, LIFE ReWaCo (**LIFE12 ENV/NL/000792**), tested incentives to increase the amount of household waste collected from different types of housing. Trials took place in three neighbourhoods in Arnhem as part of a new cost-effective waste collection system called Reversed Waste Collection (ReWaCo). This system was designed with both positive incentives to encourage recycling and negative incentives to reduce disposal. Improved doorstep collections make it easier for households to put out separated wastes, though residual waste now needs to be put into underground containers installed by the project in the three areas (with access cards given only to target communities). A comprehensive monitoring programme recorded volumes and composition of recycled and residual waste.

Photo: LIFE12 ENV/NL/000792/Gemeente Arnhem/Ivo Hutten

According to project manager Geert Boonzaaijer, the system for the collection of separated waste materials is "proceeding exceptionally well in the neighbourhoods", with volumes of collected materials above target figures and residual waste volumes lower than expected. Surveys showed residents were generally positive towards the project, which continues to produce good results. "The amounts of paper, cardboard and plastic packaging material collected separately in the three trial areas are at the same level as in 2014. Also, in the additional neighbourhoods where ReWaCo has been recently introduced the results are good," says says Mr Boonzaaijer.

Local people were employed as waste coaches for six-months during the roll out of ReWaCo across Arnhem, and this was considered essential by the project team. "They were in the neighbourhoods on a daily basis, and regularly during the evening and weekend, to provide information about the separate collection of waste, check waste containers and identify abuse," explains Mr Boonzaaijer. "Enforcement must go hand-in-hand with the provision of good information about separate waste collection," he says.

The relative simplicity and familiarity of the ReWaCo system makes it ripe for replication. "In the Netherlands, already several municipalities are introducing the ReWaCo system; and many municipalities are studying the system, using the know-how and experience gathered in Arnhem," says Mr Boonzaaijer. In part this interest is driven by new national targets for domestic waste recycling. "Every effort must be made to prevent the depletion of raw materials and fossil fuels, with the ultimate aim of transitioning to a circular economy," he concludes.

Photo: LIFE10 ENV/GR/000610

ISWM-TINOS designed a waste management scheme for the Greek island of Tinos

Another project that sought to raise awareness and encourage separation of domestic waste took place in the Greek municipality of Tinos, on a small island in the Cyclades. ISWM-TINOS (**LIFE10 ENV/GR/000610**) designed and implemented a scheme for integrated solid waste management (ISWM) based on "evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities," says project manager Tasos Vidalis. "Our ISWM system included a flexible separate collection scheme for each type of recyclable – glass, metal, paper and plastic – as well as biowaste."

The dry recyclables went to a sorting centre, while the biowaste was anaerobically treated on the island to recover energy. The positive social acceptance of the scheme led to its expansion into four additional communities adjacent to the targeted area. Household recovery rates increased in the project area to 98% for glass, 79% for plastic and metal and 74% for paper/cardboard. "The application of the ISWM-TINOS system is best suited to municipalities located in distant or insular areas where transportation costs are high and space for service facilities is limited," concludes Mr Vidalis. The system could be widely applicable, however, given that 35% of Europe consists of remote regions.

An ongoing project in Greece is tackling source separation and treatment in remote areas by demonstrating a pilot technology for processing of different dry recyclables and organic waste, to recover end products of high quality and purity. The PAVEtheWAySTE project (**LIFE14 ENV/GR/000722**) is taking place in Olympia in the Peloponnese, the area with the most illegal landfill sites in Greece. Companies in the recycling industry will be engaged in a dialogue to ensure that the end products satisfy their market specifications.

Trialling PAYT

Economic incentives to increase recycling rates were trialled in the WASTE-LESS in CHIANTI project (**LIFE09 ENV/IT/000068**), which implemented a pilot strategy for waste prevention and sustainable waste management in the province of Florence (Italy). It encouraged waste prevention through the introduction of collection schemes, accounting systems for waste from individual households and 'pay as you throw' (PAYT) incentives. The project also created reuse centres to increase the recovery of material resources.

The project's greatest achievement was to integrate these schemes into a unified approach that is easy to implement and does not require intensive investments by local communities. WASTE-LESS in CHIANTI improved collection of separate waste and helped the project area reduce by 28% the amount of unsorted waste sent to final disposal, nearly double the 15% target.

PAYT has helped households benefit from lower refuse collection fees, while less waste to landfill means lower costs for local authorities. "The project approach also provides some relevant economic and social benefits at the local level in the pilot area. These are related in particular to the positive 'territorial marketing' effects of the economic activities (tourism facilities, cafés and restaurants, shops etc.) linked to the implementation and promotion of the 'waste-less' label," explains Orsola Bolognani, from project partner Ambiente Italia.

The WASTE-LESS in CHIANTI approach is being replicated by other Italian municipalities participating in the MED Zero Waste Pro project, which is supported by the European Regional Development Fund.

As a complement to the projects that have focused on improving the management of domestic sources of MSW, the Spanish project, Waste Joint Management (**LIFE08 ENV/E/000132**) designed a collection system specifically for industrial waste. This system was implemented in the Zona Franca Industrial Estate in Barcelona. Initially voluntary, the system was made compulsory two years into the project to ensure its viability. Marked improvements were subsequently recorded for the amount of waste separated at source (up from 35 to 44%), in the quantity and type of materials recycled, and in the environmental impact of waste collection. Moreover, the companies involved benefitted from a better service and lower costs, and the amount of waste disposed of in landfill was reduced.

PAYT has helped households benefit from lower refuse collection fees

Photo: LIFE09 ENV/IT/000068

Photo: LIFE09 ENV/IT/000068

WASTE-LESS in CHIANTI installed water dispensers to reduce the use of water in plastic bottles

A key outcome was establishing an agreement whereby the companies were obliged to use the PLATAFORMA system for managing their wastes, which selects the most sustainable transport and the best option for its disposal. By coordinating and supervising the correct treatment of waste, the project created the necessary synergies to optimise waste management, while helping to match certain waste materials with new users in line with circular economy principles.

Hazardous waste

A particular concern when increasing rates of reuse and recycling is the inclusion of material contaminated with hazardous substances. The revised Waste Framework Directive notes that the constant re-injection of hazardous substances into material loops is incompatible with the transition to a more circular economy, because contamination would accumulate and result in recycled materials being inferior to primary raw materials. For this reason, the WFD states that hazardous material extraction should be a systematic part of the treatment process. The Circular Economy Package demands information on the hazardous content of products to improve traceability for chemicals of concern across value chains, especially for plastics.

In principle, hazardous substances should be prevented from accumulating in closed material loops by avoidance or substitution at the product design and manufacturing phases. LIFE has funded projects on chemical substitution (see the production

Making plastic waste less hazardous

The LIFE EXTRUCLEAN project (**LIFE13 ENV/ES/000067**) has developed an innovative technique to remove hazardous substances from plastic waste, based on the use of supercritical carbon dioxide (sc-CO_2), which is added to the melted plastic during the extrusion process. "Carbon dioxide in a supercritical state can diffuse easily into the polymer melt, taking out the hazardous contaminants," says Rosa González Leyba of project beneficiary AIMPLAS. The project demonstrated that the technology removes about 70% more hazardous contaminants than conventional 'triple washing and rinsing'. By eliminating two of the three washing and rinsing stages, the new process saves time, labour, water, chemicals and energy. In addition, less wastewater is generated at the end of the process, reducing subsequent water treatment costs. The EXTRUCLEAN technology is much more cost-efficient than traditional processes, and the implementation costs paid for themselves in a short time

"The recycled polyethylene decontaminated by this new technology shows improved properties compared to traditional recycled material, such as less odour and better mechanical properties," explains Ms González. This will enable it to be used in higher added value applications, such as packaging dangerous goods.

"The new technology can be transferred to other plastics recycling companies, by defining and performing the corresponding adaptions in the extrusion process to incorporate the use of supercritical carbon dioxide," says Ms González. "In this way, replication of the project results at the European level is possible."

chapter pp.20-29). However, substitution is not always possible, such as when plastic containers are used to store solvents or other potentially-hazardous chemicals. Contaminated plastic must be 'upcycled' before the recyclate can be reintroduced it as a secondary raw material. The LIFE EXTRUCLEAN project has adopted this approach to bring contaminated plastic back into the material loop (see box).

Many industrial processes generate hazardous waste materials that are landfilled or incinerated because they are too toxic to recycle; yet these wastes can contain potentially valuable materials. To date, LIFE has funded relatively few projects addressing the recycling of hazardous waste to recover secondary raw materials for reinjection into production cycles. One exception is the Swedish project, HYDROFLUSS (**LIFE10 ENV/SE/000042**), which demonstrated the recycling of filter cakes (pickling sludge), a waste product of steel-making that usually goes to landfill because it is considered too hazardous to treat. The project assessed the feasibility of recovering fluorspar (CaF_2) from the filter cakes, for reuse in place of virgin minerals.

When steel is made from scrap material in an AOD-converter, fluorspar is added to facilitate a reduction in carbon and an improvement in the metal's properties; but fluorspar is extracted from mineral deposits in China and Mexico and its availability is limited. The project heated the filter cakes to 1 000 °C to form a hard black solid, which was given the name hydrofluss. "The main innovation was to use thermal vacuum drying technology, traditionally used for treating contaminated soils, by docking the adjusted equipment to an existing plant for treating hazardous waste," says project manager Thomas Von Kronhelm.

As long as the market price for virgin fluorspar remains lower than the cost of producing hydrofluss, "commercialisation of the process will be difficult," says Mr Von Kronhelm. Nevertheless, he believes that in the long term the technology has the potential to replace more than 60% of the virgin fluorspar used in the steel-making process, with reduced amounts of waste going to landfill, reduced long-distance transport and dependence on imported minerals, and increased employment opportunities in the recycling industry.

Next steps for packaging waste

The revised Waste Framework Directive includes higher recycling targets for packaging materials in the commercial and industrial sectors. The recent revision of the Packaging and Packaging Waste Directive, meanwhile, has focused particularly on the consumption of lightweight plastic carrier bags. The Circular Economy Package calls for the recycling of 75% of packaging waste by 2030.

More domestic and commercial packaging waste has been recycled since the introduction of stricter EU-wide targets for paper, glass, plastic, metal and wood packaging, but there is potential to increase rates further, with economic and environmental benefits. A cluster of LIFE projects aim to increase rates of recycling for packaging and to develop more sustainable packaging materials, which will help close material loops and further the green restructuring of the packaging industry.

To remove barriers that were preventing increased recycling of packaging waste in Greece the RECYCLING SYMPRAXIS project (**LIFE07 ENV/GR/000265**) developed collection schemes in a public-private partnership involving 118 participating tourism businesses. This led to the collection of nearly 100 tonnes of glass, paper, plastic and metal packaging waste, an estimated increase of 20% in the recycling rate for these valuable materials.

Paperfoam (**LIFE99 ENV/NL/000232**) and RenewPACK (see box) both focused on developing biodegradable materials for packaging. The Paperfoam project developed a new biodegradable and recyclable packaging material, which it successfully marketed. An innovative one-step process based on injection moulding is used to make the material from all-renewable resources, such as industrial starch and natural fibres. The modular nature of the technology means that only a relatively modest investment is needed to start a Paperfoam production line, and capacity can be increased incrementally. The project's pilot demonstration showed considerable energy and CO_2 emissions savings, compared to conventional packaging production lines, and soon led to orders from five international companies. According to Mark Geerts, CEO of coordinating beneficiary Vertis B.V., the biggest barrier to gaining market share was industry resistance to an 'unknown' material.

This was gradually overcome, with the result that a separate entity (Paperfoam B.V.) was established, which by 2013 was employing around 50 people. Mr Geerts explains that the company linked up with universities, where students conducted projects with the new material. This resulted in the company employing several people from those institutions with the necessary skills for the new jobs created as a result of the LIFE project.

The Green Waste Plast project (**LIFE09 ENV/FR/000603**) demonstrated the environmental and economic benefits of recycling 'blister' packaging, a type of lightweight plastic packaging which is normally incinerated or landfilled at end-of-life. For further details see the priority sectors chapter, pp.73-88.

Paperfoam produces biodegradable packaging material made using industrial waste materials

Photo: LIFE99 ENV/NL/000232/NEEMO EEIG/Justin Toland

Waste electrical and electronic equipment

The Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU), and other EU legislation, encourages the recycling of electronic waste through mandatory targets.

Better product design is essential to improve the economic viability of the recycling process for WEEE (see production chapter pp. 16-25). Other barriers to overcome include insufficient collection of WEEE, insufficient information exchange between manufacturers and recyclers of electrical and electronic products, and a lack of data for economic operators on the potential for recycled critical raw materials.

LIFE projects have addressed the recycling of WEEE through different approaches, including information campaigns, the promotion of take-back schemes and public participation in WEEE recovery, recommendations for manufacturers and recyclers, the development of innovative techniques for the recovery of critical materials, and the creation of new economically-viable markets for recovered materials.

Critical raw materials (CRMs) are commonly used in small amounts in electronic devices but very little is recovered. The CRMRecovery project (**LIFE14 ENV/UK/000344**) aims to demonstrate viable approaches to increase the recovery of target CRMs found in WEEE by 5% by 2020, and by 20% by 2030 (for further details, see the priority sectors chapter - pp.77-92).

To increase WEEE recycling rates in Slovenia, a LIFE project focused on raising the awareness of young people with an innovative travelling exhibition. The Slovenian WEEE campaign (**LIFE10 INF/SI/000139**) visited over 200 schools with the 'E-Transformer', a lorry converted into an education centre filled with multimedia and other exhibits. The idea was that educating children would have a multiplier effect, as they act as ambassadors. The campaign also reached 89 of Slovenia's 200 municipalities, through open days and other events. The project's influence meant that more than 540 tonnes of electronic waste was collected. The E-Transformer is still on the road, and the project's approach has been transferred to neighbouring countries (Bosnia and Herzegovina, and Romania).

Using grain husks to add value to packaging

The RenewPACK project (**LIFE11 ENV/SE/000842**) is demonstrating the application of a new biodegradable material in food packaging for the first time. Xylophane, the project's coordinating beneficiary, makes the material under the brand-name Skalax®, using renewable resources. A thin layer of Skalax inside multilayer packaging (e.g. sprayed or coated inside foil or paper) has been shown to form an effective barrier against oxygen, grease, aromas and mineral oil, thus extending the shelf-life of foodstuffs.

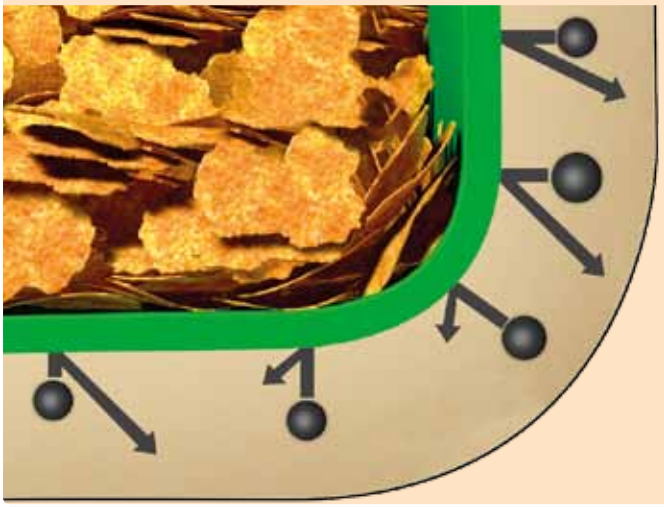


Photo: Xylophane AB

"Skalax is based on polysaccharides from the plant kingdom plus renewable and biodegradable additives," says Lisa Bindgård of Xylophane. "The natural polysaccharide xylan, one of the raw materials, can be derived from grain husks. This is today a low value by-product, which is incinerated or used as filler in animal feed." The project is demonstrating an innovative process for producing xylan from grain husks, which will provide a high-value alternative use for this underexploited resource and enable agricultural communities to diversify their income streams.

The new packaging is made to be fully biodegradable, by combining Skalax with biodegradable plastics, paper or board. It can substitute for non-renewable barrier materials, such as the synthetic plastic EVOH and aluminium foil. "Skalax provides a sustainable alternative to oil- and metal-based barrier materials," explains Ms Bindgård. "This offers packaging solutions to food producers and consumers that can easily be taken care of in national recycling systems."

Paper and board mills can add gas-barrier properties to packaging during the production process, potentially leading to "new markets for paper products and higher profitability," says Ms Bindgård. Typical end uses would be for oxygen-sensitive food products, such as snacks, dehydrated sauces and soups, as well as spices.

In Portugal, ELECTROVALUE (**LIFE07 ENV/P/000639**) demonstrated improvements in the recovery, reuse and recycling of WEEE, especially printed circuit boards (PCBs). The project set-up a pilot-scale disassembly centre to build and assess refurbished PCBs at the facilities of associated beneficiary INTERECYCLING in Santiago de Besteiros (Portugal). Of the 27 PCB components analysed, eight showed favourable cost reductions compared to new components. The reuse and resale of these components represents a business strategy with a significant potential for success, with SMEs being the target market.

However, labour costs for de-soldering were found to be decisive, especially when the cost of new components is still very cheap. The project's LCA analysis showed that the reuse of electronic components decreases environmental impacts between 12% and 36%, particularly through reduced landfilling, and the reduced need for precious metals and rare earth elements that are associated with environmentally-damaging mining operations in non-EU countries.

LIFE RE-WEEE (**LIFE14 ENV/GR/000858**) is focusing on recovering elements from WEEE and establishing reuse centres. The project is drawing up guidelines and recommendations to influence policy in Greece at all levels (retail management, local authorities, national and EU), alongside the use of best available techniques to develop technical requirements and specifications for the entire 'preparation for reuse' cycle.

Photo: LIFE14 ENV/UK/000344

Electronic products contain valuable critical raw materials

"The development of the requirements includes the evaluation of existing and developed standards in different European countries, and the composition of a set of technical requirements that could be implemented for the entire WEEE management chain in Greece," says project manager Haris Angelakopoulos. "Following the results assessment, a proposal document will be submitted to the competent authority, the Ministry of Environment and Energy, to be adopted into the legislation framework, and the developed technical requirements will be made available to other EU countries."

End-of-life vehicles

Every year, end-of-life vehicles (ELVs) generate between 7 and 8 million tonnes of waste in the EU.

The mobile E-transformer - an education centre - has visited many schools in Slovenia

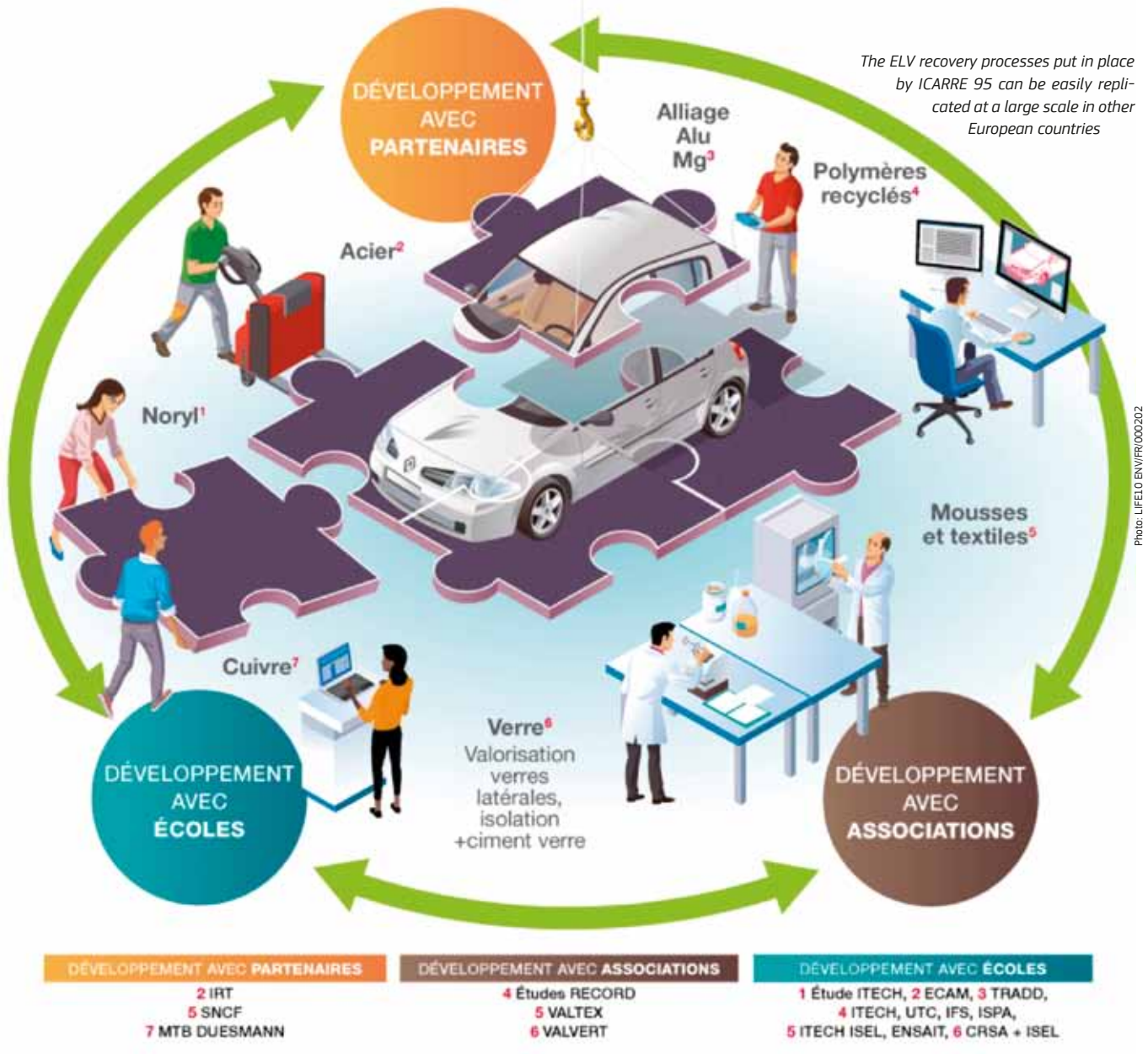
Photo: LIFE10 INF/SI/000139

The ELV Directive (Directive 2000/53/EC) aims at preventing the production of waste from vehicles and their components and was revised in 2015 with the aim of making the dismantling of ELVs a more efficient and environmentally-friendly process. It sets ambitious targets for reuse and recovery of ELVs of 95% by weight (10% of which can be achieved by energy recovery from the combustion of non-recyclable residues and 85% by reuse and recycling).

A typical car consists of ferrous and non-ferrous metals, polymers and composites, operating fluids, electronics and other diverse components. Therefore, ELVs represent a high-value waste stream, which has been specifically targeted in EU policy to prevent raw material leakage. For instance, with reference to ELVs, the Circular Economy Action Plan states that "innovation in plastics can contribute to the circular economy by improving the recyclability of plastics or reducing the weight of materials used in vehicles".

The material that remains after metals have been recovered from ELVs is known as automotive shredder residue (ASR) or 'car fluff'. ASR typically consists of glass, fibre, rubber, automobile fluids, plastics and dirt and typically it is landfilled. Finding ways of recovering ASR for use as a cost effective secondary material is necessary to achieve the new recycling targets for ELVs.

LIFE projects are making an important contribution to this task. The AUTOPLAST-LIFE project is



The ELV recovery processes put in place by ICARRE 95 can be easily replicated at a large scale in other European countries

Photo: LIFE10 ENV/FR/000202

developing innovative techniques to recover and recycle specialised plastic waste from ELVs (see box), for instance, while the projects LIFE CARWASTE and PST (see feature article pp 59-61) have demonstrated new post-shredder technology for mechanical sorting, to help bring the overall ELV recycling rate up to 95% by weight.

Material recovered from ASR could be re-used in cement and steel plants. To this end LIFE CARWASTE (**LIFE13 ENV/IT/000185**) has built a pilot plant in Ponte di Piave (Italy) that is capable of separating finely shredded (1.5 to 70 mm) material from ELVs. This fraction, called 'waste dust', is being processed into a fuel rather than being landfilled. The new process involves the use of filtering rotary valves, to separate the dust from the air, a centrifugal machine to eliminate metallic pollutants, and an 'airgrader' to extract very clean fluff. The process is constructed using a modular approach, so that it is replicable in other locations.

Taking a different approach, ICARRE 95 (**LIFE10 ENV/FR/000202**) provided solutions for increasing the recovery of parts and materials from ELVs that were previously recycled poorly or not at all. To achieve this, the project developed 'short loops' that established links with potential customers for specific recovered materials. "ELV recycling in France is an extremely dispersed activity which relies on a lot of small, highly specialised companies,"

Recovering plastic waste from ELVs

The AUTOPLAST-LIFE project (**LIFE13 ENV/IT/000559**) is developing a system for the recovery and recycling of special plastic waste from the automotive sector. The project is building a 3 000 tonne/yr pilot plant to treat polypropylene (PP) from scrap car bumpers and high-density polyethylene (HDPE) from vehicles' fuel and oil tanks.

The coordinating beneficiary VALSIR SpA is working with the waste collection cooperative, CAUTO, to create a network for the collection, selection and recovery of special plastic waste from ELVs in the Italian province of Brescia and surroundings. The network of garages and mechanics will supply the scrap bumpers and tanks.

At present, only around 10% of HDPE scraps from fuel and oil tanks can be used to produce new plastic granulate. At higher quantities, a residual petrol/oil smell is noticeable. The LIFE project is piloting a process to replace commercial additives with sodium bicarbonate ($NaHCO_3$) to provide better hydrocarbon adsorption performance, and the use of finely-ground coffee dregs (obtained from businesses) to neutralise odours from the tanks' cleaning waters. "The innovative recycling process implemented within the AUTOPLAST-LIFE project allows a remarkable reduction of smell and an increase up to 30% of granule quality, thus allowing an increase of the recycled HDPE granulate that can be mixed with virgin raw material," explains VALSIR's Andrea Sbicego.

"The recycled plastic granulate can be used by a lot of plastic product producers who use HDPE or PP. The quality is good," says Paolo Colombi of project partner CSMT Gestione. The collection network established in Brescia could easily be replicated elsewhere, indicating scope for a widespread impact after LIFE.

says Christophe Garnier, head of the Circular Economy Project at coordinating beneficiary Renault. "The ICARRE 95 project helped infiltrate this milieu, gain insight into how it works, propose changes in terms of good practices and test processes which are now operational with a view to providing effective/optimal solutions for the recovery of materials from ELVs," he explains. The project demonstrated new routes to companies using 'real size' batches of ELV parts in France, with an emphasis on creating processes that can easily be duplicated in other European countries.

ICARRE95 rolled out procedures for better and more cost-effective dismantling across project partner INDRA's network of 400 ELV centres. The project then demonstrated the 'short loops' approach for plastics and catalytic converters, in partnership with SYNOVA and DUESMANN respectively. This led to two grades of recycled polypropylene developed during the project being listed as authorised plastics for the making of panels in Renault cars. Finally, it established a network of over 50 contributors able to provide ELV parts for recovery.

With an overall material recovery rate of 88.6%, The ICARRE 95 project has exceeded the 85% goal of the Circular Economy Package. "We have demonstrated that a manufacturer could provide the industry with new tools and outlets which not only help increase end-of-life vehicle recycling rates but also generate new income which justifies the proposed investments or implementation of new practices," says Jean Phillipe Hermine, VP of Renault Environment. If the project's outcomes were applied to the 1.15 million ELVs treated in France in 2013, it would save 19 400 tonnes of raw materials and see 73 144 tonnes of waste diverted from landfills.

ICARRE 95 has provided solutions for the recovery of parts and materials from ELVs, exceeding legislative targets

Photo: LIFE10 ENV/FR/000202/Yannick Brossard

Waste to energy

The EU waste hierarchy indicates that the preferred disposal method for waste that cannot be prevented, reused or recycled, is to burn it for energy, rather than landfilling it. To this end, a 'waste to energy' initiative is being adopted within the framework of the proposed European Energy Union. This will help optimise environmental and economic benefits, and facilitate synergies with EU energy and climate policy. The focus will be on exploring how energy recovery processes can be optimised, without compromising the achievement of higher reuse and recycling rates, and how the energy generated can be best exploited.

Many LIFE projects have helped transform waste into energy resources, mainly for local use and to help power the energy production process itself. These projects have become even more relevant with the adoption of Circular Economy Package. Three projects in particular have applied the principles of the waste hierarchy by producing energy from agricultural and municipal waste streams.

In Greece, SMARt-CHP (**LIFE08 ENV/GR/000576**) demonstrated a mobile combined heat and power (CHP) unit that utilises agricultural residues from rural areas. The mobility of the CHP plant, which uses biomass gasification, enables it to be located close to feedstocks (primarily peach, olive, grape and pomegranate residues), crucially minimising transportation costs and emissions, as well as offering farmers a potential new revenue stream. Professor Anastasia Zabaniotou from the Aristotle University of Thessaloniki, the project beneficiary, says that use of all available agricultural by-products from rural areas could replace 10% of the energy generated by first generation biomass, increasing the amount of land available for food use.

Also in Greece, LIFE ENERGY-WASTE (**LIFE09 ENV/GR/000307**) designed, installed and operated a gasification unit in an urban waste recycling factory, to produce refuse-derived fuel (RDF) and solid recovered fuel (SRF). The project's innovation

was in its integration of state-of-the-art recycling, gasification and biogas technologies, and the establishment of network of stakeholders involved in various stages of the RDF/SRF utilisation chain. After identifying the main material streams generated in the treatment process at the WATT Material Recovery Facility at Ano Liossia, it was estimated that 85% of the non-recyclable fraction had thermal capacity. Pilot tests with RDF from this facility were made into pellets by associated beneficiary CERTH. A feasibility study and life-cycle assessment showed that, with some scaling up, the energy acquired from the utilisation of RDF would be sufficient for the gasification process. The project team concluded that gasification technology is financially feasible in large-scale plants.

A pilot plant in Catalonia built by the LIFE project DEMONSTRATION OF KDV TECH (**LIFE09 ENV/ES/000484**) is capable of treating up to 30 000 tonnes/yr of the non-recyclable fraction of mixed municipal waste. The process involves shredding the waste, mixing it with mineral oil and applying catalytic depolymerisation to convert it into synthetic diesel (known as DieselR).

Fluidisation was a key project innovation, enabling a wide range of waste material to be processed. In addition to diverting 40 000 tonnes/yr of urban waste from landfill, the project produced up to 15 000 tonnes/yr of alternative fuel with implied an annual reduction of 44 000 tonnes of CO_2, thus contributing to the Renewable Energy Directive's climate change mitigation and biofuel production goals.

DieselR was used to generate electricity in wastewater treatment plants (though additional treatment to reduce its sulphur content could make it suitable for vehicles). Two-and-a-half years after the project's completion, the catalytic depolymerisation plant operated by project beneficiary Griñó Ecologic was treating the whole non-recyclable waste stream of the municipality of Torredembarra, and also waste streams from the county of Alt Camp and the Ecoparc of Barcelona. A key factor favouring uptake of the technology has been increased landfilling costs. The technology consists of modular units that are easily installed and upscaled, and replicable in other EU Member States. Numerous public and private entities have shown interest in adopting the project's approach, including some of the main waste management companies in Spain.

Photo: LIFE09 ENV/GR/000307

Non-recyclable waste streams can have considerable thermal value

Tackling waste crime

Waste streams persistently attract criminal operations that profit at the expense of the environment, and legitimate operators in Europe's waste industry. These illegal practises, which can undermine waste management and circular economy objectives, are ever-changing and often obscured from view. The illegal exporting and dismantling of cars, for instance, is a major problem for automotive recyclers, undermining legitimate operators and representing leakages from material loops. For environmental and partner bodies, there are significant gaps in understanding how illegal markets behave and how to tackle criminal behaviour. This poses a major challenge, but also an opportunity for innovation.

LIFE projects that have addressed waste crime have offered useful lessons that can be applied

elsewhere. The EPOW project (**LIFE08 ENV/UK/000208**) tackled the unlicensed disposal and export of waste. Illegal operators, posing as legitimate businesses, profit by utilising unlicensed disposal sites, at the expense of unsuspecting waste contractors and responsible licensed sites. EPOW trialled a range of crime prevention techniques at two illegal waste sites in south-east England, with the aim of disrupting illegal activity, increasing the likelihood of perpetrators being caught, and diminishing the potential rewards of illegal activity.

Export of waste for recycling is a legitimate trade, but navigating the legislation and controls that apply in the global marketplace can be complex and challenging. To help address this, EPOW produced a good practice guide for officials to help ensure that waste intended for export complies with appropriate legislation and controls, and to minimise the risk of illegal export by third parties. This will reduce risks to other countries, and help keep waste as an economic resource in legitimate recycling and recovery chains.

The ongoing UK project, LIFE SMART Waste, is using a collaborative approach to enhance the understanding of waste crime, to provide regulatory agencies with greater insight and intelligence (see box). "Significant benefits can be achieved from reducing opportunities for waste crime," says LIFE SMART Waste project manager, Catherine Preston. "These include creating a more level playing field for legitimate waste management businesses, a reduction in negative impacts on communities and the environment, keeping valuable resources within the circular economy, and reducing costs to Member States through the clean-up of illegal operations."

A smarter way to reduce waste crime

The LIFE SMART Waste project (**LIFE13 ENV/UK/000549**) is demonstrating innovative ways of understanding, tackling and reducing waste-related crime, particularly activities associated with "challenging" (low quality and low value) waste streams. "One of our key objectives is to identify the drivers and enablers of waste crime at all levels, so we can build specific interventions tackling those issues," says George Hope, the project's technical team manager. "We have been greatly influenced by the vulnerability approach to crime reduction developed in criminology, which helps us identify the structural, economic, regulatory, legislative and other factors that either attract criminals or encourage non-compliant behaviours. By identifying these points of vulnerability, we can then work with the most appropriate partners to build a response." To this end, the project is developing an assessment toolkit to enable environmental regulators to evaluate the vulnerability of different waste streams.

Photo: SEPA

"We are working with partners in a number of really exciting areas. For example, we are looking at how the discipline of competitive intelligence could be used by environmental regulators to identify emerging commercial opportunities in the waste sector, to help build protection against criminal activities," explains Mr Hope. "We are also exploring the innovative use of electronic tracking devices and remote sensing technologies to map and detect waste crime, looking at how regulators can use horizon scanning and predictive analysis to better prepare for likely threats, and at how a focus on waste flows could help regulators identify points of crime not identified by standard regulatory inspection and audit."

The project identified barriers that constrain efforts to fight waste crime, especially in the key area of partnerships. "Our interventions will not be delivered by one agency alone, but require partnership groups to be built around specific objectives," says Mr Hope. The project identified three major barriers within partnerships: barriers to data and intelligence exchange; a lack of knowledge on the responsibilities and powers of each partner; and changing priorities between partners.

"A key requirement of the project is the applicability of our outputs to other environmental regulatory agencies across the UK and EU," says Mr Hope. "We are aware that a vibrant European network of environmental regulators and waste crime investigators already exists, but that it is not as inter-connected as it could be. A key outcome of LIFE SMART Waste is the provision of a collaboration platform which we think will provide, for the first time, a digital space where all European stakeholders can come together to engage in strategic problem-solving on waste crime issues. This will ultimately help us achieve a greater alignment of regulatory practices, techniques and policies to collectively tackle waste crime in Europe."

WASTE MANAGEMENT

Recovering waste materials from shredded vehicle residue

The PST project demonstrated improvements along a post-shredder technology line, which enabled the Netherlands to achieve the 95% by weight target for reuse and recycling of end-of-life vehicles.

The ELV Directive (2000/53/EC) requires Member States to take the necessary measures to ensure that the targets of 95% of reuse and recovery (at least 85% material recovery and 10% energy recovery) and 85% of reuse and recycling are attained by economic operators for all end-of-life vehicles (ELVs) by average weight per vehicle per year.

Most of this material is recovered in two stages (see box). Firstly, dismantling companies process deregistered vehicles to remove hazardous materials (e.g. petrol, oils, coolant, batteries, airbags and tyres), and spare parts that are sold back into the market. Secondly, the car body goes to a shredder company, where it is cut up and metals are removed. However, as shredder residue represents approximately 20% of ELV weight, a further stage is crucial for reaching the 95% target. This post-shredder technology (PST) offers the possibility of recovering all the remaining waste for reuse, recycling or energy recovery, and reducing the percentage by weight of ELVs disposed in landfill to practically zero.

The shredded fraction represents around 20% of the weight of an ELV and contains valuable materials

"ARN was founded in 1993 by the Dutch car industry to address environmental issues around cars," says Janet Kes, Manager of Corporate and Public Affairs for the Amsterdam-based company. Funded by the Dutch government, and with dismantling costs covered by the recycling fee (currently €45) collected for all new cars sold in the Netherlands, the company was in place to implement the accounting required for the first EU legislation on ELVs. ARN opened a new PST facility in Tiel, ARN Recycling BV, in 2011: "This was built for one goal and one goal only," says its Director Hans van de Greef, "and that was helping the Dutch government fulfil the goal of 95% ELV recycling."

How the weight of an average car is broken down

Typical car: 1 040 kg
Tyres, battery, fluids: about 40 kg
Spare parts removed by dismantling companies: 260 kg
Car body: 700-800 kg
Metal removed by shredder companies: 570 kg
Automotive Shredder Residue: 200 kg

Incremental improvements

The PST LIFE project's main objectives were to firstly optimise the PST process, to demonstrate how EU Member States can achieve the 95% target, and secondly to create high-value recycled materials and develop new markets for their use as 'secondary raw materials'.

"We had a lot of mini-projects within the LIFE project," explains Mr van de Greef, who is also the LIFE project manager. These led to optimisations in sorting, treatment and material recovery all along the PST line. "There is no other facility like this, so we had a lot of starter problems," he says. "We looked at other companies, but they were all commercially operated and so opt for the cheapest outlets, for example landfilling minerals. Our choices are going one step further, because the last steps can be expensive and this facility is not-for-profit."

Automotive Shredder Residue (ASR), also known as car fluff, arrives in Tiel by lorry from shredder companies across the Netherlands, in heavy and light fractions. "We get our material from 11 different shredder facilities, operated by six companies. So the incoming 40 000 tonnes annually is a mix from different operating systems, with inputs that are far from stable. To get continuous flow in our line took one-and-a-half years," says Mr van de Greef.

Entering the facility for the first time can be a confusing experience. Over 170 units work in unison, utilising a wide range of technologies for mechanically sorting ASR, such as milling and grinding machines, hammers and crushers, magnets for separating out metals, different types of sieves, and separation of particles by density in air (blowing) and liquid (sink-float) columns. Four main output streams are obtained: plastics, minerals, fibres and metals. The units are grouped in colour-coded modules, to differentiate the initial separation unit (blue), and the plastic (green), fibre (orange) and mineral (yellow) streams, with metals (red) extracted from all of these and processed separately further along the line.

The factory units are grouped in colour-coded modules

Major innovations

Along the PST line, the project implemented several innovations. The screw sieve was adapted from the mining industry and used for the first time as a PST. Plastics are usually separated from other materials by density, but rubber has the same density as the target plastic fraction. Therefore, the project team used the screw sieve to differentiate materials by shape, to remove the longer tube-like rubber from materials such as plastics having other shapes.

The processing line then arrives at the bouncing separator or drum screen, which separates particles according to their hardness, to remove rubber and wood from plastic and further increase the purity of the plastic fraction. When material is dropped onto a plate it bounces off, but the rubber and wood absorb the impact more and drop down on the other side of a board from the plastic particles.

"The bouncing separator was a major investment, built on the basis of LIFE-funded work, and is not commercially available," says Mr van de Greef. "Another innovation involved the sink-float units. These are normally used to separate plastics, but we adapted them to get the copper wire out of the plastic fractions too. We replaced all the pumps to get it right.

"A lot of small adjustments were made along the line, which reduced downtime and increased capacity, creating a steady flow and increasing the quality of the final material. If input constantly changes, it's difficult to adjust the machinery for optimal separation. So stabilising the process, for constant throughput and process flow was one of the biggest problems we resolved," he explains. Continuous operation has resulted in considerable cost savings, and reduced energy consumption to power the process (down 30% per tonne).

In 2015, the technical feasibility of the new PST process had been clearly demonstrated. The project

achieved 87.7% material recycling, which together with 9.3% energy recovery accounted for 97% reuse and recycling by weight of ELVs in the Netherlands.

New markets

A tour of the PST facility concludes with the laboratory, where samples are analysed and sent to potential customers. This is a process of dialogue, in which companies are asked what they need to make the material more interesting to them. So, for example, the bouncing separator answered a requirement for higher plastic purity (with 97% purity achieved in 2013). "Technical improvements were made to create new markets," notes Ms Kes.

The plastic and fibre streams are made into pellets at the facility, to increase the material's density and reduce transport costs, and sold for a variety of end uses (e.g. moulded into panels). There are over 20 types of plastic in cars, from which the plant produces three plastic end-products of different density. "The market is now more used to recycled plastics, but the real market is for production waste that is very pure. Other waste streams will not get to 100% pure plastic," says Mr van de Greef. "This is one of the challenges of the circular economy, to get more companies to adjust their production lines to use this sort of recycled material." Ms Kes also notes that with low price for raw materials such as oil, and low landfill costs, firms become less interested in using recycled materials.

Although the PST process is yet to become financially feasible, new markets developed during and since the LIFE project are moving it towards this goal. The quality of the mineral fraction, for instance, was improved due to the removal of metals. "We started using the mineral fraction in the bedding material during road construction, but we are now producing lightweight building blocks for internal walls," says Mr van de Greef. This use has a good potential and would enable the material to be upcycled or upgraded as a 'secondary raw material', rather than just recycled, to replace a valuable raw material.

The project implemented innovative post-shredder technologies

Another new product is a promising boarding material made using the fibre fraction, to replace 30% of the wood and 10% of a plastic material. This product has been trialled along canal banks to hold back soil. Fibre-reinforced plastic has also been used for street signs and for plaques at car dismantling companies. These and other applications are reducing the amount of fibre being incinerated, so replacing energy recovery with energy reuse in line with the EU waste hierarchy established in the Waste Framework Directive.

The increased capacity of the PST plant, achieved as a result of the LIFE project, has enabled the facility to process all the ASR generated in the Netherlands, with additional capacity now available to treat other waste streams, such as plastics from municipal waste. This has the potential to increase the overall profitability of the plant.

ARN is constantly looking for new markets for the end fractions. "To build a circular economy, recyclers must get a decent fee for what they do, and industry must be prepared to work with recycled materials," concludes Mr van de Greef.

Project number: LIFE10 ENV/NL/000027
Title: PST - Aim to realise 95% ELV-recycling in the Netherlands by means of post shredder technology
Beneficiary: ARN Recycling BV

Contact: Hans van de Greef
Email: hans.vandegreef@arn.nl
Website: http://www.arn.nl
Period: 01-Sept-2011 to 01-Sept-201
Total budget: €2 051 000
LIFE contribution: €991 000

SECONDARY RAW MATERIALS

Creating a market for secondary raw materials

An essential element of the transition to a circular economy is a well-functioning market for secondary raw materials – i.e. recycled materials that can be returned to the economy as new raw materials. LIFE projects have shown how to establish and stimulate such markets.

Not only does the use of secondary materials go a long way to addressing major environmental challenges, it is also a means of ensuring a more secure supply of materials, making Europe more resilient to global pressures on resources. The EU imports a greater percentage of its raw materials than other developed regions, making it vulnerable to fluctuations in availability and price.

Secondary raw materials are not widely used, but with improved waste management practices, the quantity and quality of such materials could increase to the levels that would be required by

MEIGLASS developed a cost-efficient process for treating 'dirty' cullet and thus generated more recycled glass for use in the glass container industry

Photo: LIFE06 ENV/IT/000332/NEEMO EEIG/TOLAND Justin

Creating a market for secondary raw materials

A LIFE platform meeting in Milan in June 2016 on the replicability of LIFE projects included a workshop on how to create a market for secondary raw materials.

Participants identified obstacles and potential solutions. The former included differences between Member States in the speed of implementation of relevant EU legislation and the need for some legislation to be updated in line with circular economy thinking. Other challenges included accounting for environmental costs in product pricing and persuading suppliers and customers to give greater credence to sustainability in their purchasing decisions.

Policy-makers need a better understanding of the complex challenges faced by businesses in order to develop appropriate support policy frameworks, participants said.

Proposed solutions to the legislative challenges included a call for EU regulations on waste, rather than directives, which give Member States more discretion on implementation. Legislation that could be revised to integrate circular economy concepts covers waste, ecodesign, extended producer responsibility, packaging, eco-labelling, reporting and accounting. Participants also recommended supporting legislative measures through other instruments, such as voluntary agreements, fiscal incentives and awareness-raising campaigns.

Regulations and restrictions of choice can help circular economy-based approaches compete on a more even footing with products that do not fully include environmental externalities in their pricing. Participants also believed that fiscal incentives for individuals and companies to put materials back into circulation could also support the transition to a circular economy (e.g. land-value taxes, value-extracted taxes and product levies).

The absence of EU-wide standards on waste quality and traceability makes it difficult to ascertain impurity levels or suitability for high-grade recycling. Cross-border circulation of secondary raw materials is needed to ensure they can be traded easily. Existing infrastructure and services should be better used in order to improve collection and to guarantee constant volumes of materials.

Participants suggested that public investment – including through LIFE - could play a useful role in supporting a secondary raw materials market alongside substantial private financing. EU funding of investments that go against the circular economy, such as in energy recovery from untreated waste, should be avoided or minimised.

different sectors of the economy. An economy in which value is derived from maximising utility and closing productive material loops.

Greater use of secondary raw materials also requires a set of EU-wide standards to increase trust and allow firms to use them with confidence. The Commission is in consultation with affected industries to develop standards covering areas such as impurity levels and suitability for high-grade recycling. Improving quality assurance will increase trust in secondary raw materials and help support market development.

The Commission is also clarifying existing rules on 'end-of-waste' that will make it easier to determine whether a secondary raw material can be legally classified as waste material. Its proposals provide operators with more certainty and a level playing field.

The term 'secondary raw materials' encompasses the full range of resource materials from minerals to glass, including such key areas as organic waste material for fertilisers and water re-use in agriculture. The LIFE programme has been instrumental in not only demonstrating best practice for the re-use of materials, but also in showing how a market for secondary raw materials can be established and stimulated (see box).

Re-use of waste material

Some recycled materials are available in large quantities but of much lower quality than primary materials, a phenomenon known as 'down-cycling'. LIFE projects have shown it is instead possible to 'upcycle' to produce high-quality secondary raw materials, particularly when reusing glass and glass fibres.

LIFE projects have demonstrated ways of producing quality secondary raw materials, especially from recycled glass

Photo: LIFE06 ENV/IT/000332/NEEMO EBIG/TOLAND Justin

The NOVEDI project (**LIFE07 ENV/IT/000361**) showed how glass rejects that are usually landfilled can be reincorporated into the process for manufacturing glass foam for use as glass-based cellular insulation materials. At the project's pilot plant in Piedmont, recycled rejects from 'special' glass (e.g. soda lime glass, artistic glass) were transformed into glass foam suitable for lightweight structural concrete for roofs and floors and glass foam suitable for super lightweight insulating concrete for walls.

Importantly, assessments showed that a production plant around four times the size of the pilot plant would have the economies of scale to produce competitively priced insulation materials. The pilot plant employed two full-time and three part-time workers, and the project team estimate that a further two or three employees would be needed to operate a full-scale plant.

Four years after the end of the project, the beneficiary SASIL is in the process of defining a marketing strategy for the product, under its new brand-name SAVELPOR50, and establishing a sales network.

The project concept has been replicated in several different contexts: in a large-scale plant in Switzerland, a medium-size plant in Sweden and a small-scale plant in the Czech Republic. Plants in Belgium and Canada are under construction, while there have been expressions of interest from industrial plants in Austria and Germany.

Another Italian project focused on the difficulties of re-using glass in the glass container industry, which requires cullet (crushed waste glass that is ready to be re-melted) to be 'oven ready' – i.e. free of substances such as ceramics, chinaware, stones, plastics or organic matter from food and beverages. The MEIGLASS project (**LIFE06 ENV/IT/000332**) pioneered a cost-efficient process for treating 'dirty' cullet that has been rejected by the primary cullet treatment plants. It thus demonstrated a method for generating a greater amount of high-quality recycled glass for use in the glass container industry.

By the end of the LIFE project, the beneficiary was treating a total of 200 000 tonnes/yr of dirty cullet, derived from some 1 million tonnes/yr of differentiated urban waste collected in central and northern Italy. Some 70% of the 200 000 tonnes/yr went to the glass container industry ('glassy sand'), 20% to the ceramic industry ('ceramic sand'), and 5% to the bricks industry. Only 1% of material is required to go to landfill.

The increased availability of clean cullet was shown to reduce average primary material use in the glass container industry from 50% to 30% (when substituted by glassy sand), and in some cases to as little as 10%. In addition, the number of glass containers rejected and recycled to furnace because of impurities was reduced by 1.5-2%.

LIFE FLAT to FLAT

Demand for flat glass is increasing, but its production consumes large amounts of energy and raw materials as well as producing a range of pollutants. Only around 30% of glass waste (cullet) is recycled. For reasons of quality, flat glass producers re-use only internal cullet (production losses and glass with colour faults) and some industrial cullet (from subsidiaries and recyclers). The LIFE FLAT to FLAT project (**LIFE12 ENV/BE/000214**), however, demonstrated an innovative processing technique that can use cullet containing a thousand times more ceramics, stone and porcelain material – i.e. it can come from sources that could not previously be used by the glass industry. Recycled cullet is mixed with raw materials to reach the desired quantities. To be cost-effective, collected glass must not come from too far from the recycling centre.

The LIFE project has shown it is possible to raise the content of recycled glass in flat glass to 25% and to adjust the ratio according to availability of recycled cullet. By reducing raw material consumption to this extent, the project says it can lower energy consumption by 5% and CO_2 emissions by 12%. "Cullet requires less energy to melt, and replaces carbonated raw materials," says project manager, Etienne Degand. "The glass made out of recycled cullet is exactly the same quality as glass made out of raw materials. We have created a perfect circle. We get glass back that has been produced decades ago," he explains.

The ceramics sector has also explored the greater use of secondary raw materials. The manufacture of ceramic tiles, in particular, generates significant quantities of waste (around three million tonnes/yr in Europe). While some of this waste material is re-used as low-value fillers in the construction industry, much is commonly sent to landfill. LIFE CERAM (**LIFE12 ENV/ES/000230**) sought to address this problem by showing that it is feasible to achieve a zero-waste ceramic tile manufacturing process. It has developed a new type of ceramic tile for outdoor use, such as urban paving, that is made from ceramic manufacturing residues.

The project first studied wastes generated in the ceramic production process and ancillary activities in order to determine those most suitable for use as raw material for the new product. After characterising the waste materials, the project team proceeded to formulate the correct mixture of ceramic waste to obtain the new tile. It then designed a manufacturing process based on dry milling technologies.

The end product is made up of 100% recycled material and the ceramic tile retains the same aesthetic qualities whilst providing a series of surface properties such as impermeability, cleanability, gloss, colour, surface texture, and chemical, mechanical and slip resistance. The LIFECERAM project could lead to more jobs, as the possible implementation of this production process will require the establishment of new waste processing and handling plants, or the adaptation of existing plants, as well as qualified workers to carry out the treatments needed to convert these wastes into raw materials.

Composite growth

A potential growth area in the materials sector is the replacement of metals and plastics with lighter, composite materials with a lower carbon footprint, such as carbon fibre reinforced polymer (CFRP). The high cost of production and difficulties in recycling currently act as a barrier to greater use. The CRESIM project (**LIFE11 ENV/IT/000095**) was set up to meet these challenges and to demonstrate an innovative process for producing CFRP composites from recycled carbon fibre. It showed how lightweight composites, mainly recycled from cars and aerospace parts, can be used for different applications, including automotive, public transportation vehicles and sport and leisure equipment.

Materials market

Online tools can help match up supply and demand of secondary raw materials. The Mo.re. & Mo.re. project (**LIFE08 ENV/IT/000437**) created such a tool for Italy's Lazio region. With the involvement of all operators of the relevant sectors, the project identified entire supply chains for the reclaiming and recycling of waste derived from municipal collection and separation schemes. The online platform not only promotes the use of secondary materials by purchasing companies, but it also provides an economic incentive for the seller to recycle. The platform is supported by a dynamic map that shows the supply and demand trends of different types of waste, as well as a map of all the businesses operating in different sectors in the region. Its database lists more than 1 500 contacts. The absorption capacity of locally-produced waste was calculated by conducting interviews with local businesses, which also led to the identification of 40 different waste supply chains.

These products have high physical-mechanical and aesthetic features. It is also possible to use CFRP in combination with virgin carbon fibres using this technology.

The project developed two patent pending technologies – Liquid Lay Down and Gap Injection – which could be used in a commercial plant by 2017. The cost-saving process will likely create additional employment as the CRESIM plant needs 1-2 more people to operate than traditional CFRP plants.

The CRESIM project provides a significant support for the implementation of the Waste Framework Directive, in particular, the management of hazardous wastes and reduction of waste going to landfill, as well as recycling of 'end-of-life' vehicles.

Photo: LIFE12 ENV/NL/000269

Innovative shredding and cryogenic separation technology allowed the LIFE ClosedLoopCarpet project to reduce the use of virgin raw materials in carpet manufacturing

Closing the loop

Carpet manufacturing is an archetypal 'linear' industry, consuming large quantities of primary resources and sending large amounts of waste to landfill. In addition, Europe discards some 1.6 million tonnes/yr of post-consumer carpet material, 60% of which goes to landfill, with most of the rest burned in municipal incinerators or cement kilns. The Dutch project, LIFE ClosedLoopCarpet (**LIFE12 ENV/NL/000269**) aimed to show that it is possible to reduce the use of virgin raw materials in carpet manufacturing, by demonstrating the technical and economic feasibility of a separation line based on innovative shredding and cryogenic separation technology. Impurities in the final material have previously prevented closed-loop carpet recycling. The project's breakthrough technology is capable of separating discarded carpet material into high quality primary resources (at least 97% purity), which can directly be used in the production of new carpets or for depolymerisation.

The project has put in place a pilot separation and purification line with a capacity of 92 tonnes/yr of carpet waste. As well as demonstrating the viability of the process, the pilot line will provide data on the separation of carpet waste into homogeneous polymers and be a basis for process optimisation. The beneficiary expects to invest in two-full scale demonstration lines. The increased value of recovered materials is expected to lower prices and thus further develop the market for them.

Copper mining releases many harmful emissions, and while the metal can be recycled without loss of its properties, less than half is actually recovered. The ongoing Dutch project, LIFE PCR (**LIFE14 ENV/NL/000029**) is testing an innovative closed-loop process for the recovery of copper from the bottom-ash produced by Waste-to-Energy (WtE) activities. Copper is traditionally recovered from WtE bottom-ash by mechanical methods, such as eddy current separation, at a rate of around 40% – but the quality is low. The project's technology, which uses a wet process to treat the bottom-ash and results in potentially shorter processing chains, has been shown to lead to copper recovery rates of up to 90%. It aims to treat a total of 124 500 tonnes of WtE bottom ash, resulting in the recovery of approximately 373.5 tonnes of copper during the PCR project demonstration period and the production of copper of at least 99.993% purity at a constant quality level. It is also a closed-loop process resulting in few emissions. The project will conduct an LCA of the environmental impact of the ECR

process in comparison with primary and/or secondary copper production, and with state-of-the-art copper recovery from WtE bottom-ash.

Recycled nutrients

A distinct category of secondary raw materials that has been the focus of the LIFE programme is the recycled nutrients present in organic waste material. These can be returned to soil as fertiliser, reducing the need for mineral-based fertilisers that depend on imported phosphate rock, a limited resource. However, it has been difficult to establish a market for recycled nutrient-based fertilisers owing to differing usage rules, environmental standards and quality of materials in different Member States. The Commission is thus proposing to revise EU regulation on fertilisers in order to foster a sustainable European market for such green fertilisers.

LIFE projects have played a significant role in showing how such a market could operate. One particularly successful project, LIFE ES-WAMAR (**LIFE06 ENV/E/000044**), established three companies to demonstrate in different areas the benefits of a collective approach to the processing and distribution of pig slurry. The project matched pig farmers' need to cost-effectively dispose of slurry with arable farmers' need for fertiliser. The collective management approach was found to enable cost-sharing, improved energy efficiency and more accurate field application, the latter thanks to analysis of the slurry's nutrient content and the use of tractors fitted with a computer-controlled dosage system.

The project was able to steadily increase the quantity of slurry it managed, reaching a total of 800 000 m^3 of managed manure by its conclusion. The arable farmers have widely accepted the value of the pig manure as organic fertiliser, thanks in part to information and training events for technicians and farmers. Surveys carried out in the three sites at the end of the project found that 70% of farmers polled said they are more aware of environmental issues and more engaged with correct slurry management since they joined. The project also led to the creation of 16 permanent jobs at the three management centres.

Also in Spain, the IBERWASTE project (**LIFE11 ENV/ES/000562**) further addressed the issue of disposal and re-use of pig waste, in this case from abattoirs and pork processing plants. The project created protocols for the collection, classification, disposal and preservation of all pig wastes, including blood, hair, tail and smelting water wastes. It also defined a method of using wastewater from the smelting procedure that turns the protein pig waste into a valuable fertiliser. The aim of the project was to completely close the loop, achieving 100% waste recovery from the pork industry chain and thus eliminating the sending of pig waste to sewage treatment plants. The project used ECO-hydrolysis of the wastes and assessed the usefulness for agriculture of the hydrolysates obtained. This opened up potential new markets for a hitherto valueless waste. Field trials showed that the hydrolysed solution could make an effective biostimulant for phytosanitary companies. The differential between the low costs of production

ES-WAMAR turned slurry from pig farms into a resource for arable farmers. Better management of pig slurry also helps to preserve the quality of soil and water bodies

Photo: LIFE06 ENV/E/000044

Photo: LIFE10 ENV/GR/000594

WASTEREUSE analysed alternative cultivation methods using agricultural waste

and the potential market price should make this a profitable venture for both the producer and the intermediate company.

LIFE has also been involved in projects to find new uses for agricultural waste (see box, 'New organic fertiliser'). The WASTEREUSE project (**LIFE10 ENV/GR/000594**), for instance, was set up to increase recycling of nutrients and water from agricultural waste in general, and olive oil mill waste in particular. It focused on establishing best management practices for applying waste to main market crops that maximise yields and minimise environmental impacts. The project's inventory of available techniques will enable Member States to comply with European legislation on agricultural waste as well as provide a stimulus to its re-use.

Fertilisers can also be made from by-products previously considered of no value, such as coarse wool. Sheep shearing generates some 200 000 tonnes/yr of coarse wool in the EU, each tonne of which contains around 640 kg of wool fibre. The Italian project LIFE+ GREENWOOLF (**LIFE12 ENV/IT/000439**) demonstrated the viability of converting this wool waste into fertiliser using small-scale local hydrolysis plants.

It established a pilot plant for converting the greasy wool into an effective soil fertiliser without the use of dangerous chemicals. The plant produced around half a tonne of fertiliser that can be used for organic farming and to increase the carbon sequestration of soils, especially in grasslands where sheep are bred.

The hydrolysed wool has been found to be very effective at absorbing and retaining moisture, facilitating soil water retention and preventing erosion on slopes. It was also found to enhance biogeochemical nutrient cycles.

The project's management model is economically sustainable, taking into account the sheep population and density distribution in the Piedmont region. The pilot plant can process a third of the sheared

New organic fertiliser

Life RESAFE (**LIFE12 ENV/IT/000356**) has created an organic fertiliser from urban waste, bio-char and farm residues as a substitute of chemical fertilisers. The re-use of such waste generates savings in public waste disposal (and thus CO_2 emission savings) and lowers the risk of groundwater pollution by reducing the amount of synthetic substances used. Waste re-use also reduces costs for farmers, improves the fertility of the soil and reduces the amount of energy consumed in processing operations. Project manager Silvia Serranti believes that the project is showing that, "it is possible for farmers and urban waste managers to reduce costs while obtaining environmental and economic advantages." The RESAFE fertiliser is made up of compost, animal waste and biochar – three different organic materials with three different degrees of stability. The task was to achieve a stable mix that maximises nitrogen retention and reduces the need for mineral fertilisation. The end result is expected to be soil with up to 3% higher nitrogen, phosphorus and potassium content. Furthermore, owing to the fertiliser's strengthening of the soil's ability to retain water, a 30% reduction in water consumption during crop harvesting is foreseen.

Life RESAFE

Photo: LIFE12 ENV/IT/000439

LIFE+ GREENWOOLF produced fertiliser from waste wool at small-scale local hydrolysis plants

wool in the region, and by establishing the right economies of scale the project further underscores the feasibility of producing an economically-viable product from secondary materials. There is also potential to use this green fertiliser in horticulture, adding further value to this sheep farming waste and reducing the use of synthetic fertilisers.

Water re-use

Water scarcity is a growing problem across the EU, negatively impacting on the environment and local economies. Even if water should be more efficiently used, there are also many advantages to re-using treated wastewater to boost water supplies and alleviate the pressure on over-exploited water resources. In agriculture, for example, water re-use can help move away from the use of solid fertilisers to the recycling of nutrients in wastewater. The Commission is working towards establishing minimum requirements for re-used water in order to further encourage re-use.

The textile manufacturing sector is a major consumer of water, the vast majority of which comes from primary sources. The BATTLE project (**LIFE05 ENV/000846**) aimed to increase water re-use by establishing a new best available technology (BAT) that would be viable for small and medium-sized enterprises, as well as large companies. SMEs with a production capacity of more than 10 tonnes per day are obliged to implement BATs under the Integrated Pollution Prevention and Control Directive.

The project demonstrated its BAT first at a pilot plant and subsequently at a typical medium-sized textile finishing company. The technique involves isolating potentially re-usable effluents and treating them separately using membrane filtration. The pilot plant treated 500 m^3/day of wastewater, of which 374 m^3/day was recovered on average. Not only does the re-use of water decrease the consumption of high-quality water, but it also lowers the hydraulic load at wastewater treatment plants through better treatment and removal of contaminants before the discharge of the wastewater. The goal was to include the project technology in BREF reference guidelines for the textile sector.

Another successful project, PROWATER (**LIFE04 ENV/IT/000583**), also improved water re-use in the textile industry. This Italian project pioneered a cost-effective recycling system consisting of physical-chemical pre-treatment, cross-flow ultrafiltration and ozonation.

Water re-use was improved in the textile industry by the PROWATER project

Photo: LIFE04 ENV/IT/000583

Treated wastewater was re-used effectively in a range of production processes from fabric softening to some washing processes and overall the project demonstrated that fresh water consumption could be reduced by 40% on an industrial scale, with a five year return on investment.

Cost savings will help generate employment opportunities and improve the competitiveness of companies in the sector. If widely replicated, total annual water savings could amount to tens of millions of cubic metres of fresh water.

Water scarcity is a particular problem for the agricultural sector, especially in Mediterranean regions, and here re-use represents a clear way forward. A closed, fully automated, hydroponic greenhouse system was developed by the LIFE project Adapt2Change (**LIFE09 ENV/GR/000296**) in order to be able to adapt to limited supplies of water. The project team constructed prototype greenhouses in Cyprus and Greece to demonstrate the viability of the recycling system and has produced practical guides to encourage replication in a wide range of environmental conditions.

Another agricultural project, ReQPro (**LIFE11 ENV/IT/000156**) is seeking to protect scarce water resources by reusing treated wastewater to irrigate agricultural land.

To this end, the ongoing project has carried out tertiary treatment of approximately half the flow produced by the Mancasale wastewater treatment plant in Reggio Emilia. The treated wastewater is being used to irrigate an agricultural area of some 2 000 ha. As well as saving water, the nutrients in the wastewater mean there is no need for a separate application of nitrogen and phosphorous by farmers in the demonstration area.

The project has enabled the development of a wastewater traceability system, enabling the optimal usage of reclaimed wastewater and the provision of detailed information on reclaimed wastewater volume and quality to farmers seeking to irrigate high-quality crops.

Urban wastewater can be also be efficiently recovered for use by industry. The objective of the LIFE WIRE project (**LIFE12 ENV/ES/000545**) was to demonstrate how cutting-edge technologies, such as ultra-filtration, carbon nano-structured material and reverse osmosis, can be combined to achieve recovered water of sufficient quality. It has tested different configurations of these technologies at the wastewater reclamation plant of El Prat in the Barcelona area and has defined the optimised processes - including smart operational and cleaning strategies - for different water quality grades. Project findings have shown that there can be water consumption savings of up to 100% for metal coating; up to 90% for marine fuel waste and industrial residues treatment; and up to 80% for chemicals, dyes and pigments. The project is carrying out further assessments of its waste re-use approach to demonstrate the financial and environmental advantages compared to conventional water treatment and industrial water consumption.

Tackling organic pollutants

The WaterReuse project (**LIFE12 ENV/ES/000184**) has pioneered a new approach to the energy-efficient treatment of industrial effluents containing high amounts of organic pollutants. The process completely breaks down pollutants, regardless of their toxicity or chemical structure, and thus produces a water of sufficient quality to be re-used by industry. Pedro Trinidad, project manager, says that the treatment process compares favourably with traditional biological treatments. Under seven different scenarios, it has lower operational costs, giving a return on investment in five-and-a-half years. “The cost/benefit ratio becomes more favourable with more complex effluents,” he says. “The ability to handle almost any type of organic pollutant in aqueous solution is key to its benefit over other treatments,” says Mr Trinidad. The cost/benefit ratio improves considerably when photovoltaic solar panels are introduced and the generated hydrogen is used. The WaterReuse process is designed to achieve zero discharge and thus close the loop.

SECONDARY RAW MATERIALS

Turning old sink material into **green composite sinks**

This Italian project demonstrated the possibility of producing compound material sinks using 100% recycled raw materials. It developed a new range of kitchen sinks, the first of its kind to be manufactured from closed loop and open loop recycling.

Research into the re-use of sink material in the production of compound material sinks is much needed. The attractive properties of composite material sinks – hygienic and easy to clean – have driven up demand, but the sourcing of the raw materials, especially quartz, places a heavy burden on the environment.

Furthermore, most of the waste produced in the manufacturing process of quartz composite – 20-30% of which is methyl methacrylate (MMA) and 10% is poly-methyl methacrylate (PMMA) – is sent to landfill as 'special industrial waste'. In fact, it is estimated that composite sink manufacturing in Europe results in more than 3 000 tonnes/yr of heavily polluted waste. The recovery of this waste would reduce the amount going to landfill and the excavation of primary raw materials.

The challenge of the LIFE GREEN SINKS project was to show that virgin raw materials, which are increasing in price every year, could be substituted with 100% recovered materials. The first task was to develop formulations in the laboratory with the desired properties. Using materials originating from closed loop recycling (i.e. the beneficiary's production scraps and wasted sinks) and from open loop recycling (the production waste of other national industries), it developed 12 formulations. These met the key criteria for sink composite material – i.e. resistant to stains, water, chipping, fading under sunlight, sudden changes of temperature and fracturing.

The beneficiary, DELTA, a medium-sized sink manufacturer that is part of the Plados-Telma Group, has rigorous testing apparatus near its production line in the Italian region of Marche, but LIFE financing allowed it to add to its capacity for carrying out necessary tests. For example, a dosing and mixing machine was purchased for use in the pilot testing of formulations, increasing productivity and accuracy while reducing waste.

"[Sink manufacturing] is an R&D-driven business," says Plados-Telma CEO, Sandro Bertini. "It could be very damaging to the brand to deliver something to the market that has not been sufficiently tested."

The substitution of raw materials was achieved by replacing one raw material at a time and testing the new corresponding formulas. These formulations were then evaluated in the laboratory before being produced on a pilot industrial scale. A prototype was built and a new compound was synthesised to effectively bind the components of the formulations tested.

More than 1 700 sinks were moulded to find the best formulations, and at the end of the process 12 were selected differing in material composition and colour. Three of these formulations used internally recovered mineral fillers. Many variables affect the production of a composite material, including outside temperature, and as a result constant monitoring is essential – even during production using a tested formulation. At the end of the process, three of the best formulas

The beneficiary produced a new green product line called ecogreen using the best formulas tested during the project

Formulations were tested in the laboratory before being produced on a pilot industrial scale

– white, beige and black – were chosen to create a new green product line, ecogreen.

Costs and benefits

The next step was the delivery at the end of the project of sample 'green sinks' to several of the company's customers to appear in their showrooms. According to the beneficiary, the feedback has been positive and the demand for green products is high, but at present the cost is not sufficiently competitive. "Consumers may pay 5-10% extra for a green product but not 30-40%," says Mr Bertini.

The high cost relates to the process of breaking down the old sink material with liquid nitrogen. DELTA doesn't have the capacity to perform this grinding operation itself and the materials are thus transported to a specialist and that adds to the cost. Recovered internal material can be three times as expensive as material from external sources as a result.

But external recycled quartz is cheaper than virgin material though it is of inferior quality and not perfectly white. The variable composition of the material, which can contain silicon and other minerals, creates an added difficulty. Nevertheless, part of the success of the project was to show that a composite of high quality could still be produced from secondary materials. Moreover, it showed that it was technologically feasible to then use this green composite material to produce sinks on an industrial scale.

"The quality is the same because the chemistry is the same, but the production process is smelly due to elements in the recycled scraps – we are working to stop that!" says Maria Savina Pianesi, the project leader.

Furthermore, by not using extracted raw materials, which are typically transported long distances, production of the new line of sinks consumes less energy and, as a result, has a cost-saving advantage. The project calculated that the line allows for a 64.5% reduction in energy consumption, as well for CO_2 emissions to be more than halved (56.3%).

Scaling up

Further energy savings and environmental benefits could result from using more raw material from closed loop recycling. The project succeeded in producing green formulations with around 22% of the total recovered fillers deriving from the re-use of its scraps. In total, the project recycled 7.84 tonnes of PMMA, 1.61 tonnes of MMA and 27.55 tonnes of quartz.

The ecogreen sinks have been commercially available since 2015 and Plados-Telma's marketing team is working to build acceptance. "We want to move this step by step," says Mr Bertini. Following the project, the company has been contacted by an American customer, "one of the largest manufacturers of worktops in the world", requesting additional formulations, he adds. The company's business plan is to sell 10 000 green sinks in 2016-2018. This would help to avoid around 140 tonnes of waste being sent of landfill, with quartz accounting for more than 60% of this amount. Moreover, 490 tonnes of CO_2 and 5 130 000 MJ equivalent of energy would be saved due to the use of recycled MMA and PMMA in comparison to current sink production.

In terms of socio-economic benefits, it would also lead to an increase in turnover and profits of 7-8%, creating opportunities for further jobs in addition to the two graduates employed full time as a result of the project.

Project number: LIFE12 ENV/IT/000736
Title: LIFE GREEN SINKS - Realization of green composite sinks substituting organic and mineral primary materials by recovered waste
Beneficiary: DELTA Srl

Contact: Antonio Bugiolacchio
Email: antonio.bugiolacchio@plados.it
Website: www.greensinks.com/en/
Period: 01-Jul-2013 to 01-Jul-2015
Total budget: €1 581 000
LIFE contribution: €767 000

Five priority areas for closing the loop

The EU action plan for the circular economy highlights five priority sectors that need special attention to be able to close the loop: plastics, critical raw materials, food waste, biomass and bio-based products and construction and demolition. LIFE has co-funded projects in each of these sectors.

A number of sectors face specific challenges in the context of the circular economy, because of the specificities of their products or value-chains, their environmental footprint or dependency on material from outside Europe. These sectors need to be addressed in a targeted way, to ensure that the interactions between the various phases of the cycle are fully taken into account along the whole value chain.

Priority sector one: Plastics

Increasing plastic recycling is essential for the transition to a circular economy. The use of plastics in the EU has grown steadily, but less than 30% of collected plastic waste is recycled. As of 2014, some 30% was still going to landfill, with almost 40% burned for energy. The Commission is proposing a target recycling rate for plastic packaging of 55% by 2025.

LIFE has helped to substitute biobased materials for plastics

Photo: LIFE13 ENV/ES/000067

As part of its Circular Economy Package, the Commission will adopt a strategy on plastics in the circular economy, addressing issues such as recyclability, biodegradability, the presence of hazardous substances of concern and marine litter

LIFE tackles marine litter

"Too much plastic waste, which could be recycled and be a valuable resource, ends up as microplastics in our seas. Repair and re-use schemes should be advanced," said European Commissioner for Environment, Maritime Affairs and Fisheries, Karmenu Vella, speaking at the 2015 Circular Economy conference in Brussels. The 2030 Sustainable Development Goals include a target to prevent and significantly reduce marine pollution of all kinds, including marine litter. The Circular Economy Action Plan proposes an aspirational target of reducing marine litter by 30% by 2020 for the 10 most common types of litter found on beaches, as well as fishing gear found at sea.

Two current LIFE projects are combining actions to reduce marine litter with awareness-raising campaigns aimed at preventing harmful materials being discarded into the marine environment in the first place. LIFE DEBAG (**LIFE14 GIE/GR/001127**) is raising awareness of the impact on marine ecosystems of discarded plastic bags as part of a campaign to encourage the prevention and reduction of plastic bag pollution in the marine environment. In Italy, Clean Sea LIFE (**LIFE15 GIE/IT/000999**) is organising clean-ups of beaches and the seafloor in the Asinara National Park in Sardinia and engaging with the fishing industry and diving clubs to remove existing litter, including lost fishing gear. Abandoned, lost or discarded fishing gear has also been removed in the Adriatic Sea by LIFE Ghost (**LIFE12 BIO/IT/000556**), which drew up a code of conduct for the fishing industry.

Other LIFE projects provide technical solutions to the problem of marine litter, including LIFE SMILE (**LIFE12 ENV/IT/000289**), which has taken steps to prevent solid waste in rivers reaching the sea, And the new project LIFE LEMA (**LIFE15 ENV/ES/000252**) will trial the collection at sea of marine litter using modified fishing and dredging vessels.

Reducing the impact of microplastics from synthetic textiles on marine ecosystems is a high priority and LIFE – MERMAIDS (**LIFE13 ENV/IT/001069**) is developing good practices and policy recommendations. The project expects to reduce by 70% the amount of microplastic fibres discharged in laundry wastewater.

Plastics substitution

The LIFE programme has funded a number of projects that seek to improve recycling rates, match the quality of unrecycled plastic for specific uses (so-called 'upcycling') and even substitute bio-based materials for plastics. An example of the latter is the ongoing Swedish project, DURAPULP for LIFE (**LIFE14 ENV/SE/000258**). DuraPulp is a bio-composite, a mixture of cellulose pulp and the biopolymer polylactic acid (PLA). The project beneficiary, Södra, is aiming to demonstrate that, by means of airlaid conversion technology, it can be used to manufacture 3D-formed fibre composite packaging products for a range of industry segments. The development of competitive new converting techniques for fibres opens up the possibility that fibre-based packaging could replace plastic. By demonstrating the commercial potential of the new bio-composite, the DURAPULP for LIFE team aims to have products on the market within two years of the project's end. Predicted benefits include a 65% reduction in global warming potential compared to fossil-based products and energy savings of up to 80% compared to traditional converting techniques. The project will also verify options for recycling DuraPulp, including incineration, recovery by industrial composting and material recycling in the hydro-pulping process.

LIFE - MERMAIDS is addressing the impact of microplastics from textiles on marine ecosystems

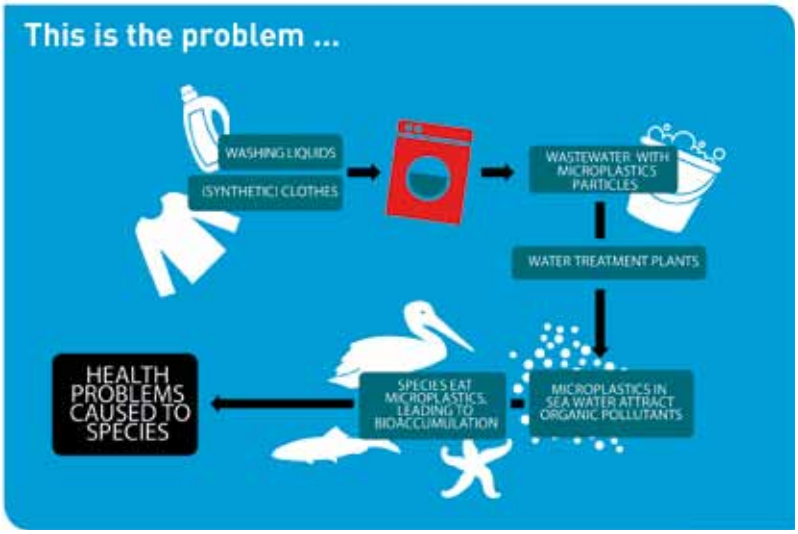


Photo: LIFE13 ENV/IT/001069

Photo LIFE15 GIE/IT/000999/Eleonora de Sabata

Clean Sea is engaging with the fishing industry and diving clubs to remove existing litter, including lost fishing gear

Techniques to optimise plastics recycling

The presence of hazardous substances can impair recycling of all types of waste. This problem can be tackled by improvements in design or by improvements to the recycling process. Led by research institute, AIMPLAS, the Spanish project LIFE EXTRUCLEAN (**LIFE13 ENV/ES/000067**) is demonstrating the viability of a new technique for eliminating hazardous substances from waste polyethylene packaging for solvents or phytosanitary products. This will be achieved by applying supercritical carbon dioxide (sc-CO_2) in the extrusion phase of the plastic recycling process. The project expects to partially, if not totally, substitute for two of the three stages involved in conventional treatments, which should reduce the consumption of energy and water. It predicts that water consumption will be halved and energy consumption cut by 90%. In addition, use of sodium hydroxide, surfactants and wastewater treatment chemicals will be reduced from 45 to 15.75 tonnes/yr. The plastic obtained from a conventional recycling process is used in applications with low added value (e.g. pallets), as they generally have inferior mechanical and organoleptic properties. The new process is expected to increase the quality of the recycled material, enabling it to be used to make packaging for hazardous substances, thereby closing the life-cycle.

LIFE long WASTE-FREE LLWF (**LIFE13 ENV/IT/000650**) addresses current deficiencies in de-moisturising of polymers and technopolymers, the fastest-growing category of plastics. Conventional treatment is very energy inefficient and effective removal of excess water often requires prolonged or multiple treatments at high temperature. This can have a negative effect on the recycled material (typically 10-15% of which is over-treated). The LLWF project aims to introduce an innovative method of measuring in real time the moisture content of polymers to be recycled, and to adjust the de-moisturising treatment accordingly. The new dehumidification technique is expected to reduce consumption of energy, raw materials and chemical additives during PVC production, as well as optimising the production cycle and cutting the amount of waste produced.

Partnership work with the cities of Copenhagen, Tampere, Malmö, Hamburg and Riga (Liepaja region) enabled the Danish-led Plastic Zero project (**LIFE10 ENV/DK/000098**) to develop a digital road map for managing plastic waste at municipal level. This can contribute to efforts to improve resource efficiency and reduce imports of raw materials.

The project began by creating an overview of local waste infrastructure. This focused on collec-

tion systems, treatment infrastructure (treatment plants, incinerators, landfills, cement kilns, etc) and regulation (outlining the responsibilities of national and local authorities and business for products, waste and waste management). Plastic Zero also measured local variables in each partner region, in terms of waste plastic composition, plastic flows from industry, retail and households, rates and quantities of separation and recycling and quality of recyclates. One of the project's conclusions is that all aspects of the local context must be taken into account for transferability of results.

The project carried out a comparative assessment of five sorting plants, including one test facility. Rates of direct plastic recovery varied from 33-43% for the commercial plants, with the test facility recovering 63%. There was also significant variation in sorting efficiency for different materials found in mixed plastic waste. These results led the project to conclude that though waste plastics are collected in many places, there is great potential for improving the exploitation of these resources.

The project demonstrated new ways to prevent and manage waste plastics in each of the partner municipalities, diverting more than 900 tonnes of plastic waste from landfills and incineration to recycling. Plastic Zero also organised collaborative forums around plastic resource and waste flows with businesses that have committed to contribute to reduced environmental impacts. Forums focused on either prevention or collection, sorting and recycling.

Recycling industrial plastic waste

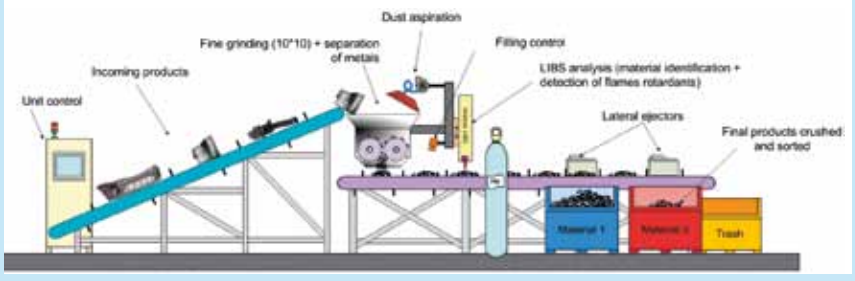
Industrial plastic waste includes plastic pieces from end-of-life vehicles (ELVs), waste electrical and electronic equipment (WEEE) and furniture. The challenge of automating the sorting of such waste means that a proper recycling chain has yet to develop.

Green Waste Plast (**LIFE09 ENV/FR/000603**) demonstrated a new process for recycling lightweight 'blister' packaging, a type of plastic waste that normally ends up in an incinerator or landfill. The project team set up a pilot installation at AB CIFRA's factory. By January 2015 this had recycled 4 500 tonnes of pre-sorted plastic waste, using thermoforming, extrusion and injection techniques to manufacture plastic products containing 30% recycled material.

Sort a black plastics problem

Laser Induced Breakdown Spectroscopy (LIBS) is a rapid chemical analysis technology that uses a short laser pulse to create a micro-plasma on the sample surface. LIBS has been shown in the laboratory to be capable of identifying the black plastics found in industrial waste. The INSPIRE-4LIFE project (**LIFE13 ENV/FR/001483**) aims to operate a pilot plant to demonstrate that LIBS can be used in an industrial environment and conditions (intensive use 24 hours/day, seven days/week). "The key point is to be able to sort with a high purity this plastic waste," explains project manager Sébastien Michel from coordinating beneficiary, Bertin Systèmes.

The new process will aim to increase the productivity of industrial plastic waste sorting - from an average of 0.25-0.3 tonnes/hour achieved by the current best available technology to 1.0 tonnes/hour. "You cannot sort all the plastics waste simultaneously, it is more efficient (for purity) to work by batch (one flow after the other). Based on a use of 8 hours per day, 250 days per year, the total weight processed will be about 2 000 tonnes per year," notes Dr Michel.



This innovative sorting system will enable rapid processing of large plastic pieces at the dismantling stage of the end-of-life object. Improved sorting will then lead to a higher quality recyclate, for example, as granulate, which compounders can use to produce and sell secondary materials to polymer producers. Improving the quality of the recycled plastic should open the way to its use in more products and markets. Identifying new end uses is one of the aims of the project. "Ideally, we will focus on the possibility of making new TV and computer screens from screens waste," says Dr Michel.

He points out that the expected cost of an industrial-scale machine to automatically sort industrial plastics would be in the region of €200 000-250 000. "Depending on the amount sorted and the value of the recycled materials, the investment could be positive after one to two years," he adds.

Smart sorting and end use

According to the Circular Economy Action Plan, "smarter separate collection and certification schemes for collectors and sorters are critical to divert recyclable plastics away from landfills and incineration into recycling."

"It is very important to crack both the sorting and useful end-application aspects in order to achieve circular economies," believes Gian De Belder, Principal Scientist, Sustainable Packaging R&D for Procter & Gamble. Mr De Belder is project manager of an ongoing LIFE project (PETCYLE – **LIFE14 ENV/BE/001065**) that aims to tackle both challenges. The project focuses on difficult-to-recycle opaque and/or sleeved PET bottles, a fast-growing category of plastic packaging. "It will use demonstration runs on both sorting and high-value end applications," says Mr De Belder.

"At the sorting stage, the PETCYLE team will add fluorescent particles – known as 'tracers' or 'markers' - to several packaging components such as a white PET bottle, a self-adhesive label that goes onto a PET bottle and a sleeved PET bottle. The bottles will then be sent to a commercial sorting line of a material recycling facility, mixed with standard collected household packaging," explains Mr De Belder. "The objective is that an upgraded sorting machine is able to identify the tracer (activated by means of laser-light) and sort this fraction into separate bales," he adds.

The sorted PET bales will subsequently be sent to a recycler for conversion into flakes and fibres, the latter of which will be used to make non-woven fabrics for a range of commercial uses. "The project will demonstrate that good quality (e.g. in specification) non-wovens can be produced starting from the marked, sorted opaque PET packaging," says Mr De Belder.

PETCYCLE expects to achieve sorting quality above 96%, "likely higher", says the project manager. "The system should be at least as accurate as current technologies such as near-infrared sorting systems, that today are able to run at purities in the range of 80-95%."

Marketability and replicability are key aspects of the project, as Mr De Belder explains: "One of the PETCycle deliverables is to calculate ROI by comparing the required investment vis-à-vis the added value generated by the collected, high-quality bales that now can find a useful end market into non-wovens (rather than being energy recovered / landfilled)." The project will also open an industry discussion on standardisation, such as through a 'barcode for recycling'. If the full value chain (brand owners, retailers, recyclers, waste manufacturers, packaging component and resin/masterbatch suppliers) is able to agree on a single system, or compatible systems, "it will limit the required investments at recyclers/material recycling facilities and make it more efficient and economically viable," concludes Mr De Belder.

According to industry association, Plastics Europe, the project has several environmental benefits: direct savings of non-renewable resources (1 000 tonnes of oil equivalent for every 1 250 tonnes of plastic recycled and 1 000 m^3 of water and 2 tonnes of CO_2 emissions for every tonne of plastic recycled). It also has a positive socio-economic impact: the beneficiary estimates that 10 potential job equivalents can be created for every 1 000 tonnes of plastic waste produced (per year, for the whole waste stream). Importantly, in terms of transferability, "the industry does not have to invest in new equipment to implement the Green Waste Plast techniques. Instead, the equipment in place can be adapted and fine-tuned to fit the new requirements," says Quirin Renard from the LIFE external monitoring team.

The LIFE project has proven the effectiveness of the process, but a significant and long-term increase in recycling of blister packaging depends on an improvement in the quality and quantity of sorted plastic waste reaching the recyclers and in overcoming the cultural reluctance to use recycled plastic. This will require further awareness-raising and proof that recycled products meet similar standards as products made from virgin plastic.

Priority sector two: Critical raw materials

Critical raw materials (CRMs) include rare earth elements and other precious metals, as well as phosphorous. These materials are considered 'critical' because they are of high economic importance for the EU and vulnerable to supply disruption. CRMs are often present in electronic devices, such as rare earths in electronic displays or precious metals in printed circuit boards, yet there is little recycling of the materials. Increasing the recovery of critical raw materials is one of the challenges that must be addressed in the move to a more circular economy.

Photo: LIFE11 ENV/FR/000744

LOOP successfully demonstrated how to recycle rare earth elements in phosphorescent powders of fluorescent bulbs

Only high-quality recycling of electronic waste can ensure the recovery of CRMs. According to the Circular Economy Action Plan, this will entail improvements in product design. The Commission is encouraging Member States to promote recycling of CRMs in its revised proposals on waste. It is also preparing a report on CRMs in the circular economy, in order to ensure a coherent and effective approach, to provide key data sources and to identify options for further action. At present, there is insufficient information exchange between manufacturers and recyclers of electronic products, the absence of recycling standards, and a lack of data for economic operators on the potential for recycled critical raw materials.

Closing the loop for fluorescent lamps

Rare earth elements are a set of 17 chemical elements whose intrinsic properties mean that they play a key role in the miniaturisation of electronics and are found in mobile phones, military aircraft, cars, medical imaging equipment, as well as green technologies such as wind turbines and energy-saving lamps.

The global demand for rare earth elements is increasing by 6% per annum and there are serious concerns that the demand for some of those elements will exceed supply in a few years. The supply balance is complicated by the fact that China, the world's largest rare earth producer, operates – frequently adjusted - export quotas for these products.

One of three LIFE projects to have dealt with CRMs, the LOOP project (**LIFE11 ENV/FR/000744**) set out to recycle rare earth elements in phosphorescent powders of fluorescent bulbs, as a way of valorising previously unexploited European 'urban sources' of such elements.

Led by the Belgian chemical company, Solvay, the project aimed to demonstrate that all current phosphorescent powder wastes in Europe (some 1 500 tonnes/yr) could be recycled, with successful recovery of at least 90% of the treated rare earth elements, glass and phosphate, whilst reducing energy consumption and emissions.

The first stage of the process took place at Solvay's Saint-Fons Chimie plant in France, where, after the recycling companies have isolated and recovered the glass, metals and plastic in used energy-saving bulbs, phosphor powders and residual glass are sent for treatment. The recovered powders are suspended in an aqueous solution and undergo a chemical attack. The powders retained after separation are then dried and packaged for transportation to La Rochelle, which is the only plant in Europe that can purify rare earth elements.

The purification process consists of thermal treatment, followed by re-slurrying, washing and nitric acid attack. The powders then pass through batteries which separate six different rare earth elements: Lanthanum, cerium, europium, terbium, gadolinium and yttrium. The rare earths then go to finishing workshops for precipitation, filtration and calcination. The final product – recycled rare earth elements – can be used to manufacture phosphors for new energy-saving lamps, completing the circle.

LIFE co-funding enabled Solvay to optimise and validate its processes both upstream (Saint-Fons Chimie) and downstream (La Rochelle). The project also gave rise to new process know-how to enable industrial-scale production in future.

"The process allowed us to treat about 90% (1 350 tonnes/yr) of rare earth oxides, glass and phosphates," explains project manager Nicolas Barthel. "When running at full capacity the process can revalorise more than 90% of phosphorescent powders," he adds. The six rare earth elements recovered are easily reused in the manufacture of energy-saving lamps and Solvay has developed specific trademarks to differentiate between virgin and recycled materials (the 'Origin' product range).

The project created 30 jobs at the two plants in France and Solvay expects it to have a wider socio-economic impact: "With this new raw material source, the fluorescent lamp and LCD industries will have the opportunity to relocate their activities in Europe, thus increasing the number of opportunities for job creation," says Mr Barthel.

The LOOP project created 30 new jobs recycling rare earth elements and using them to manufacture energy-saving lamps

Photo: LIFE11 ENV/FR/000744

Photo: LIFE14 ENV/UK/000344

CRMRecovery is recovering of a range of critical raw materials from waste electrical and electronic equipment

The LIFE RECUMETAL project (**LIFE14 ENV/ES/000450**) is demonstrating the recycling of flat panel displays (FPDs), to recover plastics and CRMs. In particular, the aim is to recover critical metals such as indium (In) and yttrium (Y) and reuse them in new applications. These metals are currently not separated or processed for reuse in the EU. The project's deployment of magnetic separation and density separation technologies should make their recovery feasible and cost-effective.

"The chemical processing plant is the main innovation of the project. Although many plants recycle flat screens by mechanical processes, none recovers critical metals," says Raquel Echeverria of project beneficiary L´Urederra Technology Centre. "This action will also contribute to another key project objective: to recycle and recover rare earth and precious metals so as to reduce dependence on China and other countries that control exports," she adds. China, for instance, controls 53% of the worldwide production of indium and 99.9% of the production of yttrium.

"Once validated on a semi-industrial scale line developed during the project, the replicability and transfer of technology will be the main target," concludes Ms Echeverria. The aim is to establish a secondary source of valuable raw materials for EU electronics companies.

The ongoing UK project LIFE 2014 CRMRecovery (**LIFE14 ENV/UK/000344**) is aiming for a 5% increase in the recovery of a range of critical raw materials from waste electrical and electronic equipment (WEEE). Specifically, the project will establish closed loop recovery of graphite, cobalt, antimony,

tantalum, rare earths and silver, gold and platinum group metals from display, consumer electronics, ICT and small household appliances.

"Our research has shown that in the UK alone, we dispose of around 1.4 million tonnes of electrical and electronic products per year, and nearly 40% of this is landfilled," says Marcus Gover, Director of coordinating beneficiary WRAP. "Yet these products contain critical raw materials such as gold and platinum, which are essential components of many household technology products and appliances. Economically and environmentally, it makes no sense to be burying them."

"The project will allow us to assess whether we can get more value from the WEEE that is collected and treated across Europe, and explore further opportunities for improving the collection of end-of-life products. These trials could have major benefits for producers and the circular economy, as well as for the environment and society as a whole," says Scott Butler of project partner the European Recycling Platform (ERP).

"The key barrier to achieving closed loop recovery of critical raw materials is the ability to recover the CRMs in large enough quantities from products at a cost effective rate to make them attractive to the user," explains Lucy Cooper, WRAP's manufacturing product manager. "As the amounts in individual WEEE items are often small, significant quantities

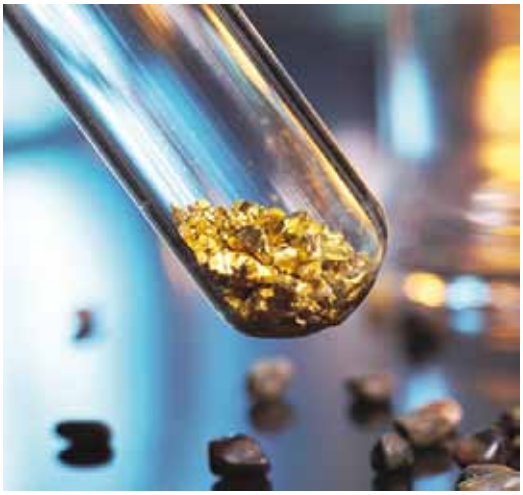


Photo: LIFE14 ENV/UK/000344

Gold nuggets recovered from WEEE

are lost in the traditional WEEE treatment process. Our project will look at how collections can impact on amounts of CRM available for recovery and the impact this has on recovery rates. The recovery trials will look at the opportunities to increase recovery, therefore making more CRMs available from the recycling process," she explains.

The project expects to collect and reprocess 100 tonnes of product from 10 collection trials (in UK, Germany, Italy and Turkey). It will use the results of these trials to develop a European-wide model of the flow of WEEE through the recovery system, a suite of possible nation-specific policy intervention routes and EU infrastructure development recommendations.

CRMRecovery is working to increase the recovery rates of critical raw materials by improving management of WEEE

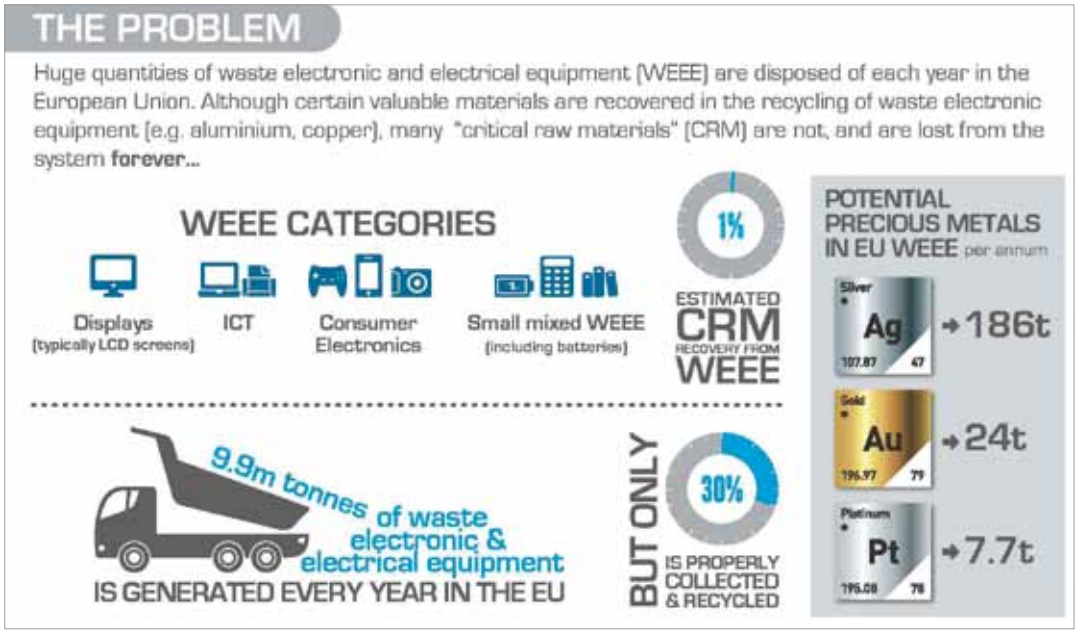


Photo: LIFE14 ENV/UK/000344

"The trials will be a unique opportunity to build synergies by sharing the experiences of collection and recovery activities by various actors in different countries," says Kai Kramer of project partner the European Advanced Recycling Network (EARN).

The project's long-term goal is to contribute to a 20% increase in recovery of target CRMs in Europe, materials worth some €381 million at current market prices.

Priority sector three: Food waste

Food waste is an increasing concern in Europe. The EU and its Member States are committed to meeting the UN Sustainable Development Goals 2030 target of halving per capita food waste at the retail and consumer level, and reducing food losses along production and supply chains.

In order to meet this target, the European Commission has set up a platform that will develop a common EU methodology to measure food waste and define relevant indicators. The main goal of this platform is to share best practices and evaluate progress towards target reductions. The Circular Economy Action Plan also identifies the need to take measures to clarify EU legislation relating to waste, food and feed and facilitate food donation and the use of former foodstuff and by-products from the food chain in feed production without compromising food and feed safety. Moreover, the Commission will examine ways to improve the use of date marking by actors in the food chain and its understanding by consumers, in particular the "best before" label.

The LIFE programme has co-funded six projects that offer useful lessons on how to create a circular economy for food waste. The earliest projects focused primarily on changing consumer behaviour. For instance, WASTEPrevKit (**LIFE05 ENV/FIN/000539**), which ran from 2005 to 2008, worked with households, schools, day care centres, vocational institutions, public administrations and enterprises in the Helsinki metropolitan area to test, disseminate and adopt best practice models and materials on waste prevention. The project ran a special information campaign dedicated to preventing food waste, with a catchy slogan that translates as "less food wasted means more money in your wallet".

It also worked directly with 14 families in the residential area of Viikki-Latokartano who kept a diary of the amount of waste they produced. Over the course of the project action these families reduced the amount of biowaste they generated by some 22%. One of the participants, Mirva Merimaa, explains that, "at first it was quite a struggle following the instructions to 'waste less food'. We had to change the way we thought and bought." By the end of the trial, this new way of thinking had become automatic. What's more, participating in the project brought on new ideas for collaborative economies.

The MINIWASTE project (**LIFE08 ENV/F/000486**) worked with households in metropolitan areas in three countries to reduce the amount of organic waste they produce. Actions took place at full-scale in Rennes (France) and Porto (Portugal) and at pilot-scale in Brno (Czech Republic). Project beneficiary ACR+ collected and analysed various (bio-) waste reduction case studies implemented in Europe to create an inventory of good practices. It also provided citizens with training to help them sort and compost food and other biowaste.

The project's strategy to reduce biowaste at source focused on distributing composting bins to citizens, developing collective composting sites and demonstration sites where people could learn composting techniques. In total, the project trained nearly 12 000 people in such techniques, diverting some 8 500 tonnes of organic waste for reuse in shared community gardens. Rather than relying on the support of volunteers to raise citizens' awareness of composting, the beneficiary proposed establishing a network of salaried ambassadors to keep promoting good practices in organic waste management.

WASTEPrevKit worked with families and ran campaigns to reduce food waste

Photo: LIFE05 ENV/FIN/000539

More recent LIFE projects have addressed complete food value chains, including legislative barriers. In Italy, a group of projects led by LOWaste (**LIFE10 ENV/IT/000373**) formed a network to successfully push for changes to the law on food waste (see box). LOWaste initially set out to create local waste markets for second life products. This involved creating a pilot 'Low waste district' for reuse and recycling in the city of Ferrara, including scalable pilot projects focusing on demolition aggregates, street furniture and play equipment, surgical textiles and used cooking oil and food scraps. The latter pilot avoided 30 tonnes of food waste, produced 4.5 tonnes of compost and demonstrated the feasibility of creating a local supply chain turning food waste from school canteens in Ferrara into compost for community allotments.

However, the project also found that the reuse and recycling necessary to build circular economies within the food industry was being held up by legal constraints. This led to the formation of an influential working group of Italian LIFE projects on waste legislation.

The Greek project WASP Tool (**LIFE10 ENV/GR/000622**) developed a web-based decision-support tool that helps local authorities to develop customised waste prevention programmes.

Creating a circular economy for food waste in Italy

The waste working group included the following LIFE projects in addition to LOWaste: ECO Courts (**LIFE10 ENV/IT/000401**), IDENTIS WEEE (**LIFE10 ENV/IT/000393**), NOW (**LIFE10 ENV/IT/000404**), NO WASTE (**LIFE10 ENV/IT/000307**), PRISCA (**LIFE11 ENV/IT/000277**), PROMISE (**LIFE08 INF/IT/000312**) and WASTE-LESS in CHIANTI (**LIFE09 ENV/IT/000068**).

"The working group identified the critical limits of the regulations on waste and concrete proposals to overcome them," recalls Alessandra Vaccari of LOWaste. These proposals were submitted to the Italian Parliament and Ministry of Environment in February 2014 during a consultation phase for PINPAS, Italy's national plan for the prevention of food waste.

"We contributed by working with members of the Parliament and by answering their questionnaire," explains Anna Brescianini, project manager of NOW. "We also invited some members of parliament to visit our project so that we could explain our experience and the most optimal solutions to adopt. After this visit, in October 2015, we reviewed the first legislative proposal before it was sent to the Senate and also sent our comments in the second reading."

Photo: LIFE10 ENV/IT/000404

In 2016, Italy became only the second EU country to pass legislation that encourages supermarkets and restaurants to stop throwing away unsold food. The new law includes new food safety regulations that will enable products that are past their 'best before' dates to be donated to charity.

This clause can be directly linked to the demonstration value of the NOW project, which worked with 26 supermarkets in Brescia to collect organic food waste and donate it to around 70 local charities who distributed it to the needy through food banks. The project's circular economy saved more than 1 500 tonnes of expired supermarket food that was still suitable for consumption and helped feed over 5 000 people per week. It also created 16 new jobs, including four for disadvantaged people.

The project achieved good local visibility by organising 37 demonstration days and forging links with 61 school classes. It also signed 85 agreements with municipalities, supermarkets and municipal waste agencies, enabling the continuation of the waste reuse cycle after LIFE.

Ms Brescianini believes that the project's model can potentially be transferred to other cities and regions in Italy and elsewhere in the EU, as long as there are "appropriate adjustments relating to the national legislation and local context." She also notes the possibility of applying it to other sources of food waste, such as wholesalers' unsold food and edible waste from small stores or canteens.

However, she adds that there remain both economic and legislative barriers to replication. "Generally, the holders of edible food have no economic advantage to implement this system. Potential beneficiaries of donations must independently meet all costs arising from the withdrawal, selection and distribution of donations," she explains. Legislative "stonewalls" include the fact that national legislation on food safety does not favour donation and precludes donated food being reused as a raw material. Another barrier is a lack of tax breaks for donating waste food.

The beauty of 'ugly fruit'

The FLAW4LIFE project (**LIFE14 ENV/PT/000817**) aims to change food consumption habits and create an alternative market for 'ugly' (or less than perfect-looking) fruit and vegetables. It aims to bring about the equal marketing of all quality fruit and vegetables regardless of their size, colour and shape. The project will achieve this goal by replicating nationally an innovative methodology (called Fruta Feia or 'Ugly Fruit'), which has already been tested in Lisbon and Porto.

"The main challenge in replicating FrutaFeia Co-Op's methodology across Portugal is to ensure that new delivery points are as financially self-sustainable as the ones we have in Lisbon," explains project manager, Isabel Soares. "This means to collect a minimum number of associated consumers eager to consume local and ugly fruit; to establish a work and trust relationship with local farmers in order to build a reliable network of ugly fruit suppliers; to find a local association or site with the conditions to host the delivery point; and to gather a team of volunteers to help the local coordinators unload the transportation van and set the boxes in the delivery points," she says.

The project manager explains that there must be at least 250 associated consumers per delivery point, taking fruit from 35 farmers within a 70 km radius. The cost to the consumer must be no more than €1.50 for a small box of 'ugly fruit' and €3 for a large box.

Fruta Feia currently saves 5.6 tonnes/week of food waste at its five delivery points (three in Lisbon, two in Porto). The aim of FLAW4LIFE is to increase the number of delivery points to 11 and the amount of food waste saved to 12 tonnes/week. According to Ms Soares, "the most important factor in creating a market for 'ugly fruit' is consumer awareness. Only by increasing it will it be possible to gather a group of consumers who do not judge the quality of produce based on aesthetics and a movement capable of changing consumption patterns."

The project aims to spread its approach across borders through collaborations and the publication of a best practice handbook. Ms Soares notes that the market for imperfect fruit and vegetables is increasing across Europe, but cautions that replication of Fruta Feia's model is only possible in similar conditions: "urban areas with an enough 'ugly fruit' consumer demand supplied by a rural region no more than 70 km away."

She also notes that there are some barriers to market growth. "These are related to quality requirements regarding appearance, whether imposed by European or national legislation or by internal company rules, which stipulate the size and shape of fruit and vegetables to be sold and lead to many unnecessary discards." The EU's 2012 'Resolution on how to avoid food wastage - strategies for a more efficient food chain in the EU' (2011/2175(INI)) - illustrates that policymakers and food retailers are increasingly looking at ways to overcome these barriers and ensure that food quality requirements are not based on appearance.

The WASP Tool includes information on the most efficient waste prevention actions that have been used throughout the EU and their applicability in specific local contexts. The LIFE project piloted use of the tool in two municipalities in Greece and one in Cyprus, where demonstration waste prevention actions took place. These included workshops, training courses and leaflets on food waste prevention, including recipes on using leftovers in Mediterranean cuisine. To assess the impact of these measures, volunteers filled out questionnaires and food waste diaries. "The intervention resulted in 9-12% food waste prevention in the participating municipalities," explains project manager, Katia Lasaridi.

"Local authorities in the wider Attica Region have expressed their interest in using the WASP-Tool in order to optimise the development of their local waste action plans," she adds, noting that, "a reference to the WASP Tool project has already been made in the national waste prevention strategy of Greece."

Priority sector four: Biomass and bio-based products

In a circular economy, a cascading use of renewable resources, with several reuse and recycling cycles, should be encouraged where appropriate. It is important to only use biomass for energy when it does not conflict with other land uses, in particular food production. The Commission will promote efficient use of bio-based resources through a series of measures including guidance and dissemination of best practices on the cascading use of biomass and support for innovation in the bio-economy.

Photo: LIFE12 ENV/ES/000913

LIFE Eucalyptus Energy is developing an integrated model for adding value to eucalyptus biomass

LIFE projects in this segment that have taken the waste hierarchy into account include Eucalyptus Energy (**LIFE12 ENV/ES/000913**), LIFE VINEYARDS4HEAT (**LIFE13 ENV/ES/000776**), LIFE OxyUp (**LIFE13 ENV/BE/000517**) and cellu2plaLIFE+ (**LIFE13 ENV/NL/000613**) – see box.

The Eucalyptus Energy project is working to generate additional value from 'waste' biomass – branches and leaves – in eucalyptus plantations in Spain and Portugal. Eucalyptus is used to make pulp for papermaking, charcoal, biochar, dyes and eucalyptus oil. There are more than 1.4 million ha of eucalyptus plantations in Spain and Portugal, generating an estimated 2.8 million tonnes/yr of biomass residues. If left unattended these can cause forest fires. Controlled burning on site, the preferred existing management method, can cause soil erosion and pollution and doesn't respect the principal of cascading use of biomass.

Vineyard biomass will be used to fuel boilers in wineries and public buildings

Photo: LIFE13 ENV/ES/000776

The Eucalyptus Energy team is constructing a pilot pyrolysis plant in Spain capable of generating more than 100 kWe of electrical energy from eucalyptus waste. "As a sub-product, the process will generate biochar," explains project manager Lucía Hernández Muñiz. "This material has a high CO_2 sequestration capacity, at least half of the pyrolysed organic material. It also has an extraordinary capacity to improve soil texture, soil water retention and soil oxygenation," she adds.

If the project is successful and the technology is shown to be cost effective, Ms Hernández says the goal is to create an industrial-scale version of the plant. This would create around 10 jobs directly.

Another project seeking to create a virtuous circle for biomass waste is LIFE VINEYARDS4HEAT. Some 80% of land in Penedès county, Catalonia, is devoted to viticulture, generating 30 000 tonnes/yr of biomass. The county capital, the municipality of Vilafranca del Penedès, will set up a biomass value chain for this vineyard waste. The town's publicly-owned water company will be responsible for collecting, drying and distributing biomass gathered

from some 3 000 ha of local vineyards. This will be used to fuel boilers, installed by the project, heating and cooling two wineries and four public buildings. LIFE VINEYARDS4HEAT will also produce 'Biomass Roadmap 2025', a 10-year strategy to transition towards a low-carbon economy in the project area.

Transferable results will include policy recommendations and good practices on the use of vineyard biomass (aimed at local, regional, national and European authorities). Some 600 vine growers and 25 wineries will be informed about the Vineyards Virtuous Circle, the project's name for its integrated governance strategy for biomass waste from vineyards.

Energy-intensive industries generate significant quantities of difficult-to-treat biomass. These waste streams include "recycled wood, polluted (creosoted) wood, solid recovered fuel (SRF) and sewage sludge," explains Jean-Christophe Muûls, the chief financial officer of Xylowatt, the coordinating beneficiary of LIFE Oxy-up. The ongoing Belgian project aims to demonstrate the technical and economic viability of an oxy-gasification process for brickmaking and packaging glass manufacturing. Mr Muûls says there is huge potential for transferability and replicability should the market move towards decentralised and decarbonised sources of energy. "The main challenge to be overcome to meet the goals of the project is the sharp drop of the natural gas price and the lack of financial support for decarbonised gas."

Harvesting cellulose from wastewater

The ongoing Dutch project, cellu2plaLIFE+, has also shown its potential for innovation in new materials. It aims to manufacture polylactic acid (PLA) from the cellulose found in wastewater "Instead of producing waste, the wastewater treatment plant (WWTP) generates an environmentally attractive feedstock, contributing to the bio-based economy by converting raw municipal wastewater into feedstock (glucose) and ultimately bioplastics," explains project manager, Bob De Boer. The cellulose will be recovered from wastewater using finescreens of 350 microns installed at a treatment plant in Beemster, managed by coordinating beneficiary, HHNK. This regional water authority installed eight finescreens in July 2016 and cellulose harvesting has begun. From October 2016, the cellulose will be converted into PLA at a new plant owned by Dutch waste management company, Attero.

The performance of both processes will be assessed by STOWA, the foundation for applied water research. "STOWA will determine environmental benefits in terms of energy use and production, sludge production, CO_2-emission and transition from mineral-based plastics to bio-based plastics," says Mr De Boer. It will also produce an environmental impact assessment of several steps of the processes and "produce an economic analysis report that gives insights into the economic performance of the wastewater treatment plant compared to its original configuration and the economic potential of the PLA produced," he adds.

The project expects to be able to use 65% of the cellulose sludge to manufacture PLA, producing some 350 tonnes/yr at the demonstration site. The remaining sludge fraction will be transformed into bio-energy.

Photo: LIFE13 ENV/NL/000613

Priority sector five: Construction and demolition

In volume terms, construction and demolition are among the biggest sources of waste in Europe. Many of the materials are recyclable or can be reused, but reuse and recycling rates vary widely across the EU (from less than 10% to over 90%). The construction sector also plays a role in the environmental performance of buildings and infrastructure throughout their life.

The recycling and recovery of construction and demolition waste (CDW) is encouraged by an EU-wide mandatory target, but the potential is not fully exploited as valuable materials are not always identified, collected separately, or adequately recovered. The Commission has presented a voluntary construction and demolition waste management protocol that aims to improve waste identification, source separation and collection, waste logistics and processing, as well as quality management. In addition, the Commission will develop guidelines for the assessment of buildings prior to their demolition or renovation, and is promoting sorting systems for CDW in the revised proposals on waste. It is currently conducting a study to identify the obstacles to, and drivers for, the recycling of construction and demolition waste, and best practices in this area.

The Commission will also develop indicators to assess environmental performance throughout the life-cycle of a building, and promote their use for building projects through large demonstration projects and guidance on green public procurement.

Photo: LIFE03 ENV/P/000506

REAGIR generated almost 3 700 tonnes of usable aggregates

REAGIR (**LIFE03 ENV/P/000506**) was one of the first LIFE projects to encourage the recycling of CDW. This Portuguese project worked with construction and demolition companies to establish a collection system for CDW in the municipality of Montemor-o-Novo (Alentejo region). At participating companies (some 61% of CDW producers in the project area), the waste was separated at source into an inert fraction for recycling, other fractions that could also be recycled or reused, and the remainder for disposal. The recyclable waste was treated at a pilot line established by the project to convert CDW into aggregates and other building materials. This enabled nearly 4 000 tonnes of waste to be recycled into usable aggregates and produced 16 000 paving blocks and 420 kerbs.

As well as highlighting the environmental and economic benefits of separation at source, the project cleaned up 20 illegal landfill sites and significantly reduced the incidence of illegal dumping of CDW. In part, this was driven by the introduction of new local regulations proposed by the project, including a mandatory requirement for operators to hold a CDW Management Certificate. These paved the way for more stringent national laws on management of this type of waste.

Another LIFE project taking a systemic approach and linking practical actions with policy was VAL-C&DW (**LIFE10 ENV/RO/000727**), which developed a pilot demolition waste management system for Buzau County, Romania. The project analysed the quantity and composition of all categories of waste categorised under Class 17 in the European Waste List and developed best practice guidelines for separate collection at source.

The pavement blocks produced by REAGIR contained 20% of recycled concrete aggregates

Photo: LIFE03 ENV/P/000506

Photo: LIFE10 ENV/RO/000727

VAL-C&DW developed a mechanical treatment plant that is producing secondary raw materials from construction and demolition waste

The mechanical treatment plant opened in January 2015 and is producing secondary raw materials for anti-dust surfacing on dirt roads and for ground levelling from CDW. The operation of the VAL-C&DW pilot system is therefore an important step on the path toward closed material cycles.

The manufacture of additional products is dependent upon changes to EU definitions of 'end-of-waste'. The project identified some suggestions for the definition of the requirements concerning CDW in a report entitled 'End of Waste'.

Another barrier to the reuse of recycled materials in construction is the habits and motivation of stakeholders. While VAL-C&DW has started the process of fostering this change in Romania, it may take years for a significant market for recycled CDW products to develop.

The Slovenian National Building and Civil Engineering Institute set up the REBIRTH project (**LIFE10 INF/SI/000138**) with the goal of increasing the recycling of industrial waste and CDW for use in the construction sector. It aimed to achieve this by raising awareness of the recycling possibilities for these materials at national, regional and local level.

An important aspect of the project involved practical demonstrations – supported by life-cycle assessment - of recycling and reuse of different types of CDW and industrial waste, including steel slag, building rubble from illegal waste dumps and cold in-place recycling for reconstruction of pavements.

In total, this Best LIFE project 2015 reached more than 33 000 people through events and on-site demonstrations of waste recycling and reuse. Surveys showed that these demonstrations and workshops were found to be particularly useful in raising awareness and disseminating best practices among the expert public, such as waste producers, demolition companies, building contractors, local and national decision-makers, and inspectors.

Figures show that there was an 11.6% increase in the reuse of construction and demolition waste in Slovenia between 2010 and 2014 and a 9% reduction in the use of materials. A survey of all 212 Slovenian municipalities also found that illegal dumping had declined. The project's on-site live demonstrations could form the basis for similar actions in other Member States. Indeed, building on the success of this LIFE project, the beneficiary and its partners are now developing a project on cross-sector material recovery with partners from Croatia, Germany, Hungary and the UK.

If not separated at source, CDW can contain hazardous wastes that pose environmental risks and can hamper recycling. The French project CDW-recycling

(**LIFE11 ENV/FR/000752**) aimed to design and set up sorting processes for the two fractions of CDW which can contain hazardous substances, namely 8-30 mm and 30-80 mm. To achieve this, project partner Pellenc Selective Technologies adapted its optical and blowing technologies for industrial use.

"The project was able to demonstrate that it is possible to sort construction and demolition waste using optical sorting machines," says project manager Killian Leroy of Veolia. Non-inert waste plaster was extracted from a flow of 'dirty' rubble, comprising 70% inert materials (aggregates) and 30% non-inert waste (plastics, wood, paper, plaster, cardboard and scrap metal). "The machines installed in the Nice sorting center (pilot site) can extract 80% on average of non-inert materials in a stream of dirty rubble," notes Mr Leroy.

As well as showing that plaster can be extracted from aggregates in sufficient quantities to reduce pollutants (sulphates) in inert landfill, the CDW-recycling project improved knowledge and skills for CDW sorting, dealing with specific constraints related to waste density, dust, humidity, outdoor conditions, and so on. In particular, the optical sorting technology was modified to combine colour analysis and chemical analysis. "This has greatly improved the sorting quality when waste is wet, which is very important because most CDW is stored outside and therefore subject to the weather," explains Mr Leroy.

The ongoing project LIFE ECO TILES (**LIFE14 ENV/IT/000801**) aims to demonstrate an innovative methodology that integrates promising research results to produce a new generation of Terrazzo tiles made from 70% recycled materials using a patented low-energy production process. "ECO TILES products will contribute to the achievement of EU 2020 goals on waste and resource efficiency, by reducing emissions, resource waste, impacts on human health and the environment," says project manager, Eleonora Paris.

The first tile samples were presented at CERSAIE, the International Exhibition of Ceramic Tile and Bathroom Furnishings, in Bologna (Italy) in September 2016. The tiles include 50-60% recycled glass (in place of aggregates) and pozzolan cement made from construction and demolition waste (c.15% of the weight of the tile).

"To obtain the same quality standards, we had to carefully verify the waste materials to be used as well as to optimise the recipes and the industrial processes. ... It is therefore a continuous process which makes university and industry work together to find the best solutions," explains Ms Paris.

The most rigorous way of ensuring the recycled materials meet the high quality standards required for ceramic tile manufacturing is for the recycler to process the waste before its delivery. "This is an extra step which, although not very desirable, helps ensure the quality of the new product made with waste. Only if the quality of the eco-product is very high, in fact, will it attract the interest of the market and the end users," says Ms Paris.

Terrazzo tiles are produced in many parts of the world, so the process, when optimised, could be widely replicated. "The real challenge will be to achieve acceptance first by stakeholders and then by consumers," she explains. The mandatory application of Leadership in Energy and Environmental Design (LEED) norms in construction would dramatically increase the demand for eco-products, concludes Ms Paris.

The challenges involved in creating a circular economy for gypsum from demolition waste are highlighted by the work of the G to G project (**LIFE11 ENV/BE/001039**) on the following pages.

The tiles are made with 70% of recycled materials such as glass and pozzolan cement from construction and demolition waste

Photo: LIFE14 ENV/IT/000801

PRIORITY SECTORS

A circular economy for **gypsum waste**

The GtoG ('Gypsum to Gypsum') project pioneered the development of a circular economy for gypsum in demolition waste. Among the project's achievements was the creation of a roadmap for a sustainable value chain.

Gypsum sticks to other construction materials in demolition waste, making it difficult to valorise the material

Gypsum is an abundant mineral that is used to make plaster and plasterboard, materials widely used in construction. With around 160 quarries and 200 factories, the European gypsum industry has an annual turnover of €7 billion, employs 28 000 people and is indirectly responsible for another 300 000 jobs. More than 1 million construction workers use products containing gypsum.

The gypsum industry generates 1% of all construction and demolition waste. This can be divided into three categories: production waste (gypsum boards that do not meet specifications and waste resulting from manufacturing; construction waste (i.e. waste from building sites); and demolition (and renovation) waste.

The chemical composition of gypsum products remains unchanged. This means that they are among the few construction materials for which closed loop recycling is possible. Despite this possibility, gypsum recycling rates are low. The main barrier to recycling is the fact that buildings are currently demolished and not dismantled, hampering the recovery of gypsum waste.

However, the gypsum industry recognises the need to recycle more, driven in part by the closure of coal-fired power stations, which supply synthetic gypsum, a by-product of flue-gas desulphurisation, and in part by increasing difficulties in opening or extending gypsum quarries.

In 2011, Eurogypsum, the European association of plasterboard manufacturers, formed a partnership of 17 organisations covering the whole gypsum supply chain to deliver a LIFE project called GtoG - 'Gypsum to Gypsum' - (**LIFE11 ENV/BE/001039**), which set out to transform the demolition waste market to achieve higher recycling rates of gypsum waste. "The aim of the project was to gather experience on the demolition market; to be a maturation of the industry and a push for it to go forward," explains Christine Marlet, Secretary General, Eurogypsum, who coordinated the project.

Closing the gypsum loop

The GtoG project aimed to boost closed-loop recycling in accordance with the criteria in article 6 of the Waste Framework Directive. This would be achieved through the dismantling of plasterboard at demolition sites, reprocessing of recyclable plasterboard waste and reincorporation of the recycled gypsum in the manufacturing process.

The first stage of the project involved a technical, environmental, economic and legislative analysis of the different stages of the value chain, carried out by UPM (Universidad Politécnica de Madrid, Spain), with the input of the other partners. This preliminary study (January-September 2013) resulted in an inventory of current practices for deconstruction, recycling and reincorporation of recycled gypsum in manufacturing processes.

The second phase of the project was a set of pilot projects carried out in Belgium, France, Germany and the UK. There were five deconstruction, five recycling and five reincorporation projects, which together combined to form five projects covering the whole value chain (see box).

Long-term success

Results of the pilot projects fed into two European handbooks: one on 'best practices in audit prior to deconstruction of buildings', the other on 'best

The pilot projects

Pilot project 1: Belgium
Partners: Demolisher: RECASS; Recycler: NWGR; Manufacturer: GYPROC
Deconstruction of a two-storey 1990 office building in Brussels
2 800 m^2 of double-sided plasterboard partition with a metallic frame, infilled with mineral wood insulation
Amount of recyclable gypsum waste: 42.94 tonnes
Usual reincorporation rate: 10-15%
Project's reincorporation rate: 30%

Pilot project 2: France
Partners: Demolisher: PIN; Recycler: NWGR; Manufacturer: PLACOPLATRE
Deconstruction of a three-storey 1998 commercial building in Paris
340 m^2 of gypsum block partition, double-sided plasterboard partition with a metallic frame, infilled with expanded polystyrene, plasterboard ceiling with a metallic frame
Amount of recyclable gypsum waste: 9.38 tonnes (+7.80 tonnes of non-recyclable gyspum waste)
Usual reincorporation rate: 15%
Project's reincorporation rate: 27.5%

Pilot project 3: United Kingdom
Partners: Demolisher: Cantillon; Recycler: NWGR; Manufacturer: Siniat
Deconstruction of a 12-storey 1980s office building in London (recycling in Avonmouth; manufacturing in Bristol) 8 640 m^2 of plasterboard partition, metal frame, glass/rock wool insulation
Amount of recyclable gypsum waste: 50.00 tonnes
Usual reincorporation rate: 15%
Project's reincorporation rate: 22%

Pilot project 4: France
Partners: Demolisher: RECASS; Recycler: NWGR; Manufacturer: GYPROC
Deconstruction of a nine-storey 1968 office building in Levallois Perret
6 740 m^2 of gypsum block partition; double-sided plasterboard partition with a metallic frame, infilled with expanded polystyrene; plasterboard ceiling with a metallic frame
Amount of recyclable gypsum waste: 67.52 tonnes
Usual reincorporation rate: 10-15%
Project's reincorporation rate: 23%

Pilot project 5: Germany
Partners: Demolisher: KSE; Recycler: GRI (Werkendam, NL); Manufacturer: Knauf Gips KG
Deconstruction of five single-storey 1965 office buildings in Graben
3 450 m^2 of plasterboard ceiling, wooden frame, mineral wood insulation; plasterboard laminate, metallic frame; plasterboard partition, wooden frame, wood wool insulation
Amount of recyclable gypsum waste: 23.64 tonnes (+13 tonnes of non-recyclable gypsum waste)
Usual reincorporation rate: 5%
Project's reincorporation rate: 17%

practices in deconstruction techniques'. They also led to the drafting of European guidelines on gypsum waste acceptance criteria for recycling, and a techno-economic assessment of the incorporation of recycled gypsum into the plasterboard manufacturing process.

"In practice, the amount of plasterboard waste collected during the project was low: there is no constancy in volumes from demolition waste. We need to add production and construction waste to make recycling more viable," explains Ms Marlet. For this reason, the project suggests that the percentage of recycled gypsum in wall panels should remain at 5% in the European Commission's green public procurement criteria.

In the project's After-LIFE Communications Plan, Eurogypsum and its partners outline a set of long-term indicators of project success. The first is a European Regulation on mandatory deconstruction and sorting on site, with the aim of increasing the urban construction and demolition mining base. "It is impossible to create an economically-viable system unless incentives are raised at national level to make deconstruction and sorting mandatory," says Ms Marlet. A second long-term target is 'design for deconstruction'. In particular, she says, "raising architects' awareness is essential if we want to increase the technical feasibility of deconstruction."

In order to increase the attractiveness of recycling, the GtoG team says that landfill taxes should be increased at national level. "The higher the landfill costs are, the better it is for recycling...If the recycling gate fee (average 55 euros/tonne) is lower than the landfill costs, (gate fee + landfill tax), there will be more chance that the demolishers will choose the recycling route; the recyclers will recycle more plasterboard waste, and the manufacturers will reincorporate more plasterboard waste in the production process," says Ms Marlet.

Another means of making recycling more attractive would be more widespread enforcement in the EU of the Council Decision 2003/33/EC on the landfill of gypsum waste in mono-cells. "Gypsum was of concern because we have calcium sulphite in plasterboard, which means that the organic material when it is put into landfill and mixed with biodegradable waste, produces hydrogen sulphide (H_2S), which is toxic. So, in the Council Decision gypsum has been classified as non-hazardous, non-inert. And because we are non inert and there is potential risk if mixed with biodegradable waste that hydrogen sulphide will be produced we need to landfill in mono-cells," explains Ms Marlet. Despite the Decision, she notes that only three EU Member States have implemented the requirement for mono-cells: Belgium, France and the UK.

Careers in deconstruction

Dismantling buildings rather than demolishing them will create a demand for new green jobs and new skills. "You need to separate, you need time and you need trained people," explains Christine Marlet. "There are no consolidated figures, but you would need more people, you would need building auditors as well; expert jobs and unskilled jobs – everything. Of course it will not increase the job numbers in the gypsum industry itself, but in recycling and deconstruction, yes," she says.

To achieve a circular economy in the gypsum industry, there is a need for recyclers in more countries (at present they are only found in Belgium, UK, France, Germany, the Netherlands and Ireland). In particular, recyclers are needed in Italy, Spain and Poland. To support this step, the GtoG team proposes an increase in R&D for non-recyclable gypsum-based waste in collaboration with gypsum manufacturers.

Finally, in order to increase the rate of reincorporation, the project proposes support for R&D to adapt the manufacturing process so as to increase the percentage of recycled gypsum in plasterboard and design for recycling. Paper is the main contaminant in the recycled gypsum which can make re-incorporation in plasterboard manufacturing difficult.

The road ahead

Thanks to the LIFE project, Eurogypsum was able to draft a *Roadmap for future implementation of a sustainable value chain*. The roadmap identifies

A transferable value chain?

As part of the LIFE project, Eurogypsum assessed the potential for transferring the gypsum value chain, interviewing industry associations representing those in the value chain of a range of other materials used in construction, included insulation, metals, glass, wood panels, recycled PVC and expanded polystyrene. The analysis concluded that, since many of the operators and issues are the same, there is potential to apply the same approach to increase recycling of other materials found in CDW.

As a demonstration of the European added value of the project, GtoG held its final conference at the European Parliament in November 2015. This included presentations by a number of stakeholders on the development of a circular economy culture in Europe.

eight steps necessary to make gypsum recycling business as usual:

- National authorities push for deconstruction and recycling of plasterboard waste;
- Construction waste is collected separately;
- National and European statistics are improved;
- Municipalities enhance the collection of plasterboard waste;
- Logistics are optimised:
- The operators of the recycling value chain cooperate;
- There is no illegal shipment of waste to other countries; and
- Plasterboard waste is landfilled in mono-cells.

Cooperation between gypsum manufacturers and recyclers is key for a sustainable gypsum recycling value chain. Such a value chain already operates on a commercial basis in the UK, France, Belgium, the Netherlands and Scandinavia. “In Germany, it’s not yet in place, but it’s starting,” notes Ms Marlet. “The GtoG project showed that it was technically feasible to reincorporate 30% of recycled gypsum in plasterboard for a short period of time,” she says. Now the project partners wish to industrialise current processes so as to reach a 30% gypsum reincorporation rate as business as usual in production by 2020 in those countries where a commercial value chain is already established. In Germany, the goal is to achieve 30% by 2025. The industry will also promote recycling and strive to establish the value chain in Spain and Italy, Poland and eastern countries from 2025 onwards.

The Roadmap includes three suggestions of how to enhance the transferability of the gypsum recycling value chain to countries where it has yet to be implemented: enhance a deconstruction mentality across Europe; establish voluntary gypsum recycling targets; and enhance the recyclability of plasterboard waste.

“The main achievement of the project was a change of mentality - for everybody - for the demolishers, for the recyclers and for manufacturers,” says Ms Marlet. “Now it’s the willingness to go forward and implement the value chain in other countries. This will not happen if there is not a favourable context, a push,” she concludes.

Project number: LIFE11 ENV/BE/001039

Title: GtoG - GtoG: From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry

Beneficiary: Eurogypsum

Contact: Christine Marlet

Email: info@eurogypsum.org

Website: www.eurogypsum.org/sustainable-construction/gtog-life-project/

Period: 01-Jan-2013 to 01-Jan-2016

Total budget: €3 566 000

LIFE contribution: €1 783 000

LIFE & Circular economy project list

Here is a complete list of LIFE projects that are featured in LIFE and the Circular economy. Arranged by theme, the list highlights more than 120 LIFE projects relevant to the circular economy. These are drawn from a total of 16 EU Member States. For more information on individual projects, visit the online database at: http://ec.europa.eu/environment/life/project/projects/index.cfm

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PRODUCTION			
LIFE99 ENV/B/000639	ECO DESIGN	Demonstration and dissemination of ecodesign in industry as support for a sustainable growth.	21
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LIFE08 ENV/E/000158	BOATCYCLE	Management, recycling and recovery of wastes of recreational boat scrapping	21
LIFE12 ENV/FR/001113	LifeCiP (LCiP)	Life Cycle in Practice	22
LIFE12 ENV/UK/000608	LIFE REBus	Developing Resource Efficient Business Models	22
LIFE13 ENV/ES/000615	LIFE ECOLAC	Prevention of dairy product's environmental impact trough ecodesign	22
LIFE10 ENV/IT/000423	B.R.A.V.E.	Better Regulation Aimed at Valorising Emas	23
LIFE12 ENV/GR/000427	LIFE RECLAIM	Landfill mining pilot application for recovery of invaluable metals, materials, land and energy	23
LIFE15 ENV/FR/000512	LIFE AGROMINE	Cropping hyperaccumulator plants on nickel-rich soils and wastes for the green synthesis of pure nickel compounds	24
LIFE07 ENV/RO/000690	ECOREG	Application of industrial ecosystems principles to regional development ECOREG	25
LIFE15 ENV/IT/000697	LIFE M3P	Material Match Making Platform for promoting the use of industrial waste in local networks	25
LIFE09 ENV/GR/000300	eSYMBIOSIS	Development of knowledge-based web services to promote and advance Industrial Symbiosis in Europe	26
LIFE10 ENV/IT/000365	PODEBA	Use of poultry dejection for the bathing phase in the tanning cycle	26
LIFE12 ENV/ES/000568	MICROTAN	Recovery of tannery wastes for functional microencapsulated products	26
LIFE14 ENV/IT/001050	LIFE ECO-PULPLAST	Local circular economy by an innovative approach for recycling paper industry pulper waste into new plastic pallets	26
LIFE10 ENV/ES/000479	BREAD4PLA	Demonstration-plant project to produce poly-lactic acid (PLA) biopolymer from waste products of bakery industry	27
LIFE13 ENV/ES/001165	LIFE WALEVA	From Whatever Residue into Levulinic Acid – an innovative way to turn waste into resource	27
LIFE08 ENV/D/000027	SUBSPORT	Substitution portal : moving towards safer alternatives	28
LIFE12 ENV/GR/001135	LIFE READ	REACH Database for Safety Data Sheets (SDSs) and Workplace Instruction Cards	28
LIFE13 ENV/IT/000470	LIFE ECODEFATTING	Environmentally friendly natural products instead of chemical products in the degreasing phase of the tanning cycle	28
LIFE14 ENV/ES/000326	LIFECITRUS	Recycling of citrus industry scrap into natural additives for food industries	28
LIFE14 ENV/LV/000174	LIFE Fit for REACH	Baltic pilot cases on reduction of emissions by substitution of hazardous chemicals and resource efficiency	28
LIFE15 ENV/IT/000654	LIFE BIOPOL	Production of Leather making BioPolymers from biomasses and industrial by products,through Life Cycle Designed processes	29
LIFE12 ENV/UK/000966	LIFE+ CEMs	Circular Economy Metrics	22, 30-33
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LIFE08 INF/RO/000507	GREEN-PRO	Promoting green products	35
LIFE10 ENV/IE/000695	DEPOTEC	Depolymerisation Technology for Rubber with Energy Optimisation to produce Carbon Products	36
LIFE12 ENV/IT/000393	Life PREFER	PRoduct Environmental Footprint Enhanced by Regions	36

PROJECT REFERENCE	ACRONYM	TITLE	PAGE
LIFE05 ENV/F/000063	IDEAL 79	Ideal 79: Sustainable Initiatives and Local Alternatives towards waste prevention	37
LIFE05 ENV/FIN/000539	WASTEPrevKit	Waste Prevention Kit for enterprises, education and households	37
LIFE07 INF/F/000185 and LIFE12 INF/BE/000459	EWWR	European Week for Waste Reduction AND.....Life EWWR+ European Week for Waste Reduction	37
LIFE10 ENV/IT/000307	NO.WA	NO WASTE	37
LIFE13 ENV/IE/000763	WISER LIFE	Working with Industrial Spaces to Exemplify Reuse	37
LIFE07 ENV/GR/000271	HEC PAYT	The Development of Pay as You Throw Systems in Hellas, Estonia and Cyprus	38
LIFE11 ENV/FR/000751	WASTE ON A DIET	Strategy to reduce waste, increase re-using and recycling, reduce incineration and storage, in a rural and urban area	38
LIFE13 ENV/UK/000493	REPURPOSE LIFE	REPURPOSE equipping community groups in estates to reuse more, clear fly tipping and improve their local environment.	39
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LIFE10 ENV/GR/000610	ISWM -TINOS	Development and implementation of a demonstration system on integrated solid waste management for Tinos in line with the waste framework directive	52
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LIFE08 ENV/E/000132	Waste Joint Management	Development and operation of an integrated model for managing Industrial Waste in the Zona Franca Industrial Estate, Barcelona	53
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LIFE13 ENV/ES/000067	LIFE EXTRUCLEAN	Removal of hazardous substances in polyethylene packages using supercritical carbon dioxide(sc-co2) in recycling process	54
LIFE99 ENV/NL/000232	Paperfoam	Paperfoam: demonstration of the applicability of an innovative technology to produce packagings, made of natural fibres and starch, which are both environmental friendly and of a high quality	55
LIFE07 ENV/GR/000265	RECYCLING SYMPRAXIS	Public-Private Partnerships to optimise waste prevention, recovery and recycling systems	55
LIFE09 ENV/FR/000603	Green Waste Plast	Recycling plastics packaging waste excluding bottle	55
LIFE10 INF/SI/000139	Slovenia WEEE campaign	Raising awareness of the importance of environmentally sound management of WEEE among identified target groups in Slovenia	56
LIFE11 ENV/SE/000842	RenewPACK	RenewPACK: Demonstration of an Innovative Renewable Barrier Material for Sustainable Food Packaging	56
LIFE14 ENV/UK/000344	CRMRecovery	Critical Raw Material Closed Loop Recovery	56

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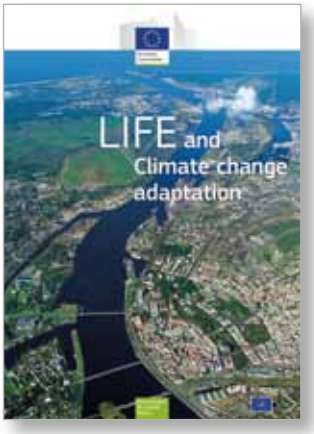

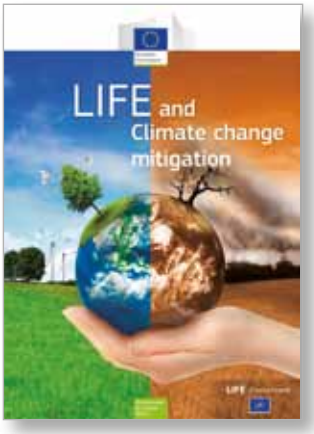

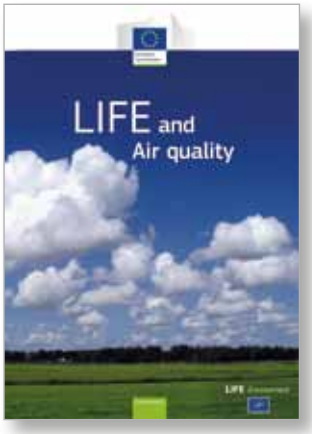

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A number of LIFE publications are available on the LIFE website: http://ec.europa.eu/environment/life/publications/lifepublications/index.htm

A number of printed copies of certain LIFE publications are available and can be ordered free-of-charge at: http://ec.europa.eu/environment/life/publications/order.htm

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LIFE "L'Instrument Financier pour l'Environnement" / The financial instrument for the environment

The LIFE programme is the EU's funding instrument for the environment and climate action

Period covered 2014-2020

EU funding available approximately €3.46 billion

Allocation of funds Of the €3.46 billion allocated to LIFE, €2.59 billion are for the Environment sub-programme, and €0.86 billion are for the Climate Action sub-programme. At least €2.8 billion (81% of the total budget) are earmarked for LIFE projects financed through action grants or innovative financial instruments. About €0.7 billion will go to integrated projects. At least 55% of the budgetary resources allocated to projects supported through action grants under the sub-programme for Environment will be used for projects supporting the conservation of nature and biodiversity. A maximum of €0.62 billion will be used directly by DG Environment and DG Climate Action for policy development and operating grants.

Types of projects Action Grants for the Environment and Climate Action sub-programmes are available for the following:

- "Traditional" projects – these may be best-practice, demonstration, pilot or information, awareness and dissemination projects in any of the following priority areas: LIFE Nature & Biodiversity; LIFE Environment & Resource Efficiency; LIFE Environmental Governance & Information; LIFE Climate Change Mitigation; LIFE Climate Change Adaptation; LIFE Climate Governance and Information.
- Preparatory projects – these address specific needs for the development and implementation of Union environmental or climate policy and legislation.
- Integrated projects – these implement on a large territorial scale environmental or climate plans or strategies required by specific Union environmental or climate legislation.
- Technical assistance projects – these provide financial support to help applicants prepare integrated projects.
- Capacity building projects – these provide financial support to activities required to build the capacity of Member States, including LIFE national or regional contact points, with a view to enabling Member States to participate more effectively in the LIFE programme.

Further information More information on LIFE is available at http://ec.europa.eu/life.

How to apply for LIFE funding The European Commission organises annual calls for proposals. Full details are available at http://ec.europa.eu/environment/life/funding/life.htm

Contact

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European Commission – Directorate-General for Climate Action – B-1049 Brussels (clima-life@ec.europa.eu).
European Commission – EASME – B-1049 Brussels (easme-life@ec.europa.eu).

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LIFE Publication / LIFE and the Circular Economy

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